SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
MONITORING AND ANALYSIS

Rule 1158 Follow-Up Study #3

Sampling Conducted
November and December, 2000

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

EXECUTIVE SUMMARY

Purpose

In June 1999, Rule 1158 affecting storage, handling and shipment of petroleum coke, coal, and sulfur was amended to further reduce particulate emissions from these sources. This study is one of an ongoing series, examining targeted compounds contained in the inhalable particulate fraction (PM_{10}) in the greater Long Beach/Wilmington Area. This series of studies consists of PM_{10} sampling in the spring/summer and fall/winter, observing trends in the elemental carbon content of collected samples.

Results generated by the current study were compared to results obtained in 1998 and 1999, previously reported in the studies *Report of Micrometeorological and Ambient Air Quality Monitoring Conducted Simultaneously in the Vicinity of the Los Angeles and Long Beach Harbors* (March 1999) and *Rule 1158 Follow-Up Study #1* (May 2000)

Sampling

Sampling was conducted coincident with the AQMD PM_{10} monitoring network one-in-six day schedule between November 8, 2000 and December 14, 2000. Sampling locations were identical to those utilized for the previous fall/winter 1999 study. It is intended that these sites be used throughout the entire series of Rule 1158 Follow-Up Studies. Field operations were contracted to RES Enviornmental, Inc. (Colton, CA), while all laboratory operations and data analysis were performed by AQMD personnel. Twenty-one samples were collected over seven non-consecutive sampling days.

Key Findings

1. Over the course of three fall/winter studies ranging from 1998 to 2000, no clear trend of change in PM_{10} concentration was observed for the Long Beach study area.

2. For the same period, ambient organic carbon showed no clear increasing or decreasing trend in the study area.

3. Ambient elemental carbon decreased steadily over the series of fall/winter studies. The three-site average EC decrease for the study sites between the 1998 and 1999 studies was 26%, and the decrease between the 1999 and 2000 studies was 24%. Overall, a three-site average EC decrease of 43% was observed over the course of the three fall/winter studies.

4. During the 2000 study, the average ambient PM_{10} for the study sites agreed closely with the results obtained at the Long Beach station, in contrast with results obtained in previous studies.

1.0 INTRODUCTION

From November 8, 2000 to December 14, 2000, PM_{10} monitoring was conducted at three locations in the cities of Long Beach (two sites) and Wilmington (one site). This study constituted the third of multiple studies evaluating improvements in local air quality precipitated by implementation of Rule 1158, as amended on June 11, 1999. The next sampling event is slated to begin in May 2001.

This study builds on a base of knowledge established by four previous studies: two spring/summer studies (1997, 2000)[1,2] and two fall/winter studies (1998, 1999)[3,4]. The primary objectives of the current study were to collect data suitable for the evaluation of:

> Current inhalable particulate (PM_{10}) ambient concentration trends for the study area.
>
> Speciation of the carbonaceous component of the collected particulate samples for elemental and organic carbon content.
>
> Comparison of 2000 concentration and carbon data with that obtained during the earlier fall/winter studies.

The prevailing winds in the study area place portions of the community downwind of coal and coke production and/or storage facilities, and fugitive dust from these activities has been a longstanding community concern. This fugitive dust contributes to increases in the ambient inhalable (PM_{10}) particulate concentration. Mobile sources such as diesel trucks, trains and ships in the area also contribute to the overall ambient particulate matter concentrations.

The June 1999 amendment of Rule 1158 affected storage, handling and shipment practices for petroleum coke, coal, and sulfur. Removal and enclosure of open coke storage piles, and modification to equipment and work practices to comply with Rule 1158 requirements is ongoing. The Rule 1158 compliance schedule mandates implementation of the majority of control measures by August 1999, with full implementation of all measures by June 2004. It is anticipated that full implementation of Rule 1158 will contribute to a decrease in ambient PM_{10} concentrations in the local area. Compliance field staff have documented a high rate of compliance with the initial rule implementation requirements. To date, these measures have included covered transport, truck washing, prompt roadway/spill clean-up and the recent removal of

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[1] South Coast Air Quality Management District. (September 1997) *Micrometeorological and Ambient Air Quality Monitoring Conducted Simultaneously in the Vicinity of the Los Angeles and Long Beach Harbors.* Diamond Bar, CA.

[2] South Coast Air Quality Management District. (October 2000) *Rule 1158 Follow-Up Study #2.* Diamond Bar, CA.

[3] South Coast Air Quality Management District. (March 1999) *Micrometeorological and Ambient Air Quality Monitoring Conducted Simultaneously in the Vicinity of the Los Angeles and Long Beach Harbors.* Diamond Bar, CA.

[4] South Coast Air Quality Management District. (May 2000) *Rule 1158 Follow-Up Study #1.* Diamond Bar, CA.

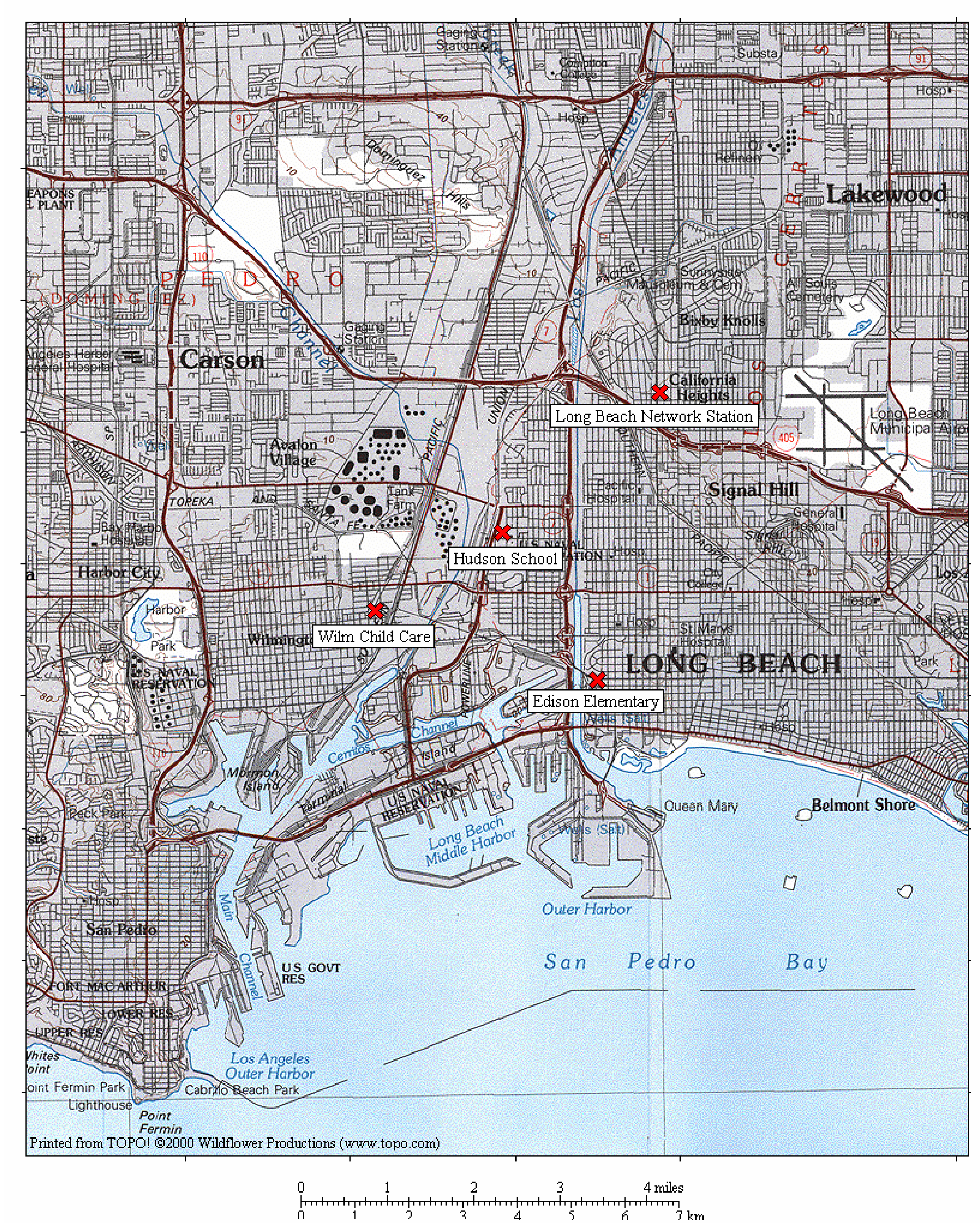


Figure 1 – Study Sampling Sites

several large open coke piles that has resulted in the reduction of fugitive coke emissions from storage, handling, and shipping operations.

2.0 PROJECT DISCUSSION

Site selection and the sampling calendar were influenced by several factors. Sampling dates were scheduled to repeat as closely as possible the sampling dates of the previous fall/winter studies, while coinciding with the EPA one-in-six monitoring schedule utilized by the AQMD in its PM_{10} monitoring network. Samples were scheduled for collection on November 8, 14, 20, 26 and December 2, 8, and 14, producing a data set consisting of twenty-one samples.

All three sites in the current study were included in the fall/winter 1998 and 1999 studies (See Figure 1.) The three current monitoring sites were chosen from seven sites used in the initial study. Selection criteria included their location relative to coal and coke facilities with respect to the local prevailing wind patterns, and their importance as locations containing student populations (the sites include two schools and a child care center). In addition, of the seven sites included in the 1998 study, the two school sites had exhibited the highest levels of ambient PM_{10} and elemental carbon. Detailed site maps can be found in Appendix A-2.

2.1 SITE DESCRIPTIONS

RES Environmental, Inc. (RES), was contracted by the AQMD to perform field operations for the current study. The consultant described the sampling locations as follows[5]:

Site 1: School Building Services Facilities/Hudson School (HUD)
2401 Webster Avenue
Long Beach, California

The monitoring site is located at the Long Beach School Building Services facility (maintenance yard), adjacent to the Hudson Middle School. The PM_{10} sampler was installed on top of two adjoining steel containers. Meteorological exposures were composed of (1), Henry Ford Freeway, which runs parallel to the monitoring site to the west and (2), maintenance yard to the north, east and south of the monitoring site. The maintenance yard consists of repairs and fabrication of materials, including welding.

[5] RES Environmental, Inc. (February 2000) *The South Coast Air Quality Management District –Rule 1158 Follow-up Study.* Colton, CA.

Site 2: Edison Elementary School (EDI)
625 Maine Avenue
Long Beach, California

Site #2 was located at the Edison Elementary School in Long Beach. The PM_{10} sampler was located on a steel container at the western side of the school and playground. The sampler was also installed on a five-foot platform to clear the school building to the east. The meteorological exposure consists of (1), a main street artery (16^{th} Street) which carries heavy vehicle traffic, is located to the north (2), school buildings to the east and south and (3), a small bus terminal to the west of the monitoring site.

Site 3: Wilmington Childcare Center (WIL)
1419 Young Street
Wilmington, California

The monitoring site was installed on the roof of the Childcare Center, near a elementary and middle school in the City of Wilmington. The meteorological exposure consists of (1), a residential area to the north (2), commercial/industrial development to the east (3), school to the south and (4) parking area/residential area to the west of the monitoring site.

2.2 SAMPLING AND ANALYSIS METHODOLOGY

The AQMD maintains a PM_{10} monitoring network throughout the South Coast Air Basin (the Basin). The Federal Reference Method (FRM) SSI PM_{10} samplers utilized in the PM_{10} network were reviewed in a recent AQMD report, and standard AQMD analytical procedures are summarized here:

The SSI sampler used in this study is the EPA's FRM sampler found in 40CFR50 Appendix J. It is used to monitor PM less than 10 microns in size (PM_{10}). For the purposes of this study, the SSI samplers are used to collect PM_{10} samples, which were also used for the determination of organic carbon (OC), elemental carbon (EC) and total carbon.

The SSI sampler contains a pump controlled by a programmable timer. An elapsed time accumulator, linked in parallel with the pump, records total pump-operation time in hours. During operation, a known quantity of air is drawn through a particle size separator, which achieves particle separation, by impaction. The correct flow rate through the inlet is critical to collection of the correct particle size so that after impaction, only particles 10 microns in size or less remain suspended in the airstream. The flow of air then passes through a quartz filter medium, upon which the particles are collected. A programmable timer automatically turns the pump off at the end of the 24-hour sampling period.

Once a sample has been collected it is returned to the laboratory, following chain-of-custody protocols, where both PM_{10} mass and carbon content are determined. Ambient PM_{10} mass is determined by subtracting the weight of the clean unsampled filter (measured in the laboratory prior to sampling) from the weight of the sampled filter containing the collected PM_{10}, to yield the mass of the PM_{10} collected on the filter. This mass is then divided by the amount of air drawn through the filter to give the ambient concentration, expressed as mass per cubic meter ($\mu g/m^3$).

Ambient carbon levels are determined by taking a small portion of the PM_{10} filter and putting it into a carbon analyzer. The analyzer consists of a computer-controlled programmable oven, computer controlled gas flows, a laser, and a flame ionization detector (FID). The sample is first heated in the oven in increasing amounts of oxygen. As the temperature rises, first organic carbon and then elemental carbon are evolved from the filter. The laser beam passes through the filter, and the transmitted intensity increases at the detector as the light-absorbing carbon leaves the filter, causing the filter to become less black. The evolved carbon is swept from the oven by gas flow, and is transported to the FID where it is detected (in the form of methane) throughout the heating process. The computer that controls these processes collects data on the oven temperature profile, laser light absorption, and FID response to determine the OC and EC content of the filter. This information, combined with the volume of air sampled, provides the OC and EC concentration in the ambient air.

3.0 DATA ANALYSIS

Data from the current study was compared with data obtained in the fall/winter 1998 and 1999 studies. For appropriate comparison to current results, only 1998 data collected during November and December was utilized – October 1998 data was omitted.

3.1 PM_{10} AMBIENT CONCENTRATION ANALYSIS

Table 1: Fall/Winter 2000 PM_{10} Concentrations at Sampling Sites

	Date							
Location	11/8/00	11/14/00	11/20/00	11/26/00	12/2/00	12/8/00	12/14/00	Average
HUD	134	56	143	73	100	28	43	82
EDI	52	48	78	73	105	18	37	59
WIL	56	45	55	65	93	16	37	52
LB Station	44	49	92	*	105	20	35	58

* No Sample

Table 1 presents the PM_{10} ambient concentrations observed during the study. Complete data tabulations can be found in Appendix A-1. Long Beach values are provided for comparison purposes. Twenty-four hour ambient PM_{10} concentrations during the study period ranged from a maximum of 143 $\mu g/m^3$ at HUD on November 20, to a minimum of 16 $\mu g/m^3$ obtained at the WIL site on December 8. The average concentration for the three study sites was 64.5 $\mu g/m^3$.

The State of California has established 50 $\mu g/m^3$ as the PM_{10} 24-hour standard. Thirteen of the twenty-four (54%) samples collected during the course of the study exceeded this standard. During the 1999 study 57% of samples exceeded the standard. The highest site average (82 $\mu g/m^3$) over the course of the study occurred at the HUD site. This continues the trend observed in previous studies, where HUD ranked highest for PM_{10}.

Figure 2: Average PM_{10} by Site and Year

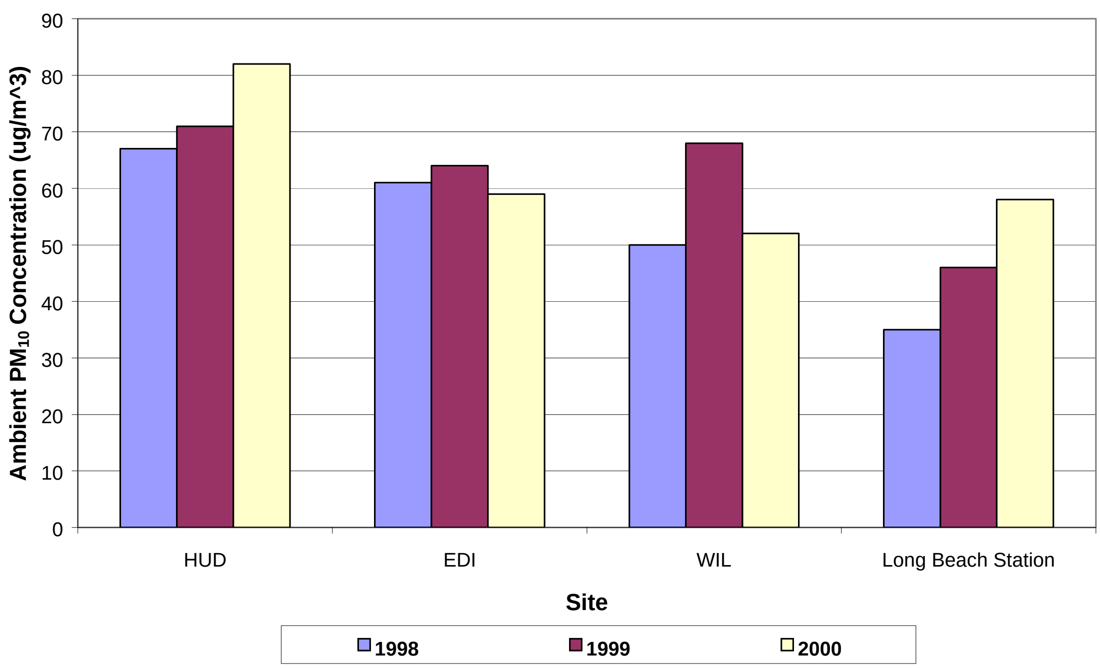


Figure 2 summarizes the ambient PM_{10} concentrations observed over the course of the three fall/winter studies. The HUD site and the Long Beach network site show a trend of increasing PM_{10} concentration, while neither the EDI nor WIL site display an easily definable trend for PM_{10} over the three year span.

When looking at these results, it must be kept in mind that PM_{10} consists of a variety of chemical species.[6] These include carbonaceous components (EC and OC), crustal materials and wind-blown soils, sulfate and nitrate formed by precursor SOx and NOx emissions primarily as a result of combustion, and sodium chloride particulate resulting in part from wind-carried sea salt. Increases in PM_{10} observed at study sites may be the result of contributions from one or several of these sources.

Previously, the Long Beach network station exhibited lower PM_{10} than any of the three study sites, leading to a hypothesis that the network station was not situated in a location adequately representative of the Long Beach community. In a departure from these observations, the Long Beach Station had an average PM_{10} higher than the WIL site and nearly equal that of the EDI site during the current study.

Figure 3: 2000 PM_{10} Study Average vs. Long Beach Station

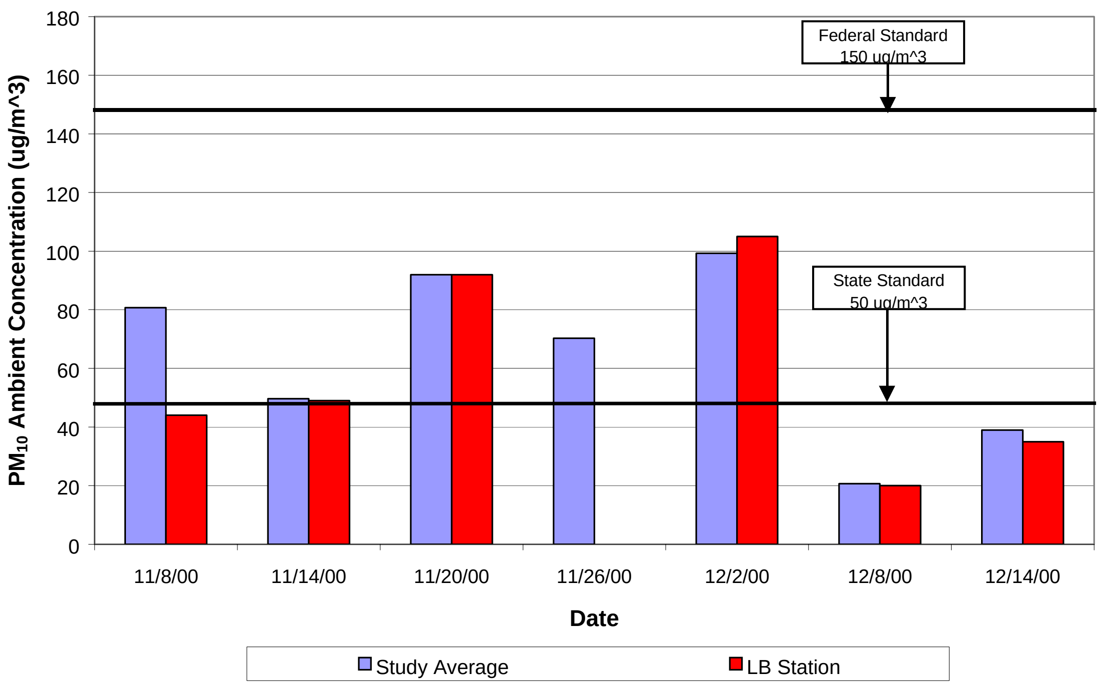


Figure 3 compares the average value for the three study sites with the Long Beach network station on each day of the 2000 study. For all dates other than November 8, the study average and the Long Beach station yield nearly identical values. On November 8, a PM_{10} result at the HUD site significantly higher than those at the EDI and WIL sites

[6] Kim. B.M., Teffera, S., Zeldin, M.D. Characterization of $PM_{2.5}$ and PM_{10} in the South Coast Air Basin of Southern California: Part 1 – Spatial Variations. *J. Air and Waste Manage. Assoc.* **2000** 50:2034-2044.

was observed, suggesting that a localized source influenced sampling at HUD. This may account for the elevation of the study average on that date.

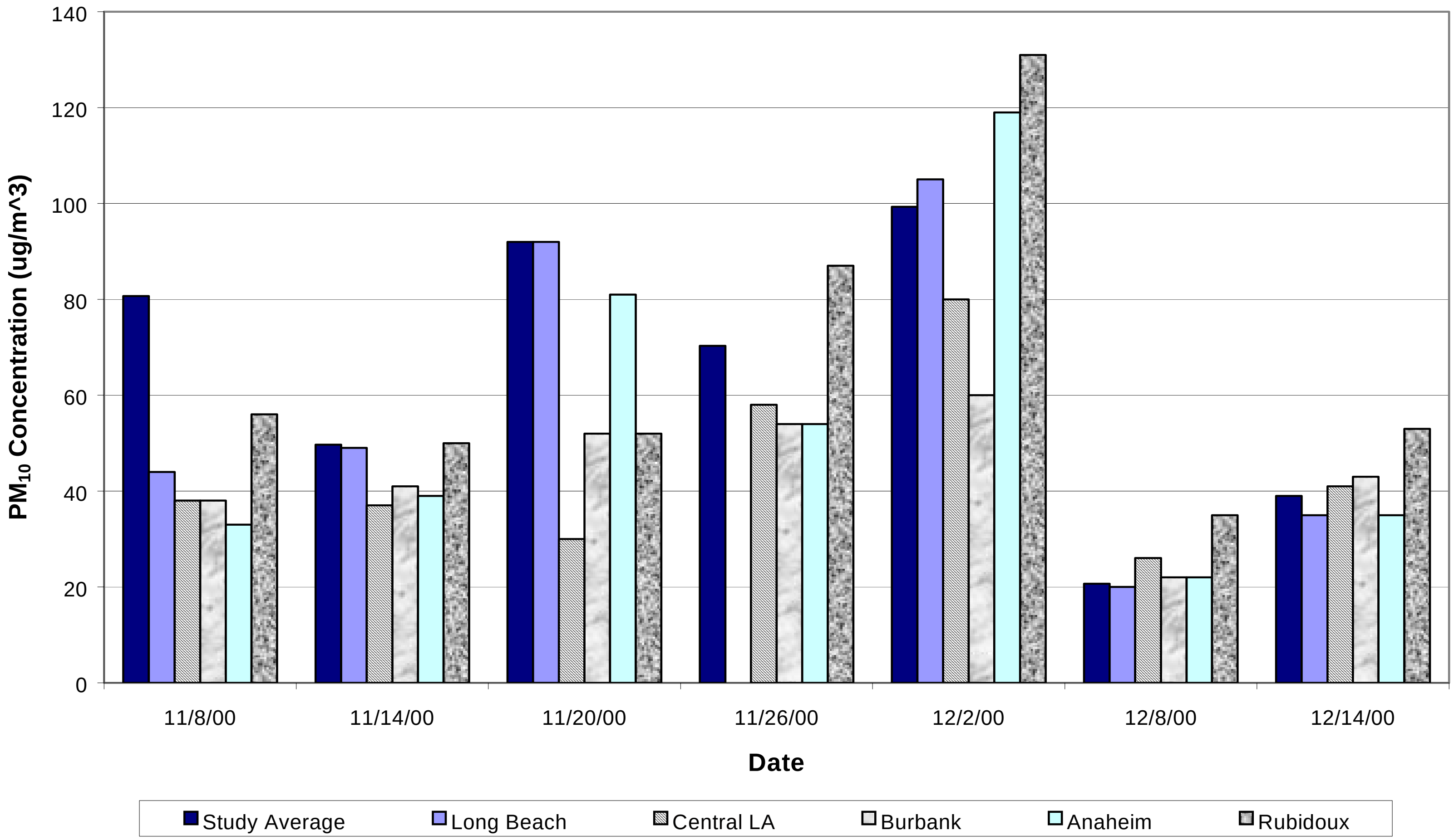
The agreement between the study average and the Long Beach station illustrated by Figure 3 indicates that during the 2000 sampling period, station results were more representative of community conditions than during either of the previous two fall/winter studies.

3.2 BASIN-WIDE PM_{10} COMPARISON

In order to place the study results in context, the study average was compared to results obtained concurrently at several other PM_{10} network sites within the Basin (Figure 4). The sites chosen for comparison are representative of the spectrum of conditions encountered in the Basin. In general, Rubidoux is among the highest PM_{10} sites in the Basin, with particulate high in nitrate and crustal materials; it is representative of the southeastern portion of the Basin. Los Angeles reflects conditions within the urban core, with particulate higher in sulfate and carbonaceous compounds than Rubidoux, resulting from a higher contribution to ambient particulate by vehicle emissions.

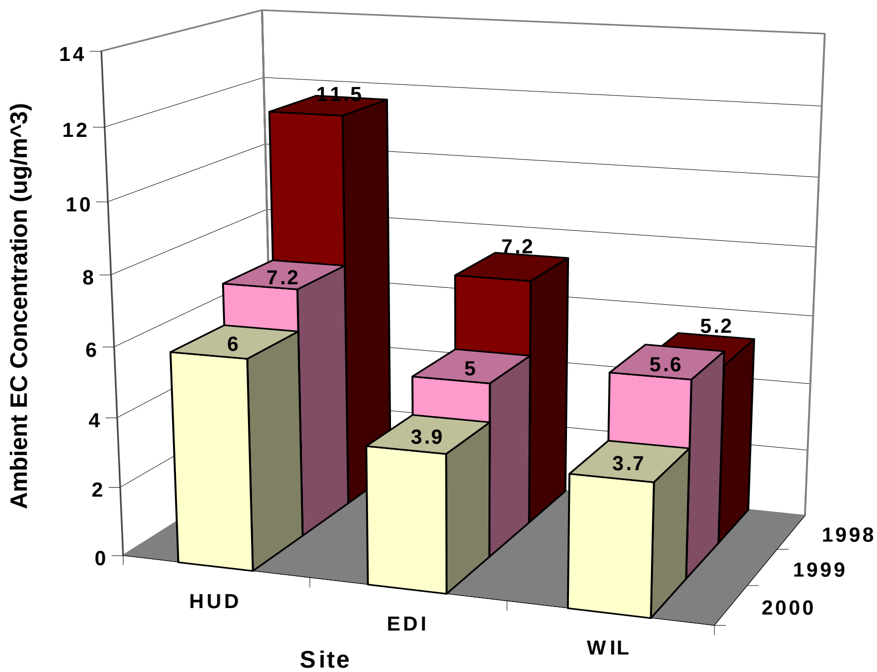
On November 8, 14 and 20, the study average PM_{10} concentration was equal to or higher than all other sites used for comparison. On the remaining four study dates, Rubidoux had the maximum PM_{10} concentration. Similar results were obtained in previous studies, with the study average higher than comparison sites four of eight days in 1999, and four of eight days in 1998.

Figure 4: 2000 PM_{10} Average vs. PM_{10} Network Sites



3.3 ELEMENTAL CARBON ANALYSIS

Figure 5: Average EC By Site and Year



Elemental carbon is of particular interest in this study, as it arises in part from coke and coal storage as well as from transportation including diesel emissions from trucks, trains and ships. Elemental carbon concentrations were averaged for each site over the duration of the study, and results are represented in Fig. 5 above. Complete data tabulations can be found in Appendix A-1. The results obtained in the current study were lower for all three sites than those obtained in both the 1998 and 1999 studies. The most marked decrease was observed at HUD, down from a study average of 11.5 $\mu g/m^3$ EC in 1998 to 6.0 $\mu g/m^3$ EC in 2000 – a 48% decrease. For all sites, the average 1998-1999 decrease was 26%, and the average 1999-2000 decrease was 24%.

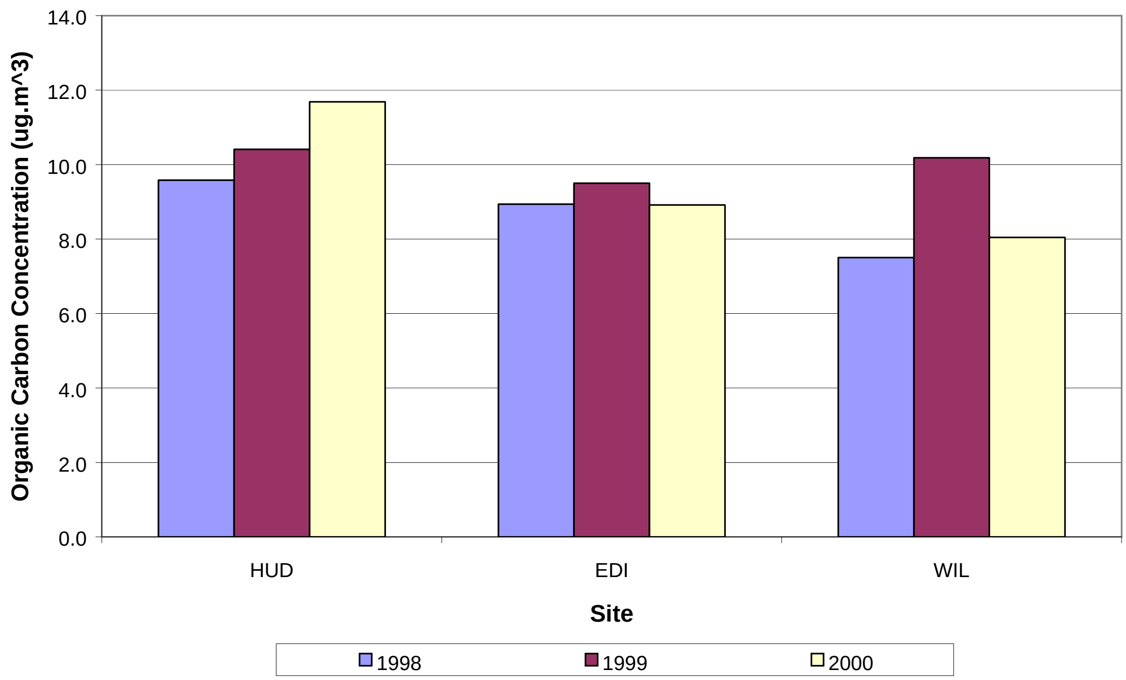
Table 2: Average Percentage of EC in PM_{10}

SITE	1998 AVERAGE	1999 AVERAGE	2000 AVERAGE
HUD	16.5%	10.3%	8.3%
EDI	11.2%	7.9%	7.3%
WIL	10.6%	8.4%	7.8%

Table 2 illustrates that the composition of PM_{10} has changed with respect to elemental carbon during the three year span covered by the fall/winter studies. While ambient PM_{10} levels show no trend across all study sites, the percentage of EC in PM_{10} has decreased each year at all sites. Again, the most marked decrease was observed at HUD, down from 16.5% EC in PM in 1998 to 8.3% EC in PM_{10} in 2000.

3.4 ORGANIC CARBON ANALYSIS

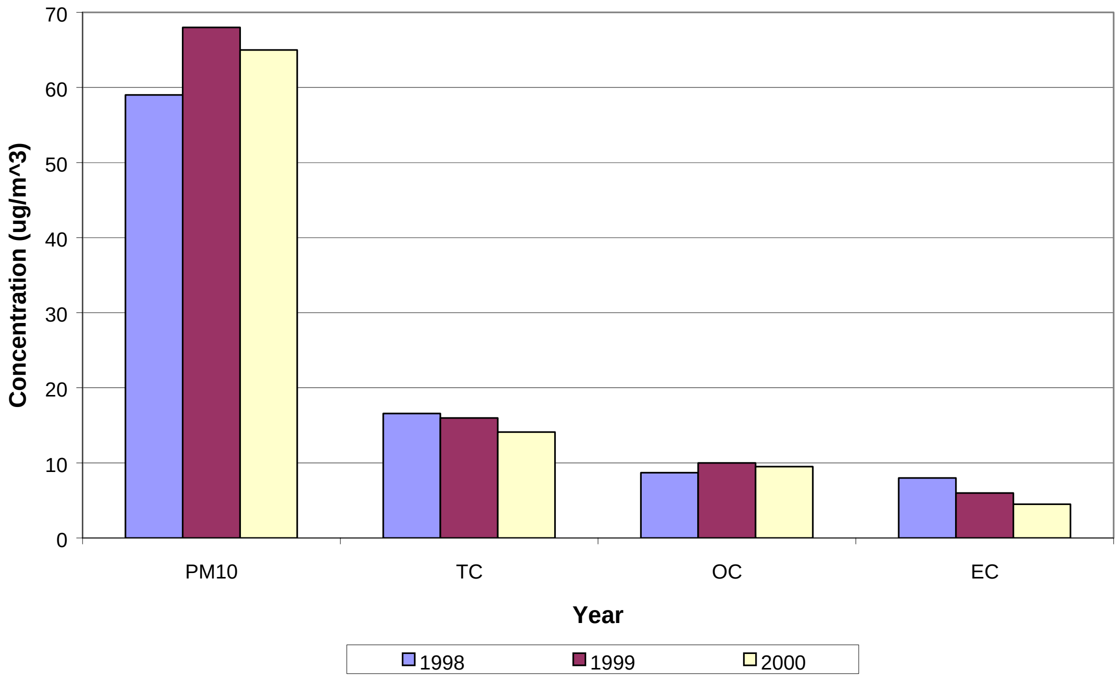
Figure 6: 2000 Study Organic Carbon Concentration By Site



Organic carbon concentrations were averaged for each site over the duration of the 2000 study, and results are compared to previous studies in Figure 6 above. Complete data tabulation can be found in Appendix A-1. The pattern presented is similar to that seen for PM_{10} (Figure 2); the HUD site shows a trend of increasing PM_{10} concentration, while neither the EDI nor WIL site display an easily definable trend for PM_{10} over the three year span. The similarities in PM_{10} and OC data over the three fall/winter studies suggest that the percentage of OC in PM_{10} has remained relatively constant, and that changes in OC ambient concentration are likely due to corresponding changes in PM_{10}.

3.4 TREND ANALYSIS

Figure 7: Three-Study Trends



Annual study averages for PM_{10}, total carbon, organic carbon, and elemental carbon are charted in Figure 7 above. As discussed in section 3.4, both PM_{10} and OC show similar three-year profiles, and exhibit no easily distinguishable ambient concentration change trend.

Elemental carbon shows a steady decline in ambient concentration over the three-study period. A slightly larger decrease is observed between the 1998 and 1999 fall/winter studies, a time-span that brackets initial implementation of the amended Rule 1158 during August 1999, followed by a continued decrease from 1999 to 2000. Total carbon (TC), essentially the sum of OC and EC, also shows a steady decline over the course of the three studies. As organic carbon shows no decreasing trend, the decrease in TC can be attributed to the decrease in elemental carbon.

4.0 CONCLUSIONS

Over the course of three fall/winter studies ranging from 1998 to 2000, no clear trend of change in PM_{10} concentration was observed for the Long Beach study area as a whole. Two sites, HUD and the Long Beach network station show a trend of increasing PM_{10}, while the two remaining study sites show neither a clear increasing nor a clear decreasing trend for ambient PM_{10}.

During the 2000 study, the average ambient PM_{10} for the study sites agreed closely with the results obtained at the Long Beach station for all study dates except November 8. In both previous studies, good agreement between the study average PM_{10} and the Long Beach station was not observed, suggesting that relocation of the station southward might yield measurements more representative of the community as a whole.

Basin-wide comparison of PM_{10} data yielded similar results for all three fall/winter studies. The study average exceeded comparison sites on 2-4 sampling dates during the studies, while Rubidoux generally exceeded all sites for the remaining sampling dates.

For each site, average organic carbon concentrations changed in concert with average PM_{10} concentrations over the course of the three studies. Consequently – like PM_{10} – organic carbon showed no clear increasing or decreasing trend in the study area. This suggests that little net change in contribution to PM_{10} by OC has occurred during the period covered by these studies.

Ambient elemental carbon decreased steadily over the series of fall/winter studies. As discussed earlier, elemental carbon arises in part from coke and coal storage as well as from transportation including diesel emissions from trucks, trains and ships. The observed decreases in EC may be attributable to decreases in the contributions from these sources. However, transportation sources are also contributors to ambient OC, for which no decrease was observed during the fall/winter studies. This might suggest a proportionally larger contribution to EC reductions by coke and coal dust controls. Comparison of Basin-wide EC trends would be necessary to substantiate this conclusion.

APPENDIX A-1 LONG BEACH PM_{10} MONITORING DATA

2000 PM10 Ambient Concentration Results

Location	11/8/00	11/14/00	11/20/00	11/26/00	12/2/00	12/8/00	12/14/00	Average
HUD	134	56	143	73	100	28	43	82
EDI	52	48	78	73	105	18	37	59
WIL	56	45	55	65	93	16	37	52
LB Station	44	49	92	*	105	20	35	58

* No Sample

2000 Organic Carbon Ambient Concentration Results

Location	11/8/00	11/14/00	11/20/00	11/26/00	12/2/00	12/8/00	12/14/00	Average
HUD	17.1	10.6	22.6	9	9.2	4.6	8.7	11.7
EDI	8.9	9.7	15.4	7.6	10.2	2.8	7.8	8.9
WIL	10.5	9.7	10.9	7	8.1	2.9	7.2	8.0

2000 Elemental Carbon Ambient Concentration Results

Location	11/8/00	11/14/00	11/20/00	11/26/00	12/2/00	12/8/00	12/14/00	Average
HUD	7.6	6.4	11.6	4.8	4.6	3.7	3.6	6.0
EDI	3.8	4.1	7.4	4.3	3.3	2	2.1	3.9
WIL	4.6	4.1	5.1	3.8	3.6	1.7	2.9	3.7

2000 Total Carbon Ambient Concentration Results

Location	11/8/00	11/14/00	11/20/00	11/26/00	12/2/00	12/8/00	12/14/00	Average
HUD	24.7	17	34.2	13.8	13.8	8.3	12.3	17.7
EDI	12.7	13.8	22.8	11.9	13.5	4.8	9.9	12.8
WIL	15.1	13.8	16	10.8	11.7	4.6	10.1	11.7

2000 Elemental Carbon as a Percentage of Total PM10

Location	11/8/00	11/14/00	11/20/00	11/26/00	12/2/00	12/8/00	12/14/00	Average
HUD	5.7%	11.4%	8.1%	6.6%	4.6%	13.2%	8.4%	8.3%
EDI	7.3%	8.5%	9.5%	5.9%	3.1%	11.1%	5.7%	7.3%
WIL	8.2%	9.1%	9.3%	5.8%	3.9%	10.6%	7.8%	7.8%

APPENDIX A-1 LONG BEACH PM_{10} MONITORING DATA (CONTINUED)

1999 PM10 Ambient Concentration Results

Location	11/2/99	11/8/99	11/14/99	11/20/99	11/26/99	12/2/99	12/8/99	12/14/99	Average
HUD	92	38	50	30	47	69	68	171	71
EDI	85	33	47	37	49	74	93	97	64
WIL	92	89	46	30	65	70	*	87	68
LB Station	77	22	38	27	38	50	55	59	46

* No Sample

1999 Organic Carbon Ambient Concentration Results

Location	11/2/99	11/8/99	11/14/99	11/20/99	11/26/99	12/2/99	12/8/99	12/14/99	Average
HUD	9.9	6	6	4.5	11	13.3	10.4	22.2	10.4
EDI	8.3	4.8	5.8	4.9	10.5	14.1	13.4	14.2	9.5
WIL	8.1	14.1	6.4	4.4	12.6	13.5	*	12.2	10.2

1999 Elemental Carbon Ambient Concentration Results

Location	11/2/99	11/8/99	11/14/99	11/20/99	11/26/99	12/2/99	12/8/99	12/14/99	Average
HUD	7.9	4.1	4.8	2.7	5.9	7.9	6.6	17.8	7.2
EDI	5.7	2.6	4	2.7	4.6	6.1	6.1	8.5	5.0
WIL	6	6.7	4.1	2.4	7.4	5.5	*	7.2	5.6

1999 Total Carbon Ambient Concentration Results

Location	11/2/99	11/8/99	11/14/99	11/20/99	11/26/99	12/2/99	12/8/99	12/14/99	Average
HUD	17.8	10.1	10.8	7.2	16.9	21.2	17	40	17.6
EDI	14	7.4	9.8	7.6	15.1	20.2	19.5	22.6	14.5
WIL	14.1	20.8	10.5	6.8	20	19	*	19.4	15.8

1999 Elemental Carbon as a Percentage of Total PM10

Location	11/2/99	11/8/99	11/14/99	11/20/99	11/26/99	12/2/99	12/8/99	12/14/99	Average
HUD	8.6%	10.8%	9.6%	9.0%	12.6%	11.4%	9.7%	10.4%	10.3%
EDI	6.7%	7.9%	8.5%	7.3%	9.4%	8.2%	6.6%	8.8%	7.9%
WIL	6.5%	7.5%	8.9%	8.0%	11.4%	7.9%	*	8.3%	8.4%

APPENDIX A-1 LONG BEACH PM_{10} MONITORING DATA (CONTINUED)

1998 PM10 Ambient Concentration Results

Location	11/1/98	11/7/98	11/13/98	11/19/98	11/25/98	12/13/98	Average
HUD	61	56	72	89	*	55	67
EDI	50	49	67	73	74	55	61
WIL	54	43	45	52	70	33	50
LB Station	43	31	39	54	*	27	39

* No Sample

1998 Organic Carbon Ambient Concentration Results

Location	11/1/98	11/7/98	11/13/98	11/19/98	11/25/98	12/13/98	Average
HUD	7.5	6.4	11.2	14.2	*	8.6	9.6
EDI	7	5.5	11.3	10.4	9.3	10.1	8.9
WIL	6.9	5.7	8.4	8.3	9.9	5.8	7.5

1998 Elemental Carbon Ambient Concentration Results

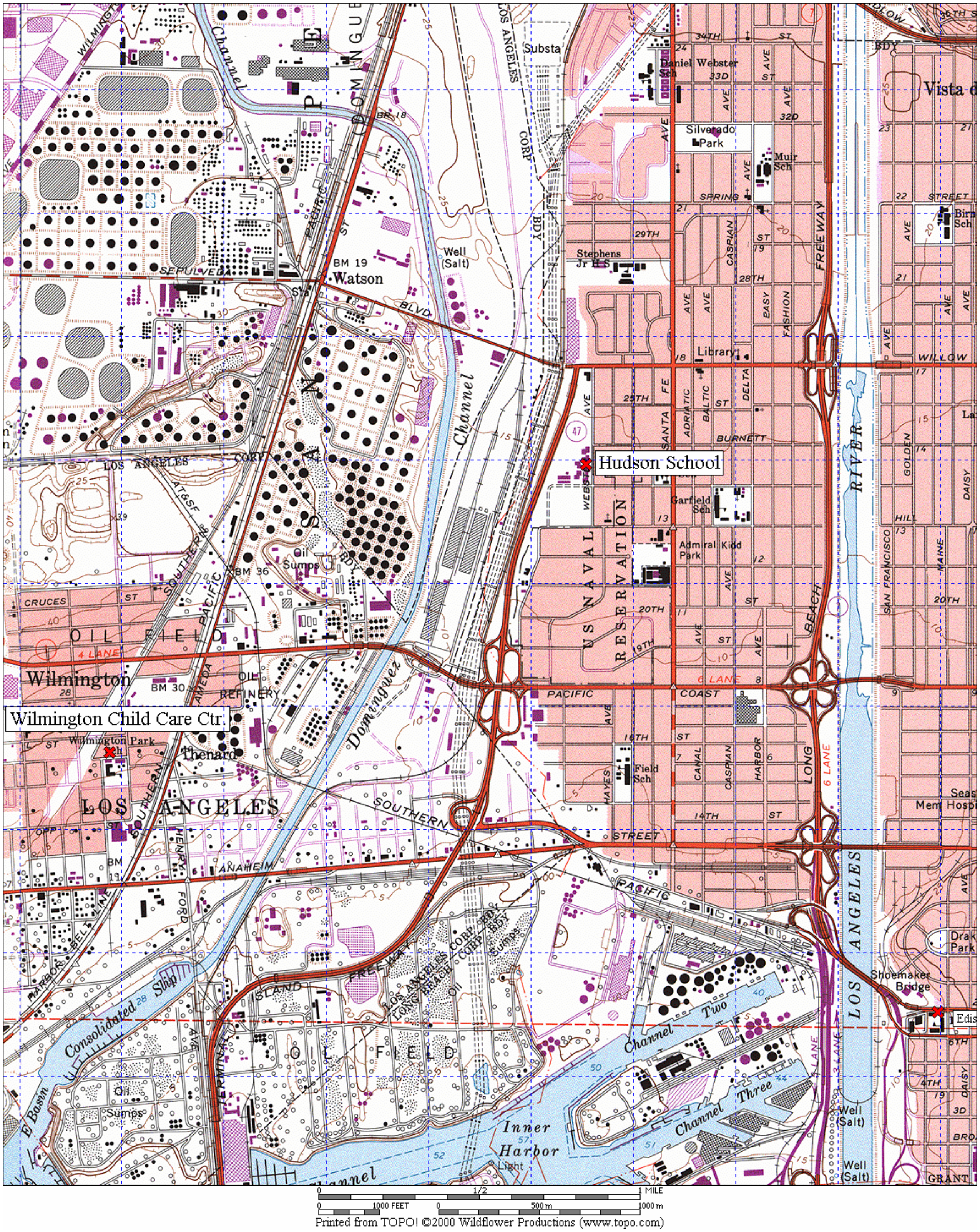
Location	11/1/98	11/7/98	11/13/98	11/19/98	11/25/98	12/13/98	Average
HUD	6.2	6.2	16.6	19.8	*	8.9	11.5
EDI	4.3	3.3	9.2	12.5	7.9	5.8	7.2
WIL	4.1	3.8	5.9	7.3	6.6	3.4	5.2

1998 Total Carbon Ambient Concentration Results

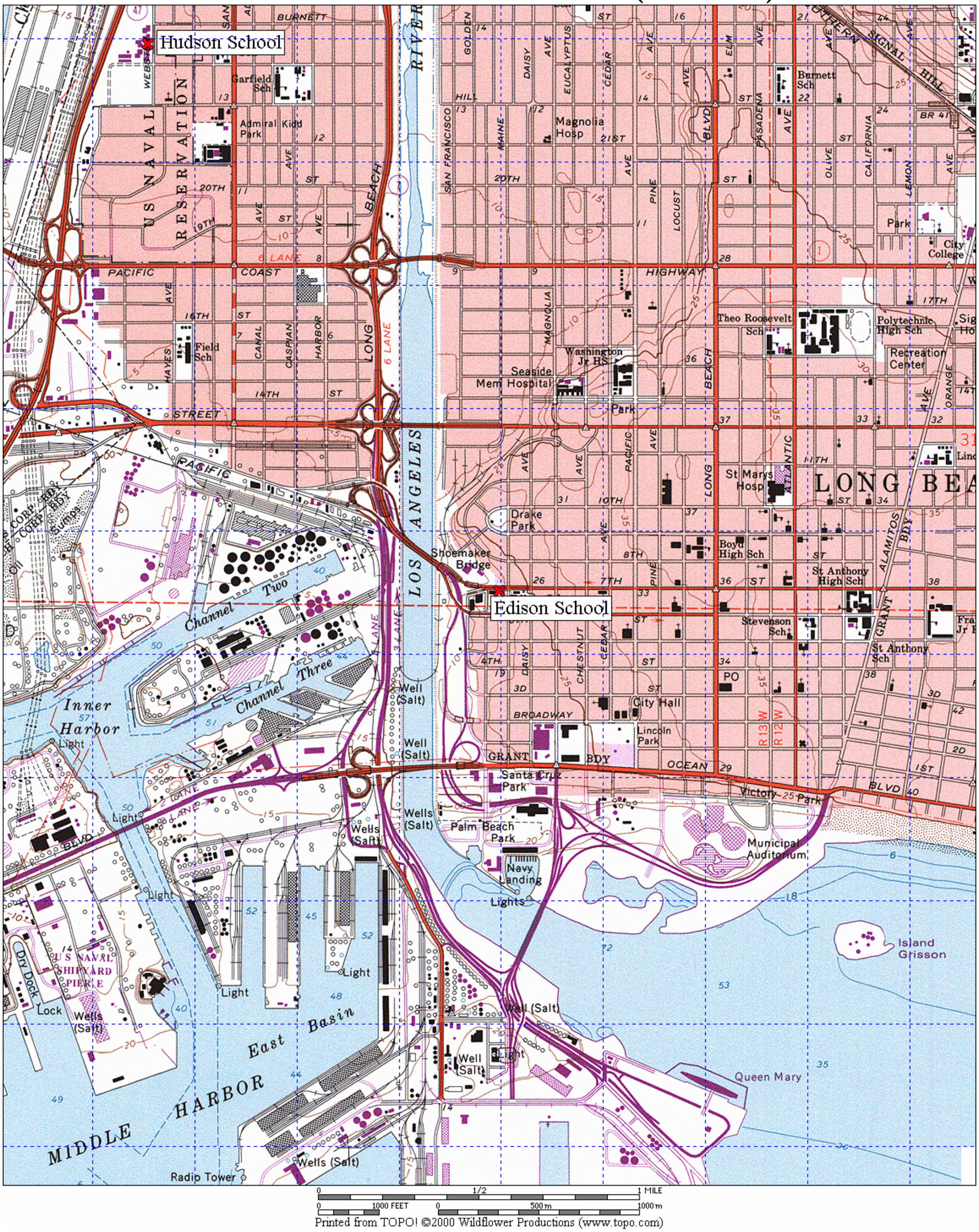
Location	11/1/98	11/7/98	11/13/98	11/19/98	11/25/98	12/13/98	Average
HUD	13.7	12.6	27.9	34	*	17.5	21.1
EDI	11.3	8.8	20.5	22.9	17.2	15.9	16.1
WIL	11	9.4	14.4	15.6	16.5	9.2	12.7

1998 Elemental Carbon as a Percentage of Total PM10

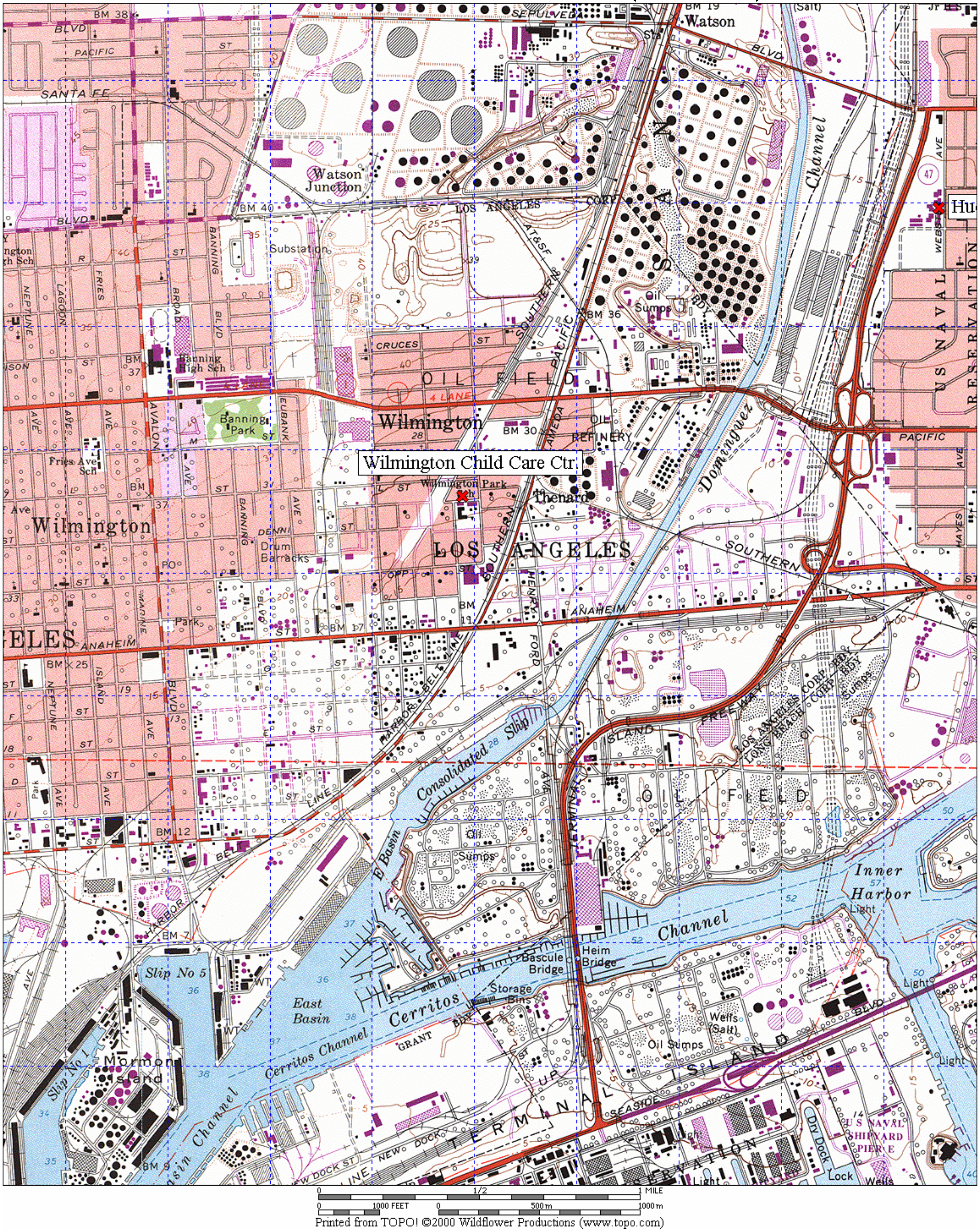
Location	11/1/98	11/7/98	11/13/98	11/19/98	11/25/98	12/13/98	Average
HUD	10.2%	11.1%	23.1%	22.2%	*	16.2%	16.5%
EDI	8.6%	6.7%	13.7%	17.1%	10.7%	10.5%	11.2%
WIL	7.6%	8.8%	13.1%	14.0%	9.4%	10.3%	10.6%



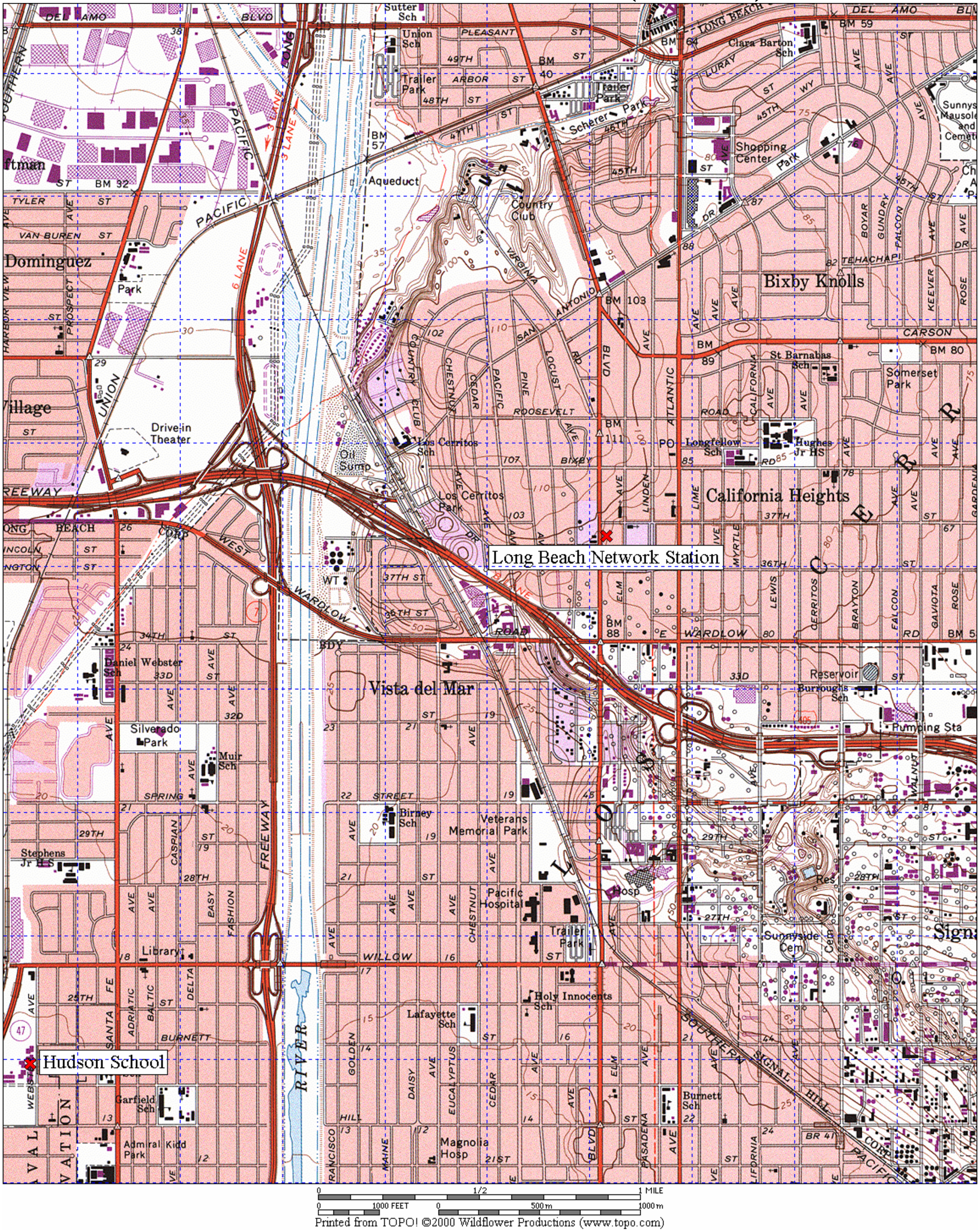
Hudson School and Surrounding Area



Edison School and Surrounding Area



Wilmington Childcare Center and Surrounding Area



Long Beach Station and Surrounding Area