AIR QUALITY REPORT FOR DAVISON FREEWAY, CITY OF HIGHLAND PARK, WAYNE COUNTY

MICHIGAN DEPARTMENT OF
STATE HIGHWAYS AND TRANSPORTATION

AIR QUALITY REPORT FOR DAVISON FREEWAY, CITY OF HIGHLAND PARK, WAYNE COUNTY

Research Laboratory Section
Testing and Research Division
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Research Report No. R-1023

Michigan State Highway Commission
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This report presents air quality information for a proposed section of the Davison Freeway in the city of Highland Park, Wayne County as shown in Figure 1. Meteorological data, and estimates of pollution levels that might occur adjacent to the roadway should it be constructed, are included.

Terrain and Demography

The proposed project is located in a highly developed residential-commercial area. The terrain surrounding the project is generally flat with no tall buildings or structures in the immediate vicinity which might hinder dispersion of pollutants.

Meteorology

Michigan lies in the normal track of migrating high and low pressure centers at all times of the year. This results in great variation in day to day weather. Frequent changes in wind speed and direction are experienced. Daily weather data recorded every third hour at Detroit City Airport were obtained from the National Climatic Center in Asheville, N. C. for the years 1967 through 1973. Figure 2 shows a 36-point bar graph of wind speed and direction occurrences. Figure 3 is a 12-point wind rose obtained by condensing the 36-point wind data.

Figure 4 shows the distribution of wind speeds observed. Wind speeds are greater than 4 mph more than 95 percent of the time. The most probable daytime wind speed was found to be 11 mph.

According to air pollution publication AP 101, U. S. Environmental Protection Agency, 1972, atmospheric mixing depths in lower Michigan are generally between 500 and 1,200 meters (547 to 1,300 yd) which is very favorable for dispersion of air pollutants.

Existing Ambient Air Quality

Existing background carbon monoxide levels were measured with the Department's mobile air pollution laboratory near the proposed project during the months of July, August and September 1976. The van was located south and west of the intersection of the Davison Freeway and I 75 as shown in Figure 1.

The hourly average background concentration of carbon monoxide was found to be 2 mg/cu m or less, 95 percent of the time and 3 mg/cu m or less, 96.5 percent of the time. Out of a data base of 543 hourly averages

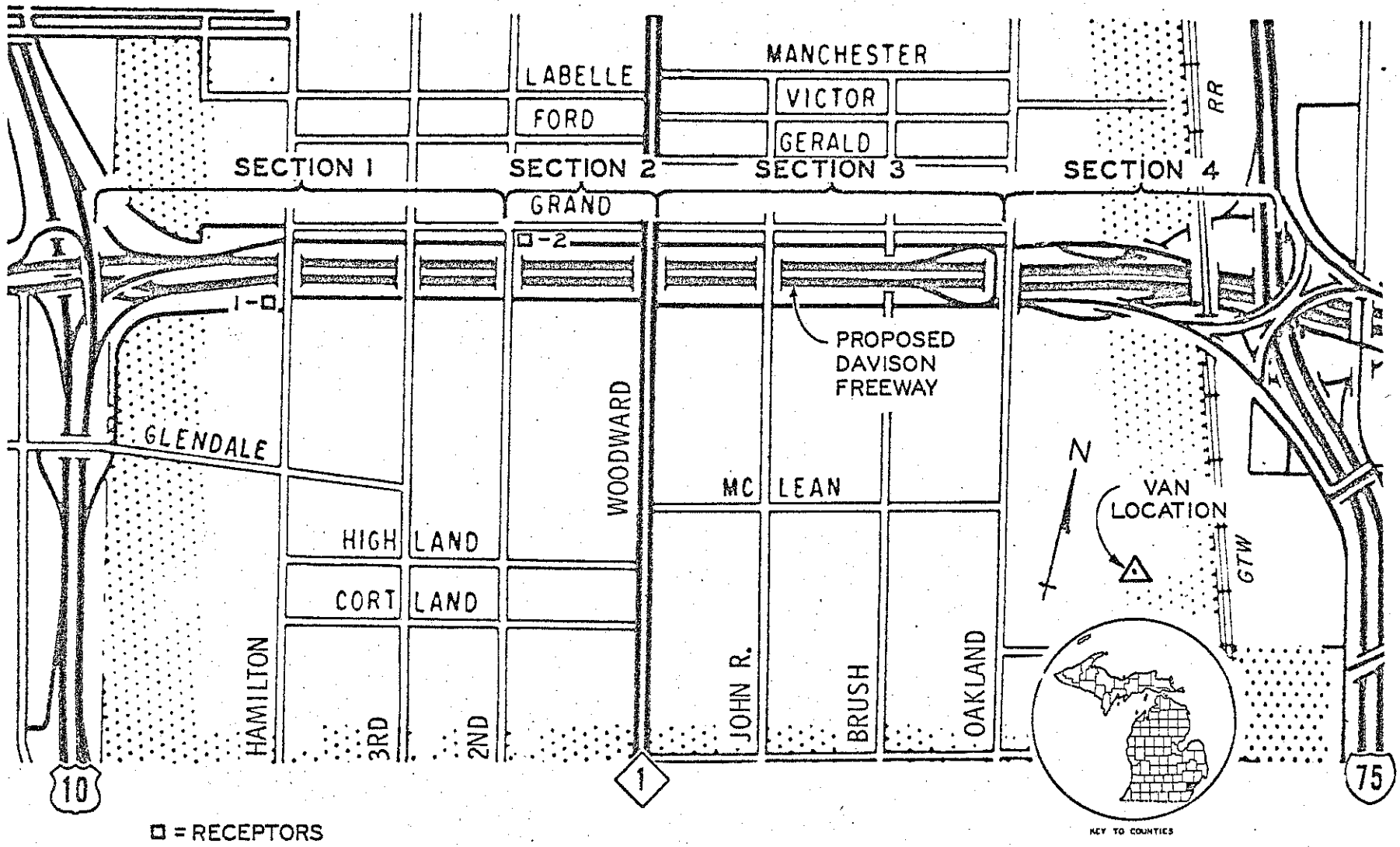

Figure 1. Proposed Davison Freeway, city of Highland Park.

only 20 averages were 4 mg/cu m or greater. All of these are shown in the following table.

Date	Hour of the Day	Carbon Monoxide, mg/cu m
August 3, 1976	0900	4
August 4, 1976	0900	4
August 25, 1976	0800	4
August 25, 1976	0900	4
August 26, 1976	0900	4
September 3, 1976	0800	7
September 3, 1976	0900	6
September 7, 1976	1800	4
September 7, 1976	1900	4
September 8, 1976	0900	4
September 8, 1976	2100	4
September 8, 1976	2200	6
September 8, 1976	2300	8
September 8, 1976	2400	7
September 9, 1976	0100	5
September 9, 1976	0600	5
September 9, 1976	0900	7
September 9, 1976	1000	5
September 9, 1976	1700	5
September 9, 1976	1800	4

The three highest 8-hour averages are as follows:

1. Highest 8 hour period September 8, 1976, 2100 hours to September 9, 1976, 0400 hours, average 4.9 mg/cu m.

2. Second highest 8 hour period September 9, 1976, 0500 hours to September 9, 1976, 1200 hours, average 3.3 mg/cu m.

3. Third highest 8 hour period August 2, 1976, 2400 hours to August 3, 1976, 0700 hours, average 2.8 mg/cu m.

Pollution Estimates

Estimates of carbon monoxide concentrations were made at a height of 1.5 meters (5 ft) above the roadway. A mathematical model based on the

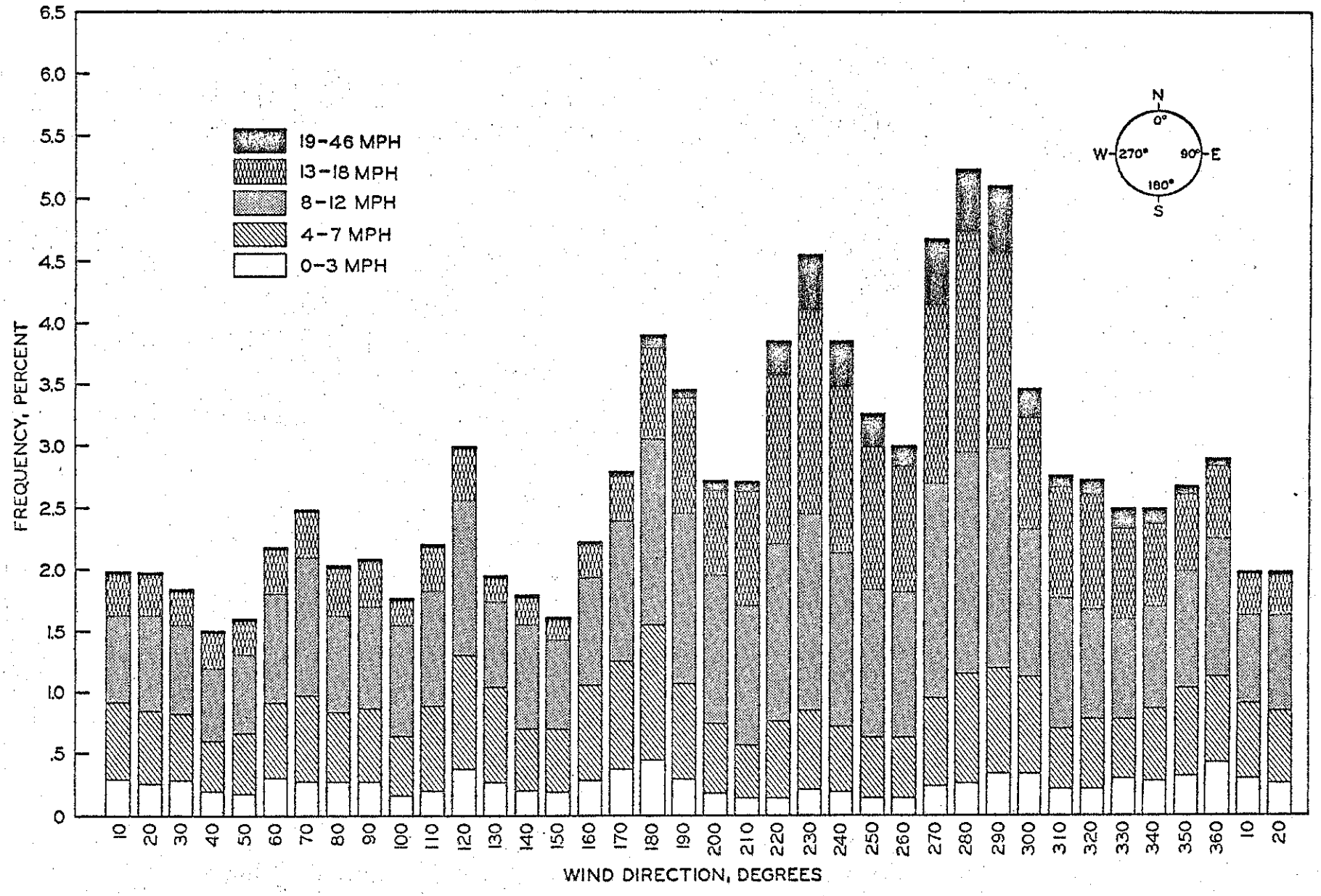

Figure 2. Wind speed and direction occurrences at Detroit City Airport.

Gaussian diffusion equation, modified for a line source, was used[1]. Inputs to the model include meteorological conditions, traffic volumes, vehicle emission factors and design of the highway.

Estimates of nitrogen dioxide concentrations are not included in this report because, while the National air quality standard is for nitrogen dioxide (NO_2), the mixture of nitrogen oxides (NO_x) emitted by vehicles consists largely of nitric oxide (NO) with less than five percent of the nitrogen oxides emitted as NO_2, according to Federal EPA data. Subsequent to being emitted from the tailpipe, NO may be converted to NO_2 at varying rates, depending on atmospheric conditions. There is no air quality standard for NO, which is much less toxic than NO_2. Thus, there is no meaningful way of comparing vehicle exhaust emissions with the air quality standard for NO_2.

Carbon monoxide concentrations were estimated for:

1) Four representative sections which covered the length of the project. See Figure 1 for the location of the sections which are identified as follows:

Section	Location
1	US 10 to Second Ave
2	Second Ave to Woodward Ave
3	Woodward Ave to Oakland Ave
4	Oakland Ave to I 75

2) Six major crossroads - Hamilton Ave, Third Ave, Second Ave, Woodward Ave, John R St, Oakland Ave (Fig. 1).

3) The years 1980, 1985, and 2000.

4) The area above the pavement and at two receptors near the proposed roadway.

[1] Beaton, J. L., Ranzieri, A. J., Shirley, E. C., and Skog, J. B., "Mathematical Approach to Estimating Highway Impact on Air Quality," Prepared by California Division of Highways, Report No. FHWA-RD-72-36. CALINE 2 modification, programmed March 1975, was used.

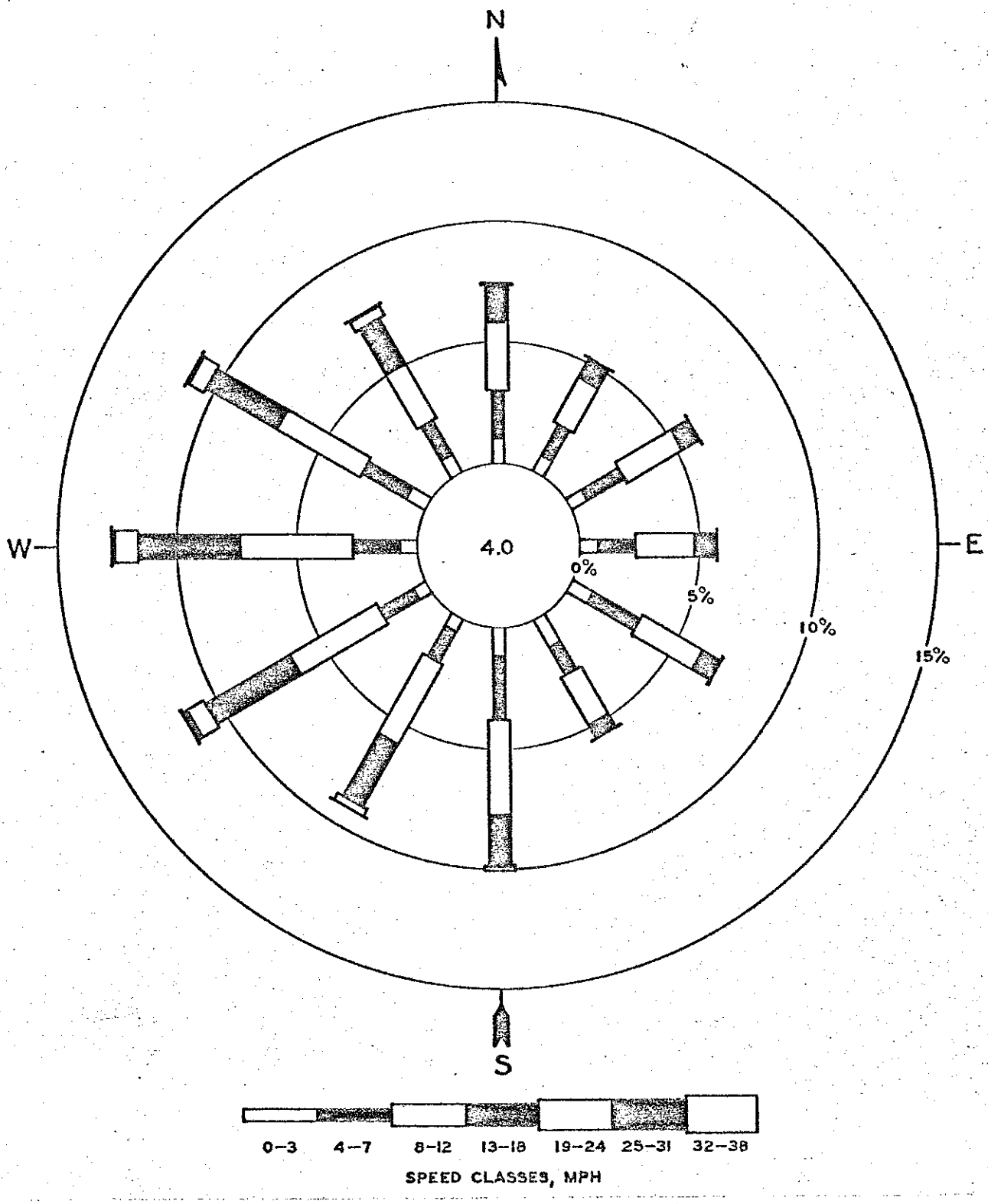

Figure 3. Frequency of wind direction and speed, percent (calms distributed).

Information used as input to the model consisted of:

1) Vehicle emission factors shown in the following table were calculated using procedures from "Compilation of Air Pollutant Emission Factors," AP 42, Supplement No. 5, December 1975 edition, U. S. Environmental Protection Agency. Emission factors were calculated at a temperature of 60 F with 10 percent of vehicles in a cold start condition, 10 percent of vehicles in a hot start condition, and the remainder of vehicles in a hot operation mode. Vehicle age mix data used were for Michigan registrations obtained from the Secretary of State. National estimates from AP 42 for average annual miles driven for various age vehicles were used.

EMISSION FACTORS FOR
CARBON MONOXIDE, g/mi

Year	Average Vehicle Speed, mph				
	25 (4)	25 (6)	30 (5)	45 (5)	55 (11)
1980	18.7	21.0	16.1	10.4	12.2
1985	8.4	10.5	7.7	4.9	7.1
2000	6.5	8.3	6.0	3.9	5.8

(00) Percent heavy duty vehicles.

2) Estimated peak traffic (4:00 to 5:00 p.m.) and off-peak traffic volumes. Traffic estimates are shown in Tables 1 and 2. Off-peak traffic was taken as 4 percent of ADT.

3) Meteorological Conditions

a) Worst meteorological conditions were taken as a 3 mph wind parallel to the roadway, under atmospheric stability class E.

b) Most probable meteorological conditions for the afternoon - an 11 mph wind at 280 degrees under atmospheric stability class D. Table 3 shows the frequency distribution of atmospheric stability classes for the meteorological data used.

4) Road Profile. All sections are depressed 20 ft with service roads at grade.

TABLE 1

TRAFFIC ESTIMATES FOR PROPOSED DAVISON FREEWAY RECONSTRUCTION

Year	Section 1			Section 2			Section 3			Section 4		
	Freeway	Service Rd		Freeway	Service Rd		Freeway	Service Rd		Freeway	Service Rd	
		Westbound	Eastbound		Westbound	Eastbound		Westbound	Eastbound		Westbound	Eastbound
1980	88,000 ⟨7,760⟩ [3,520]	3,700 ⟨260⟩ [150]	3,700 ⟨260⟩ [150]	80,000 ⟨7,090⟩ [3,200]	8,800 ⟨620⟩ [350]	8,800 ⟨700⟩ [350]	80,000 ⟨7,090⟩ [3,200]	6,600 ⟨470⟩ [265]	6,600 ⟨470⟩ [265]	59,900 ⟨4,980⟩ [2,395]	12,500 ⟨1,460⟩ [500]	12,500 ⟨940⟩ [500]
1985	103,400 ⟨9,010⟩ [4,140]	4,300 ⟨310⟩ [170]	4,300 ⟨310⟩ [170]	94,000 ⟨8,240⟩ [3,760]	10,200 ⟨750⟩ [410]	10,200 ⟨820⟩ [410]	94,000 ⟨8,240⟩ [3,760]	7,800 ⟨550⟩ [310]	7,800 ⟨550⟩ [310]	70,300 ⟨5,780⟩ [2,815]	14,500 ⟨1,620⟩ [580]	14,500 ⟨1,040⟩ [580]
2000	149,800 ⟨12,650⟩ [5,990]	6,300 ⟨430⟩ [250]	6,300 ⟨430⟩ [250]	136,000 ⟨11,550⟩ [5,440]	14,600 ⟨1,040⟩ [585]	14,600 ⟨1,160⟩ [585]	136,000 ⟨11,550⟩ [5,440]	11,100 ⟨770⟩ [445]	11,100 ⟨770⟩ [445]	101,700 ⟨8,070⟩ [4,070]	20,300 ⟨2,250⟩ [810]	20,300 ⟨1,440⟩ [810]

Commercial vehicles - freeway, all sections, 5 percent of peak, 11 percent of off-peak - service roads, all sections, 3 percent of peak, 5 percent of off-peak.

Vehicle speeds - freeway, all sections, peak 45 mph, off-peak 55 mph - service roads, all sections, peak 30 mph, off-peak 35 mph.

Freeway traffic volumes are totals for both directions.

000 = Average daily traffic, vehicles in 24 hr

⟨000⟩ = p.m. peak traffic, vehicles per hr

[000] = Off-peak traffic, vehicles per hr

TABLE 2
TRAFFIC ESTIMATES FOR MAJOR CROSSROADS

Year	Hamilton Ave	Third Ave	Second Ave	Woodward Ave	John R St	Oakland Ave
1980	28,700 ⟨2,430⟩ [1,210]	3,800 ⟨360⟩ [150]	3,400 ⟨350⟩ [140]	40,200 ⟨3,420⟩ [1,740]	4,000 ⟨450⟩ [160]	14,400 ⟨1,900⟩ [720]
1985	33,000 ⟨2,650⟩ [1,320]	4,200 ⟨380⟩ [170]	3,700 ⟨370⟩ [150]	47,800 ⟨3,740⟩ [1,910]	4,500 ⟨510⟩ [180]	19,600 ⟨2,060⟩ [780]
2000	41,800 ⟨3,320⟩ [1,670]	5,200 ⟨450⟩ [210]	4,600 ⟨440⟩ [180]	60,400 ⟨4,700⟩ [2,420]	5,600 ⟨610⟩ [220]	25,200 ⟨2,650⟩ [1,010]

Commercial vehicles - all streets except Oakland Ave, 4 percent of peak, 6 percent of off-peak - Oakland Ave, 6 percent of peak, 12 percent of off-peak.
Vehicle speeds - peak, 25 mph - off-peak, 30 mph.
Traffic volumes are totals for both directions.

000 = Average daily traffic, vehicles in 24 hr
⟨000⟩ = p.m. peak traffic, vehicles per hr
[000] = Off-peak traffic, vehicles per hr

5) Roadway Width. All sections, two 48-ft roadways with shoulders, separated by a 26-ft median. The service roads are two 33-ft roadways.

All estimates of carbon monoxide levels represent maximum one hour concentrations and are in addition to existing background levels. Table 4 presents estimates of carbon monoxide in the area over the freeway pavement. Table 5 presents estimated carbon monoxide levels above the intersections of the proposed freeway and the major crossroads.

Comparison of Estimates with Air Quality Standards

a) 8 hr carbon monoxide air quality standard - 10 mg/cu m (9 ppm)

If for 1980 the highest carbon monoxide levels from the roadway are used (Section 1), and an 8-hour period is taken as two peak hours of 9.8

mg/cu m and six off-peak hours of 5.7 mg/cu m, the 8-hour average carbon monoxide concentration from the roadway is 6.7 mg/cu m. Adding this concentration to the 1 to 3 mg/cu m estimated background, results in a total carbon monoxide concentration of 7.7 to 9.7 mg/cu m, which is below the air quality standard. For the years 1985 and 2000 the carbon monoxide concentrations are estimated to be much lower than the 1980 concentrations due to a larger percentage of exhaust controlled vehicles required by Federal law.

TABLE 3
STABILITY CLASS FREQUENCY DISTRIBUTION BY HOUR
(Percent)

Hour	Stability Class					
	A	B	C	D	E	F
1	0.0	0.0	0.0	50.8	19.8	29.5
4	0.0	0.0	0.0	50.4	19.5	30.1
7	10.6	14.4	9.4	50.3	8.3	7.0
10	4.4	14.9	22.3	58.5	0.0	0.0
13	1.8	9.2	23.0	66.1	0.0	0.0
16	1.2	7.5	23.1	66.1	1.9	0.2
19	0.0	0.0	0.0	66.7	23.7	9.7
22	0.0	0.0	0.0	53.2	22.8	24.0
Overall percent	2.2	5.7	9.7	57.8	12.0	12.6

b) One-hour carbon monoxide air quality standard - 40 mg/cu m (36 ppm)

The maximum estimated one hour concentration of carbon monoxide is 9.8 mg/cu m from the roadway plus 8 mg/cu m (the maximum ambient value measured) for a total of 17.8 mg/cu m. This is far below the 40 mg/cu m standard.

The estimated concentrations of carbon monoxide, including existing background, above and near the proposed roadway are within National air

TABLE 4
ESTIMATES OF CARBON MONOXIDE
CONCENTRATIONS FROM THE ROADWAY [1]
(Not Including Background)

Location	Traffic Projection Year	CO (mg/cu m)			
		Worst Condition, Stability E, Parallel Wind, 3 mph		Most Probable Condition,[2] Stability D	
		Peak Traffic	Off-Peak Traffic	Peak Traffic	Off-Peak Traffic
Section 1	1980	9.8	5.7	1.3	0.8
	1985	5.4	3.9	0.7	0.5
	2000	5.9	4.6	0.8	0.7
Section 2	1980	8.9	5.1	1.2	0.7
	1985	5.0	3.5	0.7	0.4
	2000	5.4	4.3	0.7	0.5
Section 3	1980	8.9	5.1	1.2	0.7
	1985	5.0	3.5	0.7	0.4
	2000	5.4	4.3	0.7	0.5
Section 4	1980	6.3	3.8	0.8	0.5
	1985	3.5	2.6	0.5	0.3
	2000	3.8	3.2	0.5	0.4

[1] Average vehicle speeds are reported in Table 1.
[2] Most probable wind speeds - 11 mph off-peak, 12 mph peak, angle between wind direction and roadway direction - all sections 30°.

quality standards. No adverse environmental effects are expected. The project is consistent with the State implementation plan for meeting National air quality standards.

Additional Information for Receptor Sites

Concentrations of carbon monoxide were estimated at one school and one church near the proposed route (Fig. 1). The locations are as follows:

1. Francis E. Willard School located on Hamilton Ave approximately 30 ft south of the proposed route.

TABLE 5
ESTIMATES OF CARBON MONOXIDE CONCENTRATIONS*
ABOVE MAJOR INTERSECTIONS (mg/cu m)
(Not Including Background)

Location	Traffic Projection Year	Worst Condition, 3 mph Wind Parallel to Proposed Roadway and 90° to Crossroad, Stability E, Peak Traffic
Hamilton Ave	1980	11.6
	1985	6.4
	2000	6.9
Third Ave	1980	10.6
	1985	5.9
	2000	6.4
Second Ave	1980	10.6
	1985	5.9
	2000	6.4
Woodward Ave	1980	12.2
	1985	6.8
	2000	7.3
John R St	1980	10.8
	1985	6.1
	2000	6.6
Oakland Ave	1980	11.6
	1985	6.6
	2000	7.1

* Tabular values are the sum of carbon monoxide from the freeway and the crossroad.

2. Bethany Baptist Church located on the southeast corner of Second Ave and Grand St approximately 115 ft north of the proposed route.

The following table shows estimated worst meteorological condition levels of carbon monoxide (including 3 mg/cu m background) at the above receptors. The meteorological conditions are a 3 mph wind blowing parallel to the proposed route under atmospheric stability class E. Such atmospheric conditions are seldom expected to occur.

Location	Distance From Roadway		Year		
	m	ft	1980 mg/cu m	1985 mg/cu m	2000 mg/cu m
Francis E. Willard School	9	30	10.4	7.0	7.3[1]
Bethany Baptist Church	35	115	5.4	4.3	4.5[2]

[1] Includes a 1.2, 0.6, and 0.6 mg/cu m contribution from Hamilton Ave for the years 1980, 1985, and 2000, respectively.

[2] Includes a 0.2, 0.1, and 0.1 mg/cu m contribution from Second Ave for the years 1980, 1985, and 2000, respectively.

The mathematical model used to estimate carbon monoxide levels is believed to yield values higher than those which will actually occur at any time. Even so, the highest estimated value including background is 10.4 mg/cu m, far below the peak Federal air quality standard of 40 mg/cu m. When carbon monoxide levels were estimated for the most probable conditions, off-peak traffic, an 11 mph wind and atmospheric stability class D - the highest value, including 3 mg/cu m background, at any of the receptors was only 3.8 mg/cu m. It should also be noted that after 1980 the carbon monoxide levels decrease markedly as new clean running cars replace older cars.

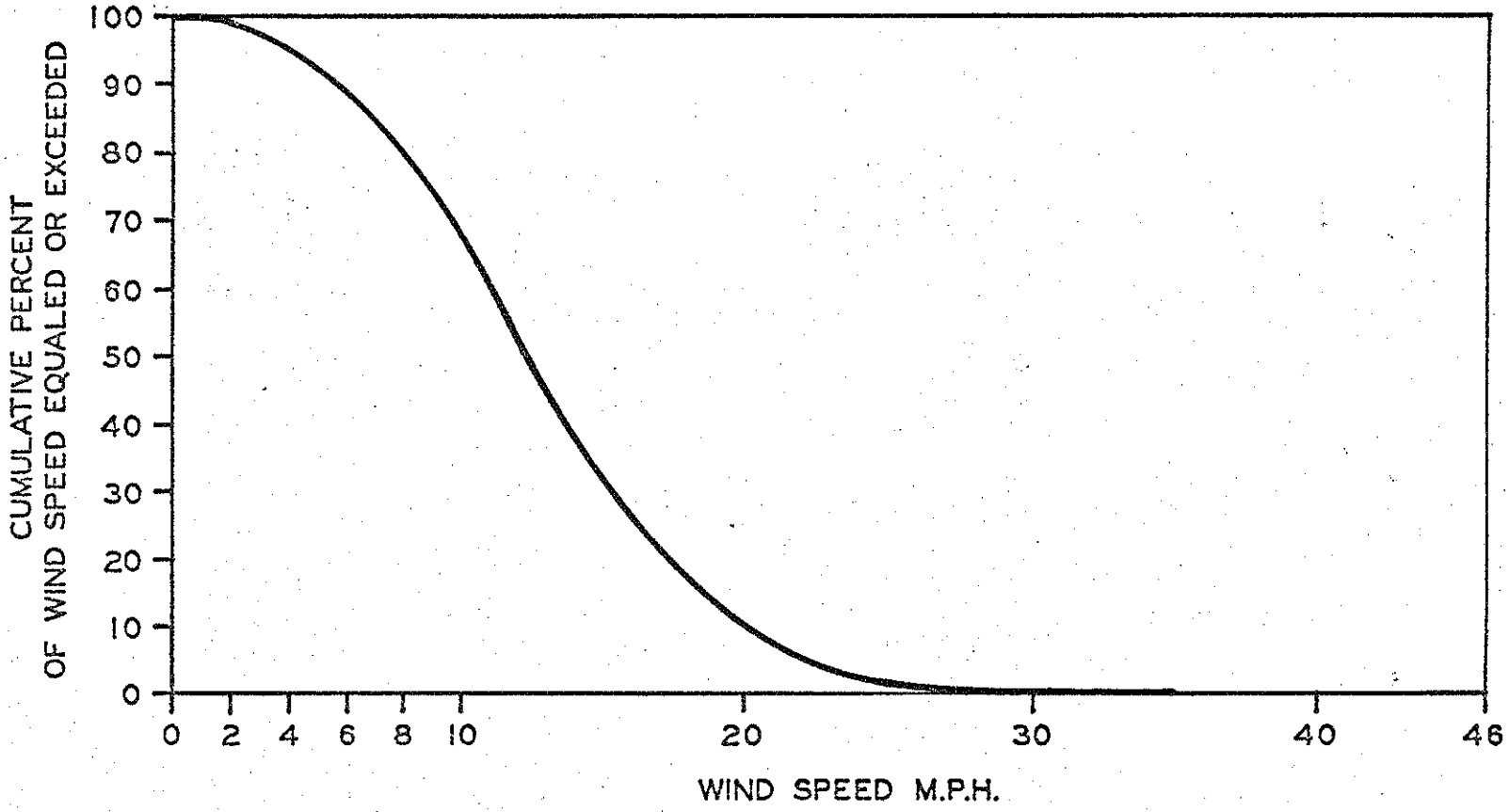

Figure 4. Wind speed distribution at Detroit City Airport.