Statewide Transportation Analysis & Research

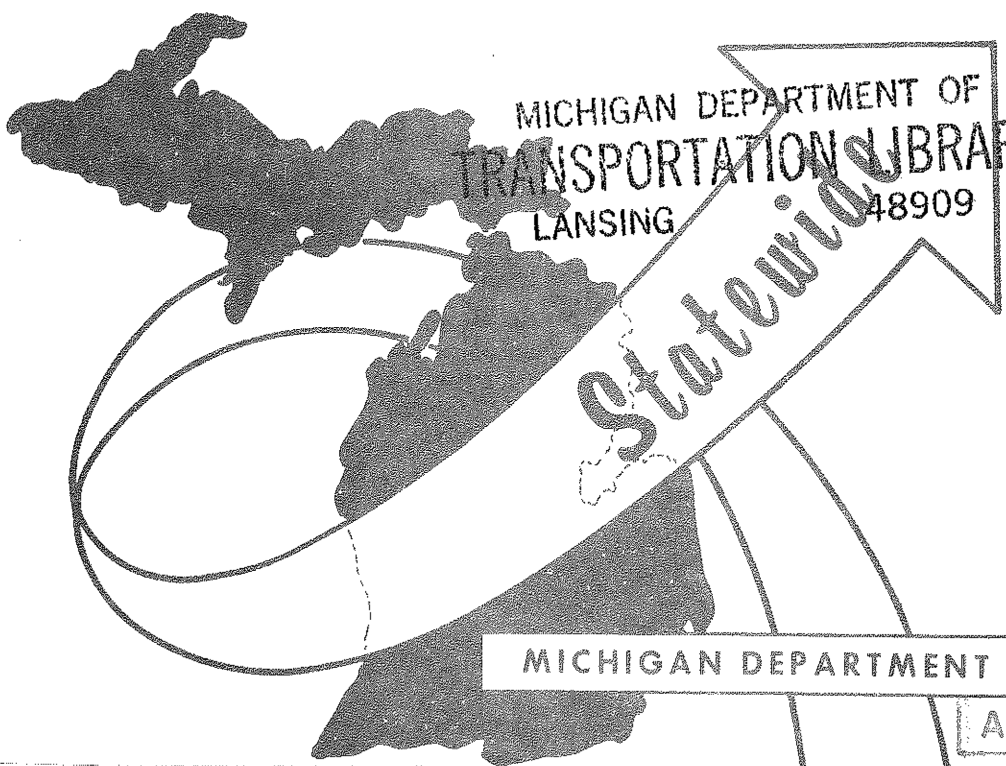
**MICHIGAN'S STATEWIDE
TRAFFIC FORECASTING MODEL**

VOLUME I-K

EFFECTIVE SPEED MODEL: A PUBLIC INTERACTION TOOL

JANUARY, 1974

STATEWIDE STUDIES



MICHIGAN DEPARTMENT OF STATE HIGHWAYS
AND TRANSPORTATION

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JANUARY, 1974
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STATE OF MICHIGAN

WILLIAM G. MILLIKEN, GOVERNOR

DEPARTMENT OF STATE HIGHWAYS AND TRANSPORTATION

STATE HIGHWAYS BUILDING – POST OFFICE DRAWER K – LANSING, MICHIGAN 48904

JOHN P. WOODFORD, DIRECTOR

January 16, 1974

Mr. Sam F. Cryderman
Deputy Director
Bureau of Transportation Planning

Dear Mr. Cryderman:

The Transportation Survey and Analysis Section is pleased to present a report entitled "Effective Speed Model: A Public Interaction Tool". The report documents the construction and testing of a model which is able to relate the congestion on a highway link to the effective running speed on that link.

This model could be used to stimulate public involvement in the transportation planning process. It communicates a measure of driving convenience which is easily understood and readily appreciated by members of the general public: for the average person, perhaps the handiest yardstick of traffic flow is his own speedometer. In addition, the model may prove useful in a new capacity-restraint algorithm. This algorithm seeks to accurately simulate the way in which traffic actually diverts from a heavily-traveled route to less-congested ones.

The Effective Speed process was implemented by Terry L. Gotts and James E. Carroll of the Statewide Studies Unit, under the supervision of Richard E. Esch. The report was prepared by Mr. Gotts.

Sincerely,

Keith E. Bushnell

Keith E. Bushnell
Engineer of Transportation
Survey and Analysis

EFFECTIVE SPEED MODEL:
A PUBLIC INTERACTION TOOL

BY

TERRY L. GOTTS

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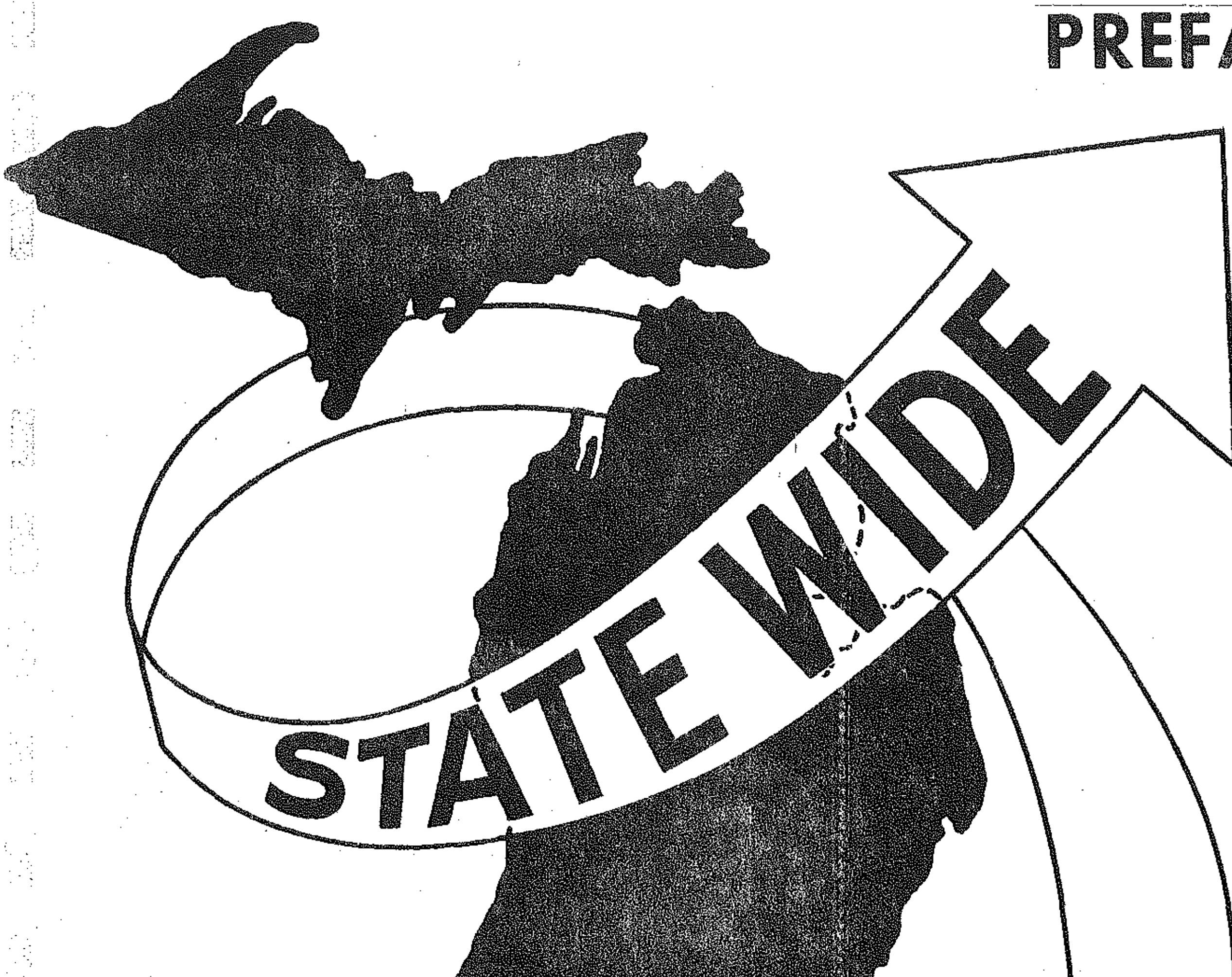


PREFACE

An increase in community involvement in the transportation planning process is an important goal behind much recent Federal legislation. One possible solution is to attempt to explain what effect each of a number of alternative transportation plans would have on every road in the highway system. Would a road become less congested or more congested as a result of each plan? How would the peak-hour speed on the road be affected?

These and other similar questions are related to the "level of service" and "effective speed" on a road. If a transportation agency could show an interested taxpayer a sample picture of traffic and say, "This is what the peak-hour traffic on the highway you drive will look like, and the speed will be about 55 miles per hour", many communication problems would be resolved. The subsequent feedback from the community might also represent a significant contribution to the final choice of a transportation plan. A person who would dismiss talk of "AADT's" or "DHV's" as jargon might appreciate a discussion of something as down-to-earth as is probable speedometer reading.

The question of degree of congestion is covered by Volume I-H in this series, entitled "Level of Service: A Public Interaction Application". This report deals with the second topic, that of expected effective driving speed.

This report is Volume I-K in the Statewide series. Previous reports in the series are:

Volume I -- Objectives and Work Program

Volume I - B-- Single and Multiple Corridor Analysis

Volume I - C-- Model Applications: Turnbacks

Volume I - D-- Proximity Analysis: Social Impacts of Alternate Highway Plans on Public Facilities

Volume I - E-- Model Applications: Cost-Benefit Analysis

Volume I - F-- Air and Noise Pollution System Analysis Model

Volume I - G-- Transportation Planning Psychological Impact Model

Volume I - H-- Level of Service Systems Analysis Model: A Public Interaction Application

Volume I - J-- Service-Area Model

Volume II -- Development of Network Models

Volume III -- Multi-Level Highway Network Generator ("Segmental Model")

Volume III-A-- Semi-Automatic Network Generator Using a "Digitizer"

Volume V Part A-- Travel Model Development: Reformation--Trip Data Bank Preparation

Volume V Part B-- Development of the Statewide Socio-Economic Data Bank for Trip Generation-Distribution

Volume VI -- Corridor Location Dynamics

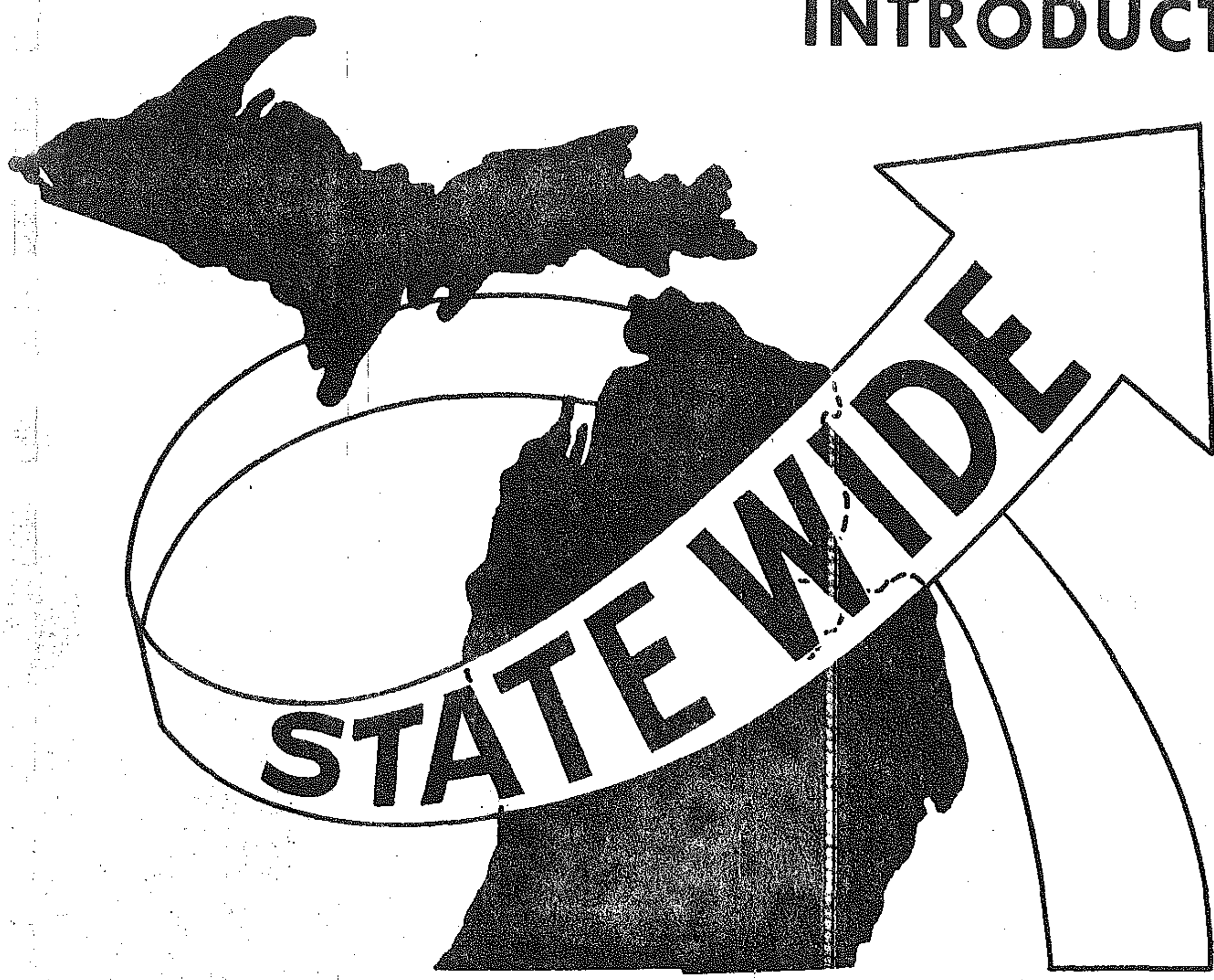
Volume VIII -- Design Hour Volume Model Development

Volume VIII-A -- Capacity Adequacy Forecasting Model

Volume VIII-- Statewide Public and Private Facility File

Volume IX -- Statewide Socio-Economic Data File

INTRODUCTION



INTRODUCTION

Some researchers have recently begun investigating the functional relationship between running speed and the so-called volume-to-capacity or "V/C" ratio.[1] This ratio is defined as the design hour volume (DHV), or thirtieth-highest hour occurring in a year, divided by the adjusted practical hourly capacity; all calculations are performed on a link-by-link basis. Studies of this relationship attempt to make precise the well-known fact that as congestion on a route increases, the effective driving speed of that route drops. They try to provide answers to questions like "By how many miles per hour does the speed on this route drop with a 10% rise in traffic?" or "Suppose rush-hour traffic is rerouted from this collector-distributor to this freeway; would people's driving time be significantly affected?"

The effective speed model automates the process and expands it to the system level. After future traffic assignments on a number of alternative transportation plans, the model demonstrates how driving speeds on each segment of rural state trunkline would change as a result of changed travel patterns and resulting volumes. Hopefully, information such as this could be a viable means of promoting public involvement in the transportation planning process.

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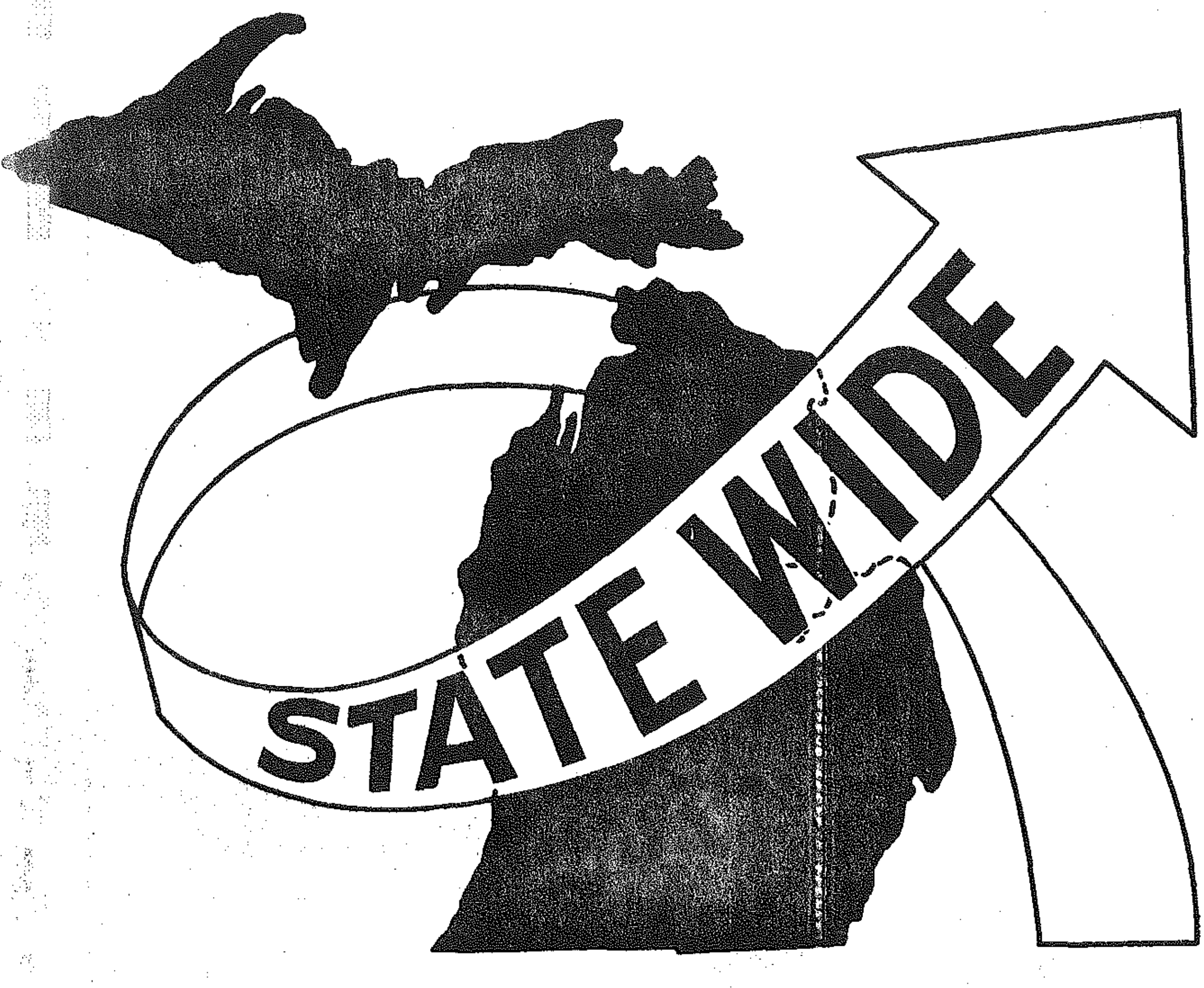
1 See, for example: Curry, D.A., and Anderson, D.G. <u>Procedures for Estimating Highway User Costs, Air Pollution, and Noise Effects</u>. NHCRP Report 133, HBR, 1972.

METHOD OF ANALYSIS



METHOD OF ANALYSIS

The Statewide Traffic Forecasting Model predicts future traffic on each subsection, or "link", of a highway network composed of all state trunklines and certain selected county roads. This network is shown graphically in the computer plot of Figure 1. Each link belonging to state trunkline is given a capacity from the Highway Sufficiency Master, a master file which is used to establish construction and maintenance priorities. A future Design Hour Volume ("DHV") is then for forecast for each rural link,[2] and the quotient of the future DHV to the hourly capacity becomes the predicted V/C ratio for that link.

Three separate sets of "curves" relating speed to V/C ratio are used. These curves are slightly-modified piecewise-linear approximations to those developed by Curry and Anderson. These curves are shown in Figures 2, 3 and 4. The actual choice of the function to be used on a given link is determined first by the type of road - - freeway, two-lane, or multi-lane non-freeway - - and secondarily by number of lanes (for freeways) or percent of length having at least 1500 feet sight distance (for two-lane roads). All speeds are for passenger cars only.

Once the curve to be used has been determined, the effective speed is simply the Y-coordinate on that curve which corresponds to the value of V/C. For example, suppose a link of four-lane freeway has a V/C ratio of 0.4. Referring to the bottom curve

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2 See Statewide Transportation Analysis and Research Volume VII, Design Hour Volume Model Development, Michigan Department of State Highways, November, 1972.

FIGURE 1: PLOT OF HIGHWAY NETWORK

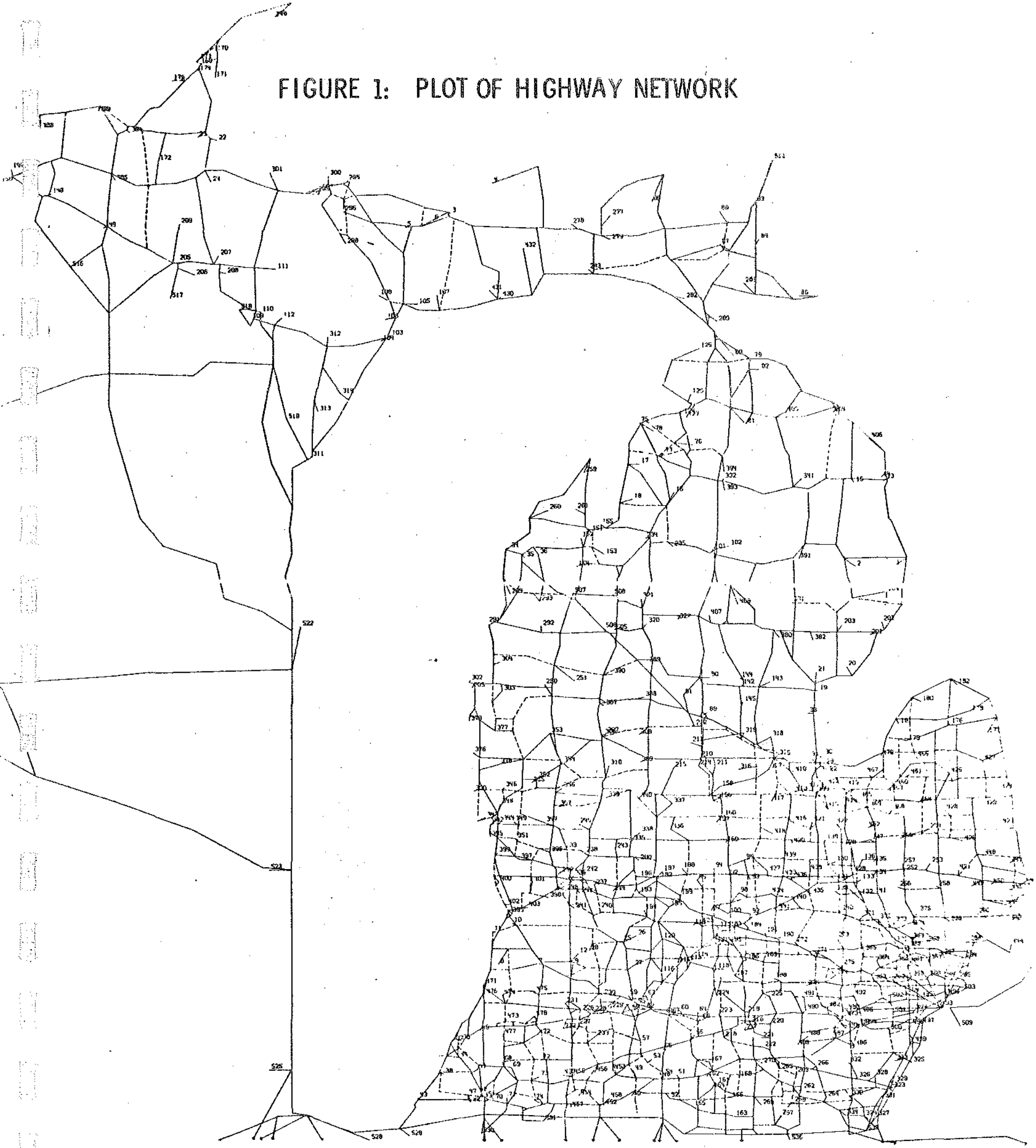


FIGURE 2 : FREEWAYS

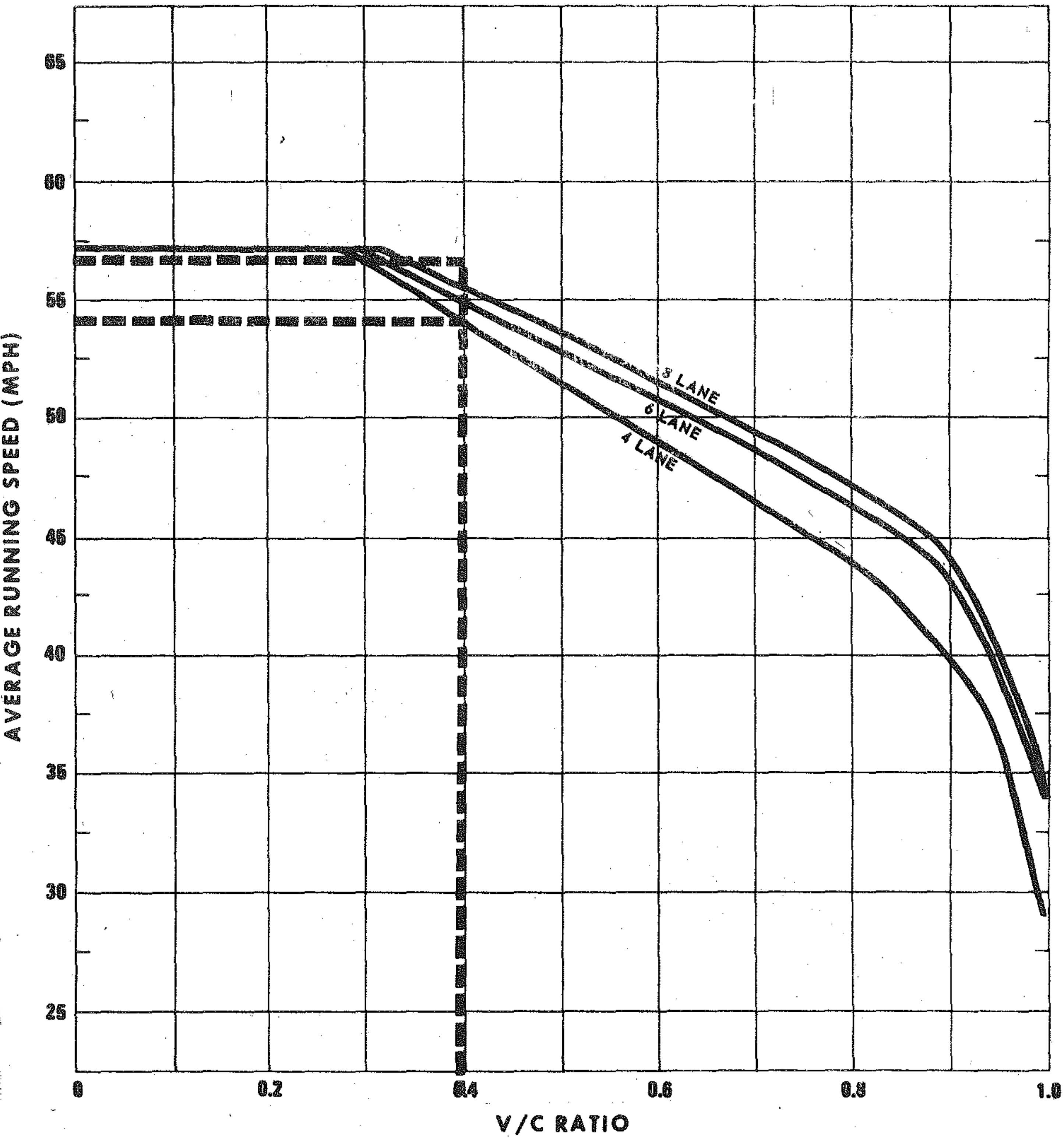


FIGURE 3 : MULTI - LANE NON-FREEWAYS

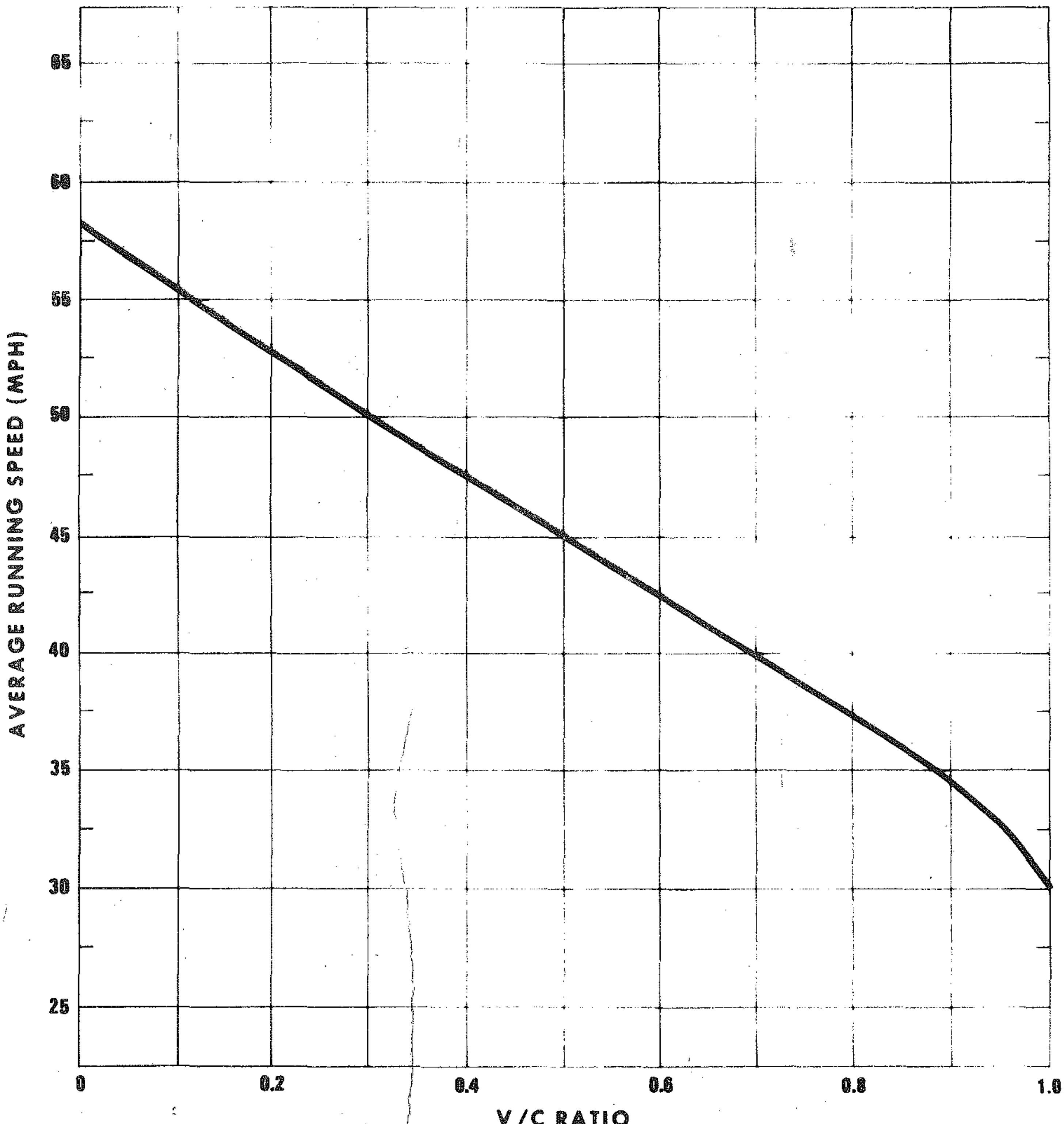
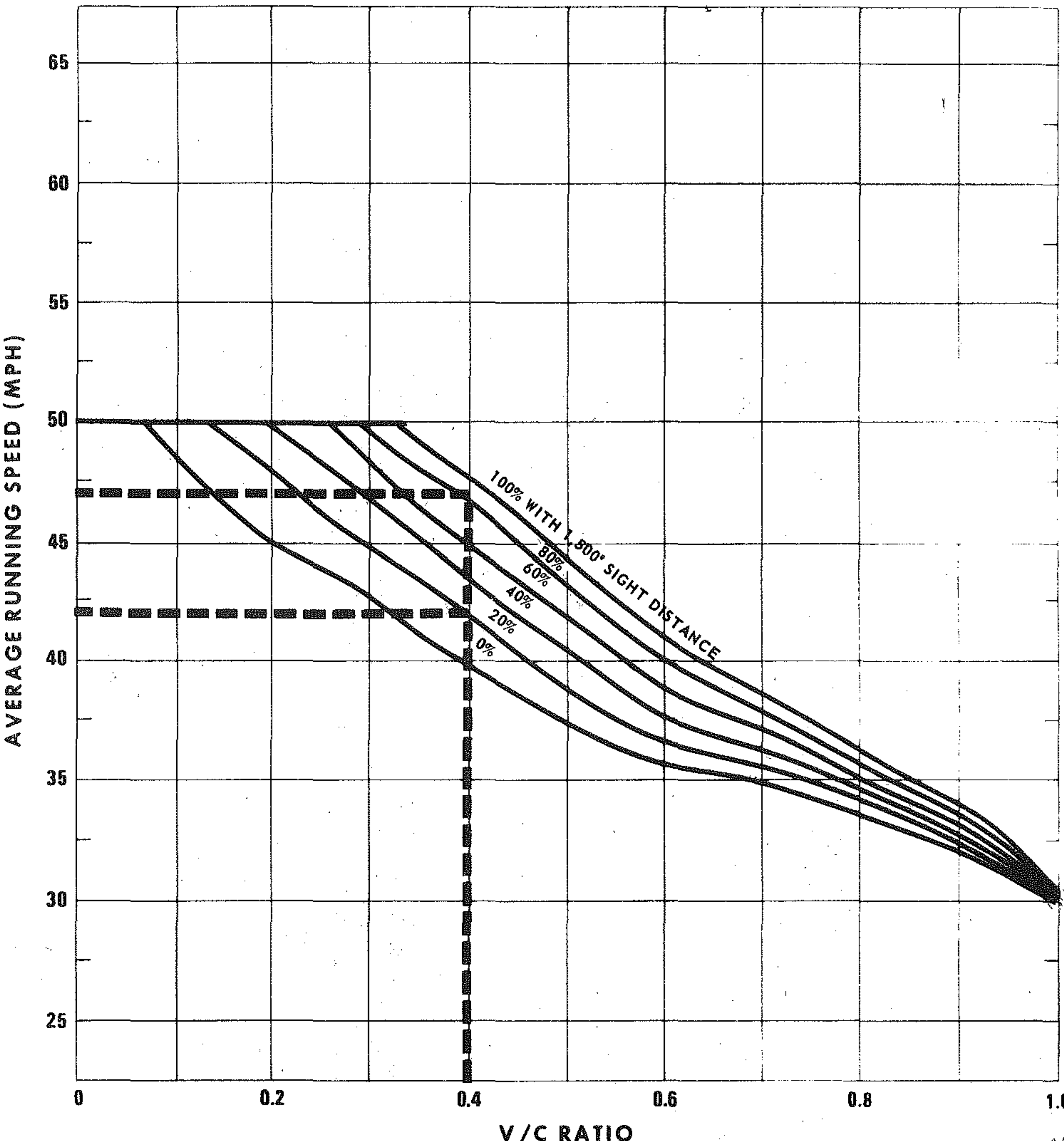


FIGURE 4: TWO - LANE ROADS



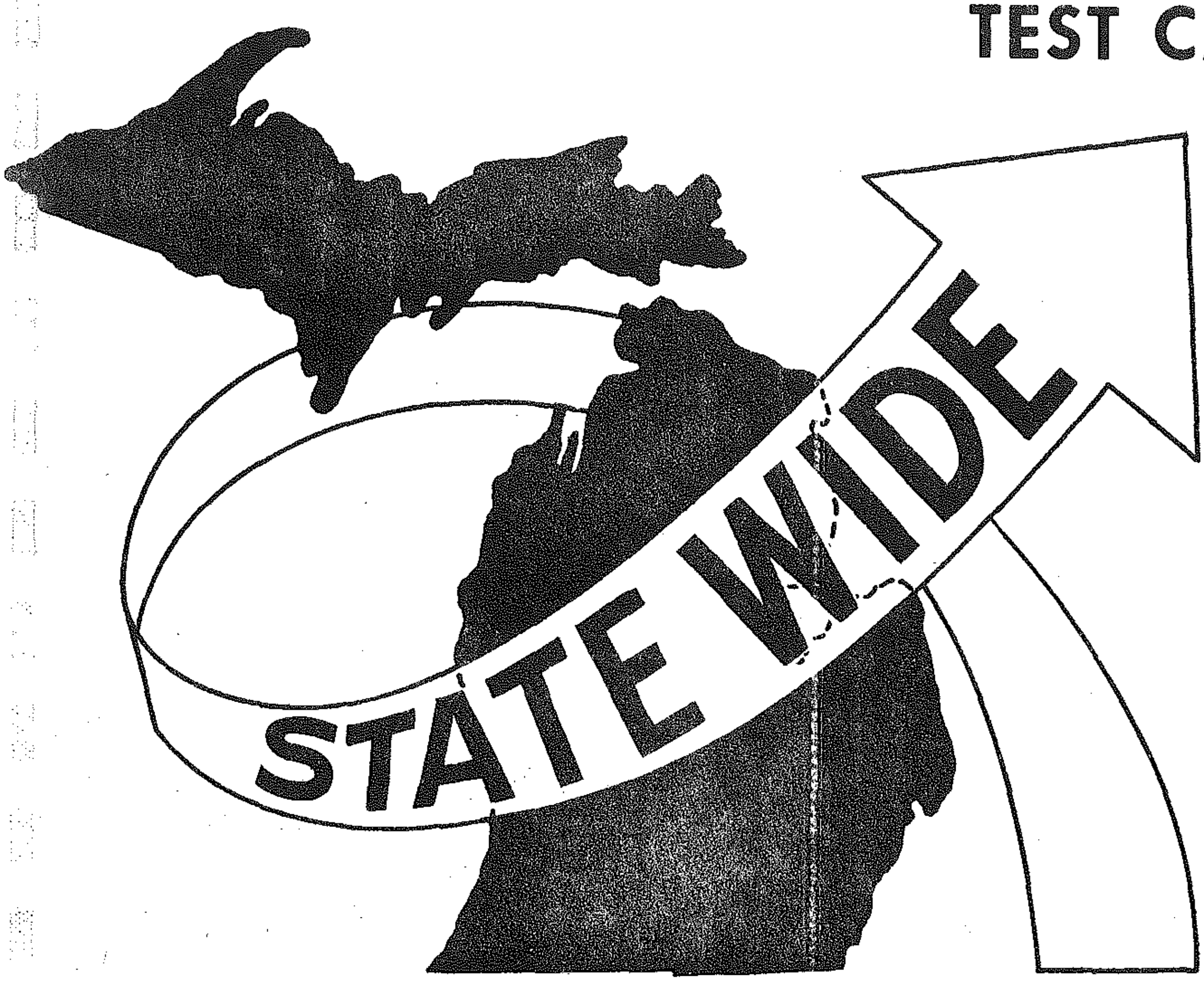
750

in Figure 2, it can easily be seen that the effective speed would be 55 miles per hour. Following the "0.4" vertical line to the "8-lane" curve, one sees that a V/C ratio of 0.4 results in an effective speed of 57 miles per hour on an 8-lane freeway.

As another example, refer to Figure 4, the family of curves pertaining to two-lane roads. Suppose that a 2-lane link has V/C = 0.4. If drivers have only 20% of that link in which they can see 1500 feet ahead - - that is, passing maneuvers can be executed safely on only 20% of the link - - the average speed is about 44 mph. But on a similar link where drivers can see 1500 feet ahead for 80% of the length of the link, the average effective speed is 47 mph. This is logical, since a greater opportunity to pass means that faster vehicles are held back by slow vehicles less frequently, and therefore average speed rises.

The computerized model behaves exactly like a person consulting a set of curves, except that the "curves" are piecewise linear functions. That is, each of the curves in Figures 2, 3, and 4 are represented internally as a sequence of points along the curve joined by short straight line segments.

TEST CASE



TEST CASE

As an example of the output of the model, a test case was selected which is actually an alternative plan being considered in a current corridor-selection process. The highway plan is shown graphically in Figure 5. The proposed additions to the existing system are indicated as heavy, dashed lines. Both new roads are two-lane roads, but they offer the advantage of not passing directly through any towns. Therefore, the relatively shorter travel time will tend to draw a good share of traffic off existing routes, making some of the existing routes more free-flowing.

The model results are shown in Figure 6, with traffic being forecasted for year 2000. Speeds are in tenths of a mile per hour. The "boxed-in" region is magnified in Figure 7. The existing assigned speed is shown below each link, and the new effective speed is displayed above the link. For example, look at old US-31 (in the middle of the right half of the Figure); although the assigned speed was 50.0 ("500"), m.p.h., the effective speed after the traffic assignment is 40.8 m.p.h. Note also that the forecasted effective speed on some sections of M-22 are actually higher than the assigned speeds, as a result of changing travel patterns.

Finally, Figures 6 and 7 contain two classes of links which are exceptional. One group consists of the county roads, shown as dashed lines. The other group is made up of centroid links, the imaginary connectors from the centroid (or center of population)

FIGURE 5: TEST HIGHWAY PLAN

NEW 2-LANE ROADS ARE SHOWN AS HEAVY DASHES

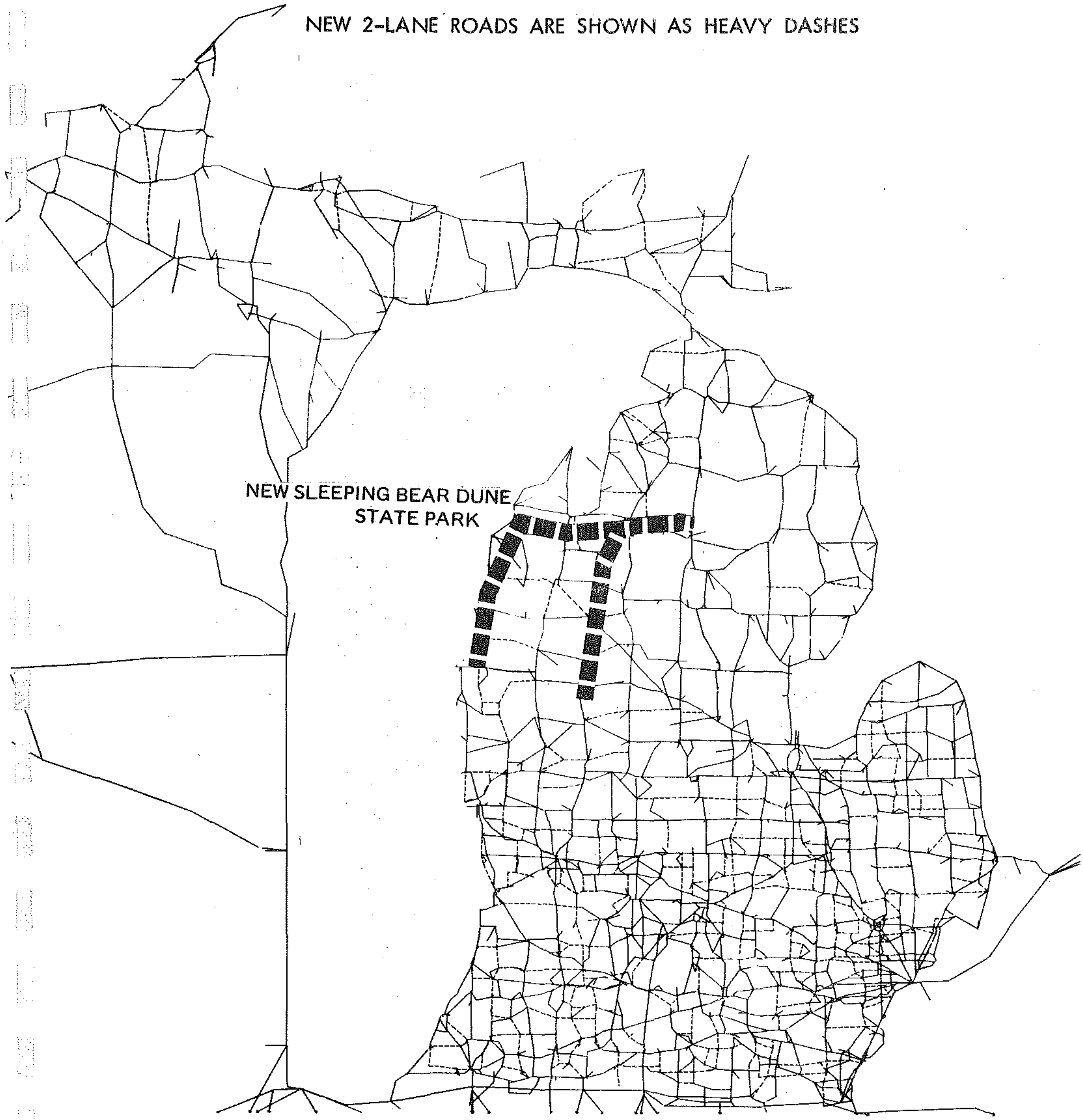


FIGURE 6: COMPARISON OF ASSIGNED AND PROJECTED SPEEDS

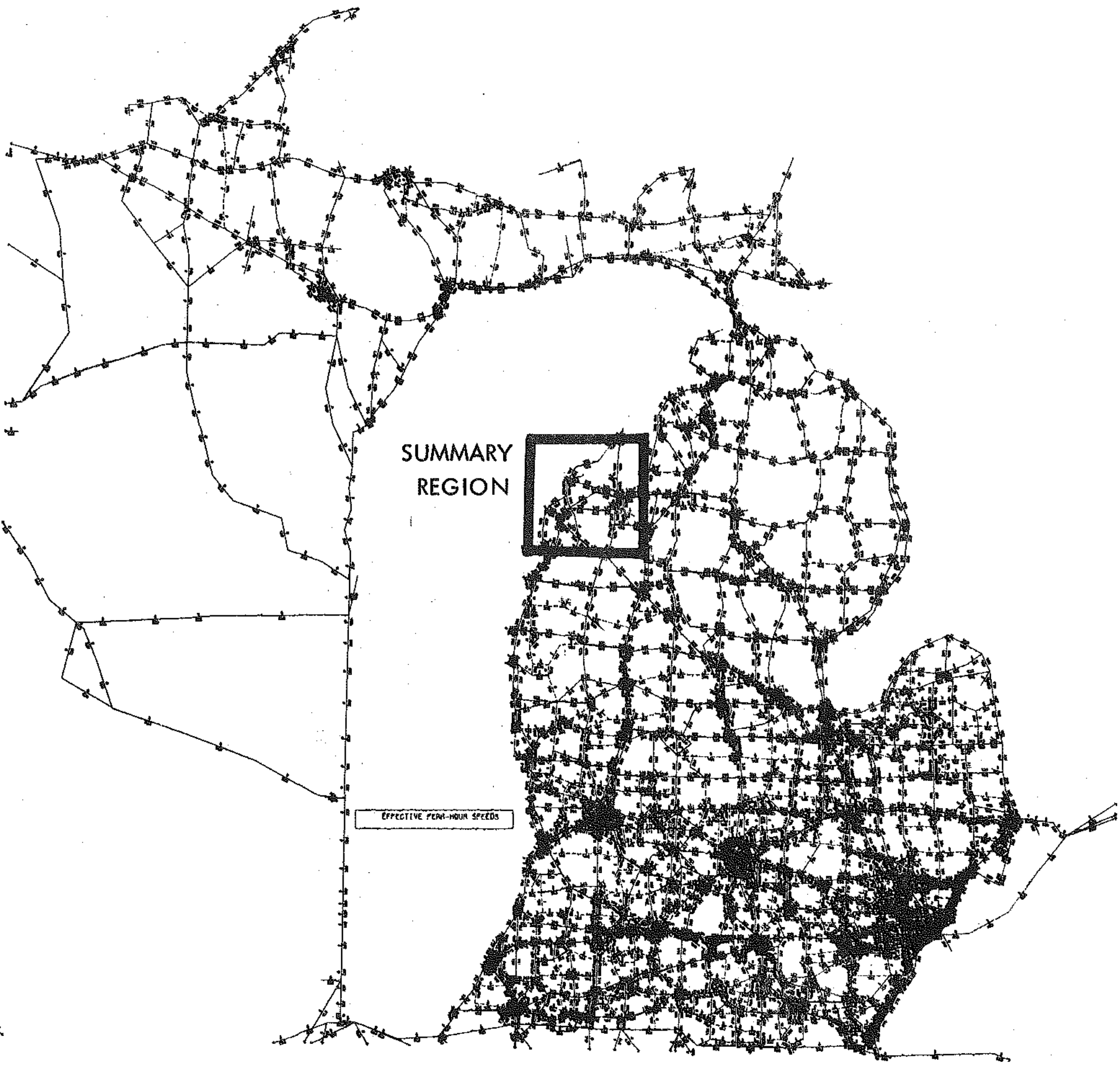
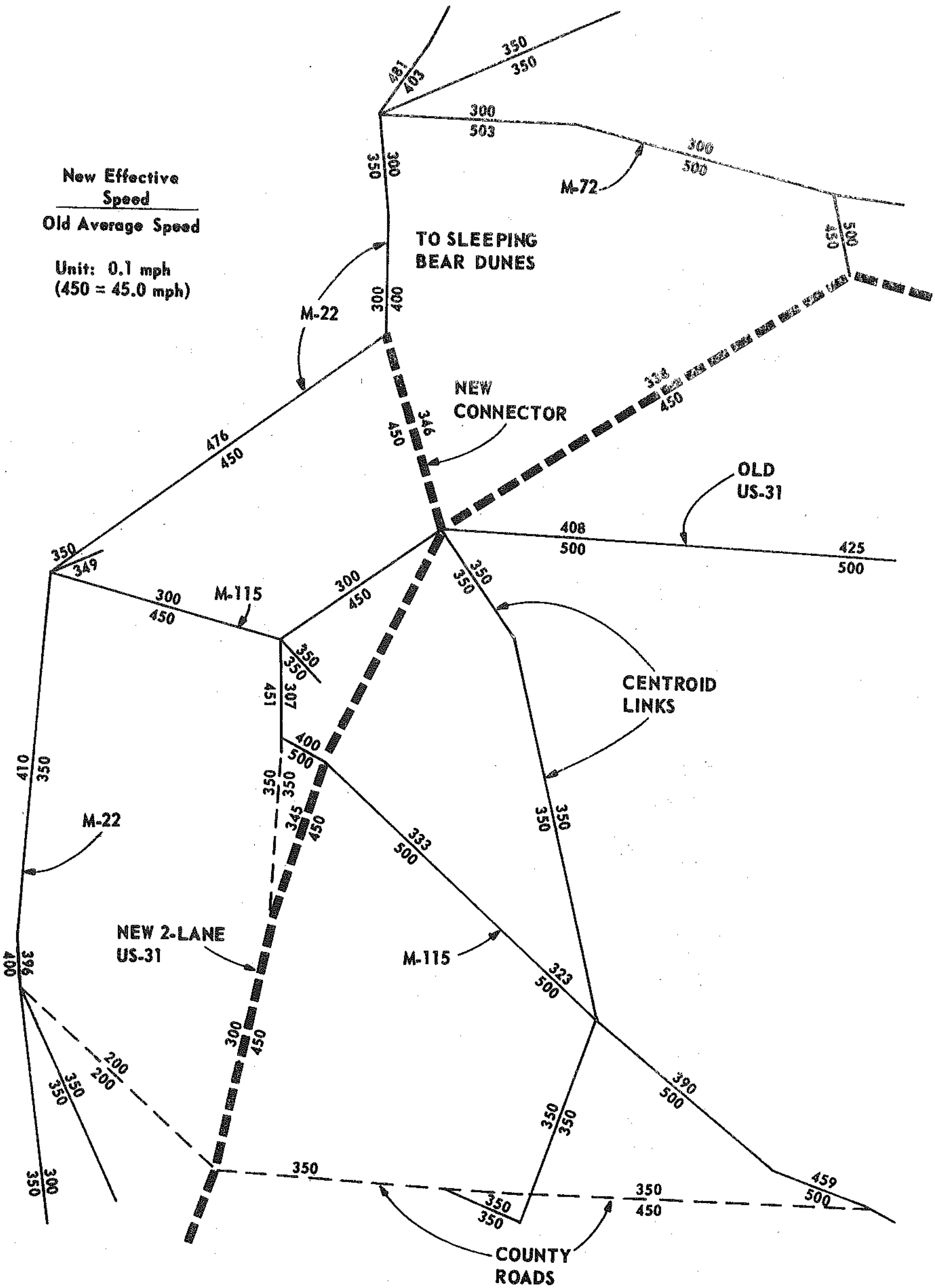


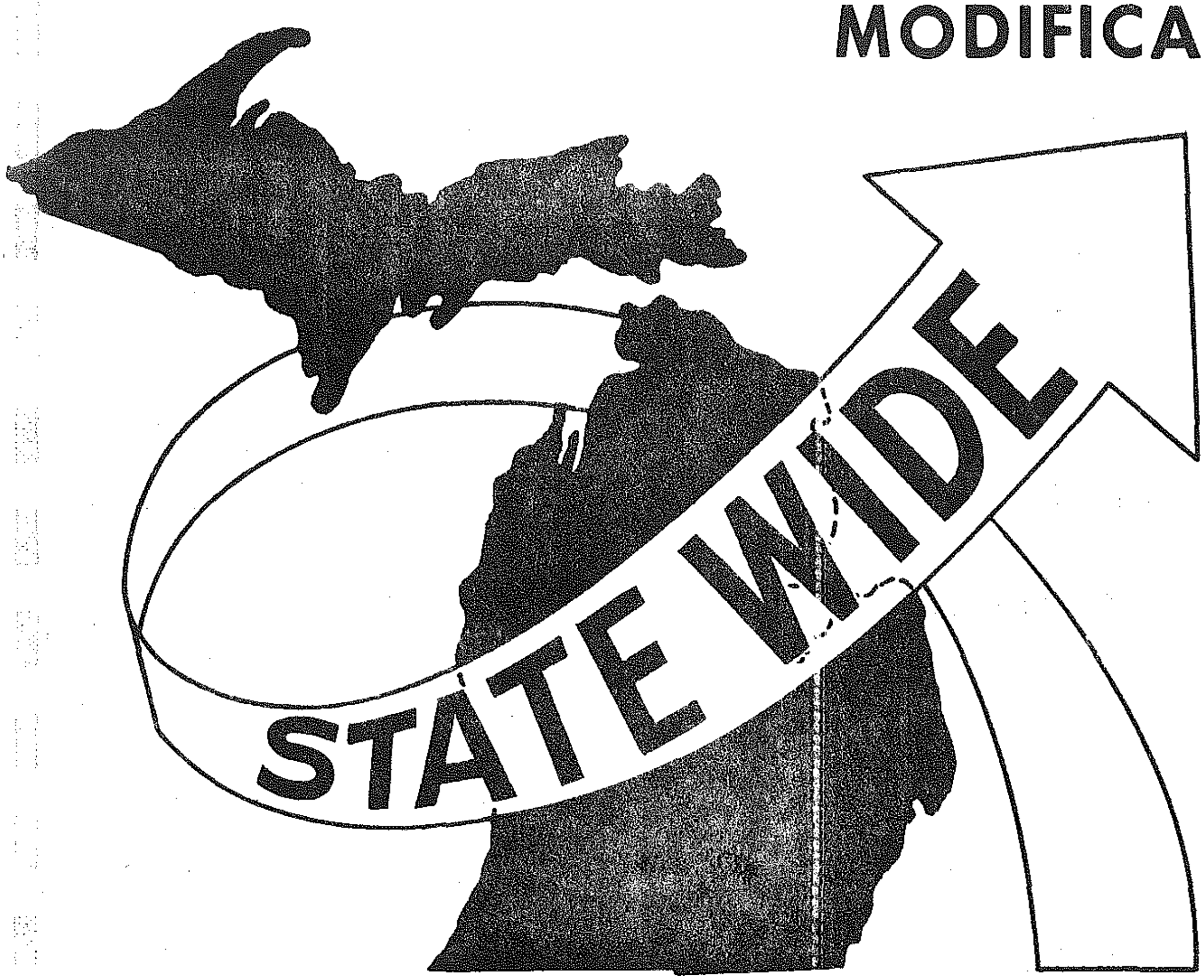
FIGURE 7: SUMMARY REGION BLOW-UP



of a traffic forecasting zone to the highway network. These are shown as solid lines and have both old and new speeds equal to 35 m.p.h.; in most cases, they are easily seen because one end is obviously not connected to the road system. Capacities are not expressed for these two classes of links, and therefore V/C ratios cannot be calculated for them. For that reason, the model leaves speeds on centroid links and county roads unchanged.

One final remark: although in this test example speeds have been allowed to increase as well as decrease, this version of the model will probably not be used in many departmental applications. In most cases, the speed assigned to a link reflects more than just a V/C ratio; it will also be a product of the percent of commercial traffic, alignment, sight restriction, lane width, surface condition, and many other link-specific factors. Therefore, the assigned speed on a link may well be the highest average speed which can reasonably be expected there. In this case, it would be illogical to permit the model to estimate a higher effective speed than has already been assigned; thus speeds will be allowed only to decrease in response to increasing levels of congestion.

FUTURE MODIFICATIONS

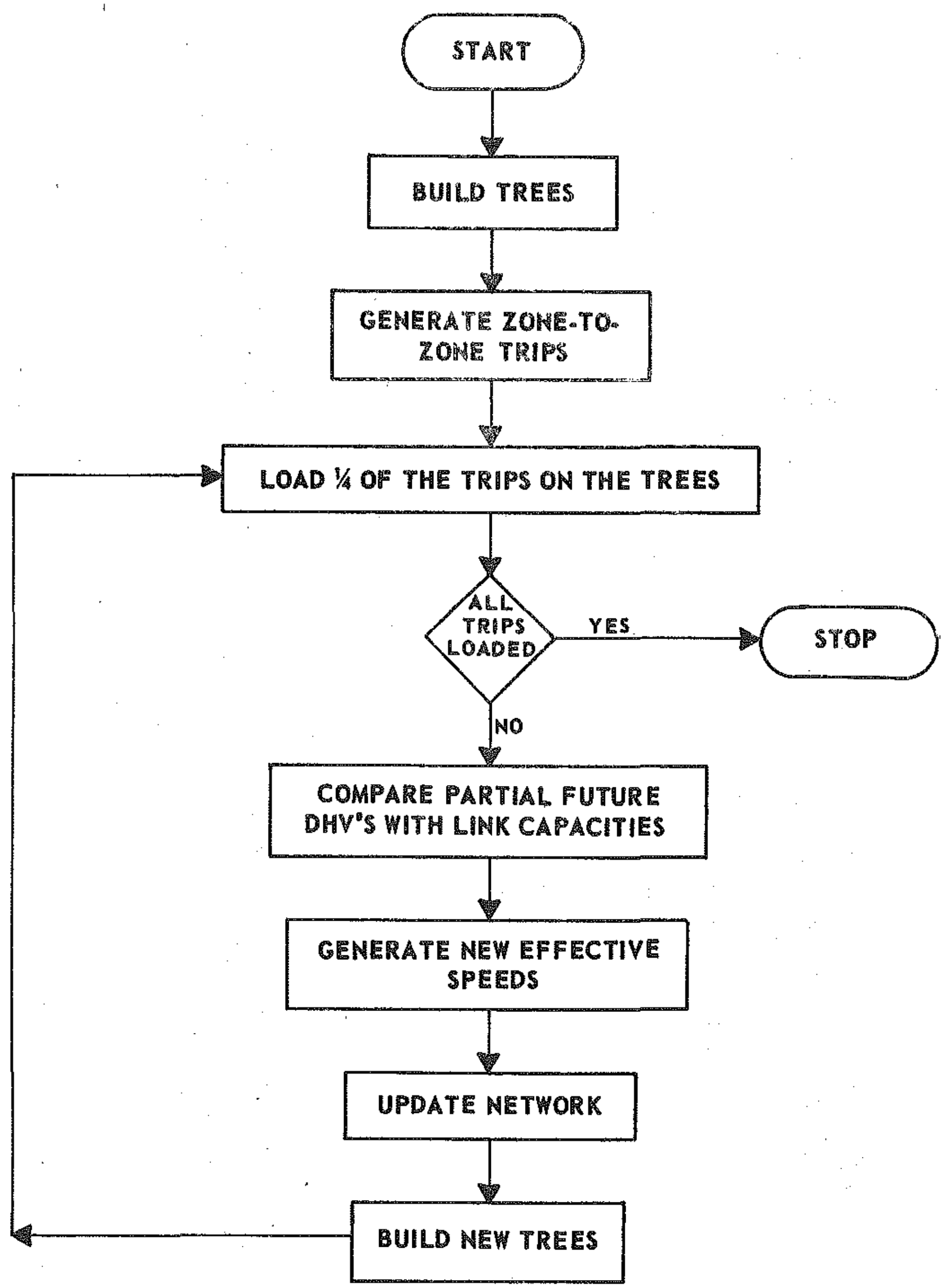


FUTURE MODIFICATIONS

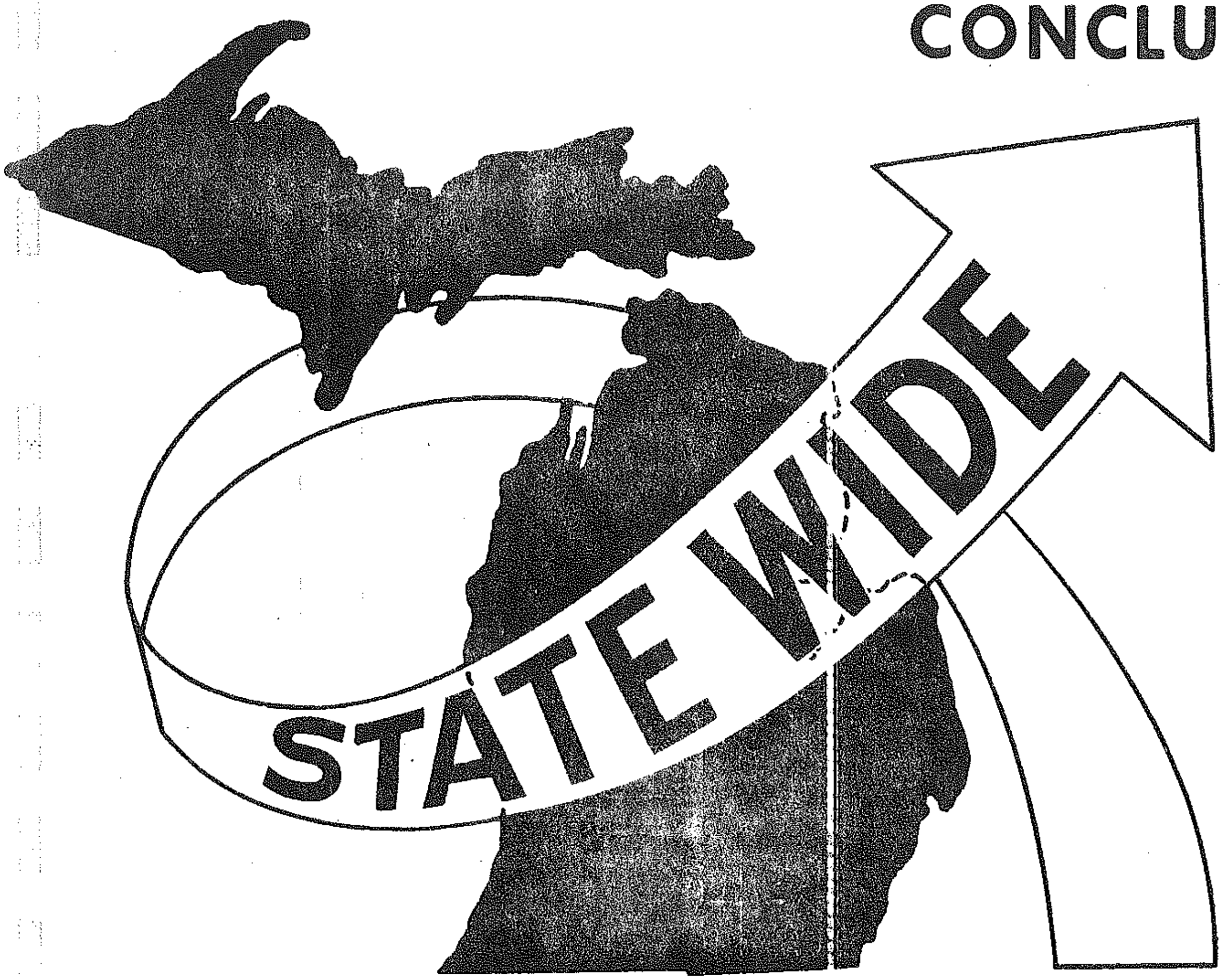
In the near future, the effective speed model will be used in conjunction with the Statewide Traffic Forecasting Model to provide a means of capacity-restraint traffic assignment. In an "all-or-nothing" assignment process -- meaning that all traffic between two zones is loaded on the single minimum-time path joining them -- this method of capacity restraint could result in an unrealistic traffic assignment by diverting a majority of the original traffic off the overloaded routes.

The Statewide capacity-restraint method uses a "partial-load algorithm". After trees are built and a trip-table created, one quarter of the trips are loaded. A partial future DHV volume is created for each link by calculating DHV = (0.25)X (future AADt)X (future DHV percent), and this value is compared with the hourly adjusted practical capacity for the link to yield a V/C ratio. From this set of values, new effective speeds are generated, new trees are built, and another 25% of the trips are loaded on the new trees and added to the volume from the first load. At this point, half the trips have been loaded; the partial volumes on each link are again compared with the link capacity and new speeds are generated by this criterion. This simulates reality, because as a route begins to fill up, traffic is diverted onto parallel routes. The process is repeated twice more, until all trips have been loaded. The sequence of operations is shown graphically in Figure 8.

FIGURE 8: DIAGRAM OF PARTIAL-LOAD PROCESS



CONCLUSION



CONCLUSION

In an effort to stimulate public involvement in the transportation planning process, the effective speed model was developed to predict future driving speeds as a result of changing travel patterns. A citizen who would be apathetic to a discussion of AADT's and DHV's as a result of a proposed transportation plan might respond more constructively if he could be shown the effect of the new plan on his driving environment, and the easiest measure of traffic flow for the average person to understand is that given by his own speedometer. Moreover, the model can be used in a capacity-restraint algorithm which may prove more logical than conventional methods. It has the potential to accurately simulate reality by diverting traffic as a route begins to fill up with traffic.

The Statewide Studies Unit hopes that this report may serve as a springboard to further discussion and investigation of possible applications or modifications. Any comments or questions should be directed to Mr. Richard E. Esch, Supervisor, Statewide Studies Unit, Bureau of Transportation Planning. He may be reached by telephone at (517)373-2663.