# 5.0 INVESTIGATION OF ANTHROPOGENIC INFLUENCES ON DAY-OF-THE-WEEK VARIATIONS IN SOCAB METEOROLOGICAL CONDITIONS

#### 5.1 Introduction

Since urban heat islands are among the most robust and well-documented of anthropogenic meteorological effects, and since it seems physically plausible that in a massively urbanized area such as the SoCAB there could be many human influences that could potentially influence the surface temperature, we felt that if a detectable variation in anthropogenic meteorological influence by day-of-the-week did exist, it would most easily be found in the temperature data. In some sense, too, variations in surface air temperature resulting from human activity should represent the integrative net effect of many of the possible human influences on local meteorological conditions.

We could locate only a limited number of papers in the peer-reviewed literature concerning possible regional variations in meteorology by day-of-the-week due to anthropogenic influences, and only one of these studies was from the United States. All of the manuscripts we found focused primarily on potential day-of-the-week variation in rainfall or temperature, or both, although one also addressed wind speed, relative humidity and solar radiation (Fujibe 1987). Fujibe (1987, 1988a,b) published a series of papers examining weekday-weekend differences in urban climate (air temperature) in Tokyo, Osaka and other Japanese cities over a nine year period. He reported lower temperatures (about 0.2 °C) on Sundays compared with weekdays. Cehak (1982) examined weekday-weekend differences in precipitation in a medium size industrialized city, Wien, Austria, but could not demonstrate a statistically significant day-of-the-week effect. Simmonds and co-workers (Simmonds and Kaval 1986; Simmonds and Keay 1997) have investigated day-of-the-week variation in rainfall and temperature in Melbourne, Australia and found no statistically significant difference between days, although some day-of-the-week trends were found for the winter season. Winter weekday precipitation was significantly (at the 5% level) greater and they attributed this

difference to atmospheric pollution (Simmonds and Kaval 1986). They concluded that pollution level had little effect on maximum temperature. In their more recent study covering 134 years of temperature records from Melbourne Simmonds and Keay (1997) found a statistically significant day-of-the-week effect only for winter, for which they found weekday maximum temperatures to be ~0.2-0.3 °C warmer than weekends. These authors considered the possible impacts of day-of-the-week variation in atmospheric pollution loading but concluded weekday-weekend differences in anthropogenic heat emissions were sufficient to explain the observed temperature differences.

More than forty years ago, Mitchell (1953) showed that the daily-minimum temperature in winter in New Haven, Connecticut, was lower on Sundays than on weekdays by about 0.6 °C. We are not aware of other such day-of-the-week analyses for U.S. cities, although we have not made an exhaustive search of the literature. To the best of our knowledge, there have been no reports in the peer-reviewed literature of studies of day-of-the-week anthropogenic meteorological conditions in the California South Coast Air Basin. In the following sections we present data from our investigations of such effects for the SoCAB.

## 5.2 Ambient Temperature Analysis

## 5.2.1 Dav-of-the-Week Effects during Summer Seasons

We began by analyzing mean hourly temperature data from 11 SCAQMD air quality monitoring stations well-distributed through the region of the SoCAB. The 3month interval 15 June to 15 September was considered for each of the five years between 1989 and 1993. We limited this analysis to a five-year period of time in order to diminish the possible effects of long-term trends in some of the anthropogenic influences (e.g., population shifts, reformulation of automotive fuels, changes in emissions regulations, and so forth). For each of the 11 stations, weekday (Tuesday/Wednesday and Wednesday/Thursday) and weekend (Saturday/Sunday) mean temperatures were computed at 4 different times of day: 0500, 1100, 1700, and 2300 PST. The latter were then subtracted from the former to obtain the weekday/weekend temperature differences shown in Table 5-1. Interestingly, with only three minor exceptions, at every station and at each of the four times of day examined, both the average Tuesday/Wednesday temperature and the Wednesday/Thursday temperature were warmer than the corresponding Saturday/Sunday temperature. Thus in 85 of the 88 cases examined (11 stations times 4 times of day times 2 pairs of weekdays), the weekday temperature was warmer than the weekend temperature, while in just 3 cases the weekend temperature was warmer than the weekday temperature.

All of these weekday/weekend temperature differences were quite small, however. The average difference (across all stations and times of day) between the Tuesday/Wednesday mean temperature and the Saturday/Sunday mean temperature was 0.6 °F, while that between Wednesday/Thursday and Saturday/Sunday was 0.7 °F.

These data suggest there may be a small difference in temperature between weekdays and weekend days that can be associated with anthropogenic influences. However, several important points need to be made. First, the weekday/weekend temperature difference as found by this analysis is very small; in fact, the values are much smaller than the corresponding standard deviations (see Table 5-1). Thus while we have found evidence for an anthropogenically-produced difference in micrometeorological conditions between weekdays and weekend days in the SoCAB, the statistical robustness of the result appears to be limited. In addition, the small magnitudes of these temperature differences suggest that any feedback on SoCAB air pollution levels will be exceedingly small. Nonetheless, the result is certainly of general scientific interest, and to our knowledge is the first ever obtained that suggests the presence of an anthropogenically-produced weekday/weekend variation in microscale meteorological conditions in the SoCAB.

Site	Time	Mean T	Std.dev.	Mean T	Std.dev.	Mean T	Std.dev.	ΔΤ	ΔT
	(PST)	TU/WE	TU/WE	WE/TH	WE/TH	SA/SU	SA/SU	TU/WE	WE/TH
								-SA/SU	-SA/SU
Anaheim	0500	64.7	3.1	65.1	3.1	65.0	3.2	-0.3	0.1
	1100	78.7	6.3	78.7	6.3	78.1	5.6	0.6	0.6
	1700	78.7	6.0	78.2	7.6	78.3	5.3	0.4	-0.1
	2300	67.3	3.3	66.8	5.7	66.9	3.0	0.4	-0.1
Azusa	0500	63.9	4.4	64.1	4.3	63.2	3.7	0.7	0.9
	1100	79.9	7.5	79.9	7.5	79.1	6.6	0.8	0.8
	1700	82.6	6.2	82.5	5.7	82.0	5.4	0.6	0.5
	2300	67.7	4.7	67.6	4.2	66.8	4.0	0.9	0.8
Burbank	0500	63.6	4.2	63.9	4.2	63.3	3.9	0.3	0.6
	1100	81.4	7.7	81.4	7.7	80.4	6.8	1.0	1.0
	1700	82.1	6.7	82.0	6.0	81.2	6.2	0.9	0.8
	2300	67.0	4.5	66.9	4.2	66.2	3.6	0.8	0.7
Hawthorne	0500	64.2	3.0	64.6	2.9	64.0	2.7	0.2	0.6
	1100	73.5	3.9	73.8	4.1	73.2	4.2	0.3	0.6
	1700	71.0	3.3	71.2	3.3	70.3	3.1	0.7	0.9
	2300	65.1	3.3	65.1	2.9	64.7	2.6	0.4	0.4
LA-Main	0500	64.5	3.9	64.7	3.8	64.1	3.4	0.4	0.6
	1100	79.8	6.8	79.7	6.8	78.7	6.2	1.1	1.0
	1700	76.7	5.6	76.6	5.0	75.7	4.6	1.0	0.9
	2300	66.4	4.1	66.4	3.7	65.6	3.4	0.8	0.8
Long Beach	0500	64.1	2.9	64.4	2.9	64.1	3.0	0.0	0.3
-	1100	75.6	5.4	75.5	5.4	74.6	5.0	1.0	0.9
	1700	74.2	4.0	74.3	3.9	73.4	3.8	0.8	0.9
	2300	65.7	3.0	66.0	3.2	65.2	3.0	0.5	0.8
Newhall	0500	59.1	5.0	59.3	5.3	58.6	5.1	0.5	0.7
	1100	87.3	8.4	87.3	8.6	86.2	8.7	1.1	1.1
	1700	89.7	7.0	89.7	7.0	89.3	7.6	0.4	0.4
	2300	67.1	5.4	67.1	5.3	66.1	5.1	1.0	1.0
Pasadena	0500	61.5	4.1	61.7	4.1	61.2	3.9	0.3	0.5
	1100	81.7	7.6	81.5	7.5	80.3	7.1	1.4	1.2
	1700	82.7	6.4	82.7	5.8	81.9	6.0	0.8	0.8
	2300	64.0	3.8	64.1	4.0	63.5	3.7	0.5	0.6
Pico Rivera	0500	63.7	3.7	64.0	3.4	63.7	3.7	0.0	0.3
	1100	80.8	6.3	80.7	6.5	79.7	5.9	1.1	1.0
	1700	80.9	5.5	80.8	4.9	80.1	4.8	0.8	0.7
	2300	66.5	3.7	66.5	3.7	65.8	3.5	0.7	0.7
Riverside	0500	62.4	4.2	62.6	4.3	62.3	4.1	0.1	0.3
	1100	84.0	8.9	84.0	8.7	83.6	7.6	0.4	0.4
	1700	85.6	6.5	85.7	5.8	84.9	6.1	0.7	0.8
	2300	67.9	4.8	67.9	4.7	67.5	4.5	0.4	0.8
Upland	0500	62.4	4.7	62.5	4.8	61.8	4.4	0.4	0.4
opiana	1100	81.5	8.5	81.6	8.4	81.3	7.4	0.0	0.7
	1700	83.4	6.3	83.6	5.7	82.8	7.4 5.7	0.2	0.3
	2300	66.5	5.1	66.5	4.8	65.9	4.6	0.6	0.8
Average		72.7	5.2	72.7	5.2	72.1	4.8	0.6	0.7

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Table 5-1. SoCAB weekday/weekend differences in mean hourly average temperature from 15 June to 15 September (1989-93). All values in  $^{\circ}F$ ; ending time of observation hour indicated.

We subsequently expended significant effort to try to derive a similar result that could be shown to be statistically significant. In general, our objective was to find a way to combine the results from the different stations in a manner that would increase the overall statistical robustness. This is complicated, however, because the temperature at the different SoCAB stations, as well as at the same station at different times of day, are clearly not independent of each other. We therefore sought and received guidance in this regard from Professor William Cumberland in the UCLA Department of Biostatistics.

He suggested that we continue our investigation by focusing on the "urban core" region of the SoCAB over the six-year period 1990-95; the five sites selected to represent this area were Azusa, Burbank, Los Angeles, Pasadena. and Pico Rivera. By focusing on a group of stations in a region of more-or-less uniform meteorological conditions, an average weekday/weekend temperature difference across all 5 stations could reasonably be used, which it was hoped would yield a more statistically robust result (with regards to weekday/weekend temperature difference).

The histograms in Figures 5-1, 5-2, 5-3, and 5-4 show the basic results of these analyses. As expected, the distributions of the temperature differences vary diurnally, with increased variability during daytime hours. We calculated student-t statistics for each of these distributions but none were statistically significant at even the 95% confidence level (Table 5-2). Interestingly, when the analysis is limited to the four-year period 1990-93 (Table 5-3), the t-test indicated there are statistically significant temperature differences at 0500 PST and 2300 PST, but this is not the case when the six-year period 1990-95 is used.

Hour (PST)	0500	1100	1700	2300
N > 0	57	48	44	49
N = 0	0	1	0	2
N < 0	42	52	57	50
N	99	101	101	101
Average	0.3	0.4	0.0	0.4
Std Dev	3.7	6.7	5.6	3.6
t-stat	0.8	0.6	-0.1	1.1

Table 5-2. Urban core weekday/weekend temperature differences 1990-95.

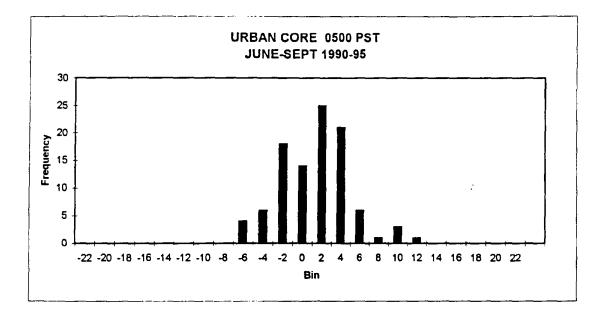


Figure 5-1. Histogram of urban core weekday/weekend average temperature (°F) differences (0500 PST). Note: The number below each bin represents the lower bound of that bin.

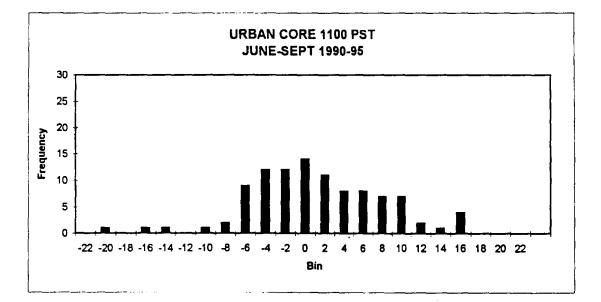
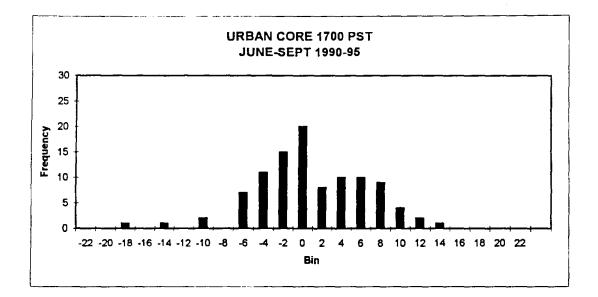


Figure 5-2. Histogram of urban core weekday/weekend average temperature (°F) differences (1100 PST). Note: The number below each bin represents the lower bound of that bin.



**Figure 5-3.** Histogram of urban core weekday/weekend average temperature (°F) differences (1700 PST). Note: The number below each bin represents the lower bound of that bin.

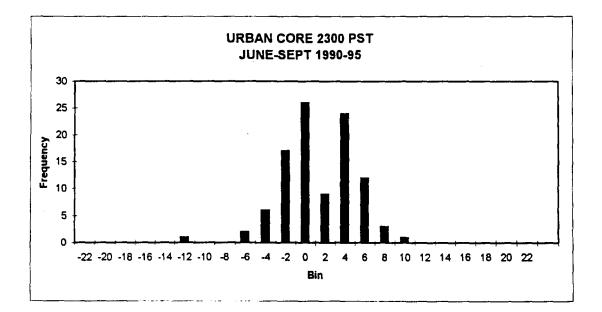


Figure 5-4. Histogram of urban core weekday/weekend average temperature (°F) differences (2300 PST). Note: The number below each bin represents the lower bound of that bin.

Hour (PST)	0500	1100	1700	2300
N > 0	42	32	31	
N = 0	0	1	0	1
N < 0	24	35	37	28
Ν	68	68	68	68
Average	0.7	0.6	0.5	0.8
Std Dev	3.4	6.5	5.4	3.1
t-stat	1.6	0.8	0.7	2.0**

 Table 5-3. Urban core weekday/weekend temperature differences 1990-93.

Significant at 90% level

"Significant at 95% level

Further reflection on these results suggests an intrinsic difficulty in attempting to establish statistical robustness of the weak weekday/weekend temperature difference suggested by our preliminary analyses. The essence of the problem is that even in a region with typically placid smog season weather conditions such as the SoCAB, there will from time-to-time be relatively dramatic changes in prevailing meteorological conditions over short time intervals (i.e., on the order of hours to days). And during the summer months, there will occasionally be relatively rapid development of either stronger onshore flow or anomalous offshore flow, or of a Catalina Eddy circulation, passage of a weak front, intrusions of warmer and cloudier subtropical air masses, and so forth. Typically a few times during the summer, such an event will likely occur between Wednesday/Thursday and the subsequent Saturday. Unlike the anthropogenic weekday/weekend temperature effect we have shown, however, the magnitude of the temperature influence of this sort of change in the prevailing synoptic-scale meteorological conditions can be quite large. Thus the small signal we are looking for could quite easily be hidden by the particular temporal distribution of these much largermagnitude events. If our sample size was large enough, however, to encompass a very large number of these changes in meteorological conditions, they should more or less cancel each other, with the weak signal we are looking for remaining. But this would require a data set consisting of a very large number of smog season weeks, which in turn

implies use of many years of data (since the period during each smog season that is comparatively quiescent meteorologically is only 12-16 weeks long). Using many years of data, though, would seem likely to introduce a new problem—namely that we would no longer be justified in assuming there is no significant year-to-year trend in anthropogenic influences. In fact, our analyses of ozone and other air pollutant data in this study show marked changes (i.e., improvements) in anthropogenically-caused air pollution over periods of even a few years or less. Ultimately, then, we are only able to conclude that if a day-of-the-week temperature effect does exist in the SoCAB, it is quite weak and therefore not likely to be of particular importance to air quality management efforts. Comparison of weekend day and weekday 850 mb temperatures & virtual temperature profiles from the 8 radar wind profile network and routine sondes in southern California would be available from 1997 onwards. Such a comparison was not available to our study.

## 5.2.2 Day-of-the-Week Effects at Los Angeles Civic Center: 1949-94

Table 5-4 shows the mean and standard deviation of the daily-maximum and daily-minimum temperature by day-of-the-week at Los Angeles Civic Center for the entire 12 months of 1949-94. This analysis was also performed using only the smog season months of May through October (Table 5-5). For both analyses there was no clear day-of-the-week effect in daily-maximum temperature, while there was a slight indication of cooler daily-minimum temperatures on weekends (especially Sundays). The mean and standard deviation temperatures by day-of-the-week were also computed for the smog seasons of 1949-71 (Table 5-6) and 1972-94 (Table 5-7). The daily-maximum temperatures for the latter period were about 1 °F warmer for each day of the week, and the daily-minimum temperatures were about 2 °F warmer for each day. This increase is presumably due to an enhancement of the urban heat island effect during the past 25 years as has been reported by many other investigators. No clear day-of-the-week effects were

Day	Daily-maximum Temperature	Standard Deviation	Daily-minimum Temperature	Standard Deviation
Monday	75.1	9.6	56.6	7.4
Tuesday	75.1	9.9	56.7	7.4
Wednesday	75.2	9.7	56.7	7.4
Thursday	74.8	9.7	56.7	7.4
Friday	74.8	9.6	56.6	7.5
Saturday	74.9	9.6	56.5	7.5
Sunday	75.0	9.7	56.3	7.6

**Table 5-4.** Temperature (°F) by day-of-the-week at Los Angeles Civic Center for January through December 1949-94.

**Table 5-5.** Temperature (°F) by day-of-the-week at Los Angeles Civic Center for May through October 1949-94.

Day	Daily-maximum Temperature	Standard Deviation	Daily-minimum Temperature	Standard Deviation
Monday	80.3	7.7	61.9	4.8
Tuesday	80.4	8.0	62.0	4.8
Wednesday	80.4	7.9	62.1	4.9
Thursday	80.2	8.0	62.1	4.9
Friday	80.2	7.7	62.1	4.9
Saturday	80.3	7.7	62.0	4.8
Sunday	80.4	7.7	61.8	4.8

**Table 5-6.** Temperature (°F) by day-of-the-week at Los Angeles Civic Center for May through October 1949-71.

Day	Daily-maximum Temperature	Standard Deviation	Daily-minimum Temperature	Standard Deviation
Monday	79.9	7.8	60.8	4.8
Tuesday	79.9	7.9	60.9	4.7
Wednesday	79.9	7.9	61.0	4.7
Thursday	79.6	8.0	61.0	4.7
Friday	79.8	8.0	61.1	<b>"</b> 5.0
Saturday	79.7	7.7	61.0	4.9
Sunday	79.9	7.8	60.8	4.9

Day	Daily-maximum	Standard	Daily-minimum	Standard
	Temperature	Deviation	Temperature	Deviation
Monday	80.7	7.6	63.0	4.5
Tuesday	80.9	<b>8</b> .1	63.0	4.7
Wednesday	80.9	7.9	63.1	4.9
Thursday	80.8	7.9	63.1	4.7
Friday	80.6	7.4	63.2	4.7
Saturday	80.9	7.6	62.9	4.5
Sunday	80.8	7.6	62.8	4.5

**Table 5-7.** Temperature (°F) by day-of-the-week at Los Angeles Civic Center for May through October 1972-94.

found in daily-maximum temperatures, but daily-minimum temperatures appeared to be slightly cooler on weekends during the latter period.

The mean weekday (Monday through Friday) daily-maximum temperature at Los Angeles Civic Center for the 1949-94 smog seasons is shown in Figure 5-5. The corresponding weekend analysis is shown in Figure 5-6. The difference between these two plots is shown in Figure 5-7. The best-fit least squares trendline revealed a gradual increase in the mean smog season daily-maximum temperature during the 1949-94 period of about 2 °F for both weekdays and weekends. This suggests the urban heat island effect has intensified during the period of investigation. Although the weekend daily-maximum temperatures increased over the 45-year period slightly more rapidly than the weekday values, as evidenced by the decreasing trendline in Figure 5-7, this effect is not likely to be statistically significant, given the large year-to-year fluctuations during the period of investigation. Thus there does not appear to exist a clear day-of-the-week temperature effect at the Los Angeles Civic Center during the 1949-94 smog seasons.

## 5.3 <u>Relative Humidity Analysis</u>

We have examined relative humidity data for an anthropogenic weekday/weekend effect. As with our initial analysis of the temperature data, we proceeded to analyze hourly-mean relative humidity data from the same 11 SCAQMD air quality monitoring stations that are well-distributed through the region of the SoCAB. Also consistent

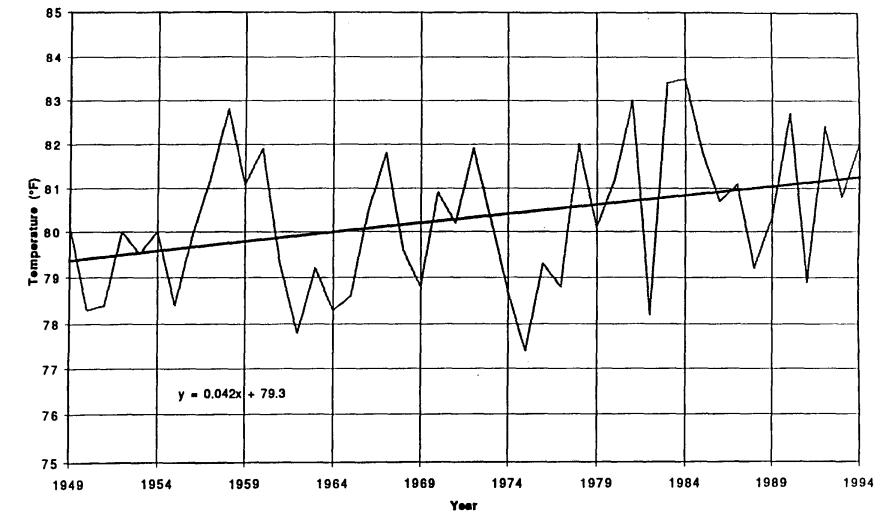


Figure 5-5. Los Angeles Civic Center mean weekday (Mon. - Fri.) dailymaximum temperature for 1949-94 smog seasons (1 May - 31 October).

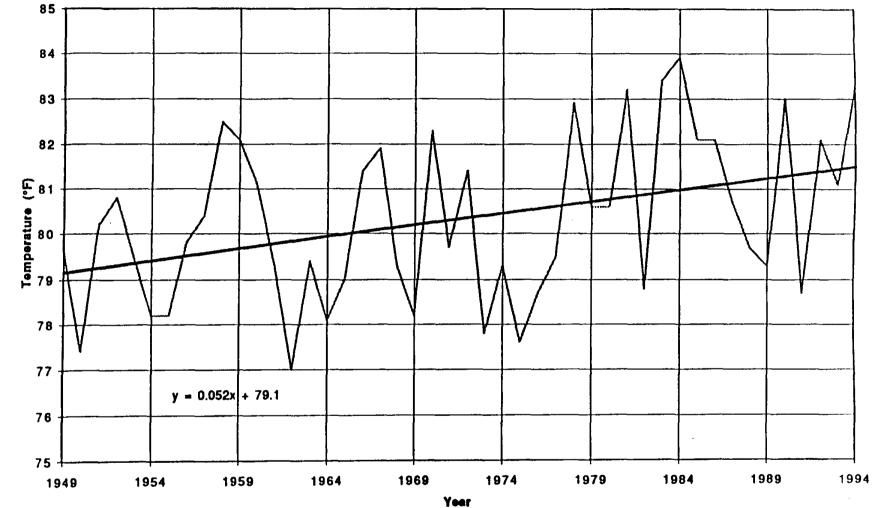
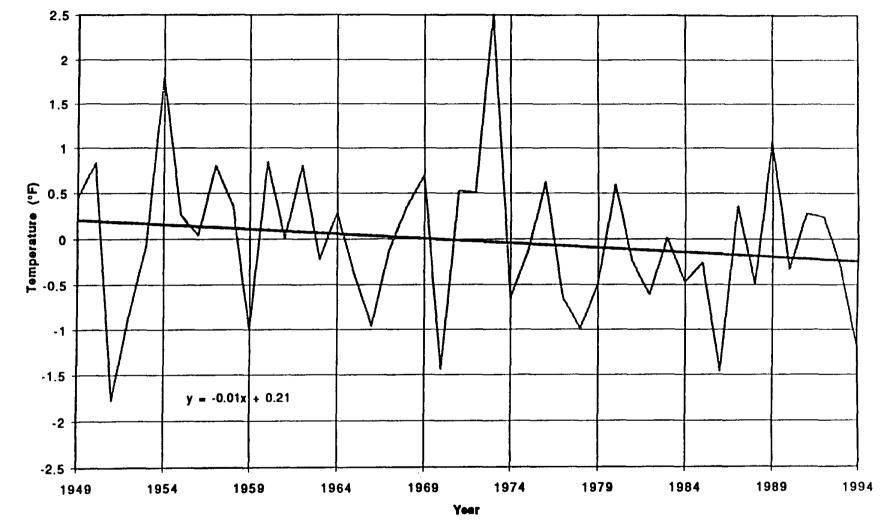


Figure 5-6. Los Angeles Civic Center mean weekend (Sat. - Sun.) dailymaximum temperature for 1949-94 smog seasons (1 May - 31 October).



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Figure 5-7. Los Angeles Civic Center mean weekday (Mon. - Fri.) minus weekend (Sat. - Sun.) daily-maximum temperature for 1949-94 smog seasons (1 May - 31 October).

with the analysis of temperature data, the 3-month interval 15 June to 15 September was used over the five-year period 1989-93.

For each of the 11 stations, weekday (Tuesday/Wednesday and Wednesday/Thursday) and weekend (Saturday/Sunday) mean relative humidities were computed for 4 different hours of the day: those ending at 0500, 1100, 1700, and 2300 PST. The weekend values were then subtracted from the weekday values to obtain the weekday/weekend relative humidity differences shown in Table 5-8. Although our results indicate a slight average increase in relative humidity on weekends (0.4%), unlike the temperature analysis there is no consistency in sign either between the various stations or the different times of day. In addition, the standard deviations are much larger than the weekday/weekend relative humidity differences. Thus no day-of-the-week signal is evident.

#### 5.4 <u>b<sub>scat</sub> Analysis</u>

Given that day-of-the-week differences in air quality have been documented in the SoCAB, it was hypothesized there could be a detectable variation in anthropogenic influence on visibility. We thus proceeded to analyze SCAQMD hourly-average  $b_{scat}$  data. Although the  $b_{scat}$  variable is not directly calibrated to a familiar visibility distance unit, and although these data are not considered to be entirely robust for a variety of technical reasons [i.e., the numerical values should not be interpreted directly (Miller 1997)], it is generally agreed the values can be considered relative to each other and thus may be used in the form of a ranking scale (that is, a lower value means better visibility).

Unfortunately, these  $b_{scat}$  data exist for only a few sites and for only some of the years during the 1986-96 smog seasons. Since Upland and Azusa had relatively high data completeness for the four smog seasons 1986-89, we performed a day-of-the-week analysis of  $b_{scat}$  at these two sites for this period. Table 5-9 shows the mean and standard deviation  $b_{scat}$  values for Upland for 15 June to 15 September 1986-89 for the hours 0400-0500, 1000-1100 am, 1600-1700, and 2200-2300 PST. A somewhat lower  $b_{scat}$  value (and thus better visibility) was evident for weekend days at Upland (Table 5-9) for all

Site Time Mean RH Std. Dev. Mean RH Std. Dev.  $\Delta RH$ WE/TH WE/TH SA/SU SA/SU WE/TH-(PST) SA/SU 9.7 9.6 -0.3 Anaheim 0500 65.6 65.9 1100 45.5 9.1 45.7 8.5 -0.2 44.5 43.9 9.5 1700 9.8 0.6 2300 63.5 10.2 62.2 9.8 1.3 Azusa 0500 66.1 11.5 68.8 10.0 -2.7 42.3 11.5 44.0 11.4 -1.7 1100 1700 38.7 9.3 38.6 10.4 0.1 -0.2 62.3 10.6 62.5 11.9 2300 0500 65.4 12.0 9.7 -1.2 Burbank 66.6 1100 39.6 10.6 40.3 10.2 -0.7 1700 37.8 9.9 37.9 10.3 -0.1 -0.2 2300 61.9 11.1 62.1 10.6 16.8 -0.8 Crestline 0500 47.4 16.1 48.2 1100 33.1 14.4 33.7 13.2 -0.6 1700 39.4 12.4 39.8 -0.4 12.7 2300 47.0 15.4 46.8 15.9 0.2 0.2 Hawthorne 0500 74.6 10.2 74.4 9.5 1100 59.1 8.4 59.0 8.8 0.1 -0.5 1700 62.8 10.0 63.3 9.0 0.1 2300 74.2 10.2 74.1 10.4 LA-Main 0500 69.9 10.8 9.2 -0.8 70.7 1100 44.4 10.8 45.8 10.8 -1.4 1700 48.1 9.9 49.1 10.1 -1.0 9.0 2300 67.4 68.0 9.8 -0.6 Long Beach 0500 70.7 10.3 70.8 10.7 -0.1 1100 51.1 7.3 51.2 7.8 -0.1 1700 8.2 0.3 51.8 51.5 8.2 2300 67.7 10.0 0.5 67.2 9.4 Pico Rivera 0500 71.7 8.7 72.0 7.7 -0.3 1100 44.5 8.4 45.7 8.6 -1.2 1700 42.9 7.6 42.6 8.2 0.3 2300 67.1 7.4 66.8 7.5 0.3 65.1 Riverside 0500 14.5 -2.0 67.1 12.8 1100 34.8 13.3 35.2 -0.4 11.2 1700 32.4 8.8 32.5 9.4 -0.1 2300 57.9 13.8 56.6 13.4 1.3 Upland 0500 12.3 64.6 67.5 10.1 -2.9 1100 38.7 12.5 39.2 11.1 -0.5 1700 36.5 8.8 -0.4 36.9 8.6 2300 61.1 10.8 60.7 11.3 0.4

**Table 5-8.** Basinwide weekday/weekend differences in mean-hourly average relative humidity from 15 June to 15 September (1989-93). All values in %; ending time of observation hour indicated.

hours examined except 0400-0500 (with largest weekday/weekend differences for the hours 1000-1100 and 1600-1700). At Azusa, (Table 5-10) the  $b_{scat}$  values were also

slightly lower on weekend days than on weekdays for each of the four examined hours. These results for Upland and Azusa, however, were not statistically significant, given the large standard deviations.

**Table 5-9.** Mean and standard deviation of  $b_{scat}$  values for the period 15 June to 15 September 1986-89 at 0400-0500, 1000-1100, 1600-1700, and 2200-2300 PST at Upland. Percent completeness represents percent of needed observations available to be used in the calculations. The number (N) of observations used in each calculation also shown.

Time (PST)	Days	Mean b <sub>scat</sub>	Standard Deviation	Percent Completeness	N
0500	TU/WE	37.4	29.4	99.1	105
0500	SA/SU	39.1	28.5	100	105
1100	TU/WE	66.1	40.3	100	106
1100	SA/SU	57.1	31.5	100	105
1700	TU/WE	42.0	28.4	100	106
1700	SA/SU	33.8	22.3	99.0	104
2300	TU/WE	34.7	26.2	100	106
2300	SA/SU	32.2	24.9	100	105

**Table 5-10.** Mean and standard deviation of  $b_{scat}$  values for the period 15 June to 15 September 1986-89 at 0400-0500, 1000-1100, 1600-1700, and 2200-2300 PST at Azusa. Percent completeness represents percent of needed observations available to be used in the calculations. The number (N) of observations used in each calculation also shown.

Time (PST)	Days	Mean b <sub>scat</sub>	Standard Deviation	Percent Completeness	N
0500	TU/WE	23.7	15.7	82.1	87
0500	SA/SU	20.4	18.8	83.8	88
1100	TU/WE	38.2	22.0	83.0	88
1100	SA/SU	35.1	35.3	84.8	89
1700	TU/WE	20.7	13.3	<b>8</b> 3.0 ·	88
1700	SA/SU	19.2	20.9	84.8	89
2300	TU/WE	19.7	13.6	82.1	87
2300	SA/SU	18.4	17.2	84.8	89

To further investigate a possible day-of-the-week variation in visibility in the SoCAB, a more recent period (15 June to 15 September 1992-94) was selected. This period was also chosen because there happened to be high data completeness in the  $b_{scat}$  data set at Azusa (one of only two sites with available  $b_{scat}$  data for that period). The top 50  $b_{scat}$  values (including any ties) were ranked at each of the following hours: 0400-0500, 1000-1100, 1600-1700, and 2200-2300 PST. For each of these four hours, the ranked values were distributed by day-of-the-week (Table 5-11).

The top 50  $b_{scat}$  values at 0400-0500 PST (Table 5-11) occurred most often on Saturday. At 1000-1100 and 1600-1700 PST, the most frequent day was Friday. No clear day-of-the-week signal appeared at 2200-2300 PST. These results suggest there was a slight tendency for lower visibility days to occur most often on Friday or Saturday at Azusa during the period 15 June to 15 September 1992-94. This result was consistent with our work in the previous phase of the present project, where it was shown that Saturday was the favored day for high ozone episodes in the SoCAB.

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Day	0400-0500	1000-1100	1600-1700	2200-2300
Monday	3	8	8	8
Tuesday	8	6	8	5
Wednesday	4	6	7	9
Thursday	9	7	7	5
Friday	8	10	12	9
Saturday	12	8	5	8
Sunday	6	5	4	6
N	50	50	51	50
b <sub>scat</sub> range	23 to 259	35 to 394	24 to 350	25 to 298

**Table 5-11.** Number of occurrences (by day-of-the-week) of top 50 ranked  $b_{scat}$  values at Azusa for the period 15 June to 15 September 1992-94 at 0400-0500, 1000-1100, 1600-1700, and 2200-2300 PST. The number (N) of observations in each analysis also shown.

## 5.5 Solar Radiation Analysis

We reasoned that if there were an anthropogenic influence on visibility, the signal might be detectable as a day-of-the-week variation in solar radiation intensity. The 1994-96 SCAQMD solar radiation data were available only from Azusa, Pico Rivera, LA-North Main, and Upland; as an initial analysis, we chose to investigate the observations from Pico Rivera. Table 5-12 shows the mean solar radiation intensity at Pico Rivera for Tuesday/Wednesday and Saturday/Sunday during 1994-96 from 15 June to 15 September, for the hours 0700-0800, 1000-1100, 1300-1400, and 1600-1700 PST. In analyzing these data, however, we noted that smog season days with significantly reduced incoming solar radiation sometimes occurred for reasons unrelated to anthropogenic effects (e.g., intrusion of marine air, and especially fog or low clouds). In order to filter out the most dramatic of such days, we chose to exclude hourly observations in the computation of the mean if the measured incident solar radiation was less than 70% of the highest value reported at that same hour on any of the previous three days or following three days. Here it has been assumed that the maximum possible solar radiation intensity at some hour is closely approximated by the highest reported observation for that hour over a period of one week. Given the high data completeness and the fact that dramatic reductions in visibility (for non-anthropogenic reasons) are unlikely to persist for seven consecutive days during the smog season months, this would seem to be a reasonable approximation.

At Pico Rivera, the mean radiation intensity was found to be slightly lower on weekdays (Tuesday/Wednesday) than on weekend days (Saturday/Sunday) for each of the four hours examined (Table 5-12), consistent with our findings of weekday/weekend differences in  $b_{scat}$ . However, this result is not statistically significant, since the standard deviations are much larger than the difference of the means between weekdays and weekends.

**Table 5-12.** Mean solar radiation intensity (in gram calories per square cm per hour) at Pico Rivera for Tuesday/Wednesday and Saturday/Sunday during the 1994-96 period from 15 June to 15 September at hours 0700-0800, 1000-1100, 1300-1400, and 1600-1700 PST. Hourly observations not included in computation of mean/standard deviation if less than 70% of the highest value reported at that hour on any of the previous three days or following three days

Time (PST)	Days	Mean Radiation Intensity	Standard Deviation	Percent Completeness	N
0800	TU/WE	242.7	40.2	69.6	55
0800	SA/SU	250.6	43.2	71.2	57
1100	TU/WE	569.8	38.1	91.1	72
1100	SA/SU	577.2	45.4	93.8	75
1400	TU/WE	579.0	41.6	94.9	75
1400	SA/SU	587.7	44.9	98.8	79
1700	TU/WE	265.9	43.9	96.2	76
1700	SA/SU	270.9	46.6	97.5	78

Future studies taking advantage of more extensive solar radiation data from the 1997 Southern California Ozone Study (SCOS97) should separate solar radiation effects on Saturday from Sunday.

## 6.0 TRENDS IN OZONE AND OZONE-PRECURSOR AMBIENT CONCENTRATIONS

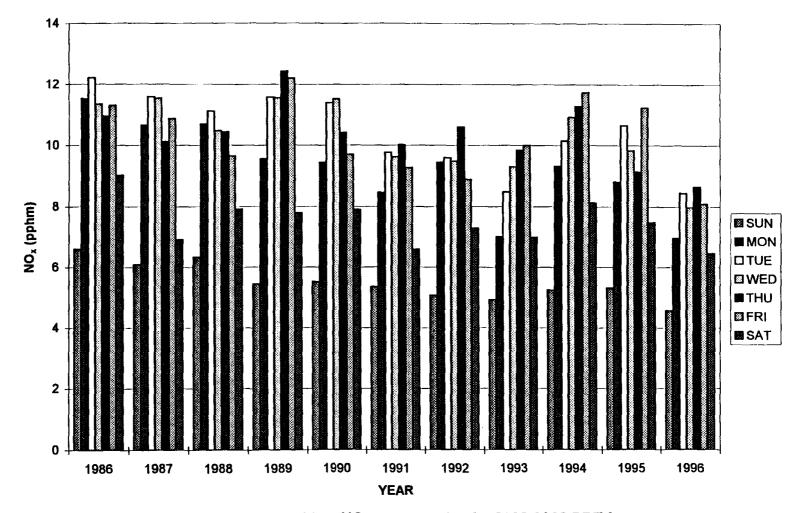
## 6.1 Basinwide Ambient Trends in NO<sub>2</sub>, NO<sub>x</sub>, and NO<sub>2</sub>/NO<sub>x</sub>

Following the acquisition of ambient data for the 1996 smog season, we examined Basinwide ozone-precursor trends over the eleven-year period 1986-96. Figure 6-1 shows a generally decreasing trend in 0600-0900 PDT Basinwide ambient  $NO_x$ concentration from 1986 to 1996, with a particularly dramatic decrease in 1996. Similarly, average 0600-0900 PDT Basinwide ambient  $NO_2$  concentrations also decreased over the 11-yr study period (Figure 6-2). Figure 6-3 shows a consistent day-ofthe-week effect for morning  $NO_x$  concentration as well as a general decrease in  $NO_x$ concentration between 1986 and 1996.

We also examined 2100-0000 PDT NO<sub>x</sub> and NO<sub>2</sub> concentrations by day-of-theweek over the 11-yr study period. A downward trend in NO<sub>x</sub> concentration is evident, as is a fairly consistent day-of-the-week difference in ambient NO<sub>x</sub> levels (Figure 6-4). Figure 6-5 shows a similar decreases in NO<sub>2</sub> concentrations over the eleven-year period, with an approximate 25% reduction for the 1996 smog season over the average for the 1992-95 smog seasons. This reduction may be responsible, in part, for the corresponding decrease in the number of first stage ([O<sub>3</sub>] = 20 pphm) episodes in the Basin from 13 in 1995 to 7 in 1996. In addition, the early evening (1800-2100 PDT) NO<sub>2</sub>/NO<sub>x</sub> ratio decreased significantly in 1996 (Figure 6-6).

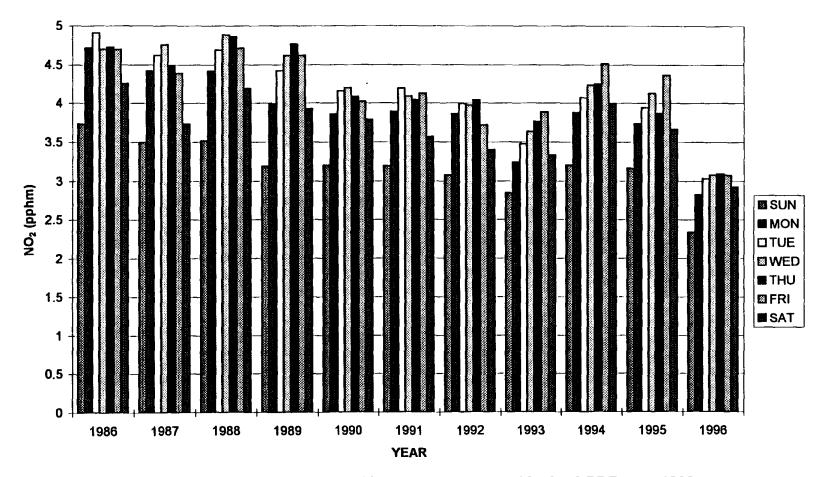
#### 6.2 Hydrocarbon Trends: 1986-95

To determine NMHC trends over the ten-year period 1986-95, we used the method of Fujita et al. (1992) to convert ambient total hydrocarbon data (THC) from the West Los Angeles, LA North-Main, Azusa, Lynwood, Long Beach, and Riverside monitoring stations to NMHC in parts-per-billion carbon (Figure 6-7). These results show a general decrease in 0600-0900 PDT NMHC over the ten-year period for all days



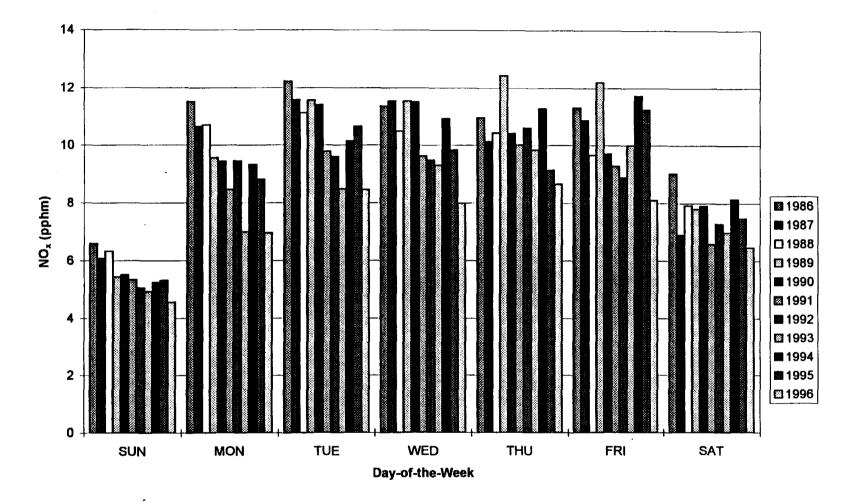
**Figure 6-1.** Basinwide average ambient  $NO_x$  concentration for 0600-0900 PDT from 1986 to 1996, May-October, by day-of-the-week.

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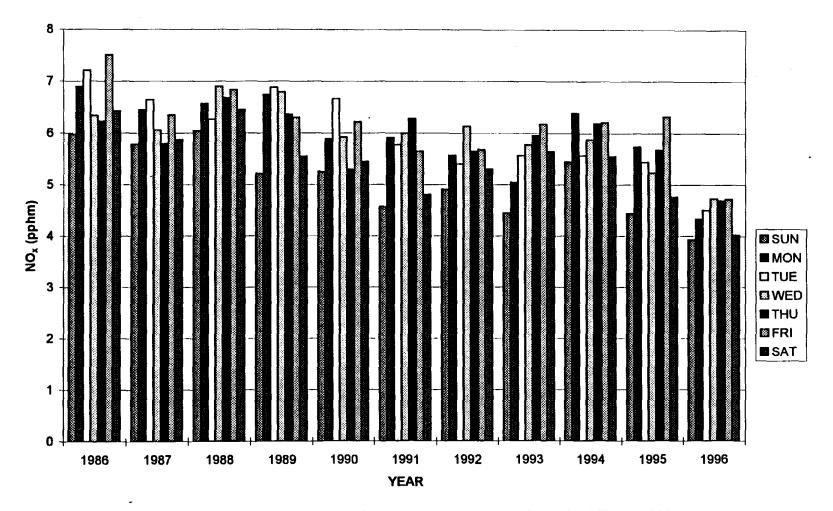
**Figure 6-2.** Basinwide average ambient NO<sub>2</sub> concentration for 0600-0900 PDT, from 1986 to 1996, May-October, by day-of-the-week.

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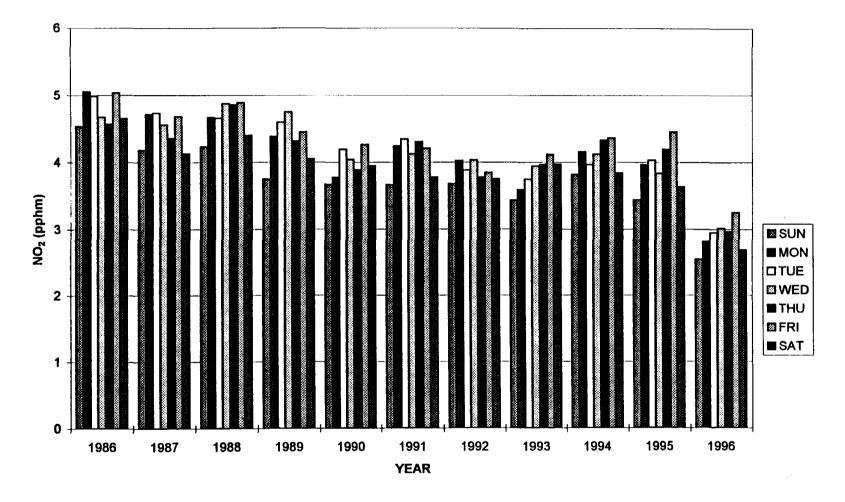


**Figure 6-3.** Basinwide average ambient NO<sub>x</sub> concentration for 0600-0900 PDT. Day-of-the-week differences by year from 1986 to 1996, May-October.

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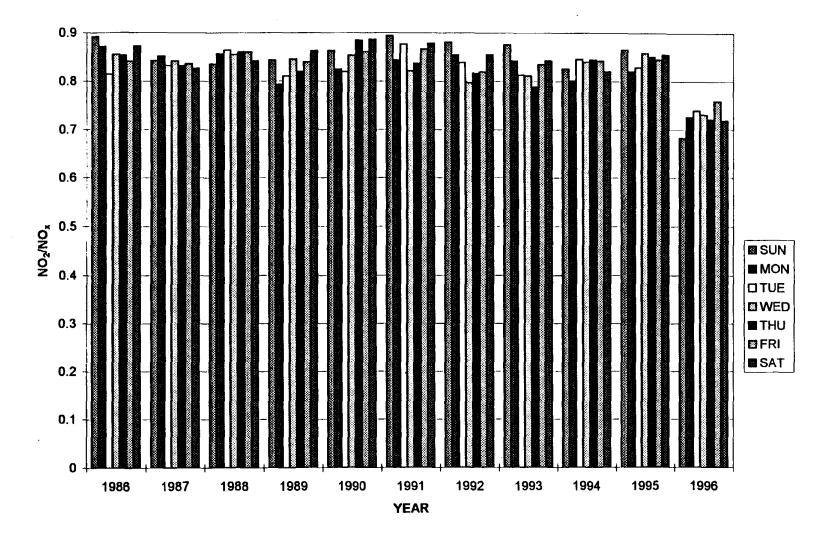
**Figure 6-4.** Basinwide average ambient  $NO_x$  concentration for 2100-0000 PDT from 1986 to 1996, May-October, by day-of-the-week.



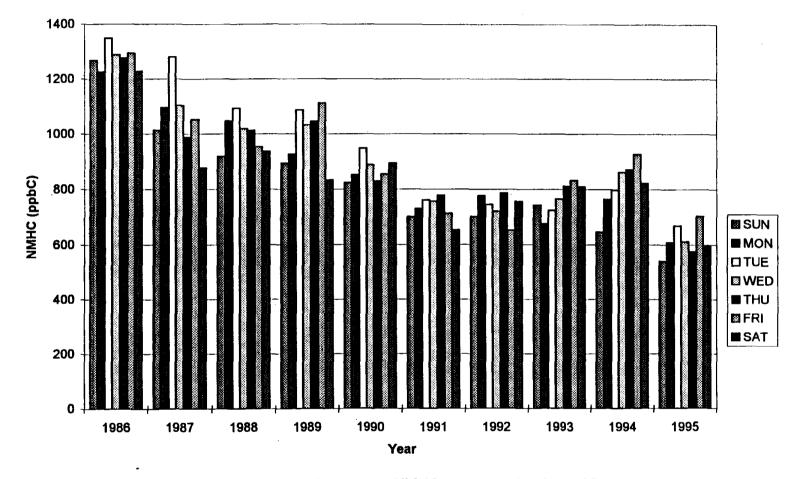
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**Figure 6-5.** Basinwide average ambient  $NO_2$  concentration for 2100-0000 PDT from 1986 to 1996, May-October, by day-of-the-week.

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**Figure 6-6.** Basinwide average  $NO_2/NO_x$  ratio for 1800-2100 PDT from 1986 to 1996, May-October, by day-of-the-week.



**Figure 6-7.** Six-site (five sites in 1995) Basin-average NMHC concentration for 0600-0900 PDT, May-October. NMHC concentrations derived from THC data.

of the week. Unfortunately, we could not include the 1996 smog season since THC monitoring was discontinued after the 1995 smog season.

## 6.3 Ozone Trends: 1986-96

## 6.3.1 Examination of Incidence and Distribution of Various Ozone Concentrations

Table 6-1 shows the number of days (D) and hours (H) of ozone concentration at or above 9, 12, 15, and 20 parts-per-hundred million (pphm) during smog season daytime hours, where "daytime" is defined as the period extending from 1100 to 2100 PDT. (Note that M represents the number of missing hourly observations during the daytime for each smog season; M generally has a value of 50 or less, but is sometimes much larger due to significant gaps in the ozone data set (which in some cases extend through the length of an entire smog season.)

The smallest number of exceedences occurred at sites in the coastal portion of the Basin, including Hawthorne, Lynwood, and Long Beach. Interestingly, West Los Angeles reported a considerably larger number of hours of ozone concentration at or above 9 pphm than these other three coastal sites.

The general trend during the 1986-96 period was toward an increasingly lower number of hours and days of exceedance, at all concentration levels. Although this trend was usually not in the form of a steady decrease (by the metrics used in this analysis), it is clear that substantial reduction in ambient ozone concentration in the Basin has occurred during the past decade. In particular, there has been substantial reduction in number of hours of *peak* ozone levels (i.e., hours with ozone concentrations at or above 20 pphm). The magnitudes of the percent decrease in number of ozone exceedances are generally much smaller (both hourly and daily) at the lower level of 9 pphm.

It is interesting to examine the H9 trend at Crestline, where slight decreases (from about 1300 hours of exceedance per year for 1986-89 to about 1200 hours of exceedance per year for 1990-94) are followed by a sudden discontinuous drop to a much lower value Table 6-1. Number of daily ozone concentrations greater than or equal to 9, 12, 15, and 20 pphm (columns D9, D12, D15, and D20, respectively) during the 1986-96 smog seasons. Hourly ozone concentrations greater than or equal to 9, 12, 15, and 20 pphm (columns H9, H12, H15, and H20, respectively) also shown for same period. Number of missing hourly observations from 11 AM to 9 PM PDT for each smog season shown in column M. ARB data used for 1986-95, AQMD data for 1996.

Stati						-1d				C									
SCAC		D15			H20		<b>U1 2</b>			Stat:		D15						Н9	м
1986	1	11	29	60	1	26	82	H9	м	1000	D20 7	26			H20				~ 3
	-				-			242	60	1986	•			101	10		167	413	-
1987	3	11	27	56	5	19	67	184	1	1987	5	26	48	81	9		141	331	25
1988	2	8	23	54	4	15	59	179	6	1988	2	18	41	90	5		111	315	26
1989	4	9	13	50	7	27	51	167	10	1989	5	18	37	79	10		107	303	21
1990	0	8	16	34	0	12	36	102	12	1990	4	20	40	79	4	42	105	306	7
1991	2	7	16	53	3	10	31	151	17	1991	1	11	37	70	1	21	87	262	8
1992	1	5	24	60	2	10	51	172	11	1992	0	8	32	59	0	12	77	205	14
1993	0	2	6	34	0	4	12	91	19	1993	0	5	20	61	0	9	44	202	13
1994	1	4	9	33	2	9	21	97	2	1994	2	- 4	14	49	5	9	- 44	169	6
1995	0	0	3	31	0	0	3	73	3	1995	0	1	8	52	0	1	12	128	4
1996	0	0	2	14	0	0	3	33	29	1996	0	1	7	29	0	1	14	76	14
												• • • •				_		•	
Stat:										Stat:						-		Avenu	
	D20	D15			H20			Н9	м		D20	D15			H20			Н9	M
1986	0	3	11	37	0	4	26	118	22	1986	0	1	8	33	0	1	10	86	10
1987	1	7	17	41	1	12	47	141	8	1987	0	2	7	21	0	2	10	46	21
1988	1	6	18	41	1	11	41	137	28	1988	1	8	17	51	3	11	35	131	103
1989	2	6	10	32	2	12	26	100	4	1989	0	4	12	38	0	8	29	121	12
1990	0	5	16	34	0	9	26	90	9	1990	0	4	12	35	0	6	22	92	14
1991	1	4	13	35	2	7	29	106	21	1991	0	4	10	47	0	5	16	116	1
1992	0	4	12	35	0	6	20	93	16	1992	0	1	10	42	0	1	16	95	8
1993	0	2	10	28	0	2	22	90	2	1993	0	1	7	28	0	1	12	65	9
1994	0	2	6	28	0	2	14	80	4	1994	0	0	0	0	0	0	0	0	1840
1995	0	1	2	30	0	1	4	62	5	1995	0	0	0	0	0	0	0	0	1840
1996	0	0	6	23	0	0	10	69	3	1996	0	0	0	0	0	0	0	0	1840
-		-								_		-							
Stat:										Stat:									
	D20	D15	D12	D9	H20	H15	H12	Н9	м		D20	D15	D12	D9	H20	H15	H12	н9	м
1986	D20 0	D15 1	D12 7	D9 20	Н20 0	H15 2	H12 14	55	9	1986	D20 0	D15 0	D12 0	D9 0	H20 0	H15 0	H12 0	н <b>9</b> 0	1840
1986 1987	D20 0 0	D15 1 1	D12 7 4	D9 20 18	H20 0 0	H15 2 3	H12 14 10	55 46	9 5	1986 1987	D20 0 0	D15 0 0	D12 0 0	D9 0 0	H20 0 0	H15 0 0	H12 0 0	н9 0 0	1840 1840
1986 1987 1988	D20 0 0 0	D15 1 1	D12 7 4 1	D9 20 18 10	H20 0 0	H15 2 3 1	H12 14 10 1	55 46 20	9 5 395	1986 1987 1988	D20 0 0	D15 0 0	D12 0 0 0	D9 0 0 0	H20 0 0	H15 0 0 0	H12 0 0 0	н9 0 0	1840 1840 1840
1986 1987 1988 1989	D20 0 0 0 0	D15 1 1 1 0	D12 7 4 1 0	D9 20 18 10 0	H20 0 0 0	H15 2 3 1 0	H12 14 10 1 0	55 46 20 0	9 5 395 1840	1986 1987 1988 1989	D20 0 0 0 0	D15 0 0 0 0	D12 0 0 0 0	D9 0 0 0 0	H20 0 0 0	H15 0 0 0	H12 0 0 0	н9 0 0 0	1840 1840 1840 1840
1986 1987 1988 1989 1989	D20 0 0 0 0	D15 1 1 0 0	D12 7 4 1 0 0	D9 20 18 10 0	H20 0 0 0 0	H15 2 3 1 0 0	H12 14 10 1 0 0	55 46 20 0	9 5 395 1840 1840	1986 1987 1988 1989 1990	D20 0 0 0 0 0	D15 0 0 0 1	D12 0 0 0 0 4	D9 0 0 0 0 19	H20 0 0 0 0	H15 0 0 0 2	H12 0 0 0 8	H9 0 0 0 41	1840 1840 1840 1840 29
1986 1987 1988 1989 1990 1991	D20 0 0 0 0 0	D15 1 1 0 0 0	D12 7 4 1 0 0	D9 20 18 10 0 0	H20 0 0 0 0 0	H15 2 3 1 0 0	H12 14 10 1 0 0 0	55 46 20 0 0	9 5 395 1840 1840 1840	1986 1987 1988 1989 1990 1991	D20 0 0 0 0	D15 0 0 0 1 1	D12 0 0 0 0 4 4	D9 0 0 0 19 28	H20 0 0 0	H15 0 0 0 2 1	H12 0 0 0 8 9	H9 0 0 0 41 64	1840 1840 1840 1840 29 14
1986 1987 1988 1989 1990 1991 1992	D20 0 0 0 0 0 0 0	D15 1 1 0 0 0 0	D12 7 4 1 0 0 0	D9 20 18 10 0 0 0	H20 0 0 0 0 0 0	H15 2 3 1 0 0 0	H12 14 10 1 0 0 0 0	55 46 20 0 0 0	9 5 395 1840 1840 1840 1840	1986 1987 1988 1989 1990 1991 1992	D20 0 0 0 0 0 0 0 0	D15 0 0 0 1 1 0	D12 0 0 0 4 4 6	D9 0 0 0 19 28 26	H20 0 0 0 0 0 0	H15 0 0 0 2 1 0	H12 0 0 0 8 9 7	H9 0 0 0 41 64 64	1840 1840 1840 1840 29 14 7
1986 1987 1988 1989 1990 1991 1992 1993	D20 0 0 0 0 0 0 0 0 0	D15 1 1 0 0 0 0 0	D12 7 4 1 0 0 0 0 0 0	D9 20 18 10 0 0 0 0	H20 0 0 0 0 0 0 0 0	H15 2 3 1 0 0 0 0 0	H12 14 10 1 0 0 0 0 0	55 46 20 0 0	9 5 395 1840 1840 1840 1840 1840	1986 1987 1988 1989 1990 1991 1992 1993	D20 0 0 0 0 0 0	D15 0 0 0 1 1 0 0	D12 0 0 0 4 4 6 2	D9 0 0 0 19 28 26 13	H20 0 0 0 0 0 0	H15 0 0 0 2 1 0 0	H12 0 0 0 8 9 7 3	H9 0 0 41 64 64 30	1840 1840 1840 1840 29 14 7 4
1986 1987 1988 1989 1990 1991 1992 1993 1994	D20 0 0 0 0 0 0 0 0 0 0	D15 1 1 0 0 0 0 0 0 0	D12 7 4 1 0 0 0 0 0 0 0	D9 20 18 10 0 0 0 0 0	H20 0 0 0 0 0 0 0 0 0	H15 2 3 1 0 0 0 0 0 0	H12 14 10 1 0 0 0 0 0 0 0	55 46 20 0 0 0	9 395 1840 1840 1840 1840 1840 1840	1986 1987 1988 1989 1990 1991 1992 1993 1994	D20 0 0 0 0 0 0 0 0	D15 0 0 0 1 1 0 0 0	D12 0 0 0 4 4 6 2 1	D9 0 0 0 19 28 26 13 7	H20 0 0 0 0 0 0	H15 0 0 0 2 1 0 0 0	H12 0 0 0 8 9 7 3 1	H9 0 0 41 64 64 30 13	1840 1840 1840 1840 29 14 7 4 19
1986 1987 1988 1989 1990 1991 1992 1993 1994 1995	D20 0 0 0 0 0 0 0 0 0 0 0	D15 1 1 0 0 0 0 0 0 0 0 0	D12 7 4 1 0 0 0 0 0 0 0 0	D9 20 18 10 0 0 0 0 0 0 0	H20 0 0 0 0 0 0 0 0 0 0 0	H15 2 3 1 0 0 0 0 0 0 0 0	H12 14 10 1 0 0 0 0 0 0 0 0 0	55 46 20 0 0 0 0 0 0	9 5 395 1840 1840 1840 1840 1840 1840 1840	1986 1987 1988 1989 1990 1991 1992 1993 1994 1995	D20 0 0 0 0 0 0 0 0 0	D15 0 0 0 1 1 0 0 0 0 0	D12 0 0 0 4 4 6 2 1 0	D9 0 0 0 19 28 26 13 7 8	H20 0 0 0 0 0 0 0 0 0 0 0 0	H15 0 0 0 2 1 0 0 0 0 0	H12 0 0 0 8 9 7 3 1 0	H9 0 0 41 64 64 30 13 14	1840 1840 1840 1840 29 14 7 4 19 108
1986 1987 1988 1989 1990 1991 1992 1993 1994	D20 0 0 0 0 0 0 0 0 0 0	D15 1 1 0 0 0 0 0 0 0	D12 7 4 1 0 0 0 0 0 0 0	D9 20 18 10 0 0 0 0 0	H20 0 0 0 0 0 0 0 0 0	H15 2 3 1 0 0 0 0 0 0	H12 14 10 1 0 0 0 0 0 0 0	55 46 20 0 0 0 0 0 0	9 395 1840 1840 1840 1840 1840 1840	1986 1987 1988 1989 1990 1991 1992 1993 1994	D20 0 0 0 0 0 0 0 0 0 0 0	D15 0 0 0 1 1 0 0 0	D12 0 0 0 4 4 6 2 1	D9 0 0 0 19 28 26 13 7	H20 0 0 0 0 0 0 0 0 0 0	H15 0 0 0 2 1 0 0 0	H12 0 0 0 8 9 7 3 1	H9 0 0 41 64 64 30 13	1840 1840 1840 1840 29 14 7 4 19
1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996	D20 0 0 0 0 0 0 0 0 0 0 0 0 0	D15 1 1 0 0 0 0 0 0 0 0 0 0	D12 7 4 1 0 0 0 0 0 0 0 0 0	D9 20 18 10 0 0 0 0 0 0 0 0 0	H20 0 0 0 0 0 0 0 0 0 0 0	H15 2 3 1 0 0 0 0 0 0 0 0	H12 14 10 1 0 0 0 0 0 0 0 0 0	55 46 20 0 0 0 0 0 0	9 5 395 1840 1840 1840 1840 1840 1840 1840	1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996	D20 0 0 0 0 0 0 0 0 0 0 0 0 0 0	D15 0 0 0 1 1 1 0 0 0 0 0	D12 0 0 0 4 4 6 2 1 0 0	D9 0 0 0 19 28 26 13 7 8 6	H20 0 0 0 0 0 0 0 0 0 0 0 0	H15 0 0 2 1 0 0 0 0 0 0	H12 0 0 0 8 9 7 3 1 0	H9 0 0 41 64 64 30 13 14	1840 1840 1840 1840 29 14 7 4 19 108
1986 1987 1988 1989 1990 1991 1992 1993 1994 1995	D20 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	D15 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	D12 7 4 1 0 0 0 0 0 0 0 0	D9 20 18 10 0 0 0 0 0 0 0 0	H20 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	H15 2 3 1 0 0 0 0 0 0 0	H12 14 10 0 0 0 0 0 0 0 0 0 0 0 0	55 46 20 0 0 0 0 0 0 0	9 395 1840 1840 1840 1840 1840 1840 1840	1986 1987 1988 1989 1990 1991 1992 1993 1994 1995	D20 0 0 0 0 0 0 0 0 0 0 0 0 0 0	D15 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0	D12 0 0 4 4 6 2 1 0 0 0 ersid	D9 0 0 0 19 28 26 13 7 8 6	H20 0 0 0 0 0 0 0 0 0 0 0 0 0 0	H15 0 0 2 1 0 0 0 0 0 0 0	H12 0 0 8 9 7 3 1 0 0	H9 0 0 41 64 64 30 13 14	1840 1840 1840 29 14 7 4 19 108 6
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1987	-			138		99		791	18	1987	8	39		137		102		729	6
1988				142		84		784	15	1988	6	26		138	9	82		643	33
1989			-	130	6	114		755	4	1989	3	26	61	117	5	61	225	600	14
1990	-	31		114	0		237	604	20	1990	0	6	21	55	0	12	53	204	11
1991		40	83	134	6	112	347	787	5	1991	7	32	67	112	11	105	265	643	42
1992	: 0	37	97	141	0	67	337	821	1	1992	0	4	21	61	0	5	42	240	3
1993	3	39	81	127	3	121	333	766	14	1993	0	7	31	87	0	14	86	368	14
1994	0	22	80	124	0	49	272	707	0	1994	0	5	26	92	0	9	69	397	18
1995	1	14	58	121	1	34	175	586	0	1995	0	4	37	92	0	8	104	429	5
1996	0	7		119	0	12		538	2	1996	Ō	1	2	6	Ó	4	8	26	1690
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1988	-	•	0	0	0	0	0		1840	1988	0	0	0	0	0	0	0		1840
1989	-			115	10		261	650	3	1989	0	-	0	0	0	-	•	-	1840
1990		16	44		0	-	137	422	7	1990	0		0	0	0	0	0		1840
1991		25		107	2	-	197	520	2	1991	0			9	0	5	9		1535
1992			32	90	0	7	73	365	1	1992	0		2	26	0	0	3	72	99
1993	-		41	88	0		105	414	21	1993	0	-	3	25	0	0	4	77	15
1994	-	14	50	109	0	31	161	562	28	1994	0	0	0	0	0	0	0	0	1840
1995		7	36	97	0	16	96	404	35	1995	0		0	0	0	0	0	0	1840
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1986							493			1986			123					1310	5
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1987		-	121			259		893	8	1987	0	ō	ŏ	- 0	õ	0	- 0		1840
1988			127			252		874	24	1988	ō	ō	ō	ō	ŏ	ō	õ		1840
1989	-		108		-	243	-	824	26	1989	ō	ŏ	ŏ	ō	ō	ŏ	ŏ	-	1840
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1991		56		131			358	692	15	1991	ō	ŏ	ō	ō	ō	ō	ŏ	-	1840
1992			103			164		754	4	1992	ō	ō	ō	ō	ō	ō	ō		1840
1993		32		128	7		265	646	i	1993	Ō	Ō	Ō	ō	ŏ	Ō	ŏ		1840
1994	-		101			142		726	2	1994	ŏ	ō	ŏ	Ō	ō	ō	ŏ		1840
1995	5 2	33	71	111	2	89	248	556	22	1995	Ó	Ó	Ō	Ó	Ó	Ó	Ō	0	1840
1996	5 1	18	51	101	3	42	159	448	5	1996	0	0	0	0	0	0	0	0	1840
Stat	ion:									Stati									
	D20		D12			H15		Н9	M			D15			H20			Н9	M
1986		69		121		294		838	314	1986	1	2	4	11	2	4	14		1490
1987	-		126			288		979	32	1987	26		130		-			1068	3
1988			129	157		328		1022	29	1988	24		130					1145	8
1989	-	79	110			248	538	930	15	1989	16	68	111			222	541	975	Э
1990		51		129		159		728	20	1990	11	53		131		157	380	777	5
1991	-	57	89	136		173		796	0	1991	16	64	100	146	37	241	506	973	4
1992		46		138		144		804	9	1992	5		107				466	991	3
1993		34		128		104	303	689	8	1993	8		102				472	944	10
1994		54		134			438	834	0	1994	- 4	35		107	7	99	329	673	302
1995		32		123	5		314	687	4	1995	4	36		126		110		764	33
1996	52	24	70	126	3	66	284	667	5	1996	1	30	75	127	2	58	273	720	3
Stat	ion	A 711	<b>5 a</b>							Stat	107.	Burl	nan k	-WP:	alm.	lven	1e		
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	D20	D15	D12			H15 288		H9 835	M 7		D20	D15	D12	D9	н20	н15	H12	H9 633	M 10
1986	D20 5 42	D15 87	D12 119	154	98	288	507	835	7	1986	D20 12	D15 55	D12 92	D9 131	н20 25	H15 148	H12 338	633	10
1980 1981	D20 5 42 7 26	D15 87 73	D12 119 116	154 146	98 50	288 206	507 446	835 766	7 17	1986 1987	D20 12 6	D15 55 41	D12 92 90	D9 131 131	H20 25 6	H15 148 91	H12 338 288	633 587	10 31
1986	D20 5 42 7 26 1 33	D15 87 73 87	D12 119	154 146	98 50 59	288	507 446 467	835	7	1986	D20 12	D15 55	D12 92	D9 131	н20 25	H15 148 91 89	H12 338	633	10
1980 1981 1988	D20 42 26 33 27	D15 87 73 87	D12 119 116 122 108	154 146 157	98 50 59 61	288 206 247	507 446 467 436	835 766 795	7 17 22	1986 1987 1988	D20 12 6 3	D15 55 41 37	D12 92 90 78 46	D9 131 131 130	H20 25 6 8	H15 148 91 89	H12 338 288 241	633 587 539	10 31 26
198( 198) 1988 1989	D20 42 26 33 27 13	D15 87 73 87 74	D12 119 116 122 108 84	154 146 157 142	98 50 59 61 18	288 206 247 226	507 446 467 436 299	835 766 795 764	7 17 22 6	1986 1987 1988 1989	D20 12 6 3 4	D15 55 41 37 20	D12 92 90 78 46	D9 131 131 130 97	H20 25 6 8 6	H15 148 91 89 49	H12 338 288 241 152	633 587 539 395	10 31 26 18
1980 1987 1988 1989 1989	D20 42 26 33 27 13 12	D15 87 73 87 74 56	D12 119 116 122 108 84	154 146 157 142 123 119	98 50 59 61 18 22	288 206 247 226 121	507 446 467 436 299 254	835 766 795 764 548	7 17 22 6 11	1986 1987 1988 1989 1990	D20 12 6 3 4 1	D15 55 41 37 20 15	D12 92 90 78 46 52	D9 131 131 130 97 101	H20 25 6 8 6 2	H15 148 91 89 49 34	H12 338 288 241 152 151	633 587 539 395 390	10 31 26 18 21
198( 1987 1988 1989 1990	D20 42 26 33 27 13 12 14	D15 87 73 87 74 56 48	D12 119 116 122 108 84 78 98	154 146 157 142 123 119	98 50 59 61 18 22	288 206 247 226 121 117 127	507 446 467 436 299 254 307	835 766 795 764 548 505	7 17 22 6 11 6	1986 1987 1988 1989 1990 1991	D20 12 6 3 4 1 4	D15 55 41 37 20 15 28	D12 92 90 78 46 52 63	D9 131 131 130 97 101 115	H20 25 6 8 6 2 6	H15 148 91 89 49 34 74	H12 338 288 241 152 151 209	633 587 539 395 390 478	10 31 26 18 21 20
198( 1982 1988 1989 1990 1991 1992	D20 42 26 33 27 13 12 14 11	D15 87 73 87 74 56 48 51	D12 119 116 122 108 84 78 98	154 146 157 142 123 119 136	98 50 59 61 18 22 26	288 206 247 226 121 117 127 119	507 446 467 436 299 254 307	835 766 795 764 548 505 608	7 17 22 6 11 6 6	1986 1987 1988 1989 1990 1991 1992	D20 12 6 3 4 1 4 6	D15 55 41 37 20 15 28 23	D12 92 90 78 46 52 63 64	D9 131 131 130 97 101 115 116	H20 25 6 8 6 2 6 9	H15 148 91 89 49 34 74 59	H12 338 288 241 152 151 209 180	633 587 539 395 390 478 482	10 31 26 18 21 20 12
198( 1982 1988 1989 1990 1990 1992	D20 42 26 33 27 13 12 14 14	D15 87 73 87 74 56 48 51 49	D12 119 116 122 108 84 78 98 85	154 146 157 142 123 119 136 121	98 50 59 61 18 22 26 18	288 206 247 226 121 117 127 119	507 446 436 299 254 307 287 263	835 766 795 764 548 505 608 563	7 17 22 6 11 6 6 1	1986 1987 1988 1989 1990 1991 1992 1993	D20 12 6 3 4 1 4 6 0	D15 55 41 37 20 15 28 23 7	D12 92 90 78 46 52 63 64 21	D9 131 131 130 97 101 115 116 60	H20 25 6 8 6 2 6 9 0	H15 148 91 89 49 34 74 59 14	H12 338 288 241 152 151 209 180 57	633 587 539 395 390 478 482 198	10 31 26 18 21 20 12 5
1980 1983 1988 1989 1990 1991 1992 1993	D20 42 26 33 27 13 12 14 11 2 3	D15 87 73 87 74 56 48 51 49 37	D12 119 116 122 108 84 78 98 85 85	154 146 157 142 123 119 136 121 122	98 50 59 61 18 22 26 18 5	288 206 247 226 121 117 127 119 79 79	507 446 436 299 254 307 287 263	835 766 795 764 548 505 608 563 563	7 17 22 6 11 6 6 1 0	1986 1987 1988 1989 1990 1991 1992 1993 1994	D20 12 6 3 4 1 4 6 0 0	D15 55 41 37 20 15 28 23 7 6	D12 92 90 78 46 52 63 64 21 22	D9 131 131 130 97 101 115 116 60 65	H20 25 6 8 6 2 6 9 0 0	H15 148 91 49 34 74 59 14 8	H12 338 288 241 152 151 209 180 57 48	633 587 539 395 390 478 482 198 215	10 31 26 18 21 20 12 5 24
198( 1987 1988 1989 1990 1991 1992 1993 1994 1995	D20 42 26 33 27 13 12 14 11 2 3 5 1	D15 87 73 87 74 56 48 51 49 37 38 17	D12 119 116 122 108 84 78 98 85 83 73 39	154 146 157 142 123 119 136 121 122 120 86	98 50 59 61 18 22 26 18 5 3 1	288 206 247 226 121 117 127 119 79 79 33	507 446 467 436 299 254 307 287 263 221	835 766 795 764 548 505 608 563 563 563	7 17 22 6 11 6 1 0 1	1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996	D20 12 6 3 4 1 4 6 0 0 0 0	D15 55 41 37 20 15 28 23 7 6 3 0	D12 92 90 78 46 52 63 64 21 22 27 11	D9 131 131 130 97 101 115 116 60 65 73	H20 25 6 8 6 2 6 9 0 0	H15 148 91 89 49 34 74 59 14 8 5	H12 338 288 241 152 151 209 180 57 48 60	633 587 539 395 390 478 482 198 215 274	10 31 26 18 21 20 12 5 24 9
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1986 1987 1988 1990 1990 1992 1993 1994 1995 1996 Stat	D20 42 26 33 27 13 12 14 11 2 3 11 12 14 11 2 5 1 2 0 5 0	D15 87 73 87 74 56 48 51 49 37 38 17 Norr D15 1	D12 119 116 122 108 84 78 98 85 83 73 39 20 212 9	154 146 157 142 123 119 136 121 122 120 86 0ng D9 28	98 50 59 61 18 22 26 18 5 3 1 Beac H20 0	288 206 247 226 121 117 127 79 79 33 33	507 446 467 436 299 254 307 287 263 221 102 H12 14	835 766 795 764 548 505 608 563 563 506 323 506 323 H9 60	7 17 22 6 11 6 6 1 1 1 1 91	1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 Stat: 1986	D20 12 6 3 4 1 4 6 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	D15 55 41 37 20 15 28 23 7 6 3 0 Res D15 40	D12 92 90 78 46 52 63 64 21 22 27 11 22 27 11 22 78	D9 131 131 130 97 101 115 116 60 65 73 44 D9 128	H20 25 6 2 6 9 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	H15 148 91 89 34 74 59 14 8 5 0 H15 124	H12 338 288 241 152 151 209 180 57 48 60 27 H12 290	633 587 539 395 390 478 482 198 215 274 138 H9 653	10 31 26 18 21 20 12 5 24 9 13 M
1986 1983 1988 1990 1990 1992 1994 1995 1996 Stat 1986	D20 5 42 7 26 1 33 1 27 1 13 1 27 1 13 1 27 1 13 1 12 1 14 1 11 1 1 1 1 1 1 2 5 3 5 1 1 2 7 0 7 0 7 0 7	D15 87 73 87 74 56 48 51 49 37 38 17 Nor D15 1 1	D12 119 116 122 108 84 78 85 83 73 39 5h D12 96	154 146 157 142 123 119 136 121 122 120 86 D9 28 13	98 50 59 61 18 22 26 18 5 3 1 Beac H20 0 0	288 206 247 226 121 117 127 119 79 33 H15 3 1	507 446 467 436 299 254 307 287 263 221 102 H12 14 9	835 766 795 764 548 563 563 563 506 323 H9 60 31	7 17 22 6 11 6 6 1 1 1 1 91 46	1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 Stat: 1986 1987	D20 12 6 3 4 1 4 6 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	D15 55 41 37 20 15 28 23 7 6 3 0 Res D15 40 33	D12 92 90 78 46 52 63 64 21 22 27 11 012 78 78	D9 131 130 97 101 115 116 60 65 73 44 D9 128 130	H20 25 6 6 9 0 0 0 0 0 0 120 9 2	H15 148 91 89 34 74 59 14 8 5 0 H15 124 80	H12 338 288 241 152 151 209 180 57 48 60 27 H12 290 251	633 587 539 395 390 478 482 198 215 274 138 H9 653 594	10 31 26 18 21 20 12 5 24 9 13 M 8 46
1986 1987 1988 1990 1990 1990 1995 1995 1996 Stat 1988	D20 42 26 33 27 13 12 14 11 2 3 12 14 11 2 3 12 14 11 20 3 12 14 10 12 13 12 14 10 10 10 10 10 10 10 10 10 10	D15 87 73 87 74 56 48 51 49 37 38 17 Nor D15 1 3	D12 119 116 122 108 84 78 98 85 83 73 39 D12 96 6	154 146 157 142 123 119 136 121 122 120 86 0ng 28 13 17	98 50 59 61 18 22 26 18 5 3 1 H20 H20 0 0 0	288 206 247 226 121 117 127 119 79 33 H15 3 1 3	507 446 467 436 299 254 307 287 263 221 102 H12 14 9 15	835 766 795 764 548 505 563 506 323 K9 60 31 46	7 17 22 6 11 6 1 0 1 1 91 46 17	1986 1987 1988 1999 1990 1991 1992 1993 1994 1995 1996 Stat: 1986	D20 12 6 3 4 1 4 6 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	D15 55 41 37 20 15 28 23 7 6 3 0 D15 40 33 47	D12 92 90 78 46 52 63 64 21 22 27 11 012 78 89	D9 131 130 97 101 115 116 60 65 73 44 D9 128 130 139	H20 25 6 8 6 2 6 9 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	H15 148 91 89 49 34 74 59 14 8 5 0 H15 124 80 125	H12 338 288 241 152 151 209 180 57 48 60 27 H12 290 251 315	633 587 539 395 390 478 482 215 274 138 498 215 274 138 493 594 708	10 31 26 18 20 12 5 24 9 13 M 8 46 20
1986 1987 1988 1990 1990 1990 1993 1996 Stat 1986 1988 1988	D20 5 42 7 26 7 33 7 13 7 13 12 14 11 2 5 14 11 2 5 1 2 0 7 0 7 0 3 0 7 0 3 0 9 0	D15 87 73 87 74 56 48 51 49 37 38 17 Norr D15 1 32	D12 119 116 122 108 84 78 85 83 73 39 20 21 21 20 20 20 20 20 20 20 20 20 20 20 20 20	154 146 157 142 123 119 136 121 122 120 86 D9 28 13 17 16	98 50 59 61 18 22 26 18 5 3 1 H20 0 0 0 0 0 0	288 206 247 226 121 117 127 119 79 33 33 H H15 3 1 32	507 446 467 436 299 254 307 287 263 221 102 H12 14 9 15 9	835 766 795 764 548 563 563 563 506 323 H9 60 316 40	7 17 22 6 11 6 1 0 1 1 91 46 17 13	1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 Stat: 1986 1987 1988	D20 12 6 3 4 1 4 6 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	D15 55 41 37 20 15 28 23 7 6 30 D15 40 33 47 30	D12 92 90 78 46 52 63 64 21 227 11 D12 78 78 89 60	D9 131 130 97 101 115 116 60 65 73 44 D9 128 130 139 120	H20 25 6 9 0 0 0 0 0 0 1 2 8 7	H15 148 91 89 49 34 74 59 14 8 5 0 H15 124 80 125 98	H12 338 288 241 152 151 209 180 57 48 60 27 H12 290 251 315 230	633 587 539 395 390 478 482 215 274 138 H9 653 594 708 588	10 31 26 18 21 20 12 5 24 9 13 M 8 46 20 46
1988 1985 1996 1995 1995 1995 1996 Stat 1986 1988 1988 1988	D20 5 42 7 26 7 33 7 13 7 13 12 14 11 2 5 14 11 2 5 0 7 0 3 0 7 0 3 0 0 7 0 0 9 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	D155 877 74 566 488 51 499 377 388 51 17 Norr D155 1 1 3 2 0	D12 119 116 122 108 84 78 85 83 73 39 20 21 21 20 29 9 6 6 6 6 6 6 4 1	154 146 157 142 123 119 136 121 122 120 86 0ng 9 28 13 17 16 8	98 50 59 61 18 22 26 18 5 3 1 H20 0 0 0 0 0 0 0 0	288 206 247 226 121 117 127 119 79 33 h H15 3 1 3 2 0	507 446 467 436 299 254 307 287 263 221 102 H12 14 9 15 9 1	835 766 795 764 548 563 563 563 506 323 49 60 316 40 13	7 17 22 6 1 6 1 0 1 1 91 46 17 13 36	1986 1987 1988 1990 1991 1992 1993 1994 1995 1996 Stat: 1986 1987 1988 1989 1990	D200 122 6 3 4 4 1 4 6 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	D1555541 3772001528 233776233000 Ress D15540 3334730021	D12 92 90 78 46 52 63 64 21 22 27 11 D12 27 88 9 60 51	D9 131 130 97 101 115 60 65 73 44 D9 128 130 120 110	H20 25 6 8 6 2 2 6 9 9 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	H15 148 91 89 49 34 74 59 14 8 5 0 H15 124 80 125 98	H12 338 288 241 152 151 209 180 57 48 60 27 H12 290 251 315 230 158	633 587 539 395 390 478 482 198 215 274 138 498 653 594 708 588 588	10 31 26 18 21 20 12 5 24 9 13 M 8 46 20 46 17
1988 1985 1996 1990 1990 1995 1996 Stat 1986 1988 1988 1988 1988	D20 5 42 7 26 1 33 1 27 1 12 1 14 1 11 2 3 5 1 D20 5 0 7 0 8 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	D155 877 7387 74 566 488 519 37 388 17 Norr D155 1 1 32 200 0	D12 119 116 122 108 84 78 98 85 83 73 39 2 5 h L D12 96 66 4 1 0	154 146 157 142 123 119 136 121 122 120 86 0000 1 288 133 17 16 8 2 8 13 17 16 8 12	98 50 59 61 18 22 26 18 22 26 18 3 1 H20 0 0 0 0 0 0 0 0 0 0 0	288 206 247 226 121 117 129 79 33 h H15 3 1 3 2 0 0	507 446 436 299 254 307 287 263 221 102 H12 14 9 15 9 1 0	835 766 795 505 608 563 563 563 563 563 563 563 563 563 563	7 17 22 11 6 1 1 1 91 46 17 13 6 8	1986 1987 1988 1999 1990 1991 1992 1993 1994 1995 1996 Stat: 1986 1987 1988 1989 1990 1991	D200 122 6 3 4 1 4 6 6 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	D155541 37720015282337763300 RessD155400333477033407302131	D12 92 90 78 46 52 63 63 64 21 22 27 11 22 27 78 89 90 51 64	D9 131 131 130 97 101 115 116 60 65 73 44 D9 128 130 139 120 139 120 110	H200 255 6 8 6 9 9 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	H155 148 91 49 34 59 34 59 14 85 0 14 85 0 124 80 124 80 125 28 84 2 64	H12 338 241 152 151 209 180 57 48 60 27 H12 290 251 315 230 158 217	633 587 539 395 395 478 482 198 215 274 138 482 198 594 708 594 708 584 457 565	10 31 26 18 21 20 12 5 24 9 13 M 8 46 20 46 20 46 17 33
1988 1985 1996 1995 1995 1995 1996 Stat 1986 1988 1988 1988	D20 5 422 7 26 8 33 9 13 9 13 9 13 9 13 9 13 9 13 9 13 9	D155 877 74 566 488 51 499 377 388 51 17 Norr D155 1 1 3 2 0	D12 119 116 122 108 84 78 85 83 73 39 5h LL D12 9 66 66 64 1 00 88	154 146 157 142 123 119 136 121 122 120 86 000 28 13 17 16 8 12 27	98 50 59 61 18 22 26 18 5 3 1 H20 0 0 0 0 0 0 0 0	288 206 247 226 1217 127 79 79 33 H15 3 1 3 20 0 0	507 446 436 299 254 307 263 221 102 H12 14 9 15 9 1 10 11	835 766 795 568 563 563 563 563 563 563 563 563 503 323 H9 60 31 46 40 13 563	7 17 22 6 11 6 1 1 1 46 17 13 36 8 7	1986 1987 1988 1999 1990 1991 1992 1993 1994 1995 1996 Stat: 1986 1987 1988 1989 1989 19991	D200 122 6 3 4 1 4 6 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	D155541 37720015282337663300 D152882337663300 D1554003334773002113177	D12 92 90 78 46 52 63 64 22 27 11 22 27 11 22 78 89 60 51 64 42	D9 131 131 130 97 101 115 116 60 65 73 44 D9 128 130 139 1200 139 1200 119 98	H20 25 6 8 6 9 9 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	H155 148 91 49 34 59 34 59 14 85 0 14 85 0 124 80 124 80 125 28 84 2 64	H12 338 241 152 151 2090 180 27 48 60 27 H12 290 251 3155 2300 251 3158 217 104	633 587 539 395 390 478 482 198 215 274 138 455 594 708 588 457 373	10 31 26 18 21 20 12 5 24 9 13 M 8 46 20 46 17 33 11
1988 1987 1988 1990 1992 1993 1995 1996 Stat 1988 1988 1988 1988 1989 1999	D2005422 4224 2664333 377413 122514 111223 12201 12201 12201 12201 12201 12201 12201 12201 12201 12201 12201 12000 12001 1200000000	D15587738774 566488511 3738774 49377388717 17747974 388774 388774 38774 377474 3777474 3777474 3777474 3777474 3777474 3777477777777	D12 119 116 122 108 84 78 98 85 83 73 39 2 5 h L D12 96 66 4 1 0	154 146 157 142 123 136 121 122 120 86 000 28 132 17 16 82 27 18	98850 59961 182266 1885 331 H2000 00000000000000000000000000000000	288 206 247 226 121 117 119 79 33 3 h H15 3 1 3 2 0 0 0 1 0	507 4466 436 299 254 307 287 263 221 102 11 15 9 15 9 1 10 11 4	835 766 795 764 505 563 563 563 563 563 503 89 60 31 46 40 13 18 60 30	7 17 22 6 11 6 6 1 1 1 91 46 17 13 36 8 7 42	1986 1987 1988 1990 1991 1992 1993 1995 1996 Stat: 1986 1987 1988 1989 1990 1991 1992 1993	D200 122 6 3 4 4 6 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	D155541 37720015282337763300 RessD155400333477033407302131	D12 92 90 78 46 52 63 63 64 21 22 27 11 22 27 78 89 90 51 64	D9 131 131 130 97 101 115 116 60 65 73 44 D9 128 130 139 120 139 120 110	H200 255 6 8 6 9 9 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	H155 148 91 89 49 34 74 59 14 85 0 124 80 125 124 80 125 42 64 11	H12 338 241 152 151 209 180 57 48 60 27 H12 290 251 315 230 158 217	633 587 539 395 390 478 482 198 215 274 138 H9 653 594 457 565 373 376	10 31 26 18 21 20 12 5 24 9 13 M 8 46 20 46 17 31 1 15
1986 1987 1988 1990 1991 1992 1993 1995 1996 Stat 1986 1988 1988 1989 1999 1999	D20         D20           5         422         263           7         6         133           8         122         14           12         14         12           13         11         12           14         12         14           15         11         11           16         2         0           16         0         0           17         0         0           10         0         0           11         0         0           12         0         0           14         0         0	D15587738774 566488511 377387744 49377388774 38851177 Norr11133220000011100	D122 1199 1166 1222 108 84 85 83 73 399 5h L D122 99 66 66 64 44 10 08 82	154 146 157 142 123 119 136 121 122 120 86 000 28 13 17 16 8 12 27	98 50 59 61 18 226 18 226 18 5 3 1 H20 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	288 206 247 226 1217 127 79 79 33 H15 3 1 3 20 0 0	507 446 436 299 254 307 263 221 102 H12 14 9 15 9 1 10 11	835 766 795 568 563 563 563 563 563 563 563 563 503 323 H9 60 31 46 40 13 563	7 17 22 6 11 6 1 1 1 46 17 13 36 8 7	1986 1987 1988 1999 1990 1991 1992 1993 1994 1995 1996 Stat: 1986 1987 1988 1989 1989 19991	D200 122 6 3 4 1 4 6 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	D1555541377200 2052823377663300 D15540333477300211317717	D12 92 90 78 46 52 52 27 11 22 27 11 012 27 88 960 51 64 42 38	D9 131 131 130 97 101 115 116 60 65 73 44 D9 128 130 139 120 119 98 89	H20 25 6 8 6 22 6 9 9 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	H155 148 91 49 34 59 14 85 0 14 85 124 80 125 98 422 94 411 39	H12 338 288 241 152 209 180 57 48 60 27 48 60 27 48 209 251 315 230 251 315 230 251 158 217 104	633 587 539 395 390 478 482 198 215 274 138 49 653 594 708 588 457 565 3776 376 286	10 31 26 18 21 20 12 5 24 9 13 M 8 46 20 46 17 33 11 15 7
1988 1988 1988 1990 1990 1990 1990 1996 Stat 1988 1988 1988 1988 1989 1999 1999	D20         D20           5         422           263         263           1         333           2         141           2         141           2         122           3         122           3         122           4         11           2         141           3         122           3         0           0	D15587738774487564887737348774487566488511773387745748749377374493773774477774777747777777777	D122 1199 1166 1222 108 84 85 83 73 399 5h L22 D122 99 66 66 64 41 00 82 4	154 146 157 142 123 119 136 121 122 120 86 000 2 8 8 000 2 8 8 13 17 16 8 12 27 18 13	98 50 59 61 18 226 18 226 18 5 3 1 1 BeacC 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	288 206 2477 2266 121 1177 127 799 333 h H15 3 1 3 2 0 0 0 1 0 0 1 1 0	507 4466 467 436 299 254 307 287 263 221 102 H12 14 9 15 9 1 0 11 4 6	835 766 795 764 505 563 563 506 323 H9 601 40 13 18 602 28	7 17 22 6 1 6 6 1 0 1 1 9 16 47 13 36 8 7 2 16	1986 1987 1988 1990 1991 1992 1993 1994 1995 1996 Stat: 1986 1987 1988 1989 1990 1991 1992 1993 1994	D20 12 6 3 4 4 6 6 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	D155541 3772000528 23377653000000000000000000000000000000000	D12 92 90 78 466 22 27 11 22 27 78 89 60 51 44 23 88 9 60 51 44 38 87	D9 131 1310 97 101 115 116 60 65 73 44 D9 128 130 139 120 139 120 110 119 88 9 78	H20 25 6 8 6 22 6 9 9 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	H155 148 91 49 34 59 14 85 0 14 85 124 80 125 98 42 64 11 39 0	H12 338 288 241 152 209 180 57 48 600 27 H12 290 251 230 251 230 158 217 104 130 17 30	633 587 539 395 390 478 482 198 215 274 138 498 653 594 708 457 565 373 376 588 457 565 373 286 205	10 31 26 18 21 20 12 5 4 9 13 M 8 46 20 46 17 33 11 15 5 5

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		D15						Н9	M			D15			H20			Н9	M
1986	23	61		126		193		630	27	1986	4	22	38	86	4		113	325	13
1987	16	43		127		112		537	18	1987	4	26	44	85	5		128	307	7
1988	16		102			130		609	12	1988	4	11	35	75	7	29	88	234	20
1989	10	36	71	115	19		231	477	11	1989	4	18	40	74	8	47	109	264	3
1990	12	43	67	104	17	97	200	436	9	1990	0	8	30	59	0	14	61	177	2
1991	8	41	65	109	15	97	224	465	8	1991	0	10	31	61	0	15	57	203	3
1992	8	32	62	111	10	76	211	433	10	1992	0	14	33	74	0	22	77	225	10
1993	6	25	60	109	8	69	181	432	12	1993	0	5	17	51	0	7	35	164	0
1994	3	23	66	108	8	50	203	469	3	1994	Ō	ō	0	0	ā	Ó	Ō	0	1840
1995	2	-	58	95	3		172	409	3	1995	ŏ	ō	Ō	ŏ	ō	ō	ō		1840
1996	õ		22	54	õ	13	54	186	32	1996	ō	ŏ	ŏ	ŏ	ŏ	ŏ	ŏ		1840
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Stati										Stati									
		D15			H20			Н9	М				D12					н9	м_
1986	0	6	14	53	0	10	34	135	63	1986	14	45		118		105		487	5
1987	1	6	15	34	1	11	33	96	22	1987	7	38		120	10		187	452	22
1988	1	4	12	27	1	8	28	80	13	1988	11	35	73	124	21	82	200	472	18
1989	0	0	10	32	0	. 0	18	84	57	1989	16	36	68	107	27	91	186	418	6
1990	Ó	1	4	11	0	1	6	30	16	1990	0	19	52	91	0	28	114	288	2
1991	0	1	ġ	26	0	1	5	63	10	1991	6	35	59	99	8	65	152	337	13
1992	Ō	ō	4	14	ō	ō	4	38	17	1992	3	25	49	99	6		125	351	6
1993	ō	ō	1	11	ō	ō	1	19	8	1993	ō	20	40	78	ō	26	96	279	36
1994	ŏ	ŏ	1	5	õ	ŏ	1	9	5	1994	ž	12	35	89	4	21	83	284	51
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1995 1996	0	0	0	1	0	0	0	1	31 3	1995 1996	0	2	36 11	83 47	0	5	66 22	268 135	22
1990	v	v	U	+	v	Ŭ	v	T	3	1990	v	v	11	47	Ų	U	~~	133	
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		D15			H20	H15		Н9	м		D20	D15	D12				H12	н9	м
1986																			
	4			100	4		132	358	4	1986	28		107				429	756	40
1987	42			100 100	4 3		132 103	358 366	4 26	1986 1987	28 15	82 61				232 141		756 666	40 7
		15							-			61		135	26		322	756	40 7 16
1987	2	15 11	44	100	3	26	103	366	26	1987	15	61	97 120	135	26 28	141	322 410	756 666	40 7
1987 1988	2 1	15 11 11	44 33	100 73	3 2	26 22	103 82	366 255	26 24	1987 1988	15 16	61 71	97 120 86	135 150	26 28	141 174 133	322 410	756 666 766	40 7 16
1987 1988 1989	2 1 1	15 11 11 12	44 33 35	100 73 79	3 2 1	26 22 19	103 82 94	366 255 290	26 24 13	1987 1988 1989 1990	15 16 15 7	61 71 51	97 120 86 77	135 150 123	26 28 29 11	141 174 133	322 410 308 243	756 666 766 608	40 7 16 20
1987 1988 1989 1990 1991	2 1 1 2 0	15 11 11 12 6	44 33 35 38 28	100 73 79 85 72	3 2 1 2 0	26 22 19 20 11	103 82 94 95 73	366 255 290 301 245	26 24 13 17 43	1987 1988 1989 1990 1991	15 16 15 7 10	61 71 51 45 47	97 120 86 77 80	135 150 123 121 112	26 28 29 11 13	141 174 133 96 115	322 410 308 243 271	756 666 766 608 521 521	40 7 16 20 9 73
1987 1988 1989 1990 1991 1992	2 1 2 0 0	15 11 11 12 6 9	44 33 35 38 28 23	100 73 79 85 72 65	3 2 1 2 0 0	26 22 19 20 11 14	103 82 94 95 73 60	366 255 290 301 245 217	26 24 13 17 43 15	1987 1988 1989 1990 1991 1992	15 16 15 7 10 7	61 71 51 45 47 29	97 120 86 77 80 68	135 150 123 121 112 122	26 28 29 11 13 10	141 174 133 96 115 60	322 410 308 243 271 192	756 666 766 608 521 521 521	40 7 16 20 9 73 54
1987 1988 1989 1990 1991 1992 1993	2 1 2 0 0 0	15 11 11 12 6 9 1	44 33 35 38 28 23 12	100 73 79 85 72 65 44	3 2 1 2 0 0 0	26 22 19 20 11 14 1	103 82 94 95 73 60 21	366 255 290 301 245 217 123	26 24 13 17 43 15 6	1987 1988 1989 1990 1991 1992 1993	15 16 15 7 10 7 5	61 71 51 45 47 29 27	97 120 86 77 80 68 52	135 150 123 121 112 122 95	26 28 29 11 13 10 5	141 174 133 96 115 60 60	322 410 308 243 271 192 163	756 666 766 608 521 521 500 394	40 7 16 20 9 73 54 162
1987 1988 1989 1990 1991 1992 1993 1994	2 1 2 0 0 0 0	15 11 12 6 9 1 5	44 33 35 38 28 23 12 23	100 73 79 85 72 65 44 66	3 2 1 2 0 0 0 0	26 22 19 20 11 14 11	103 82 94 95 73 60 21 51	366 255 290 301 245 217 123 220	26 24 13 17 43 15 6 5	1987 1988 1989 1990 1991 1992 1993 1994	15 16 15 7 10 7 5 2	61 71 45 47 29 27 34	97 120 86 77 80 68 52 70	135 150 123 121 112 122 95 107	26 28 29 11 13 10 5 3	141 174 133 96 115 60 60 59	322 410 308 243 271 192 163 190	756 666 766 608 521 521 521 500 394 480	40 7 16 20 9 73 54 162 11
1987 1988 1989 1990 1991 1992 1993 1994 1995	2 1 2 0 0 0 0 0 0	15 11 12 6 9 1 5 2	44 33 35 38 28 23 12 23 15	100 73 79 85 72 65 44 66 58	3 2 1 2 0 0 0 0 0	26 22 19 20 11 14 11 2	103 82 94 95 73 60 21 51 28	366 255 290 301 245 217 123 220 149	26 24 13 17 43 15 6 5 2	1987 1988 1989 1990 1991 1992 1993 1994 1995	15 16 15 7 10 7 5 2	61 71 51 45 47 29 27 34	97 120 86 77 80 68 52 70 59	135 150 123 121 112 122 95 107 99	26 28 29 11 13 10 5 3 1	141 174 133 96 115 60 60 59 30	322 410 308 243 271 192 163 190 152	756 666 766 521 521 500 394 480 396	40 7 16 20 9 73 54 162 11 4
1987 1988 1989 1990 1991 1992 1993 1994	2 1 2 0 0 0 0	15 11 12 6 9 1 5	44 33 35 38 28 23 12 23	100 73 79 85 72 65 44 66	3 2 1 2 0 0 0 0	26 22 19 20 11 14 11	103 82 94 95 73 60 21 51	366 255 290 301 245 217 123 220	26 24 13 17 43 15 6 5	1987 1988 1989 1990 1991 1992 1993 1994	15 16 15 7 10 7 5 2	61 71 45 47 29 27 34	97 120 86 77 80 68 52 70	135 150 123 121 112 122 95 107	26 28 29 11 13 10 5 3	141 174 133 96 115 60 60 59	322 410 308 243 271 192 163 190 152	756 666 766 608 521 521 521 500 394 480	40 7 16 20 9 73 54 162 11
1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 Stati	2 1 2 0 0 0 0 0 0 0	15 11 11 12 6 9 1 5 2 0 Sant	44 33 35 38 28 23 12 23 15 7 :a CI	100 73 79 85 72 65 44 66 58 29 .arit	3 2 1 2 0 0 0 0 0 0 0	26 22 19 20 11 14 11 2 0	103 82 94 95 73 60 21 51 28 13 y Fir	366 255 290 301 245 217 123 220 149	26 24 13 17 43 15 6 5 2 13	1987 1988 1989 1990 1991 1992 1993 1994 1995	15 16 15 7 10 7 5 2 1 0	61 71 51 45 47 29 27 34 17 8 West	97 120 86 77 80 68 52 70 59 23 23	135 150 123 121 112 122 95 107 99 64 8 And	26 28 29 11 13 10 5 3 1 0 9 9 9 9	141 174 133 96 115 60 60 59 30 12 30	322 410 308 243 271 192 163 190 152 61 Hosp	756 666 766 521 521 500 394 480 396 238	40 7 16 20 9 73 54 162 11 4 18
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1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 Stati 1986	2 1 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	15 11 12 6 9 1 5 2 0 Sant D15 58 30	44 33 35 38 28 23 12 23 15 7 23 15 7 23 23 23 23 23 23 23 23 23 23 23 23 23	100 73 79 85 72 65 44 66 58 29 arit D9 122 134	3 2 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	26 22 19 20 11 14 11 11 2 0 H15 189 70	103 82 94 95 73 60 21 51 28 13 4 Fil H12 397 264	366 255 290 301 245 217 123 220 149 84 re Stat H9 709	26 24 13 17 43 15 6 5 2 13 M 8	1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 Stati	15 16 15 7 10 7 5 2 1 0 0 10 0	61 71 51 45 47 29 27 34 17 8 West D15 11 8	97 120 86 77 80 68 52 70 59 23 23 23 D12 30	135 150 123 121 122 95 107 99 64 8 And D9 86	26 28 29 11 13 10 5 3 1 0 9 ele: H20 1	141 174 133 96 115 60 60 59 30 12 8-VA H15 24	322 410 308 243 271 192 163 190 152 61 Hosp H12 70 62	756 666 766 521 521 500 394 480 396 238 91 480 238 91 480 238 91 49 274	40 7 16 20 9 73 54 162 11 4 18 M 15 49
1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 Stati 1986 1987 1988	2 1 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	15 11 12 6 9 1 5 2 0 Sant D15 58 30 80	44 33 35 38 28 23 12 23 15 7 23 15 7 212 89 80 115	100 73 79 85 72 65 44 66 58 29 .arit D9 122 134 144	3 2 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	26 22 19 20 11 14 11 11 2 0 H15 189 70 283	103 82 94 95 73 60 21 51 28 13 412 397 264 536	366 255 290 301 245 217 123 220 149 84 re Stat H9 709 646 851	26 24 13 17 43 15 6 5 2 13 M 8 20 23	1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 Stat: 1986 1987 1988	15 16 15 7 10 7 5 2 1 0 0 10 0 20 1 20	61 71 51 45 47 29 27 34 17 8 West D15 11 8 9	97 120 86 77 80 68 52 70 59 23 23 23 212 20 20	135 150 123 121 122 95 107 99 64 D9 86 61 54	26 28 29 11 13 10 5 3 1 0 9 ele: H20 1 3	141 174 133 96 115 60 60 59 30 12 5-VA H15 24 24	322 410 308 243 271 192 163 190 152 61 Host H12 70 62 44	756 666 766 521 521 500 394 480 396 238 238 149 274 205	40 7 16 20 9 73 54 162 11 4 18 M 15 49 20
1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 Stati 1986 1987 1988 1989	2 1 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	15 11 12 6 9 1 5 2 0 Sant D15 58 30 80 40	44 33 35 38 28 23 12 23 15 7 23 15 7 23 23 15 7 5 80 115 75	100 73 79 85 72 65 44 66 58 29 122 134 144 121	3 2 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	26 22 19 20 11 14 11 11 2 0 H15 189 70 283 150	103 82 94 95 73 60 21 51 28 13 Fil H12 397 264 536 321	366 255 290 301 245 217 123 220 149 84 re Stat H9 709 645 635	26 24 13 17 43 15 5 2 13 M 8 20 23 10	1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 Stati 1986 1987 1988 1989	15 16 15 7 10 7 5 2 1 0  D20 1 2 0	61 71 51 45 47 29 27 34 17 8 West D15 11 8 9 4	97 120 86 77 80 68 52 70 59 23 23 20 20 20 15	135 150 123 121 122 95 107 99 64 D9 86 61 54 69	26 28 29 11 13 10 5 3 1 0 9 ele H20 1 3 4 0	141 174 133 96 115 60 60 59 30 12 3-VA H15 24 24 17 7	322 410 308 243 271 192 163 190 152 61 Host H12 70 62 44 32	756 666 766 521 521 500 394 480 396 238 9 238 9 238 199 274 205 172 218	40 7 16 20 9 73 54 162 11 4 18 15 49 20 20
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1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 Stati 1986 1987 1988 1989 1989	2 1 1 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	15 11 12 6 9 1 5 2 0 Sant D15 58 30 80 40 34 46	44 33 35 28 23 12 23 15 7 23 15 7 24 23 15 7 5 80 115 53 84	100 73 79 85 72 65 44 66 58 29 122 134 144 121 111 121	3 2 1 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	26 22 19 20 11 14 11 20 11 14 11 20 70 283 150 100 151	103 82 94 95 73 60 21 51 28 13 412 397 264 536 321 242 328	366 255 290 301 245 217 123 220 149 84 re Stat H9 709 646 851 635 539 656	26 24 13 17 43 15 6 5 2 13 M 8 20 23 10 50 6	1987 1988 1989 1990 1991 1993 1994 1995 1996 Stat: 1986 1987 1988 1989 1990	15 16 15 7 10 7 5 2 1 0 0 5 2 1 0 0 1 2 20 0 0 0 0 0	61 71 51 45 47 29 27 34 17 8 West D15 11 8 9 4 2 4	97 120 86 77 80 68 52 70 59 23 Los 20 20 20 15 11	1355 1500 1233 1211 1122 955 107 999 64 54 61 54 61 54 69 399 46	26 28 29 11 13 10 5 3 1 0 7 ele: H20 1 3 4 0 0 0 0	141 174 133 96 115 60 60 59 30 12 5-VA H15 24 24 17 7 3 7	322 410 308 243 271 192 163 190 152 61 Host H12 70 62 44 32 22 25	756 666 766 521 521 500 394 480 238 396 238 139 274 205 172 218 96 139	40 7 16 20 9 73 54 162 11 4 18 15 49 20 10 123 4
1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1986 1987 1988 1989 1989 1990	2 1 1 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	15 11 12 6 9 1 5 2 0 Sant D15 58 30 80 40 34 46 39	44 33 35 28 23 12 23 15 7 7 23 23 15 7 7 5 8 9 8 0 115 5 6 3 84 86	100 73 79 85 72 65 44 66 58 29 22 134 144 121 111 121	3 2 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	26 22 19 20 11 14 11 11 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	103 82 94 95 73 60 21 51 8 13 Fil H12 397 264 536 3242 328 306	366 255 290 301 245 217 123 220 149 84 re Stat H9 709 646 851 635 539 656 638	26 24 13 17 43 15 6 5 2 13 M 8 20 23 10 50 6 16	1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 Stat: 1986 1987 1988 1989 1990 1991	15 16 15 7 10 7 5 2 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	61 711 51 45 47 29 27 34 17 8 Wess D155 11 8 8 9 9 4 2 4 1	97 120 86 77 80 68 52 70 23 23 20 20 20 20 20 20 11 10 13	1355 1500 1233 1211 1122 955 107 999 64 3 Ann D9 861 61 54 69 399 466 47	26 28 29 11 13 10 5 3 1 0 H20 1 3 4 0 0 0 0 0 0	141 174 133 96 115 60 60 59 30 12 5-VA H155 24 24 17 7 7 3 7 7	322 410 308 243 271 192 163 190 152 61 Host H12 70 62 44 32 225 19	756 666 608 521 500 394 480 238 ittal 192 274 205 172 218 86 139 135	40 7 16 20 9 73 54 162 11 49 18 8 49 20 10 123 49 20 10
1987 1988 1989 1990 1992 1993 1994 1995 1996 Stati 1986 1987 1988 1989 1989 1990 1991	2 1 1 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	15 11 12 6 9 1 5 2 0 Sant 5 5 8 30 80 40 34 40 34 40 32	44 33 35 38 28 23 12 23 15 7 7 7 89 80 115 75 63 4 86 53	100 73 79 85 72 65 44 66 58 29 122 134 144 121 121 125 97	3 2 2 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	26 22 19 20 11 14 11 12 0 0 20 31 50 20 31 50 20 31 50 20 31 50 20 31 50 20 31 50 20 31 50 20 20 20 20 20 20 20 20 20 20 20 20 20	103 82 94 95 73 60 21 51 28 31 33 7 51 51 33 7 51 264 53 66 321 242 328 326 207	366 255 290 301 245 217 123 220 149 84 54 646 851 635 539 656 638 466	26 24 13 17 43 15 65 2 13 M 8 20 23 10 50 6 16 0	1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 Stati 1986 1987 1988 1989 1990 1991 1992 1993	15 16 15 7 10 7 5 2 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	61 71 51 45 47 29 27 34 17 8 Wess D155 11 8 9 9 4 4 2 2 4 1 1	97 120 86 77 80 68 52 70 59 23 20 20 20 20 20 20 15 11 10 13 7	135 150 123 121 122 95 107 99 64 86 61 54 69 39 46 47 24	26 28 29 11 13 10 5 3 1 0 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 10 1 3 3 1 0 0 9 9 9 11 13 10 0 5 5 3 1 0 0 9 9 9 9 9 11 13 10 0 5 5 9 9 9 9 9 9 9 11 13 10 0 5 5 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 11 13 10 0 5 5 9 9 9 9 9 9 9 11 10 5 5 9 9 9 9 9 9 9 9 9 11 10 5 5 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9	141 174 133 96 60 59 30 12 5-VA H155 24 24 17 7 7 7 7 7 7 1 2	322 410 308 243 271 192 163 190 152 61 H057 H12 62 44 32 225 19 14	756 6666 608 521 521 500 394 480 396 238 480 396 238 480 396 238 480 396 238 480 396 238 480 396 238 480 396 238 49 274 205 274 275 21 397 475 21 396 476 238 396 397 476 396 396 476 396 397 476 396 397 476 396 397 476 396 397 476 396 397 476 396 396 396 396 396 396 396 396 396 39	40 7 16 20 9 73 54 162 11 4 18 18 15 499 20 10 123 4 4 9 20 10 123 4 14
1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 Stati 1986 1987 1988 1989 1990 1991 1992 1993 1994	2 11 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	15 11 12 6 9 1 1 2 2 0 Sant 5 5 8 0 80 40 34 46 39 21 24	44 33 35 38 28 23 12 23 15 7 7 5 80 80 115 75 63 84 86 53 80	100 73 79 85 72 65 72 65 72 65 72 65 72 65 72 85 72 122 1122 1122 1122 1122 1121 1121 1	3 2 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	26 22 19 20 11 14 11 12 20 0 50 11 14 11 20 20 20 11 14 11 20 0 50 11 11 12 20 0 50 11 11 14 11 12 20 20 20 20 20 20 20 20 20 20 20 20 20	103 82 94 95 73 60 21 21 28 13 75 1 28 13 7 7 12 8 397 264 536 321 242 328 328 322 207 270	366 255 290 301 245 217 123 220 149 84 709 646 635 539 656 635 539 656 635 539	26 24 13 17 43 15 6 5 2 13 M 8 20 23 10 50 6 16 0 0	1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 Stati 1986 1987 1988 1989 1990 1991 1992 1993 1994	15 16 15 7 10 7 7 5 2 1 0 0 1 D200 1 1 2 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0	61 71 51 45 47 29 27 34 17 8 Wess D155 11 8 9 4 4 2 4 4 1 1 2	97 120 86 77 80 68 52 70 59 23 20 20 20 20 20 20 20 15 11 10 13 7 7 4	1355 1500 1233 1211 112 122 955 107 99 64 307 64 54 69 39 86 61 54 69 39 46 47 24 25	26 28 29 11 13 10 5 5 3 1 0 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9	141 174 133 96 60 59 30 12 5-VA H155 24 24 17 7 7 1 2 3 3 3 7 1 1 2 3 3	322 410 308 243 271 192 163 152 61 Hosp H122 61 Hosp H12 25 19 14 32 25 19	756 666 766 608 521 500 394 480 396 238 480 396 238 480 396 274 205 218 96 139 135 531 172 218 96 139 135 531 172 218 96 66 60 80 80 80 80 80 80 80 80 80 80 80 80 80	40 7 16 20 54 162 11 4 18 15 49 200 10 123 49 10 123 49 210 123 14 49 210 123 14 49 210
1987 1988 1989 1990 1992 1993 1994 1995 1996 Stati 1986 1987 1988 1989 1989 1990 1991	2 1 1 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	15 11 12 6 9 1 1 2 2 0 Sant 5 5 8 0 80 40 34 46 39 21 24	44 33 35 38 28 23 12 23 15 7 7 7 89 80 115 75 63 84 86 53	100 73 79 85 72 65 44 66 58 29 122 134 144 121 121 125 97	3 2 2 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	26 22 19 20 11 14 11 12 20 0 50 11 14 11 20 20 20 11 14 11 20 0 50 11 11 12 20 0 50 11 11 14 11 12 20 20 20 20 20 20 20 20 20 20 20 20 20	103 82 94 95 73 60 21 51 28 31 33 7 51 51 33 7 51 264 53 66 321 242 328 326 207	366 255 290 301 245 217 123 220 149 84 54 646 851 635 539 656 638 466	26 24 13 17 43 15 65 2 13 M 8 20 23 10 50 6 16 0	1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 Stati 1986 1987 1988 1989 1990 1991 1992 1993	15 16 15 7 10 7 5 2 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	61 71 51 45 47 29 27 34 17 8 Wess D155 11 8 9 4 4 2 4 4 1 1 2	97 120 86 77 80 68 52 70 59 23 20 20 20 20 20 20 15 11 10 13 7	135 150 123 121 122 95 107 99 64 86 61 54 69 39 46 47 24	26 28 29 11 13 10 5 3 1 0 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 10 1 3 3 1 0 0 9 9 9 11 13 10 0 5 5 3 1 0 0 9 9 9 9 9 11 13 10 0 5 5 9 9 9 9 9 9 9 11 13 10 0 5 5 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 11 13 10 0 5 5 9 9 9 9 9 9 9 11 10 5 5 9 9 9 9 9 9 9 9 9 11 10 5 5 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9	141 174 133 96 60 59 30 12 5-VA H155 24 24 17 7 7 7 7 7 7 1 2	322 410 308 243 271 192 163 190 152 61 H05F H12 70 62 44 432 225 19 14 10 7	756 6666 608 521 521 500 394 480 396 238 480 396 238 480 396 238 480 396 238 480 396 238 480 396 238 480 396 135 172 218 969 135 73	40 7 16 20 73 54 162 11 4 18 15 49 200 10 123 49 200 10 123 49 208

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Stati	.on:	Haw	thori	ne						Stat	ion:	Sant	ta C	lari	ta-H	onby				
	D20	D15	D12	D9	н20	H15	H12	н9	м			D15			H20		H12	Н9	м	
1986	0	0	4	20	0	0	5	36	48	1986	0	Ó	0	0	0	0	0		1840	
1987	1	2	4	14	1	\$	16	42	28	1987	Ó	0	0	Ó	Ó	0	Ó		1840	
1988	1	1	3	8	2	4	8	24	22	1988	Ō	Ó	Ō	Ō	Ō	0	Ō		1840	
1989	0	0	3	15	0	0	3	27	13	1989	10	38	71	113	22	130	290	627	49	
1990	0	0	0	6	0	0	0	9	7	1990	Ó	Ó	Ō	0	0	0	Ō		1840	
1991	0	0	0	25	0	0	Ó	63	11	1991	Ō	Ō	Ó	Ó	Ó	Ó	ō	Ó	1840	
1992	Ō	Ó	2	10	Ó	Ó	2	29	17	1992	Ō	Ō	ō	ō	ō	ō	Ō		1840	
1993	0	0	2	11	Ó	Ó	2	29	5	1993	ŏ	ŏ	Ó	Ō	ō	ō	ō	Ó	1840	
1994	Ō	Ō	Ō	7	Ō	Ō	ō	14	15	1994	ō	Ō	0	ō	ō	ō	ō		1840	
1995	0	0	1	7	Ó	0	3	15	6	1995	Ó	Ó	Ó	Ó	Ó	0	Ó	0	1840	
1996	Ō	0	2	9	0	Ō	2	21	48	1996	Ō	Ō	ō	ō	Ō	Ő	Ō	Ō	1840	
Stati	00.	Ava	lon-	Cres	Cent	Ave	0110			Stat:	ion·	Dia	mond	Bar		onle		ive		
		D15			H20		H12	Н9	м	JLAL.		D15			н20			н9	м	
1986	0	0	0	50			0		1840	1986	020	0	012	0	0	0			1840	
1987	ŏ	ŏ	ŏ	ŏ	ŏ	ŏ	ő		1840	1987	ő	ŏ	ő	ŏ	ŏ	ă	ŏ	ŏ	1840	
1988	ő	ő	ă	ŏ	ő	ő	ő		1840	1988	ő	ŏ	0	ő	ŏ	ŏ	ŏ	-	1840	
1989	ŏ	ő	ő	0	ŏ	0	0	-	1840	1989	ŏ	ő	ŏ	ő	ő	ŏ	ŏ	ŏ	1840	
1990	ō	a	ŏ	4	ő	0	ŏ	5	449	1990	ŏ	ů	ő	0	ŏ	ő	ŏ	•	1840	
1991	ő	č	ő	0	0	0 0	ŏ	-	1840	1991	ő	ŏ	ő	0	0	ő	ŏ	ő	1840	
1992	ő	ŏ	ő	ŏ	0	ŏ	ő	-	1840	1992	ő	ő	ő	Ő	ŏ	0	õ	ŏ	1840	
1993	0	0	0	ő	ő	ŏ	ő	-	1840	1993	0	0	0	0	ŏ	ő	0	-	1840	
1994	ŏ	ŏ	ŏ	ă	ŏ	ő	ő	-	1840	1994	2	9	38	98	6	21	116	364	1040	
1995	ă	0	ŏ	ŏ	ő	ő	ŏ	ŏ		1995	0	4	36	79	ő		89	296	7	
1995	0	0	0	ŏ	0	0	0	•	1840	1995	0	0	30	0	ŏ	Ő	0		1840	
1990	0	v	Ū	0	0	Ų	0	U	1040	1996	ų	Ŭ	0	U	U	v	U	v	1040	
Stati										Stat:								Canyo		
		D15				H15		Н9	м			D15			H20			H9		
1986								1055	38	1986	9	36		107		110		696	547	
1987	50					353		957	25	1967	0	0	0	0	0	0	0	0	1840	
1988	53	107	136	163	114	356	617	952	41	1988	0	0	0	0	0	0	0	0	1840	
1989	35	80	115		81	269	493	830	35	1989	1	10	42	88	3	22	102	348	73	
1990	29	72	99	131	50	202	398	677	17	1990	1	12	42	77	1	23	113	299	227	
1991	34	67	102	134	59	202	377	674	10	1991	0	9	23	78	0	21	67	270	83	
1992	27	70	113	141	53	206	430	757	27	1992	Ō	Ō	0	Ō	Ó	0	0	0	1840	
1993	19	61				175		713	- 6	1993	ō	ō	ō	ō	Ō	ō	õ	ŏ	1840	
1994	10	-	100			142		679	ŏ	1994	ŏ	ŏ	ŏ	ō	ō	-			1840	
1995	9	47		126		116		607	3	1995	ŏ	ŏ	ŏ	ă	ŏ	ō	-		1840	
1996	2	20	51	97	3		169	405	2	1996	ő	ŏ	õ	ŏ	ő	ŏ	ŏ		1840	
	-				5	-1	203	705	4	1000			•	Ű		v	v	v		

(751) in 1995. This suggests an important change in 1995 may have occurred in the chemical composition of the air transported to Crestline from the Basin.

For comparison, Figure 6-8 shows the 20-year trend in stage 1 episodes in the SoCAB. When using this metric a steady decrease in unhealthful ozone levels can be easily observed over this period.

## 6.3.2 Frequency of Occurrence of Ozone Exceedances

The percent change (from year-to-year) in number of smog season hours equal or exceeding the ozone NAAQS was computed for three groups of four sites each within the SoCAB for the period 1986-96 (Figures 6-9, 6-10, and 6-11). Only sites located in the central or eastern part of the Basin were used in this analysis, since year-to-year variation in the small number of ozone NAAQS exceedances which occur in less polluted areas (e.g., Coastal subregion) is likely to be strongly influenced by anomalous meteorological conditions, whereas the variation at the more polluted sites farther inland is likely to be dominated by the effects of non-meteorological factors such as reductions in emissions. Pasadena data are not available for this analysis during the 1992-94 period due to low data completeness.

At each of the 12 sites, the percent change was generally, from one year to the next, less than 50% (the large 1993-94 value at Central Los Angeles reflects the small total number of exceedances during those years, and thus does not actually represent a large increase in the number of exceedances). For the San Gabriel Valley sites in Figure 6-10, the largest year-to-year percent change occurred between the 1995 and 1996 smog seasons. Less dramatic decreases were found at both the sites located farther inland (Figure 6-11), and those closer to the coast (Figure 6-9). The introduction of RFG with lower mass emissions of VOC and lower VOC reactivity throughout the Basin may be largely responsible for the significant reduction in ozone in the San Gabriel Valley (Figure 6-10).

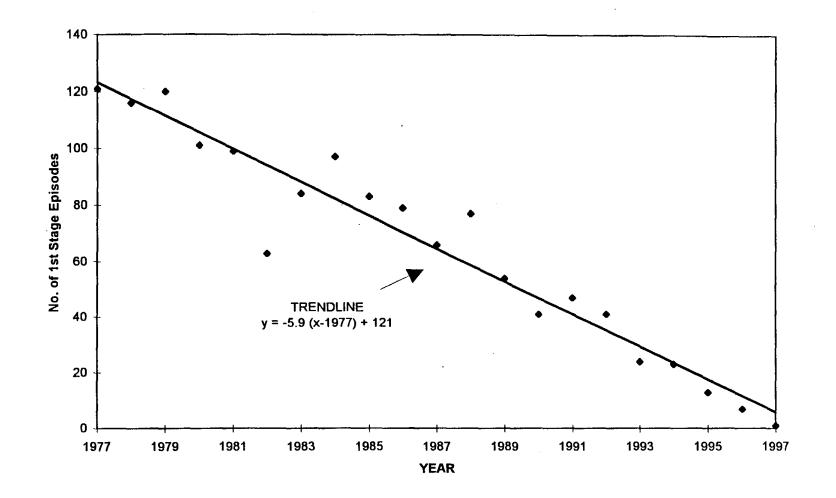


Figure 6-8. SoCAB Smog Season Stage 1 Episodes: 1977-97.

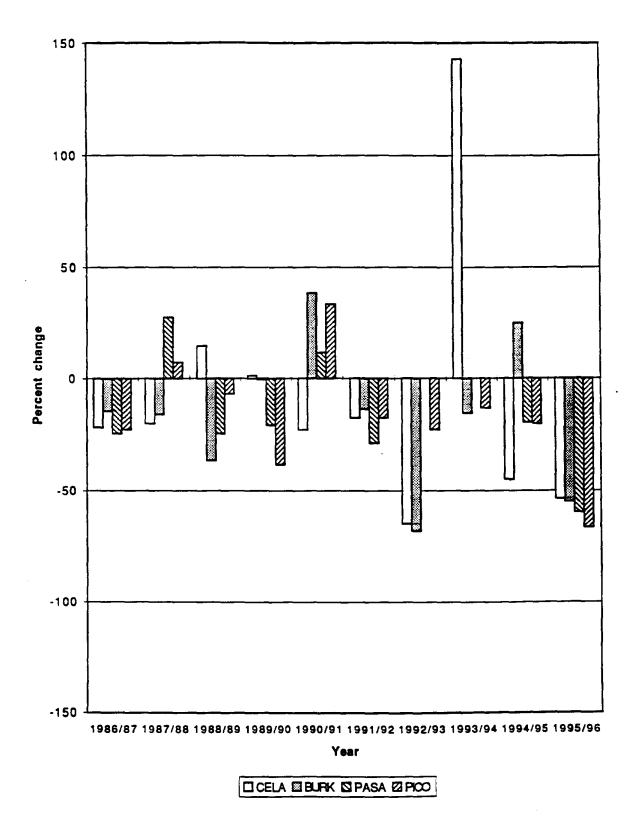


Figure 6-9. Percent change from previous smog season in number of smog season hours equal to or exceeding the ozone NAAQS.

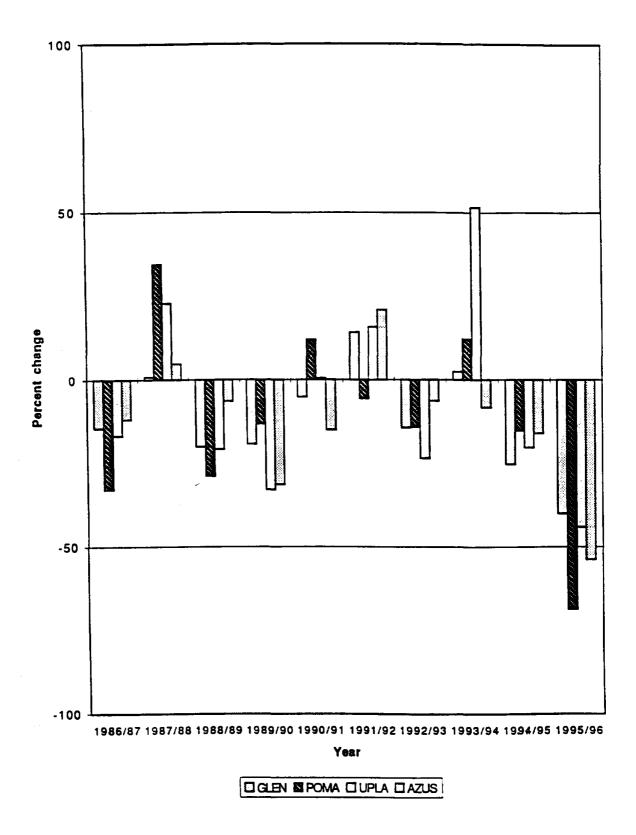


Figure 6-10. Percent change from previous smog season in number of smog season hours equal to or exceeding the ozone NAAQS.

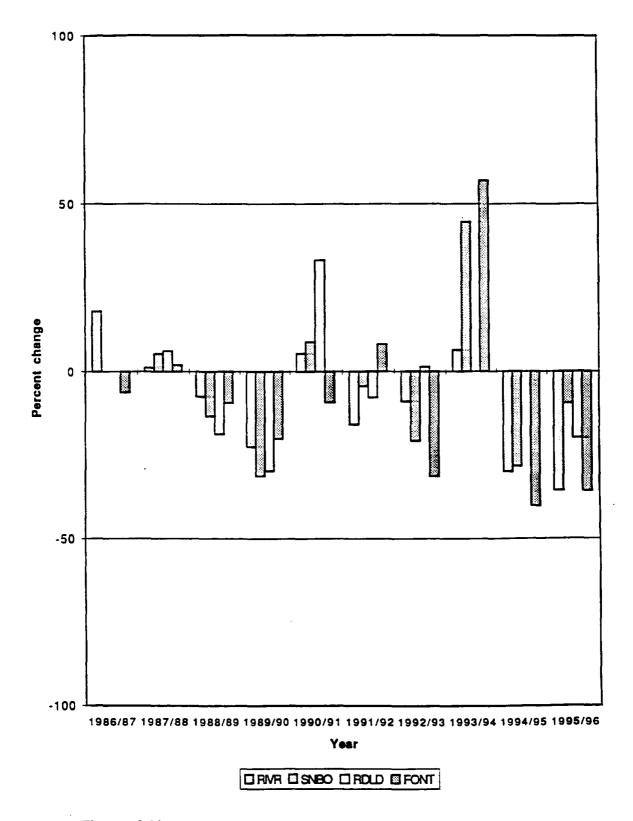


Figure 6-11. Percent change from previous smog season in number of smog season hours equal to or exceeding the ozone NAAQS.

#### 6.4 Recent Air Quality Changes

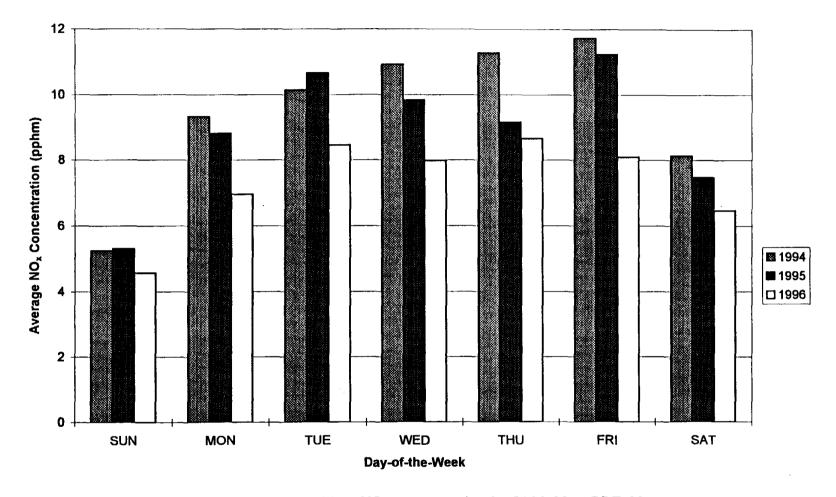
#### 6.4.1 1994-96 Smog Season Ambient Air Quality

Figures 6-12 and 6-13 show the average changes in ambient NO<sub>x</sub> and NO<sub>2</sub> ambient concentrations over the 1994-96 smog seasons during the morning commute period (0600-0900 PDT). There was a substantial decrease in both NO<sub>x</sub> and NO<sub>2</sub> in 1996 vs. 1994-95 for all days of the week, with weekend days having lower average ambient NO<sub>x</sub> and NO<sub>2</sub> concentrations than weekdays. Also, Figure 6-13 shows that Saturday morning NO<sub>2</sub> concentrations were comparable to Monday morning NO<sub>2</sub> concentrations for the 1994-96 period. Figure 6-14 shows the variation by day-of-the-week in NO<sub>2</sub>/NO<sub>x</sub> ratios during the morning (0600-0900 PDT) hours for the 1994-96 period. These weekend/weekday differences in NO<sub>2</sub>/NO<sub>x</sub> ratio were not seen for either 1800-2100 PDT or 2100-0000 PDT, the two evening time intervals evaluated (Figure 6-15).

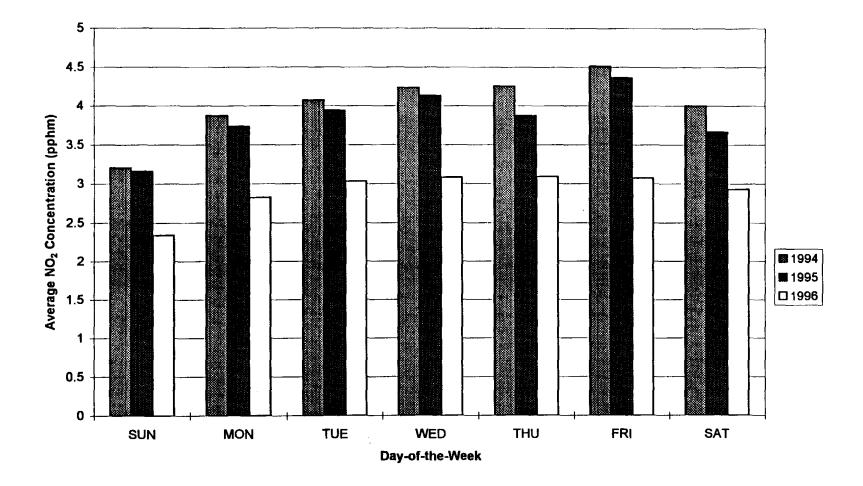
#### 6.4.2 1995-96 Smog Season Meteorological Conditions vs. Climatology

The monthly-mean daily-maximum and daily-minimum temperatures were determined for the 1995-1996 smog season months of May through October for four sites (Figures 6-16 to 6-19): Los Angeles International Airport (LAX), Los Angeles Civic Center (LACC), San Gabriel Fire Department (SGFD), and San Bernardino County Hospital (SBCH). Also shown for these sites is the corresponding 1961-90 climatological average values. At LAX (Figure 6-16), the 1995 smog season was slightly cooler than the 1961-90 mean, while 1996 was slightly warmer than the long-term average (especially during May and August). At LACC, SGFD, and SBCH, the 1995 smog season was either near or above normal, except during the months of May and June which were cooler than normal; the 1996 smog season at these sites was clearly warmer than normal.

With the exception of May and June of 1995, the 1995-96 smog seasons appear to have recorded near or above normal surface temperatures in the central and eastern



**Figure 6-12.** Basinwide average ambient NO<sub>x</sub> concentration for 0600-0900 PDT, May-October, 1994-96.



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Figure 6-13. Basinwide average ambient  $NO_2$  concentration for 0600-0900 PDT, May-October, 1994-96.

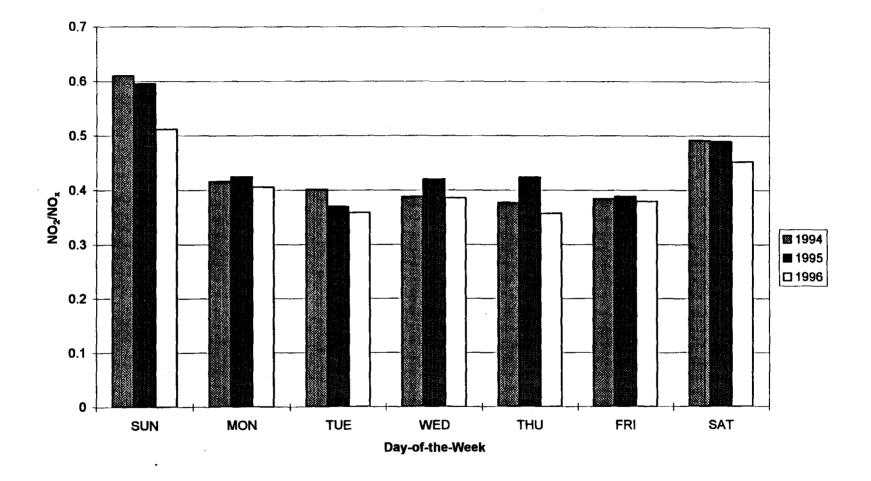
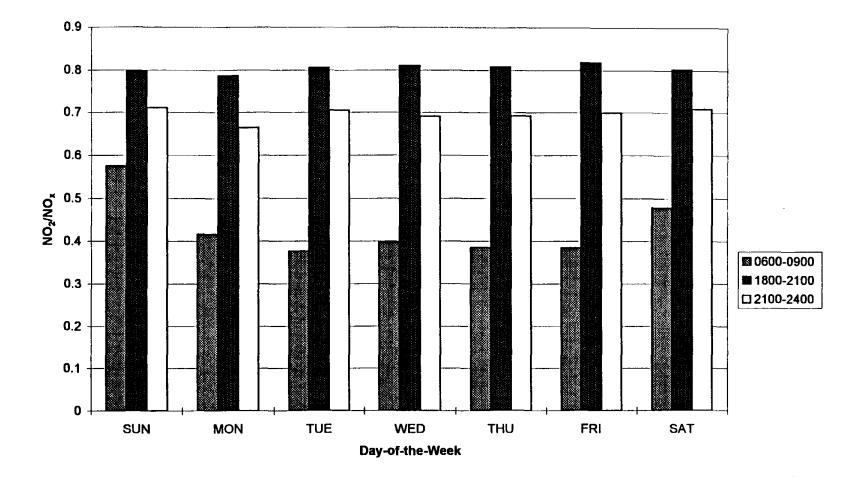


Figure 6-14. Basinwide average NO<sub>2</sub>/NO<sub>x</sub> ratio for 0600-0900 PDT, May-October, 1994-96.

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**Figure 6-15.** Basinwide average  $NO_2/NO_x$  ratio for May-October, 1994-96, for three time periods.

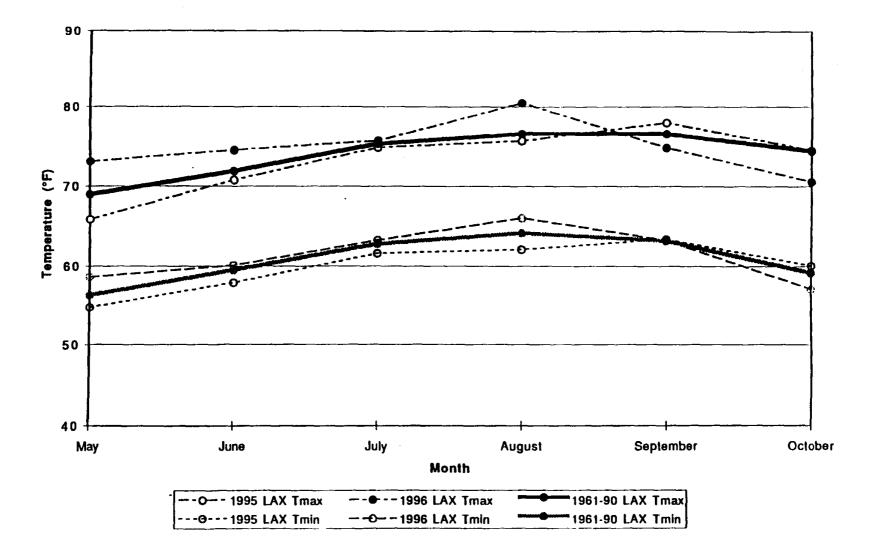


Figure 6-16. LAX mean monthly daily-maximum and daily-minimum temperature.

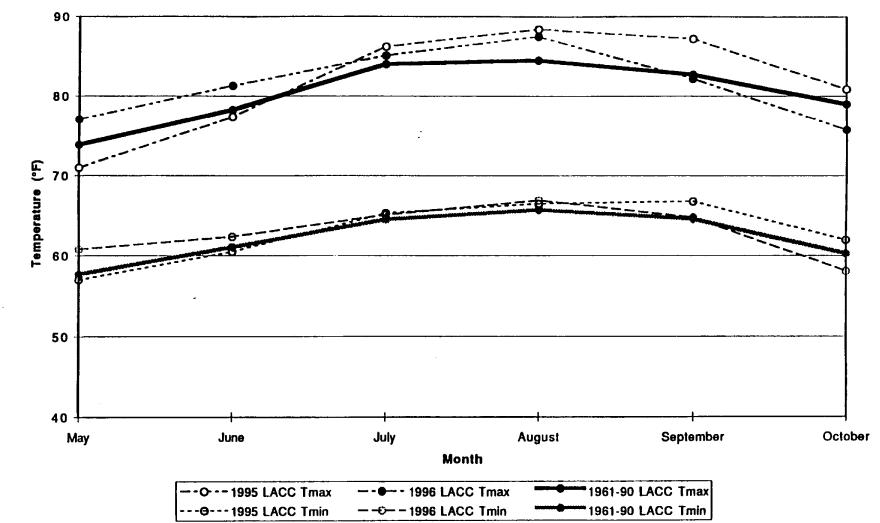


Figure 6-17. Los Angeles Civic Center mean monthly daily-maximum and dailyminimum temperature.

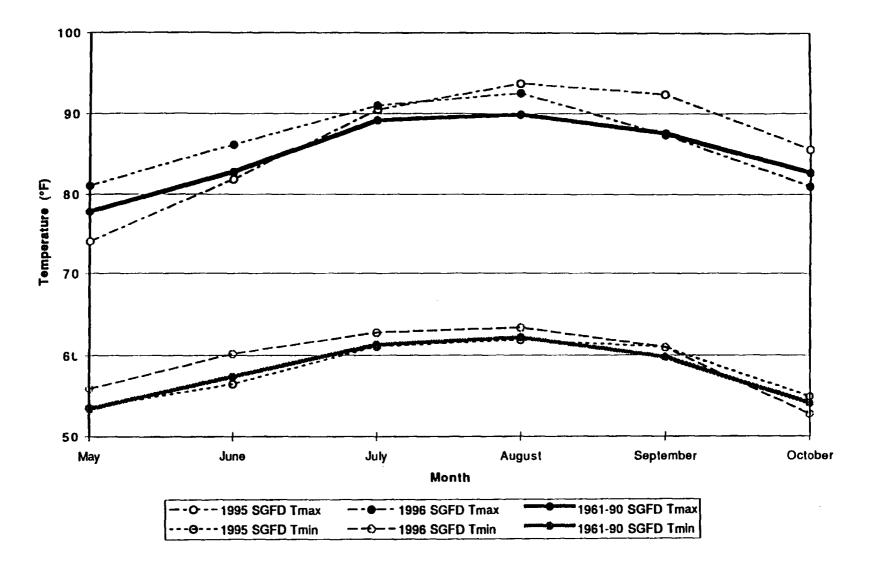


Figure 6-18. San Gabriel Fire Department mean monthly daily-maximum and dailyminimum temperature.

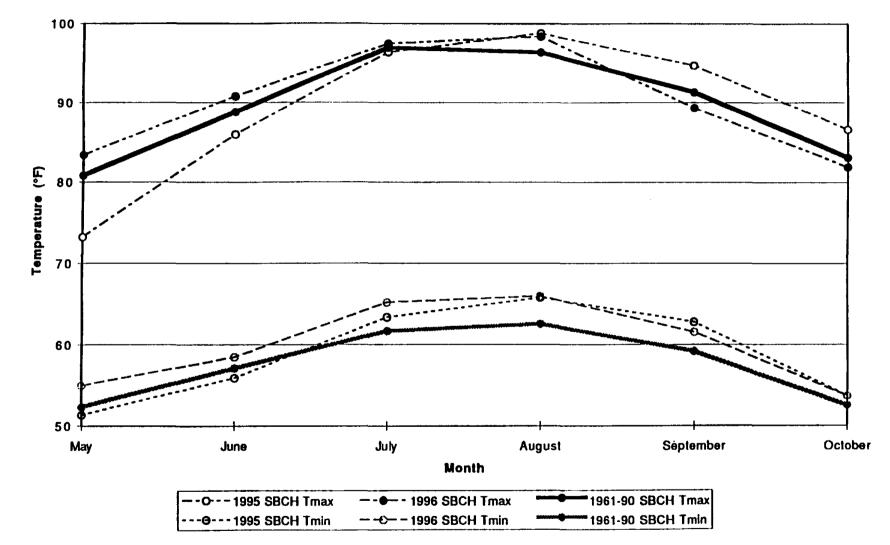


Figure 6-19. San Bernardino County Hospital mean monthly daily-maximum and daily-minimum temperature.

portions of the SoCAB. These conditions would seem to favor normal to above normal photochemical smog production rates [warmer SoCAB surface temperatures are associated with higher ozone concentrations (Blier and Winer 1996)]. This conclusion also follows from analysis of gridded 850 mb temperatures at a grid point near the SoCAB (see Figure 6-20) which showed near or above normal temperatures for the 1995-96 smog seasons (except during May-June 1995 and September-October 1996, which were cooler than the 1985-96 mean climatological values). Since a substantial *decrease* in the number of ozone exceedances was reported in the San Gabriel Valley (SGV) from 1995 to 1996 (see Table 6-1), and since this decrease was not likely due to meteorological variability, there appears to be evidence of a significant reduction in SGV ozone during the 1995-96 smog seasons resulting from non-meteorological factors.

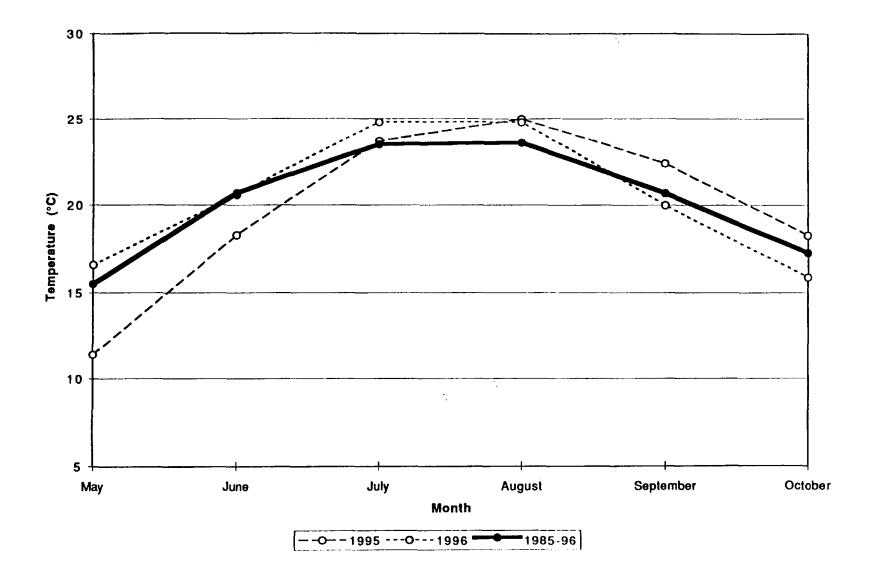


Figure 6-20. Mean 850 mb temperature (averaged over 0500 and 1700 PDT) at 33.21 °N, 116.98 °W.

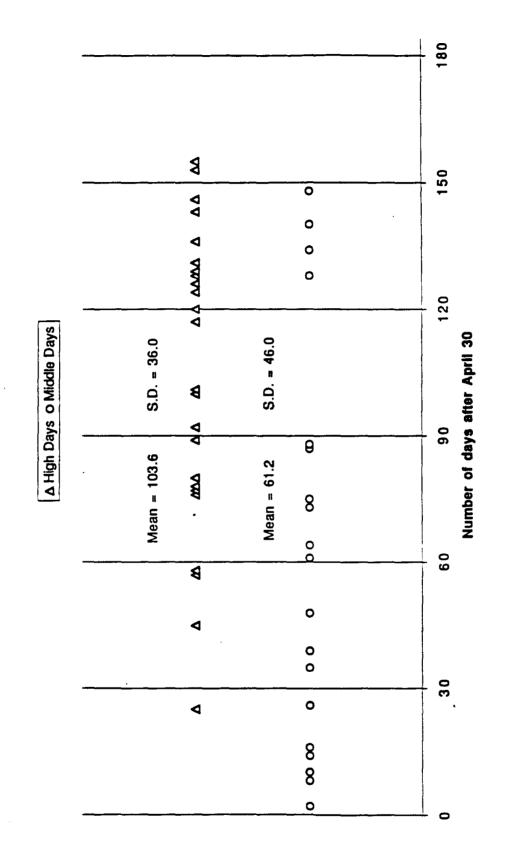
## 7.0 EXPLORATORY STUDIES

### 7.1 Analyses of Distribution of High and Middle Ozone Days: 1986-96

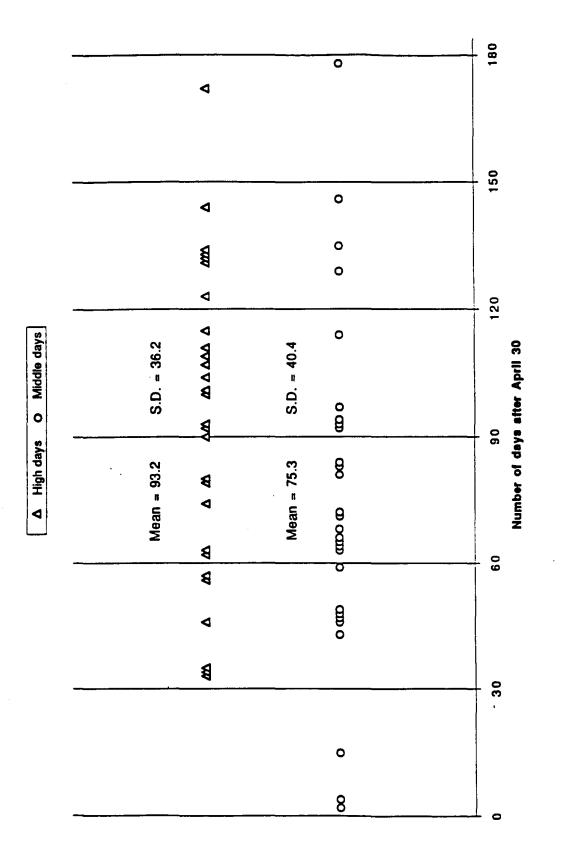
In the first phase of the project, a methodology was developed to determine a set of high ozone days and a set of middle ozone days for the 1990-93 smog seasons (Blier and Winer 1996). This same general approach has now been used to define high and middle ozone days for the 1986-89 smog seasons, as well as for 1994-96. The dailymaximum hourly-average ozone concentrations on the high ozone days ranged from 28 to 35 pphm for 1986-89, from 25 to 33 pphm for 1990-93, and from 22 to 30 pphm for 1994-96. For the middle ozone days, daily-maximum hourly-average ozone concentrations were 17 pphm for 1986-89, 15 pphm for 1990-93, and 13 pphm for 1994-96.

For each of these three periods, the distribution of the high and middle ozone days through the smog season is shown (see Figures 7-1 through 7-3). Unsurprisingly, the high ozone days tended to occur mostly during the middle four months of the smog season, while the middle ozone days were generally more broadly distributed. Additionally, there appears to be a trend towards decreasing incidence of high ozone days in September and October, though further examination of the comparability of the meteorological conditions is needed. This discussion should be expanded to explain the further broad downward trend for ozone concentrations since 1995-96 and 97 (4-6 & 4-7), a noticeable shift to early season (May) peaks, and a general shift in ozone season from May through October to June through August.

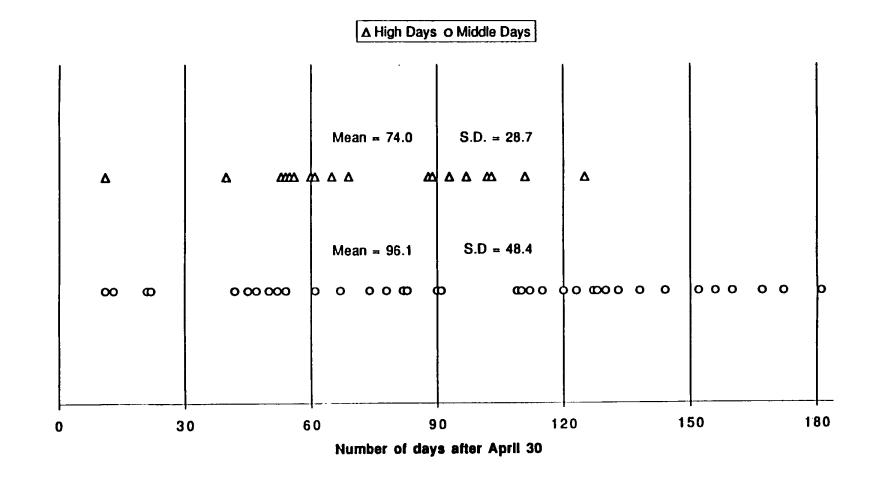
The distribution by day-of-the-week of the high ozone days of 1986-89, 1990-93, and 1994-96 is shown in Table 7-1. Although previous research suggests that Saturdays tend to have higher ozone concentrations (Blier and Winer 1996), the results for the individual periods do not reveal a clear day-of-the-week pattern, perhaps because the number of days in the analysis is too small. To see if a day-of-the-week signal could be detected with a larger number of days in the calculation, the day-of-the-week distributions in Table 7-1 were summed for the high ozone days over all three periods of











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Figure 7-3. Distribution of 18 High and 36 Middle Ozone Days for 1994-96.

analysis (fourth column, Table 7-1). The summation showed a monotonic increase in number of occurrences of high ozone days by day-of-the-week, with a minimum number of occurrences on Sundays and a maximum on Saturdays. This appears consistent with our results from Phase I of this research.

Day	1986-89	1990-93	1994-96	1986-96
Monday	0	6	0	6
Tuesday	2	4	1	7
Wednesday	4	2	2	8
Thursday	2	3	7	12
Friday	8	4	2	14
Saturday	5	8	6	19
Sunday	3	1	0	4
Total	24	28	18	70

**Table 7-1.** Distribution by day of week for the high ozone days of 1986-89, 1990-93 and1994-96.

## 7.2 Analyses Using Gridded Meteorological Data

#### 7.2.1 Superposed Epoch Analysis of High Ozone Days

As an exploratory analysis, we chose to use the method of Superposed Epoch Analysis (Panofsky and Brier 1958) to examine the concurrent and antecedent synopticscale meteorological conditions associated with the occurrence of high ozone concentrations in the Basin. This method consists of the computation of the mean of some parameter P associated with a set of event of type E which are of interest to the researcher. The mean of P is computed for equidistant time intervals leading up to, and including the time of occurrence of E in order to examine the relationship between P and E. [Mass and Albright (1989) used this technique to analyze synoptic-scale conditions associated with California Catalina Eddy events].

Accordingly, the mean 500 mb synoptic-scale field was computed at 12-hr time intervals, beginning three time intervals prior to the occurrence of the 28 high ozone days

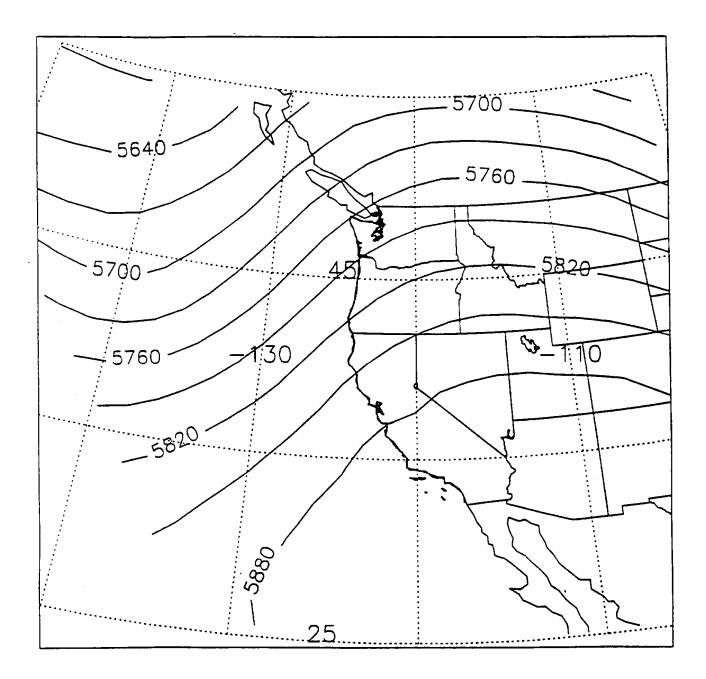


Figure 7-4. Mean 500 mb geopotential heights (gpm) at 05 PDT on 28 high ozone days (key day -1).

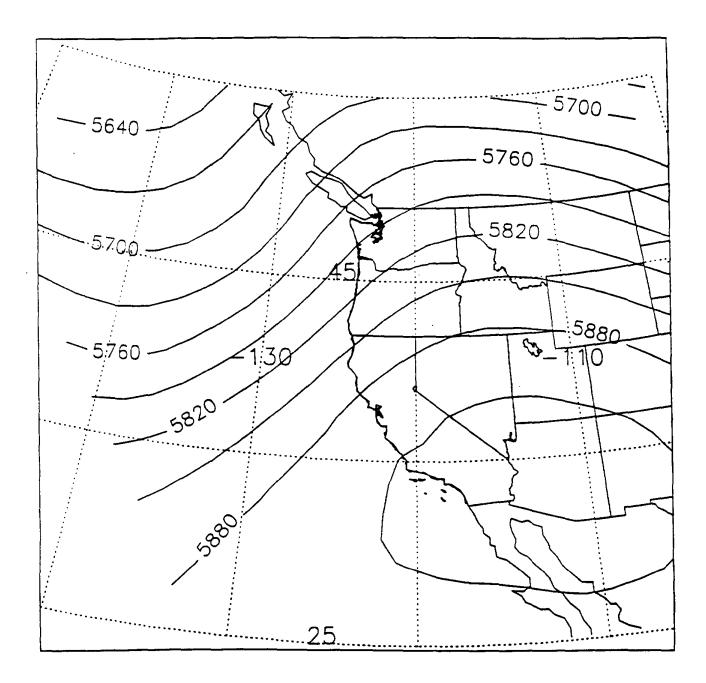


Figure 7-5. Mean 500 mb geopotential heights (gpm) at 17 PDT on 28 high ozone days (key day -1).

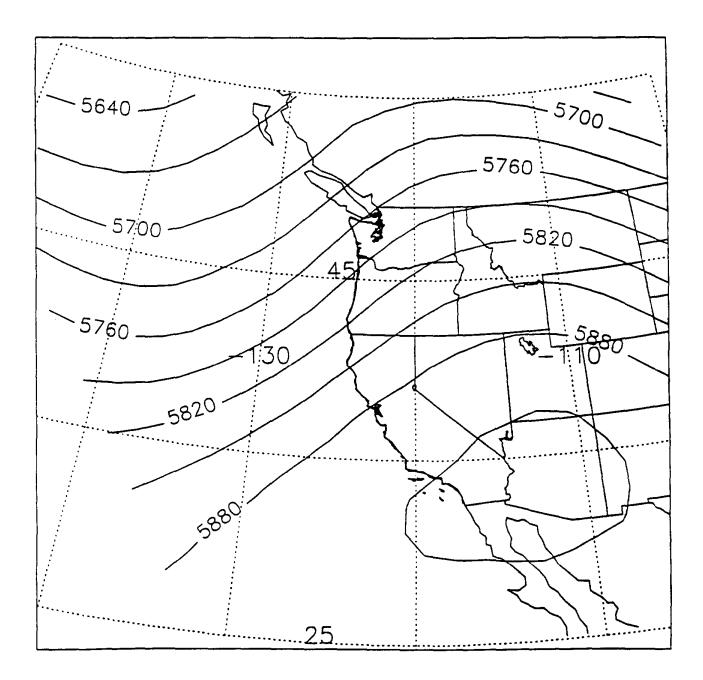


Figure 7-6. Mean 500 mb geopotential heights (gpm) at 05 PDT on 28 high ozone days (key day +0).

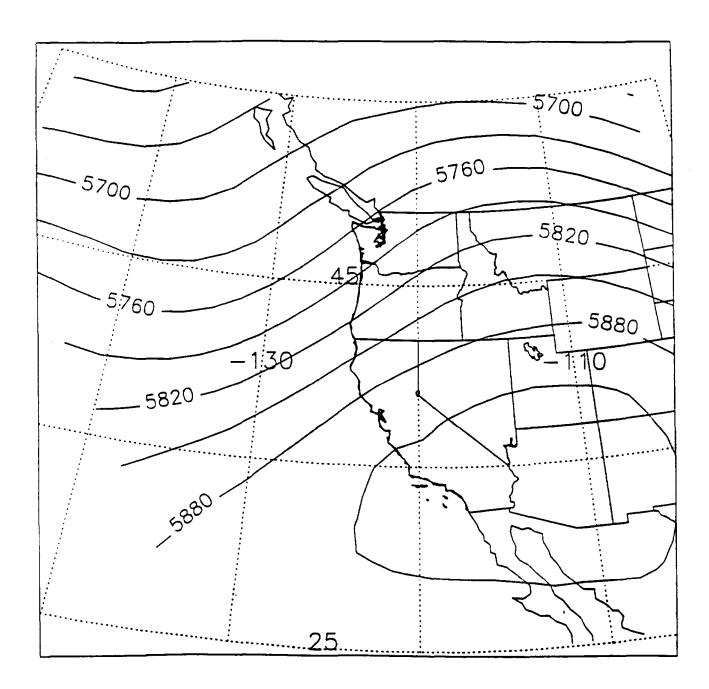


Figure 7-7. Mean 500 mb geopotential heights (gpm) at 17 PDT on 28 high ozone days (key day +0).

of 1990-93, and leading up to and including the time 1700 PDT on the afternoon of the occurrence of the high ozone days (Figures 7-4 to 7-7). The mean conditions associated with high ozone days in the SoCAB were clearly associated with a strong 500 mb ridge over the western portion of the United States, with relatively light southwest winds over the SoCAB at 500 mb, while a large trough was located over the eastern Pacific. Examination of the sequence of Figures (7-4 to 7-7) indicated that the West Coast ridge axis slowly moved eastward as the time of occurrence of high ozone in the SoCAB approached.

# 7.2.2 <u>Correlation between Gridded Constant Pressure Level Data and Daily SoCAB-</u> <u>Maximum Ozone</u>

The high correlation between 850 mb temperature and high SoCAB ozone has been known for many years (Davidson et al. 1985). To further investigate the relationship between SoCAB-maximum ozone concentrations and 850 mb temperature, we correlated the set of SoCAB-maximum ozone concentrations from the smog season days of 1994-96 with the corresponding objectively-analyzed 850 mb temperatures throughout the region occurring at 1700 PDT on the afternoon of the same day. These correlations were computed using the synoptic fields occurring at a succession of 12-hour time intervals leading up to the afternoon of occurrence of the Basin-maximum ozone concentrations (Figures 7-8 to 7-11). The region of maximum correlation coefficients was located over the SoCAB. As expected, the correlation increased as the time interval between the hour of observation of the 850 mb temperature and the occurrence of the SoCAB-maximum ozone concentration (approximately 1400-1600 PDT) decreased. The highest correlation coefficient of 0.82 occurred at 33.21 °N, 116.98 °W (Figure 7-11).

The time series of the daily SoCAB-maximum hourly-average ozone concentrations was also correlated with the corresponding time series (at each grid point) of 1700 PDT 850 mb temperatures for the 1986-89 smog seasons (Figure 7-12) and the 1990-93 smog seasons (Figure 7-13). As in the analysis for 1994-96 (Figure 7-11), both

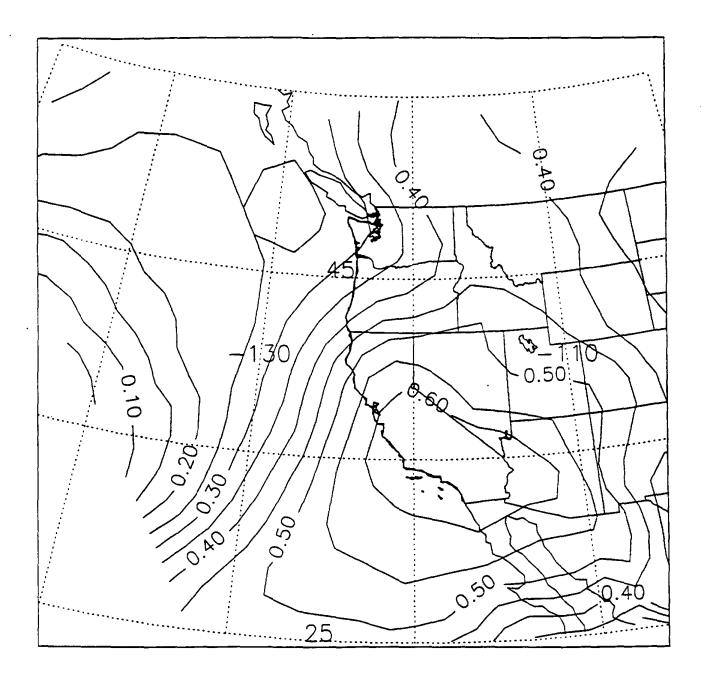


Figure 7-8. Correlation of 1994-96 smog season 05 PDT 850 mb temeprature (key day -1) vs. daily SoCAB-maximum hourly-average ozone.

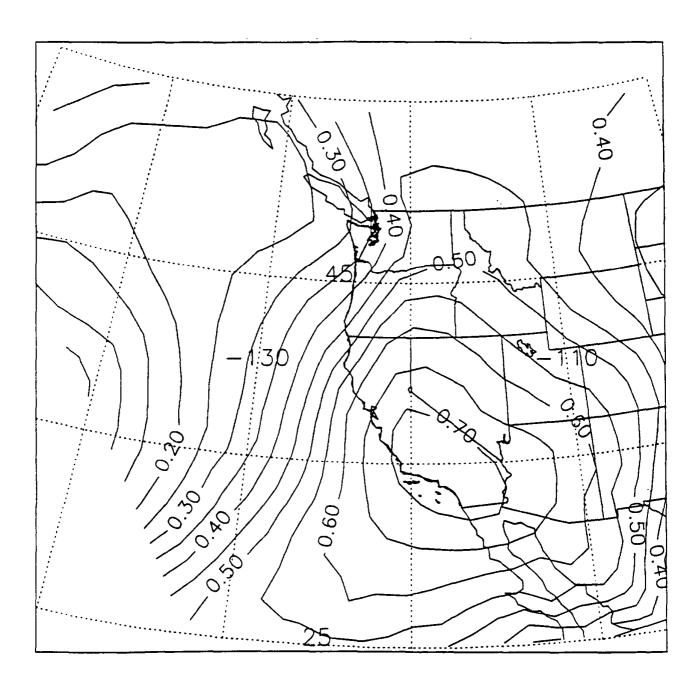


Figure 7-9. Correlation of 1994-96 smog season 17 PDT 850 mb temeprature (key day -1) vs. daily SoCAB-maximum hourly-average ozone.

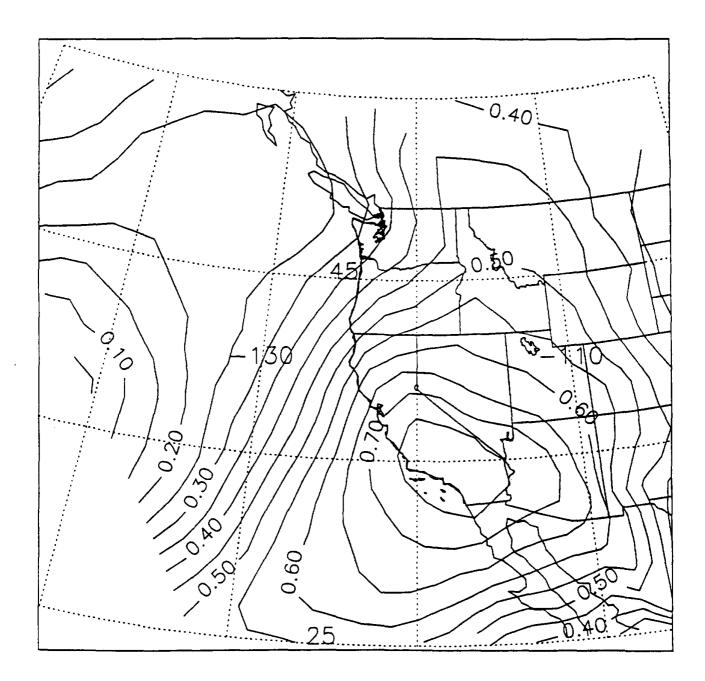


Figure 7-10. Correlation of 1994-96 smog season 05 PDT 850 mb temeprature (key day +0) vs. daily SoCAB-maximum hourly-average ozone.

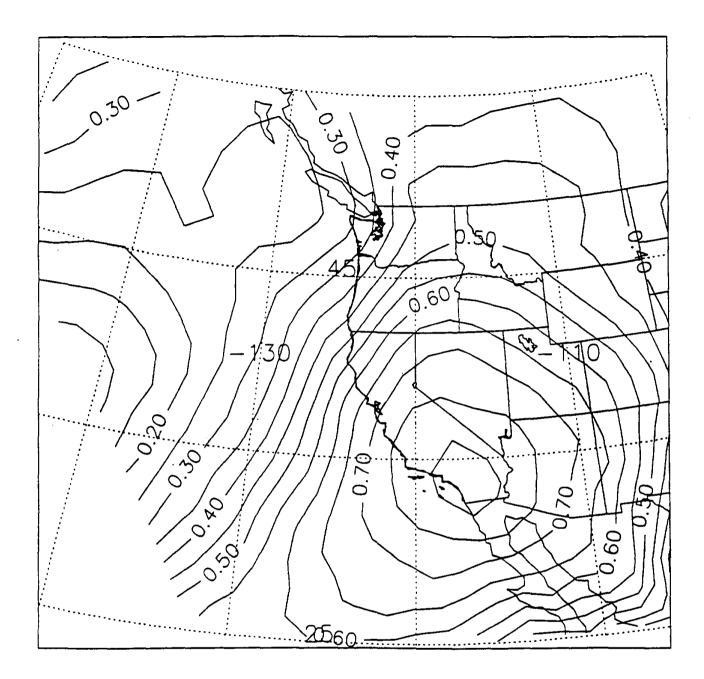


Figure 7-11. Correlation of 1994-96 smog season 17 PDT 850 mb temeprature (key day +0) vs. daily SoCAB-maximum hourly-average ozone.

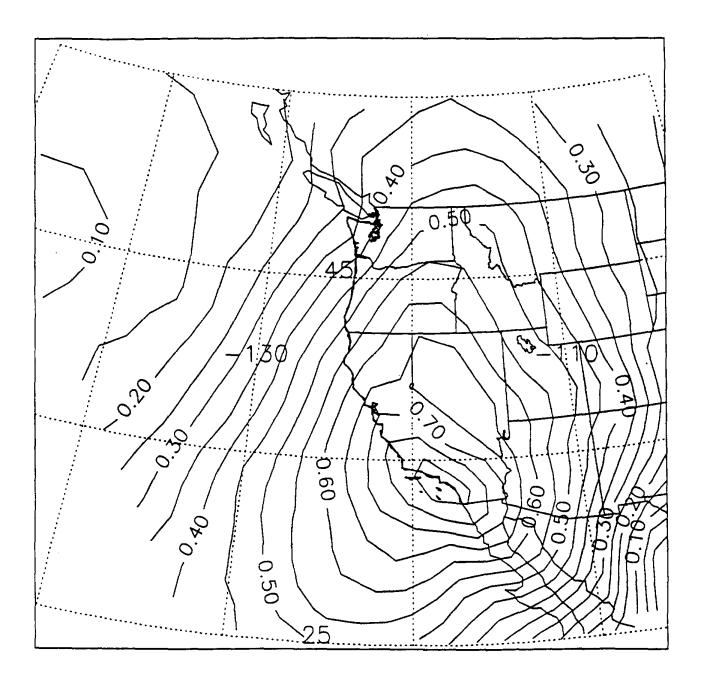


Figure 7-12. Correlation of 1986-89 smog season 17 PDT 850 mb temeprature (key day +0) vs. daily SoCAB-maximum hourly-average ozone.

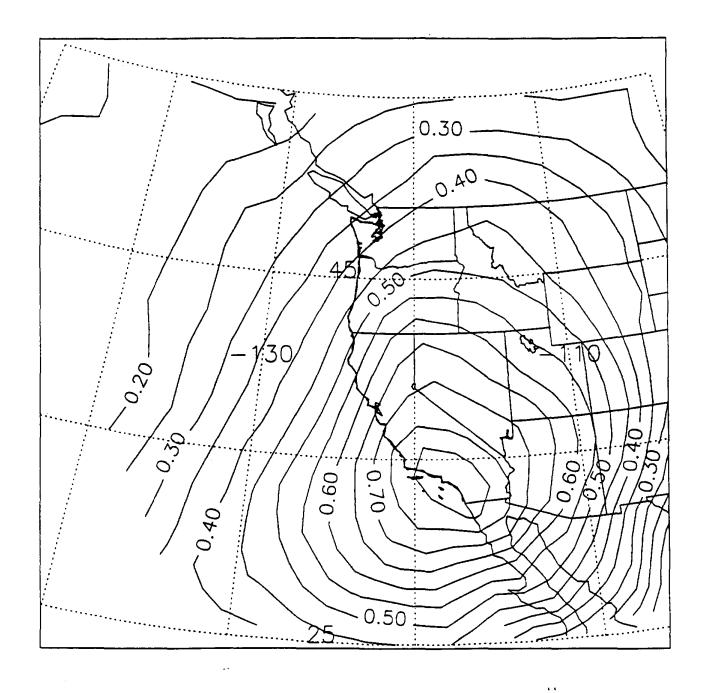


Figure 7-13. Correlation of 1990-93 smog season 17 PDT 850 mb temeprature (key day +0) vs. daily SoCAB-maximum hourly-average ozone.

of these analyses also showed highest correlation over the region of the SoCAB. The highest correlation coefficient for 1986-89 was 0.83 and occurred at 34.28 °N, 119.04 °W, while the highest correlation coefficient for 1990-93 was 0.84 and occurred at 33.21 °N, 116.98 °W (Figure 7-14).

#### 7.3 Evaluation of Industrial Emissions Data

To characterize differences in  $NO_x$  emissions by day-of-the-week for stationary sources, we examined data from approximately 80 RECLAIM sources in the SoCAB (out of approximately 200 sources regulated under RECLAIM) which reported daily  $NO_x$ emissions from May-September 1996. A summary of the results is given in Table 7-2.

Day	Average	Std. Dev.	
-	(tons/d)	(tons/d)	
Sunday .	126	122	
Monday	161	171	
Tuesday	146	166	
Wednesday	168	200	
Thursday	409	1058	
Friday	125	152	
Saturday	128	158	
Average	182	436	

**Table 7-2.** Summary of RECLAIM industrial emissions of  $NO_x$  for 82 sites from May-September 1996.

Because of the large variation in reported emissions, we excluded data for those particular days for which the standard deviation was greater than twice the mean emissions for each day of the study period. For example, Figure 7-15 shows total reported  $NO_x$  emissions for each Thursday from May-September 1996.

Table 7-3 shows both the calculated average  $NO_x$  emissions and corresponding standard deviations by day-of-the-week after screening of the data. Reported emissions

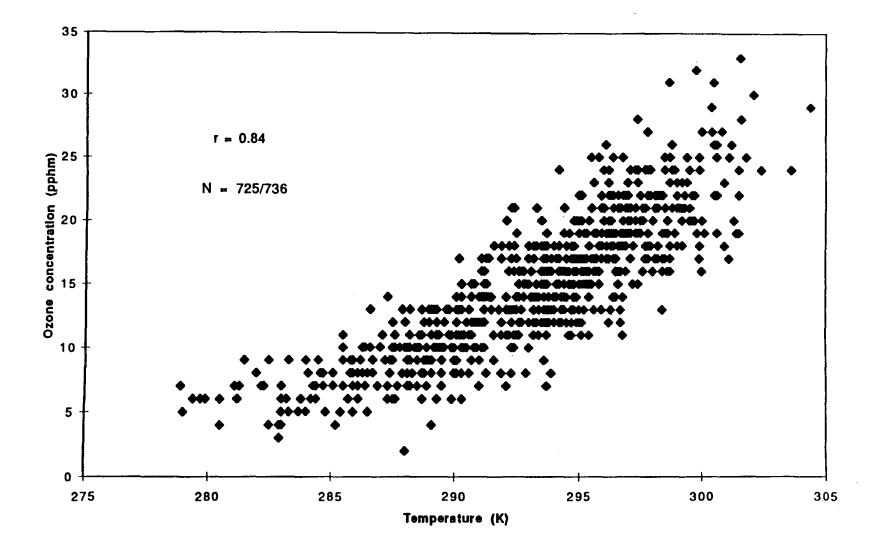
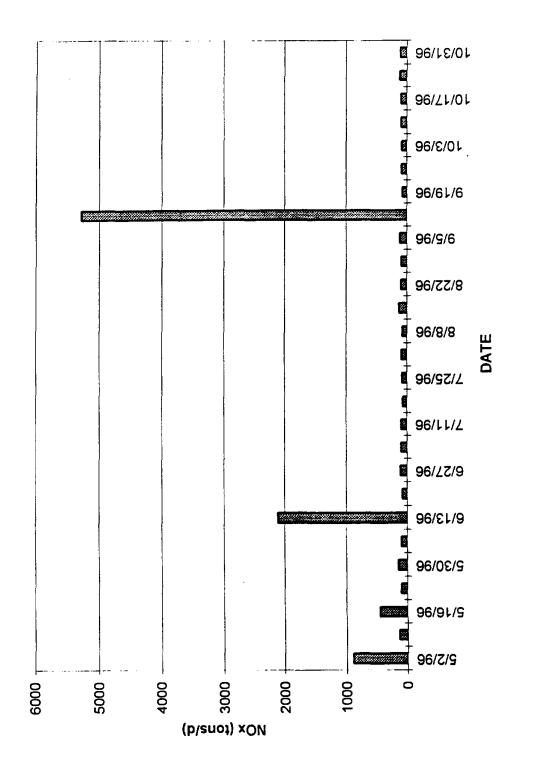


Figure 7-14. Correlation of 1990-93 smog season 1700 PDT 850 mb temperature (at 33.21 °N, 116.98 °W) vs. daily SoCAB-maximum hourly-average ozone.





Day	Average	Std. Dev	
	(tons/d)	(tons/d)	
Sunday	103	20	
Monday	103	14	
Tuesday	103	34	
Wednesday	102	20	
Thursday	101	20	
Friday	95	18	
Saturday	98	21	
Average	101	22	

**Table 7-3.** RECLAIM NO<sub>x</sub> emissions (extreme reporting days excluded).

were slightly lower on Fridays and Saturdays. However, Sunday emissions were similar to weekday emissions.

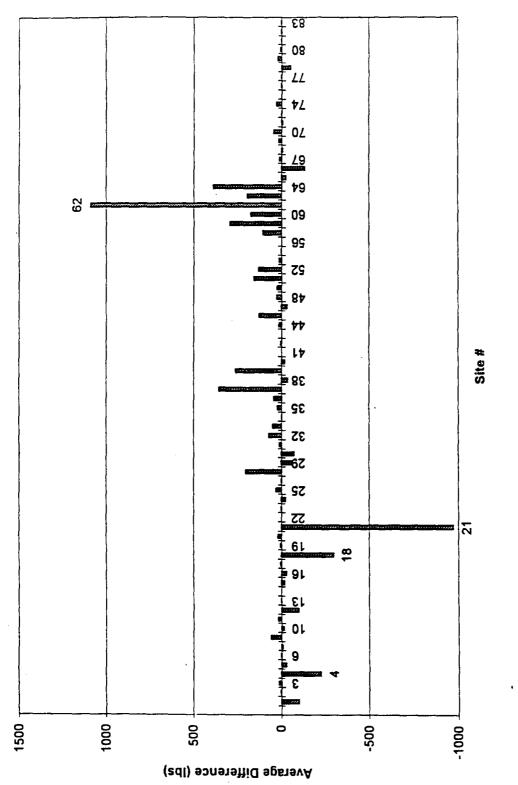
Weekday/weekend differences (post-screening) in reported RECLAIM emissions for each site are shown in Figure 7-16. To represent weekday emissions, Tuesday and Wednesday were averaged together, while Saturday and Sunday were averaged to represent weekend emissions. Figure 7-16 suggests the majority of sources have higher emissions on weekdays than on weekends, with just three sites (No. 4, 18, and 21) exhibiting significantly higher overall emissions on weekend days. These three sites are all electric power generating facilities (SIC code = 4911). Note the differences in Figure 7-16 are small (pounds) compared with the mean in tons per day.

In general, these data were of limited use in meeting the objectives of this study because no significant day-of-the week differences were found (Table 7-3).

# 7.4 Investigation of Traffic Activity Patterns

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We were interested in whether relationships could be established between 0600-0900 PDT ambient CO concentration and traffic count data, as expected from the fact that mobile sources are the only significant source of CO. Also, according to Fujita (1994), the early morning period reflects emissions primarily from on-road vehicles with minimal carryover of aged emissions at surface air monitoring stations. Towards this objective,





we explored the possible utility of a comparison (on a relative basis) between ambient CO concentrations from various SCAQMD air monitoring stations and traffic count data taken from the nearest Caltrans traffic control sites.

We were also interested in determining the degree to which traffic count data could serve as an indicator of day-of-the-week differences in the mobile source emission inventory.

To investigate whether vehicle use patterns can account for differences in SoCAB air quality between weekdays and weekend days, we performed a preliminary analysis of the Caltrans 1994-95 traffic count data for Los Angeles County. Preliminary results (from a total of 36 conventional traffic control sites) suggest a consistent day-of-the-week pattern throughout the SoCAB, with the largest traffic volume occurring on Fridays. There was also a slight upward trend in daily traffic volumes as the week progressed from Monday to Friday. In general, there was a significant decrease in traffic volume on Saturday and an even larger decrease on Sunday.

# 7.5 Analysis of Carbon Monoxide Trends by Day-of-the-Week: 1986-96

To elucidate day-of-the-week differences in mobile source activity and because of the paucity of hydrocarbon data, we investigated 0600-0900 PDT carbon monoxide (CO) concentrations at all air monitoring stations (N=14) in Los Angeles county (except Lancaster) for May-September 1986-96 (Figure 7-17). Despite an increase in vehicle miles traveled (VMT) over the eleven-year study period, 0600-0900 PDT ambient CO concentrations have decreased slightly during this period. Data completeness for all years inspected averaged over 98%. The detection limit of the continuous CO monitors used at the monitoring sites (NDIR, Bendix 8501) is 0.5 ppm, and CO data are reported to the nearest whole integer.

We examined differences in weekday/weekend 0600-0900 PDT CO trends over the eleven-year study period for the same Los Angeles county air monitoring sites (Figure 7-18). Whereas weekday (Monday through Friday average) ambient CO during the

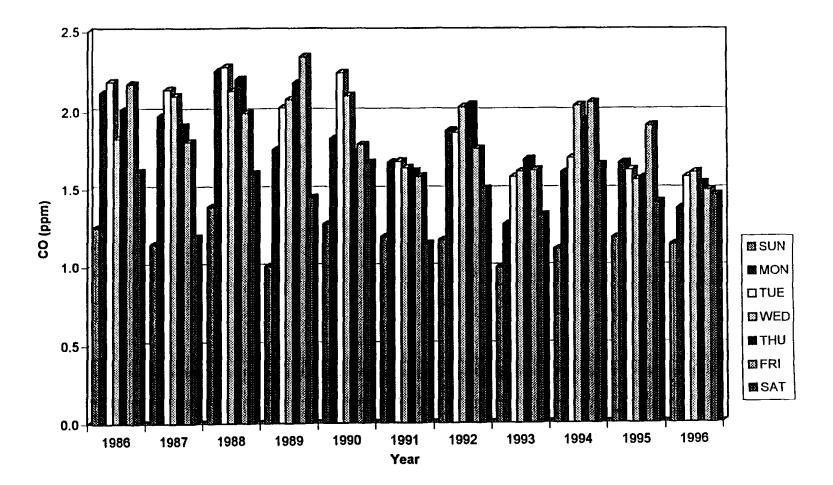


Figure 7-17. Ambient 0600-0900 PDT CO by day-of-the-week for Los Angeles County (except Lancaster) sites, May-September 1986-96.

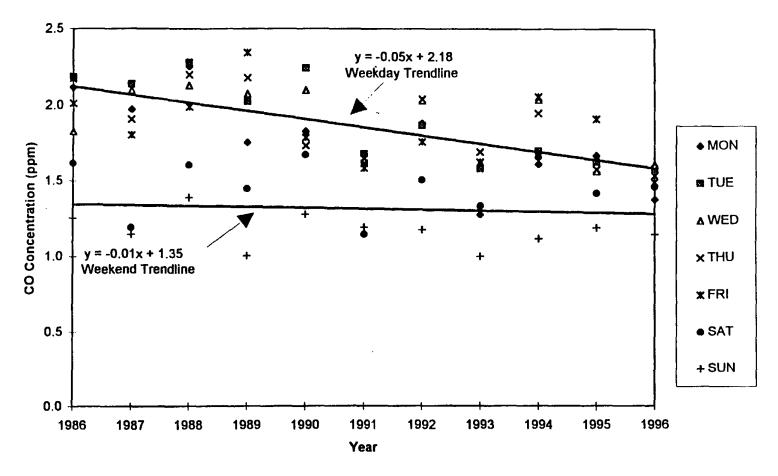


Figure 7-18. Ambient weekday/weekend 0600-0900 PDT CO concentration for Los Angeles county sites, May-September 1986-96.

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morning hours has decreased steadily, weekend (Saturday/Sunday average) ambient CO does not show a similar trend over the eleven-year period. Interestingly, both weekday and weekend 0600-0900 PDT ambient CO concentrations appear to cycle by year which is consistent with results found by Fujita (1994) in evaluating ambient CO for the June through August period for the years 1987-93.

We next examined the growing contribution of weekend ambient CO to the sevenday weekly average for all 21 SoCAB sites which monitor CO. Here, the daily mean concentrations were normalized to the weekly average. Figure 7-19 shows the normalized CO contribution from each day-of-the-week to the average weekly concentration for each year. Saturday 0600-0900 PDT average ambient CO has increased relative to the weekly 0600-0900 PDT average CO concentration from approximately 80% to greater than 90% of the weekly average for the eleven-year period studied.

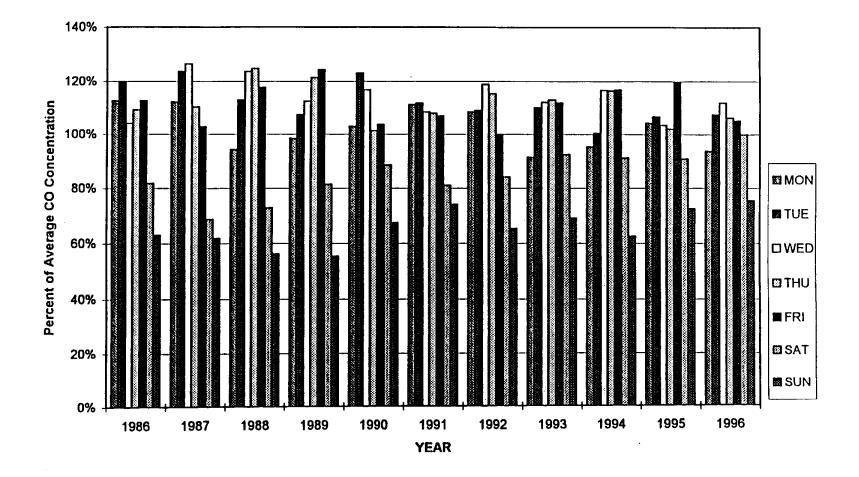


Figure 7-19. SoCAB normalized day-of-the-week ambient 0600-0900 PDT CO for May-September 1986-96.

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## 8.0 SUMMARY AND CONCLUSIONS

The principal findings and conclusions of this study are summarized in brief below. See the corresponding report sections for detailed discussions.

## 8.1 Analysis of Weekday/Weekend Differences in Ambient Air Quality

- There may have been a stronger carryover effect of Friday evening NO<sub>x</sub> on Saturday's Basin-maximum ozone than of Tuesday evening NO<sub>x</sub> on Wednesday's Basin-maximum ozone.
- For the 1986-96 smog seasons, our results suggested a modest carryover effect of Friday evening NO<sub>2</sub> emissions from the Coastal/Metropolitan and San Gabriel Valley subregions on the daily ozone maximum, either within the subregion itself or in the Basin as a whole.
- In general, our results tended to confirm the findings in Phase I of this study that morning (0600-0900) NO<sub>2</sub> in the Coastal/Metropolitan and San Gabriel Valley correlates best with the ozone maximum in the same subregion, and that Coastal/Metropolitan NO<sub>2</sub> no longer correlates well with the afternoon Basin ozone maximum (if it ever did).
- The spatial variation in location of the daily SoCAB-maximum hourlyaverage ozone concentrations was investigated in order to characterize possible day-of-the-week effects. There was a tendency for the daily SoCABmaximum ozone concentration to occur farther west on weekends.
- To determine day-of-the-week differences in ambient concentrations of NMHC, NO<sub>x</sub>, and peak ozone, we adopted methods similar to those used by Tran et al. (1996), focusing on the 1994-95 period they did not analyze in their earlier study. In general, these results suggest that temporary reductions in ozone-precursor concentrations coincide with increases in weekend Basin peak ozone levels. However, based on our eleven-year trend analysis, ozone levels in the SoCAB have substantially decreased, coinciding with a decrease in both NO<sub>x</sub> and NMHC ambient concentrations. Therefore, the transitory nature of the "weekend effect" does not provide evidence that further reduction of the NO<sub>x</sub> emission inventory will produce a corresponding increase in ambient ozone concentrations.

• Basinwide concentrations of both NO<sub>x</sub> and NMHC decreased approximately 20 percent for July through September in 1996 over 1995. At least some of this decrease, especially for NMHC, can be attributed to the introduction of California Phase 2 reformulated gasoline.

# 8.2 Investigation of Anthropogenic Influences on Day-of-the-Week Variations in SoCAB Meteorological Conditions

. In 85 of the 88 cases examined, the weekday temperature was warmer than the weekend temperature, while in just 3 cases the weekend temperature was warmer than the weekday temperature. It thus appears there may have been a small difference in temperature between weekdays and weekend days that could be associated with anthropogenic influences. However, the weekday/weekend temperature difference found by this analysis was very small; in fact, the values were much smaller than the corresponding standard deviations. Thus while we have found evidence for an anthropogenicallyproduced difference in micrometeorological conditions between weekdays and weekend days in the SoCAB, the statistical robustness of the result would appear to be limited. In addition, the small magnitudes of the temperature differences suggest that any feedback on SoCAB air pollution levels will be exceedingly small. Nonetheless, the result is certainly of general scientific interest, and to our knowledge is the first ever obtained that suggests the presence of an anthropogenically-produced weekday/weekend variation in microscale meteorological conditions in the SoCAB. Ultimately, we conclude that if a day-of-the-week temperature effect does exist in the SoCAB, it is quite weak and therefore not likely to be of particular importance to air quality management efforts.

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- A gradual increase in the mean smog season daily-maximum temperature during the 1949-94 period of about 2 °F can be observed for both weekdays and weekends at Los Angeles Civic Center. This suggests that the urban heat island effect intensified during the period of investigation. However, there did not appear to exist a clear day-of-the-week temperature effect at the Los Angeles Civic Center during the 1949-94 smog seasons.
- We have examined relative humidity data for an anthropogenic weekday/weekend effect. Although our results indicated a slight average increase in relative humidity on weekends (0.4%), unlike the temperature analysis there was no consistency in sign either between the various stations or the different times of day. In addition, the standard deviations were much

larger than the weekday/weekend relative humidity differences. Thus no dayof-the-week signal was evident for relative humidity.

- Given that day-of-the-week differences in air quality have been documented in the SoCAB, it was hypothesized that there could be a detectable variation in anthropogenic influence on visibility. We thus analyzed SCAQMD hourly-average b<sub>scat</sub> data. There was a slight tendency for lower visibility days to occur most often on Friday or Saturday at Azusa during the period 15 June to 15 September 1992-94. This result was consistent with our work in the previous phase of the present project, where it was shown that Saturday was the favored day for high ozone episodes in the SoCAB.
- We reasoned that if there were an anthropogenic influence on visibility, the signal might be detectable as a day-of-the-week variation in solar radiation intensity. At Pico Rivera, the mean radiation intensity was found to be slightly lower on weekdays (Tuesday/Wednesday) than on weekend days (Saturday/Sunday) for each of the four hours examined. However, this result was not statistically significant, since the standard deviations were much larger than the difference of the means between weekdays and weekends.

# 8.3 Trends in Ozone and Ozone-Precursor Ambient Concentrations

- We examined ozone-precursor trends over the eleven-year period 1986-96 and found an overall modest decrease in 0600-0900 PDT and 2100-0000 PDT Basinwide ambient NO<sub>x</sub> and NO<sub>2</sub> concentrations from 1986 to 1996, with a more dramatic decrease from 1995 to 1996.
- Examination of 0600-0900 PDT Basinwide ambient NMHC concentration from 1986 to 1995 revealed a pronounced decreasing trend. A general decrease in 0600-0900 PDT NMHC over the ten-year period from 1986 to 1995 for all days of the week was observed.
- We examined the incidence and distribution of various ozone concentrations for 1986-1996. The general trend during the 1986-95 period was toward an increasingly lower number of hours and days of exceedance, at all concentration levels. In particular, there has been substantial reduction in number of hours of *peak* ozone levels (i.e., hours with ozone concentrations at or above 20 pphm).
- At Crestline, slight decreases (from about 1300 hours of exceedance per year for 1986-89 to about 1200 hours of exceedance per year for 1990-94) were followed by a sudden discontinuous drop to a much lower value (751) in 1995.

- The percent change (from year-to-year) in number of smog season hours equal or exceeding the ozone NAAQS was computed for three groups of four sites each within the SoCAB for the period 1986-96. A dramatic reduction in this metric occurred for the four mid-Basin sites between 1995 and 1996, coinciding with the introduction of RFG Phase II. [ARB data analysis on RFG Phase II has shown that although there were benefits for the rest of California, many basins other than the SoCAB had higher ozone concentrations in 1996 than in 1995.]
- The 1995 smog season was slightly cooler than the 1961-90 mean, while 1996 • was slightly warmer than the long-term average. With the exception of May and June of 1995, the 1995-96 smog seasons appear to have recorded near or above normal surface temperatures in the central and eastern portions of the These conditions would seem to favor normal to above normal SoCAB. photochemical smog production rates [warmer SoCAB surface temperatures are associated with higher ozone concentrations (Blier and Winer 1996)]. This conclusion also follows from analysis of gridded 850 mb temperatures at a grid point near the SoCAB which showed near or above normal temperatures for the 1995-96 smog seasons (except during May-June 1995 and September-October 1996, which were cooler than the 1985-96 mean climatological values). Since a substantial decrease in the number of ozone exceedances was reported in the San Gabriel Valley (SGV) from 1995 to 1996, and since this decrease was not likely due to meteorological variability, there appears to be evidence of a significant reduction in SGV ozone during the 1995-96 smog seasons resulting from non-meteorological factors. This result is consistent with the substantial decrease in NMHC and NO, ambient morning concentrations seen for 1996. [It should be noted that conclusions regarding cooler or warmer temperatures in the SoCAB did not include maximum temperatures or maximum solar radiation].

# 8.4 Exploratory Studies

## 8.4.1 Analyses of Distribution of High and Middle Ozone Days: 1986-96

- High ozone days tended to occur mostly during the middle four months of the smog season, while middle ozone days were more broadly distributed.
- There appeared to be a trend towards decreasing incidence of high ozone days in September and October, though the degree of similarity in the meteorological conditions has not yet been determined.
- The day-of-the-week distribution of the highest ozone days for 1986-89, 1990-93, and 1994-96 showed a monotonic increase from Sunday to Saturday.

# 8.4.2 Analyses Using Gridded Meteorological Data

- A strong west coast ridge and an offshore trough at 500 mb were associated with high SoCAB ozone episodes during the eleven-year period 1986-96.
- On average, the 500 mb ridge over the western United States and Canada shifted slightly eastward during the 36-hour period leading up to the afternoon of occurrence of a high ozone event.
- The maximum correlation coefficient between SoCAB-maximum ozone concentrations from the 1994-96 smog season days and the corresponding objectively-analyzed 1700 PDT same day 850 mb temperatures was 0.82 and occurred in the region of the SoCAB. Similarly-calculated values for the 1986-89 and 1990-93 smog seasons were 0.83 and 0.84, respectively.

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#### 9.0 RECOMMENDATIONS FOR FUTURE RESEARCH

Because of the prevailing nature of Saturdays (Figure 1-2) in the weekend weekday phenomenon, a better characterization would be the day-of-the-week phenomenon.

Based upon the present project we recommend the following future research: development of an improved quantitative relationship between SoCAB ozone concentration and meteorology; determination of ozone trends for meteorologically similar episodes; and examination of mesoscale airflow trajectories for SoCAB high ozone episodes through simulation with a high-resolution nonhydrostatic mesoscale model. Our specific and detailed suggestions are as follows.

Control strategy evaluation is dependent upon an understanding of how reliably airshed models can predict changes in air quality resulting from decreased emissions. Assessment of the accuracy of the airshed model predictions requires comparison with observed decreases in ozone concentration over a time interval during which significant reduction in emissions has occurred. However, since the observed ozone concentration results from a combination of emissions of precursor pollutants and the meteorological conditions, determination of the accuracy of the model predictions necessitates removing meteorological variability. To do so requires a means of robustly determining the meteorological similarity with respect to ozone formation.

Varieties of approaches have previously been used to relate peak ozone concentrations in the SoCAB to the meteorological conditions. At present, however, none appear to offer significant advantage over the simple linear relationships that have been developed between ozone concentration and 850 mb temperature. These relationships, though, described at most one-half to two-thirds of the (largely-meteorological) variance. It is therefore recommended that research be undertaken to develop more sophisticated ozone-meteorology relationships; these can then be used to develop air quality trends for meteorologically similar episodes over a wide range of years.

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Also critical to the understanding of precursor transport and ozone development in the SoCAB is the determination of the three-dimensional parcel trajectories in various high-ozone episodes. Under the influence of the complex topography of the region, however, the airflow is complex and not resolvable from routinely available meteorological observations. It would therefore be desirable to determine airflow trajectories in South Coast Air Basin high ozone episodes through simulation with a highresolution nonhydrostatic mesoscale model.

Most numerical model simulations thus far performed for the region of the SoCAB have used models that can only be started from an idealized initial state, rather than from a particular initial state as determined by objective-analysis of the observational data. Thus most previous model studies of the SoCAB show idealized airflow rather than the actual airflow associated with a particular pollution episode. Numerous previous high-resolution applications of the numerical model that is recommended for this research [the National Center for Atmospheric Research Mesoscale Model Version 5 (NCAR MM5)] demonstrate its capability of starting from a well-represented synoptic-scale initial state and accurately reproducing the very-high-resolution mesoscale circulations that develop as a result of interaction with the topography. (Nonhydrostatic simulations with this model have been successfully conducted at horizontal resolutions of less than 1 km.)

A reasonable approach would start with the selection of high ozone episodes that occurred during SCAQS, SCOS97, and other field programs with intensive meteorological and air quality observations for simulation with the NCAR MM5 – both to better understand the three-dimensional transport that occurred during these episodes, and to take advantage of the high density of observational data to verify the capability of the mesoscale model. Once the accuracy has been demonstrated, the model could then be used to examine the airflow and atmospheric structure associated with select additional high ozone episodes for which only routine meteorological observations are available.

An accurate Saturday and Sunday emission inventory is a fundamental requirement for air quality simulation and for general understanding of the day-of-theweek phenomenon. The traffic counts collected during the SCOS97 and further projects in refining RECLAIM and the day-specific emission inventories' data collected during the SCOS97 would contribute to this requirement. ARB is actively engaged in this work.

To study the three-dimensional nature of the carry-over effects, three-dimensional meteorological and specialty (non-routinely measured species) air pollutant data is needed. Such data are available from the SCOS97 and from southern California studies in 1995 (Transport Corridors Study) and 1992, and from SCAQS (1987).

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