FORMATION OF
THE DETROIT FREEWAY OPERATIONS UNIT

TSD-TR-119-69

TRAFFIC and SAFETY DIVISION

DEPARTMENT OF STATE HIGHWAYS
STATE OF MICHIGAN

MICHIGAN DEPARTMENT OF STATE HIGHWAYS

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By

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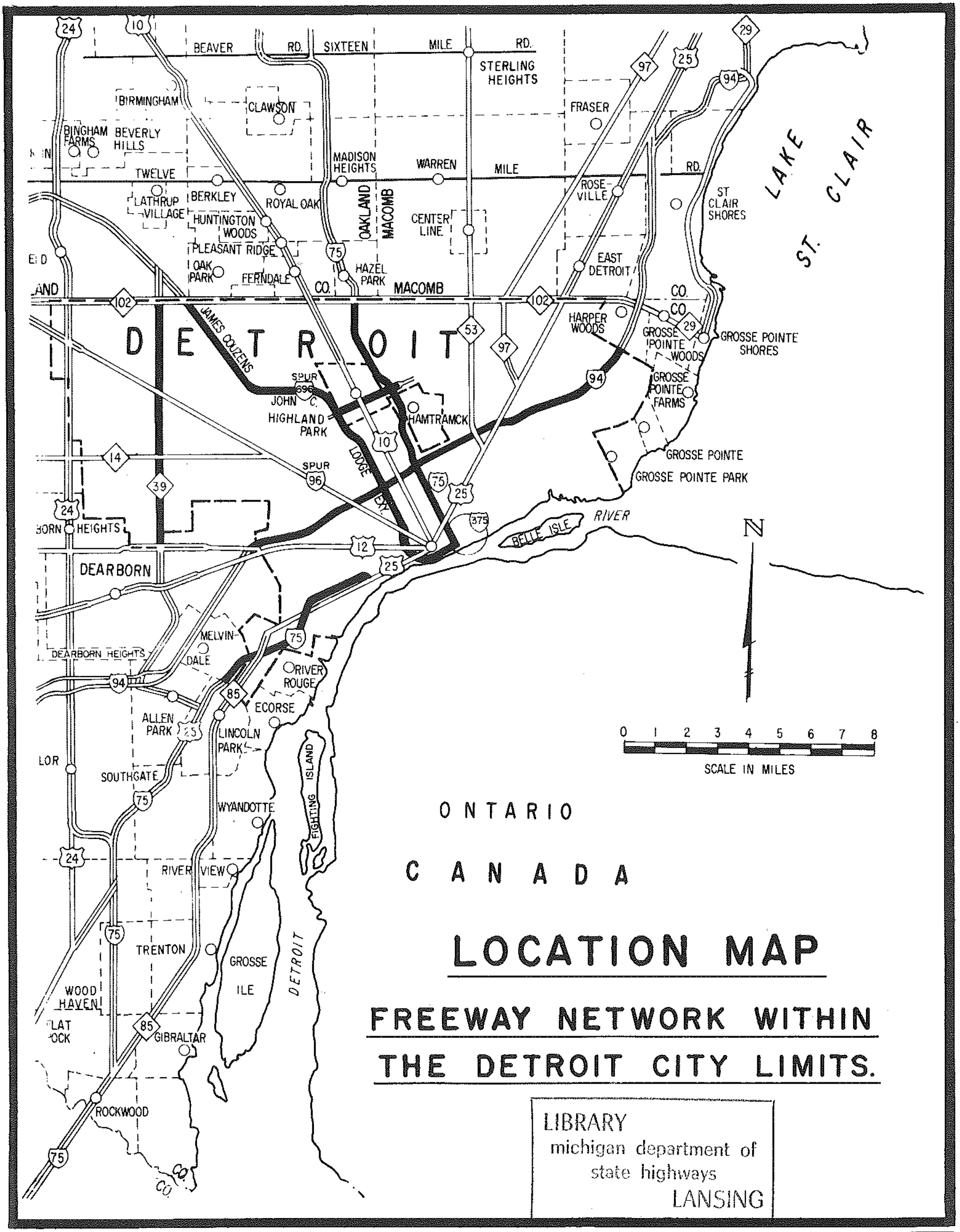

LOCATION MAP

FREEWAY NETWORK WITHIN THE DETROIT CITY LIMITS.

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SEC. I - INTRODUCTION

SEC. I
INTRODUCTION

During 1968 Deputy Director John P. Woodford instructed the Traffic and Safety Division to "conduct a final evaluation of all Freeway Operations Research findings and recommend in detail, and justify on the basis of cost effectiveness and sound engineering judgement what, if any, elements of the surveillance and control system now being researched should be made operational." That assignment was given to Mr. Bruce Conradson, an electrical engineer from the Electrical Devices Unit of the Traffic and Safety Division. As a result of that evaluation, Mr. Conradson published the report entitled "Detroit Freeway Surveillance and Control Evaluation,"[1] which made four major recommendations:

1. Termination of the John C. Lodge Television Surveillance and Control project as an operational unit, retaining its facilities for research purposes only.

2. Formation of a small full time Freeway Operations Unit composed of experienced engineers and technicians whose exclusive responsibility would be the study and treatment of bottlenecks and general traffic operational problems on the Detroit Metropolitan freeway network.

3. Formation of a Freeway Operations Advisory Committee with representatives of the Department of Streets and Traffic, City of Detroit, Wayne County Road Commission and Michigan Department of State Highways, to review

major proposals for operational changes developed by the Freeway Operations Unit.

4. Programming of sufficient funds beginning in 1969 to allow for the installation and operation of a system of electronic surveillance and entrance ramp control on selected sections of freeway in the Detroit Metropolitan area.

As a direct result of Mr. Conradson's recommendations, all four of these activities have been implemented.

The writer has been given the assignment of performing necessary preliminary planning for implementation of the full time continuing Freeway Operations function in Detroit beginning July 1969, which was approved in the proposed 1969-70 fiscal year budget. Specific tasks include:

1. Preparing a detailed work program for activities during the planning phase.

2. Reviewing roadway and traffic flow characteristics such as geometric design, accident experience, volume, capacity and unusual traffic influences, and identify problem areas subject to correction through application of traffic operational techniques either traditional or emerging from research findings.

3. Preparing a detailed inventory of traffic factors for the identified problem areas.

4. Preparing preliminary conceptual designs for applicable traffic sensing, detection, surveillance, warning and control systems.

5. Preparing a detailed outline of a work program for the Freeway Operations Unit to be established July 1969.

6. Performing other specific duties which may become evident and necessary as the program progresses.

This report documents the accomplishments in these areas and presents recommendations for the installation of hardware and implementation of procedures which have already demonstrated a capability for improving the efficiency of the Detroit freeway network in terms of safety, comfort and convenience.

For the purposes of this report, the segments of Davison and Chrysler freeways through Highland Park and Hamtramck are considered an integral part of the Detroit freeway network. All other freeways in the Detroit suburbs will not be considered in the initial phases of the proposed work. Their significance is recognized and may be assumed to have been considered in the overall analysis and planning process.

Briefly, the purpose of the Freeway Operations Unit is to determine the location, nature and extent of traffic operational problems on Detroit freeways with consideration for the effects on their corridors, and to take action to minimize these problems by applying advanced technology and positive research findings in an operational system.

This purpose will be accomplished in three phases:

I. A comprehensive inventory of the Detroit freeways to determine problem locations, including the extent and duration of congestion and hazard due to them; and their effect on the traffic corridor, and to assign a priority for treatment.

II. An intensive study of these problem locations to determine causes and contributing factors, and resultant recommendations for improvements to the existing system. Hopefully, from this intensive study would also come documentation and recommendations for future construction that would reflect the latest state-of-the-art.

III. Operational implementation of improvements determined in Phases I and II, so that the motoring public may begin to benefit from our efforts.

These phases are outlined in greater detail in Appendix A.

SEC. II - SUMMARY & RECOMMENDATIONS

SEC. II

SUMMARY AND RECOMMENDATIONS

SUMMARY

1. Traffic demand on the Detroit freeway network has already exceeded the design estimates, with the result that moderate to severe congestion exists on nearly every mile of Detroit freeways for periods ranging from three to eight hours every day. Traffic predictions for 1975 and 1990 indicate that the problem of congestion will continue.

2. In addition, approximately 6,400 accidents occur annually on Detroit freeways alone (not including ramps and service drives). At least one lane of the freeway will be blocked for this reason alone for over 629 hours, or 7.2 percent of the year.

3. A vehicle will stall or break down in the roadway approximately 6,400 times per year. At least one lane of the freeway will be blocked for this reason alone for over 591 hours or 6.7 percent of the year.

4. Maintenance operations will occupy at least one lane of the freeway for approximately 2,435 hours or 27.8 percent of the year.

5. A restriction of one lane of an urban freeway without advance warning can reduce the capacity of a three-lane

roadway to 57.1 percent of its normal capacity, and that of a four-lane roadway to 67.9 percent of its normal capacity. Whenever traffic demand exceeds these percentages, a potential bottleneck exists which will be triggered when an incident occurs which closes a lane.

6. Since the Detroit freeway network must be made to operate at maximum efficiency if the motorist is to realize the maximum return on his tax dollar, we must stand ready to use all reasonable means to reduce the number of occurrences and the magnitude of their effect.
   (a) Accidents may be reduced by improving geometric features that are contributing factors and by applying traffic control measures to minimize secondary accidents occurring in congestion triggered by another accident.
   (b) The effects of congestion may be reduced by accurate and rapid means of detecting, evaluating and assisting in eliminating causes of congestion and by control measures designed to reduce the demand upon the bottleneck and to increase the efficiency of the freeway and the traffic corridor past the bottleneck.

RECOMMENDATIONS

1. Continuing effort must be expended to provide individual attention to spot improvements for specific locations. Both traditional techniques and the latest advances in

highway technology should be utilized to minimize or eliminate when possible the problems caused when today's (and tommorrow's) traffic characteristics exceed previous expectations and design capabilities.

2. A significant number of incidents will continue to impair freeway efficiency in spite of the best efforts. Since electronic surveillance and control techniques have demonstrated their effectiveness in detecting, evaluating and alleviating the effects of such occurrences, the use of the various forms of electronic surveillance and control techniques must be investigated and applied to problem areas. Specific treatment for Detroit's most troublesome areas is outlined in the following patagraphs.

3. A network of electronic traffic sensors should be installed on the entire length of the Ford, Lodge, Chrysler, Southfield and Fisher Freeways within the Detroit city limits. This network would provide

   (a) Traffic data to determine specifications and parameters for a control system

   (b) Traffic data to be used in real-time control of traffic recorder network

   (c) Information for the permanent statewide traffic recorder network

   (d) Real-time information on changes in traffic patterns indicative of incidents in the roadway requiring aid.

4. A digital computer will be required at a reasonably central location to accept and evaluate information from the traffic sensors to activate appropriate alarms and displays, and to regulate a traffic control system.

5. A communications network will be required to transmit traffic sensor information to the computer and to transmit control and confirmation signals between the computer and the control system displays in the field. The communications network initially installed must have either expansion capability or initial provision for the total surveillance and control system as initially conceived.

6. Electronic traffic sensors should be installed on the Jeffries Freeway as concurrently as possible with its opening. Also, detector installations on portions of the Freeway Network not yet under contract should be included in initial construction.

7. Presuming an initial budget of $5,000,000 over five years for installation of a surveillance and control system, and an annual operating budget of $500,000, a comparison can be made with the present-day value of the freeway system of $12,000,000 per mile, or $591,600,000 for 49.3 miles now open to traffic.

   If the installation cost is amortized over only a single year, any increase in efficiency during that first year of full operation of 0.84 percent would equal the percentage increase in value of the freeway network because of the added surveillance and control equipment, and could be declared cost-effective. Similarly, considering annual operating costs, each subsequent year must realize an increase in efficiency of 0.084 percent to be cost effective.

By comparison, early detection of incidents through surveillance can result in reducing the time these incidents occupy the roadway by 533 hours, 20 minutes. This represents an improvement of 6.4 percent in the amount of time that the freeway is unobstructed and able to function normally.

This figure alone compares favorably with the required 0.84 percent and 0.084 percent required to be cost effective.

Further, since maintenance operations can be expected to occupy at least one lane of the freeway for at least 2,435 hours annually, or 27.8 percent of all hours of the year, and since the use of a dynamic system of on freeway controls can increase traffic volumes past such an event by 8.4 percent on a three-lane roadway and 6.3 percent on a four-lane roadway, these percentages in themselves also compare very favorably with the 0.84 percent and 0.084 percent required to be considered cost effective.

These figures alone are adequate to justify expenditures of the magnitude indicated.

Some additional benefits that have been determined in other studies and observations, include: reductions in accidents because of reductions in congestion; reductions in travel time; increases in total vehicle miles traveled; and early detection of roadway defects such as flooding and pavement blowups, resulting in prompt attention.

8. Since the Edsel Ford Freeway is the oldest (except for Davison) and most congested freeway in Detroit, with the greatest number of accidents and occurrences in the roadway, it is imperative that every reasonable means be utilized as soon as possible to remove the causes and to minimize the effects of these incidents. In the area between Wyoming and Gratiot, these means would include

   (a) alleviation of recurring congestion by installing an access control system (ramp metering)

   (b) Immediate detection and evaluation of incidents obstructing the roadway and the ability to instantly dispatch appropriate aid and minimize the duration of the blockage by installing a minimum number of television cameras with the ability to scan and evaluate apparent incidents as determined by the sensors

   (c) Increasing traffic volumes past obstructions in the roadway by 6.3 percent to 8.4 percent through the use of lane control signals.

9. An access control system should be installed on the southbound John Lodge Freeway.

10. Upon completion of research on the northbound Lodge Freeway, an operational system of ramp metering and certain refinements as required should be installed so that traffic on this freeway will continue to receive the benefits of surveillance and control.

11. A continuing evaluation of the network traffic picture, utilizing all available experience and data, must be maintained to determine the nature and extent of further refinement to, or expansion of, the surveillance and control system. It must be remembered that none of the refinements are a duplication of other parts of the system. Each component attacks a different aspect of the problem, and augments the other components to compound the benefits to the motorist. A competent staff must be provided for the Freeway Operations Unit, representing experience in at least the following disciplines:

    (a) Freeway traffic operations
    (b) Freeway control theory
    (c) Electrical and electronic theory
    (d) Practical knowledge of electronic hardware and components
    (e) Knowledge of computer applications and programming
    (f) Ability to prepare plans and specifications.

SEC. III - PRELIMINARY ANALYSIS

Sec. III

PRELIMINARY ANALYSIS

BROAD DESCRIPTION OF THE DETROIT FREEWAY SYSTEM

The present Detroit Freeway network consists of five freeways, ranging in length from 6 to 13.8 miles opened to traffic within the Detroit city limits with a total of 49.3 miles now open to traffic. None of these constitute an isolated section; that is, they each have continuity either by entering the downtown area or by continuity with completed sections of freeway leaving the city.

The completed system inside the city limits will consist of approximately 70 miles, hopefully to be completed by 1975. A brief description of each is as follows:

I-94 - Edsel Ford Freeway is the major "east-west" freeway and the only really continuous route across the city in that direction. It consists of three lanes in each direction except for a few very short (1/2 mile or less) four lane sections. This is the oldest continuous freeway (excluding a two mile section of Davison) in the city. Interchanges are spaced at 1/2 to 1 mile intervals.

696BR - John C. Lodge Freeway runs in a northwest to southeast direction and provides a route from the northwest suburbs to the central business district. It consists of three lanes in each direction, except for four short (1/2 to 1 mile) four lane sections.

Interchanges are spaced from 1/2 to 2 1/2 miles apart. The northwestern 3 1/2 miles is built between retaining walls with the service drives partly cantilevered over the shoulder area.

I-75 - Fisher Freeway is presently open from south of Detroit to a temporary ending at Lafayette Avenue, approximately one mile from the CBD. An additional three miles is presently under construction and partially open to traffic across the north end of the CBD. It consists of four lanes in each direction between Schaefer and Lafayette, and three lanes in each direction from Schaefer south to and beyond the city limits at Outer Drive. Interchanges are spaced at 1/2 to 1 mile intervals, except for a two mile interval between Schaefer and Dearborn Roads. The section between Schaefer and Fort Street consists of a high rise bridge over the Rough River shipping channel.

I-75 (and I-375) - Chrysler Freeway is the most recently opened section of Freeway in Detroit. It consists of four lanes in each direction, except for a constriction to three lanes in the center of the interchange with Davison. Interchanges are spaced 1/2 mile to 1 mile apart. This freeway now constitutes the major route from the north central suburbs to the CBD.

M-39 - Southfield Freeway serves as a north - south beltline serving the west side of the city. It consists of three lanes in each direction, with interchanges quite uniformly spaced at 1 mile intervals.

Uncompleted portions of the system consist of the following:

I-96 - (Jeffries) freeway, which will join the Fisher Freeway at Michigan Avenue and serve the west central part of the city and its suburbs. It is presently under construction, with the last section scheduled to be placed under contract in November 1971.

Davison Freeway is proposed to be extended west from the Lodge Freeway to the interchange with the Jeffries about two miles to the west. An easterly extension is also proposed, to extend east then south to the interchange with the Ford near Connors. No target date has yet been established for this section. However, this extension has been considered in determining 1975 traffic assignments.

In the same vein, the Detroit Planning Commission, in estimating 1990 traffic, has considered an extension of the Fisher Freeway east from the Chrysler to the interchange with the Ford (and the Davison Freeway extension) near Connors. There are at present no plans to construct this section.

RECURRING FACTORS CONTRIBUTING TO CONGESTION

Congestion is a daily occurrence on the Detroit freeway system. A discussion of the extent of this congestion is presented in Appendix B. Therefore, details will be spared here. It is enough to say that demand on the freeway system has already exceeded the design estimates, and will continue to remain ahead of any construction program in the foreseeable future. Three conditions exist as part of existing freeway design that prohibit available capacity from accommodating demand.

The first of these is unrestrained access at a given ramp such that the ramp volume when added to the volume of traffic already on the freeway equals a volume in excess of the capacity of the freeway at that point. This condition is complicated by the frictions generated by the merging maneuver with the degree of complication being affected by the degree of finesse or obstinacy employed by the individual drivers.

The second is a condition on the freeway commonly referred to as a "bottleneck," which restricts the ability of the freeway to handle traffic at a given point. Some examples of bottlenecks are:

a. Reduction in lanes. This is usually the easiest to observe because of the obvious geometric feature. Congestion frequently is generated at such locations, even though the lane may be ended by terminating it at an exit ramp, for two reasons: because the through volume may exceed the remaining capacity, and because the act of weaving out of the dropped lane often interferes with through traffic, thereby causing speed to decrease below optimum with a resulting decrease in through put.

b. Horizontal curvature. This is one of the more subtle forms of bottleneck, but has been demonstrated to be a regular occurrence on some moderately sharp curves. Congestion is triggered when a fairly dense platoon of traffic enters such a curve and one or more vehicles experiences difficulty "tracking" in his lane. Its apparent crowding into the next lane causes a hesitation on the part of vehicles in adjacent lanes, often resulting in their slacking speed momentarily. A decrease in speed of only a few miles per hour in an unstable traffic condition can result in congestion.

c. Vertical Alignment. The results of steep grades are well known, and certain maximum limits have been imposed in our design standards. Below the accepted maximum, certain other subtle conditions exist that are not quite as apparent. At the steeper "acceptable" grades, the rise is apparent, and traffic tends to compensate by accelerating at the start of the rise. However, at about a two percent grade, the effect is so subtle that traffic unknowingly enters the grade and begins to decelerate before the effect is realized, thereby affecting following traffic. In a dense traffic situation, congestion sets in.

The third condition affecting the demand-capacity relationship is the inability of exiting traffic to leave the freeway. This can be caused by ramp demand exceeding the ability to process traffic through a merging area or an intersection at the head of the ramp, or by a lack of storage on the ramp itself. The end result is a queue of vehicles extending back onto the freeway, thereby interfering with the through lanes.

Possible solutions to these conditions are discussed in Section IV in this report.

RANDOM FACTORS CONTRIBUTING TO CONGESTION

Because of other applications of the word, events bearing the label "random" are easily dismissed as rare occurrences not worthy of attention. In reality use of the word "random" refers to the inability to predict such events in terms of time or location. Experience has shown that random incidents comprise one of the major factors affecting freeway efficiency.

Appendix D analyzes these events based upon the most reliable data available and presents some very conservative projections of the effect of random incidents on the Detroit freeway network.

These projections indicate that in a year's time we may expect that:

1. Approximately 6,400 accidents will occur on the freeways alone (not including ramps and service drives). At least one lane of the freeway will be blocked for this reason alone for over 629 hours, or 7.2 percent of the year.

2. A vehicle will stall or break down in the roadway approximately 6,400 times. At least one lane of the freeway will be blocked for this reason alone for over 591 hours, or 6.7 percent of the year.

3. Maintenance operations will occupy a lane of the freeway for approximately 2,435 hours or 27.8 percent of the year.

ANTICIPATED BURDENS ON THE FREEWAY SYSTEM

We have already stated that the Detroit freeway network is already being asked to perform above and beyond its ability to handle today's traffic.

Appendix C discusses this problem and further predicts that based on present traffic estimates and construction schedules, today's congestion problem will be equally severe in 1975, with future construction easing congestion, but not eliminating it, by 1990. Summarizing, we anticipate that more than half of the freeway network can be expected to have a demand in excess of 70 percent of capacity, and one-quarter will have a demand in excess of 100 percent of capacity.

This might be considered tolerable at face value, but two other factors must be considered.

First, these capacities occur at level of service D, in which flow is unstable, with the possibility of stop - and - go conditions being imminent.

Second, we have determined, as discussed in Appendix E, that a restriction of one lane without adequate warning, can reduce the capacity of a three lane roadway to 57.1 percent of its normal capacity, and that of a four lane roadway to 67.9 percent of capacity.

Thus, we may conclude that whenever the demand upon a three lane freeway exceeds 57 percent of normal capacity, or when the demand on a four lane freeway exceeds 68 percent of normal capacity, we have a potential bottleneck, which will be triggered when an incident occurs which closes a lane.

NEED FOR IMPROVEMENT

Since the computations in Appendix D predict that lane blockages can be expected to occur as a result of accidents and breakdowns alone for over 1,220 hours per year, or 13.9 percent of the time, we must stand ready to use all reasonable means to reduce the number of occurrences and the magnitude of their effect.

Two basic means of accomplishing these goals are necessary:

1. Reduction of all possible accidents by removing, insofar as is feasible, their causes. This would include the improvement of geometric features such as severe curves on ramps, inadequate storage that causes backups onto the freeway, etc. It would also include adequate traffic control measures to minimize secondary accidents occurring in congestion triggered by another accident.

2. Reduction of the effects of congestion causes by both recurring factors and random occurrences. This would include accurate and rapid means of detecting, evaluating and assisting such occurrences, so as to reopen the affected lanes as soon as possible, and adequate control measures, both to reduce the demand upon the bottleneck and to increase the efficiency of the freeway and its corridor past the bottleneck.

When we realize that the present day value of a mile of urban freeway is about $9,000,000.00, we must acknowledge the fact that the highways comprising the Detroit freeway network and their associated traffic corridors must be made to operate at maximum efficiency if the motorist is to realize the maximum return on his tax dollar.

If one artery of the corridor is congested, it is not operating efficiently. If at the same time a parallel artery is operating well below capacity then it, too, is operating inefficiently.

In order to improve efficiency, the flow on the various arteries of the corridor must be balanced. Causes of congestion must be minimized and eliminated if possible. Similarly the effects of congestion, once it occurs, must be minimized.

SEC. IV - PLANNING & IMPROVEMENT

SEC. IV

PLANNING AND IMPROVEMENT

DETAILED INVENTORY OF TRAFFIC FACTORS

The various traffic factors presented in this report present a comprehensive picture of the total accident and congestion picture on Detroit's freeways. Because of limited time and manpower, all of the estimates and projections presented herein relate to the total network rather than spot locations. Each can be seen to be a conservative estimate, based on the most reliable information available.

Even using such conservative figures, it can readily be seen that the magnitude to the problem is such that the investigation of "spot locations" is a major effort in itself. For example, there are 26 separate locations on the freeways alone (not counting ramps or service drives) at which over 50 accidents per year have occurred. Certainly each of these requires an in-depth study.

With the great number of accidents and the continuing heavy demand on the system, we know that all accidents and incidents cannot be eliminated. Even with the most optimistic improvements, a significant number will remain.

For maximum efficiency, traffic flow must be "balanced" in the corridor, depending on both recurrent and transient conditions, including but not limited to demand, constrictions due to geometrics, constrictions due to incidents, etc.

Further, incidents must be detected, evaluated and removed as soon as possible.

ANALYSIS AND PROPOSED SOLUTIONS

Spot improvements to specific locations will require individual attention. Continuing effort should be expended in this direction so that advances in highway technology may be utilized to minimize or eliminate when possible the problems caused when today's (and tomorrow's) traffic characteristics exceed previous expectations and design capabilities.

Traditional methods of implementing these technological advances should still be employed when warranted. Such items as work orders to modernize signing and markings, and work orders or contracts to improve design standards, such as removing tight curves, improving acceleration and deceleration lanes, increasing storage, etc., may in many cases be effective solutions. Three such proposals have recently been let as individual contracts, and several others have been initiated but have not yet been scheduled for construction.

As previously stated, a significant number of incidents can and will continue to occur in spite of our best efforts to improve design, signing and marking. Since electronic surveillance and control techniques have demonstrated their effectiveness in detecting, evaluating and alleviating the effects of such occurrences, the use of the various forms of electronic surveillance and control techniques must be investigated and applied as appropriate to the problem. Examples of such techniques in spot locations could include access control by metering entrance ramps, and dynamic advance warning systems at recurring problem areas. These would of course be compatible with a network control system.

Further, the major recurring problems either consist of or develop into extensive congestion or high degrees of recurrence of random events (accidents, breakdowns, emergency maintenance, etc.). These events must be detected and their effect on traffic minimized by prompt action. This action takes several forms, notably prompt detection and evaluation, dispatching of appropriate aid, traffic control and driver information and routing.

Traditional methods of detection such as patrols, citizens' information, via Citizens' Band radio or telephone, helicopter, etc., continue to provide a useful service, but their benefits with respect to early detection are limited by the probability of an observer being on the scene as, or very soon after, the incident occurs.

Electronic surveillance and control techniques can be adapted to rapidly detect and minimize the effect of incidents. Surveillance is possible with either a "blind" system, utilizing one or more types of electronic sensors, or with a visual system, using closed circuit television.

SURVEILLANCE

Evaluation of the several parameters of traffic flow necessary for precise and timely control techniques based on mathematics is possible using a digital computer as a controller with data from traffic sensors as inputs. Various types of sensors, such as sonic, optic, radar, loop, infra-red, and magnetometers, have different capabilities for sensing the various values of speed, volume and occupancy. In addition, their installation and maintenance characteristics vary from type to type, some requiring an overhead structure, some requiring special mounting techniques. These factors must all be weighed, with the type of sensor used in a given location to be determined by the type of information required, the mounting facilities most feasible, its accessibility for maintenance, and its reliability.

Detection systems comprised of the above types of detectors provide only "point" information within a small area of influence. With normal or sustained condition, the values measured may be extrapolated to give an accurate representation of "area" conditions between successive detector locations. They have a capability of detecting the presence of unusual incidents providing the detection stations are quite close together, and when the efffcts are severe. However, the number of incidents which go undetected is significant, as is the number of "false alarms" in which an unusual but harmless traffic condition displays characteristics that appear to identify an incident in traffic.

Such incidents must be verified or refuted by visual observation. When such verification is provided by patrol vehicles, valuable time is often lost in dispatching specialized aid, such as wreckers, ambulances, or fire equipment to the scene.

Positive and immediate detection and evaluation of incidents is possible by the use of only one area detector, the television camera. At present the television camera is not capable of providing inputs to the computer, although the possibility is under investigation. It is, however, the only detector capable of instantly providing the most important information required in evaluating an unfortunate incident on the freeway. Such factors as severity of the incident, whether anyone was injured, or whether specialized equipment is necessary, are in most cases immediately apparent to the evaluator. While it has already been demonstrated that response time, and thereby the time that the roadway is blocked, can be reduced by about 2.5 minutes per occurrence(3), the total saving is much greater when specialized equipment is required, since this equipment is not normally dispatched until a patrol car verifies its need; when this specialized equipment is ordered by the evaluator, it can oftentimes be the first "official" aid on the scene, even ahead of the patrol car that might otherwise be the requesting unit.

Television has proven an effective tool in improving traffic flow on the Gulf Freeway in Houston. William J. McCasland, head of the Freeway Surveillance and Control Department, Texas Transportation Institute(5) reports, "Since installing the television system and the computer, there has been a reduction of accidents during the peak traffic periods by as much as 40 percent. Also during the peak periods of traffic flow, the speed of traffic has been increased 30 percent. With the decrease in accidents and the increase in traffic speed, the capacity of the freeway has been improved by 10 percent.

CONTROL TECHNIQUES

Several control techniques have been demonstrated to be effective in minimizing the effect of capacity reducing incidents. Some of these techniques and their benefits are discussed briefly in the following paragraphs. Documentation of the benefits of these techniques may be found in other sections of this report and the references.

1. Ramp metering - has a dual benefit. The first is the ability to impose a "good driving" technique on the driver at the time and place that it is needed, namely, the act of introducing one vehicle at a time into the freeway traffic stream, thus minimizing merging interferences and improving the probability of finding and utilizing an acceptable gap. The second is the ability in many cases to limit demand on the freeway to numbers capable of being handled past downstream bottlenecks and incidents. Ramp metering, however, has no capability for reaching those drivers already on the freeway to advise them of conditions ahead. Thus,

within a reasonable distance of the constriction, only a small percentage of the drivers are reached.

2. Lane control - also has a dual benefit. The first is the ability to warn approaching traffic of an obstruction in the roadway. The second is the ability to permit traffic to become better organized in advance of the incident, thereby smoothing out the process of merging into open lanes and increasing the output past the constriction by 6.3 to 8.4 percent.

3. Lane assignment - Refinements to the lane control system could also improve the organization of traffic and its quality of flow through the use of blank-out signals for specific lane assignments. For instance, back-ups from overloaded exit ramps extend onto the freeway, and the blockage is compounded by other drivers becoming trapped in the backup. Assignment of such lanes for exiting traffic only by displaying an appropriate message at critical times will better organize the approaching traffic and improve the flow in adjacent lanes. This concept is not new; assignment of lanes through conventional signing is an accepted procedure, the refinement being in the capability of activating a dynamic sign system only when the need is there.

4. Diversion of freeway traffic. In the event of an on-freeway incident, the majority of the traffic approaching the vicinity of the incident is already on the freeway and beyond the capability of a metering system to limit demand. The need also exists in this instance to divert some of the excess traffic demand off the freeway to a "bypass" route, then back to the freeway.

5. Guidance of surface corridor traffic. The concepts of ramp metering and diversion of freeway traffic both imply that at least a portion of the traffic flow will be diverted from an overburdened, and thus inefficient, freeway to an alternate route with the capability of handling the diverted traffic. Sometimes this added capability must be developed on the surface facilities. Possibilities include the improvement of signal timing and control techniques, improvement of traffic organization by lane markings, parking restrictions, and guidance of traffic to preferential routes. These possibilities, and others, will be explored in cooperation with the city and county.

It is important to note at this point that the various traffic control techniques discussed have been accepted, at least in modified form, in present day applications of conventional signing and traffic signals.

The big plus factor of electronic surveillance and control is the fact that while conventional signs and signals must be predetermined and fixed to handle the average situation or the most severe situation, thereby losing effectiveness by "crying wolf" much of the time, the dynamic electronic system has the capability of being adapted almost instantaneously to the situation at hand, with the flexibility of being able to present information in the most effective manner and location befitting the situation.

The benefit of these various devices as protection for maintenance crews is highly significant. One of the most hazardous moments in their operations is stopping in traffic to place the first warning sign; equally hazardous is the need to stop in traffic to remove these signs. A dynamic "in place, ready to activate" system removes much of this hazard. Frequently crews are called upon to perform emergency maintenance work. In light traffic, the hazard to the crew and to moving traffic is the presence of an obstruction in the face of high approach speeds. In heavier traffic, the hazard is the attendant congestion and constricted maneuvering. The timing on these emergency conditions is unpredictable. For example, flooding may occur (and has) during a heavy storm. Likewise, pavement blow-ups occur during hot weather, usually during the hottest part of the day, which coincidentally is the beginning of the afternoon peak traffic period.

In addition to the protection afforded the work crews, the utilization of the electronic detection system makes possible the closing of lanes when volumes permit, rather than at predetermined hours. During the summer of 1966 night time bridge painting operations occupied at least one lane of the Lodge Freeway for a period of 95 work days. By using electronic surveillance and control, and using real time measurements of the traffic stream, lane closures were affected based on traffic warrants at least an hour sooner than clock time warrants would permit. It was also found that night ball game traffic volumes exceeded allowable limits beyond the clock time on several occasions. In the latter case, the instrumentation forestalled inevitable congestion. Over the period of 95 days, an additional 30 hours time was permited in the roadway. Allowing an hour a day for set-up and an additional hour for clean-up time, it can be seen that the equivalent of about 13 extra days' work was accomplished. Considering that the work force and equipment would be on hand and paid for a full eight hour shift whether they worked or not, the 13 days' worth of work was accomplished for the cost of materials alone.

In view of the age of some of the older freeways (sections of the Edsel Ford were opened to traffic seventeen years ago; sections of the Lodge were open fifteen years ago), it is already apparent that major maintenance projects involving extended periods of lane closure and even freeway closure (at least on a night after night basis) will become more frequent. Such complex operations will require the most effective traffic controls and evaluation techniques available, to keep hazard to a minimum and both traffic and work efficiency at a maximum.

COST EFFECTIVENESS: BASIS OF COMPARISON

While each of the various proven elements of electronic surveillance and traffic control can improve the safety and efficiency of the freeway network and related traffic corridors, the degree of benefit must be in proportion to the cost of the system. While many of the benefits of surveillance and control are intangible or difficult to measure, other factors can be assigned an expression of effectiveness. Thus, if these tangible factors approach the value of the surveillance and control network, the installation can be deemed cost-effective.

Conradson(1) proposed an installation budget of $2,642,500 over five years, to cover the cost of design, installation and partial operation, and a continuing annual budget of $327,000 per year for continuing operation. Allowing for inflation and contingencies, and to provide a conservative comparison, let us presume an installation budget of $500,000 per year for continuing operation, and compare these figures with the present-day value of our freeway system. With 49.3 miles of freeway now open to traffic, at today's cost of $12,000,000 per mile, including structures and right-of-way, the Detroit Freeway Network is worth $591,600,000.

The cost of installation of the freeway surveillance and control network, using the above figures, would then increase the total value of the freeway network by $\frac{\$\ 5,000,000}{\$591,000,000}$ or 0.84 percent.

Again being conservative, if we amortize this cost over only one year, any increase in freeway efficiency during the first year of full operation of only 0.84 percent could be declared cost-effective.

Let us now examine some of the measurable aspects of surveillance and control.

MEASURES OF EFFECTIVENESS:

It has been determined and reported in Appendix D that 6,400 accidents and 6,400 disabled vehicles in the roadway will block a lane of traffic for an estimated 1,220 hours, 35 minutes or 13.9 percent of all hours in a year. If early detection improves response time by 2.5 minutes per incident, as documented by Keryeski and Surti [3], these vehicles will obstruct the roadway for 533 hours, 20 minutes less than before. This represents an improvement of 6.4 percent in the amount of time that the freeway is unobstructed and able to function normally. This figure alone compares very favorably with the 0.84 percent required to be cost effective in subsequent years.

In Appendix D, it was further determined and reported that maintenance operations can be expected to occupy one or more lanes of the freeway for a total of at least 2,435 hours a year, or 27.8 percent of all hours in the year. For these operations, the use of a dynamic system of on-freeway controls can increase traffic volumes past the obstruction by 8.4 percent on a three-lane roadway and by 6.3 percent on a four-lane roadway, as demonstrated in Appendix E. Again these percentages alone, considering the frequency of occurrence of this type of condition, compare very favorably with the 0.84 percent required to be cost-effective in subsequent years.

In addition to the above factors, the Texas Transportation Institute has calculated that the use of the surveillance and control system in Houston has produced benefits which, although not directly applicable to the Detroit Freeway Network, are indicative of additional benefits. They report [7] motorist savings in travel time valued at $224,000 annually on the Gulf Freeway alone. Further, they calculate that the saving in accidents on the Gulf Freeway is valued at $38,000 annually. It is the author's opinion that the above measures of the effectiveness are in themselves adequate to justify expenditures of the magnitude indicated.

Additional benefits which can be cited, and which have been determined in other studies and observations, include: reduction in accidents because of reductions in congestion;

reductions in travel time (important to the individual driver); increases in total vehicle miles traveled (more vehicles at higher average speed); and early detection of roadway defects (flooding, pavement blowups, etc.) resulting in prompt attention.

SEC. V - PRELIMINARY CONCEPTUAL DESIGNS

SEC. V

PRELIMINARY CONCEPTUAL DESIGN

While each of the aspects of surveillance and control discussed in this report has the capability of improving the efficiency of the freeway network, simple economics dictate the fact that not all possible solutions can be justified for every mile of freeway. This section will outline the components required in specific portions of the Detroit freeway network, based on present and predicted conditions. Essentially, these components will consist of a network of sensors on the entire Detroit freeway system, implementation of ramp metering in selected areas to alleviate recurring congestion, and the addition of certain refinements to augment the basic system, based on the nature and extent of recurring problems.

Exhibit V-1 is a schematic diagram of the surveillance and control concept. It can be seen from this diagram that certain aspects might be removed from the system and still retain the ability to start with the driver as the initial piece of information and return to him (and his performance) as the last action in the system. However, the "removable" items are not redundancies, but degrees of refinement with each component producing benefits to augment the others.

With this in mind, the proposed surveillance and control system will begin with a basic system on the entire freeway network, and the various refinements will be added where warranted.

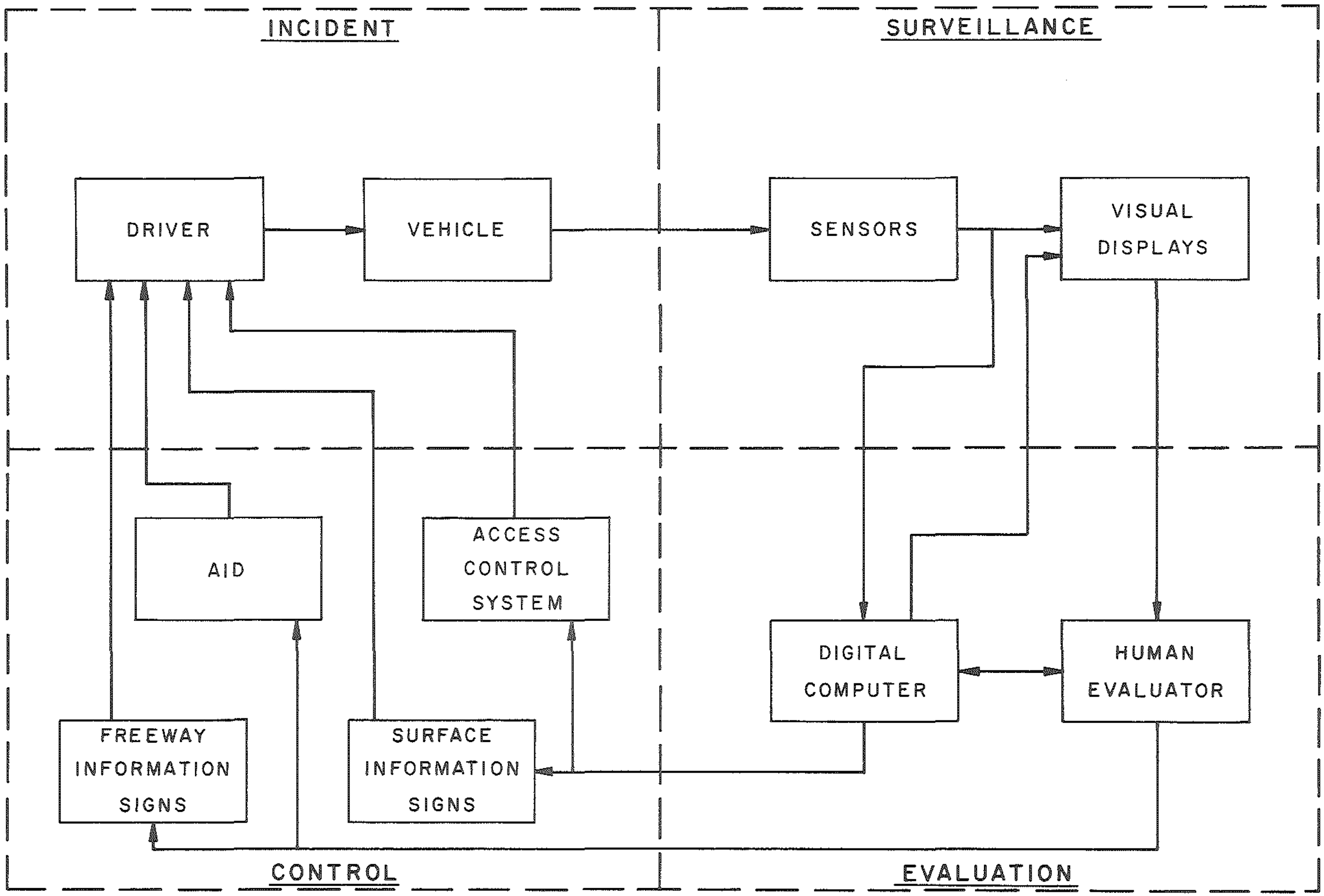

EXHIBIT V-1

SCHEMATIC DIAGRAM OF SURVEILLANCE & CONTROL SYSTEM

BASIC SURVEILLANCE AND CONTROL SYSTEM

The most basic system of surveillance and control that must be installed on the entire Detroit freeway network will consist of a network of electronic detectors to sense traffic conditions, a digital computer to evaluate traffic conditions, and some form of output device which will provide information to an evaluator for ultimate action or provide information directly to the motorist to improve his performance in the traffic stream.

Data from the detectors will provide the following basic information:

1. Basic traffic data to be analyzed by the Freeway Operations Unit staff to aid in the determination of specifications and control parameters for the operating system.

2. Information that can be used as part of the permanent statewide traffic recorder network.

3. Traffic data to be used in real-time control of traffic.

4. Changes in traffic patterns indicative of incidents in the roadway requiring aid.

The detector system will not necessarily be composed of a single type of sensor. The type will depend upon the data required, the location and the feasibility of installation.

For example, traffic volume information will be required as input and output data for each of the subsections into which the network must be divided. Thus, detectors with an accurate counting capability will be required on the freeway and ramps. These might be mounted over traffic (from overpasses or sign trusses), beneath bridge decks (sensing through the pavement), or possibly placed beneath the pavement in a nondestructive manner. By careful selection of the types of detectors, it appears possible to install most, if not all, of the detector locations without disturbing the pavement surface and with a minimum disturbance to traffic.

Since speed is the most sensitive measure of changes in the traffic stream, sensors capable of determining speed accurately will be placed at more frequent intervals at critical locations, to operate either independently or in conjunction with volume detectors.

The information from these detectors will serve as inputs to a digital computer, which will process the information so obtained, performing an evaluation process in some instances, and displaying the information in a usable way. This could take the form of a display to a human evaluator who will take appropriate action in the form of dispatching of an investigator, activating of a control device or feeding information back to the computer. It could also take the form of direct instructions to a control or information system which will provide direct information to the driver.

The exact location of the detectors comprising the total surveillance network is to be determined by the Freeway Operations Unit staff during fiscal year 1969-1970. The configuration of the computer system will also be determined during that period. One basic possibility is that of a single centrally located processing unit, which will accept all of the detector inputs. The method of communication of these inputs will be the object of study to determine the most economical yet reliable means.

Investigation may show that extensive communications of all data to and from a central computer might become unreasonably expensive. A second basic possibility will be explored, which would utilize smaller inexpensive "desk-top" computers to perform locally the major task of evaluation and control in one or several sub-systems, and provide only pertinent data and information on abnormal conditions to the central control unit, which would then activate appropriate alarms, reprogram the local computer to handle the unusual situation, and monitor the overall system, making appropriate changes in adjacent sub-systems as required.

The possibility of housing these local computers, if utilized, in existing pump houses has been investigated. They would provide an ideal housing, with adequate space, power on site, and a high degree of security, yet readily accessible. This would appear to be the least expensive mode of housing these computers.

Still speaking in terms of a basic surveillance and control system, one aspect of control that would be implemented, using as its inputs only the detector information, would be a system of ramp metering. Such a system should be implemented on those portions of the freeway that experience recurring congestion. Preliminary investigation has shown that recurring congestion occurs on the Edsel Ford Freeway in both the eastbound and westbound directions from Wyoming Avenue to Gratiot Avenue during both peak periods and frequently continues into the off-peak periods.

A similar condition continues to exist in the afternoon on the northbound John Lodge Freeway between the Edsel Ford Freeway and Wyoming Avenue, although this has been alleviated by the experimental metering system presently being implemented by the University of Michigan. It also exists in the southbound direction in the morning, with traffic backing up from Davison to a point beyond Wyoming Avenue, and on occasion as far as 6-Mile and 7-Mile Roads. These conditions continue to exist even after the opening of the Chrysler Freeway.

First consideration for the installation of an access control system should be on the Edsel Ford Freeway in the area between Wyoming and Gratiot.

This freeway is the oldest in the city, and has experienced this recurring congestion for the longest time.

No immediate relief is forthcoming in the east-west corridor served by this freeway, except for the two-mile section of the Fisher Freeway between the Jeffries Freeway and Gratiot, together with one mile of the Jeffries between the Fisher and the Ford

Freeways. This should take some pressure off the center portion of the Ford, but the congestion appears to be too extensive to be completely relieved.

The second consideration for an access control system should be given to the southbound John Lodge Freeway between 8-Mile Road and West Grand Boulevard. Action on the northbound Lodge should be held in abeyance until such time as the research studies being performed in that area are completed.

As the basic system is implemented in these areas, traffic improvements could conceivably increase output such that bottlenecks beyond the areas initially controlled would become critical, and as a result, the surveillance system would be utilized to determine when the metering system should be extended to other portions of the freeways.

Initial considerations should include the possibility that site determination or construction lead time might cause delays in utilizing the control center. As an alternative, it might be feasible to consider initial installation of the smaller computers previously discussed, operating the most crititcal subsections as a "spot improvement", with the aim of ultimately tying the subsection into the main computer at the control center when its installation is complete.

REFINEMENTS

The basic surveillance and control system just described will do a commendable jcb of balancing traffic flow in the traffic corridor providing all roadways are operating normally. It has been documented in Appendix D that for a significant amount of the time, the freeways do not operate normally. Accidents, vehicle breakdowns, and maintenance operations take place in the roadway which severely curtail the traffic handling capabilities of the freeways. When such incidents occur, even minimum metering rates can be excessive. In addition, it must be recognized that when minimum metering rates onto the freeway are imposed, an additional burden will be placed on the alternate routes.

It thus appears logical that in those areas experiencing a high concentration of incidents in the roadway, additional means must be employed to help the freeway recover its capability, thus enabling the metering system to operate at optimum rates, not necessarily at minimum rates. Observations on the John Lodge Freeway have shown repeatedly that even minimum metering rates cannot forestall congestion when one lane is blocked.

The Edsel Ford Freeway between Livernois and Gratiot is the most serious case in point. Appendix C has documented the fact that recurring congestion prevalent in that area now, and that it will remain with us, as evidenced by 1975 and 1990 traffic projections.

Appendix D has documented the fact that the accident rate in that area is significantly higher than on the rest of the Freeway network. It has also been documented that the number of vehicular breakdowns and stalled vehicles is significantly higher in that area. It is imperative that every reasonable means be utilized to remove the causes and to minimize the effect of these occurrences.

Prompt removal of the causes, that is, the vehicles or objects obstructing the roadway, requires the immediate detection and evaluation of the nature of the occurrence by trained personnel, and the dispatching of the proper type of help without delay. This is in contrast to the present procedure of verifying citizen's reports by dispatching a police officer to the scene to investigate and verify, and then request additional assistance.

It has been shown [3] that by using visual surveillance, assistance can be on the scene an average of two and one-half minutes sooner than can be done without this means of visual surveillance and evaluation, and that the time that the disabled vehicles occupy the roadway be cut nearly in half. Since Appendix D has documented the fact that accidents and disabled vehicles can be expected to occupy at least one lane of the roadway for a period of 1,220 hours per year or 13.9 percent of the time during a year, this reduction in the time that the roadway is obstructed becomes very significant.

It would be preferred that a system of closed circuit television providing full and constant coverage of the freeway network be installed. Because of economic constraints, it may not be possible to install such a system in its entirety. As an absolute minimum, a less extensive application, consisting of television cameras strategically located to provide the capability for intermittent viewing of the entire freeway between Livernois and Gratiot, is required.

Additional examples of the benefit of such an application are the fact that a high percentage of breakdowns in the roadway involve trucks on the relatively steep grades of the Dequindre overpass.

Mechanical breakdowns, such as stalled engines, burned out clutches, transmission failures and brake failures are common occurrences in that area. Since these incidents are of a type that the freeway patrol cars are not capable of handling, a prompt determination that heavy-duty equipment is needed will decrease the time it takes to clear the roadway even more than the previously stated two and one-half minutes.

Another important aspect of the visual surveillance system is the fact that this area has been proposed as the first extensive installation of operational ramp metering. Because of some of the critical values involved in the metering of traffic, the television system will provide the additional capability of evaluating the metering operation. The Texas Transportation Institute in their research on the John Lodge Freeway (NCHRP Project 20-3) found the visual surveillance of the four metered ramps south of the Davison interchange extremely helpful. Operational problems were detected and corrective action taken as they developed, as contrasted with the four metered ramps from

Davison north, in which reports were received that a certain operational situation had been happening regularly over a period of many days. Such verbal reports were often the first notice of the fact that operational deficiencies were being experienced.

It is noteworthy that the Texas Transportation Institute has seen fit to install television cameras on the Gulf Freeway in Houston which have the capability of monitoring the ramp metering system, and which has been widely publicized as being responsible for bringing immediate and effective aid to the scene of serious traffic disturbances.(5), (6)

High cost has been cited as a factor which has discouraged the use of closed circuit television for traffic surveillance. Most of the cost estimates have been based upon the installation on the John Lodge Freeway. However, it must be recognized that the initial equipment installed there was intended to be the finest available so that the concepts could be proved or disproved on their own merits, rather than on hardware reliability. Cameras are presently available at half the cost of the originals, and less, which would meet a first-quality performance specification for this purpose.

Transmission of the signal from the various locations to the control center should not be an obstacle or an unreasonable expense, since communication facilities between these points are already required as part of the basic surveillance system; the cost of the additional materials would represent almost the entire additional cost, for most of the labor costs of the installation would have been already realized.

Minimizing the effect of occurrences on the roadway takes the form of decreasing the traffic input into the critical area, increasing the traffic output past the critical area, and diverting traffic around the critical area. None of the various proposed systems can do all three of these. The ramp metering system has the capability of decreasing input into the area and some capability for diverting traffic around the critical area by limiting the number of vehicles entering the freeway and diverting those whose waiting time would become unreasonable.

Appendix E has demonstrated the fact that advance information to the motorist can improve his performance in the critical area and thereby increase the volume past the incident by as much as 8.4 percent.

Additional capabilities of the advance information system are the ability to divert traffic from the freeway via exit ramps to an alternate path through the corridor. This method was used regularly and successfully on the southbound John Lodge to divert exiting traffic from the freeway at Pallister when the next downstream exit ramp at West Grand Boulevard became congested.

An additional capability of an on-freeway information system would be the ability to assign a lane for specific movements by the use of blank-out signs. For instance, if an exit ramp without an alternate provision backs up onto the freeway, the extent of that backup could be minimized by advance warning signs limiting that lane to exiting traffic only.

The installation of an on-freeway system of lane control devices should be relatively inexpensive, for the following reasons:

1. The communications network will have already been installed in the installation of the basic system. Foresightedness would decree that additional communication lines be established as a part of the basic system to provide for future installations and for backup communications, since reliability is essential.

2. It has become the practice of the Department of State Highways Maintenance Division and the Wayne County Road Commission to install lane control signals in advance of any extended maintenance operations performed on Detroit freeways, such as bridge painting, freeway closures for heavy maintenance, etc., and to leave these devices in place for future work.

3. By coordinating the activities of the Maintenance Division and the Freeway Operations Unit, the only item that would be needed to implement the lane control system in these areas would be the provision of switching equipment.

In view of the advantages of such a system, and in view of the foregoing factors, yet considering the fact that immediate evaluation of the nature of an incident is necessary for proper actuation of these devices, it becomes imperative that a system of freeway information signs be installed concurrently with the television system through the entire area of visual coverage.

The second area that should be given consideration for high-priority attention would be the southbound John Lodge Freeway over its entire length. As indicated in Appendix C, congestion still occurs on the southbound John Lodge Freeway between Wyoming and Davison, and in the event that an incident occurs anywhere on that freeway, congestion will occur from the point of the incident back to and beyond 8-Mile Road.

In view of the fact that the University of Michigan is presently conducting research on the northbound Lodge Freeway, the Freeway Operations Unit should concentrate on the southbound traffic.

The first control application will be the implementation of a ramp metering system on the southbound entrance ramps between 8-Mile Road and the Edsel Ford Interchange to better utilize the traffic corridor.

Second, the area should be studied more closely to determine whether that aspect alone is adequate to minimize the congestion or whether additional means such as visual surveillance and an on-freeway control system should be implemented. A serious factor to consider is the fact that once a vehicle has passed the exit ramp at 7-Mile Road, it is trapped in an area two and one-half miles long before the next exit ramp. The extent of the backups could be reduced and travel times improved through the corridor if some of the traffic were able to be diverted from the freeway onto the service drive at 7-Mile Road.

As was previously mentioned, the University of Michigan is presently conducting traffic research on the northbound Lodge Freeway. As a result, some relief is presently being afforded to outbound traffic. As such, it is the intent of the Freeway Operations Unit to hold in abeyance any implementation of improvements or modifications on the northbound Lodge Freeway until the University's work is completed. However, upon the termination of their efforts, the Freeway Operations Unit should stand prepared to implement a system of operational surveillance and control on the northbound John Lodge Freeway over its entire length.

Provisions for the detection system and the communications would, of course, be incorporated into the system on the southbound Lodge as it is implemented. The foregoing specific areas are given high priority because they are the most severe problem locations that are with us today. Certainly as time goes by, traffic patterns will change and the implementation of these aspects of surveillance and control will have profound influence on traffic on the freeway network. As a result, it would be premature at this time to merely project a statement that the ultimate in refined surveillance and control system should be implemented on the entire freeway network. However, it should be realized that the system as described to this point may not be the ultimate that will be needed in the future.

None of the proposed refinements are a duplication of other parts of the system. Each component augments the others to compound the benefits. Consequently, as the plans and specifications are written, even for the basic surveillance system, reasonable provisions should be made for expansion and refinement. Implementation of these additions will be based upon the evaluation of expanded knowledge of conditions on the freeway, which will be made available through the initial instrumentation and through continued observation.

SUMMARY

In reviewing the preliminary concept of surveillance and control on the Detroit Freeway network, the following measures should be taken in the order listed:

1. The installation of a network of traffic sensors covering the entire Detroit Freeway network, consisting of the entire length within the Detroit City Limits of the:
   - John Lodge Freeway
   - Edsel Ford Freeway
   - Walter P. Chrysler Freeway (including portions of the freeway and interchange approaches in Hamtramck and Highland Park)
   - Fisher Freeway
   - Southfield Freeway

   (NOTE: Installation of sensors on the Jeffries Freeway should be coordinated with its opening. Also, detectors on Davison should be coordinated with its anticipated reconstruction and extension.)

These sensors will provide the capability of measuring traffic volumes at the input and output of the several subsections, on both the freeway and the ramps, and with the capability of measuring speed, which is the most sensitive measure of changes in the traffic stream, at more frequent intervals.

Concurrent with the sensor installation would be the installation of a digital computer capable of accepting information from these sensors as inputs and capable of operating as a real-time process control computer with the ramp metering system and selected other driver information displays as its outputs.

2. The installation of an access control system to meter entrance ramp traffic on both directions of the Ford Freeway between Livernois and Gratiot.

3. Implementation of refinements to the basic system to alleviate conditions on the Edsel Ford Freeway between Livernois and Gratiot. This is the oldest (except for Davison) and most congested freeway in Detroit, with the highest rate of accidents and occurrences in the roadway concentrated within the above limits. These

refinements would include visual surveillance for immediate evaluation of incidents, thus aiding their prompt removal and the implementation of an on-freeway information system to maximize the volume of traffic passing the incident and divert traffic to alternate routes around the incident.

4. Implementation of an access control system on the southbound John Lodge Freeway.

5. Continued liaison between the Freeway Operations Unit and the University of Michigan so that when the research work on the northbound Lodge Freeway is completed, an operational system of ramp metering and certain refinements, as required, can be implemented on that portion to replace the experimental and temporary system.

6. A continued evaluation of the network traffic picture, utilizing all of the experience and data obtained thus far, to determine the nature and extent of further refinements necessary to the system. It must be remembered that none of the refinements are a duplication of other parts of the system. Each component attacks a different aspect of the problem and augments the other components to compound benefits to the motorist.

SEC. VI - STAFFING REQUIREMENTS

SEC. VI

STAFFING REQUIREMENTS

FREEWAY OPERATIONS UNIT

The staff of the Freeway Operations Unit must represent a balance of many disciplines. These disciplines must include but must not be limited to the following:

1. Experience in freeway traffic operations
2. Freeway control theory
3. Electrical and electronic theory
4. Practical knowledge of electronic hardware and components
5. Knowledge of computer applications and programming
6. Ability to prepare plans and specifications

It would, of course, be impossible to expect that every member of the team would be a specialist in all of these areas. It is intended then that each member of the Freeway Operations Unit would specialize in one or two of these areas, yet have a broad knowledge of the others, so that a close rapport would be maintained. It is, of course, preferable that individuals meeting the foregoing requirement be assigned to the Freeway Operations Unit, and in several of these disciplines, such personnel are available within the Department of State Highways. The rest of the positions would, of course, have to be filled by those who have one or more of the required specialties, yet do not have a broad background in the other disciplines. In this case, a certain amount of time would need to be devoted to the training of such personnel.

The technical staff recommended by Conradson[1], augmented by a steno clerk, appears adequate to implement the Freeway Operations Unit during the fiscal year 1969-1970 and well into the next fiscal year.

1. A Highway Traffic Engineer 13
2. An Electrical Engineer 11

   (An Electrical Engineer 09 with some experience in electronic systems and traffic operations could be obtained initially to advance as he gains experience)
3. A Computer Systems Analyst 11
4. An Electronic Systems Specialist 11
5. A Highway Traffic Technician 06

   (with aptitude for programming and electronics)
6. A Steno Clerk 04

It appears probable that as the system is made operational, particularly since the operating hours must coincide with traffic conditions rather than an eight-to-five day, five-day week, additional operators will be required to monitor the routine operation of the system. These operators might take the form of traffic aides or possibly police officers.

SEC. VII - LIAISON & AGREEMENT WITH LOCAL AGENCIES

SEC. VII

LIAISON AND AGREEMENTS WITH LOCAL AGENCIES

FREEWAY OPERATIONS ENGINEERING SUBCOMMITTEE

Section IV of this report discussed the fact that some of the problems on Detroit freeways could be solved by the application of traditional traffic engineering methods, implemented through established procedures.

Methods, of course, might range from modifications in signing and pavement marking to and including reconstruction interchange or parts thereof. Procedures whereby these means might be accomplished could take the form of either District or Lansing work orders, or by contract.

Since the Freeway Operations Unit will be expected to make meaningful recommendations for spot improvements on the freeway network, it follows that the staff of this unit will want to consider every possible source of information to assist in the determination of proper solution. For this purpose, a Freeway Operations Engineering Subcommittee has been established, consisting of Unit Heads from the Traffic and Safety Division and the District Traffic Engineer.

The Engineering Subcommittee will serve in one respect as a resource body, providing such information as traffic accident records, selected analyses from these records, information on proposed or recommended improvements, and in general, serve of the Freeway Operations Engineering Subcommittee. In this manner, both the City and the County would be represented in the early stages of any proposed activity and would have, and legitimately so, a hand in shaping the development of the proposed improvement. This recommendation has been forwarded to the Engineer of Traffic and Safety, who in turn has submitted an invitation to both the City of Detroit Department of Streets & Traffic and the Wayne County Road Commission to designate representatives to sit on this Subcommittee.

It was further recommended that since the Detroit Police Freeway Patrol plays such an active part in the operation of the freeways, that they also be represented on this committee.

It is understood that action is pending on this recommendation.

COORDINATING COMMITTEE FOR OPERATING DETROIT FREEWAYS

Implementation of many of the possible improvements to the Detroit Freeway Network will, of course, have effect on the surface streets in the adjacent traffic corridors. Since these surface streets are for the most part under the jurisdiction of the City of Detroit and Wayne County, these agencies must of necessity have a direct interest in any operational measures that will affect traffic within their areas of jurisdiction. Further, it is anticipated that any expense involved in the implementation of traffic improvements would be share in the usual statutory percentages.

a consulting function. In another sense, this committee will serve as an advisory group which the Freeway Operations Unit will be able to draw upon for the benefit of their experience and specialized knowledge.

While in one sense the Subcommittee would serve to advise the Freeway Operations Unit with regard to specific recommendations, it would further serve to approve or disapprove recommendations for improvements submitted by the Freeway Operations Unit. It is intended that in areas other than the implementation of the surveillance and control system that the Freeway Operations Unit would submit recommendations to the Engineering Subcommittee, who would then evaluate the merit of the recommendation. Those recommendations approved by the Subcommittee would then be forwarded to the Engineer of Traffic and Safety, who in turn would, if he concurred in the recommendation, direct the appropriate Unit Head or the District Traffic Engineer to issue the required work order, or he would initiate action to have the work performed under contract.

At one of the initial meetings of the Freeway Operations Engineering Subcommittee, those present agreed unanimously that since any work involving the freeways, or access to the freeways, would have a significant effect upon the entire traffic corridor, and since that traffic corridor is comprised mainly of city streets and county roads, that a representative of the City and of the County should be designated as members

While it is intended that the City and the County be represented on the Freeway Operations Technical Subcommittee, the members selected for that Subcommittee will be chosen on the basis of their technical abilities. They will not necessarily have the authority to make major decisions.

It is therefore intended that a governing body for the Freeway Operations Unit be formed which would be composed of representatives of the City, County and State who have the authority to speak for their respective agencies in approving the implementation of the recommendations of the Freeway Operations Unit and the allocating of funds for that purpose.

This body would be known as the Coordinating Committee for Operating Detroit Freeways.

SEC. VIII - WORK PROGRAM - FISCAL 1969-70

SEC. VIII

DETAILED OUTLINE WORK PLAN FOR FISCAL YEAR 1969-1970

Although it is intended that some of the more serious spot problems be investigated during fiscal 1969-1970, these can be handled individually on a reasonably flexible schedule. In contrast, the development of the electronic surveillance and control network is a more complex procedure, and a reasonably rigid schedule must be adhered to.

The primary output of the first six months' activity will be to develop the requirements for the total surveillance and control network and to prepare plans and specifications for that portion of the installation to be placed under contract during fiscal 1970-1971.

The second six months will be devoted to

1. Securing approval and funding, and completing the necessary contractual arrangements for the first year's installations,
2. Beginning the preparation of computer programs, and
3. Beginning the preparation of plans and specifications for that portion of the installation to be placed under contract during fiscal 1971-1972.

Exhibits VIII-1a, 1b, 1c, and 1d are PERT charts showing the major steps in the development and implementation of the surveillance and control network. All events in the first six months have been assigned reasonable completion times for the

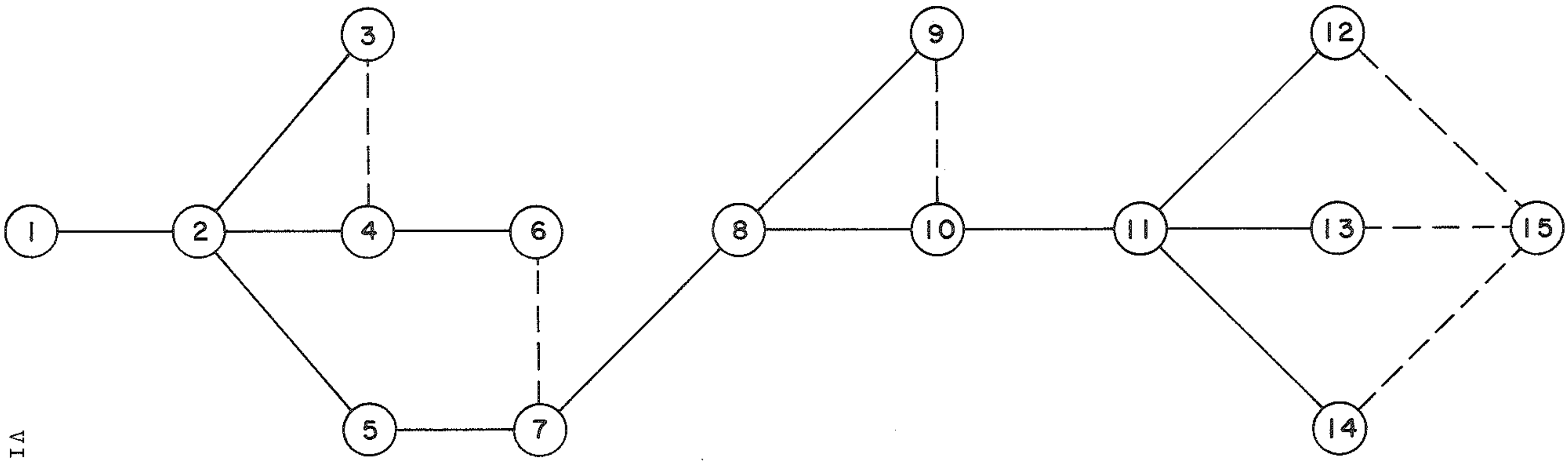

EXHIBIT VIII -1a

PERT CHART

DEVELOPMENT OF THE SURVEILLANCE & CONTROL NETWORK FOR DETROIT FREEWAYS

Work Plan for 1 JULY 1969 - 31 DEC. 1969.

(See Exhibit VIII-1C for Description & Scheduling of Activities.)

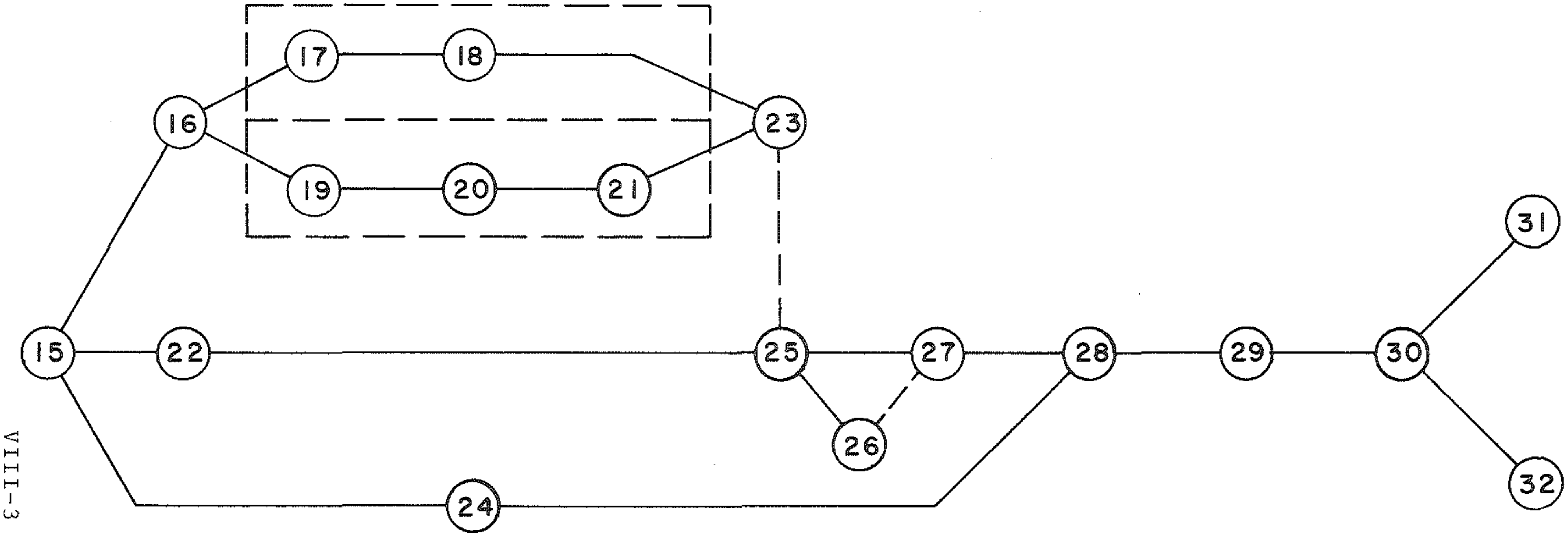

EXHIBIT VIII -1b

PERT CHART

IMPLEMENTATION OF THE SURVEILLANCE &
CONTROL NETWORK FOR DETROIT FREEWAYS

Work Plan Subsequent to 1 JAN. 1970.
(See Exhibit VIII-1D for Description of Activities. Scheduling is Indefinite. See Text.)

STATE OF MICHIGAN
DEPARTMENT OF STATE HIGHWAYS

Form 2357

EXHIBIT VIII-1C
SURVEILLANCE AND CONTROL NETWORK DESIGN WORK PLAN

START DATE 07-01-'69

TARGET DATE 12-31-'69

ACTIVITY		OPTIMISTIC TIME	LIKELY TIME	PESSIMISTIC TIME	DATE	ACTIVITY DESCRIPTION
0001	0002	002	003	004		DETERMINE SUBSECTIONS FOR ANALYSIS AND CONTROL
0002	0003	002	004	006		DETERMINE LOCATIONS FOR VOLUME SENSORS TOTAL NETWORK
0002	0004	002	004	006		DETERMINE LOCATIONS FOR SPEED AND OCC SENSORS TOT NETWK
0002	0005	002	004	006		DETERMINE LOCATIONS FOR CONTROL EQUIPMENT TOTAL NETWORK
0003	0004	000	000	000		DUMMY
0004	0006	001	002	003		DETERMINE COMPUTER INPUT REQUIREMENTS TOTAL NETWORK
0005	0007	001	002	003		DETERMINE COMPUTER CONTROL OUTPUT NEEDS TOTAL NETWORK
0006	0007	000	000	000		DUMMY
0007	0008	001	003	005		DETERMINE COMPUTER DISPLAY OUTPUT REQUIREMENTS TOT NETWK
0008	0009	001	003	004		DETERMINE COMPUTER REQUIREMENTS
0008	0010	001	004	006		DETERMINE COMMUNICATIONS REQUIREMENTS
0009	0010	000	000	000		DUMMY
0010	0011	003	005	007		COMPLETE TOTAL NETWORK DESIGN
0011	0012	002	004	006		DETERMINE CONTROL CENTER REQUIREMENTS
0011	0013	003	005	007		WRITE COMPUTER SPECIFICATIONS
0011	0014	003	005	007		WRITE SPECS FOR FISCAL 70/71 FIELD INSTALLATION
0012	0015	000	000	000		DUMMY
0013	0015	000	000	000		DUMMY
0014	0015	000	000	000		DUMMY
TOT	TIME	13	26	38	END	

STATE OF MICHIGAN
DEPARTMENT OF STATE HIGHWAYS

Form 2357

EXHIBIT VIII-1D
SURVEILLANCE AND CONTROL NETWORK INSTALLATION SCHEDULE

START DATE 01-01-70

ACTIVITY	OPTIMISTIC TIME	LIKELY TIME	PESSIMISTIC TIME	DATE	ACTIVITY DESCRIPTION
0015 0016					DECISION TO LEASE BUY OR BUILD CONTROL CENTER
0015 0022					DECISION TO LEASE BUY OR SHARE TIME ON COMPUTER
0015 0024					ISSUE CONTRACT FOR FIELD INSTALLATION FISCAL 70/71
0016 0017					LOCATE ADEQUATE FACILITY TO BUY OR LEASE AS CONTROL CTR
0016 0019					PREPARE PLANS AND SPECS FOR CONTROL CENTER
0017 0018					NEGOTIATE PURCHASE OR LEASE FOR CONTROL CENTER
0018 0025					OCCUPY FACILITIES
0019 0020					ACQUIRE SITE
0020 0021					BUILD BUILDINGS
0021 0023					OCCUPY FACILITIES
0022 0025					ISSUE PURCHASE ORDER TO ACQUIRE COMPUTER
0023 0025					DUMMY
0024 0028					INSTALL FIELD EQUIPMENT INCLUDING COMMUNICATIONS
0025 0026					WRITE COMPUTER PROGRAMS
0025 0027					DELIVER COMPUTER
0025 0026					PREPARE COMPUTER SITE INTERFACE
0026 0027					DUMMY
0027 0028					PRELIMINARY TEST COMPUTER PROGRAMS AND DEBUG
0028 0029					TIE FIELD INSTALLATIONS TO COMPUTER
0029 0030					NETWORK CHECKOUT OF HARDWARE AND SOFTWARE
0030 0031					BEGIN OPERATIONAL USE OF CONTROL NETWORK
0030 0032					BEGIN PLANNING FOR WORK TO BE LET FOR FISCAL 71/72

various activities. The major target date which should be held to as rigidly as possible is for items

(11-12) Determination of Control Center requirements

(11-13) Writing of the computer specifications, and

(11-14) Writing of the field equipment specifications for the fiscal 1970-1971 installation.

These items are scheduled for accomplishment by January 1, 1970, to allow time to apply for Federal Project funds and lead time for programming work and letting the contract. It is intended that work on the installation begin in July 1 or as close thereto as possible to take maximum advantage of good weather.

It is also intended that the control center be acquired and occupied as near to July 1, 1970 as possible. An exact date cannot be determined until the decision to build a new control center or to occupy available quarters has been made. If the decision is made to build a new control center, plans and specifications must be drawn up and construction must be accomplished; whereas if the decision is made to acquire an existing building, we might occupy the facility much sooner, possibly by July 1, and delivery and installation of the computer could be accomplished much sooner. Completion times for the remainder of the PERT chart cannot be reasonably assigned until this decision is made.

The time advantage of early occupancy of an existing facility must not overshadow the fact that the initial control center.

location must be adequate to contain the ultimate equipment, either by expansion capability within the facility, by serving as a master facility to satellite facilities, or be serving eventually as a satellite to a relocated master facility.

REFERENCES

REFERENCES

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5. "Taping for Traffic Study", Feature Article, Public Safety Systems, March/April 1969.

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APPENDIX A - SCOPE OF AUTHORIZED ACTIVITY

APPENDIX A

SCOPE OF AUTHORIZED ACTIVITY

DETROIT FREEWAY OPERATIONS UNIT

PURPOSE: To determine the location, nature and extent of traffic operation problems on Detroit Freeways and their corridors and take action to minimize these problems by applying advanced technology and positive research findings in an operational system.

Phase I: INVENTORY

Scope: Conduct a comprehensive inventory of the several Detroit Freeway corridors

1) To determine the location of problem sections and bottlenecks
2) To determine the extent and duration of congestion and hazard due to them, and
3) To assign a priority ranking for treatment.

Authority:

1) To deal directly, for inventory preparation purposes, with public and quasi-public agencies having direct contact with freeway problems, with regard to those problems. These would include, but not necessarily be limited to,
   a) District Traffic, Maintenance and Construction Divisions

b) Various Sections of the Traffic and Safety Division

c) Wayne County Road Commission

d) City of Detroit, Department of Streets and Traffic

e) City of Detroit, Police Department

f) Traffic Safety Association of Detroit

g) Automobile Assication of America (AAA)

2) To have access to plans, accident records, traffic data and other correspondence of the agencies listed above that would be meaningful in determining the location, nature and severity of problem areas.

3) To develop performance budgeting criteria to serve initially as a guide to assignment of priorities for proposed improvements and ultimately as a measure of their effectiveness.

4) To file a report summarizing the results of the inventory and recommending priorities for action.

Phase II: PLANNING IMPROVEMENT

Scope: To subject problem sections to intensive study in order to

1) Determine causes and contributing factors

2) Develop recommendations for improvement on the existing freeways and their corridors

3) Develop recommendations for design changes and/or modifications to be incorporated into future freeways

and their corridors.

Authority: To utilize all information obtained in Phase I to develop a planned program of improvements to the freeways and their corridors, including, but not necessarily limited to

1) On existing freeways and their corridors
    a) Determination of congestion, high-accident and recurring-incident areas
    b) Planning, designing and writing specifications (to be issued as a work order or a contract) for:
        1) Systems to detect and evaluate incidents (including sensors, computers and related programming)
        2) Systems to minimize the effect of "incidents", such as:
            a) Minor geometrics improvements
            b) Signing and marking improvements
            c) Access control systems (electronic and/or geometric)
            d) Driver information systems
            e) Assistance systems
            f) regulatory systems
2) For future freeways and their corridors
    a) Document design features and combinations thereof that have demonstrated inherent tendencies toward confusion, congestion and hazard.

b) Recommend for evaluation and/or adoption geometric features, construction techniques and information/control systems to be incorporated into future freeways to improve the performance of the driver and/or vehicle. These items would include, but not necessarily be limited to, implementation of features that would improve the performance of the driver and/or vehicle. These items would include, but not necessarily be limited to, implementation of features that would improve the performance of the driver by appealing to his conditioned responses, and elimination of those features that use these same responses to cause any unfavorable reaction. They would also include implementation of built-in features that use the handling characteristics of the vehicle to advantage, and the elimination of those features that cause the vehicle to react in an unfavorable or unpredictable manner.

Phase III: OPERATIONAL IMPLEMENTATION OF IMPROVEMENTS

Scope: To make practical application of past operational and research experience, and of the preparations made in Phases I and II, so that the motoring public may begin to realize the benefits accruing to him.

Authority: To cause the implementation of the improvements determined in Phase I and II, using established procedures as applicable

1) By issuing work orders and/or contracts for geometric and signing changes
2) By issuing work orders and/or contracts for geoputerized sensor/control/information system
3) By preparing and operating appropriate computer programs to
   a) Detect and evaluate traffic conditions in real-time
   b) Operate a real-time control as developed in Phase II
   c) Display an immediate output for evaluation and/or override
   d) Process data off-line for evaluation of various parameters as a check on past performance and as a guide to improvement and optimization.
4) By operating the control/information system in such a way as to maximize the efficiency of the freeway and its corridor.
5) By continuing update and review of the items used in Phase I, along with the improved information and analysis techniques born of Stage III, to maintain a dynamic traffic control system capable of recognizing new "weak links" as others are strengthened, so that appropriate action may be taken.

APPENDIX B - SOURCES OF DATA & ACKNOWLEDGEMENTS

APPENDIX B

SOURCES OF DATA

ACKNOWLEDGMENTS

In order to arrive at a meaningful objective appraisal of the Detroit freeway system and its problems, it was necessary to investigate as many reliable sources of readily available information as possible, within the limitations imposed by time and available manpower.

The data sources discussed in the following paragraphs comprise the most concrete sources of data that were available in such a form that they could be used as exhibits in this report. This information is presented as a documentation of the nature and extent of the various impediments to freeway efficiency, and more importantly serves as a major element in determining the most effective applications of technology to improve the efficiency of the freeway network.

Many persons were contacted within the organizations directly associated with operating Detroit freeways, namely the Michigan Department of State Highways, Wayne County Road Commission, Detroit Department of Streets and Traffic, Detroit Police Department, and Traffic Central, which is coordinated by the Detroit Traffic Safety Association. These people were extremely helpful in providing their personal professional knowledge of the freeway system and in referrals to key sources of information.

Omission of the names of all who provided assistance should not be considered a slight. Rather, it is a tribute to the fact that so many people at all levels responded to my requests for assistance with such cooperation and enthusiasm. We are deeply indebted to each of them.

DATA SOURCES

Much of the information required for this report was in the traditional forms, such as traffic predictions and accident experience.

TRAFFIC VOLUMES

Information on ramp and freeway traffic volumes for the Fall of 1967 and Spring of 1968 was obtained from the Detroit Department of Streets and Traffic. A report on the Woodward Avenue corridor traffic volume and travel time changes before and after opening of the Chrysler Freeway was also obtained from this source.

TRAFFIC PREDICTIONS

Traffic predictions for the Interstate freeways in Detroit for the year 1975 were obtained from the Michigan Department of State Highways, Transportation Survey and Analysis Section. These freeways consist of the Fisher (I-75) from the southwest city limit to the Chrysler, the Chrysler (I-75) from the Fisher to the north limit of Detroit, and the Edsel Ford(I-94) through the City of Detroit. Traffic predictions for 1990 are taken from the Detroit Area Traffic Study and were furnished by the City of Detroit, Department of Streets and Traffic and the Detroit Planning Commission.

ACCIDENT RECORDS

Traffic accident data for all Detroit freeways for the years 1967 and 1968 were taken from the Detroit Police Department accident records, a computer tape record of which was furnished to the Department of State Highways. A printout of this information was provided by the Computer Section, with the cooperation of the Traffic and Safety Division Accident Accident Analysis Unit.

OBSERVATIONS OF FREEWAY PATROL

Personal knowledge of the freeway and its problems was augmented by riding with an officer of the Detroit Freeway Patrol during morning peak period, from 6:30 a.m. to 9:30 a.m. and again during the evening peak period from 2:30 p.m. until 7:00 p.m. These officers pointed out several specific problem locations and verified the extent of recurring congestion.

TRAFFIC CENTRAL ADVISORIES

Another readily available source of data that provided information on recurring congestion was the teletype records of traffic advisories sent out by Traffic Central. This proved to be the only recorded source of information on traffic congestion, although they were not originally intended to serve that purpose. Traffic Central is a composite organization coordinated by the Detroit Traffic Safety Association, for the purpose of disseminating information on traffic conditions. Reports of traffic conditions are channeled to the Freeway Patrol dispatcher at Police Communications Center, who prepares and dispatches messages on traffic conditions via a teletype network to the local radio station, who, in turn broadcast the pertinent information as a public service. These messages consist of traffic advisories which provide information regarding congestion, pavement conditions, etc., and traffic bulletins which provide information concerning unusual or extremely severe conditions affecting traffic, such as serious accidents, lengthy maintenance operations, unusual traffic caused by sporting events and the like, and other unusual events such as flooding.

Figures B-1a and B-1b are congestion diagrams prepared from information obtained from the teletype records of traffic advisories, which are normally broadcast every one-half hour. Although data from specific days were used to prepare this diagram, the afternoon pattern of congestion shown is typical of a normal day with clear weather, dry pavement, and no reported severe incidents affecting traffic. Stop-and-go conditions are shown as a solid line; moderate speed, high-density traffic is shown as a dashed line; and free-flowing

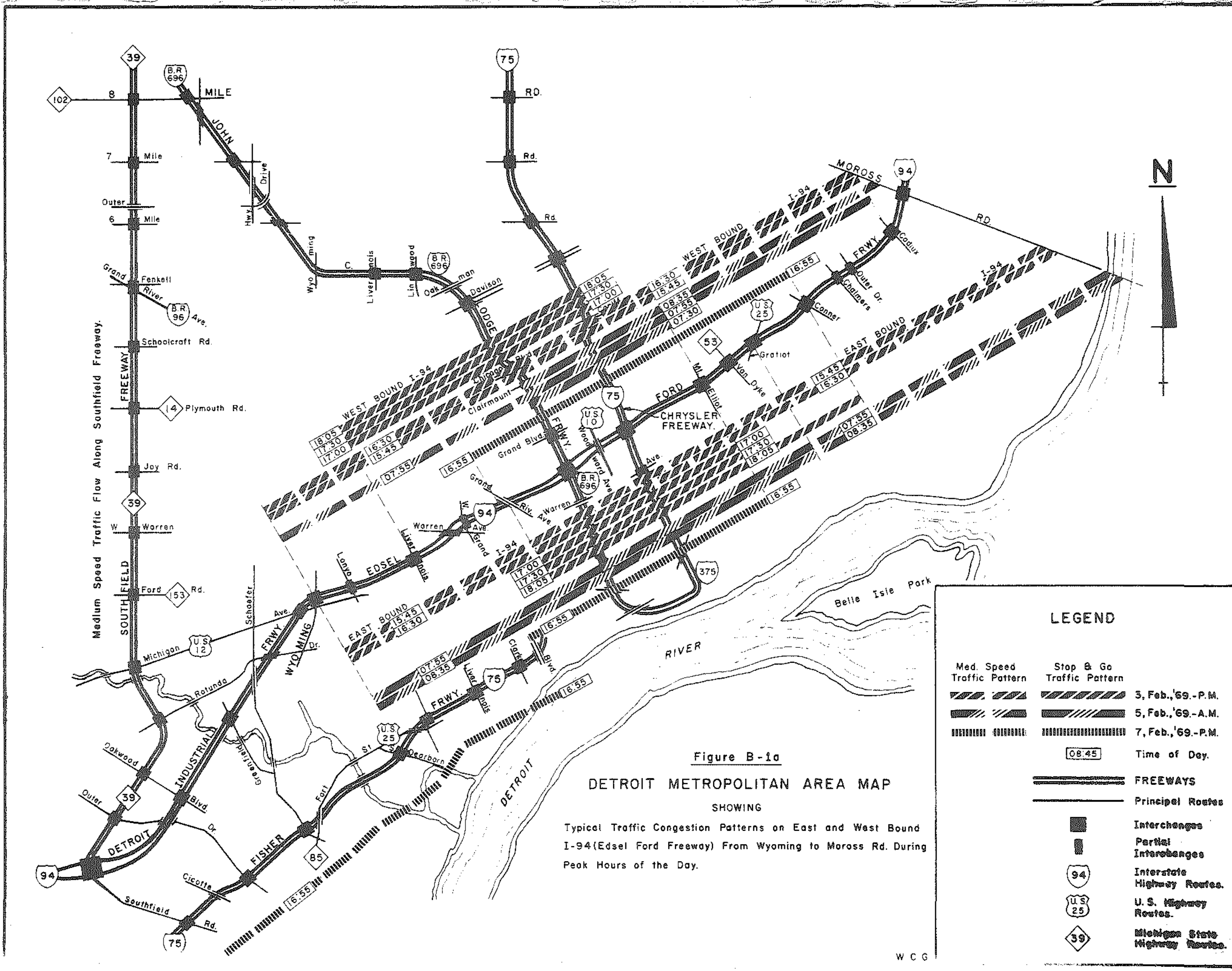

Figure B-1a

DETROIT METROPOLITAN AREA MAP

SHOWING

Typical Traffic Congestion Patterns on East and West Bound I-94 (Edsel Ford Freeway) From Wyoming to Moross Rd. During Peak Hours of the Day.

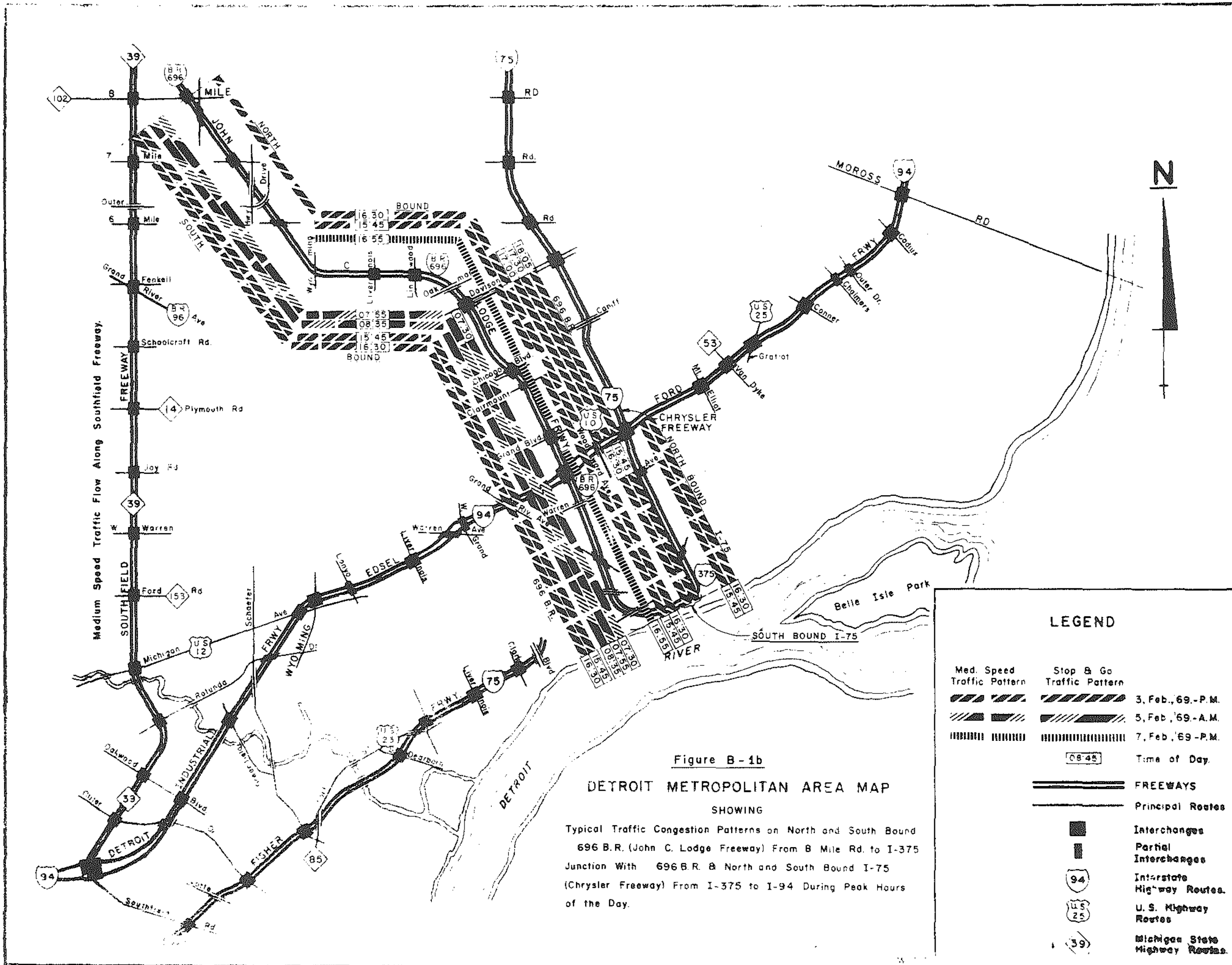

Figure B-1b

DETROIT METROPOLITAN AREA MAP

SHOWING

Typical Traffic Congestion Patterns on North and South Bound 696 B.R. (John C. Lodge Freeway) From 8 Mile Rd. to I-375 Junction With 696 B.R. & North and South Bound I-75 (Chrysler Freeway) From I-375 to I-94 During Peak Hours of the Day.

traffic for the indicated time period is left unmarked to accent the congested areas.

It should be noted, however, that the stop-and-go condition observed on the southbound Lodge freeway on the morning of February 5 is an intermittent occurrence since the opening of the Chrysler freeway, appearing on some days, but with moderate to high speed traffic through the area on other. This particular backup was triggered by a car broken down and obstructing traffic on the eastbound Ford at Dubois, reported at 7.28 a.m. which caused traffic to back up on the eastbound Ford through the ramp onto the southbound Lodge, and as far back as Seven Mile Road. The congestion caused by this incident lasted for about an hour.

This degree of congestion, caused by such a simple occurrence, is fairly commonplace.

FREEWAY PATROL RADIO LOGS

A previously untapped source of information on freeway incidents is the radio log kept by the Freeway Patrol dispatchers. It is recognized that these logs do not contain detailed information, and that they contain information only for those incidents on which radio conversations were held. They do, however, represent the only record of incidents other than reported accidents that interfered with traffic and required aid. Examples of such incidents are stalled cars, disabled trucks, debris in the roadway, and minor accidents.

A six month or one year sampling of incidents from the Freeway Patrol logs would have been extremely valuable. In order to properly and accurately glean the desired information from these logs, however, one must be reasonably well acquainted with the operations of the Freeway Patrol, their area of operation, their codes and jargon, and be able to relate various messages to each other. An attempt to instruct one very capable individual borrowed from the Construction Division and have him do this task proved unsuccessful because of his inexperience in this area. As a result, and with the feeling that much could be gained by at least some sampling of these logs, the author spent two afternoons personally reviewing these logs, and was able to gather two samples of six and seven days respectively.

Analysis of logs for the six day period from December 1, 1968 through December 6, 1968 shows radio records of 82 accidents, 55 stalls or breakdowns in the roadway, six cases of debris in the roadway affecting traffic, and 23 "other" incidents. Table B-1 lists the incidents and their locations, and Figure B-2 shows them platted on a map of the freeway system.

CROSS CHECK OF ACCIDENT RECORDS

It is known that all accidents that occur are not reported for various reasons. These accidents do, however, have an affect on traffic, in that they do occur in traffic and no matter how minor, the drivers stop in the roadway at least

TABLE B-1

EXCERPTS FROM FREEWAY PATROL LOGS

December 1, 1968 Thru December 6, 1968

Date	Time	Dir. & Freeway	Location		Breakdown			Remarks
				Acc.	Stall	Debris	Other	
12-1-68	0526	W.B. Ford	Warren/Junction			X		
	0623	S.B. S'fld.	Schoolcraft/Plymouth	X				
	0625	W.B. Ford	14th	X				
	0755	W.B. Ford	Warren		X			
	0002	S.B. Lodge	Cobo Hall		X			
	0255	W.B. Ford	W. of Van Dyke	X				
	0258	N.B. Lodge	Pingree	X				
	0303	W.B. Ford	W. of Van Dyke/ Mt. Elliott	X				
	0425	S.B. Lodge	Glendale/Elmhurst	X				Overturned
	0428	N.B. S'fld.	E. of Grand River	X				
	0828	W.B. Ford	Gratiot				X	Xmas tree in road
	1322	E.B. Ford	E. of John R		X			
	1512	S.B. Lodge	Cobo Hall		X			
	1602	W.B. Ford	Beaubien	X				3 car

Date	Time	Dir. & Freeway	Location		Breakdown			Remarks
				Acc.	Stall	Debris	Other	
12-1-68	1605	S. B. Lodge	Lafayette	X				
	1629	S. B. Lodge	Howard	X				Injury
	1645	E. B. Ford	E. of Van Dyke					?
	1647	W. B. Ford	Second	X				
	1705	W. B. Ford	E. of John R	X				
	1726	E. B. Ford	Junction/Warren		X			
	1801	W. B. Ford	Trumbull	X				
	1838	N. B. S'fld.	N. of Outer Drive	X				3 car
	2120	N. B. Lodge	6 Mile Road	X				
	2231	Ramp	S. B. Lodge - E. B. Ford				X	PLC working
12-2-68	0803	S. B. Lodge	N. of Livernois				X	Chuckhole in road
	1008	E. B. Ford	Livernois Exit Ramp		X			Small truck
	1023	S. B. Lodge	S. of Davison				X	Heavy traffic
	1324	N. B. S'fld.	N. of Grand River			X		Truck lost load
	1536	E. B. Ford	W. of Grand Blvd.		X			
	1545	S. B. Lodge	Seward				X	Pedestrian on Median
	1658	N. B. Lodge	Webb Exit Ramp	X				

Date	Time	Dir. & Freeway	Location	Acc.	Breakdown Stall	Debris	Other	Remarks
12-2-69	0407	N. B. Lodge	Clairmount	X				
	0531	E. B. Ford	Springwells	X				
	0756	S. B. Lodge	Forest	X				
	0813	S. B. Lodge	N. of Livernois				X	Were patching (See 0803)
	0937	S. B. Lodge	Forest	X				
	1305	N. B. S'fld.	S. of 6 Mile/N. of Puritan		X			Lost transmission
	1440	E. B. Ford	Mount Elliott	X				
	1604	W. B. Ford	Warren	X				
	1610	N. B. S'fld.	N. of Schoolcraft	X				
	1629	N. B. Lodge	Pallister	X				
	1750	N. B. Lodge	Temple Entrance Ramp		X			
	1807	E. B. Ford	Dubois/St. Aubin	X				
	1816	E. B. Ford	Van Dyke		X			
	2106	W. B. Ford	W. of Livernois	X				
	2143	W. B. Ford	Woodward	X				
	2208	S. B. Lodge	S. of Davison		X			Abandoned car in roadway
12-3-68	0612	N. B. Lodge	S. of Linwood		X			
	0627	S. B. S'fld.	7 Mile Rd./Curtis	X				

Date	Time	Dir. & Freeway	Location	Acc.	Breakdown Stall	Debris	Other	Remarks
12-3-69	0700	N. B. Lodge	Pallister	X				3 car, 1 injury
	1111	S. B. Lodge	Chicago	X				
	1152	N. B. Lodge	Vernor		X			Broken tie Rod
	0117	E. B. Ford	W. of Mt. Elliott	X				3 car
	0605	Ramp	S. B. Lodge - E. B. Ford		X			
	0607	S. B. Lodge	Chicago Exit Ramp		X			
	0615	S. B. Lodge	Chicago	X				2 lanes closed
	0814	N. B. Lodge	N. of Wyoming				X	Blew a tire
	0853	E. B. Ford	Second	X				
	1107	S. B. Lodge	Chicago	X				
	1151	N. B. Lodge	Seward				X	Car/trailer 15 mph in left lane
	1231	S. B. Lodge	S. of Milwaukee	X				
	1232	W. B. Ford	At Lodge	X				
	1413	S. B. Lodge	Milwaukee		X			
	1511	E. B. Ford	Mt. Elliott	X				
	1603	E. B. Ford	Mt. Elliott Off Ramp		X			Clutch gone
	1626	S. B. Lodge	6 Mile Road	X				Injury

Date	Time	Dir. & Freeway	Location		Breakdown			Remarks
				Acc.	Stall	Debris	Other	
12-3-68	1627	S. B. Lodge	N. of Puritan	X				Injury
	1734	S. B. Lodge	S. of Monterey	X				Car on median
	1746	N. B. Lodge	N. of Gladstone		X			Fast lane
	1801	N. B. Lodge	Milwaukee Exit Ramp		X			
	1846	S. B. S'fld.	Outer Drive	X				
	1905	N. B. Lodge	Pallister	X				Injury
	2025	E. B. Ford	Concord				X	Boys stoning cars
	2242	E. B. Ford	Russell				X	Car on fire
	2329	S'fld.	Joy/Chicago		X			
12-4-69	0825	S. B. S'fld.	N. of Grand River	X				
	0826	S. B. Lodge	N. of Davison		X			
	1537	E. B. Ford	Trumbull		X			Truck
	1608	S. B. Lodge	Glendale		X			
	1627	E. B. Ford	Livernois	X				
	1801	S. B. Lodge	S. of Davison	X				3 car
	2030	W. B. Ford	Chrysler/ Russell				X	Car lost hood
	2111	E. B. Ford	Conners		X			Tanker in right lane
	0342	S. B. Lodge	Pallister	X				
	0536	W. B. Ford	E. of Livernois	X				2 injuries

Date	Time	Dir. & Freeway	Location	Acc.	Breakdown Stall	Debris	Other	Remarks
12-4-68	0542	W. B. Ford	Wesson	X				
	0546	W. B. Ford	Wesson (another)	X				
	0735	N. B. S'fld.	Schoolcraft	X				
	0914	W. B. Ford	Chrysler		X			
	1047	S. B. Lodge	Howard				X	Car losing gasoline
	1132	S. B. Lodge	Cobohall		X			
	1307	W. B. Ford	W. of Trumbull	X				
	1517	N. B. Lodge	N. of Boulevard	X				
	1537	E. B. Ford	Trumbull		X			
	1629	N. B. Chrys.	Canfield		X			
	1658	N. B. S'fld.	Joy	X				
	1723	W. B. Ford	Brooklyn	X				2 car
	1739	W. B. Ford	Lonyo Ramp		X			
	1748	N. B. S'fld.	S. of Curtis		X			
	1755	E. B. Ford	Chrysler		X			Truck
	1759	S. B. S'fld.	Paul/Ford Road	X				
	1801	S. B. Lodge	S. of Davison	X				
	1813	S. B. S'fld.	At Paul	X				3 car
	1922	E. B. Ford	Chrysler		X			

Date	Time	Dir. & Freeway	Location		Breakdown			Remarks
				Acc.	Stall	Debris	Other	
12-4-68	1926	E. B. Ford	E. of Beaubien	X				On guard rail
	2019	N. B. Lodge	Hamilton		X			
	2058	Fisher	Clark				X	Boys stoning cars
	2109	E. B. Ford	Gratiot		X			
	2320	N. B. Chrys.	Jefferson	X				On median
12-5-68	1515	S. B. Lodge	Holden		X			
	1854	S. B. Lodge	Davison		X			
	2020	E. B. Ford	Woodward		X			
	2340	N. B. S'fld.	Ford to Joy				X	Freeway Patrol advises salt is needed
	0302	N. B. Lodge	Livernois Entrance Ramp	X				Truck overturned
	0550	Ramp	W. B. Ford to N. B. Lodge		X			
	0555	W. B. Ford	Dubois/Chrysler	X				
	0556	N. B. S'fld.	Joy	X				
	0607	N. B. Lodge	Davison		X			
	0645	Ramp	N. B. Lodge to W. B. Ford	X				
	0745	Fisher	Rouge Bridge				X	Freeway Patrol advises salt is needed

Date	Time	Dir. & Freeway	Location	Acc.	Breakdown Stall	Debris	Other	Remarks
12-5-68	0900	N. B. Lodge	Muirland		X			
	0911	N. B. Fisher	Schaefer		X			
	1000	W. B. Ford	Grand River		X			Semi
	1010	Fisher	Fort/Schaefer		X			Truck
	1037	N. B. S'fld.	E. of Joy			X		Bumper in roadway
	1142	W. B. Ford	W. of Van Dyke				X	Tie-up
	1153	E. B. Ford	Concord	X				
	1301	W. B. Ford	Russell			X		Tail-gate in road
	1334	E.B. & W.B. Ford	Russell					Freeway Patrol requests salt overpass
	1432	Ramp	W. Davison to S. Lodge	X				
	1502	S. B. Fisher	Schaefer	X				Semi jack-knifed
	1526	S. B. Lodge	Holden		X			
	1627	W. B. Ford	Lonyo		X			Truck
	2007	N. B. Lodge	Livernois Exit Ramp	X				Truck overturned
	2057	S. B. Lodge	Vernor		X			
	2122	E. B. Ford	W. of Chalmers	X				

Date	Time	Dir. & Freeway	Location	Acc.	Breakdown		Other	Remarks
					Stall	Debris		
12-6-68	1130	W. B. Ford	W. Grand Blvd.				X	WCRC right lane closed
	1546	N. B. Lodge	Pembroke				X	Flat-tire stopped in left lane
	1657	W. B. Ford	Blvd./Livernois		X			Right lane
	1715	W. B. Ford	Mt. Elliott - Van Dyke		X			
	0023	S. B. Lodge	Vernor	X				
	0025	N. B. S'fld.	Grand River Exit Ramp	X				
	0208	W. B. Ford	Russell Overpass		X			Clutch gone
	0229	W. B. Ford	Chrysler	X				Injury
	0251	E. B. Ford	Gratiot				X	Car going wrong-way
	0257	E. B. Ford	Conners				X	Driver slumped over wheel
	0851	S. B. Lodge	Ford				X	Pedestrian
	0927	N. B. Lodge	Pingree				X	WCRC in roadway
	1008	N. B. Lodge	N. of Pingree	X				
	1215	N. B. S'fld.	S. of Plymouth			X		Mattress
	1309	E. B. Ford	W. of Mt. Elliott	X				

Date	Time	Dir. & Freeway	Location	Acc.	Breakdown Stall	Debris	Other	Remarks
12-6-68	1456	E. B. Ford	Frontenac		X			
	1527	S. B. Lodge	Ford Freeway		X			Truck
	1644	N. B. Fisher	Rouge Bridge		X			Brakes locked Air hose broke
	1704	W. B. Ford	Scotten		X			Truck
	1842	S. B. Fisher	N. of Schaefer	X				4 car
	1842	W. B. Ford	Russell/Chrysler	X				
	1904	W. B. Ford	Woodward		X			Truck
	1905	S. B. Lodge	Clairmount		X			
	1909	W. B. Ford	Woodward	X				
	1920	W. B. Ford	Woodward	X				In fast lane
	1935	W. B. Ford	W. of St. Aubin	X				Semi & 4 cars
	1943	W. B. Ford	Mt. Elliott		X			Semi in right lane
	2127	S. B. Lodge	Vernor				X	Missing CB cover
	2322	E. B. Ford	Cadieux	X				
	2328	W. B. Ford	Westbound of Whittier	X				

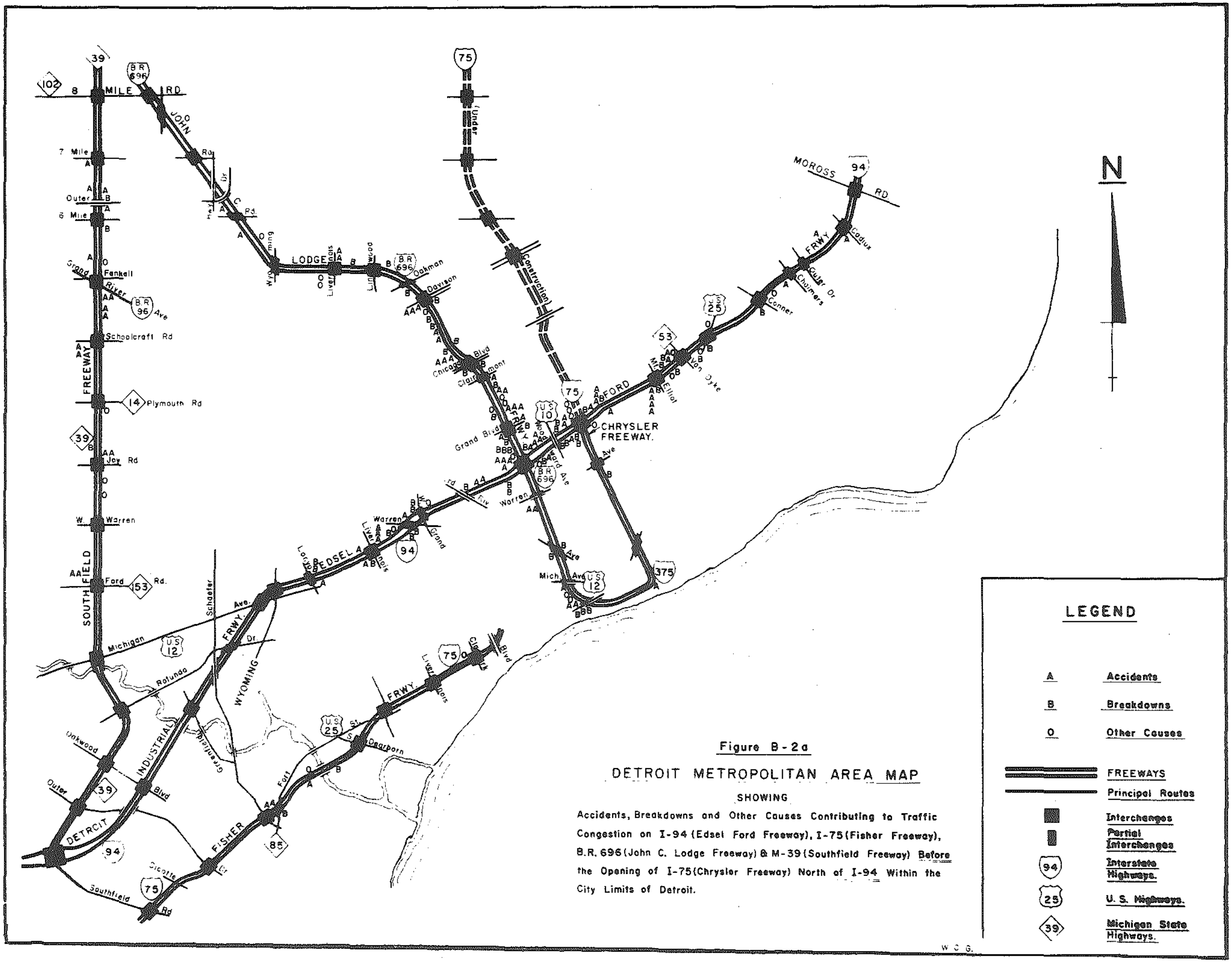

Figure B-2a

DETROIT METROPOLITAN AREA MAP

SHOWING

Accidents, Breakdowns and Other Causes Contributing to Traffic Congestion on I-94 (Edsel Ford Freeway), I-75 (Fisher Freeway), B.R. 696 (John C. Lodge Freeway) & M-39 (Southfield Freeway) Before the Opening of I-75 (Chrysler Freeway) North of I-94 Within the City Limits of Detroit.

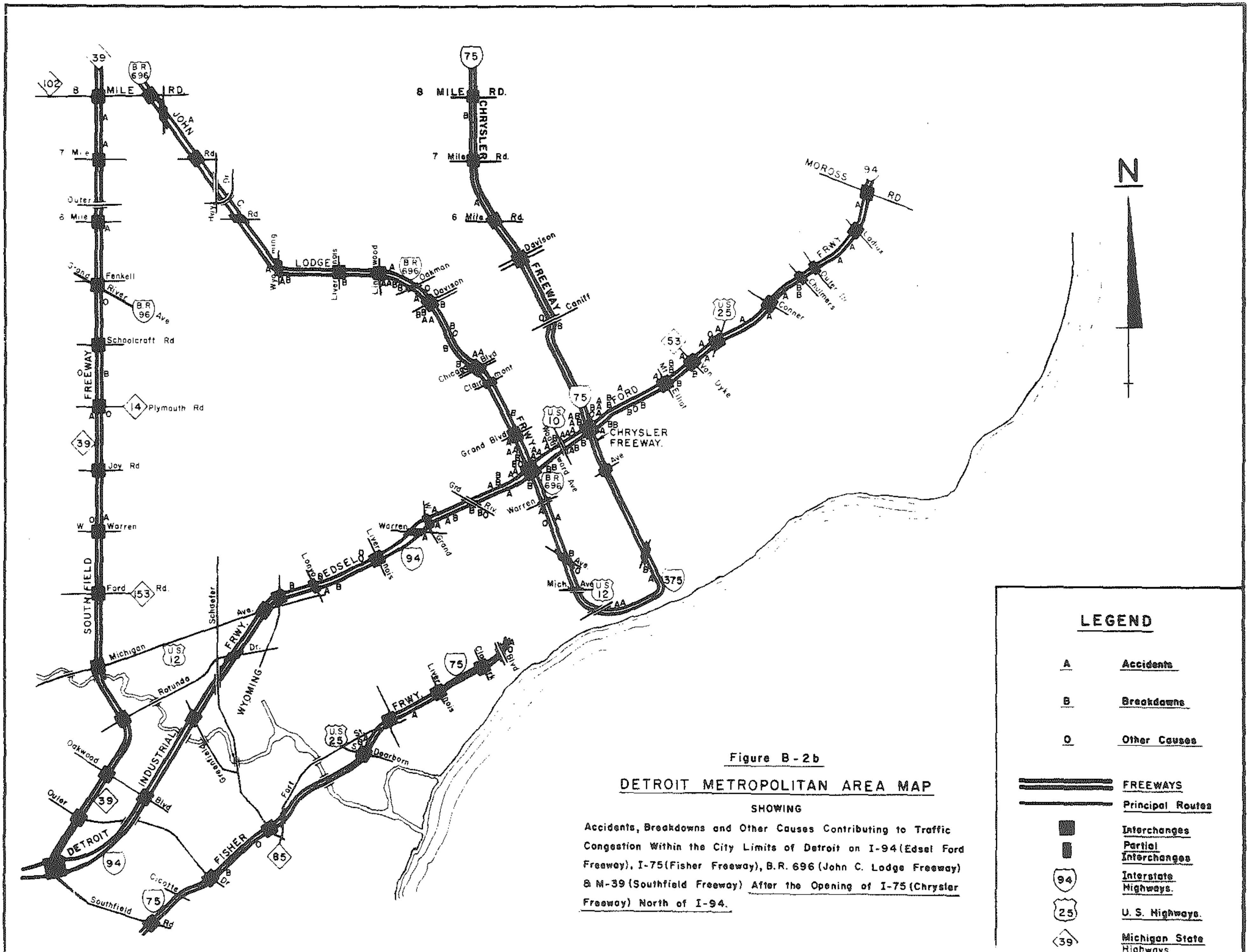

Figure B-2b

DETROIT METROPOLITAN AREA MAP

SHOWING

Accidents, Breakdowns and Other Causes Contributing to Traffic Congestion Within the City Limits of Detroit on I-94 (Edsel Ford Freeway), I-75 (Fisher Freeway), B.R. 696 (John C. Lodge Freeway) & M-39 (Southfield Freeway) After the Opening of I-75 (Chrysler Freeway) North of I-94.

momentarily, sometimes even getting out of their cars while block traffic to assess the damage. Even when they have moved to the shoulder, the damaged vehicles encourage "gawking" and a resultant congestion.

It is also known that not all accidents are recorded in the Freeway Patrol radio logs. To gain some insight into the magnitude of these omissions, a comparison was made between reported accidents and accidents noted on the Freeway Patrol radio logs, using the six day period from December 1, 1968 through December 6, 1968 (Friday through Wednesday). No attempt was made to analyze accidents by type. All accidents on the freeways were grouped in three catagories:

1. Accidents recorded in Freeway Patrol radio logs at which police were in attendance but no written report was made.
2. Accidents for which written reports were made but which were not recorded in the radio logs, and
3. Accidents recorded in the radio logs and for which written reports were made.

Table B-2 gives a comparison of these three categories of accidents for all freeways for this six day period. Realizing that this is a small sample, the percentages cannot be applied precisely, but it can be reasonably stated that the number of accidents that occur on the freeway system is about 50 percent greater than the number shown in either the radio logs or the accident reports.

TABLE B-2

COMPARISON OF REPORTED ACCIDENTS

and

ACCIDENTS RECORDED IN FREEWAY PATROL RADIO LOGS

Period: 6 Days; Dec. 1, 1968 thru Dec. 6, 1968

Freeway	Accident Report Only		Both		Freeway Patrol Logs Only	
Ford	15	30%	18	36%	17	34%
Lodge	15	33.4%	11	24.4%	19	42.2%
Southfield	7	35%	7	35%	6	30%
TOTALS FOR FORD LODGE & SOUTHFIELD	37	32.2%	36	31.2%	42	36.6%
Chrysler	1	100%	0	0%	0	0%
Fisher	4	57.2%	1	14.3%	2	28.5%
TOTAL: ALL FREEWAYS	42	34.1%	37	30.1%	44	35.8%

Total Accidents: 123

Total Reported Accidents: 79

Total Reported Accidents Per Day This Period: $\frac{79}{6} = 13.16$

Total Reported Accidents Per Day This Year: $\frac{4317}{366} = 11.79$

APPENDIX C - DISCUSSION OF RECURRING CONGESTION

APPENDIX C

DISCUSSION OF RECURRING CONGESTION

TODAY

It is readily apparent to even the casual observer that congestion has long been a daily occurrence on Detroit's freeways.

In the absence of an extensive data gathering system, several less dramatic ways were used to determine the degree of regularly occurring congestion. The only source of recorded information on recurring congestion is the traffic advisory teletypes discussed in Appendix A. Although data for only a few days was plotted in Figure B-1, these days are truly representative of the daily pattern of congestion. These advisories document the information obtained from personal observation, comments from Freeway Patrol officers, Wayne County maintenance crews that work the freeways, and many unofficial sources. Analysis of these observations shows that stop-and-go (level service F) conditions still occur daily in the following areas:

1. Edsel Ford Freeway, both eastbound and westbound, between Livernois and Conner (with heavy, slow moving traffic of level of service D existing from Livernois through Wyoming and from Conner through Seven Mile Road). This condition exists for at least three hours during the morning peak and for at least four hours during the afternoon peak.

2. Southbound John Lodge Freeway between the Edsel Ford interchange and Linwood nearly every morning. On two or three days of the week, this congestion still exists as far back as Six or Seven Mile Road, ever since the opening of the Chrysler Freeway. Level of service D exists every morning from the end of that congestion back through Eight Mile Road and from the Edsel Ford Interchange to the end of the freeway at Cobo Hall. Level of service C exists on the entire length of this freeway from the end of the morning peak through the end of the afternoon peak.

3. Northbound John Lodge Freeway from the Edsel Ford Freeway through Davison from about 2:30 p.m. until 6:00 p.m. and from the Davison through Wyoming from about 4:00 p.m. until 6:00 p.m. Level of service D exists on the rest of the freeway from about 10:00 a.m. until about 7:00 p.m., except as described above.

4. Southfield Freeway is reularly at level of service D over its entire length for about three hours during the morning peak and again for about three hours during the afternoon peak.

5. The Chrysler Freeway operates at level of service D for about two hours in the morning and again about two to three hours in the afternoon, except for two location. The congestion on the Edsel Ford Freeway

both eastbound and westbound regularly backs up through the ramps onto both the northbound and southbound roadways during both peak periods, thereby interfering with through traffic. In addition, the roadways narrow from four lanes to three for a distance of only a few hundred feet in the Davison interchange, and intermittent congestion occurs at these locations on a daily basis affecting inbound traffic in the morning peak period and outbound traffic in the afternoon.

6. The Fisher Freeway presently is operating smoothly except for a brief half hour period in the afternoon during which southbound traffic achieves level of service D. There is some congestion northbound at Lafayette because of the temporary ending but apparently no more than should be expected at such a location.

A specific discussion of today's traffic volumes is not presented here because of the fact that as of this writing no volume data is available on the freeway system after the opening of the Chrysler Freeway between the Ford Freeway and Eight Mile Road. Many have expressed the feeling that the opening of the Chrysler would affect traffic patterns on the Lodge and Ford Freeways, which presently are the two most congested freeways. While this statement is true, a continued observation of congestion patterns on the freeway network shows that the anticipated relief has not been accomplished. The extent of the daily backups has not changed significantly even though the Chrysler is carrying enough traffic to have problems of its own, notable daily periods of congestion at the bottleneck caused by the lane drops in the Davison Interchange.

NEAR FUTURE - 1975

It is universally predicted that traffic volumes are bound to increase and the Detroit freeway network is no exception.

Traffic assignments for the Interstate freeways in Detroit, namely the Fisher and Chrysler Freeways (I-75) and the Ford Freeway (I-94) for the year 1975 demonstrate this fact as shown in Table C-1a and C-1b.

Using a capacity of 1800 vehicles per hour per lane, it can be seen that 29 of the 60 locations listed on I-75 will have a demand of better than 70 percent of capacity.

Using the same capacity, we also see that I-94 will have a demand of over 70 percent of capacity at 53 of the 56 locations listed
a demand of 100 percent at 20 or the 56 locations listed,
a demand of over 120 percent at 23 of the 56 locations listed,
and a demand of over 140 percent at 12 of the 56 locations.

TABLE C-1a

1975 DESIGN HOUR VOLUMES

I-94 Thru City of Detroit

Location	1-Way Capacity	East-bound	% of Capacity	West-bound	% of Capacity
E. of Wyoming	4150/hr.	5990	111	5990	111
E. of Weir	4150	7190	133	6290	117
E. of Addison	4150	7190	133	7410	148
E. of Lonyo	4150	8010	148	8010	148
E. of Cecil	4150	8310	154	8310	154
E. of Livernois	4150	7520	139	7520	139
E. of Warren	4150	7580	140	7580	140
E. of W. Grand Boulevard	4150	7710	143	7710	143
E. of Linwood	4150	7070	131	7590	131
E. of 12th	4150	8070	149	7590	131
E. of Trumbull (W. of Lodge)	4150	6970	129	6970	129
In Lodge Inter-change	4150	3480	65	3480	65
E. of Lodge	4150	7610	141	7610	141
E. of Woodward (W. of Chrysler)	4150	6680	124	6680	124
In Chrysler Interchange	4150	3960	74	4170	77
E. of Chene	4150	5360	99	5360	99
E. of Mt. Eliott	4150	5010	93	5010	93
E. of Van Dyke	4150	4530	84	4530	84
E. of Gratiot	4150	4100	76	4100	76
E. of French Rd.	4150	3930	73	3730	73

Location	1-Way Capacity	East-bound	% of Capacity	West-bound	% of Capacity
E. of Conner	4150	5080	94	5080	94
E. of Outer Dr.	4150	4740	88	4740	88
E. of Harper	4150	4200	78	4740	88
E. Of Whittier	4150	4200	78	4200	78
E. of Cadieux	4150	4170	77	4170	77
E. of Moross	4150	4020	75	4020	75

TABLE C-1b

1975 DESIGN HOUR VOLUMES

I-75 Thru City of Detroit

Location	1-Way Capacity	North-bound	% of Capacity	South-bound	% of Capacity
S. of Outer Dr.	5400	4710	87	4710	87
N. of Outer Dr.	5400	4700	87	4700	87
N. of Schaefer	5400	4050	75	4880	91
N. of Dearborn	7200	4600	64	4600	64
N. of Fort	7200	4880	68	4880	68
N. of Springwell	7200	4850	67	4850	67
N. of Livernois	7200	5400	75	5400	75
N. of Clark	7200	5430	75	4900	75
N. of Lafayette	7200	4900	68	4900	68
N. of Porter (Not Counting I-96 & Ambass. Bridge Connection)	7200	3430	48	2820	39
N. of Vernor (Complex: See Diagrams)	7200	5800	81	5800	81
N. of Twelfth (S. of Lodge)	7200	4400	61	4400	61
N. of Lodge (At Third) - 4 Lns.	7200	5130	71	4710	65
N. of Second 4 Lns.	7200	5130	71	5140	71
W. of Chrysler (West Leg)	7200	4710	67	5140	71
N. of Fisher (North Leg)	7200	3700	51	3700	57
S. of Fisher (Chrysler = I-375)	7200	(3550)	49	(3550)	49

Location	1-Way Capacity	North-bound	% of Capacity	South-bound	% of Capacity
E. of Chrysler (Connector to Gratiot)	7200	(4400)	61	(4400)	61
N. of Mack	7200	4450	62	4450	62
N. of Warren (Approaching I-94 Ford)	7200	3750	52	3750	52
In I-94 Interchange	7200	2950	41	2950	41
N. of I-94	7200	5150	71	5150	51
N. of Clay	7200	5090	70	5090	70
N. of Holbrook	7200	3930	55	3930	55
N. of Caniff (S. of Davison)	7200	5130	71	5130	71
In Davison Interchange (3 Lns. Only)	7200	3020	-	3020	-
N. of Davison	7200	5370	74	5370	74
N. of McNichols	7200	5390	75	5390	75
N. of 7 Mile	7200	5380	74	5380	74
S. of 8 Mile	7200	4570	63	4570	63
N. of 8 Mile	7200	4600	64	4600	64

Obviously, any excess of demand over capacity will result in stoppages on the freeway. Since the usual output from a stoppage is more like 1,500 vehicles per hour per lane, it can be readily seen that unless some relief is provided by actively limiting some of the demand, the congestion will merely compound itself. One means of limiting the demand on an overloaded segment of the traffic corridor is to divert a portion of the traffic to a segment that is capable of absorbing part of the overload. The possibilities will be discussed further in another section of this report.

LOOKING AHEAD - 1990

Looking further into the future, we can anticipate two major occurrences which could to some extent counterbalance each other.

The first is the undeniable increase in traffic demand on the freeway network. The second is the possibility of relief through additional construction.

A comparison of these effects is available in the data of a Detroit Area Traffic Study for the year 1990, conducted jointly by the City of Detroit, Department of Streets and Traffic, Department of Public Works and City Planning Commission, and cooperation with the Michigan Department of State Highways and the Wayne County Road Commission.

A 1990 restrained traffic assignment map was the basis of data shown in Tables C-2a, b, c, d. The daily two-way values used on the map were reduced to hourly one-way values by dividing by two for one-way daily values, then assuming that design hour values are equal to 10 percent of the 24-hour values.

This is a simplified manner of obtaining the hourly values, but results in figures that are on the conservative side. As a result, the figures used may reflect a trend, but will not necessarily equate to the full magnitude of the problem.

These figures are again based on an anticipated network of freeways open to traffic by 1990.

Included in the DATS study is an assignment of traffic to an extension of the Fisher Freeway to extend east of Gratiot to an interchange with I-94 at Connors. There are at present no plans to build this section of freeway. As a result, the demand on the rest of the traffic corridor, notably I-94, would be increased significantly over the values given.

One other treatment that has been presented is that of double-decking the Ford Freeway to provide additional capacity without the need for acquiring addition right-of-way. Although this may be a desirable ultimate solution, it is bound to be extremely costly, and the construction of such a facility will by its very nature require many years for implementation.

Summarizing the 1990 network, we find a total of 45 out of 81 locations exceeding 70 percent of a capacity of 1800 vehicles per hour per lane, 21 out of 81 locations exceeding 100 percent of this capacity, and 2 out of 81 exceeding it by 120 percent.

TABLE C-2a

1990 ESTIMATED TRAFFIC DEMAND

I-94 Edsel Ford

DETROIT AREA TRAFFIC STUDY FIGURES

Location	2-Way Demand per hr.	1-Way Demand per hr.	1-Way Capacity per hr.	% of Capacity
W. of Michigan	8900	4450	5400	83
E. of Wyoming	8900	4450	5400	83
E. of Weir	8900	4450	5400	83
E. of Lonyo	10600	5300	5400	98
E. of Cecil	9900	4950	5400	92
E. of Livernois	10000	5000	5400	93
E. of Warren	8800	4400	5400	81
E. of W. Gd. Blvd.	12500	6250	5400	106
E. of Linwood	10700	5350	5400	99
E. of 12th	10900	5450	5400	101
E. of Trumbull	10900	5450	5400	101
In Lodge Interchange	-	-	-	-
E. of Lodge	8700	4350	5400	81
E. of Woodward	8700	4350	5400	81
In Chrysler Interchange	6600	3300	5400	61
E. of Chene	7500	3750	5400	69
E. of Mt. Elliott	8400	4200	5400	78
E. of Van Dyke	7900	3950	5400	73
E. of Gratiot	6200	3100	5400	57
E. of French Rd.	7000	3500	5400	65
E. of Conner	10000	5000	5400	92
E. of Outer Drive	9500	4750	5400	88
Harper	9500	4750	5400	88

Location	2-Way Demand	1-Way Demand	1-Way Capacity	% of Capacity
	per hr.	per hr.	per hr.	
Whittier	9500	4750	5400	88
Cadieux	10400	5200	5400	96
Moross	9600	4800	5400	89
Allard	9600	4800	5400	89
Vernier	-	-	-	-

TABLE C-2b

1990 ESTIMATED TRAFFIC DEMAND

John Lodge (I-696 BS) Freeway

Location	2-Way Demand	1-Way Demand	1-Way Capacity	% of Capacity
	per hr.	per hr.	per hr.	
N. of 8 Mile Rd.	10700	5350	5400	99
S. of 8 Mile Rd.	10800	5400	5400	100
S. of 7 Mile Rd.	10200	5100	5400	94
S. of 6 Mile Rd.	10000	5000	5400	93
E. of Wyoming	8600	4300	5400	80
E. of Livernois	9600	4800	5400	89
E. of Linwood	9900	4950	5400 (inbound)	92
S. of Davison	9500	4750	5400	88
S. of Glendale	9000	4500	5400	83
S. of Webb	9300	4650	5400	86
S. of Chicago	8700	4350	-	81
S. of W. Grd. Blvd.	8300	4150	-	77
S. of Ford Fwy.(I-94)	8800	4400	5400	82
S. of Warren	7800	3900	5400	72
S. of Grd. River	4600	2300	5400	43
S. of Fisher Fwy.	6300	3150	5400	58
S. of Michigan	2100	1050	5400	20
S. of Lafayette	2300	1150	5400	22

TABLE C-2d

1990 ESTIMATED TRAFFIC DEMAND

Southfield (M-39) Freeway

Location	2-Way Demand per hr.	1-Way Demand per hr.	1-Way Capacity per hr.	% of Capacity
N. of 8 Mile	11800	5900	5400	105
N. of 7 Mile	12200	6100	5400	113
N. of 6 Mile	12100	6050	5400	112
N. of Fenkell & Grand River	11100	5550	5400	103
N. of Schoolcraft	11600	5800	5400	107
N. of Fullerton	12400	6200	5400	115
N. of Plymouth	14000	7000	5400	129
N. of Joy	13100	6550	5400	121
N. of Warren	12700	6350	5400	117
N. of Ford Rd.	12100	6050	5400	112
S. of Ford Rd.	11600	5800	5400	107

TABLE C-2c

1990 ESTIMATED TRAFFIC DEMAND

I-75 Thru City of Detroit

Location	2-Way Demand per hr.	1-Way Demand per hr.	1-Way Capacity per hr.	% of Capacity
N. of Outer Drive	11900	5950	5400	110
N. of Schaefer	12300	6150	5400	112
N. of Dearborn	11300	5650	7200	78
Fort	11300	5650	7200	78
Springwells	11700	5850	7200	82
Livernois	11400	5700	7200	79
Clark	10400	5200	7200	72
Lafayette	10400	5200	7200	72
Porter	Complex	-	-	-
Vernor	Complex	-	-	-
12th	12500	6250	7200	87
Lodge	8600	4300	7200	60
Second	8600	4300	7200	60
W. of Chrysler (W. Leg)	8600	4300	7200	60
N. of Fisher (N. Leg)	8100	4050	7200	56
S. of Fisher (Chrysler - I-375)	7300	3650	7200	51
E. of Chrysler (Connector to Gratiot)	8000	4000	7200	56
N. of Mock	9600	4800	7200	67
Warren	10500	5250	7200	73
In I-94 Interchange	-	-	-	-
N. of I-94 (Ford)	11300	5650	7200	79

Location	2-Way Demand per hr.	1-Way Demand per hr.	1-Way Capacity per hr.	% of Capacity
N. of Clay	12500	6250	7200	87
Holbrook	11700	5850	7200	82
Caniff	12500	6250	7200	87
In Davison Interchange	-	-	5400	-
N. of Davison	14600	7300	7200	102
N. of McNichols	13000	6500	7200	91
N. of 7 Mile Rd.	14900	7450	7200	104
S. of 8 Mile Rd.	14700	7350	7200	102
N. of 8 Mile Rd.	15000	7500	7200	105

APPENDIX D - DISCUSSION OF RANDOM INCIDENTS, ACCIDENTS & TRAFFIC STOPPAGES

APPENDIX D

RANDOM INCIDENTS

ACCIDENTS AND TRAFFIC STOPPAGES

Use of the term "random" with relation to accidents and other incidents on the freeways has the tendency to mislead one to the conclusion that such occurrences are infrequent. The term is used here to describe specific events that cannot be predicted with respect to time or location. The purpose of this appendix is to examine data from the several available sources and provide a composite picture of the effects of these incidents on the traffic stream. The magnitude of the problem created by these random occurrences will then be presented in a more realistic perspective, so that an appropriate degree of effort may be devoted to minimizing the effect of these occurrences, as well as the occurrences themselves.

ACCIDENTS

Accident data from Detroit Police Department records for both 1967 and 1968 was reviewed. Since a cursory comparison showed that the pattern and quantities remained essentially the same, the only analysis of 1967 data that was made was a comparison of accidents on four metered entrance ramps before and after ramp metering was established. The preliminary analysis consisted only of sorting total accidents at various locations, and to some extent sorting by time of day. This was done to determine the severity of the accident problem and to spotlight high accident locations and areas. A more detailed analysis of the various locations is reserved for after July 1, as a part of the "spot improvement" task of the Freeway Operations Unit.

RAMP METERING BEFORE AND AFTER STUDY

Although not conducted "in-depth", the information presented here represents the first analysis ever done on the accident experience related to the ramp metering experiments conducted on the Lodge Freeway.

Table D-1a illustrates the accident experience on the ramps, including the service drive north of the nearest intersection, during the first six months of 1967 as a "before" period (metering began on July 5, 1967). Table D-1b illustrates the accident experience for the last six month of 1967, the immediate "after" period. Table D-1c is included as a before and after comparison with comparable calendar periods, while Table D-1d is included to give a comparison with the comparable "after" period to determine any "getting acquainted" effect. The tables are divided into three time periods: 6:00 a.m. to 2:00 p.m., representing normal daytime traffic without metering, 2:00 p.m. to 7:00 p.m. approximating the hours of ramp metering on four ramps: West Grand Boulevard, Seward, Chicago and Webb. The four other metered ramps were not investigated at this time because of time limitations and because they only operated for about 2 1/2 hours a day.) The remaining period

1967

NORTHBOUND "ON" RAMP ACCIDENTS

	TABLE D-1a Jan. Thru June Before Ramp Metering			TABLE D-1b July Thru Dec. Includes Metering (1415-1830)		
	0600-1400	1400-1900*	1900-0600	0600-1400	1400-1900*	1900-0600
West Grand Boulevard	0	1	0	2	10	0
Seward Street	1	0	0	0	3	0
Chicago Street	3	0	5	3	2	4
Webb Street	0	1	0	2	0	1
	4	2	5	7	15	5
				Up 75%	Up 75%	Same

*Note: None of these occured on Saturday or Sunday

1968

NORTHBOUND "ON" RAMP ACCIDENTS

	TABLE D-1c Jan. Thru June (With Ramp Metering)			TABLE D-1d June Thru Dec. (With Ramp Metering)		
	0600-1400	1400-1900*	1900-0600	0600-1400	1400-1900*	1900-0600
West Grand Boulevard (Includes Pallister)	0	9**	2	0	6**	0
Seward Street	0	1	0	0	1	0
Chicago Street	1	2	1	2	3	3
Webb Street	1	1	0	0	2	1
	2	13	3	2	12	4

*Note: None of these happened on Saturday or Sunday except **

**Note: Only one occurred on a Saturday or Sunday represents evening and night-time operation without ramp metering. Total accidents on the four ramps during the "no-metering" periods (7:00 p.m. to 2:00 p.m.) remained relatively low and stable. Likewise, accidents on the Seward, Chicago and Webb ramps remained relatively low and stable during the metering period, with the maximum on any one ramp being three accidents in a six month period. These ramps were operated on a "one-at-a-time" basis.

The West Grand Boulevard ramp, however, was operated on a "bulk-metering" basis, permitting several vehicles through on each cycle. This was done because of the high demand on this ramp and because the ramp formed the beginning of a fourth lane that extended approximately one mile, terminating at the Hamilton exit ramp.

Whereas the West Grand Boulevard ramp experienced only one accident between 2:00 p.m. and 7:00 p.m. during the six month "before" period, the number rose to ten during the six months immediately after metering was imposed (none of which occured on Saturday or Sunday), with nine more occurring during the first six months of 1968 and six more occurring during the last six months of 1968. (One each of these last two figures occurred on a Saturday or Sunday.) These factors will be given serious consideration for any and all new locations which ramp metering is proposed.

Table D-2 is a tabulation of accidents on the freeway in the area influenced by these ramps, which includes the section of the Lodge Freeway between the Edsel Ford and Davison Interchanges. Accidents in the vicinity of these two interchanges were not included. Only the before and after six month periods were investigated.

Accidents on the freeway during the day except for the metering period remained essentially the same. Accidents on the freeway during the evening and night hours increased from 89 to 100, or 12.4 percent. Accidents on the freeway during the metering period decreased from 53 to 46, or 13.2 percent.

Summing the on-freeway accidents and the ramp accidents, no change was noted during the 6:00 a.m. to 2:00 p.m. period; and an increase from 55 to 61, or 10.9 percent was noted during the 2:00 p.m. to 7:00 p.m. period, and an increase from 94 to 105, or 11.7 percent was noted during the 7:00 p.m. to 6:00 a.m. period. The grand total of all accidents increased from 316 to 333, or 5.4 percent. While this amounts to a total increase of 17 accidents for a six month period, it is noted that nine of these, or 53 percent occurred on the West Grand Boulevard ramp during bulk metering.

This information suggests that one-at-a-time ramp metering apparently has little effect on the total accident experience. In contrast, the one bulk-metered ramp has experienced a significant increase in accidents. The increase may be attributable to the mode of metering, the advance information,

TABLE D-2

1967 ON-FREEWAY ACCIDENTS

Northbound I-696, Holden to Glendale

Ramp Metering Began on July 5, 1967

	Before: 6 Months				After: 6 Months		
	January thru June				July thru December		
Location	0600-1400	1400-1900	1900-0600		0600-1400	1400-1900	1900-0600
Holden	17	7	7		16	7	13
Milwaukee/W. Gd. Blvd.	42	4	5		32	9	14
Pallister	23	6	2		29	1	7
Seward	18	5	3		13	2	7
Euclid	0	1	0		3	0	2
Pingree	7	1	2		6	2	3
Gladstone	2	0	2		8	2	2
Clairmount	17	13	17		14	8	9
Hamilton	4	3	9		2	1	3
Chicago	13	6	13		12	3	14
Calvert	4	3	7		2	2	5
Webb	8	0	12		10	6	6
Monterey	4	0	1		1	1	0
Highland	1	2	1		2	2	2
Glendale	3	2	8		10	0	13
305=	163	53	89	306=	160	46	100
				(+0.3%)	(-1.8%)	(-13.2%)	+(12.4%)
Ramps + Serv. Rds. 11= (From Table)	4	2	5	27=	7	15	5
				(+146%)	(+75%)	(+750%)	(+00%)
TOTALS 316=	167	55	94	333	167	61	105
				(+5.4%)	00%	+10.9%	(+11.7%)

visibility of the metering signals, or other factors. This information was verbally relayed to the University of Michigan research staff, who are still metering these ramps as part of their studies, on the same day that its significance became apparent.

ACCIDENTS ON THE FREEWAY

Accident reports were filed on 4,317 accidents on all freeways open to traffic during 1968. Of these, 2,093 or 48 percent occurred on the Edsel Ford Freeway, and 1,489 or 34 percent occurred on the John Lodge Freeway. These freeways constitute apprcximately 28 percent and 23 percent of the freeway mileage open to traffic during that period.

Table D-3 presents the total accident experience on the five major freeways, while Tables D-4a through 4e and Figures D-1a through 1e illustrate in numeric and graphic form the frequency distribution on each freeway, with locations identified to the nearest reference point, usually an overpass or underpass.

These figures are significant in themselves, but because of existing reporting procedures, it is known that while all accidents that occur do impede traffic, they are not all reported. To obtain a measure of the order of magnitude of these unreported accidents, a composite tabulation was made, for each of the five freeways, and is presented in Table B-2. The Freeway Patrol radio logs (See Appendix B) for the six day period from December 1 through December 6, 1968 were used

TABLE D-3

TOTAL REPORTED ACCIDENTS

1968

Location	On Fwy.	Service Drives	Entrance Ramps	Exit Ramps
Ford Freeway Wyoming to Moross	2093	481	100	84
Lodge Freeway Jefferson to 8 Mile	1489	380	85	90
Southfield Freeway 8 Mile to Ford	435	294	28	23
Totals for Ford, Lodge & Southfield	4017	1155	213	197
Chrysler Freeway Jefferson to Ford Freeway	100	83	5	28
Fisher Freeway Outer Drive to Lafayette	200	145	4	13
TOTAL: ALL FREEWAYS	4317	1383	222	238

TABLE D-4a

TABULATION OF REPORTED ACCIDENTS ON I-94 (EDSEL FORD FREEWAY)

Period: 1 Year; Jan. 1, 1968 thru Dec. 31, 1968

Location (Nearest Crossroad)	On Fwy.	On Serv. Drives & Crossroad	E. B. Entr. Ramps	E. B. Exit Ramps	W. B. Entr. Ramps	W. B. Exit Ramps
Wyoming	20	1	2	-	-	-
Weir	4	0	0	-	-	-
Addison	17	5	-	-	-	2
Lonyo	32	11	1	-	-	4
Central	12	0	-	-	-	-
Cecil	23	13	1	-	-	1
Martin	10	2	-	-	-	-
Livernois	65	15	3	3	2	2
Wesson	16	3	-	-	-	-
Junction	26	3	-	-	-	-
30th	23	6	1	2	5	-
Warren	23	15	-	-	-	-
Scotten	4	3	-	-	-	-
W. Gd. Blvd.	63	26	-	2	-	3
24th	19	2	-	-	-	-
Maybury Grand	31	3	0	0	-	-
Grand River	53	3	-	-	-	-
Linwood	39	21	2	-	3	1
14th	33	8	1	-	-	-
12th	15	6	-	-	-	-
Trumbull	105	9	-	0	2	-

Location (Nearest Crossroad)	On Fwy.	On Serv. Drives & Crossroad	E. B. Entr. Ramps	E. B. Exit Ramps	W. B. Entr. Ramps	W. B. Ramps
Lodge	158	2	4	3	14	7
3rd	14	0	-	-	-	-
2nd	63	0	-	-	-	-
Cass	63	0	-	-	-	-
Woodward	95	2	-	-	-	-
John R	52	59	-	2	7	-
Brush	33	22	-	-	-	-
Beaubien	38	10	1	-	-	0
Chrysler	94	0	0	3	1	3
Russell	94	0	-	-	-	0
St. Aubin	39	9	-	-	-	-
Dubois	24	9	-	7	1	-
Chene	-	-	0	-	-	1
Jos Campau	2	0	-	-	-	-
E. Gd. Blvd.	17	9	0	0	0	0
Mt. Elliott	157	54	3	2	6	1
Concord	25	1	-	-	-	-
Helen	4	0	-	-	-	-
Frontenal	25	6	-	-	-	-
Townsend	4	1	-	-	-	-
Van Dyke	106	19	1	9	4	3
Seminole	0	1	-	-	-	-
Burns	12	7	-	-	-	-
McClellan	22	1	-	-	-	-
Gratiot	32	3	2	9	1	1

Location (Nearest Crossroad)	On Fwy.	On Serv. Drives & Crossroad	E. B. Entr. Ramps	E. B. Exit Ramps	W. B. Entr. Ramps	W. B. Exit Ramps
Cadillac	3	2	-	-	-	-
French	41	5	2	2	1	-
Conner	59	24	1	1	7	3
Barrett	15	1	-	-	-	-
Dickerson	13	0	-	-	-	-
Coplin	2	0	-	-	-	-
Newport	1	0	-	-	-	-
Chalmers	29	10	-	3	4	-
Philip	0	4	-	-	-	-
Outer Drive	24	18	4	-	-	1
Lakepointe	1	1	-	-	-	-
Nottingham	11	5	-	-	-	-
Chadsworth	1	0	-	-	-	-
Harper (Bedford)	33	2	-	0	-	-
Courville	1	0	-	-	-	-
Whittier	6	1	-	-	-	-
Cadieux	17	14	4	0	2	1
Morang	8	3	-	-	-	-
Harper (Casino)	0	3	-	-	-	-
Moross	22	18	0	1	4	1
1968 TOTALS	2093	481	33	49	67	35
1968 Grand Total: 2758						
(1967 Totals)	(2032)	(430)	(55)	(54)	(69)	(31)
1967 Grand Total: 2671						

TABLE D-4b

TABULATION OF REPORTED ACCIDENTS ON I-696 BS (JOHN LODGE FREEWAY)

Period: 1 Year; Jan. 1, 1968 thru Dec. 31, 1968

Location (Nearest Crossroad	On Fwy.	On Serv. Drives & Crossroad	N. B. Exit Ramps	N. B. Entr. Ramps	S. B. Exit Ramps	S. B. Entr. Ramps
First St. (Wayne)	1	0	-	-	1	-
W. Jefferson	3	0	-	-	-	-
Fort	8	0	0	0	-	0
Lafayette	0	5	-	-	-	-
Howard	2	10	-	3	2	-
Porter	1	0	-	-	-	-
Michigan	11	0	-	-	1	-
Elizabeth	1	0	-	-	-	-
Vernor (Bagley)	27	3	-	-	0	0
Spruce	6	0	-	-	-	-
Gr. River	37	4	-	4	1	-
Stimpson	0	2	-	-	-	-
Selden	18	7	-	-	-	-
Forest	49	62	3	0	7	1
Warren	37	25	-	-	-	-
Merrick	13	1	-	-	-	-
Ford Freeway	121	1	4	4	17	6
Holden	27	2	-	-	-	-
W. Gd. Blvd.	97	79	0	10	3	0
Pallister	73	9	-	-	3	-

Location (Nearest Crossroad)	On Fwy.	On Serv. Drives & Crossroad	N. B. Exit Ramps	N. B. Entr. Ramps	S. B. Exit Ramps	S. B. Entr. Ramps
Seward	46	11	-	4	-	-
Pingree	26	2	-	-	-	-
Gladstone	15	2	-	-	-	-
Clairmount	56	33	0	-	-	0
Hamilton	12	0	2	-	-	-
Chicago	103	21	-	12	3	0
Calvert	20	2	-	-	-	-
Webb	55	12	2	6	0	1
Monterey	8	0	-	-	-	-
Highland	7	0	-	-	-	-
Glendale	45	4	1	-	-	2
Davison	119	0	5	1	8	5
Ford Avenue	2	0	-	-	-	-
Oakman	21	0	-	-	-	-
12th	11	0	-	-	-	-
Log Cabin	8	1	-	-	-	-
Baylis	5	1	-	-	-	-
Linwood	63	24	5	2	1	0
Alden	2	1	-	-	-	-
Muirland	6	0	-	-	-	-
Dexter	10	10	-	-	-	-
Livernois	58	22	6	2	0	4
Monica	2	0	-	-	-	-
Tuller	3	0	-	-	-	-
Greenlawn	9	7	-	-	-	-

Location (Nearest Crossroad)	On Fwy.	On Serv. Drives & Crossroad	N. B. Exit Ramps	N. B. Entr. Ramps	S. B. Exit Ramps	S. B. Entr. Ramps
Northlawn	6	1	-	-	-	-
Wisconsin	3	0	-	-	-	-
Wyoming	61	10	4	1	1	2
Puritan	25	0	-	-	-	-
Meyers	20	1	3	-	-	6
McNichols	14	1	-	-	-	-
Outer Drive	12	1	-	-	-	-
Schaefer	17	0	-	-	-	-
Seven Mile	43	2	2	1	1	3
Pembroke	15	0	-	-	-	-
Greenfield	18	1	3	-	-	5
8 Mile	11	1	-	-	-	-
TOTALS	1489	381	40	50	49	35

Grand Total: 2044

TABLE D-4c

TABULATION OF REPORTED ACCIDENTS ON M-39 (SOUTHFIELD FREEWAY)

Period: 1 Year; Jan. 1, 1968 thru Dec. 31, 1968

Location (Nearest Crossroad)	On Fwy.	On Serv. Drives & Crossroad	N. B. Exit Ramps	N. B. Entr. Ramps	S. B. Exit Ramps	S. B. Entr. Ramps
Ford Rd.	4	3	-	1	4	-
Paul	14	5	-	-	-	-
Warren	34	31	1	0	2	1
Sawyer	0	1	-	-	-	-
Tireman	12	6	-	-	-	-
Joy	24	17	0	3	1	1
Cathedral	0	4	-	-	-	-
Fitzpatrick	1	6	-	-	-	-
W. Chicago	14	9	0	0	0	0
Plymouth	49	20	2	3	1	5
Fullerton	24	4	1	0	-	1
Glendale	1	2	-	-	-	-
Schoolcraft	46	32	0	3	0	5
Lyndon	5	5	-	-	-	-
Grand River	22	15	2	-	-	0
Fenkell	12	39	-	0	0	-
Puritan	20	10	-	-	-	-
6 Mile	42	27	0	2	1	1
Outer Drive	9	18	-	-	-	-
Curtis	2	4	-	-	-	-
7 Mile	37	25	1	0	0	0

Location (Nearest Crossroad)	On Fwy.	On Serv. Drives & Crossroad	N. B. Exit Ramps	N. B. Entr. Ramps	S. B. Exit Ramps	S. B. Entr. Ramps
Pembroke	30	2	-	-	-	-
8 Mile	33	8	6	-	-	3
TOTALS	435	294	13	12	9	15

Grand Total: 779

TABLE D-4d

TABULATION OF REPORTED ACCIDENTS ON I-375 & I-75
(Walter P Chrysler Freeway)

Period: 1 Year; Jan. 1, 1968 thru Dec. 31, 1968

Location (Nearest Crossroad)	On Fwy.	On Serv. Drives & Crossroad	N. B. Exit Ramps	N. B. Entr. Ramps	S. B. Exit Ramps	S. B. Entr. Ramps
Jefferson	7	1	-	-	-	-
Congress	1	0	-	1	3	-
Lafayette	3	13	-	0	1	-
Monroe	0	6	-	-	-	-
Clinton	1	1	-	-	-	-
Gratiot	6	0	-	-	-	-
Madison	3	0	-	1	1	-
Vernor (Fisher Fwy.)	1	0	-	-	-	-
Wilkins	3	9	-	-	-	-
Mack	10	27	1	0	0	1
Canfield	6	7	-	-	-	-
Warren	24	17	0	2	0	0
Ferry	12	2	-	-	-	-
Ford Fwy. Temp. Ending	23	0	22	-	-	0
TOTALS	100	83	23	4	5	1

TABLE D-4e

TABULATION OF REPORTED ACCIDENTS ON I-75
(Fisher Freeway)

Period: 1 Year; Jan. 1, 1968 thru Dec. 31, 1968

Location (Nearest Crossroad)	On Fwy.	On Serv. Drives & Crossroad	E. B. Exit Ramps	E. B. Entr. Ramps	W. B. Exit Ramps	W. B. Entr. Ramps
Outer Drive	9	0	0	1	0	0
*Schaefer	75	12	0	0	2	2
*Dearborn	62	2	2	-	-	0
Fort St.	8	0	-	-	-	-
Springwells	21	27	2	-	-	0
Green	7	8	-	-	-	-
Beard	0	2	-	-	-	-
Waterman	2	6	-	-	-	-
Livernois	11	16	2	0	0	0
Dragoon	0	16	-	-	-	-
Cavalry	0	1	-	-	-	-
Junction	1	4	-	-	-	-
Clark	0	0	0	0	0	0
Hubbard	0	2	-	-	-	-
W. Gd. Blvd.	2	22	-	-	-	-
Lafayette Temp. Ending	2	19	6	-	-	0
Porter Service Drive Only	0	8	-	-	-	-
TOTALS	200	145	12	1	2	2

Grand Total: 362

*Includes High-Level Bridge

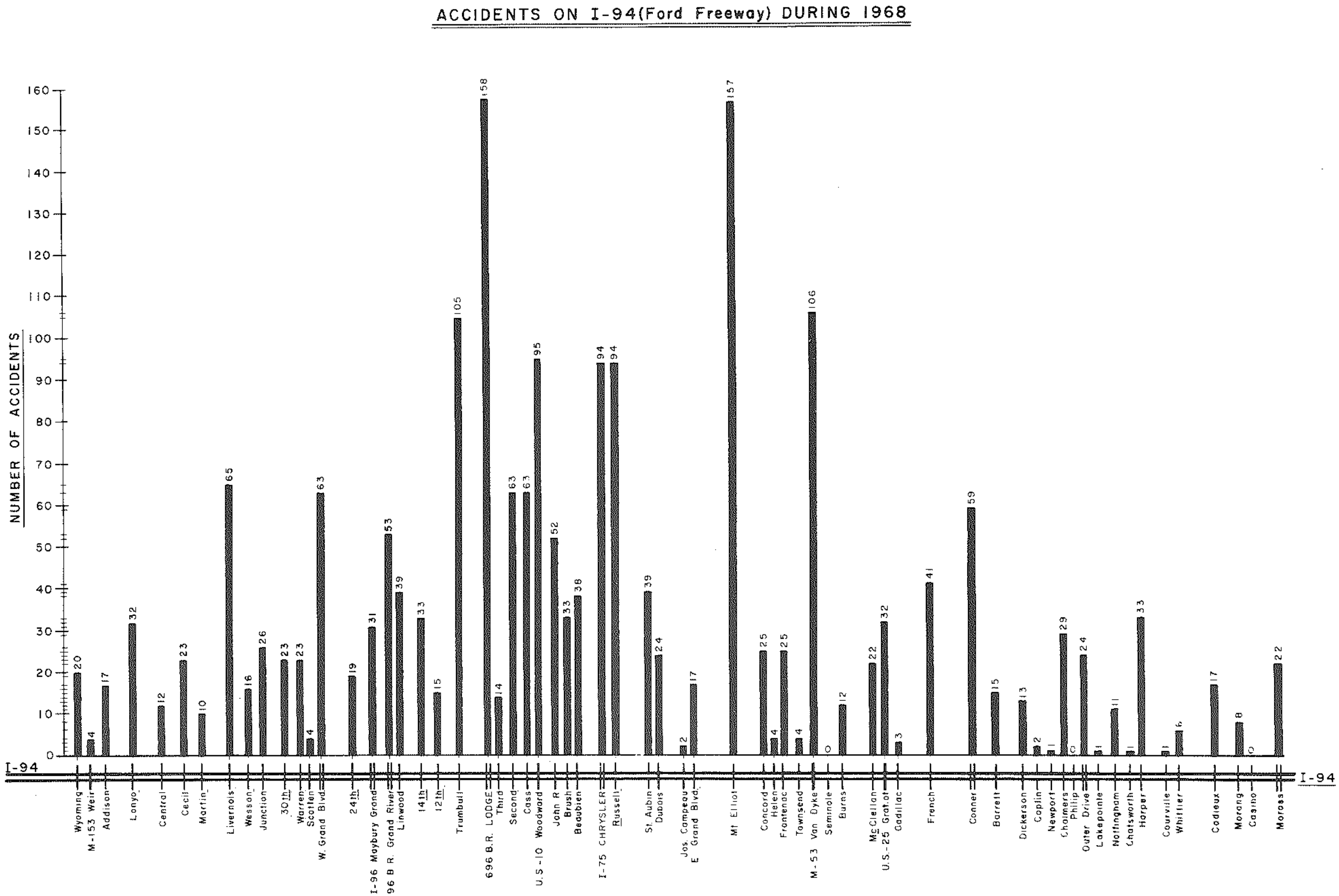

Figure D-4a LOCATION OF ACCIDENTS ON I-94(Ford Freeway) ACCORDING TO STREETS AND INTERCHANGES
(From Wyoming to Moross Rd.)

ACCIDENTS ON 696 B.R. (Lodge Freeway) DURING 1968

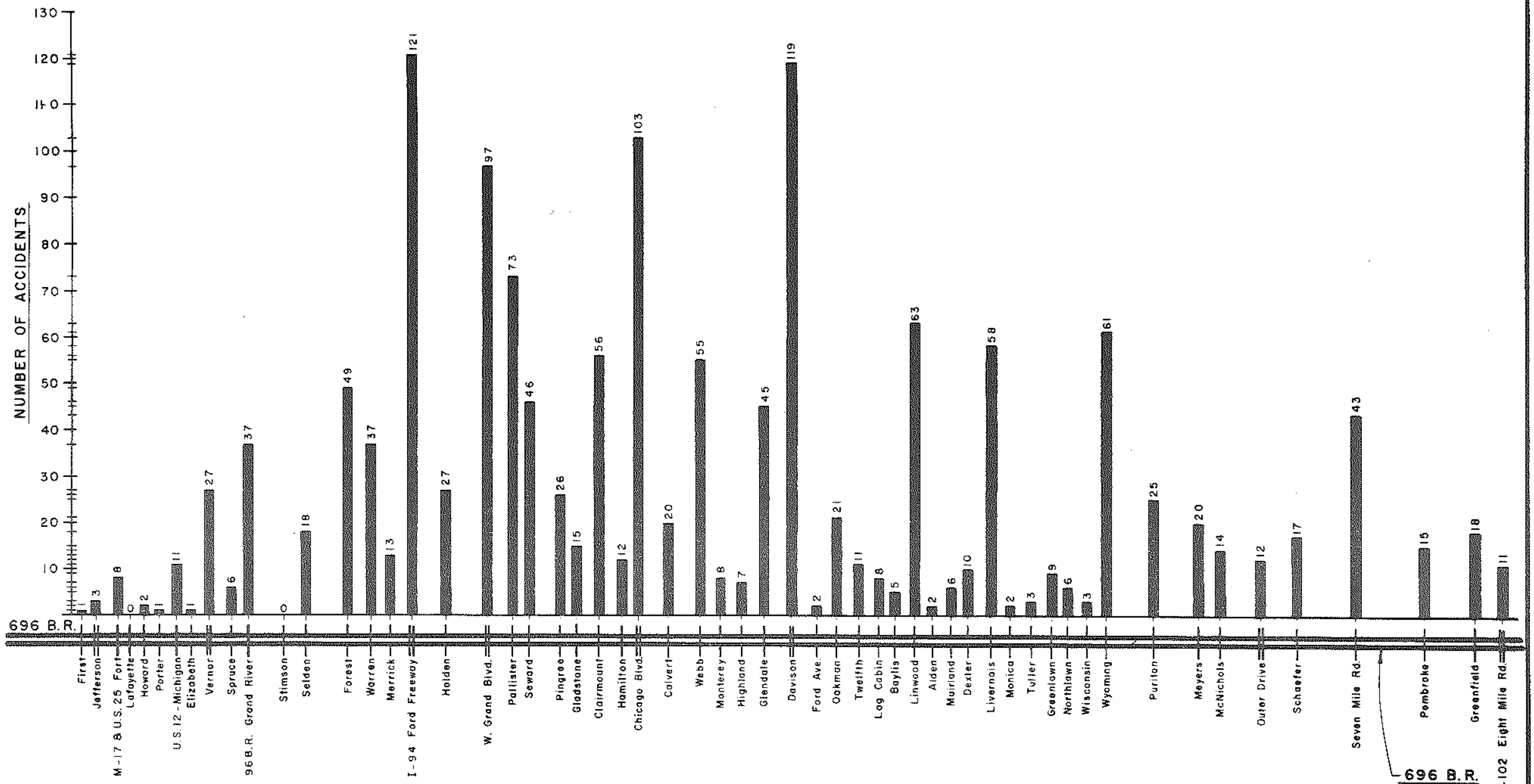

Figure D-4b LOCATION OF ACCIDENTS ON 696 B.R. (John C. Lodge Freeway) ACCORDING TO STREETS AND INTERCHANGES.
(From First St. to Eight Mile Rd.)

W.C.G.

ACCIDENTS ON M-39 SOUTHFIELD FREEWAY DURING 1968

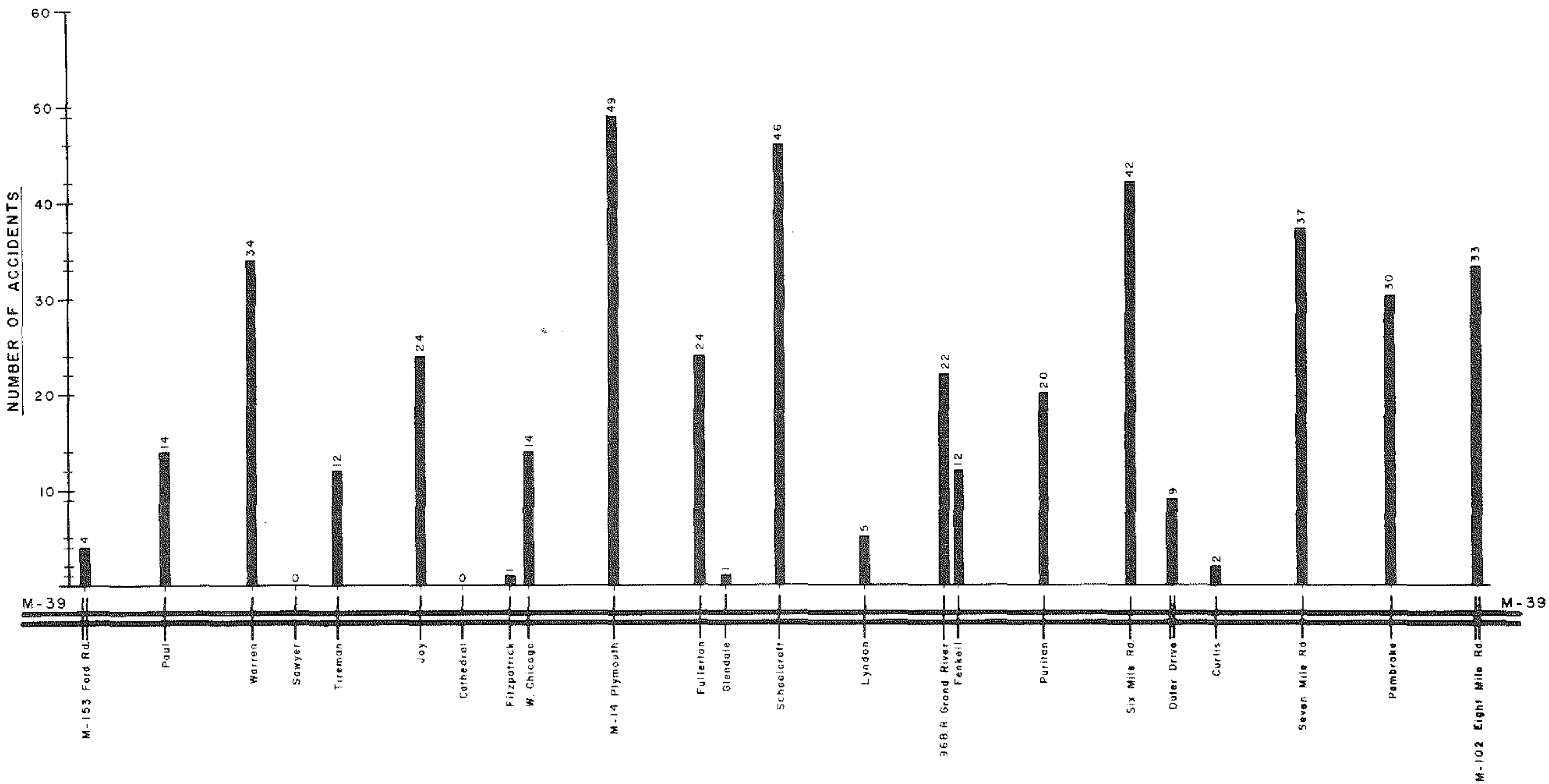

Figure D-4c LOCATION OF ACCIDENTS ON M-39 (Southfield Freeway) ACCORDING TO STREETS AND INTERCHANGES.
(From Ford Rd. to Eight Mile Rd.)

W.C.G

ACCIDENTS ON I-75(Fisher Freeway) DURING 1968

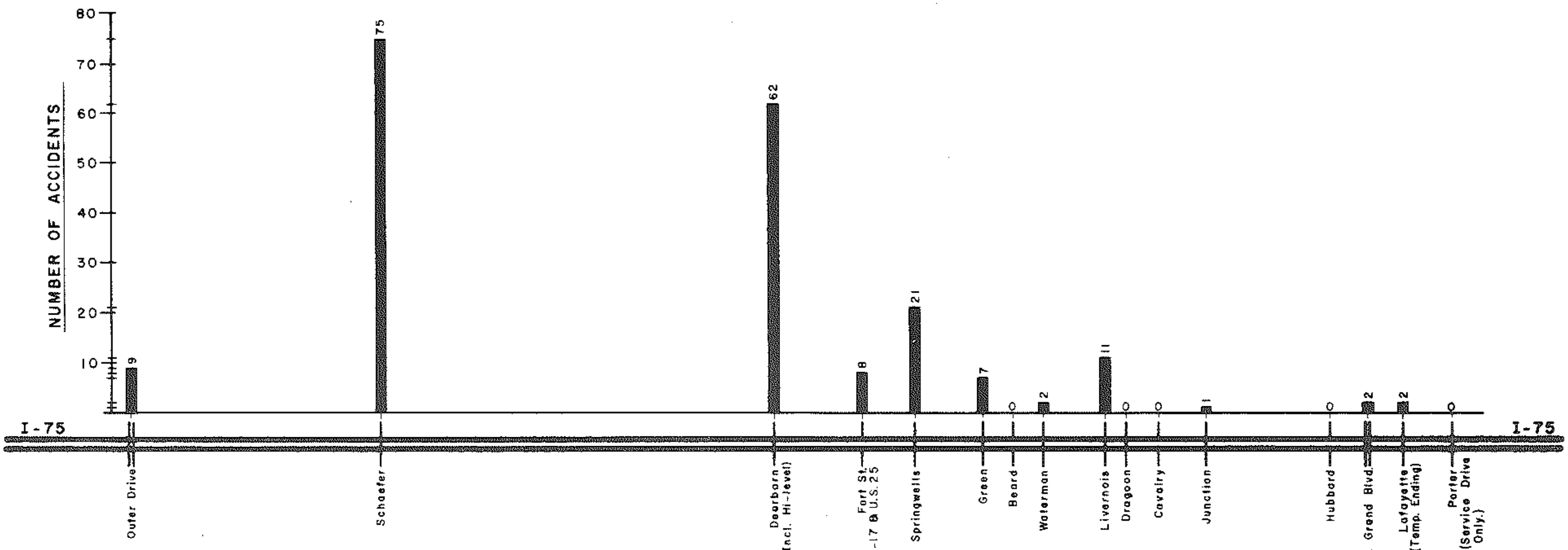

Figure D-4e LOCATION OF ACCIDENTS ON I-75(Fisher Freeway) ACCORDING TO STREETS AND INTERCHANGES.
(From Outer Drive to Porter St.)

ACCIDENTS ON I-375 & I-75(Chrysler Freeway) DURING 1968

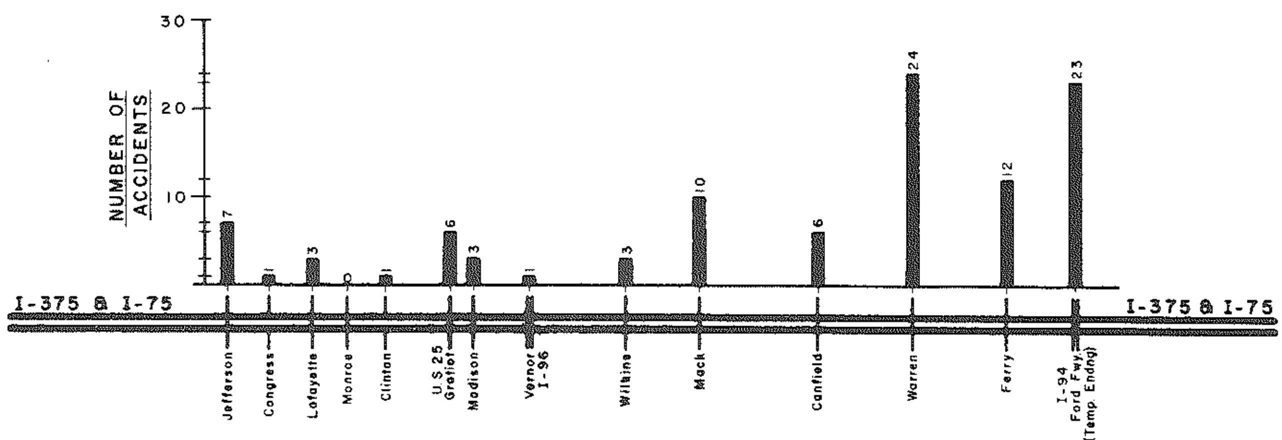

Figure D-4d LOCATION OF ACCIDENTS ON I-375 & I-75(Chrysler Freeway) ACCORDING TO STREETS AND INTERCHANGES.
(From Jefferson St. to I-94 Ford Freeway)

W.C.G.

to compile a list of all accidents that were attended by the Freeway Patrol as evidenced by the log of radio transmissions. this list was cross checked against the computer printout of all reported accidents for the same period. As a result, three categories of accident were established:

1. Those handled by Freeway Patrol for which a report was filed.

2. Those for which a report was filed but were not handled by Freeway Patrol. These were either handled directly by a precinct patrol or the report was filed at the police station.

3. Those attended by Freeway Patrol but for which no report was filed. These usually involve minor damage to the vehicles, but years of television surveillance on the Lodge Freeway have shown that traffic is still affected, since the vehicles usually stop on the freeway. Some of these stops are momentary, while others are for an extended period, either while the drivers are exchanging information or through a reluctance to move the vehicles until the police arrive. The problem is compounded by gawkers, who slow down to look and usually affect traffic in both directions.

The first and second of these categories constitute all of the reported accidents. By adding the third category to the first two, a more realistic appraisal of the effect of accidents on the freeway network is obtained.

Referring again to Table B-2, we find that during the six day study period, unreported accidents (the third category) constitute 28.5 percent to 52.2 percent of all documented accidents, on the various freeways, except the Chrysler which experienced only one documented accident on its three-mile length during the study period. An average of 35.8 percent of all documented accidents on all freeways were unreported.

To determine whether the six day sample was representative of the year, the "accidents per day" figure was compared. During the six day period, a total of 79 accidents, or 13.16 accidents per day, were reported; during the 366 day period (leap year), a total of 4,317 accidents, or 11.79 accidents per day were reported. This represents a difference in accident rates of 1.37 accidents per day, or 11.6 percent (based on the yearly rate).

Within the degree of accuracy thus established, Table B-2 may be interpreted as evidence that about one third of all documented accidents go unreported. It is quite reasonable then to presume that the total number of accidents on the Detroit Freeway network would more realistically exceed 6,400, while accidents on the Ford Freeway would be more like 3,100, and those on the Lodge about 2,200.

A study of incidents on the Lodge Freeway using 1965 data[2] showed that the average accident occupied a lane of freeway for 3.46 minutes, exclusive of the interference to traffic caused by the activities on the shoulder after the roadway is cleared. This 3.46 minutes can be considered a conservative figure, since it represents accidents that have been observed on closed circuit television, evaluated and reported to the Freeway Patrol within seconds of their occurrence.
An earlier report[3] documented a saving of 2.5 minutes per accident in the time it took for police to arrive at the scene

as a result of this form of surveillance. This saving was translated into an equivalent decrease in the period of time that the roadway was blocked in many of these accidents. Since this form of surveillance is not frequently used on the majority of Detroit freeways, we will assume that the sum of these two times represents the average time a vehicle can be expected to block the freeway. Thus, using 5.9 minutes as a reasonable average time, and 6,400 accidents as a realistic number, it is estimated that during 1968, accidents alone blocked at least one lane of the freeways for a total of 37,760 minutes, (629 hours, 20 minutes). In other words, at least one lane of the freeway network was blocked by accidents alone for 7.2 percent of the time during 1968.

OTHER INCIDENTS IN THE ROADWAY

The Freeway Patrol radio logs were reviewed to determine the number of other occurrences in traffic that resulted in lane blockages. During the six day period from December 1 through December 6, 1968, a total of 32 stalled cars, three instance of debris in the roadway, and 13 "other" incidents occurred in the roadway.

Table B-1 is a listing of the excerpts from these logs, excluding irrelevant entries.

The breakdowns in the roadway include only those for which it could be determined that traffic lanes were blocked. Incidents on the shoulder or for which it could not be determined that lanes were blocked are omitted. In this context, 32 lane blockages occurred because of breakdowns or stalls, as compared with 61 accidents during the same period. Another study using 1965 data[2] showed 861 stalls or breakdowns during the year on a 3.2 mile section of John Lodge Freeway, compared with 493 accidents on the same area and time period. The average time that these 861 stalls blocked a lane of traffic was 3.03 minutes each. Since this time represents the 2.5 minute savings brought about by the use of television surveillance and present police response policies, the average duration of each stall on the entire freeway system, not using television surveillance, can be reasonably assumed as 5.5 minutes. Realizing that not all stalls were included in the number obtained from Freeway Patrol logs, and further accepting the fact that some of the stalls recorded in the 1965 data were able to proceed under their own power (although they did in fact block a lane), let us assume conservatively that stalls and breakdowns on the freeway are equal in number to the documented accidents. Using 5.5 minutes each, we find that 6,400 stalled cars resulted in a lane of the freeway being blocked for 35,475 minutes (591 hours, 15 minutes).

In other words, a lane of the freeway was obstructed by a stalled car for 6.7 percent of the time during 1968.

COMBINED EFFECT OF ACCIDENTS AND BREAKDOWNS

The combined effect of accidents and breakdowns in the roadway as determined above represents a total time of 1,220 hours, 35 minutes, or 13.9 percent of all of the hours in a year, that at least one lane of the freeway is obstructed for these two reasons alone. While the average time of these occurrences was slightly over three minutes, they have frequently interfered with traffic for a more extensive period, and the degree of interference with freeway efficiency increases exponentially with the duration of the incident.

An excellent example of this quite common occurrence occurred on February 5, 1969. At 7:28 a.m., Freeway Patrol dispatched a car to the Edsel Ford Freeway at Dubois because of a disabled car obstructing traffic. It is not known how long the car had been there prior to this time. By 7:40 a.m. the backup caused by this obstruction extened through the Ford-Lodge Interchange and was noted by television observers watching the Lodge Freeway. Although the disabled vehicle causing the inititial obstruction remained in the roadway for only 20 minutes from the time aid was dispatched, Figure B-1 shows that as a result of this incident Traffic Central reported stop-and-go conditions on the eastbound Ford Freeway across the city to Wyoming Avenue and beyond, and in addition the backup extended through the interchange ramps, causing stop-and-go conditions on the south bound Lodge as far back as 8 Mile Road. This stop-and-go condition persisted until at least 9:00 a.m. at which time the last traffic advisory was broadcast, and affected over fifteen miles of freeway.

This degree of impairment to the efficiency of the freeway system must be considered a prime target if any significant gains in performance are to be achieved.

MAINTENANCE OPERATIONS

Another major reason for closing a lane of the freeway is the performance of both routine and emergency maintenance work. As part of an earlier study(2), an analysis was made of the effect of maintenance work on the 3.2 mile section of the John Lodge Freeway between the Ford and Davison Freeways. This study involved only the hours between 6:00 a.m. and 8:00 p.m., Monday through Friday, and is representative of most normal necessary maintenance activities. Emergency work on weekends and extraordinary night-time maintenance activities such as lane closures for extended periods for bridge painting or complete freeway closures for heavy maintenance are not included. As a result, the effects of these occurrences on traffic as presented here are quite heavily biased on the conservative side.

It was determined that during the area and time described above, maintenance crews of necessity blocked one lane of the freeway for a total of 187 hours and 47 minutes. This represents 5.3 percent of all surveillance hours (14 hour day) or 9.2 percent of all work days (8 hour day).

Maintenance work is usually done as the result of two factors; repairing "wear and tear" damage, such as patching pavement defects, cleaning catch basins, sweeping gutters and shoulder, etc; and repairing accident damage, such as repairing guard rail, replacing street lights, etc. In the first instance the amount of work to be done is reasonably consistent with the length of roadway, usually increasing with the age of the particular section. In the second instance, the work is reasonably proportional to the accident rate. To determine which was the more reasonable approach, the results of the study on 3.2 miles of the Lodge Freeway were compared to the 40.3 mile freeway network in three ways.

In the first, the total time maintenance crews occupied the roadway as determined in reference(2) was reduced to hours per mile, then expanded by the length of the freeway network. Thus 11,267 minutes equates to 63 hours, 53 minutes per mile, or 2,574 hours, 30 minutes. This represents one measure of time that some lane of the freeway network could be expected to be blocked by maintenance operations between 6:00 a.m. and 8:00 p.m., Mondays through Fridays.

In the second comparison, the total time the maintenance crews occupied the roadway as determined in reference(2) was compared with the time that the 3.2 miles of freeway was blocked by accidents, then expanded by the total predicted time that accidents were expected to block the freeway. Thus, 11,267 minutes divided by 1,706.8 minutes (from reference(2)) indicates that maintenance time equals 6.60 times the accident time. Multiplying 369 hours 4 minutes anticipated accident time by 6.60, we get 2,435 hours, 50 minutes. This represents the second measure of time that the freeway network could be expected to be blocked by maintenance operations between 6:00 a.m. and 8:00 p.m., Mondays through Fridays.

In the third comparison, maintenance time was presumed to be proportional to the number of accidents in the system. Thus 11,267 minutes was divided by 493 accidents in the comparable area and multiplied by the anticipated 6,400 accidents in the network to arrive at 2,437 hours 47 minutes. This represents the third measure of time that the freeway network can be expected to be blocked by maintenance operation between 6:00 a.m. and 8:00 p.m., Mondays through Fridays.

Again, the most conservative of these figures will be used, as has been done throughout this report

It may thus be reasonably anticipated that a lane of freeway will be blocked at some point for a period of at least 2,435 hours during the years. In other words, a lane of the freeway can be anticipated to be blocked by maintenance operations alone for 27.8 percent of the time during a year.

TOTAL COMBINED EFFECT

Adding the effect of maintenance to that of accidents and breakdowns, we may conservatively estimate that at least one lane of the freeway will be blocked for a total of 3,655 hours, or 41.7 percent of the time.

APPENDIX E - EFFECT OF LANE BLOCKAGES ON CAPACITY

APPENDIX E

EFFECT OF LANE BLOCKAGES ON CAPACITY

It has been shown in Appendix D that we can reasonably expect at least one lane of the freeway to be blocked in some location because of accident or breakdown for over 1,220 hours, or 13.9 percent of all hours in a year. The effect of this degree of interference is of great significance. Recurring observations of traffic on the John Lodge Freeway have shown that the percentage decrease in capacity without advance warning to approaching traffic is considerably greater than the percentage decrease in available lanes. Although this effect had been observed on many occasions, its extent in recent years had not been documented for various combinations of the following reasons:

1. The observations were not part of the scope of current research and were not included in published reports since the information was considered irrelevant to the specific report.
2. The circumstances of the individual occurrence were such that the researchers considered the situation "uncontrolled" as far as parameters for comparison were concerned.
3. A "controlled" experiment consisting of a deliberate lane blockage without advance warning was not permitted for reasons of hazard and liability.

LANE CLOSURE WITHOUT ADVANCE WARNING

One incident occurred on May 24, 1968 for which the author was able to "unofficially" record and save the data, which verifies the pattern of previous observations.

An accident occurred on the Eastbound Edsel Ford Freeway which backed traffic up on the left-hand exit ramp from the southbound Lodge to the eastbound Ford, then continued to back up in the left lane of the southbound Lodge. The situation was aggravated by a truck breaking down on the ramp, effectively closing the ramp. This produced the effect of a lane blockage in the left lane as far back as Milwaukee Avenue. Traffic was truly stopped in this lane, except for an infrequent movement occasioned by vehicles ahead moving out of the lane.

The overhead red "X" was not employed because the lane itself was not blocked. Figure E-1 shows the situation. Traffic volumes were obtained at a location in the three-lane section upstream of the Milwaukee entrance ramp. The few vehicles moving past the count station in the left (blocked) lane were included in the column totals. A total of 65 minutes of data was recorded, although the incident had developed and stabilized before the count began, and the count was ended while the blockage was still present.

Table E-1 gives the summary and minute traffic volumes for the situation. Table E-2 gives the minute volume distribution and frequency of occurrence of each.

A maximum volume of 61 vpm occurred once. A minimum volume of 45 vpm occurred twice. Average volume for all 65 minutes = 51.4 veh/min. Average volume (discarding the best 7 minutes) = 50.6 veh/min. Average volume (discarding the worst 7 minutes) = 52.0 veh/min. Average volume (discarding best 7 minutes and worst 7 minutes) = 51.2 veh/min.

EXHIBIT E-1
RESTRICTED FLOW STUDY

Date of Observation: 24 May, 1968.
Time of Observation: 65 Minutes (2:41 P.M. to 3:46 P.M.)
Weather: Clear. Temperature: 67°.
Pavement Condition: Dry.

DESCRIPTION OF INCIDENT:

Ramp From Southbound Lodge Freeway to Eastbound Ford Freeway Stopped Because of Accident on the Eastbound Ford Freeway. The Condition was Aggravated by a Truck That Had Broken Down on the Ramp.

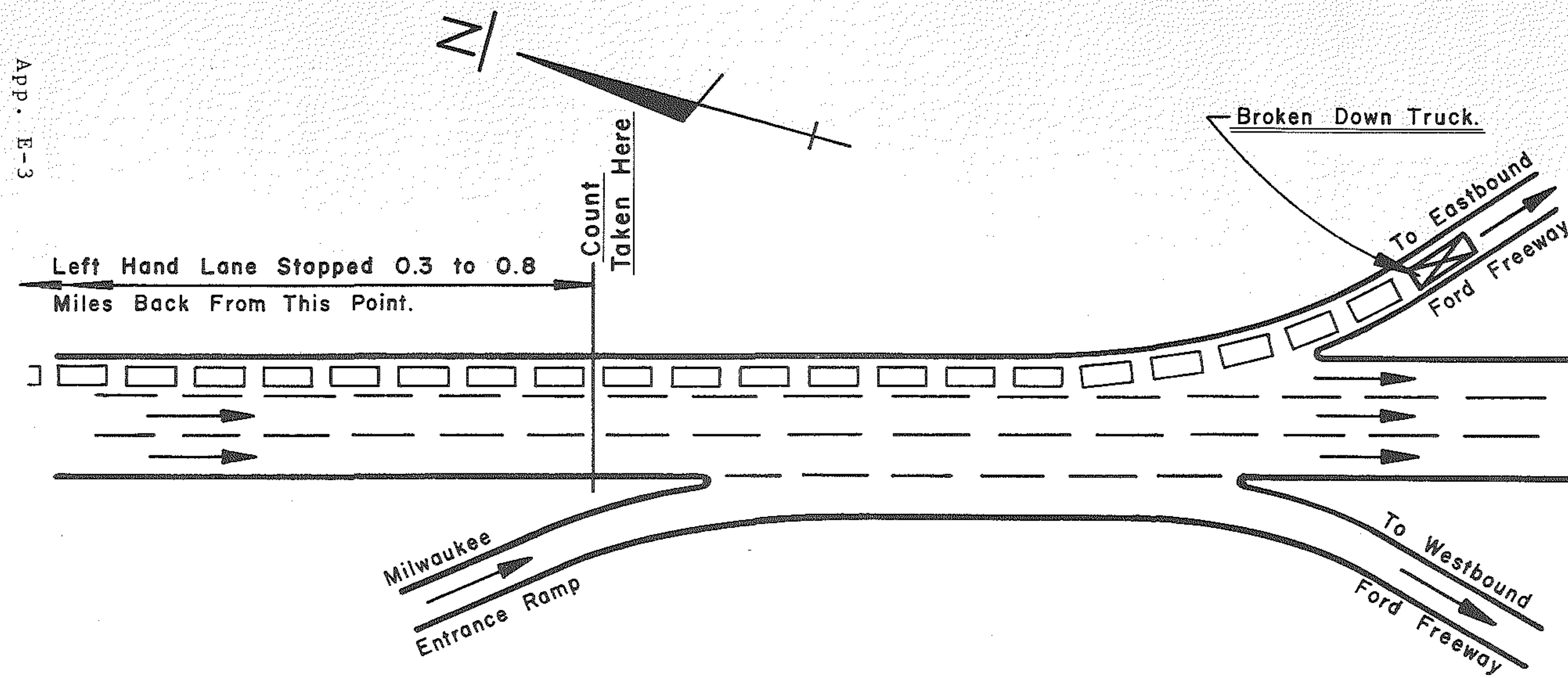

TABLE E-1

DATA FROM RESTRICTED FLOW STUDY

Friday, May 24, 1968

Minute Ending	Cumulative Total	Minute Total
1442	50	50
	99	49
1444	160	61
	211	51
1446	265	54
	315	50
1448	366	51
	415	49
1450	466	51
	515	49
1452	561	46
	614	53
1454	668	54
	720	52
1456	772	52
	821	49
1458	870	49
	919	49
1500	967	48
	1021	54
1502	1070	49
	1118	48

Minute Ending	Cumulative Total	Minute Total
1504	1170	52
	1223	53
1506	1272	49
	1321	49
1508	1377	56
	1530	53
1510	1480	50
	1525	45
1512	1575	50
	1620	45
1514	1672	52
	1726	54
1516	1777	51
	1827	50
1518	1884	57
	1938	54
1520	1985	47
	2034	49
1522	2090	56
	2143	53
1524	2197	54
	2246	49
1526	2298	52
	2354	56
1528	2407	53
	2456	49

Table E-1

Minute Ending	Cumulative Total	Minute Total
1530	2514	58
	2565	51
1532	2616	51
	2666	50
1534	2717	51
	2767	50
1536	3818	51
	2865	47
1538	2916	51
	2969	53
1540	3022	53
	3076	54
1542	3128	52
	3178	50
1544	3229	51
	3288	59
1546	3341	53

Table E-2

ONE-MINUTE VOLUME DISTRIBUTION

RESTRICTED FLOW STUDY

Friday, May 24, 1968

2-Lane Volume	1-Lane Volume	No. of Times Occurred	
61	30.5	1	Best 7 Minutes
60	30.0	0	
59	29.5	1	
58	29.0	1	
57	28.5	1	
56	28.0	3	
55	27.5	0	
54	27.0	7	
53	26.5	8	
52	26.0	6	
51	25.5	10	
50	25.0	8	
49	24.5	12	
48	24.0	2	Worse 7 Minutes
47	23.5	2	
46	23.0	1	
45	22.5	2	
		65	

Volume Total (65 min.) = 3341
Avg. Volume Lane 1 = 0 veh/min. (Blocked)
Avg. Volume Lane 2 + Lane 3 = 51.4 veh/min.
Avg. Volume per Lane = 25.7 veh/min.
Max. Volume per Lane = 30.5 (occurred 1 time)
Discarding 7 best minutes: Avg. Volume per Lane = 25.3 veh/min.
Discarding 7 worst minutes: Avg. Volume per Lane = 26.0 veh/min.
Discarding 7 best & worst minutes: Avg. Volume per lane = 25.6 veh/min.

Let us compare the average volume of 51.4 veh/min., or 25.7 veh/min. per lane, with normal capacity.

Although lane volumes of 2,000 to 2,3000 veh/hr. per lane have been frequently recorded, a volume of 1,800 vehicles per hour per lane can be accommodated more regularly, and has been used as a capacity figure in Appendix C. This relates to a volume of 30 vehicles per minute per lane. (This value was reached only once and approached only four times in 65 minutes).

Whereas normal capacity of the three-lane roadway with three lanes open is considered as 90 vehicles per minute, we see that the average capacity with one lane blocked is 51.4 vehicles per minute.

Amplifying the statement made in the lead paragraph of this Appendix, it may now be stated that by reducing the available roadway to 66.7 percent of its width without providing advance driver information, its capacity has been reduced to 57.1 percent of what it previously was.

LANE CLOSURE USING ADVANCE WARNING

It has long been an accepted fact that traffic safety and efficiency can be improved by warning the motorist of impediments to his travel path. Elaborate standards have been established and enforced in construction and maintenance areas. This type of warning can be provided when the event can be predicted, i. e. programmed.

This type of advance warning is not available, however, when the event is a random occurrence, such as an accident or a breakdown in the roadway, not is it available as the construction or maintenance crew on an urban freeway stops in the roadway to set out its first warning sign or to pick up the last one.

An alternative method of providing advance warning was developed and used on the John Lodge Freeway, which consisted of overhead lane control sign, which were remotely controlled in a dynamic system so that a warning could be displayed as soon as a lane was blocked. Two spans of these devices were normally displayed, beginning at least one-half mile in advance of the obstruction and have proven quite effective.

A study was conducted by the Texas Transportation Institute on a three-lane section of freeway to evaluate these devices(4) using a restrained application consisting of only one span of signals only 500 feet from the obstruction being compared with conventional warning signs beginning a mile from the obstruction. The conclusions stated in that report have generally been interpreted to mean that the lane control signals were ineffective.

A more realistic interpretation would be that the overhead signals, even in their restrained application, produced results comparable to conventional signing providing a full mile of advance warning. Several statements from the report follow:

1. "Traffic flow using overhead lane controls were smoother and somewhat faster than with conventional signing" (p. 83).

2. "The overhead lane control signals as used produced little operational improvement OVER CONVENTIONAL LANE CLOSURE METHODS" (p. 88).

3. "The study was not as satisfactory as desired, both because of the study area chosen, with interference from the Davison Interchange left-and-right-hand entrance ramps, as well as the results obtained" (p. 264 and following).

4. "The results of this study were not conclusive because of small sample sizes" (p. 267).

5. "Average 5-minute volumes were not conclusive because (p. 82): 300 (or 60 veh/min.) with conventional warning
295 (or 59 veh/min.) with lane signals."

In spite of the study shortcomings, this last item does provide a measure of documentation of the often-observed (but again not recently documented) ability of both forms of advance warning to produce sustained outputs in excess of 30 vehicles per minute per lane. The writer has, on many occasions during the past two years, seen maximum volumes of 35 to 40 vehicles per minute in the lane adjacent to the obstruction.

COMPARISON OF LANE CLOSURE WITH AND WITHOUT ADVANCE WARNING

Through the use of advance warning, a consistent average of at least 59 vehicles per minute can be obtained with one lane of a three-lane freeway blocked. Comparing this figure with the previously used value of 30 vehicles per minute per lane, or 90 vehicles per minute for a three-lane section, we now see that by reducing the roadway to 66.7 percent of its width, but with advance warning, its capacity is now reduced to only 65.5 percent of what it previously was.

Thus it can be seen that even with a restrained use of overhead lane control signals, it is possible to increase the capacity of a three-lane freeway with one lane blocked by 7.6 vehicles per minute, or 8.4 percent.

No data was immediately available for roadways four or more lanes in width. While it is recognized that a blockage of one lane will have less effect on a four-or-more-lane section, the principles stated will still apply. An optimistic estimate may be made by relating the previously determined values to a four lane section, presuming that one of the outside lanes is blocked, that traffic in the two center lanes is affected to the same degree as the two open lanes in the three-lane study, and that the third lane is unaffected and maintains its ability to handle 30 vehicles per minute. Whereas the four-lane capacity would be 120 vehicles per minute, the blockage without advance warning would produce 51.4 vehicles in the two center lanes plus 30 in the third lane, for a total of 81.4 vehicles per minute, or 67.9 percent of capacity. With advance warning, the two center lanes would carry 59 vehicles per minute, plus 30 in the outside lane for a total of 89 vehicles per minute, or 74.2 percent of capacity. From these figures, it can be conservatively estimated that the use of advance warning can improve the capacity of a four-lane roadway with one lane blocked by 7.6 vehicles per minute, or 6.3 percent.