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GENERATION AND ASSESSMENT OF INCIDENT MANAGEMENT STRATEGIES

VOLUME IV: SEATTLE-AREA INCIDENT IMPACT ANALYSIS: MICROCOMPUTER TRAFFIC SIMULATION RESULTS

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CHAPTER 1
INTRODUCTION

Traffic congestion, a problem in most metropolitan areas, has been growing ever since the popularity of the automobile and is not expected to stop growing in the foreseeable future. It has caused many people and businesses to relocate home and work away from the congested areas, resulting in what are commonly referred to as suburban sprawl and mini-CBDs. To target attempts at solving congestion problems, the traffic engineer distinguishes between two types of congestion: recurring and nonrecurring.

Recurring congestion occurs when the traffic demand exceeds the transportation supply. This type of congestion is often seen in cities during the peak periods of travel when large volumes of people try to get to work or home at the same time. This mass movement of vehicles overwhelms the facility so that its normal capacity is insufficient for the demand, and queues begin to build. Solutions for recurring congestion may include strategies to improve the efficiency of the facility or, simply, the construction of more facilities.

Nonrecurring congestion occurs when the normal capacity of a facility is reduced below the level of demand. Such capacity reductions may be caused by vehicular accidents and disablements or by construction activity. Incidents account for as much as 60 percent of all traffic congestion on urban facilities.

Unlike recurring congestion, nonrecurring congestion may occur at any location at any time. Therefore, solutions to such congestion problems are difficult to implement and may prove to be unjustifiably expensive. However, proposed solutions to congestion may be simulated by computer models and then analyzed for their effectiveness. Through the use of computer models for traffic behavior simulation, many alternatives may be considered.

This volume will discuss the application and evaluation of a traffic simulation model, XXEXQ. XXEXQ was applied to a network of freeways and arterials, the primary commuting routes, in the central Puget Sound region of Washington state. The evaluation of XXEXQ was based on the reasonableness of the model's results and the extent to which these results described actual traffic behavior.

Chapter 2 describes the actual application of XXEXQ to the central Puget Sound region. It outlines the operative procedures of the model by describing its input requirements and how the resulting output is interpreted. Also discussed in this chapter are the procedures used to calibrate the model. It describes the assumptions made, the acceptance criteria, and the results of the calibration efforts. Chapter 3 continues the discussion of XXEXQ by detailing its attempts to simulate incidents on the transportation network.

Chapter 4 contains the authors' conclusions and recommendations for use and further development of the XXEXQ model.

CHAPTER 2

RESEARCH APPROACH: MODEL APPLICATION

In order to analyze the effects of incidents on traffic, the appropriate model is necessary. Appendix A looks at the available models, analyzing each one with several criteria significant to model use. These criteria are year designed, scope, predictability, simulation function, type of facility covered, input requirements, outputs, and other available model features.

As discussed in Appendix A, XXEXQ has limitations that render it imperfect. However, the researchers felt that XXEXQ most easily provided the best compromise between theory, input requirements, and output. XXEXQ is specifically designed for incident evaluation and is readily adaptable to account for new findings and methodological improvements.

This section describes the area selected for the XXEXQ model application, the data needed to construct the network, the data collection process, and the major assumptions of the study.

NETWORK DESCRIPTION

The Puget Sound Area

The XXEXQ model was applied to an area within the Central Puget Sound region, an area whose principal activity centers are Seattle, Renton, Bellevue, Kirkland, and Redmond. Generally speaking, this area has developed in a linear, north/south fashion because of the physical constraints of the Puget Sound on the west and the Cascade mountains on the east. This linear spatial arrangement has created some unique transportation problems. For example, Seattle, the largest activity center in this region, is located between two large bodies of water: Puget Sound and Lake Washington.

Currently, only two transportation modes grant access to Seattle by crossing the Puget Sound: the ferry boat and the plane. Both of these modes contribute little volume to the overall freeway network and were, therefore, considered to be insignificant to this analysis. Lake Washington, however, has two floating bridges that provide access between Seattle and the greater Eastside area. Both of these bridges run east/west and are the only practical means of accessing Seattle from the east without making a lengthy trip around Lake Washington. Because of this transportation limitation, these bridges of I-90 and SR-520 receive heavy volumes of traffic during the peak periods and experience severe congestion on a routine basis.

Traveling north and south in this area, are two interstate freeways that also receive large volumes of traffic. Completed in the 1960s, Interstate 5 is the primary transportation facility for access to Seattle from the north and the south. Although planners had designed a system of freeways and highways that would provide adequate supply for decades to come, the general public expressed its concern that too much of its taxes and land were being used on transportation projects. The public's voiced concerns effectively halted future transportation projects, such as the R.H. Thompson expressway. Thus, I-5 experienced congestion within one year of its completion. To relieve some of this congestion, Interstate 405 was constructed as a Seattle by-pass. However, developers took advantage of this new access to convert small cities such as Bellevue into significant activity generators.

As a result of new freeways, highways, and spurious development processes, the central Puget Sound area no longer experienced a spoked wheel travel pattern with the Seattle CBD as the hub. Instead, this area has a suburb to suburb commuting pattern that is proving to be extremely difficult to accommodate.

The XXEXQ model was applied to a network of freeways, highways, and major arterials within the central Puget Sound Area (Figure 2.1). The principal criterion in developing the network was to describe the freeway and highway system and their common diversion routes, diversion routes that could be used in case of capacity reductions

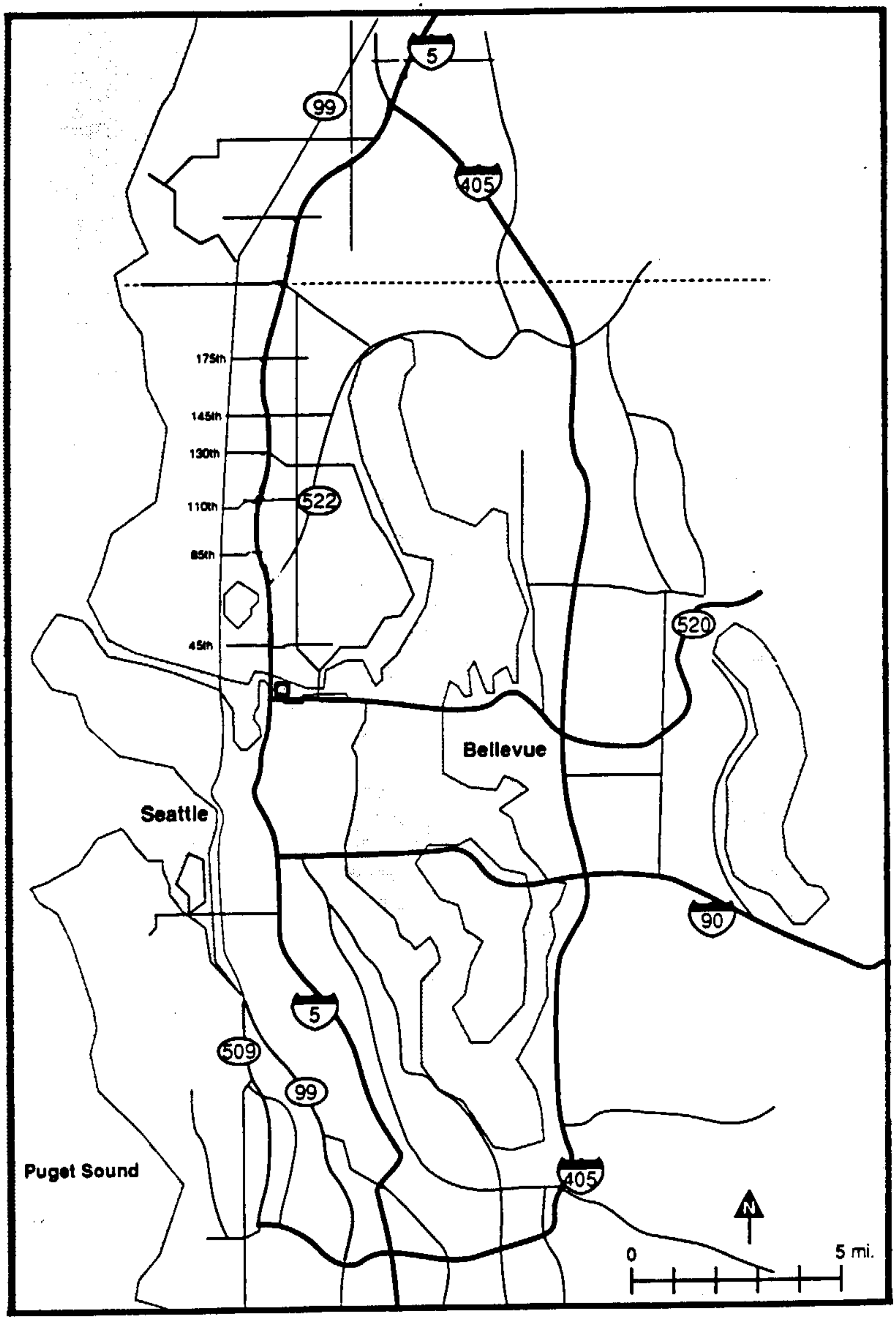


Figure 2.1 Central Puget Sound Region

on the primary system. The resulting network could then be used to estimate queue lengths on the primary routes and the increase of flow on the diversion routes.

Links and Nodes

The network consisted of 1,071 directional links, 256 nodes, and 81 origins and destinations. Of the 1,071 directional links, 387 were transportation links; the remaining 687 links were access links between the transportation network and the zone centroids.

It was impractical to include all the streets and intersections in the model; instead, the freeways, highways, and major arterials were used to represent the whole network. All other streets were assumed to contribute very little to the volumes of interzonal traffic. The transportation links described the primary commuting routes and many common diversion routes within the modeled area (see Figures 2.2 and 2.3). Routes in the study region were I-5, I-90, I-405, SR-99, SR-104, SR-167, SR-202, SR-509, SR-518, SR-520, SR-522, SR-599, SR-900, SR-908, and a number of arterials.

Origin and Destination Data

Origin and destination volumes were obtained from the Puget Sound Council of Governments Planning information. This information was available for the year 1985 at the traffic analysis zone level. The volumes were generated with the Urban Transportation Planning System, and trips originating from zones were calculated by a multilinear function based primarily on population. Trips attracted to a zone were calculated by the same type of function used for calculating the trip origins but were based on employment and retail activities. A gravity model was then used to distribute the trips from an origin to a destination This model resulted in a trip table with 512 origins and destinations for the p.m. peak period.

The 512 traffic analysis zones proved to be too detailed for this analysis so they were aggregated into 81 zones that roughly corresponded to PSCOG's forecast analysis zones. The detail of the forecast analysis zones was maintained in the immediate vicinity of

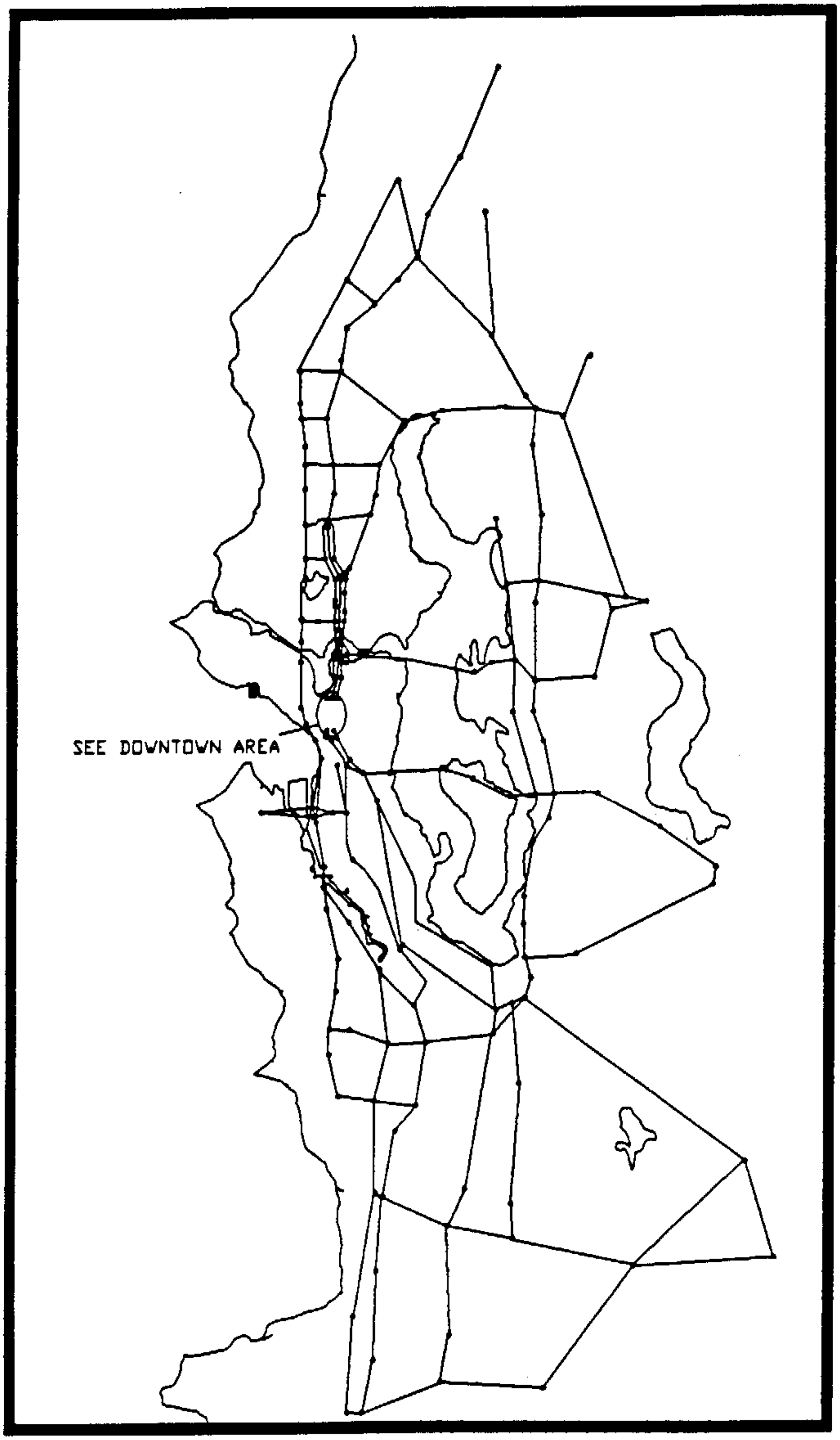


Figure 2.2 The Network

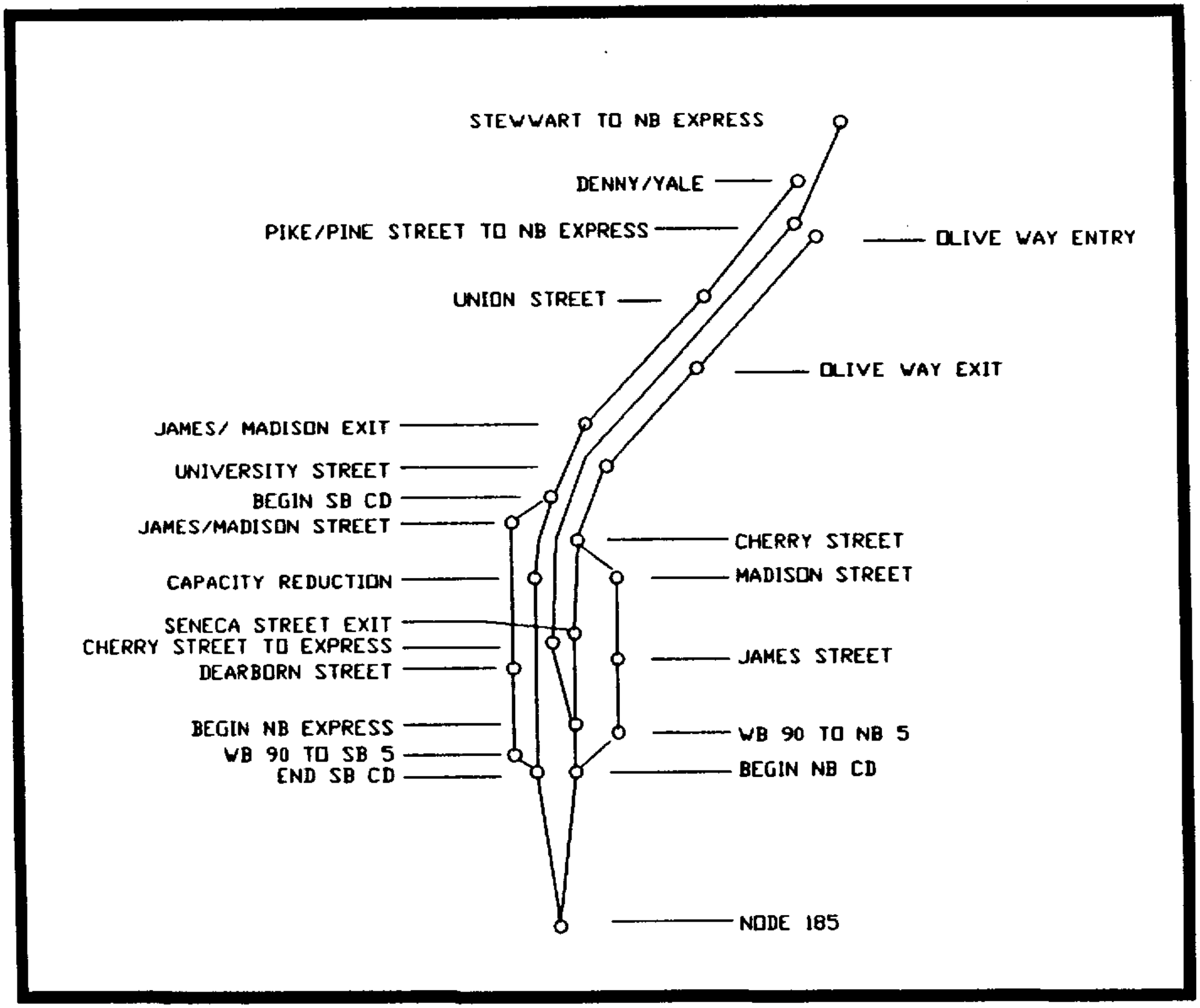


Figure 2.3 The Network in Downtown Seattle

the network, but as the distance between the network and an area increased, zones were aggregated to cover large areas (see Figure 2.4).

MODEL OPERATION

The XXEXQ model may be installed on any IBM compatible personal computer with an 80287 math co-processor and a minimum of 640 kilobytes of random access memory. This model will use nearly 560K of RAM, so special care must be taken to ensure that resident programs are kept to a minimum.

XXEXQ.EXE

The XXEXQ model was programmed in Fortran 77 and compiled in 557,546 bytes of executable code. Besides the computer requirements described above, the model requires the data files NW.DAT, OD.DAT, and CN.DAT in the same directory as XXEXQ.EXE. Execution is initiated by the command XXEXQ, and the results are placed in a file named OT.OUT.

NW.DAT

NW.DAT is a file that contains all the data pertaining to the link performance characteristics. It is structured in two parts. Each line in the first part of NW.DAT contains the link origin, the link destination, the length of the link, the capacity of the link, the speed limit of the link, and a short description of the link. After all links have been listed in terms of their performance characteristics, part 2 of NW.DAT describes the restrictions placed on links of interest during the specified time intervals. The format for NW.dat is described as follows:

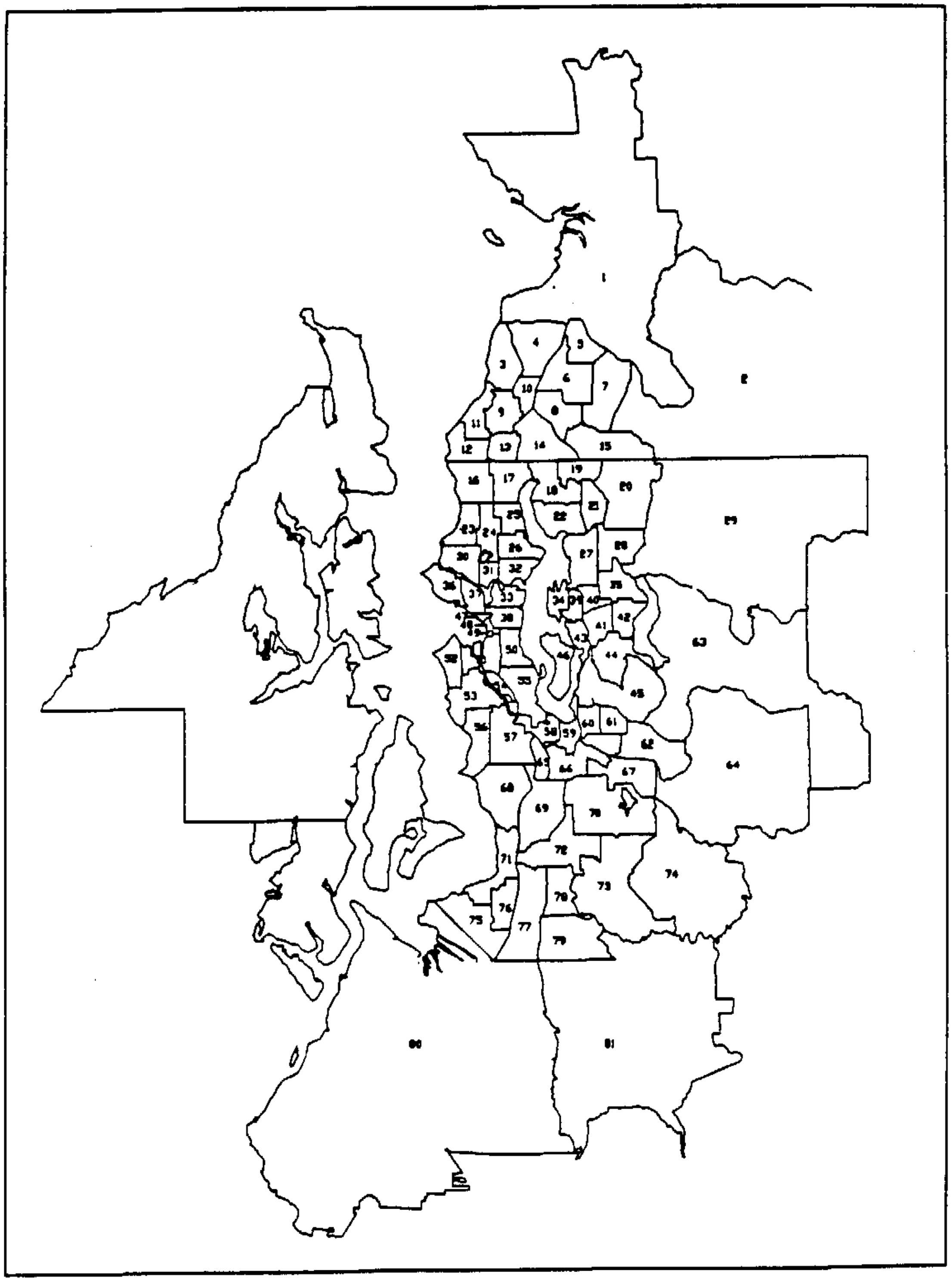


Figure 2.4 Aggregated Zones

The Format of NW.DAT, Part 1

Columns	Format	Description
1-4	I4	"From" node or A-node of link
5-8	I4	"To" node or B-node of link
9-13	F5.2	Link length, miles
14-18	F5.0	Capacity at level of service E
19-21	F3.0	Free flow speed on link, mph
22-41	5A4	Link description
79	11	1 if link results are to be printed; blank if not.

After all links have been listed, the remaining lines follow the format listed below for each time period. For example, if there were two restricted links and 12 10-minute time periods, part 2 would involve the addition of 24 rows (12 for each restricted link) to NW.DAT.

The Format of NW.DAT, Part 2

Columns	Format	Description
1-4	I4	Restricted link number
6-14	F8.6	Proportion of full capacity [0.0 to 1.0]

Although the format for NW.DAT is relatively straightforward, certain coding conventions must be followed to ensure proper execution.

1. All links are directional. Each direction of travel must be coded as a separate link.
2. The network nodes must be numbered consecutively; it is not permissible to skip over integer values.
3. An auxiliary zone centroid must be defined for each zone. If there are N zones, then node N+1 is the auxiliary zone centroid for zone 1, node N+2 is the auxiliary zone centroid for zone 2. In general, node N+i is the auxiliary zone centroid for zone i.
4. If there are N zones, then the first 2N nodes must be zone centroids and their auxiliaries.

5. All links in the NW.DAT file must be sorted in an ascending order, from the origin node and to the destination node.

6. Three connector links must be defined for each connection between a zone and a network node:

From	To	Link Properties
i	node	Regular access time values
node	N+i	Regular access time values
N+i	node	Dummy link

7. The trip table must not contain intrazonal trips, and all other cells must have at least 1 trip.

OD.DAT

The OD.DAT file contains all the information needed from the origin-destination matrix. Each line of this file lists the origin, the destination, and the number of vehicles that travel from the origin to the destination in the time period of interest. The format of this file is as follows:

The Format of OD.DAT

Columns	Format	Description
1-4	I4	Origin zone
5-7	I3	Destination zone
8-12	F5.0	Trips from origin to destination

Similar to the NW.DAT file, the OD.DAT file must be sorted in ascending order from the origin to the destination.

CN.DAT

The CN.DAT file is a description of the files NW.DAT and OD.DAT and also describes the main program values for convergence, the number of iterations, and the type of printout desired. The format needed is as follows:

The Format of CN.DAT, Part 1

Columns	Format	Description
1-5	I5	Total number of links
6-10	I5	Number of zones
11-15	I5	Total number of nodes
16-20	I5	Number of transportation links
21-25	I5	Number of records on OD.DAT
26-30	I5	Number of first network node
31-38	F8.5	Convergence criterion
39-41	I3	Maximum number of iterations
42-44	I3	Print centroid connectors? (1=yes, 2=no)
45-47	I3	Number of restricted routes
48-51	I4	Number of time periods
53-55	F3.1	System travel time adjustment ratio (see Appendix B for full definition)

The following format requires one line for each time period.

The Format of CN.DAT, Part 2

Columns	Format	Description
1-4	F4.2	Traffic intensity ratio for each time period (see Chapter 6 for full definition)
5-8	I4	Percent of uninformed drivers for each time period (see Chapter 6 for full definition)

NETWORK EXAMPLE

To illustrate the coding conventions and the proper format of the data files, NW.DAT, OD.DAT, and CN.DAT, the following example is presented.

Consider an area that is to be simulated for four 30-minute periods, has been divided into four homogeneous zones, and has a simple transportation network, as shown in Figure 2.5, and a peak hour trip table as listed below.

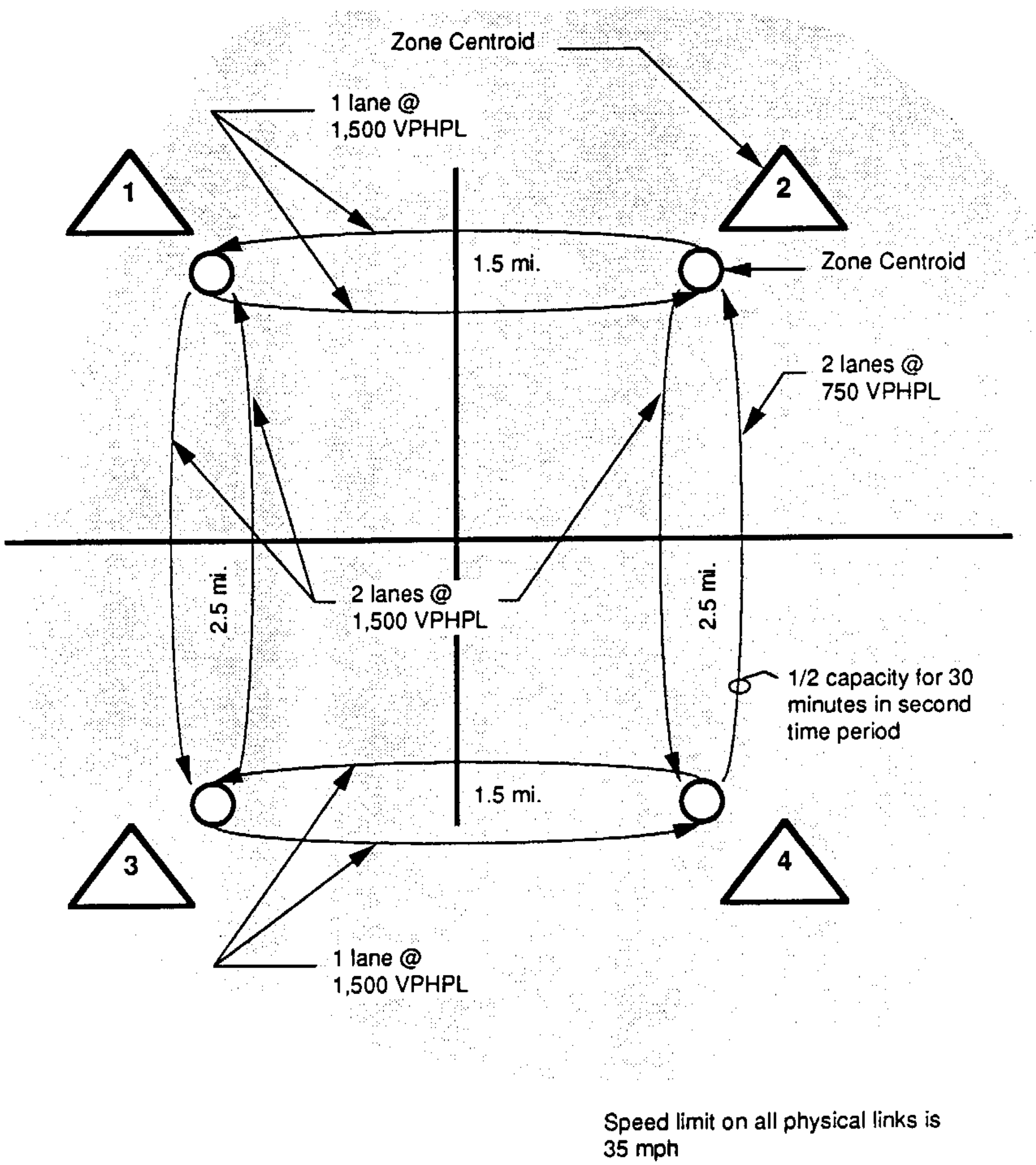


Figure 2.5. Example Transportation Network

Trip Table

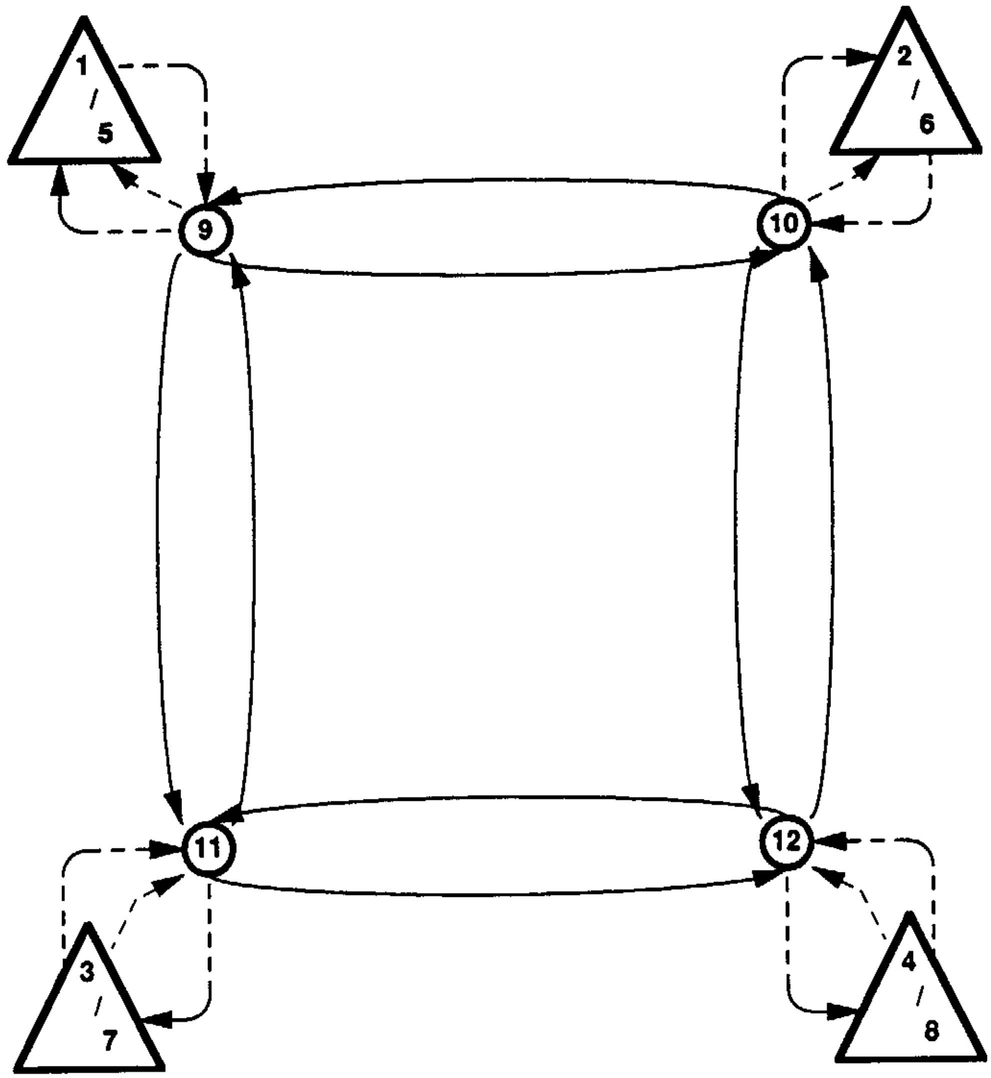
	Destination			
Origin	1	2	3	4
1		750	500	640
2	700		495	250
3	350	240		325
4	575	400	430	

The zones of this area have been represented by zone centroids (the triangles) and are numbered 1, 2, 3, and 4. For the format of XXEXQ, each zone centroid first serves as an origin and then will be renumbered to serve as a destination. Thus, the zone origins will be numbered 1 through 4 and the zone destinations will be numbered 5 through 8.

Once the zone origins and destinations have been properly numbered, the network nodes may be renumbered. In this case, the four small circles (Figure 2.5) represent the nodes and are assigned the numbers 9 through 12. See Figure 2.6 for an update on the numbering convention. Also added to this figure are the access links from the zone centroids to the network. These access links are an approximation of the transportation supply that allows vehicles to travel from the network to the zones and vice versa. Three connector links are required between a node and a zone centroid, as previously discussed.

With the numbering conventions in place and with the link performance data given in Figure 2.5, the file NW.DAT appears as shown on page 17.

Part 2, or the last four lines of the file, is dedicated to the description of the link restriction, as shown in Figure 2.5. In this case, the link from node 12 to node 10 suffers a 50 percent restriction during the second 30-minute period. This link is described in the nineteenth line of NW.DAT and is, therefore, designated as link 19 in each of the lines of part 2 in NW.DAT. Each of these lines represents one quarter of the simulation period, or 30 minutes. To describe the capacity restriction on link 19 during the second 30-minute period, the number 0.5 is coded in the second line of part 2; all other lines use 1.0 to describe full capacity.



All access links have an assumed capacity of 1,000 VPH, a speed of 25 mph, and a distance of 1 mile

Figure 2.6. Network Numbering Convention

Example of NW.DAT

```
                    COLUMN NUMBERS
         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890

   1   9     1 1000 25 ACCESS FROM ORIGIN 1 TO NODE 9
   2  10     1 1000 25 ACCESS FROM ORIGIN 2 TO NODE 10
   3  11     1 1000 25 ACCESS FROM ORIGIN 3 TO NODE 11
   4  12     1 1000 25 ACCESS FROM ORIGIN 4 TO NODE 12
   5   9    99    1  1 DUMMY LINK
   6  10    99    1  1 DUMMY LINK
   7  11    99    1  1 DUMMY LINK
   8  12    99    1  1 DUMMY LINK
   9   5     1 1000 25 ACCESS FROM NODE 9 TO DESTINATION 5
   9  10   1.5 1500 35 PHYSICAL LINK
   9  11   2.5 3000 35 PHYSICAL LINK
  10   6     1 1000 25 ACCESS FROM NODE 10 TO DESTINATION 6
  10   9   1.5 1500 35 PHYSICAL LINK
  10  12   2.5 3000 35 PHYSICAL LINK
  11   7     1 1000 25 ACCESS FROM NODE 11 TO DESTINATION 7
  11   9   2.5 3000 35 PHYSICAL LINK
  11  12   1.5 1500 35 PHYSICAL LINK
  12   8     1 1000 25 ACCESS FROM NODE 12 TO DESTINATION 8
  12  10   2.5 1500 35 PHYSICAL LINK
  12  11   1.5 1500 35 PHYSICAL LINK
  19 1.0
  19 0.5
  19 1.0
  19 1.0
```

With the data from the previous trip table, the OD.DAT data file appears as follows:

Example of OD.DAT

```
                    COLUMN NUMBERS
         1         2         3         4         5         6
123456789012345678901234567890123456789012345678901234567890

   1  2  750
   1  3  500
   1  4  640
   2  1  700
   2  3  495
   2  4  250
   3  1  350
   3  2  240
   3  4  325
   4  1  575
   4  2  400
   4  3  430
```

The last remaining file to be created is the CN.DAT file. The information needed to create this file is derived mostly from the NW.DAT and the OD.DAT files; other information that is needed depends on the modeler's preferences. Referring back to the two previous files:

The total number of links (including centroid connectors) is 20.

The number of zones is four.

The number of nodes (including zone centroids) is 12.

The number of transportation or physical links is eight.

The number of records in OD.DAT is 12.

The number of the first network node is nine.

The convergence criterion is .0005 (a typical value).

The maximum number of iterations is 10 (a typical value).

The printing of centroid connectors is not desired, therefore the value is two.

The number of restricted links is one.

The number of time periods is four.

The system travel time adjustment ratio is 1.

The travel intensity ratios for the time periods are 0.9, 1.1, 1.2, and 0.8 for the time periods one through four, respectively.

The percentage of uninformed drivers is 80.

Placed in the proper format, the CN.DAT file incorporates the above information as follows:

Example of CN.DAT

```
                        COLUMN NUMBERS
         1         2         3         4         5         6
123456789012345678901234567890123456789012345678901234567890

   20    4    12    8    12    9    .0005 10  2  1   4 1.0
0.90   80
1.10   80
1.20   80
0.80   80
```

MODEL OUTPUT

When a successful run has been accomplished, XXEXQ creates and places the simulation results in a file named OT.OUT. The length of the output varies depending on the number of links specified to be printed from the NW.DAT file. (Note that in the example NW.DAT file, only link 19 is specified to be printed.) Table 2.1 shows the output that resulted from the example files NW.DAT, OD.DAT, and CN.DAT.

The first three written lines in the output state basic information from the data file CN.DAT: the number of origin-destination pairs was 12, and the criterion set for convergence was .0005. Following these introductory statements are the link performance characteristics that were specified to be printed from the NW.DAT file.

The statement of link performance begins with the link identification number, followed by the origin node and then the destination node: 19, 12, and 10, respectively. The remainder of the link performance statement is a table with one record for each time period, or in this case four. Each record lists the time period, the volume of traffic entering

Table 2.1 Example of OT.OUT

User Equilibrium Assignment

No. of OD pairs = 12
Convergence criterion = 0.50000E-03
Link Number = 19 Physical Link
Orig Node = 12
Dest Node = 10

19	19	Capacity	Con Ratio	Veh in Q
30	564	1500	0.47	0
60	633	750	1.06	17
90	739	1500	0.63	0
120	501	1500	0.42	0

Total travel time (VEH-HRS)= 861
Average congestion ratio = 0.495026
Vehicle miles traveled = 27,915

the link, the capacity of the link during the specified time period (notice that capacity of link 19 was reduced to 600 in the second period because of the capacity restriction), the congestion ratio of the link, and the number of vehicles in the queue at the end of the period. After all the specified links have been printed, the remainder of OT.OUT lists system performance measures.

CALIBRATION OF THE MODEL

After the input data were assimilated for the network, XXEXQ was executed a number of times until the volumes on various links matched those of the ground counts. Initially, a simulated volume that came within 10 percent of the ground counts was considered to be calibrated. The process of calibrating the model involved three steps.

1. Additional elements were inserted into the network. This process included the addition of links and nodes that were inadvertently left out of the network and the addition of links and nodes that were initially considered to carry insignificant flows but later proved to be needed.
2. The network was refined. This process included adjusting capacities, lengths, and speeds of various links to closely approximate the actual conditions experienced in the field.
3. The origin destination matrix was adjusted. Trips that were not taken on the model network were removed from the system.

Adding to the Network

The first step in the calibration procedure was to achieve a successful run without errors. This first involved a painstaking search through the data files, NW.DAT and CN.DAT, to determine whether any links had been omitted or whether any had been improperly coded. On the outset, many such links were identified and corrected. However, because of the size of the network, the process of identifying miscoded links and nodes continued throughout the calibration procedure.

Because of the nature of the network node, many alterations to the network were required. Nodes, as defined in XXEXQ, had no turning restrictions. Therefore, turning restrictions that existed in the field had to be emulated in the model network. Furthermore, the researchers found that a vehicle traveling in one direction on a link could suddenly reverse direction at the next node if such a move was the shortest path. This problem proved to be quite significant near the Seattle CBD.

Near the Seattle CBD, many on- and off-ramps were available to only one direction of travel. To prohibit vehicles that were traveling in the opposite direction to exit or enter on these restricted ramps, separate links and nodes were defined for each direction of travel. This type of separated network was constructed on I-5 from Spokane street to North 175th and at other locations as necessary. Fortunately, since most interchanges had no turning restrictions, this coding convention was not needed on the entire network.

Refining the Network

Once a successful run had been accomplished, the links of the modeled network were refined to provide a more accurate description of existing conditions. Initially, many freeway links were assigned with a standard capacity of 2,000 vehicles per hour per lane. However, many of these links experienced a capacity that was significantly less than 2,000 vphpl because of merging, weaving, and geometric effects. To account for the effects caused by roadway geometry, the procedures outlined in the Highway Capacity Manual for the calculation of capacity were used. To account for other effects, maximum ground counts were used to estimate capacity whenever they were available.

Adjusting the Origin-Destination Matrix

After all reasonable refinements were applied to the network, the origin-destination matrix was changed. As mentioned earlier, the original trip table acquired from the Puget Sound Council of Governments had 512 traffic analysis zones. These zones were aggregated into 81 zones to meet the needs of the modeled network. Unfortunately, the aggregation of zones presented a couple of problems that had to be overcome before the model could be calibrated successfully.

During the aggregation process, small zones were bounded together to form one or more larger zones. The trips that occurred between the smaller zones were nullified, since intrazonal trips were not allowed. For example, consider four zones numbered 1, 2, 3, and 4. If Zones 1 and 2 were aggregated into Zone A and Zones 3 and 4 into Zone B, then the trips between Zones 1 and 2 would no longer exist because Zone A could not have intrazonal trips. Similarly, the trips between Zones 3 and 4 could no longer exist because both zones were incorporated into Zone B. Thus, an overall reduction of trips occurred whenever aggregation took place. Because of this process, 103,999 trips were eliminated from the trip table.

However, the overall reduction of trips may or may not be a problem; the existence of a problem depends entirely on the extent of detail placed within the modeled network. If a modeled network contains much detail, such as local and collector streets, then aggregation will be a significant problem since much of the traffic that used these streets has been eliminated. On the other hand, if a modeled network is rather general and incorporates only major arterials and highways, then the effects of aggregation will not be as great.

Because of the general nature of the modeled network used in this project, the effects of trip reduction due to aggregation were minimal.

Another problem that is both a function of aggregation and the network, involves forcing trips onto the modeled network that would normally not occur. This problem is most significant where zones border each other, and the problem decreases as the distance between zones increases. Placed in the perspective of this network, as the distance between a trip's origin and its corresponding destination decreased, the less likely a real vehicle was to use the modeled network links. Thus, all attempts to adjust the origin-destination matrix did not result in a more accurate matrix but resulted in a matrix that best described the ground counts on the modeled network. This distinction is important because any significant changes made to the modeled network after calibration would render the calibrated origin-destination matrix useless, or at best, render a sloppy estimation. For this reason, this step of calibration was not used until all major refinements to the network links had been completed.

The first simulation runs resulted in volumes considerably larger than the measured ground counts, sometimes 200 percent greater. To reduce these simulated volumes, trips were subtracted from the origin-destination matrix between neighboring zones immediately near the over-used links. This tactic removed the trips between zones that did not use the modeled network and proved to provide the most significant changes in the simulated volumes. After accounting for most of the trips that did not use the network, most of the simulated volumes were within 25 percent of the ground counts.

The remaining changes to the matrix involved adding or subtracting trips to achieve the 10 percent criterion. These changes were relatively small and were justifiable because of the age of the original trip table. Most changes made to the trip table were the addition of trips across Lake Washington.

RESULTS OF CALIBRATION

The results of the calibration efforts are shown in Table 2.2. This table lists the many links that were considered to be critical in the calibration efforts. The links that received the most attention, during calibration, were those that contained bridges (I-90 and SR-520 floating bridge, and Ship Canal bridge on I-5) or those that were located near an interchange.

The network was considered to be calibrated when 51 of the 55 simulated volumes were within 10 percent of the measured ground counts obtained from the Washington State Department of Transportation's Ramp and Roadway Report, 1988. The other four links had simulated volumes within 15 percent of the ground counts and were accepted as

TABLE 2.2 CALIBRATION RESULTS

LINK DESCRIPTION	FROM NODE	TO NODE	MEASURED VOLUME	SIM. VOLUME	PERCENT DIFF.
SB5: SR526 TO 128	163	164	4,070	4,248	4.37
NB5: 128 TO SR526	164	163	4,100	4,204	2.54
SB5: 164 TO I405	165	166	4,700	4,651	-1.04
NB5: I405 TO 164	166	165	4,830	4,783	-0.97
SB5: 44TH TO 220	168	169	4,810	4,783	-0.56
NB5: 220 TO 44TH	169	168	6,140	5,750	-6.35
SB5: 205TH TO 175	171	172	4,490	4,401	-1.98
NB5: 175TH TO 220	172	171	4,710	6,301	-6.10
SB5: 125TH TO NGATE	174	175	5,180	5,234	1.04
NB5: NGATE TO 130TH	175	174	8,530	8,903	4.37
SB5: NGATE TO 85TH	175	290	5,410	4,954	-8.43
NB5: 85TH TO NGATE	176	175	6,370	5,883	-7.65
NB5: LC WAY TO 85TH	177	176	6,460	6,274	-2.88
NB5: RAVENNA TO LC	178	177	6,830	7,777	13.87
NB5: SHIP CANAL	181	180	7,680	7,431	-3.24
RAMP: NB5 TO SR520	181	325	2,310	2,443	5.76
NB5: RNKE TO SHIP	182	181	7,800	7,439	-4.63
SB5: WSF TO MICH.	185	186	7,090	6,673	-5.88
SB5: MICH TO BOEING	186	187	6,930	6,838	-1.33
NB5: BOEING TO MICH	187	186	5,100	5,261	3.16
SB5: BOEING TO 599	187	188	6,290	7,039	11.91
NB5: 599 TO BOEING	188	187	5,290	5,657	6.94
NB405: I5 TO SR167	189	214	3,850	3,369	-12.49
EB518: I5 TO SR99	189	215	4,440	4,196	-5.50
SB405: 70TH TO 520	202	203	4,140	4,422	6.81
NB405: 520 TO 70TH	203	202	6,110	6,122	0.20
SB405: 44TH TO 30TH	209	210	4,480	4,067	-9.22
NB405: 30TH TO 44TH	210	209	4,080	3,896	-4.51
SB405: 30TH TO 900	210	211	3,850	4,167	8.23
NB405: 900 TO 30TH	211	210	4,520	4,242	-6.15
SB405: 169 TO 167	213	214	3,760	3,545	-5.72
NB405: 167 TO 169	214	213	4,250	4,554	7.15
EB518: SR99 TO I5	215	189	2,910	3,222	10.72
NB99: 85TH TO HOLM	225	224	2,171	2,166	-0.23
SB99: BRWY TO BAT	228	229	2,533	2,625	3.63
NB99: BAT TO BRWY	229	228	4,826	4,429	-8.23
SB99: WSF TO EMW	230	231	2,290	2,339	2.14
NB99: EMW TO WSF	231	230	2,553	2,711	6.19
SB509: GLEN TO 128	240	241	2,680	2,934	9.48
SB509: 160TH TO DES	242	243	2,020	1,981	-1.93
NB509: DES TO 160TH	243	242	1,140	1,118	-1.93
EB520: MONT TO 84TH	244	245	3,720	3,623	-2.61
WB520: SR520-I5 INT	244	326	3,450	3,687	6.87
WB520: 84TH TO MONT	245	244	3,690	3,805	3.12
EB520: 908 TO 202	249	250	1,950	1,937	-0.67
EB90: FLOATING BR.	252	253	4,830	4,723	-2.22
WB90: FLOATING BR.	253	252	1,490	1,598	7.25
EB90: 148TH TO 901	257	258	3,490	3,774	8.14
WB90: 901 TO 148TH	258	257	2,800	2,616	-6.57
SB5: 85TH TO 70TH	290	291	5,610	5,654	0.78
SB5: 70TH TO 50TH	291	292	6,230	6,457	3.64
SB5: SHIP CANAL	294	295	7,270	8,012	10.21
SB5: 520 TO BOYL	296	297	7,520	8,002	6.41
RAMP: SB5 TO 520	296	325	1,230	1,367	11.14
NBEX: LC TO NGATE	315	314	2,840	2,563	-9.75
NBEX: 42ND TO LC	316	315	4,330	4,293	-0.85
RAMP: 520 TO SB5	326	296	2,080	1,948	-6.35

satisfactory. Volumes on links for which no volume data were available were checked for reasonableness.

The calibration procedure required 42 trial runs and resulted in 14 hours of personal computer execution and approximately 200 person-hours.

CHAPTER 3

FINDINGS, INTERPRETATION, APPRAISAL, AND APPLICATION: INCIDENT SIMULATION

This chapter reviews the simulations of incidents on selected links within the central Puget Sound transportation network.

CALIBRATION OF SYSTEM SPEED AND TIME

Although referred to as calibration, the calibration procedures used for the simulation of incidents differed from the calibration discussed in Chapter 2. The calibration procedures in Chapter 2 were performed to match simulated link volumes with actual ground counts; the purpose of calibration in this step was to adjust the percentage of driver information so that the average simulated commute times and speeds would match those that were observed in the field.

System Speed

The system speed is the quotient of the total vehicle miles traveled on the network divided by the total vehicle hours consumed on the network. To simplify the estimation of the system speed, the access links between nodes and zone centroids were not included in this computation. Both the vehicles hours and the vehicle miles are printed in the last three lines of the output, OT.OUT.

The derivation of system speed from the output of the simulation results was a simple task; however, the estimation of actual system speed was less straightforward. The Puget Sound Council of Governments had estimated system speed as approximately 40 to 45 miles per hour. Unfortunately, this estimate pertained only to freeway speeds and did not include many of the signalized arterials included in this analysis. To account for the slower speeds incurred on the slower links, the initial estimate of 45 mph was reduced to 30 to 35 miles per hour.

Commute Time

The average simulation commute time was calculated by dividing the total vehicle hours by the total number of vehicles using the network. As with system speed, the total number of vehicle hours was given in the output, OT.OUT. However, the total number of vehicles was derived as the summation of all trips in the origin-destination matrix, or OD.DAT.

The actual average commute time was estimated to be 16 minutes, a value that included all commutes within the modeled network. The Puget Sound Council of Governments had suggested an average commute time of 21 minutes, but this value included an average number of incidents on the network and network access times that were not included in the estimate. Since it would have been extremely difficult to ascertain the average number of incidents within the system and where they were located, the researchers did not attempt to simulate such a scenario.

Driver Information

The percentage of drivers with information about traffic conditions has a significant effect on the overall system efficiency. By adjusting the percentage of informed drivers, the modeler can alter the values of simulated system speed and average commute times to lie within acceptable limits.

Figures 3.1 and 3.2 show the effects of driver information on system performance. Initially, increasing the percentage of informed drivers increases the performance of the system; as driver information increases, system speed increases and average commute time decreases. However, as these figures indicate, if more than 50 percent of the drivers are aware of existing traffic conditions, then the system performance slowly, but steadily, decreases. Note that the percentage of declining system performance is very network specific and will vary if incidents are present.

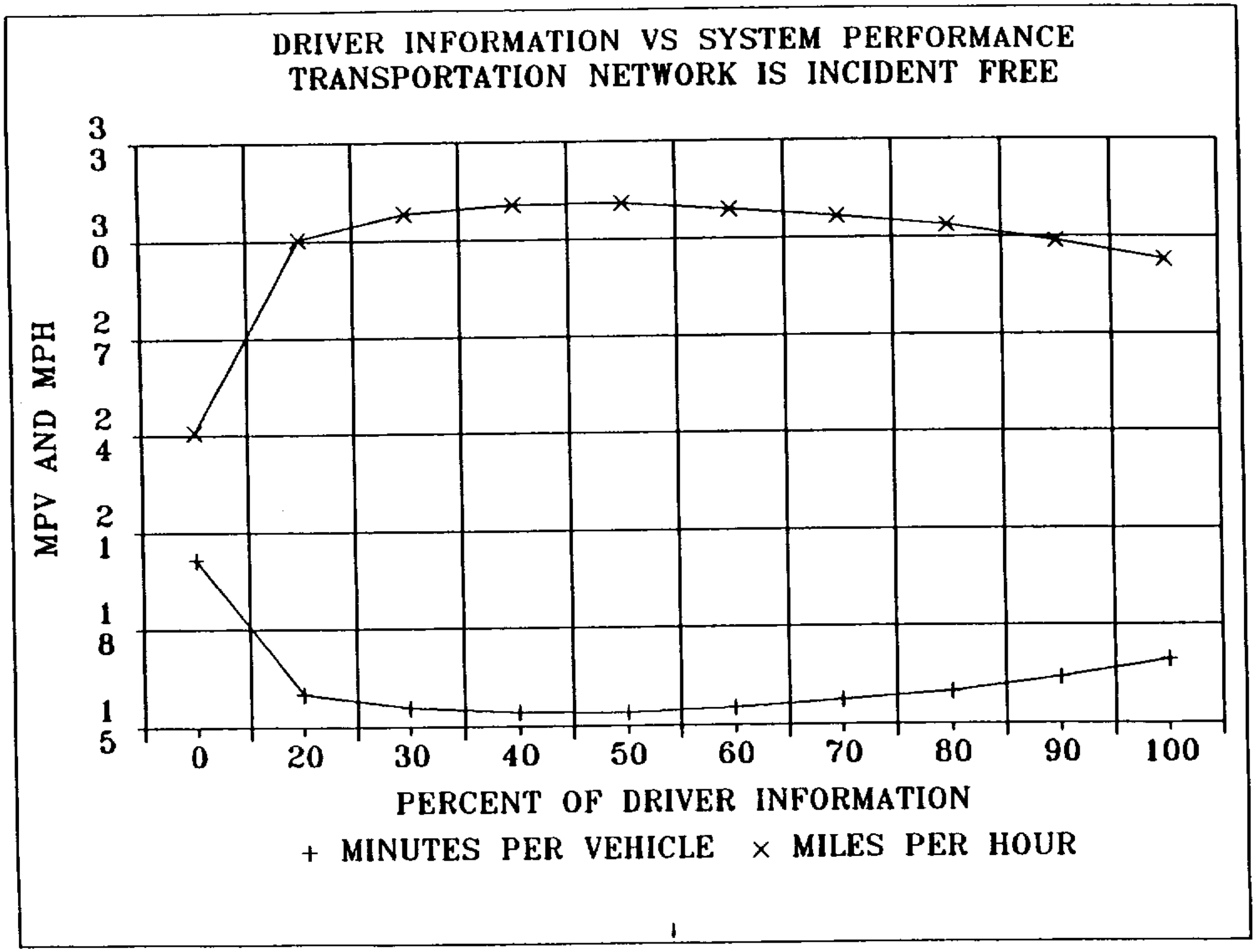


Figure 3.1 The Impacts of Driver Information on System Speed and Average Commute Time

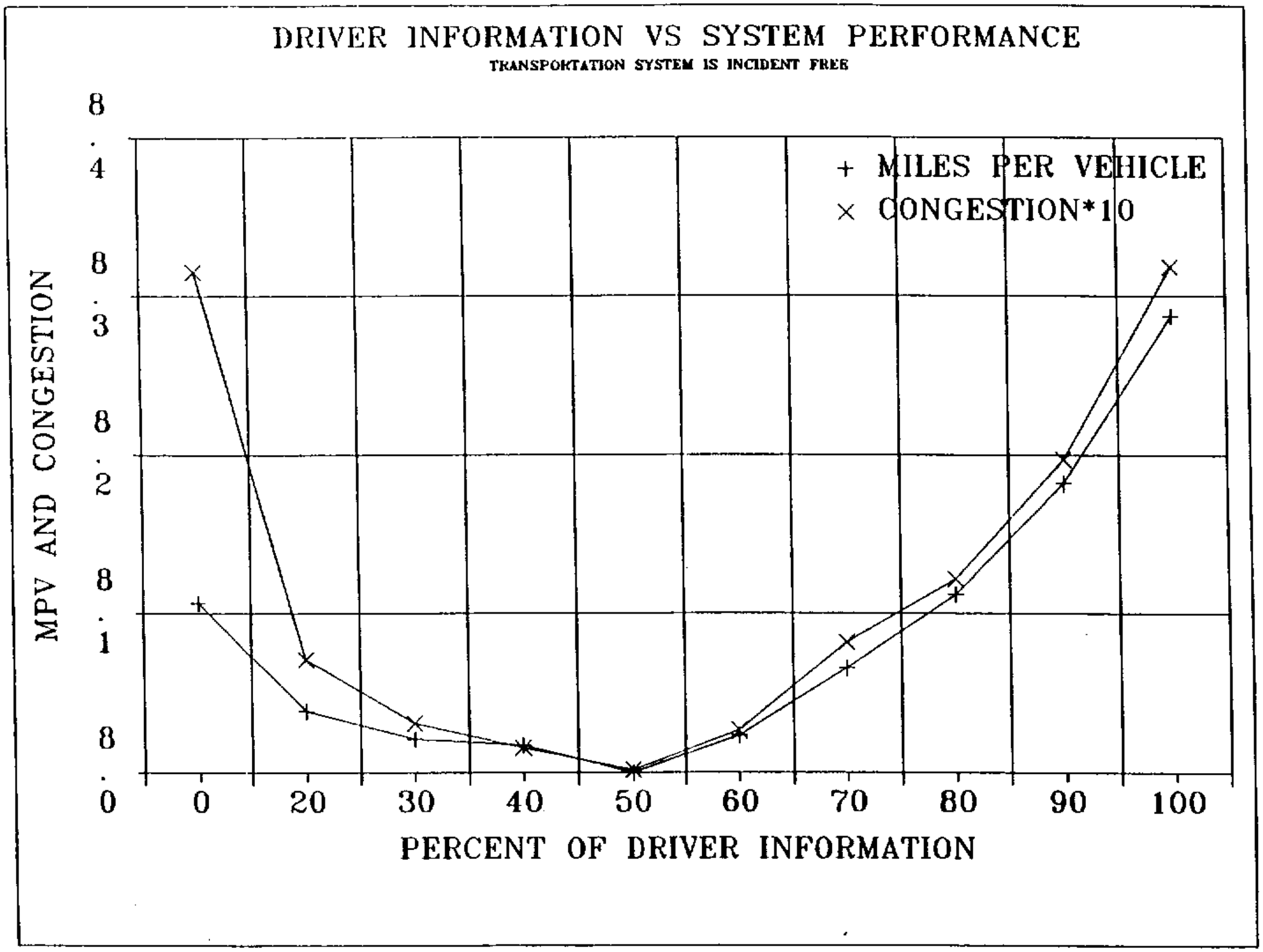


Figure 3.2 The Impacts of Driver Information on Congestion and Ave. Commute Distance

Figure 3.1 shows that two values of percentage of driver information existed for many of the system speeds and average commute times. At this stage, the researchers concluded that the choice of percentage of driver information depends not only on the values for calibrating system performance but also on the route of primary interest.

Within the central Puget Sound region, some commuting routes are more susceptible to traffic congestion than others. Such routes include the floating bridges of SR-520 and I-90 because of their high volumes of traffic and limited space in which cars can maneuver around blocking incidents. Because of their susceptibility to congestion, the drivers on these routes could reasonably be assumed to pay more attention to traffic reports than drivers who use other, less susceptible, routes. Thus, routes with higher susceptibility to congestion have a greater percentage of drivers who are aware of existing traffic conditions.

The conclusion that driver awareness varies with the route chosen leaves the user of XXEXQ with a limitation that can not be overcome. This limitation is the fact that XXEXQ uses the percentage of driver information as a system parameter: it is not route specific. Therefore, the researchers chose a value for driver information that best described the awareness on a particular route or link. In this case, the link containing the floating bridge on SR-520 was chosen, and the selected percentage of informed drivers was 60 percent.

SIMULATION OF INCIDENTS

Various incidents were simulated, and the system speed, average commute times, length of average commute, and system congestion were checked for reasonableness. For each of the first three incidents simulated, seven different XXEXQ simulation runs were made with varying incident durations (10-, 20-, 30-, 40-, 50-, and 60-minute durations) and one run was made free of incidents.

Simulation 1: Eastbound SR-520

Incident Description

For simulation purposes, a hypothetical incident was placed in the eastbound direction of travel on the Evergreen Point floating bridge of SR-520. (Recall that the origin-destination matrix was for the p.m. peak period, so eastbound would be the direction of heaviest travel). This incident was assumed to be a traffic accident that resulted in complete closure of one of the two existing lanes and caused the remaining lane to operate at 50 percent of the original capacity. With this type of incident, the operating capacity of the bridge was reduced to 25 percent of the original capacity. The lanes traveling in the opposite direction were not affected by the incident.

Coding of Incident

The 120-minute simulation duration (4:30 p.m. to 6:30 p.m.) was divided into twelve 10-minute time periods, and the incident was assumed to begin during the second time period, or 10 minutes into the simulation (i.e., 4:40 p.m.). One simulation was run for each of seven incident durations that lasted from 0 to 60 minutes (i.e., one run was executed for an incident duration of 0 minutes, another for 10 minutes . . ., and another for 60 minutes). A different NW.DAT file had to be created for each simulation run.

Since 12 time periods were used, the traffic intensity ratios for these periods had to be determined. The traffic intensity ratio is simply a ratio that translates the average origin-destination traffic demand into the demand expected in individual time periods. For example, a traffic intensity ratio of 1.2 indicates that the corresponding time period has 20 percent more traffic than the peak-hour average. The data used to derive these ratios were obtained from the Traffic Systems Management Center in Seattle. This information was converted into the needed ratios and is shown in Figure 3.3.

The OD.DAT file, regardless of the incident duration or location, remained constant in all simulation runs (OD.DAT was not included in this report because of its length; copies

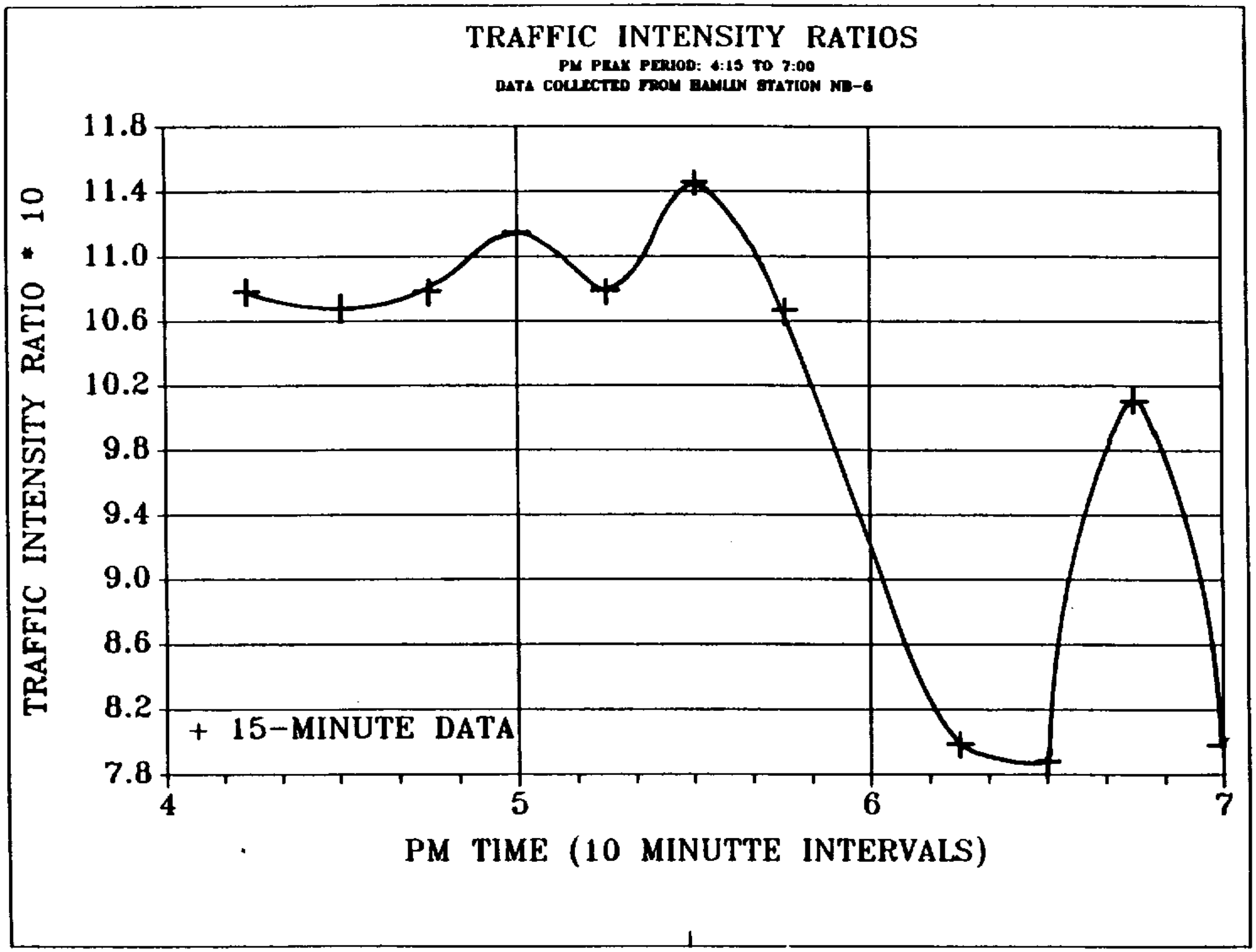


Figure 3.3 Traffic Intensity Ratios for the PM Peak Period

are available upon request). However, the NW.DAT and CN.DAT files had to be changed to reflect the incident description. In this case, part 2 of NW.DAT had 12 lines: one line for each of the 12 periods (for exposition purposes, Appendix B contains the full NW.DAT file for a 40-minute incident simulation). Each of these lines began with the link number that contained the incident or capacity reduction. The link number for the Evergreen Point floating bridge was 780. The proportion of capacity during each time period was placed in each line following the link number. As an example, part 2 of NW.DAT is shown in Table 3.1 for a 40-minute incident in the location described above.

Similar to NW.DAT, CN.DAT also had to be changed to reflect the number of time periods, the percentage of uninformed drivers, and the traffic intensity ratios. The CN.DAT filed used for the same incident is shown in Table 3.2.

TABLE 3.1 PART 2 OF NW.DAT FOR A 40 MINUTE INCIDENT

780	1.0
780	0.25
780	0.25
780	0.25
780	0.25
780	1.0
780	1.0
780	1.0
780	1.0
780	1.0
780	1.0
780	1.0

TABLE 3.2 CN.DAT FOR A SIMULATION WITH 12 TIME PERIODS

```
1071  81  337  387 6480  163  0.0005 10  2  1  12 1.23
1.07  40
1.07  40
1.09  40
1.12  40
1.09  40
1.10  40
1.15  40
1.10  40
1.03  40
0.94  40
0.84  40
0.79  40
```

With all changes accounted for in the data files, the simulation runs for the incident on the Evergreen Point floating bridge were executed.

Results From Simulation 1

Seven simulation runs were executed, one run for each incident duration. Each run required approximately 6.5 hours on a 286 10Mhz machine. The results of these runs are shown in Figures 3.4, 3.5, 3.6, and 3.7.

Figure 3.4 reveals the changes in the average commute time and system speed with respect to the duration of the incident on eastbound SR-520. In the base run (a run with an incident duration of 0 minutes) the system speed was approximately 31 miles per hour, and the average commute time was 16 minutes per vehicle. These value results matched the calibration parameters. As the incident duration increased, the system speed decreased and the average commute time increased. For the 60-minute incident, the decline in system speed was 1.4 miles per hour, and the average commute time (all drivers) increased by 0.9 minutes.

Similar to Figure 3.4, Figure 3.5 shows the relationship of the average trip length and system congestion to incident duration. In general terms, as the duration of the incident increases, so does the average trip length and the system congestion.

The results seen in Figures 3.4 and 3.5 followed a general pattern that was expected. The base run described a user equilibrium solution in which all links were capable of operating at full capacity. As this capacity was reduced by link restriction, two consequences resulted. The first consequence was the inability of the uninformed driver to respond to the capacity restriction. This inability resulted in drivers taking the same route as they did in the base run and, subsequently, being delayed by queues in the restricted link and by queues caused by the restricted link. Because the uninformed drivers took the same route, regardless of capacity restrictions, their average trip length remained the same. However, if their normal route had been affected by capacity restrictions, then they would probably have been delayed by queues and the travel time would have increased.

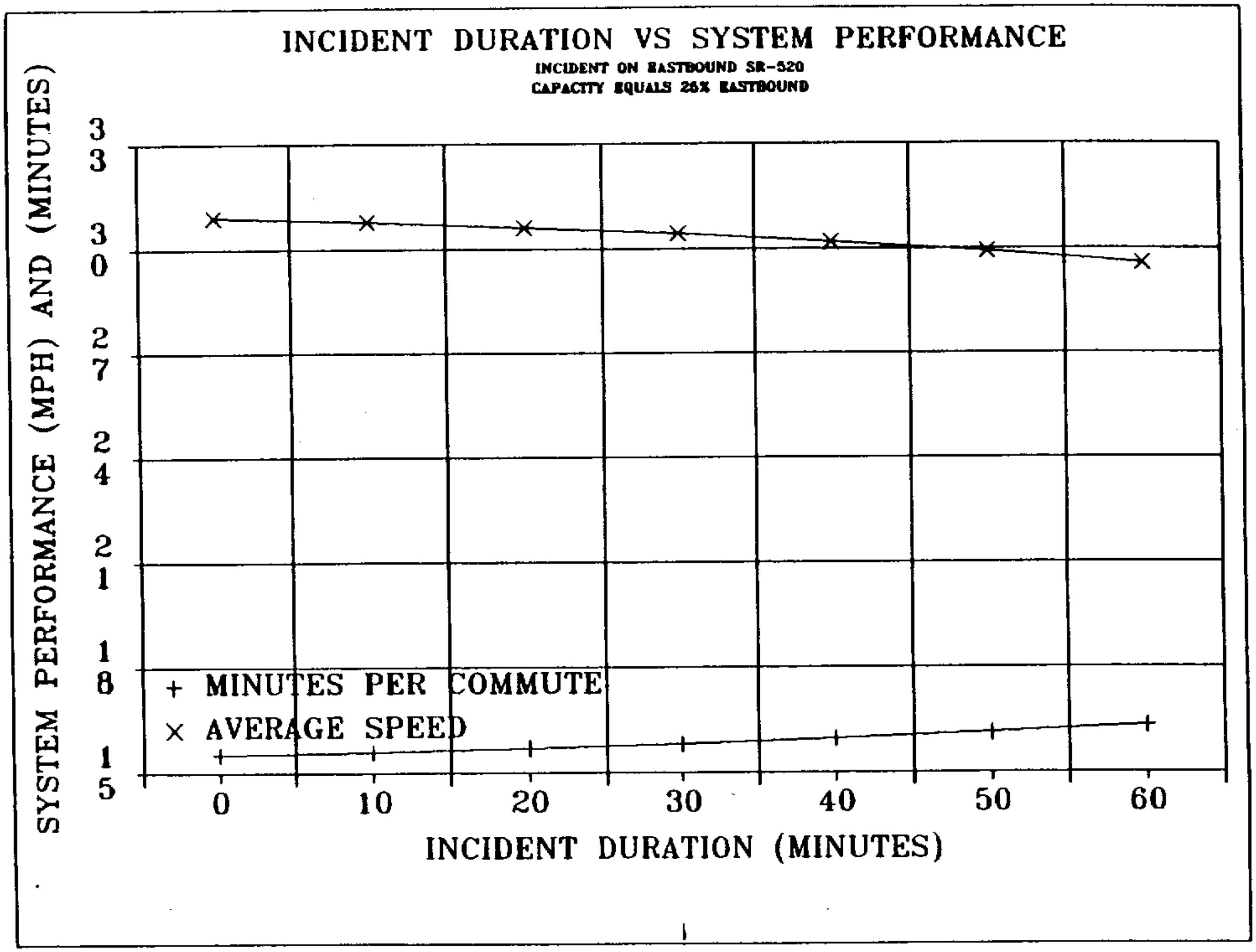


Figure 3.4 The Impacts of Incident Duration on System Speed and Average Commute Time

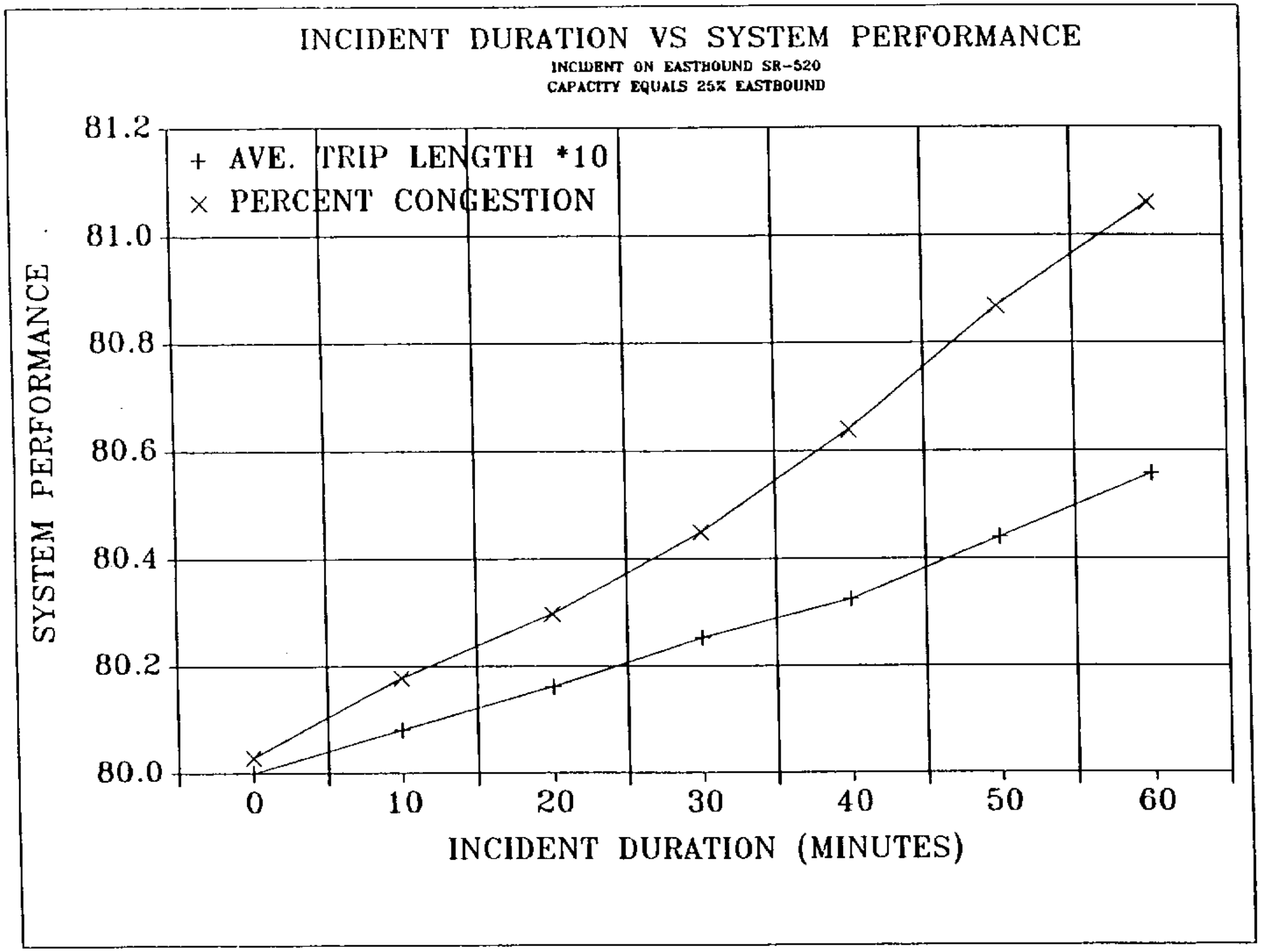


Figure 3.5 The Impacts of Incident Duration on Congestion and Average Trip Length.

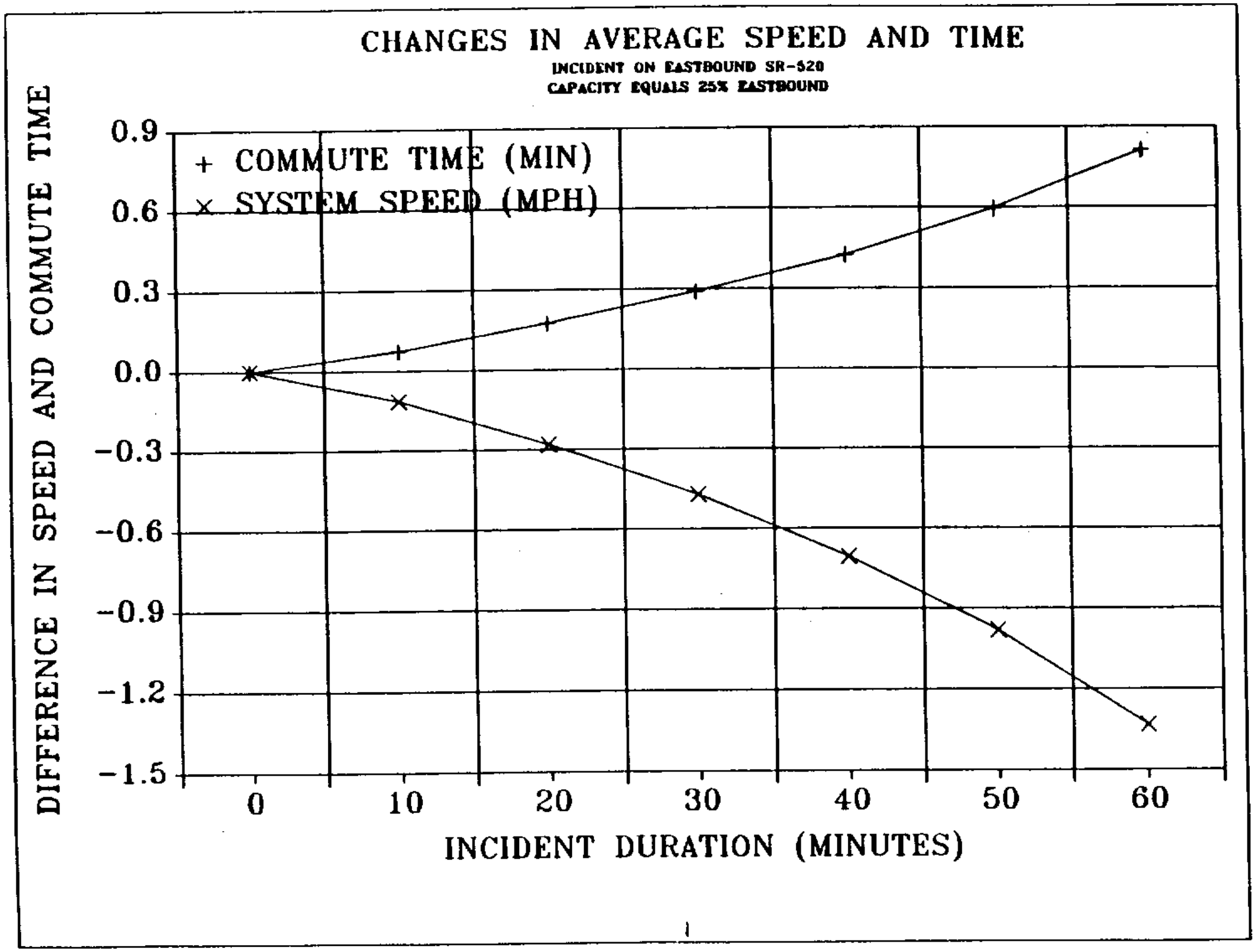


Figure 3.6 The Impacts of Incident Duration as Compared to the Base Run

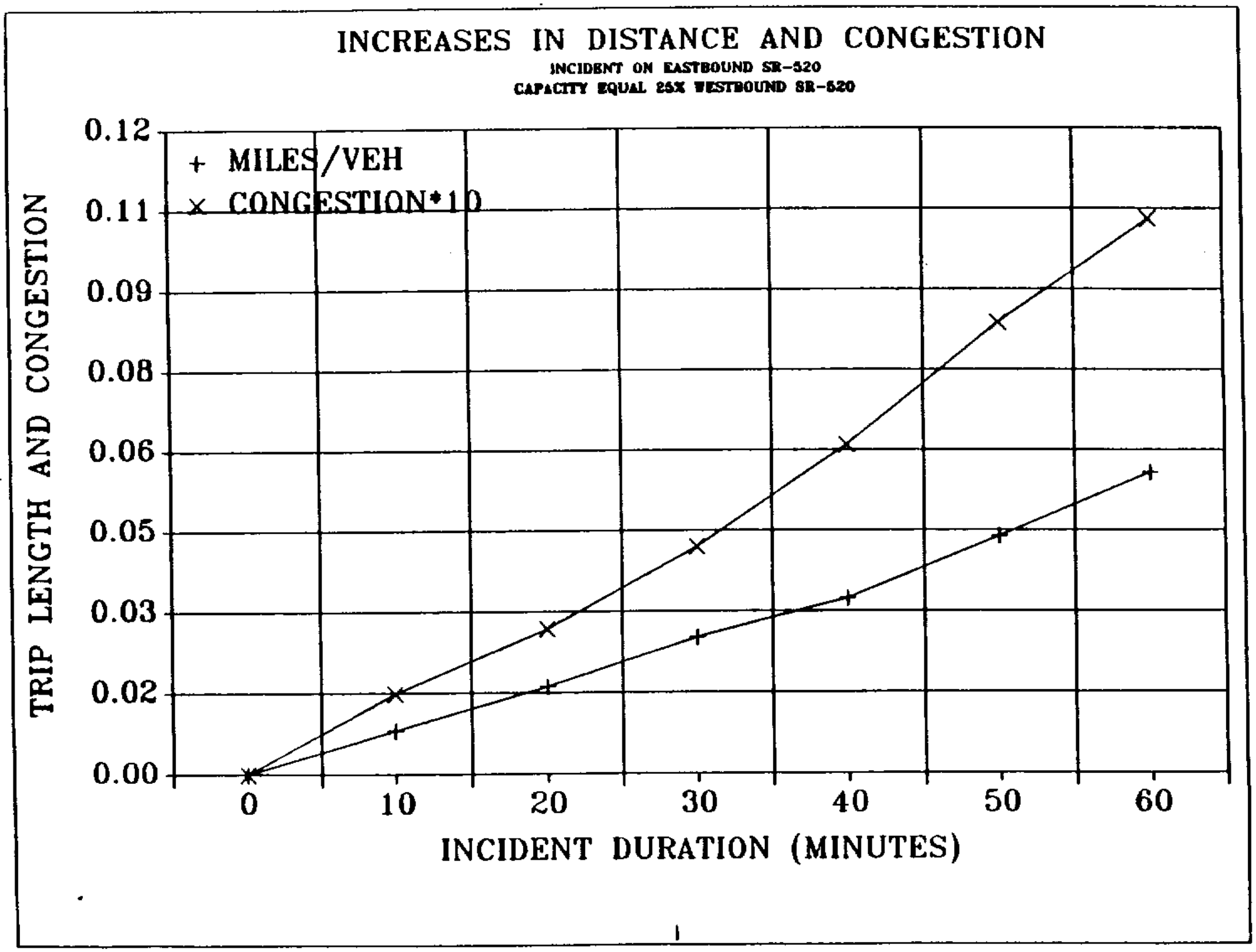


Figure 3.7 The Impacts of Incident Duration as Compared to the Base Run

The second consequence resulted from the informed drivers' ability to respond to queues and capacity restrictions. Unlike the uninformed drivers, the informed drivers found the path that offered the quickest delivery between their origin and destination. In doing so, they often diverted from their normal route to other routes that may have taken significantly shorter time but may have been longer in distance. This diversion of traffic increased congestion on other parts of the system and increased the average number of miles traveled per vehicle.

Figures 3.6 and 3.7 use the same results as Figures 3.4 and 3.5 but plot the difference between the base run and the simulations with incidents. As shown, a 60-minute incident on eastbound SR-520 near the Evergreen Point floating bridge decreased the system speed by approximately 1.33 miles per hour, increased the average commute time by 0.81 minutes, increased the average trip length by 0.06 miles, and increased the system congestion 0.01. Table 3.3 lists the increase in total vehicle-hours consumed by the system (relative to the non-incident "base case") with respect to the length of duration.

Another product of XXEXQ was the number of vehicles in a queue on any specified link. In these simulations, the restricted link was chosen for queue output. Table 3.4 lists the maximum queue in vehicles and equivalent distance for each incident duration; the equivalent distances were calculated with the assumption that headways in queues were equal to 30 feet.

In the base run, XXEXQ predicted a queue length of 1.08 miles. A queue of this length is a common occurrence on eastbound SR-520 because of the large volumes of traffic attempting to cross the lake on a routine basis. As an incident was introduced to the link containing the floating bridge and as the incident duration increased, the length of queue also increased. At a 60-minute incident duration, the maximum queue length reached a distance of 2.24 miles, a distance that would easily have backed up traffic onto Interstate 5.

TABLE 3.3 INCREASE IN VEHICLE-HOURS RESULTING FROM AN INCIDENT ON EASTBOUND STATE ROUTE 520 NEAR EVERGREEN POINT FLOATING BRIDGE

Incident Duration	Vehicle Hours
Base Case	0
10 min.	504
20 min.	1,198
30 min.	1,984
40 min.	2,918
50 min.	4,080
60 min.	5,562

TABLE 3.4 QUEUES ON RESTRICTED LINK 780: EVERGREEN POINT FLOATING BRIDGE, EASTBOUND STATE ROUTE 520

Incident Duration	Vehicles in Queue	Equivalent Distance
Base Case	379	1.08 mi.
10 min.	480	1.36 mi.
20 min.	565	1.61 mi.
30 min.	629	1.79 mi.
40 min.	695	1.97 mi.
50 min.	748	2.12 mi.
60 min.	787	2.24 mi.

TABLE 3.5 INCREASE IN VEHICLE-HOURS RESULTING FROM AN INCIDENT ON NORTHBOUND INTERSTATE 5 NEAR SHIP CANAL BRIDGE

Incident Duration	Vehicle Hours
Base Case	0
10 min.	1,123
20 min.	2,755
30 min.	5,027
40 min.	7,582
50 min.	10,751
60 min.	16,189

TABLE 3.6 QUEUES ON RESTRICTED LINK 532: SHIP CANAL BRIDGE, NORTHBOUND INTERSTATE 5

Incident Duration	Vehicles in Queue	Equivalent Distance
Base Case	400	0.57 mi.
10 min.	828	1.18 mi.
20 min.	1190	1.69 mi.
30 min.	1488	2.11 mi.
40 min.	1627	2.31 mi.
50 min.	1812	2.57 mi.
60 min.	1970	2.80 mi.

Simulation 2: Northbound I-5

Incident Description

For this simulation, an incident was introduced on northbound I-5 on the Ship Canal bridge. The incident was assumed to cause three of the four lanes to be entirely closed, and the fourth lane was assumed to remain at full capacity. Thus, the operating capacity of the bridge would be 25 percent of the original capacity. The lanes providing travel in the opposite direction were not affected by the incident.

Coding of Incident

The data files used for this incident were the same as those used for the previous incident, except that the NW.DAT file was changed to incorporate the link that contained the Ship Canal bridge, link 532. The incident start times, durations and the numbers of simulations were kept the same as in simulation 1.

Results From Simulation 2

In general, the results from the simulated incident on the Ship Canal bridge were very similar to those from the simulation of incidents on the Evergreen Point floating bridge. However, these results (as shown in Figures 3.8, 3.9, 3.10, and 3.11) did differ in the extent to which the system performance characteristics were altered. With an incident duration of 60 minutes, the system speed was reduced by 3.65 miles per hour (a 174 percent greater effect than the previous incident on SR-520); the average commute time was increased by 2.37 minutes (192 percent greater than the previous incident); the trip lengths increased by 0.13 miles (117 percent greater); and the congestion ratio increased by 0.02 (90 percent greater). Table 3.5 lists the increase in total vehicle-hours (relative to the non-incident "base case") with respect to the length of incident duration.

The queues that resulted from the incidents are listed in Table 3.6. Again and as expected, the length of queues increased as the duration of the incident increased. The

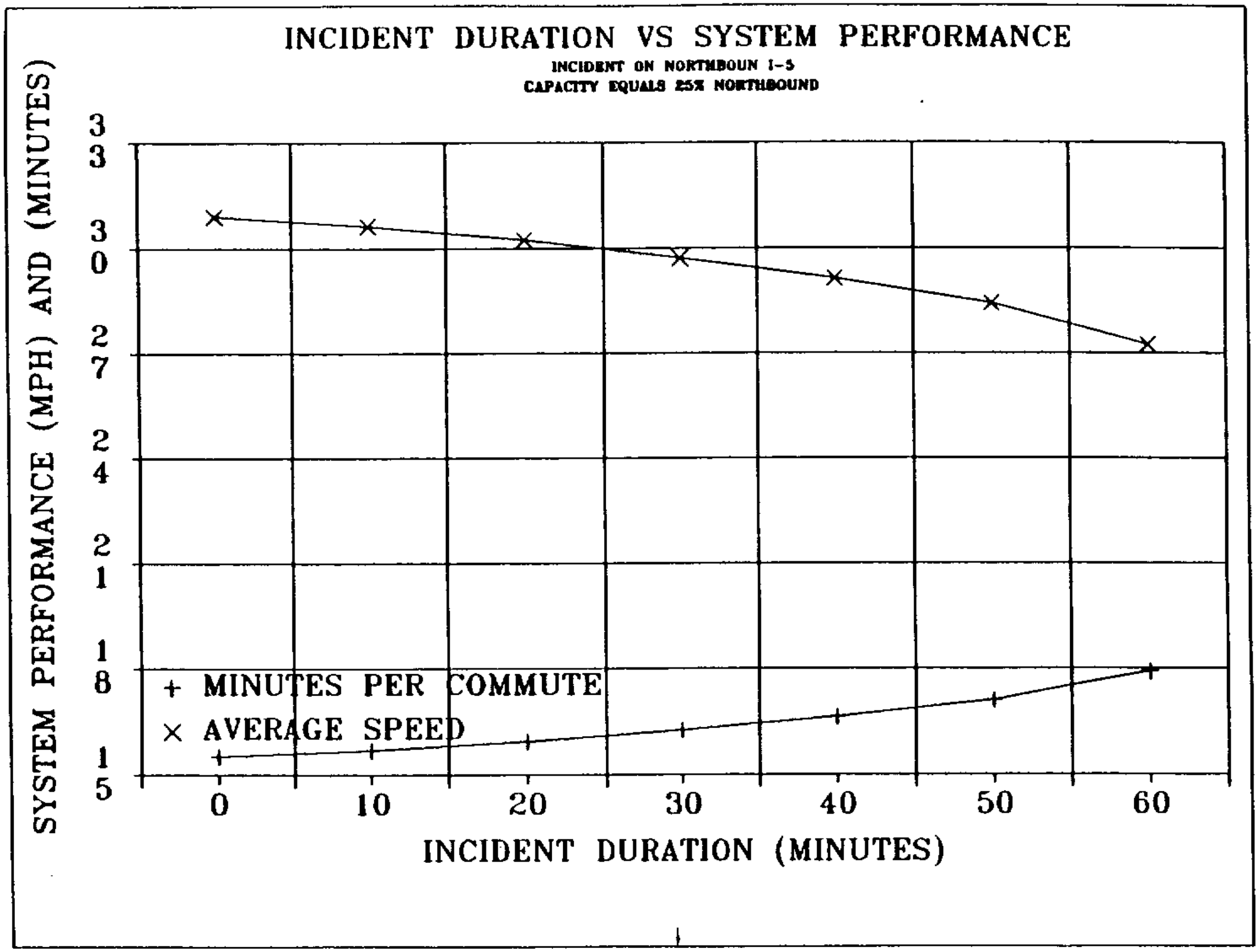


Figure 3.8 The Impacts of Incident Duration on System Speed and Average Commute Time

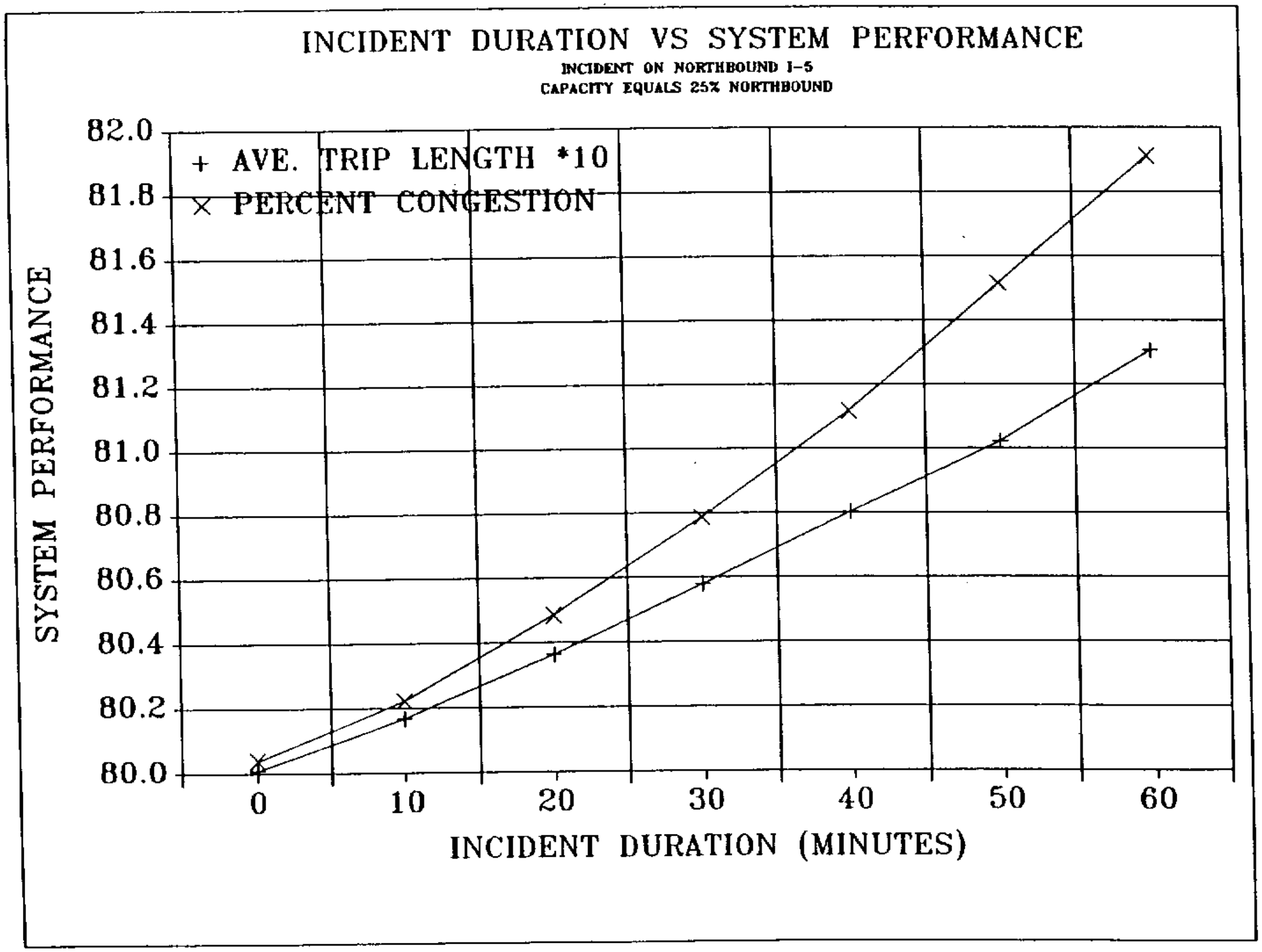


Figure 3.9 The Impacts of Incident Duration on Congestion and Average Trip Length

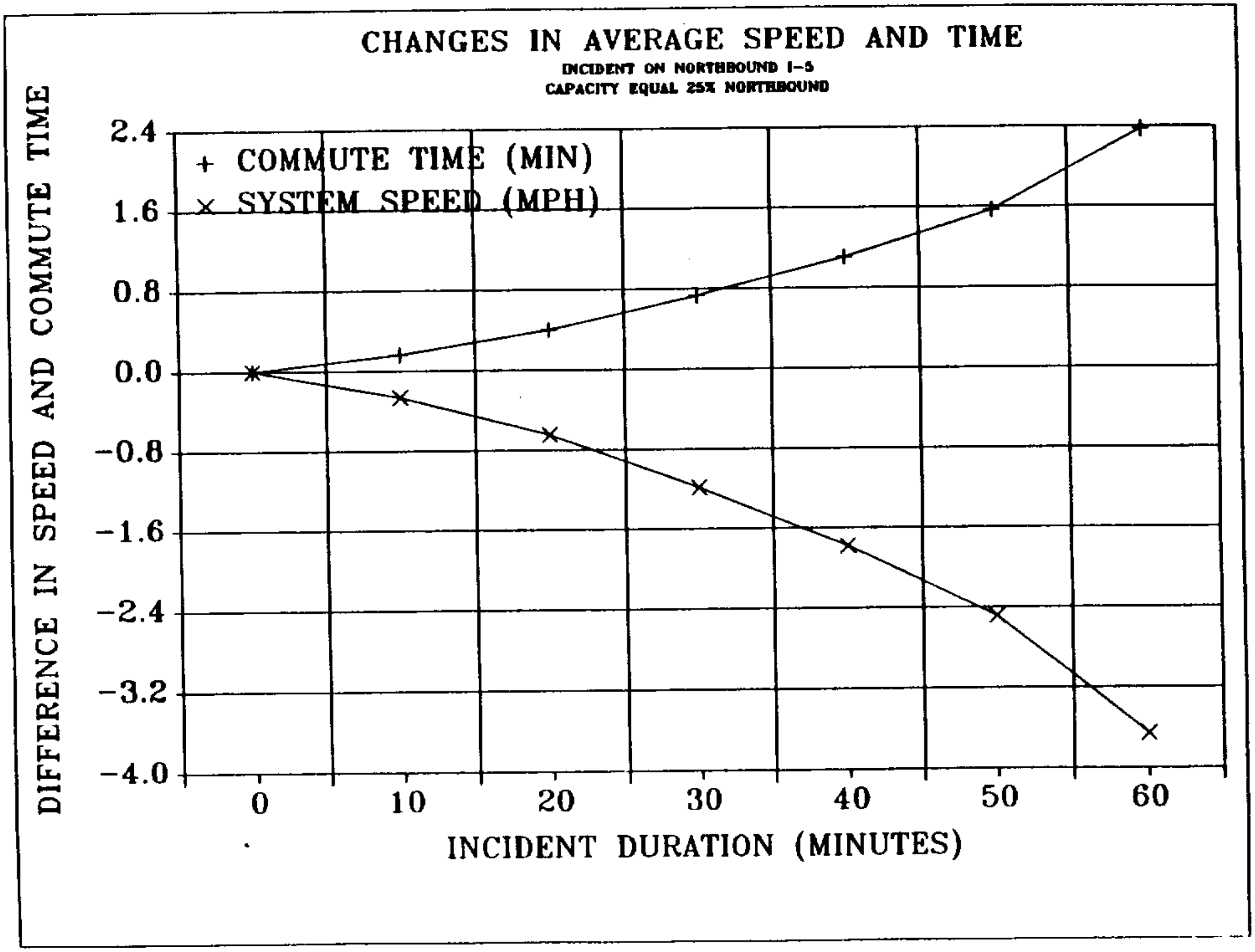


Figure 3.10 The Impacts of Incident Duration as Compared to the Base Run

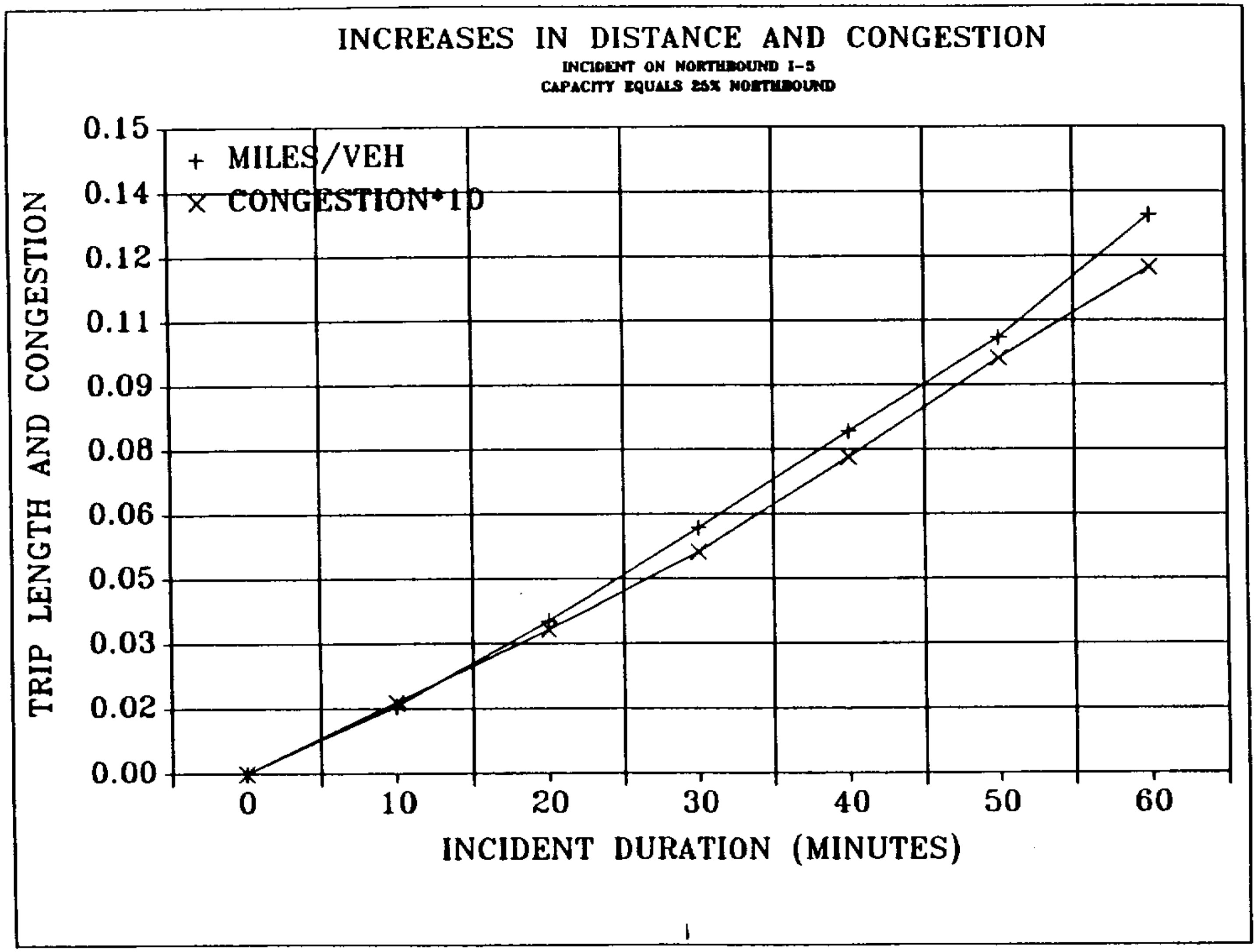


Figure 3.11 The Impacts of Incident Duration as Compared to the Base Run

maximum queue length that occurred with a 60-minute incident was 2.80 miles, a distance that would have backed traffic into downtown Seattle.

Simulation 3: Visual Interference

Incident Description

Traffic incidents often cause capacity reductions in other links that are within sight of the incident. Such an effect is the result of drivers slowing down to take a good look at the accident. These drivers (also referred to by traffic reporters as gapers, rubberneckers, swivelheads, and dipsticks) tend to slow down the flow of traffic and reduce the capacity of a fully functional link. To simulate the effects of this gaper phenomenon, a reasonable percentage of capacity reduction on a link that traveled in the opposite direction of an incident was coded.

The primary incident used for this simulation was the same incident used in simulation 1. The capacity reduction caused by visual interference was placed in the westbound lanes of SR-520 on the Evergreen Point floating bridge, and the resulting capacity was reduced to 80 percent of the original value.

Results From Simulation 3

The effects on the system from both the capacity reductions (the primary incident and the visual interference) are shown in Figures 3.12, 3.13, 3.14, and 3.15. With an incident duration of 60 minutes and a capacity reduction due to visual interference for the same length of time, the system speed was reduced by 1.40 miles per hour (a 5.3 percent greater reduction than the incident without the visual interference); the average commute time increased by 0.86 minutes (6.26 percent greater); the average trip length increased by 0.06 miles (about equal); and the congestion ratio increased by 0.012 (20 percent greater). Table 3.7 lists the increase in total vehicle-hours (relative to the non-visually impacted incident presented in simulation 1) with respect to the length of incident duration.

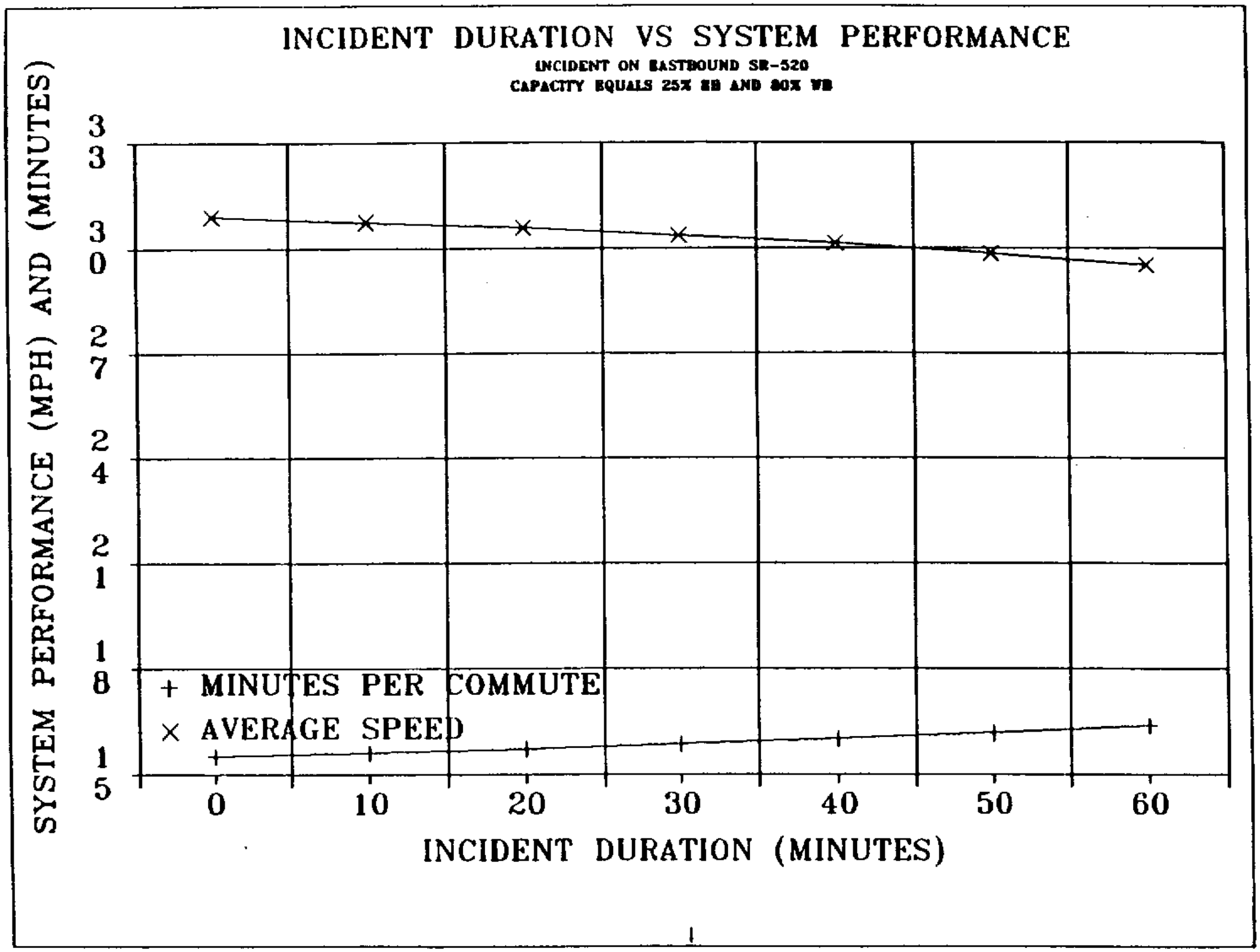


Figure 3.12 The Impacts of Incident Duration on System Speed and Average Commute Time

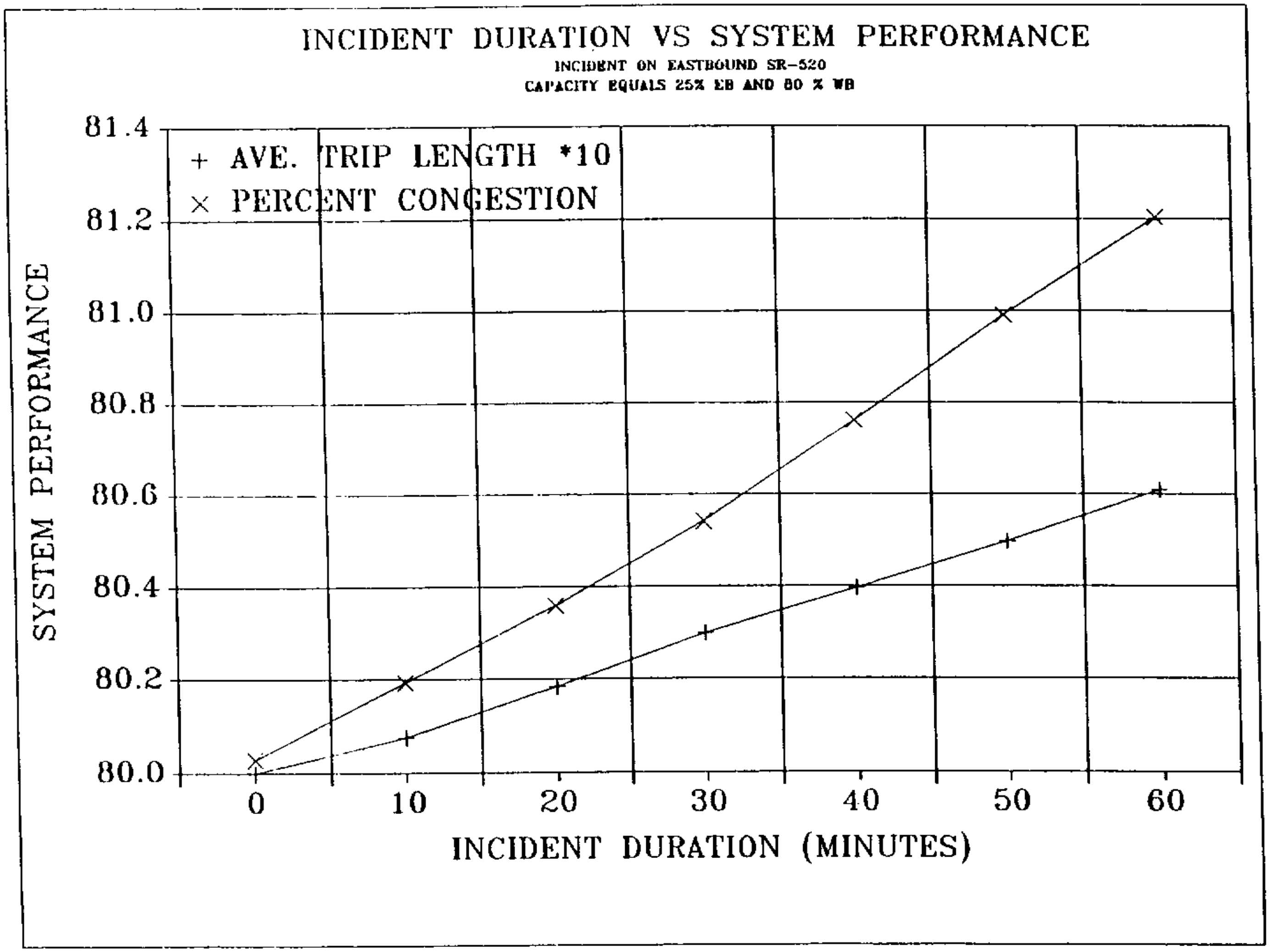


Figure 3.13 The Impacts of Incident Duration on Congestion and Average Trip Length.

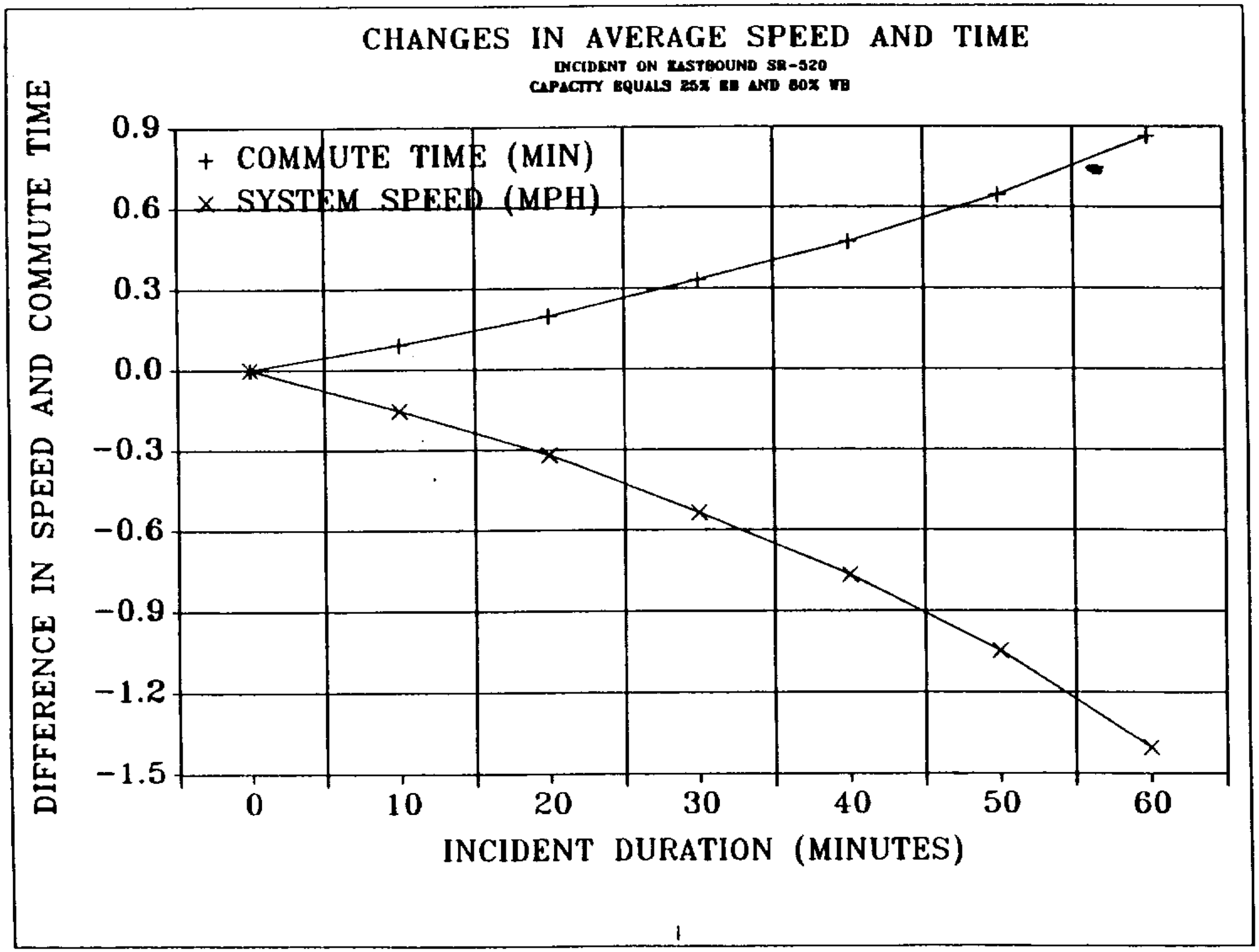


Figure 3.14 The Impacts of Incident Duration as Compared to the Base Run

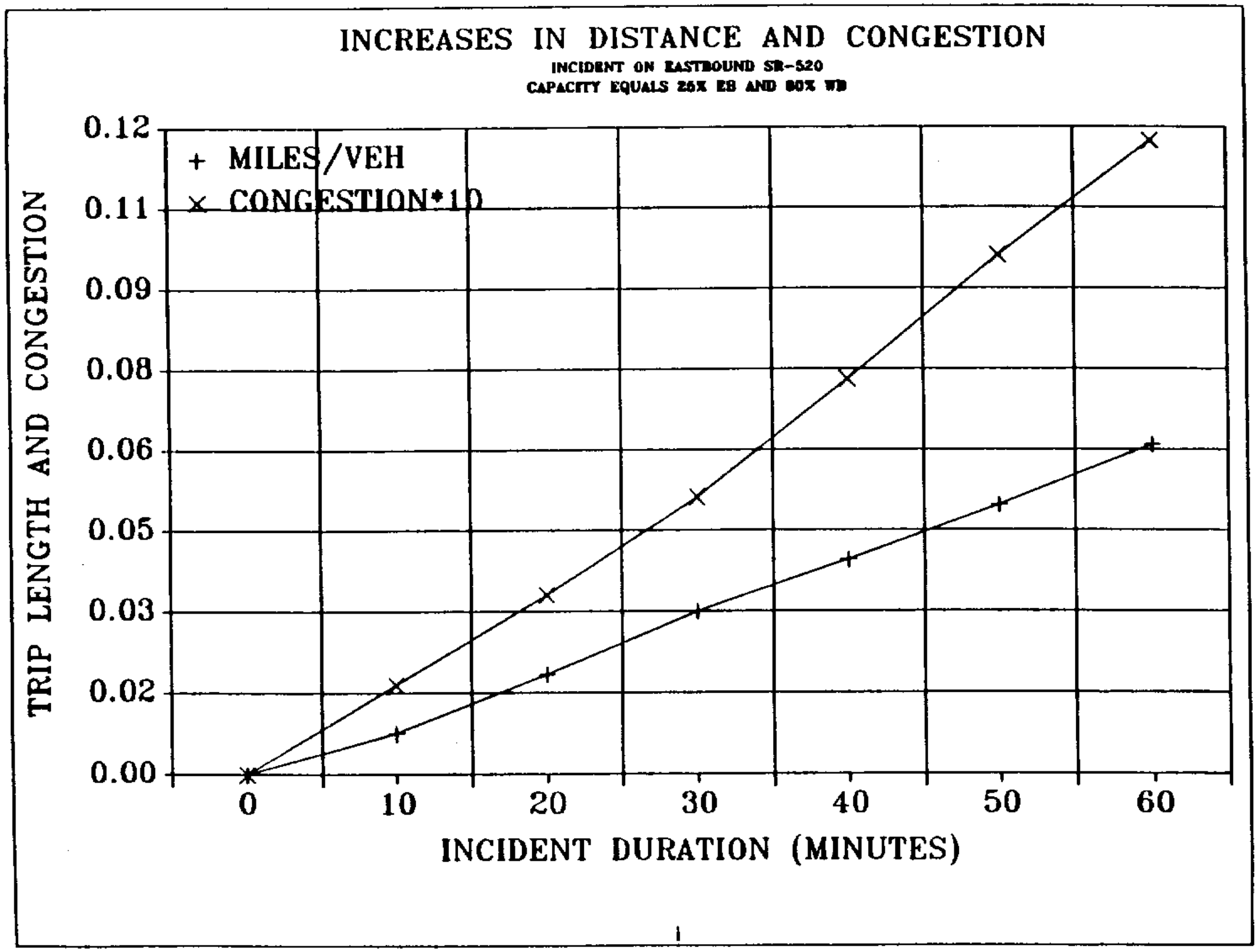


Figure 3.15 The Impacts of Incident Duration as Compared to the Base Run

TABLE 3.7 INCREASE IN VEHICLE-HOURS RESULTING SOLELY FROM THE GAPERS PHENOMENA WITH AN INCIDENT ON EASTBOUND STATE ROUTE 520 NEAR EVERGREEN POINT FLOATING BRIDGE AND THE GAPER EFFECT IN THE OPPOSITE LANES OF TRAVEL

Incident Duration	Vehicle Hours
Base Case	0
10 min.	131
20 min.	165
30 min.	289
40 min.	316
50 min.	330
60 min.	337

TABLE 3.8 QUEUES ON RESTRICTED LINK 783: EVERGREEN POINT FLOATING BRIDGE, WESTBOUND STATE ROUTE 520

Incident Duration	Vehicles in Queue	Equivalent Distance
Base Case	62	0.18 mi.
10 min.	95	0.27 mi.
20 min.	152	0.43 mi.
30 min.	211	0.60 mi.
40 min.	273	0.78 mi.
50 min.	326	0.93 mi.
60 min.	373	1.06 mi.

TABLE 3.9 LOCATION DESCRIPTIONS OF ZONES USED IN INCIDENT LOCATION ANALYSIS

ZONE 1:	SR-520: From the interchange of SR-520 and I-5 to the west end of Evergreen Point Floating bridge.
ZONE 2:	SR-520: From the west end of Evergreen Point Floating bridge to 84th Avenue.
ZONE 3:	I-5: From Spokane Street to Dearborn Avenue.
ZONE 4:	I-5: From Dearborn Avenue to Newton Street.
ZONE 5:	I-5: From Newton Street to Ravenna.
ZONE 6:	I-5: From Ravenna to NE 205th Street.

The queues that resulted from the visual interference on westbound SR-520 are listed in Table 3.8. The maximum queue length that occurred with a 60-minute visual interference was 1.06 miles.

IMPACT OF INCIDENT LOCATION ON SYSTEM PERFORMANCE

The location of an incident has a significant effect on the performance of the transportation system, a fact that was readily seen in the three previous simulations. The extent of the impact is primarily influenced by the volume of traffic that must contend (by avoidance or by traveling slowly through a queue) with the incident. To determine a relationship between the location of an incident and the degradation of system performance, simulated incidents were introduced on various links in the modeled network, and the resulting performance measures were compared with each other.

Incident Descriptions

Two freeways were selected to test the severity of impact on system performance due to incident location: Interstate 5 and State Route 520. State Route 520 was divided into two zones that spanned the distance from the interchange of I-5 and SR-520 to 84th Avenue. Interstate 5 was divided into four zones; these zones extended from Spokane Street (south of the Seattle CBD) to NE 205th Street (the north King County line). The general vicinity of these zones are shown in Figure 3.16, and the extents of each zone are listed in Table 3.9. These zones corresponded to the data analysis zones discussed in Volume II of this project report.

Two incidents were simulated for each zone, and the incidents were introduced to links of opposing direction. Thus, for example, Zone 1 had two separate simulations: one simulation placed an incident on the westbound lanes of SR-520 and the other placed an incident on eastbound lanes. Furthermore, all incidents were assumed to begin at 4:30 p.m. and had the same operating characteristics. For the first 20 minutes of simulation, the incidents reduced the operating capacity of the effected link by 75 percent. For the next

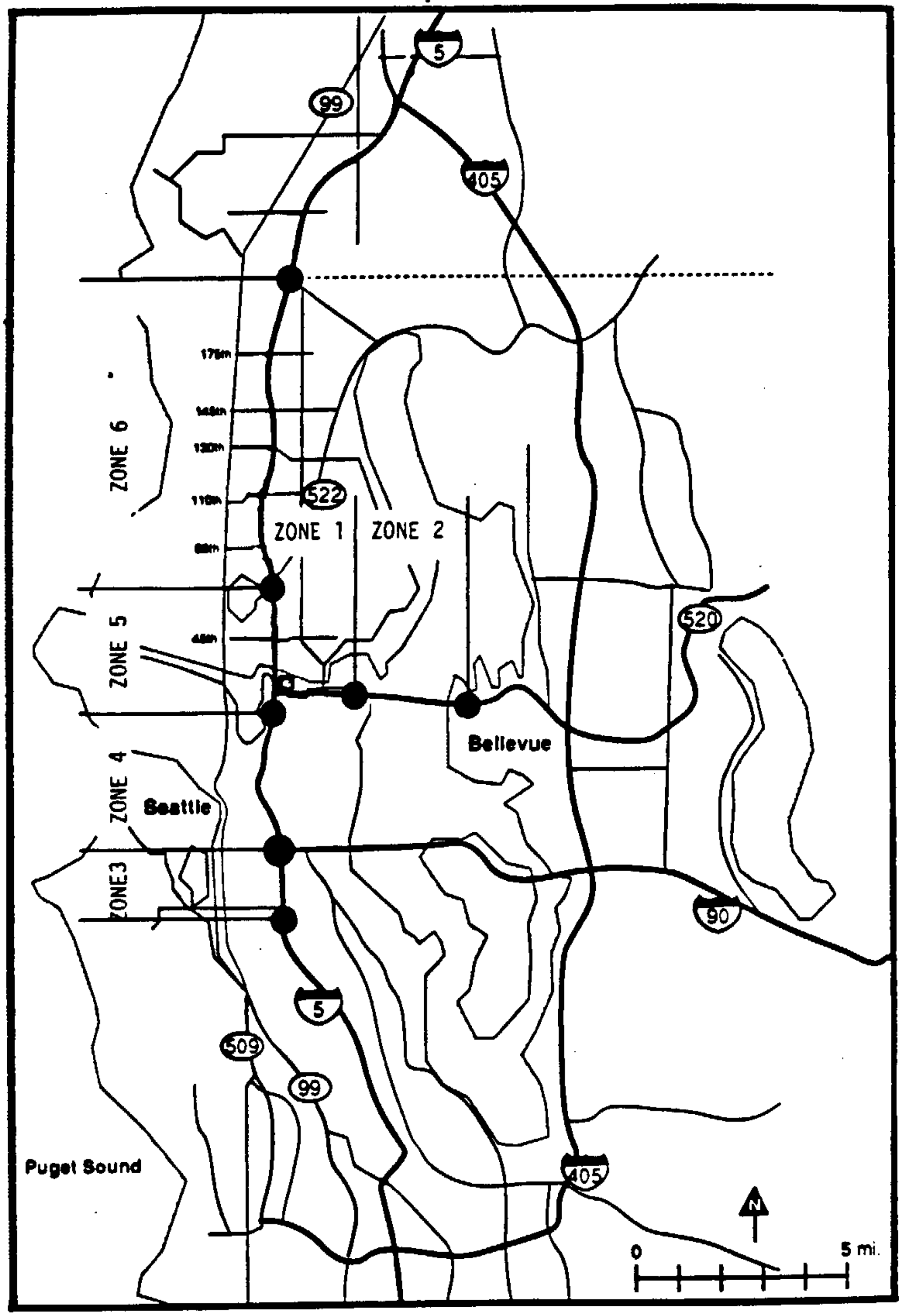


Figure 3.16 Incident Zone Locations

40 minutes, the incident was partially removed, resulting in an operating capacity that was 25 percent less than its original capacity. For the remainder of the simulation period, the link capacity was restored to its full capability. For the purposes of this test, the presence of an incident was assumed not to affect the lanes of travel in the opposite direction, an absence of the gaper phenomenon.

Simulation Results

Total travel time, or vehicle-hours, was used to measure the severity of impact caused by the incidents; these measures are shown in Figure 3.17. This figure shows that all the zones had a considerable impact on system performance. However, Zones 3 and 4 in the northbound direction dramatically influenced the system. Zone 4 (northbound I-5 between Dearborn and Newton), in particular, increased the total travel in excess of 18,000 vehicle-hours, a delay that reduced the system speed from 31 miles per hour down to nearly 26 miles per hour (see Figure 3.18). Although this reduction in system performance was relatively large, it was most probably due to the fact that the transportation system in this area has few diversionary routes. Thus, all motorists in this sector of the network are forced remain in their normal travel pattern and patiently wait until the queue dissipates.

Incidents located within Zones 1 and 2 added fewer than 2,000 vehicle-hours to the total travel time of system, an effect that was considerably less than the northbound lanes of Zones 3 or 4. This lack of influence on system performance was due to the ability of drivers to use alternative routes, such as I-90, and due to the smaller volume of traffic incurred on SR-520.

Zones 5 and 6 showed significant influence in one direction and considerably less influence in the other. An incident in the northbound direction of travel caused serious effects because of the volumes of commuters traveling away from the Seattle CBD on their homeward commute. The lack of significance of an incident in the southbound direction of travel reflected the absence of drivers traveling in the opposite commute.

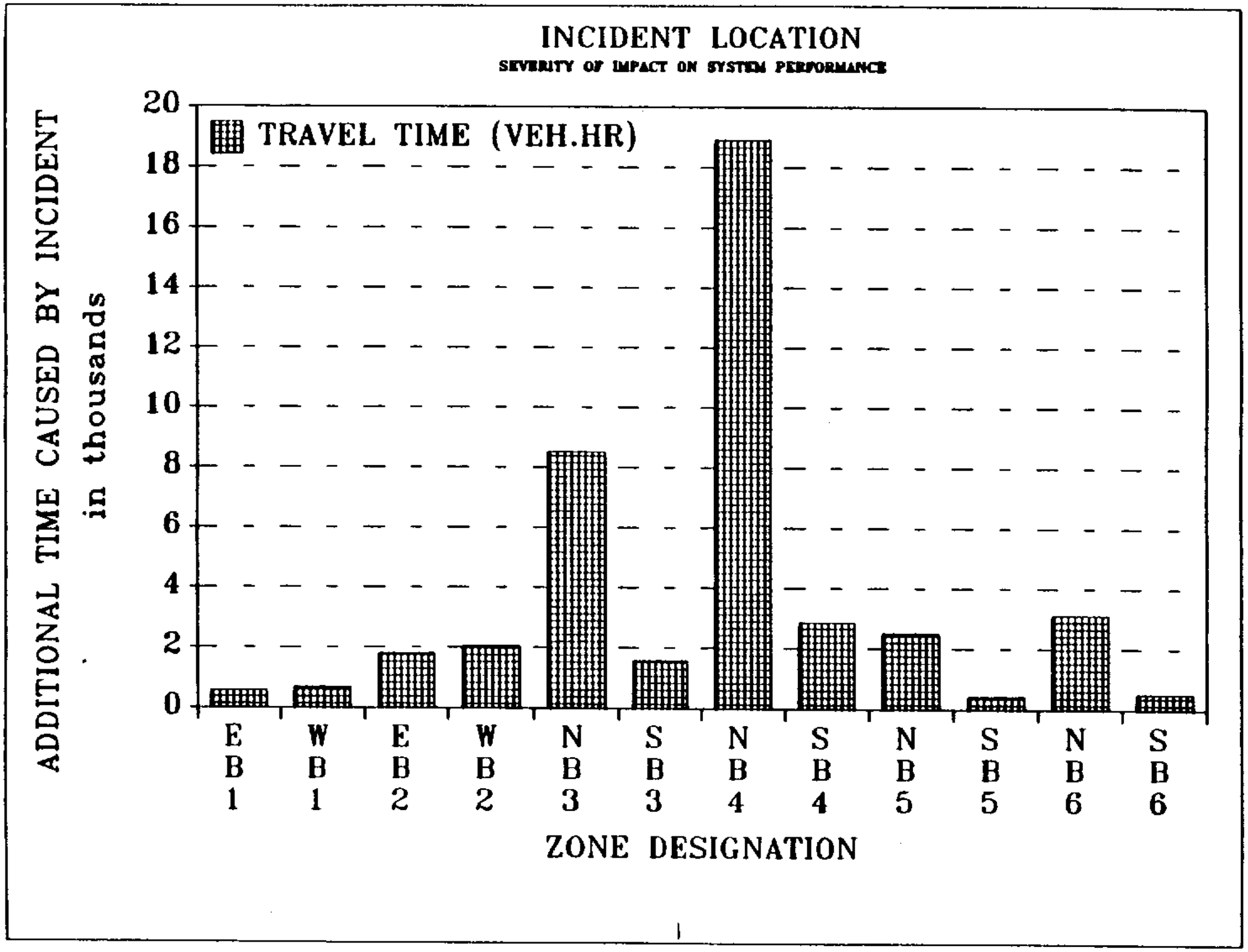


Figure 3.17 Impact of Incident Location on Total Travel Time

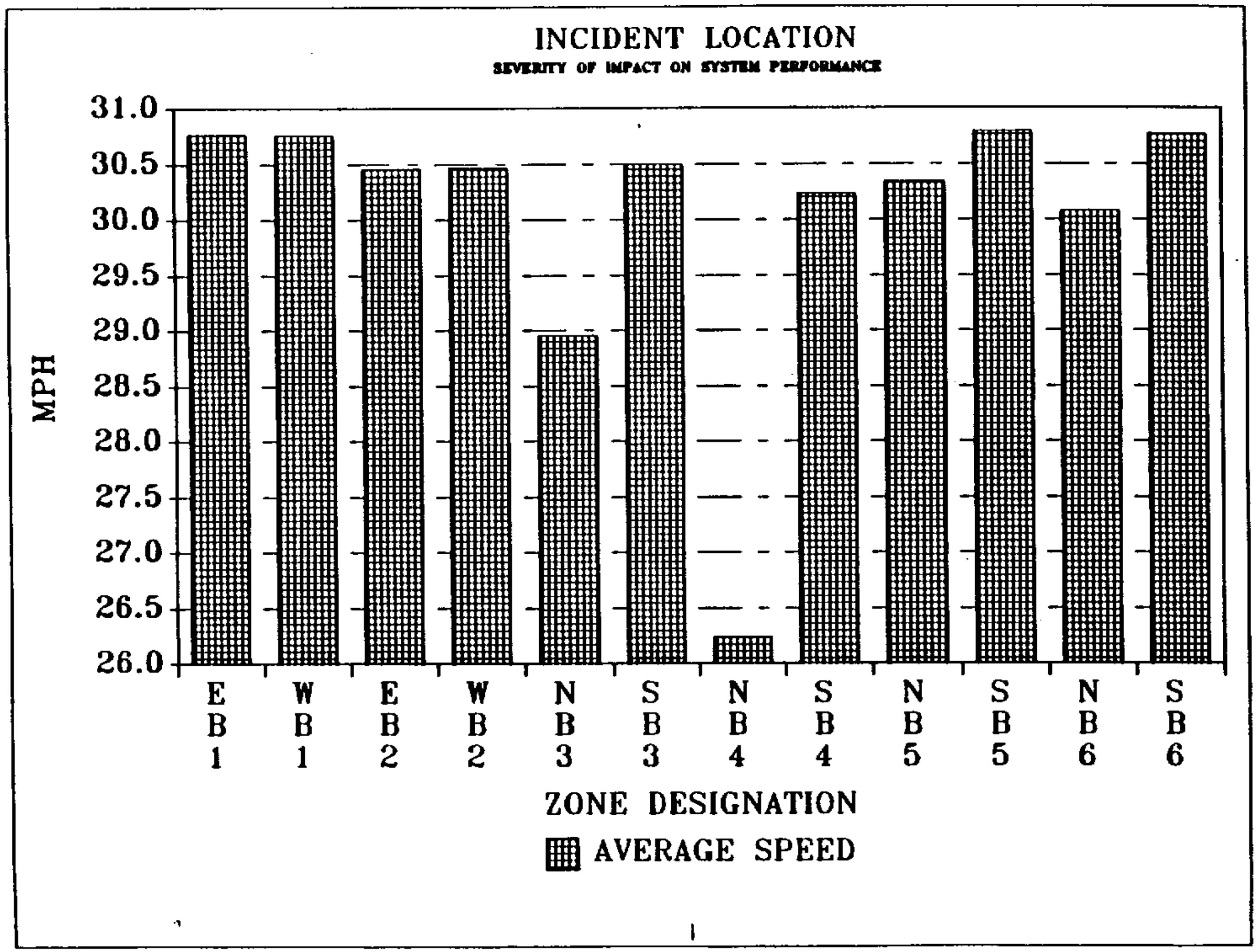


Figure 3.18 Impact of Incident Location on System Speed

SUMMARY

XXEXQ offers a user equilibrium solution to traffic assignment, as well as a variety of inputs that may be used to better describe the effects of traffic incidents and the behavior of the traveling public. Such inputs include the capacity reduction, location, and duration of a traffic incident, and the proportion of informed drivers. If reasonable estimates for the inputs are obtainable, then XXEXQ will provide acceptable results in terms of system performance and queues on individual links.

CHAPTER 4

RECOMMENDATIONS: MODEL CRITIQUE

A number of problems have been identified with the operation of XXEXQ. To resolve these problems, the following improvements to XXEXQ are recommended.

IMPROVE THE SPEED OF OPERATION

For XXEXQ to be effective at the analysis level, it will have to perform simulations much more quickly. Currently, XXEXQ requires 6-1/2 hours of execution time, or nearly one work day, on a personal computer to complete one simulation. Since XXEXQ is coded in Fortran and compiled into executable code, large savings in execution time may be gained by coding the program in other computer languages such as assembler.

PROVIDE ERROR DIAGNOSTICS

During the initial stages of coding and simulation, many mistakes can be unknowingly entered into the three data files, NW.DAT, OD.DAT, and CN.DAT. The mistakes that cause XXEXQ to abort are usually entry errors that cause data to be placed in the wrong format. If the engineer's mistakes remain undetected, XXEXQ does not diagnose the errors, so the engineer must meticulously search through the data files to discover the error. Much time could be saved if simple tests were automatically conducted on the data files.

PROVIDE CALIBRATION FILES

Currently, XXEXQ does not compare the simulated results with the measured ground counts; this process is left entirely to the user. Therefore, the engineer spends many hours performing simple tasks such as retrieving information from OT.OUT and comparing it to the calibration counts, tasks that the computer could do much faster. If XXEXQ had a fourth input file, a file that listed the link number and its corresponding ground count, and automatically compared the simulation results with this file, then the time required for the calibration procedure would be greatly reduced.

ELIMINATE DUMMY LINK AND DESTINATION CODING

As described in Chapter 2, XXEXQ requires three access links to be coded between a zone centroid and a node: one from the origin to the node, one from the node to the destination, and the third from the destination to the node. Since the third access link is required whenever the first occurs, XXEXQ should internally code this link and eliminate the need for the user to do so.

XXEXQ's requirement for an origin and a destination for each zone often confuses the person unfamiliar with XXEXQ. This action also should be performed internally.

SUMMARY

The XXEXQ model is a traffic simulation model that provides a user equilibrium solution to traffic assignment, a solution that is a better estimate of actual traffic behavior than the incremental or iterative approaches. In addition to this advantage, XXEXQ may be installed on a personal computer that has a math coprocessor. The ability to run a traffic simulation on personal computers could allow widespread use and experimentation that could not be done with models requiring mainframe computers. However, the execution time for large networks in XXEXQ is still excessive and must be reduced to be accepted in the daily routines of engineering office work.

XXEXQ enables the user to describe traffic behavior flows that are not allowed in most other models. The percentage of uninformed drivers is an input that creates a distinction between drivers that respond to the existing traffic conditions and those that do not. Drivers that listen to the radio or other information sources are given knowledge of the system that may justify their diversion to another route. Another input is the description of the location, the duration, and the capacity reduction of an incident anywhere within the network. The model's ability to accept these data allows the simulation of a wide variety of incidents, both incidents that are planned, such as construction activities, and non-planned incidents such as traffic accidents or disablements.

As a result, XXEXQ provides a method of traffic simulation that is relatively simple to use and may be incorporated into the office environment rather easily. A few changes in coding conventions and requirements have been recommended, but the overall application of the model is acceptable.

Simulations of various incidents throughout the transportation network revealed characteristics of the system that suggest a vulnerability to incident location. In particular, the northbound lanes on Interstate 5 near the Seattle Central Business District are sensitive. According to the results, when an incident occurs on the these lanes, the system performance measures, such as speed and average commute time, become significantly less efficient, a consequence that may be attributed not only to the large volumes of traffic in this area but also to the lack of diversionary routes accessible to the drivers. The incidents simulated in this area added 19,000 vehicle-hours to the total travel time of the system.

System performance on Interstate 5, north of the Seattle CBD, sustained fewer problems and less impact when incidents were simulated, but the impact depended on the direction of travel. System performance in the northbound lanes withstood the most effect; whereas the southbound lanes were influenced less. This directional result reflected the typical afternoon commuting nature of the central Puget Sound region.

System performance on other routes on the network, such as SR-520, appeared to be affected less overwhelmingly, primarily because of the availability of alternative routes and the lower volumes of traffic involved.

APPENDIX A

REVIEW OF EXISTING MODELS

APPENDIX A

REVIEW OF EXISTING MODELS

INTRODUCTION AND CRITERIA

To analyze the effects of incidents on traffic, the appropriate model is necessary. This chapter looks at the available models, analyzing each one with several criteria significant to model use. These criteria are year designed, scope, predictability, simulation function, type of facility covered, input requirements, outputs, and other available model features. A description of these criteria follows.

Year Designed

The year a model was designed can tell the user about the model because of the interests of particular decades, as well as the modeling capabilities available at that time.

Scope

Macroscopic models examine the characteristics of the stream of traffic as a whole. Microscopic models treat each vehicle as a separate unit. Microscopic models are generally very accurate in their description of the process being simulated, but they require considerably more input data, programing, computer time, and level of detail.

Predictability

Deterministic models produce a completely predictable outcome for a given sequence of events. Stochastic models produce sequences of events that are not completely predictable but that depend on events that happen during the course of the process.

Simulation vs. Function

Simulation models reproduce the behavior of the traffic under the given conditions and accumulate the results. Optimization models also reproduce the behavior of the traffic under the given conditions, but in addition they use an objective function or performance measure to determine the best solution by altering the system design.

Types of Facility Covered

Some models look at arterials only, some freeways only, and some look at both.

Methodology

Different models use different methodologies to analyze traffic and assign trips. Some are better able to change route choice, departure time, or mode, because of congestion. All models alter route choice on the basis of congestion, but few allow for changes in mode and departure time.

Input Requirements

Inputs can be categorized by the effort required to collect the data needed. Inputs include turning movements, signals, and the level of requirements for geometrics and operation. Operation involves factors such as flow, volume/capacity ratio(v/c), time slices, and speed.

Outputs

The data output define whether the model produces what the modeler ultimately desires. The outputs demonstrate the ability of the model to analyze queues, emissions, and bus networks.

The difference between time scan models, which update the model at a constant time interval (e.g., seconds), and event scan models, which update the model at event changes, was also considered. However, all the models analyzed were time scan models, so this factor was not specifically noted. Another important note is that microcomputers are commonly used in modeling. Because of the dated information available on the models, the researchers were not able to ascertain whether some older models had been adapted to microcomputers. Since most were known to have been adapted, unless the test notes otherwise, the reader may assume that all the models are designed for microcomputers.

MODELS SELECTED

The choice of which models to analyze was based on the capabilities and general purposes of the available models. For example, many models cannot model freeway traffic, and others were designed for signal network timing. Models with such characteristics were not analyzed because they did not satisfy the need to model the effects of incidents on freeway and major arterial traffic.

Table A.1 summarizes the criteria that were previously mentioned for each analyzed model. A more in-depth description of each model follows.

CORFLO

Model Development and Description

CORFLO is an integrated set of macroscopic models that simulates the flow of vehicles on networks containing freeways and arterials. The CORFLO program, which runs on a mainframe computer, was developed as a separate unit to be adapted into the Integrated Traffic Data System (ITDS) being developed for the FHWA. The CORFLO model is part of the larger family of TRAF models (TRAF (1988)), which consists of the Macroscopic Arterial Simulation Models (NETFLO Levels I and II), the Macroscopic Freeway Simulation Model (FREFLO), and the Equilibrium Traffic Assignment Model (TRAFFIC), which assigns traffic according to user equilibrium. The necessary input processor and model integration programs are also included in the stand alone CORFLO model. Although the component simulation models in CORFLO are based on deterministic models, a stochastic feature has been added in the form of a random seed number.

Model Input and Output

The data required for input to CORFLO are read from card images that include link information consisting of upstream and downstream nodes; the link lengths; number of

Table A.1. Comparison of Existing Traffic Models

	CORFLO	CORQ CORCON	FREQ	INTRAS	MACK	RFLO	SCOT	TMODEL2	XXE	XXEXQ	SIMX
Year Designed	Ongoing	late '60s	late '60s	late '70s	late '60s	new	late '60s	mid-'80s	early '80s	late '80s	late '80s
Macroscopic/ Microscopic	macro	macro	macro	micro	macro	macro	macro/ micro	macro	macro	macro	macro
Deterministic/ Stochastic	det/stoch	det	det	stoch	det	det	det	det	det	det	stoch
Simulate/Optimize	sim	sim	opt	sim	sim	sim	sim	sim	sim	sim	sim
Arterial/Freeway	art/frwy	frwy	art/frwy	frwy	frwy	art/frwy	art/frwy	art/frwy	art/frwy	art/frwy	art/frwy
Methodology	user eq	min. indiv. trav. costs	user's choice	car following theory	fluid flow	fluid flow	fluid flow min. cost	incr/iter	user eq.	sequential user eq.	utility max.
Changes	route	route	route	route	route	route	route	route	route mode	route	route/dep. time
Inputs											
Turning	yes	yes	no	yes	no	no	yes	no	no	no	no
Signals	yes	no	no	yes	no	no	yes	no	no	no	no
Geometrics (requirement — simple, intermediate, complex)	complex	simple	simple	complex	interm.	interm.	complex	complex	simple	simple	simple
Operation (requirement — simple, intermediate, complex)	complex	interm.	interm.	complex	interm.	complex	complex	interm.	simple	simple	simple
Outputs											
Queues	no	yes	yes	no	yes	implied	yes	yes	implied	yes	yes
Emissions	no	no	yes	yes	yes	no	yes	no	no	no	no
Bus	yes	no	yes	yes	no	no	no	no	no	no	no

lanes; grades; flow characteristics; volumes; traffic assignments, including an origin-destination (O-D) trip table; turning movements; nodes that receive the traffic; arterial turn pockets; channelization codes; pedestrian codes; number of special use lanes; and freeway link nominal capacities.

The user can specify the model's output statistics at various intervals during the simulation and at the end of the simulation. The statistics for each link are vehicle miles traveled, vehicle trips made, vehicle minutes moving, vehicle minutes delayed, minutes per mile, time spent per vehicle separate from delay, total volume per hour, average speed, person miles, trips, and time spent on a FREFLO link.

Model Strengths and Weaknesses

As pointed out by Rickman (1988), the strength of CORFLO is that it is an integrated model that can simulate traffic on a network that has both arterials and freeways. The main weakness of CORFLO is the input detail required to make CORFLO usable for planners and engineers. The detail is often costly and beyond the scope of most projects.

CORQ-CORCON

Model Development and Description

Between 1968 and 1975, Yager (1975) developed the CORQ model to simulate time-varying traffic demands in a 500 block freeway corridor. Working with the ideas of the CORQ model, Allen and Easa (1978) developed CORCON (the freeway-CORridor assignment and CONtrol model). CORCON is essentially the same as CORQ, with an added feature that simplifies network representation by allowing more than one directional roadway to have the same upstream and downstream nodes. Both CORQ and CORCON are macroscopic, deterministic models that assume homogeneous total system demand for the modeled time period. The simulation period is divided into small time slices, generally less than 15 minutes, so that the demand between an origin and a destination can be considered constant for the time slice. The demand during the simulation period is thus allowed to vary in time. The demand in each time slice and the queued demand of the previous time slice are assigned to the network by the principle of minimized individual travel cost (time).

Model Input and Output

The input data required for both CORQ and CORCON include capacities, volume counts, queue sizes, travel times as a function of flow, network turn prohibitions, and origin-destination information on users who could or should be affected by controls. Outputs are the predictions of the link flows, queues, and the travel time for the entire freeway corridor.

Model Strengths and Weaknesses

Several of CORQ and CORCON's weaknesses are their intensive data input requirements, their limitations to freeways only, and their limitations on network size. The main strength of the models is their ability to allow critical points in the network to receive more detail.

FREQ FAMILY

Model Development and Description

FREQ, one of the most widely used models in the U.S., was originally developed by the University of California at Berkeley in 1968 (Roden (1980)). FREQ is a macroscopic, freeway optimization model that uses a deterministic method of simulation. Since its creation, FREQ has been refined several times to the present FREQ-10 version, an interactive input processor that is menu driven and available for microcomputers. The latest version can model 26 subsections of freeway while allowing 24 time slices. FREQ is used primarily to evaluate priority-entry and normal-entry control on a freeway by predicting a time stream of impacts and travel responses, but it can also evaluate design improvements with or without freeway-entry control.

For each analysis, FREQ looks by time slice at each freeway entry point. One step in the analysis determines whether a ramp queue exists, develops, or dissipates, considers the propagation of shock waves, and calculates the appropriate delays. Another FREQ analysis calculates volume using the input demands, origin-destinations, and any existing queues, allowing queues to form on the freeways if capacity is exceeded. FREQ also computes weaving analysis, confined to on-off ramp maneuvers and capacity reductions, using the method in the Highway Capacity Manual. On the basis of the flow characteristics, it determines travel time related impacts from the Highway Capacity Manual.

Model Input and Output

Input to FREQ is read from card images and includes subsection and ramp characteristics, an origin-destination table or traffic counts for each time slice, and passenger volume data. Subsection information includes the length, number of lanes, lane width, capacity, truck factor, grade, length of grade, and design speed. Ramp characteristics include the location of on-ramps and off-ramps, special ramps, and ramp metering limits and/or capacities. Other specifications that can be input are metering plans, queue length limits, requests for congestion optimization, metering over-control protection, as well as ramp control parameters, emissions, and fuel consumption.

The output for FREQ depends on the input option control but always includes the input design features and values for simulation before control for each time slice. For each time slice, the output includes an origin-destination table, freeway travel time table, freeway performance table for each section, including queues, v/c ratios, speed, emissions, fuel consumption, mainline delay, and ramp delay. The freeway summary table gives the averaged subsection values just mentioned for each time slice. Similar outputs are provided, depending on options such as ramp metering control and optimization.

Model Strengths and Weaknesses

The strengths of FREQ come from its continued refinement to allow it to compete as a model, its ability to optimize, and the moderate requirements of input for both geometrics and operations. The main weakness of the model for this study is its design as a freeway entry and exit model.

INTRAS

Model Development and Description

INTRAS (INtegrated TRAffic Simulation) was developed in 1977 by Leiberman and Associates for use in studying freeway incident detection and control strategies (Wicks and Leiberman (1977), Wicks and Andrews (1980), and Wicks and Leiberman (1977)). INTRAS is a stochastic model that simulates the movement of each vehicle with the NETSIM car-following and lane-changing algorithms; therefore, it can examine both traffic control and geometric alternatives in most any situation. INTRAS is based on knowledge of freeway operations and surveillance systems. It incorporates detailed traffic simulation logic, which allows the user to simulate an incident at any location on a freeway link, blocking one or more lanes or confined to the shoulder, and for any length of time.

Input and Output

INTRAS input includes geometric data to describe each link length, the number of lanes, lane channelization, type of link (mainline, ramp, arterial), grade radius of curvature (for freeway links), percentage of superelevation, and pavement type. Operational data are also required and include entry-link flow rates, turning percentages at intersections, discharge headways, lost time, free-flow speeds, and the percentage of vehicles in five vehicle categories. Control data are also required, such as the type of control at intersections, actual signal timing, ramp-control operation, location and type of detectors present, and descriptions of any incident occurring during the simulation.

INTRAS output includes measures of effectiveness such as vehicle-miles, vehicle-minutes, volume, density, speed, delay per vehicle, and lane changes for specified time intervals and at the end of each simulation subinterval on both a link-specific and network-wide basis. INTRAS also includes the ability to graphically detail the trajectories of vehicles, as well as a statistical analysis module that can compare the measures of effectiveness from different simulations.

Model Strengths and Weaknesses

INTRAS's main strength is that it is a microscopic model; therefore, it analyzes the traffic very precisely. However, this strength also leads to its weakness, its requirement for very detailed input. Another weakness is that it is only applicable to freeway sections.

MACK Family

Model Development and Description

The MACK model was introduced in the late 1960s by Payne and Associates and has been refined to include in its family MACK I, MACK II, MACK III, FREFLO, and TRAFLO (now CORFLO). These are all deterministic, macroscopic freeway simulation models that consist of conservation equations and corresponding dynamic speed-density equations.

MACK I produces results that exhibit entirely dynamic responses to freeway traffic flow and that simulates a response to blocking incidents. However, it doesn't distinguish flow by lanes. MACK II, which follows MACK I and is similar to INTRAS, introduces an equilibrium speed-density relationship and a structural change in the dynamic speed relationship. Payne (1979) shows that FREFLO, which follows MACK II, provides input data diagnostics, standard measures of travel and travel time, fuel consumption estimates, and emission estimates; it also represents incidents, time-of-day control periods, surveillance systems, traffic-responsive metering schemes, and on-ramps. FREFLO was previously seen as a part of CORFLO.

Model Inputs and Outputs

The input data FREFLO requires are number and length of lanes in each section; on-ramp, off-ramp, and upstream locations and volumes by time slice; nominal section capacities; initial densities and speeds of each section; and an origin-destination model.

FREFLO output includes diagnostics, simulation, travel time, queue waiting time, diverted volume, fuel consumption, and emissions.

Model Strengths and Weaknesses

The strengths of the MACK models are their ability to simulate incidents, surveillance systems, entry control, and emissions. Their weaknesses come from their limitations to freeway simulation on mainframe computers.

RFLO

Model Development and Description

RFLO is a new IBM PC compatible traffic simulation program by Paul Ross (1988). Ross's theory is that traffic can be described as a compressible fluid that satisfies the equation "volume = speed * density." On the other hand, traffic queues are incompressible, implying that "start-up" waves travel with infinite speed. (However, a modification has been added to RFLO to give reasonable, finite speeds of propagation for start-up waves.) Traffic speed "relaxes" to a "desired" speed, which is a function of the roadway geometric conditions but does not depend upon traffic density. RFLO is also deterministic, with traffic density, speed, and volume representing long-term average traffic behavior. Because RFLO is macroscopic, stop signs, opposed left turns, and weaving cannot be directly represented and must be worked around. RFLO's size limitations are a total network length of 1000 * DX, where DX is the integration space step length (the initially supplied value is 0.1 mi); 99 links; 400 ramps no closer together than the integration step sizes; and a simulation duration of 32,000 * TM, where TM is the integration time step length (the initially supplied value is 0.0005 hr).

Model Input and Output

The input file is prepared with a text editor. Each line of the file is a command to RFLO. RFLO simulates traffic by integrating certain partial differential equations; therefore, it must be given traffic density, speed, and volume everywhere on the link at the start of the simulation, and the traffic density, speed, and volume at the upstream end of the link must be provided throughout the simulation at designated times. The links defined may be any length, but they must contain traffic traveling in one direction only. On-ramps and off-ramps are created through the designation of a location, "absolute" on-flow, and "relative" off-flow.

RFLO output contains an echo of the input; a "picture" of the entire network before the first simulation pass and a list of every link in the network; average speed and average delay at the end of the simulation and at any time upon demand; a detailed history at the network mileposts specified in the REPORT command; and simplified graphic displays of the traffic density, speed, and volume in the network as functions of time and location.

Model Strengths and Weaknesses

The strength of RFLO appears to be its newness as a model. However, this newness is also probably the cause for its weaknesses. Weaknesses appear to be limits in network size, traffic flow theory, and somewhat complex inputs.

SCOT

Model Development and Description

In the late 1960s, Leiberman and some associates began work on a model to simulate traffic patterns within an integrated freeway corridor (Hallenbeck (1988)). This work developed into what is known today as the SCOT family of models. The SCOT (Simulation of COrridor Traffic) model is a combination of DAFT (Dynamic Analysis of Freeway Traffic) and NETSIM (UTCS-1). Its sister, SCOT-Q, is a faster version of SCOT.

DAFT simulates platoons of traffic along a network of freeways using fluid-flow equations. It moves freeway platoons according to a prespecified, speed-density relation. It moves ramp and arterial platoons according to a specified free-flow speed and delays them according to volume and the ratio of green time to cycle time. Minimum cost paths, which are calculated frequently in the model, dictate the turning movement at nodes, producing a dynamic assignment of traffic as a by-product of the simulation. NETSIM simulates individual vehicles applied to signalized, at-grade intersections, where conflicts are common. The macroscopic modeling is included with microscopic modeling to decrease costs and storage requirements, while producing similar results.

Model Inputs and Outputs

The information SCOT needs is grouped into four categories. Geometric data involves street or freeway section configurations, grades, ramp and turning lane details, number and width of travel and parking lanes, and locations of internal traffic generators. Traffic demand contains data such as volumes and character of traffic, freeway speed-densities, network periphery flow rates, traffic mixes, intersection turning movements and pedestrian activity, free-flow speeds, and queue discharge rates. Control strategy parameters include traffic signal timings and synchronizations, parking restrictions and lane use policies, and traffic-actuated logic. Bus service data includes bus routes, station locations and capacity, service frequency, and mean station dwell times.

Output contains both a local and systemwide statistical view of the state of traffic on each street and intersection during the simulation period. For each street, this view entails locations and durations of queue extensions into intersections, instances of cycle failure, current number of vehicles, number of stops made, average speed, average delay per vehicle, and mean occupancy. For the whole network, this view specifically entails vehicle-miles, vehicle-minutes, and delay and travel time per vehicle-mile. Bus statistics are also compiled from the input data.

Model Strengths and Weaknesses

The strengths of the SCOT models are their ability to amalgamate macroscopic and microscopic analysis, as well as their more detailed output. As seen before, though, detailed output also can easily mean detailed input, as in this case. Complex input is one of the models' weaknesses.

SIMX

Model Development and Description

SIMX is a dynamic microscopic traffic equilibrium model that has been under continuing development in recent years (see Abu-Eisheh and Mannering (1987), Hamed and Mannering (1989) and Mannering, Abu-Eisheh, and Arnadottir (1989)). SIMX is based on a joint discrete/continuous econometric model of commuters' route choices (discrete) and departure times (continuous). The selection of route and departure time is based on a compensatory utility maximization model. Traffic assignment is performed with a dynamic algorithm that searches for market-clearing equilibrium route flows. Travel times are computed using bureau of public roads (BPR) performance functions and queueing models (see Mannering, Abu-Eisheh, and Arnadottir (1989)). To date, SIMX has been used only on very small networks, and extensions to large networks may not be feasible since the existence and uniqueness of a traffic assignment solution has only been proven for a single origin-destination pair. Model calibration, to existing ground counts, is required before forecasting.

Model Input and Output

Required inputs include a representative sample of commuters with work start times, preferred work arrival times, vehicle fuel efficiency, household income, number of vehicle passengers, traffic signal timings and link capacities, lengths, and free flow speeds. Outputs include time-varying traffic flows and total implicit commuter costs, which are derived from commuter welfare and compensating variations (see Mannering, Abu-Eisheh, and Arnadottir (1989)).

Model Strengths and Weaknesses

SIMX is the only known model that provides a theoretically consistent method of accounting for both route and departure time changes in response to time-varying events such as incidents. Unfortunately, it is extremely complex and shows little promise of ever being extended beyond the most simplistic of networks. Also, in its present form, it does not allow mode changes.

TMODEL2

Model Development and Description

TMODEL2, as described in "TMODEL2: The Tool for Transportation Planning User's Manual" (1988), simulates present conditions and analyzes the impact of future and alternative transportation demands and systems for an entire area or a specific development. The model is fairly new and uses macroscopic information to perform deterministic evaluations. TMODEL2 is said to use several innovative approaches to traditional network analysis. For example, it dynamically models intersections, with variations to model partial stop sign control, all-way stop sign control, or signal control. It also loads origins and destinations to the network with a centrally located node in each zone, thereby eliminating the need for centroid connectors, and it has easy menu-driven editing options. TMODEL2 uses a gravity model distribution and the user's choice of either incremental or iterative assignment.

Model Input and Output

TMODEL2 has both a screen graphic editor and line editor for much of the information input and output. For data not input into the model, TMODEL2 uses default values when parameters are not specified. The number of options that can be input to define various characteristics, and designate outputs desired seems almost unlimited, but the minimum required information for the model to work defines the nodes, links, and travel/land use characteristics. Definition of nodes includes a number and coordinates (x,y). Definition of links includes to/from nodes, one- or two-way direction of traffic, number of lanes, capacity, length, speed, and volume. Definition of travel/land use characteristics includes zone terminal time, number of single family dwelling units, number of multiple family dwelling units, number of retail employees, number of non-retail employees, and the intrazonal time. From the travel/land use characteristics, the program computes a deterministic origin-destination table. After the input has been completed, the trip generation phase must be completed, followed by trip distribution and assignment.

The desired output is also designated by menu driven commands and is often easily understood, since it is presented as an overlay to the underlying network in the graphic display. However, only one or two variables are observable at a time because of the overlay method.

Model Strengths and Weaknesses

The strengths of TMODEL2 are its innovative methods of analysis, as noted above, and good graphics package. However, the simplistic methods of distribution and assignment point to weaknesses that are important in incident analysis.

XXE

Model Development and Description

XXE, as introduced by Abu-Eisheh and Mannering (1986), is a methodological simulation model that forecasts the traffic-related impacts of a wide range of transportation-facility-related improvements. XXE was developed in the early 1980s in response to the high expense of the data collection and computational costs of many of the complex models developed in the late 1960s and early 1970s. The deterministic, macroscopic microcomputer package uses some of the most advanced transportation analysis techniques in its traffic, travel demand forecasting, and mode split modules. The traffic module includes a standard user equilibrium traffic assignment algorithm and uses the Bureau of Public Roads (BPR) function in defining link performance. The method of successive averages is used to assign origin-destination flows to different routes and arrive at a unique system, steady-state equilibrium. The travel demand forecasting module includes trip generation components, which assume a nonlinear regression form, and trip distribution components, which assume a multinomial logit form. Before forecasts are made, model calibration is necessary to ensure that the model replicates the present pattern as closely as possible. XXE also does not allow for departure time changes or mode changes in the time scanning periods.

Model Inputs and Outputs

Inputs needed include an origin-destination matrix; traffic counts; capacity, which can either be calculated with HCM methods or obtained from local agencies; the free flow speed, length, width, signal phasing, and cycle lengths for each link; and changes in zonal household demographics, zonal employment, and the highway network. Output results include link flow forecasts and their respective v/c ratios, overall network performance, turning movement forecasts, and other traffic flows of interest.

Model Strengths and Weaknesses

The strengths of XXE come from the advanced transportation analysis techniques it uses, and its fairly simple input requirements. XXE's primary weakness is its assumption of steady-state conditions and the fact that it does not allow for the detailed level of output that only a microscopic model can provide.

XXEXQ

Model Development and Description

Early versions of XXEXQ were developed by Hamed and Mannering (1989), and the model has been vigorously improved since then. XXEXQ uses the same theoretical approach as XXE and, in point of fact, the two programs share much of the same computer code. However, XXEXQ relaxes the steady-state assumptions of XXE by sequentially allocating traffic over time. This time-varying traffic allocation makes XXEXQ particularly well suited to the study of time-varying events such as incidents. To sequentially assign traffic over time, during a time-varying event, XXEXQ requires the user to specify the proportion of travelers with full information about the event (i.e., in the case of an incident, the proportion of travelers aware of the capacity reduction). It assumes that the remainder of the travelers have no information about the event. XXEXQ then performs two user equilibrium assignments for each time period (time periods are usually 10 minutes long) by first assigning uninformed travelers and then fully informed travelers. It assumes the fully informed travelers are aware of all time-varying system characteristics (e.g., capacity changes), the route choices of uninformed travelers, and the network queues remaining from the preceding time period. XXEXQ is not typically linked to XXE's travel demand forecasting module, although there is no limitation to doing so. Before running XXEXQ, an XXE calibration is necessary to ensure replication of existing traffic counts. As with XXE, XXEXQ does not allow for departure time or mode changes.

Model Strengths and Weaknesses

Inputs include an origin-destination matrix, traffic counts, link capacities, lengths, and free-flow speeds, proportion of travelers with information, proportion of origin-destination matrix to be assigned in each time period, and time-varying changes in capacity. Outputs include link flows by time period, link queue lengths by time period, total system travel time and vehicle miles of travel, and average system congestion.

Model Strengths and Weaknesses

XXEXQ's time-varying structure makes it very well suited to the study of incidents. It shares the relatively simple input requirements of XXE and provides most of the relevant information needed to assess the traffic related impacts of incidents. XXEXQ has the same primary weaknesses as XXE (i.e., it is macroscopic, with no provision for departure time changes).

CONCLUSION

Each model has been designed for a specific purpose, which has determined the necessary results. Therefore, each model's suitability for the needs of modeling incidents must be assessed. One of the first limitations in modeling is the model's size capability.

Both CORQ-CORCON and RFLO are limited by size to modeling smaller areas; therefore, their use in modeling incidents is constrained.

Another important characteristic is adaptability to application purpose. The purpose in this case is to model incidents on major travel ways, including both arterials and freeways. Other models such as CORQ, CORCON, INTRAS, and MACK are limited to freeway sections only, another key disadvantage.

The level of input required can also have distinct disadvantages. CORFLO, CORQ, CORCON, INTRAS, SCOT, and TMODEL2 have labor intensive demands for input.

The methodology behind the model is also very important. A model that uses a simplistic method of achieving results is much less desirable than a model that uses advanced methods. An example of a simplistic model is TMODEL2, which uses gravity model distribution and either incremental or iterative assignment. Another questionable characteristic is "fluid flow," which describes traffic as a compressible fluid. Models that do this are MACK, RFLO, and SCOT. When the methodology is not simplistic enough to adapt to large networks, such as with SIMX, usability is again limited.

XXE and its incident-assessing sister, XXEXQ, have a host of limitations, as previously discussed. Although they are far from perfect, the researchers felt that they most easily provide the best compromise between theory, input requirements, and output. XXEXQ is specifically designed for incident evaluation and is readily adaptable to account for new finding and methodological improvements.

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APPENDIX B

METHODOLOGY

APPENDIX B

METHODOLOGY

The user-equilibrium traffic assignment problem is concerned with finding the link flows for a transportation network, through the interaction between supply and demand. Demand is represented by the origin-destination matrix; supply is represented by the physical characteristics of the network and the links' performance functions. User-equilibrium uses a link selection criterion of minimizing the individual's travel time. This appendix discusses how this problem, with all its assumptions and constraints, is stated mathematically, and how equilibrium flows can be computed.

Initially, the appendix demonstrates how user-equilibrium can be applied graphically to find the flow pattern for a small network. The degree of complexity for solving larger networks graphically leads to a mathematical transformation of the problem. This approach involves the formulation of a mathematical program, the solution of which should be unique and should satisfy the user-equilibrium definition and assumptions. As the mathematical program is identified, the appendix illustrates an algorithm that searches for the solution. Before discussing this type of multivariate optimization (i.e., one involved in solving for many variables, such as the flows on all the links in the transportation problem), one-dimensional optimization is reviewed because it is used in solving the multivariate problem. Then the appendix presents the user-equilibrium traffic assignment algorithm and discusses briefly the modeling package used.

NOTATION

Before proceeding into the core of this appendix, the reader must understand the following notation:

A = The set of consecutively numbered links

N = The set of consecutively numbered nodes

R = The set of origin zonal centroids from which trips are generated

S = The set of destination zonal centroids of the zones at which trips are terminated

q = The vector representing the origin-destination matrix

q_{rs} = The element in the origin-destination matrix representing the zonal demand between origin r and destination s

K_{rs} = The set of paths connecting the O-D pair r-s

v_k^{rs} = The flow on path k connecting the O-D pair r-s

t_k^{rs} = The travel time on path k connecting the O-D pair r-s

v_a = The flow on link a

t_a = The travel time on link a, which is expressed as a function of the flow on that link, so that $t_a = f(v_a)$ represents the link performance functions

With the above notation, the following variables can be related, and then the obtained relationships can be satisfied by the math program:

- The travel time on a given path is the sum of travel times on the links composing this path, or mathematically:

$$t_k^{rs} = \sum_a t_a \cdot \delta_{a,k}^{rs} \qquad ,\forall k \varepsilon k_{rs} \quad ,\forall r \varepsilon R, \quad \forall s \varepsilon S$$

where $\delta_{a,k}^{rs}$ = 1 if link a is on path k connecting the O-D pair, r-s

= 0 otherwise

- The link flow is the sum of the flows on all the paths going through this link, or mathematically:

$$v_a = \sum_r \sum_s \sum_k v_k^{rs} \cdot \delta_{a,k}^{rs} \qquad ,\forall a \varepsilon A$$

THE GRAPHICAL SOLUTION OF USER-EQUILIBRIUM

To illustrate the user-equilibrium assignment technique, a simplified example for a small network is solved graphically here. The results of the example lead to the derivation of a mathematical formulation for the user-equilibrium problem to deal with larger, real-life networks. The basis of the example is drawn from Kanafani (1983) and Morlok (1978).

Suppose the network is the simple network shown in Figure B.1(a). Two nodes, A and B, are connected by two routes, 1 and 2. A link performance function for each, $t_1 = f(v_1)$ and $t_2 = f(v_2)$, represents the effect of flow interacting with the physical characteristics of the link, to produce a related travel time. The functions are illustrated in Figure B.1(b) and are assumed to increase monotonically. Suppose that the demand from $A \rightarrow B$ (q_{AB}) is constant. To solve the user-equilibrium flows v_1 and v_2, the demand should be distributed between the routes so that the travel times, t_1 and t_2, are the same for each. The graphical solution requires modifying the position of the link performance functions relative to each other, as illustrated in Figure B.1(c). Then on the horizontal axis, v_1 is measured from left to right and v_2 is measured from right to left, and the corresponding link performance function is fixed to equal the total demand, q_{AB}. At any point on the horizontal axis, there are two values of flows, v_1 and v_2, the sum of which is the total demand, q_{AB}.

Since no travelers can improve their travel times or reduce their costs by unilaterally switching routes, and since all used paths connecting a given O-D pair should have the same travel time, there is, therefore, only the point $(v_1, v_2)^*$ that satisfies the equilibrium conditions. At this point, the value of the two link performance functions, $f(v_1)$ and $f(v_2)$, are equal, and the resulting flow pattern causes equilibrium in the network. At any other point, such as (v_1, v_2), the cost on one of the two routes (here route 2) is higher than that on the other route (route 1), which influences some users to switch to the lower travel time route, route 1. In terms of $f(v_2) > f(v_1)$, additional users continue to switch routes,

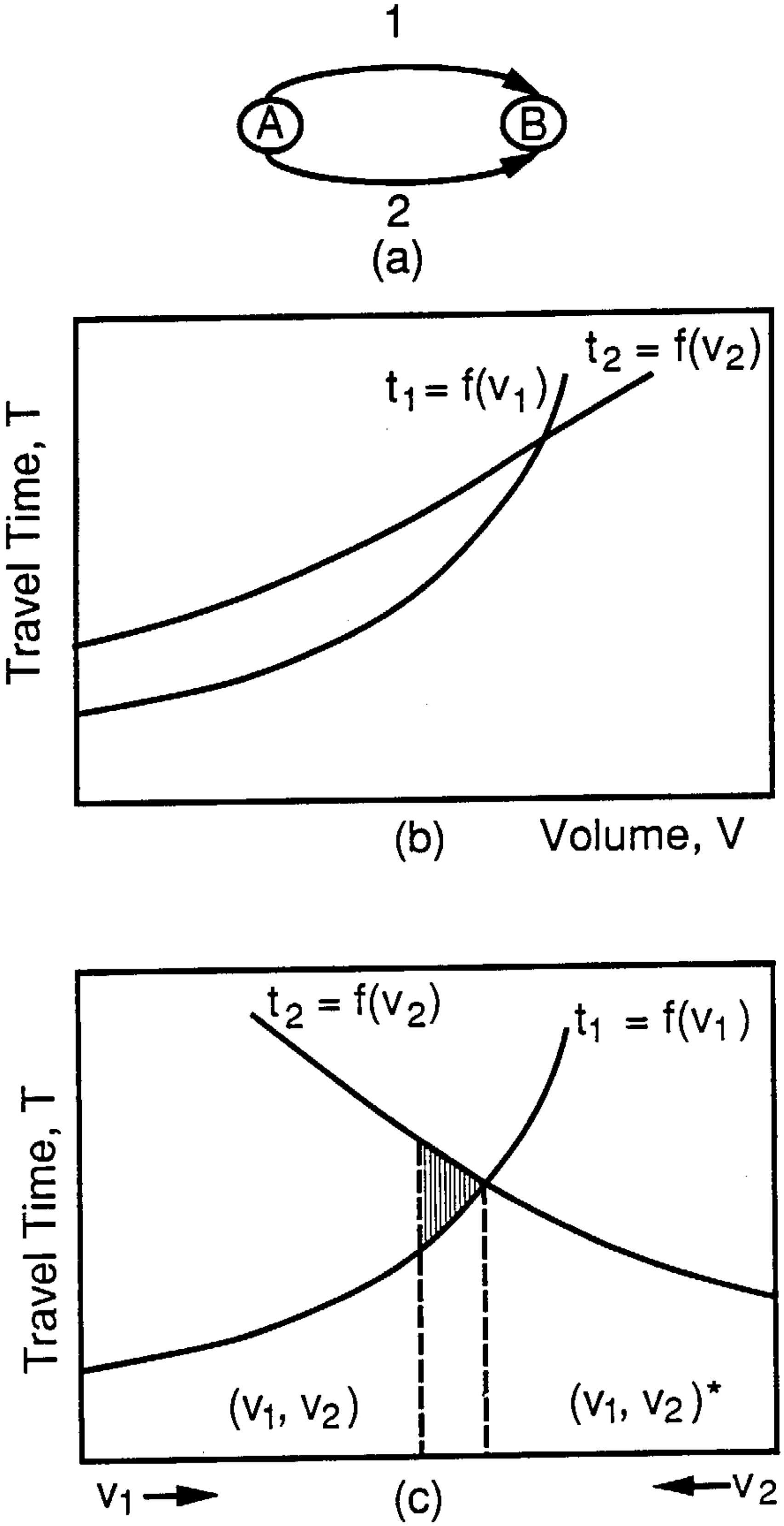

Figure B.1 Graphical solution of user-equilibrium assignment.
(a) Network structure,
(b) Link performance functions,
(c) Equilibrium assignment.

until the assignment reaches the point $(v_1, v_2)^*$. At this point, any additional switching of routes by any user of either route results in an increase of travel cost. Therefore, at $(v_1, v_2)^*$ the travel time on both routes is equal. No user has any motive to switch routes, and the equilibrium state occurs. At this point the area under both curves, $f(v_1)$ and $f(v_2)$, is minimized. At any other assignment point, such as (v_1, v_2), the area under the link performance functions equals that for $(v_1, v_2)^*$ in addition to the shaded area (see Figure B.1(c)). Under strict monotonically increasing link performance functions, this area is always positive. Thus the integral of the curves is minimal when summed at equilibrium. This can be stated mathematically and generalized for any number of links in a network.

MATHEMATICAL REPRESENTATION OF USER-EQUILIBRIUM

The above result can be expressed mathematically to solve for equilibrium flows on the links of the network as follows:

$$\text{minimize } z(v) = \text{minimize} \sum_a \int_0^{v_a} f(w)dw \tag{B.1}$$

where z(v) is the objective function, which calculates the areas under the links performance functions by summing their integrals. The objective function is used as a mean to find a set of v values that form the equilibrium solution through the minimization process.

The user-equilibrium link flows can be obtained by solving the mathematical program, subjected to the following constraints:

$$\sum_k v_k^{rs} = q_{rs} \qquad ,\forall r,s \tag{B.2}$$

$$v_k^{rs} > 0 \qquad ,\forall k,r,s \tag{B.3}$$

and satisfying that

$$v_a = \sum_r \sum_s \sum_k v_k^{rs} \cdot \delta_{a,k}^{rs} \qquad ,\forall a \tag{B.4}$$

This set of constraints is referred to as Beckmann's transformation (Beckmann et al., 1956). It transforms the definitions and restrictions to mathematical expressions. Although this transformation was delineated in 1956, the algorithms used to solve it were not developed until the late 1960s and early 1970s.

This transformation refers to the following concepts and restrictions:

- Equation B.2 represents the flow conservation constraint, so that the sum of the flows from any O-D pair on all the paths should equal the demand or travel rate for that O-D pair. This implies that every q_{rs}, or the whole origin-destination matrix, should be assigned to the network.
- Equation B.3 shows the non-negativity condition of the flows, without which the solution of the algorithm may contain negative values, which are meaningless.
- The last equation B.4 implies the role of the network structure in the program. It shows that flow on a link is expressed in terms of all path flows going through that link. The definition for $\delta_{a,k}^{rs}$ remains the same. A similar relationship for travel time is used in the algorithm implicitly to check for the minimum travel times among different paths connecting the various O-D pairs. This check is conducted by summing the travel times on all the links composing a given path, for all the paths connecting every origin-destination pair. This check is expressed mathematically as:

$$t_k^{rs} = \sum_a t_a \cdot \delta_{a,k}^{rs} \tag{B.5}$$

Two assumptions should be satisfied to apply this program. The first is that the travel time on a given link is only a function of the flow on that link, and not of any other link. This assumption can be written mathematically as:

$$\frac{\partial f(v_a)}{\partial v_b} = 0 \tag{B.6}$$

The other assumption is that the link performance functions are positive and increasing functions, which can be expressed mathematically as:

$$\frac{\partial f(v_a)}{\partial v_a} > 0 \qquad \text{(B.7)}$$

THE EQUIVALENCY AND UNIQUENESS CONDITIONS

To use the results of the mathematical program illustrated above in Equations B.1 through B.4, and to consider the link flows obtained as the equilibrium flows, two conditions should be satisfied: equivalency and uniqueness (Beckmann et al., 1956).

The Equivalency Condition

The first proof requires that the solution of the transformed program, represented by the Equations B.1 through B.4, gives equilibrium link flows and satisfies the equilibrium conditions. Such flows are assigned to equate the travel times on the used paths, and they should be less than or equal to any travel time on non-used paths between any O-D pair in the network.

The solution of a mathematical program should satisfy its first order conditions at any local minimum or stationary point of the program. This criterion is satisfied in the problem if the derivative of the objective function with respect to the flow on a particular path equals the travel time on that path (Sheffi, 1984). In addition, all the constraints of the program should hold at the point that minimizes the objective function.

The proof given by Sheffi satisfies this condition. Therefore, the flow values resulting from the solution of the program, represented by the Equations B.1 through B.4, are those satisfying the user-equilibrium conditions, and the solution of the program is a user-equilibrium traffic assignment.

The Uniqueness Condition

The second condition that should be satisfied is uniqueness, meaning that the minimization program has only one solution, which is the equilibrium flow pattern.

The uniqueness condition will be satisfied if objective function z(v)[1] is proven to be strictly convex near the solution flow pattern, the stationary point, or the vector of v's (v*), and convex elsewhere. The link performance constraints provided by Equations B.6 and B.7 should be satisfied, as well. This constraint satisfaction is known mathematically as the second order condition, and it is proved by finding the second derivative of the objective function with respect to the flows and proving that the resulting matrix of derivatives is positive.

Sheffi's proof satisfies this condition and, therefore, the program representing the user equilibrium has a unique minimum. This means that there is only one solution that minimizes the program described by the Equations B.1 through B.4

Satisfying both the conditions of equivalency and uniqueness results in only one flow pattern that minimizes the program described in the Equations B.1 through B.4, and this flow pattern is a user-equilibrium flow pattern. Therefore, the solution of this mathematical program is, in fact, the solution of the user-equilibrium problem.

THE OPTIMIZATION PROCESS

Although the problem considered here is a multivariate optimization problem because the solution involves a set of v's, i.e., flows on all the links of the network that optimize the objective function, the one-dimensional minimization will be discussed first. A discussion of minimizing a non-linear function of a singe variable, v, is presented here because such minimization is usually part of the algorithms designed for solving multivariate minimization problems. The multivariate minimization technique utilized is the convex combinations method.

[1] z(v) denotes the objective function of the vector of flows, where **the bold lettering** refers to the vector notation.

One-Dimensional Minimization

One method of solving non-linear, one-dimensional optimization problems is the so-called "bisection method," an interval reduction technique. It involves an iterative procedure that examines a series of ever-decreasing intervals, each of which includes the minimum point. The bisection method, also called a Bolzano search, has been shown to converge quickly to the solution point when functions are optimized over a closed interval [a,b] (Sheffi, 1984). The interval [a,b], which is also called feasible range, is divided into two intervals in each iteration, and that which contains the minimum point remains while the other is discarded. The procedure is repeated until a small enough interval is obtained that an approximate solution, v^*, can be estimated.

The function $z(v)$ is assumed to be continuous and uniquely defined everywhere in the interval. This assumption implies that there is a finite minimum of $z(v)$ for some v in the interval [a,b]. Also, $z(v)$ is assumed to be ditonic, so that it has a unique minimum in the interval [a,b] (see Figure B.2).

The bisection method, which is a line search (or interval reduction) technique, utilizes the geometrical interpretation of the derivative. A ditonic function is monotonic on each side of the minimum point v^*. The derivative of $z(v)$, $dz(v)/dv$, is positive to the right of v^* (i.e. $v < v^*$). For a given interval $[a_n,b_n]$[2] the derivative is computed for the middle point $(a^n+b^n)/2$, which may be denoted as v^n. Then if $dz(v^n)/dv < 0$, then $v^* > v^n$; interval $[a^n, v^n]$ and the next interval will be $[v^n, b^n]$. If $dz(v^n)/dv > 0$, then $v^* < v^n$, and the interval $[v^n, b^n]$ is discarded, the next iteration will be based on the interval $[a^n, v^n]$. In every iteration, the interval obtained is checked against a convergence criterion, until this criterion is met. Therefore, the last interval $[a^n, b^n]$ contains the minimum value of the

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[2] n here refers to the number of iterations.

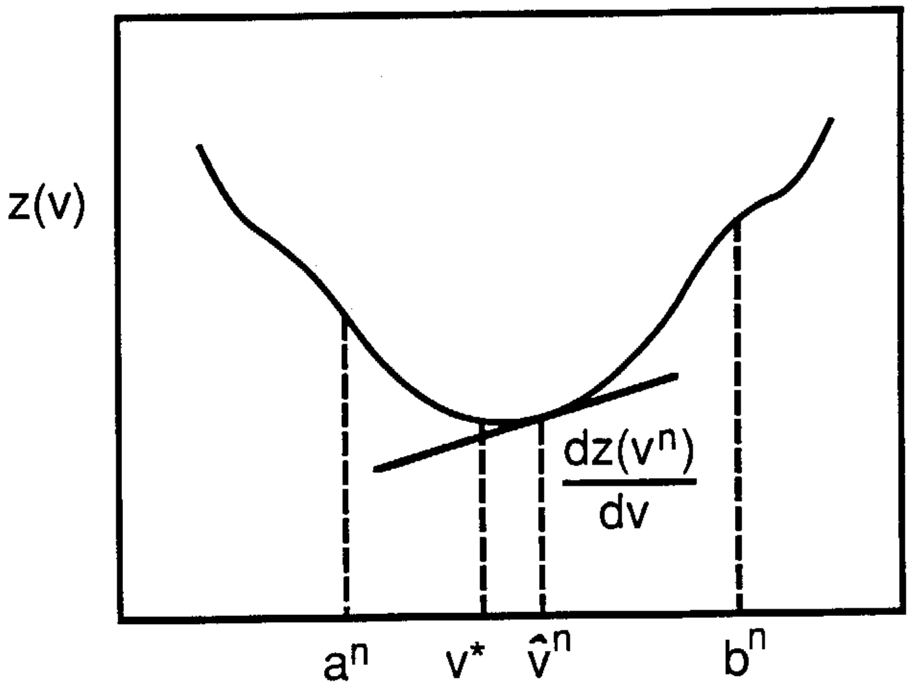

Figure B.2 The graphical representation of the bisection method objective function z(v), and the corresponding v value is approximated to be the middle point of the interval. Figure B.3 represents a flow chart of this algorithm.

__The Convex Combinations Method__

Frank and Wolfe (1956) originally suggested a multivariate minimization algorithm to solve the equilibrium problem. The algorithm is an iterative process used in the solution of many programs to search for equilibrium flows for transportation networks.

The algorithm should at first have a specific feasible solution, v^n, which may be a reasonable guess for a possible flow pattern, such as an all-or-nothing flow pattern. Two things should be sought here: the first is the descent direction, and the other is the move size. The descent direction is the best direction leading towards the minimum value of z(v) and satisfying all the constraints previously discussed (Equations B.2 through B.4), given a specific point on the objective function z(v). The move size determines how much movement to the next point on the function z(v) is necessary on the descent direction specified.

To find the descent direction, the algorithm searches over the entire feasible region for an auxiliary feasible solution $y^n = (y_1^n, y_2^n \ldots, y_I^n)$, where I is the number of links and n is the iteration number. The direction for v^n to y^n provides the maximum possible drop (or approach) towards the minimum value of z(v) by finding the descent direction that is denoted as $d^n = v^n - y^n$. This requires linear approximation of the objective function at every iteration, the solution of which, y^n, specifies the direction of search on the basis of the current solution point, v^n. This approximation simplifies the problem, because minimizing a linearized function subjected to a linear set of constraints has its solution at the boundary, or more specifically, at a corner of the feasible region.

Once the descent direction is known, the next step is to find the move size. The new solution point, v^{n+1}, lies somewhere between v^n and y^n, and its exact location is

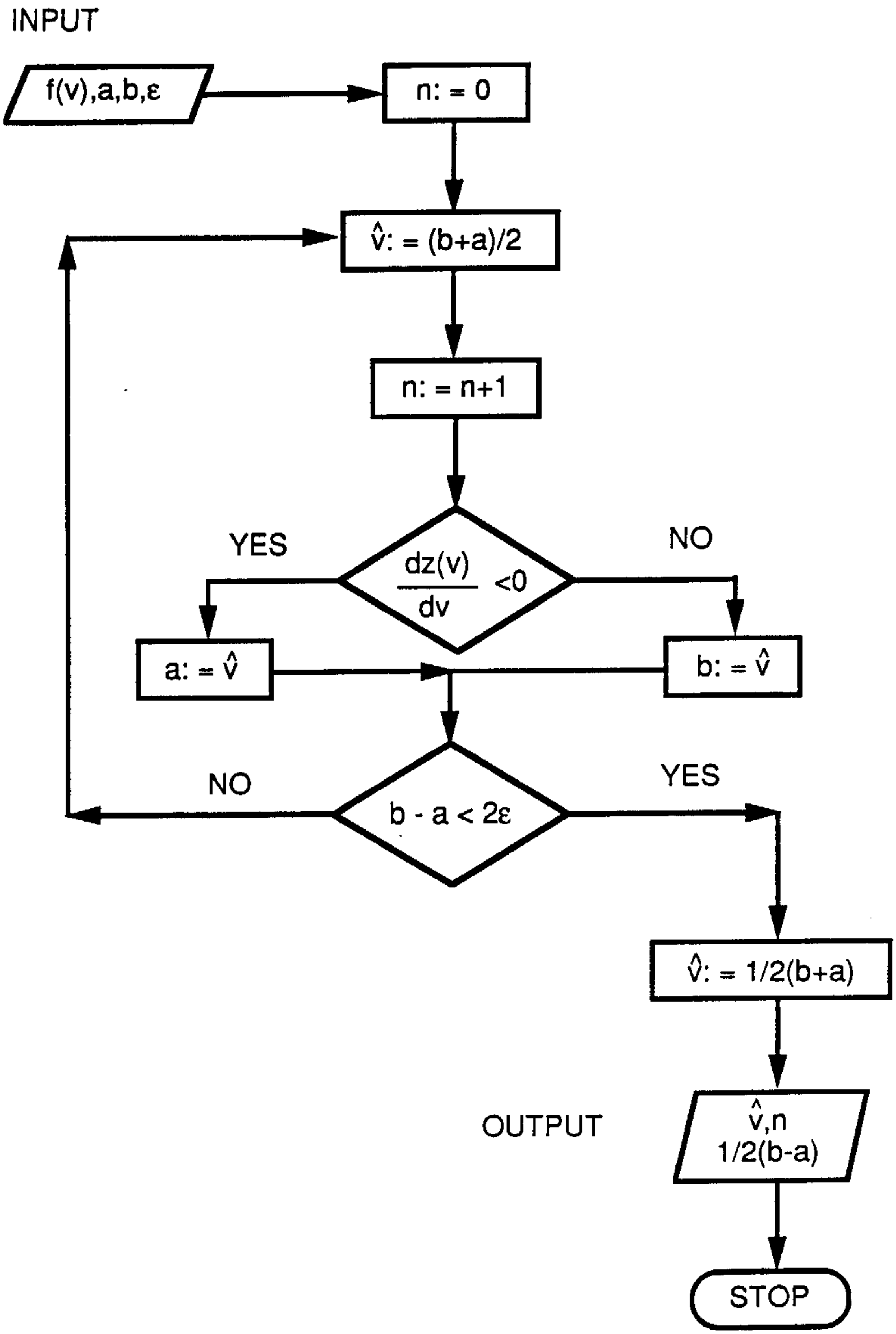

Figure B.3 A flow chart representing the bisection method

Source: Sheffi, Y., Urban Transportation Networks, 1984, p.86

determined when the move size is found. If α refers to a weighting factor to locate v^{n+1} between v^n and y^n, v^{n+1} can be written as:

$$v^{n+1} = (1 - \alpha_n)\, v^n + \alpha_n y^n \qquad ,0 \leq \alpha \leq 1 \qquad \text{(B.8a)}$$

$$v^{n+1} = v^n + \alpha\, (y^n - v^n) \qquad \text{(B.8b)}$$

$$v^{n+1} = v^n + \alpha d^n \qquad \text{(B.8c)}$$

The optimal solution for finding the move size, α, can be performed by any interval reduction technique, such as the bisection method, since the search is in a closed interval.

Finally a convergence criterion test is conducted at each iteration to check the difference in the objective function between the two points, v^n and y^n. The whole procedure is repeated until the convergence criterion is met or after a specific number of iterations.

The convex combinations algorithm is summarized in the flow chart represented in Figure B.4.

Applying the Convex Combinations Method to Solve for User-Equilibrium

The application of the above described convex combinations algorithm has proved to be suitable and efficient in solving for the equivalent user-equilibrium program described in Equations B.1 through B.4. It is guaranteed to converge to the equilibrium solution. The suitability of this algorithm is demonstrated also by the ease and efficiency with which the descent direction can be found. This involves solving a linear program, which is an approximation of the objective function. This linear program has a special structure in the case of user-equilibrium program, which simplifies its solution (Sheffi, 1984). It was derived to be:

$$\text{minimize } z_1(y) = \sum_a t_a^n \cdot y_a \qquad \text{(B.9)}$$

subjected to:

$$\sum_{rs} \sum_k g_k^{rs} = q_{rs} \qquad ,\forall r,s \qquad \text{(B.10)}$$

$$g_k^{rs} \geq 0 \qquad ,\forall k,r,s \qquad \text{(B.11)}$$

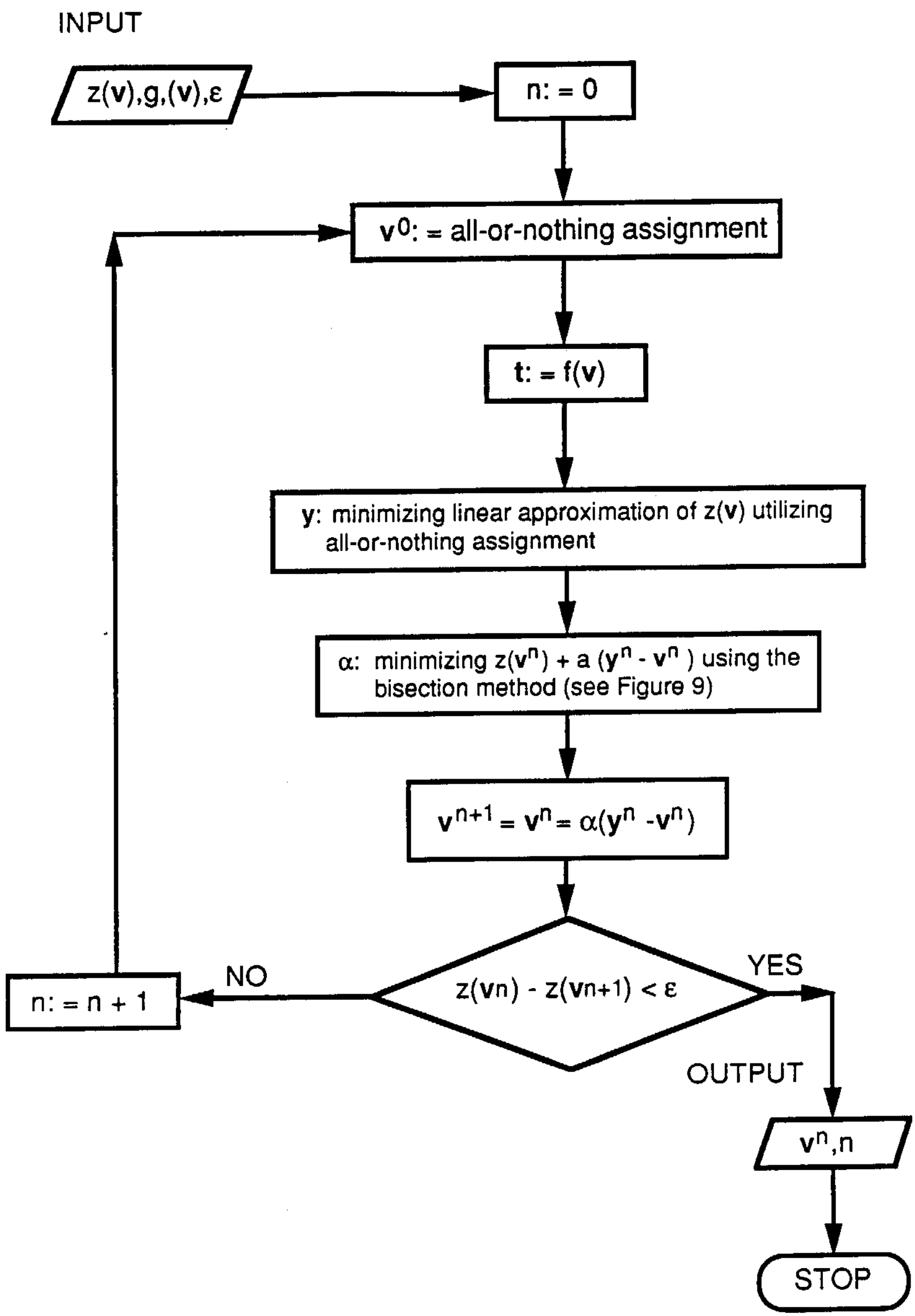

Figure B.4 A flow chart representing the convex combinations method where $z_1(y)$ = the linear approximation of the objective function $z(\underline{y})$

g_b^{rs} = the auxiliary flow on path k connecting origin-destination pair r-s

y_a = the auxiliary flow on link a, which can be found from the relationship:

$$y_a^n = \sum_{rs} \sum_k g_k^{rs} \cdot \delta_{a,s}^{rs} \qquad ,\forall a$$

from which y^n is specified, used to determine the descent direction.

Equation B.9 minimizes the total travel time over the network with fixed travel times (not flow dependent). Thus, it suggests the use of of an all-or-nothing assignment. The shortest paths between all the origins and all the destinations should be determined and used as a basis for assigning the traffic for the corresponding origin-destination pair. Therefore, the program represented by Equations B.9 through B.11 is an all-or-nothing assignment that is solved at each iteration to find y^n, the auxiliary link flows at that iteration.

The line search for the optimal move size, α, can be determined by applying the bisection method to the one-dimensional minimization problem. The derivative can easily be calculated through the procedure to find the optimum α that gives the best move size in the descent direction determined above.

In summary, for each iteration, with the current v^n, the computer should find a set of auxiliary link flows, y^n, that define the descent direction towards the next set of flows, v^{n+1}, and finally towards the minimum value of the objective function, $z(v)$. The move size towards the next point in the objective function, v^{n+1}, is governed by the optimal value of α at each iteration, which can be considered a weighting factor to determine v^{n+1} between v^n and y^n. The best method of determining when to stop the iterations is based on the obtained flows or travel times. The criterion in the used program compares the average value (over all the links) of the relative change in flow with the previous iteration to a predetermined value, say ε

$$\text{i.e., check} \quad \frac{\sum_{rs} \frac{v_a^{n+1} - v_a^n}{v_a^{n+1}}}{I} \leq \varepsilon \qquad \text{(B.12)}$$

where: I = the total number of links.

The optimization process may be stopped after a specific number of iterations have been performed. Tests on networks have demonstrated that five to six iterations will bring the solution adequately close to convergence for most situations.

The steps of the algorithm can be summarized as follows:

- Step 0: Initialization: Perform an all-or-nothing assignment that yields $\{v_a^1\}$[3] $,\forall a$
- Step 1: Updating: Set $t_a - f(v_a^n)$ $,\forall a$
- Step 2: Direction Finding: Perform an all-or-nothing assignment based on t_a^n that yields a set of auxiliary flows $\left\{y_a^n\right\}$
- Step 3: Line Search: Find α_n that solves

$$\text{minimize} \sum_a \int_0^{v_a^n + \alpha(y_a^n - v_a^n)} f(w)\, dw \quad , 0 \leq \alpha \leq 1$$

- Step 4: Move: Set $v_a^{n+1} = v_a^n + \alpha\,(y_a^n - v_a^n)$, $\forall a$
- Step 5: Convergence test: Check the convergence criterion

$$\text{i.e., check} \quad \frac{\sum_{rs} \frac{v_a^{n+1} - v_a^n}{v_a^{n+1}}}{I} \leq \varepsilon \qquad \text{(B.12)}$$

[3]The notation { } used here refers to the set of v_a's.

if met, stop. The current solution $\left\{v_a^{n+1}\right\}$, is the set of equilibrium link flows. Otherwise, set n: n+1 and go to Step 1.

OVERVIEW OF XXEXQ

Several programs have been developed to simulate user-equilibrium on highway networks using the methodological procedures discussed above. The selection of the most appropriate program is a trade-off between realistic results and computational costs. The XXEXQ program has provisions for achieving network equilibrium with a number of proven algorithms that afford considerable flexibility in terms of computational cost and forecasting accuracy. XXEXQ was originally developed at the Massachusetts Institute of Technology, and subsequent modifications of this package have been undertaken at the Pennsylvania State University and the University of Washington (Abu-Eisheh and Mannering (1986), Hamed and Mannering (1989)), to consistently produce reasonable and defensible results. The program is presented in Appendix C.

The methodological requirements (the inputs) are discussed and presented in Chapter 2. XXEXQ consists of a main program, four subroutines, and two functions. The main program processes the input requirements by preparing them for use in the associated subroutines and functions, and performs the user equilibrium assignment. XXEXQ subroutines and functions are presented below.

The Subroutines

The subroutines utilized include the following:

1. The first subroutine performs the all-or-nothing assignment. It requires finding the shortest paths from all the origins to all the destinations. It performs the initial assignment and finds the descent direction.

2. The second subroutine is the bisection technique, which calculates the optimum value of α to determine the location of the next point on the objective function.
3. The third subroutine finds the shortest time paths from all the origins to all the destinations in the network. It is used as the input from the subroutine that loads the network through an all-or-nothing assignment.
4. The last subroutine, the fourth, prepares the final results after a specific number of iterations have been performed or after the convergence criterion has been met. This subroutine presents the equilibrium flows on the links of the network. It also calculates some measures for the level of service on the links and for the network as a whole.

The Functions

The functions utilized include the following:

1. The first two functions calculate the cost function of every link, depending on the ratio of the volume/capacity, and on the shape of the link performance function (see below for additional detail). The results are used in the all-or-nothing assignment.
2. The third function calculates the integral of the cost function for all the links in order to find the value of the objective function for the resulting flow pattern at each iteration.

CHARACTERISTICS OF XXEXQ

The following sections discuss specific elements of XXEXQ and their underlying assumptions. XXEXQ has the ability to divide a two-hour simulation period into any number of time periods, to account for the effects of queues, to account for the benefits of driver information, and to restrict the capacities of one or more links.

Users can specify the number of time periods they wish to simulate. The length of each time period is determined by dividing the total simulation duration (120 minutes) by the number of time periods. For example, if 10-minute time periods are desired, then 12 periods are required, since 120/12 = 10 minutes per period.

The ability to divide the simulation into smaller time periods allows modelers to mark the progress of queue buildup or dissipation and to specify capacity restrictions of varying lengths (e.g., used to describe an incident).

Link Performance Functions

XXEXQ uses the Bureau of Public Roads function, a function that considers both the speed limit and the practical capacity of the link, to describe the performance of individual links. The form of the function appears as follows:

$$T = T_0[1 + a(V/C)^b] \tag{B.13}$$

where:

- T = the travel time for the assigned volume
- T_0 = the travel time at zero flow
- V = the assigned link volume
- C = the capacity of the link
- a,b = model parameters that vary with respect to the capacity and speed limit of the link

The parameters (a and b) vary with speed and capacity, and are shown in Table B.1.

Capacity Restriction

Often throughout a day, restrictions of capacity occur on various links in a random manner. These restrictions may be caused by incidents (accidents and disablements), weather, bridge openings, and other uncontrollable or controllable events. These restrictions have profound effects on the performance of transportation systems and cause significant alterations in travel patterns.

TABLE B.1. MODEL PARAMETERS OF THE BUREAU OF PUBLIC ROADS PERFORMANCES FUNCTIONS FOR DIFFERENT LINK CHARACTERISTICS

Speed Limit (mph)	Practical Capacity (vehicle per hour)	Model Parameters	
		a	b
0 - 30	0 - 240	0.7312	3.6596
0 - 30	249 - 499	0.6128	3.5038
0 - 30	500 - 749	0.8774	4.4613
0 - 30	750 - 999	0.6846	5.1644
0 - 30	1000+	1.1465	4.4239
31 - 40	250 - 499	0.6190	3.6544
31 - 40	500 - 749	0.6662	4.9432
31 - 40	750 - 999	0.6222	5.1409
31 - 40	1000+	1.0300	5.5226
41 - 50	500 - 749	0.6609	5.0906
41 - 50	750 - 999	0.5423	5.7894
41 - 50	1000+	1.0091	6.5856
50+	500 - 749	0.8776	4.9287
50+	750 - 999	0.7699	5.3443
50+	1000+	1.1491	6.8677

XXEXQ allows the modeler to simulate such restrictions by specifying the link and its reduced capacity. This information is specified for each time period and in this way, capacity restrictions may be simulated for varying lengths of time.

Traffic Intensity Ratio

Since it is unreasonable to assume that traffic flows at a constant rate throughout the peak periods in a day, XXEXQ allows the modeler to specify a traffic intensity ratio for varying traffic flows across time periods. For example, a time period with a traffic intensity ratio of 1.0 implies a traffic demand that is equal to the mean of the 2-hour simulation average; whereas a traffic intensity ratio of 1.2 implies a traffic demand that is 20 percent higher than the 2-hour average.

Queue Response

Although the standard user equilibrium approach to traffic assignment (as previously detailed) is superior to the incremental and iterative approaches, it does not consider the effects of queues that develop on links within the network. By breaking down the simulation period into smaller time intervals, XXEXQ allows the user to check the development of queues on links and to use this information to more precisely estimate traffic assignment in future time periods.

XXEXQ defines a queue as the number of vehicles in excess of capacity on any particular link. If, for example, 180 vehicles travel on a link in a ten-minute period and the link has a capacity of 160 vehicles, then the queue is 20 vehicles. This newly derived queue is then inserted into the link performance function of the next time period. Consider the following link performance function:

$$T = T_0[1 + a(V+Q/C)]^b \tag{B.14}$$

where:

- T = time to traverse link
- T_0 = free flow time
- V = volume assigned to link
- C = capacity of link
- Q = queue of vehicles derived from previous time period
- a,b = performance constants derived from BPR function curves

When a queue develops from a previous time period, the value of that queue is placed in the above function and increases the time to traverse the link. In this way, the effect of queues is reflected in link performance, and the smart driver (a driver who becomes aware of the queue through traffic information sources) will consider this changed condition during route choice.

Information Response

XXEXQ also differentiates between drivers who have information about existing traffic conditions and those who do not. This characteristic was added to reflect the route choice decision process some drivers would undergo when they received information about the system through the radio, TV, or other sources.

To account for the differences in route choice between uninformed and informed drivers, XXEXQ makes two assumptions: (1) uninformed drivers assume that the entire network is operating without queues or capacity restrictions, and (2) informed drivers know about queues and capacity restrictions on all links throughout the transportation system. The actual traffic assignment is performed by two separate user equilibrium solutions per time period.

The first user equilibrium solution assigns routes to all the uninformed drivers. It assumes that 100 percent of the demand is using the network while it computes the user equilibrium route choice. The link performance function appears as:

$$T = T_0[1 + a(V/C)]^b \tag{B.15}$$

In this form, the link performance function in this form maintains the first assumption: uninformed drivers have no knowledge of queues or capacity restrictions. After the traffic assignment has been completed, the volumes on all links are multiplied by the percentage of uniformed drivers, a product that removes the informed drivers from the system.

The second user equilibrium solution computes a traffic assignment for the informed drivers by using a modified link performance function that satisfies the second assumption of perfect knowledge:

$$T = T_0[1 + a\{(V_i + V_u + Q)/(C^* R_l)\}]^b \tag{B.16}$$

where:

V_i = volume of informed drivers

V_u = volume of uninformed drivers previously computed

Q = queue from previous time period

R_l = capacity restriction ratio of link in existing time period (i.e., R_l=1.0 implies no capacity reduction, R_l=0.5 implies capacity reduced to one-half of original capacity)

With the variables V_u, Q, and R_l substituted into the link performance function, the informed drivers are given all system knowledge pertaining to the route choice of uninformed drivers, the queues that developed in the previous time period, and the capacity restrictions on all links in this existing time period.

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APPENDIX C

FORTRAN LISTING OF XXEXQ

APPENDIX C

FORTRAN LISTING OF XXEXQ

```
      COMMON /TORD/TX,IPRO,AX2
      COMMON /ARCDT/ TOO,L,C,V,FL,COST,CI,FLX,FOP1,QUE
      COMMON /ODDT/ TOD,AMT
      COMMON /FST/FS,A,FSX,ORD,JS,CS
      COMMON /ODL/ ODLK
      COMMON /DMPDT/ NDMP
      COMMON /ALBET/ ALP,BET,ALP1,TYP
      COMMON /IPT/IY1,IY2,IY3,IY4,IY5,IY7,IY8,INFO,INFOP,INFOX
      COMMON /IRTX/IRT,IPRD,IRIN
      INTEGER TOO(1071),TOD(6500),FS(1071),ODLK(81),TYP(1071),INFOX(12)
     1,FSX(1071),ORD(1071),TX(1071),ORS(6500),IRT(1071),IRIN(1071)
      REAL*8 DS,DS1
      REAL L(1071),C(1071),V(1071),FL(1071),COST(1071),AMT(6500),
     1TITLE(20),ALP(18),BET(18),ALP1(18),A(1071,5),CS(12,1071),
     2CI(1071),PAV(12),SP(81,81),SP1(81,81),NFL(1071)
     3,FLX(1071),AMTR(6500),QUE(12,1071)
      OPEN (UNIT=10,FILE='NW.DAT',STATUS='UNKNOWN')
      OPEN (UNIT=16,FILE='OD.DAT',STATUS='UNKNOWN')
      OPEN (UNIT=17,FILE='CN.DAT',STATUS='UNKNOWN')
      OPEN (UNIT=9,FILE='OT.OUT',STATUS='UNKNOWN')
      READ(17,171) IY1,IY2,IY3,IY4,IY5,IY7,FY1,IY8,IPRO,NREST,
     1IPRD,AX2
  171 FORMAT(6I5,F8.5,3I3,I4,1X,F4.2)
      DO 9005 JK=1,IPRD
      READ(17,9004) PAV(JK),INFOX(JK)
 9004 FORMAT(F4.2,I4)
 9005 CONTINUE
      NARC=IY1
      NCENT=IY2
      NNOD=IY3
      ALP(1)=.731
      ALP(2)=.613
      ALP(3)=.877
      ALP(4)=.69
      ALP(5)=1.15
      ALP(6)=.62
      ALP(7)=.67
      ALP(8)=.62
      ALP(9)=1.03
      ALP(10)=.66
      ALP(11)=.54
      ALP(12)=1.
      ALP(13)=.88
      ALP(14)=.77
      ALP(15)=1.15
      BET(1)=3.66
      BET(2)=3.5
      BET(3)=4.46
      BET(4)=5.16
      BET(5)=4.42
```

```
      BET(6)=3.65
      BET(7)=4.94
      BET(8)=5.14
      BET(9)=5.52
      BET(10)=5.09
      BET(11)=5.79
      BET(12)=6.59
      BET(13)=4.93
      BET(14)=5.34
      BET(15)=6.87
      ALP1(1)=.157
      ALP1(2)=.136
      ALP1(3)=.161
      ALP1(4)=.111
      ALP1(5)=.212
      ALP1(6)=.133
      ALP1(7)=.112
      ALP1(8)=.101
      ALP1(9)=.158
      ALP1(10)=.109
      ALP1(11)=.08
      ALP1(12)=.133
      ALP1(13)=.148
      ALP1(14)=.121
      ALP1(15)=.146
      NOD=IY5
      DO 29 I=1,NOD
      READ(16,107) ORS(I),TOD(I),AMTR(I)
  107 FORMAT(I4,I3,F5.0)
      TOD(I)=TOD(I)+IY2
   29 CONTINUE
      DO 9007 IDX=1,NARC
      DO 9007 IDY=1,IPRD
      QUE(IDY,IDX)=0.0
 9007 CS(IDY,IDX)=1.0
      WRITE(9,1)
    1 FORMAT(T20,'USER EQUILIBRIUM ASSIGNMENT')
      NDMP=IY8
      DO 9000 JS=1,IPRD
      DO 9000 INFO=1,2
      FOP1=FLOAT(INFOX(JS))/100.
      INFOP1=INFOX(JS)
      INFOP=100-INFOP1
      IF(INFO.EQ.2.AND.INFOX(JS).GT.99) GO TO 9000
      PRINT*,'TIME PRD=',JS,'   INFO GRP=',INFO
      DO 5583 I=1,NOD
      IF(INFO.EQ.1) AMT(I)=AMTR(I)
      IF(INFO.EQ.2) AMT(I)=AMTR(I)*(1.-FOP1)
 5583 CONTINUE
      IF(INFO.NE.1) GO TO 9167
      DO 9168 I=1,IY1
 9168 FLX(I)=1.
 9167 CONTINUE
      IF(JS.GT.1.OR.INFO.GT.1) GO TO 9001
      DO 9221 I=1,NARC
```

```
      READ(10,135) FSX(I),TOO(I),L(I),CI(I),V(I),(A(I,J),J=1,5),IRIN(I)
  135 FORMAT(2I4,F5.2,F5.0,F3.0,5A4,37X,I1)
 9221 CONTINUE
      DO 9002 JT=1,NREST
      DO 9002 JU=1,IPRD
      READ(10,9003) JN,CKS
 9003 FORMAT(I4,1X,F8.6)
      CS(JU,JN)=CKS
 9002 CONTINUE
 9001 DO 21 I=1,NARC
      IF(CS(JS,I).LT.0.1) CS(JS,I)=0.1
      C(I)=CI(I)
      IF(INFO.EQ.2) C(I)=CI(I)*CS(JS,I)
      IF(C(I).LT.1) C(I)=1.0
      IF(V(I).LE.30) GO TO 733
      IF(V(I).LE.40) GO TO 734
      IF(V(I).LE.50) GO TO 735
      IF(C(I).LT.750) TYP(I)=13
      IF(C(I).GE.750.AND.C(I).LT.1000) TYP(I)=14
      IF(C(I).GE.1000) TYP(I)=15
      GO TO 21
  733 IF(C(I).LT.250) TYP(I)=1
      IF(C(I).GE.250.AND.C(I).LT.500) TYP(I)=2
      IF(C(I).GE.500.AND.C(I).LT.750) TYP(I)=3
      IF(C(I).GE.750.AND.C(I).LT.1000) TYP(I)=4
      IF(C(I).GE.1000) TYP(I)=5
      GO TO 21
  734 IF(C(I).LT.500) TYP(I)=6
      IF(C(I).GE.500.AND.C(I).LT.750) TYP(I)=7
      IF(C(I).GE.750.AND.C(I).LT.1000) TYP(I)=8
      IF(C(I).GE.1000) TYP(I)=9
      GO TO 21
  735 IF(C(I).LT.750) TYP(I)=10
      IF(C(I).GE.750.AND.C(I).LT.1000) TYP(I)=11
      IF(C(I).GE.1000) TYP(I)=12
   21 CONTINUE
      IF(JS.GT.1.OR.INFO.GT.1) GO TO 9015
      IF(IPRO.EQ.1) GO TO 9072
      IBB=0
      DO 9021 I=1,NARC
      IF(FSX(I).LT.IY7.OR.TOO(I).LT.IY7) GO TO 9021
      IBB=IBB+1
      IRT(IBB)=I
 9021 CONTINUE
 9072 KX=1
      KA=FSX(1)
      DO 93 I=1,NARC
      IF(FSX(I).NE.KA) GO TO 94
      ORD(I)=KX
      GO TO 93
   94 KX=KX+1
      KA=FSX(I)
      ORD(I)=KX
   93 CONTINUE
      DO 80 I=1,NARC
```

```
      TX(I)=TOO(I)
      DO 80 J=1,NARC
      IF(FSX(J).NE.TOO(I)) GO TO 80
      TOO(I)=ORD(J)
   80 CONTINUE
      KS=1
      FS(1)=1
      DO 91 I=1,NARC
      IF(ORD(I).EQ.KS) GO TO 91
      KS=ORD(I)
      FS(KS)=I
   91 CONTINUE
      KZ=ORD(NARC)+1
      FS(KZ)=IY1+1
      KS=1
      ODLK(1)=1
      DO 81 I=1,NOD
      IF(ORS(I).EQ.KS) GO TO 81
      KS=ORS(I)
      ODLK(KS)=I
   81 CONTINUE
      ODLK(ORS(NOD)+1)=IY5+1
      WRITE(9,7) NOD
    7 FORMAT(  '     NO. OF OD PAIRS =',I6)
      EPS=FY1
      WRITE(9,9) EPS
    9 FORMAT(/'      CONVERGENCE CRITERION =',E13.5)
 9015 DO 9016 I=1,IY5
 9016 AMT(I)=AMT(I)*PAV(JS)
      DO 27 I=1,IY2
      DO 27 J=1,IY2
      SP(I,J)=0.
   27 SP1(I,J)=0.
      CALL AON(FL,NARC,NNOD,NOD,NCENT,SP)
      K=1
      ITER=0
      FOBJ=0
      DO 70 I=1,NARC
      A1=ALP1(TYP(I))
      B1=BET(TYP(I))
      IF(JS.EQ.1) FOBJ=FOBJ+FINT(L(I),C(I),V(I),FL(I),FLX(I),
     1A1,B1,FOP1,INFO,QUE(JS-1,I))
      IF(JS.GT.1) FOBJ=FOBJ+FINT(L(I),C(I),V(I),FL(I),FLX(I),
     1A1,B1,FOP1,INFO,QUE(JS,I))
   70 CONTINUE
      CONV=2.*EPS
      DO 61 I=1,NCENT
      DO 62 J=1,NCENT
      SP1(I,J)=SP(I,J)
   62 CONTINUE
   61 CONTINUE
      IRID=0
   10 CALL DUMP(ITER,CONV,FOBJ,CONV1,IRID)
      K=K+1
      IF(IRID.EQ.1) GO TO 9000
```

```
      IF(K.GT.NOMP) GO TO 9000
      IF(CONV.LE.EPS) IRID=1
      IF(IRID.EQ.1) GO TO 10
      ITER=ITER+1
      CALL AON(NFL,NARC,NNOD,NOD,NCENT,SP)
      CALL BISECT(NFL,NARC,NNOD)
      CONV=0.
      FOBJ=0.
      DO 20 N=1,NARC
      A1=ALP1(TYP(N))
      B1=BET(TYP(N))
      IF(JS.EQ.1) FOBJ=FOBJ+FINT(L(N),C(N),V(N),NFL(N),FLX(N),
     1A1,B1,FOP1,INFO,QUE(JS-1,N))
      IF(JS.GT.1) FOBJ=FOBJ+FINT(L(N),C(N),V(N),NFL(N),FLX(N),
     1A1,B1,FOP1,INFO,QUE(JS,N))
      XN=ABS(NFL(N)-FL(N))
      IF(XN.EQ.0) GO TO 20
      D=NFL(N)
      IF(D.EQ.0.) D=FL(N)
      CONV=CONV+XN/D
      FL(N)=NFL(N)
   20 CONTINUE
      CONV=CONV/FLOAT(NARC)
      GO TO 10
 9000 CONTINUE
      STOP
      END
C
C
C
      SUBROUTINE AON(NFL,NARC,NNOD,NOD,NCENT,SP1)
      COMMON /ARCDT/ TOO,L,C,V,FL,COST,CI,FLX,FOP1,QUE
      COMMON /ODDT/ TOD,AMT
      COMMON /FST/FS,A,FSX,ORD,JS,CS
      COMMON /ODL/ ODLK
      COMMON /ALBET/ ALP,BET,ALP1,TYP
      COMMON /IPT/IY1,IY2,IY3,IY4,IY5,IY7,IY8,INFO,INFOP
      REAL L(1071),C(1071),V(1071),FL(1071),COST(1071),AMT(6500),
     1NFL(1071),SP(1071),SP1(81,81),ALP(18),BET(18),ALP1(18),A(1071,5)
     2,FLX(1071),CI(1071),QUE(12,1071)
      INTEGER TOO(1071),TOD(6500),FS(1071),ODLK(81),PRED(1071),TYP(1071)
     1,FSX(1071),ORD(1071)
      DO 10 N=1,NARC
      A1=ALP(TYP(N))
      B1=BET(TYP(N))
      NFL(N)=0
      IF(JS.EQ.1) COST(N)=COSTFN(L(N),C(N),V(N),FL(N),FLX(N),A1,B1,FOP1
     1,INFO,QUE(JS,N))
      IF(JS.GT.1) COST(N)=COSTFN(L(N),C(N),V(N),FL(N),FLX(N),A1,B1,FOP1
     1,INFO,QUE(JS-1,N))
   10 CONTINUE
      DO 20 I=1,NCENT
      I1=ODLK(I)
      I2=ODLK(I+1)-1
      IF(I1.GT.I2) GO TO 20
```

```
      CALL SHPATH(I,PRED,SP,NARC,NNOD)
      DO 30 K=I1,I2
      J=TOO(K)
      J73=J-NCENT
      SP1(I,J73)=SP(J)
   60 J1=PRED(J)
      IF(J1.EQ.0) GO TO 30
      N1=FS(J1)
      N2=FS(J1+1)-1
      DO 40 N=N1,N2
      IF(TOO(N).EQ.J) GO TO 50
   40 CONTINUE
   50 NFL(N)=NFL(N)+AMT(K)
      J=J1
      GO TO 60
   30 CONTINUE
   20 CONTINUE
      RETURN
      END
C
C
C
      SUBROUTINE BISECT(NFL,NARC,NNOD)
      COMMON /ARCDT/ TOO,L,C,V,FL,COST,CI,FLX,FOP1,QUE
      COMMON /FST/FS,A,FSX,ORD,JS,CS
      COMMON /ALBET/ ALP,BET,ALP1,TYP
      COMMON /IPT/IY1,IY2,IY3,IY4,IY5,IY7,IY8,INFO,INFOP
      REAL L(1071),C(1071),V(1071),FL(1071),COST(1071),NFL(1071),ALP(18)
     1,BET(18),ALP1(18),A(1071,5),CI(1071),FLX(1071),QUE(12,1071)
      INTEGER TOO(1071),FS(1071),TYP(1071),FSX(1071),ORD(1071)
      AMN=0.
      AMX=1.
   10 AMD=(AMX+AMN)/2.
      IF((AMX-AMN).LE.0.0005) GO TO 20
      D=0.
      DO 30 N=1,NARC
      X=FL(N)+AMD*(NFL(N)-FL(N))
      A1=ALP(TYP(N))
      B1=BET(TYP(N))
      IF(JS.EQ.1) CST=COSTFN(L(N),C(N),V(N),X,FLX(N),A1,B1,FOP1
     1,INFO,QUE(JS,N))
      IF(JS.GT.1) CST=COSTFN(L(N),C(N),V(N),X,FLX(N),A1,B1,FOP1
     1,INFO,QUE(JS-1,N))
   30 D=D+CST*(NFL(N)-FL(N))
      IF(D.GT.0.) AMX=AMD
      IF(D.LE.0.) AMN=AMD
      GO TO 10
   20 DO 40 N=1,NARC
   40 NFL(N)=FL(N)+AMD*(NFL(N)-FL(N))
      RETURN
      END
C
C
C
      FUNCTION COSTFN(D,C,V,FL,FLX1,A,B,FOP1,INFO,Q)
```

```
      COSTFN=D/V
      IF(C.GT.0.AND.INFO.EQ.1) COSTFN=COSTFN*(1.+A*((FL+FLX1*FOP1)/C)
     1**B)
      IF(C.GT.0.AND.INFO.EQ.2) COSTFN=COSTFN*(1.+A*((FL+FLX1*FOP1+Q)/C)
     1**B)
      RETURN
      END
C
C
      FUNCTION COSTFN1(D,C,V,FL,A,B,Q)
      COSTFN1=D/V
      IF(C.GT.0.) COSTFN1=COSTFN1*(1.+A*((FL+Q)/C)**B)
      RETURN
      END
C
C
C
      FUNCTION FINT(D,C,V,FL,FLX1,A,B,FOP1,INFO,Q)
      FINT=(D/V)*(FL+FLX1*FOP1)
      IF(INFO.EQ.2) FINT=(D/V)*(FL+FLX1*FOP1+Q)
      IF(C.GT.0.AND.INFO.EQ.1) FINT=FINT*(1.+A*((FL+FLX1*FOP1)/C)**B)
      IF(C.GT.0.AND.INFO.EQ.2) FINT=FINT*(1.+A*((FL+FLX1*FOP1+Q)/C)**B)
      RETURN
      END
C
C
C
      SUBROUTINE SHPATH(R,PRED,SP,NARC,NNOD)
C
C  THIS SUBROUTINE COMPUTES SHORTEST PATHS FROM R TO ALL OTHER NODES.
C  PRED(I) CONTAINS PREDECESSOR OF NODE I, SP(I) CONTAINS LENGTH OF
C  PATH TO NODE I.
C
      COMMON /ARCDT/ TOO,L,C,V,FL,COST,CI,FLX,FOP1,QUE
      COMMON /FST/FS,A,FSX,ORD,JS,CS
      REAL L(1071),C(1071),V(1071),FL(1071),COST(1071),SP(1071),
     1CI(1071),FLX(1071),A(1071,5),QUE(12,1071)
      INTEGER TOO(1071),FS(1071),PRED(1071),CL(1071),R,FSX(1071)
     1,ORD(1071)
      DO 10 I=1,NNOD
      SP(I)=1.E20
      PRED(I)=0
   10 CL(I)=0
      SP(R)=0
      CL(R)=NNOD+1
      I=R
      NT=R
   20 IA=FS(I+1)-1
      S=SP(I)
      IA1=FS(I)
      IF(IA1.GT.IA) GO TO 30
      DO 40 IR=IA1,IA
      K=TOO(IR)
      SD=S+COST(IR)
      IF(SD.GE.SP(K)) GO TO 40
```

```
      PRED(K)=I
      SP(K)=SD
      IF(CL(K)) 50,60,40
   60 CL(NT)=K
      NT=K
      CL(K)=NNOD+1
      GO TO 40
   50 CL(K)=CL(I)
      CL(I)=K
   40 CONTINUE
   30 ICL=CL(I)
      CL(I)=-1
      I=ICL
      IF(I.LE.NNOD) GO TO 20
      RETURN
      END
C
C
C
      SUBROUTINE DUMP(ITER,CONV,FOBJ,CONV1,IRID)
      COMMON /TORD/ TX,IPRO,AX2
      COMMON /ARCDT/ TOO,L,C,V,FL,COST,CI,FLX,FOP1,QUE
      COMMON /FST/FS,A,FSX,ORD,JS,CS
      COMMON /ALBET/ ALP,BET,ALP1,TYP
      COMMON /IPT/ IY1,IY2,IY3,IY4,IY5,IY7,IY8,INFO,INFOP,INFOX
      COMMON /IRTX/IRT,IPRD,IRIN
      REAL L(1071),C(1071),V(1071),FL(1071),COST(1071),NFL(1071)
     1,ALP(18),BET(18),ALP1(18),VCR(1071),CAP(1071),A(1071,5),LX(1071)
     2,CS(12,1071),RFL(12,1071),RCP(12,1071),BEI(1071)
     3,CI(1071),FLX(1071),VX(1071),QUE(12,1071)
      INTEGER TOO(1071),FS(1071),TYP(1071),VC1(1071),VC2(1071),FSX(1071)
     1,ORD(1071),TX(1071),IRT(1071),IRIN(1071),INFOX(12),IFTO(1071)
      IF(IRID.EQ.1) GO TO 53
      IF(ITER.NE.(IY8-1)) RETURN
   53 K=0
      IF(INFO.NE.1) GO TO 9162
      DO 9161 I=1,IY1
 9161 FLX(I)=FL(I)
 9162 IY6=2*(IY2)+1
      IK6=IY6
      IF(IPRO.EQ.1) IK6=1
      DO 10 I=IK6,IY3
      J1=FS(I)
      J2=FS(I+1)-1
      IF(J1.GT.J2) GO TO 10
      DO 20 J=J1,J2
      IF(TOO(J).LT.IK6) GO TO 20
      K=K+1
      IFTO(K)=J
      LX(K)=L(J)
      VX(K)=V(J)
      NFL(K)=FL(J)
      VCR(K)=FL(J)/C(J)
      CAP(K)=CI(J)*CS(JS,J)
      IZA=0
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   98 IZA=IZA+1
      IF(IZA.GT.(IY1+1)) GO TO 99
      IF(ORD(IZA).EQ.I) GO TO 99
      GO TO 98
   99 VC1(K)=FSX(IZA)
      VC2(K)=TX(J)
   20 CONTINUE
   10 CONTINUE
      IF(INFO.EQ.2) GO TO 9011
      DO 9010 I=1,K
 9010 BEI(I)=NFL(I)
      IF(INFO.EQ.1.AND.INFOP.LT.1) GO TO 9011
      RETURN
 9011 IF(JS.EQ.1) SLXG=0
      IF(JS.EQ.1) STXG=0
      P=FLOAT(INFOP)/100.
      DO 9012 I=1,K
      S=BEI(I)*(1-P)
      S1=NFL(I)
      IF(INFOX(JS).GT.99) S1=0.
      RFL(JS,I)=S+S1
      RCP(JS,I)=CAP(I)
      SLXG=SLXG+LX(I)*RFL(JS,I)/(FLOAT(IPRD)/2.)
      A1=ALP(TYP(IFTO(I)))
      B1=BET(TYP(IFTO(I)))
      QUE(JS,IFTO(I))=0
      CITY=AX2*CAP(I)
      IF(JS.EQ.1) CST=COSTFN1(LX(I),CITY,VX(I),RFL(JS,I),A1,B1,
     1QUE(JS,IFTO(I)))
      IF(JS.GT.1) CST=COSTFN1(LX(I),CITY,VX(I),RFL(JS,I),A1,B1,
     1QUE(JS-1,IFTO(I)))
      STXG=STXG+CST*RFL(JS,I)/(FLOAT(IPRD)/2.)
      IF(RFL(JS,I).LE.RCP(JS,I).AND.QUE(JS-1,IFTO(I)).EQ.0) GO TO 9012
      QUE(JS,IFTO(I))=QUE(JS-1,IFTO(I))+(RFL(JS,I)-RCP(JS,I))/
     1(FLOAT(IPRD)/2.)
      IF(QUE(JS,IFTO(I)).LT.0) QUE(JS,IFTO(I))=0.0
      IF(QUE(JS-1,IFTO(I)).LE.0) QUE(JS-1,IFTO(I))=0
      GO TO 9012
 9013 QUE(JS,IFTO(I))=(RFL(JS,I)-RCP(JS,I))/(FLOAT(IPRD)/2.)
 9012 CONTINUE
      IF(JS.EQ.IPRD) GO TO 9014
      RETURN
 9014 SXC=0
      ZBID=0
      DO 9042 I=1,K
      IF(IPRO.EQ.1) IRT(I)=I
      DO 2714 JX1=1,IPRD
      IF(JX1.EQ.1) VC=RFL(JX1,I)/RCP(JX1,I)
      IF(JX1.GT.1) VC=(RFL(JX1,I)+QUE(JX1-1,IFTO(I)))/RCP(JX1,I)
      IF(VC.LT.5.) SXC=SXC+VC
      ZBID=ZBID+1.
      IF(VC.GE.5.) SXC=SXC+5.
 2714 CONTINUE
      IF(IRIN(IRT(I)).NE.1) GO TO 9043
      WRITE(9,9015) IRT(I),(A(IRT(I),J),J=1,5),VC1(I),VC2(I)
```

```
9015 FORMAT(//,1X,'LINK NUMBER =',I5,5X,5A4,//,1X,'ORIG NODE =',I5,
    1/,1X,'DEST NODE =',I5)
     WRITE(9,7117)
7117 FORMAT(//,10X,'IN FLOW',15X,'CON RATIO',4X,'VEH IN QUE')
     WRITE(9,3095)
3095 FORMAT(1X,'PERIOD',3X,'DEMAND ',3X,'CAPACITY',3X,'(DMND PROJ)',
    13X,'(DMND PROJ)')
     WRITE(9,3096)
3096 FORMAT(1X,'------',3X,'--------',3X,'---------',4X,'-----------',
    12X,'----------')
9043 DO 9042 JX=1,IPRD
     IF(IRIN(IRT(I)).NE.1) GO TO 9042
     ISA=IFIX(RFL(JX,I))
     ISB=IFIX(RCP(JX,I))
     IF(JX.EQ.1) VC=RFL(JX,I)/RCP(JX,I)
     IF(JX.GT.1) VC=(RFL(JX,I)+QUE(JX-1,IFTO(I)))/RCP(JX,I)
     IF(VC.GT.50.) VC=0.0
     IQQ=IFIX(QUE(JX,IFTO(I))+.5)
     IP=JX*120/FLOAT(IPRD)
     WRITE(9,3097) IP,ISA,ISB,VC,IQQ
3097 FORMAT(1X,I6,4X,I5,5X,I5,8X,F5.2,8X,I4)
9042 CONTINUE
     WRITE(9,2)
   2 FORMAT(//,'**************************************************************
    1*******************************')
     SXC=SXC/ZBID
     WRITE(9,9020) STXG,SXC,SLXG
9020 FORMAT(/'      TOTAL TRAVEL TIME (VEH-HRS)            =',F13.0,/,
    1'      AVG. CONGESTION RATIO                  =',F13.6,/,
    3'      VEHICLE MILES TRAVELED                 =',F13.0)
     RETURN
     END
```

APPENDIX D

NW.DAT AS USED FOR THE CENTRAL PUGET SOUND REGION

APPENDIX D

NW.DAT AS USED FOR THE CENTRAL PUGET SOUND REGION

```
 1 163  3.5 1000 25 ACCESS ZONE 1 TO I-5
 2 163 12.0 1000 25 ACCESS ZONE 2 TO I5
 2 260  7.1 1000 25 ACCESS ZONE 2 TO SR 522
 3 218  1.3 1000 25 ACCESS ZONE 3 TO SR 99
 4 164  1.6 1000 25 ACCESS ZONE 4 TO I5
 4 218  2.4 1000 25 ACCESS ZONE 4 TO SR99
 5 164  2.4 1000 25 ACCESS ZONE 5 TO I5
 5 283  3.2 1000 25 ACCESS ZONE 5 TO SR527
 6 165  2.8 1000 25 ACCESS ZONE 6 TO I5
 6 283  1.3 1000 25 ACCESS ZONE 6 TO SR527
 7 196  3.0 1000 25 ACCESS ZONE 7 TO I405
 7 260  4.4 1000 25 ACCESS ZONE 7 TO SR 522
 8 166  1.5 1000 25 ACCESS ZONE 8 TO SR 5
 8 196  2.4 1000 25 ACCESS ZONE 8 TO I405
 8 283  1.6 1000 25 ACCESS ZONE 8 TO SR527
 9 167  1.4 1000 25 ACCESS ZONE 9 TO I5
 9 168  1.0 1000 25 ACCESS ZONE 9 TO I5
 9 219  0.3 1000 25 ACCESS ZONE 9 TO SR99
10 165  1.3 1000 25 ACCESS ZONE 10 TO I5
10 167  1.0 1000 25 ACCESS ZONE 10 TO I5
11 219  1.6 1000 25 ACCESS ZONE 11 TO SR99
12 220  1.3 1000 25 ACCESS ZONE 12 TO SR99
13 169  0.8 1000 25 ACCESS ZONE 13 TO I5
13 170  0.5 1000 25 ACCESS ZONE 13 TO I5
13 171  1.0 1000 25 ACCESS ZONE 13 TO I5
14 168  2.2 1000 25 ACCESS ZONE 14 TO I5
14 171  3.3 1000 25 ACCESS ZONE 14 TO I5
14 196  1.7 1000 25 ACCESS ZONE 14 TO I405
15 196  2.2 1000 25 ACCESS ZONE 15 TO I405
15 197  1.9 1000 25 ACCESS ZONE 15 TO I405
15 260  1.0 1000 25 ACCESS ZONE 15 TO SR522
16 172  0.8 1000 25 ACCESS ZONE 16 TO I5
16 221  0.6 1000 25 ACCESS ZONE 16 TO SR99
16 222  0.8 1000 25 ACCESS ZONE 16 TO SR99
17 171  1.6 1000 25 ACCESS ZONE 17 TO I5
17 172  1.3 1000 25 ACCESS ZONE 17 TO I5
17 173  1.9 1000 25 ACCESS ZONE 17 TO I5
17 264  1.3 1000 25 ACCESS ZONE 17 TO SR522
18 199  2.1 1000 25 ACCESS ZONE 18 TO I405
18 263  0.9 1000 25 ACCESS ZONE 18 TO SR522
19 197  0.2 1000 25 ACCESS ZONE 19 TO I405
19 198  0.5 1000 25 ACCESS ZONE 19 TO I405
19 262  0.7 1000 25 ACCESS ZONE 19 TO SR522
20 260  2.8 1000 25 ACCESS ZONE 20 TO SR522
20 261  2.1 1000 25 ACCESS ZONE 20 TO SR 522
21 199  0.8 1000 25 ACCESS ZONE 21 TO I405
21 200  1.7 1000 25 ACCESS ZONE 21 TO I405
22 200  1.6 1000 25 ACCESS ZONE 22 TO I405
22 286  0.6 1000 25 ACCESS ZONE 22 TO SR908
23 223  1.3 1000 25 ACCESS ZONE 23 TO SR99
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23 224  0.7 1000 25 ACCESS ZONE 23 TO SR99
23 225  1.4 1000 25 ACCESS ZONE 23 TO SR99
24 175  0.3 1700 25 NORTHGATE TO SB5:GNW
24 176  1.2 1000 25 GREEN TO NB5:85TH
24 290  1.4 1500 25 85 TO SB5:GREENWOOD
24 314 99.0    1  1 OFFRAP
25 173  1.9 1000 25 ACCESS ZONE 25 TO I5
25 174  1.4 1000 25 ACCESS ZONE 25 TO I5
25 265  0.6 1000 25 ACCESS ZONE 25 TO SR522
26 176  0.7 1000 25 WEDGE TO NB5:85TH
26 177 99.0    1  1 OFFRAP
26 265  1.6 1000 25 ACCESS ZONE 26 TO SR522
26 290  2.2 1500 25 85 TO SB5:WEDGEWOOD
26 291  2.0 1500 25 LAKE CITY TO SB5
26 293  2.2 1500 25 RAVENNA TO SB5:WEDGE
26 315 99.0    1  1 OFFRAP
27 201  0.5 1000 25 ACCESS ZONE 27 TO I405
27 202  0.2 1000 25 ACCESS ZONE 27 TO I405
28 201  1.6 1000 25 ACCESS ZONE 28 TO I405
29 250  5.8 1000 25 ACCESS ZONE 29 TO SR520
30 226  1.3 1000 25 ACCESS ZONE 30 TO SR99
30 227  1.4 1000 25 ACCESS ZONE 30 TO SR99
30 228  2.2 1000 25 ACCESS ZONE 30 TO SR99
31 178 99.0    1  1 OFFRAP
31 179  1.0 1000 25 WALLING TO NB5:50TH
31 180  1.0 1500 25 WALLING TO NB5:45TH
31 227  0.7 1500 25 WALLINGFORD TO SR99
31 292  1.2  750 25 50 TO SB5:WALLINFORD
31 294  0.5 1500 25 45TH TO SB5:WALLINGFORD
31 316 99.0    1  1 OFFRAP
31 334  0.3 1000 25 ACCESS:WALLINGFORD TO 45TH
32 178 99.0    1  1 OFFRAP
32 179  1.9 1000 25 UDIST TO NB5:50TH
32 180  1.9 1000 25 UDIST TO NB5:45TH
32 244  3.0 1000 25 U-DIST TO MONTLAKE ON SR520
32 292  1.0  750 25 50 TO SB5:UDIST
32 293  1.4 1500 25 RAVENNA TO SB5:UDIST
32 294  1.0 1500 25 45TH TO SB5: UDIST
32 316 99.0    1  1 OFFRAP
33 181  0.5 1000 25 ACCESS Z33 TO NB 5 AT ROANOKE
33 182 99.0    1  1 OFFRAP
33 244  0.6 1000 25 ACCESS ZONE 33 TO SR520
33 295 99.0    1  1 OFFRAP
33 297  0.5 1500 25 BOYLSTON TO SB5
34 245  0.4 1000 25 ACCESS ZONE 34 TO SR520
34 246  0.7 1000 25 ACCESS ZONE 34 RO SR520
34 247  1.3 1000 25 ACCESS ZONE 34 TO SR520
35 248  0.7 1000 25 ACCESS ZONE 35 TO SR520
35 249  2.0 1000 25 ACCESS ZONE 35 TO SR520
36 228  2.2 1000 25 ACCESS ZONE 36 TO SR99
36 229  3.3 1000 25 ACCESS ZONE 36 TO SR99
37 228  1.0 1000 25 ACCESS ZONE 37 TO SR99
37 229  1.6 1000 25 ACCESS ZONE 37 TO SR99
38 183  1.0 1000 20 PILL HILL TO NB5:OLI
38 306 99.0    1  1 OFFRAP
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38 309  1.0 1000 20 PILL HILL TO NB5 ML
38 311 99.0    1  1 OFFRAP
38 312 99.0    1  1 OFFRAP
39 204  0.5 1000 25 ACCESS ZONE 39 TO I405
39 247  1.5 1000 25 ACCESS ZONE 39 TO SR520
39 288  0.2 1000 25 ACCESS ZONE 39 TO SR908
40 204  1.1 1000 25 ACCESS ZONE 40 TO I405
41 204  1.6 1000 25 ACCESS ZONE 41 TO I405
41 205  0.8 1000 25 ACCESS ZONE 41 TO I405
42 204  2.7 1000 25 ACCESS ZONE 42 TO I405
42 248  1.3 1000 25 ACCESS ZONE 42 TO SR520
42 257  1.8 1000 25 ACCESS ZONE 42 TO I90
43 204  1.7 1000 25 ACCESS ZONE 43 TO I405
43 256  1.0 1000 25 ACCESS ZONE 43 TO I90
44 207  1.3 1000 25 ACCESS ZONE 44 TO I405
44 257  0.8 1000 25 ACCESS ZONE 44 TO I90
45 208  2.2 1000 25 ACCESS ZONE 45 TO I405
45 209  1.6 1000 25 ACCESS ZONE 45 TO I405
45 210  2.1 1000 25 ACCESS ZONE 45 TO I405
46 253  1.9 1000 25 ACCESS ZONE 46 TO I90
46 254  1.0 1000 25 ACCESS ZONE 46 TO I90
46 255  0.8 1000 25 ACCESS ZONE 46 TO I90
47 183  0.5 1000 20 ZONE 47 TO NB5 ML:MR
47 229  0.3 1000 15 ACCESS ZONE 47 TO SR99
47 298 99.0    1  1 OFFRAP
47 299  0.3 1500 25 MERCER TO SB5
47 300  0.4 1500 25 DENNY TO SB5
47 317  0.5 1500 20 ZONE 47 TO NB5 EX:MR
47 318  0.5 1000 20 ZONE 47 TO NB5 EX:ST
48 300  0.3 1500 25 DENNY TO SB5
48 301 99.0    1  1 OFFRAP
48 302 99.0    1  1 OFFRAP
48 307  0.3 1000 20 DWNTN TO NB5 ML:UNIV
48 308  0.4 1000 20 DWNTN TO NB5 ML:CHER
48 309 99.0    1  1 OFFRAP
48 311 99.0    1  1 OFFRAP
48 312 99.0    1  1 OFFRAP
48 319  0.3 1000 20 DWNTN TO NB5 EX:PIKE
48 320  0.3 1000 20 DWNTN TO NB5 EX:CHER
48 328  0.2 1000 15 ACCESS ZONE 48 TO SR99
48 335  0.5 1500 25 ACC TO I5 FROM JAMES
49 185  1.7 1000 25 ACCESS KINGDOME TO JCT I5 & WSFRWY
49 309 99.0    1  1 OFFRAP
49 311 99.0    1  1 OFFRAP
49 312 99.0    1  1 OFFRAP
49 321  1.5 1000 25 ACCESS KINGDOME TO WSFRWY
49 327  0.3 1000 25 ACCESS KINGDOME TO SR99 @ 1ST AVE
49 336 99.0    1  1 ONRAP
50 185  1.0 1500 25 MT BAKER TO I5
50 251  1.3 1000 25 ACCESS ZONE 50 TO I90
50 266  0.5 1000 25 ACCESS ZONE 50 TO SR900
51 185  1.0 1000 25 ACCESS INDUSTRY TO JCT I5 & WSFRWY
51 230  0.6  500 25 ACCESS ZONE 51 TO WSF
51 321  1.0 1500 25 INDUSTRY TO WSFRWY
51 336 99.0    1  1 OFFRAP
```

52	289	1.0	1000	25	ACCESS ZONE 52 TO WSF
53	232	1.3	1000	25	ACCESS ZONE 53 TO SR99
53	239	1.4	1000	25	ACCESS ZONE 53 TO SR509
54	186	0.5	1000	25	ACCESS ZONE 54 TO I5
54	231	0.8	1000	25	ACCESS ZONE 54 TO SR509
55	266	2.6	1000	25	ACCESS ZONE 55 TO SR900
55	267	2.3	1000	25	ACCESS ZONE 55 TO SR900
56	217	1.1	1000	25	ACCESS ZONE 56 TO SR509
56	240	2.2	1000	25	ACCESS ZONE 56 TO SR509
56	241	1.2	1000	25	ACCESS ZONE 56 TO SR509
57	215	2.0	1000	25	ACCESS ZONE 57 TO SR99
57	233	2.1	1000	25	ACCESS ZONE 57 TO SR99
57	234	0.8	1000	25	ACCESS ZONE 57 TO SR99
57	241	1.0	1000	25	ACCESS ZONE 57 TO SR509
58	188	1.3	1000	25	ACCESS ZONE 58 TO I5
58	268	1.7	1000	25	ACCESS ZONE 58 TO SR900
58	269	1.6	1000	25	ACCESS ZONE 58 TO SR900
59	211	1.2	1000	25	ACCESS ZONE 59 TO I405
59	213	0.8	1000	25	ACCESS ZONE 59 TO I405
59	268	0.8	1000	25	ACCESS ZONE 59 TO SR900
60	210	1.1	1000	25	ACCESS ZONE 60 TO I405
60	211	0.2	1000	25	ACCESS ZONE 60 TO I405
60	212	0.7	1000	25	ACCESS ZONE 60 TO I405
61	270	0.5	1000	25	ACCESS ZONE 61 TO SR900
62	213	3.2	1000	25	ACCESS ZONE 62 TO I405
62	270	2.4	1000	25	ACCESS ZONE 62 TO SR900
63	250	6.3	1000	25	ACCESS ZONE 63 TO SR520
63	259	2.7	2000	25	ACCESS ZONE 63 TO I90
64	271	7.1	1000	25	ACCESS ZONE 64 TO SR900
64	279	2.7	1000	25	ACCESS ZONE 64 TO SR18
65	214	1.9	1000	25	ACCESS ZONE 65 TO I405
66	214	0.5	1000	25	ACCESS ZONE 66 TO I405
67	213	4.0	1000	25	ACCESS ZONE 67 TO I405
67	276	3.3	1000	25	ACCESS ZONE 67 TO I405
68	235	0.7	1000	25	ACCESS ZONE 68 TO SR99
68	236	1.0	1000	25	ACCESS ZONE 68 TO SR99
68	243	2.5	1000	25	ACCESS ZONE 68 TO SR99
69	190	1.6	1000	25	ACCESS ZONE 69 TO I5
69	191	1.3	1000	25	ACCESS ZONE 69 TO I5
69	192	2.1	1000	25	ACCESS ZONE 69 TO I5
69	272	1.9	1000	25	ACCESS ZONE 69 TO SR167
70	276	2.4	1000	25	ACCESS ZONE 70 TO SR515
70	277	2.2	1000	25	ACCESS ZONE 70 TO SR515
71	193	0.9	1000	25	ACCESS ZONE 71 TO I405
71	236	3.2	1000	25	ACCESS ZONE 71 TO SR99
71	237	1.0	1000	25	ACCESS ZONE 71 TO SR99
72	272	1.6	1000	25	ACCESS ZONE 72 TO SR167
72	273	1.0	1000	25	ACCESS ZONE 72 TO SR167
72	277	1.6	1000	25	ACCESS ZONE 72 TO SR515
72	278	1.2	1000	25	ACCESS ZONE 72 TO SR515
73	280	3.2	1000	25	ACCESS ZONE 73 TO SR18
73	281	2.1	1000	25	ACCESS ZONE 73 TO SR18
74	280	3.0	1000	25	ACCESS ZONE 74 TO SR516
74	282	2.3	1000	25	ACCESS ZONE 74 TO SR516
75	237	3.5	1000	25	ACCESS ZONE 75 TO SR99

75	238	2.1	1000	25	ACCESS ZONE 75 TO SR99
76	194	0.7	1000	25	ACCESS ZONE 76 TO I5
76	237	1.5	1000	25	ACCESS ZONE 76 TO SR99
77	194	1.3	1000	25	ACCESS ZONE 77 TO I5
77	275	1.1	1000	25	ACCESS ZONE 77 TO SR167
78	274	0.8	1000	25	ACCESS ZONE 78 TO SR167
78	275	2.0	1000	25	ACCESS ZONE 78 TO SR167
79	275	1.7	1000	25	ACCESS ZONE 70 TO SR167
79	281	3.0	1000	25	ACCESS ZONE 79 TO SR18
80	195	10.0	1000	25	ACCESS ZONE 80 TO I5
80	238	10.0	1000	25	ACCESS ZONE 80 TO SR99
81	275	7.9	1000	25	ACCESS ZONE 81 TO SR18
81	281	6.3	1000	25	ACCESS ZONE 81 TO SR18
82	163	99.0	1	1	DUMMY
83	163	99.0	1	1	DUMMY
83	260	99.0	1	1	DUMMY
84	218	99.0	1	1	DUMMY
85	164	99.0	1	1	DUMMY
85	218	99.0	1	1	DUMMY
86	164	99.0	1	1	DUMMY
86	283	99.0	1	1	DUMMY
87	165	99.0	1	1	DUMMY
87	283	99.0	1	1	DUMMY
88	196	99.0	1	1	DUMMY
88	260	99.0	1	1	DUMMY
89	166	99.0	1	1	DUMMY
89	196	99.0	1	1	DUMMY
89	283	99.0	1	1	DUMMY
90	167	99.0	1	1	DUMMY Z9
90	168	99.0	1	1	DUMMY Z9
90	219	99.0	1	1	DUMMY Z9
91	165	99.0	1	1	DUMMY Z10
91	167	99.0	1	1	DUMMY Z10
92	219	99.0	1	1	DUMMY Z11
93	220	99.0	1	1	DUMMY Z12
94	169	99.0	1	1	DUMMY Z13
94	170	99.0	1	1	DUMMY Z13
94	171	99.0	1	1	DUMMY Z13
95	168	99.0	1	1	DUMMY Z14
95	171	99.0	1	1	DUMMY Z14
95	196	99.0	1	1	DUMMY Z14
96	196	99.0	1	1	DUMMY Z15
96	197	99.0	1	1	DUMMY Z15
96	260	99.0	1	1	DUMMY Z15
97	172	99.0	1	1	DUMMY Z16
97	221	99.0	1	1	DUMMY Z16
97	222	99.0	1	1	DUMMY Z16
98	171	99.0	1	1	DUMMY Z17
98	172	99.0	1	1	DUMMY Z17
98	173	99.0	1	1	DUMMY Z17
98	264	99.0	1	1	DUMMY Z17
99	199	99.0	1	1	DUMMY Z18
99	263	99.0	1	1	DUMMY Z18
100	197	99.0	1	1	DUMMY Z19
100	198	99.0	1	1	DUMMY Z19

100	262	99.0	1	1	DUMMY	Z19
101	260	99.0	1	1	DUMMY	Z20
101	261	99.0	1	1	DUMMY	Z20
102	199	99.0	1	1	DUMMY	Z21
102	200	99.0	1	1	DUMMY	Z21
103	200	99.0	1	1	DUMMY	Z22
103	286	99.0	1	1	DUMMY	Z22
104	223	99.0	1	1	DUMMY	Z23
104	224	99.0	1	1	DUMMY	Z23
104	225	99.0	1	1	DUMMY	Z23
105	175	99.0	1	1	DUMMY	
105	176	99.0	1	1	DUMMY	
105	290	99.0	1	1	DUMMY	
105	314	99.0	1	1	DUMMY	
106	173	99.0	1	1	DUMMY	Z25
106	174	99.0	1	1	DUMMY	Z25
106	265	99.0	1	1	DUMMY	Z25
107	176	99.0	1	1	DUMMY	
107	177	99.0	1	1	DUMMY	
107	265	99.0	1	1	DUMMY	Z26
107	290	99.0	1	1	DUMMY	
107	291	99.0	1	1	DUMMY	
107	293	99.0	1	1	DUMMY	
107	315	99.0	1	1	DUMMY	
108	201	99.0	1	1	DUMMY	Z27
108	202	99.0	1	1	DUMMY	Z27
109	201	99.0	1	1	DUMMY	Z28
110	250	99.0	1	1	DUMMY	Z29
111	226	99.0	1	1	DUMMY	Z30
111	227	99.0	1	1	DUMMY	Z30
111	228	99.0	1	1	DUMMY	Z30
112	178	99.0	1	1	DUMMY	
112	179	99.0	1	1	DUMMY	
112	180	99.0	1	1	DUMMY	
112	227	99.0	1	1	DUMMY	
112	292	99.0	1	1	DUMMY	
112	294	99.0	1	1	DUMMY	
112	316	99.0	1	1	DUMMY	
112	334	99.0	1	1	DUMMY	
113	178	99.0	1	1	DUMMY	
113	179	99.0	1	1	DUMMY	
113	180	99.0	1	1	DUMMY	
113	244	99.0	1	1	DUMMY	
113	292	99.0	1	1	DUMMY	
113	293	99.0	1	1	DUMMY	
113	294	99.0	1	1	DUMMY	
113	316	99.0	1	1	DUMMY	
114	181	99.0	1	1	DUMMY	
114	182	99.0	1	1	DUMMY	
114	244	99.0	1	1	DUMMY	Z33
114	295	99.0	1	1	DUMMY	
114	297	99.0	1	1	DUMMY	
115	245	99.0	1	1	DUMMY	Z34
115	246	99.0	1	1	DUMMY	Z34
115	247	99.0	1	1	DUMMY	Z34

116	248	99.0	1	1	DUMMY	Z35
116	249	99.0	1	1	DUMMY	Z35
117	228	99.0	1	1	DUMMY	Z36
117	229	99.0	1	1	DUMMY	Z36
118	228	99.0	1	1	DUMMY	Z37
118	229	99.0	1	1	DUMMY	Z37
119	183	99.0	1	1	DUMMY	
119	306	99.0	1	1	DUMMY	
119	309	99.0	1	1	DUMMY	
119	311	99.0	1	1	DUMMY	
119	312	99.0	1	1	DUMMY	
120	204	99.0	1	1	DUMMY	Z39
120	247	99.0	1	1	DUMMY	Z39
120	288	99.0	1	1	DUMMY	Z39
121	204	99.0	1	1	DUMMY	Z40
122	204	99.0	1	1	DUMMY	Z41
122	205	99.0	1	1	DUMMY	Z41
123	204	99.0	1	1	DUMMY	Z42
123	248	99.0	1	1	DUMMY	Z42
123	257	99.0	1	1	DUMMY	Z42
124	204	99.0	1	1	DUMMY	Z43
124	256	99.0	1	1	DUMMY	Z43
125	207	99.0	1	1	DUMMY	Z44
125	257	99.0	1	1	DUMMY	Z44
126	208	99.0	1	1	DUMMY	Z45
126	209	99.0	1	1	DUMMY	Z45
126	210	99.0	1	1	DUMMY	Z45
127	253	99.0	1	1	DUMMY	Z46
127	254	99.0	1	1	DUMMY	Z46
127	255	99.0	1	1	DUMMY	Z46
128	183	99.0	1	1	DUMMY	
128	229	99.0	1	1	DUMMY	
128	298	99.0	1	1	DUMMY	
128	299	99.0	1	1	DUMMY	
128	300	99.0	1	1	DUMMY	
128	317	99.0	1	1	DUMMY	
128	318	99.0	1	1	DUMMY	
129	300	99.0	1	1	DUMMY	
129	301	99.0	1	1	DUMMY	
129	302	99.0	1	1	DUMMY	
129	307	99.0	1	1	DUMMY	
129	308	99.0	1	1	DUMMY	
129	309	99.0	1	1	DUMMY	
129	311	99.0	1	1	DUMMY	
129	312	99.0	1	1	DUMMY	
129	319	99.0	1	1	DUMMY	
129	320	99.0	1	1	DUMMY	
129	328	99.0	1	1	DUMMY	
129	335	99.0	1	1	DUMMY	
130	185	99.0	1	1	DUMMY	
130	309	99.0	1	1	DUMMY	
130	311	99.0	1	1	DUMMY	
130	312	99.0	1	1	DUMMY	
130	321	99.0	1	1	DUMMY	
130	327	99.0	1	1	DUMMY	

130	336	99.0	1	1	DUMMY	
131	185	99.0	1	1	DUMMY	
131	251	99.0	1	1	DUMMY	Z50
131	266	99.0	1	1	DUMMY	Z50
132	185	99.0	1	1	DUMMY	
132	230	99.0	1	1	DUMMY	Z51
132	321	99.0	1	1	DUMMY	
132	336	99.0	1	1	DUMMY	
133	289	99.0	1	1	DUMMY	Z52
134	232	99.0	1	1	DUMMY	Z53
134	239	99.0	1	1	DUMMY	Z53
135	186	99.0	1	1	DUMMY	Z54
135	231	99.0	1	1	DUMMY	Z54
136	266	99.0	1	1	DUMMY	Z55
136	267	99.0	1	1	DUMMY	Z55
137	217	99.0	1	1	DUMMY	Z56
137	240	99.0	1	1	DUMMY	Z56
137	241	99.0	1	1	DUMMY	Z56
138	215	99.0	1	1	DUMMY	Z57
138	233	99.0	1	1	DUMMY	Z57
138	234	99.0	1	1	DUMMY	Z57
138	241	99.0	1	1	DUMMY	Z57
139	188	99.0	1	1	DUMMY	Z58
139	268	99.0	1	1	DUMMY	Z58
139	269	99.0	1	1	DUMMY	Z58
140	211	99.0	1	1	DUMMY	Z59
140	213	99.0	1	1	DUMMY	Z59
140	268	99.0	1	1	DUMMY	Z59
141	210	99.0	1	1	DUMMY	Z60
141	211	99.0	1	1	DUMMY	Z60
141	212	99.0	1	1	DUMMY	Z60
142	270	99.0	1	1	DUMMY	Z61
143	213	99.0	1	1	DUMMY	Z62
143	270	99.0	1	1	DUMMY	Z62
144	250	99.0	1	1	DUMMY	Z63
144	259	99.0	1	1	DUMMY	Z63
145	271	99.0	1	1	DUMMY	Z64
145	279	99.0	1	1	DUMMY	Z64
146	214	99.0	1	1	DUMMY	Z65
147	214	99.0	1	1	DUMMY	Z66
148	213	99.0	1	1	DUMMY	Z67
148	276	99.0	1	1	DUMMY	Z67
149	235	99.0	1	1	DUMMY	Z68
149	236	99.0	1	1	DUMMY	Z68
149	243	99.0	1	1	DUMMY	Z68
150	190	99.0	1	1	DUMMY	Z69
150	191	99.0	1	1	DUMMY	Z69
150	192	99.0	1	1	DUMMY	Z69
150	272	99.0	1	1	DUMMY	Z69
151	276	99.0	1	1	DUMMY	Z70
151	277	99.0	1	1	DUMMY	Z70
152	193	99.0	1	1	DUMMY	Z71
152	236	99.0	1	1	DUMMY	Z71
152	237	99.0	1	1	DUMMY	Z71
153	272	99.0	1	1	DUMMY	Z72

153	273	99.0	1	1	DUMMY Z72
153	277	99.0	1	1	DUMMY Z72
153	278	99.0	1	1	DUMMY Z72
154	280	99.0	1	1	DUMMY Z73
154	281	99.0	1	1	DUMMY Z73
155	280	99.0	1	1	DUMMY Z74
155	282	99.0	1	1	DUMMY Z74
156	237	99.0	1	1	DUMMY Z75
156	238	99.0	1	1	DUMMY Z75
157	194	99.0	1	1	DUMMY Z76
157	237	99.0	1	1	DUMMY Z76
158	194	99.0	1	1	DUMMY Z77
158	275	99.0	1	1	DUMMY Z77
159	274	99.0	1	1	DUMMY Z78
159	275	99.0	1	1	DUMMY Z78
160	275	99.0	1	1	DUMMY Z79
160	281	99.0	1	1	DUMMY Z79
161	195	99.0	1	1	DUMMY Z80
161	238	99.0	1	1	DUMMY Z80
162	275	99.0	1	1	DUMMY Z81
162	281	99.0	1	1	DUMMY Z81
163	82	3.5	1000	25	ACCESS Z1 5
163	83	12.0	1000	25	ACCESS Z2 5
163	164	2.8	4650	55	SB5: 526 TO 128th
164	85	1.6	1000	25	ACCESS Z4 5
164	86	2.4	1000	25	ACCESS Z5 5
164	163	2.8	4650	55	NB5: 128t TO 526
164	165	2.5	4650	55	SB5: 128t TO 164th
165	87	2.8	1000	25	ACCESS Z6 5
165	91	1.3	1000	25	ACCESS Z10 5
165	164	2.5	4650	55	NB5: 164t TO 128th
165	166	1.3	6200	55	SB5: 164t TO 405
166	89	1.5	1000	25	ACCESS SR5 TO ZONE 8
166	165	1.3	6200	55	NB5: 405 TO 164th
166	167	1.1	6000	55	SB5: 405 TO 196th
166	196	3.5	3100	55	SB405: 5 TO 527
166	218	2.7	2000	55	NB525: 405 TO 99
167	90	1.4	1000	25	ACCESS Z9 5
167	91	1.0	1000	25	ACCESS Z10 5
167	166	1.1	6000	55	NB5: 196t TO 405
167	168	0.8	6000	55	SB5: 196t TO 44th
168	90	1.0	1000	25	ACCESS Z9 5
168	95	2.2	1000	25	ACCESS Z14 5
168	167	0.8	6000	55	NB5: 44th TO 196th
168	169	1.4	6000	55	SB5: 44th TO 220th
168	219	1.6	1000	25	524 5 TO 99
169	94	0.8	1000	25	ACCESS Z13 5
169	168	1.4	6000	55	NB5: 220t TO 44th
169	170	1.0	6000	55	SB5: 220t TO 236th
170	94	0.5	1000	25	ACCESS Z13 5
170	169	1.0	6000	55	NB5: 236t TO 220th
170	171	0.5	6000	55	SB5: 236t TO 205th
171	94	1.0	1000	25	ACCESS Z13 5
171	95	3.3	1000	25	ACCESS Z14 5
171	98	1.6	1000	25	ACCESS Z17 5

171	170	0.5	6000	55	NB5: 205t TO 236th
171	172	1.6	6000	55	SB5: 205t TO 175th
171	220	1.8	1000	25	W104 5 TO 99
171	264	2.6	1550	30	E104 5 TO 522
172	97	0.8	1000	25	ACCESS Z16 5
172	98	1.3	1000	25	ACCESS Z17 5
172	171	1.6	8000	55	NB5: 175t TO 205th
172	173	1.6	6000	55	SB5: 175t TO 145th
172	332	0.8	1000	25	WB 175TH: ML5 TO SR99
173	98	1.9	1000	25	ACCESS Z17 5
173	106	1.9	1000	25	ACCESS Z25 5
173	172	1.6	8000	55	NB5: 145t TO 175th
173	174	0.8	8000	55	SB5: 145t TO 125th
173	331	1.5	1500	25	EB 145TH:ML5 TO SR522
173	333	1.0	1000	25	WB 145TH:ML5 TO SR99
174	106	1.4	1000	25	ACCESS Z25 5
174	173	0.8	8000	55	NB5: 125t TO 145th
174	175	1.4	8000	55	SB5: 125t TO NORTHGGATE
175	105	0.5	1500	25	SB5: TO NORTHGATE:GREENWOOD
175	174	1.4	8000	55	NB5::NORTHGATE TO 130TH
175	224	0.7	700	25	WB 175TH:ML5 TO SR99
175	290	1.1	8000	55	NORTHGATE TO 85TH ML5 SB
175	330	1.5	1000	25	EB NORTHGATE WAY:ML5 TO SR522
176	105	1.2	1000	25	NB5: TO GREEN:85TH
176	107	2.7	1000	25	NB5: TO WEDGE:85TH
176	175	1.6	8000	55	85TH TO NORTHGATE ML5 NB
176	290	0.1	1500	25	WB 85TH:NB5: TO SB5:
177	107	2.5	1000	25	NB5: TO WEDGE:LAKE CI
177	176	0.7	8000	55	LAKE CITY OFF TO 85TH ML5 NB
177	329	0.6	1100	45	NB 522:NB I5 TO JCT EX RAMP
178	112	1.2	1000	25	NB5: TO WALLING:RAVEN
178	113	2.2	1000	25	NB5: TO UDIST:RAVENNA
178	177	0.5	8000	55	RAVENNA OFF TO LAKE CITY OFF ML5 NB
179	112	99.0	1	1	ONRAP
179	113	99.0	1	1	ONRAP
179	178	0.4	10000	55	50TH ON TO RAVENNA OFF ML5 NB
180	112	1.0	1500	25	NB5: TO WALLING:45TH
180	113	1.9	1000	25	NB5: TO UDIST:45TH
180	179	0.3	8000	55	N45TH TO 50TH ON ML5 NB
180	294	0.1	1500	25	N45TH: NB5 TO SB5
181	114	99.0	1	1	ONRAMP ONLY
181	180	1.4	8000	55	SR520 TO 45TH ML5 NB
181	325	0.2	1700	30	NB5: TO EB520
182	114	1.2	1500	25	NB5: ML TO ROANOKE
182	181	0.5	8000	55	ROANOKE TO SR520 ML5 NB
183	119	99.0	1	1	ONRAP
183	128	0.5	1000	20	NB5: ML TO ZONE 47:MR
183	182	1.0	8000	55	MERCER TO ROANOKE ML5 NB
184	251	0.3	1800	40	RAMP: NB5: TO EB90
184	310	1.2	6000	55	JCT NBCD TO JCT NBEX ML5 NB
184	313	0.6	2000	55	JCT NBCD TO JCT WB90 CD5 NB
185	130	1.7	1000	25	ACCESS JCT I5 & WSFRWY TO KINGDOME
185	131	1.0	1500	25	I5 TO MT BAKER
185	132	1.0	2000	25	ACCESS JCT I5 & WSFRWY TO INDUSTRY
185	184	1.1	8000	55	WEST SEATTLE FRWY TO JCT NBCD ML5 NB

185	186	1.7	8000	55	SB5: WSF TO MICHIGAN
185	321	0.5	4000	40	JCT I5 TO 4TH MLWS WB
186	135	0.5	1000	25	ACCESS Z54 5
186	185	1.7	8000	55	NB5: MICH TO WSF
186	187	3.3	8000	55	SB5: MICH TO BOEING ACCESS
187	186	3.3	8000	55	NB5: BOEING ACCESS TO MICHIGAN
187	188	2.1	8000	55	SB5: BOEING ACCESS TO 599
187	267	0.2	1500	35	I5 TO ML KING
188	139	1.3	1000	25	ACCESS Z58 5
188	187	2.1	8000	55	NB5: 599 TO BOEING ACCESS
188	189	1.5	12000	55	SB5: 599 TO 405
188	234	1.7	3100	25	NB5: 99 5 TO 99
189	188	1.5	10000	55	NB5: 405 TO 599
189	190	2.2	8000	55	SB5: 405 TO 188TH
189	214	2.3	3000	55	N405 5 TO 167
189	215	1.3	5000	55	E518 5 TO 99
190	150	1.6	1000	25	ACCESS Z69 5
190	189	2.2	8000	55	NB5: 188T TO 405
190	191	1.1	8000	55	SB5: 188T TO MILITARY
190	235	1.1	2000	25	W188TH 5 TO 99
191	150	1.3	1000	25	ACCESS Z69 5
191	190	1.1	8000	55	NB5: MILI TO 188TH
191	192	2.0	8000	55	SB5: MILI TO 516
192	150	2.1	1000	25	ACCESS Z69 5
192	191	2.0	8000	55	NB5: 516 TO MILITARY
192	193	2.4	8000	55	SB5: 516 TO 272Nd
192	273	2.6	3100	25	E516 5 TO 167
193	152	0.9	1000	25	ACCESS Z71 405
193	192	2.4	8000	55	NB5: 272N TO 516
193	194	3.0	8000	55	SB5: 272N TO 320TH
194	157	0.7	1000	25	ACCESS Z76 5
194	158	1.3	1000	25	ACCESS Z77 5
194	193	3.0	8000	55	NB5: 320T TO 272ND
194	195	1.9	8000	55	SB5: 320T TO 18
195	161	10.0	1000	25	ACCESS Z80 5
195	194	1.9	8000	55	NB5: 18 TO 320TH
195	238	2.9	3100	55	S18 5 TO 99
195	275	2.9	3100	55	N18 5 TO 167
196	88	3.0	1000	25	ACCESS Z7 405
196	89	2.4	1000	25	ACCESS Z8 405
196	95	1.7	1000	25	ACCESS Z14 405
196	96	2.2	1000	25	ACCESS Z15 405
196	166	3.5	3100	55	N405 527 TO 5
196	197	2.3	3100	55	S405 527 TO BEARDSLEE
196	283	4.0	1550	25	N527 405 TO 164TH
197	96	1.9	1000	25	ACCESS Z15 405
197	100	0.2	1000	25	ACCESS Z19 405
197	196	2.3	3100	55	N405 BEAR TO 527
197	198	0.9	3100	55	S405 BEAR TO 522
198	100	0.5	1000	25	ACCESS Z19 405
198	197	0.9	3100	55	N405 522 TO BEARDSLEE
198	199	0.9	6000	55	S405 522 TO 160TH
198	261	1.0	3100	25	N522 405 TO 202
198	262	1.3	3100	35	S522 405 TO 527
199	99	2.1	1000	25	ACCESS Z18 405

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199 102  0.8 1000 25 ACCESS Z21 405
199 198  0.9 6000 55 N405 160T TO 522
199 200  2.3 6000 55 S405 160T TO 124TH
200 102  1.7 1000 25 ACCESS Z21 405
200 103  1.6 1000 25 ACCESS Z22 405
200 199  2.3 6000 55 N405 124T TO 160TH
200 201  2.2 6000 55 S405 124T TO 908
201 108  0.5 1000 25 ACCESS Z27 405
201 109  1.6 1000 25 ACCESS Z28 405
201 200  2.2 6000 55 N405 908 TO 124TH
201 202  0.7 6000 55 S405 908 TO 70TH
201 284  2.5 3100 25 S908 405 TO WILLOWS RD
201 287  1.1 3100 25 W908 405 TO LK WA BL
202 108  0.2 1000 25 ACCESS Z27 405
202 201  0.7 6000 55 N405 70TH TO 908
202 203  2.6 6000 55 S405 70TH TO 520
203 202  2.6 6000 55 N405 520 TO 70TH
203 204  1.0 8000 55 S405 520 TO 8TH
203 247  1.0 4000 55 W520 405 TO LK WA BL
203 248  2.2 4000 55 E520 405 TO 148TH
204 120  0.5 1000 25 ACCESS Z39 405
204 121  1.1 1000 25 ACCESS Z40 405
204 122  1.6 1000 25 ACCESS Z41 405
204 123  2.7 1000 25 ACCESS Z42 405
204 124  1.7 1000 25 ACCESS Z43 405
204 203  1.0 8000 55 N405 8TH TO 520
204 205  1.7 6000 55 S405 8TH TO 132ND
205 122  0.8 1000 25 ACCESS Z41  405
205 204  1.7 6000 55 N405 132N TO 8TH
205 206  1.0 6000 55 S405 132N TO 90
206 205  1.0 6000 55 N405 90 TO 132ND
206 207  0.9 6000 55 S405 90 TO COAL CRK
206 256  0.9 6000 55 W90 405 TO BELL WY
206 257  1.510000 55 E90 405 TO 148TH
207 125  1.3 1000 25 ACCESS Z44 405
207 206  0.9 6000 55 N405 COAL CRK TO 90
207 208  0.9 5000 55 S405 COAL CK TO LK WA BL
208 126  2.2 1000 25 ACCESS Z45 405
208 207  0.9 5000 55 N405  LK WA BLVD- COAL CK
208 209  1.8 5000 55 S405  LK WA BLVD- 44TH
209 126  1.6 1000 25 ACCESS Z45 405
209 208  1.8 5000 55 N405 44TH TO LK WA BL
209 210  1.0 5000 55 S405 44TH TO 30TH
210 126  2.1 1000 25 ACCESS Z45 405
210 141  1.1 1000 25 ACCESS Z60 405
210 209  1.0 5000 55 N405 30TH TO 44TH
210 211  1.1 5000 55 S405 30TH TO  900
211 140  1.2 1000 25 ACCESS Z59 405
211 141  0.2 1000 25 ACCESS Z60 405
211 210  1.1 5000 55 N405 900 TO 30TH
211 212  0.9 5000 55 S405 900 TO SUNSET BL
211 270  1.8 5000 55 E900 405 TO 138TH
212 141  0.7 1000 25 ACCESS Z60 405
212 211  0.9 5000 55 N405 SUNS BL TO 900
212 213  0.5 5000 55 S405 SUNS BL TO 169
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213	140	0.8	1000	25	ACCESS Z59 405
213	143	3.2	1000	25	ACCESS Z62 405
213	148	4.0	1000	25	ACCESS Z67 405
213	212	0.5	5000	55	N405 169 TO SUNSET BL
213	214	1.7	4000	55	S405 169 TO 167
213	269	0.3	4000	25	W900 405 TO 515
213	279	8.7	4000	25	S169 405 TO 18
214	146	1.9	1000	25	
214	147	0.5	1000	25	ACCESS Z66 405
214	189	2.3	4000	55	S405 167 TO 5
214	213	1.7	4000	55	N405 167 TO 169
214	268	0.9	1500	35	N167 405 TO 900
214	272	5.0	4000	55	S167 405 TO 84TH
215	138	2.0	1000	25	ACCESS Z57 99
215	189	1.3	4000	55	E518 99 TO 5
215	216	1.9	4000	55	W518 99 TO DESMOINES WY
215	234	2.7	4000	25	N99 518 TO 599
215	235	2.1	4000	25	S99 518 TO 188TH
216	215	1.9	4000	55	E518 DESMOINES WY TO 99
216	217	0.6	2000	35	W518 DESMOINES WY TO 508
217	137	1.1	1000	25	ACCESS Z56 509
217	216	0.6	4000	55	E518 508 TODESMOINES WY
217	241	1.3	4000	55	N509 518 TO 128TH
217	242	0.8	4000	55	518 TO 160TH
218	84	1.3	1000	25	ACCESS Z3 99
218	85	2.4	1000	25	ACCESS Z4 99
218	166	2.7	2000	55	S525 99 TO 405
218	219	3.8	2500	30	S99 525 TO 524
219	90	0.3	1000	25	ACCESS Z9 99
219	92	1.6	1000	25	ACCESS Z11 99
219	168	1.6	1000	25	524 99 TO 5
219	218	3.8	2500	30	N99 524 TO 525
219	220	3.2	2500	30	S99 524 TO 104
220	93	1.3	1000	25	ACCESS Z12 99
220	171	1.8	1000	25	E104 99 TO 5
220	219	3.2	2500	30	N99 104 TO 524
220	221	1.1	2500	30	S99 104 TO RICHMOND BCH
221	97	0.6	1000	25	ACCESS Z16 99
221	220	1.1	2500	30	N99 RICH BCH TO 104
221	332	0.5	2500	30	SB SR99:185TH TO 175TH
222	97	0.8	1000	25	ACCESS Z16 99
222	332	0.8	2500	30	NB SR99:WESTMINSTER TO 175TH
222	333	0.7	2500	30	SB SR99:WESTMINSTER TO 145TH
223	104	1.3	1000	25	ACCESS Z23 99
223	224	1.5	2500	30	S99 130T TO HOLMAN RD
223	333	0.7	2500	30	NB SR99:130TH TO 145TH
224	104	0.7	1000	25	ACCESS Z23 99
224	175	0.7	1000	25	EB 175TH:SR99 TO ML5
224	223	1.5	2500	30	N99 HOLM RD TO 130TH
224	225	0.8	1800	30	S99 HOLM RD TO 85TH
225	104	1.4	1000	25	ACCESS Z23 99
225	224	0.8	2500	30	N99 85TH TOHOLMAN RD
225	226	0.6	2500	30	S99 85TH TO GREEN LK
225	290	0.7	1000	25	WB 85TH:SR99 TO SB5:
226	111	1.3	1000	25	ACCESS Z30 99

226	225	0.6	2500	30	N99 GREEN LK TO 85TH
226	227	1.4	3600	45	S99 GREEN LK TO 45TH
227	111	1.4	1000	25	ACCESS Z30 99
227	112	0.7	1500	25	SR99 TO WALLINGFORD
227	226	1.4	5400	45	N99 45TH TO GREEN LK
227	228	1.3	3600	45	S99 GREEN LAKE TO BRIDGEWY
227	334	0.7	1500	25	SR99 TO 45TH
228	111	2.2	1000	25	ACCESS Z30 99
228	117	2.2	1000	25	ACCESS Z36 99
228	118	1.0	1000	25	ACCESS Z37 99
228	227	1.3	5400	45	N99 BRID WY TO GREEN LK
228	229	2.1	5400	45	S99 BRID WY TO BATTERY
229	117	3.3	1000	25	ACCESS Z36 99
229	118	1.6	1000	25	ACCESS Z37 99
229	128	0.3	1000	15	ACCESS SR99 TO ZONE 47
229	228	2.1	5400	45	N99 BATT TOBRIDGE WY
229	328	0.6	6000	50	SB SR99:BATTERY TO DWNTWN
230	132	0.6	1000	25	ACCESS Z51 WSF
230	231	1.7	2600	30	S99 WSF TO EMW
230	327	1.7	6000	50	NB SR99: WSFRWY TO 1ST AVE
231	135	0.8	1000	25	ACCESS Z54509
231	230	1.7	2600	30	N99 EMW TO WSF
231	232	1.1	2600	30	S99 EMW TO MWS
232	134	1.3	1000	25	ACCESS Z53 99
232	231	1.1	2600	30	N99 MWS TO EMW
232	233	1.3	3100	25	S99 509 TO DESMOINES WY
232	239	0.3	4000	55	S509 MWS TO CLOVERDALE
233	138	2.1	1000	25	ACCESS Z57 99
233	232	1.3	3100	25	N99 DESMOINES WY
233	234	1.7	3100	25	S99 DESMOINES WY
234	138	0.8	1000	25	ACCESS Z57 99
234	188	1.7	3100	25	S599 99 TO 5
234	215	2.7	3100	25	S99 599 TO 518
234	233	1.7	3100	25	N99 599 TO DESMOINES
235	149	0.7	1000	25	ACCESS Z68 99
235	190	1.0	2500	35	E188TH 99 TO 5
235	215	2.1	2000	25	N99 188T TO 518
235	236	2.8	2000	25	S99 188T TO 516
235	243	1.0	2000	25	W188TH 99 TO 508
236	149	1.0	1000	25	ACCESS Z68 99
236	152	3.2	1000	25	ACCESS Z71 99
236	235	2.8	2000	25	N99 516 TO 188TH
236	237	4.1	2000	25	S99 516 TO 509
237	152	1.0	1000	25	ACCESS Z71 99
237	156	3.5	1000	25	ACCESS Z75 99
237	157	1.5	1000	25	ACCESS Z76 99
237	236	4.1	2000	25	N99 509 TO 516
237	238	3.2	3100	25	S99 509 TO 18
238	156	2.1	1000	25	ACCESS Z75 99
238	161	10.0	1000	25	ACCESS Z80 99
238	195	2.9	3100	55	N18 99 TO 5
238	237	3.2	3100	25	N99 18 TO 509
239	134	1.4	1000	25	ACCESS Z53 509
239	232	0.3	4000	55	N509 CLOV TO MWS
239	240	1.6	4000	55	S509 CLOV TO GLENDALE

240	137	2.2	1000	25	ACCESS Z56 509
240	239	1.6	4000	55	N509 GLEN TO CLOVERDALE
240	241	1.0	4000	55	S509 GLEN TO 128TH
241	137	1.2	1000	25	ACCESS Z56 509
241	138	1.0	1000	25	ACCESS Z57 509
241	217	1.3	4000	55	S509 128T TO 518
241	240	1.0	4000	55	N509 128T TO GLENDALE
242	217	0.8	4000	55	160TH TO 518
242	243	2.1	4000	55	160TH TO DESMOINES WY
243	149	2.5	1000	25	ACCESS Z68 509
243	235	1.0	2500	35	E188TH 508 TO 99
243	242	2.1	4000	55	DESMOINES WY TO 160TH
244	113	3.0	700	25	MONTLAKE TO U-DIST FROM SR520
244	114	0.6	1000	25	ACCESS Z33 520
244	245	3.7	3600	55	E520 MONT TO 84TH
244	326	0.6	4000	55	WB520 TO I5 RAMPS
245	115	0.4	1000	25	ACCESS Z34 520
245	244	3.7	4000	55	W520 84TH TO MONTLAKE
245	246	0.7	4000	55	E520 84TH TO 92ND
246	115	0.7	1000	25	ACCESS Z3 4520
246	245	0.7	4000	55	W520 92ND TO 84TH
246	247	0.7	4000	55	E520 92ND TO LAKE WASH BLVD
247	115	1.3	1000	25	ACCESS Z34 520
247	120	1.5	1000	25	ACCESS Z39 520
247	203	1.0	4000	55	E520 LAKE WASH BLVD TO 405
247	246	0.7	4000	55	W520 LAKE WASH BLVD TO 92ND
247	287	2.5	3100	25	N908 520 TO CENTRA WY
247	288	1.0	3100	25	SBELL WY 520 TO 8TH
248	116	0.7	1000	25	ACCESS Z35 520
248	123	1.3	1000	25	ACCESS Z42 520
248	203	2.2	4000	55	W520 148T TO405
248	249	2.7	4000	55	E520 148T TO 908
249	116	2.0	1000	25	ACCESS Z3 5520
249	248	2.7	4000	55	W520 908 TO 148TH
249	250	1.0	4000	25	E920 908 TO 202
249	284	0.7	1550	25	N908 520 TO WILLOWS RD
250	110	5.8	1000	25	ACCESS Z29 520
250	144	16.3	1000	25	ACCESS Z63 520
250	249	1.0	4000	25	W920 202 TO 908
250	285	0.8	3100	25	N202 520 TO 164TH
251	131	1.3	1000	25	ACCESS Z50 90
251	252	1.0	4800	55	RAINIER TO LAKE WASH BLVD
251	266	1.1	1500	35	E900 90 TO M.L. KING Jr. WAY
251	313	0.3	1800	40	RAMP: WB90 TO NB5:
251	337	0.3	1800	40	RAMP: WB90 TO SB5:
252	251	1.0	1670	55	LAKE WASH BLVD TO RAINIER
252	253	2.5	5400	55	E90 LAKE WASH BLVD TO W MERCER
253	127	1.9	1000	25	ACCESS Z46 90
253	252	2.5	1670	55	W90 W MERCER TO LAKE WASH BLVD
253	254	0.9	6680	55	E90 W MERCER TO ICW
254	127	1.0	1000	25	ACCESS Z46 90
254	253	0.9	2000	55	W90 ICW TO W MERCER
254	255	1.2	6680	55	E90 ICW TO E MERCER
255	127	0.8	1000	25	ACCESS Z46 90
255	254	1.2	3100	55	W90 E MERCER TO ICW

255	256	0.7	6680	55	E90 E MERCER TO BELL WY
256	124	1.0	1000	25	ACCESS Z43 90
256	206	0.9	8000	55	E90 BELL WY TO 405
256	255	0.7	6000	55	W90 BELL WY TO E MERCER
256	288	2.7	3100	25	NBELL WY 90 TO 8TH
257	123	1.8	1000	25	ACCESS I90 TO ZONE 42
257	125	0.8	1000	25	ACCESS Z44 90
257	206	1.5	8000	55	W90 148T TO 405
257	258	2.3	8000	55	E90 148T TO 901
258	257	2.3	8000	55	W90 901 TO 148TH
258	259	2.1	8000	55	E90 901 TO 900
259	144	2.7	2000	25	ACCESS Z63 90
259	258	2.1	8000	55	W90 900 TO 901
259	271	0.5	3100	55	W900 90 TONEWPORT WY
260	83	7.1	1000	25	ACCESS Z2 522
260	88	4.4	1000	25	ACCESS Z7 522
260	96	1.0	1000	25	ACCESS Z15 522
260	101	2.8	1000	25	ACCESS Z20 522
260	261	2.0	3100	55	S522 9 TO 202
261	101	2.1	1000	25	ACCESS Z20 522
261	198	1.0	3100	55	S522 202 TO 405
261	260	2.0	3100	55	N522 202 TO 9
261	285	6.9	1550	25	S202 522 TO REDMOND WY
262	100	0.7	1000	25	ACCESS Z19 522
262	198	1.3	2500	35	N522 527 TO 405
262	263	2.6	2500	35	S522 527 TO 68TH
263	99	0.9	1000	25	ACCESS Z18 522
263	262	2.6	2500	35	N522 68TH TO 527
263	264	1.4	2500	35	S522 68TH TO 104
264	98	1.3	1000	25	ACCESS Z17 522
264	171	2.6	1550	30	W104 522 TO 5
264	263	1.4	2500	35	N522 104 TO 68TH
264	331	1.6	2000	35	SB 522:SR104 TO 145TH
265	106	0.6	1000	25	ACCESS Z25522
265	107	1.6	1000	25	ACCESS Z26522
265	330	0.7	2000	35	SB 522:SR513 TO NORTHGATE WAY
265	331	1.0	2000	35	NB 522:SR513TO 145TH
266	131	0.5	1000	25	ACCESS Z50 900
266	136	2.6	1000	25	ACCESS Z55 900
266	251	1.1	1500	35	W900 M.L. KING Jr. WAY TO90
266	267	4.9	1500	35	E900 M.L. KING Jr. WAY TO 5
266	268	8.5	1500	35	S167 M.L. KING Jr. WAY TO 900
267	136	2.3	1000	25	ACCESS Z55 900
267	187	0.2	1500	35	ML KING TO I5
267	266	4.9	1500	35	W900 5 TO M.L. KING Jr. WAY
267	268	3.9	1500	35	E900 5 TO 167
268	139	1.7	1000	25	ACCESS Z58 900
268	140	0.8	1000	25	ACCESS Z59 900
268	214	0.9	1500	35	S167 900 TO 405
268	266	8.5	1500	35	N167 900 TO M.L. KING Jr. WAY
268	267	3.9	1500	35	W900 167 TO 5
268	269	0.6	1000	25	E900 167 TO 515
269	139	1.6	1000	25	ACCESS Z58 900
269	213	0.5	3100	25	E900 515 TO 405
269	268	0.6	1000	25	W900 515 TO 167

269	276	2.6	3100	25	S515 900 TO 176TH
270	142	0.5	1000	25	ACCESS Z61 900
270	143	2.4	1000	25	ACCESS Z62 900
270	211	1.8	3100	55	W900 138T TO 405
270	271	6.8	1550	55	E900 138T TONEWPORTWY
271	145	7.1	1000	25	ACCESS Z64 900
271	259	0.5	3100	55	E900 NEWP WY TO 90
271	270	6.8	1550	55	W900 NEWP WY TO 138TH
272	150	1.9	1000	25	ACCESS Z69 167
272	153	1.6	1000	25	ACCESS Z72 167
272	214	5.0	3100	55	N167 84TH TO 405
272	273	1.7	3100	55	S167 84TH TO 84TH
273	153	1.0	1000	25	ACCESS Z72 167
273	192	2.6	3100	25	W516 167 TO 5
273	272	1.7	3100	55	N167 516 TO 84TH
273	274	4.1	3100	55	S167 516 TO 277TH
273	278	2.7	3100	25	E516 167 TO 515
274	159	0.8	1000	25	ACCESS Z78 167
274	273	4.1	3100	55	N167 277T TO 516
274	275	1.4	3100	55	S167 277T TO 18
275	158	1.1	1000	25	ACCESS Z77 167
275	159	2.0	1000	25	ACCESS Z78 167
275	160	1.7	1000	25	ACCESS Z79 167
275	162	7.9	1000	25	ACCESS Z81 18
275	195	2.9	3100	55	S18 167 TO 5
275	274	1.4	3100	55	N167 18 TO 277TH
275	281	3.3	3100	55	N18 167 TO AUB/BLK DIAMOND
276	148	3.3	1000	25	ACCESS Z67 405
276	151	2.4	1000	25	ACCESS Z70 515
276	269	2.6	3100	25	N515 176T TO 900
276	277	4.1	1550	25	S515 276T TO 240TH
277	151	2.2	1000	25	ACCESS Z70 515
277	153	1.6	1000	25	ACCESS Z72 515
277	276	4.1	1550	25	N515 240T TO 276TH
277	278	1.0	1550	25	S515 240T TO 516
278	153	1.2	1000	25	ACCESS Z72 515
278	273	2.7	3100	25	W516 515 TO 167
278	277	1.0	1550	25	N515 516 TO 240TH
278	280	4.1	1550	25	E516 515 TO 18
279	145	2.7	1000	25	ACCESS Z64 18
279	213	8.7	1550	25	N169 18 TO 405
279	280	5.4	1550	55	S18 169 TO 516
279	282	3.8	1550	25	S169 18 TO 516
280	154	3.2	1000	25	ACCESS Z73 18
280	155	3.0	1000	25	ACCESS Z74 516
280	278	4.1	1550	25	W516 18 TO 515
280	279	5.4	1550	55	N18 516 TO 169
280	281	5.2	1550	55	S18 516 TOAUB/BLK DIAMOND
280	282	4.8	1550	25	E516 18 TO 169
281	154	2.1	1000	25	ACCESS Z73 18
281	160	3.0	1000	25	ACCESS Z79 18
281	162	6.3	1000	25	ACCESS Z81 18
281	275	3.3	3100	55	S18 AUB/DIAMOND TO 167
281	280	5.2	1550	55	N18 AUB/DIAMOND TO 516
282	155	2.3	1000	25	ACCESS Z74 516

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282 279  3.8 1550 25 N169 516 TO 18
282 280  4.8 1550 25 W516 169 TO 18
283  86  3.2 1000 25 ACCESS  Z5 527
283  87  1.3 1000 25 ACCESS  Z6 527
283  89  1.6 1000 25 ACCESS  Z8 527
283 196  4.0 1550 25 S527 164T TO 405
284 201  2.5 3100 25 N908 WILL RD TO 405
284 249  0.7 1550 25 S908 WILL RD TO 520
284 285  0.6 3100 25 S908
285 250  0.8 3100 25 S202 164T TO 520
285 261  6.9 1550 25 N202 REDM  WY TO  522
285 284  0.6 3100 25 N908
286 103  0.6 1000 25 ACCESS Z22 908
286 287  1.9 1550 25 S MARKET 116 TO CENTRAL
287 201  1.1 3100 25 E908 LAKE WASH BLVD TO 405
287 247  2.5 3100 25 S908 CENT WY TO 520
287 286  1.9 1550 25 NMARKETCENT TO 116TH
288 120  0.2 1000 25 ACCESS Z39 908
288 247  1.7 3100 25 NBELLWY 8TH TO 520
288 256  2.7 3100 25 SBELLWY 8TH TO 90
289 133  1.0 1000 25 ACCESS ZONE 52 TO WSF
289 323  1.8 4000 45 WEST SEATTLE TO SR99 OFF MLWS EB
290 105  1.4 1500 25 SB5: TO 85:GREENWOOD
290 107  2.2 1500 25 SB5: TO 85:WEDGEWOOD
290 176  0.1 3000 25 EB 85TH:SB5: TO NB5:
290 225  0.7 1000 25 EB 85TH:SB5: TO SR99
290 265  4.0 1800 40 SB5: TO LAKE CITY
290 291  1.2 8000 55 85TH TO 70TH AND LAKE CITY WAY ML5 SB
291 107  2.0 1500 25 SB5: TO LAKE CITY
291 292  0.6 8000 55 70TH TO 50TH ML5 SB
292 112  1.2  750 25 SB5: TO 50:WALLINGFOR
292 113  1.0  750 25 SB5: TO 50:UDIST
292 293  0.1 8000 55 50TH TO RAVENNA ON ML5 SB
292 334  1.3 1500 25 SB5: TO 45TH
293 107 99.0    1  1 ONRAP
293 113 99.0    1  1 ONRAP
293 294  0.7 8000 55 RAVENNA ON TO 45TH ON ML5 SB
294 112 99.0    1  1 ONRAP
294 113 99.0    1  1 ONRAP
294 180  0.1 1500 25 N45TH:SB5: TO NB5:
294 295  0.9 8000 55 45TH ON TO ROANOKE OFF ML5 SB
295 114  0.5 1500 25 ROANOKE TO SB5:
295 296  0.5 8000 55 ROANOKE OFF TO SR520 ML5 SB
296 297  0.310000 55 SR520 TO BOYLSTON ON ML5 SB
296 325  0.2 1700 35 SB5: TO EB520
297 114 99.0    1  1 ONRAP
297 298  0.410000 55 BOYLSTON ON TO MERCER OFF ML5 SB
298 128  0.3 1500 25 SB5: TO MERCER
298 299  0.5 8000 55 MERCER OFF TO MERCER ON/STEWART OFF ML5
299 128  0.3 1500 25 SB5: TO STEWART
299 300  0.5 8000 55 MERCER ON/STEWART OFF TO DENNY ON ML5 SB
300 128 99.0    1  1 ONRAP
300 129 99.0    1  1 ONRAP
300 301  0.310000 55 DENNY ON TO UNION OFF ML5 SB
301 129  0.0 1500 25 SB5: TO UNION
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301	302	0.1	8000	55	UNION OFF TO JAMES/MADISON OFF ML5 SB
302	129	0.5	1500	25	SB5: TO JAMES
302	303	0.2	6000	55	JAMES/MADISON OFF TO JCT SBCD ML5 SB
303	304	0.2	4000	55	JCT SBCD TO JCT SBEX ML5 SB
303	335	0.4	4000	55	JCT SBCD TO JAMES/MADISON ON CD5 SB
304	305	1.2	6000	55	JCT SBEX TO JCT SBCD ML5 SB
305	185	1.1	8000	55	JCT SBCD TO WEST SEATTLE FRWY ML5 SB
306	119	1.0	1000	20	NB5: TO PILL HILL:OLI
306	183	0.4	8000	55	OLIVE OFF TO OLIVE ON AND MERCER ML5 NB
307	129	99.0	1	1	ONRAP
307	306	0.1	8000	55	UNIVERSITY TO OLIVE OFF ML5 NB
308	129	99.0	1	1	ONRAP
308	307	0.3	8000	55	JCT NBCD TO UNIVERSITY ML5 NB
309	119	99.0	1	1	ONRAP
309	129	1.3	1000	20	NB5: ML TO DWNTN:SENE
309	130	0.4	1000	20	NB5: TO KINGDOME
309	308	0.2	4000	55	SENECA TO JCT END NBCD ML5 NB
310	309	0.2	6000	55	JCT NBEX TO SENECA ML5 NB
310	320	0.3	2000	55	JCT NBEX TO CHERRY ON ESB5: NB
311	119	1.0	1000	20	NB CD TO PILL HILL:M
311	129	0.4	1000	20	NB5: CD TO DWNTN:MAD
311	130	0.6	500	15	NB5: CD TO KINGDOME
311	308	0.1	2000	55	MADISON OFF TO JCT NBCD CD5 NB
312	119	1.0	1000	20	NB CD TO PILL HILL:J
312	129	0.5	1000	20	NB5: CD TO DWNTN:JAM
312	130	0.5	500	15	NB5: CD TO KINGDOME
312	311	0.1	6000	55	JAMES OFF TO MADISON OFF CD5 NB
313	312	0.7	6000	55	JCT WB90 TO JAMES OFF CD5 NB
314	105	0.4	1000	25	NB5: EX TO GREEN:NGAT
314	175	0.5	2500	55	NORTHGATE OFF TO JCT ML5 EX5 NB 1 HOV
315	107	2.5	1000	25	NB EX TO WEDGE:LAKEC
315	314	1.8	4500	55	LAKECITY OFF TO NORTHGATE OFF EX5 NB 1 HOV
315	329	0.6	1200	45	NB 522:NB EX TO JCT EX RAMP
316	112	1.0	1500	25	NB5: EX TO 42ND
316	113	2.0	1000	25	NB5: EX TO UDISTRICT
316	315	2.0	6000	55	42ND OFF TO LAKE CITY OFF EX5 NB
317	128	99.0	1	1	ONRAP
317	316	1.4	8000	55	MERCER ON TO 42ND OFF EX5 NB
318	128	99.0	1	1	ONRAP
318	317	0.4	8000	55	STEWART ON TO MERCER ON EX5 NB
319	129	99.0	1	1	ONRAP
319	318	0.5	6000	55	PIKE ON TO STEWART ON EX5 NB
320	129	99.0	1	1	ONRAP
320	319	0.6	4000	55	CHERRY ON TO PIKE ON EX5 NB
321	130	1.5	1000	25	ACCESSWSFRWY TO KINGDOME
321	132	1.0	1500	25	WSFRWY TO INDUSTRY
321	185	0.5	4000	40	4TH AVE TO JCT I5 MLWS EB
321	322	0.9	4000	45	4TH AVE TO SR99 ON MLWS WB
322	289	1.8	4000	45	SR99 ON TO WEST SEATTLE MLWS WB
323	230	0.3	1000	25	RAMP TO SR99 WSFRWY EB
323	321	0.9	4000	45	SR99 OFF TO 4TH AVE MLWS EB
324	230	0.1	5000	45	WS OFF TO WSON SR99 SB
324	322	0.3	1500	35	RAMP TO WSFRWY WB SR99 SB
325	244	0.6	3600	55	EB520 TO I5 RAMPS
326	181	0.2	1300	40	WB520 RAMPS TO NB5:

326	296	0.2	3000	40	WB520 RAMPS TO SB5:
327	130	0.3	1000	25	ACCESSSR99 TO KINGDOME @ 1ST AVE
327	324	1.7	6000	50	SB SR99: 1ST AVE TO WSFRWY
327	328	0.6	6000	50	NB SR99: 1ST AVE TO DWNTWN
328	129	0.2	1000	15	ACCESSSR99 TO ZONE 48
328	229	0.6	6000	50	NB SR99:DWNTWN TO BATTERY
328	327	0.6	6000	50	SB SR99:DWNTWN TO 1ST AVE
329	291	0.6	940	45	SB 522:JCT TO ML5
329	330	1.9	1500	35	NB 522:12 AVE TO NORTHGATE WAY
330	175	1.5	1000	25	WB NORTHGATE WAY:SR522 TO ML5
330	265	0.7	2500	35	NB 522: NORTHGATE WAY TO SR513
330	329	1.9	1500	35	SB 522:NORTHGATE WAY TO 12TH AVE
331	173	1.5	1000	30	WB 145TH:SR522 TO ML5
331	264	1.6	2500	35	NB 522:146TH TO SR104
331	265	1.1	2500	35	SB 522:145TH TO SR513
332	172	0.8	1000	25	EB175TH:SR99 TO ML5
332	221	0.5	2500	35	NB SR99:175TH TO 185TH
332	222	0.8	2500	30	SB SR99:175TH TO WEST MINSTER
333	173	1.0	1000	25	EB 145TH:SR99 TO ML5
333	222	0.7	2500	30	NB SR99:145TH TO WESTMINSTER
333	223	0.7	2500	30	SB SR99:145TH TO 130TH
334	112	0.3	1000	25	ACCESS :N45TH TO WALLINGFORD
334	227	0.7	1000	25	N45TH TO SR99
334	294	0.5	1500	25	N45TH TO SB5:
335	129	99.0	1	1	ONRAP
335	336	0.4	8000	55	JAMES/MADISON ON TO DEARBORN/EB90 OFF CD5
336	130	0.5	1500	25	SB I5CD ACC DEARBORN
336	132	1.0	1500	25	SB I5CD ACC DEARBORN
336	251	0.3	3600	40	RAMP: SB5: TO EB90
336	337	0.4	4000	55	DEARBORN/EB90 TO WB90 ON CD5 SB
337	305	0.1	4000	55	WB90 ON TO JCT SBCD CD5 SB
780	1.0				
780	0.25				
780	0.25				
780	0.25				
780	0.25				
780	1.0				
780	1.0				
780	1.0				
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780	1.0				