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B02

December 2, 1991

Mr. Michael Koerber
Lake Michigan Air Directors Consortium
2350 E. Devon, Suite 242
Des Plaines, IL 60018

Dear Mike:

Attached is a copy of the Atlanta AWMA Conference Paper that I sent to Mike Rodgers.

Very truly yours,

Norman E. Bowne
Senior Program Manager

NEB/lma

Attachment

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November 8, 1991

Dr. Michael Rodgers
Georgia Institute of Technology
Air Quality Laboratory
Atlanta, Georgia 30332

Dear Dr. Rodgers:

Attached is a copy of the paper delivered by Michael Koerber at the AWMA conference in Atlanta on November 5, 1991.

Very truly yours,

Norman E. Bowne
Senior Program Manager

NEB/lma

Attached

Doc:NB012591.LTR

SUMMER 1991 FIELD MEASUREMENTS

THE LAKE MICHIGAN OZONE STUDY

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ABSTRACT

Measurements of air quality and meteorology were made in the Lake Michigan area during the summer of 1991. These data will be used for evaluation of models that calculate ozone concentrations. The ultimate use of the models will be to evaluate control strategies to achieve compliance with the ambient air quality standard for ozone. Routine air quality observations were obtained hourly from the existing state networks in WI, IL, IN and MI and from an additional 20 monitors installed for the project. Special measurements were made from boats and aircraft. The observation network is described and preliminary results for two ozone episodes are discussed.

SUMMER 1991 FIELD MEASUREMENTS

THE LAKE MICHIGAN OZONE STUDY

INTRODUCTION

The Lake Michigan area experiences numerous events when the ozone concentration exceeds the National Ambient Air Quality Standard. Control strategies used to date have been unsuccessful in achieving the desired reductions in ozone levels in this region and nationally. The number of exceedances observed in 1988 was the highest in ten years. A number of reasons have been cited for the continued non-attainment problem, including ineffective rules, insufficient enforcement programs, overly optimistic forecasts of emission reductions, inadequate data bases and inaccurate air quality models. A study is required to address the questions of whether the modeled source/receptor relationships fail because of the inadequacy or unrepresentativeness of model formulations, yet unknown limitations in chemical mechanisms, emissions uncertainties, or adverse meteorological conditions. Evidence suggests the complex lake shore meteorology may be the most influential factor on concentration patterns, but all aspects of the problem require attention.

The states of Illinois, Indiana, Michigan and Wisconsin have joined the U. S. Environmental Protection Agency to develop a program of measurement, air quality model development and evaluation of the model to calculate ozone concentrations. These parties have sponsored a Scoping Study (Haney, et. al.), and have developed a program of modeling and measurements that is designed to produce the necessary information and tools to develop appropriate ozone mitigation strategies. A major step in that process was the 1991 Summer Field Measurements Program. The 1991 measurement program was conducted during the period from June 10 to August 9.

GOALS AND OBJECTIVES. The broad goals and objectives of the Lake Michigan Ozone Study (LMOS) are given in detail in the Conceptual Design Plan (ENSR 1990). Basically, these goals and objectives are to develop the best available understanding of elevated ozone concentrations in the Lake Michigan area through the use of measured data and photochemical modeling techniques. The end product of the study is to provide a technically credible photochemical reactive grid model that can be used to assess strategies and support revised implementation plans. The objective of the 1991 Summer Field Measurements Program was to provide measurements for model development and evaluation.

DESIGN PROCESS. The project was conducted under a fast-paced schedule designed to meet regulatory and court mandated deadlines. The project began with a Scoping Study which provided an initial broad design for the program. A pilot study in 1990 provided valuable experience for the design of the full scale measurements conducted in 1991. Contractors were commissioned to perform the tasks associated with the 1991 measurements, data handling, data analyses, model development and verification. State and U.S. EPA staff formed a technical oversight group called the Project Team to advise the Lake Michigan Air Directors Consortium, LADCo. LADCO wrote the contracts for the work. The Project Team is listed below in Table 1.

Table 1
Project Team Members

Larry Bruss, Chair (1991)	Wisconsin
Ed Doty	USEPA
David Guinnup	USEPA
John Hillery	Wisconsin
Dennis Lawler	Illinois
Louis Pocalujka	Michigan
John Schroeder	Michigan
Terry Sweitzer	Illinois
Mike Worrel	Indiana
Dick Zeiler	Indiana

The contractors and other participants and the responsibility of each is listed in Table 2.

Table 2
Summer 1991 Participants

ENSR Consulting and Engineering	Project Management
Environmental Science & Engineering /ENSR Consulting and Engineering	Routine Surface Field Measurements
NOAA - Boulder, CO	Aircraft AQ Sampling
Wisconsin DNR	Aircraft AQ Sampling
North American Weather Consultants	Aircraft AQ Sampling Ship Operation SF6 Tracer Tests
SRI International	Airborne Ozone Analyzer
Sonoma Technology Inc /Technical Business Systems	Upper Air Measurements (Radar Profilers and Rawinsondes)
National Weather Service	Supplemental Rawinsondes
Murray & Trettel	Weather Forecasting
Battelle	VOC, Carbonyl Analysis
ESE/ENSR	PAN
ESE/ENSR and MCI (Australia)	AIRTRAK Measurement Systems
WI, IL, IN, MI	Surface Air Quality, Meteorology, General Support
AeroVironment	Quality Assurance
Sonoma Technology/Sigma Research	Data Analysis
Radian Corp	Emissions Inventory Preparation
SAI Inc	Information Management Photochemical Modeling
ASTeR	Prognostic Modeling
Pacific Environmental Services	QA Emissions Inventory
ERDAS/Northern Illinois Univ.	Satellite Imagery

enormous. The 1991 program approximated the idealized requirements by using the States' existing air quality and meteorological measurements with enhancement to provide more detailed surface measurements over the study domain than have been made in the past.

The existing upper air measurement network operated by the National Weather Service was augmented with added soundings at existing stations and new state-of-the-art radar profiler instruments, see Figure 4. Vertical profiles of winds and temperature were obtained in much more spatial and temporal detail than before. Ships were deployed to measure air quality and meteorological conditions both in the surface layer and at levels aloft over Lake Michigan where observations do not exist on a routine basis.

Aircraft measured air quality aloft along several flight paths in an attempt to define the upwind boundary condition and the areal and temporal distributions of aerometric data within the study domain. An experimental DIAL airborne laser system was employed to map the regional distribution and along-path vertical profile of ozone on a few days. Figure 5 illustrates the flight paths.

RESULTS

Routine surface measurements of air quality and meteorology were conducted continuously by the state and private monitors that are normally situated in the study region. The monitors that were installed for the study were all operating toward the end of May and continued until the end of August. The radar profilers operated continuously. The VOC/carbonyl, balloon soundings, boats and aircraft operated on call for special events. Several episodes occurred during the field program. Preliminary data are presented during the talk, but are not provided as part of the printed paper because the data have not been through appropriate quality control checks and have not been sanctioned for release.

The first event occurred during the period from June 18 to 21. Ozone concentrations above the ambient air quality standard occurred in Illinois and Indiana. Wind directions were east to northeast. We did not activate the special measurement platforms because our design was to accommodate south to west winds. In addition, the peak concentrations were generally ten percent above the standard.

The next event occurred during the period from June 25 to June 29. Tuesday, June 25 had southerly winds with building ozone levels showing peaks near 100 ppb. On Wednesday, the winds

OVERVIEW OF THE FIELD PROGRAM

The 1991 Field Program consisted of several distinct areas of effort. They were; 1) a region-wide air quality and meteorological monitoring effort with two-dimensional data plane monitoring corridors, 2) ozone and precursor flux planes near the Chicago metropolitan, industrial complex and across Lake Michigan, 3) documentation of the boundary conditions of the study area, 4) operation of enhanced States' existing air quality monitoring networks, and 5) operation of enhanced meteorological measurements at the surface and at levels aloft. The measurements and how they fit these tasks are described below.

The sampling period was June 17 to August 9, 1991. A week of set-up and practice for procedures was scheduled for June 10 to 16 with June 12 being an "Operational Shakedown Day" during which all systems operated as if it were a regularly scheduled, although short, intensive measurement day. Twelve intensive sampling days were desired. We had intensive measurements on seven. All systems made around the clock observations during intensive study days as weather conditions permitted.

The study domain and surface measurement sites are illustrated in Figure 1. These air quality and meteorological monitoring locations were designed to document the region wide ozone and precursor distribution. The primary wind directions of interest are southerly to westerly. This map shows the ozone monitoring sites. Most, but not all, had surface meteorological measurements associated with them. Note that three boats were used on the lake to supplement the land based stations to give us a better idea of what was happening over this rather large area in the middle of our domain of interest.

Oxides on nitrogen are an important ingredient in the ozone chemistry. We measured them at the sites illustrated in Figure 2. The "X" markers indicate new sites that were placed in service for the this program.

Figure 3 shows the locations of the measurements for volatile organic compounds and carbonyls. Two-hour integrated samples were collected in canisters and on cartridges four times during the day at most sites. Sites located in major source areas were only sampled twice daily. The arrangement of samplers was designed to provide us with background information, speciation in the source areas and speciation in our expected receptor areas.

It would have been desirable to perform the measurements at hundreds of locations and several heights above the ground. The resources however, to conduct such an idealized experiment are

remained southerly at 10 to 15 miles per hour and peak ozone levels over 150 ppb were observed in Wisconsin from Milwaukee to Manitowoc. Values near 120 ppb were observed in western Michigan. Thursday, June 27 had winds shifting more to the southwest at 10 to 15 miles per hour and the highest ozone concentrations were just over 110 ppb in Michigan. Friday had similar weather conditions and the highest values were just over 120 ppb in Michigan. Saturday was the last day of the episode, although the boats and aircraft were removed from service so the crews could be rested, and ozone levels reached near 130 ppb in Michigan.

The third, brief episode occurred on July 6 and 7 but special sampling was not conducted due to the unavailability of certain key measurements. Peak hourly concentrations were near 150 ppb at Milwaukee and Manistee, MI on the 6th. Peak levels were only 120 ppb at the Illinois-Wisconsin state line on the 7th. The synoptic weather pattern for this episode was quite similat to that for the late June episode noted above and the mid-July episode noted below.

The fourth and a major episode occurred from Tuesday July 16 to Saturday July 20. Winds were from the south on Tuesday, but became southwesterly on Wednesday and remained from the southwest until Saturday. Speeds were 10 to 15 miles per hour. Highest concentrations on Tuesday were near 120 ppb at the Illinois - Wisconsin state line, near Manistee, MI and in Door County, WI. High concentrations on Wednesday were near 130 ppb at Benton Harbor and South Haven, MI. Concentrations exceeded 150 ppb in Michigan on Thursday, but were generally below 100 ppb on the west side of the lake. The intensive measurements by the boats and aircraft ended on Thursday. High concentrations of ozone continued to be observed in Michigan on Friday with peaks over 150 ppb between Mears and Frankfort. Saturday was the last day of the episode with peak concentrations just over 130 ppb in Wisconsin and near 100 ppb in Michigan.

A final summer episode occurred after August 9. Although the boats, aircraft and VOC sampling were not available, the enhanced surface network was still in place. Late in August, concentrations reached the 180 ppb level in eastern Wisconsin. On August 26, 15 stations in eastern Wisconsin exceeded the ambient ozone standard.

Some of the historical high concentration episodes in Wisconsin have been associated with lake breeze wind circulations. Special experiments were planned to study the depth and penetration of the lake breeze. A lake breeze was established on the first day of each of the two major events sampled, but the vertical extent and depth of inland penetration was small. However, even this small extent had some effect on concentrations near the lake shore.

Aircraft sampling showed that ozone was well mixed aloft. Concentration distributions frequently showed little difference in the vertical from the ground to the top of the mixed layer.

The concentrations of ozone measured during the summer of 1991 should be adequate for assessing the perfomance of the air quality model and perhaps even be sufficient for evaluation of control strategies. The concentrations measured in Wisconsin in June were in the highest 20 percent of historical measurements. The concentrations measured in Michigan were in the highest 5 percent of historical measurements. Data recovery was excellent and we look forward to the examination of these events by the modelers and data analysts.

REFERENCES

Haney, J.L., S.G. Douglas, L.R. Chinkin, D.R. Souten, C.S. Burton and P.T. Roberts, 1989: Ozone Air Quality Scoping Study for the Lower Lake Michigan Air Quality Region, Systems Applications, Inc.

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Figure 1. Ozone monitoring locations in the Lake Michigan Ozone Study area of interest.

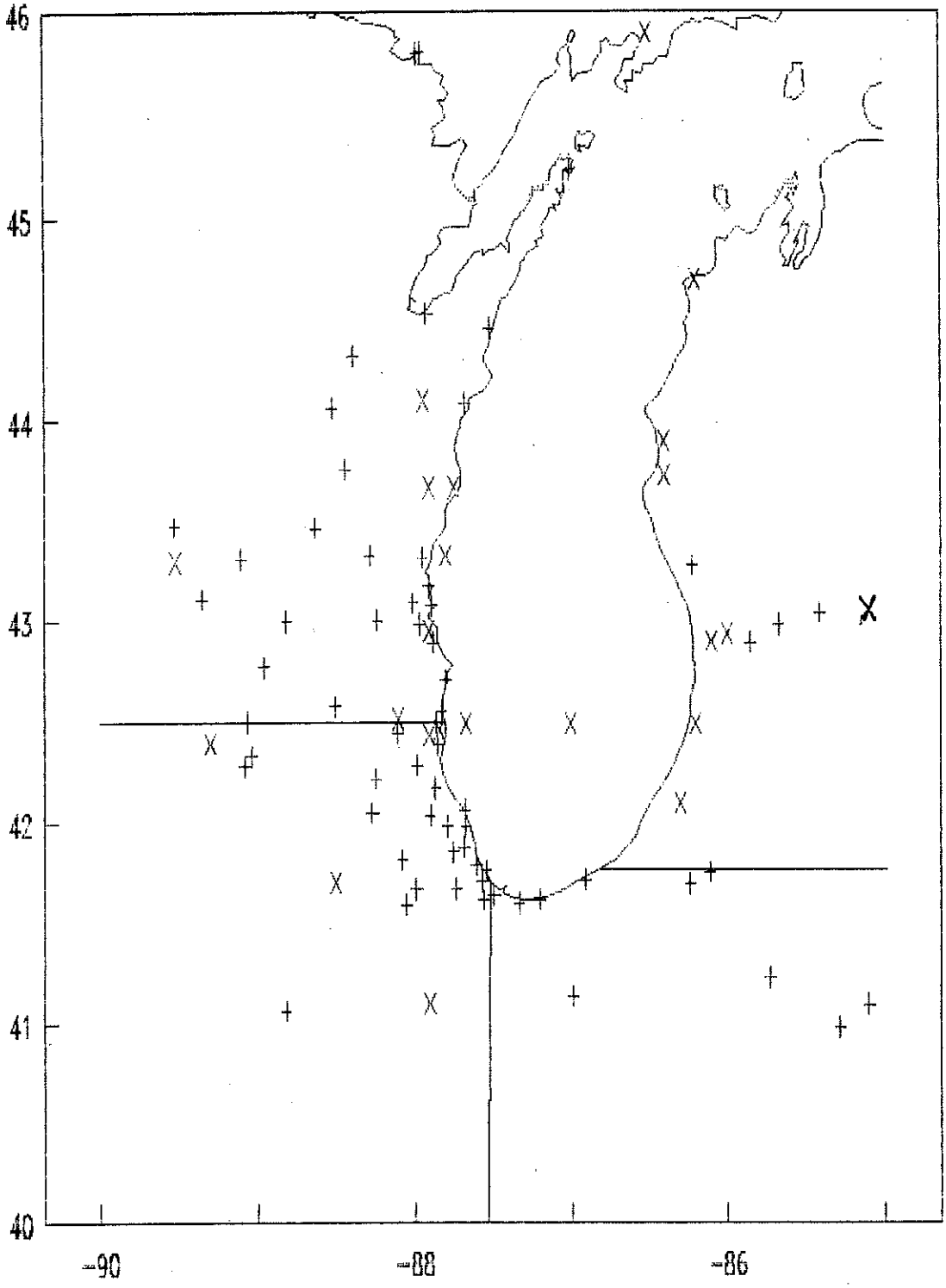
Figure 2. Oxides of nitrogen monitoring locations in the Lake Michigan Ozone Study area of interest.

Figure 3. VOC and Carbonyl monitoring locations in the Lake Michigan Ozone Study area of interest.

Figure 4. Upper air meteorological monitoring locations in the Lake Michigan Ozone Study area of interest.

Figure 5. Aircraft flight tracks for air quality measurements in the Lake Michigan Ozone Study area of interest.

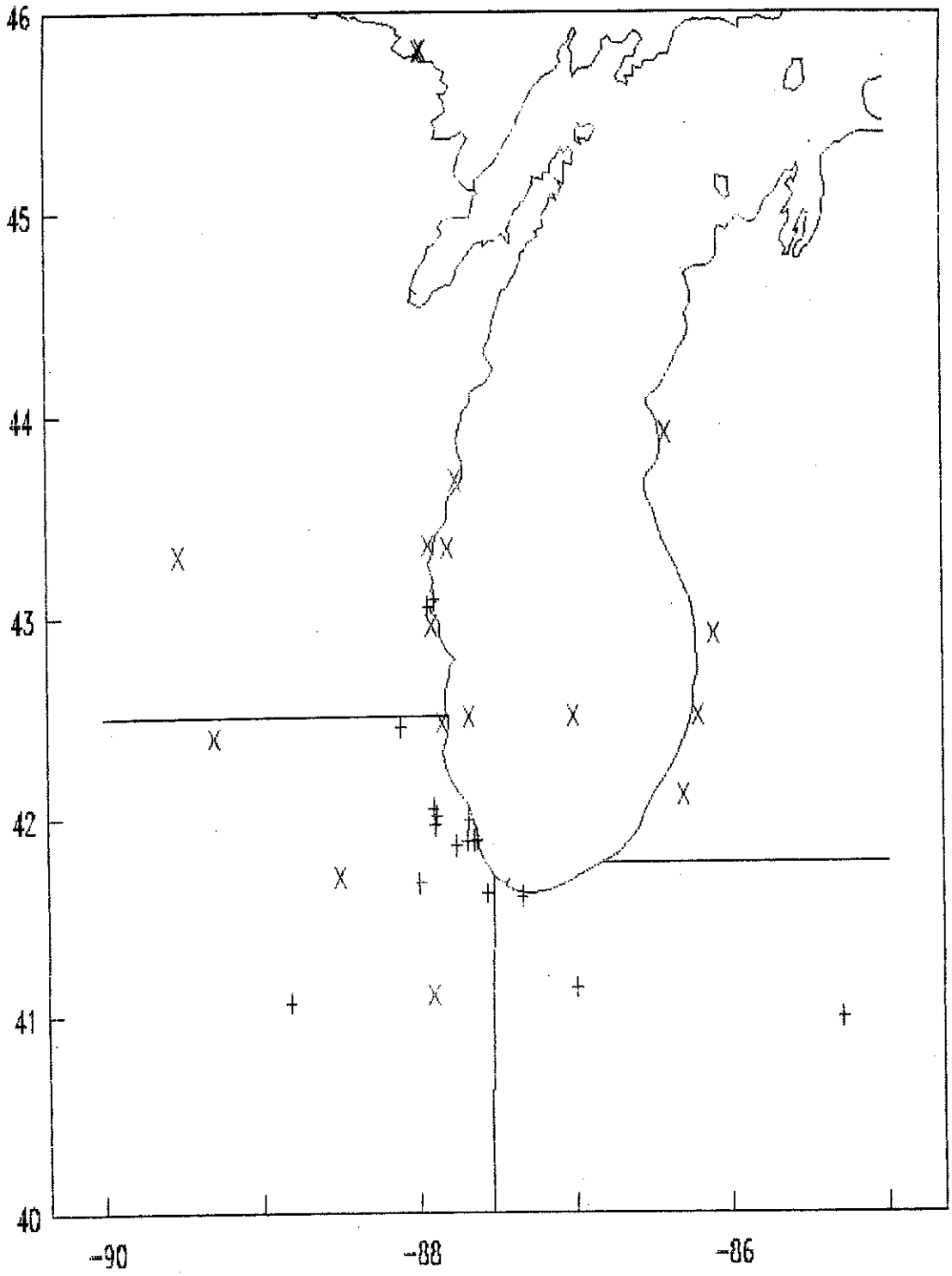
LAKE MICHIGAN OZONE STUDY



Ozone Monitoring Sites

\+ Existing Sites X New Sites

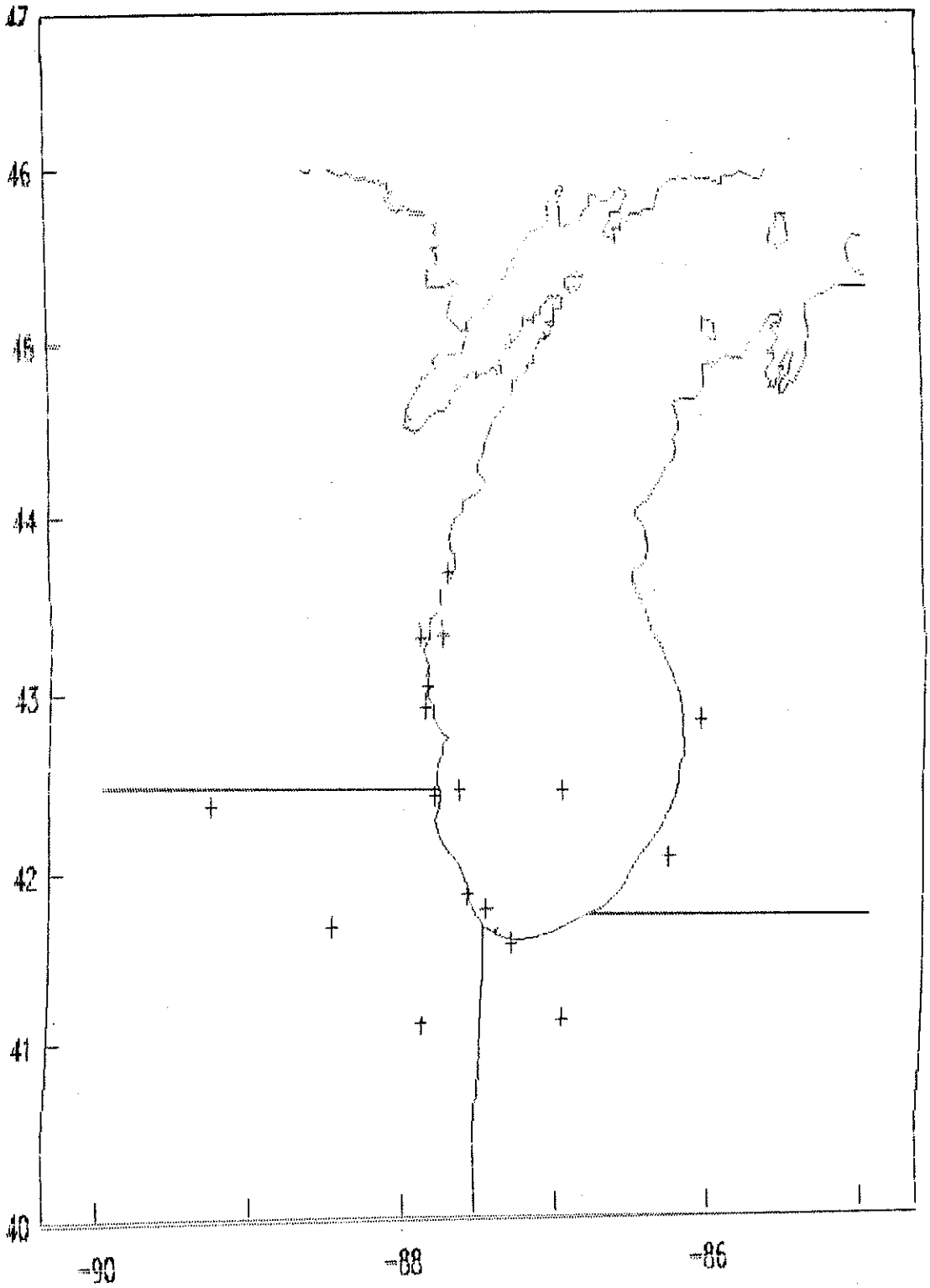
LAKE MICHIGAN OZONE STUDY



NOx Monitoring Sites

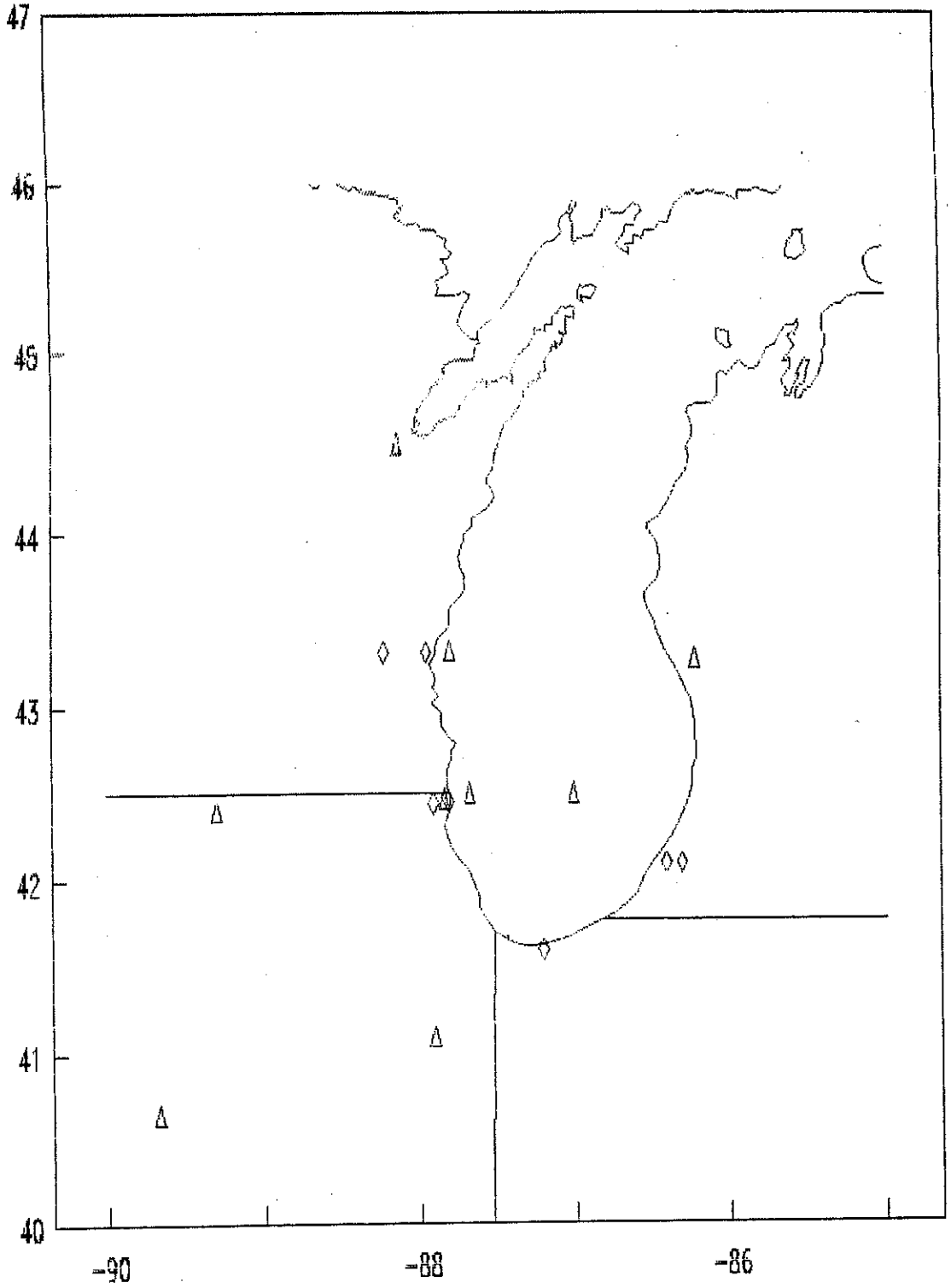
+ Existing Sites X New Sites

LAKE MICHIGAN OZONE STUDY



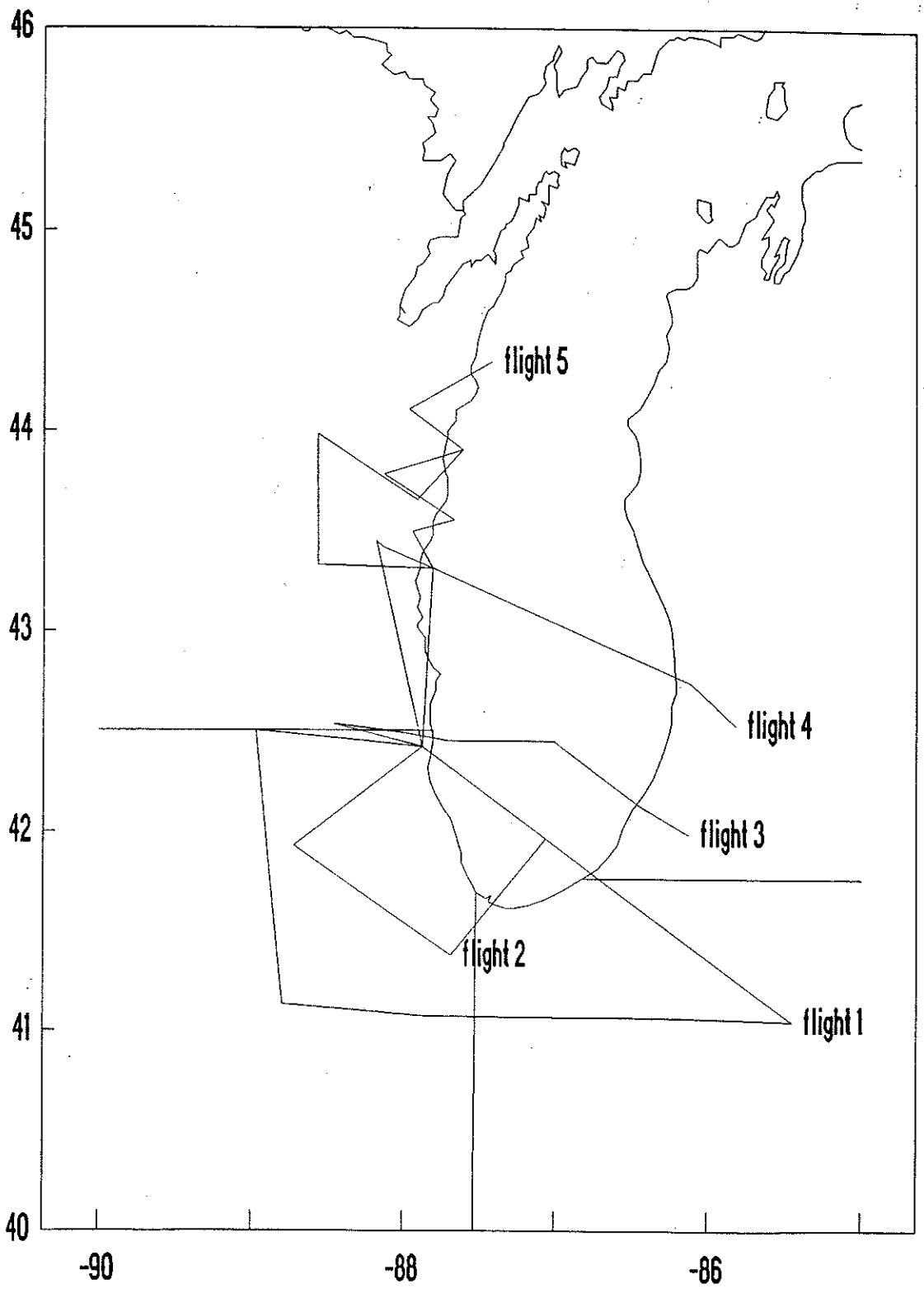
VOC Monitoring Sites

LAKE MICHIGAN OZONE STUDY



UPPER AIR SITES

◊ PROFILERS Δ RAWIN



Flight Patterns