INTRODUCTION

This document is the first edition of the PAMS Data Analysis "Results" Report, a summary and compilation of salient examples and illustrations of the uses of data from the Photochemical Assessment Monitoring Stations (PAMS) program[1]. As such, the Report utilizes examples of analyses available at the time of its development and contains no independent or "new" analyses. However, this Report will be updated periodically and will include the results of future analyses performed by the Office of Air Quality Planning and Standards (OAQPS) and others. The Report summarizes the current state of PAMS data analysis as a vehicle for transferring the resultant techniques and insights, and encouraging a dialogue among analysts using the data.

I.1 PURPOSE

This report is intended to capture the best examples of the uses of PAMS data to understand the tropospheric ozone issue and to motivate regulatory and control program activity. Although the design is to show "what can be done" with PAMS data, the hope is that these examples will also serve to catalyze a commitment to making full use of this rich data set, to instruct those interested in analyzing the data and to, some degree, help guide those endeavors. In no case, have all existing examples been used. Instead, those of greatest illustrative power or unique character have been chosen for inclusion.

The primary audience for this Report is comprised of air quality data analysts charged with and/or interested in using the PAMS data. Obviously, the document also addresses issues and covers subjects which are of importance to ozone control program and regulatory staff, as well as photochemical modelers. Finally, through this Report, policy and decision-makers grappling with the complex issues of the tropospheric ozone will discover the applicability and relevancy of PAMS data to this environmental challenge.

I.2 DOCUMENT ORGANIZATION

The report is organized into the following five chapters:

- Characterization of ambient air quality data for ozone and its precursors;
- PAMS data in support of ozone modeling applications;
- Evaluating emissions factors, models and inventories with PAMS data;

[1] 40 CFR 58 Subpart E.

- Observational based methods for determining VOC/NO_x effectiveness; and
- Quality assurance.

The order of the subject matter implies neither a suggested sequence for the reader nor a required process for analyzing data from the PAMS program. Each chapter is constructed as a"stand alone" description of the associated subject and therefore can be read independently. An effort has been made through citations and footnotes to "link" all examples which transcend the individual chapters allowing the reader to reference previous discussions which dealt with the example of interest. The figures and tables for each chapter have been appended to the end of the respective text in the order presented in the material.

I.3 PAMS - A BRIEF DESCRIPTION

I.3.1 Why PAMS?

Of the six criteria pollutants, the most pervasive environmental problem continues to be ozone. The most prevalent photochemical oxidant and an important contributor to "smog", ozone is unique among the NAAQS pollutants in that it is not emitted directly into the air, but instead results from complex chemical reactions in the atmosphere between volatile organic compounds (VOCs) and nitrogen oxide (NO_x) emissions in the presence of sunlight. Further, there are literally thousands of sources of VOCs and NO_x across the country. To track and control ozone we need to understand not only the pollutant itself, but also the chemicals, reactions, and conditions that go into forming it.

In 1991, the National Academy of Sciences (NAS) released a report entitled, Rethinking the Ozone Problem in Urban and Regional Air Pollution, criticizing the EPA for failing to establish monitoring networks to adequately track trends in ozone precursor emissions, corroborate emission inventories, and support photochemical modeling. In accordance with the "enhanced monitoring" provisions of Title I of the Clean Air Act Amendments of 1990, EPA developed the PAMS program to address the concerns raised by the NAS[2,3]. The PAMS program reflects the need to complement the Agency's historically based emissions modeling approach with

[2] In addition to the NAS report, the PAMS program is part of the Agency's response to recommendations contained in the 185b Report to Congress.

[3] Another current effort reflecting the Agency's response to the recommendations of the NAS is the North American Research Strategy for Tropospheric Ozone (NARSTO), a field study and modeling research program with which the PAMS program has close interaction.

ambient techniques, consistent with the basic tenets of the NAS report.

I.3.2 Regulatory Requirements

Section 182(c)(1) of the 1990 Clean Air Act Amendments called for improved monitoring of ozone and its precursors, VOC and NO_x, to obtain more comprehensive and representative data on tropospheric ozone. Responding to this requirement, EPA promulgated regulations to initiate the PAMS program in February 1993. The PAMS program requires the establishment of enhanced monitoring networks in all ozone non attainment areas classified as serious, severe or extreme. The 22 affected ozone areas, shown in Figure I-1, cover 113 thousand square miles and have a total population of 79 million people[4].

Each PAMS network will consist of as many as five monitoring stations, depending on the area's population[5]. Table I-1 displays the ozone non-attainment areas required to implement the PAMS program and the number of sites they are expected to implement. The PAMS stations will be carefully located based on meteorology and other conditions at the site. Figure I-2 presents a schematic of a model network for a larger non-attainment area. Generally, each PAMS network will consist of as many as four different monitoring sites (Types 1, 2, 3, and 4) designed to fulfill unique data collection objectives. The Type 1 site is located upwind of the metropolitan area to measure ozone and precursors being transported into the area. The second site, Type 2, is referred to as the maximum precursor emissions impact site[6]. As the name implies, it is designed to collect data on the type and magnitude of ozone precursor emissions emanating from the metropolitan area and is typically located downwind of central business district. These sites operate according to a more intensive monitoring schedule than other PAMS stations, are capable of measuring a greater array of precursors and are suited for the evaluation of urban air toxics also. The Type 3 stations are intended to measure maximum ozone concentrations, and are sited downwind of the Type 2 sites and therefore of the urban area as well. The fourth PAMS site is

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[4] The text and map both reference the twenty-two areas originally required to participate in the PAMS program. However, Beaumont, Texas was reclassified to a moderate non attainment status effective June 1996 and therefore no longer affected by PAMS requirements. Hence, there are actually twenty-one non attainment areas subject to PAMS requirements currently.

[5] For more detailed descriptions of PAMS network requirements, see the PAMS Implementation Manual, EPA-454/B-93-051, 1994.

[6] A second type 2 site may be required in some PAMS areas and is positioned to capture the precursor emissions in the second-most predominant morning wind direction. This additional type 2 site constitutes the fifth PAMS site in the network.

located downwind of the non attainment area to assess the ozone and precursor levels exiting the area and potentially contributing to the ozone problem in other areas.

States which experience significant impact from long-range transport of ozone or its precursors, or are proximate to other nonattainment areas (even in other States) can collectively submit a network description which contains alternative sites to those that would be required for an isolated area as shown in Figure I-2[7]. Such coordinated network plans should be based on the example depicted in Figure I-3, and must include a demonstration that the alternative design satisfies the monitoring data uses and fulfills the PAMS objectives[8].

I.3.3 Status

Over its first four years, the PAMS program has exhibited steady and successful growth. Currently, there are approximately seventy PAMS surface air quality and meteorology monitoring stations established and operating across the nation. This represents at least one monitoring station in each of the twenty areas involved in the PAMS program[9]. Table I-2 lists the established and operating PAMS monitoring sites by non-attainment area and provides their AIRS site identification numbers. Table I-3 summarizes the minimum network requirements by non-attainment area and sampling frequencies by PAMS site type.

The data collected at the PAMS sites includes measurements of ozone, oxides of nitrogen, a target list of VOCs including several carbonyls (see Table I-4) as well as surface and upper air meteorology. Most PAMS sites measure 56 target hydrocarbons on an hourly basis during the ozone season. Included in the monitored VOC species are nine compounds classified as hazardous air pollutants (HAPs). The type 2 sites also collect data on carbonyl compounds every three hours during the ozone monitoring period. All stations measure ozone, nitrogen oxides and surface meteorological parameters on an hourly basis.

The PAMS networks produce a wealth of information invaluable to the development and

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[7] PAMS Implementation Manual pages 2-4 to 2-6.

[8] Both California (South Coast Air Basin and Southeast Desert Modified AQMD non attainment areas) and Lake Michigan (Chicago and Milwaukee non attainment areas) have adopted approved plans for "combined" networks.

[9] Although there are twenty-two areas classified as serious, severe or extreme for ozone, the flexibility of the PAMS program allowed areas (in close proximity to one another) in two regions consolidate their monitoring operations [see footnote 8] and one original area has been reclassified [see footnote 4]. Therefore, only nineteen PAMS networks exist.

evaluation of ozone control strategies and programs. In addition to providing a long term perspective on changes in atmospheric concentrations in ozone and its precursors, the PAMS program will specifically help to improve emission inventories, serve as input to photochemical grid models, provide information to evaluate population exposure, and provide routine measurements of selected HAPs. Most importantly, PAMS will assist in delivering a more complete understanding of the complex problem of ozone, so that we may move toward the best solution[10].

I.4 FURTHER INFORMATION

I.4.1 Comments

Please forward your comments, suggestions, etc. to:

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I.4.2 Request for Additional Copies

Additional copies of this report are available through the Emissions, Monitoring and Assessment Division. Please contact Linda Ferrell at 919-541-5558 to request a copy.

[10] For a more complete discussion of the intended uses of PAMS data, see Section I of the PAMS Implementation Manual and its treatment of PAMS' data quality objectives.

Figure I-1.

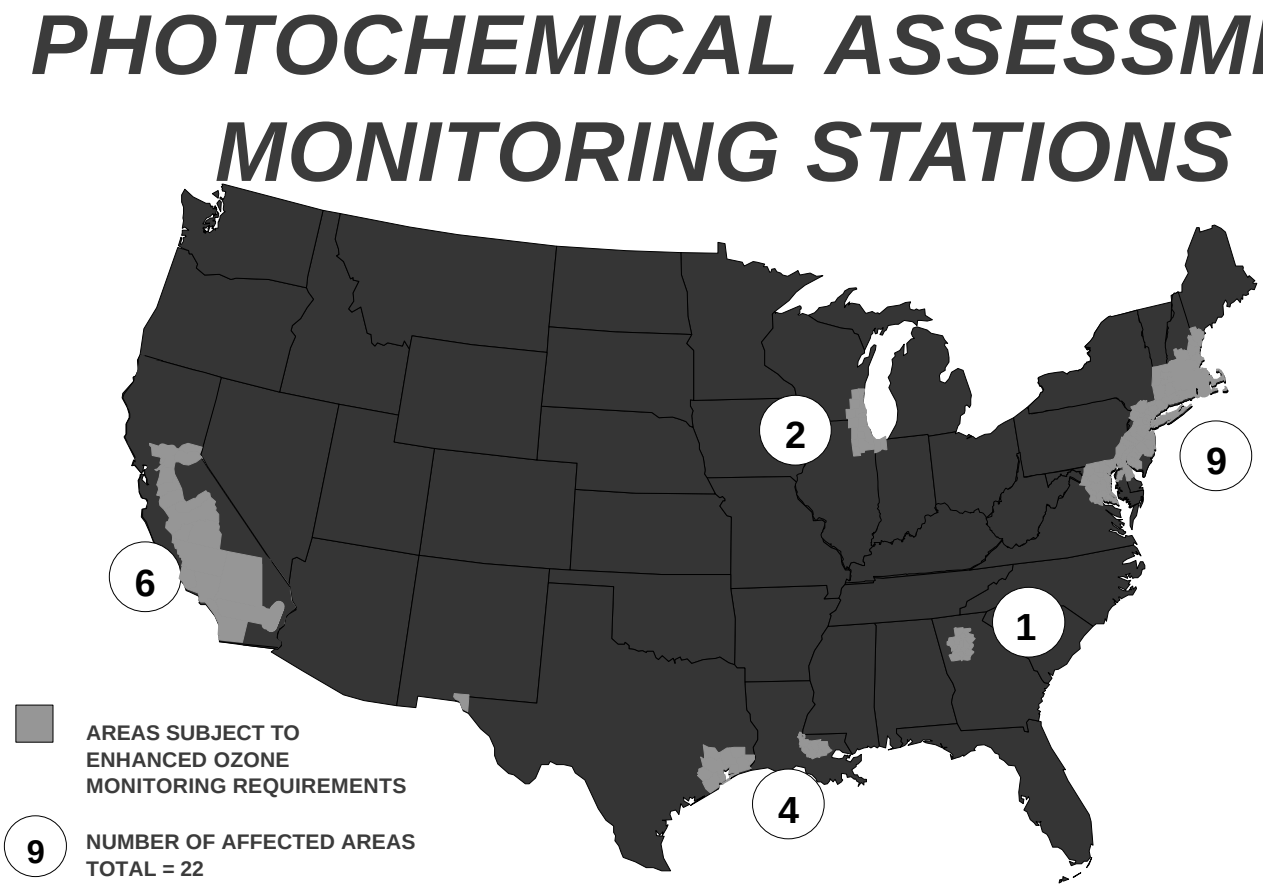
PHOTOCHEMICAL ASSESSMENT MONITORING STATIONS
2
9
6
1
4
AREAS SUBJECT TO ENHANCED OZONE MONITORING REQUIREMENTS
9
NUMBER OF AFFECTED AREAS
TOTAL = 22

Figure I-2. Basic PAMS Scheme

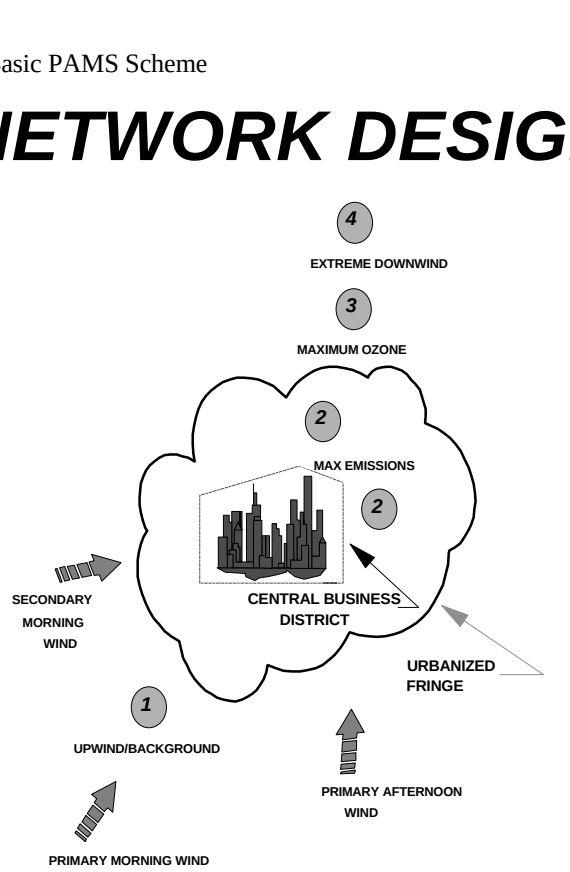

Figure I-3. Multi-Area and Transport Area Network Design

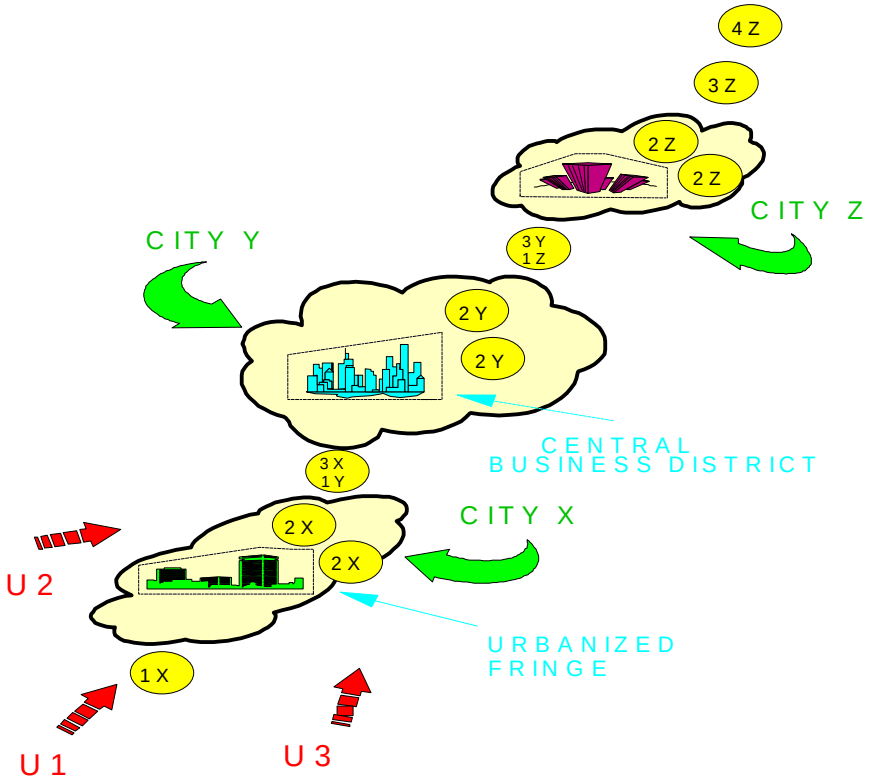

Table I-1. PAMS Requirements for Currently Affected Areas

CURRENTLY-AFFECTED AREA NAME	POPULATION RANGE	CLASSIFICATION OF NONATTAINMENT AREA	MINIMUM NUMBER OF REQUIRED SITES
Beaumont-Port Arthur, TX[1]	Less Than	Serious	2
Portsmouth-Dover-Rochester, NH-ME	500,000	Serious	2
Southeast Desert Modified AQMA, CA		Severe	2
Baton Rouge, LA		Serious	3
El Paso, TX	500,000 to	Serious	3
Springfield, MA	1,000,000	Serious	3
Ventura County, CA		Severe	3
Milwaukee-Racine, WI	1,000,000 to	Severe	4
Providence-Pawtucket-Fall River, RI-MA	2,000,000	Serious	4
Sacramento, CA		Serious	4
Atlanta, GA		Serious	5
Baltimore, MD		Severe	5
Boston-Lawrence-Worcester, MA-NH		Serious	5
Chicago-Gary-Lake County (IL), IL-IN-WI		Severe	5
Greater Connecticut, CT		Serious	5
Houston-Galveston-Brazoria, TX	More Than	Severe	5
Los Angeles-South Coast Air Basin, CA	2,000,000	Extreme	5
New York-New Jersey-Long Island, NY-NJ-CT		Severe	5
Philadelphia-Wilmington-Trenton, PA-NJ-DE-MD		Severe	5
San Diego, CA		Severe	5
San Joaquin Valley, CA		Serious	5
Washington, DC-MD-VA		Serious	5
Totals	-----	22 Areas	90

[1]Reclassified on 6/1/96 to moderate nonattainment status therefore not required to implement PAMS program.

TABLE I-2. PAMS MONITORING SITES

AREA	SITE	
Boston	Borderland #1	25-005-1005
	Lynn - #2	25-009-2006
	Newbury - #3	25-009-4004
	Cape Eliza., ME- #4	23-005-2003
Connecticut	Sherwood Island #1/#3	
	E. Hartford #2	
	Stafford #3	
Portsmouth	Stratham #1	33-xxx-xxxx
	Kittery, ME #2	23-031-3002
Providence	W. Greenwich #1	
	E. Prov #2	
	(Borderland, MA #3)	
Springfield	Agawam #1	25-013-0003
	Chicopee #2	25-013-0008
	Ware #3	25-015-4002
New York	Purchase #2	
	Botanical Gardens #2	
	(Sherwood Island, CT #3)	
Baltimore	Fort Meade, MD #1	24-003-0019
	Essex #2	24-005-3001
	Morgan State #2	24-510-0050
	Aldino #3	24-025-9001
	(Lums Pond, DE #4)	10-003-1007
	Clifton Pk. or Living Rm #2A	xx-xxx-xxxx

Philadelphia	Lums Pond (DE) #1 East Lycoming Lab #2 Rider College (NJ) #3	
Washington	Corbin, VA #1 (Caroline Co. Met Only #1) McMillan Reservoir #2 (Fort Meade, MD #3) (Lums Pond, DE #4)	51-033-0001 51-033-0002 11-001-0043 24-003-0019 10-003-1007
Atlanta	Yorkville #1 So DeKalb #2 Tucker #2 Conyers #3	
Lake Michigan	Braidwood #1 Milwaukee UWM #2 Chicago NWU #2 Chicago-Jardine #2 Gary, IN #2 Harrington Bch #3 Zion #4 Manitowoc, WI #4	17-197-1007 55-079-0041 17-031-0039 17-031-0072 18-089-1016 55-089-0009 17-097-1007 55-071-0007
Houston	Galveston #1 Galleria #2 Clinton Dr #2 HRM No. Three #2 Deer Park #2 Aldine #3	
Baton Rouge	Pride #1/#3 Capitol #2 Bayou Plaquemine #3/#1	22-033-0008 22-033-0009 22-047-0009
El Paso	N. Campbell #2 Chamizal #2 UTEP #3	

AREA	SITE	
South Coast/ SEDAB	Pico Rivera #2 Azusa #3 Banning #2 Upland #4/1	06-037-1601 06-037-0002 06-065-0002 06-071-1004
San Diego	El Cajon #2 Overland #2A Alpine #3	
Ventura Co	El Rio #2 Simi Valley #3	06-111-3001 06-111-2002
Sacramento	Del Paso #2 Folsom #3 Elk Grove-Bruceville	
San Joaquin	Golden St Ave #2 (Bkrsfld) Clovis-Villa #2 Arvin #3 Parlier #3	06-029-0010 06-019-5001 06-029-5001 06-019-4001

Table I-3. PAMS Minimum Network Requirements

MINIMUM NETWORK REQUIREMENTS

POPULATION OF MSA/CMSA	FREQ TYPE	SITE LOCATION
LESS THAN 500,000	A or C	(1)
	A/D or C/F	(2)
500,000 TO 1,000,000	A or C	(1)
	B/E	(2)
	A or C	(3)
1,000,000 TO 2,000,000	A or C	(1)
	B/E	(2)
	B/E	(2)
	A or C	(3)
GREATER THAN 2,000,000	A or C	(1)
	B/E	(2)
	B/E	(2)
	A or C	(3)
	A or C	(4)

VOC SAMPLING FREQUENCY REQUIREMENTS

Type	Requirement
A	8 3-Hour Samples Every Third Day 1 24-Hour Sample Every Sixth Day
B	8 3-Hour Samples Everyday 1 24-Hour Sample Every Sixth Day (year-round)
C	8 3-Hr Samp 5 Hi-Event/Prev Days/Every 6th Day 1 24-Hour Sample Every Sixth Day

CARBONYL SAMPLING FREQUENCY REQUIREMENTS

Type	Requirement
D	8 3-Hour Samples Every Third Day
E	8 3-Hour Samples Everyday
F	8 3-Hr Samp 5 Hi-Event/Prev Days/Every 6th Day

MINIMUM PHASE-IN

YEARS AFTER PROMULGATION	NUMBER OF SITES OPERATING	OPERATING SITE LOCATION RECOMMENDATION
1	1	2
2	2	2,3
3	3	1,2,3
4	4	1,2,3,4
5	5	1,2,2,3,4

Table I-4. PAMS Target Species

VOC COMPOUNDS

Ethylene
Acetylene
Ethane
Propylene
Propane
Isobutane
1-Butene
n-Butane
trans-2-Butene
cis-2-Butene
Isopentane
1-Pentene
n-Pentane
Isoprene
trans-2-Pentene
cis-2-Pentene
2,2-Dimethylbutane
Cyclopentane
Total NMOC
2,3-Dimethylbutane
2-Methylpentane
3-Methylpentane
2-Methyl-1-Pentene
★ **n-Hexane**
Methylcyclopentane
2,4-Dimethylpentane
★ **Benzene**
Cyclohexane
2-Methylhexane
2,3-Dimethylpentane
3-Methylhexane
★ **2,2,4-Trimethylpentane**
n-Heptane
Methylcyclohexane
2,3,4-Trimethylpentane
★ **Toluene**
2-Methylheptane
3-Methylheptane
n-Octane
★ **Ethylbenzene**
★ **m/p-Xylene**
★ **Styrene**
★ **o-Xylene**
n-Nonane
Isopropylbenzene
n-Propylbenzene
m-Ethyltoluene
p-Ethyltoluene
1,3,5-Trimethylbenzene
o-Ethyltoluene
1,2,4-Trimethylbenzene
n-Decane
1,2,3-Trimethylbenzene
m-Diethylbenzene
p-Diethylbenzene
n-Undecane

CARBONYL COMPOUNDS

★ **Acetaldehyde**
Acetone
★ **Formaldehyde**

★ **Hazardous Air Pollutants (HAPs)**