

Application of Large Network Traffic Assignments to Small Area Route Location Studies

E. F. GRAHAM, Assistant Traffic Engineer, California Division of Highways

Modern electronic computers have been very useful in the distribution of interzonal trips and in the assignment of these trips to large networks of streets and freeways. Once a freeway system has been selected, however, there still remains the problem of precisely locating individual freeway segments of the overall system. These location studies usually require the assignment of traffic to several alternate locations and economic comparisons of these alternates.

A method of utilizing output data from large network traffic assignments for small area route location studies is described. The method involves a procedure whereby the study area used for the distribution of trips is reduced in size for the purpose of assigning traffic to alternate route locations. Results indicate that this reduced network method can offer considerable savings in machine processing time without loss of accuracy in route location studies.

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This paper reports on a method of utilizing output data from large network traffic assignments for small area route location studies.

BACKGROUND

The distribution of trips by gravity model methods requires that the study area be large enough that a complete universe of trips is included in the analysis. Because the gravity model principle is based on the relative competition of all zones for the attraction of trips, the study area usually includes an entire self-contained community. For a small area study, encompassing only a portion of a larger urban area, distribution of trips on a gravity model may be done in one of two ways:

1. Assume traffic volumes at the external cordon stations and distribute trips to and from these cordon stations as if they were internal zones. The difficulty in this method is the selection of an appropriate travel time from each internal zone to the cordon station, since the cordon station location is not truly representative of the actual geographic location of the external end of the trips.

2. Expand the study area boundary so that a portion of the external area can be divided into additional zones. By moving the external boundary far enough out, most

of the trips crossing the original cordon boundary now become internal trips, and any inaccuracy in the method of handling external cordon stations is thus reduced to a minimum. This expansion of the study area usually results in a large network of street and freeway links, requiring considerable computer time for determining minimum paths and the assignment of trips. In addition to the computer time involved, the resulting difference in user costs between alternates may appear insignificant as the total user cost for each alternate will include a large amount of vehicle miles and minutes for network links that are approximately equal for all alternates.

The following paragraphs describe a procedure whereby an expanded study area is used for the distribution of trips by gravity model methods and the area is then reduced in size to assign traffic to alternate route locations.

STUDY METHOD

The procedure was tested on a typical route location project in a metropolitan area. Shown in Figure 1 is the portion of the route under study and its relationship to other segments of the freeway system. For the purpose of trip development, the entire area within the dashed line (divided into 212 traffic zones) was included in the gravity model trip distribution. The area was then reduced in size to a small sector consisting of only 38 of the original 212 zones (outlined by shading in Fig. 1) for assignment of trips to the various alternates. The other 174 zones outside the reduced sector were replaced by 9 external cordon stations at points where street or freeway links crossed the reduced sector cordon boundary. The following steps were required to develop a triangular table for this reduced area and to assign trips to alternate route locations.

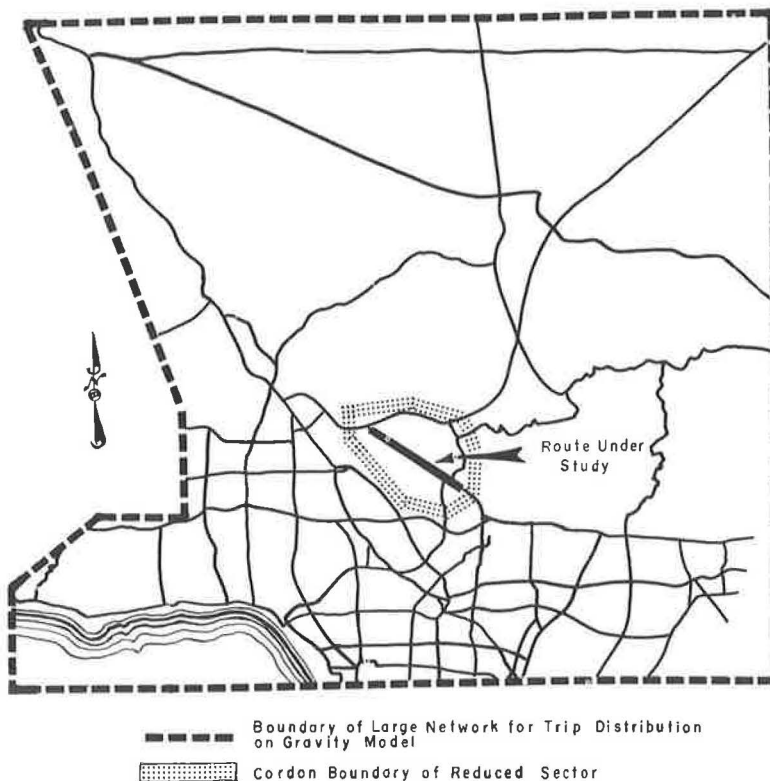


Figure 1. Complete and reduced study areas.

1. A triangular table was developed for the entire 212 zone area of Figure 1 using gravity model methods of trip distribution. For this step an assumption had to be made as to the location of the route under study to calculate interzonal travel times.
2. Traffic was assigned, based on time and distance savings, using the California diversion curve, to the full area network. This was the same network used in the previous step for the gravity model trip distribution.
3. A cordon boundary was drawn around the smaller area, and external cordon stations were established at points where links of the network crossed the cordon line (Fig. 2). The selection of the cordon boundary was based on judgment, considering natural barriers and also the effect the alternate route locations would have on trips assigned to links crossing the cordon boundary.
4. A reduced triangular table was developed for the small area inside the cordon boundary. Three categories of trips made up this reduced triangular table: those with one end inside the cordon boundary and the other end outside the cordon boundary (external-internal), those with both ends outside the cordon boundary but assigned to links crossing the boundary (external-external), and those with both ends inside the cordon boundary (internal). These trips were developed separately and then combined to form the completed triangular table, consisting of all the interzonal transfers for the 38 zones plus 9 external cordon stations, as outlined in the following:
 - a. External-internal trips—From a selected link analysis program on the large network traffic assignment, there was available, for each link crossing the reduced sector cordon boundary, the number of trips for each of the many individual zone-to-zone transfers assigned to the cordon link.

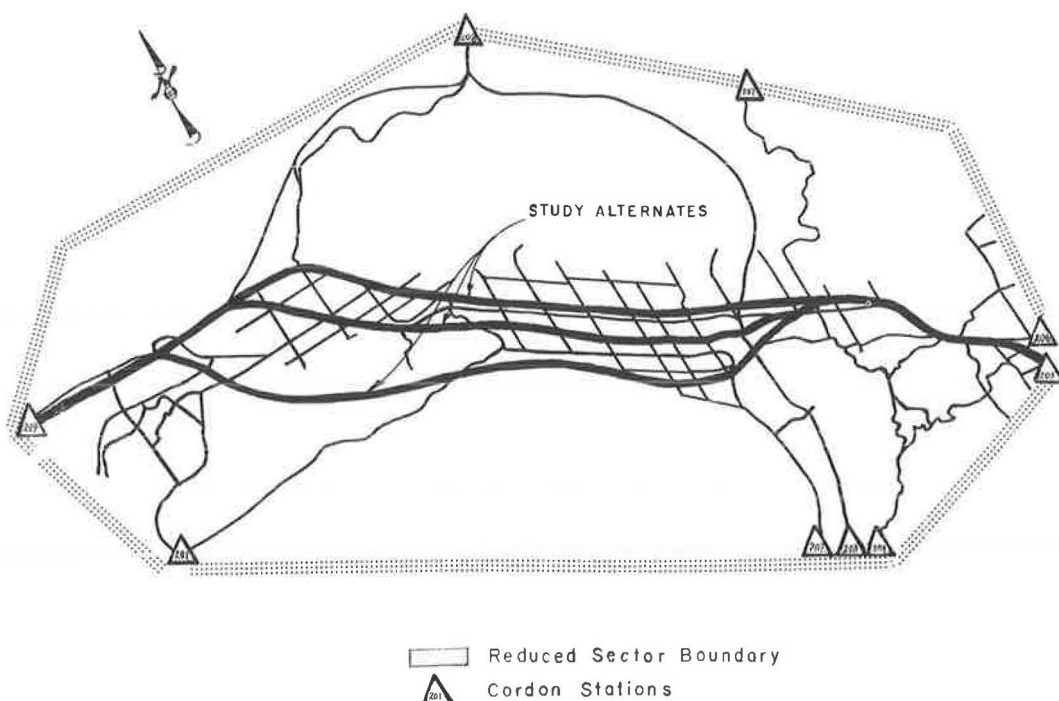


Figure 2. Study alternates.

With this information and a list of the zones which remained inside the cordon boundary, trips passing through each cordon link were sorted and totaled, by internal zone, to produce a table of trips between the 9 external cordon stations and the 38 internal zones.

- b. External-external trips—Those trips which had neither origin nor destination at one of the 38 internal zones had to cross the cordon boundary twice. With knowledge of which transfers were assigned to each cordon link from the selected link analysis on the large network, a search was made by the computer of the records for each of the other cordon station links to locate where these trips crossed the opposite cordon boundary. By totaling all the zone-to-zone transfers common to each pair of cordon station links, a triangular table of trips between each of the 9 external cordon stations was developed.
- c. Internal trips—Trips with both ends inside the cordon boundary were obtained by sorting out the appropriate zone-to-zone transfers from the large area triangular table.
- d. The final reduced sector triangular table was developed by combining the tables from steps a, b, and c.
5. The network was reduced in size to include only the links within the cordon boundary, and minimum time paths were computed for the alternates on this reduced network.
6. Trips from the reduced sector triangular table were assigned to the reduced networks for each of the alternate locations of the freeway by means of the California diversion curve.

Although it is possible to produce a reduced triangular table by subjectively grouping external zones around the reduced sector cordon stations and adding up the trips from the large network triangular table, the method outlined here eliminates this judgment by making use of traffic assignment data to assign these external trips to the appropriate cordon stations. Because a diversion curve is used in the traffic assignment procedure, this method also allows for a split between two or three cordon stations of the trips between some of the pairs of zones.

ANALYSIS

Three alternates were studied—two involving freeway locations (alternates B and H, Fig. 2) and a hypothetical existing system (alternate X) in which all other freeways were considered to be constructed except the portion of the route under study. For test purposes, traffic was assigned to all three alternates utilizing two different networks of streets and freeways, one based on the large area used for gravity model trip distribution and the other for the reduced sector within the cordon boundary.

As the traffic assignment program produces both profile volumes and total vehicle-miles and minutes of travel by type of facility, the accuracy of the reduced network concept can be evaluated by comparing, on the full and reduced network basis, profile volumes and 20-year user savings.

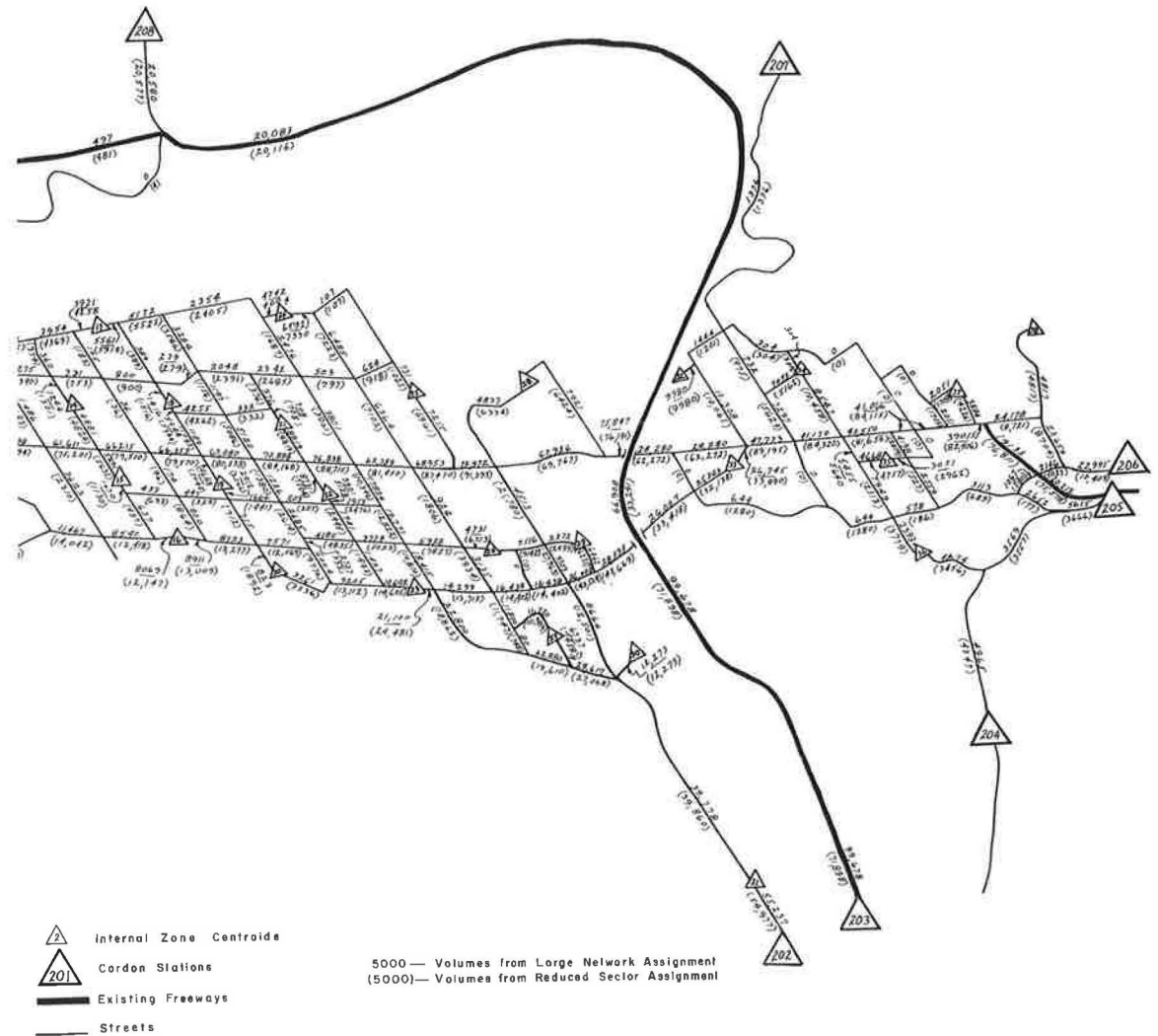
Table 1 compares, by both methods, the 20-year user cost and savings for the alternates studied. It can be seen that although the total user costs are considerably

TABLE 1
COMPARISON OF 20-YEAR USER COSTS AND SAVINGS^a

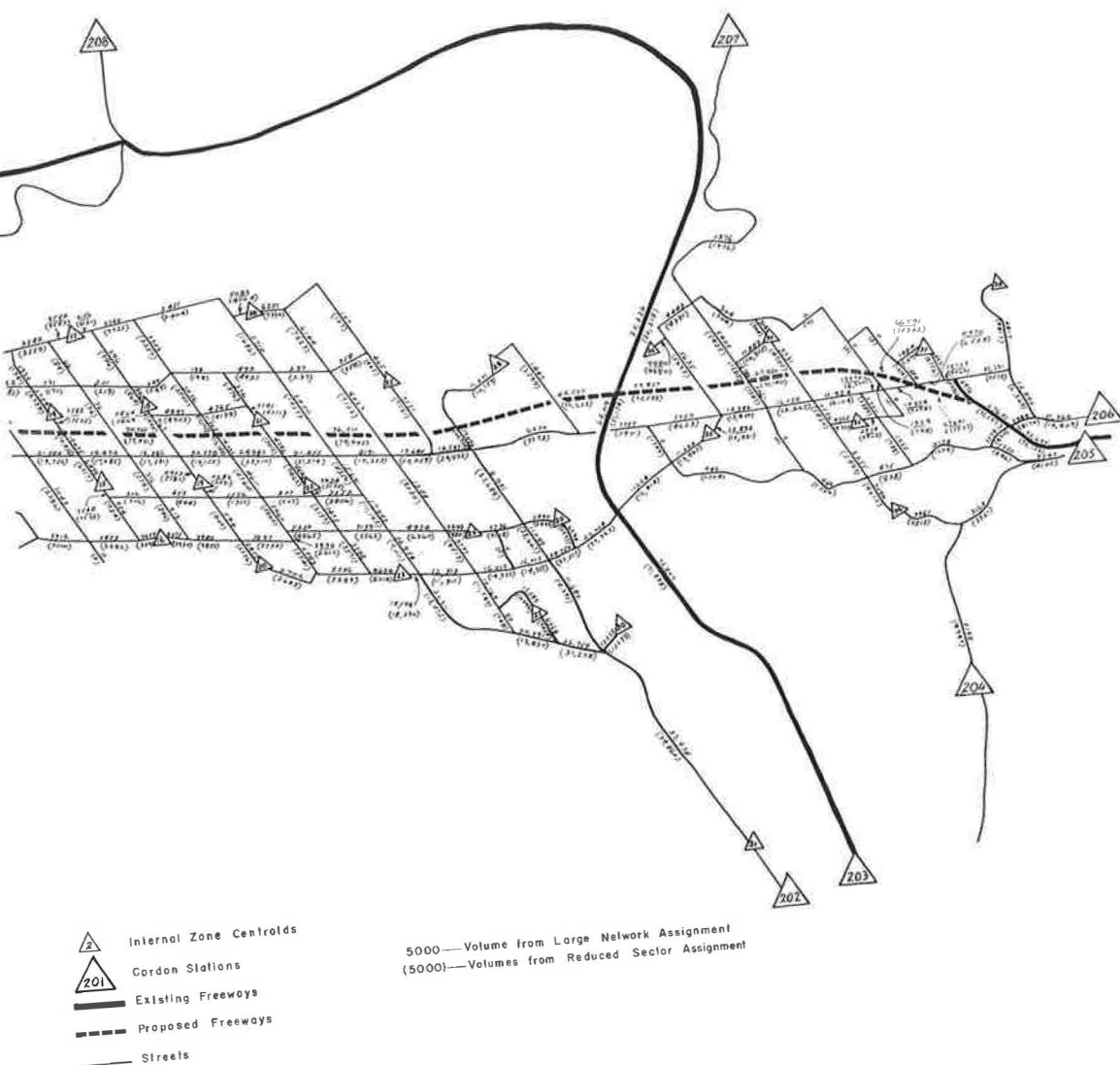
| Alt. | Full Network | | Reduced Network | |
|------|---------------------|-------------------------|---------------------|-------------------------|
| | Tot. User Cost (\$) | User Saving over X (\$) | Tot. User Cost (\$) | User Saving over X (\$) |
| X | 12,821,315,000 | — | 1,287,817,000 | — |
| B | 12,678,509,000 | 142,806,000 | 1,144,083,000 | 143,734,000 |
| H | 12,693,065,000 | 128,250,000 | 1,157,095,000 | 130,722,000 |

^aAt 0 percent interest.

Figure 3. Comparison of traffic volumes assigned



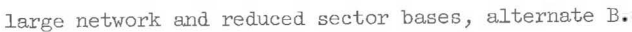
large network and reduced sector bases, alternate X.



large network and reduced sector bases, alternate H.



Figure 5. Comparison of traffic volumes assigned on



different because of the size of the network in the traffic assignment, the user savings of alternates B and H when compared to X are close enough to be within the normal accuracy of traffic forecasting. This comparison also shows that the difference (user savings) is significant, regardless of how small a percentage it is of the total user cost. Using alternate B as an example, the \$142,806,000 20-year savings on the full network represents only 1.1 percent of the total user cost, but the \$143,734,000 on the reduced network represents 12.5 percent of the user cost. Yet, these two values of user savings are within 1 percent of each other, indicating that the \$143,000,000± user savings is a real value. It would be erroneous to round out the 20-year user cost on the full network to 2 or 3 places and call all the alternates equal.

Figures 3, 4, and 5 show, on network maps for the three alternates, comparisons of profile volumes for individual links within the reduced sector as assigned by the two methods. For alternates B and H, the volumes compare very closely by both the full and reduced network methods. In this regard it should be noted that the outlined method makes one important assumption: that the alternates to be studied are close enough to the alignment assumed in distributing trips so as not to change the basic corridors to which trips were assigned on the full network basis.

There was quite a large variation, however, in the two profiles for alternate X. This is due to the fact that alternate X has no freeway in the corridor under study, whereas the triangular table for the small area was developed on the assumption that a freeway existed. (The reduced network triangular table was based on trips assigned to alternate B.) Therefore, when assigning to alternate X on the full network, trips through the area were apparently assigned on other freeways outside the reduced sector; however, on the reduced network these trips were assigned along existing streets within the cordon boundary.

A minor technical problem occurred in assigning traffic to alternate B on the reduced network. A large variation in traffic volume resulted on a segment of the freeway just inside the cordon line as compared to the assignment on the full network. This was found to be due to a street link which closely paralleled the freeway and tied in at the same cordon station, pulling too many of the cordon station trips away from the freeway. An adjustment was made to the distance on this street link and the assignment was rerun, resulting in the freeway volume matching closely the volume from the full network. It is believed that this problem could have been avoided if the cordon boundary had been moved farther from the study area. As stated earlier, the cordon boundary was chosen by judgment; to take advantage of natural barriers and thus reduce the number of links crossing the cordon to a minimum, the boundary was kept rather close to the alternates being studied. It is suggested in future studies using the reduced network method that the cordon boundary be moved farther away from the study alternates to inclose a larger area.

CONCLUSION

The results of this study indicate that the reduced network method can offer considerable savings in machine processing time without loss of accuracy in route location studies. Because the diversion curve method of assignment used by California compares time and distance along three routes between each pair of zone centroids (requiring three separate runs through the minimum path program), approximately 10 hours of processing time was required on an IBM 704 computer for each alternate on the full 212-zone network. This was cut down to only 1 hour for the 38-zone reduced network.

Another advantage is the elimination from the output of much data for the many interzone transfers outside the small area which are not affected by alternates within the cordon area. More experience is needed, however, in the selection of appropriate cordon boundaries for the small area.

It should be noted that the reduced network concept is not limited just to projects where trips were distributed on a gravity model. The same procedure can be applied to any large network traffic assignment, regardless of the method of trip distribution.

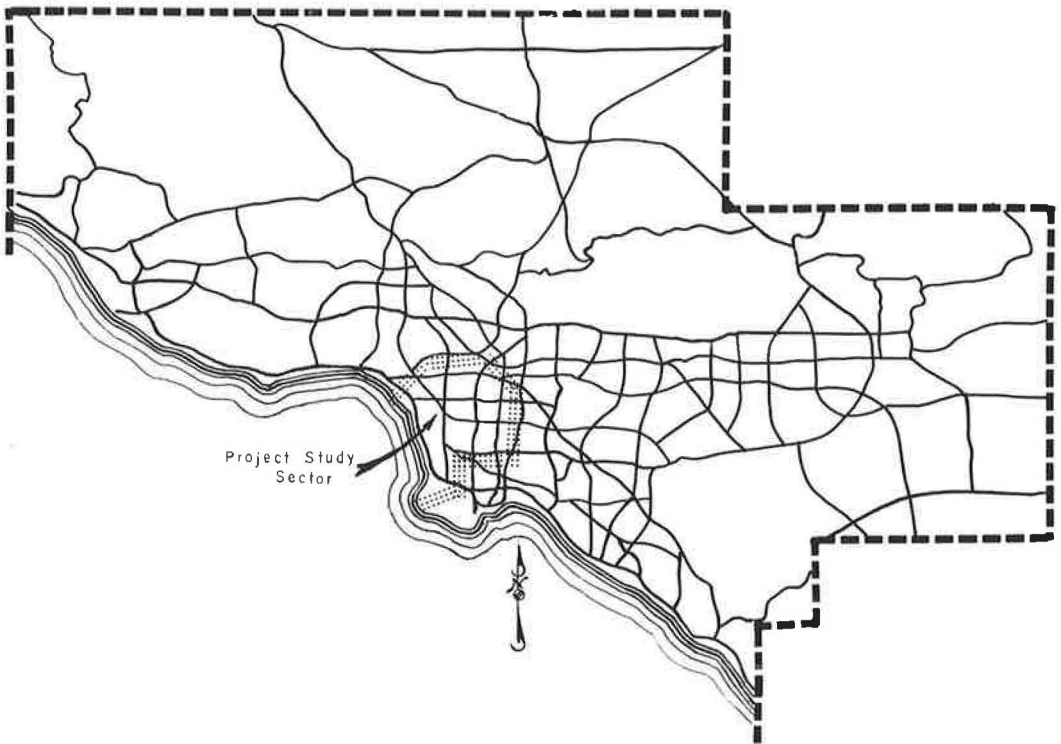


Figure 6. LARTS 1980 freeway system.

FUTURE APPLICATIONS

This same method can be used to isolate and study in more detail small segments of a large urban transportation network. For example, as part of the Los Angeles Regional Transportation Study (LARTS), trips were assigned to the system of freeways shown in Figure 6. Route location studies are currently under way on several individual segments of this system.

Some of the previous route adoption studies for freeway segments of this system involved a complete gravity model analysis on a large network basis for each individual project. Now that LARTS trip data are available, they are being used, where possible, in making these route location studies. On several current projects where the variations in alternate freeway locations are not enough to affect the basic corridors to which trips were assigned by LARTS, the output data from the LARTS traffic assignment will be used to develop reduced triangular tables for small study areas.

In one of these projects, a cordon boundary was drawn around a 200-sq mi sector of the 9,000 sq mi LARTS study area. Figure 6 shows the LARTS study network and the reduced sector area used in this project. The reduced sector contains only 87 zones plus 55 cordon stations, as compared to a total of 710 zones and cordon stations for the entire LARTS area. A reduced triangular table for this sector was developed, using essentially the same method outlined in this report. Traffic was assigned, with satisfactory results, to various study networks within the reduced sector cordon boundary.