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UNIVERSITY OF CALIFORNIA, DAVIS

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SOURCES OF VISIBILITY DEGRADATION
IN THE LAKE TAHOE AIR BASIN

Thomas A. Cahill
Principal Investigator

Lowell L. Ashbaugh
John B. Barone
Investigators

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and the
Air Quality Group, Crocker Nuclear Laboratory,
University of California, Davis, CA 95616

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Final Report to the
Research Division
California Air Resources Board
Jack Suder
Project Manager
Personnel

Principle Investigator – Thomas A. Cahill
Professor of Physics

Investigators:
Lowell Ashbaugh
M.S., Public Health,
University of California, Berkeley

John Barone
B.A., Mathematics,
Kent State University, Ohio

Supporting Members of the Air Quality Group,
Crocker Nuclear Laboratory, University of California,
Davis, CA 95616

Robert A. Eldred, Ph.D.
Patrick J. Feeney, M.A.
Robert G. Flocchini, Ph.D.
Danny J. Shadoan, M.S.
Gordon W. Wolfe, Ph.D.
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<tr>
<td></td>
<td>January 25, 1977</td>
<td></td>
</tr>
</tbody>
</table>
ABSTRACT

Air quality in the Lake Tahoe region has been a concern for a number of years. This study was designed to examine some of the sources of the air pollution in the Lake Tahoe basin. The first step was an evaluation of the Air Resources Board sampling of 1973. From this data the local contribution of different gas and particulate pollutants was postulated. A sampling station was then established at South Lake Tahoe and particulates in three size regions were collected and analyzed for elemental content. To determine if the data from this station were representative of the basin, a profile of Lake Tahoe was developed. It was determined that the concentrations of the major elements were quite different from site to site. It was also found that the most polluted site was South Lake Tahoe. A spatial profile in South Lake Tahoe was then conducted to determine the sources in this region. It was possible to identify automotive traffic as one source in the area. The origin of the sulfur aerosols was not identified.
Executive Summary

This study was designed to examine air quality in the Lake Tahoe Basin with emphasis on particulates.

The first step in the study was an examination of the data collected in 1973 at Lake Tahoe by the California Air Resources Board. The data showed that while some sites exhibited very good air quality others exhibited poor air quality. In general mean pollutant concentrations were comparable to other urban areas in California. After separating sites into clean, basin average, and dirty the contribution due to local anthropogenic sources was determined. Estimates indicate that at least 75% of CO, NO_x, and Pb are local. There was no indication of a local source of oxidant.

In October 1975 a Sierra Multiday Impactor was placed at the Park Avenue ARB station. Twenty four hour samples were analyzed in three size regions (20 - 3.6 μ, 3.6 - .65 μ, .65 - .10 μ) for elemental content. Samples were collected for nine months. Four elements were then examined as important tracers; Si as a tracer of soil, Cl as a tracer of road salt, Pb as a tracer of automotive activity and S as a possible tracer of fuel oil combustions. The following trends were observed.

1. Coarse Chlorine and coarse silicon concentrations were at a maximum during January 1976.
2. Fine lead was highest in January.
3. Fine sulfur did not correlate with lead although coarse silicon did during the winter months.
4. Fine sulfur had the highest concentration in the summer.

As part of the project a spatial examination of particulates in the Lake Tahoe Basin was undertaken. In August 1976 multiday impactors were placed at the Park Avenue station, Sugar Pine Point and Tahoe City. Twenty four hour samples were collected for fourteen days. Samples were also collected for one day by means of a total filter at eight sites duplicating the 1973 ARB study. These samples were changed every two hours between 9:00 a.m. and 7:00 p.m. on August 10, 1976. There was a significant difference in the concentration of major elements (Si, S, Fe, Pb) from site to site. The South Lake Tahoe stateline area was found to have the poorest air quality. Because of the findings of the basin profile two small scale profiles were designed to determine the aerosol sources in South Lake Tahoe. Samples were collected in December and January at eight sites.
The most striking trend was the sharp rise in soil and automotive aerosol concentrations downwind of Highway 50. Sulfur did not exhibit this behavior.

From the data gathered during this study the following conclusions can be drawn:

1. The Lake Tahoe basin has a pollution problem comparable to other non-industrial urbanized areas in California. This is consistent with the ARB study of 1973.

2. The elemental aerosol concentrations in the Lake Tahoe basin are spatially non-homogeneous with highest levels associated with the higher population and traffic densities.

3. The South Lake Tahoe profiles indicate the existence of two major sources. The first source is automobile traffic on Highway 50. The second source is characterized by the anomalous behavior of Sulfur. The source of sulfur in the basin could not be identified with the data available.
I. Introduction

Air quality in the Lake Tahoe basin has been the subject of great concern by numerous individuals and agencies. One of the perplexing problems in the basin is the ubiquitous haze formation observed during summer months. The cause of this visibility-degrading process has not been fully understood. Moreover, the origin and movement of pollutants which cause visibility reduction in the basin has not been documented.

The aerosol monitoring study at Lake Tahoe was designed to determine the main basin aerosol concentration and the source(s) of aerosols in the basin. This information can be used to identify the cause of visibility degradation in the basin. Two weeks of monitoring data at three sites around the basin in August 1976 were used to establish the mean basin aerosol concentration. During this monitoring effort, a basin wide (eight stations, see figure 2) temporal sampling effort was initiated to ascertain the temporal fluctuations in aerosol concentration (appendix A contains sites and sampling times). Information gained in this phase of the study indicated that South Lake Tahoe was the major source area in the Basin. An intensive study of South Lake Tahoe was initiated in December 1976 and January 1977 (see appendix A for sampling dates and sites). This study was used to determine the major sources in the South Lake Tahoe area.

It should be noted that all inferences and judgements contained in the report represent only the view of the author.
II. Historical Data

A. 1973 ARB Tahoe Basin Study

During the summer of 1973 the Air Resources Board measured nine pollutant concentrations at the sites shown in figure 1. For most pollutants the concentrations had large spatial variation; the arrangement in Table 1 is from cleanest to most impacted. The gas pollutants are the average maximum concentration in parts per million of air; the particulates are an average of one to seven measurements taken at random and expressed in micrograms per cubic meter of air.

In order to isolate pollutants transported into the Tahoe Basin or produced by biological activities from those due to local anthropogenic sources, an attempt was made to determine background concentrations. For most pollutants, the lowest average concentration at any of the sites were chosen as the background. For carbon monoxide the lowest average hourly concentration was assumed to be the background.

These background concentrations are shown in the upper row of Table 2. The four sites which had the lowest concentrations are averaged in the data for clean sites. The four sites with the largest concentrations are in the row for impacted sites. All ten sites were included in the basin average. For comparison, the concentrations for sites in three other basins in California are included.

Two pollutants, oxidant and total suspended particulates are reasonably uniform around the lake. The data for TSP is insufficient to understand its behavior. For the seven sites where more than one measurement was taken the scatter at the same site was as great as the variation between sites. Most of these pollutants were either transported into the basin or were produced by background biological activities.

The remainder of the pollutants show wide variation in concentrations. The local anthropogenic contribution may be estimated by subtracting the background from the total.

The fractions of the pollutants due to local activities are given in Table 3. The clean and impacted sites are the same as in Table 2.

B. Particulate Monitoring

In August 1974 and December 1974, 24 hour particulate concentrations were measured at the South Lake Tahoe Fire Station #1, using a multiday impactor. The concentrations of twelve elements for all particles below 20 microns are shown in Table 4. The only elements which changed radically from summer to winter were...
TABLE I

Air Pollutants in Lake Tahoe Basin Concentrations Reported in 1973 Study

<table>
<thead>
<tr>
<th>Sites</th>
<th>OX</th>
<th>CO</th>
<th>HC</th>
<th>NMHC</th>
<th>NOₓ</th>
<th>NO₂</th>
<th>NO</th>
<th>Pb</th>
<th>TSP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sugar Pine Point</td>
<td>.076</td>
<td>1.4</td>
<td>2.4</td>
<td>0.23</td>
<td>.009</td>
<td>.006</td>
<td>.006</td>
<td>.10</td>
<td>77*</td>
</tr>
<tr>
<td>Incline Village</td>
<td>.063</td>
<td>1.5</td>
<td>2.5</td>
<td>0.17</td>
<td>.012</td>
<td>.009</td>
<td>.003</td>
<td>.20</td>
<td>95*</td>
</tr>
<tr>
<td>Martis Valley</td>
<td>.055</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>.015</td>
<td>.013</td>
<td>.006</td>
<td>.15</td>
<td>78*</td>
</tr>
<tr>
<td>Lake Forrest</td>
<td>.067</td>
<td>1.8</td>
<td>2.1</td>
<td>0.20</td>
<td>.016</td>
<td>.008</td>
<td>.009</td>
<td>.16</td>
<td>64</td>
</tr>
<tr>
<td>Tahoe City</td>
<td>.085</td>
<td>1.5</td>
<td>5.8</td>
<td>0.67</td>
<td>.020</td>
<td>.016</td>
<td>.012</td>
<td>.15</td>
<td>50</td>
</tr>
<tr>
<td>Tahoe Keys</td>
<td>---</td>
<td>1.5</td>
<td>3.0</td>
<td>1.10</td>
<td>.042</td>
<td>.030</td>
<td>.015</td>
<td>.23</td>
<td>47</td>
</tr>
<tr>
<td>King's Beach</td>
<td>.075</td>
<td>3.2</td>
<td>3.2</td>
<td>0.20</td>
<td>.041</td>
<td>.029</td>
<td>.012</td>
<td>.58</td>
<td>43*</td>
</tr>
<tr>
<td>Nevada Beach</td>
<td>.052</td>
<td>2.2</td>
<td>4.1</td>
<td>0.86</td>
<td>.057</td>
<td>.048</td>
<td>.010</td>
<td>.25</td>
<td>54</td>
</tr>
<tr>
<td>South Lake Tahoe</td>
<td>.062</td>
<td>5.1</td>
<td>3.0</td>
<td>0.80</td>
<td>.065</td>
<td>.028</td>
<td>.039</td>
<td>---</td>
<td>54</td>
</tr>
<tr>
<td>Stateline</td>
<td>.049</td>
<td>6.4</td>
<td>5.2</td>
<td>1.97</td>
<td>.068</td>
<td>.041</td>
<td>.024</td>
<td>1.73</td>
<td>87</td>
</tr>
</tbody>
</table>

--- No sample taken

* deleted five values assigned to local sources

GASES: Average of maximum hour; parts per million of air

PARTICULATES: Average of 24 hour samples taken at random times; in micrograms per cubic meter of air.
<table>
<thead>
<tr>
<th></th>
<th>OX</th>
<th>CO</th>
<th>HC</th>
<th>NMHC</th>
<th>NOₓ</th>
<th>NO₂</th>
<th>NO</th>
<th>Pb</th>
<th>TSP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Background</strong></td>
<td>.065</td>
<td>.65</td>
<td>1.75</td>
<td>0.18</td>
<td>.009</td>
<td>.006</td>
<td>.003</td>
<td>.05</td>
<td>45</td>
</tr>
<tr>
<td><strong>Clean sites</strong> (1)</td>
<td>.065</td>
<td>1.6</td>
<td>2.3</td>
<td>0.20</td>
<td>.013</td>
<td>.009</td>
<td>.006</td>
<td>.15</td>
<td>79</td>
</tr>
<tr>
<td><strong>All sites</strong></td>
<td>.065</td>
<td>2.7</td>
<td>3.48</td>
<td>0.68</td>
<td>.035</td>
<td>.024</td>
<td>.014</td>
<td>.40</td>
<td>65</td>
</tr>
<tr>
<td><strong>Impacted Sites</strong> (2)</td>
<td>.060</td>
<td>4.2</td>
<td>3.9</td>
<td>0.93</td>
<td>.058</td>
<td>.039</td>
<td>.021</td>
<td>.85</td>
<td>60</td>
</tr>
<tr>
<td><strong>Monterey</strong></td>
<td>.04</td>
<td>1.0</td>
<td>---</td>
<td>---</td>
<td>.03</td>
<td>.000</td>
<td>.020</td>
<td>.23</td>
<td>36</td>
</tr>
<tr>
<td><strong>Sacramento</strong></td>
<td>.09</td>
<td>2.0</td>
<td>2.0</td>
<td>---</td>
<td>.06</td>
<td>.040</td>
<td>.020</td>
<td>.49</td>
<td>78</td>
</tr>
<tr>
<td><strong>Los Angeles</strong></td>
<td>.11</td>
<td>6.0</td>
<td>3.0</td>
<td>---</td>
<td>.17</td>
<td>.110</td>
<td>.100</td>
<td>2.7</td>
<td>116</td>
</tr>
</tbody>
</table>

(1) Clean: Sugar Pine Point, Incline Village, Martis Valley, Lake Forest

(2) Impacted: King's Beach, Nevada Beach, South Lake Tahoe, Sahara Tahoe

**GASES:** parts per million of air

**PARTICULATES:** micrograms per cubic meter of air
<table>
<thead>
<tr>
<th></th>
<th>CO</th>
<th>HC</th>
<th>NMHC</th>
<th>NOₓ</th>
<th>NO₂</th>
<th>NO</th>
<th>Pb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clean sites</td>
<td>59%</td>
<td>24%</td>
<td>10%</td>
<td>31%</td>
<td>33%</td>
<td>50%</td>
<td>67%</td>
</tr>
<tr>
<td>All sites</td>
<td>76%</td>
<td>50%</td>
<td>74%</td>
<td>74%</td>
<td>75%</td>
<td>79%</td>
<td>88%</td>
</tr>
<tr>
<td>Impacted sites</td>
<td>85%</td>
<td>55%</td>
<td>81%</td>
<td>81%</td>
<td>85%</td>
<td>86%</td>
<td>95%</td>
</tr>
</tbody>
</table>
sodium and chlorine which were much higher in December and Sulfur which was larger in August. For comparison, the concentrations at four other California sites are included.

From October 1975 through June 1976 similar 24 hour samples were collected at the Park Avenue ARB station in South Lake Tahoe. The particles were separated into three size regions: coarse, 3.6 to 20 microns; intermediate, 0.6 to 3.6 microns; and fine, 0.1 to 0.6 microns. The coarse particles are considered non-respirable and primarily natural; the intermediate and fine are respirable and primarily anthropogenic. Concentrations were measured for twenty elements; of these four are considered tracers: silicon for soil, chlorine for salt, sulfur for fuel combustion and lead for automobiles.

The South Lake Tahoe data were compared with those of other California sites, operating simultaneously in the ten-site ARB particulate monitoring network. All of the tracer elements had size distributions typical of the sites. 75% of the silicon was in the coarse region; for other sites the range was 71% to 79%. Chlorine was distributed approximately equally on each stage (38% coarse, 22% intermediate, 40% fine), as it is at all other inland sites away from marine influences. 59% of the sulfur was in the fine region and 26% in the intermediate. South Lake Tahoe had slightly more coarse sulfur and less intermediate than other sites. Lead was typical with 68% fine and 21% intermediate. The total concentrations of these four elements in South Lake Tahoe is compared with those in four other sites in Table 5. SLT is much cleaner than sites in Southern California, slightly cleaner than Visalia and Chico and approximately as clean as Lakeport. The lead values compare with those obtained in 1973 - 1974 in Salinas.

These four tracer elements were examined for yearly trends at South Lake Tahoe. The average monthly concentration for coarse silicon and chlorine and for fine sulfur and lead are shown in Figure 2. The following important trends were recognized.

1. Coarse silicon and coarse chlorine were at a maximum during January and were well correlated during the nine months period. (However, there is not a correlation between the daily 24 hour concentrations). This peak is peculiar to South Lake Tahoe, as most sites show a level silicon concentration.

2. Coarse silicon and fine lead have a similar pattern during most of the year.
### TABLE 5

Average Concentrations of Four Tracer Elements in Selected California Sites in 1975 - 76.

<table>
<thead>
<tr>
<th></th>
<th>Silicon</th>
<th>Sulfur</th>
<th>Chloride</th>
<th>Lead</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Lake Tahoe</td>
<td>1.7</td>
<td>0.15</td>
<td>0.11</td>
<td>0.31</td>
</tr>
<tr>
<td>Los Angeles</td>
<td>2.7</td>
<td>1.01</td>
<td>0.57</td>
<td>2.29</td>
</tr>
<tr>
<td>Visalia</td>
<td>4.4</td>
<td>0.88</td>
<td>0.21</td>
<td>0.79</td>
</tr>
<tr>
<td>Chico</td>
<td>2.3</td>
<td>0.28</td>
<td>0.14</td>
<td>0.51</td>
</tr>
<tr>
<td>Lake County</td>
<td>1.1</td>
<td>0.19</td>
<td>0.15</td>
<td>0.07</td>
</tr>
<tr>
<td>Salinas (1973-74)</td>
<td>1.0</td>
<td>0.49</td>
<td>1.15</td>
<td>0.26</td>
</tr>
</tbody>
</table>

### TABLE 6

Mean Elemental Concentrations for Selected Elements and Sites at Lake Tahoe

<table>
<thead>
<tr>
<th></th>
<th>Park</th>
<th>Tahoe City</th>
<th>Sugar Pine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Si Stage I</td>
<td>1095 ng/m³</td>
<td>1064</td>
<td>536</td>
</tr>
<tr>
<td>Pb Stage 3</td>
<td>287 ng/m³</td>
<td>110</td>
<td>51</td>
</tr>
<tr>
<td>S Stage 3</td>
<td>324 ng/m³</td>
<td>240</td>
<td>292</td>
</tr>
</tbody>
</table>
3. The fine lead concentration during two weeks in August 1976 was nearly as high as in January 1976. The typical pattern for other California sites is a decrease of lead concentration during the summer.

4. The fine sulfur concentration remained near 110 ng/m³ for November through February, with lower values for October, March and April. A second, much higher peak occurred during the summer.

5. Fine lead and fine sulfur were not correlated.

The monitoring data has been previously reported to the Air Resources Board.

III. Basin Profile Study

As a part of the present study, three multiday impactors were operated at strategic locations around Lake Tahoe. The units were located at Park Avenue (the ARB monitoring station), Sugar Pine point and Tahoe City. Each unit was started on August 4, 1976 and operated for two weeks, ending August 16, 1976. Samples were analyzed for the elements Na→Pb using IEXE. Data for this study are reported in Appendix B. On August 10, during the monitoring period, samples were collected at eight other locations around the Lake. The sites chosen for this sampling were similar to those chosen by the ARB in the 1973 study (See Figure 3). Samples were collected in 2 hour increments starting at 9:00 a.m. and ending at 7:00 p.m. All samples were collected using .8 μm nuclepore filters and were analyzed for elements Na→Pb using IEXE. Data are reported in Appendix C.

Samples collected during the monitoring period exhibited significantly different values at each site (See Table 6). Average silicon values were nearly the same at Tahoe City and Park Avenue, but were significantly lower at Sugar Pine Point. Lead values were generally highest at Park Avenue and lowest at Sugar Pine Point. A similar behavior was exhibited by the Total Mass collected at these stations. Mean sulfur values were slightly higher in South Lake Tahoe, and were lowest at Tahoe City. Examination of the full data set (See Appendix C) indicated that elemental concentrations varied significantly from site to site around the Lake.

Data from the August 10 study also indicated a variation in elemental concentration around the Lake (Figures 4, 5). In addition, a large temporal variation occurred at each site (Figure 4). Peak concentrations of automotive pollutants
**upwind construction, 9 AM - 4:30 PM**
LAKE TAHOE SITES

TRAFFIC 8/10/76, NOON, RELATIVE TO PARK AVENUE

* CLOSEST MAJOR ROAD
** UPPER LIMITS USED IF NO Pb, S SEEN.
(Pb) occurred from 3 - 5 in the afternoon. South Lake Tahoe (Park Avenue and Tahoe Y, the latter located on Tata Lane) had the highest lead concentrations in each time period. The only other site that recorded an enhanced lead value was Tahoe City. Sierra Ski Ranch was the cleanest site, although local construction upwind of the sampler from 9 AM to 4:30 PM did enhance soil values, as indicated by the silicon values.

The day selected for the basin profile study was chosen in order to avoid weekend traffic and match, as much as possible, typical weather patterns in the Lake Tahoe area and the Sacramento Valley. Synoptic weather summaries are given in Appendix F for the days before and after the study day, as well as the day itself, and they show typical Sacramento summer conditions in terms of minimum and maximum temperatures, wind speeds and direction. Particulate levels were measured at Davis, and sulfur, specifically, was close the mean values normally observed at Sacramento, although slightly lower. This was also true of oxidant, which was at about 2/3 of typical summer levels. Also in Appendix F is a map, similar to figure 3, that shows the average wind direction around noon on 8/10/76 with noon directions reported in the 1973 ARB study. The directions are similar at all locations for which comparisons are possible, again showing that the day chosen was typical of summer conditions. The wind measured at Sierra Ski Ranch was from the west, thus allowing possible transport from the Sacramento Valley.

The results of the basin profile for lead and sulfur are compared, in Figure 5, with mean vehicle trips per day from the 1974 Tahoe Regional Transportation Study (TRTS) as estimated for 1975. Traffic values at the south end of the basin around noon on 8/10/76, relative to Park Avenue - Highway 50 values, are also shown, and they are similar to the TRTS values. The agreement between the traffic data and the airborne lead data confirms the conclusions of the 1973 ARB study concerning the local automotive source of this pollutant. The sulfur profile is similar to that of lead, but possesses significant differences, especially on the lack of a sulfur enhancement at the north end of the lake and the easterly shift of the peak at the south end of the lake. Silicon and other soil-like materials followed a profile similar to that of lead and traffic.
IV. South Lake Tahoe Spatial Profiles

The results of the Basin Profile Study indicated that the poorest air quality was highly localized in the vicinity of the South Lake Tahoe/Stateline area. Two small scale profiles were designed to determine the source(s) of pollution in this area. The first sampling period was on December 4, 1976. Little, if any, snow had fallen prior to this date, and unseasonably warm weather had prevented the ground from freezing. As a result, the sources of soil aerosol were fully available. The second sampling period was on January 25, 1977. A small amount of snow had fallen, leaving patches of snow-covered ground. Most other exposed soil areas were frozen or wet, with the result that very little exposed soil surface was available as a source of soil aerosol.

The sampling array (Figure 6) was chosen for the following reasons:

(1) To estimate the effect of Highway 50 on area air quality.
(2) To sample a cross section of the most heavily impacted neighborhood (South Lake Tahoe).
(3) To check the Park Avenue site vs. other parts of the community.

The profile of January 25, 1977, did not include site #7. All other sites were identical for both profiles. Site locations are listed in Appendix A.

During both sampling periods the wind was predominantly from the Lake (Figure 6), although the first profile extended partly into the evening downslope wind regime. An atmospheric stability measurement, the bulk Richardson number, was made periodically on December 4, 1976. Data for both sample periods are reported in Appendices D and E.

The most striking trend observed in the profiles (Figure 7) was the sharp rise in soil and automotive aerosol concentrations downwind of Highway 50. Sulfur, however, did not exhibit similar behavior. Silicon concentrations were high during both sampling periods, but much higher after the snow than before. Lead exhibited the
expected behavior of a sharp rise just downwind of Highway 50, then a decrease downwind. Sulfur, however, was present at very high levels at Site #6, furthest from the highway, and at the beach and Pier Sites, upwind from Highway 50. Site #6 was located at the highest elevation of all sampling sites. Chlorine was detected in higher concentrations in January than in December, although it was not present in sufficient quantities to determine a spatial trend. At the Park Avenue ARB site, concentrations of nearly every element were lower than at the other community sites south of Highway 50 (Sites #4, #7, and #8).

Figure 6
V. **Interpretation**

A. Seasonal trends

The most cursory examination of the nine months of particulate monitoring data reveals that the Lake Tahoe basin has a pollution problem comparable to other urbanized non-industrial areas in California. This conclusion is consistent with the results of the Air Resources Board study of gaseous pollutants in 1973. Although monitoring data were not collected during the summer of 1976, seasonal trends can be identified with the aid of the two weeks of August data collected for this study (Figure 2). These trends indicate the following:

1. January has the highest particulate load of all winter months. The suspected source of most particulates during this period is area highways. This contention is supported by the very high levels of coarse silicon and chlorine in January, when lead was also at a peak level. The chlorine source is most probably salt spread on the roads. The silicon source during this period, when most soil areas are covered by snow, is most probably sand spread on the roads. The salt and sand is ground into relatively fine particles by passing automobiles, then entrained into the air by traffic-generated turbulence.

2. Lead exhibits a bi-annual peak, one in January and one during the summer. The summer peak is clearly indicated by the two week average for August.

3. Sulfur remains at a relatively constant level during the winter months (November through February). Lower levels occur in October, March, and April. During the summer, however, sulfur is detected in much higher concentrations than in the winter.
B. Pollutant Origins - Basin vs. Transport

The profiles conducted in August, 1976, by the Air Quality Group, and in the Summer of 1973 by the ARB, clearly indicate that pollution in the Lake Tahoe basin is spatially non-homogeneous (Figure 5, Table 1). The degree of pollution is highly correlated with population and traffic densities around the basin, suggesting that pollution is locally generated. In addition, temporal variations observed during daylight hours at all sites around the Lake further support the hypothesis of local pollutant generation. If the basin air pollution were transported from the Sacramento or Reno area, concentrations would be fairly uniform throughout the basin, both spatially and temporally.

A further example of spatial variance, although on a much smaller scale, is provided by the two South Lake Tahoe studies. The extreme variability of pollutants on a small scale (Figure 7) strongly supports the hypothesis of local sources.

C. Major Sources

The South Lake Tahoe profiles indicate the existence of two major sources. The first source, Highway 50, contributes the greatest aerosol mass in the South Lake Tahoe area (Figures 7, 8). A second source is suggested by the anomalous behavior of sulfur. The sulfur concentration does not correlate with lead spatially, eliminating automobiles as a direct source. The highest sulfur levels occur at South Lake Tahoe, (Park Avenue site). Although it is not possible to directly identify the source of sulfur due to the limited scope of this study, a likely source is combustion of fuel oil within the basin.
FIGURE 8

Particles 3.0 - 20 μm
January 25, 1977

μg/m³

Si
Al
Fe
K
Ti
Zn

UPWIND ROAD DOWNWIND
D. Visibility Reduction

Mie scattering by particulates is the primary mechanism governing reduction of visibility. Previous studies (e.g. ARB Staff Report 75-20-3) have implicated secondary pollutants as the primary light-scattering component of pollution in several California cities. If the same mechanism is at work in the Lake Tahoe area, then the levels of fine sulfates and nitrates control visibility. While it is not possible at this time to identify the specific source of sulfur in the South Lake Tahoe area, it is without doubt local. The suspected sources of secondary sulfur are combustion of fuel oil, natural gas, and automotive effluents. This suggests that visibility reduction is directly related to population levels and traffic volume within the basin.

E. Meteorology

Meteorological data including cloud conditions, visibility, temperature, dew point, and wind speed and direction were collected at the Tahoe Valley Airport and at Truckee. Data for the time periods sampled are tabulated in Appendix F. For the period of August 4 to August 16, 1976 data for morning and afternoon only are presented. For December 4, 1976 and January 25, 1977, all available data are shown.

In addition to the local meteorological data, daily weather maps were examined for the sampling periods. The synoptic weather was examined for non-typical conditions as well as to evaluate the possibility for transport of pollutants from the Sacramento Valley.

During August 1976 typical summertime conditions prevailed during the sampling period until August 14. On that date a low pressure system moved into the Pacific Northwest and rain fell in the Tahoe basin until around noon on the 15th. The upper level disturbance remained in the area through August 16, although no further rainfall was recorded. Prior to August 14 upper level winds were fairly constant from 20-30 knots from the Southwest or West-Southwest. Thus the possibility for transport existed prior to August 14.
On December 4, 1976, the upper level wind pattern showed zonal flow across the entire U.S. Over California the winds were Westerly at 20-25 knots. Hence, transport from the Sacramento Valley was possible. A similar pattern existed the day before. At the Tahoe Valley Airport, local cloud conditions revealed diurnal convective mixing occurred to about 10,000 feet. Excellent visibility, light to moderate winds, and warmer than average temperatures were recorded.

On January 25, 1977, the upper level winds were very similar to those of December 4, 1976. The only difference was a high pressure ridge in the Gulf of Alaska, causing Northwest winds over the extreme western edge of the U.S. The upper level winds at Reno were 20 knots from the Northwest. The upper level disturbance was reflected in the Tahoe Valley Airport data. Visibilities were slightly reduced, temperatures were somewhat cooler than average and humidity was higher than average. Winds were variable but light. Transport from the Sacramento Valley on this day was less likely than on December 4, 1976.
Conclusions

From the data gathered during this study the following conclusions can be drawn.

1. The Lake Tahoe basin has a pollution problem comparable to other non-industrial urbanized areas in California. This is consistent with the ARB study of 1973.

2. The elemental aerosol concentrations in the Lake Tahoe basin are spatially non-homogeneous with highest levels associated with the higher population and traffic densities. Further examination of particulates shows that:
   a. Lead exhibits a bi-annual peak, one in January and one during the summer.
   b. Sulfur was relatively constant during the winter months but showed elevated levels in the summer.
   c. Particulate loading was highest in January. This can be attributed to the area highways as shown by the high levels of coarse silicon and chlorine and fine sulfur.

3. The South Lake Tahoe profiles indicate the existence of two major sources. The first source is the automobile traffic on Highway 50. The second source is characterized by the anomalous behavior of sulfur. It was not possible to identify the source with the present data.
APPENDIX A

Sampling Locations
Appendix A

Field Studies at Lake Tahoe

1. Lake Profile - August 10, 1976
   Sites: Sierra Ski Ranch
          Tahoe Y (Tata Lane, USFS)
          Park Avenue (ARB site-roof)
          Nevada Beach Recreation Area
          Highway 28 (2 mi N US 50)
          Kings Beach (SRA)
          Tahoe City (SRA)
          Sugar Pine Point State Park

   Samplers: Filter Units (no sizing)
   Measured: Particulates (Na→Pb)
              (by Particle Induced x-ray Emission, UCD)

2. Highway 50 Profile - December 4, 1976
   Sites: #1 Beach near Stateline
          #2 Public Pier, end of Ski Run Blvd
          #3 South of Hwy 50 (30 m) on Ski Run
          #4 South of Hwy 50 (500 m) on Ski Run
          #8 South of Hwy 50 (1200 m) on Ski Run
          #6 South of Hwy 50 (1600 m) just off Ski Run (at end)
          #5 Park Avenue (ARB Site)
          #7 Forest Road, between Wildwood and Pine Grove Avenue

   Samplers: Sequential Filter Units (2 size cuts)
   Measured: Particulates (Na→Pb) coarse, fine
              Flow calibrated on site by spirometer
   Time Period: 9:00 AM to 6:00 PM

3. Highway 50 Profile - January 25, 1977
   All sites same as on 12/4, however site #7 was eliminated
   Samplers: Sequential Filter Units (2 size cuts)
   Measured: Particulates (Na→Pb) coarse, fine
   Time Period: 10:00 AM to 5:00 PM
APPENDIX B

Basin Monitoring

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### Stations

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(3) Park Avenue  
(4) Nevada Beach  
(5) Highway 28  
(6) King's Beach  
(7) Tahoe City  
(8) Sugar Pine Point
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| (4)     | 670 | 2287| 316 | --  | 450 | 194 | --  | 397 | --  | --  | --  | --  |
| (5)     | 520 | --  | 266 | --  | 136 | 91  | --  | 194 | --  | --  | --  | --  |
| (6)     | 1231| 2307| 336 | --  | 290 | 568 | 191| --  | 1261| --  | --  | --  |
| (7)     | 2358| 5992| 688 | --  | 775 | 727 | 240| --  | 1700| --  | --  | --  |
| (8)     | 506 | --  | 415 | --  | 267 | 140 | --  | 312 | --  | --  | --  | --  |

--Below minimum detection limit

### Stations

1. Sierra Ski
2. Tahoe Y
3. Park Avenue
4. Nevada Beach
5. Highway 28
6. King's Beach
7. Tahoe City
8. Sugar Pine Point
APPENDIX D

SOUTH LAKE TAHOE PROFILE

December 4, 1976
Appendix D

Stage 1 (3.0 - 20 \(\mu m\))

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APPENDIX E

SOUTH LAKE TAHOE PROFILE

January 25, 1977
Appendix E

Stage 1 (3.0 - 20 μm)

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-- Below minimum detection limit
APPENDIX F

METEOROLOGICAL DATA
Monday, August 9, 1976

The Weather

SACRAMENTO AREA — Fair through tomorrow. Highs in the upper 80s and lows in the upper 60s to mid 70s. Showers are forecast for the middle of the week and for the weekend. For the rest of the week, look for mostly clear skies with some scattered clouds.

BAY AREA — Fair through tomorrow with coastal low clouds. Highs in the upper 80s to mid 90s. Lows in the upper 60s to lower 70s. Showers are expected in the area.

VALLEY — Fair through tomorrow but with some afternoon clouds. Highs in the lower 90s. Lows in the upper 60s to mid 70s. Showers are possible in the evening.

SIERRA NEVADA — Fair through tomorrow with some afternoon clouds. Highs in the upper 80s to lower 90s. Lows in the upper 60s to mid 70s. Showers are possible in the evening.

NAPA AND SONOMA VALLEYS — Fair through tomorrow, with some afternoon clouds. Highs in the upper 80s to lower 90s. Lows in the upper 60s to lower 70s. Showers are possible in the evening.

Sacramento Data

Sacramento's highest temperature yesterday was 97 degrees; the low during the night was 62 degrees.

Rainfall — Sacramento City to 4 a.m.

Showers and thunderstorms will be found tonight scattered across parts of the mid-Mississippi Valley, western Lakes region and the east Gulf coast. For the rest of the states, fair weather should prevail.

The Forecasts

SACRAMENTO AREA — Fair through tomorrow. Highs in the upper 80s and 90s. Lows tonight in the upper 60s to mid 70s. Showers are forecast for the middle of the week and for the weekend. For the rest of the week, look for mostly clear skies with some scattered clouds.

BAY AREA — Fair through tomorrow with coastal low clouds extending inland locally night and early mornings. Highs in the upper 90s and 100s. Lows in the lower 60s to upper 70s. Showers are possible in the evening.

VALLEY — Fair through tomorrow but with some afternoon clouds. Highs in the lower 90s. Lows in the upper 60s to lower 70s. Showers are possible in the evening.

SIERRA NEVADA — Fair through tomorrow with some afternoon clouds. Highs in the upper 80s to lower 90s. Lows in the upper 60s to lower 70s. Showers are possible in the evening.

NAPA AND SONOMA VALLEYS — Fair through tomorrow, with some afternoon clouds. Highs in the upper 80s to lower 90s. Lows in the upper 60s to lower 70s. Showers are possible in the evening.

Los Angeles Data

Los Angeles' highest temperature yesterday was 97 degrees; the low during the night was 62 degrees.

Rainfall — Los Angeles City to 4 a.m.

Showers are forecast by the National Weather Service for parts of the Great Lakes region and the Northern Rockies this evening. Elsewhere, fair weather will prevail. Highs today will range from 72 in Seattle to 101 in Phoenix.

The Forecasts

SACRAMENTO AREA — Fair through tomorrow. Highs in the upper 80s and 90s. Lows tonight in the upper 60s to mid 70s. Showers are forecast for the middle of the week and for the weekend. For the rest of the week, look for mostly clear skies with some scattered clouds.

BAY AREA — Fair through tomorrow with coastal low clouds extending inland locally night and early mornings. Highs in the upper 90s and 100s. Lows in the lower 60s to upper 70s. Showers are possible in the evening.

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Los Angeles Data

Los Angeles' highest temperature yesterday was 97 degrees; the low during the night was 62 degrees.

Rainfall — Los Angeles City to 4 a.m.

Sacramento Data

Sacramento's highest temperature yesterday was 97 degrees; the low during the night was 62 degrees.

Rainfall — Sacramento City to 4 a.m.

Smog Report

Yesterday's peaks downtown. Oxidant .5 to .75 parts per million.

Oxidant readings above .5 parts per million and carbon monoxide readings above .05 parts per million are considered adverse to sensitive persons, animals and vegetation.
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* Clouds - Height in hundred feet  
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** R- = light rain
## TRUCKEE

August 1976

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*Clouds - Height in hundred feet*
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*Clouds - Height in hundred feet
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*Clouds - Height in hundred feet