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REGIONAL AIR POLLUTION STUDY: Expeditionary Research Program, Summer 1975

Environmental Sciences Research Laboratory
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U.S. Environmental Protection Agency
Research Triangle Park, North Carolina 27711

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REGIONAL AIR POLLUTION STUDY

EXPEDITIONARY RESEARCH PROGRAM

SUMMER 1975

By

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For

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1. INTRODUCTION

1.1 Background

The Congress of the United States has recognized that air pollution control is one of the most important problems facing our large urban and industrial centers. Through the Clean Air Act*, Congress has charged the EPA with:

1. Protecting and enhancing the quality of the Nation's air resources so as to promote public health and welfare and the productive capacity of its population.

2. Initiating and accelerating a national research and development program to achieve the prevention and control of air pollution.

3. Providing technical and financial assistance to State and Local governments in connection with the development and execution of their air pollution prevention and control programs.

4. Encouraging and assisting the development and operation of regional air pollution control programs.

Based upon these Congressional charges, the EPA has developed a series of programs implemented through various offices of the Agency. The Office of Research and Development is responsible for providing the scientific and technological bases for the establishment of criteria and standards, and the pollution control technologies to alleviate or deter adverse effects, primarily upon human health. The programs of the Office of Research and Development place emphasis on four major areas of activity.

1. The development and standardization of techniques for the measurement of pollutants, both at their source and in the ambient environment.

2. The quantification of the effect of human exposure to air pollutants on both health and welfare.

3. The development of cost-effective control technologies.

4. The development of relationships between sources of pollution and ambient air quality through an understanding of pollutant emission, transport, transformation, and removal processes.

*Clean Air Act and its amendments, particularly the Clean Air Amendments of 1970 and the Air Quality Act of 1967.

The Regional Air Pollution Study (RAPS), a major program of the Office of Research and Development, is focused primarily on the fourth area of activity, the verification and development of relationships between sources of pollution and ambient air quality measurements on the scale of an air quality control region. Material advancements in technology and methodology of air quality monitoring and other aspects of air pollution control, particularly improvementin emission inventory procedures, are also expected.

The verification and development of these relationships will allow control actions to become more sophisticated and selective. General control actions can be confidently tested through these relationships to develop strategies for a region which provide the desired level of control for the lowest cost. The verification and development of such relationships will also allow impact on air quality to become a factor in community and industrial planning for future growth. They can also be utilized to optimize the size of a monitoring network needed to define a region's air quality.

1.2 Goals and Objectives of the Regional Air Pollution Study

The goals of the RAPS are:

1. Verification of relationships between sources of pollution and ambient air quality for all criteria pollutants on the scale of an air quality control region.

2. Development of improved relationships for source, transport, dispersion, transformation, and removal processes for all criteria pollutants (sulfur dioxide, particulates, carbon monoxide, nitrogen oxides, oxidants and hydrocarbons), but particularly for sulfur oxides.

The attainment of these broad goals requires the achievement of several major objectives:

1. Development of improved emission inventory procedures to supply emission data for the study region with unprecedented high spatial and temporal resolution.

2. Development of an atmospheric monitoring system capable of reporting pollutant and meteorological characteristics of the atmosphere over the study region with very high accuracy and temporal resolution.

3. Creation of an extensive validated data bank containing emission, air quality and meteorological data, as well as other relevant information, for the study region, with appropriate data handling procedures, to be used in verification of existing and improved relationships.

4. Improvement in our understanding of the pollutant transport and

dispersion processes of the atmosphere through experimental studies of energy and momentum fluxes over the study region.

5. Improvement in our understanding of the pollutant transformations occurring in the atmosphere through experimental studies of the role of sulfur dioxide, carbon monoxide, nitric oxide, and organics in producing sulfates, nitrogen dioxide, nitrates, ozone, organic aerosols and other finely divided particulate materials in the atmosphere over the study region.

6. Improvement in our understanding of pollutant removal processes, particularly experimental determination of dry deposition velocities of sulfur dioxide for various types of land surfaces in the study region.

7. Improvement in our understanding of local-scale phenomena which complement regional-scale relationships.

1.3 Products of the Regional Air Pollution Study

As a result of achieving these objectives, several products can be expected from the RAPS. The primary product is a group of relationships between sources of pollution and ambient air quality which are available to other EPA Offices, air pollution control and planning agencies of State, Regional, County and Local governments, and industry. These relationships will be in an appropriate form for use; they will have been tested and verified, and their best use identified in consideration of their accuracy and required input data, as well as their spatial and temporal resolution.

A second major product is improved methodologies for emission inventories. Because of the stringent demands of the RAPS, new approaches to emission inventories must be developed. This will result in methodologies offering air pollution control agencies an opportunity to improve their inventories and thereby their understanding of pollution sources in their areas and control of these sources.

Another important product is a data bank with unprecedented resolution of air quality, meteorological and emission information. This data bank, with its associated data management system, will be invaluable in the testing and verification of relationships between pollution sources and ambient air quality. This extensive description of a region may also suggest new forms for these relationships and assist in the development of new relationships.

The RAPS will also provide an opportunity for new instruments and instrument systems to be tested under field conditions and compared with a state-of-the-art monitoring system. This will allow verification of their measurements and a demonstration of their utility in monitoring systems of the future.

A very important product of the RAPS, and perhaps one with the greatest implications for future control of air pollution, is an improved understanding of the processes of pollutant transport and dispersion, and pollutant transformation and removal in the atmosphere. These may be expressed as improvements in the overall relationships between sources and ambient air quality.

1.4 Selection of Study Area

Thirty-three Standard Metropolitan Statistical Areas larger than 400,000 population were evaluated by the Stanford Research Institute (SRI), with regard to:

1. Surrounding area - Isolation from other large areas containing sources of considerable air pollution, presence of a clear-cut gradient of emissions around the edge of the urban area, and absence of large bodies of water.

2. Heterogeneous emissions - Presence of a satisfactory mixture of emissions and types of sources within the area.

3. Area size - An indication of the scope and magnitude of the study for each site.

4. Pollution control program - Existence of a well-developed control program as a source of background data, experience, and industrial cooperation.

5. Historical information - Adequate meteorological, air quality, economic, and other forms of information for the study.

6. Climate - Relatively uncomplicated meteorological patterns and a climate suitable for year-round outside work.

The SRI recommendation that St. Louis be selected as the study site was accepted and approved by the EPA.

1.5 Report Organization

This report contains, in addition to this introductory section, three sections dealing with the RAPS.

Section 2 presents an overview of the RAPS to show the role of the Expeditionary Research Program in achieving the goals and objectives of the RAPS.

Section 3 presents the details of the Expeditionary Research Program, focusing on the Summer 1975 exercise.

Section 4 contains a status report on model evaluation, model development, RAPS data bank, and emission inventory.

2. REGIONAL AIR POLLUTION STUDY OVERVIEW

2.1 Introduction

For maximum utility, relationships for a region between pollution sources and ambient air quality generally take the form of a system of mathematical simulation models, which may include models for pollutant source characteristics, models for pollutant transport and dispersion processes, models for transformation and removal processes, and models for various local phenomena. These systems of models are the focus of the RAPS. The project of verifying and developing these models consists of three fundamental sub-projects, as shown in Figure 1:

1. Model Evaluation and Development - Testing and verification of existing systems of models, and the development of improved models with subsequent testing and verification.

2. Data Management - A bridge between the sub-projects of model evaluation and development and data gathering made necessary by the complexity of available systems of models and the sheer volume of data needed for model development, testing and verification.

3. Data Gathering - Providing the values that the attributes of the various models can have and defining the relationships involved in the component models.

These three sub-projects are intimately related, as shown in Figure 1. Assumptions concerning the source and atmospheric processes in the various models direct, through the data management sub-project, the gathering of data; analysis of the data gathered through the data management sub-project, which will confirm or refute those assumptions, and may, in fact, disclose an unsuspected relationship that changes the model structure.

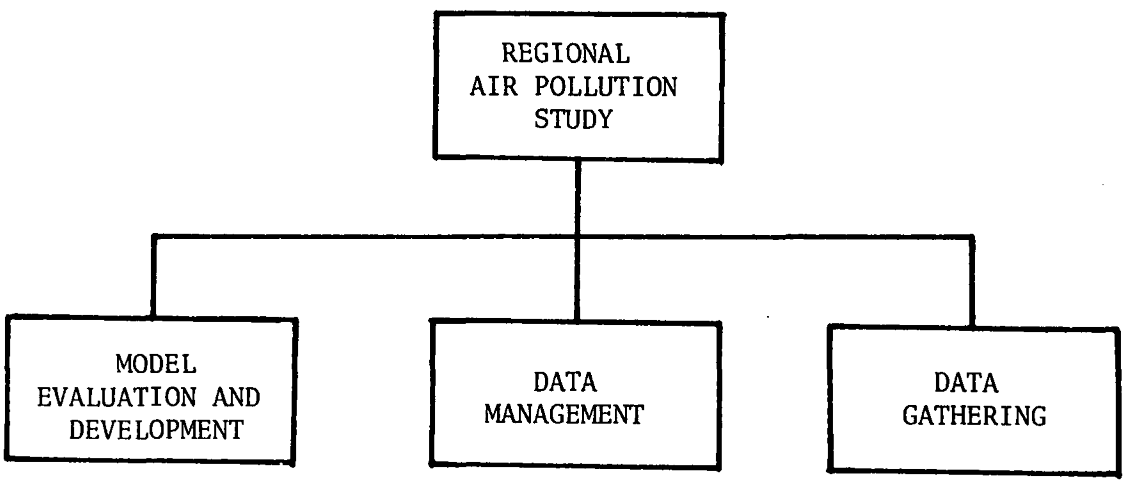


FIGURE 1 - WORK BREAKDOWN FOR THE REGIONAL AIR POLLUTION STUDY SHOWING INTERRELATIONSHIPS BETWEEN SUB-PROJECTS

This section of the report examines each of these sub-projects in turn, showing their component activities and interrelationships.

2.2 Model Evaluation and Development

Functionally there are three types of models:

1. Diagnostic - Use meteorological and emission inputs to compute pollutant distribution.
2. Predictive - Use current initial conditions to predict meteorological and emission fields and hence future pollutant distribution.
3. Climatic - Use long-term data to describe changes in the mesoclimate as a result of mesoscale urbanization.

Considering the needs of air pollution control agencies, the primary emphasis in the RAPS has been placed on diagnostic models. Further, the emphasis has been placed upon deterministic, physically-based relationships between emissions and ambient air quality.

While there are presently a large number of such models in use, none except the most simple have demonstrated a quantitative capability to predict the air quality of a region within a specified degree of accuracy. A major thrust of the RAPS is the evaluation of existing models using a significant set of regional atmospheric and emission data. Model development, while important, particularly in the areas of pollutant transformation and removal, is given a lower priority.

As the name of the sub-project implies, in the evaluation and development of models, two distinct, but related, activities are needed, as shown in Figure 2:

1. Evaluation of models utilizing the data gathered in the RAPS.
2. Development of improved models by synergistic combinations of existing models, or new approaches suggested by the experiments associated with the RAPS.

The primary objective of model evaluation and development is a group of models in a form useable to various control and planning agencies. These models will have been tested, verified and their best use determined.

2.3 Data Management

The RAPS involves an average data collection in excess of one-million observations per day over a period of two years. The objectives of the data management sub-project are to develop and maintain a data management system

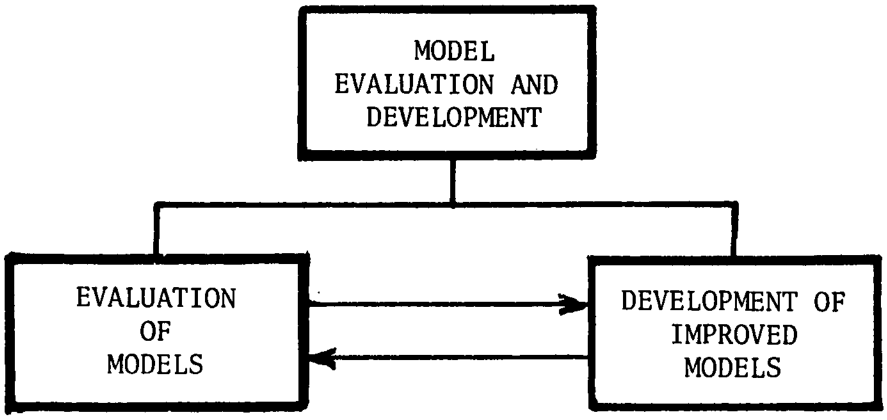


FIGURE 2 - WORK BREAKDOWN OF MODEL EVALUATION AND DEVELOPMENT SUB-PROJECT SHOWING INTER-RELATIONSHIPS BETWEEN ACTIVITIES

responsive to user requirements within the framework of the RAPS objectives. It is also to act as the interface between the data-gathering and the model evaluation and development sub-projects. In addition, data integrity must be kept as high as possible through validation programs while minimizing the computer requirements. All of this required efficient storage and retrieval software, simple on-line display and analysis capability, time distribution of data in user specified formats, periodic data base summary reports and adaptability to changing needs and schedules.

The work breakdown diagram for this sub-project is shown in Figure 3 and reveals two major activities:

1. Develop and Maintain the RAPS Data Bank - The archiving of the data gathered, together with appropriate insertion and access software.

2. Fulfill User Requirements- Develop systems to respond to the requirements of the Model Evaluation and Development Sub-Project and the Data Gathering Sub-Project.

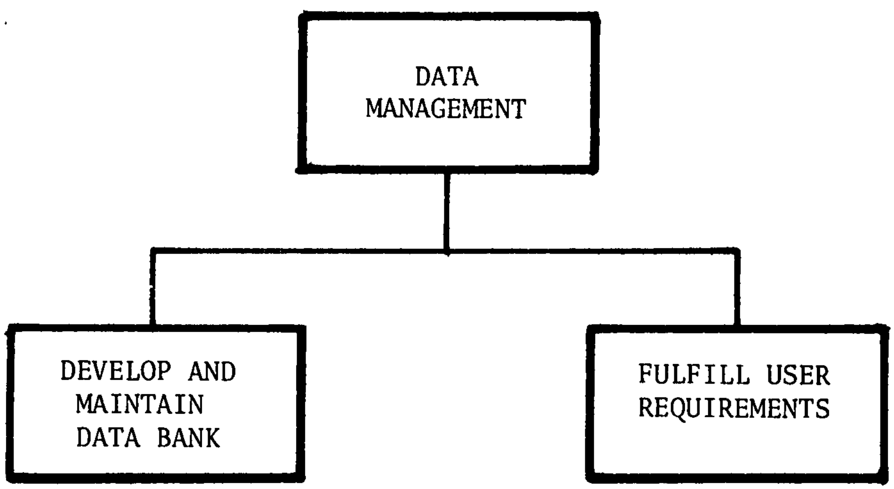


FIGURE 3 - WORK BREAKDOWN FOR DATA MANAGEMENT SUB-PROJECT

2.4 Data Gathering

2.4.1 General

Data gathering on both a routine and special basis is a fundamental sub-project carried-out in the program of the RAPS. The data gathered includes detailed information concerning pollution sources, meteorological conditions and air quality throughout the region. The data gathering sub-project can be visualized in terms of three activities as shown in Figure 4:

1. Emission Inventories - to identify, locate and quantify sources of pollutants in the St. Louis region.

2. Continuous Atmospheric Monitoring - to produce a data base of sufficient scope to support the RAPS objectives and extend the understanding of atmospheric phenomena.

3. Expeditionary Research Program - supply detailed data to better understand selected pollutant and atmospheric phenomena.

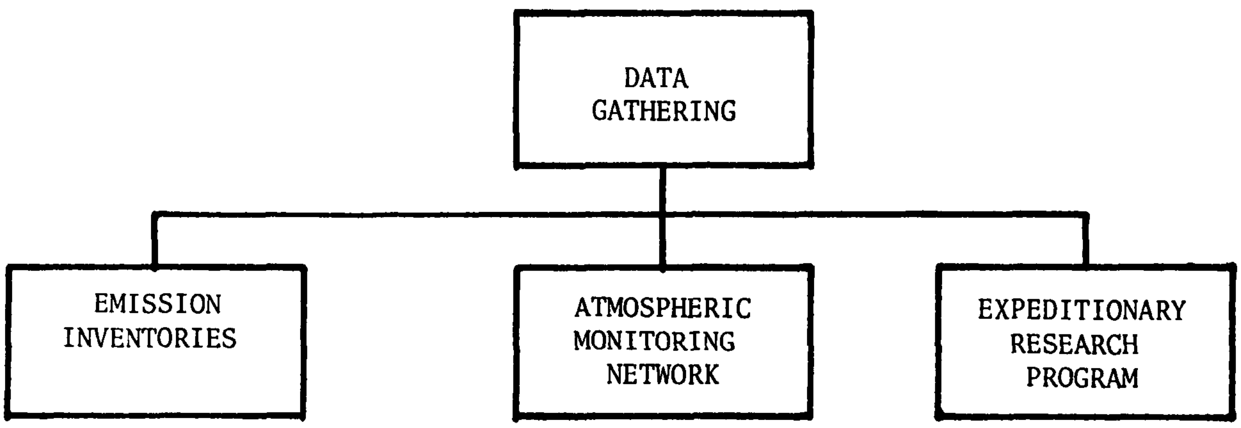


FIGURE 4 - WORK BREAKDOWN OF DATA GATHERING SUB-PROJECT

Each of these activities fills an essential role in achieving the RAPS goals and objectives.

Another activity includes efforts to ensure the quality and integrity of data obtained by the RAPS. This is accomplished through a two-pronged effort:

1. The computer checks the values of each received datum for reasonableness. Such a check compares the datum, its rate of change with time, and variation from site to site, with an upper and lower bound associated with that measurement and, if appropriate, generates an error code so that an investigation, and possibly corrective action, can be undertaken.

2. An independent audit and study of all data gathering activities is performed. This independent audit includes:

    A. A systematic, on-site qualitative review of the existing data handling procedures for the Regional Air Monitoring System (RAMS) and Upper Air Sounding Network (UASN).

    B. A systematic, on-site/off-site qualitative review of documentation, data collection, retrieval and validation techniques employed by the various RAPS field investigators during any of the intensive exercises; and

    C. A systematic, on-site quantitative audit to collect information on the precision and accuracy of the air quality and meteorological measurements obtained from and generated by the RAMS.

2.4.2 Emission Inventories

Emission inventories are an essential part of any attempt to predict air quality through a regional air quality simulation model. The accuracy of such predictions is directly proportional to the overall accuracy of the inventories. In consideration of the various air quality model input requirements, the RAPS inventories are based on the following criteria:

1. Pollutants - Sulfur dioxide, carbon monoxide, nitrogen oxides, hydrocarbons (by types), particulates, and heat emissions.

2. Resolution - Temporal, hourly, for each hour; Spatial, 0.01 kilometer point sources, 1 square kilometer grid squares.

3. Area Covered - The St. Louis Air Quality Control Region.

4. Period Covered - Hourly throughout the period of the RAPS data acquisition.

5. Units - Emissions by metric weight; distance in kilometers; location in Universal Transverse Mercator (UTM) coordinates; elevation in meters above sea level.

6. Other information - Data on sources (e.g., stack height, exit temperature, velocity) where appropriate; data for mobile sources, such as traffic flow, and aircraft movements, as required for use in appropriate emission models.

The sources to be inventoried can be classified according to the nature of the source. Such a classification system is presented in Table 1. This scheme is intended to accommodate all possible sources and pollutants in a format structured according to the methodology that must be used to gather the data and/or according to the method that the information must be applied in diffusion modeling.

The primary division of sources into categories separates stationary from mobile sources, since these present radically different problems with respect to both emission inventories and modeling. In the secondary division, stationary sources are divided into area sources and point sources, whereas mobile sources are composed of area and line sources. Dividing the mobile sources into area or line sources is a matter of expediency. Well-defined and heavily traveled traffic arteries, such as freeways, can be treated as individual line sources. The more diffuse traffic on city streets can best be handled on an area basis.

The division of stationary sources into point and area sources is necessarily arbitrary. The point sources, or source units, are those large enough to warrant individual consideration. Area source units are, by contrast, units having relatively small emissions, and they cannot for practical purposes be treated individually. The emissions from those small units existing in a given area are therefore aggregated and estimated from some facts, such as the consumption of fuel within the specified area.

The criterion of size for the definition of point source units is relative, and is related mainly to the precision desired for the inventory and for the diffusion estimates derived from it. A unit emitting a small absolute quantity of pollutant material may in fact be an important point source if it nevertheless contributes an appreciable fraction of the total emission of that specific pollutant into the region. A given source unit may be relatively insignificant with respect to one pollutant of interest, and at the same time be a very large emitter of another pollutant.

The source processes are conveniently classified as either combustion or noncombustion processes. Combustion processes are defined as those in which the pollutants are produced exclusively by the burning of fuels or of solid or liquid wastes. They include all those processes in which there is indirect transfer of the heat produced (e.g., boilers, indirect-fired air heaters) as well as incinerators, internal combustion engines, and gas turbines. Noncombustion processes comprise all other pollutant sources not falling under the specific definition of combustion processes. They include operations in which combustion takes place, but in which part or all of the pollutants emitted arise from operations other than the burning of fuel or wastes. Examples are those processes in which the products of fuel combustion come into direct contact with materials being processed, such as calcining of

Table 1

CLASSIFICATION OF SOURCES FOR EMISSION INVENTORY

Source Category	Stationary Sources				Mobile Sources	
Source Subcategory	Area Sources		Point Sources		Area and Line Sources	
Source Process	Combustion	Noncombustion	Combustion	Noncombustion	Combustion	Noncombustion
Source Units	Commercial Institutional Residential Small Industrial Fuel Use Space heaters Water heaters Boilers Waste Disposal Incinerators	Commercial Small Industrial Venting of organic vapors (dry cleaning, painting, gasoline storage and handling food preparation	Utilities Power plants Municipal incinerators Industrial Boiler and power plants Indirect-fired air and process heaters Stationary internal combustion engines Stationary gas turbine engines Incinerators	Industrial Direct-fired process units All other industrial processes, material storage and handling	Surface Vehicles Passenger cars Trucks and buses Commercial vehicles Railroads Vessels Off-highway vehicles and equipment Aircraft Piston engines Gas turbines	Surface Vehicles and Aircraft Venting of fuel vapors Wear of tires and brakes
Pollutants	Gases and Vapors SO_2 NO_x CO Hydrocarbons and derivatives HCL HF Odors Particulates Fly ash and its specific chemical components Smoke	Gases and Vapors Organic vapors (solvents, gasoline) Odors Particulates Organic aerosols Smoke	Gases and Vapors SO_2 NO_x CO Hydrocarbons and derivatives HCL HF Odors Particulates Fly ash and its specific chemical components Smoke	All pollutants	Gases and Vapors SO_2 NO_x CO Hydrocarbons and derivatives Odors Particulates Smoke Lead Oil aerosols Derivatives of fuel additives	Hydrocarbon Vapors Particulates Organic Inorganic

Source: "Regional Air Pollution Study: A Prospectus, Part II - Research Plan", Table V-1 materials in kilns.

By far the largest number of pollutant sources, stationary and mobile, are combustion sources. In particular, combustion processes comprise the most important area source units, and estimates of emissions from these numerous contributors can be made from estimates of fuel consumption. The most important noncombustion sources are industrial, and are generally point sources.

The emission inventory activity consists of three basic sub-activities, as shown in Figure 5:

1. Establishing Emission Inventory Methodologies - Developing methodologies for each of the inventories needed in the RAPS in light of the characteristics of each category of sources, and the state-of-the-art for such inventories, and the RAPS needs.

2. Developing the Emission Inventory Data System - Design and implementation of a system capable of recording, storing, retrieving, editing, and updating all data required for the computation of emissions consistent with the RAPS requirements.

3. Gathering Emission Inventory Data - According to methodologies and data system.

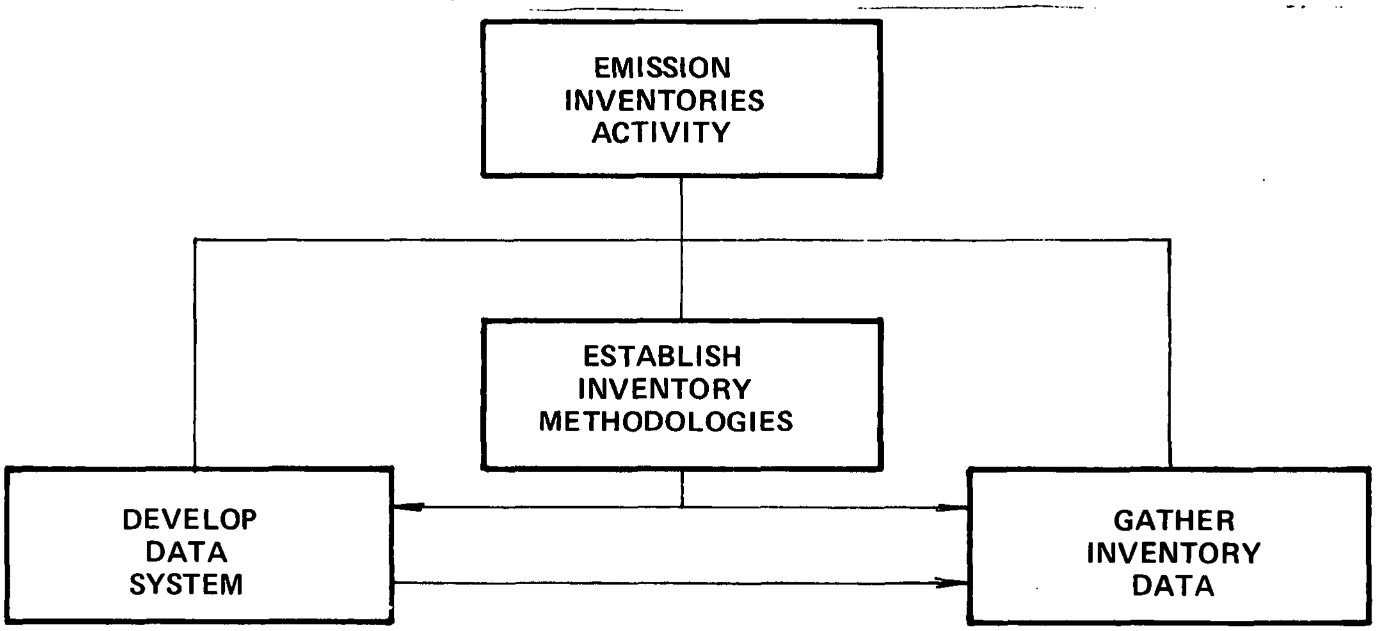


FIGURE 5 - WORK BREAKDOWN OF THE EMISSION INVENTORIES ACTIVITY SHOWING INTERRELATIONSHIPS BETWEEN SUB-ACTIVITIES

2.4.3 Atmospheric Monitoring Network

The operation of the atmospheric monitoring network in support of the RAPS constitutes the longest and most concentrated effort ever undertaken to define and describe an urban atmosphere. It far surpasses previous data collection efforts in terms of volume and diversity. The majority of this data will be routinely gathered by the various components of the atmospheric monitoring network. This network consists of an extensive ground-based Regional Air Monitoring System. (RAMS), an Upper Air Sounding Network (UASN), and an aerial monitoring system as shown in Figure 6.

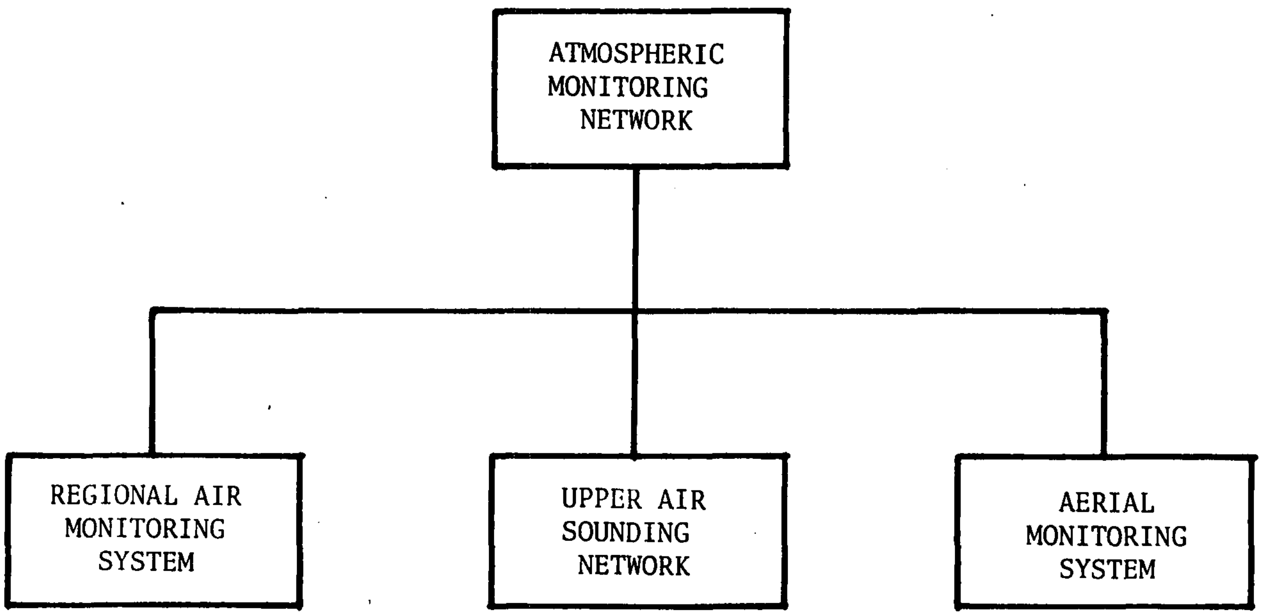


FIGURE 6 - COMPONENTS OF THE RAPS ATMOSPHERIC MONITORING NETWORK

The RAMS consists of 25 remotely-operated, automated stations controlled and polled via telemetry by a central data acquisition system. The locations of these stations are shown in Figure 7. The stations are individually "managed" by mini-computers which provide for automatic calibration of the pollutant gas instruments. It is the objective of this network to provide a long term, uniform, verified data base of ground-based measurements of various air pollutants, as well as solar radiation and meterological variables. The instrumentation included in the RAMS are summarized in Table 2.

RAPS Stations

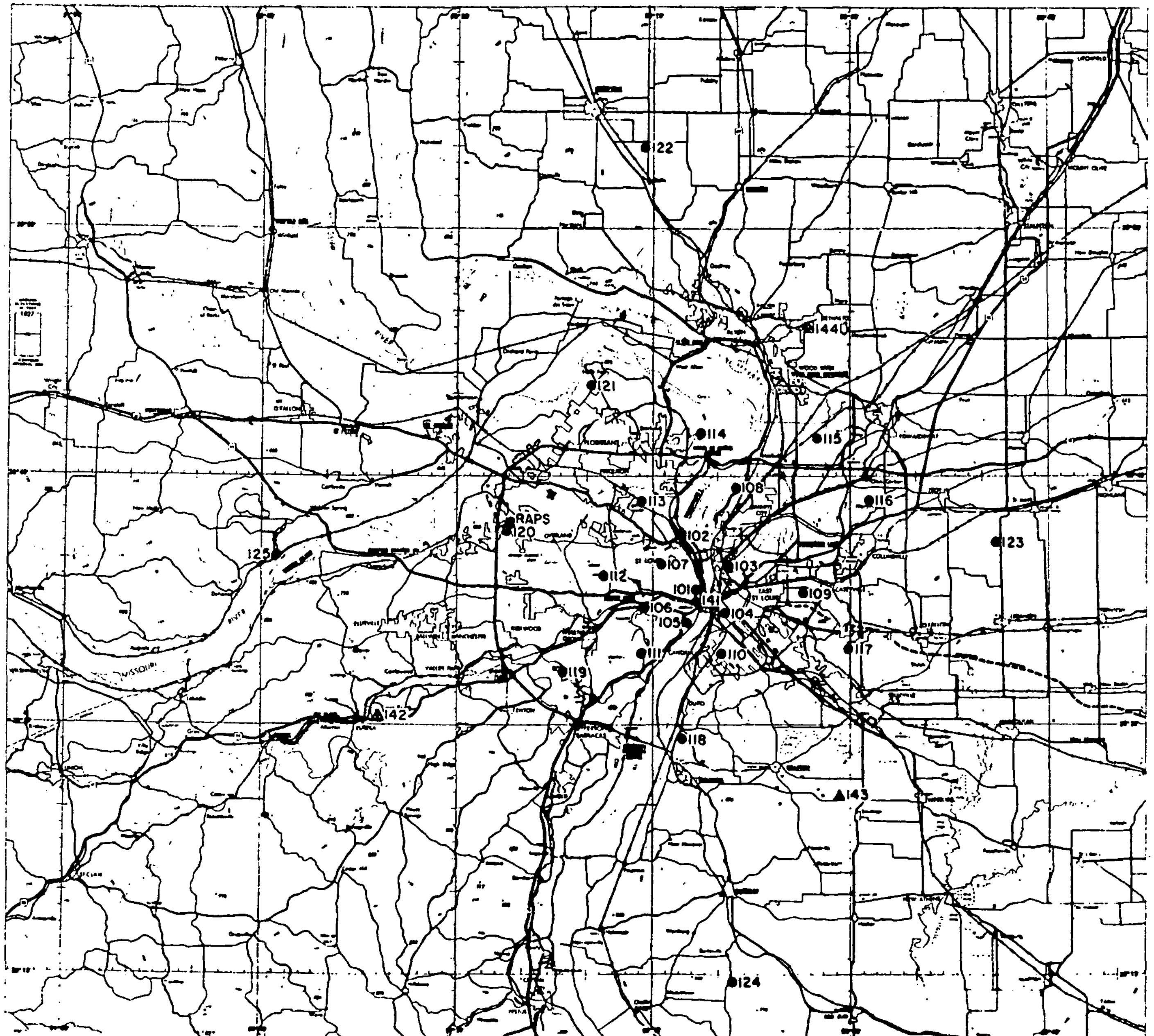


FIGURE 7

RAMS INSTRUMENTATION

Table 2

INSTRUMENTATION	STATION														
	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115
OZONE ANALYZER MONITOR LABS 8410	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
OXIDES OF NITROGEN ANALYZER MONITOR LABS 8440	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
CO-CH_4-THC ANALYZER BECKMAN 6800	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
VISIBILITY ANALYZER MRI 1561	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WIND SPEED MRI 1022S	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WIND DIRECTION MRI 1022D	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
TEMPERATURE MRI 840-1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
TEMPERATURE GRADIENT (6m & 30m) MRI 840-2	X	X		X	X	X	X		X		X	X	X		
DEW POINT (3m) CAMBRIDGE 880	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
BAROMETRIC PRESSURE (3m) SOSTMAN 363	X								X			X			
WIND TURBULENCE R. M. YOUNG 27002					X		X		X		X		X		
GAS BAG SAMPLERS XONICS (2 EA.)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
TOTAL SULFUR ANALYZER MELOY SA 185		X					X		X	X	X	X			

RAMS INSTRUMENTATION

Table 2

INSTRUMENTATION	STATION														
	116	117	118	119	120	121	122	123	124	125					
OZONE ANALYZER MONITOR LABS 8410	X	X	X	X	X	X	X	X	X	X					
OXIDES OF NITROGEN ANALYZER MONITOR LABS 8440	X	X	X	X	X	X	X	X	X	X					
$CO-CH_Y$-THC ANALYZER BECKMAN 6800	X	X	X	X	X	X	X	X	X	X					
VISIBILITY ANALYZER MRI 1561	X	X	X	X	X	X	X	X	X	X					
WIND SPEED MRI 1022S	X	X	X	X	X	X	X	X	X	X					
WIND DIRECTION MRI 1022D	X	X	X	X	X	X	X	X	X	X					
TEMPERATURE MRI 840-1	X	X	X	X	X	X	X	X	X	X					
TEMPERATURE GRADIENT (6m & 30m) MRI 840-2							X	X							
DEW POINT (3m) CAMBRIDGE 880	X	X	X	X	X	X	X	X	X	X					
BAROMETRIC PRESSURE (3m) SOSTMAN 363							X	X	X	X					
WIND TURBULENCE R. M. YOUNG 27002															
GAS BAG SAMPLERS XONICS (2 EA.)	X	X	X	X	X	X	X	X	X	X					
TOTAL SULFUR ANALYZER MELOY SA 185		X	X	X				X	X	X					

RAMS INSTRUMENTATION

Table 2

INSTRUMENTATION	STATION														
	.101	102	103	.104	105	106	107	108	109	110	111	112	113	114	115
TS-SO_2-H_2S ANALYZER TRACOR 270 HA	X		X	X	X	X		X					X	X	X
DICHOTOMOUS SAMPLER LAWRENCE BERKELEY LAB			X		X	X		X				X			X
HIGH VOLUME SAMPLER SIERRA 305			X		X	X		X				X			X
SOLAR RADIATION PYRANOMETER EPPLEY - QUARTZ			X	X				X						X	
SOLAR RADIATION PYRHELIOMETER EPPLEY - GG 395			X											X	
SOLAR RADIATION PYRGEOMETER EPPLEY - RG 695			X											X	
METEOROLOGICAL TOWER SS - SELF SUPPORTING G - GUYED	30m SS	30m SS	30m SS	30m SS	30m SS	30m SS	30m SS	10m SS	30m SS	10m SS	30m SS	30m SS	30m SS	10m SS	10m SS
MATERIALS EXPOSURE STUDY			X		X	X		X				X			X

RAMS INSTRUMENTATION

Table 2

INSTRUMENTATION	STATION									
	116	117	118	119	120	121	122	123	124	125
TS-SO_2-H_2S ANALYZER TRACOR 270 HA	X				X	X	X			
DICHOTOMOUS SAMPLER LAWRENCE BERKELEY LAB			X		X		X		X	
HIGH VOLUME SAMPLER SIERRA 305			X		X		X		X	
SOLAR RADIATION PYRANOMETER EPPLEY - QUARTZ			X				X			
SOLAR RADIATION PYRHELIOMETER EPPLEY - GG 395			X				X			
SOLAR RADIATION PYRGEOMETER EPPLEY - RG 695			X				X			
METEOROLOGICAL TOWER SS - SELF SUPPORTING G - GUYED	10m SS	10m SS	10m SS	30m SS	30m SS	10m SS	30m G	30m G	30m G	30m G
MATERIALS EXPOSURE STUDY			X		X		X			

The UASN consists of four stations, one in an urban area and three in rural areas. The locations of these stations are also shown in Figure 7. Two of the stations (Sites 143 and 144) operate only during intensive experiment periods. The RAMS network provides a relatively dense data base of surface winds, temperature and relative humidity. The combination of these data with those obtained from the UASN allows the determination of changes in winds and stability throughout the area, particularly as they relate to terrain features and synoptic scale meteorology. It is the objective of the UASN to provide a data base of the upper air structure over the St. Louis region. This data base consists of winds, temperature, dew point and relative humidity aloft. This provides the basis for more extensive definition of the urban boundary layer as part of the Expeditionary Research Program.

The RAMS and UASN are augmented by the use of instrumented helicopters which act as vertical extensions of the RAMS. This aerial monitoring system functions only during selected periods to coincide with data gathering by the various research investigators. The aerial system consists of three Sikorsky-58 helicopters modified to carry two complete aerial monitoring systems; the third helicopter serves as back-up. Data collected consists of vertical distribution of pollutants and meteorological variables above the surface. In addition to providing data for model validation, they are also able to obtain data on conditions at the lateral boundaries of the St. Louis region.

2.4.4 Expeditionary Research Program

A basic objective of the RAPS is to improve our understanding of fundamental atmospheric processes. The relatively extensive characterization of the St. Louis region resulting from the emission inventories and continuous atmospheric monitoring provides an excellent background for research programs investigating various atmospheric pollutant processes. Several expeditionary investigations are planned to be carried out during the full scale operation of the Continuous Atmospheric Monitoring Network. These field expeditions supply short-term, detailed atmospheric observations in support of the development and validation of source-ambient air quality relationships. They extend and augment the data from the RAMS and UASN and concentrate on improving our understanding of particular atmospheric processes.

These expeditionary investigations are carried out during three periods of intensive research each year, at about February, August and November. The periods selected represent the two extremes of climate, fuel utilization, and seasonal variation in sources, with a transitional period between. The fall transitional period was selected over the spring due to the higher frequencies of violent weather in the spring and stagnation in the fall.

The investigation to be conducted during the Expeditionary Research Program can be categorized, as shown in Figure 8:

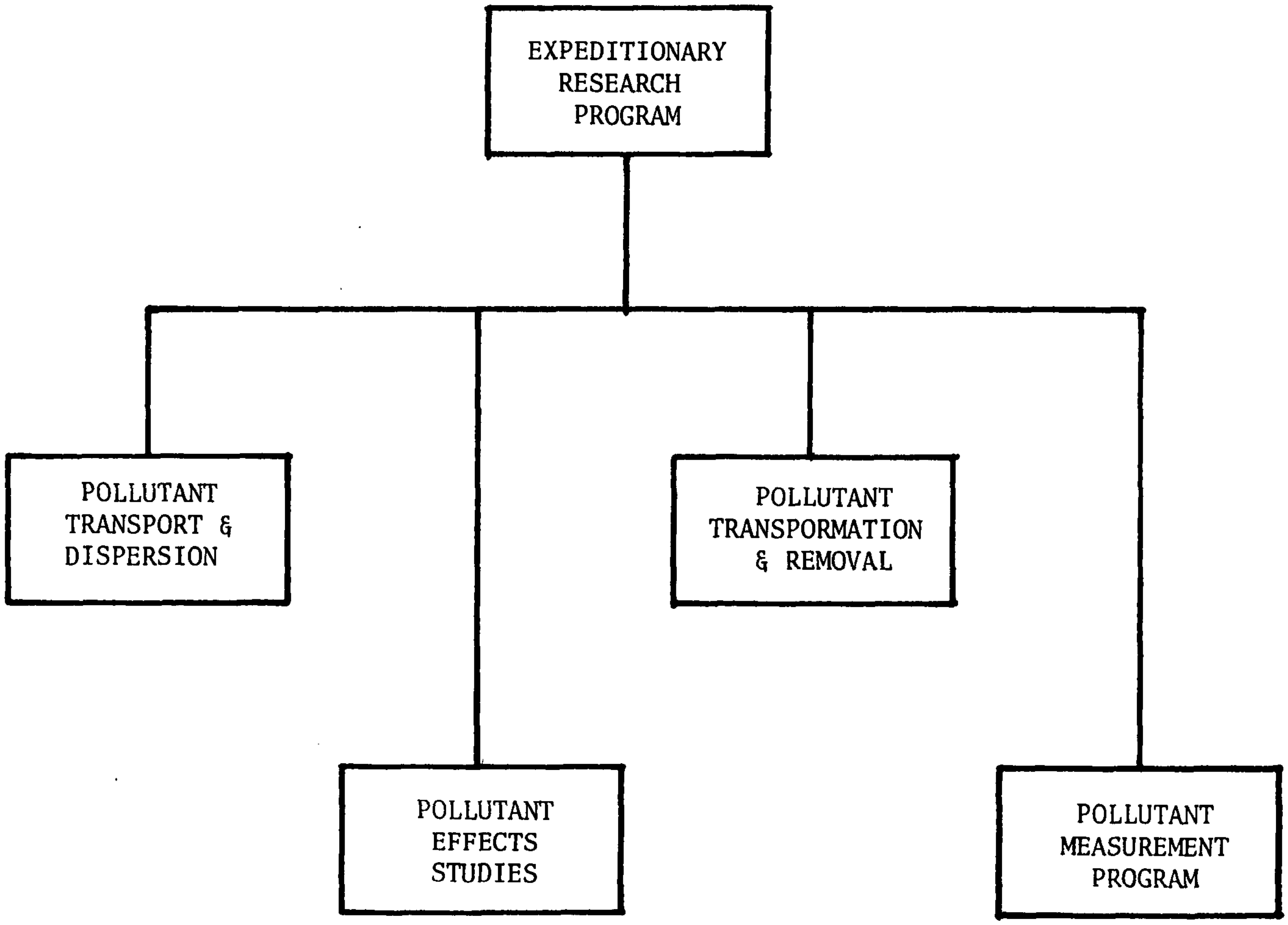


FIGURE 8 - WORK BREAKDOWN FOR THE RAPS EXPEDITIONARY RESEARCH PROGRAM

1. Pollutant Transport and Dispersion Studies - Investigations aimed at improving our understanding of the transport and dispersion of pollutants after they are released to the atmosphere.

2. Pollutant Transformation and Removal Studies - Studies designed to uncover the basic mechanisms for transformation of one pollutant to another, or to a non-pollutant, in the atmosphere and at the solid-atmosphere and water-atmosphere interfaces.

3. Pollutant Measurement Program - Conduct field measurements utilizing new and/or different instrumentation methods to determine how representative the RAMS measurements are for the St. Louis atmosphere.

4. Pollutant Effects Studies - Measurement of selected effects of pollutants on living and non-living systems.

3. EXPEDITIONARY RESEARCH PROGRAM, SUMMER 1975

The principal objectives of the field expeditions are to supply short-term, detailed atmospheric observations in support of the validation and development of source-ambient air quality relationships, and to extend and augment the data from the RAMS and UASN and to concentrate on improving our understanding of particular atmospheric processes. As previously indicated, the investigations to be conducted during the RAPS Expeditionary Research Program (ERP) can be categorized into four areas:

1. Pollutant Transport and Dispersion Studies
2. Pollutant Transformation and Removal Studies
3. Pollutant Measurement Program
4. Pollutant Effects Studies

3.1 Pollutant Transport and Dispersion Studies

The transport and dispersion of pollutants in the atmosphere occurs principally in the planetary boundary layer. These series of experiments are directed toward understanding and subsequently describing the relationships between atmospheric dynamic, kinematic, and energetic processes which occur in this boundary layer and the resultant transport and diffusion of effluents. Of particular interest is the impact on the boundary layer of the widely varying thermal and mechanical properties of the urban surface. Knowledge of this impact in terms of the temporal and spatial structure of the boundary layer over the urban area is limited since few measurements have been made, and even fewer studies have been carried out to relate the sparse observations to underlying physical causes.

Since mathematical dispersion formulations are inherently limited in accuracy by definition of the boundary layer structure, including its turbulent properties as implicitly assumed in these formulations, better description of this structure is vital for model validation studies. In addition, a better knowledge of the influence of the urban surface on the boundary layer structure will permit application of results obtained in the St. Louis region to other areas, whether existent or hypothetical.

The experiments associated with the Pollutant Transport and Dispersion Studies may be segregated into two areas of emphasis, those primarily dealing with describing the effect of the urban area on the boundary layer and those associated with understanding the mechanism that produce this urban effect. The former refers to the spatial and temporal definition of the boundary layer over the St. Louis region, whereas the latter refers to the investigations into various components of the energy budget for the St. Louis region. The breakdown of the experiments associated with the Pollutant Transport and Dispersion Studies is shown in Figure 9.

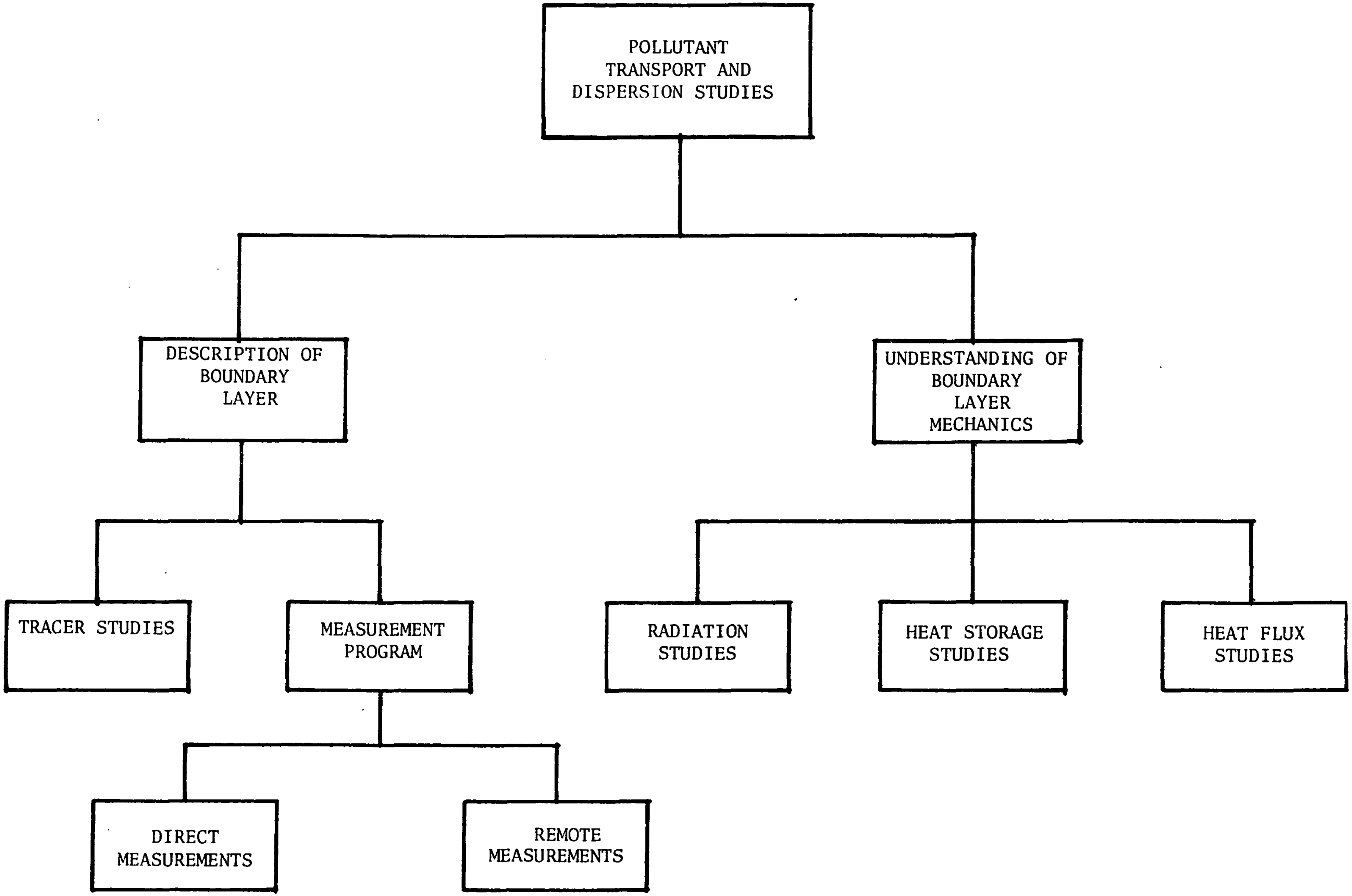


FIGURE 9 - WORK BREAKDOWN FOR RAPS POLLUTANT TRANSPORT AND DISPERSION STUDIES

3.1.1 Boundary Layer Measurement Program

The objective of the measurement program is to spatially and temporally describe the boundary layer over the St. Louis region. The techniques to be used can be categorized as direct, in the sense that the measurement is made of a sample of the air representative of the area around the measurement system, or remote, where measurements are made of atmospheric properties some distance from the measurement system. For direct measurements, a group of specially instrumented aircraft and ground vehicles with special pibal teams are used to obtain detailed information concerning structure and turbulent properties of the atmosphere.

The data from the Upper Air Sounding Network and the Aerial Monitoring System will also be used in the definition of the boundary layer, although the helicopters generally cannot descend to low enough altitudes and cannot adequately cover the center of the urban area. These constitute the other data available for boundary layer definition.

The remote measurements consist of lidars and an acoustic echo sounder. The lidars will be used to scan for the aerosol loading both day and night to obtain a measure of mixing depth and aerosol structure above the mixing depth. Temporal sequences from a stationary (but movable) lidar van and spatial patterns from this van and the NERC-LV C-45 lidar aircraft will be obtained. The sounder determines the height of the mixing layer by a return of an acoustic echo at the level of a sharp change in air density. It is permanently implanted at the Upper Air Sounding Network Station located in downtown St. Louis to constantly monitor the mixing depth over the urban area and cross check the UASN data.

Experiment descriptions for the Summer of 1975 are presented in the following pages.

Measurement of Boundary Layer Structure
Summer 1975

Key Personnel:

J. McElroy, Monitoring Systems Research and Development Laboratory - EPA

Research Goal:

Determine the detailed temporal and spatial variability in the urban boundary layer structure under a wide spectrum of weather and wind conditions

General Experiment Design:

In past intensive studies, emphasis was placed on the rapid transitional periods around sunset and sunrise. This will continue to the extent that "gaps" in the data base will be filled. Experiments will also be conducted to ascertain effects of local land-use features such as Forest Park or the Mississippi River. Intercomparisons of various techniques for determining mixing layer depth which began during the Winter '75 exercises will be continued.

A small helicopter, a panel van, a second surface vehicle, a mobile ground-based lidar, and a downward-pointing lidar flown in a fixed-wing aircraft will be operated in coordinated fashion during boundary layer structure experiments. Coordination will be achieved using communications radios. Personnel from Meteorology Laboratory and a contractor will participate in this program. The helicopter will be obtained through the selected contractor.

The helicopter will make vertical soundings from near ground level through the extent of the boundary layer across the metropolitan area roughly in the direction of the mean low-level wind. From these soundings vertical profiles of temperature, dew point temperature, total light scatter from aerosols (nephelometer), and sulfur dioxide concentration will be obtained. Locations and frequencies of soundings will be determined in real time, based on information by observers in the various vehicles via radio. Level traverses will also be made where appropriate. Pollutant data is primarily collected to aid in real time and post analysis of weather information to the extent that such data serves as a tracer for physical processes.

The panel van and second surface vehicle will be utilized to map the near-surface features of the structure. The panel van has identical instrumentation and will generally travel in line with the helicopter. The other surface vehicle has sensors for measuring temperature and dew point temperature and will provide detailed information concerning these parameters in areas selected in real time.

The lidars will be used to furnish details of boundary layer structure, chiefly mixing depth, which cannot effectively be obtained utilizing the helicopter. The mode of operation for the ground-based lidar will depend on the anticipated degree of spatial and temporal variability during sampling periods. The airborne lidar (NERC-LV) will generally be flown when extreme variability in structure, mainly temporal, is anticipated. This will probably only be used for a two-week interval during the intensive. The ground-based lidar will be operated over extended periods at the downtown upper air site in coordination with the acoustic sounder to compare these different methods of measuring mixing depth and data on boundary layer structure.

Quality Assurance Plans:

Extensive calibrations will be performed on all equipment at the NERC's prior to and following the intensives. Limited calibrations will be performed before and after each experiment. All such calibrations will be placed into the logs for the respective equipment.

Field Schedule:

Field experiments will be conducted over a one month period beginning about July 14, 1975.

Data Management Information:

Data obtained by the helicopter, panel van, and ground-based and airborne lidars will be collected on magnetic tape. That obtained by the second surface vehicle will be collected on analog strip charts. In addition, temperature and pressure-altitude are collected on analog strip charts in the helicopter and panel van for real time decision-making. Lidar data for the ground-based vehicle is also collected on a video disc, thus permitting polaroid prints of signal returns from single or composite firings if a cathode ray tube display system is available.

The facilities at the RAMS Central Facility will be used for reading magnetic tapes for the lidar. Additionally, the digitizer at this facility will be used for the processing of data collected on analog strip charts. At present, it is planned that this digitized data and other data collected on magnetic tapes will be processed by R. Browning's group at NERC-RTP.

Rawinsonde and pibal data from all RAPS upper air stations and hourly-averaged data from all RAMS stations will be required for post analysis. Unchecked data will be required during the intensive for preliminary analyses. In addition, limited rawinsonde, pibal, and "instantaneous" RAMS data from selected stations will be required in real time for decision making in the field. Parameters of primary interest at the RAMS stations include wind speed, wind direction, temperature, dew point temperature, total light scatter from aerosols, and carbon monoxide and sulfur dioxide concentrations.

Logistics and Services Required from RAPS/STL:

1. Office space and radio facilities to direct various units participating in the experiments.

2. Weather forecasting for day-to-day planning of experiments.

3. May require additional personnel to assist in operating equipment and as observer in helicopter.

Power Requirements:

No RAMS power required.

Boundary Layer Studies
Summer 1975

Key Personnel:

A. Auer, University of Wyoming

Research Goals:

1. Determination of the space-time variability of atmospheric structure over St. Louis region in terms of temperature, moisture, wind and turbulence.

2. Determination of the boundaries of the urban plume to approximately 55 km of downtown St. Louis.

General Experimental Design:

The University of Wyoming Queen Air aircraft will be the principal instrument platform. This will be supported by two mobile meteorological units and a mobile radiosonde unit. The experiments will be conducted as a series of concentrated case studies which take advantage of existing weather conditions. Of particular interest are effects of aerosols on radiational properties and, hence, on the boundary layer, and gross estimates of heat, moisture and Aitken nuclei budgets over several land use and areas under specific conditions.

Quality Assurance Plans:

Equipment is calibrated prior to and following the experiment period at the University of Wyoming. During experiments, fly-bys will be made with other RAPS aircraft.

Field Schedule:

July 15 to August 20

Data Management Information:

The aircraft has an on-board computer which keeps track of and records on magnetic tape, temperature, potential temperature, dew point, specific humidity, doppler winds, Aitken nuclei, turbulence intensity, and equivalent potential temperature. These data tapes will be processed by the University of Wyoming and made available in the form of reports and/or papers.

Power Requirements:

None

Potential Problem Areas:

Coordination with J. McElroy and B. Ackerman

3.1.2 Boundary Layer Tracer Studies

Tracer studies are utilized to determine the patterns resulting from the transport and dispersion of airborne material over the St. Louis region. Tracer studies are one technique in which known amounts of identifiable materials (gases or particulates) are released and sampled downstream at different positions and times. The release of balloons, floating at constant altitude (tetroons) serves to track the transport wind and is another technique for tracing. The introduction of tracers enables the analyst to start with a known source at a specific location and to avoid confusion with other sources in subsequent measurements downstream. During the tracer studies for the RAPS, measures of the tracer dispersion and its variations are related to measures of atmospheric turbulence and transport; atmospheric indices in turn are related to meteorological analysis based on observations feasible for routine acquisition.

Tracer experiments are designed to supplement data concerning the dispersion of airborne materials. Of particular interest is the standard deviation of the vertical distribution of material in a plume, since this is most likely to be influenced by the urban environment. Also of interest is the variation of the standard deviation of the horizontal distribution with range and height. These apply to both short scale experiments of a few kilometers and long scale tests in excess of 100 kilometers.

For the purpose of examining the transport and dispersion characteristics of the atmosphere, four types of experiments can be performed:

1. Simultaneous release of several tracers at various heights or at various crosswind or along-the-wind distances.

2. Injection of a tracer into an actual source of pollution.

3. Study of tracers incorporated in the urban plume a distance from the urban area.

4. Tetroon studies over extended areas around the city.

No boundary layer tracer studies are planned for the Summer of 1975.

3.1.3 Radiation Studies

Existing observational data have revealed differences in the radiation budget of an urban area with respect to a neighboring rural area. As land use varies, differences in radiation budgets also vary. To establish this radiation budget variation, a series of experiments has been designed involving selected RAMS stations and a specially instrumented aircraft from Pennsylvania State University. The most important component of the surface radiation budget, and in fact the total surface heat budget, is the available total solar radiation. This includes both the direct radiation and the diffuse or sky radiation.

Sensors are installed at selected RAMS stations to measure the UV direct and sky visible, IR and long-wave radiations. These are supplemented by normal incidence pyrheliometers at some of the sites with the ability to place different types of filters in the light path and thereby measure different spectral components of the direct radiation. These include a portion of the visible spectrum free of molecular absorbers and a portion of the infrared spectrum including water vapor absorption.

At several key solar hour angles, aircraft observations of downward and upward solar fluxes and downward and upward total radiation are made both at low level and just above the boundary layer. Sufficient flights are conducted under various meteorological conditions to:

1. Provide direct information on solar heating and infrared cooling rates for the boundary layers over urban and rural areas.
2. Provide a relative measure of the spatial distribution of the surface albedo and the thermal emission.

The flights are over several representative land use types so that appropriate radiation budgets can be prepared.

Experiments planned for the Summer of 1975 are described on the following pages.

Radiation Measurements
Summer 1975

Key Personnel:

J. Peterson, E. Flowers - MTL, EPA
D. Thompson - Pennsylvania State University

Research Goals:

1. Measure surface albedo of representative land use areas throughout St. Louis.

2. Measure vertical variation of solar radiation as a study of the effect of pollutants on atmospheric heating and cooling rates.

3. Validate solar radiation ground monitoring network.

4. Evaluate urban-rural variability in solar radiation.

General Experiment Design:

Pennsylvania State University's Aerocommander 680E meteorological research aircraft will be utilized as the platform for the airborne radiation measurements. This aircraft has six Eppley Precision Spectral Pyranometers, three "looking up" and three "looking down." Each set of three measures the incident global solar irradiance in three broad spectral bands: ultraviolet, visible and infrared. Similar sets of pyranometers are also installed on the roofs of RAMS stations 103, 104, 108, 114, 118 and 122, which are in urban and rural areas and on the roof of the MTL LIDAR van. The aircraft also has upward and downward "looking" Eppley pyrgeometers to measure long wave radiation.

A flight path will be designed over selected land use types, such as rural (field and forest), new residential, old residential, commercial, and industrial. To determine the effect of sun angle and building shadows, albedo measurements will be taken at 8-9 a.m., noon, and 3-4 p.m. To minimize atmospheric effects, low-level (about 1000 ft.) flights will also be made to determine the gross urban-rural effects.

During each two to three hour flight, two vertical profiles will be made, one in relatively clean air upwind of the city and one in the downwind conditions. For each profile, the aircraft will climb to approximately 10,000 ft. and in descending, level-off for about one minute of measurements at 1,000 ft. intervals above the haze and 500 ft. intervals within the haze, to 500 ft. above the ground.

In the aircraft, three atmospheric aerosol sensors will be available: nephelometer, Royco counter for size distribution and Environmental-One cloud condensation nuclei counter. A number of supporting parameters will also be measured and recorded: temperature, dew point, pressure, indicated speed, ground speed, drift angle, pitch, roll, heading, VOR-DME, radio altitude, date and time. A Barnes PRT-5 radiation thermometer is also available for measurements of ground-surface temperature.

Lidar data would be valuable in the analysis of the radiation data, and the Lidar van will be utilized during mid-day. The sensors installed on the roof of the van will be used to support the Lidar observations. The van will, whenever possible, be positioned beneath the aircraft during the vertical flux profiles to provide a ground check on the aircraft measurements.

Quality Assurance Plans:

The calibration factors provided by Eppley for the sensors on the aircraft are checked with a Link-Fuessner pyrheliometer. On a clear day the Link-Fuessner is used to determine the solar beam flux density in a plane perpendicular to the direction of the sun. The Eppley units are then compared with these results.

RAMS sensors and some of the aircraft sensors are checked by comparison with a reference pyronometer.

Field Schedule:

Aircraft measurements for three weeks starting July 13. Additional time may be required for RAMS checks.

Data Management Information:

The Penn State aircraft has a digital data recording system which will be utilized to record <u>all</u> measurements (radiation, aerosol and supporting) on magnetic tape. The data system has 35 channels of input plus fixed information (ID, date, time). All channels are scanned twice per second.

Following each flight the output tape will be taken to the RAMS computer for an initial view of the data. This includes a listing and plots of parts of the data. Calibration factors will be applied and a tape of all measurements in engineering units (not voltages) will be brought to Penn State for further processing and then to RTP for analysis. A one or two day turn-around time is sufficient. We estimate that during the three week experiment, ten tapes will be generated, each with some 14,000 scans of 35 channels of data. Rockwell currently possesses the computer program for this task.

Computer time is required at RTP for analysis of tapes.

During the experimental period, RAMS radiation data and UASN data are required. Following this period, the validated data, with calibration and other applicable inputs applied, will be required.

Logistics and Services Required from RAPS/STL:

Access to RAMS stations 103, 104, 108, 114, 118 and 122 is necessary for checks and cleaning with space on the counter to locate a recording system.

Central computer time and software for a "quick look" at the data and a preliminary processing of the data is required. During the investigation period a print-out of the one-minute data from all radiation sensors at the six sites from 0300 to 2100 daily is desired. At one line/minute, 60 lines/page this will amount to only 504 pages for 28 days.

Operational data from the UASN is required. On selected days copies of the rawinsonde measurements will be required.

Use of the Las Vegas helicopters for as many as ten vertical sampling profiles is requested. Profiles should be made during cloud free conditions, between 0900 and 1500 CST from near ground level to as high as 10,000 feet. The top of the profile should be at least 1000 feet above the top of the mixing layer. The profiles should be made over RAMS sites having a pyrheliometer (103, 114, 118, 122). At any single site the profiles should be separated by approximately 1/2 hour or more in time. It is requested that both helicopters be equipped with operating ROYCO counters.

Weather forecasting service - data cannot be taken on cloudy days, thus forecasting for the next day is extremely important in scheduling personnel and equipment. Primary time for forecasting cloud conditions is 0700 - 1200.

Power Requirements:

Only at aircraft hanger

Potential Problems:

Weather

Coordination of Lidar unit with J. McElroy.

3.1.4 Heat Flux Studies

The measurement of vertical sensible heat flux through the boundary layer is approached using four different measurement platforms due to limitations involved with each. At the surface, a 4m array of fast response thermistor and vertical velocity measurements units called a Fluxatron is used. Above 300 meters a specially instrumented NCAR aircraft is used. This aircraft can detect the sensible heat flux as well as the latent heat flux. Between these two may be a specially developed tethered balloon. This will serve as a platform for sensible heat flux instrumentation, such as that in the Fluxatron, at several altitudes in the boundary layer. Below the surface are arrays of thermistors imbedded in typical urban and rural surfaces.

Descriptions of experiments planned for the Summer of 1975 are presented on the following pages.

Heat Flux Studies
Summer 1975

Key Personnel:

J. McElroy

Research Goal:

Determine the sensible heat flux near the surface and below the surface.

General Experiment Design:

The measurement of vertical sensible heat flux is approached using three different measurement platforms. The high level platform is described under "High Level Vertical Flux Studies" as the National Center for Atmospheric Research (NCAR) aircraft. At the surface a 4 meter array of fast response thermistor and vertical velocity measurement units called a Fluxatron is used. Sub-surface heat flux is based upon arrays of thermistors imbedded in typical urban and rural surfaces.

Three fluxatrons will be utilized to measure sensible heat flux near the surface and within the "building canopy" over a variety of land-use types and under various ambient weather situations. These devices will primarily be utilized in support of the NCAR aircraft operation. According to present plans, one fluxatron will be set up near the surface in a rural area, and two on urban rooftops.

The sub-surface heat flux array will be installed this year and its data recorded on a magnetic tape system. It is planned to operate these for at least one, and possibly two, annual cycles.

Quality Assurance Plans:

The fluxatrons will be calibrated against standards operated by B. Hicks of Argonne National Laboratory.

Field Schedule:

Fluxatrons will be operated over a one month interval beginning July 14. The thermistor arrays will be operated from date of installation for 1 or 2 years. Installation should occur prior to July 14.

Data Management Information:

Data from the Fluxatrons will be collected on analog strip charts and extracted manually. The data will then be made available in tabular form to the RAPS Data Bank.

The data from the thermistor arrays will be processed by R. Browning's group at Research Triangle Park.

Logistics and Services Required from RAPS/STL:

1. Installation of sub-surface thermistor arrays.

2. Routine maintenance of Fluxatrons.

3. Use of digitizer to reduce analog Fluxatron data.

4. Site selection and local coordination for installation of Fluxatrons.

Power Requirements:

110V, 0.5a service at Fluxatron sites.

Potential Problem Areas:

Finding satisfactory location for thermistor arrays.

High Level Vertical Flux Studies
Summer 1975

Key Personnel:

B. Ackerman, Illinois State Water Survey

Research Goals:

1. To determine the vertical fluxes of momentum, sensible heat and moisture in upper boundary layer over St. Louis and surrounding rural areas.

2. To relate the eddy fluxes in the upper boundary layer, calculated directly from the products of the turbulent quantities, to the profile approximations.

3. To study morphology of boundary layer during transition periods.

General Experiment Design:

This experiment is based upon a specially instrumented aircraft from the National Center for Atmospheric Research (NCAR). This aircraft is capable of measuring the mean and fluctuation components of the three-dimensional air velocity, temperature and humidity. The aircraft will be operated 4 to 5 hours at a time, mostly mid-day, but also during some nocturnal and transition periods. At the same time, data on upper air winds in appropriate area will be taken by double theodolite pibal teams at 5 to 6 sites with balloon launches at 20 minute intervals. The sites have not been selected as yet.

Two tethered balloons with NCAR instrument packages will also be utilized at two locations to obtain boundary layer profiles of temperature and humidity up to 600 m. They will be located at one urban site and one rural site. The sites have not been selected as yet.

Quality Assurance Plans:

Instrumentation is calibrated and checked by NCAR using bench tests and comparison equipment. As the data is processed, it is scanned for unusual variations, etc.

Field Schedule:

July 1 - 31, 1975

Data Management Information:

Experimental data is recorded on magnetic tape archived at NCAR. Pibal and tethered balloon data are recorded on data sheets, keypunched and computer processed at Illinois State Water Survey. These are then used to generate experiment reports which are available to the RAPS.

Post-Operational Data Requirements:

A. Unchecked soundings and the RAMS meteorological data for operations summary.

B. Checked data at a later date for analyses.

Logistics and Services Required from the RAPS/STL:

1. Assistance in siting boundary layer profilers. This equipment involves an instrument package, tethered balloon (about 14 ft. long) and receiver and recorder equipment. Would like to locate at or near RAMS sites. Require 110-volt 60 cps electric power, small amount of inside operational space for small receiver and recorder (less than desk top), open space for tent to house balloon when not is use. Site has to be secure. Help in locating site would be appreciated.

2. Unchecked data from sounding sites on request for operational purposes.

3. Operational forecast by 9 a.m. Second forecast late afternoon. Will be operating nominally on a 7-day week, but only in suitable weather conditions.

Power Requirements:

110V, 60 hz at tethered balloon sites

Potential Problem Areas:

1. Weather

2. Coordination with Dr. McElroy and Dr. Auer.

3.2 Pollutant Transformation and Removal Studies

At the present time, much more is known concerning sources of atmospheric pollutants than about their ultimate fate. Studies of the nature and role of pollutant transformation and removal processes represent some of the most important and meaningful studies in the field of air pollution research today. The RAPS provides a detailed description of the St. Louis region's atmosphere and pollution, which can provide a base for experiments dealing with pollutant transformation and removal.

The formation rate and mechanism of particulate sulfur compounds in the atmosphere is one of the outstanding problems of current environmental research. Sulfur compound aerosol particles can contribute to a reduction in visibility and, more importantly, have been linked to adverse health effects. Recognizing these adverse effects, the research needs, and the pervasiveness of sulfur compounds in a large proportion of the community atmospheres across the country, this problem has been selected as the focus of the RAPS pollutant transformation and removal process studies.

The study of gas to particle conversion and removal must proceed along five broad fronts as shown in Figure 10:

1. Point source plume study to identify sulfur oxides and nitrogen oxides transformations in plumes.

2. Urban plume study to determine urban plume size and composition under a variety of meteorological conditions in order to identify major rate processes which take place in the urban air mixture.

3. Photochemical reaction study to ascertain the photochemically stimulated transformations which occur in the atmosphere of the St. Louis region.

4. Characterization of aerosols sampled in the St. Louis region in terms of their physical and chemical properties and their probable origins and evolution.

5. Study of dry removal processes to determine the dry deposition rate for SO_2 as a function of different land classes.

3.2.1 Point Source Plume Studies

Plume transformations are an integral part of atmospheric chemistry and become part of the overall set of transformations occurring in an urban atmosphere. The emission inventory can predict the types and amounts of pollutants released from stationary sources in a given area, but without knowledge of the transformations during plume dilution, one cannot properly use the emissions data in a regional source-ambient air quality relationship.

Of particular interest are:

1. A determination of diurnal variation in and the extent to which

sulfur dioxide is converted to sulfate in plumes and the role of humidity in the conversion.

2. A determination of the rate of oxidation of nitric oxide to nitrogen dioxide and the extent to which nitric acid is formed, particularly in power plant plumes.

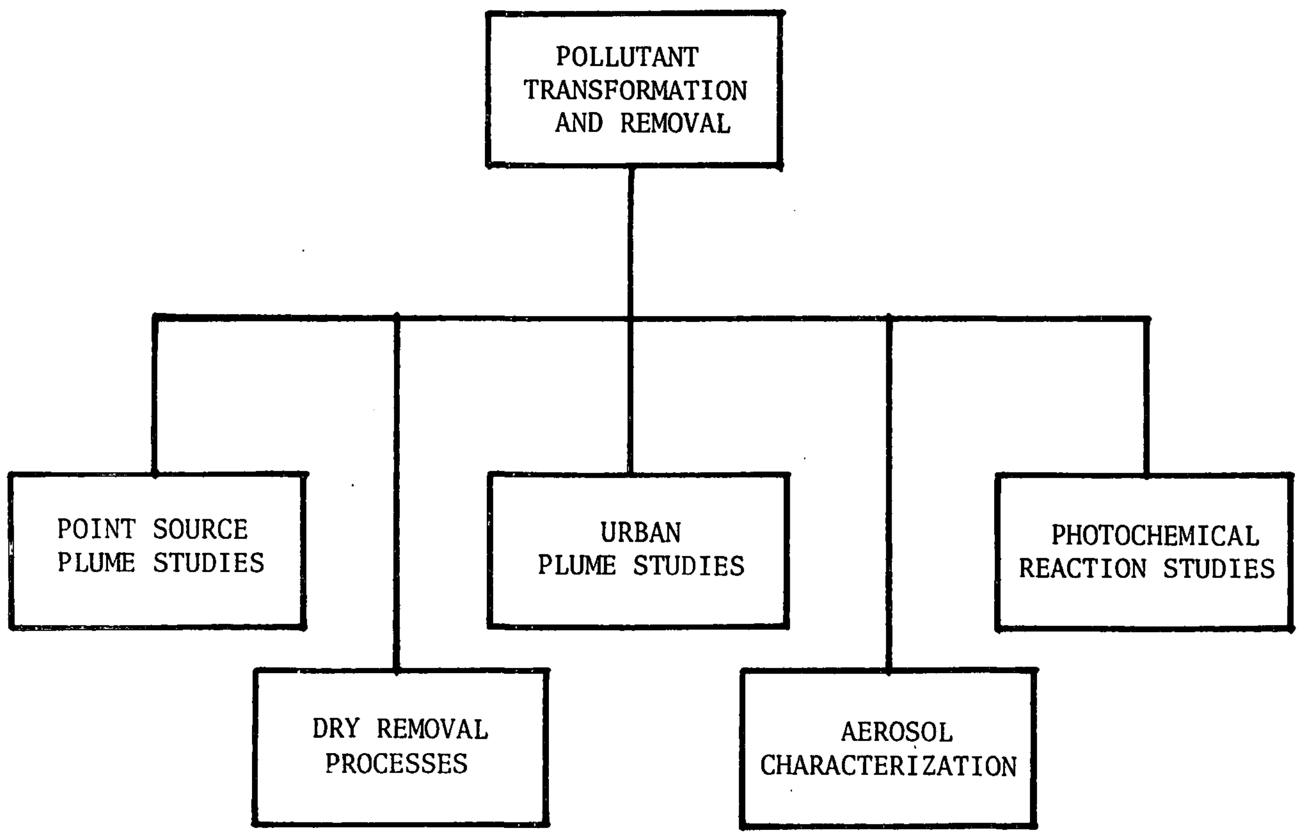


FIGURE 10 - WORK BREAKDOWN OF POLLUTANT TRANSFORMATION AND REMOVAL RESEARCH PROGRAM

These are attained through a coordinated effort by aircraft and surface vechicles using sophisticated monitoring and sampling equipment.

Point source plume studies planned for the Summer of 1975 are described on the following pages.

Plume Mapping Program
Summer 1975

Key Personnel:

W. Wilson, F. Durham - AARS - EPA
R. Husar - Washington University
D. Blumenthal - Meteorology Research, Inc.
K. Whitby - University of Minnesota
R. Paur - AARS - EPA
W. Vaughn - Environmental Measurements, Inc. (EMI)

Research Goals:

1. Elucidate rate processes acting on aerosols and aerosol precursor gases in large energy plant plumes, focusing on sulfates and the sulfate precursor, SO_2.

2. Testing and tune-up of existing dispersion (aerosol) growth (dry) removal models for single plumes.

General Experiment Design:

It is anticipated that the Meteorology Research, Inc. instrumented aircraft will be available in St. Louis from July 15 to August 12. This aircraft is capable of continuously monitoring b_{scat} condensation nuclei, O_3, NO_x, CO, SO_2, temperature, RH, turbulence and altitude. In addition, a miniature University of Minnesota system for monitoring aerosol size distribution, and a Hi Vol type of filter system will also be installed. The filter from the later system will be subsequently analyzed for particulate mass and various chemical species.

This aircraft will be utilized in mapping the pollutant concentrations, aerosol properties, etc., of the plume over a 100 km path. Measurements will be made while flying across the plume at preselected traverse points at different altitudes. The altitude increments will range from 200 to 1000 ft., depending on meteorological conditions, plume configuration, etc. A scout aircraft will be used to locate the plume for the MRI aircraft.

A team of three pibal operators in mobile units will be synchronized with the aircraft to enable calculation of pollutant fluxes at each given plume cross section.

Also coordinated with the aircraft, a surface mobile unit from EMI will be utilized to measure plume sulfur dioxide flux overhead and total sulfur levels at ground level.

The downward looking Lidar aircraft from NERC/LV will also be used to define the plume under study and examine the particulate matter in the plume.

These data will be combined and analyzed to determine rates of disappearance and formation of various pollutants and intermediates. This information will be utilized to test and improve an existing model for sulfur dioxide sulfate transformation.

Quality Assurance Plans:

Calibration cross-check with RAPS, helicopters, AARS trailer, MRI Aircraft, EMI truck.

Schedule:

Between July 15 and August 15

Data Management Information:

Data will be gathered using Metro-Data Model 620 analog/digital data collection units. These units record the data on a special magnetic tape cassette. The cassette reader is interfaced with a PDP 11/15, which is hard-wired to the Washington University IBM 370. The data will be pre-processed on the PDP-11 and the output dumped on the 370's line printer and 9 track IBM compatible magnetic tapes. These tapes will be distributed to the appropriate groups for analysis, with a copy sent to the RAPS data management for incorporation in the RAPS Data Bank.

Logistics and Services Required from RAPS/STL:

1. Meteorological forecasts are most important in planning the experiments, since they cannot be conducted with precipitation or when the plume contacts the ground too quickly. RAPS/STL will be relied upon to prepare these forecasts.

2. Support will also be needed in supplying the mobile pibal team for the experiments.

3. UASN data will be needed to project plume behavior.

Power Requirements:

None required from RAMS.

Potential Problem Areas:

1. Weather

2. The experiments involve several delicate instrument and sampling systems in different vehicles requiring close coordination and teamwork. In such a complex arrangement, the possibility of human and mechanical malfunctions exists.

Power Plant Plume Mapping
Summer 1975

Key Personnel:

L. Newman - Brookhaven National Laboratory

Research Goals:

1. Investigate rates of conversion of SO_2 to particulate sulfate, using the isotopic ratio technique in a coal-fired power plant plume.

2. Investigate the rate of conversion of NO to NO_2 in a coal-fired power plant plume.

General Experimental Design:

Samples of the power plant plume for isotopic ratio and concentration measurements will be obtained through the use of a single engine Cessna 182 outfitted with a high volume filter assembly. The essential features of the sampling system are a glass fiber prefilter for particulate sulfur removal, followed by alkaline impregnated papers to remove SO_2. Samples will be processed in the laboratory (Brookhaven) in a manner suitable for isotopic ratio measurements. A Sign - X Laboratories electroconductivity analyzer will be used to record SO_2 concentrations for purposes of locating the plume.

Another aircraft, possibly a Cessna 206, will be utilized to monitor nitrogen oxides and ozone, using chemiluminescent instrumentation.

A typical experiment will consist of obtaining a background measurement upwind of the plant and at plume altitude. When feasible, the plume will then be sampled at a minimum of five distances downwind to a maximum of about 100 km. Sufficient sampling will be conducted at each distance to collect a minimum of 1 mg of SO_2 on the filter (amount needed for isotopic ratio analysis).

The samples and data are returned to Brookhaven National Laboratory for analysis.

Measurements for particle size will also be made utilizing a diffusion battery in the EPA van and compared with the Whitby aerosol analyzer. Measurements will also be made for sulfate levels and acidity at the EPA van and two RAMS sites to be selected based on a daily evaluation of the predicted wind fields.

Quality Assurance Plans:

Field equipment will be calibrated prior to and following each data gathering mission using a controlled ozone source and a standard cylinder of nitric oxide in nitrogen.

Laboratory analysis will be subject to existing laboratory quality assurance plans.

Field Schedule:

July 21 to August 4
and a two week period around September 1

Data Management Information:

Data will be reduced at Brookhaven National Laboratory and produced as a series of tables. Plans to incorporate these data in the RAPS Data Bank are not complete.

Logistics and Services Required from RAPS/STL:

1. Weather forecasts

2. Assistance in case of instrument failure

3. Pibal support in vicinity of power plant(s)

Power Requirements:

Facilities for samplers at selected RAMS sites.

Potential Problem Areas:

1. Weather

2. Equipment Failure

3. Coordination with Dr. W. Wilson's experiments

High and Low Level Plume Tracer Study
Summer 1975

Key Personnel:

W. Wilson, AARS - EPA
F. Shair, California Institute of Technology
R. Husar, Washington University
C. Chetlynne, Control Systems Laboratory - EPA

Research Goals:

1. Determine relative contribution of high vs. low level sources to sulfur oxides and nitrogen oxides.

2. Determine pattern and concentration of single plumes for model evaluation.

General Experiment Design:

Sulfur hexafluoride and another Freon type tracer will be used as a conservative tracer in selected plumes to establish both plume location and pollutant dilution. The plumes will be a high plume such as that from the Labadie power plant, and a low plume as that from an industrial boiler with a relatively short stack.

Samples will be collected at the RAMS stations, in the NERC/LV helicoptors, and possibly in the MRI aircraft, using a specially designed plastic syringe device developed by Shair. At the same time, the instruments in each of these units will be monitoring the levels of sulfur oxides, nitrogen oxides and particulates. The syringes will be returned to the RAMS Central Facility for analysis by frontal chromatography, with electron capture detection, using gas chromatographs installed in the Aerosol Laboratory.

Normalization of the sulfur oxides and nitrogen oxides data by the tracer concentrations for various distances downwind yield sulfur dioxide and nitric oxide loss rates, as well as sulfate, nitrogen dioxide, and nitrate formation rates.

Quality Assurance Plans:

Cross-check tracer analyses with other groups operating in area.

Schedule:

Ten days between July 15 and August 15. Selection depends on equipment status and weather outlook.

Data Management Information:

Data management plans are not complete. After the experiment is completed, all UASN data and RAMS data for sulfur dioxide, nitric oxide, nitrogen dioxide, sulfate and nitrate will be required. A complete set of data from NERC/LV helicoptors for the time they were utilized in support of this experiment will also be required.

Logistics and Services Required from RAPS/STL:

1. Shair automated syringe samplers to be placed at each RAMS site.

2. Electron capture gas chromatographs to be placed in aerosol laboratory at central facility.

3. Operational forecasts seven days a week for wind speed and direction, atmospheric stability, inversion heights and percipitation.

4. Use of NERC/LV helicoptors on five selected days to collect samples and monitor pollutant levels.

Power Requirements:

110 volt receptacle at each RAMS site for sampler.

Potential Problem Areas:

1. Weather.

2. May need support in collecting samples at RAMS sites.

3. Availability of NERC/LV helicoptors on short notice for the experiments.

3.2.2 Urban Plume Studies

The urban plume study is closely related to the point source plume study in that similar equipment is required, and as one follows a large plume over sufficient distance, it becomes incorporated in the urban plume. The primary difference is that a determination of the urban plume size and composition under a variety of meteorological conditions helps to identify the major rate processes, such as chemical reactions, gas-particle conversion and dry removal, which take place in the urban air mixture.

With wind field data, the total flux of pollutants is determined and compared with the corresponding emission flux to assess the importance of conversion processes and/or the quality of emission inventories. By comparing sulfur dioxide to total sulfur at various distances downwind, the importance of chemical conversion can be determined. A comparison of changes in the total mass of the aerosol and size distribution permits estimation of gas-particle conversion rates. These determinations, when combined with emission data and vertical pollutant profiles, afford a method of determining the importance of dry deposition.

A description of the urban plume study for Summer of 1975 is presented in the following pages.

Urban Plume Study
Summer 1975

Key Personnel:

W. Wilson, AARS - EPA
A. Waggoner, R. Charlson, University of Washington
K. Whitby, University of Minnesota
R. Husar, Washington University
P. Frenzen, Argonne Nat. Lab
D. Blumenthal, Meteorology Research Incorporated

Research Goals:

1. Characterize background pollutant levels in air entering the St. Louis region.

2. Characterize changes in gas and aerosol pollutants during long-range transport.

General Experiment Design:

Dr. Charlson and the University of Washington mobile laboratory will initially be located at Tyson Valley, WSW of St. Louis. Following a two week period, this equipment will be moved to northwestern Arkansas near Table Rock Lake. At the same time, the EPA mobile aerosol laboratory will be located approximately 100 km NNE of St. Louis. By monitoring air entering the St. Louis region, characteristic background pollutant levels for the region can be developed. As the urban plume passes over the downwind laboratory, a determination of its composition will help to identify the major rate processes, such as chemical reactions, gas-particle conversion and dry removal, which take place in the urban air mixture.

Quality Assurance Plans:

Not completed

Schedule:

North of St. Louis, July 15 to August 15.

South of St. Louis, August 1 to September 1.

Data Management Information:

No RAMS/RAPS requirements, data plans not complete.

Logistics and Service Required from RAPS/STL:

None

Power Requirements:

None

Potential Problem Areas:

None defined

3.2.3 Photochemical Reaction Studies

Photochemical oxidant formation, while not nearly as important in St. Louis as in an area such as Los Angeles, has an important potential impact on the sulfur dioxide to sulfate conversion. For this reason, three groups of related experiments are used to explore photochemical reactions. First is the Bag Irradiation Experiment. Its purpose is to ascertain the photochemically stimulated transformations in the sulfur cycle in order to develop appropriate chemical kinetic models for the St. Louis region.

The approach taken in the bag irradiation study is to isolate chemical effects from meteorological and variable emissions effects by irradiating representative atmospheric samples in irradiation chambers. Two identical samples are collected in Teflon or Tedlar bags, and the contents of one bag are modified by the addition of particular materials. During the simultaneous irradiation of the two bags, the results are compared and related to known and/or postulated chemical and physical phenomena.

The details of photochemical oxidant formation in the St. Louis area will be provided by a combination of two experiments. One is an ongoing series of smog chamber studies being conducted by Dr. Pitts of the University of California at Riverside; the other is a hydrocarbon characterization of the St. Louis atmosphere by gas chromatography. The chamber studies investigate the reaction rates for individual hydrocarbons under various conditions of concentration and presence of other reactants. These kinetic results can be applied to the St. Louis region after determination of which hydrocarbons (between C_2 and C_{10}) are typically present and to what concentration in the St. Louis atmosphere. This is accomplished by fuel analysis, particularly gasoline, and analysis of gas bag samples collected from all across the St. Louis region.

Plans for the photochemical reaction study for the Summer of 1975 are presented on the following pages.

Photochemical Studies
Hydrocarbon Characterization
Summer 1975

Key Personnel:

S. Kopczynski, RAPS/STL
R. Mindrup, Rockwell International

Research Goals:

1. Evaluate the contribution of various sources, particularly automotive, to the hydrocarbon levels in the St. Louis atmosphere.

2. Assess the photochemical smog potential of the St. Louis atmosphere on a regular basis.

General Experimental Design:

Selected RAMS stations will be sampled to relate morning hydrocarbon composition and loadings to smog levels developed later in the day and to other pollutant species measured (viz. total particulates, chemical elements, visibility). This sampling will be a continuation of the present sampling schedule and will be conducted throughout the summer.

The Las Vegas helicopters will be utilized to collect bag samples as part of the vertical extension of RAMS and pollutant transport. The helicopters will also be utilized to collect samples from the vicinity of various emission sources. Samples will be analyzed to characterize the composition of such emissions (viz. refineries, auto plants, power plant plumes, chemical plants, etc.)

Samples will be taken in Teflon bags and returned to the RAMS Central Facility for gas chromatographic analysis for C_1 to C_{10} hydrocarbons, as well as total hydrocarbon, carbon monoxide, and nitrogen oxides analyses.

Quality Assurance Plans:

The instrumentation utilized in the Gas Chromatograph Laboratory was selected to provide the latest, most accurate, and dependable systems possible. Operational procedures have been developed for all instruments to insure maximum performance. To insure that high-quality data are generated by the laboratory, all instruments are subjected to preventative maintenance and repair, both on a routine and an "as needed" basis. A detailed description of all maintenance performed, both routine and unscheduled, is entered in the Maintenance Log Book, which is indexed for each instrument in the laboratory.

Data accuracy is assured by performing both daily detailed and monthly general instrument calibration with quality control standards. The results of calibrations are entered in the Operational Log Book for each instrument, along with the sample analysis for that day. To check repeatability of the instrumentation, one of the bag samples will be analyzed in duplicate before and after each set of samples. This verification, along with daily calibration, will provide a check for variations in instrument parameters such as, temperature, pressure, flow rate, etc. A periodic cross-check between different instruments is frequently made using the quality control gas standards. An independent auditing check of the sample analysis is conducted weekly by the EPA Task Coordinator to spot-check the data reported.

Schedule:

Hydrocarbon characterization is designed to be a routine series of analyses conducted by the Gas Chromatograph Laboratory at the RAMS Central Facility. It should be in full operation prior to July 15, 1975 and continue for at least one year from this date.

Data Management Information:

The data is initially recorded in the form of strip chart chromatograms, punch tape and/or teletype printouts. Next, the data is given one of its first quality reviews by manually inspecting the data for general chromatograph form factors and quantitative values for each gas component. Following review and approval, the data is tabulated on a special pre-printed form for keypunching.

At the end of approximately a ten-day collection period, the data forms are sent to Research Triangle Park for keypunching and keypunching validation. The cards are then shipped to the RAMS Central Computer Facility, St. Louis, for processing and further validation. Keypunching errors are normally corrected by computer operators at the RAMS Computer Facility, provided they are not excessive. Should a significant quantity of keypunch errors develop that the RAMS computer operators cannot process in their normal schedule, the card decks and data sheets are returned to RTP for repunching.

Data processing entails checking the cards for index number consistency, as provided for by the form, and producing a triple-copy printout of labeling information, and for each component the name, code number, concentration (PPB), ratio relative to CO, and flags if the concentration or ratio is outside an upper and lower set of limits. Four quantities, aggregated by software, are treated as components in all respects: sum of non-methane paraffins, olefins, aromatics, and non-methane hydrocarbons. Validation of the data concludes upon successful visual inspection and comparison of the data with the chromatogram and original tabulated data. Also, special attention will be directed to flagged data for validity and proper annotation.

Upon completion of data validation, a 600 foot, 9 track, 800 BPI, odd-parity magnetic data tape is prepared and sent to RTP, along with a copy of the printout. One copy of the remaining two printouts is sent to the EPA RAPS Task Order Coordinator (St. Louis) and the third copy retained by the RAMS Central Computer Facility.

Post operational data requirements include concurrent helicopter analyses as well as wind trajectory analysis on sampling days (both aloft and surface), hourly RAMS data for stations being sampled (up to 5) with spiraled stations requiring 1 minute average data during each hour interval of the spiral.

Preliminary data processing of gas chromatography analyses and RAMS data are required within 48 hours.

Logistics and Services Required from RAPS/STL:

1. Helicopter sampling is required on 10 days, 2 flights/day, 5 bag samples/flight. Meteorological conditions required are distinct, persistent winds, surface and aloft (7-10 mph) low mixing heights, and both sunny and overcast days. Both early morning and afternoon flights are required. Actual dates are flexible and can be specified as flight plans are developed. Forecasting, including mixing height and surface winds and winds aloft, are required prior to helicopter take off.

2. Vertical profiles are required at 2 stations, 1 spiral per day, 10 days per station. Meteorology and forecasting similar to above, as well as stagnant conditions, are required.

3. Source sampling require helicopter samples on overcast days, stagnant or light, persistent winds, 4 samples per source/flight (2 upwind-2 downwind), 5 sources, 2 days per source.

4. Support of the Chromatographic Laboratory at the RAMS Central Facility.

5. Collection and replacement of sampling bags at selected RAMS stations.

Power Requirements:

None over present system.

Potential Problems:

None Identified.

3.2.4 Aerosol Characterization

Fine particle pollutants are the most obvious, as well as the least understood, component of air pollution. The most easily noted effect of these particulates is visibility loss. Furthermore, the particulate matter plays an important role in the removal of gaseous pollutants, apparently acting as a sink for nitrogen oxides, sulfur dioxide and organics. The fine particulates have also been indicated as having an adverse impact on human health.

The purpose of this series of experiments is the characterization of the aerosols sampled in the St. Louis region in terms of their physical and chemical properties and their probable origins and evolution. An extensive array of instruments and devices has been assembled into two moveable laboratories, each with a computer compatible data acquisition system, to measure the chemical and physical properties of the St. Louis aerosol. In addition, several other aerosol sampling and analysis apparatus are expected to be installed as part of this study. Measurements are made in either real time or as aerosol samples which are collected for subsequent chemical analysis using various state-of-the-art and traditional techniques.

Experiments dealing with aerosol characterization for the Summer 1975 are described on the following pages.

Aerosol Characterization I
Summer 1975

Key Personnel:

S. Friedlander, California Inst. of Tech.
R. Draftz, Illinois Inst. of Tech.
A. Waggoner, University of Washington
J. Husar, Washington University
W. Wilson, AARS-EPA

Research Goals:

1. Determine from ambient measurements, the contribution of various sources to the ambient aerosol.

2. Determine an aerosol emission inventory with size and composition information by combining aerosol data with wind field, inversion height, and trajectory measurements.

General Experiment Design:

Install four wind direction controlled aerosol samples, a Battelle impactor, a Sierrahead Hi-Vol and a manual dichotomous sampler at each of our local agency hi-vol sites. The aerosol samples thus obtained will be analyzed for size-resolved aerosol composition and examined by optical and electron microscopy.

Quality Assurance Plans:

Not Completed.

Schedule:

July 15 to August 15.

Data Management Information:

No data needed in a near real time mode; however, historical data on wind speed and direction, inversion heights, and emissions together with Hi-Vol and dichotomous sampler data are required. Data reduction plans have not been completed.

Logistics and Services Required from RAPS/STL:

1. Routine weather forecasts with particular emphasis on wind speed, direction and inversion forecasts.

2. Use of Aerosol Laboratory at the Central Facility for sample analysis, instrument checks and minor repairs.

Power Requirements:

None identified.

Potential Problem Areas:

1. Cooperation with local agencies for use of their sampling sites.

2. Obtaining appropriate emission data.

Aerosol Characterization II
Summer 1975

Key Personnel:

J. Winchester, W. Nelson - Florida State University
W. Wilson - AARS-EPA

Research Goals:

1. Continuous sampling and elemental analysis of particulate material in the atmosphere of the St. Louis region to identify sources of these particulates.

2. Test new sampler design.

3. Obtain limited data on element distribution with particle size by impactor collection.

General Experimental Design:

Operation of "Streaker" samplers on the RAMS meteorological towers by replacing the Nucleopore filter once a week at each station for the duration of the intensive experiment period. The accumulated filters are analyzed on an hour-by-hour basis at Florida State for elements from Lithuim to Lead in Atomic number. The accumulated elemental analyses are tested for correlation with wind trajectories and various pollutant concentrations.

Two to four eight-stage impactors may also be operated to explore the variation of elemental analysis with particle size.

A new design "Streaker" will also be mechanically tested by running under field conditions.

Quality Assurance Plans:

EPA will operate comparison devices, including Hi-Vols, Lundgren impactors, LBL samplers and streakers in a side-by-side test in vicinity of portions of streaker network. Also check flows regularly before and after changing filter using flow meter. Analytical methods are checked through intercomparisons with other laboratories using similar and other methods.

Field Schedule:

Collect samples July 14-August 11.

Data Management Information:

Parameters measured: Elemental analysis of particulate samples, time of sample, place of sample.

Data volume: Between 600 and 700 analyses for each of 20 to 25 locations. Each analysis is as two sets of data, the first from Lithium to Chlorine, the second from Sulfur to Lead.

Data reduction: Because of complexity of analysis equipment, samples must be analyzed and data reduced at Florida State. Data reduction will be completed as facility utilization allows.

Data form: Magnetic tape and as a report.

Data needs: Require wind trajectories for each hour of sampling period, upper air data, gaseous pollutant concentrations for each RAMS station and precipitation data. These should be available before analysis of samples is begun.

Logistics and Services Required from RAPS/STL:

1. Require personnel to operate system - need to change filter once per week at each RAMS station, and check flow rate.

2. Require personnel to service samplers prior to July 15 to put samplers in running order.

Power Requirements:

Place at each RAMS station to plug in a standard 110 extension cord to carry about 2 amps.

Potential Problem Areas:

Replacement parts may be needed at some locations to make samplers operational.

Vacuum tubing will run from pump at base of mast to sampler at 30 ft. Caution must be exercised in other operations on the mast.

3.2.5 Dry Removal Processes

The removal of pollutants from the atmosphere under dry conditions (no precipitation) occurs as a result of gravitational settling for sufficiently large particles and turbulent transport, impaction, Brownian diffusion, and molecular diffusion for successively smaller particle sized and gaseous substances. The rate of removal for gases depends upon the chemical and physical nature of the ground surface, the presence of vegetation and the growth stage of the vegetation.

Of particular interest is the dry deposition velocity for sulfur dioxide. One approach is to use the gradient method for its determination. The deposition velocity is defined through the mass transfer relationship and experimentally determined via direct measurements of the SO2 vertical concentration gradient near the surface and the turbulent dispersion coefficient. Measurements should be made over several homogeneous surface types.

A mobile laboratory can also be utilized in removal experiments by comparing the flux of the pollutant of interest upwind and downwind of selected homogeneous surface types.

Efforts to measure the dry deposition velocity of sulfur dioxide for the summer of 1975 are presented on the following pages.

FIXED-SITE AND MOBILE-MODE
SO_2 DEPOSITION FLUX MEASUREMENTS
SUMMER 1975

Key Personnel:

W. Wilson, AARS-EPA
W. Dannevik, Environmental Quality Research, Inc.
R. Husar, Washington University, St. Louis

Research Goals:

Fixed-site: Assessment of reproducibility and representativeness of experimental technique and characterization of diurnal variability in dry deposition flux and velocity, under conditions of fixed site characteristics.

Mobile-mode: Characterization of absorption phenomena agricultural canopies and larger vegetation groupings.

General Experimental Design:

Experimental technique based on the flux/gradient (i.e., profile) method, in which vertical concentration profiles of SO_2 and turbulence parameters are combined to estimate vertical turbulent flux of SO_2 within the surface boundary layer.

This program represents a continuation of the Summer 1974 and Winter 1975 measurement series. A total of approximately 65 SO_2 deposition velocity measurements are planned.

Quality Assurance Plans:

Daily zeroing of Theta-Sensor SO_2 monitor utilizing charcoal filters is planned. It is hoped that the RAPS Winnebago mobile calibration laboratory can be used at least twice. Primary source for SO_2 vertical profiles is eight bubbles spaced in the lowest 6 meters above canopy and within canopy. Flow rate checks from mobile calibration laboratory would be desirable.

Field Schedule:

Fixed-Site Measurements: June 1 - July 12
Mobile Measurements: July 15 - August 31

Logistics and Service Required from RAPS/STL:

Access to weather facsimile and teletype service C data for operational planning purposes, and near-real time RAMS SO_2 data for siting of mobile measurements and go/no go for Fixed-site measurements would be very useful.

3.3 Pollutant Measurement Program

The Regional Air Pollution Study, being based upon the best available monitoring instrumentation at the time of its design, provides an excellent opportunity to test new instruments and techniques to monitor air quality. By use of some of these newly developed instruments, the RAMS approach to monitoring by selection of a point to represent a 1 km grid area can also be evaluated. Thus two types of experiments will be conducted, as shown in Figure 11:

1. Instrument evaluation studies-determining the strengths and weaknesses of newly developed instruments and instrument systems. These can be segregated as evaluation of gaseous pollutant monitors and evaluation of aerosol monitors because of the unique problems associates with each.

2. Variability studies - evaluating the variability of pollutant levels over a 1 km area around selected RAMS stations

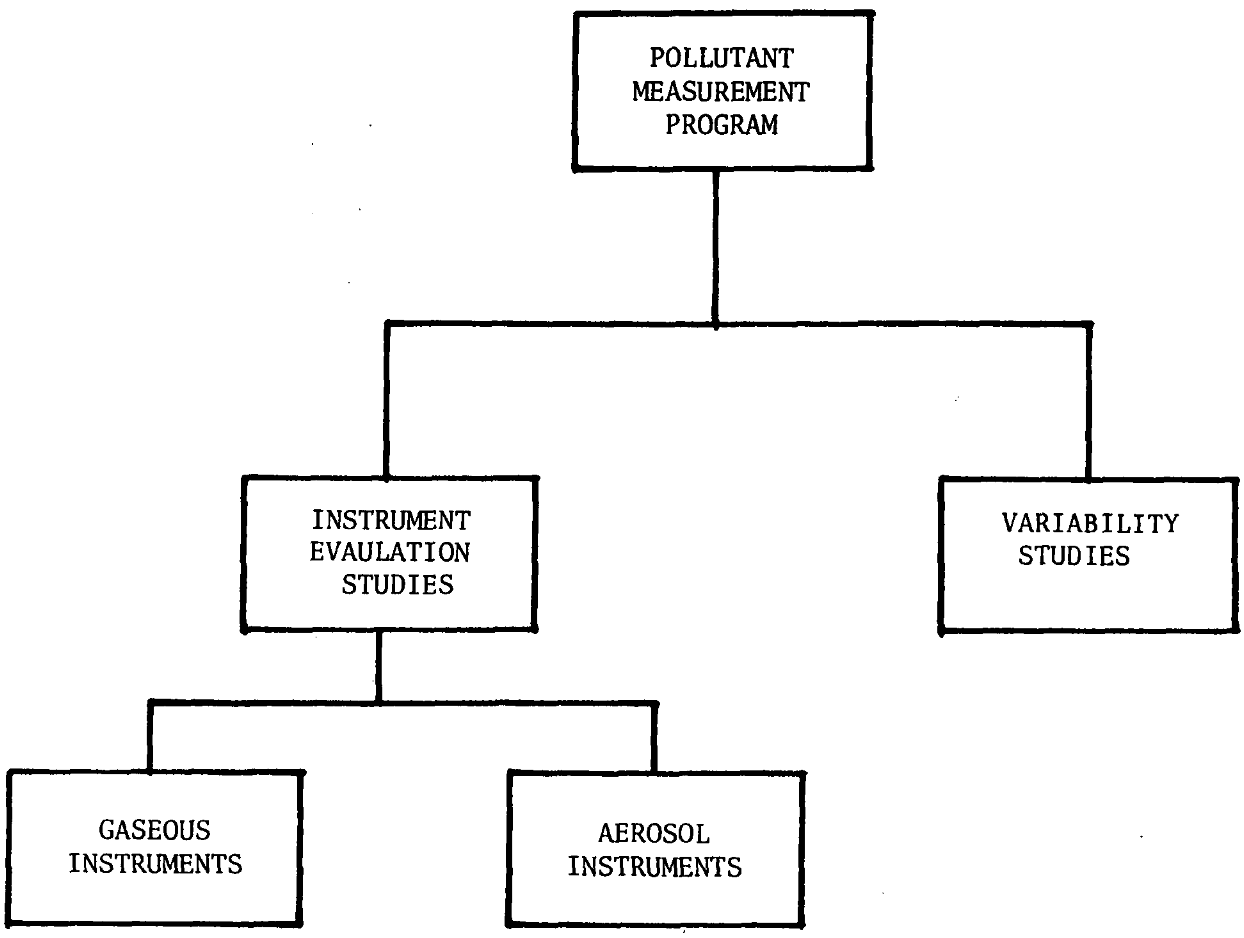


FIGURE 11 WORK BREAKDOWN OF POLLUTANT MEASUREMENT PROGRAM

3.3.1 Gas Monitoring Instrument Evaluation

New instrumentation for monitoring ambient levels of various gases will be evaluated under field conditions by comparison with RAMS results or other appropriate standards. The currently envisioned evaluations include the nitrogen dioxide laser-induced fluorescent monitor, the MIT laser system for carbon monoxide, ozone, nitric oxide and possibly ammonia, and the GE ILAMS for ozone, ammonia and ethylene. Others may be added as the programs develops.

The nitrogen dioxide monitor test is accomplished by running the unit in series with a RAMS chemiluminescent instrument and comparing the results. It is expected that the laser fluorescence monitor is more accurate than the RAMS instrument since it is a "non-destructive" method using the physical properties of nitrogen dioxide. The chemiluminescent unit requires the air stream to be reduced over a catalyst to form nitric oxide from the nitrogen dioxide. The nitric oxide is then detected by its chemiluminescence as it reacts with ozone to form nitrogen dioxide. The complexity of this process presents potential problems in accuracy. During the test periods, independent checks are made by wet chemical procedures.

In the evaluation of the open path monitors, portable monitors traverse the monitoring path and the averages thus obtained are compared with the laser system results. In this way the time and spatial averages determined by the open path monitors can be validated. Additional operational evaluation can be run as part of the pollutant variability experiments.

Long Path Monitoring
Summer 1975

Key Personnel:

E. Hinkley	MIT Lincoln Labs
R. Ku	MIT Lincoln Labs
J. Sample	MIT Lincoln Labs
J. Gormley	MIT Lincoln Labs
W. McClenny	EPA, Research Triangle Park, N.C.
L. Chaney	University of Michigan
G. Russervine	Northrup Corporation

Research Goals:

1. To compare real-time, path-averaged readings with point monitors at selected RAMS sites.
2. To conduct validation tests for a long path monitor, using portable point monitors.
3. To compare typical path-averaged readings at one rural and one urban RAMS site.
4. To provide a data base from which long path data can be used to check atmospheric model predictions.

General Experimental Design:

Trace gas concentrations are determined by measuring wavelength dependent attenuation of radiation over long atmospheric paths. The measurement system is located in a mobile van, the measurement path being defined by a steerable mirror which directs a laser beam to a remotely placed reflector. The mobile van will be set up at RAMS sites 108, 105 and one other location yet to be selected.

Quality Assurance Plans:

Calibrations established hourly by recording response due to standards. NBS certified standard reference materials (SRM's) will be used for calibration of NO and CO. Ultraviolet absorption will be used for established O_3 concentrations. Large concentrations of the target gas (NO, CO or O_3) with over-shoot paths are used to duplicate total gas burdens (average concentration times path distance) over the measurement path and thereby to establish a system calibration.

Pre-mix bottles of calibration gases will be checked by arranging a calibration check visit from the RAPS mobile calibration facility.

Field Schedule:

July 1 to July 28-Site 108

July 28 to August 15-Site 105

August 15 to November 1-not yet scheduled

Data Management Information:

Operational Data Needs.

RAMS readings for CO, NO, O_3 and total hydrocarbons plus wind direction, wind speed, dew point, barometric pressure and ambient temperature will be needed. Request key to RAMS stations 105 and 108 so that computer can be interrogated and specific pollutants can be measured on a recorder.

Post-Operational Data.

Written records of RAMS results giving one minute averages of specific pollutants during limited time spans (hours). Data request will be called in as information is required. This data will be requested frequently throughout the field exercises and will be used for day-after comparison with long path monitor.

Written record of RAMS results giving half-hourly averages for all pollutants and all meteorological conditions on all week days during which long path monitoring occurred. Needed only at end of each two week interval.

Data Plans:

Data reduction will take place at Lincoln Labs unless a HP 9830 is available in the mobile van in St. Louis.

Data formats will be suitable for input to the RAPS data base.

Logistics and Services Required from RAPS/STL:

1. Telephone-installed for period and at location as indicated under Schedule and Location.

2. Parking Space-30 ft. by 10 ft. required adjacent to the RAMS station.

3. Information-expected power shortage or voltage reduction, extreme weather conditions, and operational status of the monitors inside the closest RAMS station.

4. No requirements for on-site data processing at the central facility.

Power Requirements:

Electrical - 10 kw at sites 105 and 108 (these sites were used for the same purpose last summer so that no new installation should be required).

Potential Problem Area:

Weather.

Ammonia Measurements
Summer 1975

Key Personnel:

W.A. McClenny, G. Russiwurm-FMDS, CPL, NERC / RTP
L. Hrubesh-Lawrence Livermore Laboratory
C. Russovini-Northrup Corporation

Research Goals:

Determine ammonia levels characteristic of the St. Louis atmosphere.

Provide basic tests to determine sample integrity under typical ambient air conditions.

General Experimental Design:

A field test of several ammonia monitors is planned. This test is not necessarily connected with the RAPS, but it may be convenient to perform the tests at St. Louis University. Dr. L. Hrubesh of Lawrence Livermore Laboratory will provide a monitor based on microwave absorption, and a prototype chemiluminescence ammonia monitor will be used. A laboratory prototype of a new type of NH_3 monitor, known as an optoarvistic detector, will also be available for comparison.

Quality Assurance Plans:

Depend on monitoring unit selected but rely upon frequent calibration with appropriate reference materials.

Field Schedule:

August 15 to September 30 operation of unit.

Data Management Information:

Data will be reduced at RTP or Lawrence Livermore Laboratory and supplied as a report.

Logistics and Services Required from RAPS/STL:

None at this time.

Power Requirements:

Arrangements made at St. Louis University.

Potential Problem Areas:

None identified.

3.3.2 Aerosol Monitoring Instrument Evaluation

Aerosols, due to the diversity of their sources, physical properties, and chemical properties, present special challenges to air monitoring technology. As part of the pollutant measurement program, the Field Methods Development Section of the Chemistry Physics Lab is supervising an extensive array of instruments, devices and analytical methods used for aerosol measurements in the St. Louis atmosphere. These include both newly developed instrumentation and standard sampling devices. These are each teamed with established and new techniques for sample analysis. Some of the equipment and analysis methods being used are shown in Table 3. Newly developed instruments and methods will be added as they become available.

Experiment description for the summer of 1975 is presented on the pages following Table 3.

TABLE 3 - AEROSOL INSTRUMENTATION, SAMPLING EQUIPMENT

AND ANALYSIS TECHNIQUES

INSTRUMENTS AND SAMPLING EQUIPMENT	AEROSOL ANALYSIS TECHNIQUES
High Volume Samplers	Gravimetric mass determination
Manual Dichotomous Samplers	Ammonium by ion selective electrode
Lundgren Impactors	Acidity by Gran titration
Prototype Sulfuric Acid Aerosol Analyzer	Sulfate by Thorin titration
	Sulfate by flash volatilization
	Nitrate by electrode and colorimetric methods
	Carbon by combustion
	X-ray fluorescence
	Infra-red analysis for general ion content
	Valence state by electron scattering cross-section analysis
	Light elements (Li to Cl) by proton scattering

Aerosol Measurements

Summer 1975

Key Personnel:

R. Baumgardner - FMDS/EPA
T. Dzubay - FMDS/EPA
L. Hines - FMDS/EPA
P. Lamothe - FMDS/EPA
C. Sawicki - FMDS/EPA
R. Stevens - FMDS/EPA
T. Novakov - Lawrence Venkley Laboratory
P. Cunningham - Argonne National Laboratory
J. Moyers - University of Arizona
R. Husar - Washington University

Research Goals:

1. To field test and evaluate several methods for aerosol sampling and analysis which are being developed by FMDS and other contractors and participants.

2. To conduct the tests at one rural RAMS site in order to test the methods with a wide range of concentrations and chemical species.

3. To test the comparability between samples collected in manual dichotomous samplers which we will provide and samples collected by the automated dichotomous samplers within the RAMS stations.

4. To test ability of methods for determining the mass balance of aerosol in two size ranges by measuring mass, carbon, nitrate, ammonium ions, oxidation states of nitrogen and sulfur, total sulfur, sulfate, sulfuric acid, strong acid and elemental composition.

General Experimental Design:

A mobile laboratory will be set up at both an urban site (RAMS 106) and a rural site (RAMS 124). This van will contain a Sulfuric Acid Aerosol Analyzer, a prototype Ultrasensitive Sulfur Dioxide Monitor, a prototype Ammonia Monitor, and a beta gauge mass monitor. Also operated in conjunction with the van are a High Volume Sampler (Hi Vol), five Manual Dichotomous Samplers (MDS), a Lundgren Impactor, a Sulfuric Acid Sampler, one Automated Dichotomous Sampler (ADS), and a Florida State University "Streaker."

Some relevant details of the MDS and ADS are shown in Table 4. The utilization of filter media in the samplers is shown in Table 5. A summary of measurements for determining mass balance is presented in Table 6, and Table 7 contracts various techniques for the analysis of sulfur and sulfur-related materials.

TABLE 4 - DETAILS OF THE MANUAL AND AUTOMATED DICHOTOMOUS SAMPLER (MDS AND ADS)

	Size Range	Size Code	Filter dia., mm	Sample dia., mm	Flow Rate l/min.
MDS					
Fine	0-3.5	F	37	29	14
Coarse	3.5-20	C	37	29	14
Total	0-20	T	126	114	200
ADS					
Fine	0-24	F	37	28	50
Coarse	2.4-20	C	37	28	50

TABLE 5 - UTILIZATION OF FILTER MEDIA IN MDS AND HI VOL SAMPLER

Sampler	Fine	Coarse	Total
MDS 1	Fluoropore	Fluoropore	Quartz
MDS 2	Fluoropore	Fluoropore	Glass Fiber
MDS 3	Fluoropore	Fluoropore	Quartz
MDS 4	Fluoropore	Fluoropore	Quartz
MDS 5	Quartz	Quartz	Glass Fiber
Hi Vol	Quartz	Quartz	Glass Fiber
ADS	Cellulosic	Cellulosic	Glass Fiber

*Hi Vol Flow Rate: 1000 l/min (35 dfm)

In addition, an infra-red analysis of aerosols collected in the Lundgren impactor will be performed by Cunningham of Argonne National Laboratory, and sulfuric acid analysis by a low temperature volatilization technique will be made by Lamothe of FMDS/EPA.

TABLE 6

SUMMARY OF MEASUREMENTS FOR DETERMINING MASS BALANCE

Parameter	Sampler	Size Code	Method	Lab
Mass	MDS, HiVol	F,C,T	Gravimetric	EPA
Mass	ADS	F,C	Beta Gauge	LBL
Mass	Two Mass	F,T	Beta Gauge	WU
Elemental (Z>12)	ADS	F,C	XRF	LBL
Elemental (Z>20)	Streaker	T	Proton Scattering	FSU
Ammonium	MDS	F,C, T	Ion Selective Electrode	Northrup
Strong acid	MDS	F,C, T	Gran titration	Northrup
Sulfate			See Table 7	
Nitrate	MDS	F,C, T	Electrode Colorimetric	Ariz. U
Carbon	MDS	F,C, T	Combustion	EPA

TABLE 7

ANALYSIS OF SULFUR AND SULFUR COMPOUNDS

DURING SUMMER, 1975

Parameter	Method	Investigator	Sampler
S	XRF	Loo (LBL)	ADS
S	Proton Scattering	Nelson (FSU)	Streaker
S	XRF	Northrup	MDS 1,2,3, 4
$SO_4^=$	Thorin Titration	Northrup	MDS 1
$SO_4^=$	NASN	AIHL	MDS 5
$SO_4^=$	AIHL	AIHL	MDS 5
	Barium Chloranilate		
Soluble S	Flash Volatitization	Husar	MDS 3
Oxides of S	ESCA (S, $S^=$, $SO_3^=$, $SO_4^=$)	Novakov	MDS 4
NH4+	Ion Selective Electrode	Northrup	MDS 1
H^+	Gran Titration	Northrup	MDS 1

Quality Assurance Plans:

Standard laboratory quality assurance checks will be made for the laboratory analyses. The other equipment will be checked for proper flow-rates and results compared between equipment. Calibration standards traceable to NBS will be used as appropriate for the monitoring equipment.

Field Schedule:

- o Manual Dichotomous Sampler

  August 10 - 31
  12:15 PM to 11:45 AM (23½ hours)

- o Automated Dichotomous Sampler

Urban site (106)	2 hours	August 10 - 25
	12 hours	August 25 - 31
Rural site (124)	2 hours	August 10 - 25
	12 hours	August 25 - 31

- o RTI Van

Urban site	August 10 - 20
Rural site	August 20 - 31

Data Management Information:

Plans not complete.

Logistics and Services Required from RAPS/STL:

1. Permission to operate the specified equipment at the requested urban and rural sites. At the urban site it will be necessary to operate all of the samplers and the van within the fenced-in security area. At the rural site, at least the samplers must be within the fenced-in area.

2. Four (4) keys for unlocking the gates and doors.

3. Six (6) 20A, 115 V, 60 Hz circuits. Two outdoor outlets are needed for each circuit.

4. For the automated dichotomous samplers operated within RAMS at the two sites, please change the sampling interval from 2 hours to 12 hours at Noon, August 25.

5. Power drop for the instrumented van at the urban and rural sites; a fused switch box, 100 A, 220 V is needed.

6. Parking place for the 32-foot long instrumented van is needed at both the urban and rural sites.

7. The above power drop must be located within 45 feet of the parking place for the van.

Power Requirements:

At the two selected RAMS stations, six 20 A, 115 V, 60 Hz circuits and one 100 A, 220 V, 60 Hz circuit are needed.

Potential Problem Area:

None identified.

3.3.3. Variability Studies

The siting criteria employed for the RAMS sitings and various quality assurance and data validation procedures used in the RAMS measurements were instituted to minimize instrument-related errors and unrepresentative siting effects. However, natural fluctuations over the one kilometer square grid employed by most mathematical simulation models are still expected. These variability studies quantitatively assess the representativeness of the RAMS air quality and meteorological observations and/or the degree of ambient variability with which the computations of mathematical simulation models may be verified effectively and their dependency upon emission field and land use variations.

Pollutant variability is measured utilizing several different systems. These include open path monitors, such as the MIT tunable laser system, the GE ILAMS gas laser system, and the Barringer COSPEC III operated by Environmental Measurements, Inc.; portable monitors than can be carried by a man or small vehicle; a mobile unit carrying and array of air quality instrumentation similar to the RAMS instrumentation; and bag samplers. The initial effort is to develop a coordinated methodology leading to more extensive subsequent field expeditions. In these experiments, measurements of sulfur dioxide, ozone and carbon monoxide are made with the portable units and later by the open path units. The mobile unit is also able to monitor these pollutants and nitrogen oxides, hydrocarbons and aerosols (by Nephelometry).

The portable and mobile units are deployed to determine the spatial and temporal pollutant variability by traveling along prescribed paths or by being stationed along prescribed paths. In either case, spatial and temporal variabilities are obtained from which averages and variances are calculated.

The open path units measure the average values of the various pollutants over a prescribed area around a RAMS station by setting up various measurement paths centered at the station. These values are compared with the RAMS output to determine how representative the RAMS results are of the area and the relationships between the results.

Bag samples allow an independent check on the average values of relatively non-reactive pollutants by continuous sampling along prescribed paths and subsequent analysis of the contents of the bag.

The meteorological variability experiments determine, for specified areas, the meteorological heterogeneity in order to parameterize the relationship between point (station) measurements and grid-averaged measurements. The basic approach is to use a mobile van traversing specified one square kilometer areas around selected RAMS stations. The selected areas have land use patterns which result in relatively homogeneous aerodynamic roughness. The van makes temperature and humidity measurements along a prescribed travel pattern in the area of interest, with extra measurements being made during transitional periods.

The variability study planned for the summer of 1975 is described on the following pages.

Pollutant Variability
Summer 1975

Key Personnel:

W.A. McClenny, R.J. Paur-FMDS, CPL, NERC/RTP
L.W. Chaney-University of Michigan
R.T. Ku, E.D. Hinkley, F.O. Sample-MIT Lincoln Labs

Research Goals:

1. To compare readings at the RAMS stations with readings taken in the area which the station represents.

2. To determine subgrid pollutant variability at selected sites and under various macro-meteorological conditions.

3. To determine any siting bias inherent in the placement of the RAMS station at selected sites.

General Experimental Design:

MIT open path monitor located near RAMS sites 108 and 105 to measure concentrations of carbon monoxide, nitric oxide and ozone over four paths placed in quadrants surrounding the RAMS station. Path length will be between 0.5 and 1 km.

Point monitors are carried across the site area or located in selected sites around RAMS station. Point monitors are used to check experimental values obtained with path monitors. Both point monitors and path monitors are then compared with RAMS readings. Subsequent analysis establishes degree of correlation and nature of relationship between grid-average and RAMS. Representativeness of RAMS data is also obtained by comparison with field instrumentation results.

Quality Assurance Plans:

Calibration of point monitors will be accomplished using 1% neutral buffered potassium iodide for ozone and standard cylinders for carbon monoxide and nitric oxide. These will be checked using gas phase titration and ultraviolet absorption for ozone, and referencing nitric oxide levels to ozone by gas titration.

Field Schedule:

July 1 to July 28 - Site 108

July 28 to August 15 - Site 105

Data Management Information:

Parameters measured: Concentrations of CO, NO and O_3 as analog signals on chart recorders.

Data Volume: Approximately 45 days (at six hours per day) of data will be recorded.

Data Reduction: L. Chaney at University of Michigan will reduce variability data by 1 December 1975. Data will be reduced in St. Louis or at University of Michigan.

E.D. Hinkley, et al, will process long path data to incorporate calibration sequences. Tapes of data will be made available to RAPS data manager with approximately one month's lag time.

Data Form: Tapes with data averaged over time periods compatible with needs of Data Management for long path experiments. Reports on pollutant variability and RAMS representativeness.

Logistics and Services Required From RAPS/STL

Two copies of a Daily Report of CO, NO, O_3 and all meteorological data for stations 105 and 108 for 9 A.M. to 5 P.M., June 23 and September 30 as 10 min. averages and as 1 min. averages for selected time periods.

Request four periods of pollutant variability data at site 108 between June 23 and August 1, using Las Vegas helicopters.

Access to the RAMS stations 105 and 108 to make comparisons with the station readings for SO_2, NO, NO_x, CO and O_3.

Permission to use a recorder at sites 105 and 108.

Power Requirements:

Existing station outlets for van at 105 and 108.

Potential Problem Areas:

If computer in van develops a problem, may wish long path tapes to be processed at Central Facility.

No pollutant variability studies when raining; long path studies can continue.

3.4 Pollutant Effects Studies

Air pollution problems are concerned not only with engineering, chemistry, physics and meteorology, but also have large-scale impacts on the economic and social life of a community and a nation. The Regional Air Pollution Study does not have as a goal the quantification of these impacts; however, it provides an unparalleled opportunity for other studies to be conducted toward accumulating information on these community air pollution impacts. If these additional studies collect the necessary economic and social data for the St. Louis area, they can be related to the RAPS data on detailed air pollution concentrations and exposure. The resulting correlations between detailed physical and social information on air pollution within the community should lead to an increased understanding and more accurate assessment of the actual impact of air pollution on the life of a community.

There are several obvious costs of air pollution to the community. These include damage to health, damage to property through corrosion and staining, and reduced property values due to the unwillingness of buyers to accept obvious impacts of air pollution, such as increased dust, odors, etc. It is presently planned to investigate the first two of these in conjunction with the RAPS as ongoing programs not necessarily related to the Summer 1975 experimental period. Information on the studies is included to make the RAPS participants aware of these programs.

3.4.1 Damage to Health

The Human Studies Laboratory of the Environmental Protection Agency has arranged with St. Louis University Medical School to investigate some of the relationships between human health and air pollution. This study will be carried-out in two phases. Phase one, which will be complete prior to July 1, 1975, is a study of between 10 and 20 letter carriers from the Benton Park Postal Station. These will all be male non-smokers who work outside all day in an area with relatively high air pollution. All will be given a thorough physical, including pulmonary function and chest x-rays, and an extensive medical history taken. Then for an eight-week period they will receive an examination each work-day after they return from their rounds. This includes pulmonary function, chest examination, blood examination for carbon monoxide effects, and appropriate cultures and other blood analysis. At the same time, air quality data will be acquired from the local RAMS station (Station 105) and correlations with the health data sought.

Phase two will start in October 1975, and consists of a study of about ten asthmatics and ten healthy non-smokers. These people will live in the general area of the Benton Park Postal Station. The asthmatics will be selected from regular patients of the St. Louis University Hospital Clinic. These people will be visited daily by a physician to examine the person, including pulmonary function, etc., as with the postal workers. Any respiratory problems will be reported, and these reports will be compared with the RAMS air quality data (Station 105) to evaluate the role of air pollution in aggravating respiratory problems.

In Phase two, an instrument designed to continuously monitor aero-allergens will be installed and operated in Station 105 and its readings included with the air quality data to preclude interference by unusual levels of pollens, molds, etc., during the season when this may be a problem.

3.4.2 Damage to Materials

The Materials Section of the Environmental Protection Agency has been conducting controlled environment chamber studies to assess the damaging effects of air pollutants - SO_2, NO_2, O_3 - on various materials. From the data, dose-response relationships and damage predictive equations are being developed. Field studies are now being conducted to complement the laboratory work. These field studies attempt to evaluate the overall agreement between the laboratory results and real world damage observed and measured under ambient environmental conditions. The RAPS offers an ideal opportunity to make these comparisons, in terms of the nature of the pollutants, high degree of monitoring network sophistication, and sufficient number and placement of sites.

Nine exposure sites at existing RAMS network monitoring sites in greater St. Louis have been selected for these tests. They are sites 103, 105, 106, 108, 112, 115, 118, 120 and 122. The sites reflect a concentration gradient of atmospheric sulfur pollutants, primarily from steam power generating facilities.

The materials to be exposed in this study are:

1. Galvanized Steel.
2. Weathering Steel - Corten A, U. S. Steel Corp.
3. Aluminum.
4. Household Paints - Oil Base and Latex.
5. White Cherokee Marble.
6. Silver.
7. Textiles - Nylon Hose.

The materials effects data is evaluated and attempts made to establish cause - effect relationships by statistically analyzing the effects data and corresponding air quality data.

4. RAPS STATUS

4.1 Status of Model Evaluation and Development

Several models are in the process of being adapted to St. Louis so that evaluation can be made utilizing the RAPS data base. Potential candidate models which may be considered include:

1. IBM sulfur dioxide model.
2. Lawrence Livermore Laboratory's LIRAC-1 and LIRAC-2.
3. Environmental Research and Technology Model.
4. Model by the Center for the Environment and Man.
5. Xonics CAPSE, MADCAP, and others.
6. System Application Inc.
7. General Research Corporation photochemical model.
8. Systems, Science and Software's PICK.
9. Several Gaussian models for inert species.
10. Hanna's model and other approaches to photochemical modeling.

At present the major problem is a lack of inventory data. Presently available are the NEDS point source yearly averages for 1970 and the NEDS area source yearly averages for 1970 on a non-RAPS grid system. In July, it is expected that the RAPS sulfur dioxide point source hourly average inventory will be available. However, the RAPS sulfur dioxide area source hourly averages will not be available until spring of 1976. Work is therefore proceeding on adapting the 1973 NEDS area source inventory to the RAPS grid system for use with the RAPS point source data. This should be completed by fall of 1975 so that evaluation efforts can proceed.

4.2 Status of RAPS Data Bank

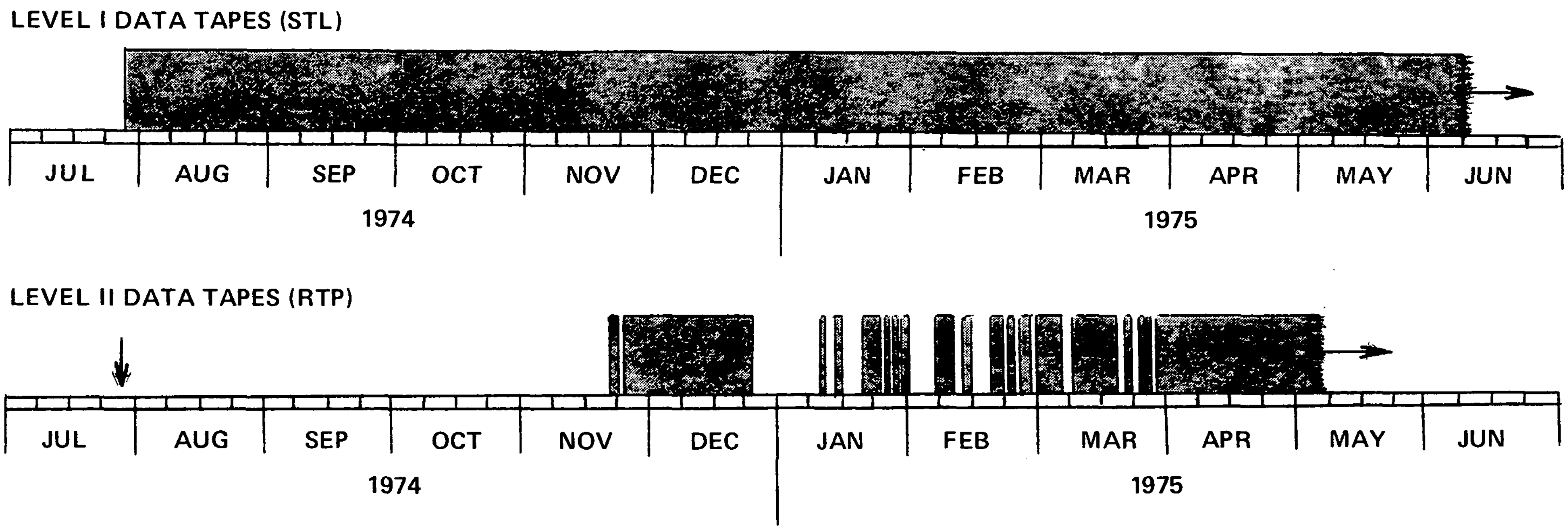
The RAPS data bank consists primarily of the RAMS data. Data from the UASN is being incorporated as software allows, and the data from expeditionary research programs and the emission inventory is included as it becomes available. The RAMS data is compiled from the stations onto Level I tapes (voltages). This is then processed in St. Louis to convert to engineering units in appropriate format, apply calibration factors, and perform status checks to eliminate data from improperly operating instruments. This generates a

Level II tape. The data from each instrument is then compared with allowable "windows" for the data, and data beyond the limits are flagged. This processing is presently done at Research Triangle Park, but will be shifted to St. Louis in the near future. Presently, these Level II tapes are placed in an archive. As software is developed later this year, all these tapes will undergo Level III and Level IV checks. At Level III, each station's data will be statistically checked for consistency over time and that which is found inconsistent will be flagged. At Level IV the data from different stations will be statistically compared for consistency over space (network consistency) and that which does not meet criteria for acceptability will be identified in a like manner.

Figure 12 summarized the present status of the data bank. Level I tapes have been accumulated since the startup of the RAMS in July, 1974. Only a portion of these have been processed to Level II and placed in the archive. The remaining tapes will be processed as soon as software can be adapted to other computer facilities. New tapes will be processed as they are received.

FIGURE 12

AVAILABILITY OF RAMS DATA TAPES AT LEVEL I IN ST. LOUIS (STL)
AND LEVEL II IN RESEARCH TRIANGLE PARK (RTP)



4.3 Status of Emission Inventory

The RAPS emission inventory efforts consist of twenty-one separate but related projects. The overall status of the inventory is shown in Table 8. The status of each individual project is presented in Table 9. Of particular interest is the RAPS Emission Inventory Handbook which summarized the methodologies being used for the evaluation of each type of source. The Table of Contents for this report is attached to this section as Exhibit 1. Also of interest is the design of the RAPS emission inventory data handling system. A copy of the design is included in this section as Exhibit 2. It presents examples of the output format for data from the inventory.

TABLE 8 - OVERALL STATUS OF RAPS EMISSION INVENTORY

INFORMATION	AVAILABILITY
1. NEDS POINT SOURCES (YEARLY AVERAGE)	YES
2. NEDS AREA SOURCES (YEARLY AVERAGE, 1970) (APPORTIONED TO NON RAPS GRID SYSTEM)	YES
3. RAPS POINT SOURCES (HOURLY AVERAGE)	JULY
4. NEDS AREA SOURCES (YEARLY AVERAGE, 1973) (APPORTIONED TO RAPS GRIDS)	FALL 1975
5. RAPS AREA SOURCES (HOURLY AVERAGE)	SPRING 1976

TABLE 9 - STATUS OF RAPS INVENTORY PROJECTS

	PROJECT	ANTICIPATED COMPLETION DATE	REPORT AVAILABLE
1.	RAPS PRELIMINARY EMISSION INVENTORY	COMPLETE	YES
2.	VESSEL METHODOLOGY & INVENTORY (DOT/TSC)	JAN-75	BEING PRINTED
3.	RAIL METHODOLOGY & INVENTORY (DOT/TSC)	JULY-75	NO
4.	AIRPORT METHODOLOGY & INVENTORY	COMPLETE	YES
5.	STATIONARY AREA SOURCE METHODOLOGY AND INVENTORY	JUNE-75	NO
6.	OFF-HIGHWAY MOBILE SOURCE METHODOLOGY	COMPLETE	YES
7.	DATA HANDLING SYSTEM	APR-75	NO
8.	FIELD EXPEDITION SUPPORT METHODOLOGY	COMPLETE	BEING PRINTED
9.	HIGHWAY LINE SOURCE METHODOLOGY	COMPLETE	BEING PRINTED
10.	HIGHWAY LINE SOURCE MEASUREMENTS (DOT/FHWA)	MAR-75	NO
11.	POINT & AREA HC COMPONENT METHODOLOGY	COMPLETE	YES
12.	EMISSION INVENTORY HANDBOOK	MAY-75	BEING PRINTED
13.	POINT SOURCE METHODOLOGY AND INVENTORY	COMPLETE	BEING PRINTED
14.	HEAT METHODOLOGY & INVENTORY	JULY-75	NO
15.	PRECISION ANALYSIS	AUG-75	NO
16.	STATIONARY INVENTORY OF SO_2 COMPONENTS AND PARTICLE SIZE DISTRIBUTION	NOV-75	NO
17.	NON-CRITERIA POLLUTANT INVENTORY	NOV-75	NO
18.	AUTOMOTIVE AREA SOURCE METHODOLOGY & INVENTORY	NOV-75	NO
19.	FUGITIVE DUST METHODOLOGY AND INVENTORY	OCT-75	NO
20.	SOURCE TESTING FOR EMISSION FACTORS	JUNE-76	NO
21.	EVALUATION & FIELD VALIDATION METHODOLOGY OF EMISSION MODELS	MAR-76	NO

EXHIBIT 1

TABLE OF CONTENTS

R A P S

EMISSION INVENTORY HANDBOOK

RAPS Emission Inventory Handbook

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H. Line Sources

Highway (Line Source) Methodology
Railroad Methodology and Inventory

I. Emission Models

J. Validation of Area and Line Emission Models

Validation Methodology
Field Measurements

K. RAPS Emission Inventory Data Handling System

Purpose and Scope
Hardware System
Software Development

L. Information Transfer

EXHIBIT 2

R A P S

EMISSION INVENTORY DATA HANDLING SYSTEM

RETRIEVAL DESIGN

SC553.T020CR March 5, 1975

REGIONAL AIR POLLUTION STUDY

100% Completion Report for Task Order No. 20
Step III - Retrieval Design

RAPS Emission Inventory Data Handling System

General Order No. 553

Contract No. 68-02-1081

Prepared For

ENVIRONMENTAL PROTECTION AGENCY

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by

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STEP III
Retrieval Design

1.0 INTRODUCTION

This report details the results of Rockwell's efforts in design of retrieval formats for the RAPS Emission Inventory. Summary reports similar to those commonly used in NEDS have been formatted with provision for hourly or other time interval data in tabular form. For consistency, data for input to the modeling program will be formatted in a manner similar to the input formats; the modeler will select the fields of interest. Retrieval may be made on any element of the data base which was defined as key (in Step IV report), by a user accessing the data base directly through System 2000. The retrieval keys available to the user through the RAPS Emission Inventory Data Handling System were initially defined in the Step II report and will be detailed in Section 4.

2.0 SUMMARY FORMATS

Four formatted summaries will be available to the user through the RAPS Emission Inventory Data Handling System:

1. Complete Point Source Listing
2. A Condensed Point Source Listing
3. A Daily Summary
4. A Complete Data Base Dump Selectable by Plant or Area.

2.1 Point Source Listing

An example of the format for the RAPS Emission Inventory Point Source Listing appears as Figure I. Tabulation of the data continues for as many pages as required. For a given plant, the descriptive information appears on the first page only; the main heading reflecting data and page number and the column headings are repeated on each page. Data may be tabulated for any of the time intervals allowed as retrieval keys.

2.2 Condensed Point Source Listing

A sample of the format for the Condensed Point Source Listing appears as Figure II. As for the Point Source Listing all time interval data 's in tabular form with descriptive information on the first page only; date and page identifier and column headings appear on each page.

FIGURE I

POINT SOURCE LISTING

NAME: ILL. POWER COMPANY
ADDRESS: WOOD RVR STA EAST ALTON 92024
CITY(000): UNKNOWN
COUNTY(4680): MADISON CO
STATE(14): ILLINOIS

PLANT ID: 0001
POINT ID: 01
AQCR(70): METROPOLITAN ST. LOUIS
SIC(4911): ELECTRIC SERVICES
OWNERSHIP: UNKNOWN

SCC(1-01-002-02): EXTCOMB -ELECTRIC GENERATN-BITUMINOUS COAL ->100MMBTU PULVDRY

UTM GRID COORDINATES	STACK PARAMETERS	EMMISSION FACTORS	FUEL CONTENT
UTM ZONE: 0015	STACK HEIGHT: 0250	SO2: AP-42	SULFUR: 2.90%
HORIZONTAL: 748.70 KM	STACK DIAMETER: 015.5	CO: AP-42	ASH: 10.6%
VERTICAL: 4305.40 KM	GAS TEMPERATURE: 0329	NOX: AP-42	HEAT: 22 MBTU/TON
	GAS FLOW RATE: 0154649	HC: AP-42	
	PLUME HT(NO STACK):0000	PART: AP-42	

CONTROL EQUIPMENT

POLLUTANT:	***** SO2 *****	***** CO *****	***** NOX *****	***** AC *****	**** PARTICULATE **
PRIMARY:	NONE	NONE	NONE	NONE	GRAVITY COLLECTOR
SECONDARY:	NONE	NONE	NONE	NONE	NONE
EFFICIENCIES:	00.0%	00.0%	00.0%	00.0%	15.0%

****

COMPUTER CALCULATED EMISSIONS

DATE	HOUR	SO2	CO	NOX	HC	PART
10/03/74	01	104.0 KG	8.5 KG			
10/03/74	02	105.7 KG	8.1 KG			
10/03/74	03	106.4 KG	7.7 KG	35.0 GM		
.	.	.	.	.		
.	.	.	.	.		
.	.	.	.	.		

CONDENSED POINT SOURCE LISTING FOR PARTICULATE
FOR ALL VALUES > THAN OR = TO 0
EMISSIONS ARE IN KILOGRAMS PER HOUR

* * * * * * * * * * * * * * * * * *

0001: ILL. POWER COMPANY — POINT: 01
WOOD RVR STA EAST ALTON 92026 — OWNERSHIP:UNKNOWN
4680: MADISON — SIC: 4911
14: ILLINOIS — SCC: 1-01-002-02
070: METROPOLITAN ST. LOUIS
123: GRAVITY COLLECTOR — EFF= 15 %

* * * * EMISSIONS IN KG * * * *

DATE	HOUR	SO2	CO	NOX	HC	PART
10/03/74	01	104.0	8.5	7.3	2.0	
10/03/74	02	105.7	8.1	6.9	2.2	
10/03/74	03	106.2	7.8	6.5	2.3	.2

2.3 Point Source Daily Summary

An example of a daily summary is included as Figure III. Daily totals for the five pollutants of interest are tabulated by SCC sub-fields I, II, and III. All categories relative to the St. Louis inventories will be included in the summary.

2.4 Data Base Dump

To ensure data base integrity or allow correction of misplaced data, the List Command in the Immediate Access mode may be invoked to produce an indented listing of data base contents selectable by level ∅ entry in the data base. (A level ∅ entry for Point Source is a Plant). This listing should allow detection of incorrect insertions into the data base, and enable deletion and reinsertion of the entries.

* The dump feature necessitates inclusion of the Report Type DUMP as an acceptable entry on Card 8, columns 1-4.

FIGURE III

MM/DD/YY PS ST. LOUIS EMISSION INVENTORY PAGE 1

POINT SOURCE DAILY SUMMARY

FOR AQCR 070 ON MM/DD/YY

FUEL COMBUSTION ***************	PARTICULATES ************ KG/DAY	SO2 ************ KG/DAY	NOX ************ KG/DAY	HC ************ KG/DAY	CO ************ KG/DAY
EXTERNAL COMBUSTION					
ELECTRIC GENERATION					
BITUMINOUS COAL	____	____	____	____	____
RESIDUAL OIL	____	____	____	____	____
DISTILLATE OIL	____	____	____	____	____
NATURAL GAS	____	____	____	____	____
TOTAL (ELEC GEN)	____	____	____	____	____
INDUSTRIAL FUEL					
BITUMINOUS COAL	____	____	____	____	____
RESIDUAL OIL	____	____	____	____	____
DISTILLATE OIL	____	____	____	____	____
NATURAL GAS	____	____	____	____	____
PROCESS GAS	____	____	____	____	____
WOOD	____	____	____	____	____
LIQUID PETROL GAS	____	____	____	____	____
TOTAL (INDUSTRIAL)	____	____	____	____	____
COMM-INSTITUTIONAL FUEL					
BITUMINOUS COAL	— ETC —				
RESIDUAL OIL					
DISTILLATE OIL					
NATURAL GAS					
LPG					
TOTAL (COM-INST)					

3.0 MODELING TAPE FORMATS

Upon request from the user ** a tape containing the requested subset of the data base will be produced; the tape will contain the data in card image format. Should the requested time interval for the data differ from that stored in the data base, the appropriate model will be applied and the requested time interval data will be calculated.

Only the data card format will differ from the input formats (see Step II Report); cards 1-4 will contain the same information as on input but with columns 72-80 left blank. To avoid redundancy in the data descriptors for card type 5, all 80 columns of the card image will be utilized; data will be present in 16 fields of width 5. The start and stop times determine the quantity of data present in the card type 5 images.

4.0 RETRIEVAL KEYS

Retrieval may be made directly on any element of the data base defined as key. (See Appendix A, Step II Report; or, Step IV Report, Section 4)

Card type 7 contains fields for each of the RAPS Emission Inventory Data Handling System retrieval keys. These keys include those available through NEDS. Retrieval is made by inserting the acceptable entry on which the data is to be selected in the appropriate field as defined in Step II. The following are the component keys for retrieval under the data handling system.

1. State
2. UTM Zone
3. County
4. City
5. Area ID
6. Plant ID
7. Stack ID
8. Point ID
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The immediate goal of the Regional Air Pollution Study (RAPS) is the evaluation of existing local and regional scale air quality simulation models. Inherent in this effort is the creation of a comprehensive, accurate, and readily-retrieval data base containing emission rates, concentrations of atmospheric pollutants, and pertinent meteorological measurements. An integrated program has been prepared for the conduct of the RAPS which includes data collection on both a routine and an expeditionary basis. This report describes the Summer 1975 RAPS Expeditionary Research Program which was designed to procure detailed atmospheric observations to better understand selected pollutant and atmospheric phenomena. Data collection activities are described in each of four areas: (1) Pollutant Transport and Dispersion; (2) Pollutant Transformation and Removal; (3) Pollutant Measurement Program; (4) Pollutant Effects Studies. The general experiment design, quality assurance plans, data management procedures, and operational requirements are presented for each experiment to be conducted. Finally, existing information is summarized in the form of status reports for three basic elements of activity within RAPS; (1) Model Evaluation and Development; (2) RAPS Data Bank; (3) Emission Inventories.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
*Air Pollution		13B
*Surveys		14B
Meteorological data		04B
Atmospheric Disperion		04A
Transport properties		14G
Chemical analysis		07D
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