AIR POLLUTION EPISODE AVOIDANCE GUIDE FOR

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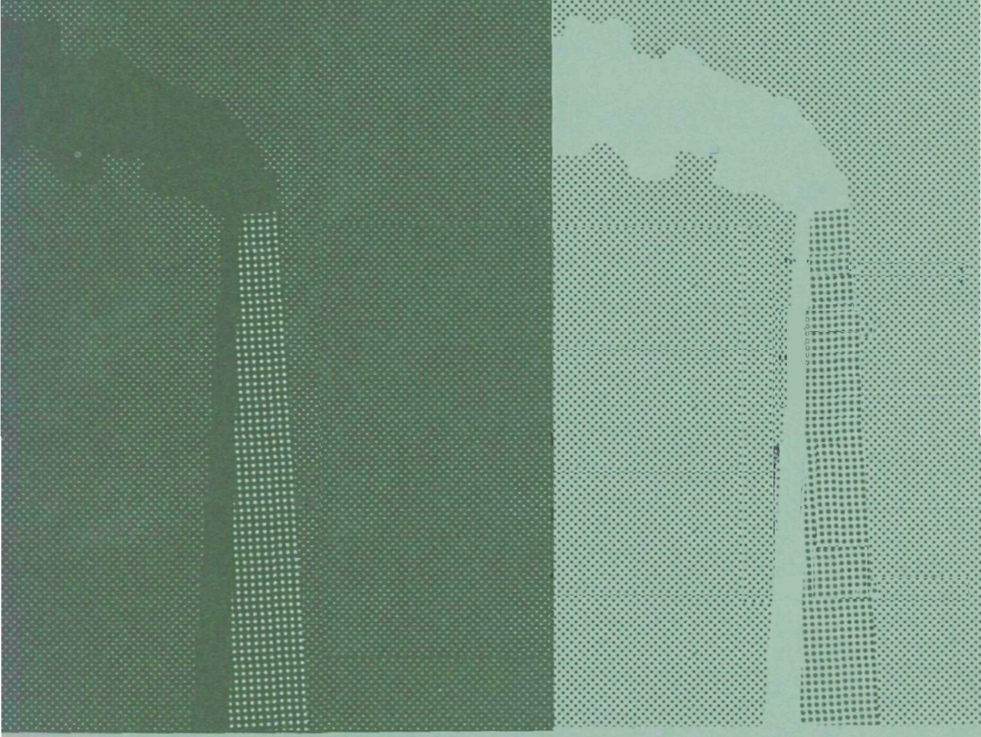

U. S. ENVIRONMENTAL PROTECTION AGENCY

GUIDE FOR AIR POLLUTION EPISODE AVOIDANCE

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FOREWORD

This *Guide* has been made available through the efforts of the Air Pollution Control Office's (APCO's) Emergency Operations Control Center and is intended to assist air pollution control officials and local governmental authorities in the formulation and implementation of emergency action plans for the avoidance of air pollution episodes. The *Guide* describes the planning necessary to forestall the adverse effects of air pollution episodes. Different regions have various legal and administrative frameworks, as well as different meteorological, topographical, and emission-source characteristics. Certain requirements are common to all regions, however, such as the need for: (1) information on emission sources, (2) information on the meteorology of the area, and (3) action plans for recognizing potentially severe episodes and coping with them.

The necessity for developing a guide such as this was established by the requirements set forth under Section 303 of the Air Quality Amendments of 1970. Section 303 reads as follows:

> "Notwithstanding any other provision of this Act, the Administrator, upon receipt of evidence that a pollution source or combination of sources (including moving sources) is presenting an imminent and substantial endangerment to the health of persons, and that appropriate State or local authorities have not acted to abate such sources, may bring suit on behalf of the United States in the appropriate United States District Court to immediately restrain any person causing or contributing to the alleged pollution to stop the emission of air pollutants causing or contributing to such pollution or to take such other action as may be necessary."[1]

Within EPA, the Air Pollution Control Office (APCO) is responsible for implementing the actions required to meet the provisions of the Act. Figure 1 depicts the APCO activities that are aimed at episode prevention and control. The Critical Areas Report ranked 64 Standard Metropolitan Statistical Areas (SMSA) according to criteria based on pollutant, meteorological, and population data. Five ranking schemes were used to select the 10 most episode-prone areas. The episode emergency plans of these cities were then evaluated with respect to the general nature of the pollution problems of these cities, the major elements included in their plans, and the completeness and detail of their emergency plans.

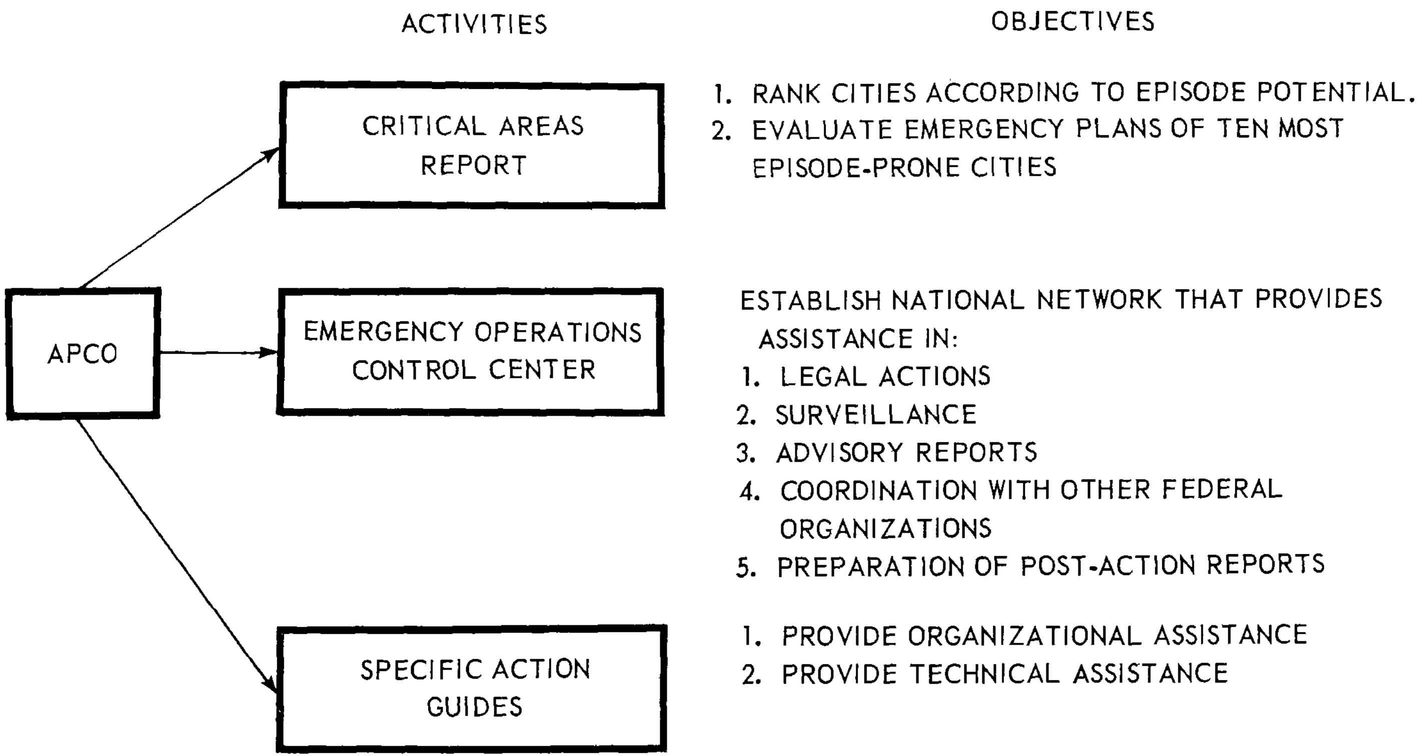

Figure 1. APCO'S role in planning for episode avoidance.

The Emergency Operations Control Center (EOCC) has been established in Durham, North Carolina. The Center receives and processes data relating to air pollution episodes and, as required, initiates avoidance actions to supplement those undertaken by local authorities. The Center essentially functions as an interface between the policy levels of Federal authority and an actual event or problem.

Each State is required by Section 110 of the Clean Air Act of 1970[1] to adopt and submit to the Administrator of the Environmental Protection Agency a plan that provides for the implementation, maintenance, and enforcement of national ambient air quality standards within each air quality control region that is wholly or partly within that State. Each implementation plan must include a system for curtailing pollutant emissions on an interim basis whenever such action appears necessary for the prevention of short-term episodes of high pollutant concentrations.

The material presented in this *Guide* covers the planning, technical, social, economic, legal, and administrative factors of importance in episode avoidance and control activities and in the establishment of an action center. The first chapter introduces the reader to the nature of episodes and the second presents an overview of episode avoidance plans and their implementation. Subsequent chapters present detailed information on specific topics related to the design and function of episode avoidance plans.

A glossary of technical terms commonly used is provided at the end of the *Guide.* Additional technical references are cited by chapter.

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1. United States Congress. Clean Air Act of 1970. PL 91-604, 42 USC 1857 *et seq*., Sections 110 and 303. Washington, D.C. December 1970.

GUIDE FOR AIR POLLUTION EPISODE AVOIDANCE

1. GENERAL INTRODUCTION

1.1 AIR POLLUTION EPISODES

Air pollution episodes occur under meteorological conditions, generally temperature inversions, that reduce the effective volume of air in which the pollutants are diluted. As the inversion persists and emission sources continue to contribute to the community's ambient air, concentrations of pollutants increase. Thus, just as attainment of regional air quality standards are dependent upon optional emission reduction strategies selected to achieve these long-term goals, avoidance of short-term air pollution episodes is dependent upon an emission reduction plan selected to provide rapid, short-term emissions control.

Exposure to high pollutant concentrations during episodes has been associated with excess* human mortality and morbidity. Reduced visibility and damage to vegetation and animals have also been demonstrated to result from periods of extreme pollution.

A review of episode documentation showed that one or more of the following factors was characteristic of each episode:

1. Stagnating anticyclonic weather systems were present.
2. Temperature inversions were noted.
3. Wind speeds were low.
4. Concentrations of smoke, sulfur dioxide, and other pollutants increased to critical levels.
5. Mortality associated with peak concentrations of air pollutants increased.
6. Morbidity increased with air pollution levels.
7. Effects were rapid.

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*"Excess" death or mortality is defined as the difference between the death rate during an episode and that normally associated with the geographical location and season of the year in question.

8. Death and illness occurred in all age groups.
9. Excess deaths increased with increasing age.
10. Effects of episodes on health seemed to be due to a combination of several pollutants.
11. Deaths were generally the result of respiratory or cardiovascular problems.
12. Coughing and eye irritation that occurred were related to pollution levels.
13. The duration of episodes generally ranged from 2 to 7 days.
14. Average sulfur dioxide levels ranged from 0.5 to 0.8 ppm.
15. Animals may have succumbed to air pollution.

Many borderline cases of critical air pollution may go unreported. A brief episode may not be reported in the technical literature because the number of people severely affected is not large enough to attract public attention. The 1953 episode in New York, for example, was not reported until 9 years later.[1] In his survey of episodes, Goldsmith[2] states that:

> "The toll of excess mortality and morbidity in disasters has never been appreciated at the time; therefore, protective measures were not taken."

Since the causes were not known, they were never reported. Awareness of air pollution is growing, however, and techniques for monitoring pollution are improving. High Air Pollution Potential Advisories (HAPPA), which are bulletins that warn of meteorological conditions leading to the accumulation of air pollutants, were initiated on a regular basis in August 1960.[1-3]

Air pollution episodes are becoming more frequent in the United States. Figure 1-1 indicates episodes reported in the technical literature over a 100-year period. Reported critical periods of air pollution go back as far as 1873. London has had 10 reported episodes since that date. New York City has had seven reported episodes since 1953, at least two of which were general episodes for the entire Eastern United States.[2-4] Other well-known episodes occurred in the Meuse Valley of Belgium and in Donora, Pennsylvania. Minor "incidents" have been reported in St. Louis, Missouri;[5] Cincinnati, Ohio;[2] Weirton, West Virginia;[7] Rotterdam, Holland;[2] Hamburg, Germany;[2] and Osaka, Japan.[2] Critical periods of smog have occurred frequently in Los Angeles, California, and outbreaks of asthma have been reported in New Orleans, Louisiana, and the Tokyo-Yokohama area of Japan. Detailed documentation is not available on most of the reported air pollution episodes, especially those occurring before 1957.

Lynn, Steigerwald, and Ludwig[3] have described in some detail the November-December 1962 air pollution episode in the Eastern United States.

Figure 1-2 shows the ratio of "episode" to "normal" particulate levels in an elliptical area from New York to Boston during that incident. Levels of benzene-soluble organics rose to seven times normal and total particulate concentrations rose to three to four times normal. Figures 1-3 and 1-4 show

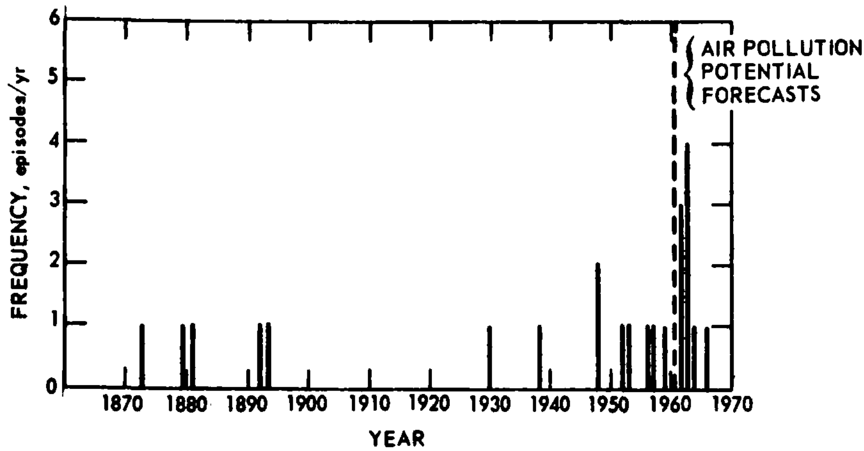

Figure 1-1. Frequency of air pollution episodes.

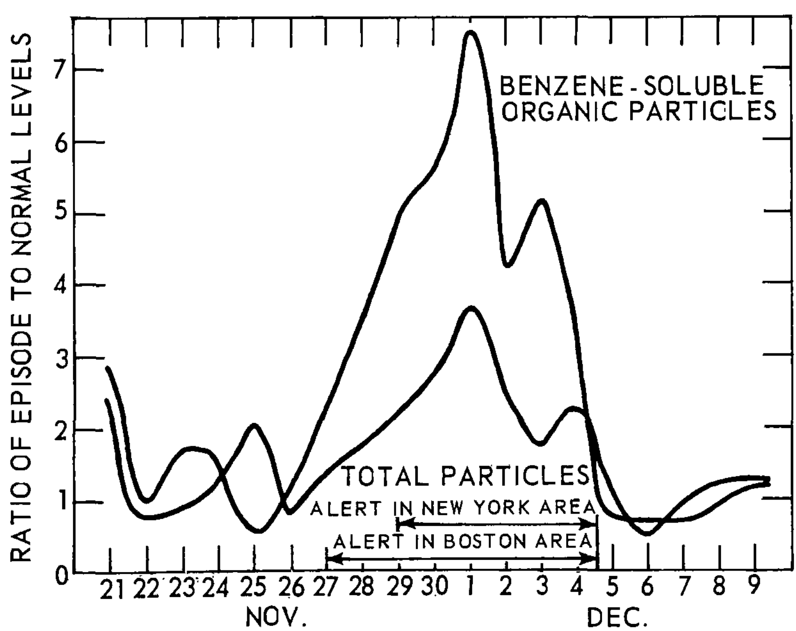

Figure 1-2. Ratio of episode to normal particulate levels in the Boston-New York area.

CAMP statistical data from Washington, D.C., and Philadelphia, Pennsylvania, during an episode.

1.2 PLANNING FOR EPISODE AVOIDANCE

1.2.1 General

Until recently, most communities in the United States have not had the means by which to avoid or control air pollution episodes. Little if any action had been taken to minimize pollutant concentrations during stagnant meteorological conditions. The public had likewise received little or no education concerning ways to reduce the adverse physiological effects of short-term, severe dosages of pollutants. Positive episode-avoidance action was not taken because of inadequate knowledge of episode conditions and because of the lack of advance planning for such emergencies.

We have now reached a point where effective episode planning is feasible. Improved air quality monitoring and air pollution meteorological systems are available, and research is being conducted to improve further those sensing techniques essential for forecasting and evaluating episode conditions. Accurate forecasts will make it possible for authorities to take the action necessary to

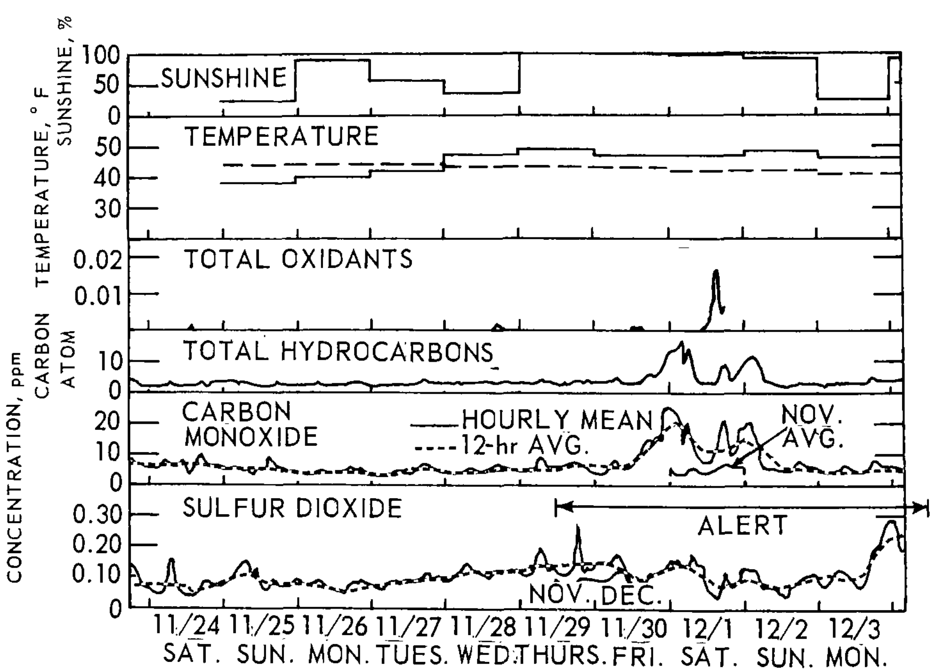

Figure 1-3. Continuous Air Monitoring Project statistical data, Washington, D. C.

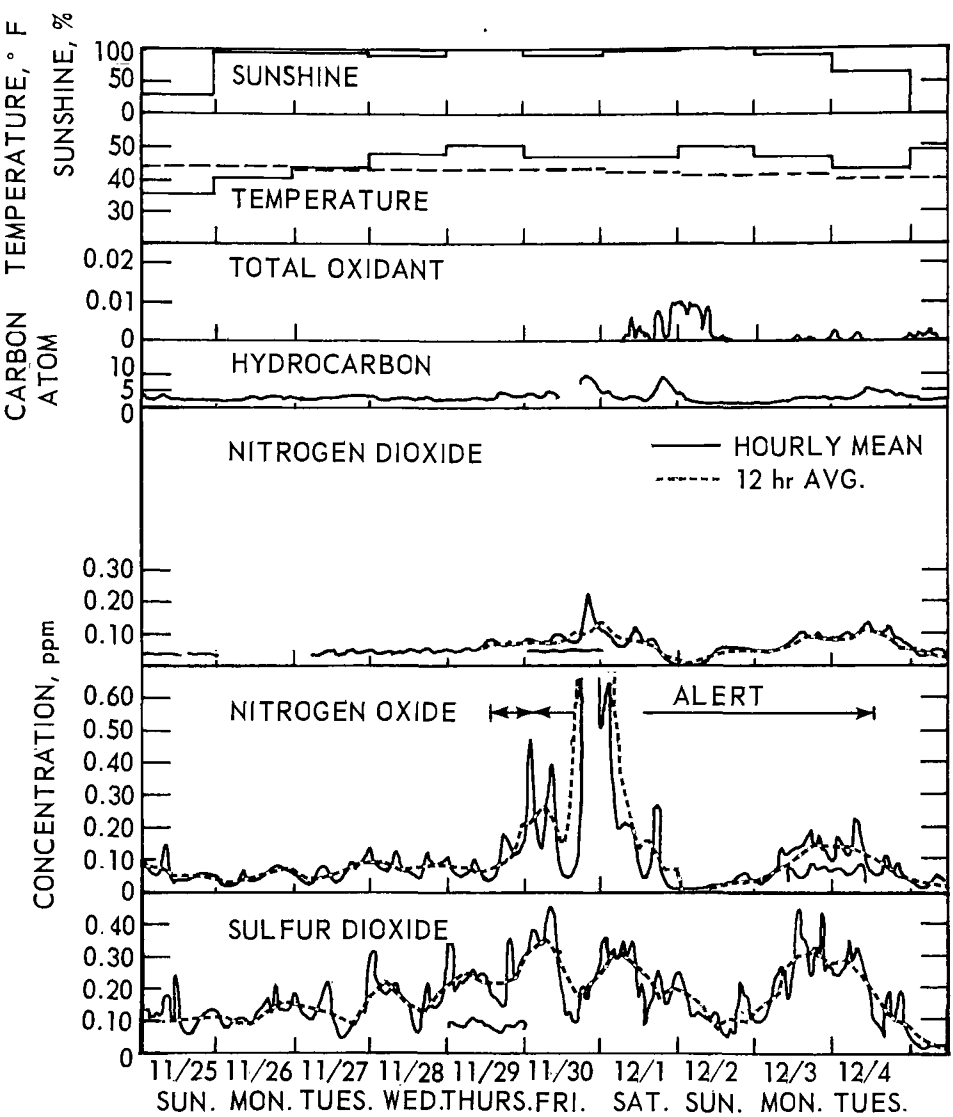

Figure 1-4. Continuous Air Monitoring Project statistical data, Philadelphia, Pennsylvania.

prevent the continued deterioration of ambient air as adverse meteorological conditions persist.

Public awareness has also stimulated emergency action planning. Allergic individuals, the elderly, and other persons who are severely affected by high pollutant concentrations are usually those most concerned about measures for preventing episodes.

The most important goal of the emergency action plan is the temporary curtailment of the emission of pollutants into the ambient air. Since stagnant air masses will prevent dilution of pollutants, the only feasible method for protecting society is to minimize the flow of pollutants from emitters. Adequate planning is necessary to coordinate control efforts and to ensure that sources are temporarily curtailed as soon as required.

Total community involvement is required for a successful episode-avoidance plan. It is essential that both large and small emitters cooperate to the fullest extent possible. Severe episodes will place direct demands on the public in areas such as curtailing automotive traffic and using less electricity and heat. Such restrictions are uncommon in our society, but rapid compliance will be essential during episodes. Each citizen must be made fully aware of his public responsibility during an episode so that cooperation under emergency conditions will be immediate and automatic.

The responsibility for devising an emergency action plan will usually rest with the control agency in each community. The plan must provide a strategy for optimum action under the specific conditions likely to be encountered in the community. Expense and inconvenience should be divided as equitably as possible within the limits imposed by the mandatory requirement that emissions be decreased to a level that will effectively prevent detrimental effects.

In designing an emergency action plan, the control authority must capitalize on available resources. Control agency staff, voluntary manpower, and available funds must be used effectively in order to meet the needs of the community. The most recent automatic data processing equipment and telemetry systems will not necessarily be required; relatively unsophisticated techniques may adequately serve the needs of many communities. In addition to illustrating the operations of model emergency action plans, this *Guide* indicates which resources are essential for effective episode avoidance.

The requirements for an emergency action plan (EAP) are presented in Figure 1-5. A discussion of plan requirements follows.

1.2.2 Information on Atmospheric Conditions

Knowledge of atmospheric conditions before, during, and after an episode is mandatory. Routine air quality and meteorological monitoring provides data that may be evaluated to determine potential episode conditions. Episodes themselves are detected by direct measurements of air quality, while potential episodes are often detected by the presence of meteorological conditions conducive to the occurrence of episodes. In measuring air quality, concentrations of particulates, carbon monoxide, sulfur oxides, oxidants, and other pollutants are monitored by sensing stations located within the region. Meteorological conditions are monitored by weather stations within the

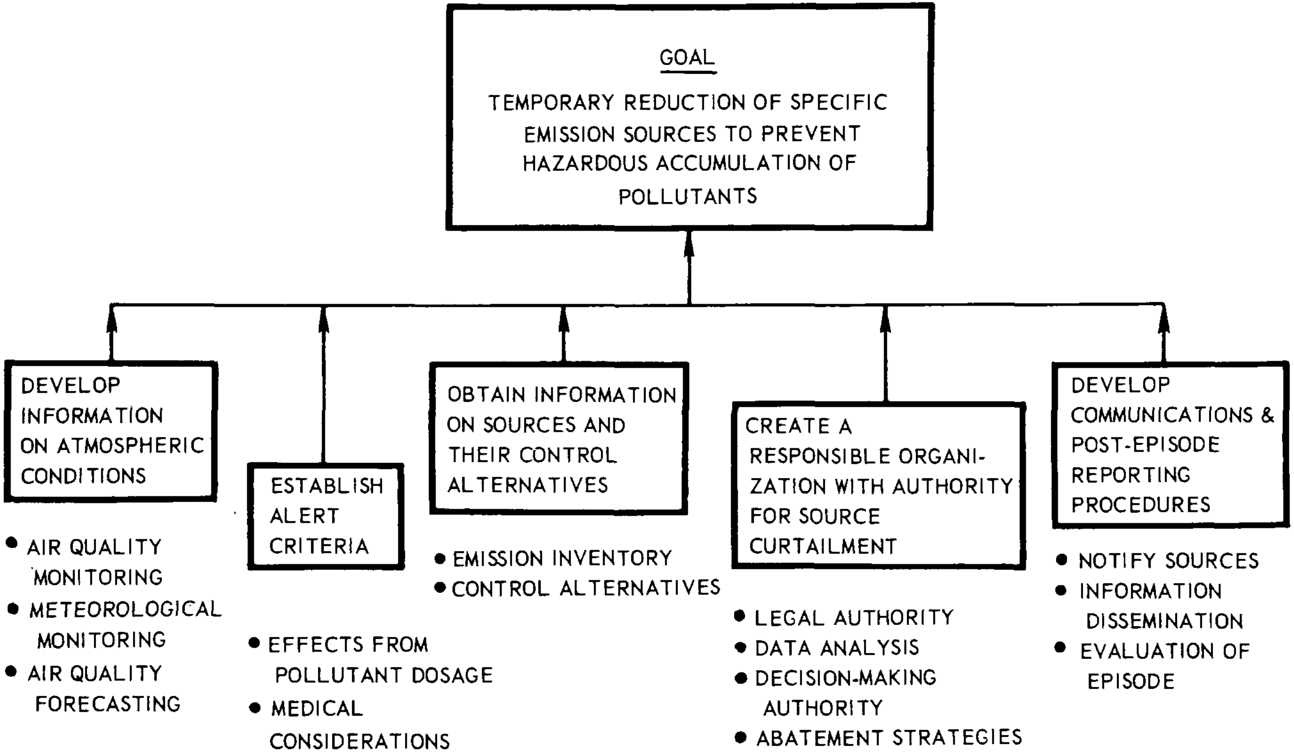

Figure 1-5. Emergency Action Plan requirements.

community or by the National Weather Service. As an aid to communities throughout the nation, High Air Pollution Potential Advisories (HAPPA) are prepared and disseminated by the National Meteorological Center (NMC) in Suitland, Maryland.

The frequency of air quality and meteorological measurements should be increased during episodes. The control authority will require current data in order to compare pollutant levels with criteria levels and promptly initiate emergency control actions when maximum permissible levels are exceeded. Data on present air quality, as well as forecasts of expected pollutant concentrations for periods of 24 to 48 hours, are essential to the decision-making process.

Some specific steps that must be executed in preparing an EAP are:

1. Define the mensural systems necessary to recognize the existence of alert criteria conditions.
2. Define the physical data to be monitored routinely; specify intensified monitoring (meteorological and air sampling) during potential episodes.
3. Establish procedures and systems for processing and reviewing data during potential episodes, including meteorological predictions.
4. Procure enough air-sampling and meteorological data to define concentrations of pollutants under various localized conditions.

1.2.3 Alert Criteria

Alert criteria are air pollutant concentrations at which certain pre-planned episode emission-reduction strategies are implemented. These alert levels must take into account air quality and meteorological factors, as well as socio-economic and health considerations within the community. Each community must devise criteria that meet the needs of the local situation. Guidelines for developing alert criteria levels are as follows:

1. The *first level* may only indicate the presence of adverse meteorological conditions.
2. The *second level* may be the signal for interim control action to begin, reflecting the occurrence of pollutant concentrations approaching the applicable short-term air quality standard.
3. The *third level* may indicate that air quality is continuing to deteriorate and that additional control actions are needed.
4. The *final alert level* may call for an immediate maximum curtailment of all appropriate sources in the region.

The number of alert levels should be compatible with the types of sources existing in the community and the abatement strategies deemed reasonable. Throughout the planning phases, *emphasis should be on preventing high pollutant concentrations, rather than on taking corrective action once they have occurred.*

Some steps to be taken in preparing alert criteria for an EAP are as follows:

1. Assemble the emission and air-sampling information necessary to define the local physical problem.
2. Establish a committee to review and recommend alert criteria; representatives from medicine, business, meteorology, air pollution engineering, government, law, and public safety (police) should be included on the committee.
3. Review the criteria that have been adopted in other, similar areas. Prepare arguments for revising them or for developing new criteria.
4. Establish responsibility and procedures for calling alerts.
5. Plan for annual review of the alert criteria and for special review following a major episode.

1.2.4 Information on Sources and Control Alternatives

The objective of an EAP is the immediate reduction of emissions during episodes so that air quality requirements are met. Control strategies are normally used to determine the specific control actions and the required degree of control for each source. These measures are necessarily selective, requiring emergency curtailment of non-essential, easily controlled sources first and postponing drastic measures until it becomes apparent that initial curtailments are insufficient.

Extensive emission data are required for the design of an equitable abatement strategy and the prediction of the effectiveness of this strategy. Source data are needed for predictive purposes.

An emission inventory is the accepted method of obtaining source data. Gross patterns of emissions can be determined from "paper" surveys of emission sources and subsequent "emission-factor" calculations. Direct determinations of emissions from individual sources are preferred since they are more accurate. Information obtained from such inventories is generally categorized by four main types of emission sources:

1. Fuel combustion by stationary sources.
2. Combusion of refuse material.

3. Transportation.

4. Industrial processes.

An analysis of emergency source-curtailment alternatives is required in order to determine potential emission reductions for the community. Each alert level will require a different degree of source curtailment. Control techniques used in emergency situations will often differ from those used under normal conditions. Emergency control alternatives normally include the following actions:

1. Switching to a low-sulfur fuel.
2. Shifting power loading.
3. Curtailing production operations.
4. Postponing operations.
5. Reducing traffic.
6. Stopping all non-essential activities.

1.2.5 Responsible Organization with Authority for Source Curtailment

The organization that has responsibility for establishing, enforcing, and coordinating emergency episode activities that satisfy the requirements of an EAP will normally develop from or be part of the control agency. This organization must be capable of utilizing resources available for episode avoidance. A system must be designed that provides those in authority with optimum decision-making information and enables them to take the necessary action.

The organization may obtain the voluntary cooperation of emitters, but it must also have adequate legal authority to enforce emission reduction plans. Exactly what will constitute adequate legal authority will depend to some extent on the way State and local officials interpret the various laws and ordinances under which they might act. It is desirable, however, that prompt action be legally possible and that specific penalties be levied for non-compliance with orders issued to curtail pollution or otherwise deal with an episode.[8]

Cooperation in episode-avoidance planning is essential in interstate regions. Pollutants emitted by sources in one state may be transported across state boundaries; to cope effectively with episodes, then, all the states involved must participate in a coordinated effort.

In designing an episode-avoidance organization, certain factors must be evaluated. Some essential actions to be taken include:

1. Determining the boundaries of the region and exploring cooperative relations with adjoining areas, and deciding on interagency strategies for calling alerts.
2. Establishing the lines of authority for emergency actions (these may be different at each alert level).
3. Establishing the legal authority to exercise emergency control actions, including civil or criminal law-enforcement tools.

1.2.6 Communications and Procedures for Reporting

A well-planned information-dissemination program serviced by an efficient communication system is essential for episode avoidance. The effectiveness of the episode-avoidance system is highly dependent upon rapid and accurate transmission of input data from surveillance equipment to the control activity and abatement instructions from the control authority to the emitters.

The degree of sophistication of this system will vary according to the size of the city and the resources available. A large city with sufficient resources may have on-line telemetry systems for rapid transmission of monitoring data. A small city with restricted funds may depend upon telephone communications, using city employees such as policemen or firemen. The number of data inputs is the major factor determining the magnitude and cost of a communication system.

During an alert, most information will be transmitted to the public through the news media. Information concerning the duration and intensity of the episode, health precautions, and other aspects of episode conditions will be widely disseminated. Certain control directives may be transmitted through the news media, but most will probably be transmitted by telephone.

Dissemination of information following an alert can serve to clarify any misunderstandings that may have arisen during the alert. In addition, an evaluation of the severity of the episode, the action that was taken to minimize hazardous conditions, and public recognition of extra-agency cooperation may be broadcast after the episode.

Communication activities will:

1. Determine the information desired by State and Federal authorities, and the form in which it is to be submitted.
2. Design the local information system, including flow-diagram showing police, civil defense, public safety, and private communication links; coordinate with each participant and define roles.
3. Prepare sample news releases; consult with other control agencies experienced in problems of dealing with the public in these matters.

4. Establish a direct, 24-hour-per-day communications link with major emission sources; establish contacts and alternates for each.

Documentation of data during the episode and reporting of episode-related activities are essential parts of an EAP. Such reporting is important for legal purposes and for providing more effective actions for future episode control. Actions related to post-episode reporting should:

1. Determine whether legal documentation of data is required.
2. Prepare an outline of points to be covered in a summary of the event for news media.
3. Prepare a technical summary, to include a record of the times of emission-curtailment actions, sampling-station histories, and observed effects, as well as the climatology of the event.
4. Prepare a report on control agency activities during the "potential-episode" stage to point out where improvements are possible.

1.2.7 Implementing the Emergency Action Plan

An extremely flexible Emergency Action System (EAS) is needed to implement an emergency action plan. The EAS will conduct only routine surveillance under normal conditions but must be capable of expanding its activities rapidly during episodes. The EAS will usually be developed within an existing air pollution control agency. The minimum resources required are as follows:

1. *Routine Manning.* The services (perhaps only part-time) of one individual knowledgeable in air quality surveillance.
2. *Emergency Manning.* The services of a director, an engineer, and meteorologists during alerts and actual episodes.
3. *Meteorological Services.* A source of local meteorological data, either a private weather service or the United States Weather Bureau.
4. *Air Quality Monitoring Network.* A specified number of air sampling stations that regularly monitor key pollutants. These stations should be capable of short-interval sampling during an episode.
5. *Emergency Action Center (EAC).* A room or area that has been designated and equipped for emergency action activities.

The EAS will have various modes of operation, the number of which will depend upon the size of the region, the resources available for episode-avoidance, and other factors. The operations are based on the degree of activation of the EAS as it responds to the increasing severity of an episode and are thus progressively more complex.

The following discussion will be based on a system of three operational modes:

1. *Routine Surveillance.* The condition between emergencies, when the major activity is surveillance.
2. *Partial Activation.* The condition created in response to increased ambient pollutant concentrations or to a forecast of stagnant meteorological conditions.
3. *Full Activation.* The condition during an episode, with the EAS responding to the emergency.

The EAS will switch from the less complex routine mode to full activation simultaneously with changes from normal to episode atmospheric conditions. Additional equipment and manpower are drawn into the EAS as it progresses from one operational mode to the next higher mode. Figure 1-6 shows how the respective modes are coordinated.

The Routine Surveillance Mode (Figure 1-7) is the normal mode of operation. Its essential tasks are the reception, evaluation, and recording of air quality and meteorological data. Ambient conditions are surveyed in search of episode indicators; when no indicators are observed, input data are recorded and other required actions are taken. When increased ambient pollutant concentrations are observed or when High Air Pollution Potential Advisories (HAPPA) are announced, operations of the Routine Surveillance Mode are discontinued and those of the Partial Activation Mode are initiated.

It is important that a standard operating procedure be established. The operator in charge of routine data inputs should know the precise conditions that require switching to the Partial Activation Mode of the EAS and should know how and where he can contact the EAC Coordinator when alert conditions are forecast.

The EAC staff will have to be supplemented temporarily in order to perform the additional tasks associated with the Partial Activation Mode (Figure 1-8). At a minimum, a coordinator (supervisor) and an additional engineer should join the staff during this mode. The extra staff members will be necessary because of the increased rate of data input and the need to communicate with other organizations, the public, and managers of emission sources.

The input data should be recorded and displayed in the EAC. Adequate staff should be available to receive, evaluate, and display the relevant data.

The Coordinator should help analyze the situation, direct activities within the EAC, plan for requirements associated with the Full Activation Mode, and communicate with outside authorities and the public. An alert should be publicly announced, and the Coordinator should notify emission sources,

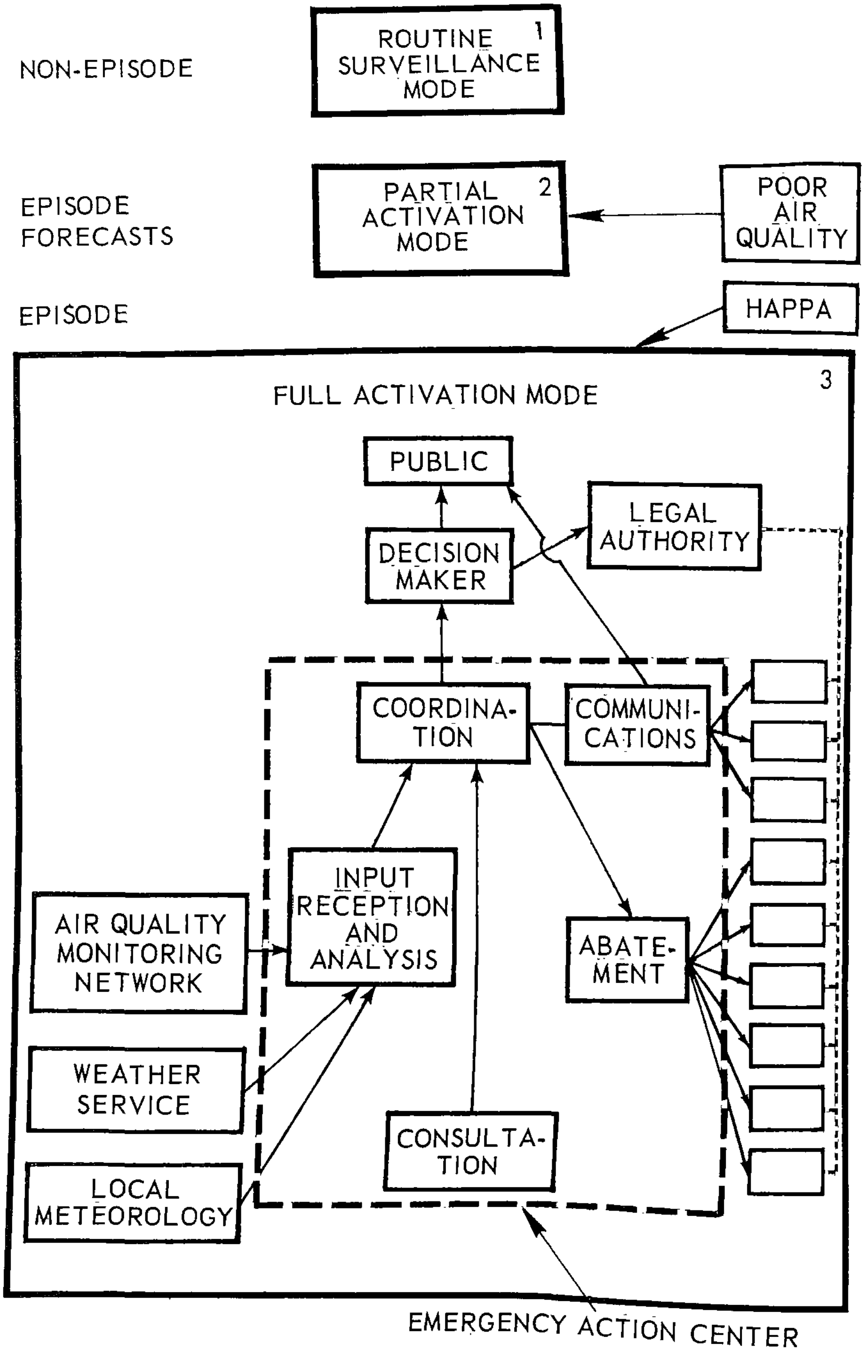

Figure 1-6. Emergency Action System.

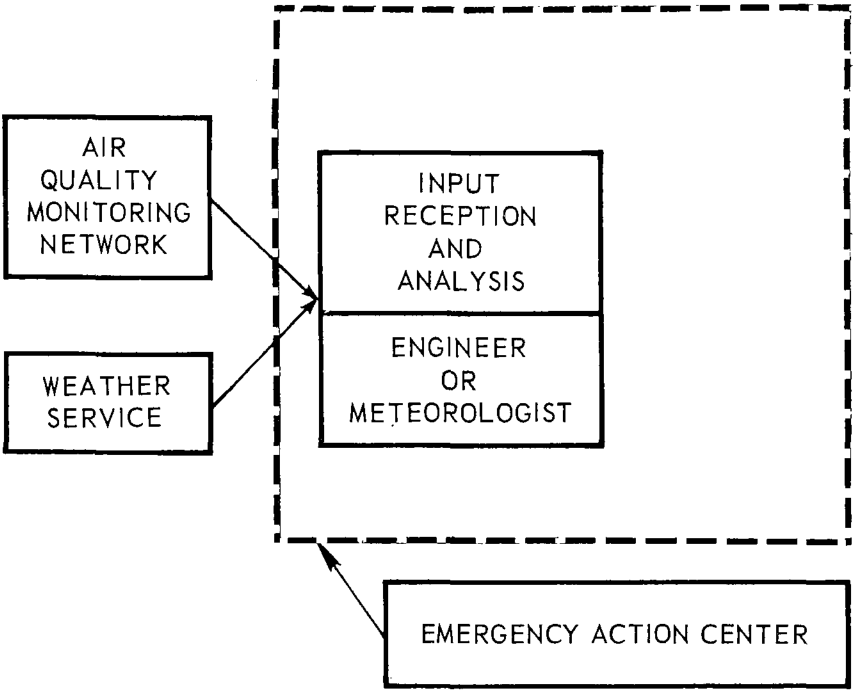

Figure 1-7. Information flow during Routine Surveillance Mode.

request voluntary abatement of non-essential activities, and provide technical assistance if required.

The Partial Activation Mode will continue until the episode forecast is retracted or until episode conditions are declared. When the episode forecast is retracted, the EAC will return to the Routine Surveillance Mode. A report should be prepared that documents the actions taken during the Partial Activation Mode and the air quality and meteorological conditions that were observed.

The Full Activation Mode is initiated when an episode is declared. The EAC operates at full capacity during this mode, and all essential air pollution control agency personnel should be actively participating in emergency activities. Previously designated specialists in medicine, law, engineering, communications, and transportation should be at the EAC or on call for consultation. Figure 1-9 shows the organization that coordinates the efforts of these personnel.

At this stage, there should be direct communication between the Coordi-

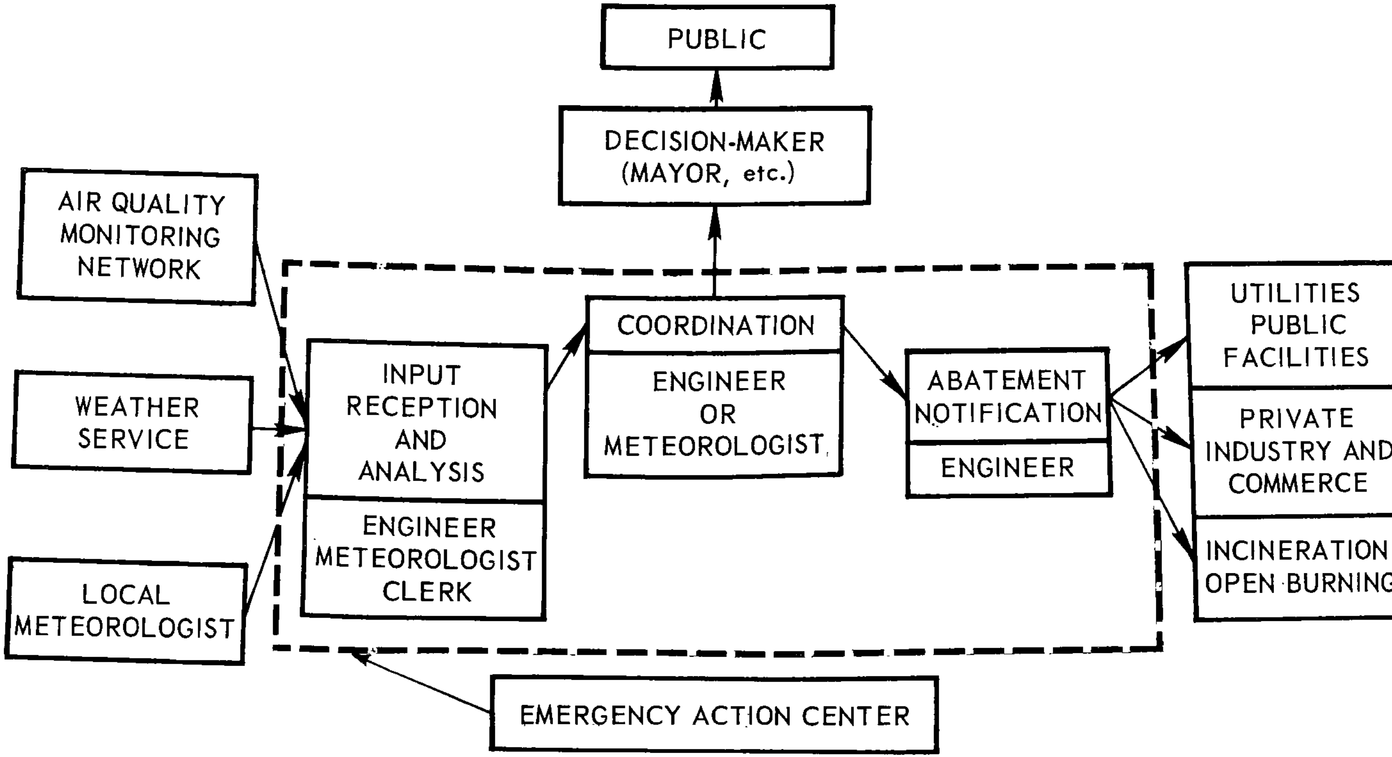

Figure 1-8. Information flow during Partial Activation Mode.

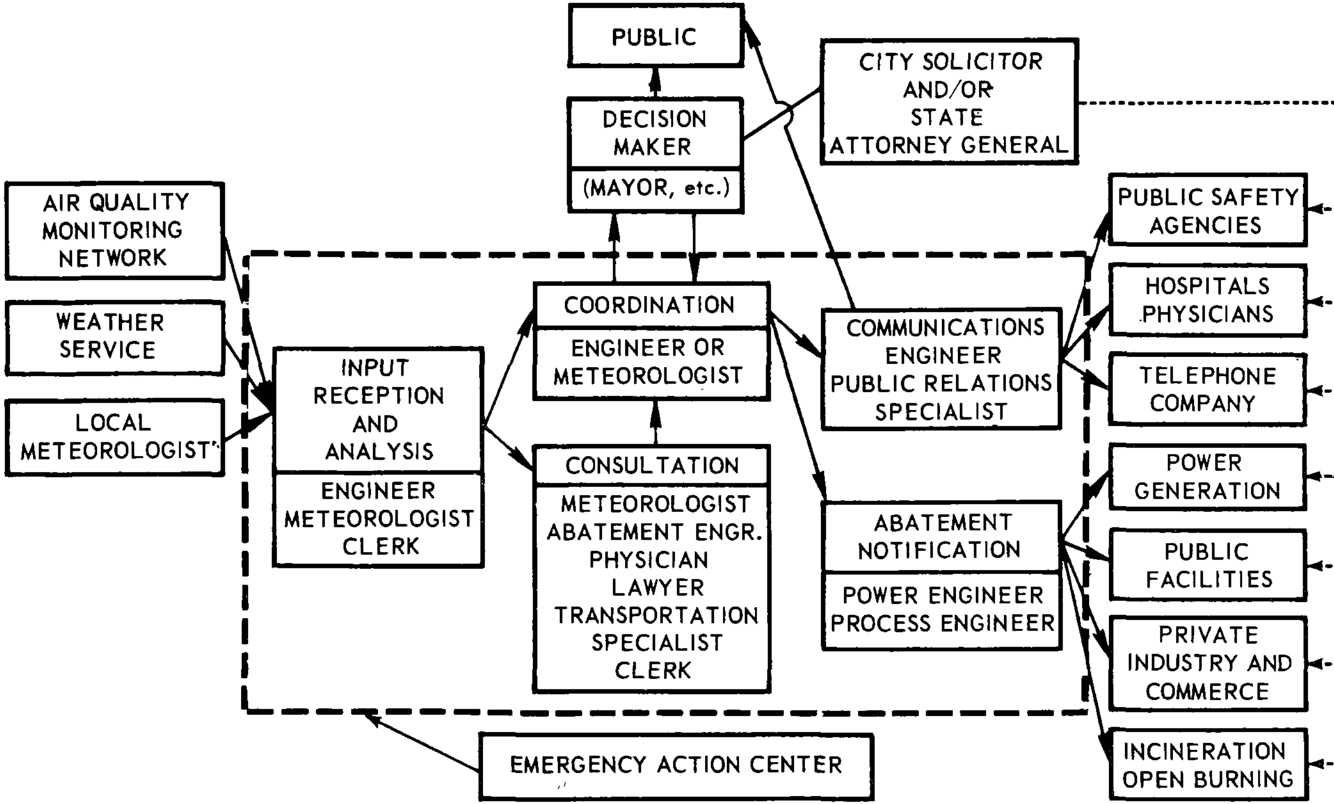

Figure 1-9. Information flow during Full Activation Mode.

nator and the highest-level local authority within the region, such as the mayor of the principal city. In most cases, this authority will be responsible for direct contact with the public and will authorize necessary emergency actions. The City Solicitor (or equivalent officer) and the State Attorney General may also be involved in certain legal decisions. Channels that require the participation of persons outside the EAC should be established as part of the standard operating procedures. Abatement notification to area emission sources will be transmitted by telephone or in person. The police department may be used to assist in curtailment of both stationary and mobile source activity.

Upon termination of the episode, a public announcement to that effect will be made and all sources will be advised that they may return to the normal rate of activity. An episode report is prepared that documents all actions taken and records the effects of the episode.

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2. INFORMATION ON POLLUTANTS

2.1 POLLUTANTS AND THEIR EFFECTS

There is substantial evidence that man-made air pollutants, particularly at the dosage levels encountered during episodes, result in the following generalized effects: (1) reduction of visibility; (2) deterioration of fabrics, metals, and building materials; (3) damage to vegetation and animals; and (4) injury to man himself.

This chapter summarizes the present body of information on types and sources of air contaminants, together with their generally accepted effects on man and his environment. Additional information on the effects of air contaminants is contained in the Air Quality Criteria documents published by the Air Pollution Control Office.

Pollutants have been classified[1] into four broad categories, as shown in Table 2-1.

Table 2-1. TYPES OF AIR POLLUTANTS

Type	Examples
Particulate matter	Carbonaceous particles, tars, oils, insoluble metal, fumes and dusts, amorphous lead, organic debris
Irritants	Gases, such as SO_x, NO_x, CL; soluble dusts; acidic mists
Oxidants	Ozone, aldehydes, olefins, peroxyacetyl nitrate
Systemic poisons	CO, H_2S, cyanides, nicotine, pesticides

2.1.1 Particulates

Particles of solid (and occasionally liquid) matter in the air constitute an important portion of community air pollution in most cities and towns in the

United States. Sources of particulates include such activities as fuel combustion, manufacturing and processing operations, and open burning and incineration of refuse.

Particulate air pollution is widely regarded as objectionable because it is often aesthetically bothersome, it interferes with visibility, and it is associated with the soiling and corrosion of metals, fabrics, and other materials. Its adverse effects on health are subtle but significant nonetheless. In general, concern about the health effects of particles is related to: (1) the ability of the human respiratory system to remove such particles from inhaled air and retain them in the lung; (2) the presence in such particles of mineral substances having toxic or other physiological effects; (3) the presence in such particles of polycyclic hydrocarbons that are known carcinogens; (4) the demonstrated ability of some fine particles to enhance the harmful physiological activity of irritant gases when both are simultaneously present in inhaled air; and (5) the ability of some mineral particles to increase the rate at which sulfur dioxide in the atmosphere is converted by oxidation to sulfur trioxide, which is far more active physiologically.

The size of airborne particles has an important bearing on the likelihood of their reaching the lungs. Generally, coarse particles, about five microns or more in diameter, lodge in the nasal passages. Smaller particles penetrate into the lungs at a rate that increases with decreasing particle size. Particles smaller than two to three microns usually reach the deeper structures of the lungs, where there is no protective mucous coating.

The ability of particles to accentuate the adverse physiological effects of simultaneously inhaled gases is one of the most important aspects of health hazards associated with particulate air pollution. Combinations of gases and particles have been shown to cause toxicological changes in rodents, resistance to air flow in the respiratory tract, and bactericidal action.[2,3]

2.1.2 Irritants

The major irritant gases are the oxides of sulfur and nitrogen. Documented severe air pollution episodes have in common the fact that sulfur dioxide levels in ambient air were excessively high, as were levels of other gases and particles. Although the pattern was not uniform for all cases, the elderly, the very young, and those with pre-existing cardiorespiratory disease have been most seriously affected.

The sulfur oxides found as atmospheric pollutants are sulfur dioxide, sulfur trioxide, and their acids and acid salts. Fossil fuels such as coal and petroleum contain sulfur, and when the fuel burns, the sulfur is converted to sulfur dioxide and, to a lesser degree, sulfur trioxide. Since fossil fuels are widely used in the United States to heat buildings and generate electric power, atmospheric pollution by sulfur oxides is widespread and is especially prevalent in cities.

Petroleum refineries, smelting plants, coke processing plants, sulfuric acid manufacturing plants, coal refuse banks, and refuse burning activities are also major sources of sulfurous pollution.

There is considerable evidence that sulfur oxide pollution aggravates existing respiratory disease in humans and contributes to its development. Sulfur dioxide alone irritates the upper respiratory tract;[4] adsorbed on particulate matter, the gas can be carried deep into the respiratory tract, where it injures lung tissue.[5] Sulfuric acid mists of a certain particle size can also penetrate deeply into the lung and damage tissue.

Epidemiological and clinical studies substantiate that certain persons are more sensitive to sulfur oxide pollution than others. Prolonged exposure to relatively low levels of sulfur dioxide has been associated with increased cardiovascular morbidity in older persons. Prolonged exposure to higher concentrations of sulfur dioxide has been associated with an increase in respiratory disease death rates and an increase in complaints by school children of non-productive cough, mucous membrane irritation, and mucous secretion. The residual air in the lungs of emphysema patients has been significantly reduced when the patients breathed ambient air that had been filtered of pollutants.[4,6]

Sulfur oxides pollution can also adversely affect more robust individuals. Experiments in which healthy human volunteers were exposed to sulfur dioxide concentrations several times higher than the taste-threshold concentration indicate that such exposures will produce changes in pulmonary function, including increased respiration rates, decreased respiratory flow rates, and increased airway resistance. The impairment of function is greater when the sulfur dioxide is administered together with particulate matter. Some of the general effects of SO_2 on man are depicted in Figure 2-1.

Oxides of nitrogen are an important group of atmospheric contaminants in many communities. They are produced during the high-temperature combustion of coal, oil, gas, or gasoline in power plants and in internal combustion engines. The combustion process fixes* atmospheric nitrogen to produce the oxides. At high temperatures, nitric oxide is formed first and then reacts with oxygen in the atmosphere to form nitrogen dioxide. This oxidation is quite rapid with high concentrations of nitric oxide but much slower with low concentrations. In sunlight, especially in the presence of organic material—a situation typified by Los Angeles-type photochemical smog—the conversion of nitric oxide to nitrogen dioxide is greatly accelerated.

Nitrogen dioxide is considerably more toxic than nitric oxide, acting as an acutely irritating substance. It is more injurious than equal concentrations of

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*Nitrogen fixation in this context is the conversion of free nitrogen into combined forms, specifically the oxides, through combustion.

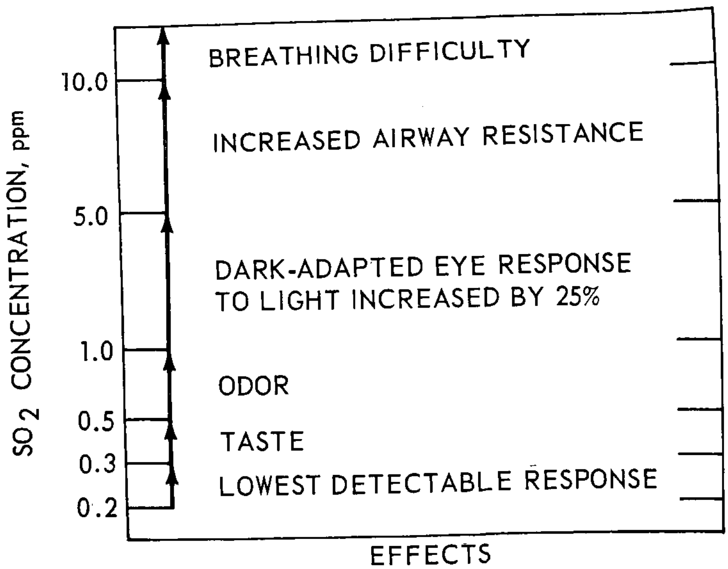

Figure 2-1. Effects of SO_2 on man.

carbon monoxide. The proven effects of NO_2 on man and lower animals are confined almost entirely to the respiratory tract. With increasing dosage, acute effects occur, such as odor perception, nasal irritation, discomfort on breathing, acute respiratory distress, pulmonary edema, and death. Nitrogen dioxide's relatively low solubility permits its penetration into the lower respiratory tract. Delayed or chronic pulmonary changes may occur from high but sublethal concentrations and repeated or continuous exposure of sufficient magnitude.[7-9] Some documented effects of NO_2 on man are shown in Figure 2-2.

2.1.3 Oxidants

Oxidants are a major class of compounds found in photochemical smog. Emissions from motor vehicles are a prime factor in the formation of smog in virtually all parts of the country. Other factors that contribute to smog formation are the combustion of fuels for heat and electric power generation, burning of refuse, evaporation of petroleum products, and handling and use of organic solvents. The principal identifiable oxidants in polluted urban air are ozone and the peroxyacyl nitrates (PAN).

The most commonly experienced effect of photochemical smog is eye irritation.[10] Although the components causing eye irritation have not been precisely identified, there is some correlation between the occurrence of eye irritation and overall levels of oxidants in the atmosphere. A characteristic

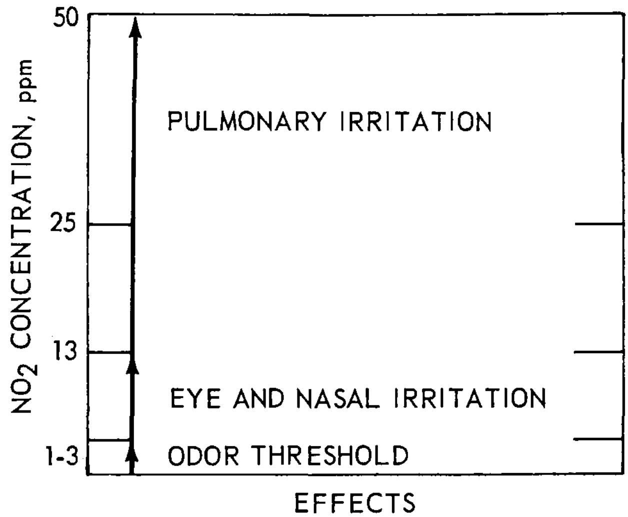

Figure 2-2. Effects of NO_2 on man.

pungent odor is associated with photochemical smog, and ozone is responsible for the acrid component of this odor.

Studies have shown that it is harder for humans, particularly those suffering from chronic respiratory disease, to breathe in areas having even a moderate level of photochemical air pollution (0.10 ppm total oxidant or higher).[1,11,12]

The effects of ozone on man are shown in Figure 2-3. Although they are not precisely the same as the effects of other photochemical oxidants, they are characteristic of this class of pollutants.

2.1.4 Systemic Poisons

The major episode systemic poison is carbon monoxide. Not only is it one of the most common urban air pollutants, but it can also be one of the most harmful to man. Its ability to decrease the oxygen-carrying capacity of the blood makes this gas lethal in high concentrations. Though all processes involving the combustion of carbonaceous material produce carbon monoxide, the motor vehicle is by far the most important source that emits this pollutant to the atmosphere. The wide use of motor vehicles, coupled with their discharge of pollutants from points close to the ground, makes them the prime cause of a community's pollution by carbon monoxide.

Carbon monoxide poisoning is a well-understood phenomenon. As with many other harmful gases, the degree of damage man sustains as a result of exposure to carbon monoxide is related to the concentration of the gas in

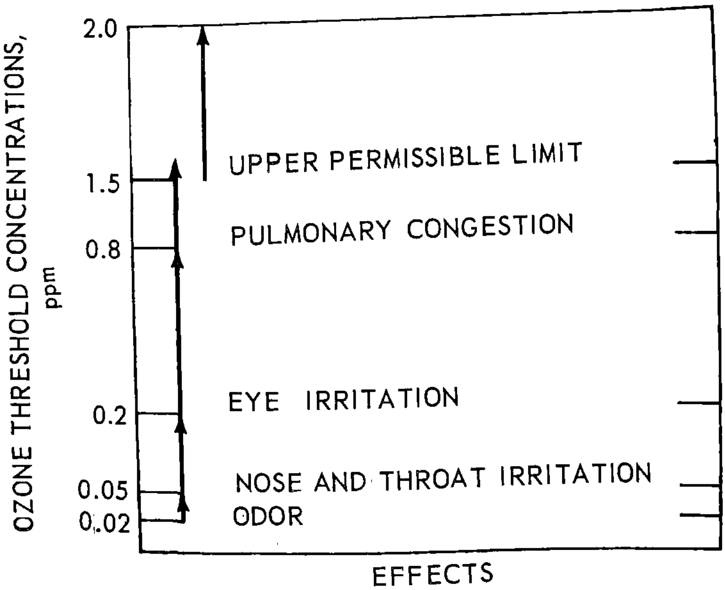

Figure 2-3. Effects of ozone on man.

inhaled air and the length of exposure.[13,14] The hazards of carbon monoxide arise mainly from its strong affinity for hemoglobin, which carries oxygen to body tissues. When carbon monoxide combines with hemoglobin, the tissues are deprived of needed oxygen. At concentrations of slightly more than 1,000 ppm carbon monoxide kills quickly. The recommended upper limit for safety

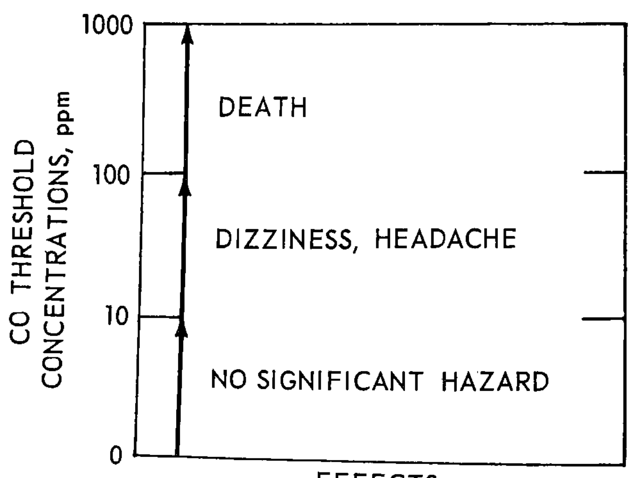

Figure 2-4. Effects of CO on man.

of healthy industrial workers exposed for an 8-hour period is now 50 ppm. At approximately 100 ppm, most people experience dizziness, headache, lassitude, and other symptoms. These effects are graphically illustrated in Figure 2-4.

It is quite possible that during episodes the levels of carbon monoxide reached in vehicles and close to highways are frequently high enough to affect some especially susceptible persons, such as those suffering from anemia or other diseases that decrease the oxygen-carrying capacity of the blood, or those with cardiorespiratory disease. The extra burden placed on the body by the reduction in the oxygen-carrying capacity of the blood induced by carbon monoxide may cause injury to vital organs. People already burdened by the presence of carbon monoxide in their blood because of tobacco smoking or occupational exposure may also be adversely affected by the extra amount of carbon monoxide they inhale from contaminated air.

2.1.5 Episode Pollutant Levels

Table 2-2 illustrates the variability in episode atmospheres as indicated by the ranges of pollutants recorded for a sample of 20 episodes.[4,5,15-18]

Table 2-2. POLLUTANT LEVELS FOR 20 EPISODES

Pollutant or effect	Range	Average
SO_2	0.1 to 9.8 ppm	0.45 ppm
Particulates	200 to 4500 $\mu g/m^3$	1760 $\mu g/m^3$
Soiling index	1.0 to 8.4 Coh	4.3 Coh
CO	1.0 to 25 ppm	9.5 ppm

Ten of the 20 episodes were accompanied by fog; all appeared to be directly associated with temperature inversion. Effects on people in these areas were characterized by complaints of eye irritation, upper respiratory involvement, shortness of breath, aggravation of chronic lower respiratory and cardiovascular ailments, and, in some cases, death. Excluding the Donora, Pennsylvania, episode, in which the excess deaths (see definition in Section 1-1) reached 1.54 per thousand population, excess deaths averaged 0.124 per thousand, ranging from 0 to 0.6 per thousand.

2.1.6 Emergency Action Plan Criteria

Following are the suggested EAP criteria that trigger the pre-planned episode emission reduction scheme:

1. Status: *Forecast*—The *Forecast* level indicates that an internal watch will

be activated by a Weather Service HAPPA or equivalent report stating that a high air pollution potential will exist for the next 36 hours.

2. Status: *Alert*—The *Alert* level is that concentration of pollutants at which short-term health effects can be expected to occur. An *Alert* will be declared when *any one* of the following levels is reached:

   SO_2—0.3 ppm, 24-hour average
   Particulate—3.0 Coh, 24-hour average
   SO_2 and Particulate combined—Product of 24-hour SO_2 average (ppm) and Coh equal to 0.2
   CO—15 ppm, 8-hour average
   Ox—0.1 ppm, 1-hour average

   and meteorological conditions are such that this condition can be expected to continue for 12 or more hours.

3. Status: *Warning*—The *Warning* level indicates that air quality is continuing to deteriorate and that additional abatement actions are necessary. A *Warning* will be declared when *any one* of the following levels is reached:

   SO_2—0.6 ppm, 24-hour average
   Particulate—6.0 Coh, 24-hour average
   Combined SO_2 and Coh—Product of 24-hour SO_2 average (ppm) and Coh equal to 1.0
   CO—30 ppm, 8-hour average
   Ox—0.4 ppm, 1-hour average

   and meteorological conditions are such that this condition can be expected to continue for 12 or more hours.

4. Status: *Emergency*—The *Emergency* level is that level at which a substantial endangerment to human health can be expected. These criteria are absolute in the sense that they represent a level of pollution that must not be allowed to occur. An *Emergency* will be declared when it becomes apparent that *any one* of the following levels is imminent:

   SO_2—1.0 ppm, 24-hour average
   Particulate—10 Coh, 24-hour average
   Combined SO_2 and Coh—Product of 24-hour SO_2 average (ppm) and Coh of 2.4
   CO— 50 ppm, 8-hour average
   75 ppm, 4-hour average
   125 ppm, 1-hour average
   Ox—0.4 ppm, 4-hour average
   0.6 ppm, 2-hour average
   0.7 ppm, 1-hour average

It should be made clear that an *Alert, Warning,* or *Emergency* can be declared on the basis of deteriorating air quality alone; a High Air Pollution Potential Advisory report need not have been issued. The appropriate episode status should be declared when any monitoring site records ambient pollution concentrations above those designated in the criteria. The criteria should be applied to individual monitoring sites and not to area-wide air quality.

The levels used to designate an Air Pollution Emergency are those that pose an imminent and substantial danger to public health. Because these levels should not be permitted to occur, an Air Pollution Emergency should be declared when it appears that these levels may occur.

2.2 EMISSION SOURCES AND INVENTORIES

Episode avoidance planning must include a study of the sources of pollution and their emissions. Before any decisions can be made regarding emergency emission reduction strategies, an accurate, up-to-date inventory of all significant air pollution sources in the area must be made.

Air pollutants are emitted by every combustion process and by most industrial operations. Exactly which sources are problems in any given area can only be determined by an emission inventory that catalogs all pollution sources and their locations and emissions. This inventory will be similar to that obtained for routine air pollution control purposes. It should, however, include any significant increases in emission levels during specific periods of the year or at specific times of the day.

2.2.1 Emission Inventories

When an emission inventory is conducted, pollutant sources are divided into two main categories: area and point sources. Area sources include small multiple sources such as automobiles and other transportation sources; residential fuel combustion and refuse disposal; and commercial, institutional, and small industrial fuel combustion and refuse disposal sources, all of which, in general, individually emit less than 50 to 100 tons of any pollutant per year. Point sources are the larger combustion, incinerator, and industrial sources that individually emit more than 50 to 100 tons of any pollutant per year.

Information with which to estimate emissions can be gathered from a wide variety of sources. Methods for determining gross patterns of emissions are described in the Public Health Service publication, "Rapid Survey Technique for Estimating Community Air Pollution Emissions."[19] In this publication, emission sources are classified as:

1. Fuel combustion in stationary sources.
2. Combustion of refuse material.
3. Transportation.
4. Industrial processes.

2.2.2 Fuel Combustion in Stationary Sources

These sources should be classified by type of user (that is, industrial, commercial, utility, etc.), type of fuel burned, quantity of fuel consumed, and geographical location. Sources of data include:

1. Local building, boiler, and similar permit records.
2. Local utilities.
3. Suppliers of fossil fuels.
4. Large-volume fossil fuel users.
5. Local large industries.
6. U.S. Bureau of Census.
7. U.S. Bureau of Mines.
8. State (fuel) associations.
9. State petroleum marketing associations.
10. National Coal Association.
11. American Petroleum Institute.

Chemical analyses of fuels for sulfur and ash content are not always readily available, except from large-volume users, and may have to be estimated on the basis of the source of the fuel.

A typical emission questionnaire is shown in Figure 2-5. This type of questionnaire can be sent to all major fuel users.

The Air Pollution Control Office, 411 West Chapel Hill Street, Durham, North Carolina, has prepared emission inventories for several cities in the United States, and personnel in the Air Quality and Emission Data Division are available for advice and consultation to agencies responsible for air pollution control.

2.2.3 Combustion of Refuse

Burning is a technique commonly used to reduce the volume of refuse. The nature and amount of refuse generated have changed noticeably in recent years. For example, the increased use of paper in packaging material and the wide use of plastics has resulted in a 2 to 4 percent annual increase in the amount of refuse generated per capita. Recent studies indicate that about 10 pounds of mixed refuse are generated per capita per day in the United States. Of this amount, about 5.3 pounds are collected and disposed of on-site at a dump, landfill, or municipal incinerator.[20] Some estimate of the waste disposal practices used in a particular area must be made, since emissions vary widely,

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AIR CONTAMINANT EMISSIONS SURVEY

FOR OFFICE USE ONLY

Mailed ________ Rec'd. ________

UTM GRID COORDINATE:

____

Firm name: ________

Person to contact regarding this report: ________ Title: ________ Phone: ________

Mailing address: ________

Plant address: ________

Nature of business: (Products) ________ Standard Industrial Classification Code ________

Employees at plant location: ________ ; if seasonal, give range ________ .

SECTION I – FUEL USE FOR GENERATION OF HEAT, STEAM, AND POWER

Normal operating schedule: ________ Hours per day ________ Days per week ________ Weeks per year

Seasonal and/or peak operation period: (Specify) ________

Estimate of percent of total fuel consumed to provide space heat: ________

A	B	C	D	E	F	G	H	I	J	K	L
Sources or No. of boilers (A)	Size of unit (input) (B) 10^6 Btu/hr.	Type unit (C)	Fuel data (D)					Air cleaning equipment		Estimate of contaminants (M)	
			Type fuel (E)	Amount per year (F)	Heat content (G) Btu	Percent sulfur (G-H)	Percent ash (coal only) (G-H)	Type (I)	Efficiency (J) %	Type (K)	Quantity (L)

SECTION II – REFUSE DISPOSAL

Refuse disposed of ________ On site ________ Off site – Location of disposal site and/or name of hauler: ________

Normal on-site combustion operating schedule: ________ Hours per day ________ Days per week ________ Weeks per year

Seasonal and/or peak operation period: (Specify) ________

A	B	C	D	E	F	G	H
Waste material		Method of disposal (See code below)	Incinerator capacity, lb/hr	Auxiliary fuel used (O)	Type and efficiency, air cleaning equipment (I-J)	Estimate of contaminants (M)	
Type (N)	Amount per year (F)					Type (K)	Quantity per year (L)

Figure 2-5. Typical source emission questionnaire.

NOTE: NO CARBON NECESSARY FOR THIS FORM – NCR PAPER

SECTION III – PROCESS EMISSIONS

Normal operating schedule: ____________ Hours per day ____________ Days per week ____________ Weeks per year.

Seasonal and/or peak operation period: ____________

NOTE: For intermittent operations, indicate approximate frequency and duration so that estimates of yearly emissions may be obtained.

A	B	C	D	E	F	G	H
Processes or operations releasing contaminants to atmosphere (A-P)	Materials processed and/or used at operations		Quantity of gas discharged from process or operation	Type and efficiency air cleaning equipment (I-J)	Estimate of contaminants (M)		Basis of estimate (R) (Please specify basis)
	Type (O)	Quantity per year (P)			Type (K)	Quantity per year (L)	

(A) Multiple sources may be grouped if units burn the same fuel and are similar in size and type.
(B) Nameplate data are sufficient.
(C) Hand-fired; underfeed, traveling-grate or spreader stoker; cyclone furnace; pulverized, wet or dry bottom with or without fly ash reinjection; rotary or gun-type oil burner; etc.
(D) Fuel data are to be reported on an "as burned basis."
(E) Coke, bituminous coal, anthracite coal; No. 1, 2, 4, 5 or 6 fuel oil; natural gas; LPG; refinery or coke oven gas; wood, etc.
(F) Pounds, tons, or gallons per year.
(G) If unknown, please give name and address of fuel supplier:
(H) Sulfur and ash content for each fuel should be a weighted average.
(I) Cyclone, scrubber, electrostatic precipitator, baghouse, settling chamber, etc.
(J) Please state if efficiency is a rated or operating efficiency.
(K) Fly ash, sulfur oxides, etc. (include chemical description)
(L) Pounds or tons per year.
(M) Give stack test data if available, or otherwise specify basis used.
(N) Rubbish, garbage, mixed garbage and rubbish, waste paper, wood chips or sawdust, etc.
(O) Indicate whether auxiliary fuel is used in incinerators and pit burning, and the amount.
(P) Sulfuric acid-chamber, aluminum smelting-crucible furnace, iron melting-cupola, cement manufacture-dry process, solvent cleaning, or other (please specify).
(Q) Acid produced, tons; metal charged or processed, tons; cement produced, bbl.; solvent consumed, gallons; etc. per year.
(R) Process material balance studies, field tests by plant or by equipment manufacturers, or other basis.
(S) List sources from column A, Sections I II, III which utilize each stack.

METHOD OF DISPOSAL CODE:

1. Open-burning dump
2. Sanitary landfill (no burning)
3. Burned in boiler or furnace.
4. Incinerator, single chamber.
5. Incinerator, multiple chamber
6. Incinerator, rotary.
7. Conical metal burner.
8. Other (Specify)

STACK DATA

SOURCES VENTED (S)	HEIGHT (Feet)	INSIDE DIAMETER (Feet)	EXIT GAS		
			Temperature of	Velocity (FPS)	Moisture (%)

Any supplemental material or data considered pertinent (reports, summaries, test results, maps, flow diagrams) may be submitted with this form.

Date ____________ Name and title of official submitting reports ____________

NOTE: USE ADDITIONAL SHEETS IF NECESSARY RETAIN PINK COPY

PAGE 2

Figure 2-5. (continued) Typical source emission questionnaire.

depending on the mode of disposal. In addition, a questionnaire such as that shown in Figure 2-5 can be sent to all major refuse disposal facilities. Once the quantities of refuse and their mode of disposal have been estimated, factors already available can be used to calculate emissions.[21]

2.2.4 Transportation

Mobile sources of air pollution include automobiles, buses, locomotives, trucks, ships, and airplanes. Of these, automobiles, buses, and trucks usually contribute significantly to general community pollution. Areas around large airports will, of course, be affected by aircraft emissions.

Automobile emissions can be determined on the basis of gasoline sales in the study area and available emission factors.[21] Diesel-fueled traffic is mostly of the long-haul type, and emission estimates are based on mileage, traffic flow, and emission factors. Traffic flow maps can be used to estimate seasonal variations in vehicle emissions and to locate major concentrations of vehicle emissions.

2.2.5 Industrial Process Emissions

A major function of the emission inventory is to quantify emissions from industrial processes in the area. The steps involved in this portion of the survey include:

1. Determining the names and locations of all industrial operations in the area by using a directory of manufacturers, Chamber of Commerce guide, etc.
2. Obtaining production and emission data through questionnaires, personal visits, stack testing, or estimating procedures.
3. Calculating emission rates by applying emission factors to production data.

Irrespective of whether questionnaires are used, personal visits to the larger industries are desirable so that physical data may be obtained and a cooperative working atmosphere established between the control agency and industries. Much more information can be collected from visits than from questionnaires.

The physical data collected should anticipate the use of dispersion calculations; a sample list of information to be gathered follows:

1. Exact location, including property boundaries.
2. Plant capacity (normal and maximum).
3. Fuel usage by shift, day of week, month, and season.

4. Fuel type and composition, especially sulfur and ash content.
5. Fuel heating value.
6. Number, length, and frequency of operating levels (if the industrial process is continuous).
7. Number and frequency of batches (if the industrial process is "batch").
8. Height from which pollutants are emitted, diameter of stack, and velocity and temperature of exit gases.
9. Emission rate of pollutants in grams per second or pounds per hour, including variations (mean and standard deviation). If emissions are not known, the process throughput rates should be obtained and emissions estimated by using emission factors, material balances, or other estimating procedures.
10. Size distribution of particles emitted into the atmosphere.
11. Type, age, efficiency, and cost of pollution control equipment.
12. Plans for expansion.
13. Process flow diagrams.
14. Presence of settled dust.
15. Estimation of ventilation and hooding effectiveness.
16. Presence of odors, eye irritants, fallout, etc.
17. Housekeeping practices, as an indication of general maintenance.
18. Individuals to be contacted on air pollution matters and their telephone numbers (both business and home).
19. Number of supervisory employees.
20. Number of hourly employees (the number of employees is related to the automobile population, a possible factor in curtailment planning).

Source sampling may also be used to determine emissions. Although this procedure provides quantitative data, it is time-consuming and only provides data for the particular condition under which the plant was operating while tests were conducted.

Some regulations require that certain commercial and industrial sources be monitored periodically by the owner. This is the case for SO_2 pollution from sulfuric acid plants in New Jersey. Other regulations, as in Cleveland, Ohio, require a "test by a disinterested third party" at the request of the air pollution control authority, at the owner's expense. In most large air pollution control agencies, some source-sampling capability has been developed and is used for the following purposes:

1. To validate operating permits.

2. To establish emission rates.

3. To test for compliance with emission codes.

For carrying out episode-avoidance plans, source sampling may be desirable or necessary to determine emissions under other than normal operating conditions and to test for compliance with curtailment plans.

Few sources can be sampled during an actual episode because of the short time available. Spot-checking is a useful measure, however, and will tend to make industries more conscious of the efficacy of their control efforts. Annual updating of emission data is required to maintain an effective control program. In large cities, retrieval of emission information in sufficient time to permit effective judgments during an episode-forecast period may be difficult; in such situations, automated data storage and retrieval systems are required.

A permit system that calls for review of all new or altered combustion and process equipment is an extremely strong tool for developing and maintaining an up-to-date source inventory. The records of other municipal departments (such as the building department, transportation agencies, and waste disposal department), together with information from federally supported studies, will also provide a basis for updating information on emission sources.

2.3 AEROMETRIC MONITORING

The objective of air sampling is to measure pollutants at receptor sites. The data required for routine air pollution control are usually obtained by random, continuous, or sequential sampling. Continuous air sampling is desirable for episode avoidance, since episodes can be expected to last only a few days and control actions must be promptly imposed. Averaging times of 1 to 4 hours are usually adequate, although automated systems may use averaging times as short as 5 minutes. Random sampling at this rate may be impractical; it is probably no more expensive to collect 5-minute samples continuously for a week than to collect 5-minute randomly spaced samples for a week.

Based on alert criteria now in use, 1-hour averaging times are adequate for surveillance of episode conditions. Shorter averaging times provide information on data-collecting excursions but increase the need for automation because of the bulk of the data obtained. Averaging times longer than 6 hours are not desirable because of the delay in response this imposes. After an alert is announced, data are needed fairly quickly so that requests for information on the event can be met.

2.3.1 Site Selection

Designing a sampling network is difficult, since defining and measuring effectiveness are elusive processes. If the problem is that of episode avoidance rather than the control of chronic air pollution, the measure of effectiveness is the success achieved in avoiding public health "disasters," given adequate emission curtailment methods. A single station may be sufficient to describe conditions in a given area; unless this fact has been established with some certainty, however, a larger number of stations is desirable.

Selection of the actual number of sampling sites remains a practical problem. Stalker[22] has studied the problem, relating variance estimates to required accuracy. Tools are available for designing a network on a cost-effectiveness basis, using optimizing techniques, but have not yet been applied to this problem. One practical difficulty is the assigning of an effectiveness measure consistent with the objectives.

Presently, from 3 to 14 sampling stations, employing continuous-monitoring instrumentation, are in use in large urban areas. Because of the high cost, network size will probably continue to depend largely on local budgets.

Episode conditions threaten human welfare, and monitoring sites should be located in areas where this welfare is most threatened:

1. In densely populated areas.
2. Near large stationary sources of pollutants.
3. Near hospitals.
4. Near high-density traffic interchanges.
5. In homes for the aged.

A network of sites is useful in determining the range of pollutant concentrations within an area. Although the most desirable monitoring sites are not necessarily the most convenient, consideration should be given, for reasons of access, security, and existing communications, to the use of public buildings: schools, firehouses, police stations, hospitals, and water or sewage plants. In addition, local industrial or commercial installations might be willing to exchange data or even permit sampling on their sites.

2.3.2 Monitoring Techniques

To avoid episodes, air quality data are needed within a few hours after pollutant concentrations have been measured. The rapid dissemination of data is possible via telephone, but the trend is toward automated monitoring networks. A compilation of methods presently used to measure ambient air quality is presented in Table 2-3.

Both chemical and physical techniques are utilized in air quality analysis. Chemical analysis always involves the use of consumable supplies so that chemicals must be replaced at the same rate at which samples are taken.

Table 2-3. AIR QUALITY MONITORING SUMMARY

Pollutant	Principle of measurement	Operating mode[a]	Minimum sampling period	Cost per unit, $		
				Continuous	Sequential	Manual
Aldehydes	Colorimetric	S, M	4 hr		1200[b]	250[a]
Carbon monoxide	Non-dispersive IR	C	5 min	4000		
	Detector tube	M	5 to 30 min			150
Fluorides	Colorimetric	S, M	4 hr		1200[b]	
Hydrocarbons	Flame ionization	C	5 min	3000		
	Gas chromatography	C, S, M	5 to 30 min	5000 to 10,000	1500[b]	100[a]
Hydrogen sulfide	Chemisorption on treated tape	S, M	2 hr		800	100[a]
	Colorimetric	C, S, M	30 min	7000	1200[b]	250[a]
	Detector tube	M	5 min to 30 min			150
Nitrogen oxides	Colorimetric	C, S, M	5 min to 1 hr	3000	1200[b]	250[a]
Oxidants	Colorimetric	C, S, M	5 min to 1 hr	5000	1200[b]	250[a]
	Coulometric	C	5 min	1000		
Particulates	Transmission or reflectance	S	2 hr		1000	
	Gravimetric	M	24 hr			200[a]
Sulfur dioxide	Conductivity	C, S, M	5 min to 1 hr	2000 to 5000	1200[b]	250[a]
	Colorimetric	C, S, M	5 min to 1 hr	2500 to 7000	1200[b]	250[a]
	Coulometric	C	5 min	3500		
	Flame photometric	C	5 min	4000		

[a] C—Continuous; S—Sequential; M—Manual.
[b] Related analytical equipment required.

Currently available instruments store enough chemicals to permit operation from 3 days to 1 month. In some cases, analytical reagents for specific air contaminants are toxic or corrosive and require protective storage. The relatively complex equipment used to make physical measurements must be properly installed and maintained by trained personnel. Equipment accuracy is affected by mechanical shock, temperature extremes, variations in power supply or line voltage, dirty or dusty atmosphere, and corrosive chemicals.

A recent trend in air quality monitoring is the portable laboratory, built like a house trailer, which can be moved to and operated at different sites. The mobile trailer offers considerable flexibility in the choice of sampling site and can be used in the investigation of specific problem areas.

All of the analytical equipment used for air quality monitoring requires routine servicing. When this equipment is used continuously, personnel must visit the instrument sites at least twice a week. During episode conditions there will be no time to check out methods, run blanks, or calibrate instruments. These procedures must be followed on a predetermined, routine schedule, probably daily, according to a check list.

The accuracy of all analyses must be established periodically as verification of analytical results. Automated instruments for field measurement have a long-term accuracy of about ± 5 percent. Instruments are calibrated with an air sample of known composition. Regular calibration is necessary to ensure comparability of measurements with respect to time and location.

An important factor in air monitoring accuracy is the possible interference by extraneous substances with the chemical procedures used to detect pollutants. Since typical urban air contains a large number of chemicals, their effects on detection methods must be considered. Typical interfering substances that have been identified are:

1. Ozone, nitrogen dioxide, and heavy metal particulates, which affect the accuracy of sulfur dioxide detection by the West-Gaeke method. Modifications in the method have been made to minimize these effects.[23]
2. Ammonia and nitrous oxide, which interfere with the detection of sulfur dioxide by the conductivity method.
3. Sulfur dioxide, hydrogen sulfide, and reducing gases, which interfere with the detection of oxidants by the neutral buffered-potassium iodide method.

The interfering substances present will vary from city to city and their effects must be evaluated by actual measurements. Experienced personnel are required for reliable analyses of these effects. The Air Pollution Control Office and other organizations offer training courses in the proper use of chemical techniques and instruments.

Measurements result in a numerical value of pollutant concentration. There is a continuous output of data from continuous analyzers. The measured values are read from meters or recorded on strip-chart recorders. Each analyzer may have its own recorder, or several may be combined to record on one chart with a multi-pen or multi-point recorder. In systems with a number of analyzers, readings are recorded on teleprinters or on punched or magnetic tape. The teleprinter provides immediate readout, and tapes utilize automatic data reduction facilities. Consolidation of data should be carefully considered in order to reduce storage, permit suitable identification, and provide for easy reduction and analysis.

For decision-making during an episode, data presentation methods should be evolved that will, ideally, present at a glance the concentrations of each monitored contaminant in terms of peak reading, current 1-hour average, and previous 6-hour and 24-hour averages.

2.4 PROCESSING AND DISPLAYING INFORMATION

Whatever methods of inventory, registration, and regulation are used for emission source intelligence, the result will be data that require continual sorting and evaluation. In the smaller urban areas, emission inventory data can be processed and analyzed manually. Maintaining an updated inventory is a continuing responsibility and, in a large urban area, can involve the considerable expenditure of funds. Careful planning of an information processing and display system will help in realizing maximum benefit from the funds available.

A large urban area will have thousands of sources. Manual processing and analysis is tedious, and some analyses may be next to impossible to perform manually in the time available. Computer systems for the storage, retrieval, processing, and analysis of emission-source data are becoming more common. The ingredients for such a system are as follows:

1. Acquisition of or access to a computer with both random- and sequential-access auxiliary storage facilities, so that filing and file maintenance can be accomplished rapidly and efficiently.
2. Development of a coding system,[25] preferably in cooperation with other urban agencies such as Planning and Housing, Urban Renewal, Building Permits and Inspection, Public Works, etc. Some data requirements are common to all of these departments as well as to air pollution control agencies. Coding parameters should include:
    a. Pollution control equipment, cost, and performance.
    b. Emission source categories and process rates.
    c. Location of sources, keyed to (x, y) mapping coordinates.
    d. Types of pollutants.
    e. Quantities of pollutants.

f. Stack heights and gas flow rates, temperatures, and velocities.
g. Methods and results of curtailment at each alert stage.
h. Complaint histories.
i. Fuel-use information, rates, and fuel-switching capability.

3. Information retrieval programming so that any set of parameters can be retrieved from the files selectively. For example, the planner may wish to know the location of all plants using high-sulfur coal that emit an average daily quantity of SO_2 between Q_1 and Q_2 and from which particulate pollutants are emitted in excess of Q_3.

4. Analysis programming, so that emission source data may be evaluated and correlated with ambient exposures as desired. In the event that a computerized real-time monitoring system is used, source-related information can be correlated with monitoring data as an aid in making control decisions.

Table 2-4. ANNUAL FUEL CONSUMPTION IN INTERSTATE AIR POLLUTION STUDY AREA, 1963

Fuel	Consumer category	Annual consumption	Percent of total
Coal, tons/yr	Industry[a]	1,628,000	21.8
	Steam-electric utilities	4,874,000	65.3
	Residential	738,000	9.9
	Other	222,000	3.0
	Total	7,462,000	100.0
Fuel oil—residual, gal/yr	Industry	106,223,000	99.0
	Steam-electric utilities	642,000	0.5
	Residential	n[b]	n[b]
	Other	n[b]	n[b]
	Total	106,865,000	100.0
Fuel oil—distillate, gal/yr	Industry	8,284,000	6.1
	Steam-electric utilities	0	0
	Residential	120,543,000	88.9
	Other	6,414,000	5.0
	Total	135,233,000	100.0
Gas, 1×10^6 ft^3/yr	Industry	68,151	51.8
	Steam-electric utilities	9,252	7.0
	Residential	51,078	38.9
	Other	2,974	2.3
	Total	131,454	100.0

[a]An additional 1,327,000 tons is used in the production of coke.
[b]n = Negligible.

Table 2-5. AIR POLLUTANT EMISSIONS FROM COMBUSTION OF FUELS IN STATIONARY SOURCES IN INTERSTATE AIR POLLUTION STUDY AREA, 1963

(tons/year)

Fuel	User category	Aldehydes	B(a)P[a]	Carbon monoxide	Hydro-carbons	Nitrogen oxides	Sulfur oxides	Partic-ulates
Coal	Industrial	3	414	2,442	814	16,276	98,390	37,990
	Steam electric	11	7	1,220	487	51,261	244,443	22,400
	Residential	1	157	18,873	3,682	2,945	46,194	18,873
	Other	n[b]	31	3,587	714	571	13,800	5,450
	Subtotal	15	609	26,100	5,697	71,053	402,827	84,713
Fuel oil	Industrial	93	10	94	93	2,055	14,300	683
	Steam electric	n[b]	n[b]	n[b]	n[b]	41	31	n[b]
	Residential	113	n[b]	113	113	2,015	3,590	671
	Other	6	1	6	6	103	198	34
	Subtotal	212	11	213	212	4,214	18,119	1,388
Gas	Industrial	111	2	89	n[b]	5,376	15	423
	Steam electric	4	n[b]	n[b]	n[b]	1,793	3	68
	Residential	244	n[b]	74	244	2,935	9	354
	Other	20	1	5	20	210	n[b]	27
	Subtotal	379	3	168	264	10,314	27	872
	Total	606	623	26,500	6,173	85,581	420,973	86,973

[a]Benzo(a)pyrene in lb/yr.
[b]n = Negligible.

Table 2-6. INDUSTRIAL COAL USE BY BURNER TYPE AND TYPE OF AIR POLLUTION CONTROL DEVICE USED IN INTERSTATE AIR POLLUTION STUDY AREA, 1963

Type of firing equipment	No control devices		Settling chambers or water sprays		Cyclones or other inertial separators		Multiclones or ESP[b]		Total	
	Number of units[a]	Quantity of coal burned, tons/yr	Number of units[a]	Quantity of coal burned, tons/yr	Number of units[a]	Quantity of coal burned, tons/yr	Number of units[a]	Quantity of coal burned, tons/yr	Number of units[a]	Quantity of coal burned, tons/yr
Underfeed stokers	13	21,000	5	2,400					18	23,400
Chain-grate stokers	24	244,000	11	325,000	7	88,000			42	657,000
Traveling-grate stokers	5	5,600	5	135,000	3	23,000			13	163,600
Hand-fired	12	4,000							12	4,000
Pulverized-coal units					10	114,000	22	516,000	32	630,000
Spreader stokers with ash reinjection					3	35,000	1	50,000	4	85,000
Spreader stokers without ash reinjection	2	8,000	6	17,000	1	28,000	1	15,000	10	68,000
Totals	56	282,600	27	479,400	24	288,000	24	581,000	131	1,631,000
Percent of total	42.8	17.4	20.6	29.3	18.3	17.7	18.3	35.6	100	100

[a]The number of units given represents the number of boilers, not installations. An installation with two boilers is entered as 2.
[b]Multi-stage cyclones or electrostatic precipitators.

With or without computers, emission-source information may be presented in either tabular or graphic form, depending upon the use to which it will be put. Fuel-use information can be displayed as shown in Table 2-4, which indicates annual consumption of fuel by consumer category; the amount for each category is expressed in tons or gallons and as a percentage of the total for each category, giving the user of the information both absolute and relative data on coal, oil, and gas. Other examples of tabulated information are shown in Tables 2-5 and 2-6. Such data may also be represented effectively in bar or line graphs, as in Figure 2-6.

Another graphic approach to data display is the use of density maps, such as

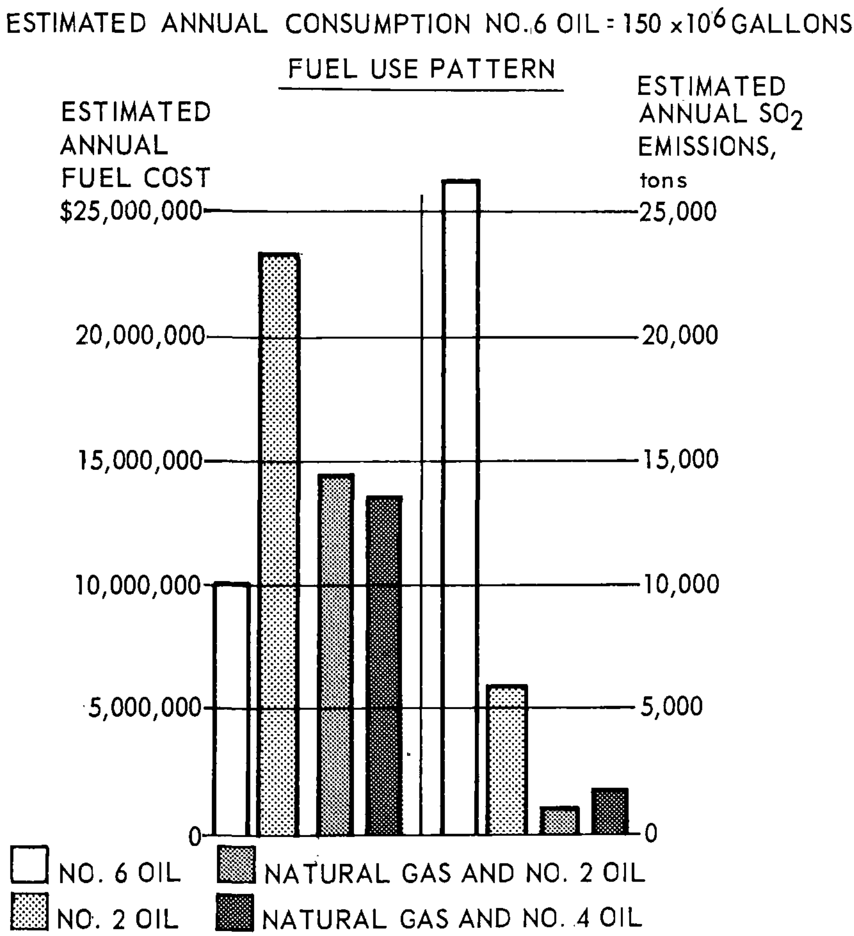

Figure 2-6. New York City-owned installations: estimated annual oil consumption, SO_2 emissions, and fuel costs. Based on 1966 emission data.

the one shown in Figure 2-7, and location maps, as in Figure 2-8. Maps such as these may be used to advantage in pinpointing the location of present and potential problem areas when emergency control measures are being planned. Either total or average emissions are computed for each grid square, and a density symbol is assigned to the square according to the magnitude of the emissions.

Careful consideration should be given to the arrangement of data in tabular or graphic displays so that important relationships among categories of information are easily seen and understood.

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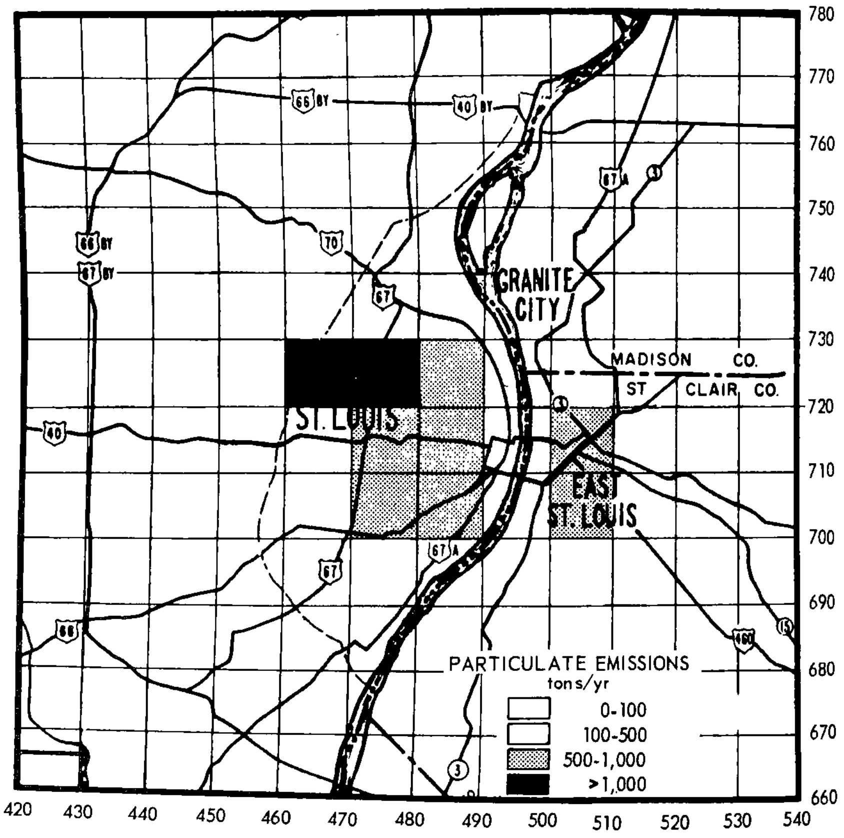

Figure 2-7. Emissions of particulates from residential use of fuels.

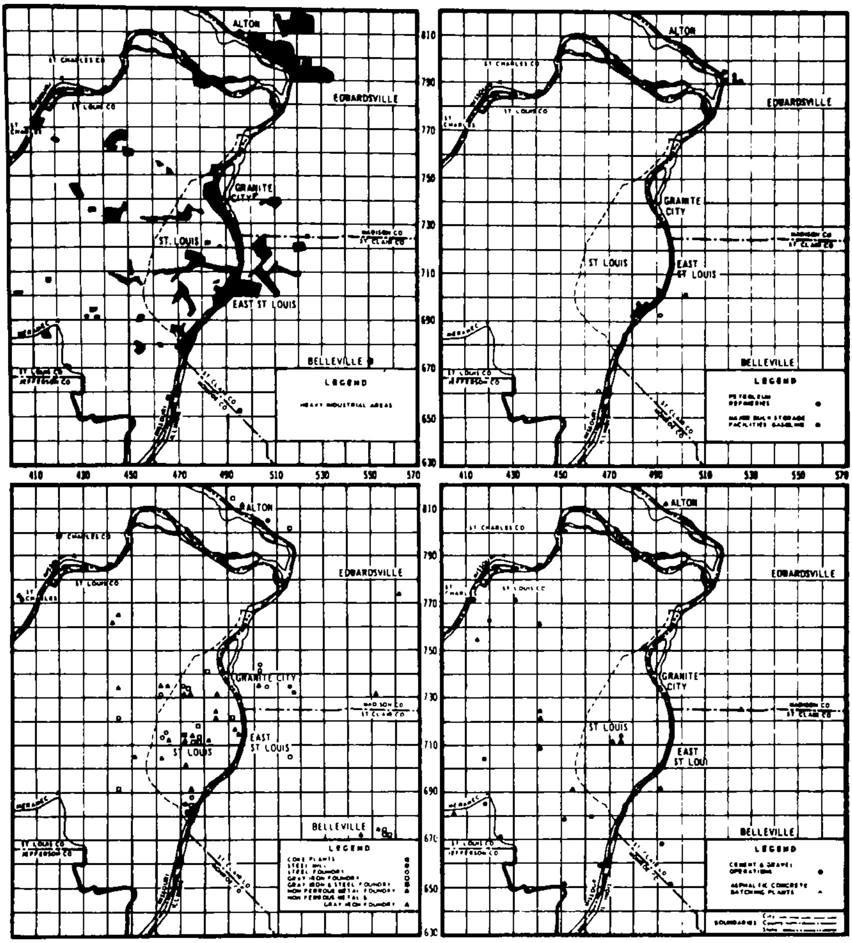

Figure 2-8. Major industrial operations.

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3. INFORMATION ON EPISODES

3.1 REGIONAL FACTORS AFFECTING EPISODES

The nature and degree of air pollution potential vary considerably across the United States. The main factors causing these differences are emission characteristics, meteorology, and topography. For planning purposes, it is necessary to appreciate the nature of these differences and to identify the characteristics specific to a given area.

Emission measurements used in detecting episodes are the same as those used for detecting chronic air pollution control. It is a familiar fact that oxidants are at present the greatest recognized problem in Los Angeles, whereas particulates and sulfur dioxide are more serious problems on the Eastern Seaboard. The need for relating emergency control actions to the local problem is clear. Plans must be flexible, since emission characteristics will change as improved, but irregular, pollutant controls are introduced. The absence of a satisfactory preventive for NO_x emissions and the growth of the automobile population are cases in point. Section 2.2 presented a detailed overview of the types and character of emission sources that must be considered in episode-prevention planning.

Diurnal variations represent a local characteristic that could influence the strategy for declaring alerts (see Figure 3-1). Seasonal variations, such as a predominance of oxidant pollutants in summer and sulfur dioxide in winter, may exist in many areas.

The meteorological character of a region depends on geographical location and local topography. Topography accounts largely for local variations in the broad-scale weather patterns that dominate an area. The following classification of areas based on similarity of weather and topographic conditions, has been published in the *Federal Register*:

Great Lakes—Northeast Area	Great Plains Area
Mid-Atlantic Coastal Area	Rocky Mountain Area
Appalachian Area	Washington Coastal Area
South Florida Area	California-Oregon Coastal Area

Of these, the Appalachian and Rocky Mountain Areas are most likely to be

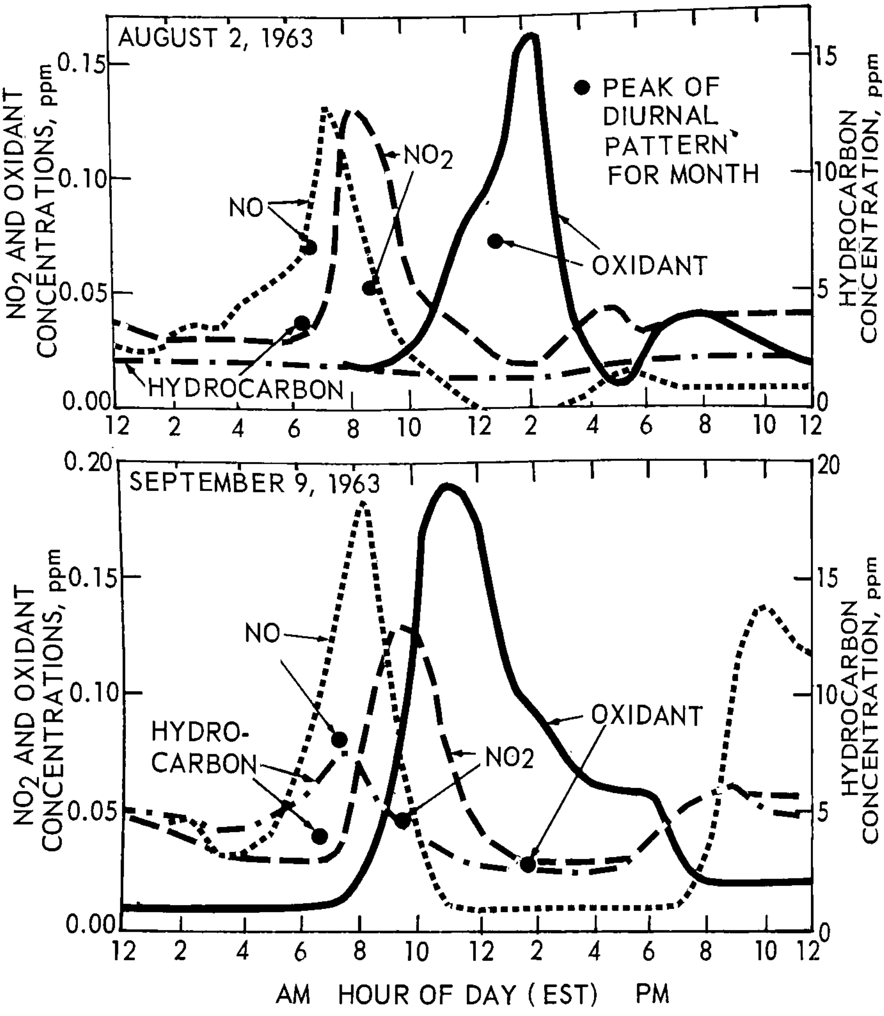


Figure 3-1. Typical diurnal patterns during incidents of photochemical smog formation compared to normal monthly peaks.

dominated by stagnant air masses and light winds. The other areas are normally well-ventilated except for local and transitory variations. Figure 3-2 presents isolines that depict the total number of days of high air pollution potential forecast for the United States for the periods indicated.

Because topography accounts largely for local variations in the broad-scale weather patterns that dominate the area during particular weather situations, a brief discussion of topographic features follows:

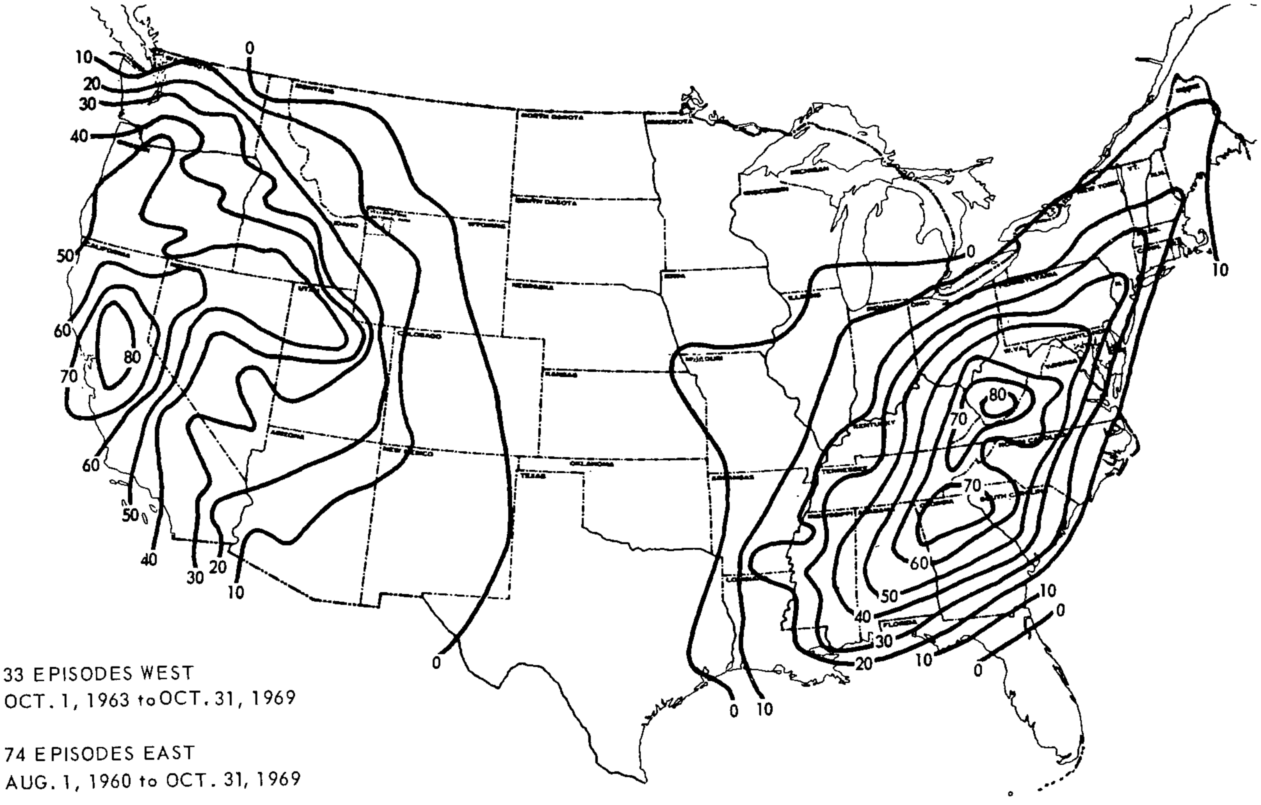


Figure 3-2. Forecast high air pollution potential days.

Terrain—Roughness, profile, slope, elevation, valley spacing, valley width. Flat, open terrain is more exposed to broad-scale movement of air than is rough, mountainous terrain, and it is generally less subject to air pollution episodes.

Vegetation—Dimensional characteristics, physical properties, distribution. Heavily wooded clusters tend to develop a micro-climate under the leafy canopy, marked by light winds and temperature inversion. Pollutants entering this regime may accumulate and may persist longer than in nearby open areas.

Hydrology—Shape, size, distribution, and dynamic properties of nearby water bodies. Adjacent land and water surfaces absorb and radiate solar heat differently; the resulting contrast in temperature helps drive the land-sea breeze during the warmer months of the year. In coastal communities, when the wind systems are weak, pollution tends to "slosh back and forth," with diurnal reversals of the surface wind, which moves off the coast at night and returning inland by day.

Degree of Urbanization—Compared with the surrounding countryside, cities influence local weather and pollution distribution in the following ways:

1. Man-made structures reduce wind speed and channel the flow through streets that lie along the general wind direction.
2. Buildings retain incident daytime heat and radiate it at night to the surrounding air, thus acting to warm the air through a layer that is several times higher than the urban skyline.
3. The higher temperature, rougher profile, blocking of wind, and net influx of air into the city act to increase vertical movement of the air above the city. Pollutants that might otherwise accumulate under a nocturnal temperature inversion become distributed through the thicker layer of atmospheric mixing above the city.
4. The above effects, plus the added presence of particulate matter, act to increase cloudiness and precipitation near a city.

Topographic factors, coupled with atmospheric processes that vary with season, time of day, and dominating weather systems, produce complex local wind patterns. Two patterns associated with the following terrain configurations are especially important in air pollution studies.

1. Ridges—Winds tend to follow the orientation of ridges and troughs in "ribbed" or "washboard" terrain. Communities may be receptors for pollution that is channeled over considerable distances along the valleys.
2. Cup-Shaped Valleys—An industrial valley that is virtually surrounded by peaks and ridges is particularly prone to hazardous levels of air pollution. During clear, still nights, cold air collects in pools and pockets at the

valley bottom and may persist for long periods of time. A community nestled in this terrain may appear picturesque within a morning blanket of fog and smoke, but it could be suffering severe air contamination.

Deciding what pollutants require control in a given locality now depends mostly on past research, historical occurrence, and a common-sense view of existing and predicted emission-source contributions to the atmosphere. Sulfur dioxide, carbon monoxide, oxidants, hydrocarbons and their photochemical products, oxides of nitrogen, and particulate matter are of universal interest; one or another may be the principal problem in a given area at a given time. Reduction of these air contaminants will have an impact on ambient concentrations of trace metals and other low-concentration pollutants. Individual sources may contribute fluorides, chlorides, odors, and many kinds of particles in localized areas, but these represent a relatively minor problem in a "first attack on episodes," in which the concern is the protection of general health in whole cities and regions.

3.2 EPISODE METEOROLOGY

The two necessary ingredients of an episode are the presence of significant emission sources and receptors and the occurrence of episode-potential meteorological conditions.

Normally, pollutants are well-dispersed in the atmosphere by turbulent mixing and wind transport. Turbulence and wind usually diminish at night and intensify during the day. From time to time, however, a stagnant high-pressure system lies over an area for a period of days, during which turbulent mixing and wind transport are abnormally weak. Under these conditions, airborne contaminants may accumulate and eventually reach the concentrations that characterize an air pollution episode.

Hence, episode prediction requires two steps:

1. Predicting the occurrence and duration of episode-potential weather conditions. These conditions may obtain independently of the presence or absence of air pollution sources.

2. Predicting concentrations of pollutants resulting from source emissions in the area affected by episode-potential conditions.

A brief discussion of turbulent mixing, wind transport, and high-pressure stagnation is included in Appendix C.

3.2.1 Forecasting Air Pollution Potential

Air pollution potential may be defined, from the meteorological standpoint, as a set of weather conditions conducive to the occurrence of high concentrations of air pollutants.

Observations over the United States have indicated that when certain meteorological conditions are met in the vicinity of a source or sources of air pollution, the pollutants tend to disperse slowly with respect to the usual rates of atmospheric diffusion and transport. These conditions are usually a combination of low mixing height and light winds, which occur most often near the center of a high-pressure system (anticyclone). The intensified pollution continues until meteorological conditions change so that the affected area is ventilated better.

3.2.2 High Air Pollution Potential Advisories (HAPPA)

High Air Pollution Potential Advisories (HAPPA) are reports prepared at the National Meteorological Center (NMC) in Suitland, Maryland, by meteorologists of the National Oceanographic and Atmospheric Administration (NOAA) of the U.S. Department of Commerce.

Advisories are based on reports received hourly via teletype from Weather Service stations in the United States and on numerous analyses and forecasts prepared by the NMC. With its computer facilities, the NMC prepares mixing-depth and wind-speed data from all upper-air observing stations in the contiguous United States (about 70 stations). These data are analyzed, interpreted, and integrated with other meteorological information.

High Air Pollution Potential Advisories based on these data are transmitted daily at 12:20 p.m., EST, to National Weather Service stations, via teletype service "C." When meteorological conditions do not warrant issuance of an advisory, the teletype message is "none today." When the forecast indicates that an advisory should be issued, the message designates the affected areas. The daily message indicates significant changes in the boundaries of HAPPA areas, including termination of an episode.

After extensive experimentation and testing, the HAPPA program went into routine daily operation on August 1, 1960, to service the portion of the United States east of the Rocky Mountains. Effective October 1, 1963, the program was expanded to include all of the contiguous United States.

Because atmospheric transport and dispersion typically vary with location and with time, the forecasting staff cannot prepare advisories for each city in the United States. For this reason, NOAA meteorologists limit their forecasts to areas of at least 75,000 square miles, roughly the size of Oklahoma, in which stagnation conditions are expected to persist for at least 36 hours. Individual Weather Service stations may modify these generalized forecasts on the basis of local meteorological conditions.

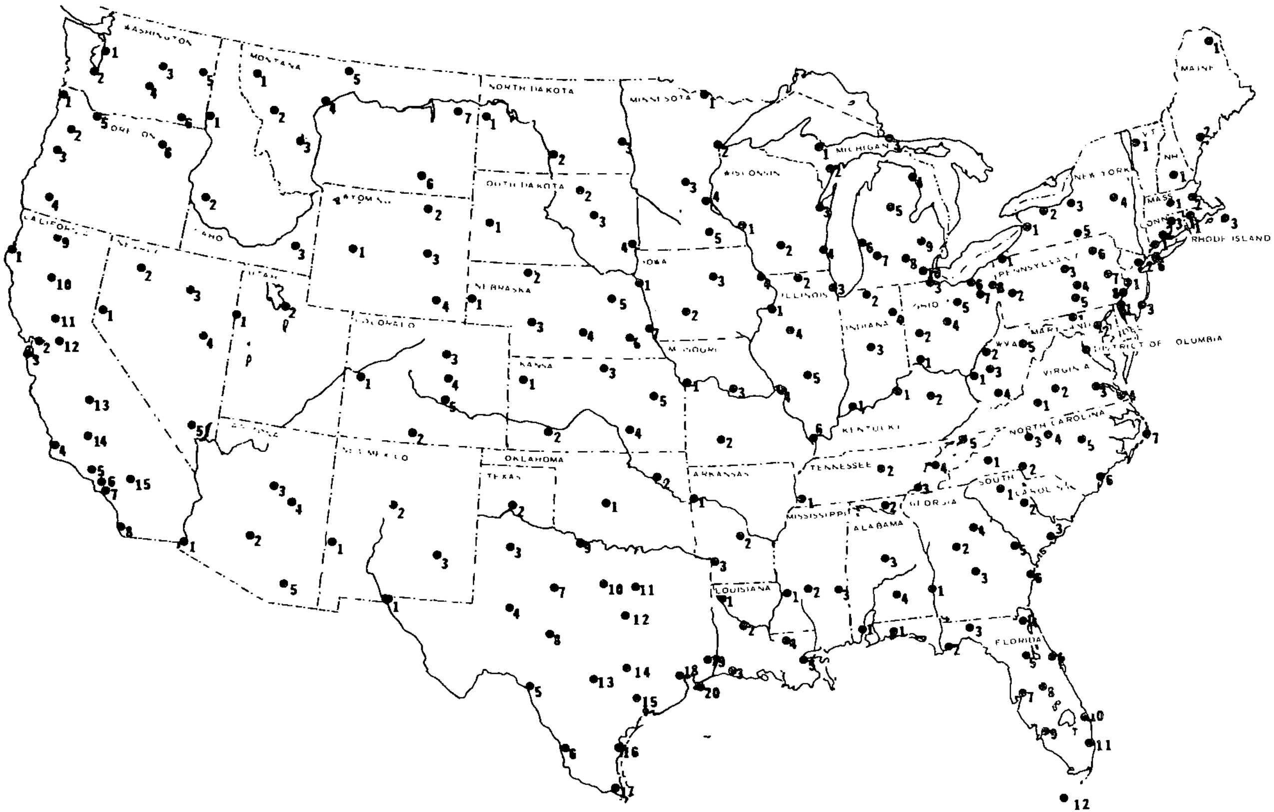


Figure 3-3. National Weather Service Stations in United States.

ALABAMA
1. MOBILE
2. HUNTSVILLE
3. BIRMINGHAM
4. MONTGOMERY
ARIZONA
1. YUMA
2. PHOENIX
3. FLAGSTAFF
4. WINSLOW
5. TUCSON
ARKANSAS
1. FORT SMITH
2. LITTLE ROCK
3. TEXARKANA
CALIFORNIA
1. EUREKA
2. OAKLAND
3. SAN FRANCISCO
4. SANTA MARIA
5. BURBANK
6. LOS ANGELES
7. LONG BEACH
8. SAN DIEGO
9. MOUNT SHASTA
10. RED BLUFF
11. SACRAMENTO
12. STOCKTON
13. FRESNO
14. BAKERSFIELD
15. POMONA
COLORADO
1. GRAND JUNCTION
2. ALAMOSA
3. DENVER
4. COLORADO SPRINGS
5. PUEBLO
CONNECTICUT
1. BRIDGEPORT
2. NEW HAVEN
3. HARTFORD
DELAWARE
1. WILMINGTON
DISTRICT OF COLUMBIA
FLORIDA
1. PENSACOLA
2. APALACHICOLA
3. TALLAHASSEE
4. JACKSONVILLE
5. ORLANDO
6. DAYTONA BEACH
7. TAMPA
8. LAKELAND
9. FORT MYERS
10. PALM BEACH
11. MIAMI
12. KEY WEST
GEORGIA
1. COLUMBUS
2. ATLANTA
3. MACON
4. ATHENS
5. AUGUSTA
6. SAVANNAH
IDAHO
1. LEWISTON
2. BOISE
3. POCATELLO
ILLINOIS
1. MOLINE
2. ROCKFORD
3. CHICAGO
4. PEORIA
5. SPRINGFIELD
6. CAIRO
INDIANA
1. EVANSVILLE
2. SOUTH BEND
3. INDIANAPOLIS
4. FORT WAYNE
IOWA
1. SIOUX CITY
2. DES MOINES
3. WATERLOO
4. DUBUQUE
KANSAS
1. GOODLAND
2. DODGE CITY
3. CONCORDIA
4. WICHITA
5. TOPEKA
KENTUCKY
1. LOUISVILLE
2. LEXINGTON
LOUISIANA
1. SHREVEPORT
2. ALEXANDRIA
3. LAKE CHARLES
4. BATON ROUGE
5. NEW ORLEANS
MAINE
1. CARIBOU
2. PORTLAND
MASSACHUSETTS
1. WORCESTER
2. BOSTON
3. NANTUCKET
MARYLAND
1. FREDERICK
2. BALTIMORE
MICHIGAN
1. MARQUETTE
2. ESCANABA
3. SAULT STE. MARIE
4. ALPENA
5. HOUGHTON LAKE
6. MUSKEGON
7. GRAND RAPIDS
8. LANSING
9. FLINT
10. DETROIT
MINNESOTA
1. INTERNATIONAL FALLS
2. DULUTH
3. ST. CLOUD
4. MINNEAPOLIS
5. ROCHESTER
MISSISSIPPI
1. VICKSBURG
2. JACKSON
3. MERIDIAN
MISSOURI
1. KANSAS CITY
2. SPRINGFIELD
3. COLUMBIA
4. ST. LOUIS
MONTANA
1. KALISPELL
2. MISSOULA
3. HELENA
4. GREAT FALLS
5. HAVRE
6. BILLINGS
7. GLASGOW
NEBRASKA
1. SCOTTS BLUFF
2. VALENTINE
3. NORTH PLATTE
4. GRAND ISLAND
5. NORFOLK
6. LINCOLN
7. OMAHA
NEVADA
1. RENO
2. WINNEMUCCA
3. ELKO
4. ELY
5. LAS VEGAS
NEW HAMPSHIRE
1. CONCORD
NEW JERSEY
1. TRENTON
2. NEWARK
3. ATLANTIC CITY
NEW MEXICO
1. SILVER CITY
2. ALBUQUERQUE
3. ROSWELL
NEW YORK
1. BUFFALO
2. ROCHESTER
3. SYRACUSE
4. ALBANY
5. BINGHAMTON
6. NEW YORK CITY
NORTH CAROLINA
1. ASHEVILLE
2. CHARLOTTE
3. WINSTON-SALEM
4. GREENSBORO
5. RALEIGH
6. WILMINGTON
7. CAPE HATTERAS
NORTH DAKOTA
1. WILLISTON
2. BISMARCK
3. FARGO
OHIO
1. CINCINNATI
2. DAYTON
3. TOLEDO
4. COLUMBUS
5. MANSFIELD
6. CLEVELAND
7. AKRON-CANTON
8. YOUNGSTOWN
OKLAHOMA
1. OKLAHOMA CITY
2. TULSA
OREGON
1. ASTORIA
2. SALEM
3. EUGENE
4. MEDFORD
5. PORTLAND
6. PENDLETON
PENNSYLVANIA
1. ERIE
2. PITTSBURGH
3. WILLIAMSPORT
4. READING
5. HARRISBURG
6. SCRANTON
7. ALLENTOWN
8. PHILADELPHIA
RHODE ISLAND
1. PROVIDENCE
SOUTH CAROLINA
1. GREENVILLE-SPARTANBURG
2. COLUMBIA
3. CHARLESTON
SOUTH DAKOTA
1. RAPID CITY
2. ABERDEEN
3. HURON
4. SIOUX FALLS
TENNESSEE
1. MEMPHIS
2. NASHVILLE
3. CHATTANOOGA
4. KNOXVILLE
5. BRISTOL
TEXAS
1. EL PASO
2. AMARILLO
3. LUBBOCK
4. MIDLAND
5. DEL RIO
6. LAREDO
7. ABILENE
8. SAN ANGELO
9. WICHITA FALLS
10. FT. WORTH
11. DALLAS
12. WACO
13. SAN ANTONIO
14. AUSTIN
15. VICTORIA
16. CORPUS CHRISTI
17. BROWNSVILLE
18. HOUSTON
19. PORT ARTHUR
20. GALVESTON
UTAH
1. WENDOVER
2. SALT LAKE CITY
VERMONT
1. BURLINGTON
VIRGINIA
1. ROANOKE
2. LYNCHBURG
3. RICHMOND
4. NORFOLK
WASHINGTON
1. SEATTLE
2. OLYMPIA
3. WENATCHEE
4. YAKIMA
5. SPOKANE
6. WALLA WALLA
WEST VIRGINIA
1. HUNTINGTON
2. PARKERSBURG
3. CHARLESTON
4. BECKLEY
5. ELKINS
WISCONSIN
1. LA CROSSE
2. MADISON
3. GREEN BAY
4. MILWAUKEE
WYOMING
1. LANDER
2. SHERIDAN
3. CASPER
4. CHEYENNE

Figure 3-3 (continued). National Weather Service Stations in U.S.

Users of the service should realize that boundaries of the HAPPA forecast areas cannot be delineated exactly. For practical purposes, the lines defining the advisory areas should be interpreted as bands roughly 100 miles wide.

To receive these advisories, air pollution control or research officials must initiate arrangements with the nearest Weather Service station (see Figure 3-3). Once arrangements have been made, the local Weather Service office will notify forecast users when their area of interest is included in an advisory. Since the forecasts are issued for a given area only when meteorological conditions warrant, it is possible that some affiliates of the program will not receive any notifications at all and that many will receive them only rarely.

Because the forecasts are for special purposes, NOAA suggests that they be disseminated through local air pollution agency channels. Any public announcements should be given as predictions of pollution conditions rather than as weather news, and should relate to the issuing agency rather than to the Weather Service office.

4. CONTROL ACTIONS FOR EPISODES

4.1 EMERGENCY ACTION STRATEGIES

An Emergency Action Strategy (EAS) is an integrated, pre-planned group of emission curtailment and related actions available to the air pollution control authority for episode avoidance. The strategy is designed so that it will cause minimum social and economic inconvenience to the community.

Source emission inventories and specific source curtailment plans are vital inputs for determining the optimum strategy for emergency control actions. For each recorded pollutant source, these inputs provide information on: (1) relative contributions of pollutants, (2) means of reducing pollutant emissions, (3) proper timing of curtailment actions, and (4) economic penalties of curtailment actions.

This information must be combined with information on local requirements for pollutant emission reduction to form the basis of a plan for controlling individual emitters in order to avoid an episode.

The minimum control action taken should be that required to preclude health damage to the population of the area. This level of control is usually determined on the basis of a system that correlates different levels of required actions with potential health damage. Pollutant exposure for these levels will vary; a typical breakdown is presented in Table 4-1.

If possible, the emergency actions taken will be graded according to the various alert levels. Actions can be planned either to correspond to the alert levels or, in more sophisticated systems, to be flexible and dependent upon real-time simulation of the episode.

In this chapter, strategies presented for the control of pollutant concentrations during an episode will range from the simple case of a single source to a highly sophisticated real-time simulation. Possible strategies, together with the information required, are shown in Table 4-2. Each agency must evaluate its own problems and limitations to determine which plan of action is most suitable.

Table 4-1. EPISODE STATUS VERSUS POLLUTANT LEVELS

Alert level[a]	Status	Condition[a]
0	Forecast	High Air Pollution Potential Advisory (Meteorology)
I	Alert	Approaches maximum allowable concentration. Still safe, but approaching point at which preventive action is needed.
II	Warning	Air contamination level at which a preliminary health menace exists.
III	Emergency	Air contamination level at which a dangerous health menace exists.

[a]Los Angeles County APCD Rule 156.

Table 4-2. POLLUTANT CONTROL STRATEGIES

Strategies	Source inventory	Shutdown plans	Social and economic value	Diffusion model for planning	Real-time diffusion model	Real-time economic effects
Simple						
Proportional	X	X	–	–	–	–
Sequential	X	X	–	–	–	–
Cost-effect	X	X	X	–	–	–
Simulated						
Intermittent modeling	X	X	X	X	–	–
Real-time control	X	X	X	X	X	X

4.1.1 Simple Strategies

In certain localities the great bulk of the pollutants will be emitted by one to four large power-generating or industrial-processing plants. In such a situation, control actions center around curtailing these large sources, and a minimum of simulation is required. Each plant would be required to submit curtailment plans compatible with the control required for the different alert levels. Alternate actions by which to achieve these goals would be evaluated by the source, and the control authority could accept or reject the suggested plans.

In the typical situation, however, there will be many sources emitting a variety of pollutants. Although large sources will contribute a significant proportion of the pollutants, control of these sources alone may not be sufficient to avoid an episode. In addition, the system may involve interacting elements. For example, it may be desirable to shift power generation from fuel oil to gas; however, sufficient gas may not be available unless certain industrial or commercial plants are closed down. Obviously, a number of alternatives must be considered.

The simplest approach is to identify the pollutants emitted and the rates at which they are emitted from each source, and then select a control strategy that will reduce emissions by fixed percentages for each alert level. For these purposes, ground-level concentrations are considered to be proportional to emissions, so that cutting emissions by one-third cuts ground-level concentrations by one-third. Typical simple strategies that do not involve detailed simulation modeling are discussed below.

4.1.1.1 Proportional Strategy

All sources must reduce emissions by fixed percentages corresponding to different alert levels. This approach may be difficult to implement and can involve appreciable economic penalties.

4.1.1.2 Sequential Strategy

Selecting the largest controllable sources first, control actions are sequenced to give the required reduction at each stage. For example, the first action might be fuel shifting in power generation with a resulting 40 percent reduction in SO_2 emissions. If the pollutant level continues to build up to the next action phase, the next largest emitters will be curtailed, and the next, until the required reduction in emissions is achieved.

4.1.1.3 Cost-Effectiveness

Under this approach, possible control actions are ranked on the basis of probable disruption of the area's normal life and economy. The cost-effectiveness determination made is static, inasmuch as estimates and strategies are evolved well in advance of the episode. Control actions are selected to provide the reduction desired for each alert level, with the least disturbance to the community. Some of the actions taken in the early alert phase may be requests for voluntary compliance, such as restrictions in automobile traffic. As the episode becomes more severe, compliance will be mandatory and necessary enforcement actions will be taken.

The cost-effectiveness strategy is the best of those considered, providing the curtailment survey has supplied an adequate basis for ranking the approximate effects of the control actions. An illustration of the strategy for a hypothetical case is shown in Table 4-3. For simplicity, only one pollutant (SO_2) is

Table 4-3. COST-BENEFIT STRATEGY (SIMPLE)

Source	Emissions, tons/day	Action and proposed selected action	Pollutant reduction, tons/day	Social effect	Economic effect
Power generation	100	Shut down plant	100	Very high	Very high
		Switch to remote plants	85	None	Moderate
		● Switch to low sulfur fuel oil	70	None	Small
		Switch to natural gas	95	High[a]	Moderate[a]
Industrial plant A (Batch processing plant)	20	Immediate shutdown			
		● No new batch starts	10	Small	Moderate
Industrial plant B (Continuous petrol chemical)	5	Immediate shutdown	5	High[b]	High[b]
		● Leave as is	0	None	None
Individual incinerators	5	● Immediate shutdown	5	Small	None
Municipal incinerators	20	● Immediate shutdown	20	None[c]	Small[c]
		Reduce throughput	10	None	Small
		Leave as is	0	None	None
Automobiles	20	Enforced restrictions on use	15	High	High
		● Voluntary restrictions on use	10	Moderate	Small
		Leave as is	None	None	None
Commercial heating[d] and power	20	Shut down completely	18	Moderate	Moderate
		● Reduce work force	12	Small	Small
		Leave as is			
School heating[d]	10	● Shut down completely	9	Moderate	None
		Reduce length of day	6	Small	None
		Leave as is	0	None	None

[a]Assumes that natural gas is being used for other activities such as residential heating, chemical plants, etc. These operations would have to be curtailed to provide natural gas for power generation.

[b]Plant may be damaged by action.

[c]The incinerator can only backlog for 4 days refuse; social and economic penalties become severe if shut down for longer than this. Revert to reduced throughput at third day of episode.

[d]Reduction in power requirement further reduces emissions from power plant.

considered, of which 200 tons per day are normally emitted and distributed as shown. At an assumed alert stage, a 70 percent reduction in emissions is desired. The actions chosen to achieve this reduction are selected as the best compromise between desired emission reduction and economic and social effects. Obviously this case is appreciably simplified, although the footnotes to the table indicate a few of the interactions that might occur. The interactions make computer simulation appealing, but simple approximations are quite useful and do not require special capabilities.

4.1.2 Simulated Strategies

Much is being done to improve the simple approach. Analytical tools are being developed with which to make strategy decisions. These tools would be used intermittently, prior to the episodes, or applied with real-time sensing.

4.1.2.1 Intermittent Modeling

Models can be used as planning tools to compare alternate control actions. Factors such as population distribution, dose-response, and diurnal cycles may be considered. Economic effects may be approximated. Intermittent modeling can be quite simple or extremely complicated, depending upon the amount of detail included.

4.1.2.2 Real-Time Control

One problem with the strategies previously presented is that they are predetermined, based on the predicted pattern of an episode. Since an episode is an uncommon event, the expected pattern may not be followed, and actions may be poorly timed or more or less severe than required. A more flexible strategy would offer appreciable advantages, provided there were means for predicting accurately the results of the control actions. Large-scale, computer-based management information systems are progressing to the point where this goal will soon be realized. The basic elements of such a program are shown in Figure 4-1. These elements include:

1. Real-time or nearly real-time processing of meteorological and air-sampling data.
2. Local meteorological forecasts.
3. Episode dispersion model, including local factors and simulation of effects of transient buildups.
4. Current emission inventory and location of sources.
5. Curtailment plans, including the time required for different actions by class and location of sources.

6. Economic data showing the effects of curtailment activities.
7. Population distribution and dose-response data.

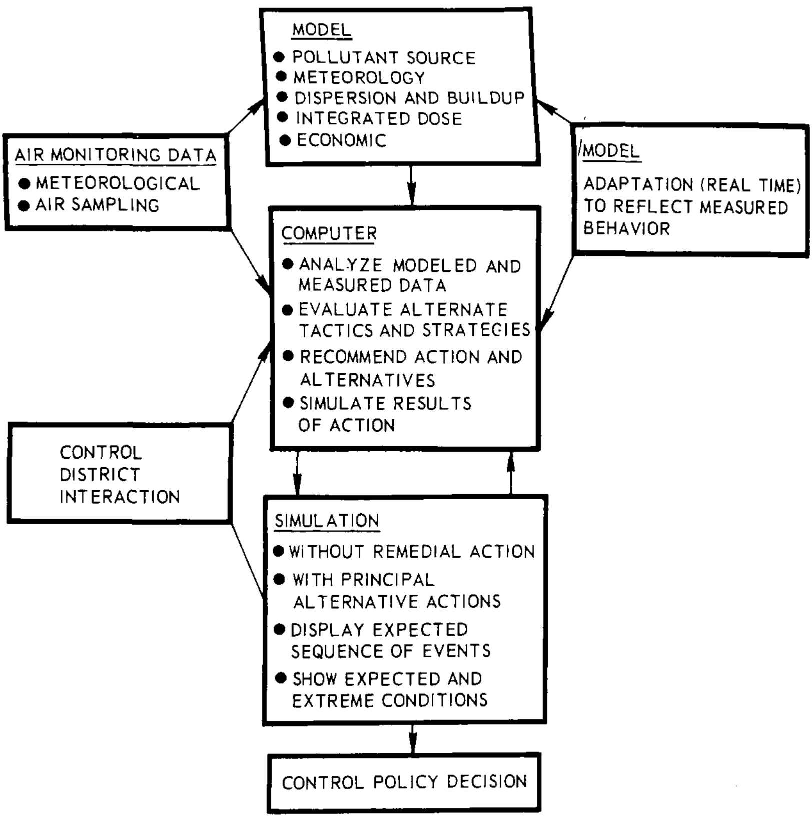


Figure 4-1. Simulation and ideal modeling in emergency action planning.

The output of such programs would include isopleths of receptor dosage as a function of time and control strategy, as well as including the economic penalty associated with the various strategies. The control authority would then project the results of various strategies and select the best cost-effectiveness strategy that maintains the population dosage (concentration of pollutants) below a desired level. Such programs are presently under investigation by non-Federal authorities in Chicago and by the Air Pollution Control Office. If these programs become generally available, they will represent a powerful tool for the control of air pollution episodes.

4.2 EMERGENCY EMISSION CONTROL METHODS

The only way to effect a reduction in ambient concentrations of pollutants during an episode is to reduce emissions from the various sources in the affected area.

In order to reduce pollutant emissions to the required level, the control agency must first know which emitters are controllable, the types and quantities of pollutants being emitted, the time required to reduce emissions, and the effectiveness of the control action. This information must be obtained by the local agency through its emission inventory and from emission curtailment plans supplied by the major emission sources.

Curtailment of industrial and commercial operations, without actual shutdown, may sometimes represent the most effective means of reducing the quantities of pollutants emitted. Care should be taken to ensure that the curtailment will actually result in an overall pollutant reduction. The purposes of such curtailment include reduction of:

1. Pollutants directly emitted by the affected operation.
2. Power demands upon utilities, to enable them to reduce their emissions.
3. Natural gas usage, so that gas can be used in more essential operations such as power generation.
4. Transportation requirements, with a resultant lowering of power demands and mobile-source emissions.

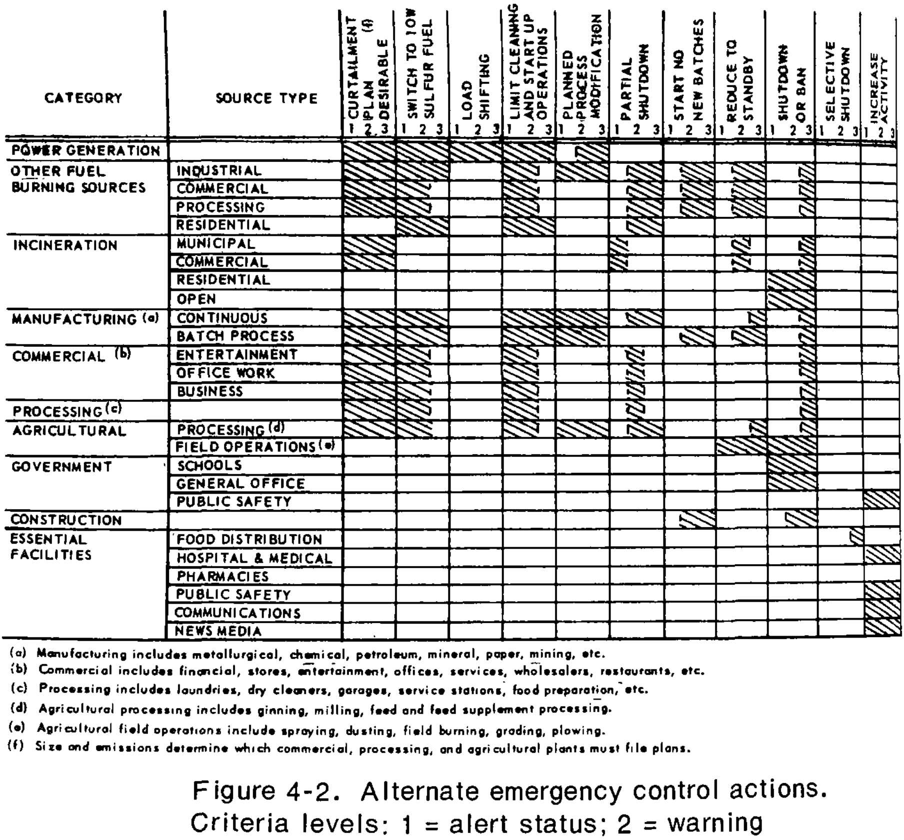
4.2.1 Stationary Sources

Control of all stationary-source emissions during episodes is impractical, but fuel switching and curtailment of some major sources, among many possible strategies, can accomplish reductions. Selection of the best approach will depend upon the mix of emission sources in the given area.

4.2.1.1 Emergency Emission Reduction Actions

Emission control actions that could be implemented as various EAP criteria levels are reached are given below and in Figure 4-2. Which of these actions should be implemented can only be determined by a detailed review of each local situation.

1. Prohibit open burning of trash, leaves, paper, or demolition debris (if not already prohibited).
2. Prohibit the use of municipal, home, commercial, governmental,



(a) Manufacturing includes metallurgical, chemical, petroleum, mineral, paper, mining, etc.
(b) Commercial includes financial, stores, entertainment, offices, services, wholesalers, restaurants, etc.
(c) Processing includes laundries, dry cleaners, garages, service stations, food preparation, etc.
(d) Agricultural processing includes ginning, milling, feed and feed supplement processing.
(e) Agricultural field operations include spraying, dusting, field burning, grading, plowing.
(f) Size and emissions determine which commercial, processing, and agricultural plants must file plans.

Figure 4-2. Alternate emergency control actions. Criteria levels: 1 = alert status; 2 = warning status; and 3 = emergency status.

institutional, or industrial incinerators. Extinguish incinerator fires or, if that is not practical, bank such fires.

3. Delay start-up of new industrial equipment.
4. Postpone start-up and shut-down of industrial plants.
5. Lance boilers or blow soot only when it is absolutely necessary and then according to a schedule that takes advantage of the best meteorological dispersion conditions (usually early in the afternoon).
6. Reduce industrial processes that emit sulfur dioxide and/or fly ash to minimal operation.
7. Reduce consumption of all heating fuel, by decreasing indoor temperature to minimum comfort level.
8. Impose on the general population brown-out conditions comparable to those used during wartime.
9. Close down nonessential commercial, retail, and industrial establishments.
10. Prohibit the cleaning of storage vessels containing toxic or odorous compounds.
11. Enforce mandatory requirement that industrial batch operations discharging SO_2 be closed down.
12. Require bituminous coal users burning more than 2000 tons of coal annually to switch to low-sulfur (1 percent or less) coal.
13. Require that all residual oil consumers who use more than 500,000 gallons of residual oil annually switch to low-sulfur (1 percent or less) oil.
14. Require that natural gas be burned in those industries and power-generating facilities where gas and equipment are available.
15. Require that all power-generating facilities and all industrial units have a 5-day supply of low-sulfur (1 percent or less) fuels available for consumption at all times. This requirement would apply to any boiler or aggregate of boilers in one location whose total rated hourly capacity equals or exceeds, for example, 100,000 pounds of steam hourly.

4.2.1.2 Reduction in Fuel-Burning and Industrial-Process Emissions

A number of actions may be taken to reduce the quantity of emissions from fuel burning and industrial processes without appreciably affecting the overall throughput of the operation. These are typically steps that may be economically undesirable for normal operation, but that represent feasible operating modes during potential-episode conditions. Possible actions are discussed below.

4.2.1.2.1 Fuel switching–Natural gas or light fuel oil may be burned in most oil-burning facilities and in some coal-fired furnaces. Considerable replanning is necessary to establish the fuel-switching alternative as a control measure, since fuel supplies must be available when required.

Large consumers of coal or high-sulfur oil (e.g., power generating plants, central heating plants, and industrial plants), may have dual fuel capability for reasons other than air pollution control, in which case this alternative would require only the necessary communications, distribution of available fuels, and provision for stock-piling reserve supplies. Many small industrial furnaces have oil or gas standby furnaces that could be fired up during episodes, thus reducing the load on coal- or residual-oil-fired furnaces.

Some factors that must be considered in fuel-switching actions are:

1. Availability of substitute fuels.
    a. Relative scarcity of alternate fuels.
    b. Competitive demands.
2. Availability of storage.
    a. Space requirements.
    b. Handling facilities.
    c. Turnover of stockpile.
3. Technical features.
    a. Alternate burners.
    b. Ash compatibility with furnace design.
    c. Particulate emissions.
    d. Auxiliary equipment (heaters, pumps).

The feasibility of substituting low-sulfur oil or gas for high-sulfur coal must be examined by experienced combustion engineers for each specific situation.

4.2.1.2.2 Industrial process adjustment and/or curtailment–The possibilities for reducing emissions by process adjustments are practically endless and must be tailored to each process. If a control agency staff is available, cooperative analysis with company engineers may turn up possibilities, but in a large city with thousands of sources this is likely to be possible for only the major point sources. Any measure contributing to reduced exit loadings or to better dispersion should be considered a potential means of reducing pollutant levels in ambient air.

Reduction in process throughput or stoppage of waste stream recirculation will generally decrease emissions. Delay of certain noncritical functions, temporary (presumably less profitable) adjustment of control "set-points," and increasing stack temperatures or velocities are possible general approaches to be investigated. Soot blowing, cleaning, painting, and chemical recovery operations may be temporarily deferred.

Again, no general emission-reduction guide can be offered, and each process must be studied in detail to determine some optimum reduction strategy. This is especially true for high-temperature continuous operations.

4.2.1.2.3 Increasing collector efficiencies—Some types of emission control systems are amenable to increased collection efficiency. Thus, the pressure drop through variable-throat scrubbers can be increased (with a corresponding increase in fan horsepower), or the liquid flow rates may be increased to increase efficiency. Electrostatic precipitator efficiency may be increased in some cases by increasing voltages and/or current (up to a limit), or by energizing a standby precipitator section, if available. The type of control equipment used routinely to reduce emissions will dictate the approaches available in this area.

4.2.1.2.4 Power interchange—The electric power industry must have excess capacity to handle peak demands and to provide for maintenance of equipment. During the period preceding a potential episode it may be possible to shift the electrical load within and between power systems to reduce the quantity of pollutants emitted in a particular region. Power interchange is a complex, system-wide procedure involving continuous equalization of generation and load. Typical actions might include maximum use of hydroelectric or nuclear power; shifting to plants utilizing low-sulfur fuel; shifting to plants with superior pollutant removal or dispersion capability (scrubbers, taller stacks); or shifting to more favorably located plants (downwind). Power interchange by power companies must be a cooperative effort, and reliance must be placed on power system engineers to exploit the available alternatives at the time of the incident.

4.2.1.2.5 Curtailment of nonindustrial operations—Aside from emissions due to heating, commercial operations are not usually a major source of pollutants. In the early stages of an alert, it may be desirable to request that commercial operations reduce heating and/or cooling loads.

Heating and, sometimes, refuse disposal are the main sources of residential emissions. Requests for voluntary reductions in heating, made by lowering the thermostat temperature and reducing power consumption, are among the few reasonable actions that can be taken. A ban on backyard burning can also be imposed.

In addition to shutdowns of facilities actually emitting pollutants, facilities that do not directly emit pollutants could be shut down when they indirectly contribute to pollution through power demands, natural gas usage, and transportation requirements.

4.2.2 Mobile Sources

The primary mobile source contributing to air pollution is the private automobile. Control of automobile travel can be voluntary, indirect, or compulsory.

4.2.2.1 Voluntary Control

Requests can be made for voluntary curtailment of unnecessary automobile traffic.

4.2.2.2 Indirect Control

Indirect control of automobile traffic consists of making travel unnecessary or inconvenient. Closing down facilities employing large numbers of people will eliminate much of the travel (both public and private) to places of work. Entertainment and retail business shutdowns will effectively limit many other trips. Closing down main thoroughfares (freeways, turnpikes, etc.) and parking lots will make travel more difficult and less convenient. This is probably the most effective means of controlling automobile travel.

4.2.2.3 Compulsory Control

A permit system can be established limiting travel on roads to those cars that have permits. Permits might be given, for example, to workers in medical, public safety, and other essential industries.

4.3 EMISSION CURTAILMENT DATA

Reducing pollutant emissions as a means of avoiding potential episodes requires information not ordinarily available to the local control authority. Information pertaining to fuel switching, shifting of power loading, and curtailment or postponement of operations can only be obtained through the development of a close and knowledgeable contact with the sources. These data should preferably be obtained as part of the emission inventory.

The cost to the control agency of performing a detailed analysis of each facility would be prohibitive. Instead, the operator of each major source will need to perform a curtailment or shutdown analysis of his facility, on the basis of guidelines provided by the agency. A formal Emergency Curtailment Plan should be prepared by each major source and submitted to the agency for approval. The plan should specify both the expected emission reduction and timing of the actions to be taken. The responsibility for economic evaluation of curtailment actions by major sources rests with each source. The agency should consult with the source or exercise enforcement powers in cases where wide discrepancies exist between the effectiveness of the suggested curtailment and requirements for emission reduction.

A separate questionnaire will be required in order to obtain information necessary for episode avoidance planning. The elements to be covered by the questionnaire are:

1. Dual fuel capability.

   a. Advance notice desired.
   b. Ash and sulfur content of normal fuel.
   c. Ash and sulfur content of alternate fuel.
   d. Time required to switch fuel.
   e. Seasonal availability of alternate fuel.
   f. Added or reduced costs of dual fuel capability (capital and operating costs).

2. Process curtailment data.

   a. Advance notice required.
   b. Emission time-history during curtailment (see below).
   c. Emission rate after curtailment.
   d. Desirable curtailment time.
   e. Minimum curtailment time (for "high" alerts).
   f. Number of employees released during curtailment.
   g. Curtailment period allowable without substantial loss.
   h. Time after which curtailment imposes serious (unrecoverable) economic burden.
   i. Estimated economic loss per day of curtailment.

Each source may be required to submit or to have available for inspection curtailment plans showing the data detailed above, together with the operational changes to be made for reducing emissions. Additional information on time-histories of pollutant emissions, advance notice required, and side effects is presented in the following sections.

4.3.1 Time-Histories of Pollutant Emissions

The "time-history" is merely a record of changes in pollutant emissions with time, as shown in Figure 4-3. In planning the curtailment of emissions of a given pollutant, it is desirable to know the time-history for the following reasons:

1. Curtailment may cause some emissions to increase temporarily.

2. The time required to achieve a reduction in concentrations will be important for future planning.

3. Emissions during restart may influence the decision to curtail.

The preparation of curves plotting total emissions versus time for a community will, of course, depend on the summation of individual source emissions. This will be difficult at the present time, because emissions under changing operational conditions are not known. Estimates provided by individual sources, based on knowledge of the operations, can be obtained

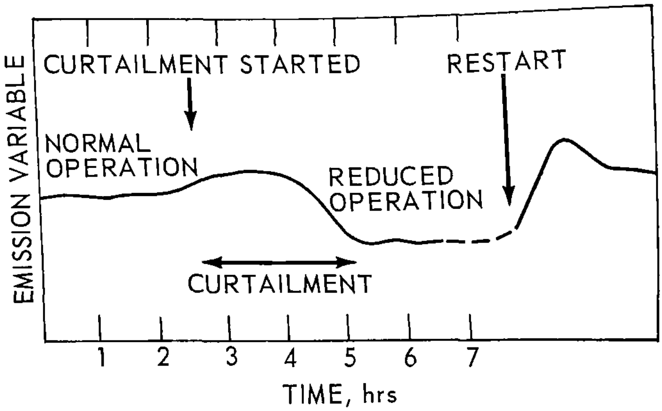


Figure 4-3. Time-history of pollutant emissions.

during the inventory process or as part of a permit system. Better yet, curtailment emission estimates may be required by regulators of individual curtailment plans.

The time required for emission reduction may be the most useful data produced from time-histories. In some cases, emissions may rise during curtailment before descending to the new reduced level. The effect may not be severe if the time period of elevated emissions is brief. Where the number of sources is large, the summation and display of these data are best done by computer.

4.3.2 Advance Notice Required

The advance notice needed by emitters subject to curtailment may vary from an hour to several days. This information can be supplied only by persons having a knowledge of the process and its relationship with other processes, either within or external to a given operation. The advance notice required and the details involved in notifying the affected sources are important parts of the total Emergency Action Plan.

4.3.3 Side Effects

There will be important side-effect considerations in most curtailment plans:

1. Releasing employees at unusual times may be beneficial in spreading out traffic flow.

2. Telephone switchboards may be overcrowded.

3. The suppliers and customers of each emissions source may be affected, and the curtailment plan for each source should anticipate such effects.

4.4 ILLUSTRATIONS OF EMERGENCY CONTROL PROCEDURES

In order to illustrate the operation of an Emergency Action Plan (EAP), descriptions of typical actions to be taken by control agencies during an episode are presented in this chapter. It is important to realize that the highly sophisticated systems described are not a prerequisite to all EAP's. A simple EAP may involve only two or three sampling stations, procedures for curtailing emission sources, and a single criterion selected to prevent a disaster. An EAP must fit the needs of each individual situation.

4.4.1 Operations of a Typical Emergency Action Plan

It is assumed that the control agency employs a four-stage system corresponding to that in Figure 4-4, with each stage defined by particular pollutant levels or dosage and forecast meteorological conditions. The example outlined below has been formulated around status criteria developed for one specific area.[1]

4.4.1.1 Stage 1. Forecast Stage

The first indication of the potential episode is the meteorological forecast. The national High Air Pollution Potential Advisory (HAPPA) informs the control authority that potential episode conditions will exist in the area for at least the next 36 hours. The control agency prepares for the potential episode by taking the following actions:

1. Intra-agency:

    a. Notifies responsible control agency personnel.
    b. Notifies members of the Emergency Action Committee.
    c. Requests increased meteorological soundings.
    d. Increases the air sampling activity.
    e. Plans personnel assignments to provide for continual manning of control centers.
    f. Activates control center (prepares to contact extra-agency groups).
    g. Checks communications center.
    h. Increases inspection of major sources to assure compliance with abatement regulations.
    i. Uses dispersion model to predict future *trend* of pollutant levels.

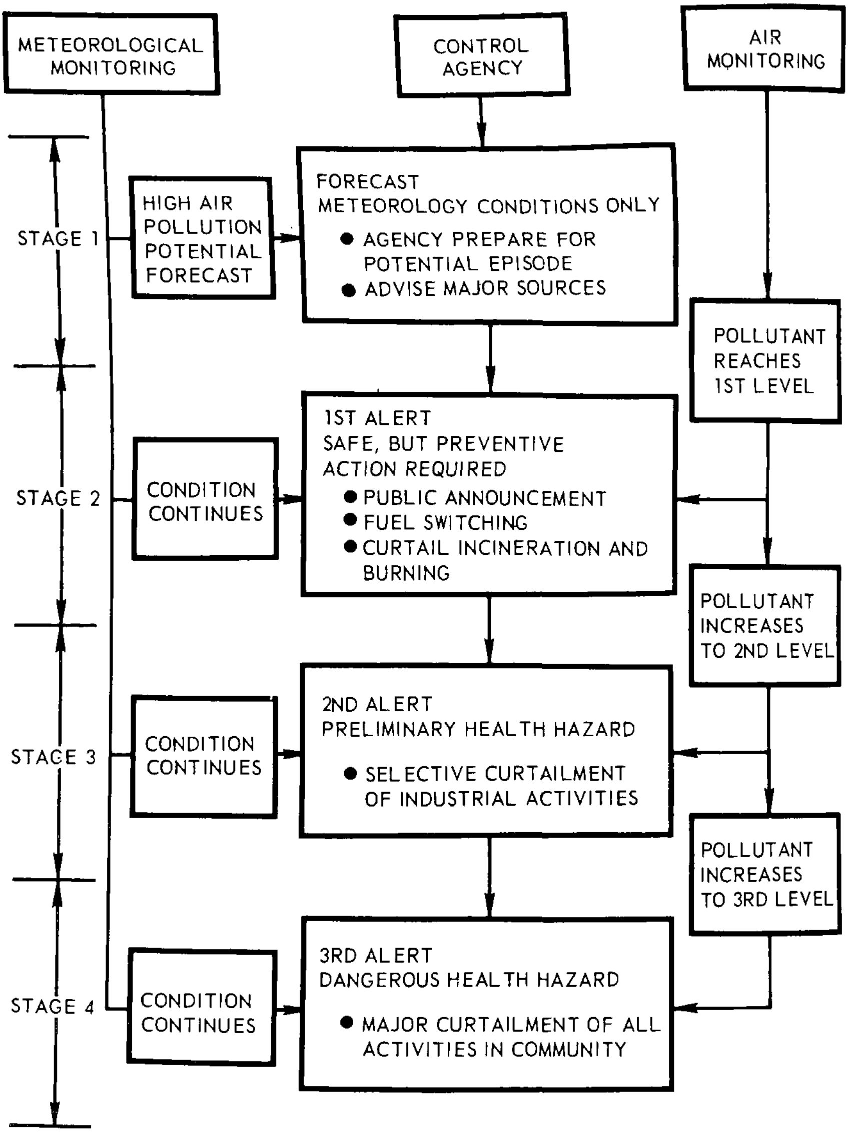


Figure 4-4. Four-stage alert sequence.

2. Extra-agency:

   a. Notifies public officials, and police, fire,* and public health departments of possibility of episode.
   b. Requests media—TV, radio, newspapers—to advise public of possible adverse situations (optional at forecast stage).
   c. Notifies industry of condition and requests abbreviated review of selected curtailment procedures. (In some cases, power generation might voluntarily switch to gas or to low-sulfur oil or coal).
   d. Notifies telephone company of conditions and requests activation of planned emergency telephone communications.

Basically, these operations are designed to prepare the system for action during an episode. The primary concern is to observe trends in rising pollutant levels. In the hypothetical case being presented here, the automated sampling system indicated steadily rising levels of SO_2.

4.4.1.2 Stage 2. First Alert

First Alert air pollution levels are attained. Meteorological information indicates that this condition will persist for at least 12 more hours. The responsible Control Officer calls a First Alert. Actions immediately taken are as follows:

1. Intra-Agency:

   a. Control Officer formally declares First Alert.
   b. Meteorological soundings and air sampling are increased.
   c. All agency personnel are notified of schedules for expected duration of emergency.
   d. Field inspections are increased.
   e. Decision-making model is employed to determine best actions in case a second alert level is reached, and to predict future trends.

2. Extra-agency:

   a. Public officials—police, fire, and public health—are notified.
   b. News media are requested to advise public of adverse conditions using prepared news release. Public is asked to take the following steps:

      (1) Restrict unnecessary travel; use car pools where feasible.
      (2) Reduce residential thermostats; avoid using unnecessary electrical power, restricting it to 40 watts per room.
      (3) Stay indoors and rest as much as possible.
      (4) Highly sensitive individuals should consult their doctors.
      (5) Ban all public incineration and all public fires.

*Fire Departments are often relied upon by the public for emergency information.

c. Notify industry of First Alert level and request activation of applicable curtailment procedures, namely:
   (1) Power generation facilities switch to natural gas and/or low-sulfur fuel. Recommend switching of maximum load to remote sites and site C, which is downwind.
   (2) City incinerators reduce to 50 percent throughput.
   (3) City schools stand by to close if situation persists for 24 more hours.
   (4) Specified large fuel users switch to low-sulfur fuel.
   (5) All industries voluntarily minimize the use of electrical power.
   (6) Specified industries are not to start any new batches.
   (7) Specified industries and commercial operations stand by for shutdown operations.

d. Request Public Health Officials to alert health agencies for shutdown operations and for special data to be acquired.

The results of the industrial curtailments are apparent. Nevertheless, SO_2 dosages continue to rise (considering diurnal fluctuations), but at a much reduced rate. The power company reports public and industrial compliance with the request for power reduction, as seen in somewhat reduced power demands. The police department reports no discernible decrease in automobile traffic. Listed agency phones are essentially out-of-commission, because of the large number of calls from the public requesting information and reporting violations that are mostly in the form of small quantities of visible smoke. Agency communication is unaffected, however, since separate lines are being used in the control center.

The air sampling system indicates a rapid increase in CO concentrations, exceeding the First Alert level for this contaminant. The dispersion model predicts that Second Alert levels will be reached in 8 to 10 hours for CO and in 12 to 14 hours for SO_2 and particles. Meteorologists indicate that a break in the weather can be expected in 24 to 48 hours. The Control Officer recognizes that a Second Alert level will probably be reached and, after discussion with the Emergency Action Committee, decides that an intermediate status report to the public is desirable. At this point, the responsible Control Officer notifies public officials, industry, news media, and the police, fire, and health departments of the continuing emergency and requests that they be ready to implement a Second Alert. The news media inform the public of the probability of a Second Alert and detail the actions to be taken if Second Alert levels are reached, namely, the closing of many commercial establishments and main traffic arteries.

4.4.1.3 Stage 3. Second Alert

The SO_2 and particulate levels continue to increase until Second Alert levels are reached. Meteorologists inform the control center that wind speeds will increase in 18 hours and precipitation may be expected in 36 to 48 hours. The Control Officer consults with his technical staff to determine what would occur if no further action were taken. Meteorological estimates indicate a trend toward higher levels for SO_2, with Third Alert levels probable in 18 to 24 hours at present emission rates. The Control Officer calls a Second Alert. Actions immediately taken are as follows:

1. Intra-agency:

   a. Control Officer formally declares a Second Alert.
   b. Control Officer notifies State Governor of impending state of emergency (only Governor can declare Third Alert).
   c. All previous emergency actions continued.
   d. Control Officer notifies agency inspection and enforcement personnel of Second Alert and requests that they concentrate on inspecting high-sulfur-fuel-burning facilities required to shut down.

2. Extra-agency:

   a. Notifies public officials, including police, fire, and local public health personnel.
   b. Requests police to close main arteries (freeways, parkways, etc.) as planned.
   c. Requests news media to advise public of continuing adverse conditions.
   d. Requests public to continue to comply with all previous restrictions.
   e. Informs public of closing of main traffic arteries.
   f. Informs public of those commercial and business activities that are curtailed.
   g. Notifies industrial and commercial plants of Second Alert, and requests activation of applicable curtailment procedures, namely:

      (1) All previous curtailment actions remain in force.
      (2) All burning of high-sulfur fuel is banned for industrial and commercial units, unless a permit for critical operation has been issued.
      (3) Specified large industries are ordered to shut down or to stand by for shutdown per curtailment plans.
      (4) All nonessential commercial and business operations employing over 100 employees are ordered closed per curtailment plans.
      (5) All restaurants and entertainment establishments are ordered closed.
      (6) All incinerators (both city and private) are order to shut down.

Results are immediately apparent. Within 2 hours, the power company reports greatly reduced loads, permitting it to switch all loads to remote plants. The police department requests a 4-hour delay in closing traffic arteries, to permit workers from closing facilities to get home. Permission is granted by

Control Officer. Field inspectors report general compliance with the shutdown order. Enforcement officers are dispatched to two noncomplying plants. Two of the remote air-sampling stations appear erratic. Technicians are dispatched to repair them.

The air-sampling data show a slow reduction in SO_2 and particulate concentrations. The carbon monoxide concentration momentarily increases and then starts to taper off as traffic decreases. Meteorologists predict a marked increase in wind speed within the next 12 hours, because of the approach of a cold front.

Pollution levels continue to fall as atmospheric activity starts to disperse the pollutants, and finally a light rain begins to fall. Air sampling stations show a rapid decrease in pollution levels. The episode is over.

The control Officer takes the following actions:

1. Intra-agency:

   a. Formally declares the emergency to be over.
   b. Notifies State Governor of termination of alert conditions.
   c. Notifies all agency employees of termination of alert conditions.
   d. Notifies the agency personnel that only a minimum crew is required after all data are secured for post-episode report.
   e. Assigns reporting responsibility to staff; report for news media has high priority.

2. Extra-agency:

   a. Notifies public officials and police, fire, and public health personnel.
   b. Requests that public health officials start to collect data on mortality and morbidity.
   c. Requests news media to advise public of termination of alert conditions.
   d. Notifies power and telephone companies of termination, and warns them to anticipate impact of resumption of normal activities.
   e. Notifies industrial, commercial, and business facilities of termination of the alert.
   f. Notifies hospitals of availability of atmospheric data to support health studies.

A few days after the episode, the agency begins preparation of functional post-episode reports. One such report for internal distribution is an evaluation of the effectiveness of agency operations. A technical report is also required on meteorological, air sampling, and public health data.

The example presented above only serves to illustrate the flow of information during actual operation of an emergency action plan, and many simplifications have been made. A real episode plan, for example, would have to consider the actual timing of all events relative to normal day-night variations in emission and weather factors. The example does serve, however, to illustrate the major elements of a plan, which include:

1. Delineation of responsibility (the Control Officer was the sole critical-point decision-maker in the hypothetical plan).
2. The necessity for effective communication systems for information acquisition and dissemination.
3. The importance of real-time air sampling and meteorological data.
4. The value of predictive models in decision making.
5. The need for clear-cut criteria for each alert level.
6. The need for detailed advance planning of all possible actions.
7. The need for self-evaluation in a post-episode report.

4.4.2 Emission Reduction Actions (State of New Jersey)

This Section presents the Standby Plans and Orders (Sections 4 and 5) of the State of New Jersey for the prevention and control of air pollution emergencies. This material was taken from Chapter 12 of the New Jersey Air Pollution Control Code. The effective date of the emergency regulation was October 24, 1969.

Section 4–STANDBY PLANS

"4.1 Any person responsible for the operation of a source of air contamination as set forth in Table 1 of this Section shall prepare standby plans, consistent with good industrial practice and safe operating procedures, for reducing the emission of air contaminants into the outdoor atmosphere during periods of an AIR POLLUTION ALERT, AIR POLLUTION WARNING, and AIR POLLUTION EMERGENCY. Standby plans shall be designed to reduce or eliminate emissions of air contaminants into the outdoor atmosphere in accordance with the objectives set forth in Tables I-III which are made a part of this Section.

4.2 Any person responsible for the operation of a source of air contamination not set forth under Section 4.1 shall, when requested by the Department in writing, prepare standby plans, consistent with good industrial practice and safe operating procedures, for reducing the emission of air contaminants into the outdoor atmoshere during periods of an AIR POLLUTION ALERT, AIR POLLUTION WARNING, and AIR POLLUTION EMERGENCY. Standby plans shall be designed to reduce or eliminate emissions of air contaminants into the outdoor atmosphere in accordance with the objectives set forth in Tables I-III.

TABLE I
EMISSION REDUCTION OBJECTIVES[2]

Source of Air Contamination	Air Pollution Alert
1. Coal or oil-fired electric power generating facilities.	a. Substantial reduction by utilization of fuels having lowest available ash and sulfur content. b. Maximum utilization of mid-day (12:00 Noon to 4:00 p. m.) atmospheric turbulence for boiler lancing and soot blowing. c. Substantial reduction by diverting electric power generation to facilities outside of Alert Area.
2. Coal or oil-fired process steam generating facilities having a capacity to burn in excess of four tons of coal per hour or 600 gallons of fuel oil per hour.	a. Substantial reduction by utilization of fuels having lowest available ash and sulfur content. b. Maximum utilization of mid-day (12:00 Noon to 4:00 p. m.) atmospheric turbulence for boiler lancing and soot blowing. c. Reduction of steam load demands consistent with continuing plant operations.
3. A — Manufacturing industries of the following classifications which employ more than twenty (20) employees at any one location: Primary Metals Industries Petroleum Refining and Related Industries Chemical and Allied Products Industries Paper and Allied Products Industries Glass, Clay and Concrete Products Industries AND B — Other persons required by the Department to prepare standby plans.	a. Substantial reduction of air contaminants from manufacturing operations by curtailing, postponing, or deferring production and allied operations. b. Maximum reduction by deferring trade waste disposal operations which emit particles, gases, vapors or malodorous substances. c. Reduction of heat load demands for processing consistent with continuing plant operations. d. Maximum utilization of mid-day (12:00 Noon to 4:00 p. m.) atmospheric turbulence for boiler lancing or soot blowing.
4. Municipal and commercial refuse disposal operations.	a. Maximum reduction by prevention of open burning on all refuse disposal areas. b. Substantial reduction by limiting burning of refuse in incinerators to the hours between 12:00 Noon and 4:00 p. m.

TABLE II
EMISSION REDUCTION OBJECTIVES[2]

Source of Air Contamination	Air Pollution Warning
1. Coal or oil-fired electric power generating facilities.	a. Maximum reduction by utilization of fuels having lowest available ash and sulfur content. b. Maximum utilization of mid-day (12:00 Noon to 4:00 p. m.) atmospheric turbulence for boiler lancing and soot blowing. c. Maximum reduction by diverting electric power generation to facilities outside of Warning Area.
2. Coal or oil-fired process steam generating facilities having a capacity to burn in excess of four tons of coal per hour or 600 gallons of fuel oil per hour.	a. Maximum reduction by utilization of fuels having the lowest available ash and sulfur content. b. Maximum utilization of mid-day (12:00 Noon to 4:00 p. m.) atmospheric turbulence for boiler lancing and soot blowing. c. Reduction of steam load demands consistent with continuing plant operations. d. Making ready for use a plan of action to be taken if an emergency develops.
3. A — Manufacturing industries of the following classifications which employ more than twenty (20) employees at any one location: Primary Metals Industries Petroleum Refining and Related Industries Chemical and Allied Products Industries Paper and Allied Products Industries Glass, Clay and Concrete Products Industries AND B — Other persons required by the Department to prepare standby plans.	a. Maximum reduction of air contaminants from manufacturing operations by, if necessary, assuming reasonable economic hardship by postponing production and allied operations. b. Maximum reduction by deferring trade waste disposal operations which emit particles, gases, vapors or malodorous substances. c. Reduction of heat load demands for processing consistent with continuing plant operations. d. Maximum utilization of mid-day (12:00 Noon to 4:00 p. m.) atmospheric turbulence for boiler lancing or soot blowing.
4. Municipal and commercial refuse disposal operations.	a. Maximum reduction by prevention of open burning on all refuse disposal areas. b. Complete elimination of the use of incinerators.

TABLE III
EMISSION REDUCTION OBJECTIVES[2]

Source of Air Contamination	Air Pollution Emergency
1. Coal or oil-fired electric power generating facilities.	a. Maximum reduction by utilization of fuels having lowest available ash and sulfur content. b. Maximum utilization of mid-day (12:00 Noon to 4:00 p. m.) atmospheric turbulence for boiler lancing and soot blowing. c. Maximum reduction by diverting electric power generation to facilities outside of Emergency Area.
2. Coal or oil-fired process steam generating facilities having a capacity to burn in excess of four tons of coal per hour or 600 gallons of fuel oil per hour.	a. Maximum reduction by reducing heat and steam demands to absolute necessities consistent with preventing equipment damage. b. Maximum utilization of mid-day (12:00 Noon to 4:00 p. m.) atmospheric turbulence for boiler lancing and soot blowing. c. Taking the action called for in the emergency plan.
3. A — Manufacturing industries of the following classifications which employ more than twenty (20) employees at any one location: Primary Metals Industries Petroleum Refining & Related Industries Chemical and Allied Products Industries Paper and Allied Products Industries Glass, Clay and Concrete Products Industries AND B — Other persons required by the Department to prepare standby plans.	a. Elimination of air contaminants from manufacturing operations by ceasing, curtailing, postponing or deferring production and allied operations to the extent possible without causing injury to persons or damage to equipment. b. Elimination of air contaminants from trade waste disposal processes which emit particles, gases, vapors or malodorous substances. c. Maximum reduction of heat load demands for processing. d. Maximum utilization of mid-day (12:00 Noon to 4:00 p. m.) atmospheric turbulence for boiler lancing or soot blowing.
4. Municipal and commercial refuse disposal operations.	a. Maximum reduction by prevention of open burning on all refuse disposal areas. b. Complete elimination of the use of incinerators.

4.3 Standby plans as required under Sections 4.1 and 4.2 shall be in writing and show the source of air contamination, the approximate amount of reduction contaminants and a brief description of the manner in which the reduction will be achieved during an AIR POLLUTION ALERT, AIR POLLUTION WARNING, and AIR POLLUTION EMERGENCY.

4.4 During a condition of AIR POLLUTION ALERT, AIR POLLUTION WARNING, and AIR POLLUTION EMERGENCY standby plans as required by this Section shall be made available on the premises to any person authorized to enforce the provisions of the Air Pollution Emergency Control Act.

4.5 Standby plans as required by this Section shall be submitted to the Department upon request within thirty days of the receipt of such request; such standby plans shall be subject to review and approval by the Department. If, in the opinion of the Department, such standby plans do not effectively carry out the objectives as set forth in Tables I-III, the Department may disapprove said standby plans, state its reason for disapproval and order the preparation of amended standby plans within the time period specified in the order. Any person aggrieved by the order requiring the preparation of the revised plan is entitled to a hearing in accordance with C.26:2C-14.1 of the Air Pollution Control Act. If the person responsible fails within the time period specified in the order to submit an amended standby plan which in the opinion of the Department meets the said objectives, the Department may revise the standby plan to cause it to meet these objectives. Such revised plan will thereafter be the standby plan which the person responsible will put into effect upon the issuance of an appropriate order by the Governor."

Section 5—STANDBY ORDERS

"Following are standby orders which might be appropriate for use by the Governor upon his declaration that an Air Pollution Emergency exists:

5.1 Air Pollution Alert

a. Any person responsible for the operation of a source of air contamination as set forth in Table I of Section 4 shall take all AIR POLLUTION ALERT actions as required for such source of air contamination; and shall particularly put into effect the standby plans for an AIR POLLUTION ALERT.

b. There shall be no open burning by any persons of tree waste, vegetation, refuse, or debris in any form.

c. The use of incinerators for the disposal of any form of solid waste shall be limited to the hours between 12:00 Noon and 4:00 p.m.

d. Persons operating fuel-burning equipment which requires boiler lancing or soot blowing shall perform such operations only between the hours of 12:00 Noon and 4:00 p.m.

5.2 Air Pollution Warning

a. Any person responsible for the operation of a source of air contamination as set forth in Table II of Section 4 shall take all AIR POLLUTION WARNING actions as required for such source of air contamination; and shall particularly put into effect the standby plans for an AIR POLLUTION WARNING.

b. There shall be no open burning by any persons of tree waste, vegetation, refuse, or debris in any form.

c. The use of incinerators for the disposal of any form of solid waste or liquid waste shall be prohibited.

d. Persons operating fuel-burning equipment which requires boiler lancing or soot blowing shall perform such operations only between the hours of 12:00 Noon and 4:00 p.m.

5.3 Air Pollution Emergency

a. Any person responsible for the operation of a source of air contamination as described in Table III of Section 4 shall take all AIR POLLUTION EMERGENCY actions as listed as required for such source of air contamination; and shall particularly put into effect the standby plans for an AIR POLLUTION EMERGENCY.

b. All manufacturing establishments except those included in Section 5.3a will institute such action as will result in maximum reduction of air contaminants from their operations by ceasing, curtailing, or postponing operations which emit air contaminants to the extent possible without causing injury to persons or damage to equipment.

c. All places of employment described below shall immediately cease operations:

(1) Mining and quarrying of non-metallic minerals.

(2) All contract construction work except that which must proceed to avoid physical harm.

(3) Wholesale trade establishments, i.e., places of business primarily engaged in selling merchandise to retailers, to industrial, commercial, institutional or professional users, or to other wholesalers, or acting as agents in buying merchandise for or selling merchandise to such persons or companies.

(4) All offices of local, county, and state government including authorities, joint meetings, and any other public body; except to the extent that such offices must continue to operate in order to enforce the requirements of this order pursuant to statute.

(5) All retail trade establishments except pharmacies and stores primarily engaged in the sale of food.

(6) Banks; credit agencies other than banks; securities and commodities brokers, dealers, exchanges and services; offices of insurance carriers, agents and brokers; real estate offices.

(7) Wholesale and retail laundries; laundry services and cleaning and dyeing establishments; photographic studios; beauty shops, barber shops; shoe repair shops.

(8) Advertising offices; consumer credit reporting, adjustment and collection agencies; duplicating, addressing, blueprinting; photocopying, mailing, mailing list and stenographic services; equipment rental services, commercial testing laboratories.

(9) Automobile repair, automobile services, garages.

(10) Establishments rendering amusement and recreation services including motion picture theatres.

(11) Elementary and secondary schools, colleges, universities, professional schools, junior colleges, vocational schools, and public and private libraries.

d. There shall be no open burning by any person of tree waste, vegetation, refuse, or debris in any form.

e. The use of incinerators for the disposal of any form of solid or liquid waste shall be prohibited.

f. The use of motor vehicles is prohibited except in emergencies with the approval of local or state police."

4.5 USE OF MODELING IN EMERGENCY ACTION PLANS

In general, a model is a representation of something; specifically, a mathematical model is the expression of the functional relationships among the components of the thing being represented. Today, mathematical modeling is finding wider application than ever before, primarily because computers permit the rapid solution of complex problems. The equations that make up the model may describe theoretical or empirical relationships. Usually, it is necessary to measure some parameters when fitting the model to a specific situation so that the calculated results represent the actual conditions as accurately as required.

In air quality work, the end product desired from a model generally is the simulation of ambient air sampling for different periods of time under different meteorological conditions at the given locations. Emission reduction costs and the effects on receptors are problems requiring other models, so that a set of related models is necessary to cover the fields of interest. Models for studying the dispersion of air pollutants have been under development since the 1930's and are now being studied intensively.[3-6] Health and economic effects models for air-pollution work are in the formative stages of development.

4.5.1 Urban Dispersion Models

The transport and dilution of air pollutants can be described by a model that properly treats the mean and turbulent (or random) structure of the wind. The values assigned to the mean and turbulent motions are generally derived from three meteorological factors: wind speed and direction, atmospheric stability, and mixing heights. These factors are in turn influenced by large-scale atmospheric circulation, local and regional topography, land-water relationships, man-made structures, season, time of day, etc. Some of these items may at times be treated along with the three meteorological factors noted above.

Wind speed and direction are often ambiguous during an air pollution episode; that is, wind speed approaches zero and direction is highly variable. As a consequence, existing urban diffusion models that require discrete values for the wind can not specify air quality during episode or near-episode conditions. This is a severe problem and one that is receiving a great deal of urgent attention.

4.5.2 Other Models

In the analysis of episodic air pollution, some modeling approaches that appear useful include the use of (1) statistical models that correlate meteorology and pollutant concentrations, (2) economic models, and (3) dosage and health-effect models.

4.5.2.1 Statistical Models

As previously indicated, the techniques listed above are either in the initial application or developmental phases. A discussion, however, of their basic operating principles, assumptions, input requirements, and possible utilization in episode control is in order.

Since the meteorological processes in the atmosphere are somewhat random, statistical or stochastic models can be developed that correlate meteorological variables with pollutant concentrations. This involves performing regression analysis on a large collection of data. The resulting regression equation can be used as a prediction equation when current or forecast meteorological variables are used. Work along these lines has been done by the Los Angeles County Air Pollution Control District.[7] The statistical approach requires a large amount of data to ensure the significance of the results. Because episodes are not frequent events, the statistical approach is limited to localities that have a large fund of synchronous air quality and meteorological data.

4.5.2.2 Economic Models

The objective of economic modeling is to simulate the impact on society of the implementation of an Emergency Action Plan. It is important to note that the number of cost elements described is not an argument for impeding the adoption of emergency action plans, since human health is at stake.

Although no models have been completely tested and exercised for this purpose, several approaches are under development.

The purpose of such techniques is to provide estimates of the comparative or relative costs of competing control actions, and not to forecast precise costs suitable for budget administration. Several ground rules are used to develop an economic model:

1. Major alternative control actions must be defined.
2. Direct and indirect resource requirements for these actions must be identified and expressed in terms of cost.
3. Investment costs must be identified and distinguished from operating costs.
4. Costs must be expressed as incremental costs so that only the relevant costs identifiable with a particular action are included.
5. Time when each cost is incurred must be indicated.

4.5.2.3 Dosage and Health-Effects Models

There are two principal factors in the determination of the effects of air pollution on the population: concentration of contaminant (amount per volume of air) and time of exposure. Dose is defined as the product of the concentration and the period over which it exists. In Figure 4-5, the dose is portrayed as the area under the time-concentration curve.

The model necessary for computing the dose consists only of the integration of concentration with respect to time. The dose of each constituent may be computed to determine its effects on the exposed population. The total effects, however, are usually dependent on interactions of several pollutants.

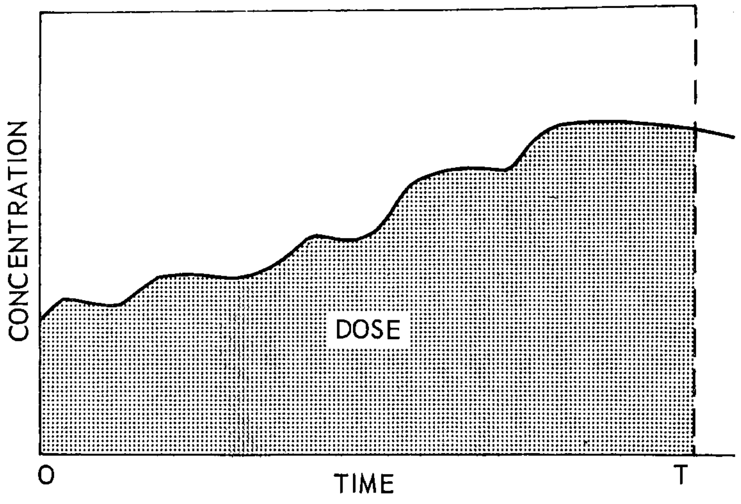


Figure 4-5. Pollutant buildup with time.

Integration of the pollutant buildup with time at all the particular geographical positions of interest will generate the dose isopleths pictured in Figures 4-6 and 4-7. By superimposing these isopleths on the geographical distribution of the population, the number of people subjected to the various doses can be determined.

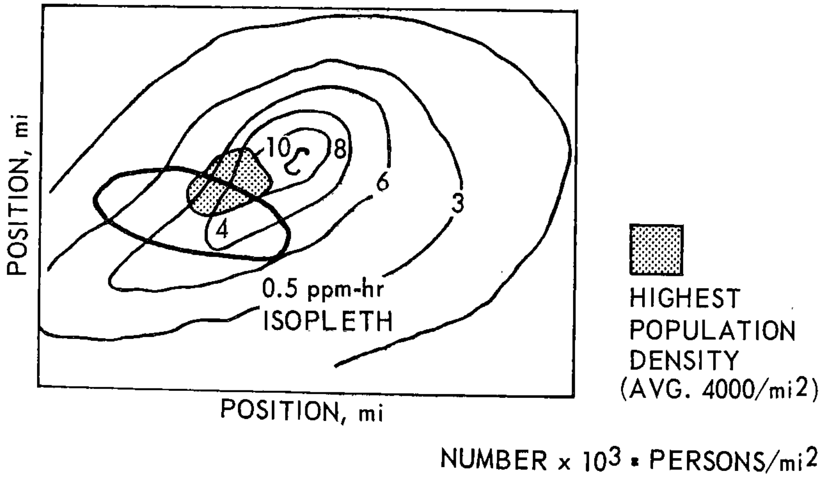


Figure 4-6. Geographic distribution of normal individuals.

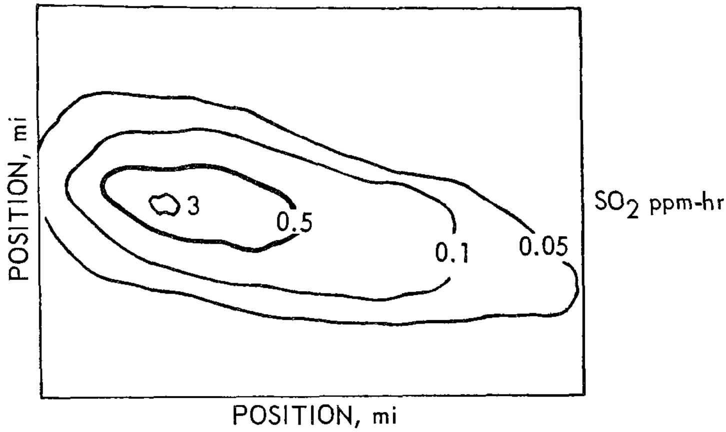


Figure 4-7. Dose isopleth during an episode.

4.6 REFERENCES

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5. LEGAL, SOCIAL, FINANCIAL, AND COMMUNICATIONS FACTORS

5.1 LEGAL AND ADMINISTRATIVE CONSIDERATIONS

The authority to act and the ability to act are absolutely essential to the implementation of an Emergency Action Plan. This chapter is a general discussion of these two requirements.

The legal and administrative problems associated with episode conditions must be resolved by the agency prior to any possible alert. Although the agency itself can and should resolve all administrative problems, it is imperative that legal counsel be obtained to ensure that the agency has authority to act in accordance with its Emergency Action Plan. It is the responsibility of the supporting legal counsel, that is, the city solicitor or staff attorney, to make this determination. It is, however, the responsibility of the control authority to seek this counsel at the outset. The agency's attorney should be involved in the formulative stages of the EAP, rather than merely being contacted to "make it legal" after the plan has been drafted.

5.1.1 Legal Requirements

Specific legal authority must first exist for the implementation of an EAP. The legislature or governing body must not be prohibited by the State Constitution from conferring this authority on the air pollution control agency. Figure 5-1 indicates the legal requirements for rendering the agency's EAP viable.

All legislation must be consonant with State and Federal constitutional safeguards. These safeguards require that air pollution control laws be the proper exercise of the government's police power and that the right to due process obtain. As is seen in Figure 5-1, the origin of the agency's authority lies indirectly in a State's Constitution.

It is therefore most important that the EAP be based on the protection of public health and welfare to satisfy the police power requirement. Should arbitrary values be chosen for alert levels, for example, the law or regulation

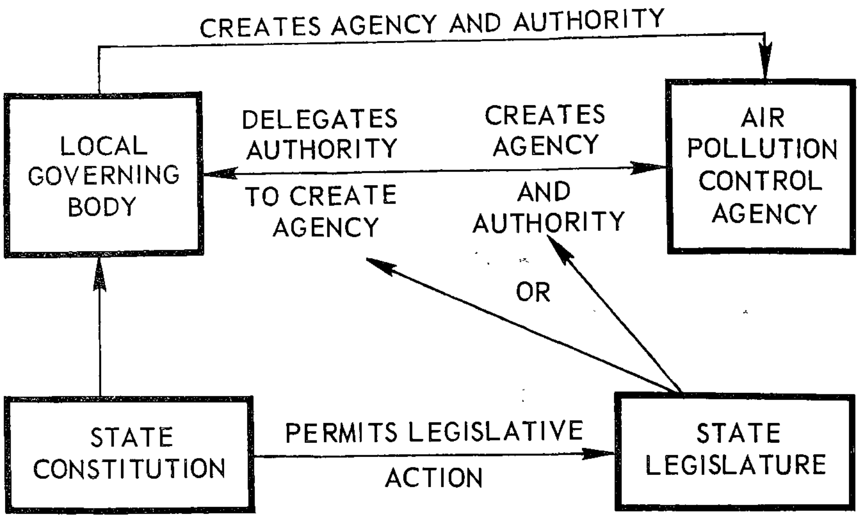

Figure 5-1. Legal relationships.

may be deemed invalid since it bears no relation to the public health, safety, or welfare. The legislative draftsman, therefore, must ascertain that the supporting data are legally adequate. Compelling reasons must exist for requiring either individuals or corporations to expend abnormal amounts of money on episode avoidance plans, equipment, and material.

The legal requirement that the EAP must meet is that of due process. In general, this safeguard requires that the emergency measures be reasonable, clear, and appropriate.

When an episode occurs, pollutant-emitting sources must be apprised of their responsibilities under the EAP in clear and certain terms. The regulation must be written in such a way that it can be clearly understood by the person or entity affected. Not all industries will be amenable to the same abatement actions. The impact that an emitter has on the episode is dependent upon location, size, and type of process. For example, a power company cannot be properly placed in the same classification as the municipal incinerator, but industrial incinerators and municipal incinerators fall within the same class. Once a proper classification has been established, all emitters within a class must be treated equally. If one member of a class may continue operations, all must be permitted to continue.

The EAP cannot be implemented without authority for the plan's creation. The local authorities must be given the power to regulate either by virtue of the State Constitution or through State legislative action.

In most cases, State legislative action will be the approach taken because the

State has the primary responsibility of protecting its citizens' health and providing for their safety.

Two approaches may be taken. The first is in the form of a "Disaster Act" by which the Legislature grants power to the Governor to declare that an emergency exists within a specified area and to issue orders as required pursuant to the abatement of the emergency. The language of the law must provide for reasonable, forcible entry by enforcement personnel to determine compliance with the Governor's orders and, where compliance is found not to exist, any necessary action required to produce compliance. Air pollution control agency personnel will thereby have the authority to shut down a process or operation. It is also recommended that violation of the Disaster Act be made a high misdemeanor to discourage noncompliance.

To illustrate the mechanics of a Disaster Act, a brief outline of the "Air Pollution Emergency Control Act" of the State of New Jersey follows. This act provides that the State Commissioner of Health, upon determining that air pollution constitutes an unreasonable and urgent risk to health, communicate such determination to the Governor. The Governor, upon receipt of such communication, may declare that an emergency exists and assume powers to:

1. Prohibit, restrict, or condition motor vehicle travel of every kind, including trucks and buses in the area.
2. Prohibit, restrict, or condition the operation of retail, commercial, manufacturing, industrial, or similar activity in the area.
3. Prohibit, restrict, or condition the operation of incinerators in the area.
4. Prohibit, restrict, or condition the burning or other consumption of any type of fuel in the area.
5. Prohibit, restrict, or condition the burning of any materials whatsoever in the area.
6. Prohibit, restrict, or condition any and all other activity in the area that aggravates or potentially aggravates the air pollution emergency.

The United States Departments of Health, Defense, and the State and local police plus Air Pollution Control enforcement personnel are designated to enforce the Governor's orders using such reasonable force as required. Specifically they may:

1. Enter any property or establishment whatsoever–commercial, industrial, or residential–believed to be violating said order and, if a request does not produce compliance, cause compliance with said order.
2. Stop, detour, reroute, and prohibit motor vehicle travel and traffic.
3. Disconnect incinerator or other types of combustion facilities.
4. Terminate all burning activities.

5. Close down or restrict the use of business, commercial, retail, manufacturing, industrial, or other establishments.

The second approach is to obtain injunctive relief through the courts. Because of the emergency nature of an episode, it is imperative that a preliminary mandatory injunction be obtained without delay. Such a proceeding is heard before a judge without a jury. Since it is an equitable action, the burden-of-proof requires a mere preponderance of evidence as opposed to the "beyond-a-reasonable-doubt" burden imposed in criminal proceedings.

Various levels of action are specified by an EAP. For the most part, implementation of the EAP will depend directly upon local legislation and indirectly upon State legislation, unless the local control agency derives its authority directly from the State legislature.

The agency should establish legal authority requiring that persons responsible for the operation of a source of air contaminants prepare process emission data and emergency standby plans. The plans must be consistent with good industrial practice for reducing emissions in the event that emergency conditions prevail or are predicted. The standby plans should be designed to reduce or eliminate emissions in accordance with specific objectives defined in legislation. The legal authority may include the authorization to enforce the specific control conditions identified. The control agency should have the right to approve or disapprove the proposed plans.

These plans, in addition to providing control measures, provide evidence for preliminary mandatory injunctions.

When episode conditions extend beyond regional boundaries within a State or result from emissions in one region impinging on another within the State, cooperation between regions is required. Since this cooperation may not always be voluntarily obtained, it is necessary that State legislation specify that emergency abatement action be taken by the offending region. The State "Disaster Act" could be the vehicle for this provision. As a practical matter, however, the State legislation should also provide for the submission of an EAP by each region so that appropriate, cooperative action may be taken when necessary. In this regard, interregional data acquisition is an important consideration. Even in the absence of specific State legislation, it is still important that the control agency seek data from its contiguous regions in order to support possible injunctive relief.

Many air quality control regions encompass interstate areas, thus causing a jurisdictional problem. A comprehensive episode-avoidance program should be developed for application on a regional basis. Such a program can be operated by mutual agreement between States, with enforcement authority continuing to reside in the individual jurisdictions.

In the absence of a regional authority, parallel legislation may be passed in the adjoining States. This legislation should provide that action be taken in concert to abate emergency situations.

As with intrastate episode-avoidance planning, the interstate program may have to depend on voluntary cooperation, especially in the acquisition of emergency control, in the absence of cooperative State legislation.

5.1.2 Recommended Format for Regional Emergency Control Regulations

Whether the emergency legislation takes the "Disaster Act" approach or the "injunctive" approach, it is recommended that the following items be included in the enacted legislation:

1. Purpose.
2. General–When regulations apply.
3. Sampling Stations–Minimum number and general type.
4. Air Sampling–Specify who will establish the procedures.
5. Reports–Nature and frequency.
6. Plans–Requirement that notified industries must submit emission data and emergency standby plans.
7. Declaration of Alerts–Who will make declarations; on what basis declaration will be made; who and what entities will be notified; polluters to maintain system for rapid communication.
8. Definition of Alert Stages.
9. Action to be Taken–Specifies who does what for each alert level; authority of APC officer to take abatement actions.
10. End of Alert–Specifies procedure for termination.
11. Enforcement–Who has enforcement powers.
12. Scientific Committee–Prescribes make-up and duties of this entity; committee is of a continuing advisory type.
13. Emergency Action Committee–Prescribes make-up and duties of this entity; committee mainly advises the APC officer during episodes.

The EAP cannot be implemented without authority for the plan's creation. The local authorities must be given the power to regulate either by virtue of the State Constitution or through State legislative action.

5.2 SOCIAL IMPLICATIONS OF EPISODES

In the broadest sense, social considerations encompass all those factors that relate to human society, the welfare of human beings as members of society, the interaction of the individual and the group, and the cooperative and interdependent relationships among members of the group. Of these, health and legal considerations are treated in other sections of this *Guide.* Several other factors, however, must be considered when plans are made for actions to be taken during an episode.

1. Any action taken will have social effects.
2. Generally, these effects will increase with the duration of the episode.
3. Initially, the effects will usually be in the nature of inconveniences.
4. The effects are primarily those related to restrictions on freedom of movement and normal activity, and the anxieties associated with a pervasive hazard from which there is no escape.
5. Finally, with some exceptions, these effects disappear at the termination of the episode.

The principal means by which the air pollution control authority can minimize adverse social effects is education of the public. The planner must provide for effective public information programs before, during, and after an episode. The public must be prepared to endure the inconveniences of personal restriction and to assess calmly the nature of the hazard.

The first social effects felt by the public will be relatively minor inconveniences resulting from voluntary compliance with appeals to reduce travel, postpone social functions, and reduce the use of energy-consuming devices (lighting, heating, and cooling). Even though these inconveniences will be widespread, they are generally not serious enough to become a major deterrent to implementation of the emergency plan. These inconveniences become more serious as the episode continues. Before mandatory travel restrictions are applied, sufficient warning should be given to allow people to get home, obtain essential food supplies, or perform other necessary activities that involve the use of an automobile. This phase requires considerable care in both planning and execution. Panic must be avoided because the pollution situation can be made worse through a sharp increase in traffic at this time. The long-range deleterious effects, however, of enforced immobilization and virtual isolation can be reduced through adequate preparation.

During the period of the emergency itself, the primary social effect is in the form of a direct threat to public health. Some other effects that the planner must recognize are the increasing anxiety of the public, disturbances of domestic tranquility, requirements for emergency services (medicines and food), and increased loading of the telephone system.

When the episode is over, most of these social effects, aside from certain health and economic factors, will ease and disappear. The planner should provide, however, for response to a continued public and private clamor for adequate avoidance procedures, not only by being prepared to face recriminations but, more importantly, by planning to take advantage of constructive criticism and sharpened public awareness of episode situations.

Surveys have been conducted in several cities to determine public attitudes toward air pollution. Generally, these surveys have been oriented toward the routine situation rather than toward episodes. Based on a survey of Johnstown, Pennsylvania, Crowe[1] concluded that the social characteristics having the greatest influence on a person's awareness and appreciation of the air pollution problem are level of education, social position, and location of present residence. In reviewing six studies in an attempt to find trends in attitude formation, DeGroot[2] found that the main determinant is the actual pollution level at the location of residence. He concluded that public education should emphasize what can be done and by whom, since further public dissemination of information on the existence of air pollution only raises the levels of anxiety and feelings of social impotence. Medalia[3] studied an essentially one-industry community (Clarkston, Washington) in which awareness of the pollution problem was closely related to length of residence and occupation of the household head.

Under severe episode conditions, these findings may not obtain, in that everyone will be aware of the situation. The extent to which people will define the condition as an individual or social (community) problem, on the other hand, may well parallel the findings of the surveys. The air pollution control planner should conduct a survey of the area of concern in order to determine beforehand the public attitude in his specific area. Based on these findings, the planner should educate the public not only for routine situations but also in such a way as to minimize public and individual anxieties during an episode. Finally, the intensified post-episode awareness should be used as a basis for introducing appropriate improvements in the community's control program.

5.3 COSTS RELATED TO EPISODE CONTROL ACTIONS

The benefits of improved air quality are as difficult to assess as the costs of air pollution control. As with any health-related problem, the costs of air pollution involve human factors that are difficult to express as equivalent dollars. The benefits of episode control include the avoidance of acute illness and death. The duration of much of the economic impact is a few days; when human lives are involved, costs of control are relatively slight in comparison to the possible benefits. Although several items of cost are discussed here, it is not suggested that they constitute substantive reasons for impeding the development of emergency action plans.

During the source inventory, information can be gathered that will assist the air pollution control agency in evaluating part of the economic impact of emergency action options. It is to industry's advantage to release accurate economic and emission data, so that actions will be realistic and effective. The necessary information may be supplied voluntarily, or regulations may be required. The control agency must scrupulously observe industrial proprietary rights to economic and technical information.

The costs incurred by industry during an episode will be a combination of the fixed or regularly recurring costs associated with being prepared for an episode, and costs approximately proportional to the duration of emergency abatement action during an episode. Both of these classes of costs will vary widely in magnitude and nature from place to place, among types of industries, and among various plants within each industry.

In evaluating economic impact, the costs to industry, direct costs to the individual, and costs to the community must be considered. Cost categories include the following:

5.3.1 Costs Related to Maintenance of Emergency Action Plans

In this category are included the costs to industry incurred in the compilation of data and in the formulation and updating of Emergency Action Plans. For most industries, these costs will be nominal.

5.3.2 Costs Related to Special Emergency Equipment

This category includes costs of plant equipment or other capital property required for emergency emission curtailment. Costs are involved in actions such as fuel substitution and plant modifications, as well as in the provision of fuel storage space and handling equipment. This class of costs will be significant in industries such as power generation that cannot simply shut down.

5.3.3 Direct Costs of Implementing Emergency Control Actions

Costs of temporarily modifying the normal activity of the plant include such items as investment in stockpiled low-sulfur fuel; special labor to curtail, shutdown, or otherwise modify the activity; costs of uneconomic production runs; and products or processes damaged by shutting down. This class of costs may be significant in large industries having continuous high-temperature processes.

5.3.4 Costs Related to Raw Material

The industry may have to plan for holding or diverting incoming raw materials during a period of curtailment or shutdown. Transportation during a severe episode will be severely curtailed, so that some industries may be faced with storage problems.

5.3.5 Product Losses

These costs, resulting largely from losses in production during curtailment, are proportional to the duration of the episode, and include, for example, extra costs for low-sulfur fuel.

5.3.6 Sales Losses

Some sales losses, such as those by transportation systems and amusement industries, are absolute and cannot be made up by later deliveries. Many sales of products will be delayed rather than lost, but there may also be some profits lost as a result of the inability to fill outstanding orders.

5.3.7 Defaulted Contracts

Closely related to lost sales are the costs in penalties, legal fees, and future business related to defaulted contracts. This may not be a significant item because of the short time span involved.

5.3.8 Costs Related to Employees

The salaries of some employees will continue through a shutdown; wage losses will be incurred by others during an episode shutdown.

5.3.9 Start-Up Costs

This class includes costs related to the recall of employees as well as the direct costs of starting up the plant. These costs are similar to shutdown costs in that they are one-time and may include such items as uneconomic production runs, periods of equipment inefficiency, and abnormal material consumption.

5.3.10 Costs Related to Management

Costs related to management consist of time taken away from production activities before, during, or after the actual episode. Other factors such as insurance, accounting, and legal costs may also be included. Dealing with episodes, however, is but a small addition to management duties related to the conduct of business.

5.3.11 Costs to Control Agency

The costs of an episode *per se* to the control agency are primarily those related to additional testing and surveillance and to 24-hour manning of the emergency control system. Most of the control system will be used for routine activities as well as during an episode.

5.3.12 Miscellaneous Costs

Additional costs that may be faced by a community include those associated with: extra policing; extension of the school year; overtime for post-episode refuse disposal; losses in park vegetation, zoological specimens, and similar items; the additional load on health agencies during and after episodes; and emergency deliveries of necessities. This class of costs is sensitive to the severity, duration, and frequency of episodes, and may be relatively insignificant.

5.4 COMMUNICATION WITH PUBLIC

A well-planned information dissemination program serviced by an efficient communication system is essential to successful episode avoidance. To be effective, the information program must be developed and the communication system provided beforehand. The information channels involved in an air pollution alert will vary for each community. They will be the same channels, however, that are used in day-to-day communication between the control agency and the public. A summary listing follows of the steps for disseminating information on air pollution alerts within and outside the control agency.

5.4.1 Information Programming Prior to an Alert

The air pollution control agency is responsible for generating all information and instructions on what is expected and required of the public during an air pollution alert. To be most effective, information, especially that related to alert levels, should be developed and circulated prior to the occurrence of an episode.

A program for the dissemination of air pollution alert information should include:

1. Advance preparation of information covering:

    a. Data that will cause the alert warning system to be activated.
    b. Explanation of the various stages or levels of the alert.
    c. Which actions are voluntary, which are required by law, and at what stages of the alert they will be required.
    d. What the individual can do to protect his family, his health, and his property during each stage of an episode.

2. Advance development of a program for dissemination of alert warnings.

3. Establishment of priorities for the release of information during an alert.

Some of the primary tools for information dissemination available to an air pollution control agency are given below.

1. *Press Releases*

    The press release should be the primary means of communicating with the news media. All information released to the news media should be in the form of press releases, so that a record of what has been said at what time and by whom is always available. Sample press releases should be worked out ahead of time and cleared through administrative channels. A typical press release[4] is shown in Figure 5-2.

2. *Press Conferences*

    Although the press conference provides an opportunity for officials to appear before representatives of the news media, its use should be limited to specific times and situations. If all the information can be contained in a press release, do not call a press conference. Visual information should be provided at press conferences, such as samples of monitoring equipment, charts and graphs showing levels of pollution and weather conditions, and photographs showing air pollution conditions and the results of compliance with control provisions.

    Instances in which a press conference can be useful in an episode information dissemination program include:

    a. Announcement of initial and subsequent stages of the alert. A press conference is warranted at this time, since the information to be given to news media is for the widest possible distribution and may be involved and detailed. It is suggested that representatives of government and industry be present at the press conference.

    b. Announcement of termination of the alert. Since not all the episode effects information will have been developed at the time of the alert termination press conference, an announcement should be made

NEWS RELEASE (Date) ________________ Agency
Department of Air Pollution Control
(Address)
(City)

FOR IMMEDIATE RELEASE CONTACT: (Staff Member Phone No.)

At 12:30 p.m. today (date), the local Weather Service notified the City's Department of Air Pollution Control that weather conditions consisting of a high pressure area and low wind speeds were developing in the metropolitan ___(city)___ area. These are the same weather conditions that are being formed over the Eastern seaboard from Maine to the Carolinas. These weather conditions are expected to continue until late tomorrow (date) and may result in an increase in the levels of some air pollutants.

"There has been some increase in the levels of sulfur dioxide, but the proportions of other contaminants have not reached a point at which calling of an 'air pollution alert' is necessary or required," stated Mr. __________, (title).

Mr. ____________ also announced that the Air Pollution Control Department's laboratory had been placed on a 24-hour operational basis. Normally, the staff works a 40-hour week while the instruments measuring air quality record their results continually without attention around the clock. "However", the ___(title)___ said, "in order to be fully cognizant of the problems as they arise, we shall maintain a close watch on the conditions and report to the public if there is need for any specific activity." Mr. ________, air pollution specialist for the ___(city)___ Weather Service, stated that because cool air at the surface was trapped by a lid of warm air aloft, it would remain stagnant over the ___(city)___ area. It is expected that the Department of Air Pollution Control will issue another statement within 24 hours.

Figure 5-2. Sample press release.

indicating a time at which complete information on the effects of the episode will be available.

c. Announcement of the medical, physiological, sociological, and economic effects of an alert. This press conference may be held at a convenient time following the alert. If this conference was announced at the alert termination press conference, every effort should be made to hold it as soon as information is available.

3. *Telephone Calls*

The commercial telephone system will be a primary means for disseminating information to governmental agencies, large emission sources, and other individual recipients. Where volume indicates, direct lines may be arranged for use during emergency periods.

4. *Television and Radio Interviews*

Every effort should be made to comply with requests for specific radio and television interviews. Although radio and television interviewers will be interested specifically in the conditions of the alert, every effort should be made by the air pollution control agency representative to include information concerning the agency's day-to-day operation and concern for the public welfare.

5. *Letters of Inquiry*

Every air pollution control agency receives letters of inquiry from the public. These letters are one of the best barometers an air pollution control agency can have for determining the public attitude toward air pollution control, and, as well, afford an opportunity for dissemination of information to interested citizens.

6. *Medical Societies and Hospital Associations*

Medical societies can be of outstanding service by creating and disseminating information to physicians concerned with respiratory and cardiac patients. Aiding in the development of health studies related to episodes can be a specific function of these organizations.

7. *Speaking Dates*

A presentation should be prepared for use by control agency speakers who are asked to speak at civic meetings.

8. *Schools*

The Board of Education can help by distributing literature through students to their homes.

9. *Mailings*

Although the postage costs will represent a major item, mail distribution can be used effectively just before an "episode season," if desired.

5.4.2 Information Dissemination During an Alert

Upon notification of a potential episode, the air pollution control agency should have the episode information plan ready for activation. The following guidelines for an information program to be used during an air pollution alert may be adapted to fit the needs and capabilities of the local agency. The elements of such a plan are unique, although the plan uses the same channels of communication and the same tools of information dissemination that are used in day-to-day information programming.

When the local air pollution control agency receives a HAPPA bulletin from the weather bureau, either by phone or on the NOAA local weather loop, those in the air pollution control agency responsible for implementing emergency action are notified. After a decision is made that alert conditions exist, the lines of communication are as follows:

1. The news media are informed that an air pollution alert has been called and that within the next forecast period (usually 6 hours) additional information will be released. Immediate contact is necessary, since the news media are on the local weather circuit and will already have received the advisory. Since many of the major sources of air pollution are also on the NOAA weather loop, they will receive this information at the same time the news media receive it.

2. The next series of notifications is made to those activities that may be affected by the initial alert and to those that must muster support forces or make mechanical or operational changes in their industrial processes to meet the requirements of the various stages of the alert. This notification will probably be by telephone.

3. The news media should be the primary means of communication with the general public as subsequent stages of the alert are reached. The announcement of what each of the various affected segments of the general public will be required to do can best be communicated through the news media. In addition to announcing the various alert stages, the news media will also announce what emergency actions are to be taken.

5.4.3 Information Dissemination Following an Alert

Dissemination of information following an alert can serve to clarify misunderstandings that arose during the alert. In addition, information can be

WHEN AIR POLLUTION IS HEAVY

Here's what you can do to help yourself and your neighbor

. Use public transportation wherever possible. Use your automobile only if absolutely necessary. If you must drive, try to team up with neighbors or co-workers.

AIR POLLUTION FROM AUTOMOBILES
IS A MAJOR PROBLEM

. Reduce room temperatures to the legal minimum, unless health considerations prevent such action.

AIR POLLUTION FROM HEATING EQUIPMENT
IS A MAJOR PROBLEM

. Stop all outdoor burning.

AIR POLLUTION FROM OPEN OR REFUSE BURNING
IS A MAJOR PROBLEM

. Use as little electricity as possible, either for lighting or appliances.

AIR POLLUTION FROM POWER PLANTS
IS A MAJOR PROBLEM

. Observe the restrictions recommended by your health department or air pollution control agency.

IF YOU SUFFER FROM A RESPIRATORY AILMENT OR HEART CONDITION--

Remain indoors with the windows closed.

Don't smoke. Avoid rooms where others are smoking.

Eliminate unnecessary physical exertion.

Stay under your physician's care.

AIR POLLUTION CONTRIBUTES TO RESPIRATORY DISEASE

Figure 5-3. Flyer published by the National Tuberculosis and Respiratory Disease Association.

disseminated that will result in a better overall air pollution control program and a more effective episode-avoidance system. Analysis and evaluation of information collected during the episode may require considerable time. The channels of communication for post-alert information are the same as those available to the control agency for information developed prior to and during the alert. An important item of information that the control agency should disseminate in the post-alert period is a statement of public recognition of the cooperation received from other government agencies and from those segments of industry and the public that have been directly affected.

5.4.4 Public Education

Public education on air pollution should be a continuing program. During air pollution episodes, short, to-the-point messages should be prepared for public distribution. The messages may be disseminated by television and newspapers, or by posters and flyers. A flyer published by the National Tuberculosis and Respiratory Disease Association (Figure 5-3) is a good example of such a message.

5.5 REFERENCES

1. Crowe, M. J. Toward A "Definition Model" of Public Perceptions of Air Pollution. J. Air Pollution Cont. Assoc. **18**(3):154-157, 1965.
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3. Medalia, N. Z. Community Perception of Air Quality: An Opinion Survey in Clarkston, Washington. U.S. DHEW, Public Health Service. Washington, D.C. Publication Number 999-AP-10. 1965.
4. Glenn, T. A., Jr. Regional Air Pollution Warning System. J. Air Pollution Cont. Assoc. **16**(1):22-24, January 1966.

6. EMERGENCY ACTION CENTERS

This chapter outlines the basic concepts of an Emergency Action Center (EAC) that will serve as the operational control and communications point during an episode. Specifically, the EAC will perform the technical functions required of the local air pollution control agency to avoid or minimize an episode. Additionally, it will serve as the local terminal of communications with the APCO Emergency Operations Control Center (EOCC), which performs analogous functions at the Federal level.

6.1 GENERAL OBJECTIVES

The objective of the EAC is to serve as the facility for reception and processing of data relating to air pollution episodes and for determination and initiation of avoidance actions. The EAC will serve as the interface between the policy levels of authority and the event or problem. It will accept information, process raw information into intelligence data, and implement corrective action based on policy and the processed technical information. Figure 6-1 illustrates this role. The block labeled "Authority" represents the

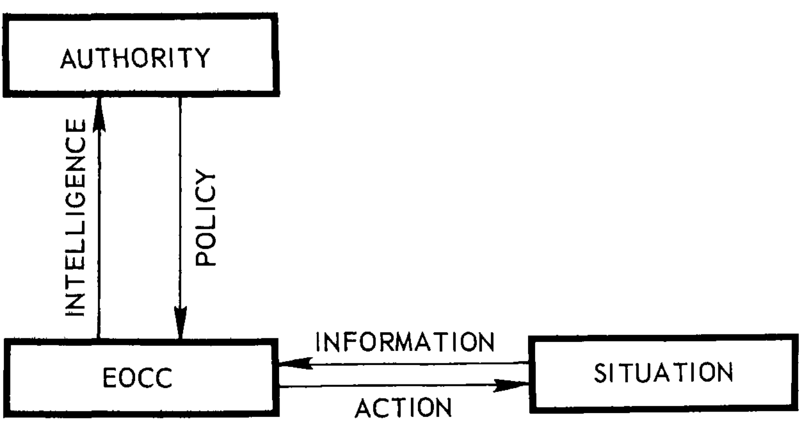

Figure 6-1. Role of Emergency Operations Control Center.

mayor, the commissioner of public health, or the director of the air pollution control agency, depending upon the action under consideration and the degree to which policy has been delegated for such actions.

The courses of action open are those discussed in Chapter 9. The underlying philosophy is that corrective action should be taken by the lowest technically and politically competent local authority, with higher levels getting involved only to the extent necessary.

The EAC will issue curtailment action directives to appropriate emission sources, as specified in the Emergency Action Plan (EAP). The EAC will inform APCO's EOCĈ of the air quality and meteorological conditions and of the abatement actions being taken. Finally, the EAC will prepare post-episode analyses to expand the data base for future episode avoidance actions.

6.2 ORGANIZATION

One concept of the organization and operation of an EAC is shown in Figure 6-2. Action could be triggered by one or more of the following: a High Air Pollution Potential Advisory bulletin (HAPPA), which forecasts widespread stagnant conditions for an appreciable period of time (predetermined); a report of air quality poorer than criteria (predetermined); or a request for assistance from municipal, State, or regional authorities.

While the flow chart is the basic framework around which this EAC conceptual design is built, it must be recognized that the events, procedures, and decision points each represent sub-routines. For example, the box labeled "Activate EAC" represents that portion of the EAC Standard Operating Procedures (SOP) that tells the duty officer: (1) whom to call in, (2) what circuits to call up, (3) whom to advise that the EAC is operational, (4) what additional data to obtain, and (5) other specific actions. Standard Operation Procedures are outlined in a later section.

6.3 LOCATION

The EAC should be located on the basis of trade-offs among characteristics weighted according to their importance. Among such characteristics, the most important are:

1. Availability of technically competent personnel.

2. Compatibility with local organizational structure; that is, functional command lines.

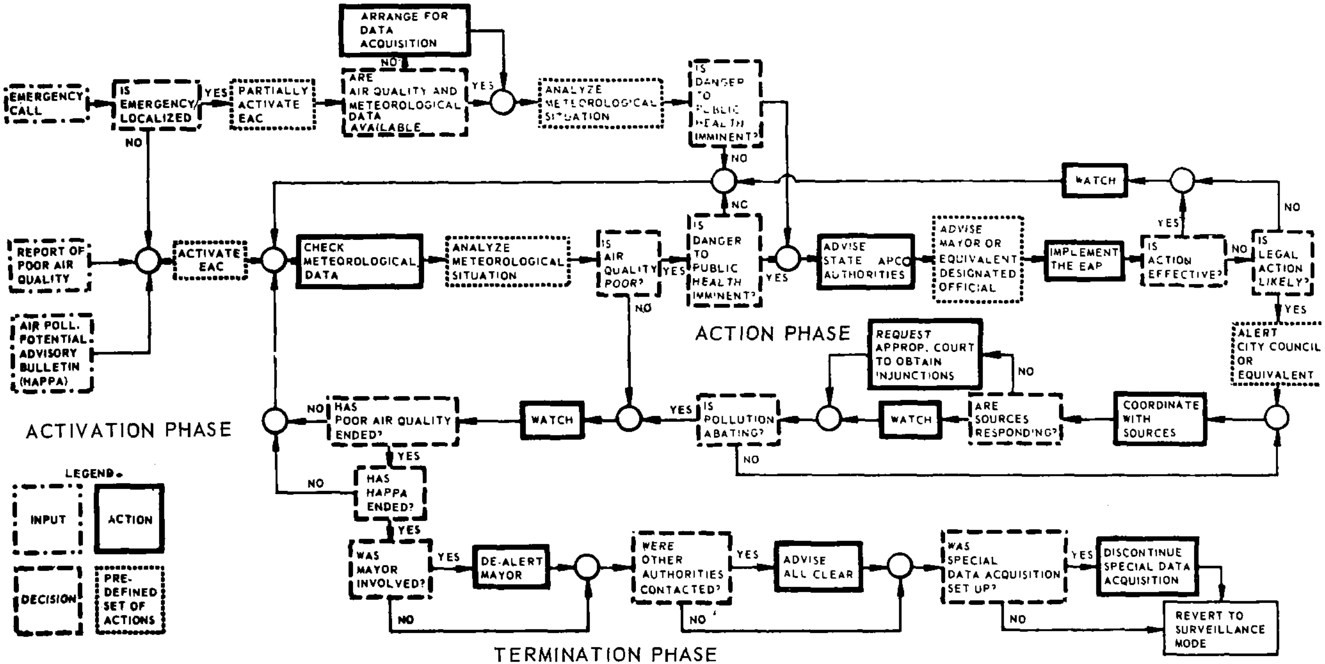

Figure 6-2. System flow chart for Emergency Action Center.

3. Desirability of location as base for future expansion into more sophisticated control center.
4. Availability of communication links to the rest of the country.
5. Accessibility; that is, proximity to transportation.
6. Proximity to higher authority.
7. Availability of physical space.
8. Accessibility to news media.
9. Proximity of supporting services, such as meteorological services.

The availability of technically competent staff deserves heavy weighting, since it is uneconomical to man the EAC on a continuing full time basis. Since episodes are sporadic, personnel will be drawn primarily from other organizations. The staff should, however, be immediately available when an emergency arises. Likewise, compatibility with the normal organizational structure deserves heavy weighting, since a smooth and efficient transition into the emergency mode is essential. The location of the EAC should be such that its activation will create the least possible disruption of routine business.

Communications, transportation, and access to the responsible policy authority are important elements, but from the operational point of view they do not have the same priority as the necessary personnel. Of these factors, however, good communications will be the most important.

Another element to be taken into consideration is growth potential, since future expansions are more likely to come about by improvement of the initial EAC rather than through construction of a completely new facility.

Other elements, such as space available and proximity to the news media and to supporting services, are worthy of consideration but are more amenable to alternate arrangements, especially if the communications are good.

6.4 COMMUNICATION REQUIREMENTS

Selected air quality data should be obtained from existing monitoring networks. In order to keep the amount of data within the limits imposed by manual processing and yet obtain valid intelligence during an episode, two pieces of information every 2 hours from no more than 25 locations is about the optimum reporting rate.

During the episode season, at times when there is no HAPPA or other meteorological advisory bulletin in effect, reports can be made daily at a scheduled time; maximum and minimum readings for the day should be included. If an advisory is in effect, the reporting frequency should be increased to every 2 hours. The data could be telephoned in to the EAC , or a special teletype circuit could be established. The latter would require operators at the terminals but would provide hard copy. With either telephone or teletype, the network should be organized to minimize the number of messages into the EAC.

An EAC staffed with a meteorologist and serving a large and complex metropolitan region should be equipped with NOAA Teletype Services A and C, and a tie-in with the national weather facsimile system, which originates at the National Meteorological Center in Suitland, Maryland. Supplementary meteorological data might be available from non-transmitted sources such as air pollution monitoring systems, cooperative observers, and private or institutional facilities. These data sources should be inventoried and their telephone numbers listed, since individual telephone calls will be the only practical means of communication with these sources.

The minimum essential communication equipment required for an EAC of the type described above would be one facsimile receiver and two teletype receivers. Telephone service will be required on a continuing basis for daily reports. During episodes, four lines could be kept busy, one for incoming calls and one for each of the three professionals. The EAC should have, therefore, at least one (and preferably two) lines of its own and, in addition, should have access to three other lines. The additional lines could be those normally used by key individuals on the emergency roster for conducting routine duties between episodes.

6.5 MANNING REQUIREMENTS

Representative staffing requirements are summarized in Table 6-1. These requirements are based on the concept of varying the degree of activation of the EAC according to the situation.

Between episodes, at least one individual—preferably someone at the junior-engineer level of experience or higher—should have the primary duty of maintaining the EAC. His job would involve the receipt and posting of daily reports on air quality from selected locations, and a daily check of advisories and other meteorological data. If this principal responsibility does not require his full time, he can be given other duties outside the EAC. It must be clear that other duties are secondary to operation of the EAC. Arrangements should be made to obtain and post weekend and holiday as well as weekday reports.

During the episode season, a duty roster should be maintained of individuals, in addition to the person in charge of the EAC, who are authorized to decide when the EAC is to be partially or fully activated. At least one of these individuals must be available by phone at all times. Duty roster personnel

Table 6-1. MANNING REQUIREMENTS

Activation level	On-duty	On-call
Routine (non-episode)	One person (40 hr/wk)	Duty officer
Partial[a] (local emergency)	Supervisor Alternate(s)	Meteorologist(s) Abatement engineer(s) plus those below:
Full[a]	Supervisor Meteorologist(s) Abatement engineer(s) Clerk	Public relations specialists Medical Legal Specialized engineers Communications technician

[a]EAC operates continuously during emergency; manning is scheduled in shifts as required.

could include those individuals who are designated as full-time supervisors, meteorologists, and abatement engineers when the EAC is fully activated.

During a widespread episode, the EAC will require full-time participation on the part of all specialists necessary and available, especially meteorologists and engineers. At least one person should be in the EAC at all times and, depending upon the severity of the emergency, others may be required to be physically present (rather than on call). Consequently, the roster of available personnel must be sufficiently long to allow the supervisor to assemble his team. Ideally, the roster should include:

1. Supervisor and two alternates.
2. Meteorologists.
3. Abatement engineers knowledgeable in process emission control, power plant emission control, vehicular and mass transportation control, and natural gas and electric power distribution.
4. Medical doctor and alternate.
5. Lawyer and alternate.
6. Public relations specialist and alternate.

7. Clerks.
8. Communications technician and alternate.

6.6 FUNCTIONS OF PRINCIPAL PERSONNEL

1. Supervisor—In addition to being responsible for the operation of the EAC, the Supervisor integrates the meteorological forecast and air quality reports as analyzed by the meteorologist with the recommendations of the engineer(s) to determine the control options available. He also formulates the course(s) of action that either he will direct the EAC to take or will recommend to a higher authority as appropriate.

2. Meteorologist—The meteorologist analyzes meteorological factors that influence dispersion of air pollutants and makes short-range forecasts for those areas subject to an episode. He uses not only data from the National Weather Service (A, C, and Facsimile), but also air quality and other data reported from the locations under surveillance. His forecast and associated atmospheric status reports should be in a form directly usable by the supervisor and higher authorities in their decision-making processes.

3. Control Engineer—The control engineer makes a technical analysis of the resources available for emission control and the effectiveness of the measures being taken to effect the controls. Based on the results, he will recommend an appropriate curtailment strategy.

6.7 PHYSICAL LAYOUT

The essential consideration here is to have an identifiable location specifically associated with Emergency Actions. Even if not manned all the time, the EAC should retain its identity. It should not be merely a makeshift conversion of someone's office during an actual episode. The displays of trends and other data should be kept up-to-date between episodes, not only to maintain "ready" status but also to help keep the organization episode-minded. Although posting of data should be permitted by authorized personnel only, the posted data should be available to anyone who cares to drop in and observe.

The EAC room should be conveniently located in relation to supporting services, meteorological and communication services in particular. It should not be an integral part of the meteorological center *per se* but should be next door or down the hall if possible.

The data displays for the EAC may be manually maintained. Charts with movable markers can be used, with magnetic markers for the data points. In non-episode EAC operations, only the high and low for each day would be shown. During an episode, or after issuance of a HAPPA bulletin, readings would be posted every 2 hours.

A room as large as 20 by 30 feet could be required. Although the actual layout will depend on the size, shape, door and window locations, and other features of the room finally selected, a representative plan is shown in Figure 6-3.

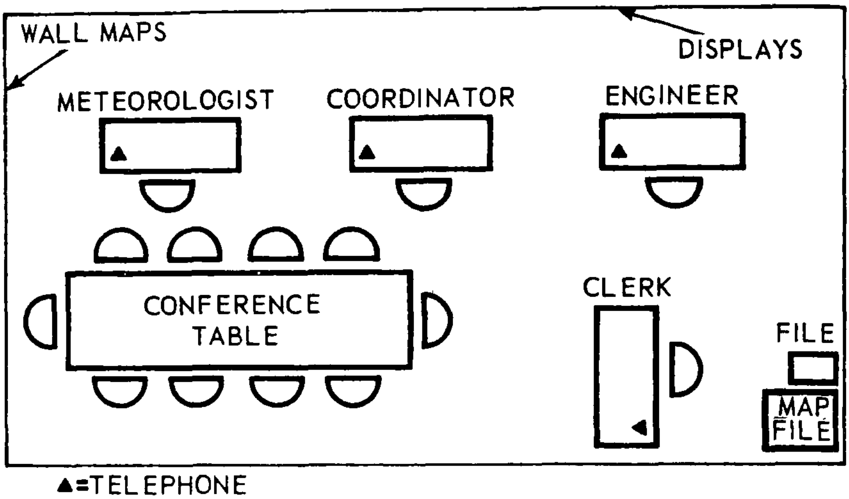

Figure 6-3. Typical Emergency Action Center layout.

The layout is designed to accommodate the recommended staff and equipment during full activation. At least one wall should be free from windows or other obstructions to permit the mounting of display panels. A 30-foot wall should accommodate up to twenty-seven 2- by 3-foot displays. The desks of the staff should face the displays and be far enough away, about 6 feet, to allow wide-angle observation. Additional space is allocated to meteorological service teletypes, files, and a clerk-typist. Teletypes should preferably be in a separate room to minimize noise in the EAC.

6.8 REPRESENTATIVE COSTS

The initial costs are estimated as follows:

2 Teletype installations at $50 each	$100
1 Facsimile at $150	150
2 Telephone lines at $10 each	20
10 Displays at $50 each	500
4 Desks at $100 each	400
1 File at $50	50
1 Map file at $150	150
1 Typewriter at $400	400
	$1770

Monthly costs, not including personnel salary or room rental, are estimated as follows:

2 Teletypes at $75 each	$150
30 Rolls of facsimile paper at $5 each	150
30 Rolls of teletype paper at $1.50 each	45
1 Telpack line at $15	15
2 Telephone lines at $10 each	20
	$380

The costs for weather services are as follows (redundancy is not required if these are already available).

Each teletype drop, receive only, $50 installation fee plus $75 per month.

Facsimile: follows GSA schedule; $150 for recorder includes delivery, lease, and maintenance; paper is between $4 and $7 per roll, which on continuous service lasts about 2 days.

Other costs would be comparable to those involved in operating a small business office and involve expenses for telephone lines, expendable office supplies, etc.

In addition to the minimum essential equipment, it would be desirable to have a Polaroid camera and film at the EAC, so that reference photographs may be taken of the display charts. The use of closed-circuit television to permit remote viewing of displays is considered to be an unwarranted refinement for the EAC. Between episodes the time lapse in viewing displays is not crucial; during episodes the situation is sufficiently important to require that officials who need current information be physically present at the EAC site.

6.9 STANDARD OPERATING PROCEDURES (SOP)

An SOP will have to be developed during the implementation phase of the EAC. It should be detailed to the level necessary for the EAC to function. As experience is gained, the SOP should be modified and expanded to provide a basis for feasible systematic operations under emergency, and perhaps hectic, conditions. The SOP should contain information of the types listed below. For convenience, items are arranged here in the form of an annotated table of contents for a representative SOP:

Representative Table of Contents	*Remarks*
1.0 Administration	
1.1 Authorization	This section can either be a reference to and abstract of, or an actual copy of, the memorandum, letter, or other document that authorized establishment of the EAC. It should specify the general functions of the EAC and assign the responsibilities for its operation.
1.2 Purpose of the EAC	Essentially the same information as is contained in the corresponding section of this chapter.
1.3 Organization Chart	Should show the organizational relationships of the EAC within the local government structure. Relationships during an emergency may be different from those between emergencies.
1.4 Levels of Activation 1.4.1 1.4.2 1.4.3	Contain the same definitions as in Chapter 3.
2.0 Routine Operations	
2.1 Manning	Specifies the number and skills of personnel on duty and on call for both normal work day and weekend-holiday schedules. Actual names are not part of the SOP, but should be listed in separate duty rosters.

Representative Table of Contents	*Remarks*
2.2 Hours of Operation	Specifies when the EAC is to be manned during non-emergency conditions.
2.3 Duties of On-Site Personnel	Statements of the responsibilities and functions of assigned personnel.
2.4 Duties of On-Call Personnel	Statements of the responsibilities and functions of assigned personnel.
2.5 Communications Procedures	Specifies communications procedures peculiar to the EAC and, by reference, the procedures used in other systems, such as Weather Services A and C and Weather Facsimile, to which the EAC has access.
2.6 Communications Schedules	Establishes the routine schedules for reporting of air quality data from locations under surveillance.
2.7 Posting Data	Includes specific instructions for maintenance of data displays including: 1. Meaning of symbols. 2. Schedule for updating. 3. Maintenance of permanent records. 4. Authority for changing posted data.
2.8 Reaction to a Potential Emergency	Outlines the expected reaction to: 1. An emergency call. 2. A report of poor air quality. 3. A HAPPA that forecasts stagnant meteorological conditions.
2.9 Maintenance of Log	Contains instructions on: 1. Format of log. 2. What should be recorded. 3. Periodic sign-off (for example, weekly during non-episode season, daily during episode season with no emergency). 4. Disposition of log book.
3.0 Emergency Operations	
3.1 Criteria for Activation	Lists conditions to be met for activation

Representative Table of Contents	Remarks
	of the EAC. Basically, they should be similar to the criteria for declaring a first alert for the area affected.
3.2 Personnel Rosters	Specifies the number and skills of personnel needed to man the EAC. Actual names are not part of the SOP, but should be in separate up-to-date duty rosters.
3.3 Activation Procedures	Lists the steps required to activate the EAC (1) partially and (2) fully. The section is specific and includes information on personnel to call in, personnel to alert but not call in, and additional communications, if any, to activate.
3.4 Reporting Schedules	Contains instructions for increasing the frequency of air quality reports from affected locations. The normal daily rate might be increased to a rate as frequent as once very 2 hours.
3.5 Maintenance of Data Displays	In addition to the routine posting of daily readings, the more frequent readings must be recorded. This article details changes in display format and contains instructions for any additional displays, such as for 6-hour doses, that may be desirable during an emergency.
3.6 Criteria for Advising the Mayor or Equivalent Authority	Lists types of situations that must be brought to the personal attention of the Mayor (or equivalent authority) or his designated representative.
3.7 Means of Advising the Mayor	Sets forth explicit instructions on how to advise the Mayor or equivalent authority.
3.8 Coordination with the City Counsel or Equivalent	Specifies the procedures by which the Counsel is alerted for potential legal action and, if required, asked to initiate injunctive procedures.
3.9 News Releases	Outlines who can make releases, what

Representative Table of Contents	Remarks
	means should be used, and general guidelines for requesting assistance of the news media in making public announcements.
3.10 Maintenance of Log Book	Contains instructions for keeping a log of the emergency. It treats the same type information as in 2.9 above.
4.0 Termination of Emergency	
4.1 All-Clear	Includes 1. Criteria for the "all-clear." 2. Personnel who should be notified and the means for notifying them.
4.2 Reverting to Routine Operations	Instructions for terminating the emergency operation, releasing personnel and circuits, changing reporting schedules, disposition of displays, and similar items.
4.3 After-Action Report	Specifies the format, authorship, content, and distribution of the post-episode report.

APPENDIX A.

GLOSSARY OF AIR POLLUTION TERMS

1. Acute — Having a sudden onset and a short and relatively severe course.

2. Aerosol — A dispersion of solid or liquid particles of microscopic size in gaseous media. Examples are smoke, fog, and mist.

3. Air Pollution — The presence of unwanted material in the air. The term "unwanted material" refers to material in sufficient amount and under such circumstances as to interfere significantly with comfort, health, or welfare of persons, or with full use and enjoyment of property.

4. Air Pollution Index — One of a number of arbitrarily derived mathematical combinations of air pollutants that gives a single number attempting to describe the ambient air quality.

5. Ambient Air Quality — A physical and chemical measure of the concentration of various chemicals in the outside air. The quality is usually determined over a specific time period (for example, 5 minutes, 1 hour, 1 day).

6. Anticyclone — An area of relatively high atmospheric pressure. In the northern hemisphere, the wind blows spirally outward in a clockwise direction.

7. Atmosphere, The — The whole mass of air, composed largely of oxygen and nitrogen, that surrounds the earth.

8. Atmosphere, An — A specific gaseous mass, occurring either

naturally or artificially, that can contain any number of constituents and in any proportion.

9. Breathing Zone	That stratum of the atmosphere in which people breathe.
10. Coh	Abbreviation for coefficient of haze, a unit of measurement of visibility interference.
11. Collection Efficiency	The percentage of a specified substance retained by a gas-cleaning or gas-sampling device.
12. Collector	A device for removing and retaining contaminants from air or other gases. Usually this term is applied to cleaning devices in exhaust systems.
13. Combustion	The reaction of carbon-containing substances (or other oxygen-demanding materials) with oxygen, producing a rapid temperature increase in a flame.
14. Density	The mass per unit volume of a substance.
15. Diffusion, Molecular	A process of spontaneous intermixing of different substances, attributable to molecular motion, that tends to produce uniformity of concentration.
16. Dispersion	The most general term for a system consisting of particulate matter suspended in air or other gases.
17. Diurnal	Daily, especially pertaining to actions or events that are completed within 24 hours and that recur every 24 hours.
18. Droplet	A small liquid particle of such size and density as to fall under still conditions, but which may remain suspended under turbulent conditions.
19. Dust	A term loosely applied to solid particles predominantly larger than colloidal and capable of temporary suspension in air or other gases.

20. Dust Fall	The amount of large particulate matter deposited per month per square mile of land.
21. Dust Loading	An engineering term for "dust concentration," usually applied to the contents of collection ducts and the emissions from stacks.
22. Efficiency	The ratio of attained performance to absolute performance, commonly expressed in percent.
23. Emissions	The total substances discharged into the air from a stack, vent, or other source.
24. Emission Inventory	A list of primary air pollutants emitted into a given community's atmosphere, in amounts (commonly tons) per day, by type of source.
25. Emission Mixture	The total mixture in the atmosphere of emissions from all sources.
26. Environment	The aggregate of all external conditions and influences affecting the life, development, and, ultimately, the survival of an organism.
27. Episode	The occurrence of stagnant air masses during which air pollutants accumulate, so that the population is exposed to an elevated concentration of airborne contaminants.
28. Fly Ash	The finely divided particles of ash entrained in flue gases, arising from the combustion of fuel. The particles of ash may contain incompletely burned fuel.
29. Fog	Visible aerosols in which the dispersed phase is liquid. In meteorology, a visible aggregate of minute water droplets suspended in the air near the earth's surface.
30. Fume	Properly, the solid particles generated by condensation from the gaseous state, generally after volatilization from melted substances and often accompanied by a chemical reaction such as oxidation. Fumes flocculate and sometimes coalesce. Popularly, the term is used in reference to any or all types of contaminants

and, in many laws or regulations, with the added qualifications that the contaminant have some unwanted action.

31. Gas	One of the three states of aggregation of matter, having neither independent shape nor volume, and tending to expand indefinitely.
32. Grab Sample	A sample of an atmosphere obtained in a very short period of time, such that the sampling time is insignificant in comparison with the duration of the operation or the period being studied.
33. Impaction	A forcible contact of particles (often used synonymously with impingement).
34. Impinger	Broadly, a sampling instrument using impingement for the collection of particulate matter.
35. Inversion	A layer of air in which temperature increases with height.
36. Isokinetic	A term describing a condition of sampling, in which the flow of gas into the sampling device, at the opening or face of the inlet, has the same flow rate and direction as the ambient atmosphere being sampled.
37. Mass Concentration	Concentration expressed in terms of substance per unit volume of gas or liquid.
38. Mist	A term loosely applied to dispersions of liquid droplets, the dispersion being of low concentration and the particles of large size. In meteorology, a light dispersion of water droplets of sufficient size to be falling.
39. Month	For reporting analyses of ambient air on a monthly basis, rate results are calculated to a base of 30 days.
40. Odor	That property of a substance that affects the sense of smell.
41. Odor Unit	Unit volume of air at the odor threshold.
42. Odorant	Odorous substance.

43. Opacity Rating — A measurement of the opacity of emissions, defined as the apparent obscuration of an observer's vision to a degree equal to the apparent obscuration of smoke of a given rating on the Ringelmann Chart.

44. Oxidants — A measure of the presence of organic oxidizing chemicals, such as ozone, in the ambient air. An indicator of photochemical smog.

45. Particle — A small discrete mass of solid or liquid matter.

46. Particle Concentrations — Concentration expressed in terms of number of particles per unit volume of air or other gas. Note: In expressing particle concentrations, the method of determining the concentration should be stated.

47. Particle Size — The size of liquid or solid particles, expressed as the average or equivalent diameter.

48. Precipitation, Meteorological — The precipitation of water from the atmosphere in the form of hail, mist, rain, sleet, and snow. Deposits of dew, fog, and frost are excluded.

49. Precision — The degree of agreement of reported measurements of the same property. Expressed in terms of dispersion of test results about the mean result, obtained by repetitive testing of a homogenous sample under specified conditions.

50. Pollutant — Any matter that, upon discharge to the ambient air, creates or tends to create a harmful effect upon man, his property, convenience or happiness, or that causes the contamination in ambient air to exceed legally established limits, or that is defined as a pollutant by a regulatory agency.

51. Receptor — Any person or piece of property upon which an air pollutant creates an effect.

52. Ringelmann Chart — Actually a series of charts, numbered from 0 to 5, that simulate various smoke densities by presenting different percentages of black. A Ringelmann No. 1 is equivalent to 20 percent

black; a Ringelmann No. 5, 100 percent. Used for measuring the opacity of smoke arising from stacks and other sources by matching with the actual effluent the various numbers, or densities, indicated by the charts. Ringelmann numbers are sometimes used in setting emission standards.

53. Sampling	A process consisting of the withdrawal or isolation of a fractional part of a whole. In air analysis, the separation of a portion of an ambient atmosphere, with or without simultaneous isolation of selected components.
54. Smog	A combination of "smoke" and "fog." Applied to extensive atmospheric contamination by aerosols arising partly through natural processes and partly from human activities. Often used loosely for any contamination of the air.
55. Smoke	Small gas-borne particles produced by incomplete combustion, consisting predominantly of carbon and other combustible material, and present in sufficient quantity to be detectable in the presence of other solids.
56. Soot	Agglomerations of particles or carbon impregnated with "tar" that are formed in the incomplete combustion of carbonaceous material.
57. Synergism	The cooperative action of separate substances such that the total effect is greater than the sum of the effects of the substances acting independently.
58. Tape Sampler	A device used in the measurement of both gases and fine particulates. It allows air sampling to be done automatically at predetermined times.
59. Thermal Turbulence	Air movement and mixing caused by convection.
60. Topography	The configuration of a surface, including its relief and the position of its natural and man-made features.

61. Vapor	The gaseous phase of matter that normally exists in a liquid or solid state.
62. Volume Concentration	Concentration expressed in terms of gaseous volume of substance per unit volume of air or other gas, usually expressed in percent or parts per million.
63. Week	For reporting analysis of ambient air on a weekly basis, results are calculated to a base of seven consecutive 24-hour days.
64. Year	For reporting analysis of ambient air on a yearly basis, results are calculated to a base of twelve 30-day months.

APPENDIX B. HISTORY OF EPISODES

Most of the air pollution episodes of the past have not been reported. Today, public awareness is growing and techniques for monitoring are improving. Future documentation of episodes should therefore be much better than in the past.

Table B-1 presents a list of past episodes. Information given includes the location and date of the episodes evaluated, pollutant types and concentrations, meteorological conditions, and health effects noted. Table B-2, a bibliography of episode references, should be of considerable assistance in providing detailed information relative to many of the documented episodes.

Table B-1. EPISODE HISTORY

Location and date	Ref	Pollutants: Type	Pollutants: Range	Meteorology	Health Effects: Diseases and symptoms	Health Effects: Excess deaths
London						
Dec. 9-11, 1873	1			Fog		650[a]
	2					
	3					
Jan. 26-29, 1880	1			Fog		1176
	2					
	3					
	4					
Feb. 1882	1			Fog		Excess deaths noted
Dec. 1891	1			Fog		Excess deaths noted
Dec. 28-30, 1892	1					779
	2					
	3					
Nov. 26-Dec. 1, 1948	1	Black suspended matter	200 to 2800 mg/m^3	Temp. (min) 25 to 43°F		700 to 800
	2			(max) 37 to 54°F		
	3	SO_2	0.09 to 0.75 ppm	Wind vel. 0 to 4.6 mph		
	5			Visibility, 27 to 440 yd		
Dec. 5-9, 1952	1	SO_2	0.09 to 1.34 ppm	Temp. (min) 24 to 39°F	Bronchitis	4000[b]
	2	Black suspended matter	400 to 4500 mg/m^3	(max) 31 to 40°F	Emphysema	
	3			Wind vel. 9 to 5.8 mph	Cardiovascular (ischemic heart disease)	
	4			Visibility 22 to 240 yd		
	5			Fog	Acute wheezy chests	
	6				Dyspnoea	
	7				Fever	
	8				Yellow-black sputum	
	9					
	10					

Table B-1 (continued). EPISODE HISTORY

Location and date	Ref	Pollutants		Meteorology	Health Effects	
		Type	Range		Diseases and symptoms	Excess deaths
London (cont'd.)						
Jan. 3-6, 1956	2	SO_2	0-19 to 0.55 ppm	Temp. (min) 29 to 36°F		1000
	5	Black suspended	700 to 2400 mg/m^3	(max) 36 to 47°F		
	6	matter		Wind vel. 0 to 8.1 mph		
	11			Visibility 5 to 12,000 yd		
Dec. 2-5, 1957	2	SO_2				
	4	Black suspended				
	5	matter				
	6	Critical levels				
	12	set at:				
		SO_2	0.40 ppm			
		Black suspended	200 mg/m^3			
		matter				200 to 250
Dec. 5-10, 1962	1	Smog				
	2	SO_2	1.98 ppm		Wheezy chests	700
	4		highest hourly		Bronchitis	
	8		concentration		Dyspnoea	
	13				Fever	
					Yellow-black sputum	
					Heart failure	
Jan. 7-22, 1963	2					700
New York, N.Y.						
Nov. 18-22, 1953	1	SO_2	Concentrations	Wind $\leq$7 mph	Eye irritation	Excess deaths
	2		up to 0.86 ppm	Elongated high-	Coughing	noted
	8		2.92 to 8.38 Coh	pressure system		
	14		units	3000 ft inversion		

Table B-1 (continued). EPISODE HISTORY

Location and date	Pollutants: Ref	Pollutants: Type	Pollutants: Range	Meteorology	Health Effects: Diseases and symptoms	Health Effects: Excess deaths
New York, N.Y. (cont'd.)						
Nov. 28-Dec. 4, 1962	1	SO_2	Max peaks >1.0 ppm on many days	Temp. avg. 46 to 57°	Cardiac	
	2			Wind speed ⩽2 mph (early morning and late evening)	Respiratory	
	15					
	16	CO	Max 1-hr avg of 22.4 ppm			
	17					
	18	SO_2	0.07 to 1.5 ppm (daily avg)			
		Smoke shade	2 to 7 Coh units			
		SO_2 (24-hr avg)	0.1 to 0.7 ppm			
Dec. 30, 1962-Jan. 15, 1963	16	SO_2 (24-hr avg)	0 to 0.5 ppm	Followed 8 days after very cold spell. Very few atm. inver. Few hr with winds <5 mph		Excess deaths noted
		Smoke shade	1 to 6.0 Coh units			
Jan. 29-Feb. 12, 1963	2	SO_2	0.2 to 0.5 ppm	Few winds <5 mph	Influenza	200 to 400
	16	Smoke shade	1.5 to 7 Coh units	Few inversions	Pneumonia	
	19	SO_2 (avg hourly)	0.46 ppm	Stagnating anticyclones were absent	Vascular lesions	
		Smoke shade	47% of days ⩾4 Coh units		Cardiac	
			73% of days ⩾0.40 ppm			
Oct. 10-27, 1963	17	SO_2	Avg >0.30 ppm for sustained periods	Temp. avg >60° F		
	18			Few winds >2 mph		
		CO	Max 1-hr avg - 27.5 ppm	Peak of drought period		
		Total hydrocarbons	- general level 3.0 ppm			

Table B-1 (continued). EPISODE HISTORY

Location and date	Ref	Pollutants: Type	Pollutants: Range	Meteorology	Health Effects: Diseases and symptoms	Health Effects: Excess deaths
New York, N.Y. (cont'd.)						
Feb. 27-Mar. 10, 1964	16	SO_2 Smoke shade	0.0 to 7 ppm 2 to 5 Coh units	A few inversions A few winds <5 mph		Excess deaths noted, 168
Nov. 23-25, 1966	2 20 21 23 24 25	SO_2 Smoke shade CO	0.02 to 1.02 ppm 0.5 to 8.2 Coh units 1 to 13 ppm	Temp. (min) 34 to 49°F (max) 49 to 65°F Wind speed 2.7 to 5.6 mph Temp. inver. during a.m. and p.m. Anticyclonic conditions Vertical mixing depths 1214 to 1813 feet	Influenza Pneumonia Heart disease Bronchitis Asthma Malignant neoplasms of respiratory system Vascular lesions of central nervous system	
Donora, Penn. Oct. 27-31, 1948	1 2 3 4 10 22 26 27	SO_2 (last day) H_2SO_4 mist Other sulfur compounds O_3 NO_X Organic compounds Smoke	Concentrations unknown unknown unknown unknown unknown unknown unknown	Temp. inversion Fog Stagnant anticyclone	Cough Respiratory irritation Sore throat Chest constriction Dyspnoea Eye irritation Vomiting Nausea Heart diseases Bronchitis	

Table B-1 (continued). EPISODE HISTORY

Location and date	Ref	Pollutants: Type	Pollutants: Range	Meteorology	Health Effects: Diseases and symptoms	Health Effects: Excess deaths
Meuse Valley, Belgium						
Dec. 1930	1	SO_2	Concentrations	Fog	Cardiovascular	60 to 80[e]
	2		unknown	Wind speed -0.62 mph	Hypotension	
	3	H_2SO_4	unknown	Ceiling - 246 ft	Alkalosis	
	10	HF	unknown	Temp. inversion	Sore throat	
	26	NO_2	unknown		Cough	
	28	CO	unknown		Nausea	
	29	CO_2	unknown		Vomiting	
Eastern U.S.						
Nov. 27-Dec. 5,	1	Avg. organic particulate was 6[f]		Quasi-stationary		
1962	15	times normal level		anticyclone		
(2 to 7.5 days)		Avg. particulate was 2 to 3 times[f]		Low winds		
		normal level				
		(Avg. of 3 to 13 cities)				
Washington, D.C.		SO_2	0.04 to 0.29 ppm			
		CO	2 to 24 ppm			
		Total hydrocarbon	2 to 17 ppm			
		Total oxidants	0 to 0.017 ppm			
Philadelphia, Penn.	*SO*	SO_2	*0.04 to 0.45 ppm*	*Temp. 42 to 50° F*		
		NO	0 to >0.65 ppm			
		NO_2	0 to 0.22 ppm			
		Hydrocarbon	1 to 10 ppm			
		Total oxidants	0 to 0.01 ppm			

Table B-1 (continued). EPISODE HISTORY

Location and date	Ref	Pollutants: Type	Pollutants: Range	Meteorology	Health Effects: Diseases and symptoms	Health Effects: Excess deaths
Eastern U.S. (1962 cont'd.)						
Cincinnati, Ohio		SO_2	0.01 to 0.28	Temp. 45 to 52° F		
		NO	0 to 0.57 ppm			
		NO_2	0.03 to 0.23 ppm			
		Hydrocarbon	0.3 to 1.7 ppm			
		Total Oxidants	0 to 0.025 ppm			
		Ozone	0 to 0.008 ppm			
Chicago, Illinois		SO_2	0.05 to 0.87 ppm	Temp. 45 to 51° F		
		NO	0.11 to 0.59 ppm			
		NO_2	0.04 to 0.18 ppm			
New York, N.Y.		SO_2	0.07 to 1.50 ppm	Temp. 46 to 57° F		
Eastern U.S. Nov. 20-26, 1966		SO_2 levels peak in morning		Light winds Poor horizontal ventilation Stagnating high-pressure system		
		(Pollutant ranges listed below are 24-hour means)				
Pittsburgh, Penn.				Avg. temp. 32 to 53° F p.m. mixing depth 990 to 3320 ft Avg. wind speed 5.5 to 12.5 mph		
Birmingham, Ala.		Soiling index	0.5 to 2.2 Coh units	Avg. temp. 51 to 65° F p.m. mixing depth 2460 to 3600 ft Avg. wind speed 1.6 to 9.2 mph		

Table B-1 (continued). EPISODE HISTORY

Location and date	Ref	Pollutants: Type	Pollutants: Range	Meteorology	Health Effects: Diseases and symptoms	Health Effects: Excess deaths
New York, N.Y.		SO_2	0.01 to 0.07 ppm	Avg. temp. 36 to 54° F		Approx.
		CO	1 to 13 ppm	p.m. mixing depth		24/day
		Soiling index	2.8 to 6.0 Coh units	540 to 3600 ft		
				Avg. wind speed		
				3.9 to 10.8 mph		
Washington, D.C.		SO_2	0.01 to 0.07 ppm	Avg. temp.		
		NO	0.04 to 0.48 ppm	p.m. mixing depth		
		Hydrocarbons	3 to 6 ppm	630 to 5100 ft		
				Avg. wind speed		
				3.6 to 8.5 mph		
Boston, Mass.		SO_2	0.11 to 0.30 ppm	Avg. temp. 34 to 51° F		
		Suspended particulate	45 to 220 mg/m^3	p.m. mixing depth		
				845 to 4060 ft		
				Avg. wind speed		
				6.0 to 9.5 mph		
Philadelphia, Penn.		SO_2	0.03 to 0.26 ppm	Avg. temp. 36 to 53° F		
		NO	0.04 to 0.48 ppm	p.m. mixing depth		
		NO_2	0.03 to 0.08 ppm	845 to 3880 ft		
		Hydrocarbons	3 to 5 ppm	Avg. wind speed		
		CO	0 to 10 ppm	4.5 to 9.2 mph		
		Suspended particulate	80 to 390 mg/m^3			
		Soiling index	0.8 to 3.8 Coh units			
Newark, N.J.		SO_2	0.12 to 0.40 ppm			
		NO	0 to 0.40 ppm			
		NO_2	0.02 to 0.14 ppm			
		Hydrocarbons	1 to 13 ppm			
		CO	15 to 32 ppm			
		Soiling index	1.5 to 6.5 Coh units			
Baltimore, Md.		Suspended particulate	20 to 220 mg/m^3			
		Soiling index	0.7 to 1.8 Coh units			

Table B-1 (continued). EPISODE HISTORY

Location and date	Ref	Pollutants: Type	Pollutants: Range	Meteorology	Health Effects: Diseases and symptoms	Health Effects: Excess deaths
Eastern U.S. (1966 cont'd.)						
Los Angeles, Calif.	25	Ozone Hydrocarbons NO_x		Frequent prolonged temp. inversions Smog	Eye irritation Mild resistance to perspiration	
Cincinnati, Ohio May 16-17, 1962	30	Max. hourly concentration Total oxidant: 5/16 5/17 NO 5/16 5/17 NO_2 5/16 5/17	 0.14 ppm 0.19 ppm 0.13 ppm 0.13 ppm 0.20 ppm 0.24 ppm	Temp. >90° F Avg. wind speed <4 mph Quasi-stationary anticyclone Clear skies High degree of insolution Nocturnal radiation inversion (formed each night) varied 200 to 400 ft		
New Orleans, La. (Since early 1950's)	31 32 33	Silica crystal particle (city dump) Emissions from public elevator also suspected		Associated with winds of very low velocity	Asthma outbreak[g]	
Tokoyo–Yokohama, Japan 1946-1963	35 36	Dustfall Sulfation Pollution particularly noticeable in fall and winter (evening and night)	No data No data	Meteorological conditions unfavorable for removing air pollution	Acute bronchitis Asthma Acute attacks coincided with periods of concentrated air pollution. People leaving area; become ill again on returning.	

Table B-1 (continued). EPISODE HISTORY

Location and date	Ref	Pollutants: Type	Pollutants: Range	Meteorology	Health Effects: Diseases and symptoms	Health Effects: Excess deaths
Minneapolis, Minn., 1956	1	Emissions from processing plants of grain industry			Asthma outbreaks	
Weirton, W. Va. Prior to Sept. 1960	32	Associated with carbon monoxide effluent from industrial stacks		Inversion layer, with stagnation	13 people hospitalized	
Rotterdam Dec. 2-7, 1962	1	SO_2	5 times normal			Increase in mortality noted
Hamburg Dec. 3-7, 1962	1	SO_2 Dust pollution	5 times normal 2 times normal			
Osaka, Japan Dec. 7-10, 1962	1	Pollution levels high				60
St. Louis, Mo. Nov. 28, 1939[h]	37	Smoke	(Nighttime darkness through the day)	Temperature inversion Windless period		

[a] Also cattle.
[b] Also cattle; excess deaths calculated on 7 and 15 day moving average.
[c] Excess deaths calculated on 7 day moving average. Deaths occurred on first day. Morbidity coincided closely with mortality.
[d] 43% of population was effected.
[e] Also cattle.
[f] Average of 3-13 cities.
[g] 100 emergency room visits at one hospital with two resulting deaths.
[h] Known as "Black Tuesday."

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APPENDIX C. EPISODE METEOROLOGY

For a given distribution of sources of pollution, the concentration of pollutants in the atmosphere depends primarily on two factors, the vertical variation of temperature and the direction and strength of the wind. The vertical variation of temperature controls the rate at which the contaminants spread upward and clean air from above is mixed downward into the polluted air. The wind speed determines how much air the pollution is initially mixed into, and the irregularities of wind speed and direction govern the rate at which the pollution spreads horizontally as it is carried downwind.

Figure 1 illustrates why the vertical distribution of temperature is such an important factor. As illustrated by the solid curve in the middle diagram of the figure, the temperature usually decreases upward at a rate somewhat less than the rate of adiabatic cooling of a parcel displaced upward, which is shown by the dashed line. Thus if a small amount of contaminated air is pushed upward it will become slightly colder than the surrounding air and tend to fall back, but because of the small difference in temperature it will fall slowly and have time to mix with the surroundings and become diluted. If the air has been heated from below so that its temperature decreases with height more rapidly than the rate of adiabatic cooling, as in the left diagram, a parcel of air

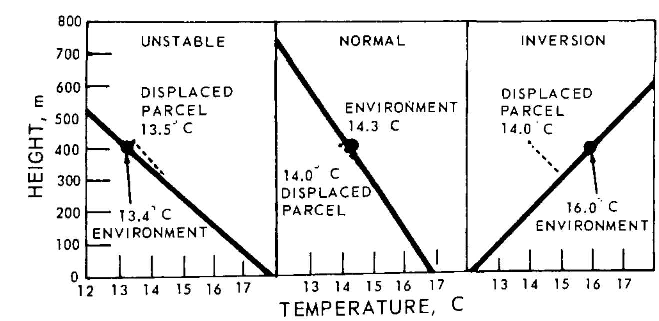

Figure C-1. Examples of effect of vertical temperature variation on upward mixing of pollutants; effect of displacing parcel of air 100 m.

*Extracted from Neiburger, M. The Role of Meteorology in the Study and Control of Air Pollution. Bulletin of the American Meteorological Society 50:957, December 1969.

displaced upward will be warmer than the air around it and tend to rise still further. In this circumstance, pollutants emitted near the ground will diffuse upward rapidly. But if the condition in the right diagram prevails, in which the temperature of the layer increases with height, that is, an inversion layer prevails, a parcel of air displaced upward through the layer would become much cooler than the surrounding air. Its displacement would be resisted by a downward force that would keep it from being lifted much and would cause it to return rapidly to its original position. Pollutants in this last case would not be mixed upward at all.

Although the temperature usually decreases with height, inversions are not infrequent, especially near the ground. They occur particularly at night, when the ground is cooled because of outgoing radiation not compensated for by incoming radiation from the sun. Thus, in Figure 2, in which the average hourly temperature at various heights at Oak Ridge, Tennessee, in September and October 1950, are displayed, an inversion is seen to have existed on the average from shortly before sunset to shortly after sunrise. Figure 3 shows the annual frequency of such inversions over the United States, expressed in percentage of total hours. Inversions occur more than one-fourth of the time over almost all of the United States. Anywhere pollutants are emitted into the air, high concentrations can be expected for a considerable part of the time.

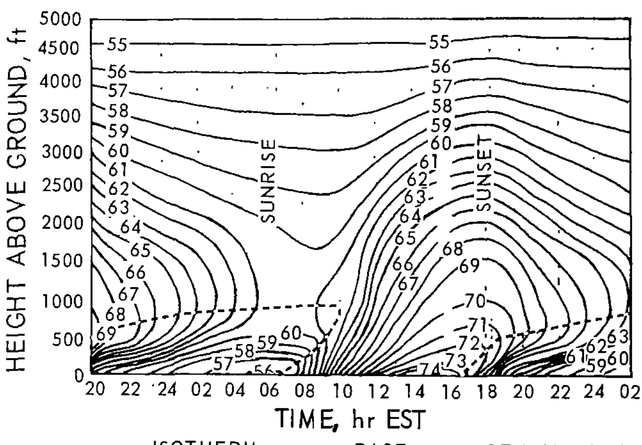

Figure C-2. Average temperature at various heights and times of day in Oak Ridge, Tennessee, September and October 1950.

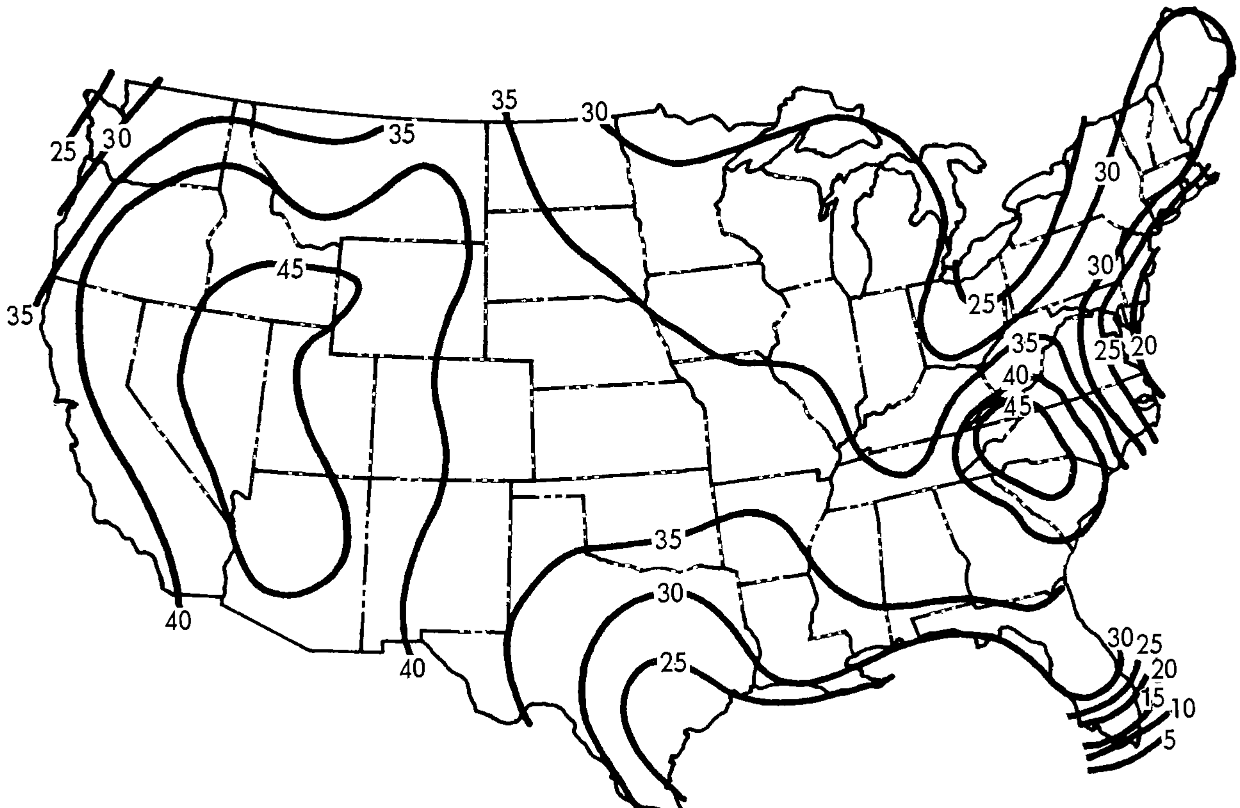

Figure C-3. Annual frequency of low-level (ground) inversions over the United States, in percent of total hours.