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OOPERATIVE HIGHWAY RESEARCH PROGRAM
REPORT 71-2

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AN ANALYSIS OF TRAFFIC OPERATION ON THE WESTBOUND LANES OF INTERSTATE ROUTE 70

KINGSHIGHWAY BOULEVARD TO LUCAS-HUNT ROAD

MISSOURI STATE HIGHWAY DEPARTMENT
FEDERAL HIGHWAY ADMINISTRATION

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16. Abstract

The objective of this study was to examine the operation of the subject freeway section and determine the feasibility and extent of measures necessary to improve operation.

Aerial photography, travel time studies and ground counts were used to determine the effect of the geometrics of the freeway and the various elements of the traffic stream and to determine the feasibility of diverting traffic to alternate routes.

While two major bottleneck locations were found to exist, the demand was found to exceed the capacity for the entire study section. One feasible alternate route was found which could be used to carry traffic diverted from three ramps serving the area. The demand-capacity ratio indicates a need for an additional lane, however the potential benefits do not justify the extensive work necessary to add a lane.

It was recommended that sometime in the future further study be conducted over the entire freeway length to determine the feasibility and possible location of metering or other traffic management systems.

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AN ANALYSIS OF TRAFFIC OPERATION ON THE WESTBOUND LANES OF INTERSTATE ROUTE 70 BETWEEN KINGSHIGHWAY BOULEVARD AND LUCAS-HUNT ROAD

STUDY 70-2

Prepared By

Missouri State Highway Department

Division of Planning

September 1971

In Cooperation with

U.S. Department of Transportation

Federal Highway Administration

The opinions, findings, and conclusions expressed in this publication are not necessarily those of the Federal Highway Administration.

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INTRODUCTION

Traffic operating conditions on Interstate Route 70 in the St. Louis area have been under surveillance for a number of years as part of a continuing program. Operation on the westbound lanes between Kingshighway Boulevard and Lucas-Hunt Road has deteriorated to the point where congested conditions in the afternoon last for more than a two-hour period.

While the surveillance studies define the general limits of this congestion, they are not detailed enough to determine the locations of individual bottlenecks or the extent of their effect upon operations.

The purpose of this study was to examine the operation of this portion of freeway and determine the feasibility and extent of measures necessary to improve operation.

CONCLUSIONS

The peak demand volume exceeds the capacity of the freeway for the entire study area except the area between the west end of the reversible lanes and the on-ramp east of Riverview. This demand exceeds the capacity of the present three lanes as far west as Bermuda Road and periodically to Florissant Road. Two major bottleneck locations exist, the five percent grade west of Jennings Station Road, which forms the downstream end of the congestion and the area just east of Riverview Boulevard.

Operating conditions on the routes which could serve as alternates for the longer trips are so poor that it would be next to impossible to divert significant traffic volumes away from the area.

The route over Natural Bridge and Florissant Road, from Kingshighway west however could be utilized without too great a loss in travel time.

Both present and estimated future volumes on the study section are higher than the remainder of I-70. An additional lane on this section would provide uniform 'per lane' volumes over most of the freeway west of the reversible lanes. The extensive interchange and structure modifications, combined with the right-of-way and normal widening costs makes the addition of a lane impractical in view of the limited funds and extensive needs elsewhere on the highway system.

Traffic on 3 ramps could be metered to provide acceptable service on the freeway, although a significant volume would have to be diverted to parallel routes. The freeway network in St. Louis has reached a point where it is no longer practical to do spot location studies. Any future studies should consider the entire system in an area. Standards describing the level of service to be maintained must be established.

RECOMMENDATIONS

It is recommended that further study be conducted to determine the hardware requirements and cost of metering the on ramps at Kingshighway, Goodfellow and east of Riverview.

It is recommended that future studies of this nature consider the entire freeway system in an area rather than short segments or sections.

STUDY AREA

The general area covered by the study is shown in Figure 1. Travel time studies, indicated by the arrows, included those routes within the corridor which could serve as alternates to the congested area on I-70.

Figure 2 shows the area of I-70 covered by the operations study. The numbered sections are the areas covered by aerial photography.

In addition to showing the study area, Figure 2 has been utilized to show the peak hour volumes and peak five-minute flow rates.

MARK TWAIN EXPRESSWAY

TRAFFIC STUDY

ST. LOUIS, MO.

LOCATION MAP

STUDY AREA ROUTES

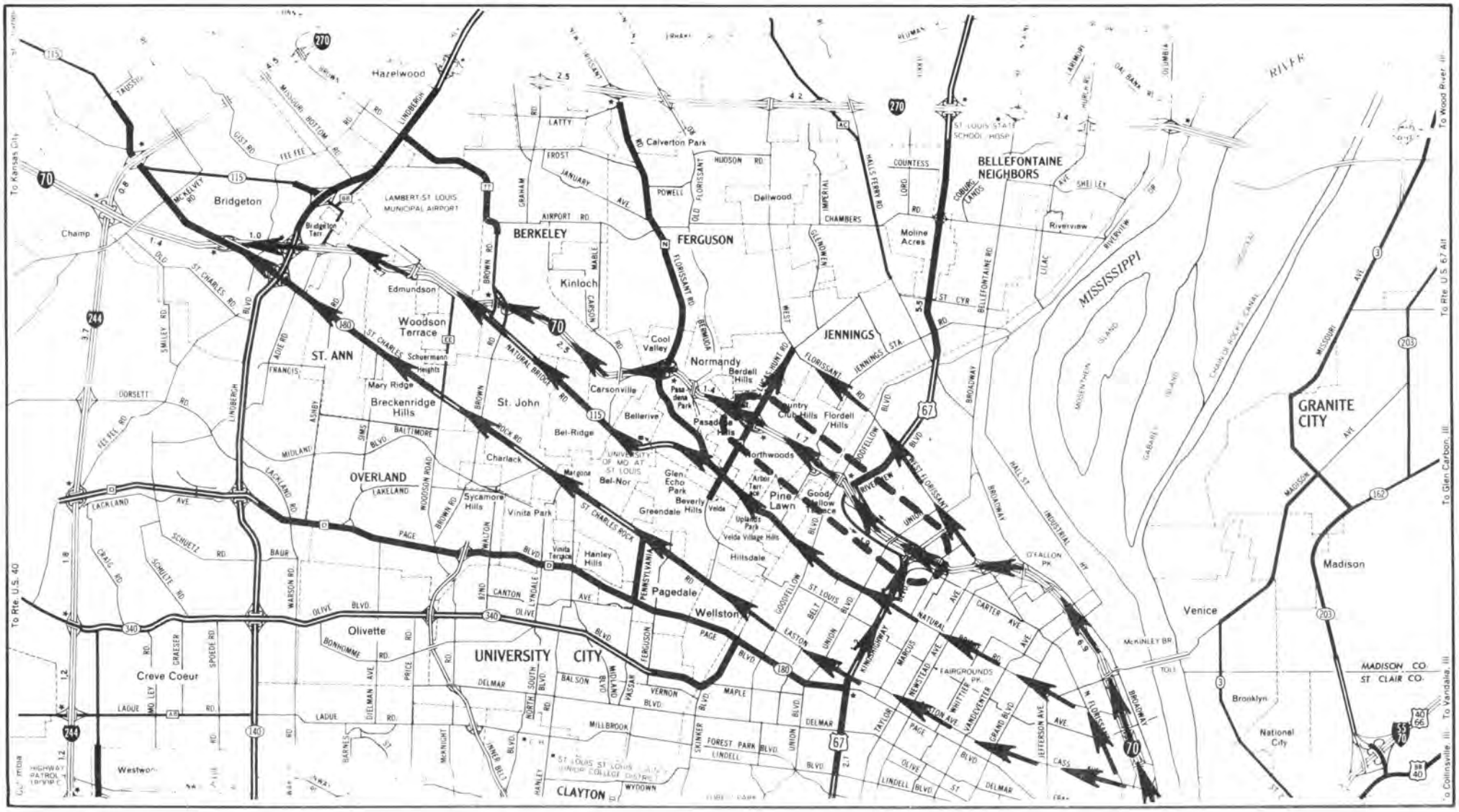
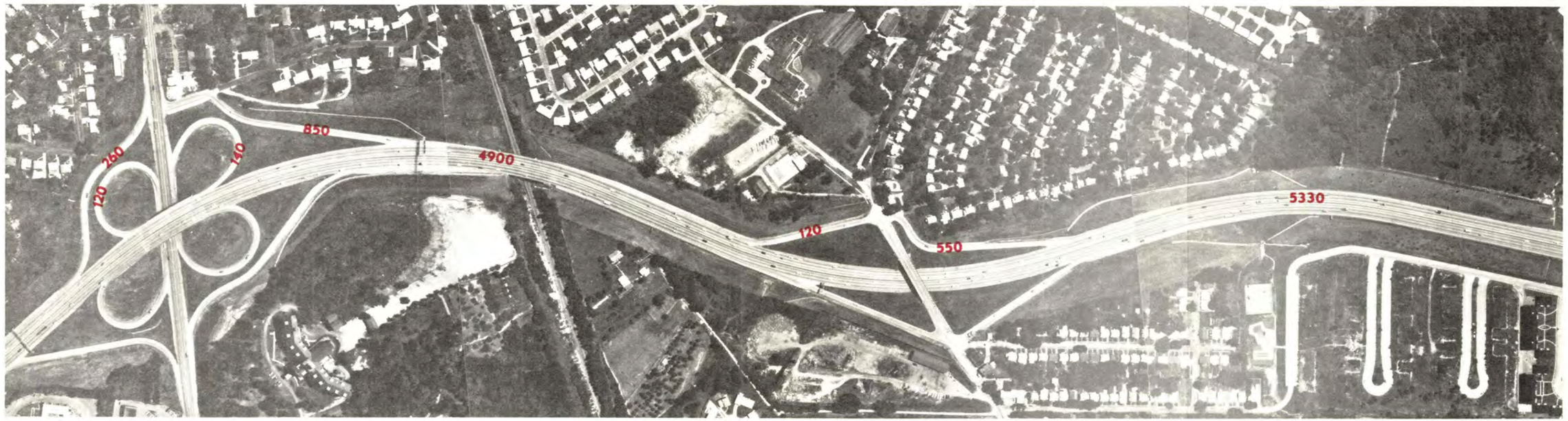


FIGURE 1

MARK TWAIN EXPRESSWAY
ST. LOUIS, MISSOURI



FLORISSANT ROAD

XXXX PEAK HOUR

BERMUDA ROAD

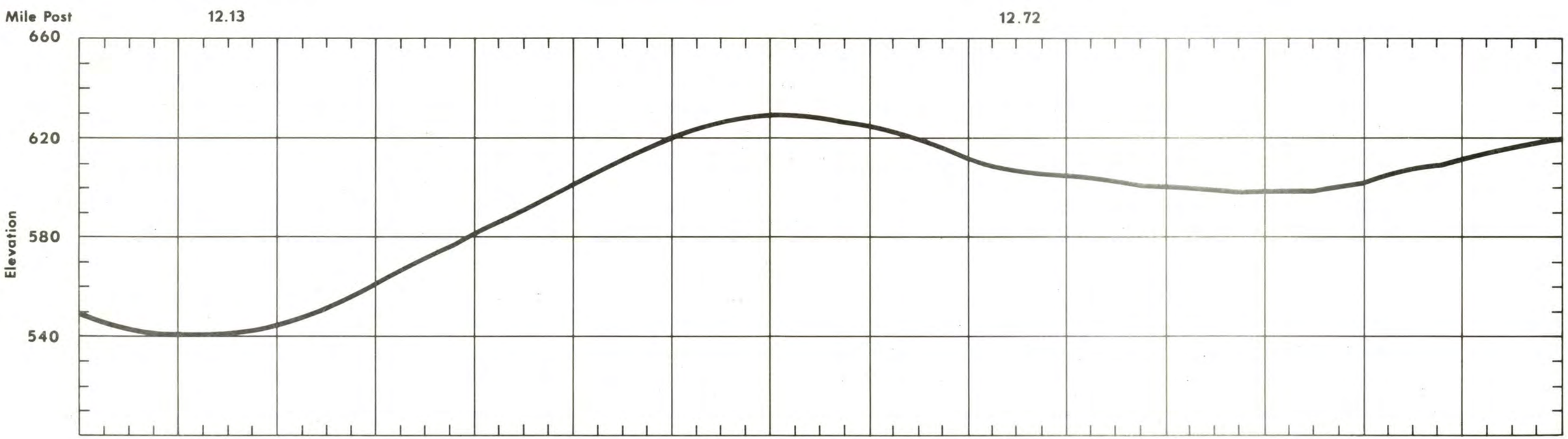


Figure 2-A

MARK TWAIN EXPRESSWAY
ST. LOUIS, MISSOURI

SECTION I

LUCAS & HUNT ROAD

XXXX PEAK HOUR

(XXXX) PEAK 5 MIN. FLOW RATE

COLLEGE AVE. PED. O'PASS

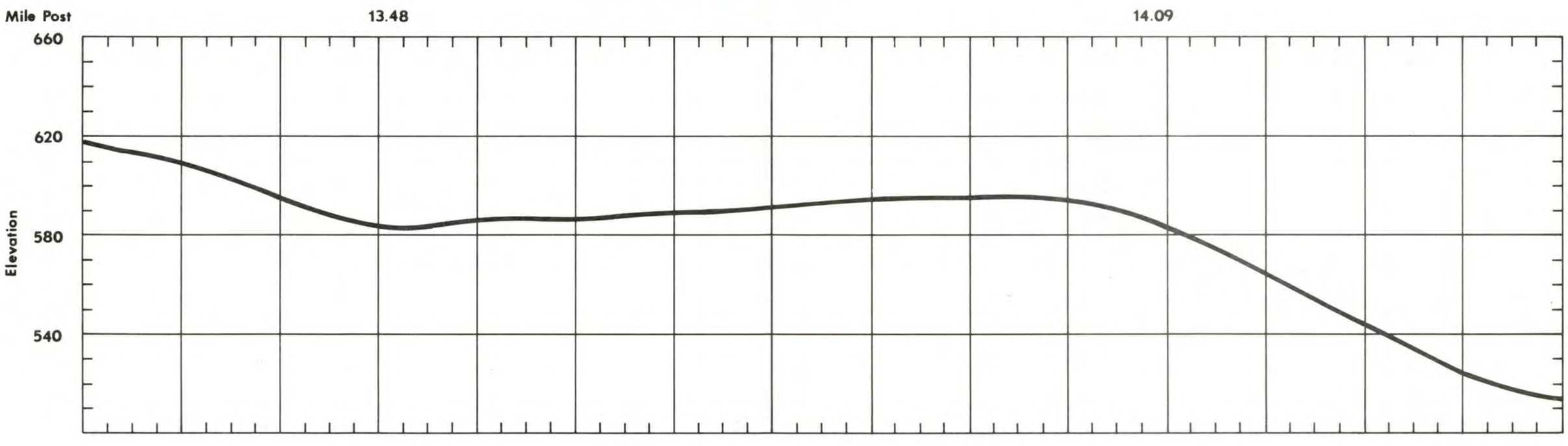


Figure 2-B

MARK TWAIN EXPRESSWAY
ST. LOUIS, MISSOURI

SECTION 2 — JENNINGS STA. RD.

SECTION 3 — GOODFELLOW BLVD.

SECTION 4 — RIVERVIEW BLVD.

XXXX PEAK HOUR

(XXXX) PEAK 5 MIN. FLOW RATE

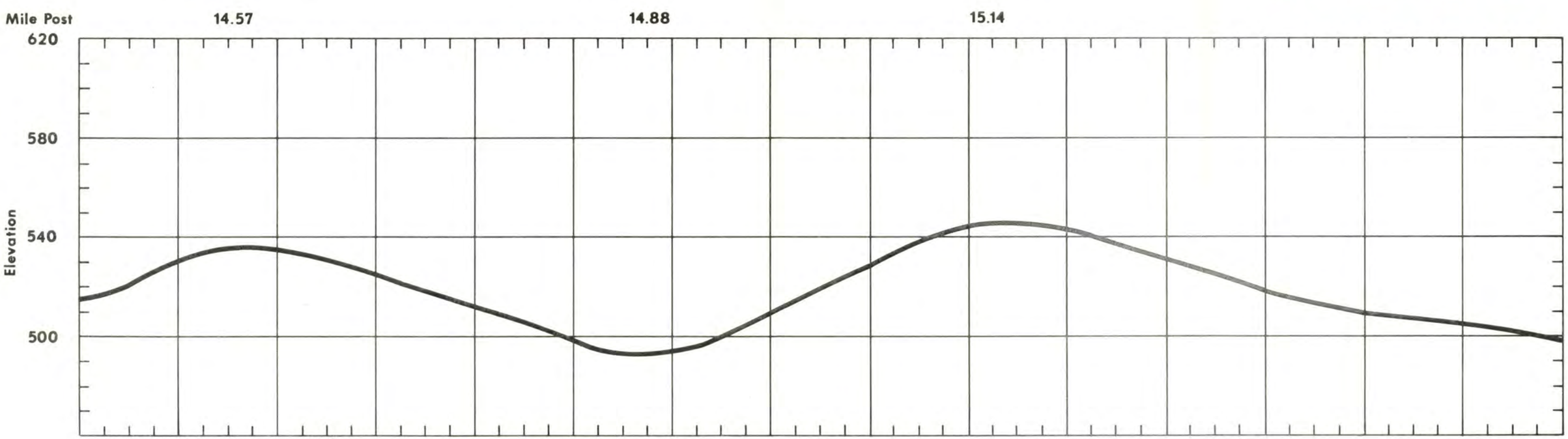


Figure 2-C

MARK TWAIN EXPRESSWAY
ST. LOUIS, MISSOURI

SECTION 5

PEDESTRIAN OVERPASS — UNION BLVD. — KINGSHIGHWAY BLVD.

XXXX PEAK HOUR

(XXXX) PEAK 5 MIN. FLOW RATE

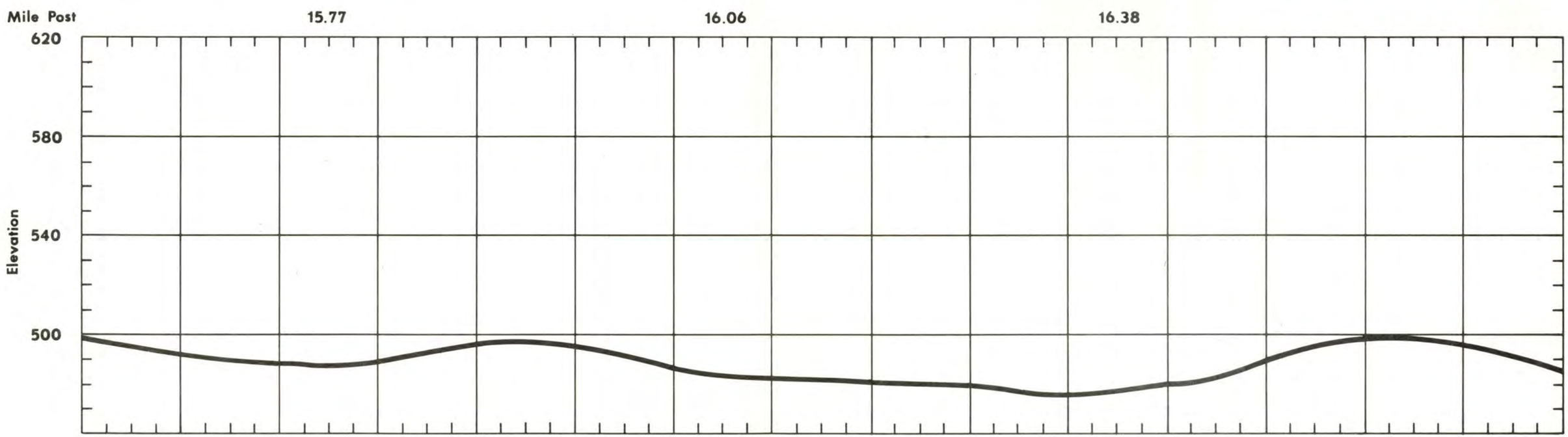


Figure 2-D

TRAVEL TIME

Travel time studies were made at the locations shown in Figure 1. These studies were made in order to determine whether an alternate route could be found for the peak flow period which would compare favorably enough with the Freeway so that traffic could be diverted to, and be expected to use the route to some point beyond the congested area. The diversion would be accomplished by metering or closing ramps during the peak period.

In all cases during the off-peak hour, travel times shown in Table 1 were considerably more favorable on the freeway. With one exception, all freeway routes were also favorable during the worst peak hour runs. The exception was the route over West Florissant from I-70 to the junction with Lucas-Hunt. Since this alternate route begins at an off-ramp, there is no means of forcing traffic to use this route. The amount of traffic which could be induced to use this route through an education campaign would not be sufficient to relieve the congested conditions downstream.

The large amount of stop time on alternate routes would discourage traffic even if the total trip time were comparable, since stop time has a way of multiplying in the motorist's mind.

The alternate route over Natural Bridge Road and Florissant Road, from Kingshighway west, is fairly comparable during periods of peak congestion on the freeway. If traffic were forced to find an alternate route through extensive ramp closures or metering this route would be the most likely choice. Travel time on routes feeding Natural Bridge Road from I-70 would vary depending on starting point.

TABLE I

TRAVELTIME SUMMARY

Routing	Distance (Miles)	Traveltime (Minutes) Off-Peak	4-5	5-6	Ave. Peak Hr. Stop Time (Min.)
West Florissant to Junction West Florissant and Lucas-Hunt Road					
By I-70 and Lucas-Hunt Road	5.35	6.90	12.74	11.46	.37
By West Florissant	4.00	9.68	9.88	11.02	2.63
Cass Avenue to I-70 and Natural Bridge Road					
By I-70	13.04	13.92	20.75	19.90	.37
By West Florissant & Natural Bridge Road	11.27	25.33	29.15	29.54	4.70
Cass Avenue to I-70 and St. Charles Rock Road					
By I-70	16.04	16.84	24.08	23.15	.37
By Cass-Easton-St. Charles Rock Road	14.73	42.30	45.45	40.79	9.01
Cass Avenue to I-70 and Florissant Road					
By I-70	9.62	10.36	16.36	15.28	.37
By Natural Bridge and Florissant	8.89	20.96	21.95	24.06	3.12
Kingshighway to I-70 and Florissant Road					
By I-70	4.37	4.73	10.54	9.26	.37
By Natural Bridge and Florissant	4.59	11.41	11.42	13.22	1.59
Kingshighway to I-70 and Natural Bridge Road					
By I-70	7.79	8.29	14.93	13.88	.37
By Natural Bridge Road	6.97	15.78	18.62	18.70	3.17
Kingshighway to I-70 and St. Charles Rock Road					
By I-70	10.79	11.21	18.26	17.13	.37
By St. Charles Rock Road	10.23	27.55	26.76	25.29	4.32

ANALYSIS OF WEAVING AND MERGING

There are three locations within the study area where weaving between ramps occurs.

Table 2 compares weaving volumes at these locations with the general theoretical values from the Highway Capacity Manual.

None of the locations had weaving volumes which would exceed the values for level C.

At each location where data was available, the five-minute merge rate exceeded the level C theoretical volume. At the on-ramp east of Riverview Boulevard, the five-minute merge rate exceeded the capacity, and the merging operation was at or near capacity for the entire peak hour. This was the only location where the ramp volume was excessive. At the other locations most of the merging problem was due to the high through lane volumes.

The short weaving and acceleration-deceleration lengths undoubtly have some effect on through lane operation. Under present conditions, congestion on the through lanes make it impossible to observe the effect of weaving and merging traffic through this section.

If traffic flow is substantially improved, consideration should be given to modifying the interchanges to provide better weaving and merging conditions.

TABLE 2
Comparison of Actual and Theoretical Weaving Volumes

Location	Weaving Dist.	Weaving Volume Hour	Weaving Volume 5-Min. Rate	Theoretical Volume* Level E (Capacity)	Theoretical Volume* Level C (5-Min. Rate)	Level C Hour
Jennings Station Rd. S to W & E to S	930'	367	612	2000	1450	2000
Goodfellow on to Jennings Sta. E-N Off	520'	635	1284	2000	1450	2000
Service Road East of Riverview on-off ramp	690'	887	1440	2000	1450	2000

* for minimum of 500' weaving distance

TABLE 3
Comparison of Actual and Theoretical Merging Volumes

	Volume Hour	Volume 5-Min. Rate	Level E (Capacity)	Level C (5-Min. Rate)	Level C Hour
Jennings Station N-W	1681	1968	2000	1800	1500
Jennings Station S-W	1459	1764	2000	1800	1500
Goodfellow On-ramp	1667	NA	2000	1800	1500
On-ramp East of Riverview	1984	2172	2000	1800	1500

OPERATIONAL ANALYSIS

The study area was divided into sections (see Figure 2) for the detailed film study of operations. These data were used to isolate operation at each suspected bottleneck location. The speeds and volumes just before, during, and just after breakdown were used to determine the flow rates which corresponded to the maximum limits for service levels C, E and F. (Level D was eliminated since operation generally drops directly from C to E and F.)

A comparison of the speeds and volumes shown cumulatively at the input and output points of a section (Figure 3) was used to determine the net effect of each section on operation.

The service volumes for levels C and E are shown in Figures 4-8, along with the peak hour demand and volume. The demand is the volume that would exist if flow were not restricted by congestion. Demand volumes were obtained by counting input volumes on the reversible lane section where traffic was free-flowing and adding and subtracting ramp volumes. The actual volume at any location does not match the demand due to the breakdown in operation.

The area above the level E line generally indicates the time during which the freeway cannot carry the demand, even for short periods of time. The area between the C and E lines is the time when congestion is found. The congestion resulting from the first periods of excess demand usually restricts flow such that operation does not recover during the periodic drops in demand.

The low capacity of Section 1 restricts, or meters, the flow so that no congestion is found within the study area beyond the top of the grade, even though the high demand continues downstream.

At times backup from Section 1 restricted operation on the upstream sections before their capacity was reached. This made it necessary to estimate some values for these sections. The backup from Section 4 always blocked operation at the end of the reversible lanes before the volume reached a critical level.

Since the peak traffic flow rates exceed the capacity by such a large amount, there are no spot, or "design." improvements which would relieve the congestion.

The period of peak demand at the two major bottlenecks locations last too long for short term metering designed to smooth out flow to be effective. Extension of the acceleration lane east of Riverview would have only minimal effect due to the high volumes involved.

As with most congested freeways, the problem is one of excess demand over capacity. Solutions available are to increase capacity by constructing additional lanes, reduce volume by metering or otherwise restricting access or a combination of these. Sooner or later a point is reached, when it is impracticable to keep adding lanes. When this point is reached, traffic operation on the freeway must be controlled if acceptable levels of service are to be maintained. Before any long range solution to a capacity problem can be found, the desired level of service and ultimate number of lanes must be determined.

This section of the expressway has always carried a larger volume of traffic than the remainder of I-70. Future projections indicate this trend will continue. For this reason, this section will probably remain a bottleneck, making it difficult to achieve optimum operation on the rest of the freeway. An additional lane would create balanced V/C ratios over much of the freeway, allowing any control system to operate more effectively.

An additional lane would not only have to be added to the present congested area but would have to extend westward to a point where the demand would be less than the desired service level volume. Ideally, this would be from the end of the reversible lanes to Carson Road. Practically, this could be reduced and completed in stages.

A system of priorities, using excess demand as the major traffic criteria, has been established. In any case, the first priority would have to be the downstream section) in this case, it also has the first major bottleneck). In order to avoid a bottleneck at the end of the added lane, it should be carried to Bermuda Road and preferably to the first off-ramp at Florissant Road. The lack of lateral clearance under Bermuda Road would be a factor. A logical starting point would be the on-ramp from Goodfellow.

The next major problem area is Section 4 just west of Riverview Boulevard. Here, the additional lane should start at the on-ramp and tie in with the first addition. Since this would mean complete reconstruction of the Goodfellow underpass, it would probably be necessary to end the lane at the Goodfellow off-ramp. This would reduce the merging volume by the amount using the Goodfellow ramp and provide a longer merging distance. An intermediate solution would be to meter or otherwise restrict use of the on-ramp during the peak period. This would only be effective if traffic would move to an alternate ramp upstream, in which case the Goodfellow on-ramp would receive most of this traffic. The resulting volume could be handled since the ramp would become an additional through lane.

In all probability, traffic diverted from this ramp would find it easier to use the Kingshighway on-ramp rather than cross the Riverview and turn left on Goodfellow. The Kingshighway on-ramp would also have to be restricted. This would also divert some traffic to Natural Bridge Road which was one of the better alternate routes.

The next step would be the widening under Goodfellow.

The final stage would be to extend the lane back to the end of the reversible lanes and forward to Carson Road. While this step is least important on the basis of meeting the capacity, it is necessary on the basis of future volumes and merging conditions at the end of the reversible lanes.

The balanced lane volumes resulting from this construction would allow future operational plans to provide uniform service and optimum operating conditions over most of the freeway. While this study is confined to the westbound lanes, the widening which would involve replacing structures and interchange modification, should include the eastbound lanes.

The total cost to add a lane to each direction would be in the neighborhood of $8,000,000, which would include some right-of-way, replacement of the Goodfellow and Bermuda Road structures and the interchange modification work necessary to meet interstate standards. While this plan is the most attractive from a traffic flow or motorist service standpoint, the cost makes it impractical at this time. A metering plan represents a more immediate solution which could be implemented without excessive capital improvements.

If metering is to be considered as part of the solution it would be well to consider a plan sufficient to eliminate most of the congestion in the area. If construction were to follow, the metering could be adjusted to take advantage of the increased capacity.

Table 3 shows input volumes from the reversible lane section along with ramp volumes metered to produce a five minute volume of 400 at the two major bottlenecks, which should allow level C operation.

The ramps to be metered under this plan are the Kingshighway on-ramp, the on-ramp east of Riverview Boulevard and the Goodfellow on-ramp.

Based on volumes counted during the study, metering of Goodfellow would be for a 25 minute period. These data are not intended to be a metering plan but are shown to illustrate the nature of the problem.

Hopefully, the diverted traffic would use Union or Kingshighway Boulevards and Natural Bridge and Florissant Roads to bypass the area. Assuming the excess traffic would be diverted rather than delayed at the ramp, a total increase in travel time of 3400 minutes daily for the 765 vehicles diverted could be expected. This would be offset by a total reduction in travel time of 37,000 minutes for the Freeway Traffic, based on a 90 minute metering period.

Ideally, a system responsive to available capacity should be used. This would allow the most efficient use of the facility. The plan could, however be operated satisfactorily by use of historical data with adjustments made as the operation was observed.

Field measurements to obtain current data and an educational campaign would have to precede the metering.

METERING PLAN
MARK TWAIN EXPRESSWAY

		Sec. 5					Sec. 4					Sec. 3				Sec. 1	
		Kingshighway On-ramp						On-ramp-W. of Riverview					Goodfellow On-ramp			Jennings Sta.	
Time Ending	Thru. lanes Vol.	Pres. Vol.	Metered Vol.	Acc. excess	Off ramp Vol.	Thru lane Vol.	Off ramp Vol.	Pres. Vol.	Metered Vol.	Acc. excess	Thru lane Vol.	Off Ramp	Pres. Vol.	Metered Vol.	Acc excess	Net On Off	Thru lane Vol.
4:05	392	40	27	13	17	402	28	39	26	13	400	10	59	11	48	- 1	400
10	294	64	79	--	14	359	16	46	57	2		28	69	42	75	-14	
15	354	36	25	11	15	364	14	74	50	26		28	72	57	90	-29	
20	352	62	31	42	22	361	11	101	50	77		25	60	52	98	-27	
25	387	49	24	67	16	395	17	45	22	100		24	50	43	105	-19	
4:30	337	30	48	49	22	363	15	33	52	81		22	28	32	101	-10	
35	266	46	121	--	21	333	7	48	74	55		21	35	36	100	-15	
40	381	49	28	21	25	384	15	53	31	77		24	29	26	103	- 2	
45	369	51	23	49	19	373	5	69	32	114		28	34	41	96	-13	
50	415	48	5	92	25	345	5	83	10	187		28	42	42	96	-14	
55	399	45	15	122	30	384	6	65	22	230		25	38	40	94	-15	
5:00	406	32	21	133	71	356	5	73	49	254		31	29	88	35	-57	
05	382	33	24	142	45	361	6	62	45	271		16	30	43	22	-27	
10	360	43	35	150	45	350	3	66	53	284		20	37	44	15	-24	
15	382	32	15	167	36	361	3	86	42	328		19	26	45	--	-26	
20	373	48	32	183	57	348	1	79	53	354		16	16	20	--	- 4	
25	402	38	19	202	55	366	4	78	38	394		20	33	35	--	-15	
5:30	360	32	28	206	64	324	5	92	81	405		16	24	11	13	5	

Est. Diverted: 49 + 206 + 405 + 105 = 765
Travel Time Increase = 4.42* min. x 765 = 3381 min.
Travel Time Savings = 5.17** x 2200 = 37,224 min.
* 2.42 excess over Natural Bridge Rd. + 2 min. from ramp to Natural Br.
** Peak Hour time - off Peak time

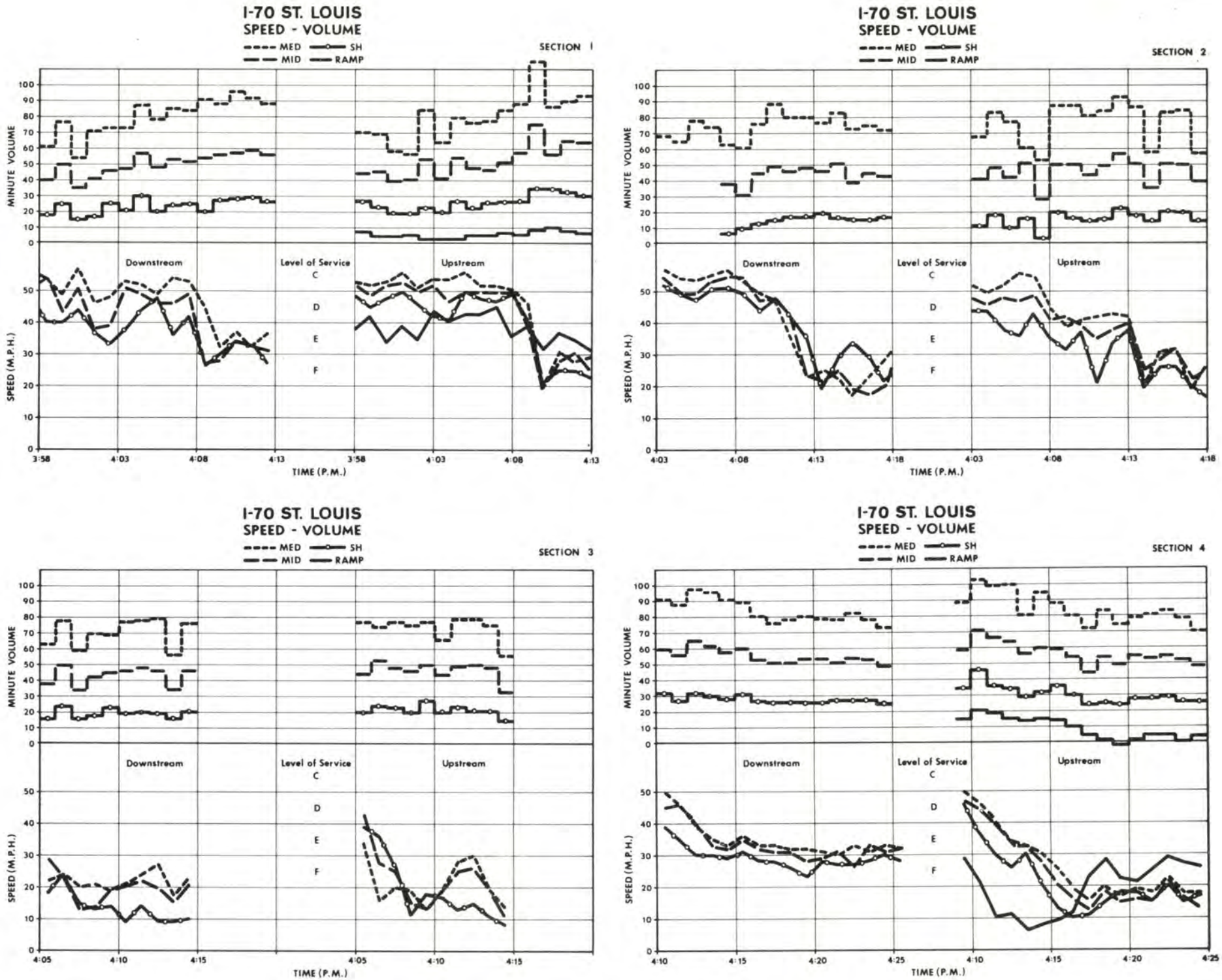

I-70 ST. LOUIS
SPEED - VOLUME
MED
SH
MID
RAMP
SECTION 1
SECTION 2
SECTION 3
SECTION 4
MINUTE VOLUME
SPEED (M.P.H.)
Downstream
Upstream
Level of Service
C
D
E
F
TIME (P.M.)

Figure 3

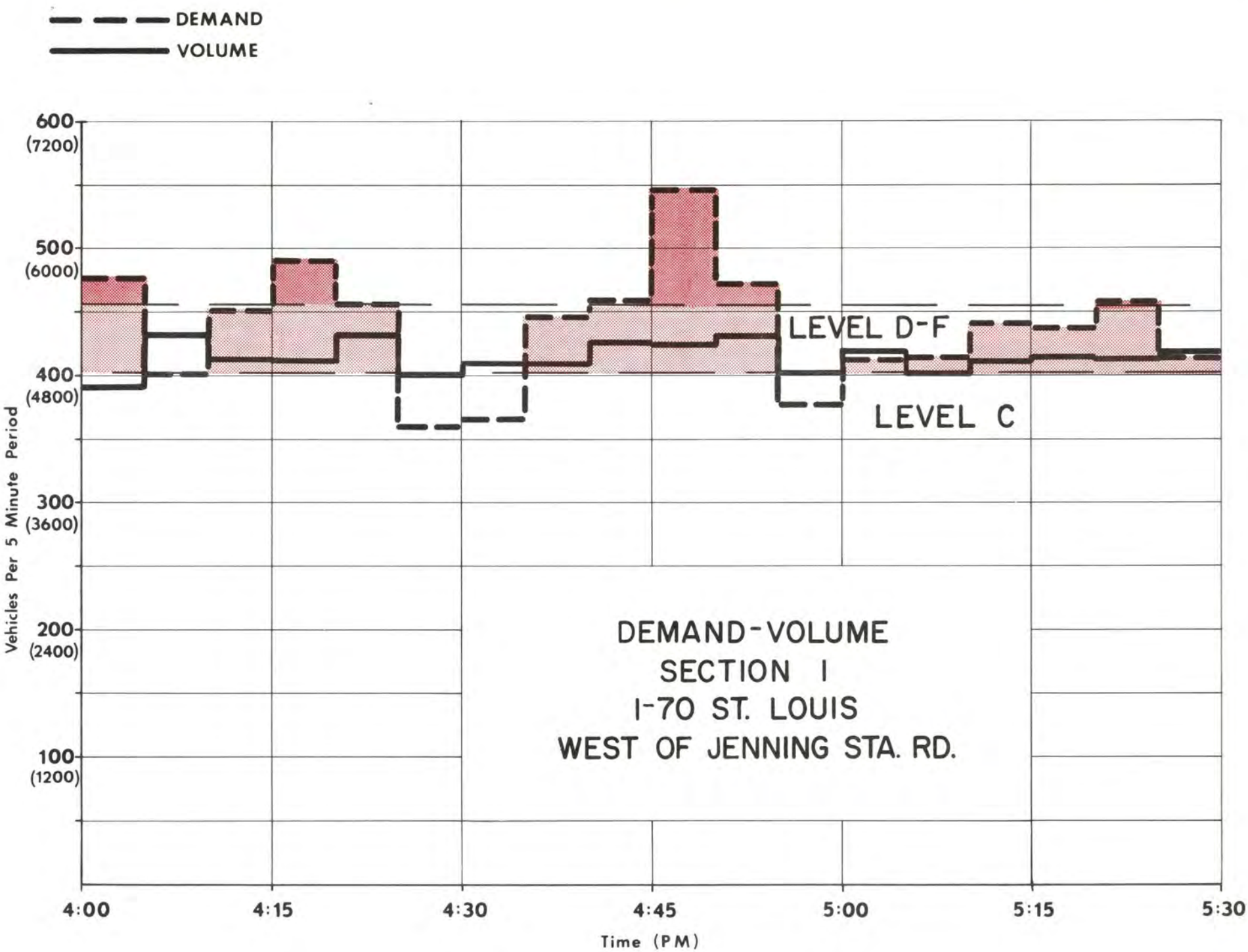

DEMAND
VOLUME
600
(7200)
500
(6000)
400
(4800)
300
(3600)
200
(2400)
100
(1200)
Vehicles Per 5 Minute Period
LEVEL D-F
LEVEL C
DEMAND-VOLUME
SECTION I
I-70 ST. LOUIS
WEST OF JENNING STA. RD.
4:00
4:15
4:30
4:45
5:00
5:15
5:30
Time (PM)

Figure 4

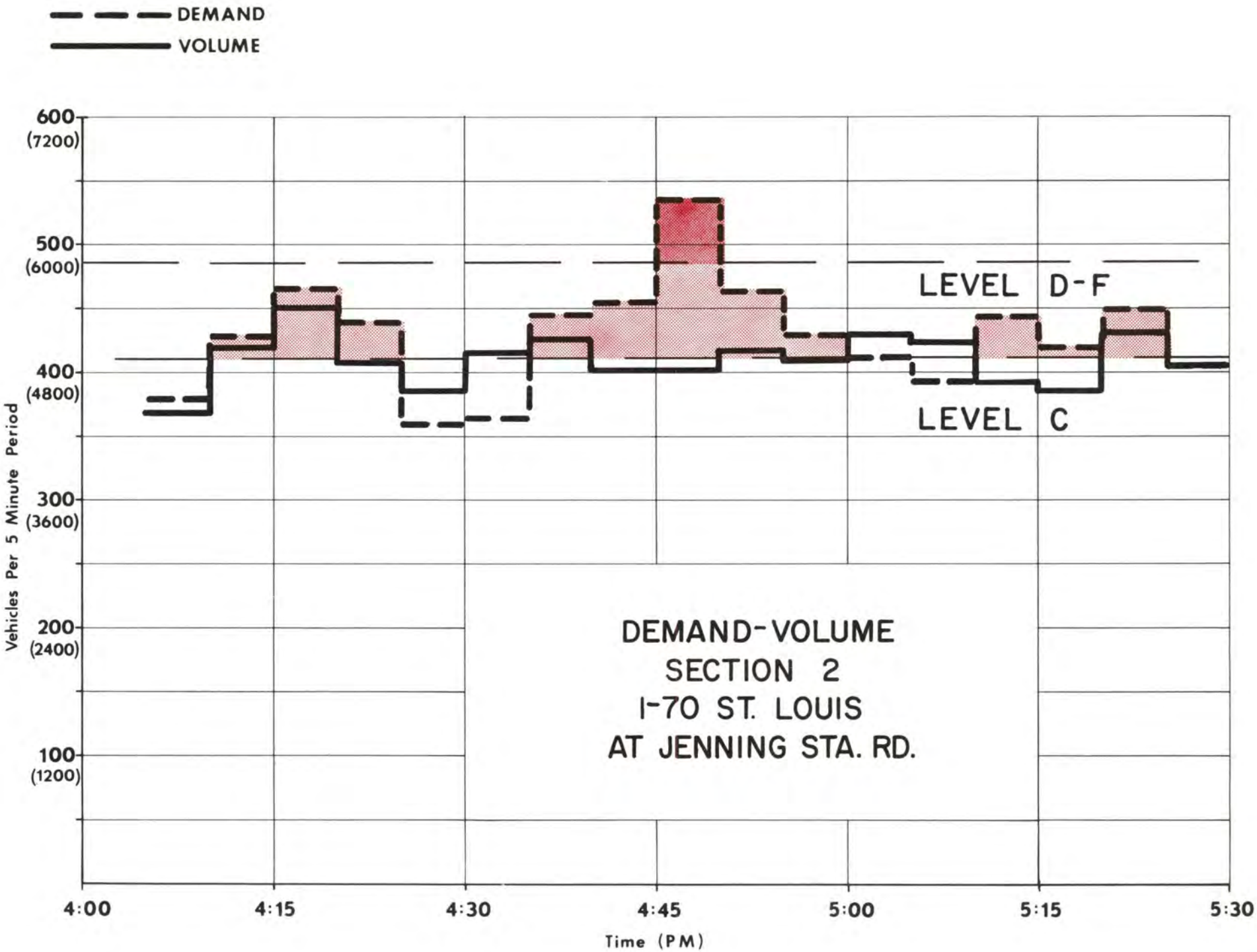

DEMAND
VOLUME
600
(7200)
500
(6000)
400
(4800)
300
(3600)
200
(2400)
100
(1200)
Vehicles Per 5 Minute Period
LEVEL D-F
LEVEL C
DEMAND-VOLUME
SECTION 2
I-70 ST. LOUIS
AT JENNING STA. RD.
4:00
4:15
4:30
4:45
5:00
5:15
5:30
Time (PM)

Figure 5

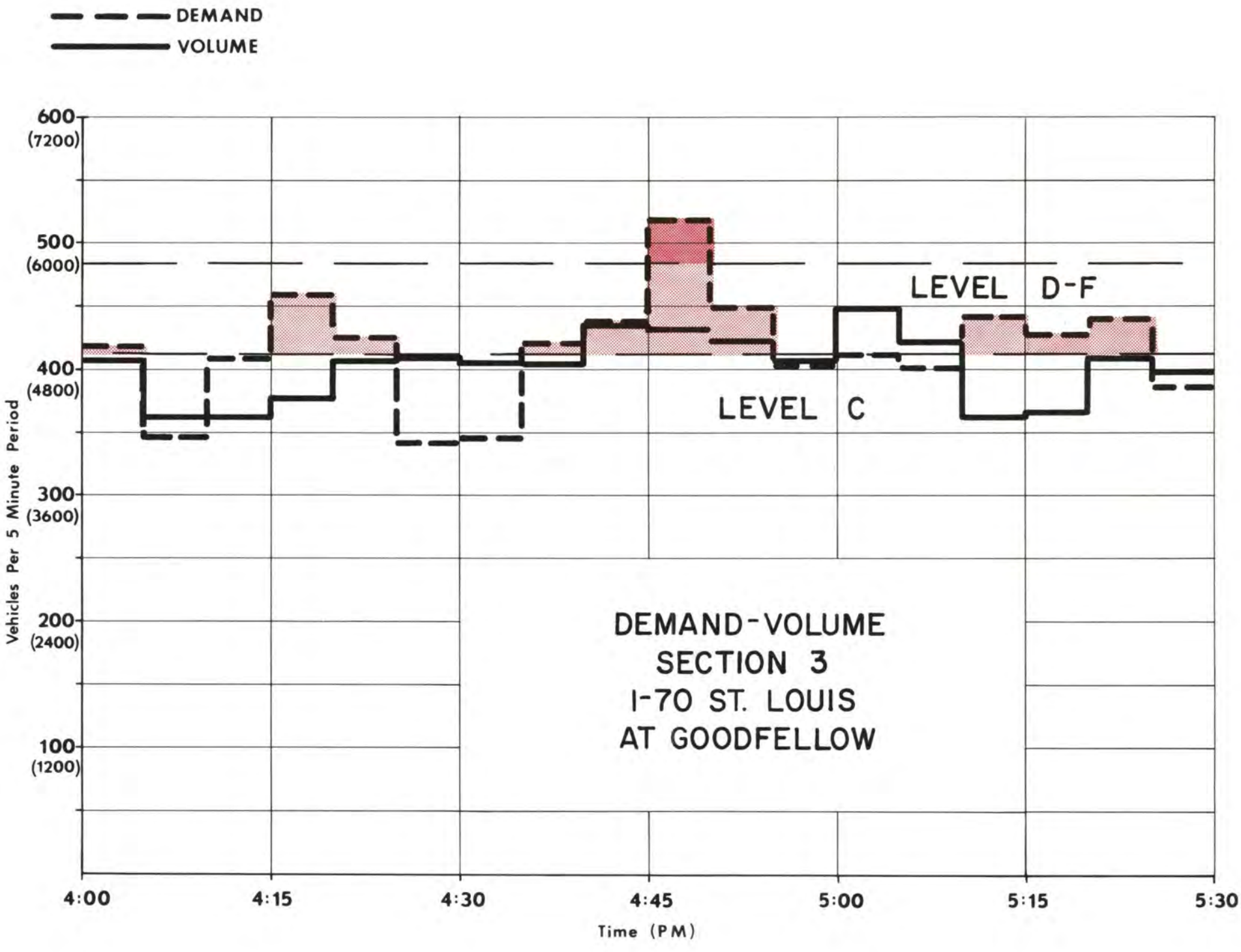

DEMAND
VOLUME
600
(7200)
500
(6000)
400
(4800)
300
(3600)
200
(2400)
100
(1200)
Vehicles Per 5 Minute Period
LEVEL D-F
LEVEL C
DEMAND-VOLUME
SECTION 3
I-70 ST. LOUIS
AT GOODFELLOW
4:00
4:15
4:30
4:45
5:00
5:15
5:30
Time (PM)

Figure 6

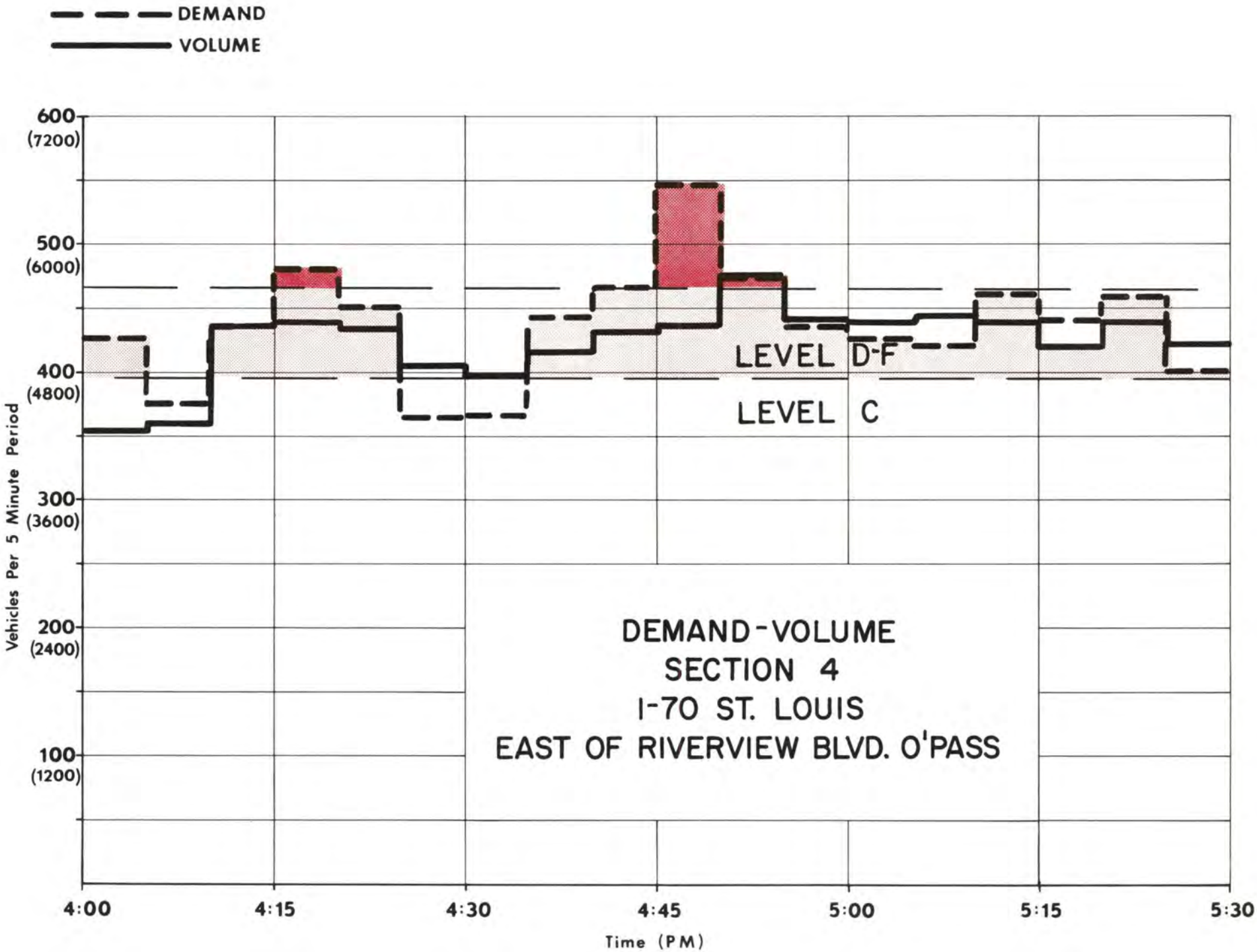

DEMAND
VOLUME
600
(7200)
500
(6000)
400
(4800)
300
(3600)
200
(2400)
100
(1200)
Vehicles Per 5 Minute Period
LEVEL D-F
LEVEL C
DEMAND-VOLUME
SECTION 4
I-70 ST. LOUIS
EAST OF RIVERVIEW BLVD. O'PASS
4:00
4:15
4:30
4:45
5:00
5:15
5:30
Time (PM)

Figure 7

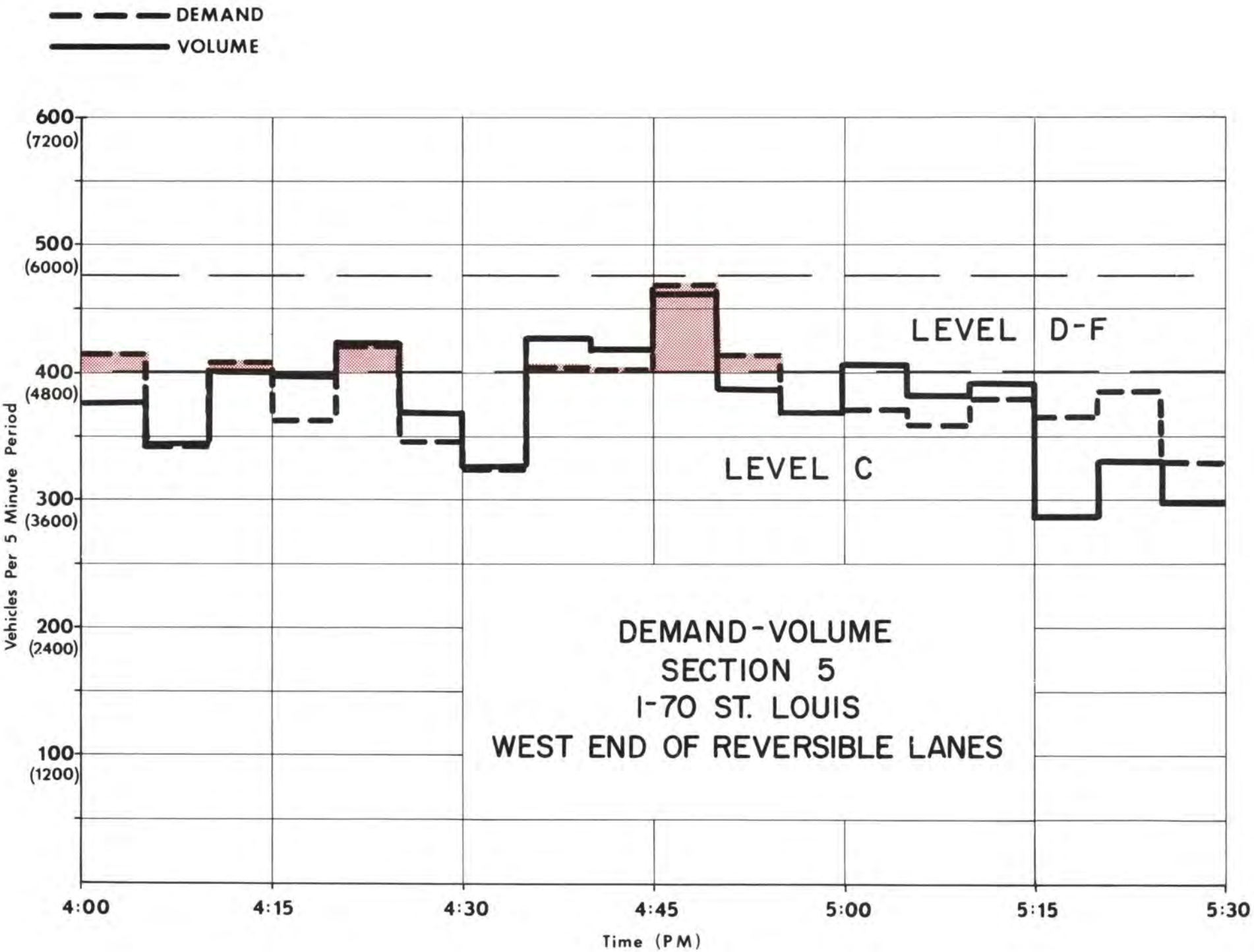

DEMAND
VOLUME
600
(7200)
500
(6000)
400
(4800)
300
(3600)
200
(2400)
100
(1200)
Vehicles Per 5 Minute Period
LEVEL D-F
LEVEL C
DEMAND-VOLUME
SECTION 5
I-70 ST. LOUIS
WEST END OF REVERSIBLE LANES
4:00
4:15
4:30
4:45
5:00
5:15
5:30
Time (PM)

Figure 8

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