POST-CONSTRUCTION AIR QUALITY MONITORING FOR M 99 IN LANSING

MICHIGAN DEPARTMENT OF TRANSPORTATION

TESTING AND RESEARCH DIVISION
RESEARCH LABORATORY SECTION

POST-CONSTRUCTION AIR QUALITY MONITORING FOR M 99 IN LANSING

Research Laboratory Section
Testing and Research Division
Research Project 79 TI-564
Research Report No. R-1199

Lansing, July 1982

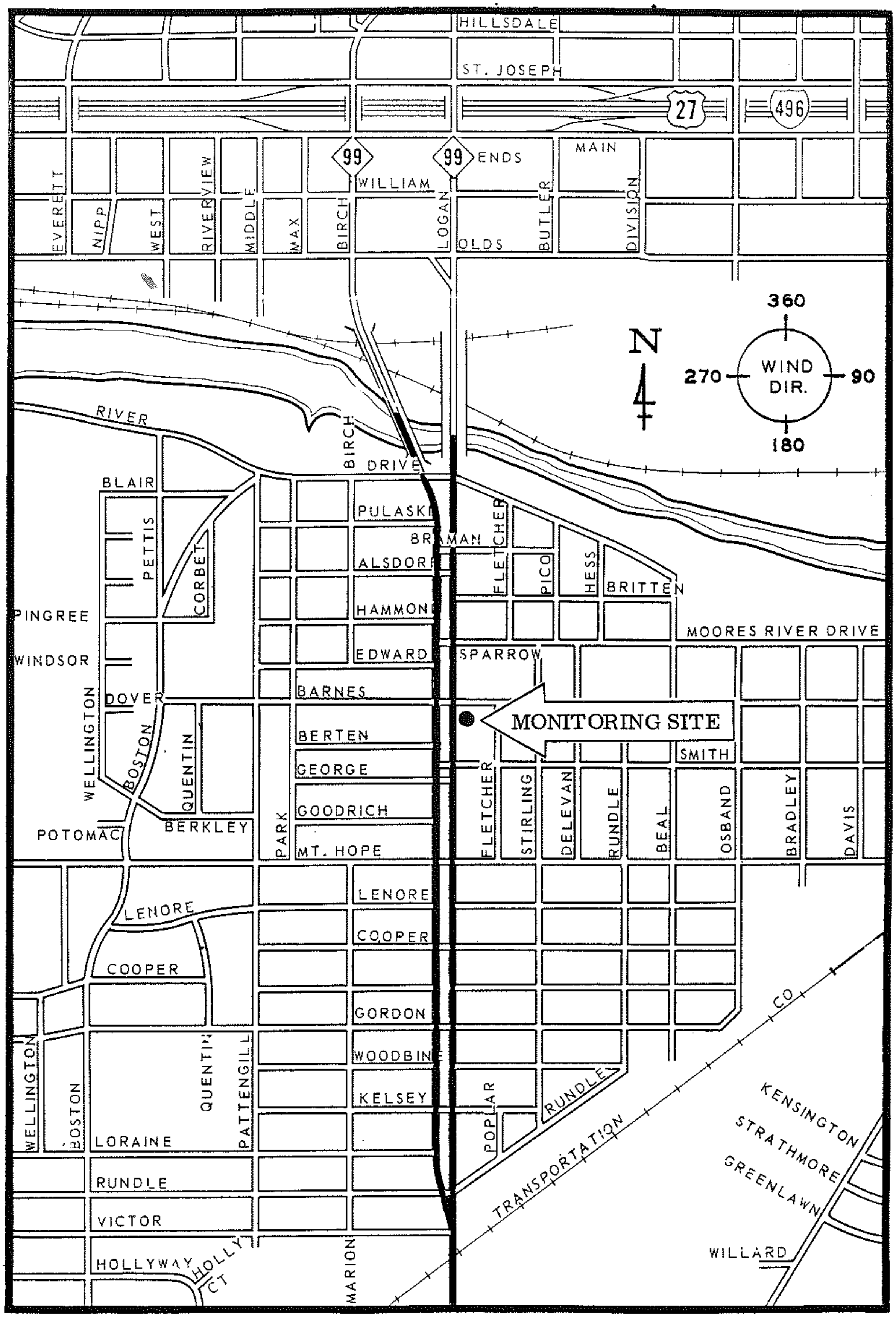

Figure 1. M 99 (Logan St) in the City of Lansing.

structures, 4) accessible to electrical power, 5) adequately secure, and 6) the property owner was cooperative.

A three to four month monitoring period is generally considered a minimum duration for adequate air quality monitoring. Scheduling conflicts involving the property owner's business at the site and our own monitoring priorities preempted performing the monitoring for one continuous period, thus two periods were required. Period 1 monitoring (March 14 to April 26, 1979) was performed with the Department's mobile air quality monitoring van while Period 2 monitoring (February 3 to March 31, 1981) was performed with a trailer unit. The second period was needed to ensure inclusion of high carbon monoxide winter conditions.

Carbon monoxide and meteorological data (wind speed and direction) were recorded every five minutes, 24 hours a day. The five-minute readings were reduced to one-hour and eight-hour averages. The 10 highest one-hour averages of carbon monoxide, along with the date of occurrence, hour of the day, wind speed, wind direction, and ambient temperature for both periods are shown in Table 1. The data in Table 1 show that 90 percent of the 10 highest one-hour carbon monoxide levels occurred during or near the a.m. peak hour (7:15 to 8:15), 70 percent occurred when the wind was blowing from a westerly direction (225 to 315 degrees) across M 99 toward the monitor, and 70 percent occurred when the wind speed was 3 mph or less. The inset, upper right, in Figure 1 shows the method used to designate wind direction.

The remaining carbon monoxide data show:

1) 99 percent of 1,869 total one-hour averages were 5 mg/cu m or less,

2) 68 percent of the 5 mg/cu m or higher levels occurred between 7:00 and 9:00 a.m.,

3) 57 percent of the 5 mg/cu m or higher levels occurred when the wind speed was 3 mph or less.

The 10 highest eight-hour averages of carbon monoxide along with the date of occurrence, ending hour of eight-hour period, wind speed, and wind direction, and ambient temperature for both monitoring periods are shown in Table 2. The highest eight-hour averages show essentially the same trends as the highest one-hour averages, usually included the a.m. peak traffic, occurred when the wind was blowing from a westerly direction (225 to 315 degrees) and when wind speeds were low.

TABLE 1
HIGHEST MEASURED CARBON MONOXIDE CONCENTRATIONS
ONE-HOUR AVERAGES

Date of Occurrence	Ending Hour	Carbon Monoxide, mg/cu m	Wind Direction, degrees	Wind Speed, mph	Temperature, degrees F
Period 1 - March 14 to April 29, 1979					
April 10	7	10.3	260	2	28
March 29	8	9.2	240	1	20
March 27	8	8.6	300	4	51
April 3	8	7.5	260	3	31
March 29	9	7.3	290	3	49
March 27	7	6.6	240	1	19
April 10	8	6.1	260	2	64
March 21	7	5.9	260	2	36
April 17	9	5.8	340	3	39
April 22	21	5.7	No Data	1	30
Period 2 - February 3 to March 31, 1981					
February 4	9	13.0	260	5	2
February 4	8	11.5	250	4	3
February 5	8	7.3	220	9	4
March 25	8	7.1	160	1	33
February 4	22	6.7	260	5	3
March 25	9	6.6	160	1	37
March 23	7	6.1	360	2	30
February 12	8	6.0	200	6	-4
March 3	7	5.9	290	1	23
March 24	8	5.6	360	1	31

TABLE 2
HIGHEST MEASURED CARBON MONOXIDE CONCENTRATIONS
EIGHT-HOUR AVERAGES

Date of Occurrence	Ending Hour	Carbon Monoxide, mg/cu m	Wind Direction, degrees	Wind Speed, mph	Temperature, degrees F
Period 1 - March 14 to April 29, 1979					
March 27	14	3.8	240-360	1-7	19-31
March 21	14	3.7	320-350	2-4	39-44
March 29	13	3.7	270-270	3-5	47-56
April 22	1	3.5	210-260	1-7	51-60
April 13	23	3.5	260	3-6	51-60
April 22	24	3.4	250-260	1-4	57-70
April 10	13	3.3	100-260	1-2	28-45
April 3	13	3.3	240-320	2-4	30-44
March 26	15	3.3	280-320	6-10	19-28
March 20	24	3.2	270-300	2-6	49-58
Period 2 - February 3 to March 31, 1981					
February 4	13	5.4	230-330	4-8	2-7
February 4	23	4.4	250-300	4-6	3-9
March 25	12	3.8	160-300	0-2	32-46
February 6	19	3.7	250-270	6-14	21-24
March 3	13	3.3	260-300	1-5	23-29
February 11	23	3.3	250-290	2-11	-1-9
February 9	23	3.3	220-250	3-12	14-20
February 12	13	3.2	200-210	5-8	-5-6
February 13	13	3.2	200-250	2-6	7-16
March 23	13	2.9	330-090	1-3	30-47

TABLE 3
TRAFFIC COUNTS*

M 99 - 1979						M 99 - 1981					
South of Barnes			North of Barnes			South of Barnes			North of Barnes		
Total Both Directions	North-bound	South-bound	Total Both Directions	North-bound	South-bound	Total Both Directions	North-bound	South-bound	Total Both Directions	North-bound	South-bound
31,346	15,996	15,350	34,591	18,471	16,120	29,081	14,533	14,548	31,083	15,839	15,244
(2,458)	(1,682)	(776)	(2,640)	(1,965)	(675)	(2,266)	(1,508)	(758)	(2,757)	(2,014)	(743)
[3,081]	[1,419]	[1,662]	[3,661]	[1,489]	[2,172]	[2,598]	[1,006]	[1,592]	[2,790]	[1,074]	[1,716]
<1,250>	<640>	<610>	<1,380>	<740>	<640>	<1,160>	<580>	<580>	<1,240>	<630>	<610>

Barnes Ave - 1979		Barnes Ave - 1981	
West of M 99 Total Both Directions	East of M 99 Total Both Directions	West of M 99 Total Both Directions	East of M 99 Total Both Directions
2,446	2,499	2,298	2,020
(285)	(198)	(301)	(176)
[253]	[290]	[211]	[208]
<98>	<100>	<92>	<80>

* Estimated average speed through intersection 10 mph, 12 percent commercial traffic.
000 24 hr volume
(000) a.m. peak traffic
[000] p.m. peak traffic
<000> off-peak traffic (4 percent of 24 hr volume)

All one-hour and eight-hour carbon monoxide averages are easily within Federal air quality standards (one-hour - 40 mg/cu m; eight-hour - 10 mg/cu m).

Traffic Counts

Traffic volume counts were performed adjacent to the Barnes Ave - M 99 intersection by the Transportation Planning Division on February 14 and 15, 1979 for a 24-hour period beginning at 11:00 a.m. on February 14, and on March 17 and 18, 1981 beginning at 1:00 p.m. on March 17. Traffic counters were located 100 ft north and 100 ft south of Barnes Ave on both the northbound and southbound roadways. Counters were also located on Barnes Ave 100 ft east of M 99 and 100 ft west of M 99. Volumes were recorded every 15 minutes during each period. The volumes presented in Table 3 are summarized into total and directional 24-hour volumes, one-hour volumes (off-peak traffic), and the highest a.m. and p.m. hour volumes.

The data show: 1) volumes on M 99 recorded north of Barnes Ave, which reflect Barnes Ave turning movements, are higher than volumes recorded south of Barnes Ave; 2) the M 99 p.m. peak hour volume is higher than the a.m. peak hour volume; and, 3) the M 99 a.m. peak hour occurs between 7:15 and 8:15, the p.m. peak hour occurs between 4:30 and 5:30. Traffic volumes for 1981 are lower than 1979 volumes.

Carbon Monoxide Calculations

Carbon monoxide concentrations were estimated for the monitoring site near the intersection of reconstructed M 99 and Barnes Ave using the CALINE 3 line source dispersion model. Input parameters to the model consisted of:

1) Vehicle emission factors calculated at 30 F using "Mobile Source Emission Factors," March 1978, U. S. Environmental Protection Agency.

2) Peak a.m. and p.m. hour traffic volumes and speeds (Table 3). The CALINE 3 model was run at traffic speeds of 10, 8, and 7 mph to simulate various degrees of stop and go traffic as might occur at an intersection during peak traffic hours. The estimated average peak traffic speed used in calculations for comparison with measured values was 10 mph.

3) Meteorological conditions. The CALINE 3 model was run at several wind angles (0, 10, 20, etc.) to the roadways to determine the angle which

TABLE 4
HIGHEST CALCULATED ONE-HOUR CARBON MONOXIDE CONCENTRATIONS FROM THE ROADWAY

Wind Direction, degrees	Wind Angle to M 99	For 1979 Traffic and Emission Factors, mg/cu m	For 1981 Traffic and Emission Factors, mg/cu m
270	90	7.7	5.3
280	80	8.4	5.5
290	70	8.8	5.7
300	60	9.7	6.4
310	50	9.7	6.4
320	40	10.3	7.2
330	30	10.6	7.6
340	20	9.7	7.6
350	10	7.3	6.6
360	0	4.2	3.6

TABLE 5
HIGHEST CALCULATED EIGHT-HOUR CARBON MONOXIDE CONCENTRATIONS FROM THE ROADWAY

Wind Direction, degrees	For 1979 Traffic and Emission Factors, 30 F, mg/cu m	For 1981 Traffic and Emission Factors, 30 F, mg/cu m
270	1.9	1.4
280	2.1	1.4
290	2.2	1.5
300	2.3	1.7
310	2.3	1.6
320	2.6	1.8
330	2.7	1.9
340	2.5	1.8
350	2.0	1.4
360	1.1	0.7

produced the highest carbon monoxide level at the monitoring site. A low wind speed of 2.2 mph (1 m/sec) under atmospheric stability class D* was used with all wind angles.

4) Roadway geometry. M 99, two 40-ft north-south roadways separated by a 60 ft median; Barnes Ave, one 30-ft east-west roadway. All roadways are at grade.

5) Surface roughness. A value of 108 cm was used, representing city land use with predominantly single family residential.

6) Mixing height - 100 m. This represents the height to which vertical mixing of the atmosphere is occurring. The value of 100 m is not favorable for dispersion of pollutants.

Table 4 presents calculated estimates of one-hour carbon monoxide concentrations for the following conditions:

1) A distance of 12 meters from the outside traffic lane of M 99 and 12 meters from Barnes Ave. The distance from each of the roadways to the sample intake of the air quality monitoring laboratory was 12 meters.

2) For a traffic speed of 10 mph.

3) And for wind directions northwest of M 99 (winds quartering across M 99 and Barnes Ave toward the mobile monitoring laboratory).

Table 5 presents estimates of eight-hour carbon monoxide levels calculated from one-hour concentrations using a technique described in a

---

* The atmospheric stability class describes the amount of vertical movement of air near the earth's surface due to temperature differentials. During periods of bright sunlight the earth's surface is heated and warm air close to the earth's surface rises, carrying any pollutants present with it. This is an unstable condition which aids in dispersing pollutants. When there is no upward movement of warm air away from the earth's surface, the atmosphere is considered stable. A stable atmosphere tends to increase pollutant concentrations because dispersal of pollutants is impaired. Atmospheric stability classification is based on six classes varying from Stability A defined as an extremely unstable condition to Stability F defined as a moderately stable condition. Stability D is defined as a neutral condition. This is the condition most prevalent in Michigan (approximately 50 to 60 percent of the time).

Federal Highway Administration report, "Project Level Considerations to Assure Adequate Air Quality Analysis," June 1977. The technique is as follows:

$$\frac{V_8}{V_1} \times \text{(1-hr CO concentration)} \times P = \text{8-hr CO concentration}$$

where: V_8 = average hourly traffic volume in both directions during the eight-hour period of interest

V_1 = peak hour traffic volume in both directions

P = one to eight-hour meteorological persistence factor for the eight-hour period.

A value of P = 0.6 is suggested unless data are available to calculate a persistence factor. No data were available to calculate a persistence factor for the project area.

A typical calculation follows:

$$\text{8-hr avg.} = \frac{\text{640 vehicles per hour}}{\text{1,682 vehicles per hour}} \times 3.1 \text{ mg/cu m} \times 0.6 = 0.7 \text{ mg/cu m}$$

Background Carbon Monoxide Levels

The monitoring data include background levels—carbon monoxide already in the ambient air before the air picked up any pollutants from M 99. These background levels were estimated by examining the monitoring data for those wind directions between 45 and 165 degrees and wind speeds of 5 mph or greater. These winds come from east of M 99 with sufficient speed to sweep pollutants from the highway away from the monitor. The following table shows the highest background levels for the 1979 and 1981 data.

Year	One-Hour	Eight-Hour
1979	3.0 mg/cu m	1.8 mg/cu m
1981	2.1 mg/cu m	1.6 mg/cu m

These must be added to the estimated concentrations from the roadway to make comparisons with the highest measured carbon monoxide concentrations.

Comparison of Measured and Calculated Carbon Monoxide Levels

The highest calculated (background added) and measured carbon monoxide levels are shown below. The two highest measured one-hour averages, 13.0 and 11.5 mg/cu m, and the highest eight-hour averages for the 1981 data were due to congested traffic caused by a snow storm. The highest value recorded during more normal traffic is shown in parentheses.

Year	One-Hour Averages, mg/cu m		Eight-Hour Averages, mg/cu m	
	Measured	Calculated	Measured	Calculated
1979	10.3	13.6	3.8	4.5
1981	13.0 (7.3)	9.7	5.4 (3.8)	3.5

Except for the unusually high measured values during congested 1981 traffic, the calculated values are in good agreement with or are higher than the measured values. The model is designed to yield estimates that will be slightly higher than measured values. Calculations for traffic speeds lower than 10 mph revealed that the 7 mph estimates agreed with the concentrations measured during congested snow storm traffic.

Conclusions

The CALINE 3 model, coupled with EPA vehicle emission factors (Mobile I) produced estimates of carbon monoxide concentrations in agreement with or above measured concentrations for normal traffic flow. The model correctly indicates that observed carbon monoxide levels will be below the Federal air quality standards adjacent to M 99 in Lansing.

These results indicate that the model will also perform acceptably for other at-grade Michigan highways in similar terrain.