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**RESULTS OF GASEOUS ORGANIC  
COMPOUND MEASUREMENTS AROUND  
THE SANTA MONICA AIRPORT**

**Final Report  
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## TABLE OF CONTENTS

| <u>Section</u>   | <u>Page</u> |
|--|-------------|
| LIST OF FIGURES .....  | iii         |
| LIST OF TABLES .....   | iii         |
| EXECUTIVE SUMMARY .....  | ES-1        |
| 1. DESIGN AND APPROACH .....   | 1-1         |
| 2. NON-METHANE ORGANIC COMPOUND BACKGROUND .....   | 2-1         |
| 2.1 Sources and Formation .....  | 2-1         |
| 2.2 Measurement Technique .....  | 2-1         |
| 3. OBJECTIVES OF THE SAMPLING PROGRAM .....  | 3-1         |
| 3.1 Ambient Air Samples .....  | 3-1         |
| 3.2 Jet Exhaust Samples .....  | 3-1         |
| 4. AMBIENT AIR QUALITY SAMPLES .....   | 4-1         |
| 4.1 Sampling Logistics .....   | 4-1         |
| 4.2 Meteorology During Ambient Sampling .....  | 4-3         |
| 4.3 Airport Activity Data .....  | 4-3         |
| 4.4 Ambient Hydrocarbon Characterization .....   | 4-3         |
| 5. JET EXHAUST SAMPLES .....   | 5-1         |
| 5.1 Sampling Logistics .....   | 5-1         |
| 5.2 Jet Exhaust Characterization .....   | 5-1         |
| 5.3 Jet Exhaust Compared to Diesel-powered and Gasoline-powered Vehicle<br>Exhaust ..... | 5-4         |
| 6. SUMMARY OF RESULTS .....  | 6-1         |
| 7. CONCLUSIONS .....   | 7-1         |
| APPENDIX A: SAMPLE ANALYSIS RESULTS FOR GASEOUS ORGANIC<br>COMPOUNDS .....               | A-1         |

## LIST OF FIGURES

| <u>Figure</u>  | <u>Page</u> |
|--|-------------|
| 4-1. Locations of the two ambient sampling sites.....  | 4-2         |
| 4-2. Wind direction and speed during the sampling period .....   | 4-4         |
| 4-3. Total non-methane organic compound concentrations at the SMO and Sardis sites.....  | 4-5         |
| 4-4. Number of aircraft operations during the 2-hr samples at the Santa Monica Airport .....   | 4-5         |
| 4-5. Weight percent benzene at the SMO and Sardis sites.....   | 4-7         |
| 4-6. Weight percent toluene at the SMO and Sardis sites.....   | 4-7         |
| 4-7. Weight percent meta/para-xylenes at the SMO and Sardis sites .....  | 4-8         |
| 4-8. Weight percent acetaldehyde at the SMO and Sardis sites.....  | 4-8         |
| 4-9. Weight percent 1,3-butadiene at the SMO and Sardis sites.....   | 4-9         |
| 4-10. Acetaldehyde concentrations at the SMO and Sardis sites.....   | 4-9         |
| 4-11. 1,3-Butadiene concentrations at the SMO and Sardis sites .....   | 4-10        |
| 4-12. Benzene concentrations at the SMO and Sardis sites .....   | 4-10        |
| 5-1. Total non-methane organic compound concentrations in each jet exhaust sample .....  | 5-2         |
| 5-2. Acetaldehyde concentrations in the jet exhaust samples. Four of the concentrations are missing as a result of laboratory difficulties ..... | 5-2         |
| 5-3. 1,3-butadiene concentrations in the jet exhaust samples .....   | 5-3         |
| 5-4. Benzene concentrations in the jet exhaust samples .....   | 5-3         |

## LIST OF TABLES

| <u>Table</u>  | <u>Page</u> |
|---|-------------|
| 5-1. Comparison of various NMOC fractions from different sources .....                    | 5-4         |
| A-1. Concentrations of gaseous organic compounds for the ambient and exhaust samples..... | A-2         |

## EXECUTIVE SUMMARY

The City of Santa Monica requested the assistance of Sonoma Technology, Inc. to evaluate the possible air quality impacts of aircraft operations at the Santa Monica Airport on the nearby community. In the process of our evaluation, several factors persuaded us to perform on-site air quality monitoring to evaluate the possible impacts of the airport, as opposed to performing modeling or preparing an emission inventory. First, we discovered that there is a lack of information available on emissions from the type of aircraft operated at the Santa Monica Airport. An accurate emission inventory can not be prepared without information on aircraft emission rates and profiles of the individual species contained in those emissions. Without an accurate emission inventory, an accurate assessment of the impact of the airport's emissions on the nearby community can not be made using modeling. In addition, the terrain surrounding the airport is complex, with changes in elevation immediately east and west of the airport that create complex flow patterns and mixing. These complexities limit the applicability and accuracy of air quality modeling. Therefore, it was decided that the most reliable approach was to conduct air quality monitoring. The objectives of the air quality monitoring program were to (1) evaluate the local air quality, (2) develop emissions profiles for the exhaust of the aircraft frequenting the airport, and (3) assess the exposure of the nearby community to the emissions from the aircraft.

We designed the sampling program to meet these specific objectives, taking into account the complex local environment. Samples of both ambient air and aircraft exhaust were collected to provide information about the source and the receptor.

We decided to collect and analyze samples to determine the concentrations of a number of organic compounds, including both hydrocarbons (HC) and several oxygen-containing compounds; collectively, these compounds are called non-methane organic compounds (NMOCs). The concentrations of these organic compounds are fundamental to understanding the emissions impact of combustion sources. There is an abundance of information about the distribution of these compounds in ambient air and vehicular exhaust.

The ambient sampling program was designed to capture the highest possible contributions from the airport and to assess the potential exposure to these compounds in the nearby neighborhood. The design included placing one of the samplers as close as possible to the end of the airport runway and taking samples during the busiest airport operating hours. The sampler located at the end of the airport runway was placed to provide an upper bound on the impact of the aircraft emissions on the local community. In order to assess the potential impacts of the aircraft emissions on the nearby community, we placed a second NMOC sampling system in the neighborhood east of the airport. The NMOC samples were collected simultaneously at these two sites. Any differences in NMOC concentrations between the two sites would provide an indication of the local variability in NMOC concentrations, the dispersion rate of the aircraft emissions, and the relative impact of the aircraft emissions compared to other local sources.

Jet exhaust samples were collected near the end of the airport runway just as a jet was taking off. These samples were taken in short durations of 5 to 10 seconds in order to maximize the measured relative contribution of jet exhaust and minimize the measured relative contribution of other emissions sources.

(2)

We reached the following conclusions from our analyses of the organic compound samples collected in the area near the east end of the runway at the Santa Monica Airport.

The periods of highest exposure to total non-methane organic compounds (TNMOCs) and several specific organic compounds, including 1,3-butadiene and benzene, are during the night when winds are from the northeast, not from the airport. Acetaldehyde concentrations are similar during the day and night, so the daily exposure to acetaldehyde is distributed between periods when the airport is closed and when it is open.

For several non-methane organic compounds (NMOCs), including benzene, 1,3-butadiene, and acetaldehyde, the weight percent measured in jet exhaust was similar to or lower than the weight percent in gasoline-powered vehicle exhaust and diesel-powered vehicle exhaust. Therefore, jets can not be solely responsible for the ambient concentrations of these NMOCs. In addition, none of the NMOCs were unique or present in unusually high weight percents in jet exhaust.

The range of jet exhaust concentrations for several NMOCs, including benzene, 1,3-butadiene, and acetaldehyde, is similar to the range of concentrations for the same compounds in the ambient air samples collected either with or without airport influence. Therefore, jet exhaust can not be the major contributor to ambient concentrations of these compounds.

The ambient NMOC compositions were similar for all samples collected at the SMO and Sardis sites, despite dramatic changes in wind direction, wind speed, mixing height, temperature, airport operations, roadway traffic, etc. The similarity of the NMOC compositions under this range of conditions indicates that the sources of NMOCs are regionally consistent, meaning that the major contributors are present in similar amounts in all directions surrounding the Sardis and SMO sites. This is also true for the NMOCs associated with jet exhaust, including acetaldehyde, benzene, and 1,3-butadiene. Therefore, we conclude that jet operations at the airport are not the major contributor for the measured NMOCs; other sources must be the major contributors.

## 1. DESIGN AND APPROACH

The City of Santa Monica requested the assistance of Sonoma Technology, Inc. to evaluate the possible air quality impacts of aircraft operations at the Santa Monica Airport on the nearby community. In the process of our evaluation, several factors persuaded us to perform on-site air quality monitoring to evaluate the possible impacts of the airport, as opposed to performing modeling or preparing an emission inventory. First, we discovered that there is a lack of information available on emissions from the type of aircraft operated at the Santa Monica Airport. An accurate emission inventory can not be prepared without information on aircraft emission rates and profiles of the individual species contained in those emissions. Without an accurate emission inventory, an accurate assessment of the impact of the airport's emissions on the nearby community can not be made using modeling. In addition, the terrain surrounding the airport is complex, with changes in elevation immediately east and west of the airport that create complex flow patterns and mixing. These complexities limit the applicability and accuracy of air quality modeling. Therefore, it was decided that the most reliable approach was to conduct air quality monitoring. The objectives of the air quality monitoring program were to (1) evaluate the local air quality, (2) develop emissions profiles for the exhaust of the aircraft frequenting the airport, and (3) assess the exposure of the nearby community to the emissions from the aircraft.

We designed the sampling program to meet these specific objectives, taking into account the complex local environment. Samples of both ambient air and aircraft exhaust were collected to provide information about the source and the receptor.

We decided to collect and analyze samples to determine the concentrations of a number of organic compounds, including both hydrocarbons (HC) and several oxygen-containing compounds; collectively, these compounds are called non-methane organic compounds (NMOCs). The concentrations of these organic compounds are fundamental to understanding the emissions impact of combustion sources. There is an abundance of information about the distribution of these compounds in ambient air and vehicular exhaust. Ambient NMOC concentrations are routinely measured at several sites in the Los Angeles area; these concentrations can be compared with the measured ambient concentrations near the airport. In addition, the composition of aircraft emissions can be compared to the emissions of other sources found in the area, such as gasoline-powered vehicles, diesel-powered vehicles, and gasoline stations. These comparisons will help identify unique species that are emitted from any of the sources in the area, including aircraft operations at the airport, and will allow a simple evaluation of the relative contributions of the separate emissions sources to ambient concentrations.

The ambient sampling program was designed to capture the highest possible contributions from the airport and to assess the potential exposure to these compounds in the nearby neighborhood. The design included placing one of the samplers as close as possible to the end of the airport runway and taking samples during the busiest airport operating hours. We chose this strategy for several reasons, including the urban location and the complex terrain of the airport. There are numerous sources of NMOCs in the area that can overwhelm the measurements of emissions from the airport. To maximize our chances of detecting NMOC emissions from the aircraft, we placed one set of sampling equipment to intercept emissions from the aircraft as often as possible. The complex terrain also dictated that we place the sampling

equipment close to the aircraft emissions. We were concerned that the mixing associated with the steep drop in elevation between the airport and the neighborhood east of the airport and the busy traffic on Bundy Drive would disperse the aircraft emissions to the point that they would be difficult to detect, relative to emissions from other sources. The sampler located at the end of the airport runway was placed to provide an upper bound on the impact of the aircraft emissions on the local community. In order to assess the potential impacts of the aircraft emissions on the nearby community, we placed a second NMOC sampling system in the neighborhood east of the airport. The NMOC samples were collected simultaneously at these two sites. Any differences in NMOC concentrations between the two sites would provide an indication of the local variability in NMOC concentrations, the dispersion rate of the aircraft emissions, and the relative impact of the aircraft emissions compared to other local sources.

Jet exhaust samples were collected near the end of the airport runway just as a jet was taking off. These samples were taken in short durations of 5 to 10 seconds in order to maximize the measured relative contribution of jet exhaust and minimize the measured relative contribution of other emissions sources.

## 2. NON-METHANE ORGANIC COMPOUND BACKGROUND

### 2.1 SOURCES AND FORMATION

Non-methane organic compounds are a class of chemicals that are ubiquitous in our atmosphere. In the urban environment, there are two main sources of NMOCs. One source is combustion; unburned or partially burned NMOCs are contained in engine exhaust. The other source is vaporization; for example, NMOCs vaporize when a gasoline tank is filled. NMOCs are emitted in the ambient air by several sources: gasoline-powered vehicles, diesel-powered vehicles, power plants, gas stations, aircraft, cooking, wood burning, dry cleaning, etc. Virtually anything that is burned is composed of NMOCs and forms gaseous NMOCs as it burns.

The type of fuel burned and the efficiency of the engine determine the type and quantity of NMOCs contained in vehicular exhaust. Jet fuel is similar to diesel fuel, while piston airplane fuel is similar to gasoline. All of these fuels contain several overlapping NMOCs and thus produce similar emissions. Some emissions sources output unique NMOCs, or tracers, that allow us to identify that source. For example, gasoline-powered vehicles are the only source of methyl-tertiary-butyl-ether (MTBE). Scientific literature does not document any unique NMOCs in jet exhaust.

### 2.2 MEASUREMENT TECHNIQUE

The NMOC measurement technique used in our sampling program determines the total concentration of NMOCs and the concentrations of 78 individual NMOCs in samples collected in polished stainless-steel cans. The Oregon Graduate Institute performed the laboratory analyses. The measurement technique is specified by the U.S. Environmental Protection Agency (EPA) and is referred to as Compendium Method TO-14A. This EPA document details the sample collection, sample analysis, can-cleaning methods, and calibration techniques. This EPA document and instrument-specific operating parameters are available upon request.

We reported the quantities of NMOCs measured in the samples in two different ways. One approach was to report the quantities in terms of concentration, expressed as parts per billion carbon (ppbC), which indicates the number of molecules of carbon in the compound per one billion molecules of air. An NMOC concentration in ppbC can be converted to ppb by dividing the concentration by the number of carbon atoms in the respective NMOC. For example, an acetaldehyde concentration of 1 ppbC is the same as an acetaldehyde concentration of 0.5 ppb because acetaldehyde has two carbon atoms. The other approach was to report the quantity of NMOCs as a fraction or percent of total non-methane organic compounds (TNMOCs). Methane (natural gas) is eliminated from measurement reporting because it is unreactive and very abundant in ambient air. We used fractions or percents to normalize the concentrations and facilitate comparisons among various samples. We refer to both of these measures in this report.

### 3. OBJECTIVES OF THE SAMPLING PROGRAM

#### 3.1 AMBIENT AIR SAMPLES

We measured the NMOC concentrations at the east end of the airport runway and in the community east of the airport. Each of the ambient NMOC samples was taken simultaneously at these two sites. We designed the ambient NMOC sampling program with several objectives in mind.

- Evaluate the local NMOC concentrations and their variability by time of day, wind direction, wind speed, and emissions activities.
- Determine if the NMOC concentrations on the airport property were significantly different from those in the nearby community.
- Determine whether jet emissions are identifiable in the ambient samples.
- Compare the NMOC concentrations in the Santa Monica area to those in surrounding communities using data collected by the South Coast Air Quality Management District (SCAQMD) and the California Air Resources Board (ARB).

We collected the ambient samples over 2-hr time periods. Two hours is a suitable sampling period for several reasons. First, average concentrations are the most appropriate to use to evaluate any human exposure impacts of aircraft emissions on the community. The majority of ambient NMOC sampling programs across the country that address human exposure employ sampling times of 2 hours or 24 hours. Second, the sampling period needed to be short enough to minimize the changes in wind direction during the sampling in order to interpret where the air came from. Third, samples were to be collected during the busiest periods of operation for the airport.

#### 3.2 JET EXHAUST SAMPLES

We collected samples of jet exhaust to characterize the NMOCs emitted by jets frequenting the airport. We collected these exhaust samples for several reasons.

- Jet emission profiles are necessary to understand the possible impact on ambient air quality in the surrounding community.
- We needed to determine whether any unique or uncommon NMOCs exist in jet exhaust. Uncommon means that NMOCs are not present in significant concentrations in other local sources such as motor vehicles or gas stations.
- We could not locate in the scientific literature any NMOC characterizations for small jets similar to those operated at the Santa Monica airport. The only NMOC characterization we did locate was for a large, commercial jet. This profile contained obvious and gross inaccuracies.
- We needed to compare jet exhaust to other sources of NMOCs in the area such as diesel-powered vehicles and gasoline-powered vehicles.

We collected jet exhaust samples in durations of 5 to 10 seconds while the jets were taking off.

#### 4. AMBIENT AIR QUALITY SAMPLES

##### 4.1 SAMPLING LOGISTICS

We performed NMOC sampling on December 18, 19, 20, and 21, 2000. We collected ambient samples simultaneously at the east end of the runway (SMO) and on Sardis Avenue (Sardis). Figure 4-1 shows the locations of the two sites. Note that Bundy Drive, a busy thoroughfare, is located between the two sites. Two gas stations are located near the sites: one on the northeast corner and the other on the southeast corner of Bundy and National Boulevard. Aircraft refueling occurs on both the north and south sides of the runway. Our air quality monitoring sites were located approximately 200 yards apart. The SMO site sat approximately 30 feet higher than the Sardis site. We placed the SMO sampling equipment along the centerline of the runway in an attempt to capture the highest aircraft exhaust concentrations possible.

We collected 15 samples simultaneously at each of the sites. Each sample was collected over two hours to obtain an average concentration for that time. Sampling systems operated on timers, collecting samples each day at 0200 to 0400 PST, 0700 to 0900 PST, 1200 to 1400 PST, 1600 to 1800 PST, and 2100 to 2300 PST. The sample inlets were located approximately 5 feet off the ground. This height provided an air sample representative of the air typically inhaled by humans. The sampling system integrity was checked at least once each day for proper timing, airflow rate, and sample intake. We did not experience any problems with the sampling systems.

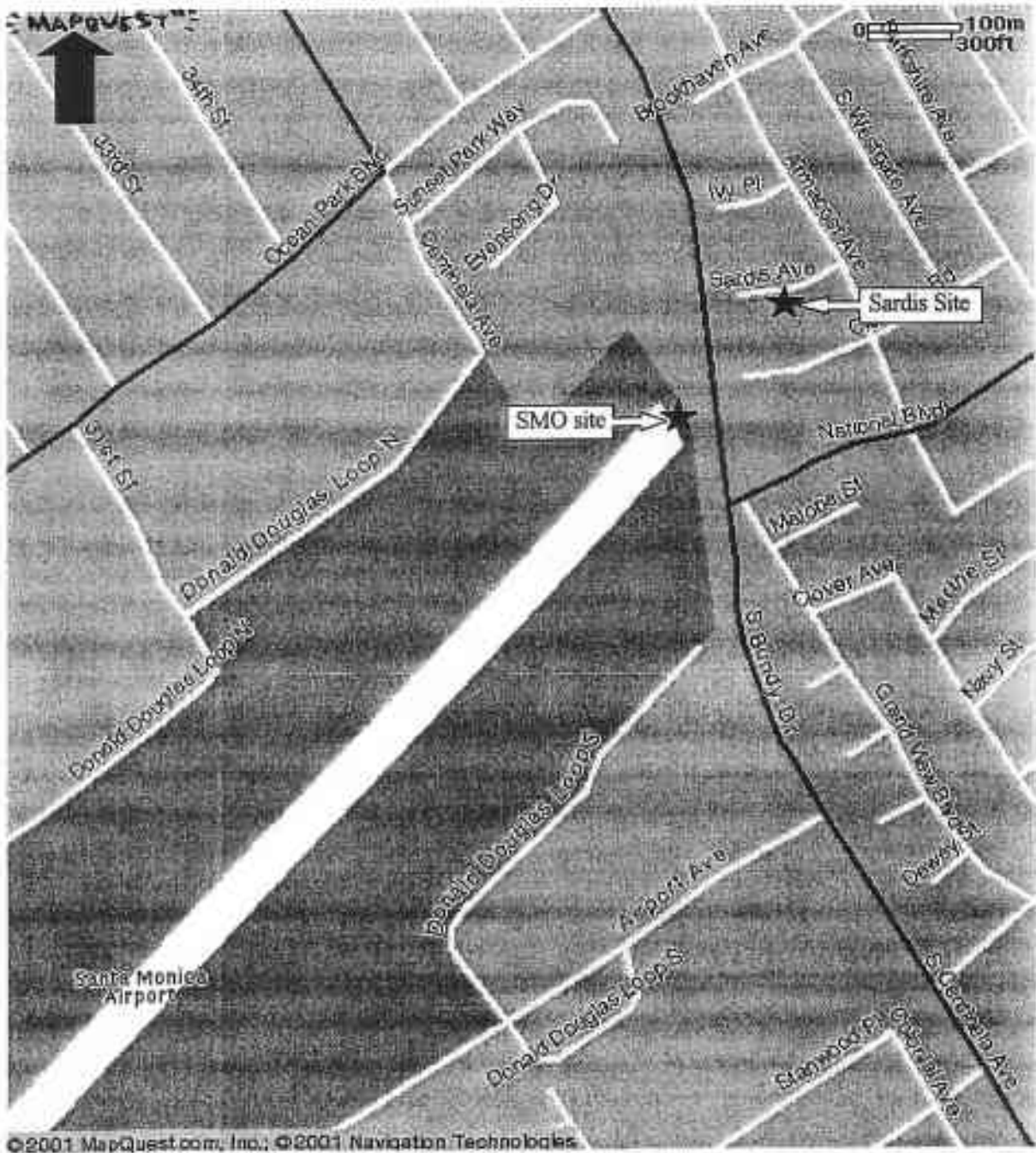


Figure 4-1. Locations of the two ambient sampling sites.

#### 4.2 METEOROLOGY DURING AMBIENT SAMPLING

The National Oceanic and Atmospheric Administration (NOAA) maintains a meteorological observation station at the Santa Monica Airport. We requested and obtained wind, temperature, and visibility data from this station, and used the data to assist with the interpretation of the observed NMOC concentrations.

Meteorology plays a key role in ambient HC concentrations, and the meteorology varied significantly during the sampling period. Santa Ana winds were blowing from the east and north on the first sampling day, December 18, 2000. These brisk winds brought clean air into the L.A. Basin. The dramatic drop in ambient pollutant concentrations due to this wind pattern was evident both visually and in our NMOC samples. At 1100 PST on the second sampling day, December 19, 2000, the winds shifted to blowing from the southwest (typical sea breeze). On the second and third sampling days, daytime winds were out of the southwest and nighttime winds were out of the northeast; this is a seabreeze-landbreeze pattern typical for this location. Figure 4-2 shows a time series plot of the wind directions and speeds during the sampling period.

The Santa Monica area experiences a fairly constant wind pattern throughout the year. On most days, winds are out of the southwest during the day and out of the northeast during the night. The transitions from offshore to onshore and vice versa typically occur between the hours of 0900 to 1100 PST and 2000 to 2100 PST, respectively. Consequently, emissions from the Santa Monica Airport typically blow toward the northeast across Bundy Drive during the late morning, midday, and early evening and blow toward the southwest, away from Bundy Drive, overnight and into the early morning.

#### 4.3 AIRPORT ACTIVITY DATA

Two different organizations regularly compile information about Santa Monica Airport operations. The Federal Aviation Administration (FAA) Tower maintains hourly records of the number of operations occurring at the airport. The FAA Tower records the total number of takeoffs or landings by hour between the hours of 0700 and 2100 daily. The Santa Monica Airport Security Guards patrolling the airport record all jet takeoffs and landings at the airport on a 24-hr basis. We obtained both of these types of reports for all of the sampling days and used the activity data to compare with our NMOC concentration data. Records of the comparisons are presented later in this report.

#### 4.4 AMBIENT HYDROCARBON CHARACTERIZATION

Several factors affect the ambient NMOC concentrations, including meteorology, local emissions, background concentrations, and chemical reactions. The amount of variability is immediately apparent in Figures 4-3 and 4-4, which plots the NMOC concentrations we measured. Each point is plotted at the sample start time and represents a 2-hr average concentration. The first six samples, taken on December 18, 2000, at 1600 to 1800 PST and 2100 to 2300 PST, and on December 19, 2000, at 0200 to 0400, 0700 to 0900, 1200 to 1400, and 1600 to 1800 PST, have significantly lower NMOC concentrations than the rest of the samples.

These low concentrations are the result of brisk Santa Ana winds. The visibility was high on this day, further testament to the purity of the air that was transported in by the Santa Ana winds. As shown in Figure 4-2, the Santa Ana conditions shifted after 1100 PST on December 19; the winds coming from the northeast shifted to coming from the southwest. As night fell on December 19, the NMOC concentrations began to rise. During the remainder of the sampling program, we observed the typical diurnal pattern of high nighttime NMOC concentrations and low daytime concentrations.

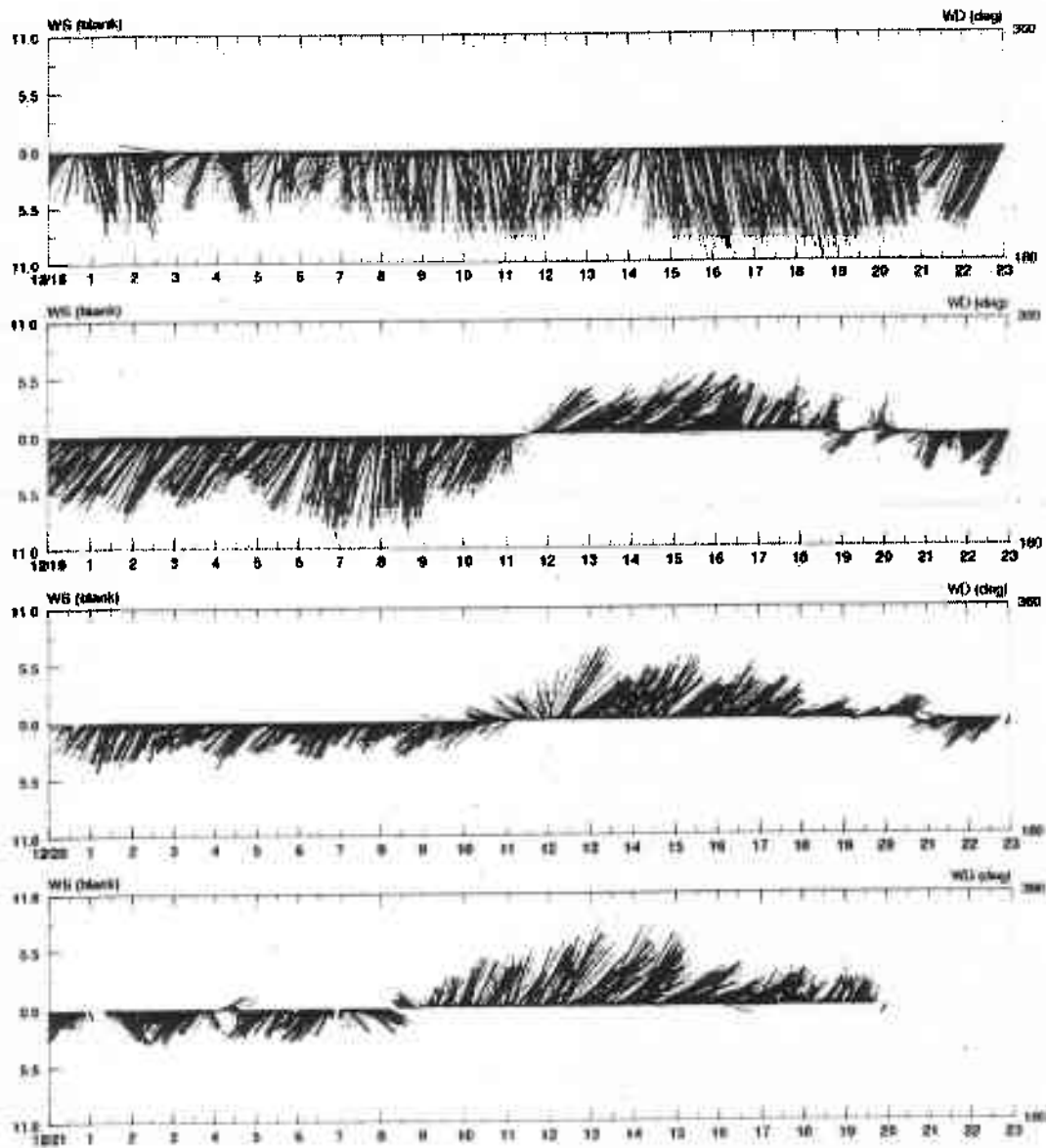


Figure 4-2. Wind direction and speed during the sampling period. The barbs indicate the direction toward which the wind is heading. The length of the barb is proportional to the speed of the wind in mph.

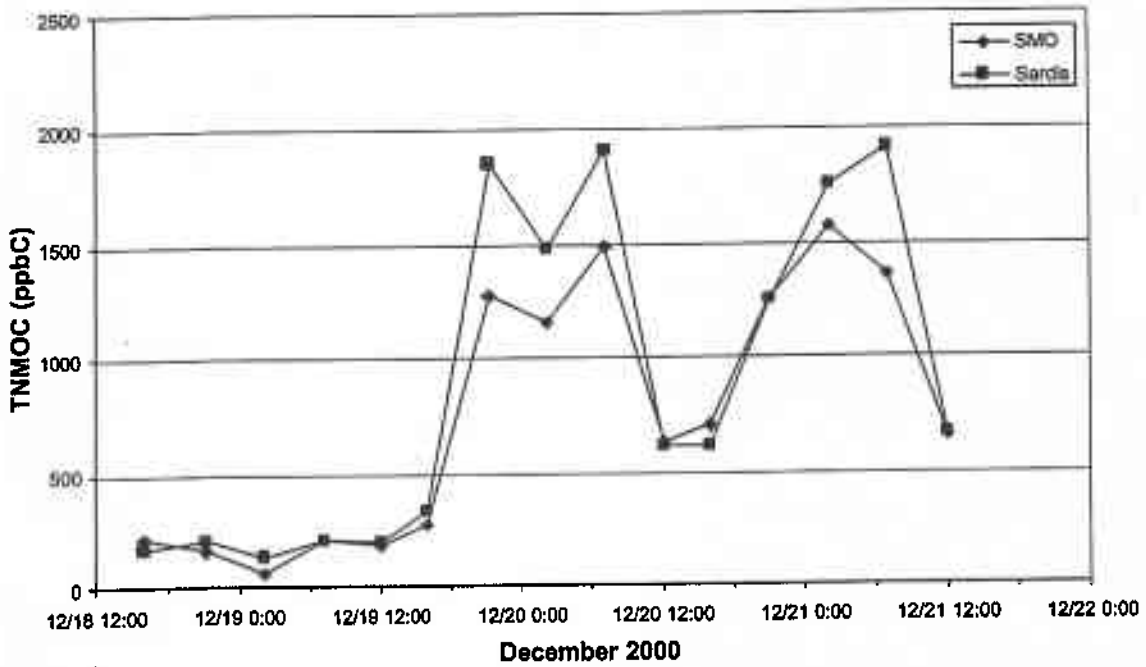


Figure 4-3. Total non-methane organic compound concentrations at the SMO and Sardis sites. Each point represents a 2-hr average concentration and is plotted at the sample start time.

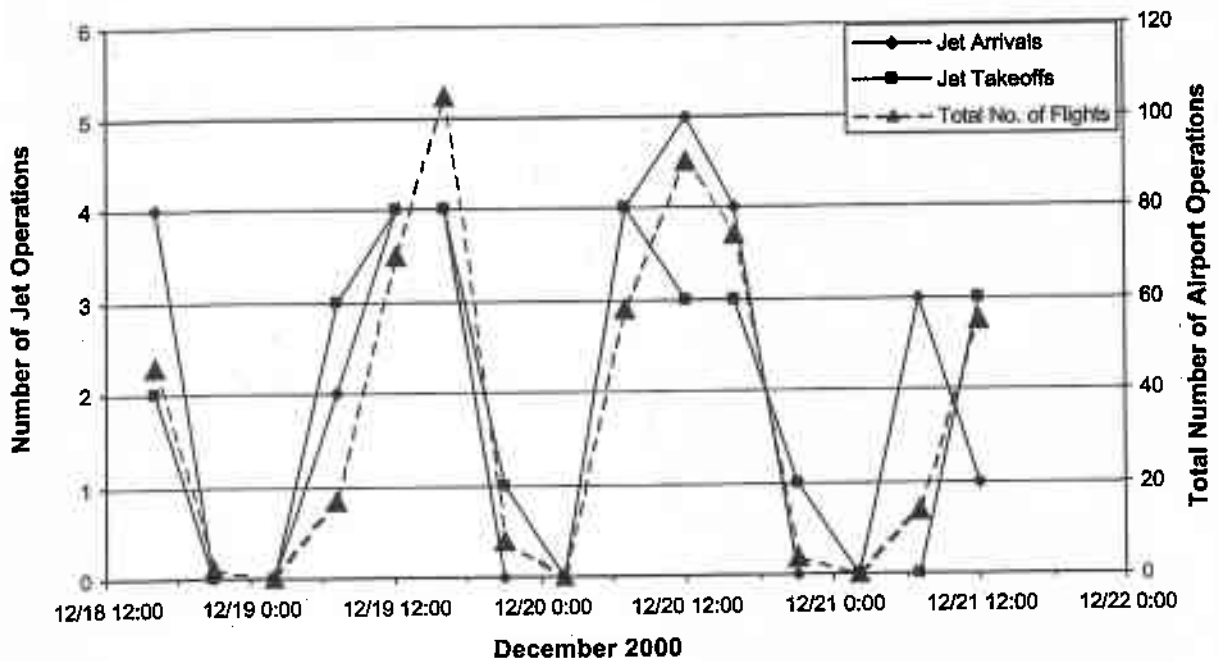


Figure 4-4. Number of aircraft operations during the 2-hr samples at the Santa Monica Airport.