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FREEWAY SURVEILLANCE STUDIES

1969 Annual Report

MISSOURI STATE HIGHWAY DEPARTMENT
BUREAU OF PUBLIC ROADS

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DEPARTMENT OF
JUN 29 1973

FREEWAY SURVEILLANCE STUDIES

1969 ANNUAL REPORT

STUDY 68-1

Prepared by

Missouri State Highway Department

Division of Planning

April 1970

in cooperation with

U.S. Department of Transportation
Federal Highway Administration
Bureau of Public Roads

The opinions, findings, and conclusions expressed in this publication are not necessarily those of the Bureau of Public Roads.

ABSTRACT

Results of a series of Phase I urban freeway surveillance studies conducted in the St. Louis and Kansas City areas are presented as indications of existing service levels. Aerial mosaics as well as traffic counts and capacities of Interstate 70 in St. Louis and Kansas City and Route 40 in St. Louis are used to present topographic and geometric characteristics of the study sections as well as analyses of current traffic volumes and trends, vehicular densities, and levels of service. Deficiencies ascertained by the study are presented with recommendations for their correction.

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INTRODUCTION

In the spring of 1964 the Missouri State Highway Department initiated a series of urban freeway surveillance studies. The purpose of these studies was to locate and measure the growth of congestion, to pinpoint areas needing detailed study, and to identify operational problems which could be eliminated or alleviated. It was envisioned that the results of these studies would provide justification for such operational improvements as additional lanes, ramp and interchange modifications, and traffic surveillance and control projects. To date, these investigations have been confined to the St. Louis and Kansas City Metropolitan areas.

Two types of studies have been made in order to accomplish the above mentioned objectives. Phase I studies are designed to locate and measure congestion, and to identify the areas needing further study. Detailed analyses and recommendations for elimination or alleviation of particular site problems are the products of Phase II studies.

This report covers three Phase I studies conducted during the summer of 1968.

Congestion is measured in terms of the "level of service" provided motorists during the peak hours of operation. By definition, level of service is defined by the v/c (volume/capacity) ratio and the prevailing operating speed. Whichever yields the lowest level of service governs. More on this can be found in the Appendix of this report. As stated there, it is possible to determine the level of service based on operating speed in terms of vehicular density on the freeway. Aerial photography has been used for this purpose. Traffic counts and capacities based on the 1965 Highway Capacity Manual[1] have also been used to determine levels of service. Whenever the two level of service estimates do not agree, the lowest should be assumed.

This report is divided into three major parts: Part I covers Interstate 70 in Kansas City; Part II, Interstate 70 in St. Louis; and Part III, Route 40 in St. Louis. Each part provides the following information: topographic and geometric characteristics of the study section, an analysis of current traffic volumes and trends, an analysis of vehicular densities and levels of service, a list of deficiencies, and recommendations for future action.

This is the sixth in this series of reports. Previous titles include the following:

> "Peak Hour Traffic and Congestion on the Mark Twain Expressway", Report 2-64, October 1964.

"Peak Hour Traffic and Congestion on U.S. Route 40, Daniel Boone Expressway, St. Louis, Missouri", Report 1-65, March 1965.

"1967 Freeway Surveillance Study, Southeast Freeway, Kansas City, Missouri", MCHRP Report 68-10, October 1968.

"1967 Freeway Surveillance Study, Mark Twain Expressway, St. Louis, Missouri", MCHRP Report 68-11, November 1968.

"1967 Freeway Surveillance Study, Daniel Boone Expressway, St. Louis, Missouri", MCHRP Report 68-12, December 1968.

[1] "Highway Capacity Manual, 1965, Highway Research Board Special Report 87"

PART I

INTERSTATE 70

KANSAS CITY, MISSOURI

STUDY AREA

The study section corridor is pictured in Figures A-1 and A-2. This aerial mosaic shows the most important geometric and alignment features as well as the current legal speed limits. Distances from one point to another can be readily determined from the continuous milepost markings.

Eastward from The Paseo (milepost 2.67) Interstate 70 passes through rolling terrain. Curves and grades in excess of three degrees and three percent are common and are contributing factors in the congestion found on this section.

Near the western end of the study section, Interstate 70 forms two sides of the freeway loop around the central business district. This loop is characterized by numerous on and off-ramps and inadequate weaving and merging distances. Capacity is severely reduced by the conflicts inherent in these maneuvers; however, the loop is still under construction and some relief may be afforded by the completion of the west leg and the extension of the south leg to form the Interstate 670 connection to Kansas City, Kansas.

At the present time only two changes are proposed in the number of driving lanes provided. It has been proposed that the four lane section immediately east of Grand Avenue (milepost 1.43) be increased to six lanes for continuity and increased capacity. It is also planned to expand the four lane section from Interstate 435 to Pittman Road (mileposts 8.33 to 10.02) to eight lanes to accommodate the anticipated increase in traffic adjacent to the Harry S. Truman sports complex.

TRAFFIC VOLUMES

Average annual daily traffic volumes are shown in Figures 1A, 1B, and 1C. The highest volume in the westbound lanes is 49,460 and occurs at the 14th Street Interchange, just east of the I-35 off-ramp. The highest volume in the eastbound lanes is 48,500 and occurs at the 14th Street Interchange, just east of the Troost Street on-ramp and west of the eastbound I-35 on-ramp.

Annual average daily traffic volumes at the permanent count station near Van Brunt have increased between 1967 and 1968 approximately 8% in the westbound lanes and 5% in the eastbound lanes to those volumes shown on the volume map.

An analysis indicates the peak hours are generally from 7:00 to 8:00 A.M. in the westbound lanes, and from 4:00 to 5:00 P.M. in

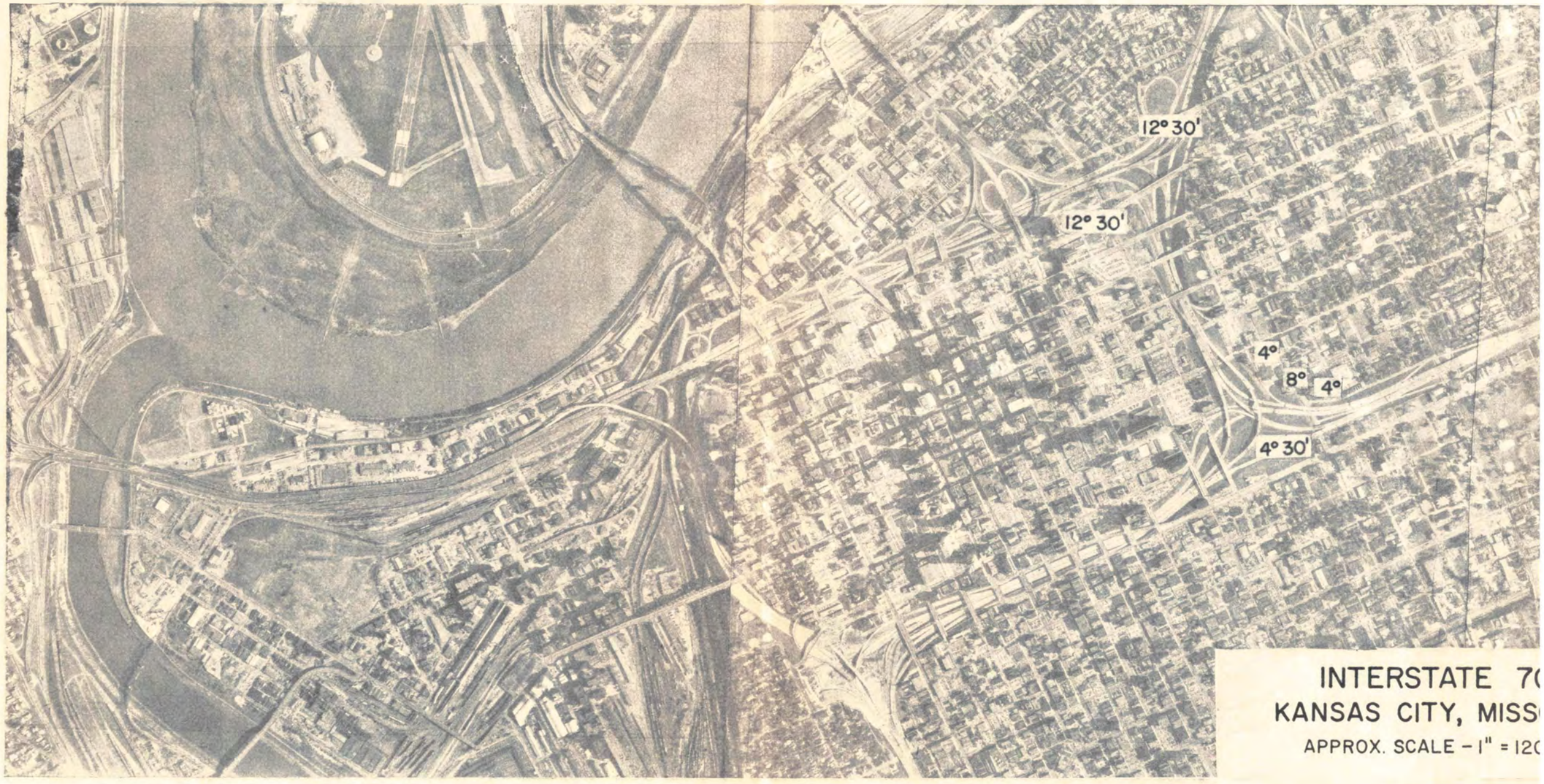
STUDY AREA

INTERSTATE 70

KANSAS CITY, MISSOURI

FIGURES A-1 AND A-2

STUDY AREA	BEGIN STUDY AREA MISSOURI-KANSAS STATE LINE	BLUFF STREET	GRAND AVENUE	THE PASEO
MILE POSTS	0.00	0.79	1.43	2.67
GRADES		+3% -3%	5% 5% 4% -5.5% WB -6% EB	
SPEED LIMITS	55 M.P.H	45 M.P.H.		55 M.P.H.
NUMBER OF LANES	3 LANES WB 4 LANES EB	3 LANES 3 LANES	PROPOSED 3LA. 2 LANES 3LA. 2LA. 3LA. 2 LANES 2 LANES 3 LA 2LA 3LA 4 2LA 3LA. PROPOSED 3LA.	



INTERSTATE 7(
KANSAS CITY, MISS(
APPROX. SCALE - 1" = 12(

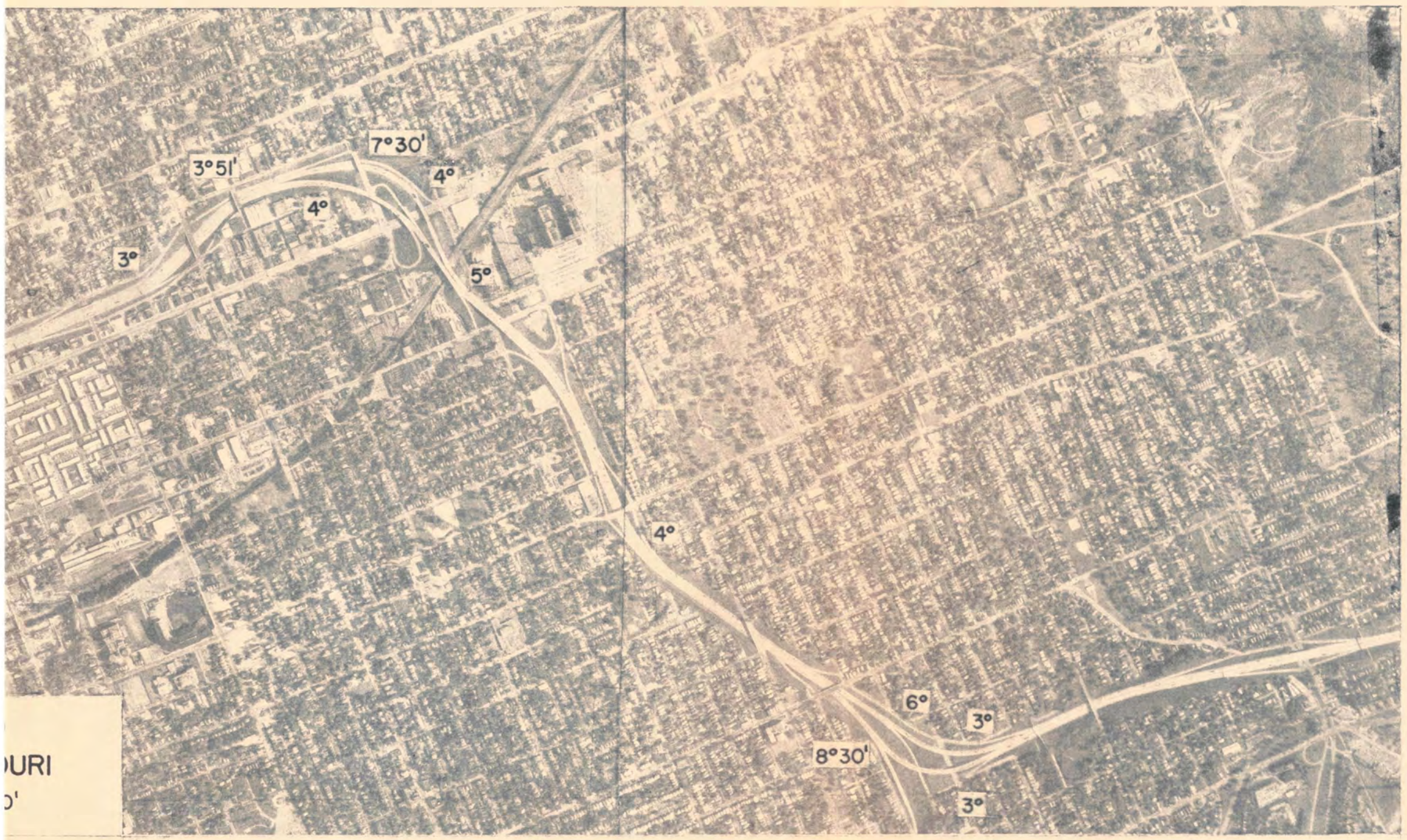
BENTON-TRUMAN 23RD STREET 27TH STREET JACKSON VAN BRUNT BLVD.

4.07 4.93 5.38 5.69 6.55

+4% -3% +3% -4% WB -3% EB -3%

55 M.P.H.

8 LANES 6 LANES



U.S. 40 | MANCHESTER | I-435 | BLUE RIDGE CUT-OFF | PITTMAN ROAD

6.98 | 7.61 | 8.33 | 9.28 | 10.02

+3.5% | +4%

55 M.P.H. | 55 M.P.H. | 70 M.P.H.

6 LANES | 4 LANES

PROPOSED 8 LANES I-435 TO PITTMAN ROAD

OLD U.S. 40 BLUE RIDGE BLVD.

11.03

+4%

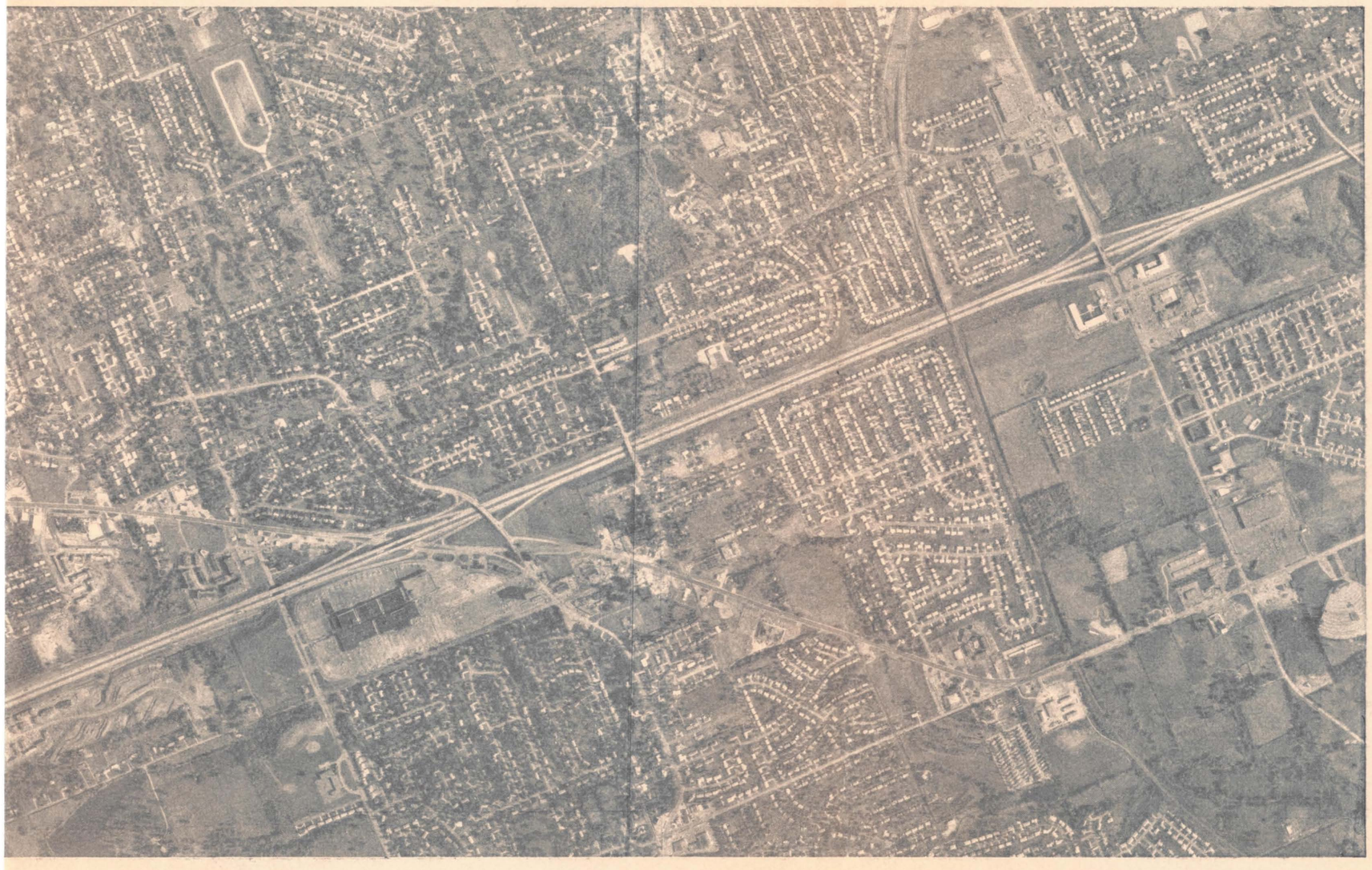
-4%

70 M.P.H.

4 LANES

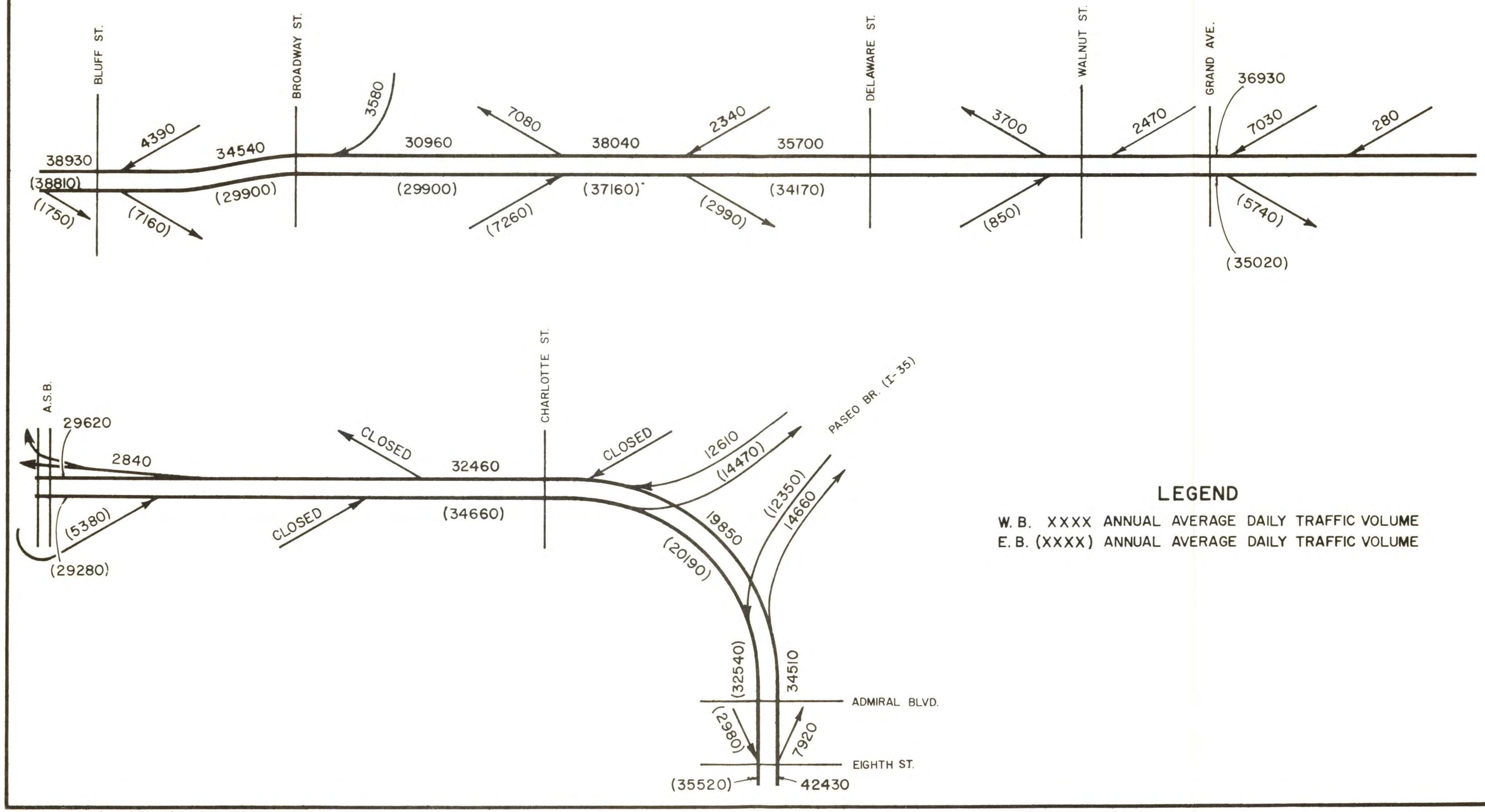
NOLAND ROAD END STUDY AREA

12.53



INTERSTATE 70

KANSAS CITY, MISSOURI



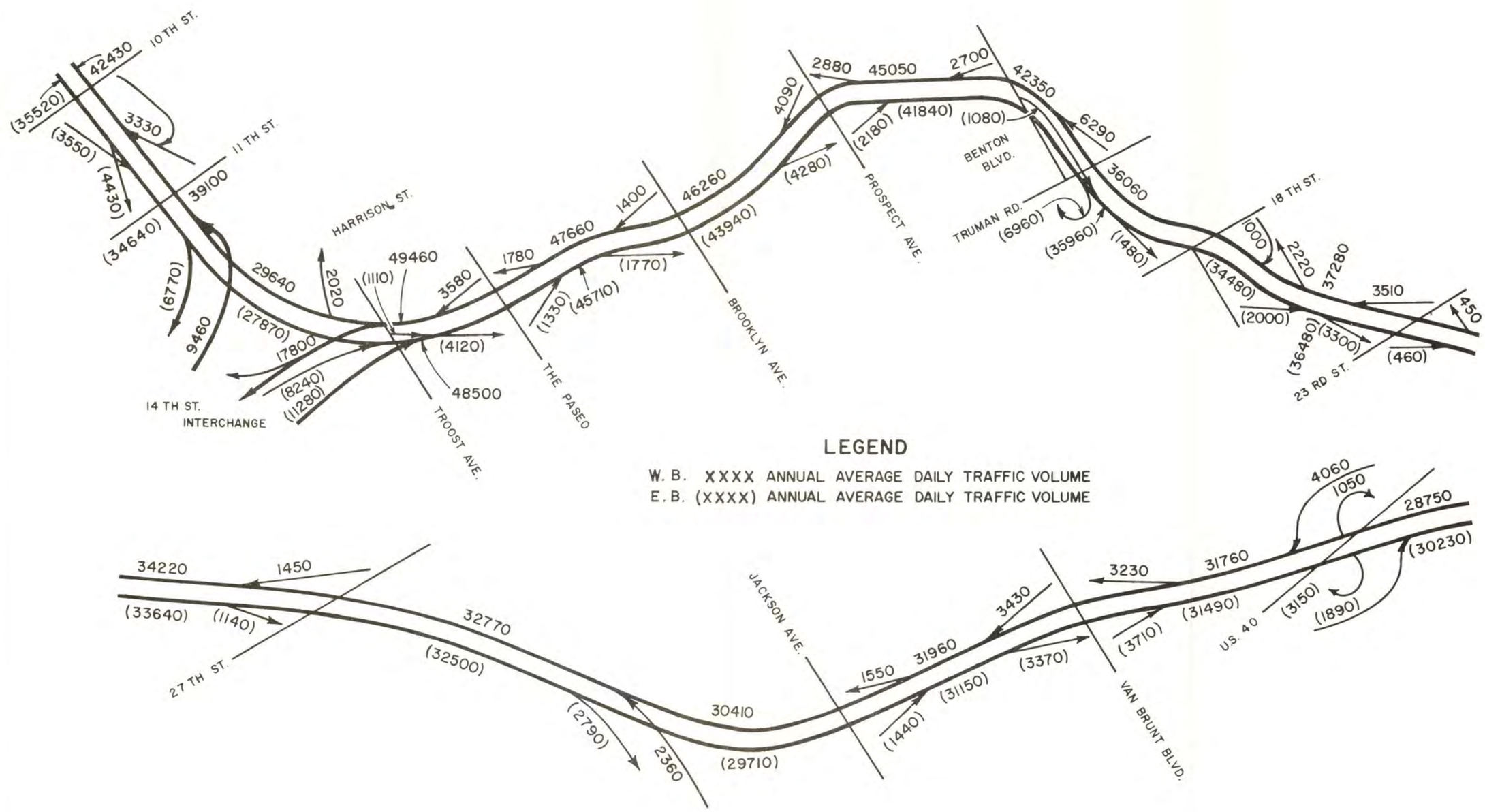
LEGEND

W. B. XXXX ANNUAL AVERAGE DAILY TRAFFIC VOLUME
E. B. (XXXX) ANNUAL AVERAGE DAILY TRAFFIC VOLUME

FIGURE 1A ANNUAL AVERAGE DAILY TRAFFIC

INTERSTATE 70

KANSAS CITY, MISSOURI



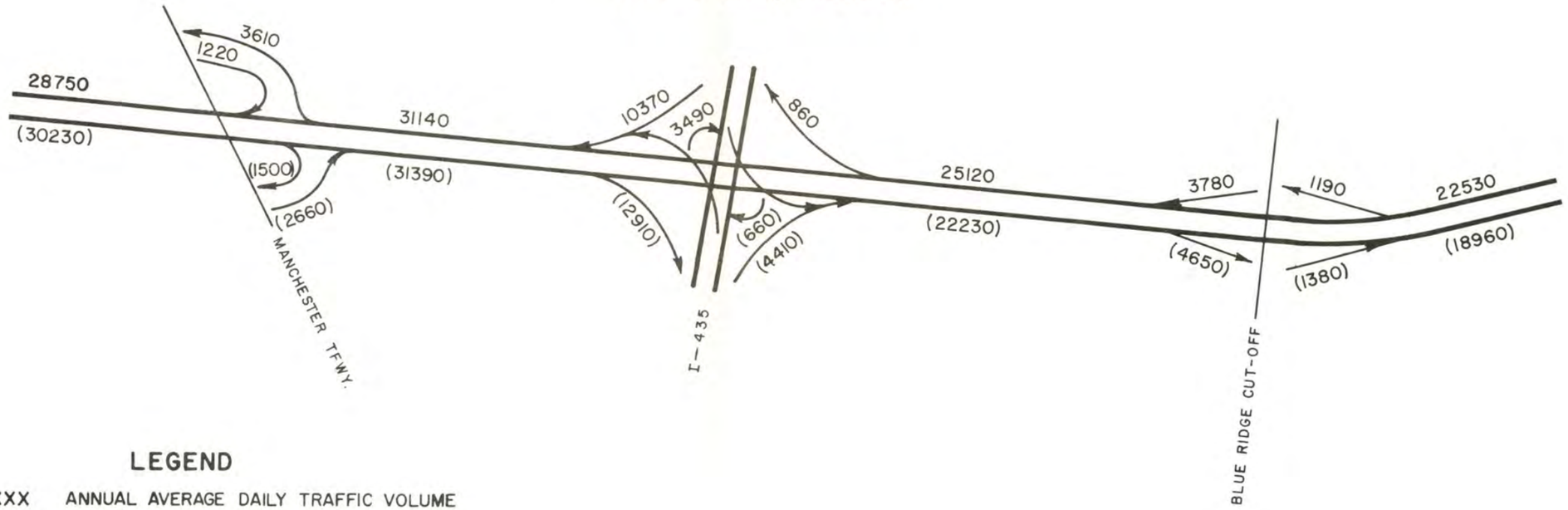
LEGEND

W. B. XXXX ANNUAL AVERAGE DAILY TRAFFIC VOLUME
E. B. (XXXX) ANNUAL AVERAGE DAILY TRAFFIC VOLUME

FIGURE 1B ANNUAL AVERAGE DAILY TRAFFIC

INTERSTATE 70

KANSAS CITY, MISSOURI



LEGEND

W. B. XXXX ANNUAL AVERAGE DAILY TRAFFIC VOLUME
E. B. (XXXX) ANNUAL AVERAGE DAILY TRAFFIC VOLUME

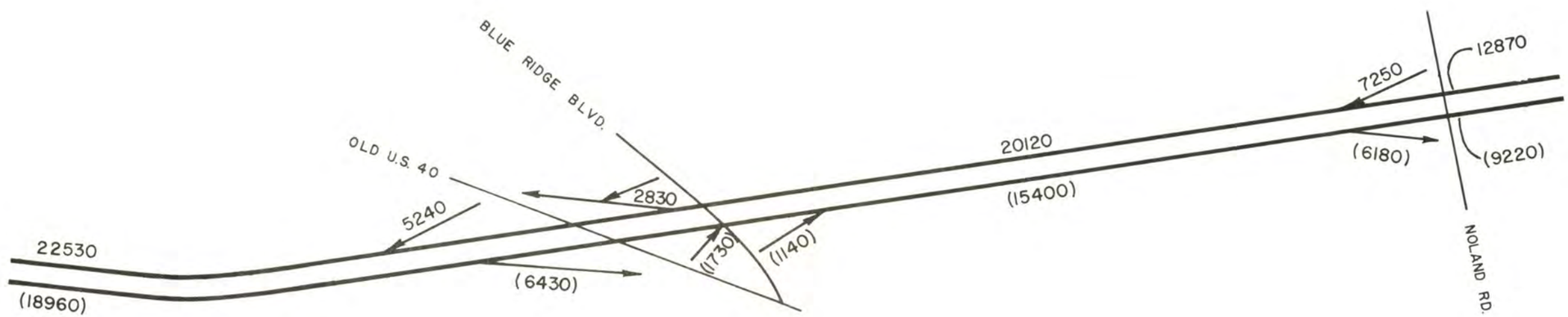


FIGURE 1C ANNUAL AVERAGE DAILY TRAFFIC

the eastbound lanes. In Figures 2A, 2B, and 2C, the morning peak hour volumes are shown without parentheses and the afternoon peak hour volumes are shown with parentheses.

Normally, the peak period occurs during the morning in the westbound lanes and during the afternoon in the eastbound lanes; however, the 6th Street leg of the CBD loop provides access to downtown Kansas City from both the east and the west. Consequently, a significant volume occurs during both the morning and afternoon peak periods in each direction.

The highest peak hour volume (5, 960) in the westbound lanes occurs between the Brooklyn Avenue on-ramp and the Paseo off-ramp. During this same peak hour period, a volume of 5, 080 occurs in the eastbound lanes near the east end of the Lewis and Clark Viaduct; however, 1, 210 of these exit at Bluff Street relieving most of the freeway of this traffic.

The highest peak hour volume (6, 070) in the eastbound lanes occurs just east of the 14th Street Interchange between the Troost Street on-ramp and the Paseo off-ramp. During this same period a volume of 4, 600 occurs in the westbound lanes near the east end of the Lewis and Clark Viaduct.

The growth in hourly volumes at the permanent count station just west of Van Brunt is shown in Figure 2D. Average hourly volumes are plotted as a solid line for 1967 and as a dash line for 1968. They show significant growth during the off-peak hour periods.

Over the one year interval shown, there was no significant growth during the peak hour in the westbound lanes; however, during the remaining daylight hours there was a growth of between 8 and 25 percent.

Similarly, there was only a 1 percent growth during the peak hour in the eastbound lanes while during the remaining daylight hours there was a growth of between 6 and 16 percent.

This indicates the volumes are nearing capacity during the peak hours which are lasting longer and spreading into the off-peak hour periods.

VOLUME-CAPACITY RATIOS AND LEVELS OF SERVICE

Tables 1A, 1B, 2A, and 2B show the volume-capacity (v/c) ratios and indicated levels of service for each segment of I-70 during the morning and afternoon peak hours. A comparison of this table with the density contour maps of the following section will bring to light some apparent descrepancies between the indicated levels of service. These differences result from the different methods of determining level of service rather than from error. Although the v/c ratio is most frequently used to deter-

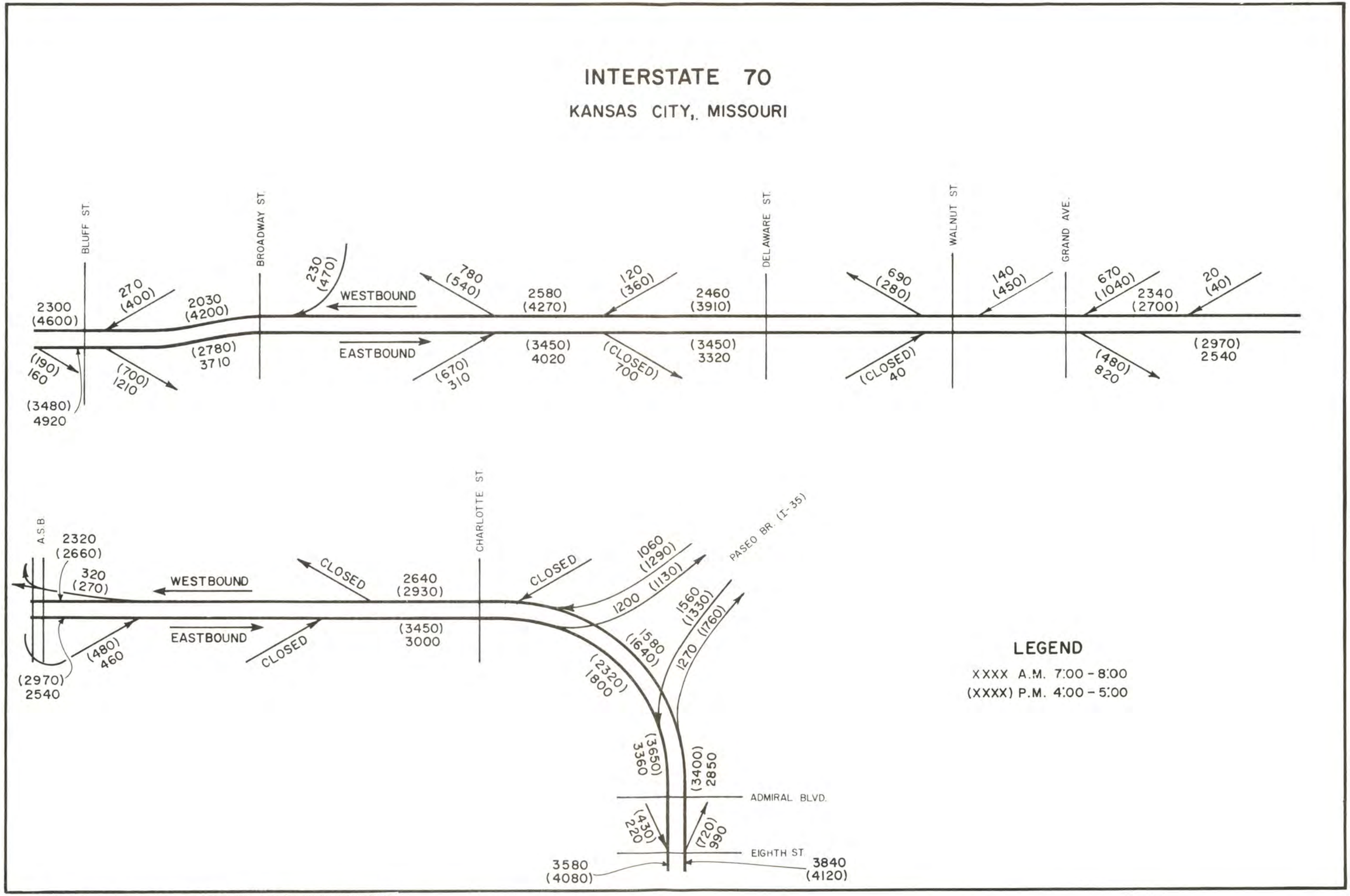


FIGURE 2A AVERAGE PEAK HOUR TRAFFIC VOLUME

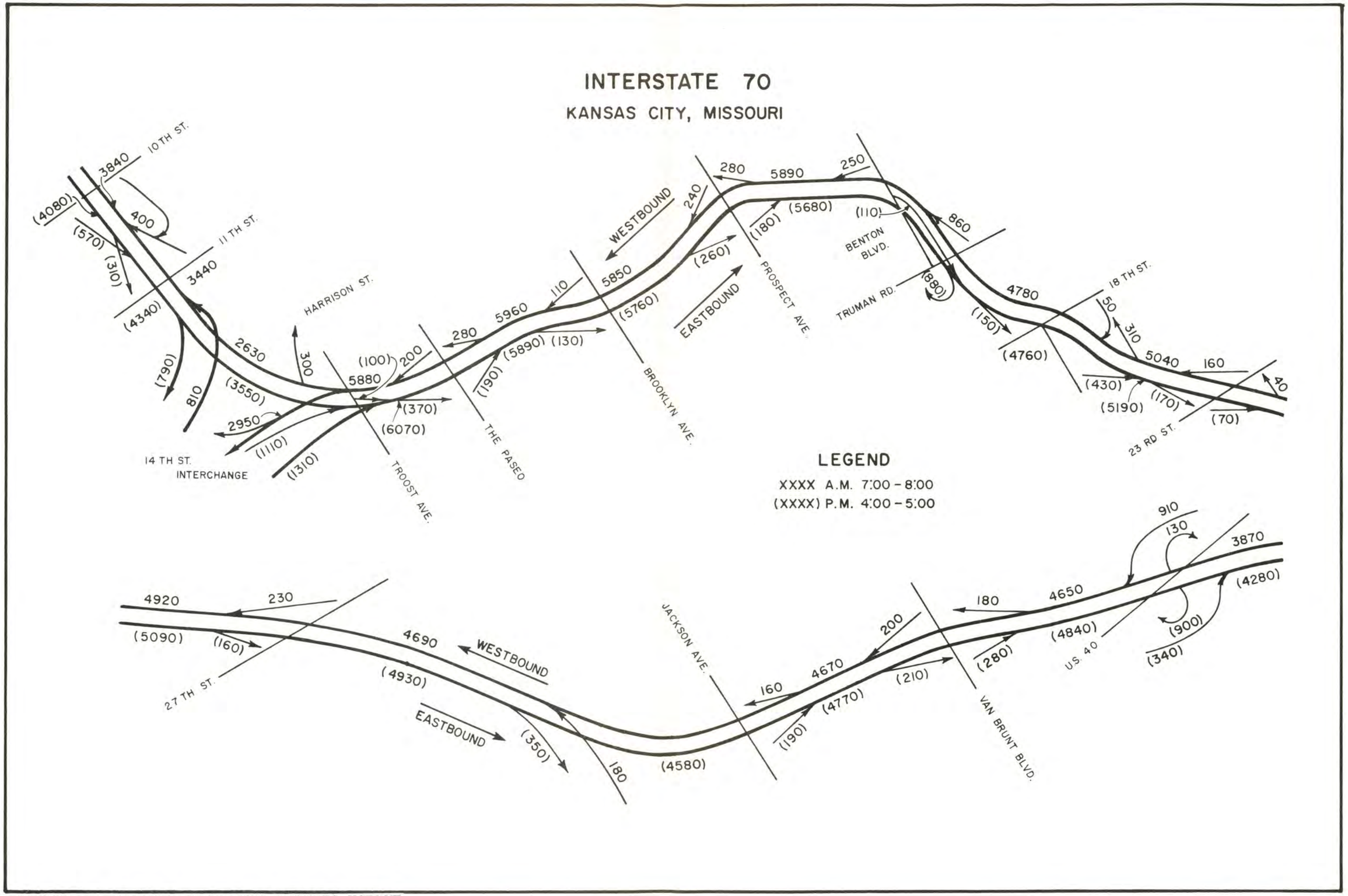
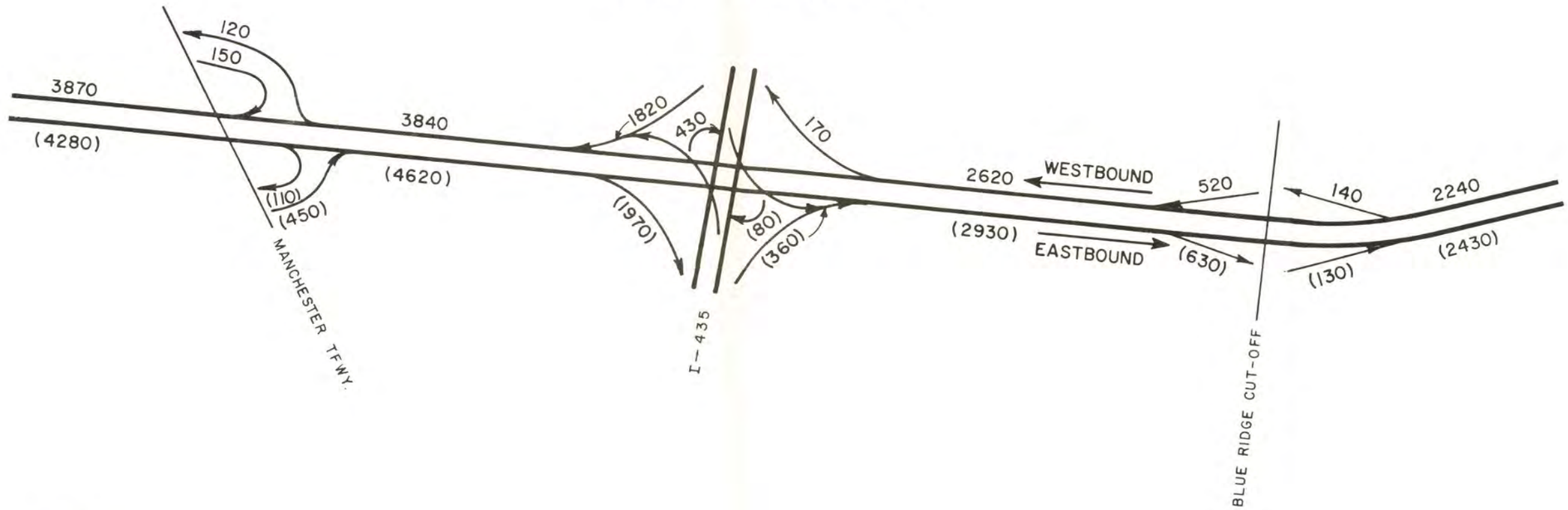


FIGURE 2B AVERAGE PEAK HOUR TRAFFIC VOLUME

INTERSTATE 70

KANSAS CITY, MISSOURI



LEGEND

XXXX A.M. 7:00 - 8:00

(XXXX) P.M. 4:00 - 5:00

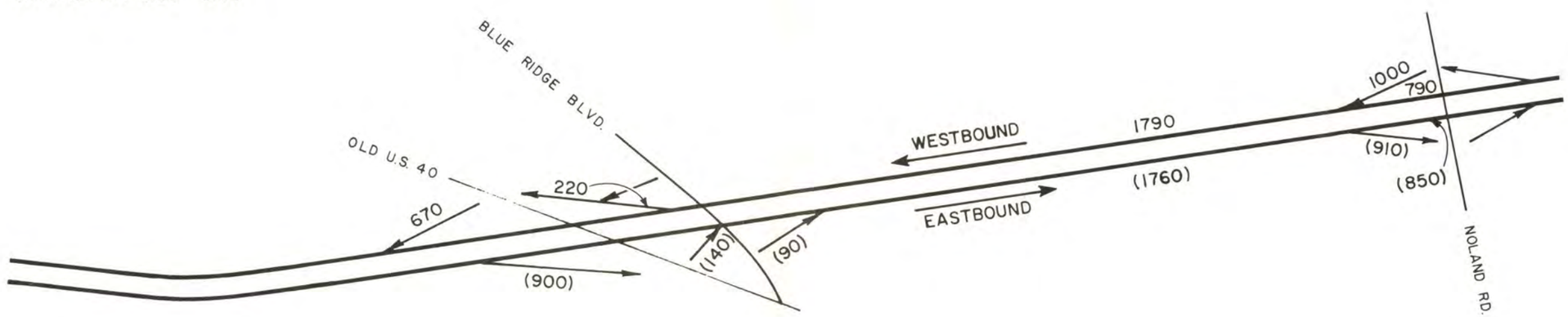
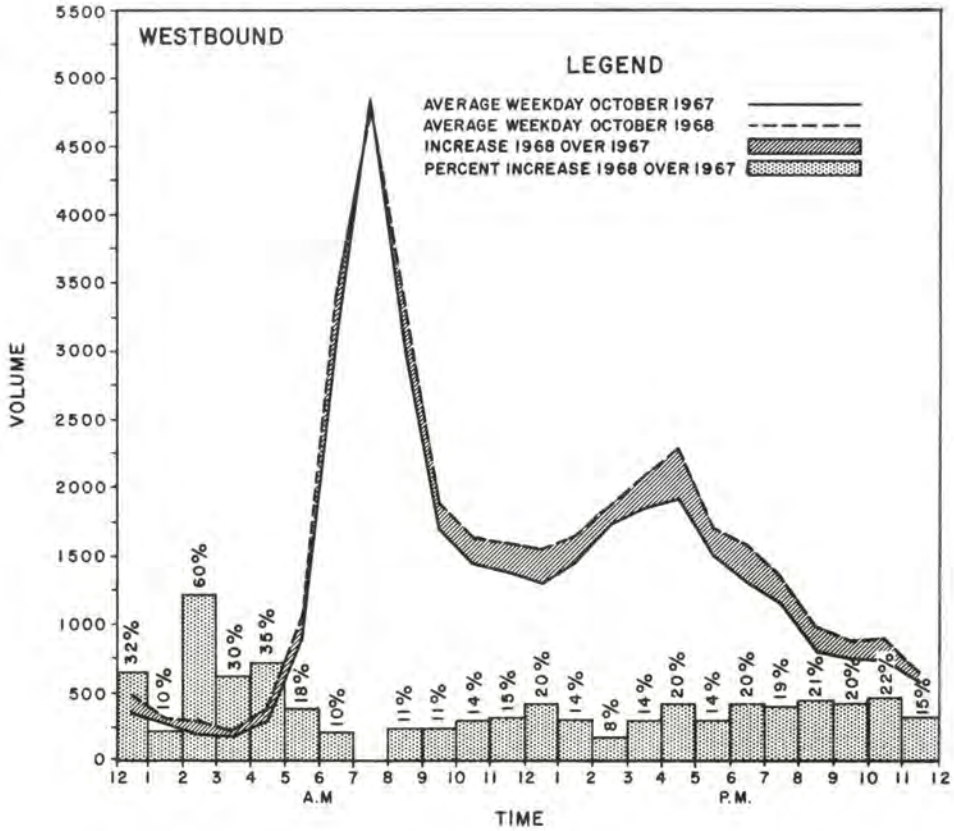


FIGURE 2C AVERAGE PEAK HOUR TRAFFIC VOLUME

HOURLY TRAFFIC VARIATIONS

INTERSTATE ROUTE 70, VAN BRUNT

KANSAS CITY, MISSOURI



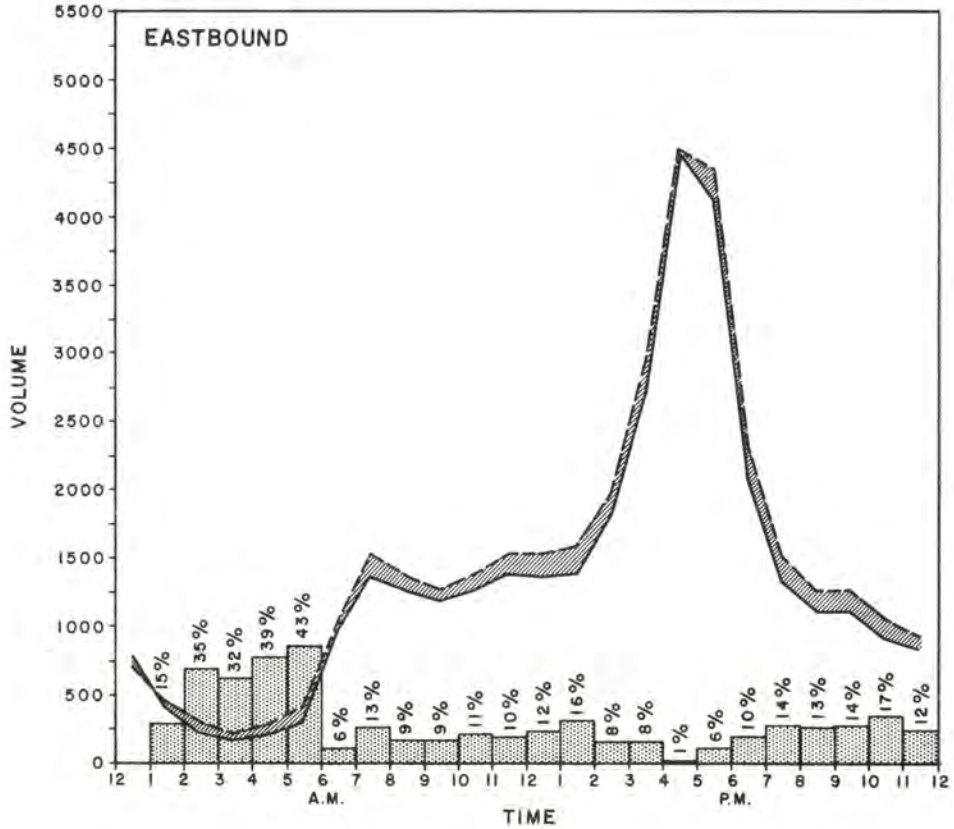


FIGURE 2D

mine level of service for design purposes, it is felt that level of service based on operating speed (as determined by vehicular density) is a better means of evaluating operations on an existing facility.

TABLE 1A

VOLUME-CAPACITY RATIOS AND LEVELS OF SERVICE
I-70, KANSAS CITY, MISSOURI

Westbound Peak Hour-7:00 to 8:00 A.M.

Section	Description	Capacity	Volume	V/C	Level of Service
1	Mo. - Kansas Line to East End of Lewis and Clark Viaduct	5299	2300	.43	B
2	End of Lewis & Clark Viaduct to Bluff St. On-Ramp	5354	2300	.43	B
3	Bluff St. On-Ramp to Broadway St. On-Ramp	5354	2030	.38	A
4	Broadway St. On-Ramp to Wyandotte St. Off-Ramp	5409	1800	.33	A
5	Wyandotte St. Off-Ramp to Delaware St. On-Ramp	4645	2580	.56	B
6	Delaware St. On-Ramp to Delaware St. Off-Ramp	5409	2460	.45	B
6a	Delaware St. Off-Ramp to Grand On-Ramp	5409	3150	.58	B
6b	Grand On-Ramp to ASB N. to W. On-Ramp	5409	3010	.56	B
6c	ASB N. to W. On-Ramp to ASB S. to W. On-Ramp	3606	2340	.65	C
6d	ASB S. to W. On-Ramp to ASB Off-Ramp	3606	2320	.64	C
7	ASB Off-Ramp to I-35 On-Ramp	4645	2640	.57	B
8	I-35 On-Ramp to I-35 Off-Ramp	3096	1580	.51	C

TABLE 1A (Continued)

Section	Description	Capacity	Volume	V/C	Level of Service
9	I-35 Off-Ramp to Admiral St. Off-Ramp	4947	2850	.58	B
9a	Admiral St. Off-Ramp to 10th St. On-Ramp	5063	3840	.76	D
9b	10th St. On-Ramp to I-35 On-Ramp	5063	3440	.68	C
10	I-35 On-Ramp to Harrison St. Off-Ramp	3375	2630	.78	D
11	Harrison St. Off-Ramp to 14th St. Off-Ramp	3763	2930	.78	D
12	14th St. Off-Ramp to Paseo On-Ramp	7527	5880	.78	D
13-14	Paseo Off-Ramp to Brooklyn St. On-Ramp	7527	5960	.79	D
15	Brooklyn St. On-Ramp to Prospect Ave. On-Ramp	7139	5850	.82	E
16	Prospect Avenue Off-Ramp to Benton St. On-Ramp	6751	5890	.87	E
16a	Benton St. On-Ramp to Truman Rd. On-Ramp	6751	5640	.84	E
17	Truman Rd. On-Ramp to 18th St. On-Ramp	5063	4780	.94	F
18	18th St. Off-Ramp to 23rd St. On-Ramp	5063	5040	1.00	F
19	23rd St. Off-Ramp to 27th St. On-Ramp	5529	4920	.89	E
20	27th St. On-Ramp to Jackson St. On-Ramp	5529	4690	.85	E
20a	Jackson Ave. On-Ramp to Jackson Ave. Off-Ramp	5529	4510	.82	E

TABLE 1A (Continued)

Section	Description	Capacity	Volume	V/C	Level of Service
21	Jackson Ave. Off-Ramp to Van Brunt On-Ramp	5063	4670	.92	F
22	Van Brunt Off-Ramp to U.S. 40 On-Ramp	5529	4650	.84	E
23	U.S. 40 Off-Ramp to Manchester On-Ramp	5529	3870	.70	C
24	Manchester St. Off-Ramp to I-435 On-Ramp	5470	3840	.70	C
25	I-435 Off-Ramp to Blue Ridge Cut-Off On-Ramp	3647	2620	.71	D
26	Blue Ridge Cut-Off to U.S. 40 On-Ramp	3647	2240	.61	C
27	U.S. 40 Off-Ramp to Noland Road	3647	1790	.49	B

TABLE 1B

VOLUME-CAPACITY RATIOS AND LEVELS OF SERVICE
IN THE WESTBOUND LANES

4:00 to 5:00 P.M.

Section	Description	Capacity	Volume	V/C	Level of Service
1	Mo. - Kansas Line to E. End Lewis and Clark Viaduct	5299	4600	.87	E
2	End of Lewis & Clark Viaduct to Bluff St. On-Ramp	5354	4600	.86	E
3	Bluff St. On-Ramp to Broadway St. On-Ramp	5354	4200	.78	D
4	Broadway St. On-Ramp to Wyandotte St. Off-Ramp	5409	3730	.69	C

TABLE 1B (Continued)

Section	Description	Capacity	Volume	V/C	Level of Service
5	Wyandotte St. Off-Ramp to Delaware St. On-Ramp	4645	4270	.92	F
6	Delaware St. On-Ramp to Delaware St. Off-Ramp	5409	3910	.72	C
6a	Delaware St. Off-Ramp to Grand On-Ramp	5409	4190	.77	D
6b	Grand On-Ramp to ASB N. to W. On-Ramp	5409	3740	.69	D
6c	ASB N. to W. On-Ramp to ASB S. to W. On-Ramp	3606	2700	.75	D
6d	ASB S. to W. On-Ramp to ASB Off-Ramp	3606	2660	.74	C
7	ASB Off-Ramp to I-35 On-Ramp	4645	2930	.63	C
8	I-35 On-Ramp to I-35 Off-Ramp	3096	1640	.53	C
9	I-35 Off-Ramp to Admiral St. Off-Ramp	4947	3400	.69	C
9a	Admiral St. On-Ramp to 10th St. On-Ramp	5063	4120	.81	D

TABLE 2A

VOLUME-CAPACITY RATIOS AND LEVELS OF SERVICE
I-70 KANSAS CITY, MISSOURI

7:00 to 8:00 A.M. Eastbound

Section	Description	Capacity	Volume	V/C	Level of Service
1	Mo. - Kansas Line to Bluff St. Off-Ramp	6988	5080	.73	C
2	Bluff St. Off-Ramp to Broadway Off-Ramp	5296	4920	.93	F

TABLE 2A (Continued)

Section	Description	Capacity	Volume	V/C	Level of Service
3	Broadway Off-Ramp to Broadway On-Ramp	4527	3710	.82	E
4	Broadway On-Ramp to Main Street	5350	4020	.75	D
5	Main St. Off-Ramp to Main St. On-Ramp	5350	3320	.62	C
6	Main St. On-Ramp to Oak St. Off-Ramp	5350	3360	.63	D
7	Oak St. Off-Ramp to ASB On-Ramp	3567	2540	.71	D
8	ASB On-Ramp to I-35 Off-Ramp	4527	3000	.66	C
9	I-35 Off-Ramp to I-35 On-Ramp	3018	1800	.60	C
10	I-35 On-Ramp to 8th St. On-Ramp	4527	3360	.74	D
11	8th St. On-Ramp to 10th St. Off-Ramp	5470	3580	.65	C

TABLE 2B

VOLUME-CAPACITY RATIOS AND LEVELS OF SERVICE
I-70 KANSAS CITY, MISSOURI

Eastbound Peak Hour 4:00 to 5:00 P.M.

Section	Description	Capacity	Volume	V/C	Level of Service
1	Mo. - Kansas Line to Bluff St. Off-Ramp	6988	3670	.53	B
2	Bluff St. Off-Ramp to Broadway Off-Ramp	5296	3480	.66	C
3	Broadway Off-Ramp to Broadway On-Ramp	4528	2780	.61	C

TABLE 2B (Continued)

Section	Description	Capacity	Volume	V/C	Level of Service
4	Broadway On-Ramp to Main St.	5350	3450	.64	C
5	Main St. Off-Ramp to Main St. On-Ramp	5350	3450	.64	C
6	Main St. On-Ramp to Oak St. Off-Ramp	5350	3450	.64	C
7	Oak St. Off-Ramp to ASB On-Ramp	3567	2970	.83	E
8	ASB On-Ramp to I-35 Off-Ramp	4527	3450	.76	D
9	I-35 Off-Ramp to I-35 On-Ramp	3018	2320	.77	D
10	I-35 On-Ramp to 8th Street On-Ramp	4998	3650	.73	D
11	8th Street On-Ramp to 10th Street Off-Ramp	5470	4080	.75	D
12	10th Street Off-Ramp to 10th Street On-Ramp	5470	4340	.79	D
13	10th Street On-Ramp to I-35 Off-Ramp	7294	4340	.60	B
14	I-35 Off-Ramp to 14th Street On-Ramp	3647	3550	.97	F
15	14th St. On-Ramp to I-35 On-Ramp	5470	4660	.85	E
16	I-35 On-Ramp to Troost St. On-Ramp	7449	5970	.80	D
17	Troost St. On-Ramp to Paseo Off-Ramp	7449	6070	.81	D
18	Paseo On-Ramp to Brooklyn St. Off-Ramp	7449	5890	.79	D
19	Brooklyn St. Off-Ramp to Prospect Off-Ramp	6906	5760	.83	E

TABLE 2B (Continued)

Section	Description	Capacity	Volume	V/C	Level of Service
20	Prospect Off-Ramp to Change in Lanes (Kansas St.)	6906	5680	.82	E
21	Kansas Street to Benton St. On-Ramp	5179	4910	.95	F
22	Benton St. On-Ramp to 18th St. Off-Ramp	5179	4910	.95	F
23	18th St. Off-Ramp to 19th St. On-Ramp	5354	4760	.89	E
24	19th St. On-Ramp to 23rd St. Off-Ramp	5645	5190	.92	F
25	23rd St. On-Ramp to 27th St. Off-Ramp	5587	5090	.91	F
26	27th St. Off-Ramp to Jackson Avenue Off-Ramp	5645	4930	.87	E
27	Jackson Ave. Off-Ramp to Jackson Ave. On-Ramp	5645	4580	.81	D
28	Jackson On-Ramp to Van Brunt Off-Ramp	5645	4770	.84	E
29	Van Brunt On-Ramp to U.S. 40 Off-Ramp	5645	4840	.86	E
30	U.S. 40 On-Ramp to Manchester Off-Ramp	5470	4280	.78	D
31	Manchester On-Ramp to I-435 Off-Ramp	5470	4620	.84	E
32	I-435 On-Ramp to Blue Ridge Cut-Off Off-Ramp	3920	2930	.75	D
33	Blue Ridge Cut-Off On-Ramp to U.S. 40 Off-Ramp	3920	2430	.62	C
34	U.S. 40 On-Ramp to Noland Road	3920	1760	.45	B

TRAFFIC DENSITIES AND LEVELS OF SERVICE

Figure 3A through 4B reflect the prevailing levels of service and vehicular densities on the study section throughout typical morning and afternoon peak periods during the summer of 1968. The relationship between these two indicators of traffic service is explained in the Appendix.

As the densities shown in Figures 3A through 4B increase, the average operating speeds decrease. For example, as the vehicular density increases from 30 to 60 vehicles/lane/mile, the average operating speeds can be expected to drop from 55 to 30 miles/hour. According to the 1965 Highway Capacity Manual, an operating speed of less than 30 miles/hour is associated with level of service "F".

By comparing average peak hour densities, density contour maps can also be used to measure the increase or decrease in congestion on a given section during a certain period of time. The results of a comparison of morning peak hour operations in the westbound lanes is shown in Table 3.

TABLE 3
AVERAGE DENSITIES AND OPERATING SPEEDS
IN THE WESTBOUND LANES
7:00-8:00 A.M.

Location	Average Density[1] 1967	Average Density[1] 1968	Average Speed[2] 1967	Average Speed[2] 1968
10th Street to the westbound off-ramp from I-70 to I-35 at the 14th St. Interchange	26	38	57	47
The Paseo to Benton Blvd.	34	35	51	50
Benton Blvd. to 27th St.	41	43	45	43
27th St. to Blue Ridge Cut-off	50	40	36	45

[1] In vehicles/lane/mile

[2] In miles/hour

The drop in average density between 27th Street and the Blue Ridge Cut-off may be due to daily variation in traffic patterns. Additional data are to be obtained during the summer of 1970.

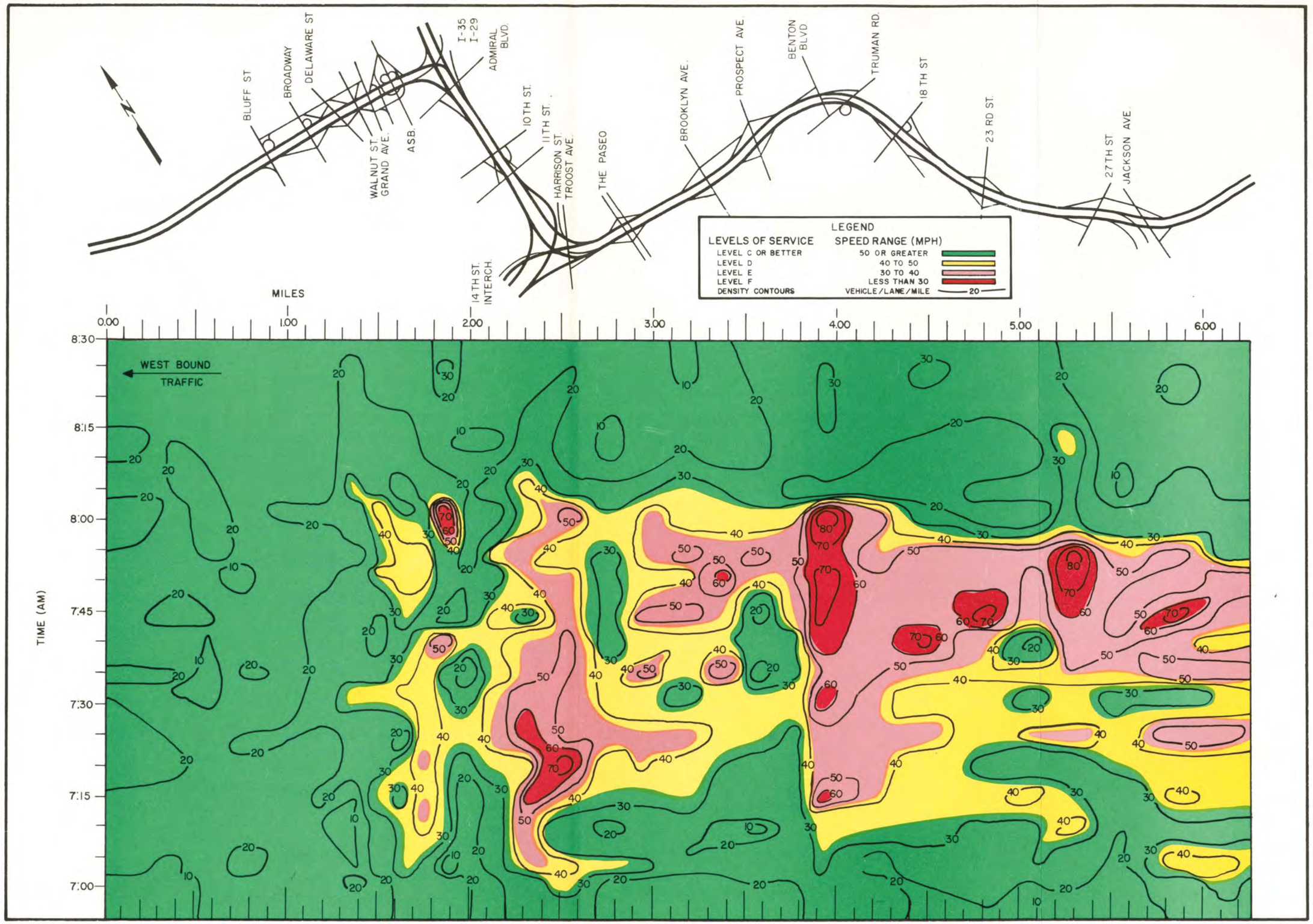


FIGURE 3A TRAFFIC DENSITY CONTOURS AND LEVELS OF SERVICE DURING THE MORNING PEAK PERIOD ON THE WESTBOUND LANES

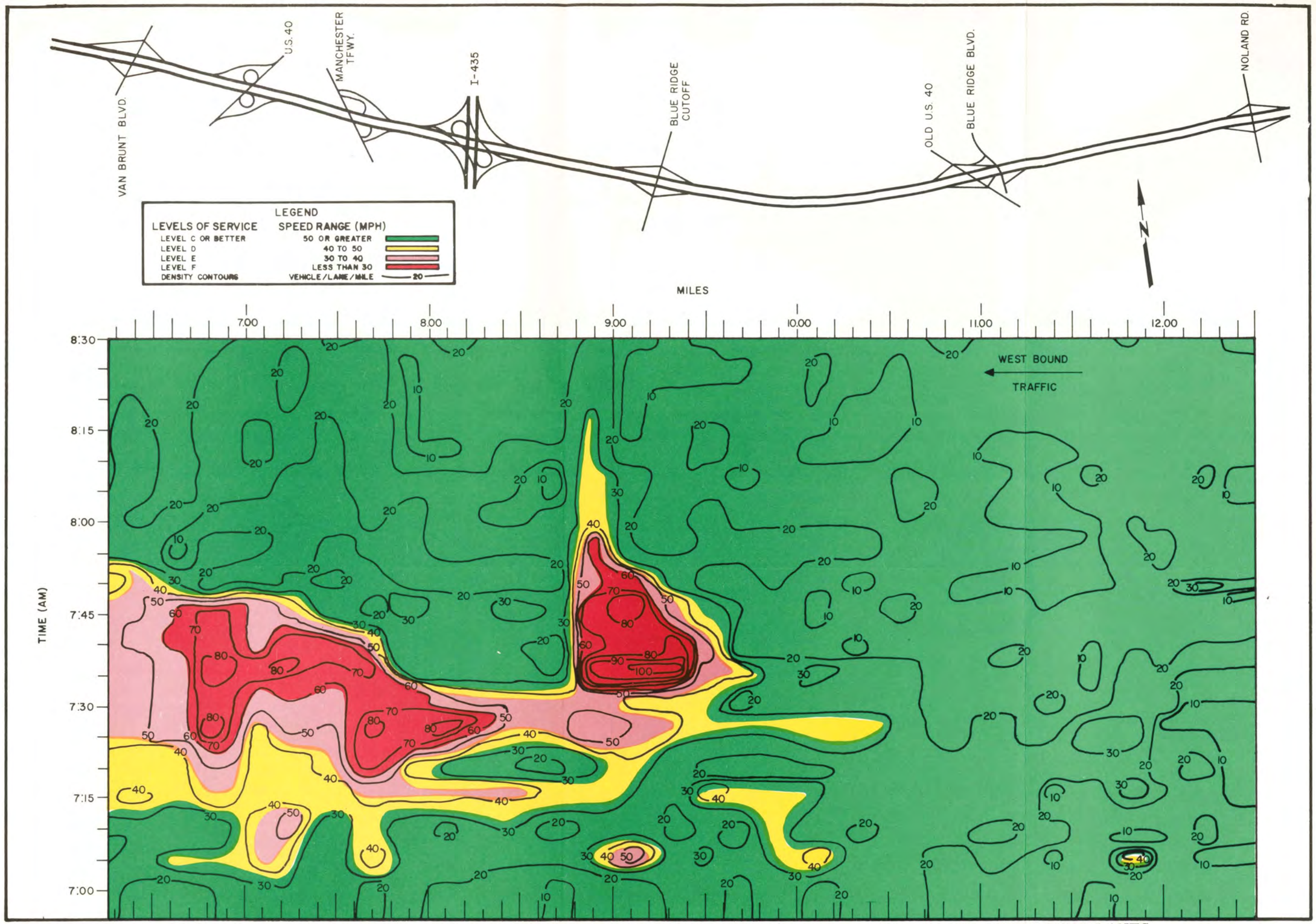


FIGURE 3B TRAFFIC DENSITY CONTOURS AND LEVELS OF SERVICE DURING THE MORNING PEAK PERIOD ON THE WESTBOUND LANES

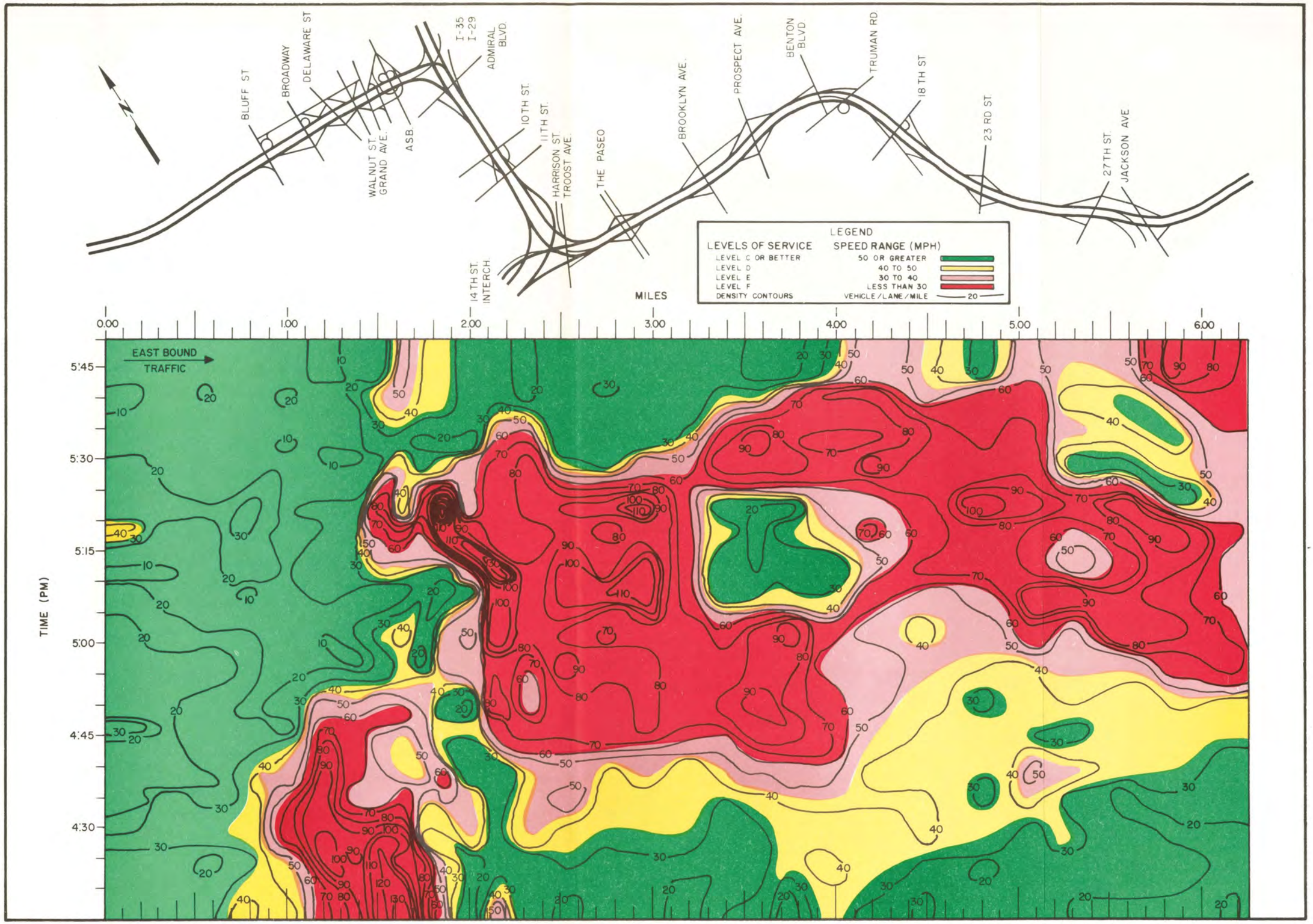


FIGURE 4A TRAFFIC DENSITY CONTOURS AND LEVELS OF SERVICE DURING THE AFTERNOON PEAK PERIOD ON THE EASTBOUND LANES

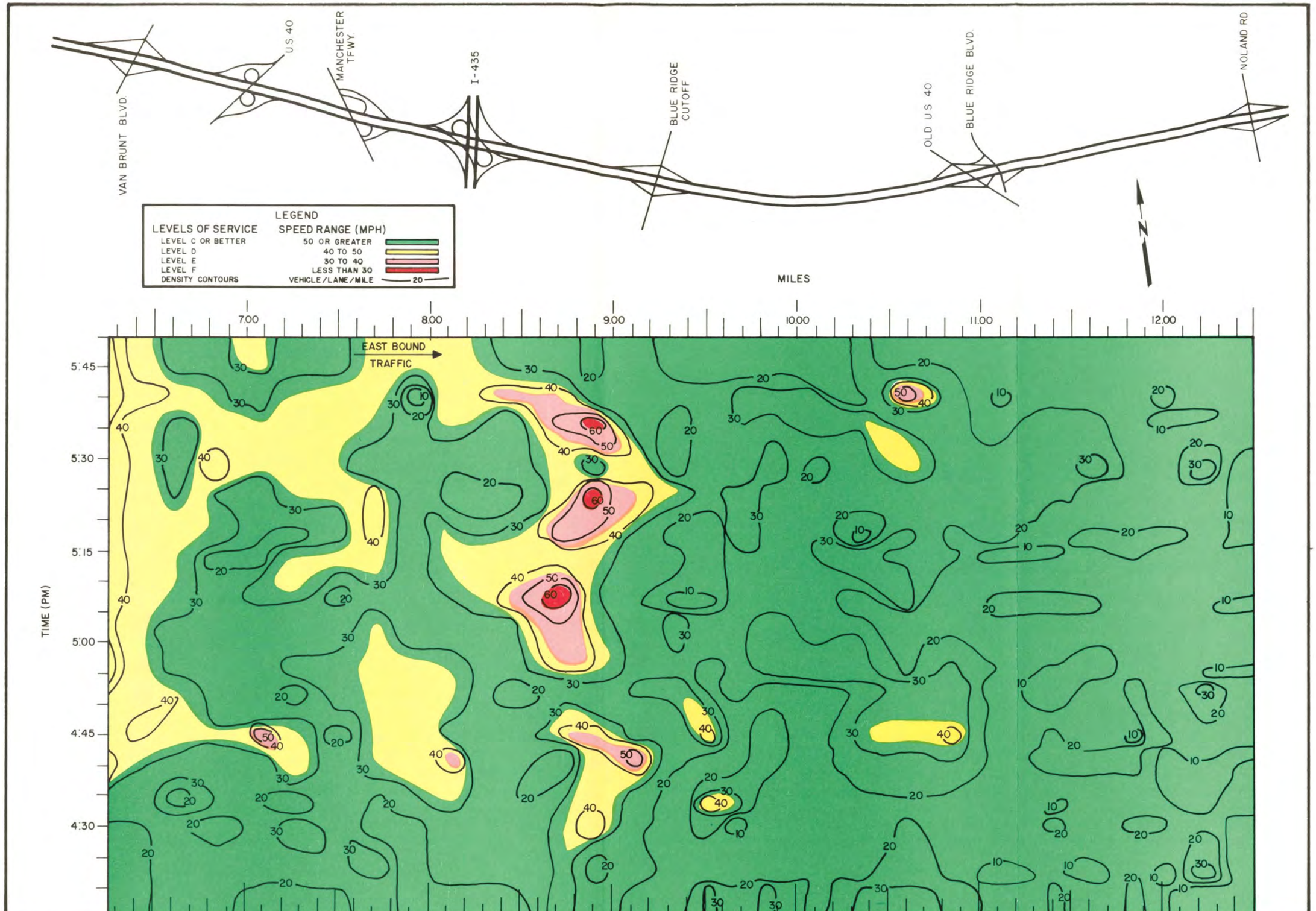


FIGURE 4B TRAFFIC DENSITY CONTOURS AND LEVELS OF SERVICE DURING THE AFTERNOON PEAK PERIOD ON THE EASTBOUND LANES

Table 4 makes a similar comparison of operating conditions in the eastbound lanes during the afternoon peak hour.

TABLE 4
AVERAGE DENSITIES AND OPERATING SPEEDS
IN THE EASTBOUND LANES
4:00-5:00 P.M.

Location	Average Density 1967	Average Density 1968	Average Speed 1967	Average Speed 1968
ASB Bridge to Brooklyn Ave.	38	58	47	30
Brooklyn Ave. to Van Brunt	39	52	46	35
Van Brunt Blvd. to Blue Ridge Cut-off	42	31	45	54

Both Tables 3 and 4 indicate that average density (and congestion) are growing on Interstate 70.

DEFICIENT LEVELS OF OPERATION

In this report, any area operating at Level F for 10 minutes or more is considered to be deficient in providing satisfactory operating conditions. Even a period of this duration will soon result in rather severe congestion.

Figures 3A and 3B reflect deficiencies in the westbound lanes at the following locations:

(1) From 10th Street to the east end of the 14th Street interchange, traffic operates at Levels E and F for 1 hour. This is likely the result of a 12° curve, the directional split at the 14th Street interchange, the merging traffic from I-35 and 10th Street, and a 4 percent grade through this location.

(2) Between the Paseo and Benton Boulevard traffic operates at Level E for 15 minutes. The density in this area is relatively lighter than it is on either side thereof. Traffic is probably being metered through this area from the bottleneck at the Benton-Truman Interchange.

(3) From the Benton-Truman Interchange to 27th Street traffic operates at Levels E and F up to 50 minutes. There are 3 grades of over 3 percent, an 8°30' curve, and an on-ramp volume of 860 vehicles from Truman Road, all of which apparently combine to produce this deficient level of operation. When the additional lane is picked up at Benton Boulevard the level of service almost improves to Level D.

(4) Between 27th Street and the Blue Ridge Cut-off traffic operates at Levels E and F for 20 minutes. The merging volumes of 520 vehicles at Blue Ridge Cut-off, 1820 vehicles at I-435, and 910 vehicles at U.S. 40 are probably the most significant causes of this deficient level of service.

Figures 4A and 4B reflect deficient levels of service at the following locations in the eastbound lanes:

(1) Between Bluff Street and the ASB Bridge traffic operates at Level F for 30 minutes or more. This is most likely a surge of traffic from workers returning home.

(2) Between the ASB Bridge and Brooklyn Avenue traffic operates at Level F for one hour. This is the most congested area of the study.

Along the 6th Street leg the distance between ramps is apparently inadequate for smooth merging and weaving manuevers. At the 6th Street and 14th Street interchanges grades, curves and changes in number of lanes combine to radically impair the flow of traffic. In addition, there are significant merging and weaving problems between the 10th Street On-ramp and the Paseo access ramps.

(3) Between the Benton-Truman Interchange and Van Brunt Boulevard the probable significant causes of the Level E and F operations are the 4 percent and 3 percent grades, and the $7^{\circ}30'$ and $8^{\circ}30'$ curves.

A four percent grade and merging traffic contribute to the congestion developing between I-435 and Blue Ridge Cut-off. Although the congestion could be expected to increase with the extension of I-435 northward, the additional lanes planned for this area should provide the needed relief.

RECOMMENDATIONS

1. It is recommended that another level of service analysis of the study section be made in the summer of 1970. The proposed study should also investigate the feasibility of alleviating the afternoon congestion in the eastbound lanes between the CBD loop and Van Brunt Boulevard.

2. A thorough study of the capability of the CBD to handle future traffic should be made as soon as possible. Some work could be done as soon as the final design is set.

PART II

INTERSTATE 70 ST. LOUIS

MISSOURI

STUDY AREA

The Mark Twain Expressway in St. Louis is characterized by rolling terrain, consequently there are numerous curves and grades over the study area.

It serves widespread industrial facilities from downtown St. Louis to St. Charles. The volumes during the peak hours are increasing slowly, while the volumes during the off-peak hours are increasing rapidly. This indicates the volumes have reached capacity during the peak hours, that the peak periods are lasting longer, and that they are extending into the off-peak hours.

One of the most beneficial features of this freeway are the reversible lanes which begin at Union Boulevard and extend to just east of O'Fallon Street and Cass Avenue. The reversible lanes relieve the regular through lanes of the high volumes during the peak hours so that traffic flows smoothly over the area which they cover.

The study area extends from Route 94 west of St. Charles to the Eads Bridge in downtown St. Louis as pictured in Figures A-1, A-2, and A-3.

TRAFFIC VOLUMES

Annual average daily volumes are shown on Figures 1A, 1B, and 1C. The reversible lane volumes are shown with an R immediately following them.

The highest annual daily volume in the eastbound lanes is 48, 690 and occurs on the through lanes just east of Palm Street.

The highest annual daily volume in the westbound lanes is 45, 650 and occurs at the Lucas and Hunt permanent count station.

The highest eastbound annual daily average volume in the reversible lanes is 7, 440 from West Florissant to O'Fallon Street.

The highest westbound annual daily average volume in the reversible lanes is 9,480 from West Florissant to O'Fallon Street.

Counts at the permanent count station at Lucas and Hunt indicate an annual increase from 1967 to 1968 of 3 percent in the eastbound lanes and 3 percent in the westbound lanes.

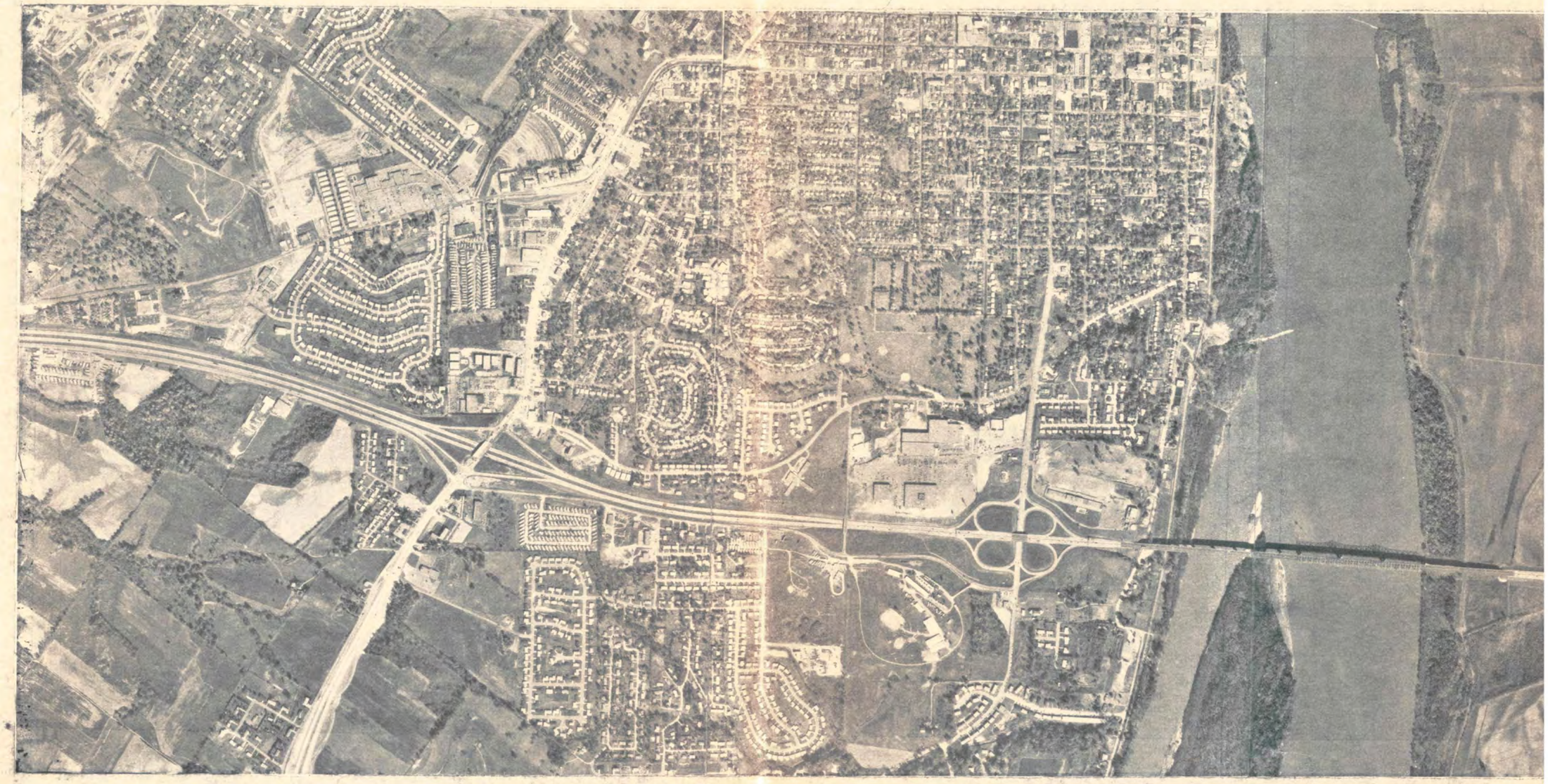
STUDY AREA

INTERSTATE 70

ST. LOUIS, MISSOURI

FIGURES A-1 A-2 A-3

STUDY AREA	BEGIN STUDY AREA ROUTE 94	FAIRGROUND ROAD	I-70 LOOP	ST. LOUIS COUNTY LINE
MILE POSTS	0.00	0.75	1.10	1.82
GRADES			900' -4.00%	1400' -4.40%
SPEED LIMITS	70 M.P.H			
NUMBER OF LANES	←			



I-270-244 McKELVEY ROAD

4.374 4.71

2100'
+4.00%

500'
-4.00%

4 LANES

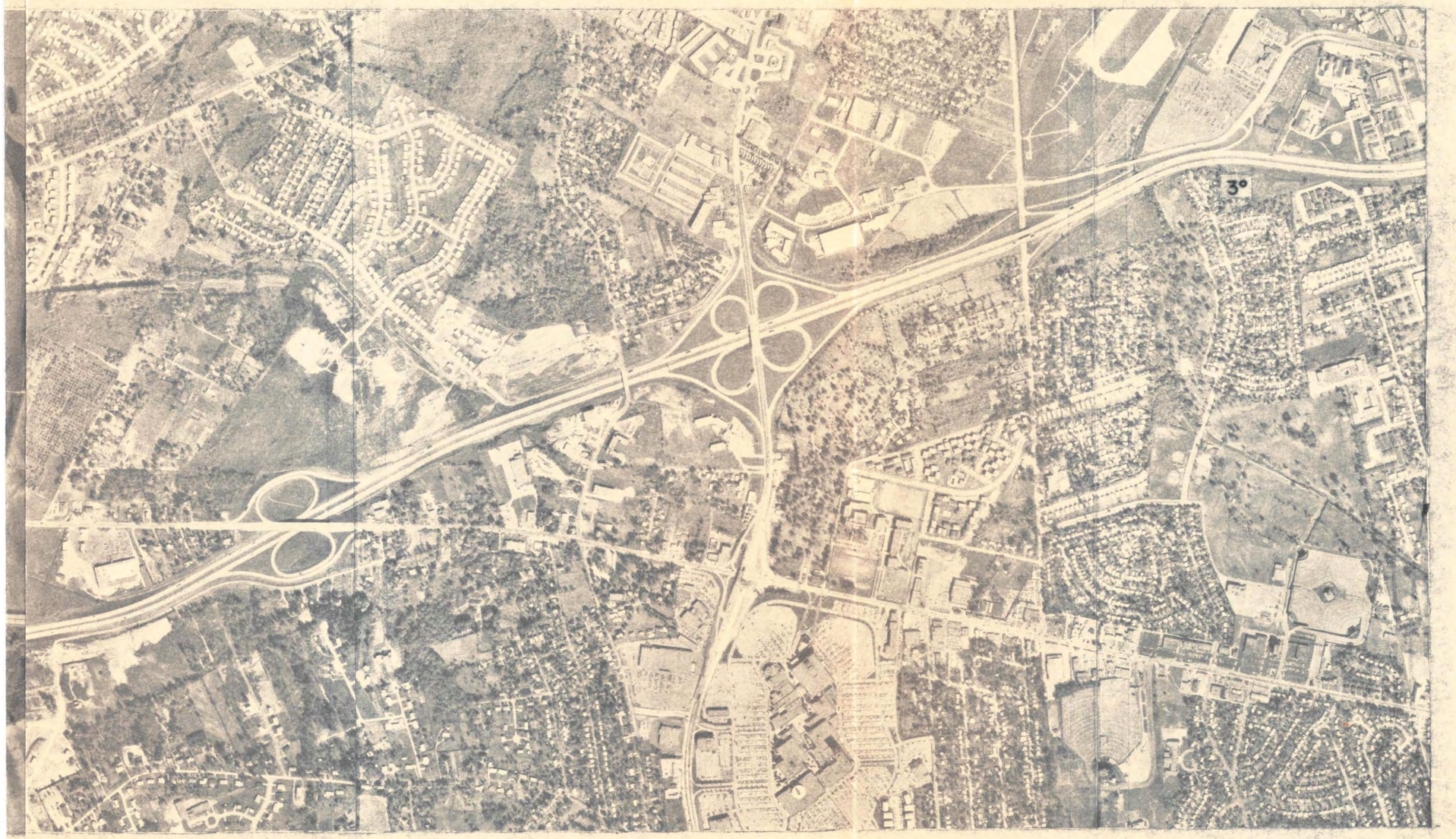
MARK TWAIN EXPRESSWAY
ST. LOUIS, MISSOURI
APPROX. SCALE - 1" = 1200'

MO. 180 FEE FEE ROAD LINDBERGH BLVD. CYPRESS ROAD

5.89 6.815 7.35

900' +4.63% | 800' -4.12% | 1100' -4.00% | 2300' +3.00%

70 M.P.H. 55 M.P.H.



AIRPORT ENTRANCE

8.45

700'
-4.00%

600'
-3.5%

55 M.P.H.

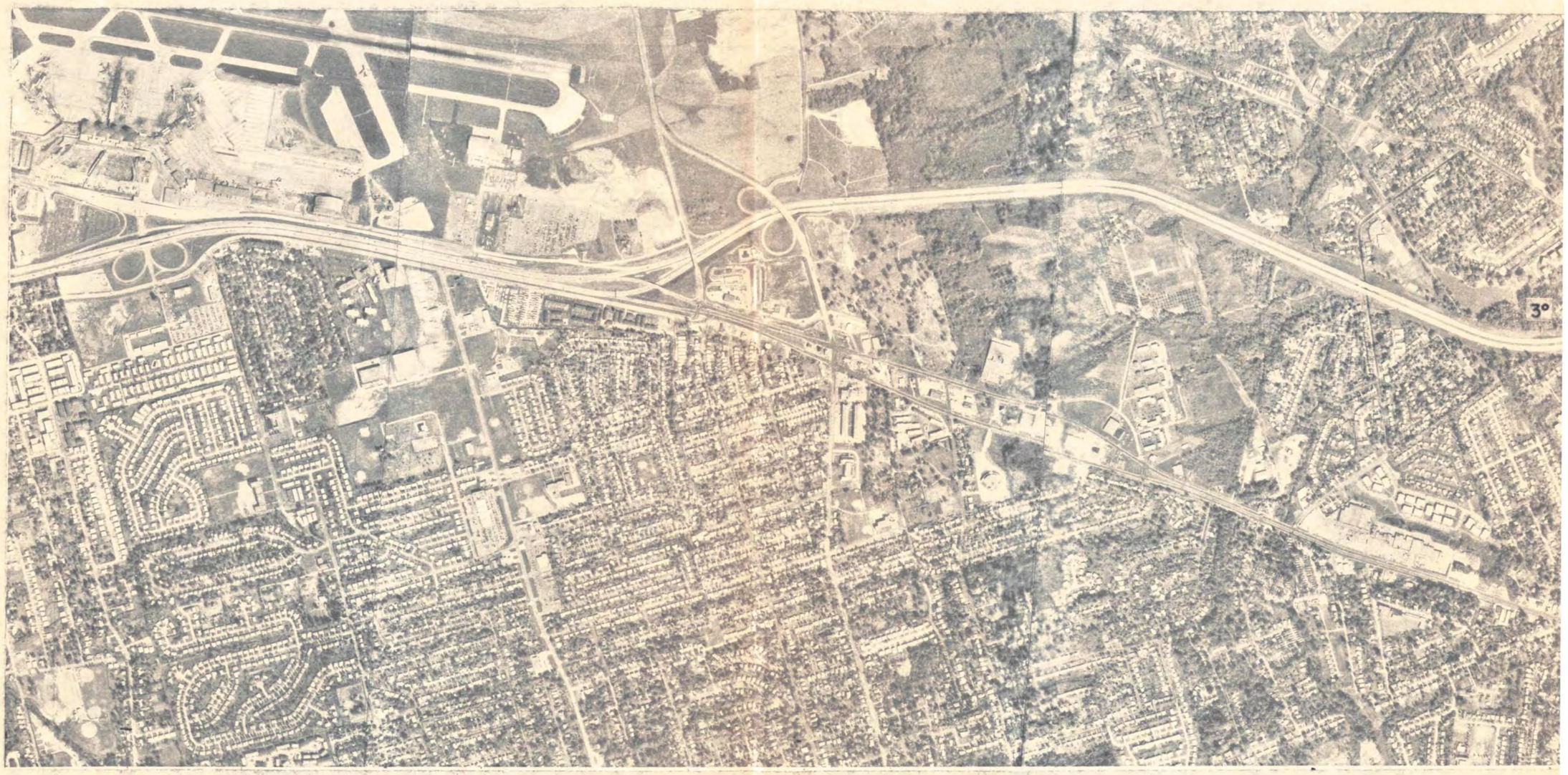
4 LANES ⟶ ⟵ 6 LANES AS OF OCTOBER 1969

NATURAL BRIDGE RTE. TT BROWN ROAD

9.47 9.56 9.77

CAF

1500'
+3.50%



SON ROAD

11.52

FLORISSANT BLVD.

12.13

2376'
+5.7%

BERMUDA ROAD

12.72

55 M.P.H.

LUCAS & HUNT ROAD

13.48

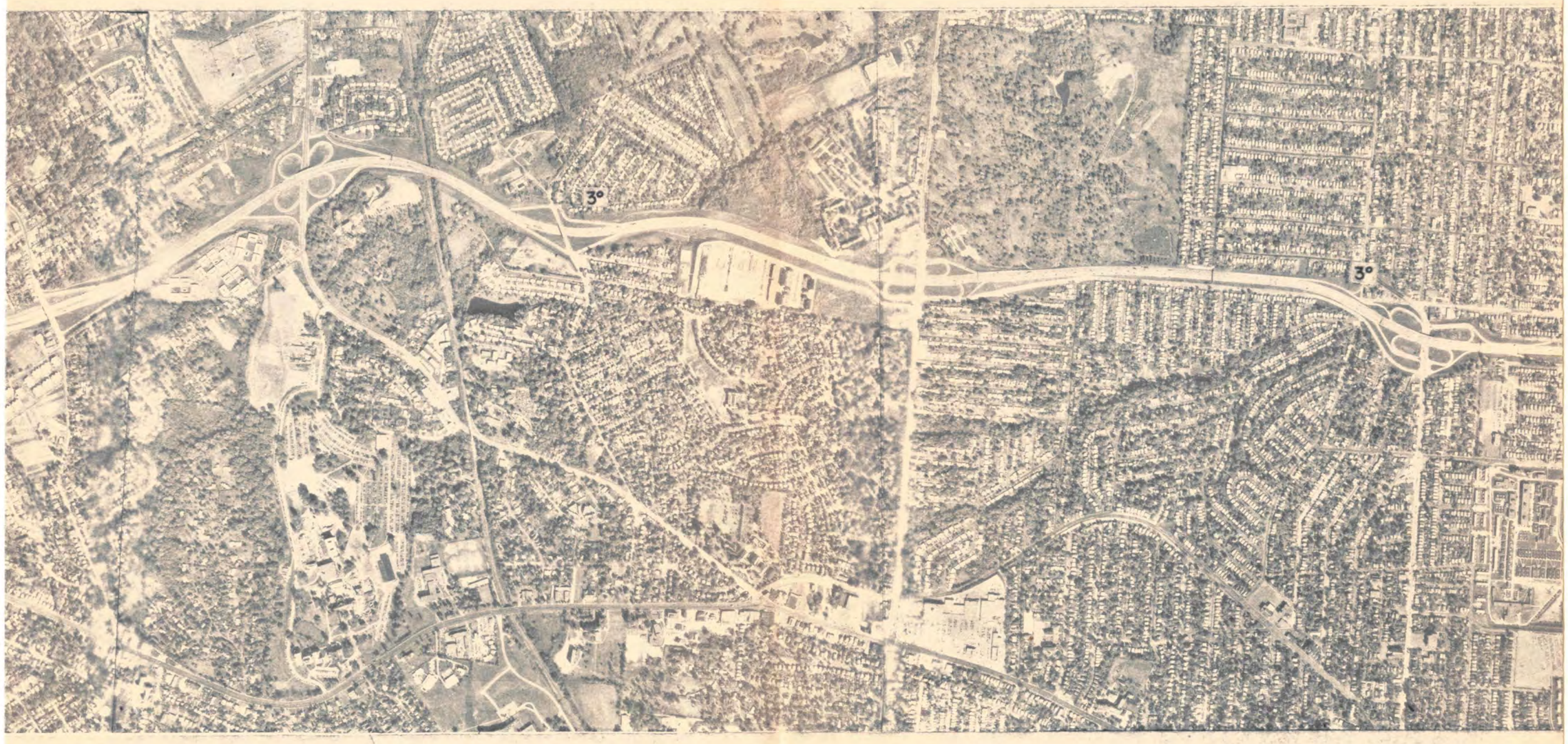
1850'
-5%

JENNINGS STATION ROAD

14.57

G

14.88



OODFELLOW BLVD.	RIVERVIEW BLVD.	PEDESTRIAN OVERPASS	UNION BLVD.	KINGSHIGHWAY BLVD.	SHREVE AVE.	W. FLORISSANT AVE.
3	15.14	15.77	16.06	16.38	16.81	17.42

800' +3.70% | 1000' -3.30%

55 M.P.H.

6 LANES ——+—— 8 LANES (2 REVERSIBLE)

O'FALLON | ADELAIDE AVE. | E. PRAIRIE DR. | E. GRAND | ANGELICA | McKINLEY BRIDGE | BRANCH | N.

17.90 | 18.42 | 18.80 | 19.02 | 19.52 | 19.85 | 20.33

400' -3% | 500' +3.0

55 M.P.H.

8 LANES (2 REVERSIBLE)

MARKET BROOKLYN AVE. CASS AVE. VETERANS BR. EADS BR. END STUDY AREA

20.80 21.20 21.51 22.12

%

400' -5%

55 M.P.H.

3 LANES REVERSIBLE LANES END 6 LANES

INTERSTATE ROUTE 70
ST. LOUIS, MISSOURI

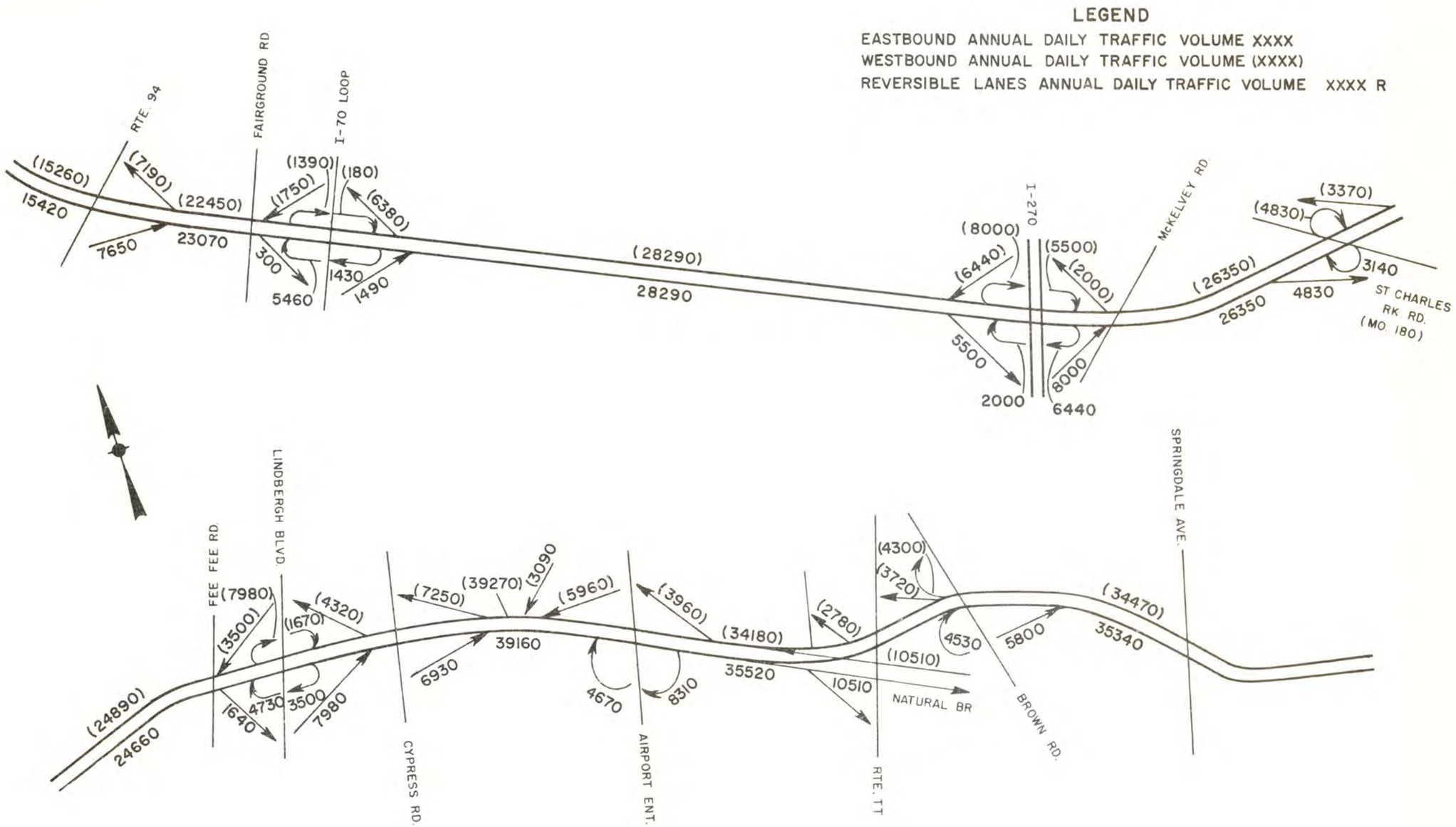


FIGURE 1A ANNUAL AVERAGE DAILY TRAFFIC

INTERSTATE ROUTE 70
ST. LOUIS, MISSOURI

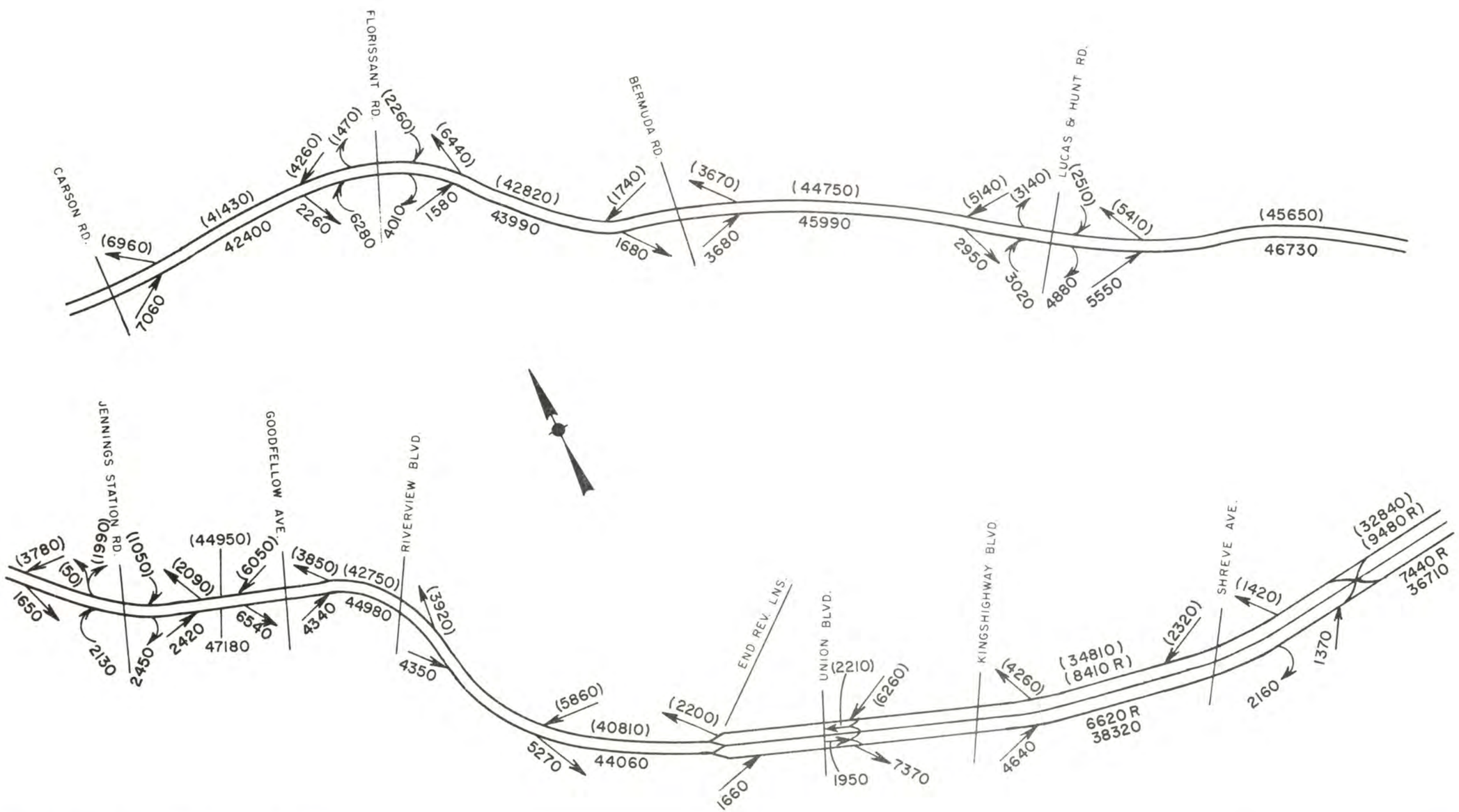


FIGURE 1 B ANNUAL AVERAGE DAILY TRAFFIC

INTERSTATE ROUTE 70
ST. LOUIS, MISSOURI

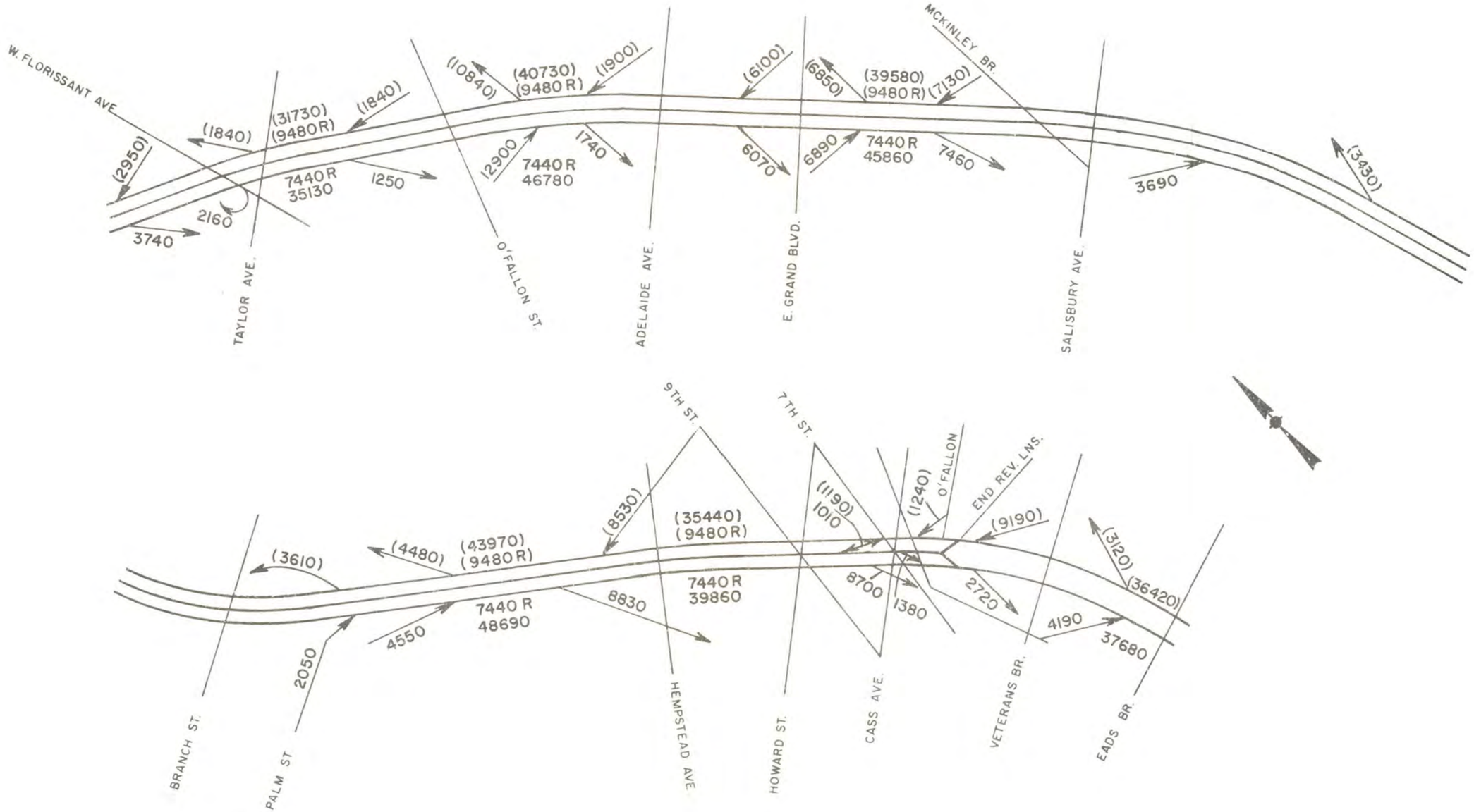


FIGURE 1C ANNUAL AVERAGE DAILY TRAFFIC

An analysis of the counts indicate that the peak hours are generally from 7 to 8 a.m. in the eastbound lanes, and from 4 to 5 p.m. in the westbound lanes. The morning peak hour volumes are shown without parentheses and the afternoon peak hour volumes with parentheses in Figures 2A, 2B and 2C.

The highest peak hour volume in the eastbound lanes is 6,500 on the through lanes just east of Riverview Boulevard.

The highest peak hour volume in the westbound lanes is 5,350 at the permanent count station at Lucas and Hunt.

The highest peak hour volume in the reversible lanes is 2,630 during the morning on the eastbound lanes from West Florissant to O'Fallon Street.

The highest peak hour volume in the reversible lanes is 2,130 during the afternoon in the westbound lanes from West Florissant Avenue to O'Fallon Street.

The growth in the hourly volumes at the permanent count station on the east side of Lucas and Hunt between 1964 and 1968 is shown on Figure 2D. Average hourly volumes are plotted as a solid line for 1964 and as a dash line for 1968.

The growth during the peak hour is a small, almost insignificant growth - 3 percent - for both directions. During the daylight hours other than the peak hours, the growth is as much as 46 percent and no less than 11 percent in the eastbound lanes and as much as 44 percent and no less than 32 percent in the westbound lanes. The evening, night and early morning hours show trends that are erratic because the volumes found are relatively small.

This growth trend indicates capacity may have been reached during the peak hours, that the peak periods are lasting longer, and that they are extending into the off-peak hours.

VOLUME-CAPACITY RATIOS AND LEVELS OF SERVICE

Tables 1A and 1B show the volume-capacity (v/c) ratios and levels of service for each segment of I-70 during the morning and afternoon peak hours. A comparison of this table with the density contour maps of the following sections will bring to light some apparent discrepancies between the indicated levels of service. These differences result from the different methods of determining level of service rather than from error. Although the v/c ratio is most frequently used to determine level of service for design purposes, it is felt that level of service based on operating speed (as determined by vehicular density) is a better means of evaluating operations on an existing facility.

INTERSTATE ROUTE 70
ST. LOUIS, MISSOURI

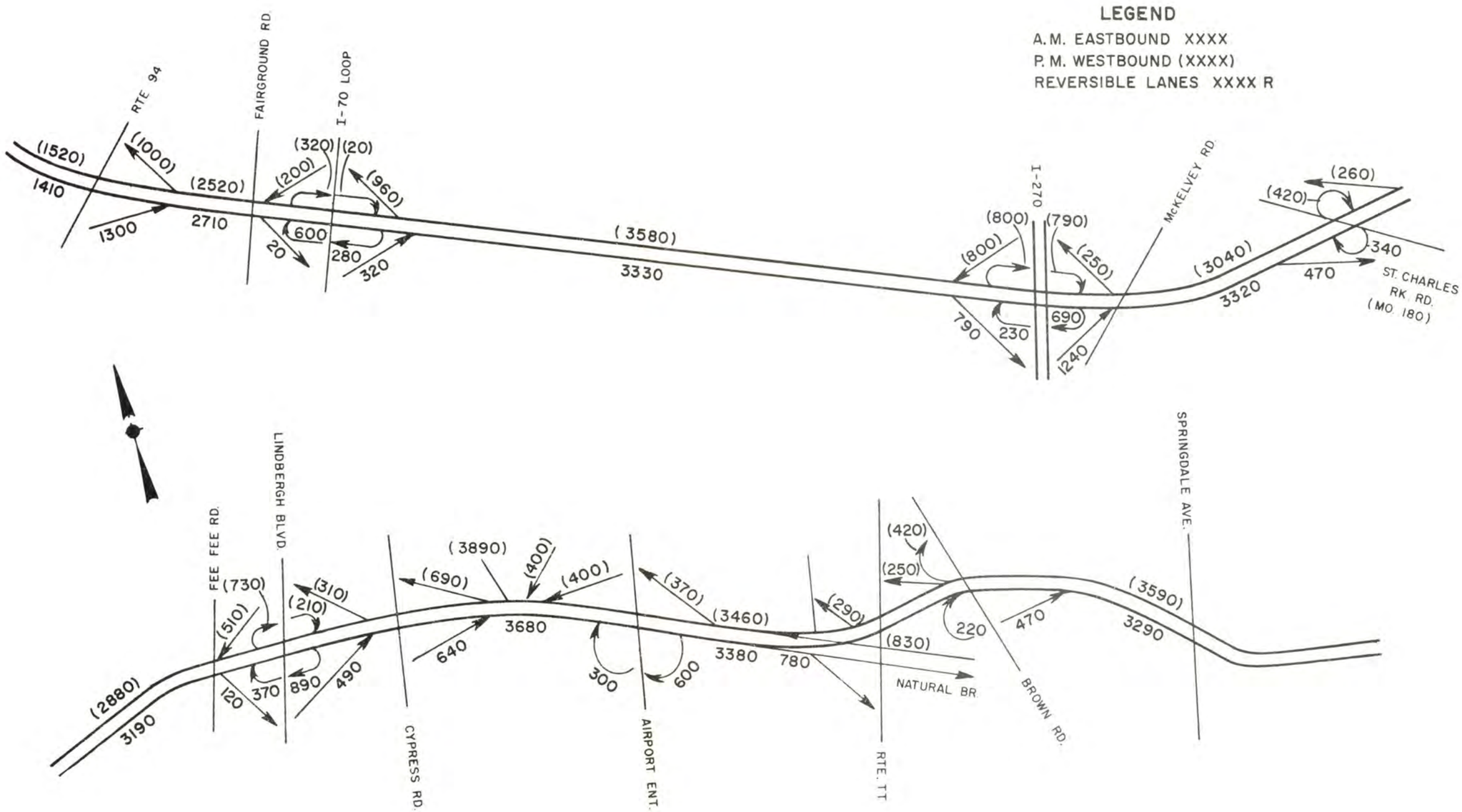


FIGURE 2 A AVERAGE PEAK HOUR TRAFFIC VOLUME

INTERSTATE ROUTE 70
ST. LOUIS, MISSOURI

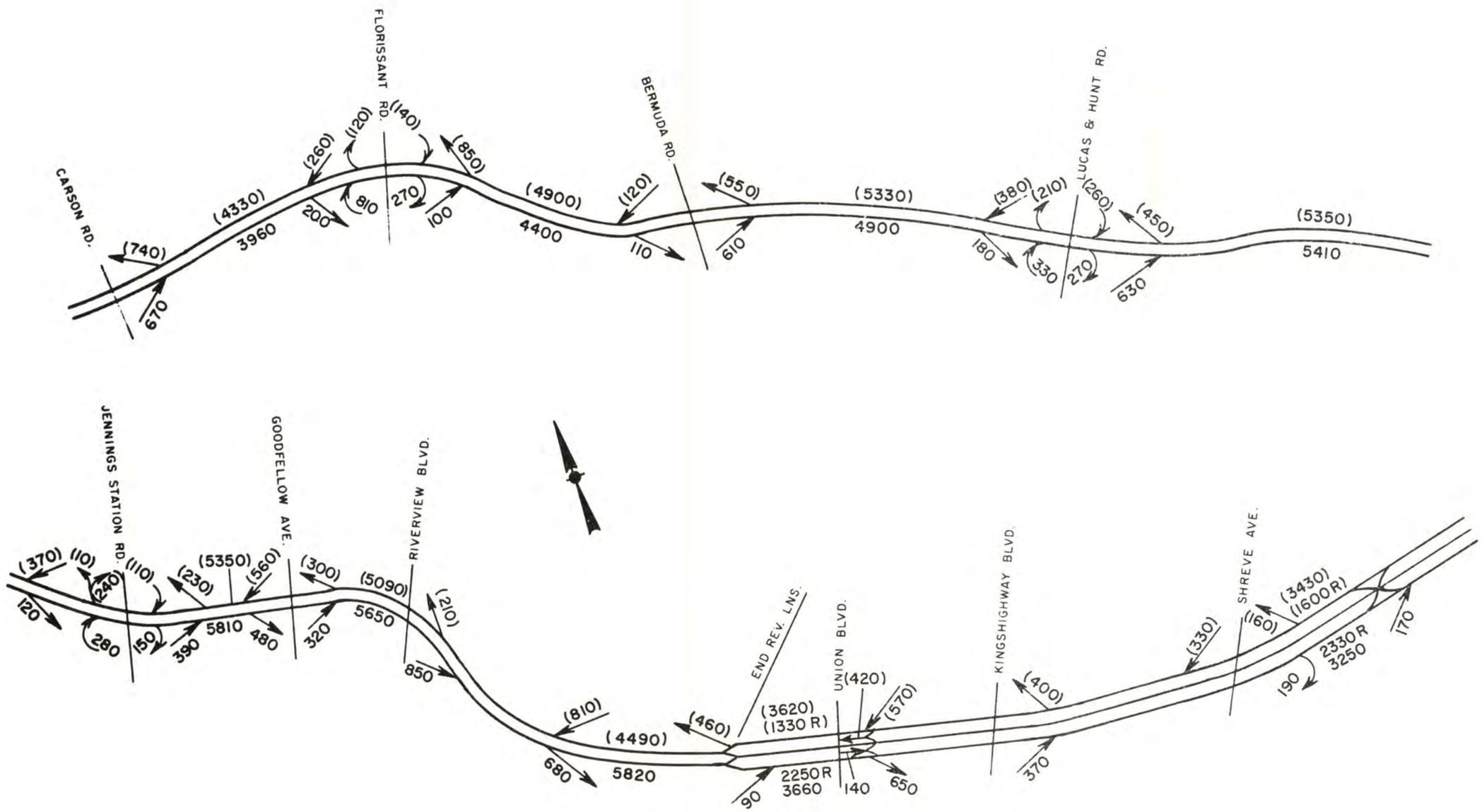


FIGURE 2 B AVERAGE PEAK HOUR TRAFFIC VOLUME

INTERSTATE ROUTE 70
ST. LOUIS, MISSOURI

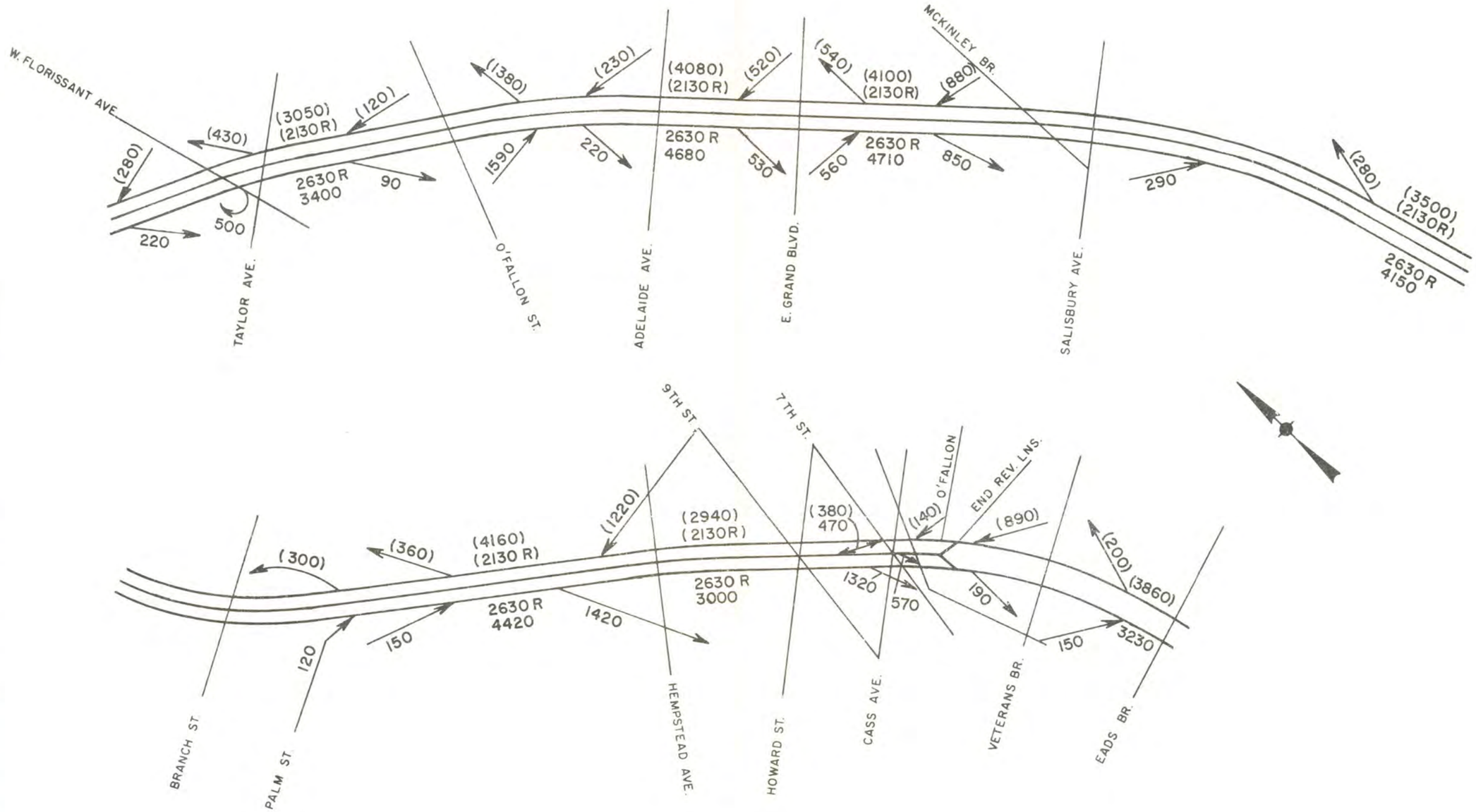
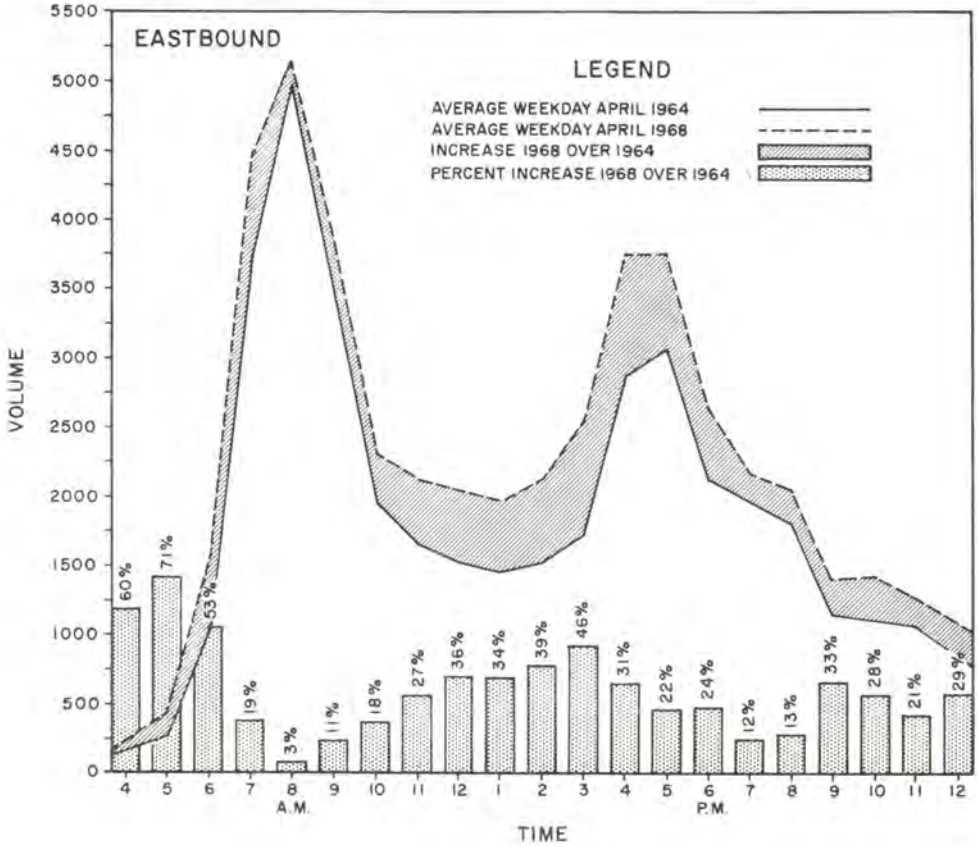


FIGURE 2 C AVERAGE PEAK HOUR TRAFFIC VOLUME

HOURLY TRAFFIC VARIATIONS

INTERSTATE ROUTE 70, EAST OF LUCAS AND HUNT

ST. LOUIS, MISSOURI



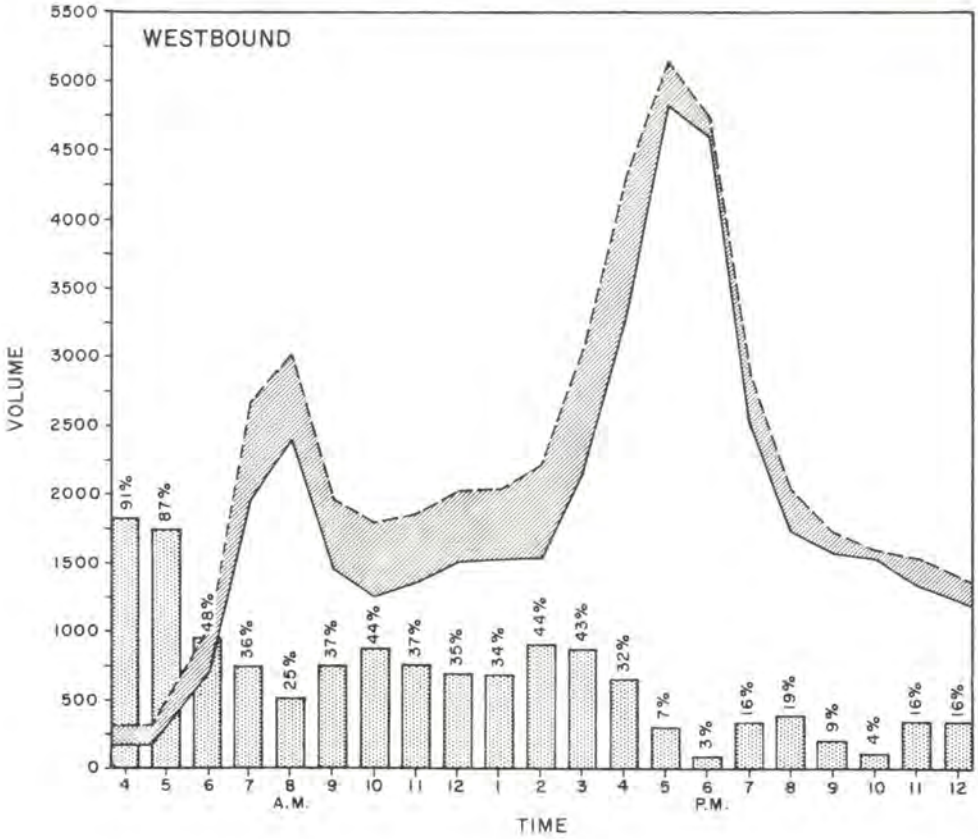


FIGURE 3D

TABLE 1A

VOLUME-CAPACITY RATIOS AND LEVELS OF SERVICE
I-70 ST. LOUIS, MISSOURI

Eastbound Peak Hour 7:00 to 8:00 A.M.

Section	Description	Capacity	Volume	V/C	Level of Service
1A	Rte. 94 to I-70 Loop Interchange	3648	2710	.74	D
1B	I-70 Loop Interchange to I-270	3648	3330	.91	F
1	I-270 to St. Charles Rock Road	3840	3320	.86	E
2	St. Charles Rock Road to Lindbergh Blvd.	3560	3190	.90	E
3	Lindbergh Blvd. to Cypress Road	3880	3040	.78	D
4	Cypress Road to Airport Entrance	3840	3680	.96	F
5	Airport Entrance to Natural Bridge Rd.	5820	3380	.58	B
6	Natural Bridge Rd. to Brown Road	5820	2600	.45	B
7-8	Brown Rd. to Carson Rd.	5587	3290	.59	C
9	Carson Rd. to West Florissant Rd.	5645	3960	.70	C
10	West Florissant Rd. to Bermuda Rd.	5299	4400	.83	E
11	Bermuda Rd. to Lucas and Hunt Rd.	5645	4900	.87	E
12	Lucas and Hunt Rd. to Jennings Sta. Rd.	5354	5410	1.01	F
13	Jennings Sta. Rd. to Goodfellow Blvd.	5354	5810	1.08	F
14	Goodfellow Blvd. to Riverview Blvd.	5354	5650	1.05	F
15	Riverview Blvd. to Plover	5645	6500	1.15	F
16	Plover to Alcott	5645	5820	1.03	F
17	Alcott to Union	4598	3660	.80	D
18	Union to Kingshighway Blvd.	4598	3660	.80	D
19	Kingshighway Blvd. to Shreve Ave.	5354	3440	.64	C
20	Shreve Ave. to Florissant Ave.	4598	3250	.71	C
21	Florissant Ave. to O'Fallon Park Rd.	4598	3400	.74	D
22	O'Fallon Park Road to Adelaide	5354	4900	.92	F
23	Adelaide to Grand Blvd.	5354	4680	.87	E
24	Grand Blvd. to Bremen	5354	4710	.88	E

TABLE 1A (Continued)

Eastbound Peak Hour 7:00 to 8:00 A.M.

Section	Description	Capacity	Volume	V/C	Level of Service
25	Bremen to Destrehan	5354	4000	.75	D
26	Destrehan to Palm	5299	4150	.78	D
27	Palm to N. Market St.	5354	4270	.80	D
28	N. Market to Brooklyn Ave.	5354	4420	.83	E
29	Brooklyn Ave. to Cass Ave.	5354	3000	.56	B
30	Cass Ave. to O'Fallon	5023	1680	.33	A
31	O'Fallon to Veteran's Bridge	5023	1680	.33	A
32	Veteran's Bridge to Ead's Bridge	5023	1680	.33	A

REVERSIBLE LANES

Eastbound Peak Hour 7:00 to 8:00 A.M.

Section	Description	Capacity	Volume	V/C	Level of Service
17	Beginning of Reversible Lanes to Union Boulevard	3647	2250	.62	C
18	Union Blvd. to Kingshighway Blvd.	3647	2250	.62	C
19	Kingshighway Blvd. to Shreve Ave.	3722	2330	.63	C
20	Shreve Ave. to Florissant Ave.	3647	2630	.72	D
21	Florissant Ave. to O'Fallon Pk. Rd.	3647	2630	.72	D
22	O'Fallon Pk. Rd. to Adelaide	3722	2630	.71	D
23	Adelaide to Grand Ave.	3722	2630	.71	D
24	Grand Blvd. to Bremen	3722	2630	.71	D
25	Bremen to Destrehan	3722	2630	.71	D
26	Destrehan to Palm	3722	2630	.71	D
27	Palm to N. Market	3722	2630	.71	D
28	N. Market to Brooklyn Ave.	3722	2630	.71	D
29	Brooklyn Ave. to End of Reversible Lanes	3722	2630	.71	D

TABLE 1B

VOLUME-CAPACITY RATIOS AND LEVELS OF SERVICE
I-70 ST. LOUIS, MISSOURI

Westbound Peak Hour 4:00 to 5:00 P.M.

Section	Description	Capacity	Volume	V/C	Level of Service
1A	Rte. 94 to I-70 Loop Interchange	3648	2520	.69	D
1B	I-70 Loop Interchange to I-270	3648	3580	.98	F
1	I-270 to St. Charles Rock Road	3680	3040	.83	E
2	St. Charles Rock Rd. to Lindbergh Blvd.	3880	2880	.74	D
3	Lindbergh Blvd. to Cypress Rd.	3680	3200	.87	E
4	Cypress Rd. to Airport Entrance	3680	3890	1.06	F
5	Airport Entrance to Natural Bridge Rd.	5520	3460	.63	C
6	Natural Bridge Rd. to Brown Rd.	5820	3170	.54	B
7-8	Brown Rd. to Carson Rd.	5299	3590	.68	C
9	Carson Rd. to W. Florissant Rd.	5354	4330	.81	D
10	West Florissant Rd. to Bermuda Rd.	5299	4900	.92	F
11	Bermuda Rd. to Lucas and Hunt Rd.	5645	5330	.94	F
12	Lucas and Hunt Rd. to Jennings Sta. Rd.	5354	5350	1.00	F
13	Jennings Sta. Rd. to Goodfellow Blvd.	5354	5350	1.00	F
14	Goodfellow Blvd. to Riverview Blvd.	5354	5090	.95	F
15	Riverview Blvd. to Plover	5354	5300	.99	F
16	Plover to Alcott	5354	4490	.84	E
17-18	Alcott to Union	4714	3620	.78	D
19	Kingshighway Blvd. to Shreve Ave.	5413	3600	.67	C
20	Shreve Ave. to Florissant Ave.	4714	3430	.73	D
21	Florissant Ave. to O'Fallon Park Rd.	4714	3050	.65	C
22	O'Fallon Park Rd. to Adelaide	5413	4310	.80	D
23	Adelaide to Grand Blvd.	5413	4080	.75	D
24	Grand Blvd. to Bremen	5413	4100	.76	D
25	Bremen to Destrehan	5413	3220	.59	C

TABLE 1B (Continued)

Westbound Peak Hour 4:00 to 5:00 P.M.

Section	Description	Capacity	Volume	V/C	Level of Service
26	Destrehan to Palm St.	5357	3500	.65	D
27	Palm St. to N. Market	5413	3800	.70	C
28	N. Market to Brooklyn	5413	4160	.77	D
29	Brooklyn Ave. to Cass Ave.	5413	2940	.54	B
30	Cass Ave. to O'Fallon	5413	2940	.54	B
31	O'Fallon to Veteran's Bridge	5078	2800	.55	B
32	Veteran's Bridge to Eads Bridge	5078	3860	.76	D

REVERSIBLE LANES

Westbound Peak Hour 4:00 to 5:00 P.M.

Section	Description	Capacity	Volume	V/C	Level of Service
17	Beginning of Reversible Lanes to Union	3647	1330	.36	B
18	Union to Kingshighway Blvd.	3647	1330	.36	B
19	Kingshighway Blvd. to Shreve Ave.	3722	1600	.43	B
20	Shreve Ave. to Florissant Ave.	3647	2130	.58	C
21	Florissant Ave. to O'Fallon Pk. Rd.	3647	2130	.58	C
22	O'Fallon Pk. Rd. to Adelaide	3722	2130	.57	C
23	Adelaide to Grand Blvd.	3722	2130	.57	C
24	Grand Blvd. to Bremen	3722	2130	.57	C
25	Bremen to Destrehan	3722	2130	.57	C
26	Destrehan to Palm	3722	2130	.57	C
27	Palm to N. Market St.	3722	2130	.57	C
28	N. Market to Brooklyn Ave.	3722	2130	.57	C
29	Brooklyn Ave. to Cass Ave.	3722	2130	.57	C

TRAFFIC DENSITIES AND LEVELS OF SERVICE

Figures 3A through 3D and 4A through 4D are density contour maps and reflect current peak period operating conditions in the eastbound and westbound lanes.

The density contour maps show density and operating speed during the peak periods on a time-distance chart. As the density increases the operating speed decreases. Speed is expressed in color codes and related to levels of service as determined by the 1965 Highway Capacity Manual. These relationships are explained in detail in the Appendix by Figures A-1 and A-2 and explanation thereof.

In Figures 3A, 3B, 3C, and 3D, the average density for 1968 on a given section during a certain period of time compared to that of 1967 is as follows:

Location	Average Density[1]		Average Speed[2]	
	1967	1968	1967	1968
Florissant Road to Lucas & Hunt	61	54	27	34
From Lucas & Hunt to Riverview Boulevard	66	59	23	28

[1] In vehicles/lane/mile [2] In miles/hour

For practical purposes these two days show no significant difference. An examination of the density contour maps shows almost identical conditons on these two random days of two different years. It appears to warrant a detailed study.

In Figures 4A, 4B, 4C, and 4D, the average density for 1968 compared to that of 1967 is as follows:

Location	Average Density[1]		Average Speed[2]	
	1967	1968	1967	1968
Florissant Road to Bermuda Rd.	31	44	54	43
0.3 mile east of Lucas & Hunt to the end of the reversible lanes	77	70	19	22

[1] In vehicles/lane/mile [2] In miles/hour

For practical purposes these two days show no significant difference. An examination of the density contour maps shows almost identical conditions on these two random days of two different years. It appears to warrant a detailed study.

DEFICIENT LEVELS OF OPERATION

Any area operating at Level F for 10 minutes or longer is considered deficient.

The following areas during the morning in the eastbound lanes are operating at deficient levels:

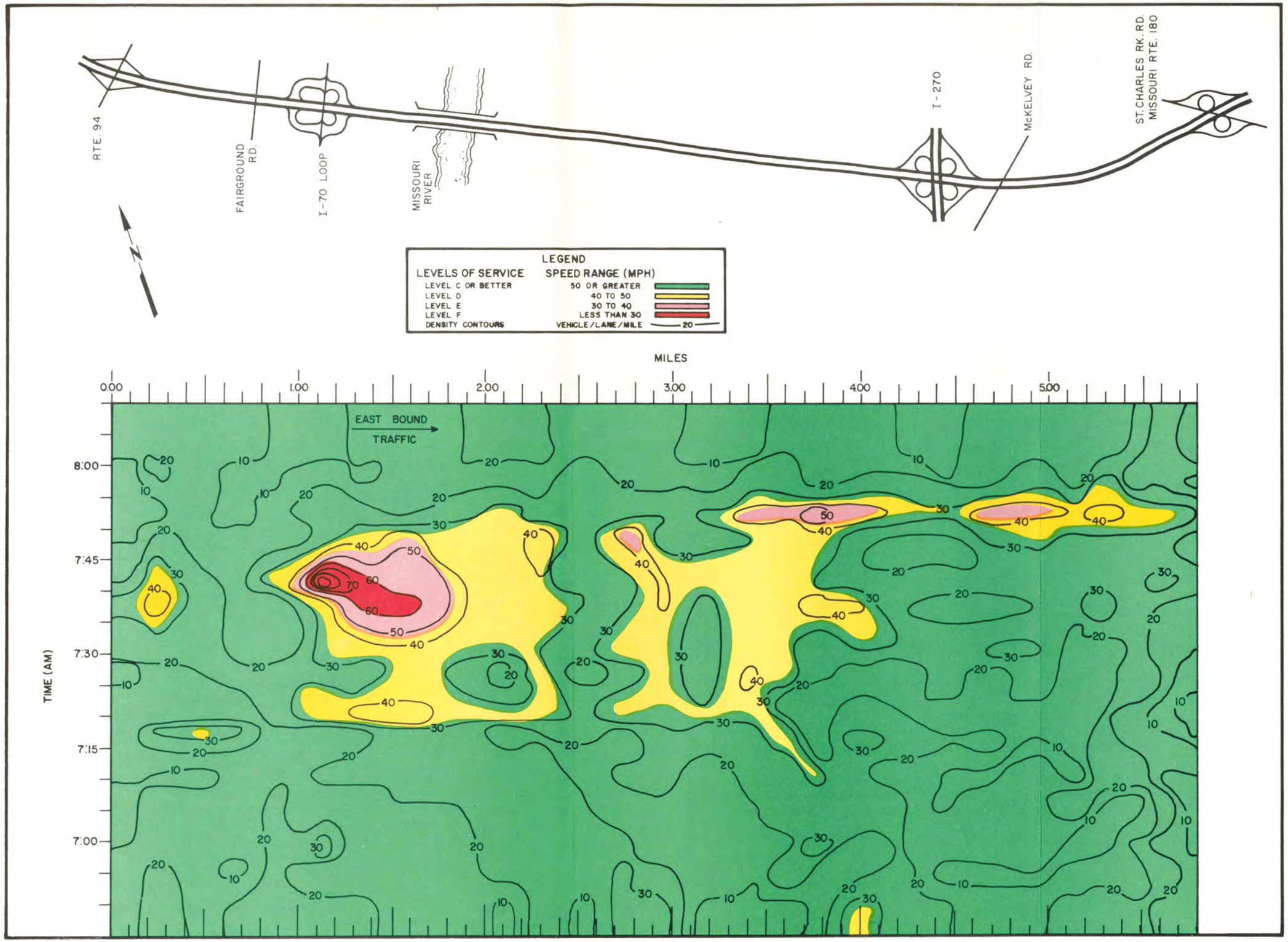


FIGURE 3A TRAFFIC DENSITY CONTOURS AND LEVELS OF SERVICE DURING THE MORNING PEAK PERIOD ON THE EASTBOUND LANES

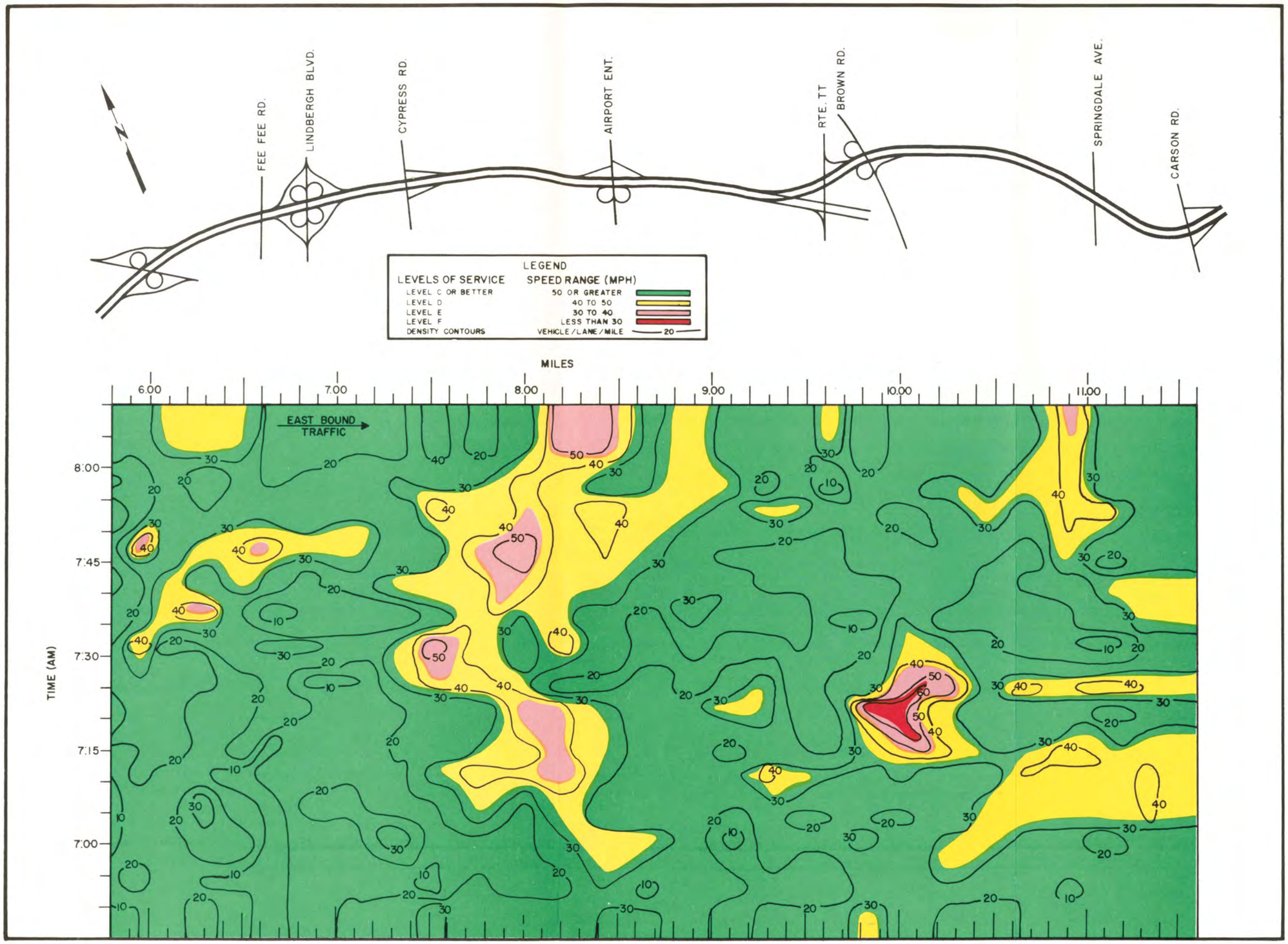


FIGURE 3B TRAFFIC DENSITY CONTOURS AND LEVELS OF SERVICE DURING THE MORNING PEAK PERIOD ON THE EASTBOUND LANES

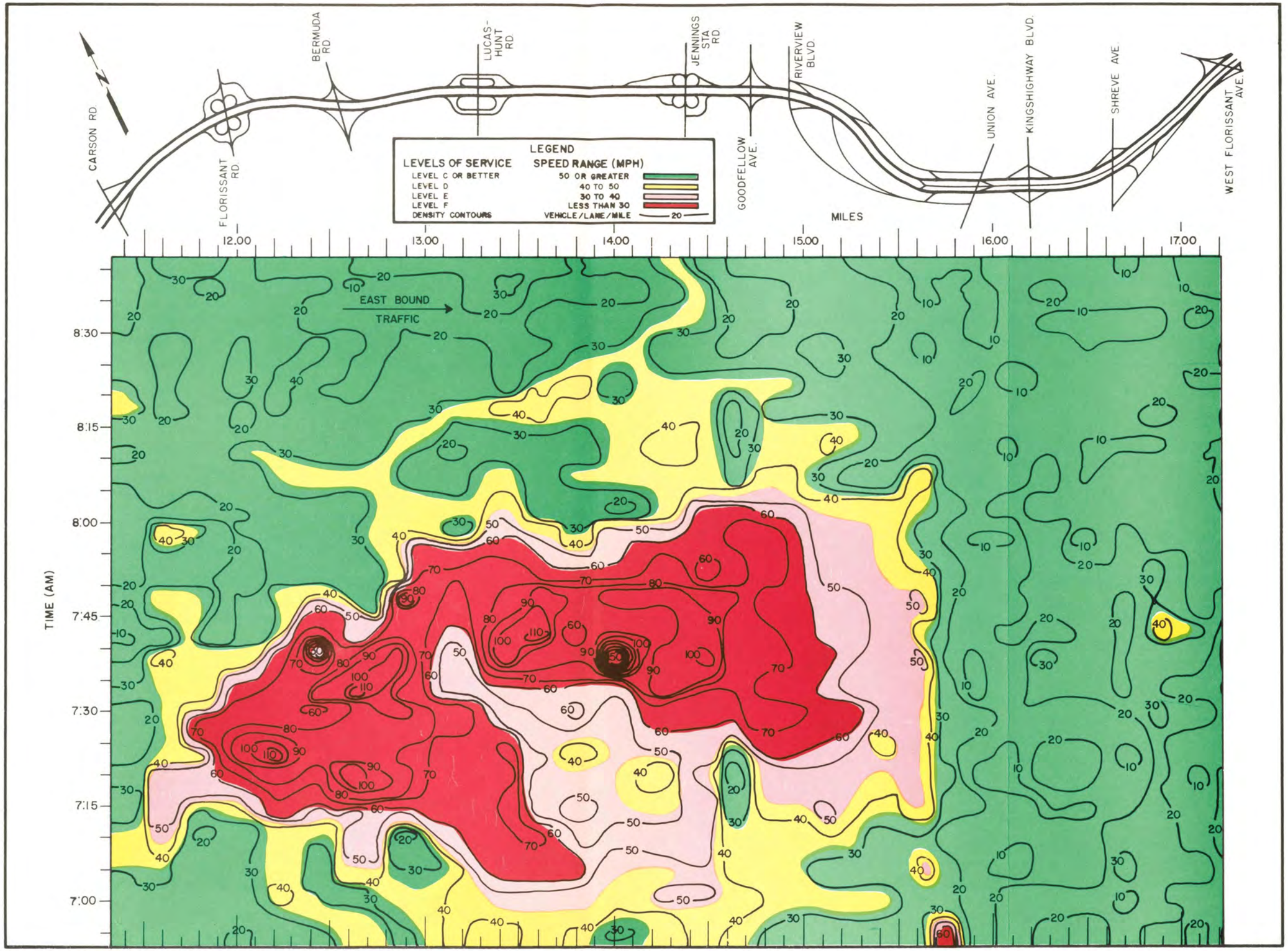


FIGURE 3C TRAFFIC DENSITY CONTOURS AND LEVELS OF SERVICE DURING THE MORNING PEAK PERIOD ON THE EASTBOUND LANES

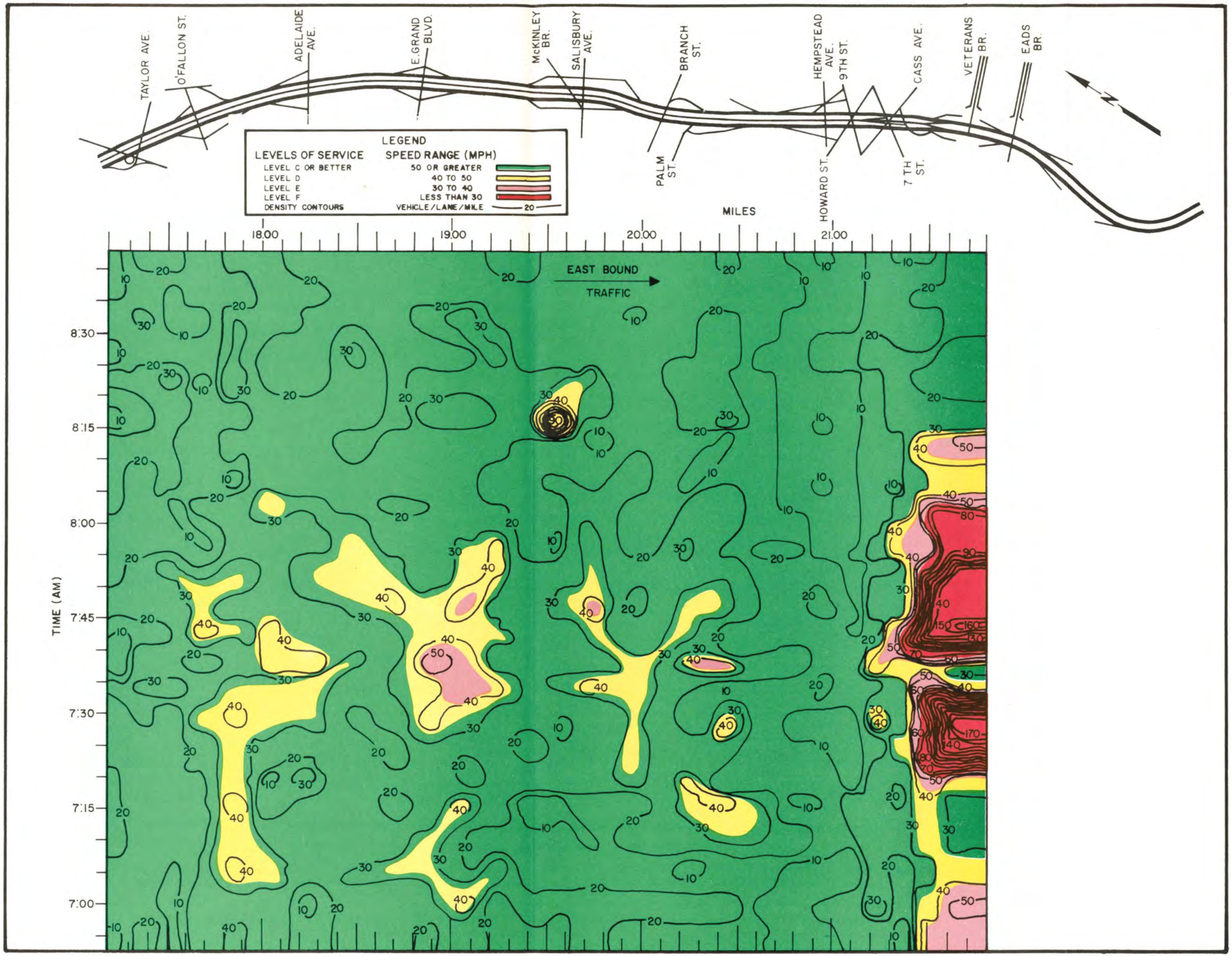


FIGURE 3D TRAFFIC DENSITY CONTOURS AND LEVELS OF SERVICE DURING THE MORNING PEAK PERIOD ON THE EASTBOUND LANES

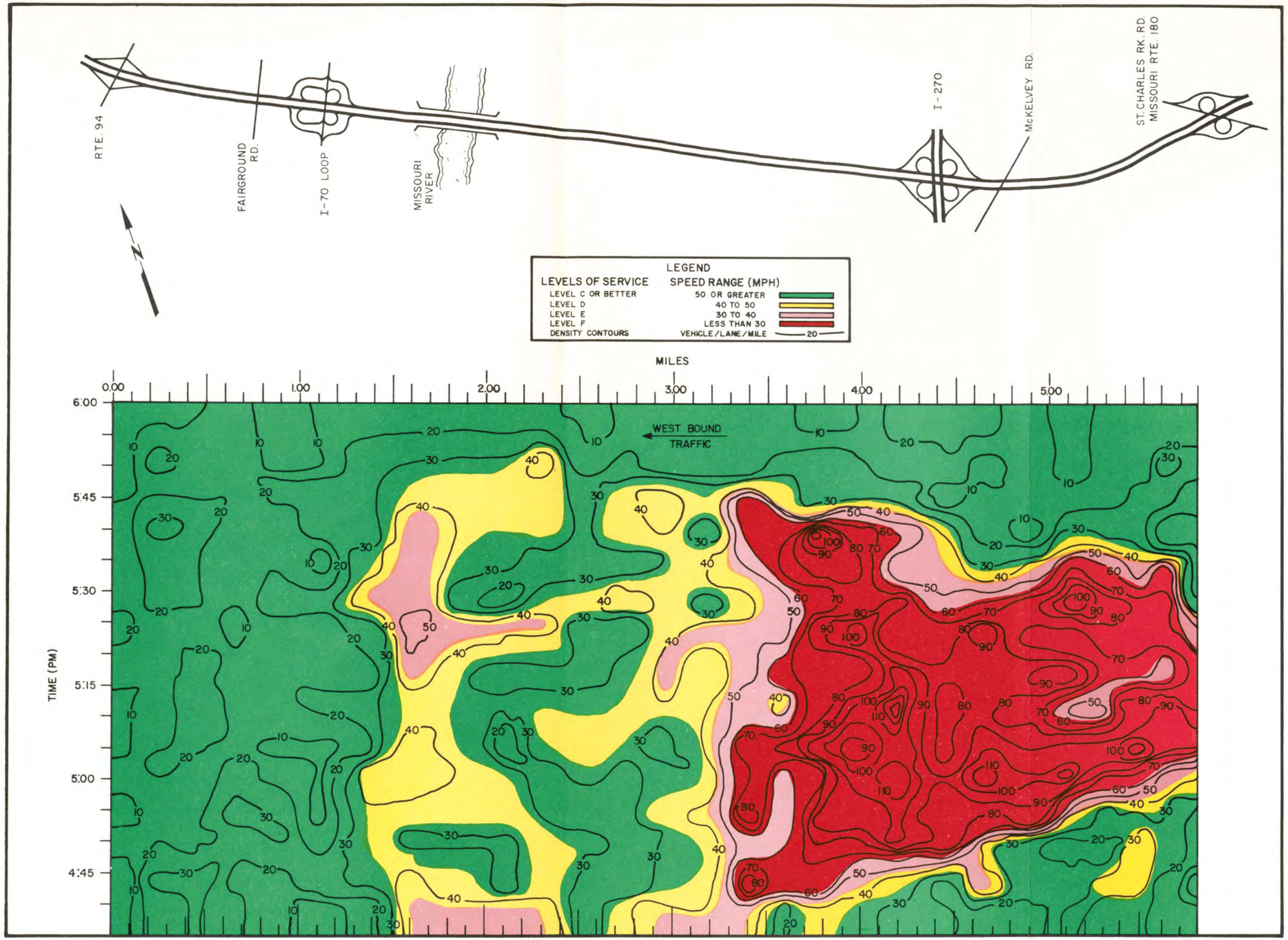


FIGURE 4A TRAFFIC DENSITY CONTOURS AND LEVELS OF SERVICE DURING THE AFTERNOON PEAK PERIOD ON THE WESTBOUND LANES

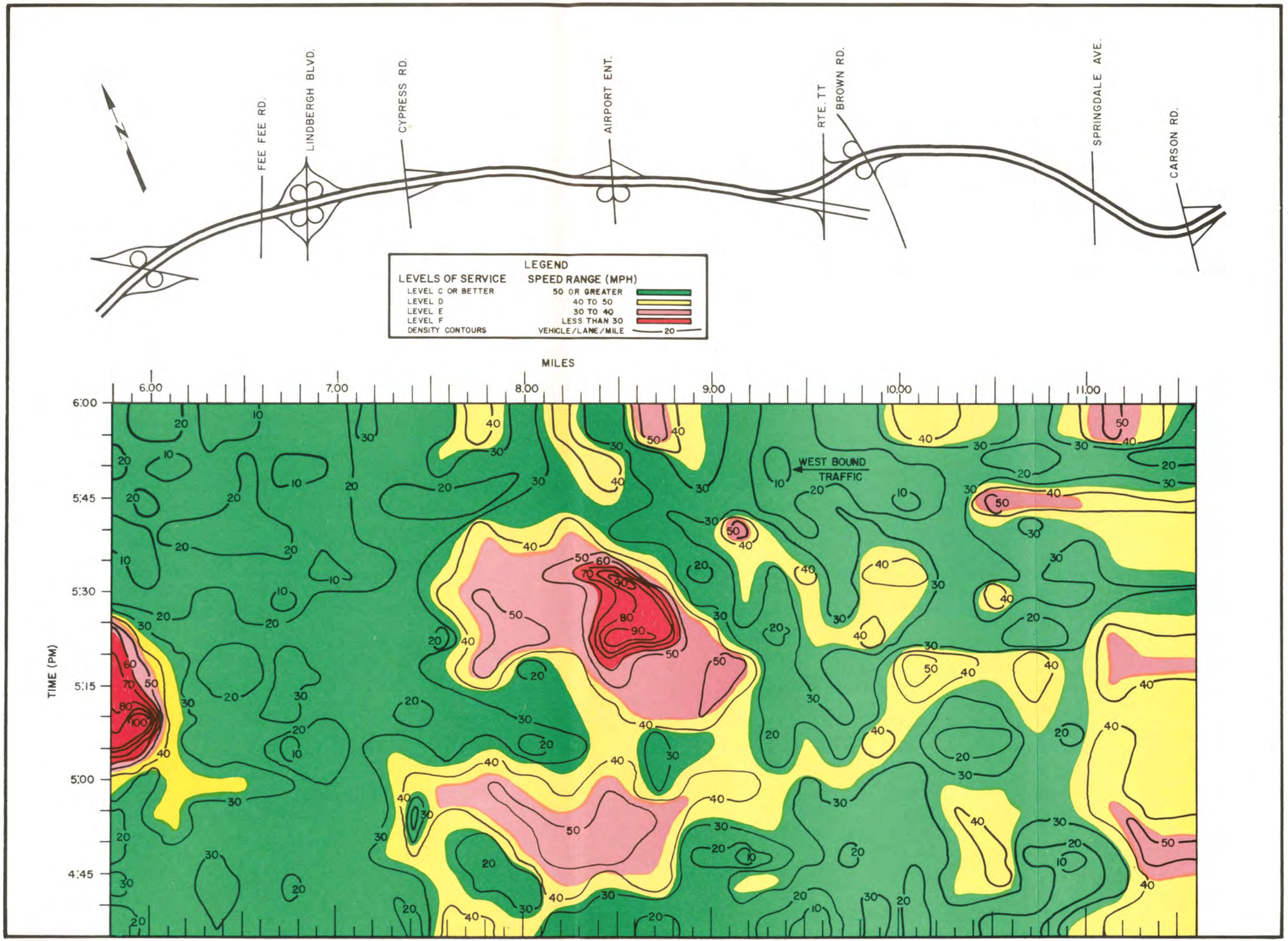


FIGURE 4B TRAFFIC DENSITY CONTOURS AND LEVELS OF SERVICE DURING THE AFTERNOON PEAK PERIOD ON THE WESTBOUND LANES

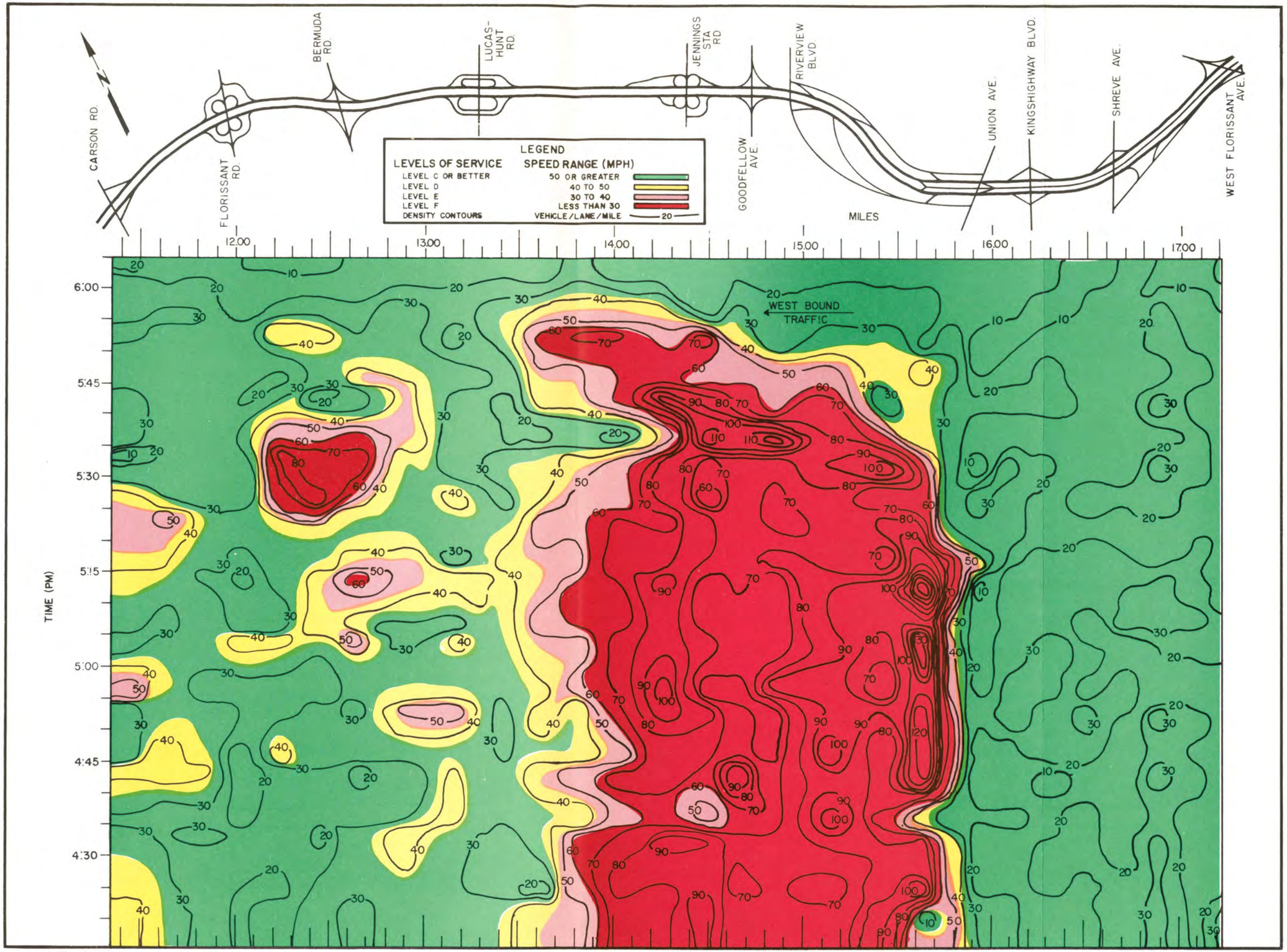


FIGURE 4C TRAFFIC DENSITY CONTOURS AND LEVELS OF SERVICE DURING THE AFTERNOON PEAK PERIOD ON THE WESTBOUND LANES

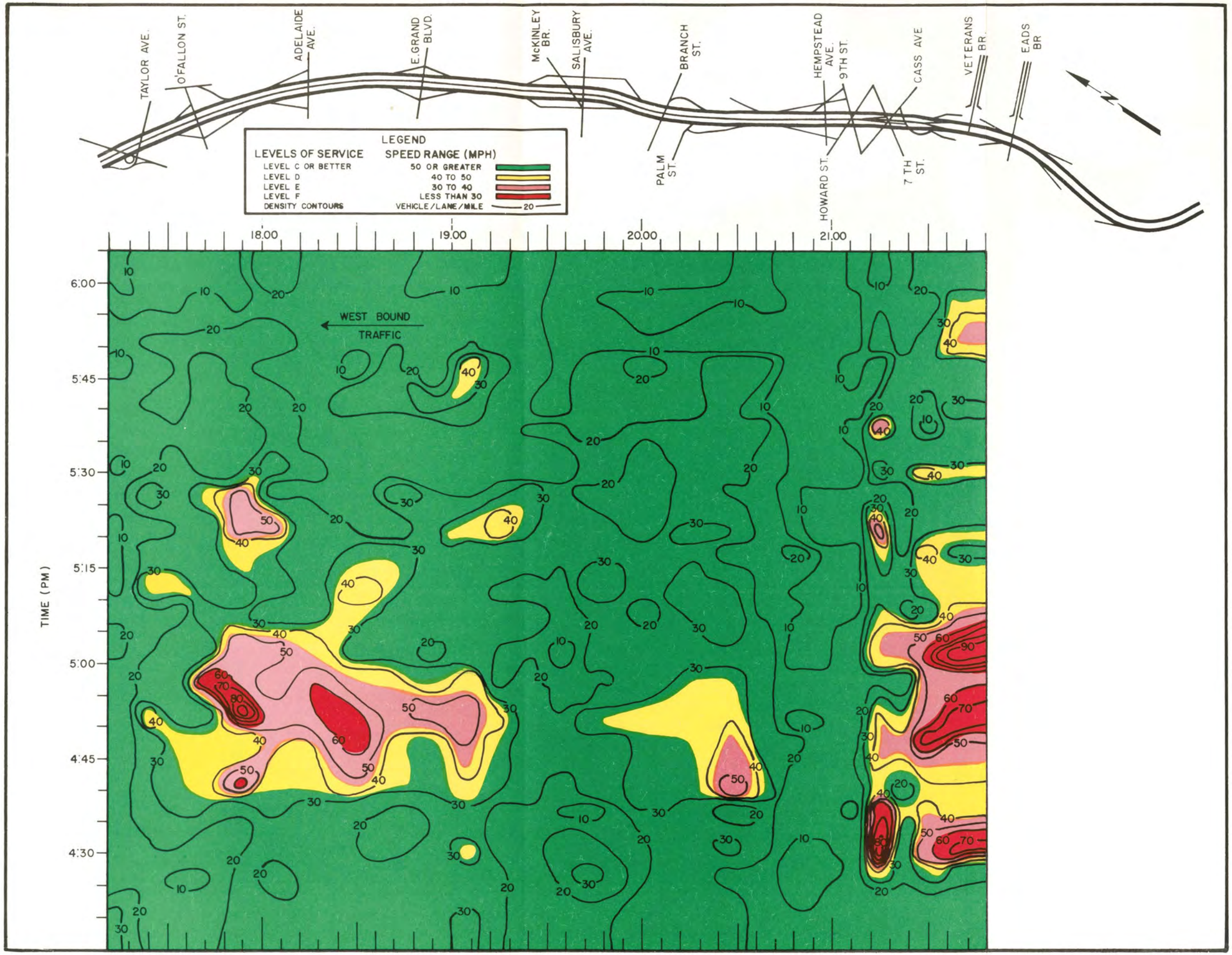


FIGURE 4D TRAFFIC DENSITY CONTOURS AND LEVELS OF SERVICE DURING THE AFTERNOON PEAK PERIOD ON THE WESTBOUND LANES

(1) Between the beginning and ending of the I-70 Loop in St. Charles, traffic operates at Levels E and F for 15 minutes. There is a 4 percent decline from this loop to the bridge.

(2) For 0.5 mile from the east end of the Brown Road interchange, traffic operates at Level F for 10 minutes. There is a merging volume of 220 and one of 470 from Brown Road.

(3) Between Florissant Road to the beginning of the reversible lanes at Union Boulevard, traffic operates at Level F for up to one hour. There are 4 curves of 3 degrees or more, and 2 grades-an incline and a decline from Lucas and Hunt to Jennings Station Road. Adding to this situation are merging volumes of 910 at Florissant Road, 610 at Bermuda Road, 960 at Lucas and Hunt, and 850 at Riverview Boulevard.

(4) From Cass Avenue at the end of the reversible lane to Eads Bridge, traffic operation is at Level F for 25 or more minutes.

Deficient levels of operation during the afternoon in the westbound lanes are as follows:

(1) From 1.075 miles west of I-270 to St. Charles Rock Road, traffic operates at Level F for one hour. There is a 4 percent grade at McKelvey Road and a net volume increase of 700.

(2) Traffic operates at Levels E and F for 20 minutes between Cypress Road and Natural Bridge Road. There are three grades of 3.5 percent at Route TT west of Natural Bridge Road, 4 percent at airport entrance, and 4 percent at Cypress Road. There is a 3° curve just east of Cypress Road, a change in lanes at airport entrance, and merging volumes of 830 at Natural Bridge Road and two of 400 each at airport entrance. The current 5 year R & W program includes adding a lane in each direction from Airport Road to Lindbergh Boulevard which should provide relief to this condition.

(3) Between Florissant Road and Bermuda Road, traffic operates at Level F for 10 to 15 minutes. There is a 3° curve at Bermuda Road.

(4) From 0.3 mile east of Lucas and Hunt to the end of the reversible lanes at Union Boulevard, traffic operates at Level F for approximately two hours. There are 3 curves of 3°, $3^{o}3'$, and 3° with a 5 percent grade between Lucas and Hunt and Jennings Station Road.

(5) Between O'Fallon Park Road and East Grand Boulevard, traffic operates at Levels E and F for 15 minutes. There is a 520 merging volume from East Grand and 880 from Salisbury Avenue.

(6) Between the end of the reversible lanes at Cass Avenue and Eads Bridge, traffic operates at Levels E and F for 20 minutes.

RECOMMENDATIONS

There are three locations where significant congestion appears. The first is in the eastbound lanes during the morning between Florissant Road and Union Avenue. The second and third occur during the afternoon in the westbound lanes between Lucas and Hunt Road and Union Avenue, and between the Missouri River and St. Charles Rock Road.

Currently detailed traffic studies are being conducted at the last two locations.

It is recommended a similar detailed traffic study be conducted at the first location when time permits.

PART III

DANIEL BOONE EXPRESSWAY

ST. LOUIS, MISSOURI

STUDY AREA

The Daniel Boone Expressway (U.S. 40) in St. Louis is characterized by numerous grades since it extends over rolling terrain.

The east end beyond Jefferson Street is under construction at present and when completed will connect the Daniel Boone Expressway with the Poplar Street Bridge across the Mississippi River to Illinois. This is the most centrally located route through St. Louis with I-70 extending to the north and west, and I-55 extending to the south and west.

It serves as ready access to residential and commercial traffic to and from downtown St. Louis and from arterial routes like Choteau Avenue, Clayton Road, the Inner Belt Expressway, and the circumferential Route I-244.

TRAFFIC VOLUMES

Annual average daily traffic volumes are shown in Figure 1A. The highest volume in the eastbound lanes is 53,460 just east of the Clayton Road on-ramps. The highest volume in the westbound lanes is at Hampton Avenue with 56,120.

Counts at the permanent count station at Lucas and Hunt on I-70 indicate an increase in annual average daily traffic of 12% between 1967 to 1968 in the eastbound lanes and 5% in the westbound lanes. Since the increase and conditions on I-70 and the Daniel Boone Expressway have been almost identical and there is no permanent count station on the Daniel Boone Expressway, the counts at the Lucas and Hunt permanent counter are considered indicative of the growth on both routes.

The peak hours are from 7:00 to 8:00 A.M. in the eastbound lanes - shown without parentheses - and from 4:00 to 5:00 P.M. in the westbound lanes - shown with parentheses in Figure 2.

The highest peak hour volume in the eastbound lanes is 5,580 just east of the Clayton Road on-ramp. The highest peak hour volume in the westbound lanes is 5,810 at Hampton Avenue.

GROWTH TRENDS

The permanent counting station on the Daniel Boone Expressway has not been in its present location long enough to show trends, but the trends shown by Figure 2D of Part II of this report are considered very similar.

STUDY AREA

DANIEL BOONE EXPRESSWAY

ST. LOUIS, MISSOURI

FIGURES A-1 AND A-2

STUDY AREA	BEGIN STUDY AREA I-244 BALLAS ROAD									SPOEDE ROAD
MILE POSTS	12.84									14.71
GRADES	900' +3.9%	900' -5.9%	550' +5%	550' -4.4%	620' +6.0%	650' +4.5%	1050' -3.49%			
SPEED LIMITS	55 M.P.H.									
NUMBER OF LANES										

PR

LINDBERGH BLVD.

15.24

500' -3.5% | 675' -6 %

4 LANES

POSED 6 LANES

CLAYTON ROAD

15.85

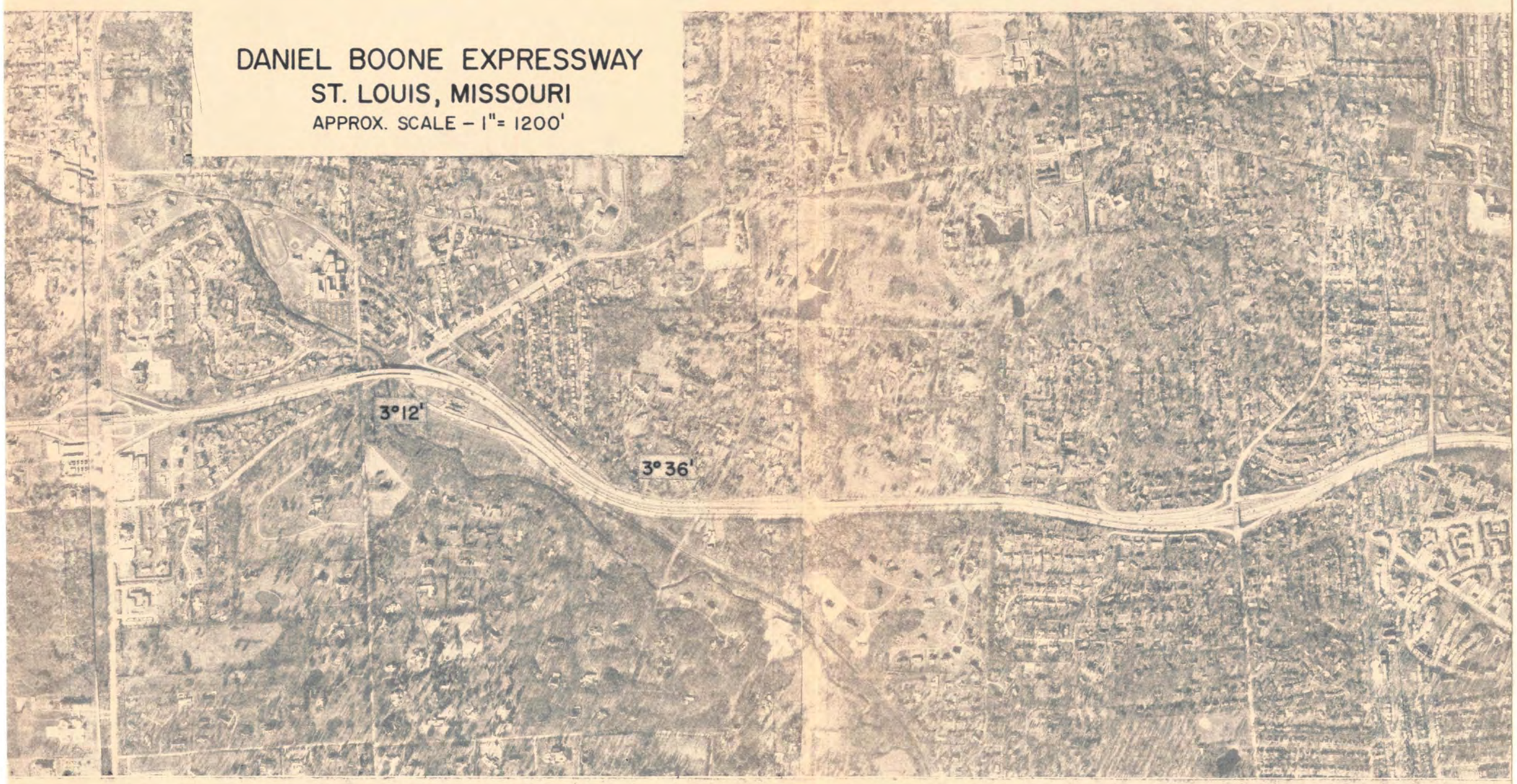
700' -4.4%

55 M.P.H.

McKNIGHT ROAD

17.71

1200' +5.34% | 570' -4.66%



DANIEL BOONE EXPRESSWAY

ST. LOUIS, MISSOURI

APPROX. SCALE – 1" = 1200'

BRENTWOOD BLVD. | INNER BELT EXPRESSWAY | HANLEY ROAD | LACLEDE STATION ROAD | BIG BEND

19.23 | 19.51 | 20.05

1250' +4.1% | 1480' -5.0% | 600' -4.2% | 1000' +5%

55 M.P.H.

6 LANES

BELLEVUE

20.44

1000'
+5%

55 M.P.H.

6 LANES

McCAUSLAND AVENUE

20.79

900'
-5%

CLAYTON ROAD

21.14

907'
+4.8%

HAMPTON

21.93

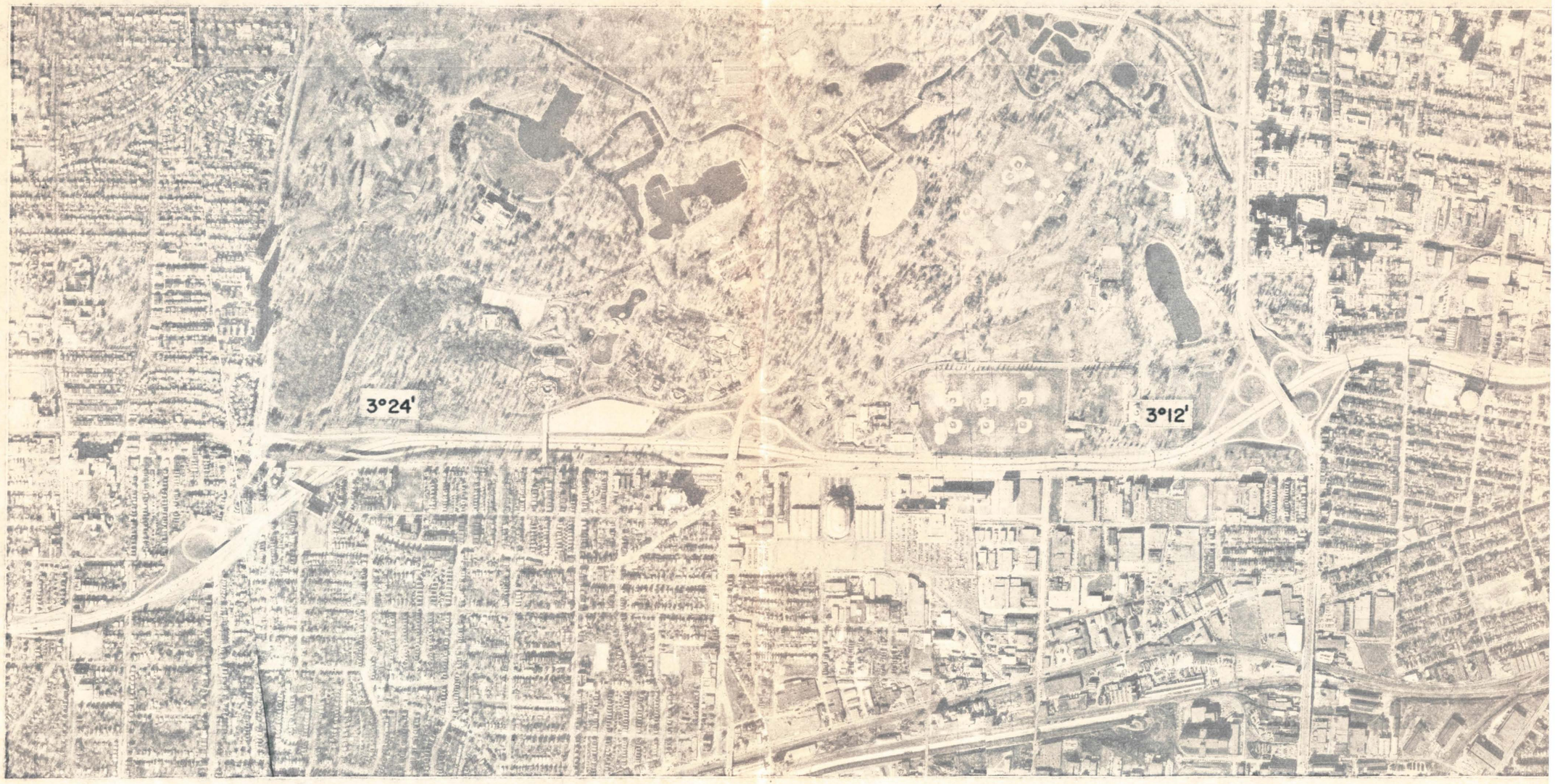
KINGSHIGHWAY

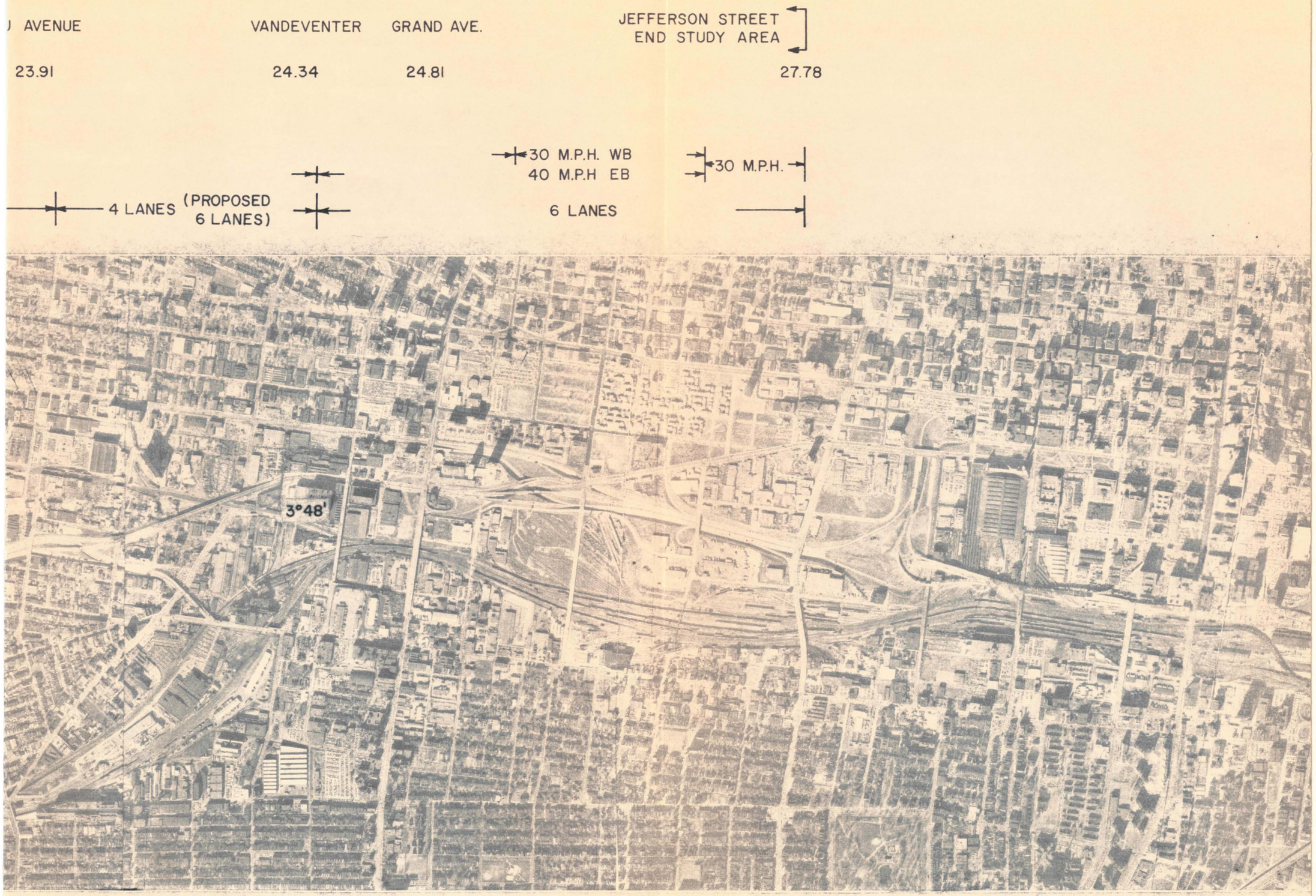
23.10

55 M.P.H.

6 LANES

CHOTEA




J AVENUE
VANDEVENTER
GRAND AVE.
JEFFERSON STREET
END STUDY AREA
23.91
24.34
24.81
27.78
30 M.P.H. WB
40 M.P.H EB
30 M.P.H.
4 LANES (PROPOSED 6 LANES)
6 LANES
3°48'

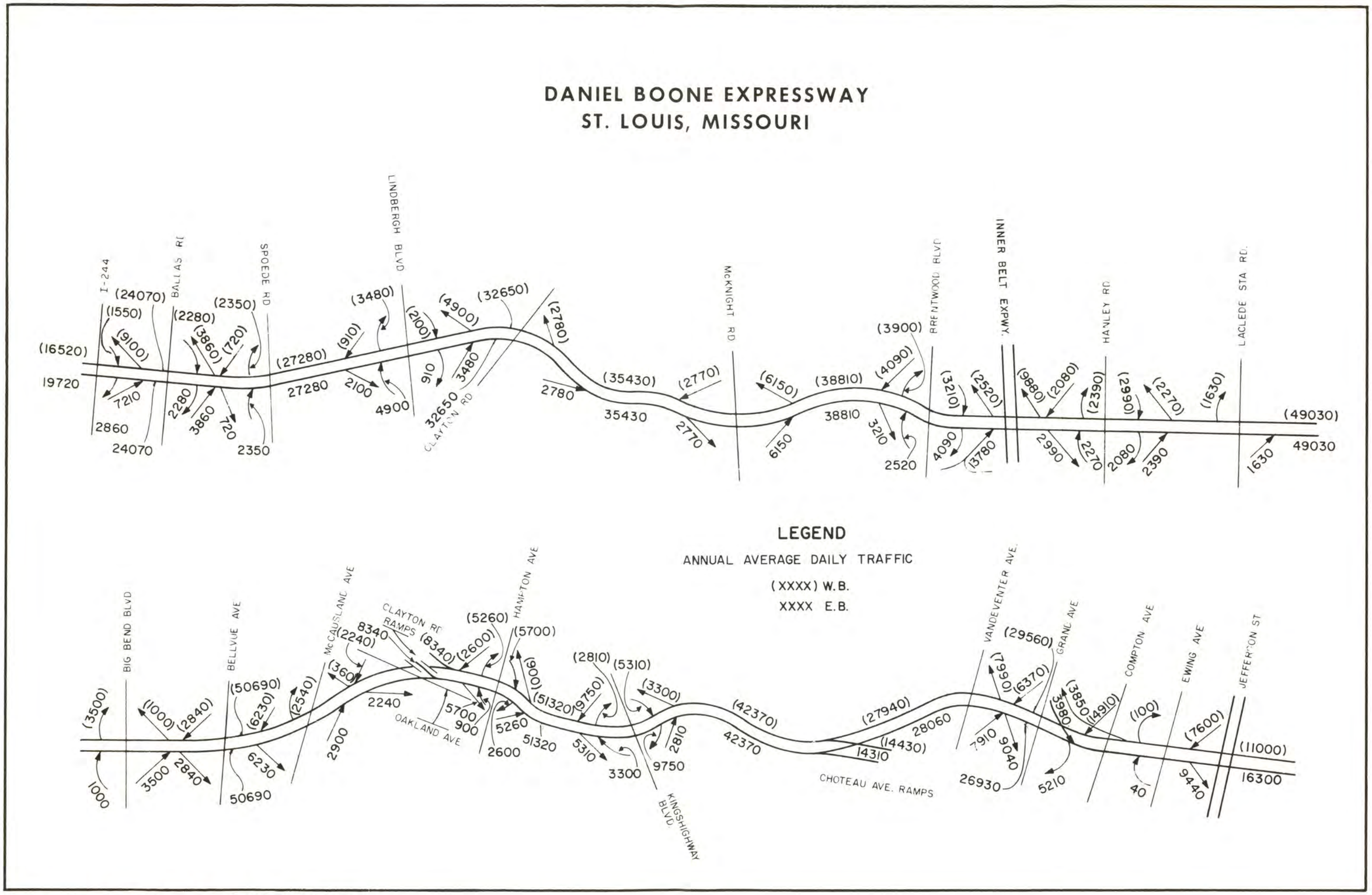


FIGURE 1 ANNUAL AVERAGE DAILY TRAFFIC

DANIEL BOONE EXPRESSWAY
ST. LOUIS, MISSOURI

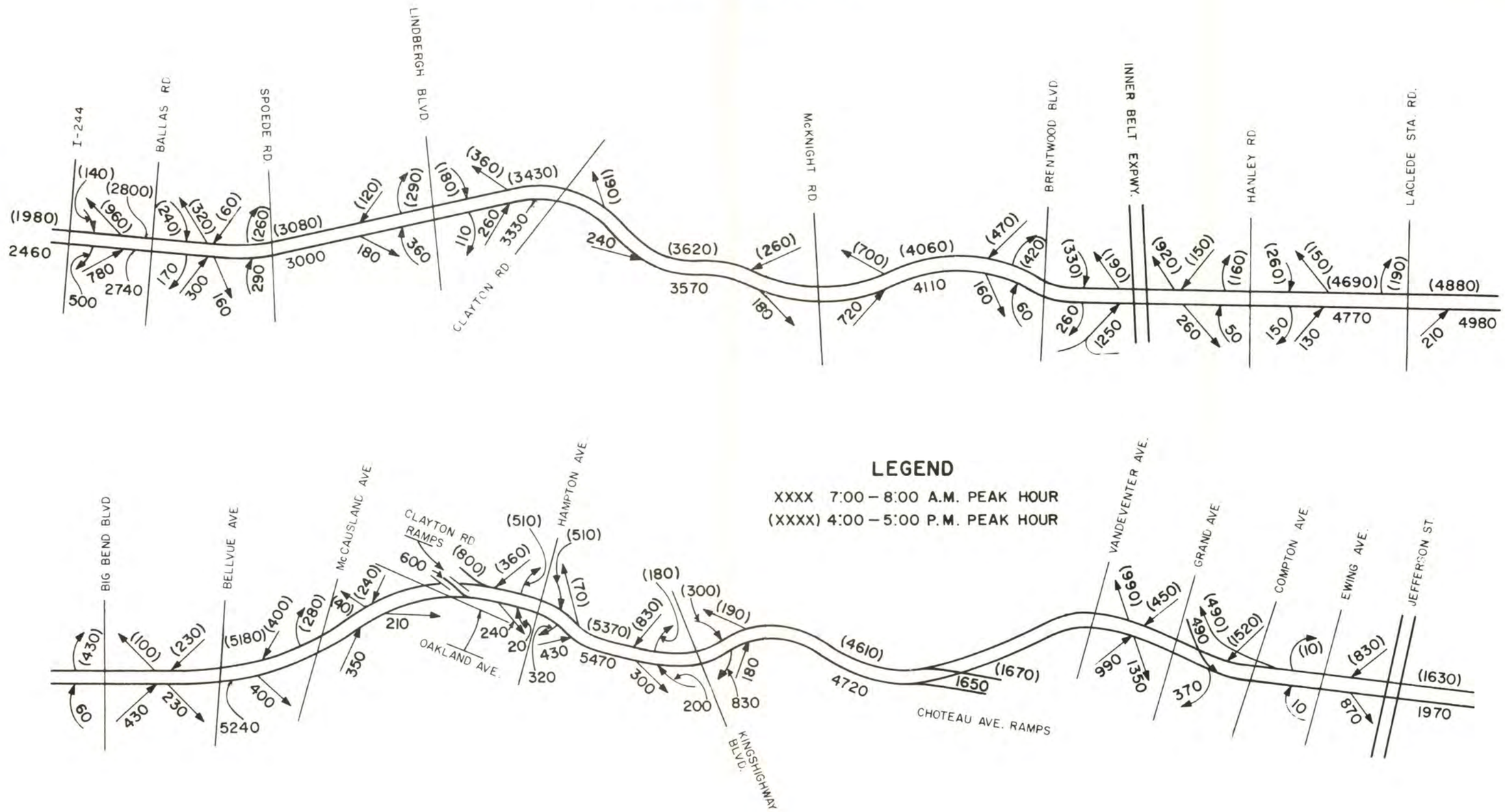


FIGURE 2 ANNUAL PEAK HOUR TRAFFIC VOLUME

VOLUME-CAPACITY RATIOS AND LEVELS OF SERVICE

Tables 1A and 1B show the volume-capacity (v/c) ratios and indicated levels of service for each segment of I-70 during the morning and afternoon peak hours. A comparison of this table with the density contour maps of the following section will bring to light some apparent discrepancies between the indicated levels of service. These differences result from the different methods of determining levels of service rather than from error. Although the v/c ratio is most frequently used to determine level of service for design purposes, it is felt that level of service based on operating speed (as determined by vehicular density) is a better means of evaluating operations on an existing facility.

TABLE A

VOLUME-CAPACITY RATIOS AND LEVELS OF SERVICE
DANIEL BOONE EXPRESSWAY, U.S. 40
ST. LOUIS, MISSOURI

Eastbound Peak Hour 7:00 To 8:00 A.M.

Section	Description	Capacity	Volume	V/C	Level of Service
1	I-244 to Ballas Road	3647	2740	.75	D
2	Ballas Road to Spoede Road	3760	2870	.76	D
3	Spoede Road to Lindbergh Boulevard	3647	3000	.82	E
4	Lindbergh Boulevard to Clayton Rd.	3920	3330	.85	E
5	Clayton Road to McKnight Road	3760	3570	.94	F
6	McKnight Road to Brentwood Blvd.	5704	4110	.72	C
7	Brentwood Boulevard to Hanley Rd.	5302	5000	.94	F
8	Hanley Road to Laclede Station Road	5302	4770	.90	E
9	Laclede Station Road to Big Bend Blvd.	5527	4980	.90	E
10	Big Bend Blvd. to Bellevue	5302	5470	1.03	F
11	Bellevue to McCausland	5302	5240	.99	F
12	McCausland to Oakland	5880	5190	.89	E
13	Oakland to Hampton	5640	5580	.99	F
14	Hampton to Kingshighway	5880	5470	.93	F
15	Kingshighway to Chouteau	5132	4720	.92	F
16	Chouteau to Vandeventer	3175	3070	.86	E
17	Vandeventer to Grand	5351	4060	.76	D
18	Grand to Compton	5351	2340	.44	B

Section	Description	Capacity	Volume	V/C	Level of Service
19	Compton to Ewing	5351	2830	.53	B
20	Ewing to Jefferson Street	5351	2840	.53	B

TABLE B

VOLUME-CAPACITY RATIOS AND LEVELS OF SERVICE
DANIEL BOONE EXPRESSWAY, U.S. 40
ST. LOUIS, MISSOURI

Westbound Peak Hour 4:00 To 5:00 P.M.

Section	Description	Capacity	Volume	V/C	Level of Service
1	I-244 to Ballas Road	3647	2800	.77	D
2	Ballas Road to Spoede Road	3760	2880	.77	D
3	Spoede Road to Lindbergh Blvd.	3647	3080	.84	E
4	Lindbergh Blvd. to Clayton Road	3920	3430	.88	E
5	Clayton Road to McKnight Road	3760	3620	.96	F
6	McKnight Road to Brentwood Blvd.	5704	4060	.72	C
7	Brentwood Blvd. to Hanley Road	5302	4790	.91	F
8	Hanley Road to Laclede Station Rd.	5302	4690	.88	E
9	Laclede Station Road to Big Bend Blvd.	5527	4880	.88	E
10	Big Bend Blvd. to Bellevue	5302	5410	1.02	F
11	Bellevue to McCausland	5302	5180	.98	F
12	McCausland to Oakland	5880	5100	.87	E
13	Oakland to Hampton	5640	5660	1.00	F
14	Hampton to Kingshighway	5880	5370	.91	F
15	Kingshighway to Chouteau	5132	4610	.90	E
16	Chouteau to Vandeventer	3175	2940	.82	E
17	Vandeventer to Grand	5351	3930	.73	D
18	Grand to Compton	5351	3480	.65	C
19	Compton to Ewing	5351	2450	.46	B
20	Ewing to Jefferson Street	5351	2460	.46	B

The average density in areas with deficient levels of operation for 1967 compared with 1968 during the morning in the eastbound lanes is as follows:

Location	Average Density[1] 1967	Average Density[1] 1968	Average Speed[2] 1967	Average Speed[2] 1968
From McKnight Road to the Inner Belt Expressway	25	26	58	56
From the Inner Belt Expressway to Clayton Road	39	60	46	27
From Clayton Road to Chouteau Ave.	50	50	36	36
From Chouteau to Grand Avenue	45	40	42	46

In order to show development during the afternoon in the westbound lanes, the average density is given below for 1967 and 1968:

Location	Average Density[1] 1967	Average Density[1] 1968	Average Speed[2] 1967	Average Speed[2] 1968
McKnight Road to Inner Belt Exp.	30	77	54	14
Inner Belt Expressway to Clayton Rd.	35	60	50	27
Clayton Road to Chouteau Avenue	61	73	26	16
Chouteau Avenue to Grand Avenue	53	79	33	11

[1] In vehicles/lane/per [2] In miles/hour

TRAFFIC DENSITIES AND LEVELS OF SERVICE

The density contour maps shown on Figures 3A, 3B, 4A and 4B reflect current operating conditions on the Daniel Boone Expressway.

DEFICIENT LEVELS OF OPERATION

Those areas where deficient levels of operation occur during the morning in the eastbound lanes are described as follows:

(1) In the area from I-244 to Lindbergh Boulevard traffic operates at Levels E and F up to 25 minutes. Some of the factors which contribute to this adverse condition are the 4 grades ranging from 4 percent to 6 percent.

FIGURE 3A TRAFFIC DENSITY CONTOURS AND LEVELS OF SERVICE DURING THE MORNING PEAK PERIOD ON THE EASTBOUND LANES

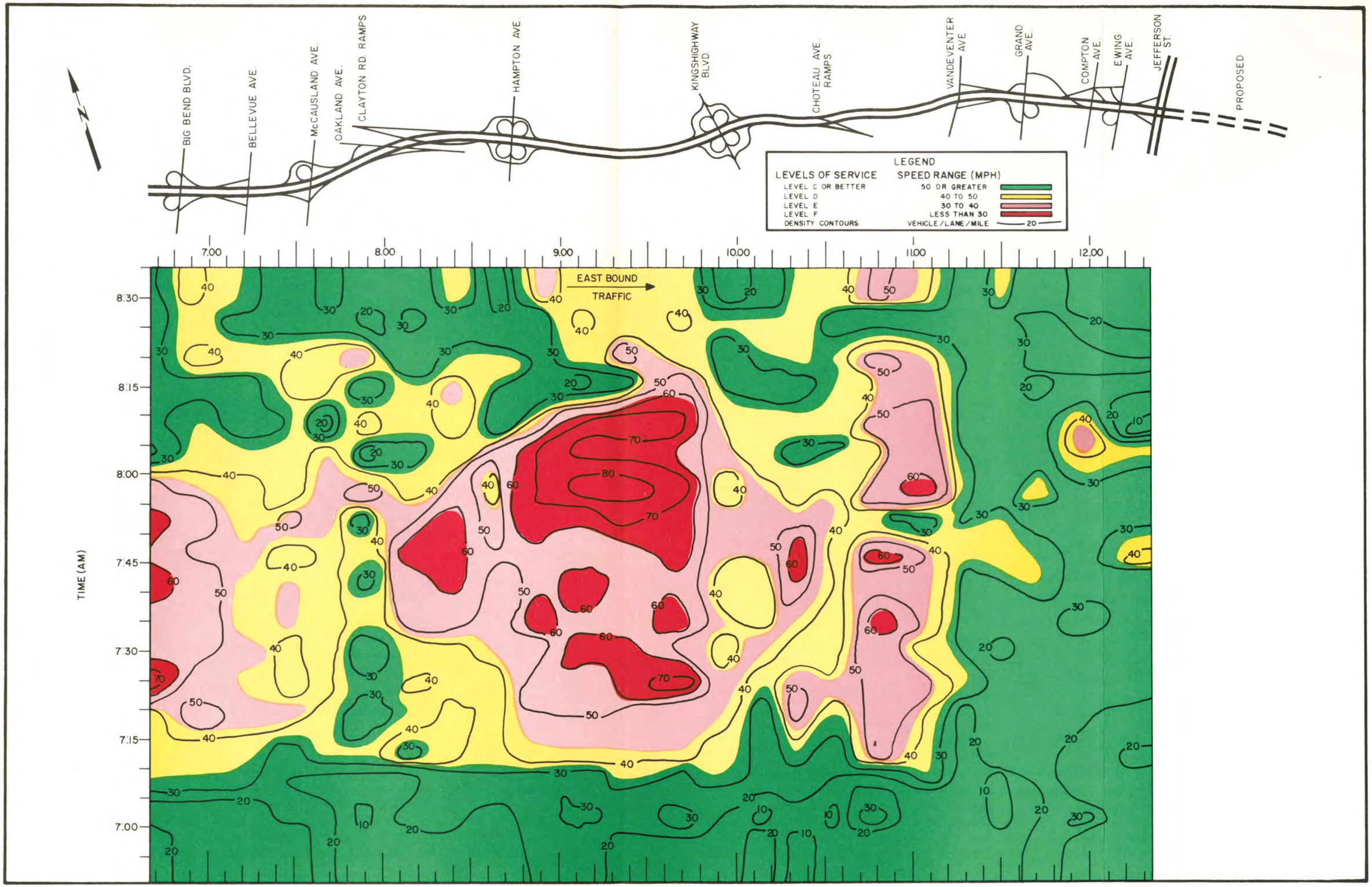


FIGURE 3B TRAFFIC DENSITY CONTOURS AND LEVELS OF SERVICE DURING THE MORNING PEAK PERIOD ON THE EASTBOUND LANES

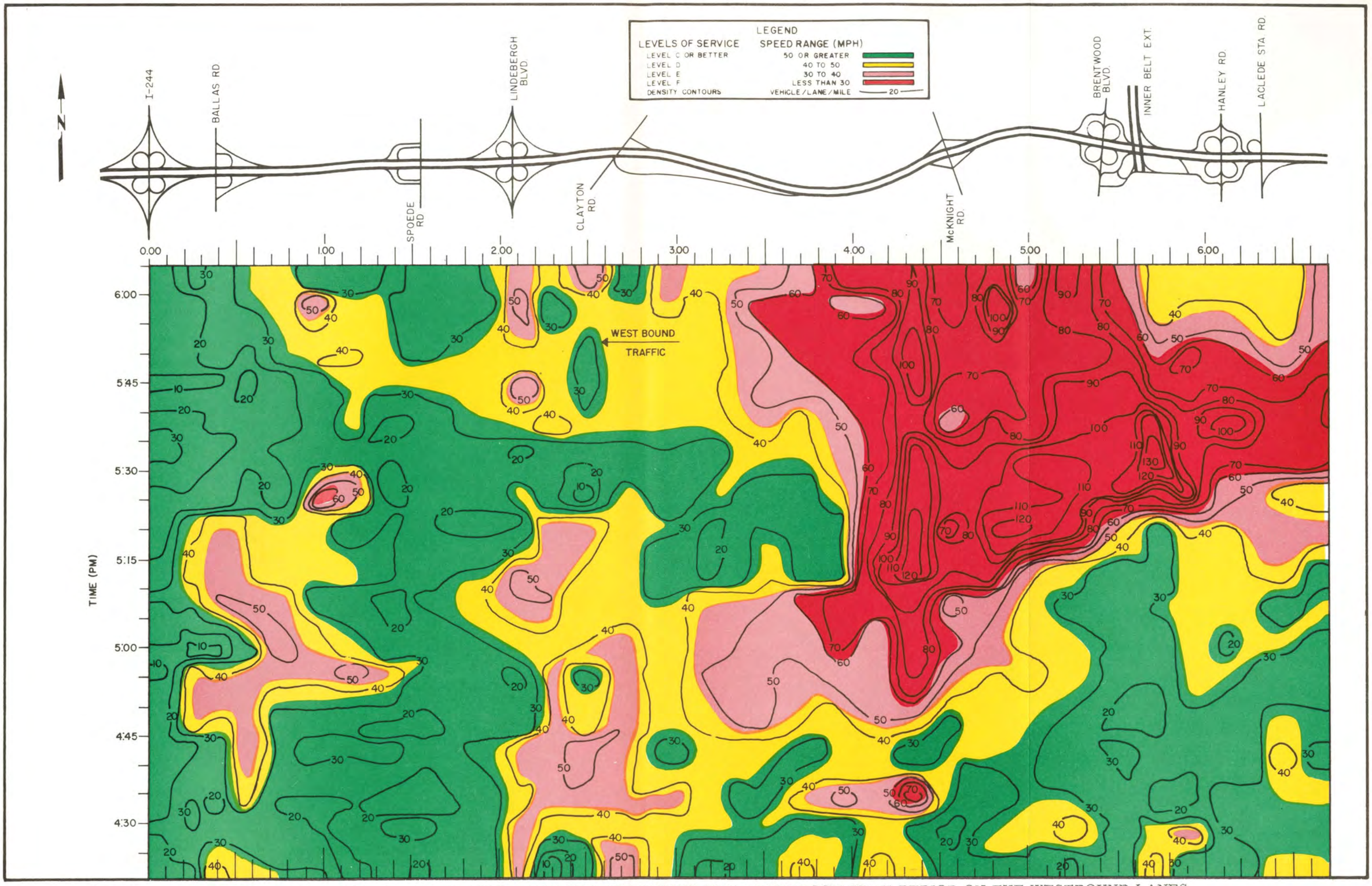


FIGURE 4A TRAFFIC DENSITY CONTOURS AND LEVELS OF SERVICE DURING THE AFTERNOON PEAK PERIOD ON THE WESTBOUND LANES

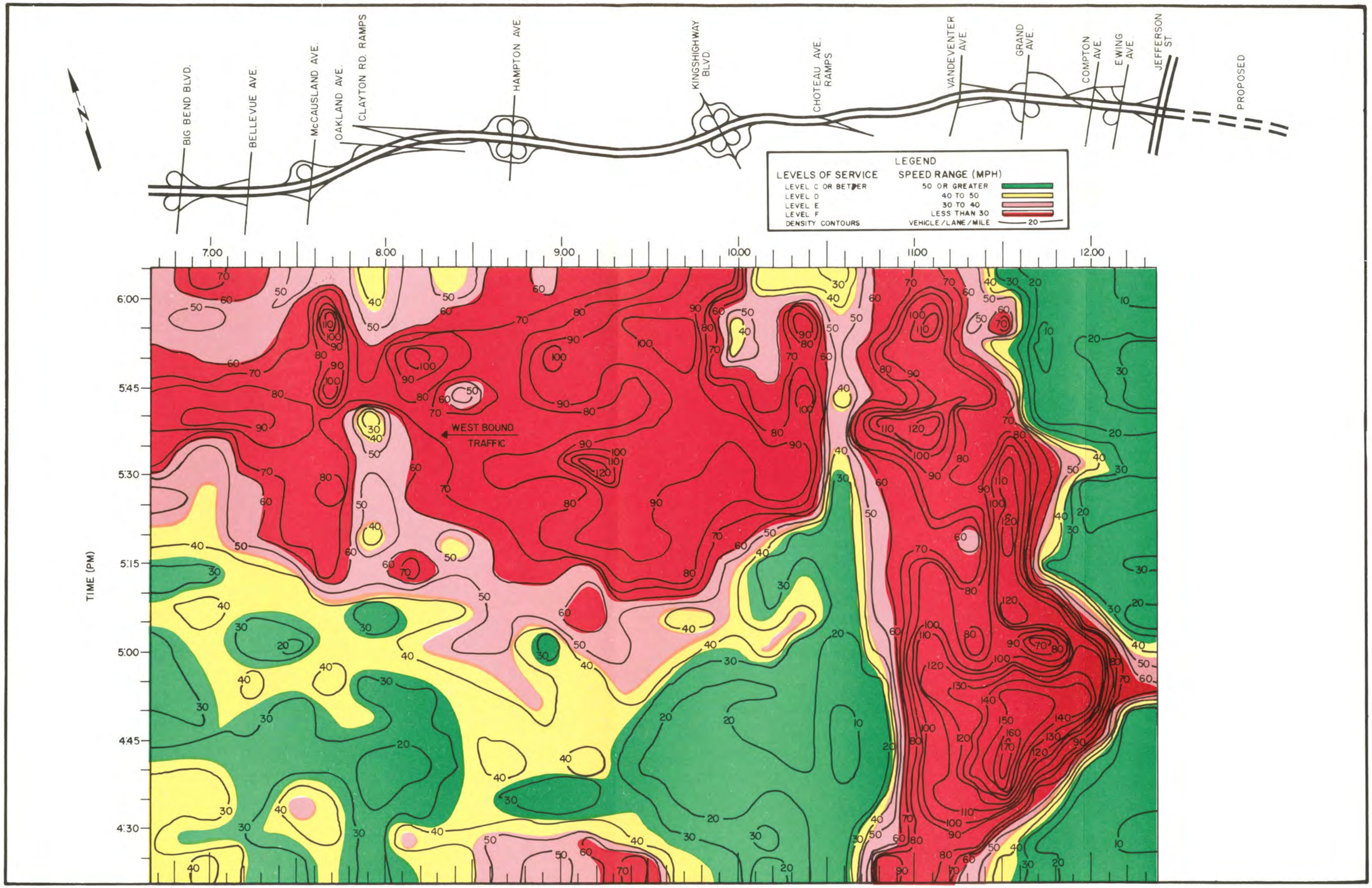


FIGURE 4B TRAFFIC DENSITY CONTOURS AND LEVELS OF SERVICE DURING THE AFTERNOON PEAK PERIOD ON THE WESTBOUND LANES

(2) From Lindbergh Boulevard to McKnight Road traffic operates at Levels E and F for up to 1 1/2 hours. Traffic operation here is influenced by a 5 percent grade at McKnight Road, a merging volume of 720 at McKnight Road, and is improved by a change in lanes from 2 to 3 at McKnight Road.

(3) Between the Inner Belt Expressway and Bellevue Avenue, traffic operates at Levels E and F up to 45 minutes. Two significant factors contributing to this situation are a 5 percent grade at Bellevue and a volume of 1250 merging at the Inner Belt Expressway.

(4) Between Clayton Road and Chouteau Avenue traffic operates at Levels E and F for 1 hour. Significant influences of this condition are a 5 percent grade east of Clayton Road and 2 curves of over 3°.

(5) The next bottleneck is east of Chouteau Avenue to Compton Avenue wherein traffic operates at Levels E and F for 2 hours. Some of the contributing causes of this condition are a 3° curve at Vandeventer Avenue, a reduction in number of lanes from 3 to 2 at Chouteau Avenue, and a merging volume of 990 at Vandeventer Avenue.

(6) Finally, a Level F condition up to 20 minutes exists between Compton Avenue and Jefferson Street. This area is where traffic is feeding off to downtown St. Louis with a speed limit of 30 m.p.h.

Areas where deficient levels of operation occur during the afternoon in the westbound lanes are as follows:

(1) Between I-244 and Ballas Road traffic operates at Level E for 35 minutes. One of the contributing factors is probably the 6 percent grade at Ballas Road.

(2) There is a 15 to 20 minute operation at Level E between Lindbergh Boulevard and Clayton Road. There is a 3° curve at Lindbergh Boulevard, a 6 percent grade at Lindbergh, and a 4 percent grade at Clayton Road which are undoubtedly contributing factors of this condition.

(3) Between Clayton Road and the Inner Belt Expressway traffic operates at Levels E and F for an hour or more. A 4.6 percent grade reduction from 3 to 2 lanes at McKnight Road are apparently the cause of this condition.

(4) Levels E and F up to 30 minutes are prevalent between the Inner Belt Expressway and McCausland Avenue. This is probably partially due to a 4 percent grade at Laclede Station Road, a 5 percent grade at the Inner Belt Expressway, a 5 percent grade at McCausland Avenue, and a 3° curve at McCausland Avenue.

(5) From McCausland Avenue to Compton Avenue traffic operates at Levels E and F for 50 minutes. The lanes reduce from 3 to 2 at Chouteau Avenue, there is a 3° curve at Clayton Road, one at Kingshighway, and one at Vandeventer which are most likely the significant factors of congestion.

(6) From Compton Avenue to Jefferson Street traffic operates at Level F for 20 minutes. This is perhaps partially influenced by a speed limit of 40 m.p.h.

RECOMMENDATIONS

The heavy congestion from Lindbergh Boulevard to McKnight Road during the morning and the heavy congestion from just west of McKnight Road to Hanley Road during the afternoon is primarily due to the change in lanes at McKnight Road from 3 to 2. Since the work schedule includes adding additional lanes from I-244 to McKnight Road this problem may be resolved.

APPENDIX

TRAFFIC DENSITIES AND LEVELS OF SERVICE

The phrase "level of service" has been growing in popularity since publication of the 1965 Highway Capacity Manual. It describes the quality of service provided the motorist by a particular section of highway at any given time and usually refers to one of the six levels of operation defined below.

Level A

Level A is defined as free-flow operation, with operating speeds at or greater than 60 m.p.h. The service volume at this level is 1400 pcph total for two lanes in one direction under ideal conditions. Each additional lane provided above two will result in a one-way service volume increase of about 1000 pcph.

Level B

Level B is in the higher speed range of stable flow. It is defined by the requirements that operating speeds be at or greater than 55 m.p.h. This gives a maximum service volume of 2000 pcph total for two lanes in one direction under ideal conditions, with each additional lane above two providing about 1500 pcph.

Level C

A requirement for level of service C is an operating speed of at least 50 m.p.h. Under ideal conditions for two lanes in one direction, the peak 5-minute flow rate cannot exceed 3000 pcph total for one direction. Each additional lane will provide one-way peak flow rate increase of about 1800 pcph.

Level D

In level D, which is in the lower speed range of stable flow, traffic operation approaches instability, with operating speeds in the neighborhood of 40 m.p.h. Under ideal conditions on a 4-lane freeway, the peak 5-minute flow rate cannot exceed 3600 pcph total for one direction on two lanes.

Level E

Level E is the area of unstable flow, involving overall operating speeds of about 30-35 m.p.h. Traffic volumes approach and even reach capacity, or about 2000 pcph per lane under ideal conditions.

Level F

Level F provides unacceptable service, indicative of forced flow, stop-and-go conditions, often resulting from a breakdown in level E operations or even in a direct plunge from level D operation. Operating speeds range downward from 30 m.p.h. to zero in the extreme case of a complete jam. The freeway acts as a storage area for vehicles backing up from a downstream bottleneck.

According to the capacity manual, the level of service is determined by the operating speed and the volume-capacity (v/c) ratio. As indicated in Figure A-1, there is a range of speeds and v/c ratios which define each level of service. It should also be noted that the v/c ratio range for each level of service varies slightly with the number of lanes provided and the peak hour factor while the speed ranges do not.

It has been observed that operating speed is closely correlated to vehicular density and geometrics. This correlation is reflected in Figure A-2, which gives the results of several field studies. The effects of density and gradient are clearly visible. Figure A-2 also shows that the relationship between vehicular density and operating speed is very close for sections of similar geometrics.

Figure A-2 was developed from spot speed and volume measurements made on three different freeways. These measurements were used to compute spot densities at each location. Density vs. speed charts were plotted and a "least squares fit" was made for each location shown in Figure A-2. Data gathered from all locations were used to develop an equation for relating speed and density (Line 7 on Figure A-2). This equation has a standard error of 4.4 m.p.h., that is, the error should be less than 4.4 m.p.h. two-thirds of the time. At each location where data was collected, the speed limit was 55 m.p.h.; therefore, it was unlikely that many speeds above 55 m.p.h. would have been recorded, regardless of the density. Because of this, the speed-density relationship above 55 m.p.h. is considered unreliable, and the levels of service above level C (50-55 m.p.h.) cannot be distinguished.

Used in combination with the density contour charts, Figure A-2 provides a convenient means of estimating level of service based on operating speed. (For existing situations, this solution seems adequate.) The densities equivalent to each limiting value of operating speed can be determined and plotted on the density contour charts, thus defining the probable level of service on each section during any time period included in the chart.

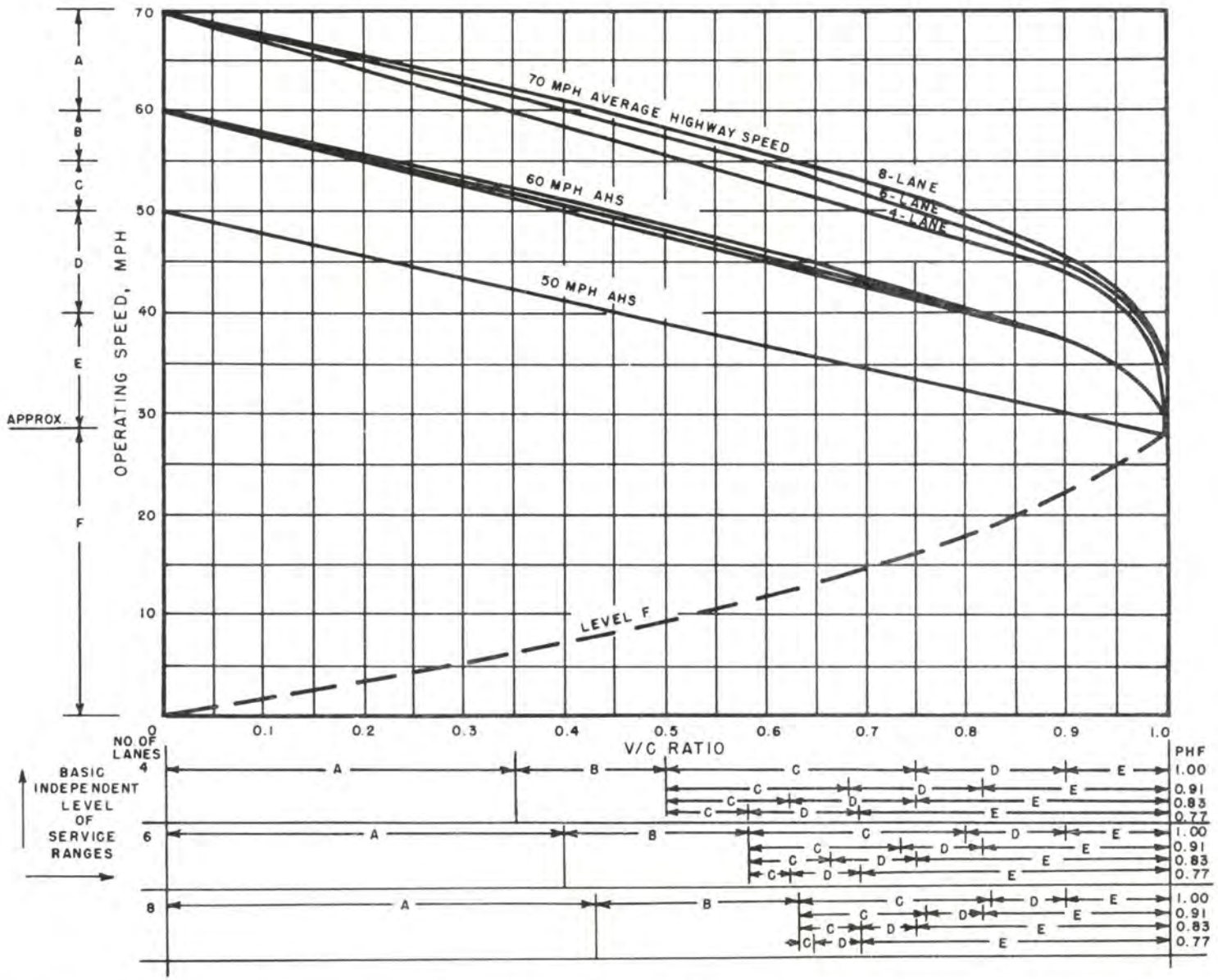


FIGURE A-1 LEVEL OF SERVICE RELATIONSHIPS

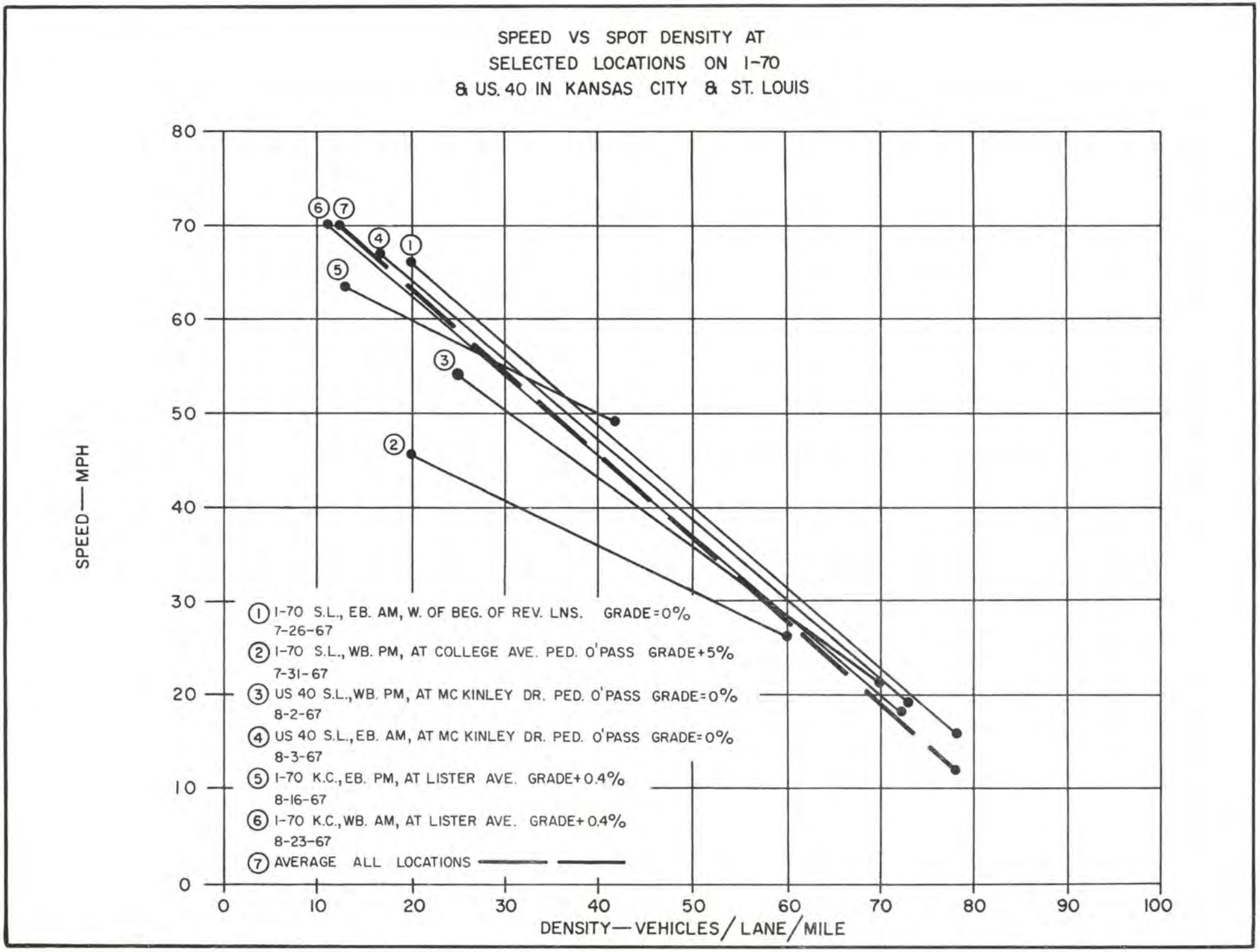


FIGURE A-2. SPEED VS. DENSITY - SELECTED LOCATIONS

The limiting values of speed, volume, and density are summarized in Table A-3.

TABLE A-3

Limiting Values of Each Level of Service

Level	Minimum Operating Speed (mph)	Maximum Volume Pcph*	Density V/L/M**
A	60	700	35
B	55	1000	35
C	50	1500	35
D	40	1800	45
E	30	2000	60
F	0-30	Varies	> 60

* Passenger cars per hour
**Vehicles per lane per mile

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