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Evaluation of Pavement Marking at Merging and Diverging Areas

by

© Hansel Hon Chung Wang

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

OF Master of Science

IN

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled Evaluation of Pavement Marking at Merging and Diverging Areas submitted by Hansel Hon Chung Wang in partial fulfilment of the requirements for the degree of Master of Science in Civil Engineering.

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ABSTRACT

The purpose of this thesis is to evaluate the pavement marking at merging and diverging areas from the views of safety and capacity. Two non-accident methods of evaluation were utilized - the Critical Incident Survey and the Vehicle Trajectory Survey, with the application of the before-and-after principle.

The Critical Incident Survey involved a manual traffic counting technique. It began with the identification of the types of critical incident at each test location. The number of critical incidents by type were recorded for each test marking pattern during its peak periods. Assuming that the effectiveness of each test marking pattern decreases with increasing number of critical incidents experienced at the test locations and vice versa, the number of critical incidents and the number of critical incidents per unit volume were used as parameters for evaluation of the test marking patterns. The former was tested statistically for significance while the latter was presented visually in the form of a profile.

The Vehicle Trajectory Survey involved a filming technique. The behaviour of traffic passing through the critical areas of merging and diverging were recorded by a 16 mm movie camera. By tracing the travel paths of vehicles, vehicle dynamics were readily derived. Assuming that lateral displacement and longitudinal velocity were able to reflect some differences in drivers' response to the test marking

patterns and thus their effectiveness, in terms of safety and capacity, they were selected as measures. The variances of the parameters and the means of the longitudinal velocity were used as measures of comparison.

Conclusions were arrived at independently through these two surveys. The principal findings include :

1. For the continuity lines at merging and diverging areas, a wider marking pattern (20/30 cm) is more effective than that of the current Canadian Standard.
2. Patterns with the merging and diverging areas closed by the continuity lines are more effective than those with these critical areas opened.

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SUMMARY

Pavement marking is an indispensable means of delineation in a roadway system. A survey conducted among traffic engineers in 1976 (4) identified the following functions of pavement marking in the merging and diverging areas :

1. Identification of the existence and location of the area;
2. Identification of lane functions;
3. Warning of associated hazards, such as the possibility that other vehicles will be slowing down or behaving unpredictably, unusual geometric features, short distances available for maneuvering or obstruction at the end of the area (e.g. ramp nose curb).

There seems to be some indications that the Canadian pavement marking standard for these critical areas of merging and diverging only partially fulfills the specified goals, while design standards used in several other countries are more effective from the views of safety and capacity. However, each foreign marking standard is acceptable and operative only in its local situation which is characterized by factors of local driving habits etc.. Direct application of any of these standards without being validated for the local situation may not be able to secure its optimal functions. Moreover, as the international standards do vary among themselves, selection has to be made. Consequently, an evaluation of the foreign marking standards in the local context is deemed necessary in order

to identify an effective marking pattern for Canadian application.

A research project entitled "Marking of Merging and Diverging Areas" was undertaken to evaluate pavement marking at these critical areas. Approaches adopted in this project were multidisciplinary in nature, and two were treated in this thesis. These two approaches were employed to evaluate the effectiveness of pavement marking from traffic engineering point of view, focusing on the aspects of safety and capacity.

Firstly, a methodology called Critical Incident Survey (CIS) was modified and utilized for this particular purpose. A critical incident is defined as an unusual driver behaviour which oscillates between or beyond the safety and capacity limits of the roadway and driving conditions, be it caused by the driver's misjudgement or carelessness, the obscure situation as a result of erroneous geometric design, or the inadequate delineation systems at the vicinity of the roadway. It was assumed that the effectiveness of a test marking pattern at a test location decreases with increasing number of critical incidents experienced and vice versa.

The procedures of data collection included :

1. Identification and typification of critical incidents (or unusual driver behaviour) at the test locations;
2. Preparation of standard data collection forms;
3. Field observation and recording of critical incidents at the test locations.

The observers were asked to record the number of critical incidents by types and the volume of traffic in 15 min. intervals. Observations were be made during the peak period of a weekday at each test location. Each observation period lasted for 1 1/2 hour. A crew of four members was formed and was divided into two groups, each of which was responsible for one test location during each observation period. The procedure of data collection was repeated for each test pattern. After the application of each test pattern at the test locations, about three to four weeks were required to complete the survey satisfactorily for that stage due to interruptions by bad weather or traffic accidents. The survey was carried out in the summer of 1978, spanning a period of four months (from May to September).

Data collected for each test marking pattern were first expressed in number of critical incidents per vehicle according to types and were plotted to form a critical incident profile. The critical incident profile of each marking alternative for the same location was plotted on one graph so as to offer a visual presentation where some of the changes in drivers' responses to the test patterns could be identified easily. In order to make some concrete conclusions, the data was then expressed in absolute number of critical incidents by types, and the differences in the number of critical incidents between alternative marking patterns were analyzed statistically at a 5% level of significance.

The second methodology, called Vehicle Trajectory Survey, was employed as an alternative method of evaluation to the Critical Incident Survey. The objective of this method was to trace the travel paths of vehicles as they passed through these critical areas, before and after the application of each test marking pattern, in order to obtain the relevant vehicle dynamics. This method was based on the following assumptions :

1. The variability of vehicle dynamics reflect the variability of the performance of drivers;
2. An increase in the total variability of the performance of drivers would first increase the probability of deviation or error large enough to result in collision; and secondly decrease the capacity of the roadway (the reverse will be true);
3. An increase in the range of observed behaviour responses might imply an increase of the probability of occurrence of deviant performance; thus accidents are more likely to happen.

As this method of evaluation required filming, the traffic at the test location was recorded by means of a 16 mm movie camera mounted on a tripod. After the application of each new alternative marking pattern, at least three days were allowed before the survey was conducted in order to reduce the novelty effect. Test locations were only filmed during their peak periods on weekdays. The travel paths of vehicles through the test locations were then extracted from the films with the following procedures :

1. Projection of movie films on a screen;
2. Calibration of the length measured on the screen with the length measured on the roadway;
3. Digitization of the positions of vehicles by one second increments;
4. Tracing of vehicle travel paths.

The travel path of a vehicle was defined by the lateral and longitudinal displacements with respect to a reference line and a reference point on the roadway at each second. As the trajectory was known, higher derivatives of velocities and accelerations were readily obtainable. For this particular purpose, only the variance of lateral displacement, the variance and means of longitudinal velocity were selected among the vehicle dynamics for statistical significance analysis.

Independent conclusions were arrived at through these four parameters, namely: the number of critical incidents (from Critical Incident Survey), variance of lateral displacements, variance of longitudinal velocity and means of longitudinal velocity. It could be concluded generally that wider marking (20/30 cm) is more effective to current Canadian Standard (10 cm); and patterns with the merging and diverging areas closed by continuity lines are more effective than those with these critical areas opened.

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I. INTRODUCTION

Driving involves constant perceptual reorganization of the environment and the driver's position relative to it. The driver is seen as having three main functions: perception, decision making and control. As it has been identified by Michael(1) and Naatanen(2), the manner in which these functions interact is extremely complicated. Moreover, globally, the driver is only one of the elements in the triple system of driver-vehicle-environment. He continuously receives input from the other elements of the system. Thus, the task of driving is more complicated than is generally appreciated. When a driver approaches a merging area, he has to increase the rate of sampling of lead and following traffic, to monitor lead traffic and scan gaps in the through stream for acceptability, to initiate merging maneuvers and to re-establish stream speed. When he approaches a diverging area, the driver has to position his vehicle in the appropriate lane in advance, increase the rate of sampling of leading and following traffic, enter the deceleration lane, decelerate to ramp speed and enter the ramp. The behaviour of drivers at these critical areas, are largely influenced physically, psychologically and perceptually by elements of environment like the geometric features of the roadway, the delineation systems in the vicinities etc.. Delineation systems ,presumably, can contribute to the ease and safety of the driving task provided they are designed to take advantage of the drivers' sensory and mental capabilities and to compensate for their deficiencies. Especially in cases where the roadway design standards do not meet with drivers' expectations(3), delineation systems become indispensable. They subject to less physical limitation as compared to the geometric features of the roadway, consequently, they are more liable to alteration and improvement.

Although they are elements of the delineation system, pavement markings, in many instances, complement instead of supplement the functions of signs. Pavement markings do have some advantages over signs in delineation: they keep the eyes, and thus the attention, of drivers on the roadway while messages are communicated to them; since they are on a roadway, they are subjected to less competition for the attention of drivers; in adverse weather conditions of heavy rain and fog, they are the only delineation means visible to the drivers; of course, they also define the boundaries of travel paths for the drivers.

A survey conducted among traffic engineers in 1976 (4) identified the following functions of pavement marking in merging and diverging areas:

1. Identification of the existence and location of the area;
2. Identification of lane functions;
3. Warning of associated hazards, such as the possibility that other vehicles will be slowing down or behaving unpredictably, unusual geometric features, short

distance available for maneuvering or obstructions at the end of the area (i.e. ramp nose curb).

In the case of lane drop situations on highways, a recent report published by NCHRP (24) points out:

"In general, it has been observed that existing lane drop design standards (American standards) fail to provide an effective means of warning drivers of the presence and location of the impending lane drop. Very little standardization of lane drop geometric design or traffic control device treatment exists in the field, resulting in much driver confusion regarding lane drop maneuvers. In many instances, lane drops are not physically well defined; they can be difficult to see because they might blend into their background or be hidden over crest of a grade, advance warning traffic control devices are many times misleading or obscure."

Therefore, as result of the research project which was designated NCHRP project 3-16, the principles developed to serve as guideline for lane-drop designs included:

1. When a lane is added at an on-ramp and dropped at a nearby off-ramp, the entering drivers should be notified that the lane they are travelling in is not a continuous lane for through traffic;
2. Consistent and appropriate traffic control devices should be used in advance of a lane-drop.

There seems to be some indications that the Canadian pavement marking standard for these critical areas of merging and diverging (Appendix A) only partially fulfills the specified goals, while design patterns used in several other countries, especially Australia, Austria, Great Britain, Japan, Netherlands and West Germany are more effective from the views of safety or capacity(5). However, each foriegn marking standard is acceptable and operative only in its local situation which is characterized by factors of local driving habits, social value, norm acceptance and sense of cost and benefit. Direct application of any of these standards without validation for the local situation may not be able to secure its optimal functions. Besides, as the international standards do vary among themselves, selection has to be made. Consequently, the evaluation of the foreign marking standards in the local context is deemed necessary in order to identify an effective marking pattern for Canadian application.

Methods of evaluation of highway improvements dependent on accident records have been widely used by highway agencies. It has been realized, however, that there are certain disadvantages which render these methods of evaluation less effective:

1. Accident histories take a long time to develop and much pain and suffering could have been caused.
2. A high percentage of accidents are not reported and thus the current records are not complete.

3. Some of the recorded accidents are biased because of subjective reports of some but not all parties involved.

Consequently, more and more highway agencies today have begun to use non-accident information such as observed traffic conflicts, or other traffic safety and capacity parameters as measures of effectiveness of highway safety improvements. This information is readily accessible and developed within a relatively short time thus pilot studies on some highway improvements before country-wide implementation are possible.

Methods of evaluation of highway safety improvements independent of accident experiences have been developed. They are basically divided into 2 categories:

1. Those oriented toward the direct assessment of the means of improvement.
2. Those oriented toward the measurement of drivers' responses to the means of improvement.

A research project entitled "Marking of Merging and Diverging Areas" was undertaken to evaluate the effectiveness of pavement marking at these critical areas. Methods of the second category were adopted in this project, two of which were treated in this thesis.

A. The Objective of the Thesis

It is the objective of this thesis to evaluate the effectiveness of pavement marking patterns in merging and diverging areas. The methodologies involved were to measure the parameters which were assumed to be able to reflect the drivers' responses to the marking patterns at these critical areas.

B. The Organization of the Thesis

Chapter II deals with the selection of test patterns and test locations. In Chapter III, methodologies that have been used for the evaluation of highway delineation improvement are critically reviewed; the emergence of the presently adopted methods of evaluation, namely: Critical Incident Survey and Vehicle Trajectory Survey are justified. Chapter IV is devoted to a detailed treatment of the Critical Incident Survey while Chapter V is a description of the Vehicle Trajectory Survey. Conclusions are discussed in Chapter VI and the recommendations based on the findings in the preceding chapters constitutes the last chapter.

II. BACKGROUND

A. Selection of Test Patterns.

A review of the Canadian and the international standards of pavement marking in merging and diverging areas (6) led to the identification of variables used for these purposes. They included:

1. Line width.
2. "Closed" or "Open" sections(Table 1.).
3. Line/gap lengths and ratios.
4. Pattern of gore areas.
5. Changes of separation (lane) line patterns.
6. Arrows and special symbols.

To study the effects of each of these variables was not only unmanageable but also impractical. Too many combinations of the variables at too few test locations, would be detrimental to the evaluation, since it would be impossible to separate the effects of individual variables on one hand, and drivers might be confused on the other. It was therefore decided to evaluate selectively some potential candidate variables and their practical combinations. The variables and their candidates for testing are summarized in Table 2.and the transitions of selected combinations of variables is illustrated in Figure 1. It should be noted that the width of edge lines in merging and diverging areas was increased with that of the continuity lines. It was not treated as an individual variable.

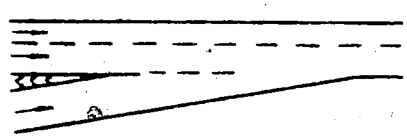
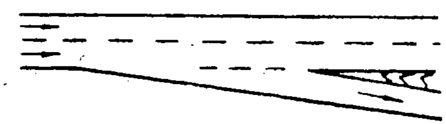
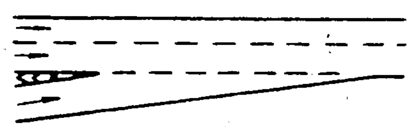
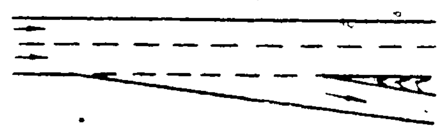
Section	Merging	Diverging
"Open"		
"Closed"		

Table 1 "CLOSED" AND "OPEN" SECTIONS AT MERGING AND DIVERGING AREAS

Variables	Candidates Selected
Line width (cm)	10, 20, 30
Section	Closed, Open
Line/gap length and ratios	3m/6m
Pattern of gore area	30 cm chevron

Table 2 THE VARIABLES AND THEIR CANDIDATES FOR THE DESIGN OF TEST PATTERN

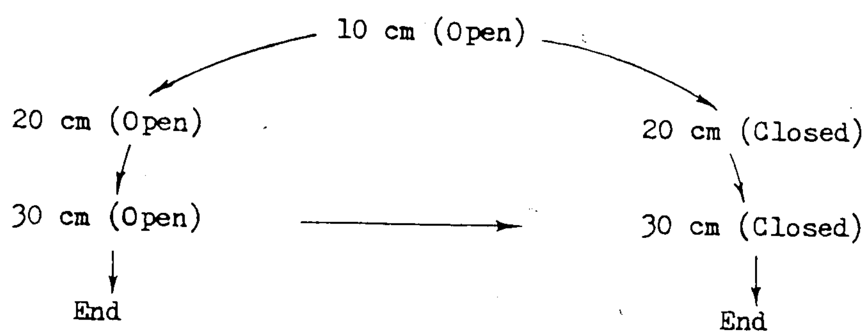


Fig. 1 TRANSITIONS OF SELECTED COMBINATIONS OF VARIABLES OF PAVEMENT MARKING IN THE MERGING AND DIVERGING AREAS

B. Selection of Test Locations

The criteria for the selection of test locations included:

1. Adequate merging and diverging situations.
2. Adequate traffic volumes during the peak periods (too little traffic would render data collected difficult, too much traffic or overly saturated would obscure the effects of marking on the behaviour of drivers). Traffic conditions at the level of service of D or E would be desirable.
3. The test locations should be far enough apart from one another so that there would not be any "carried over" effects remaining with the drivers as he travels from one test location to another.

As the Whitemud Freeway complex between Fox Drive and 159 St. in Metropolitan Edmonton (Appendix B) seems to meet these requirements, it was therefore selected (7). A summary of the test locations and their respective test patterns is shown in Appendix C.

C. Implementatment of Test Patterns at the Test Location

Implementation of test patterns at the test locations was carried out in stages (7). The first stage was the application of Canadian Standard markings with the exception of 30 cm chevrons at the gore areas. The chevrons remained unchanged throughout all the stages. The second stage consisted of widening the continuity lines of all the locations to 20 cm and closing some of the merging or diverging areas at the same time. The shoulder lanes, in all cases, were increased to 20 cm wide. At the third stage, the width of continuity lines was increased to 30 cm, and closed sections were used wherever applicable. There was an exception at the test location on Whitemud Freeway entering from 149 St. (E.B.), while the width of the continuity line was increased to 30 cm, it remained an open section at the third stage. This merging section was closed at the final stage.

A schedule of activities during the stage of data collection can be found in Appendix D.

III. METHODS OF EVALUATION

A. Introduction

Methods of evaluation of highway safety improvement essentially fall into two categories. They are namely: accident-based methods, and non-accident-based methods(10). Although accident data at any critical location remain the ultimate measures of the effectiveness of any traffic engineering devices, their practicality is greatly reduced by their own limitations (10,11). Accident data are either incomplete or inaccurate. Past accident experiences are not appropriate when either major changes in geometric or traffic control devices have been implemented, or major changes in traffic characteristics have taken place. Besides, accident histories take a long time to develop and much pain and suffering could be avoided if methodologies of evaluation which take shorter time are generated.

B. Critical Incident Survey

Among the objective non-accident indicators, the Traffic Conflict Technique (TCT) could have been selected as a substitute for an accident-based method in this project. The General Motor Research procedure (11) defines a traffic conflict as an evasive action of a driver which is evidenced by brake-light indicators or weaving maneuvers (lane changes) forced on the driver by an impending accident situation or a traffic violation. However, in the situation of a merging or a diverging area, an impending accident might not involve more than one vehicle, e.g. a late return to the through lane from an exiting ramp resulted in knocking down the 'EXIT' sign mounted on the concrete. Other weaknesses of the TCT had also been identified by Allen, Shin and Cooper (12). They includes:

1. The variability of braking habits among drivers;
2. The lack of measure of severity of a conflict situations;
3. Driver escaping from an impending accident by acceleration instead of deceleration;
4. The loss of information on the vehicles other than the one with the right-of-way;
5. The invisibility of brake lights due to mechanical failure;
6. The uncertainty of the purpose of the braking.

Moreover, the capacity factor and its relationship with the safety factor are not considered to any extent (15).

Because of the undesirable deficiencies of the accident-based method and the Traffic Conflict Technique, and because of the necessity of comparing the effectiveness of different marking patterns which were to be applied to the test locations consecutively within a relatively short time, a methodology had to be developed such that it was:

1. Non-accident-based;
2. Objective;
3. Accurate;

4. Measuring parameters which indicate the modes of the potential accidents;
5. Taking into account the factor of capacity.

A methodology called Critical Incident Survey (CIS) (15) was modified and utilized for this particular purpose. A critical incident is defined as an unusual driver behaviour which oscillates between or beyond the safety and capacity limits of the roadway and the driving conditions, be it caused by the drivers' misjudgement or carelessness, the obscure situation as a result of erroneous geometric design, or the inadequate delineation systems at the vicinity of the roadway.

It was assumed that the effectiveness (in terms of safety and capacity) of a test marking pattern at a test location decreases with increasing number of critical incidents experienced and vice versa. the procedures of the method are described in Chapter IV.

This method does have some disadvantages. The data collected during the Critical Incident Survey does not incorporate the effect of the ever changing traffic situation. The time required for data collection may be impractically long before conclusions of reasonable degree of statistical significance could be drawn. Furthermore, this method may not be sensitive enough to detect some changes in drivers' behaviour which do reflect the effectiveness of the test marking patterns. For these reasons, it seemed expedient to develop yet another method.

of evaluation which would complement the shortcomings of the Critical Incident Survey.

C. Vehicle Trajectory Survey

Vehicle dynamics or traffic performance measures such as spot speed, lateral displacement, headway, acceleration, and deceleration profiles are parameters commonly used as measures of effectiveness of highway improvement. They can be measured easily in the field and possess sufficient sensitivity to reflect even relatively intangible changes in drivers' responses before and after the improvement. Apparently, some, if not all, of these parameters can be utilized to measure the effectiveness of marking in merging and diverging areas.

A traffic performance measure was defined as any measurable parameter that describes the flow of traffic at a point or over a section of roadway in the merging or diverging area. These measures can take the form of various statistics such as mean, variance, skewness, or percentile. The Information-Decision-Action (IDA) sequence file and an Accident-Prior-Movement (APM) analysis(19) can be applied in identifying those traffic performance measures which would reflect drivers' responses to the test marking patterns at these critical areas. For a specific geometric situation, the Information-Decision-Action analysis defines the desired driver actions, determines the decisions necessary to effect these actions, and then specifies the information needed by a driver to make the required decisions. The most useful element of the Information-Decision-Action analysis for its application in this study is the identification of actions required by a driver when he is negotiating the merging or diverging area. These actions would be transposed into the respective traffic performance measures. The Acident-Prior-Movement approach of identifying appropriate traffic performance measures for a given situation is to identify all types of accidents that can possibly occur and determine the corresponding vehicular movement(s) preceding each type of accident. Subsequently, traffic performance measures which best describe or quantify these movements can be established. In this study, the traffic performance measures selected were checked against the Information-Decision-Action sequence file for the merging and diverging maneuvers and the parameters of lateral and longitudinal displacements, velocities, and accelerations were found to be able to reflect drivers' actions involved in negotiating these critical areas (Table 3).

These parameters can be measured at certain points of interest at the vicinities of the merging and diverging areas. Nevertheless since most of these points are interdependent and since the objective is to study the action and reaction of drivers to the test marking patterns at these critical areas, that is over a section of roadway, a methodology, other than those of discrete-point-data-collection types, has to be employed to capture the

SITUATION	ACTION SEQUENCE	ACTION TO BE TAKEN	DECISION TO BE MADE	TRAFFIC PERFORMANCE MEASURE
DIVERGING	1	Enter diverge maneuver area	Exercise caution; increase surveillance sampling rate	–
	2	Maintain lane position	No tracking modification required	–
	3	Establish position in appropriate lane for diverges	Tracking/speed modification required	Lat. $x, \dot{x}, \ddot{x}$ Long. $y, \dot{y}, \ddot{y}$
	4	Initiate diverging	Appropriate location for tracking/speed modification to initiate maneuver	Lat. $x, \dot{x}, \ddot{x}$, Long. $y, \dot{y}, \ddot{y}$
	5	Establish position in desired traffic stream	Tracking/speed modification required	Lat. $x, \dot{x}, \ddot{x}$, Long. $y, \dot{y}, \ddot{y}$
MERGING	1	Enter merging maneuver area	Exercise caution; increase surveillance sampling rate	–
	2	Maintain lane position	No tracking modification required	–
	3	Establish position (w. r.t. main stream traffic - gap creation) in the acceleration ramp/lane	Little tracking but speed modification required	Lat. $x, \dot{x}, \ddot{x}$ Long. $y, \dot{y}, \ddot{y}$
	4	Initiate merging maneuver	Appropriate location for tracking/speed modification to intiate maneuver	Lat. $x, \dot{x}, \ddot{x}$, Long. $y, \dot{y}, \ddot{y}$
	5	Establish position in desired traffic stream	Tracking/speed modification required	Lat. $x, \dot{x}, \ddot{x}$ Long. $y, \dot{y}, \ddot{y}$

Legend: x = Lateral displacement
$\dot{x}$ = Lateral velocity
$\ddot{x}$ = Lateral acceleration
y = Longitudinal displacement
$\dot{y}$ = Longitudinal velocity
$\ddot{y}$ = Longitudinal acceleration

Table 3 TRAFFIC PERFORMANCE MEASURES FOR MERGING AND DIVERGING SITUATIONS FROM INFORMATION - DECISION - ACTION SEQUENCE FILE 'in-between' information which, otherwise, might not be available. A second methodology called Vehicle Trajectory Survey was employed as a complementary method to the Critical Incident Survey in the evaluation of marking at merging and diverging areas.

The immediate objective of this method of evaluation is to trace the travel paths of vehicles passing through these critical areas before and after the applicaton of each test marking pattern. However, the vehicle trajectories do nothing more than present visually some characteristics of drivers' behaviours at the merging and diverging areas. In order to achieve the ultimate objective of 'quantifying' the effectiveness of the test marking patterns, for comparison , vehicle dynamics or traffic performance measures such as lateral and longitudinal displacements, velocities etc, which are readily derivable from the vehicle trajectories, have to be used.

This method of evaluaton is complicated by the problem of interpretation. The difficulty arises from the fact that statistical significance may not necessarily coincide with practical significance. For example, a shift of 20 cm in lateral displacement toward the separation line following the application of a continuity line in a diverging situation may be statistically significant and, therefore, it can be concluded that the treatment has had an effect on the drivers. The question remains, however, as to whether this change in lateral displacement is a practical improvement, since there is essentially an absence of any legal or physical one-and-only-one correct way in negotiating any particular roadway situation. Michael's concept of variability(1) becomes helpful at this point. He reasons that :

1. The variability of vehicle dynamics reflects the variability of the performance of drivers;
2. An increase in the total variability of the performance of drivers would increase the probability of deviation or error large enough to result in collision and vice versa; and secondly, decrease the capacity of the roadway;
3. An increase in the range of observed behaviorial responses might imply an increase of the probability of occurence of deviant performance, thus, accidents are more likely.

Therefore, the variance which is a measure of the range of variability of the parameters was used for the comparison of the effectiveness of the test marking pattern.

In 1970, Ackroyd and Madden (16,17) succeeded in the development and use of the instrumentation of multi-channel event-recording apparatus (METRA) synchronized with the time lapse cinephotography (TLC) to study the various aspects of traffic behaviour at rural motorway interchanges. The system consisted of:

1. Some form of vehicle-detector on the road surface e.g. pneumatic road surface tubes and diaphragm units;

2. Time and data receiving equipment;
3. Permanent recording equipment.

With this instrumentation, they could measure the vehicle dynamics directly in the field at certain critical point at the interchange areas.

In order to simplify the installation equipment for data collection, a 16 mm movie camera was utilized instead to record the behaviour of traffic at the merging and diverging areas. As the Vehicle Trajectory Survey involved a filming technique, it had certain advantages over other methods of evaluation discussed previously. They included:

1. The test marking patterns could be evaluated empirically within a relatively short period of time;
2. Some changes of drivers' response, e.g. a shifting of 20 cm toward the separation line as a result of widening the continuity line, which could not be recorded during the Critical Incident Survey was readily observed by this method;
3. As data for each test pattern was collected within 3 to 4 weeks, variation of other environmental factors e.g. signs, physical geometric features, could be minimized;
4. A great deal of information could be obtained from the film at leisure e.g. volume, vehicle classification, positioning and headway etc.;
5. A complete visual record of events, which appeared to be the best way to study the merging and diverging maneuvers and gap acceptance was available;

6. The raw data can be accessed repetitively.

However, its disadvantages included:

1. Selections of meaningful traffic performance measures were sometimes difficult;
2. As significant data collection effort was generally required, it was usually impossible to evaluate the treatment across all variables - e.g. day versus night etc.;
3. Even if it was accepted that a reduction in variability of a specific traffic performance measure did indicate a probable reduction in accident rates, it was hard to quantify the correlation;
4. The effectiveness of the various treatments, as quantified by traffic performance measures, could not be stated in terms of dollar for cost benefit studies;
5. A suitable vantage point for the camera was not always readily available, especially if natural drivers' behaviours were to be observed;
6. Filming was dependent on weather conditions;
7. Extraction of data was very tedious and time consuming;
8. Accurate spot speed measurements could not be obtained, they were replaced by the average running speed over a marked section of considerable length of roadway.

The following Chapters deal with these two methods of evaluation separately.

IV. CRITICAL INCIDENT SURVEY

A. Introduction

The Critical Incident Survey involved a manual traffic counting technique. It consisted of two phases - data collection and data analysis. The phases of data collection included :

1. Identification and typification of critical incidents (or unusual driver behaviours) at the test locations;
2. Preparation of standard data collection forms;
3. Field observation and recording of critical incidents at the test locations.

A crew of four members was formed and it was divided into two groups, each of which was responsible for one test location during each observation period. The procedure of data collection was repeated for each test marking pattern. After the application of the test patterns at the test locations, about three to four weeks were required to complete the survey satisfactorily for that stage due to interruptions caused by bad weather and traffic accidents. The survey was carried out in summer, 1978, spanning a period of four months (from May to September). Data collected was then presented visually to show the differences in drivers' responses on the test marking patterns and then analyzed statistically for significance.

B. Data Collection

Types of Critical Incidents

Before data collection began, preliminary observations had been made at each test location and all possible types of critical incident were then identified.

In the case of the merging situation, they included:

1. Merging into the mainstream by entering Lane 2 or the curb lane through the zone near the concrete from the taper (Fig. 2);
2. Merging into the mainstream by entering Lane 3 or the median lane through the zone near the concrete from the taper (Fig. 3);
3. Merging into the mainstream by entering Lane 2 or the centre lane through the zone between the concrete and the tip of the gore area from the taper (Fig. 4);
4. Merging into the mainstream by entering Lane 3 or the median lane through the zone between the concrete and the tip of the gore area from the taper (Fig. 5);
5. Merging into the mainstream by entering Lane 2 or the centre through the zone near the tip of the gore area from the tape (Fig. 6);
6. Merging into the mainstream by entering Lane 3 or the median lane through the zone near the tip of the gore area from the taper (Fig. 7);
7. Slowing down or stopping unnecessarily in the taper due to confusion (Fig. 8);
8. Escaping from encroachment on the prohibited zone at the

end of the acceleration taper (Fig. 9);

9. Running on a prohibited zone at the end of the acceleration taper (Fig. 10);

10. Lane 2 thru vehicle weaving into the acceleration taper (Fig. 11);

11. Merging into the mainstream by entering Lane 2 or the centre lane through the zone near the tip of the gore area from the ramp which continues (Fig. 12);

12. Merging into the mainstream by entering Lane 2 or the centre lane through the zone between the concrete and the tip of the gore area from the ramp which continues (Fig. 13);

13. Lane 2 through vehicle weaving into the ramp which continues, at the tip of the gore area (Fig. 14);

14. Lane 2 thru vehicle weaving into the ramp which continues, through the zone between the concrete and the tip of the gore area (Fig. 15);

15. Slowing down or stopping unnecessarily in the ramp which continues, due to confusion (Fig. 16);

16. Merging into the mainstream by entering Lane 3 or the median lane through the zone near the tip of the gore area from the ramp which continues (Fig. 17);

17. Merging into the mainstream by entering Lane 3 or the median lane through the zone between the concrete and the tip of the gore area from the ramp which continues (Fig. 18);

18. Merging into Lane 2 or only at the very end of the

dropped lane (Fig. 19);

19. Encroaching on the prohibited zone before merging movement is complete. (Fig. 20);

20. Running on the prohibited zone (Fig. 21).

In the case of diverging situation, they included:

1. Lane 1 exiting vehicle entering the taper at the area close to the concrete (Fig. 22);

2. Lane 1 exiting vehicle entering the taper at the zone between the concrete and the tip of the gore area (Fig. 23);

3. Lane 1 exiting vehicle entering the taper at the tip of the gore area (Fig. 24);

4. Lane 2 exiting vehicle entering the taper at the tip of the gore area (Fig. 25);

5. Lane 2 exiting vehicle entering the taper at the zone between the concrete and the tip of the gore area (Fig. 26);

6. Lane 3 exiting vehicle entering the taper at the tip of the gore area (Fig. 27);

7. Lane 1 thru vehicle being 'drafted' into the deceleration taper and only escapes near the tip of the gore area (Fig. 28);

8. Lane 1 thru vehicle being 'drafted' into the deceleration taper and only escapes through the zone between the concrete and the tip of the gore area (Fig. 29);

9. Lane 1 thru vehicle being 'drafted' into the

deceleration taper and only escapes through the zone close to the concrete (Fig. 30);

10. Exiting vehicle slowing down or stopping unnecessarily due to confusion (Fig. 31);
11. Lane 1 thru vehicle weaving unnecessarily into lane 2 upstream of the point of divergence due to the uncertainty of the situation ahead (Fig. 32);
12. Lane 1 through vehicle being 'drafted' into the deceleration lane and only escapes near the tip of the gore area (Fig. 33);
13. Lane 1 thru vehicle being 'drafted' into the deceleration lane and only escapes through the zone between the concrete and the tip of the gore area (Fig. 34);
14. Lane 1 thru vehicle being 'drafted' into the deceleration lane and only escapes through the zone close to the concrete (Fig. 35);
15. Lane 2 exiting vehicle entering the ramp at the tip of the gore area (Fig. 36);
16. Lane 2 exiting vehicle entering the ramp through the zone between the concrete and the tip of the gore area (Fig. 37);
17. Lane 2 exiting vehicle entering the ramp at the area close to the concrete (Fig. 38);
18. Lane 3 exiting vehicle entering the ramp at the tip of the gore area (Fig. 39);
19. Exiting vehicle slowing down or stopping unnecessarily

due to confusion (Fig.40).

Procedure

After the critical incidents (or unsual driver behaviours) at the test locations were identified and categorized into standard types, data collection forms (Appendix E) were prepared. During the survey, the observers were to check the appropriate boxes under the types of critical incident as they occured. The duration of each observation period was 1 1/2 hour. The number of critical incidents (according to types) and traffic volume (number of vehicles passing through the section of the roadway) were recorded at the end of each 15 min. interval. For each test marking pattern, data was collected only during the peak periods of 3 weekdays (excluding the afternoon peak of Friday). Several precautions were taken in order to eliminate as much as possible systematic and random errors. They were:

1. The observers were stationed at locations where they were practically concealed so that the drivers would not be distracted;
2. Before data collection began, the observers were given 'in class' and 'on field' training. The observers were assigned to the same locations for all test marking patterns so that consistency of judgement could be maintained;
3. The observers were asked to record all 'controversial' cases - the occurence of erratic maneuvers other than

MERGING SITUATIONS

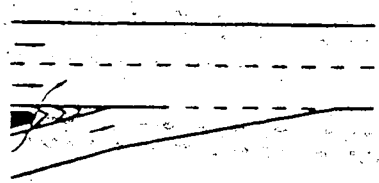


Fig. 2 CRITICAL INCIDENT 1

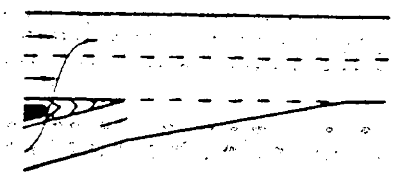


Fig. 3 CRITICAL INCIDENT 2

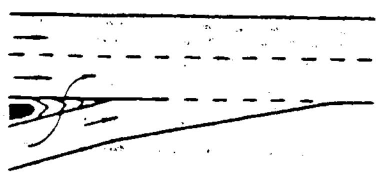


Fig. 4 CRITICAL INCIDENT 3

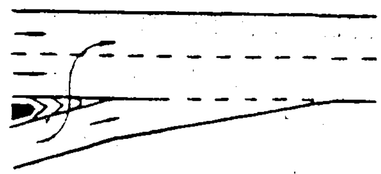


Fig. 5 CRITICAL INCIDENT 4

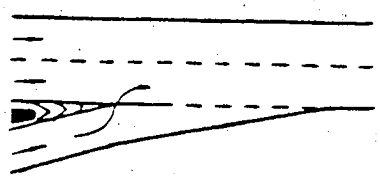


Fig. 6 CRITICAL INCIDENT 5

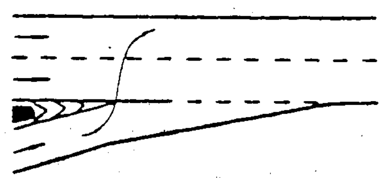


Fig. 7 CRITICAL INCIDENT 6

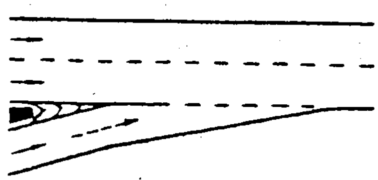


Fig. 8 CRITICAL INCIDENT 7

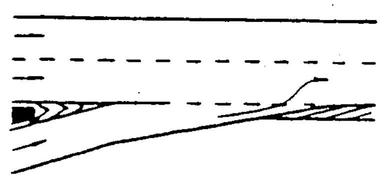


Fig. 9 CRITICAL INCIDENT 8

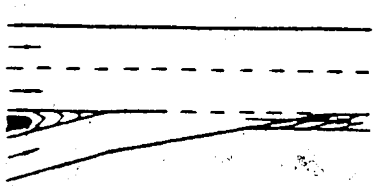


Fig. 10 CRITICAL INCIDENT 9

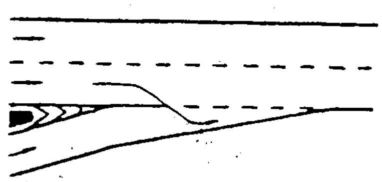


Fig. 11 CRITICAL INCIDENT 10

MERGING SITUATIONS

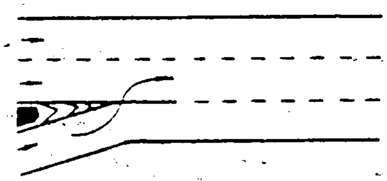


Fig. 12 CRITICAL INCIDENT 11

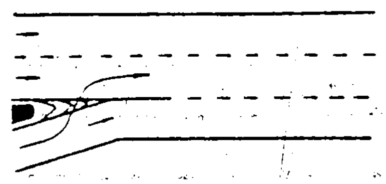


Fig. 13 CRITICAL INCIDENT 12

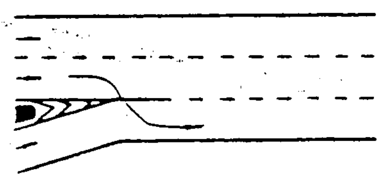


Fig. 14 CRITICAL INCIDENT 13

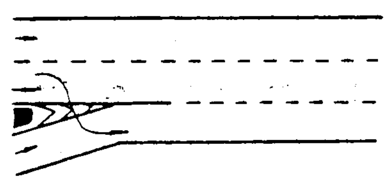


Fig. 15 CRITICAL INCIDENT 14

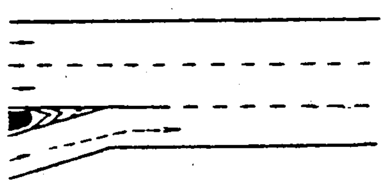


Fig. 16 CRITICAL INCIDENT 15

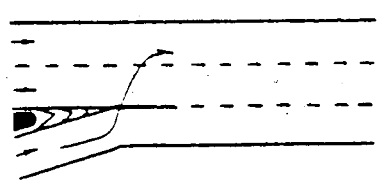


Fig. 17 CRITICAL INCIDENT 16

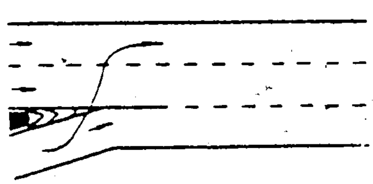


Fig. 18 CRITICAL INCIDENT 17

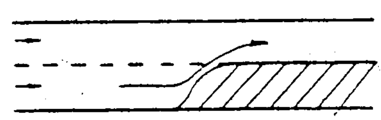


Fig. 19 CRITICAL INCIDENT 18

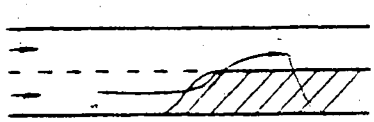


Fig. 20 CRITICAL INCIDENT 19

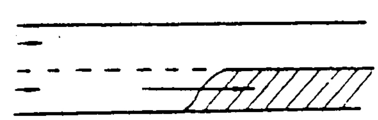


Fig. 21 CRITICAL INCIDENT 20

DIVERGING SITUATIONS

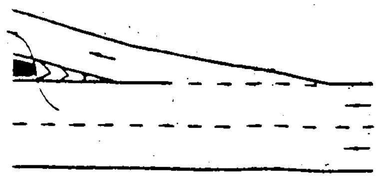


Fig. 22 CRITICAL INCIDENT 1

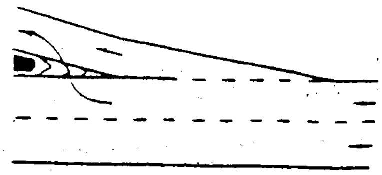


Fig. 23 CRITICAL INCIDENT 2

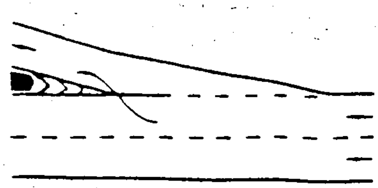


Fig. 24 CRITICAL INCIDENT 3

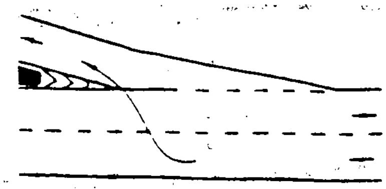


Fig. 25 CRITICAL INCIDENT 4

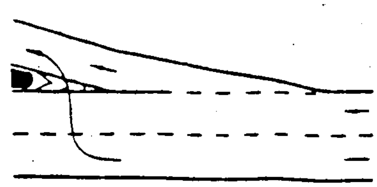


Fig. 26 CRITICAL INCIDENT 5

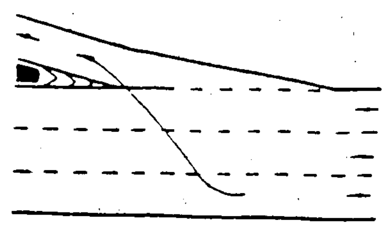


Fig. 27 CRITICAL INCIDENT 6

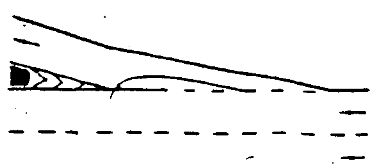


Fig. 28 CRITICAL INCIDENT 7

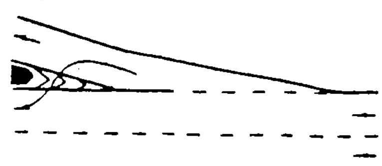


Fig. 29 CRITICAL INCIDENT 8

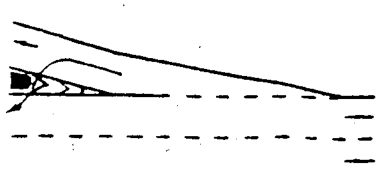


Fig. 30 CRITICAL INCIDENT 9

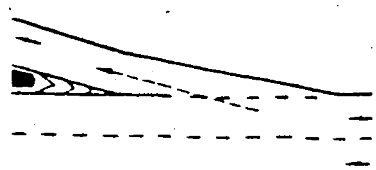


Fig. 31 CRITICAL INCIDENT 10

DIVERGING SITUATIONS

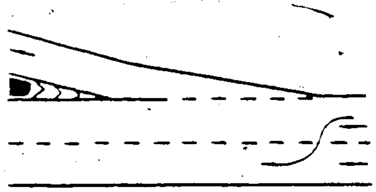


Fig. 32 CRITICAL INCIDENT 11

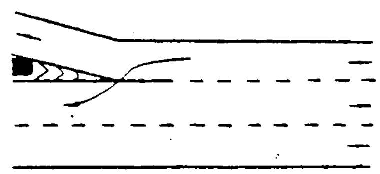


Fig. 33 CRITICAL INCIDENT 12

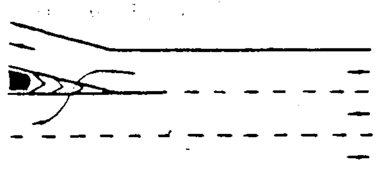


Fig. 34 CRITICAL INCIDENT 13

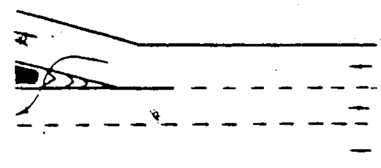


Fig. 35 CRITICAL INCIDENT 14

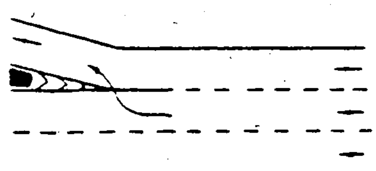


Fig. 36 CRITICAL INCIDENT 15

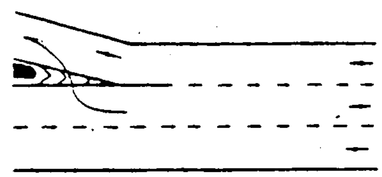


Fig. 37 CRITICAL INCIDENT 16

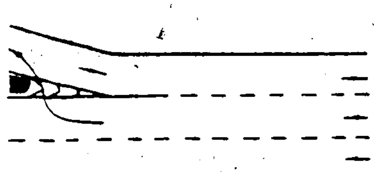


Fig. 38 CRITICAL INCIDENT 17

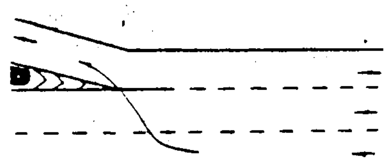


Fig. 39 CRITICAL INCIDENT 18

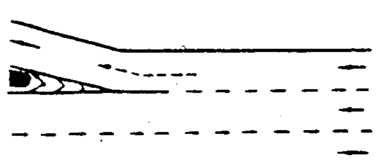


Fig. 40 CRITICAL INCIDENT 19

the ones listed in the data collection forms for later assessment;

4. After the application of each test pattern at each test location, at least three weekdays (practically one week) were allowed for the drivers' adjustment prior to data collection, so that the 'novelty' effect could be reduced;
5. As data was only collected during the peak periods of weekdays, (6:45 to 8:15 am for the morning peak and 3:45 to 5:15 pm for the evening peak), the same group of drivers would probably be observed each time, and thus the results of the survey would be more credible;
6. All data were collected under similar weather and lighting conditions;
7. All road signs and environmental factors remained the same throughout the stages of the data collection.

Data Inventory

Data collected was summarized in Appendix F.

C. Data Analysis

Critical Incident Profile

As valid comparisons of critical incident experiences of test marking patterns could only be made under similar traffic conditions, the data was brought down to the same denominator of number of critical incidents per unit volume (or per vehicle) before they were plotted according to types, forming a "critical incident profile". When the critical incident profiles of all test marking patterns at each test location were plotted on one graph, some changes of driver responses to the test pattern could be identified visually. Figures 41 to 47 are the critical incident profiles for the test locations.

Statistical Analysis

Before the data collected had undergone statistical evaluation, no judgement could be rendered to the significance of the changes of driver responses to the test marking patterns. Curves of significance test for accident reduction from Manual of Traffic Engineering Studies (18) were utilized for this purpose (Appendix G). The curves were plottings of critical incident reduction required to be significant at 5% level versus number of critical incidents before the application of each test marking pattern. As Curve 2 which was based on chi-square distribution was above Curve 1 which was based on poisson distribution, the former minimized the probability of inferring a reduction as significant when the opposite was true, thus constituted a conservative test while the latter minimized the probability of judging a reduction as non-significant when in fact the change was really significant, thus constituted a liberal test.

The average number of critical incidents by types per observation period was used as parameters of comparison between alternative marking patterns. If the effectiveness of test marking pattern 1 was compared to the effectiveness

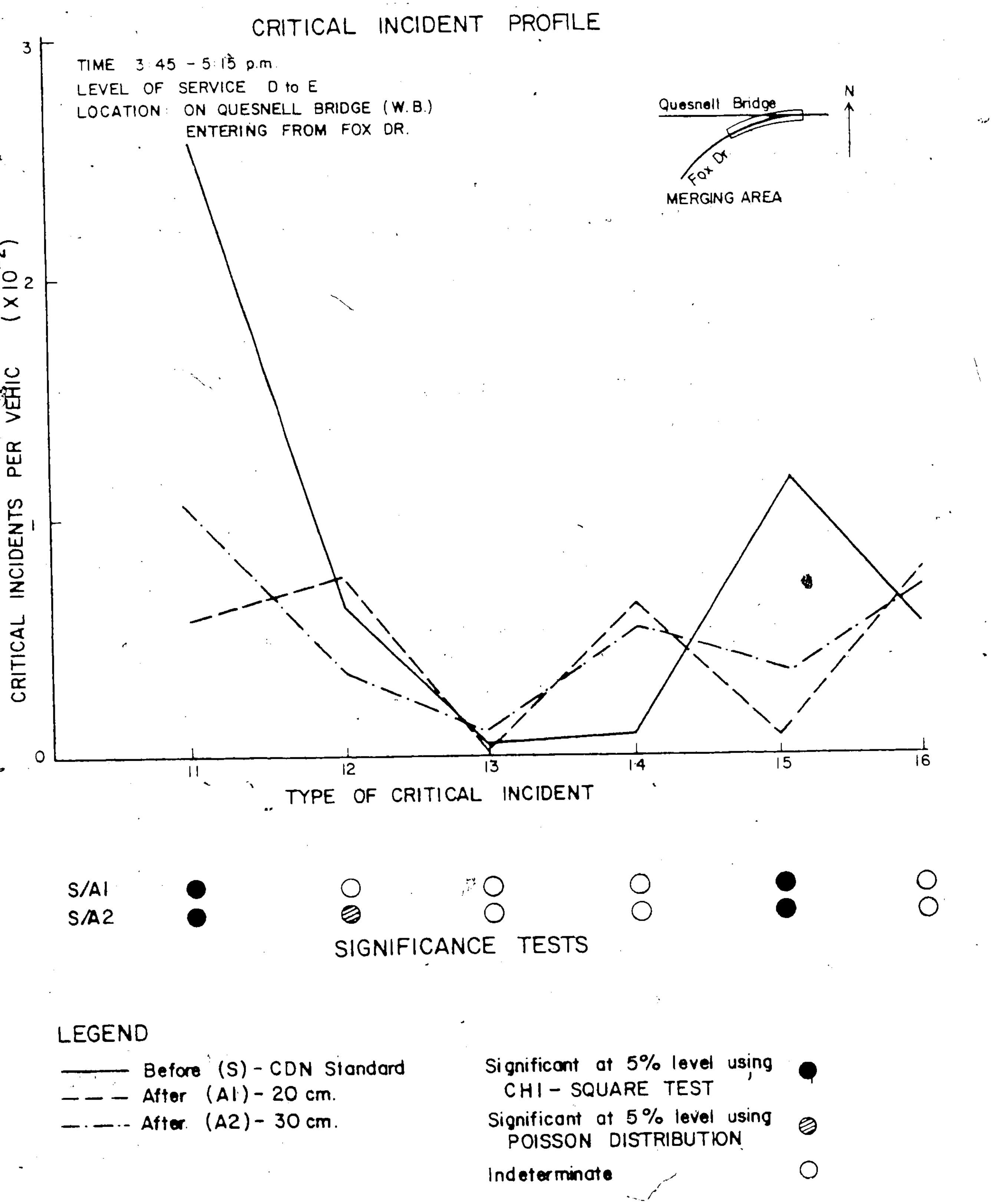


Fig. 41 CRITICAL INCIDENT PROFILE & THE SIGNIFANCE TESTS ON QUESNELL BRIDGE ENTERING FOX DR.

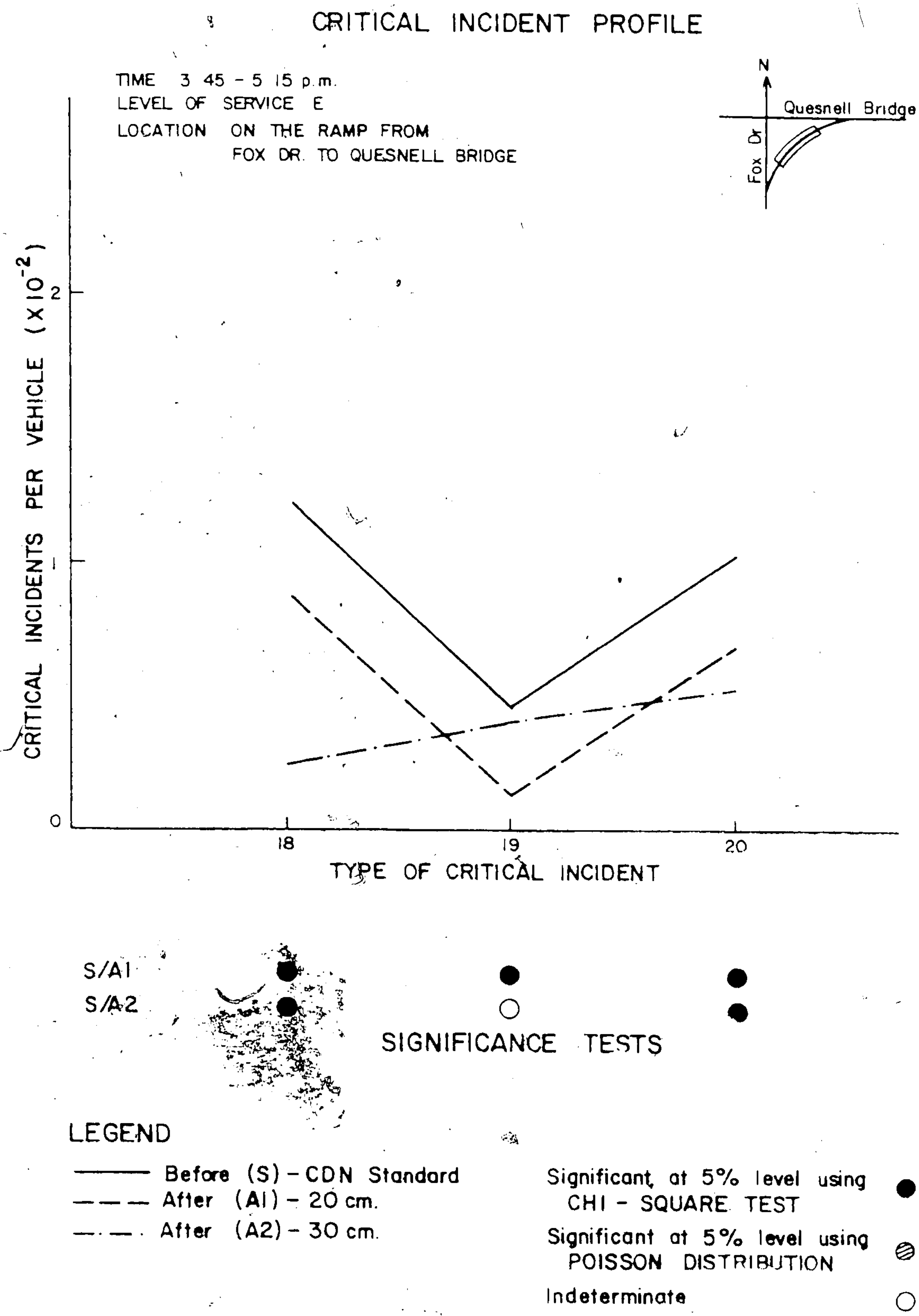


Fig. 42 CRITICAL INCIDENT PROFILE & THE SIGNIFICANCE TESTS ON THE RAMP FROM FOX DRIVE TO QUESNELL BRIDGE

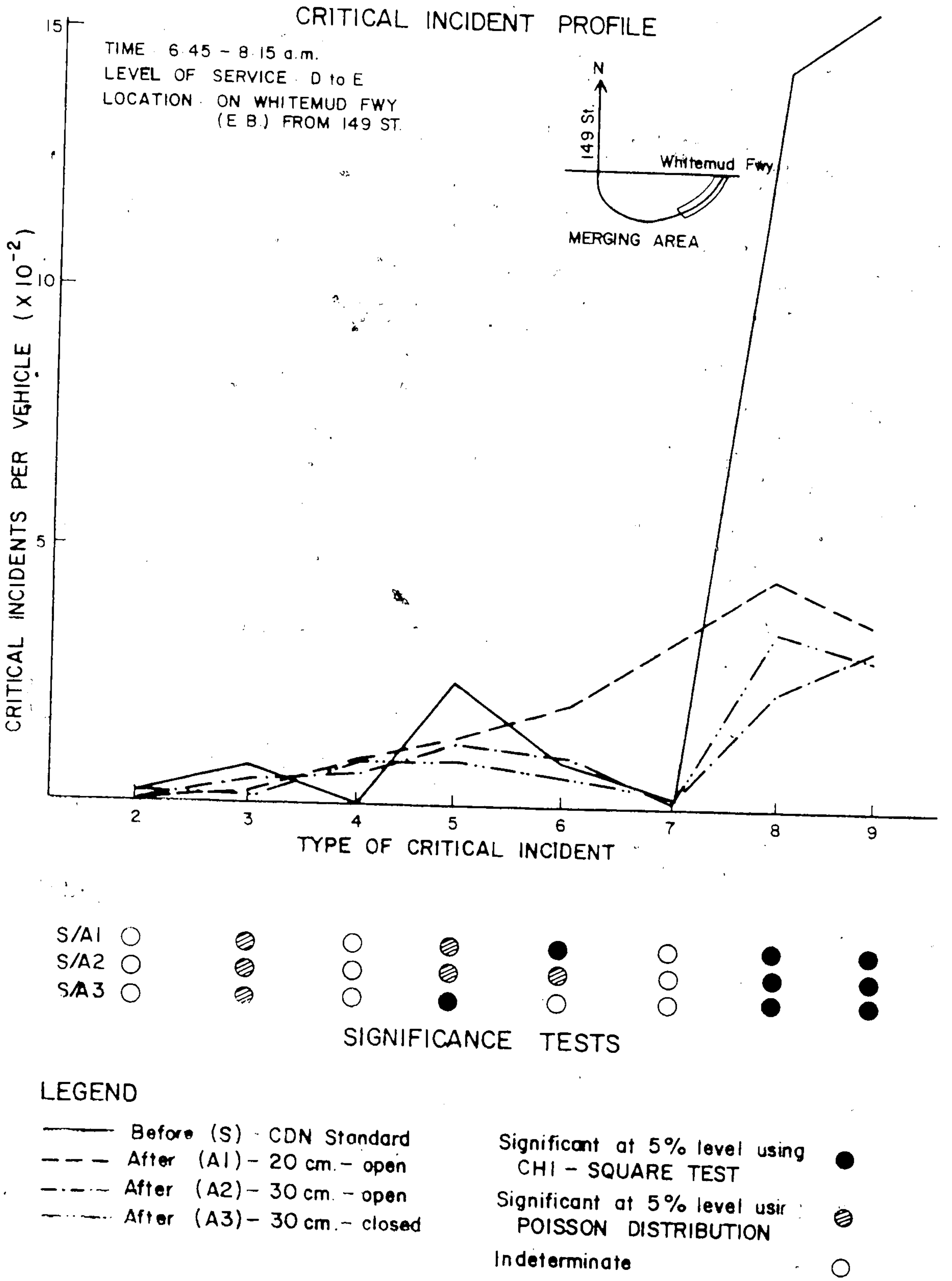


Fig. 43 CRITICAL INCIDENT PROFILE & THE SIGNIFICANCE TESTS ON WHITEMUD FWY. (E.B.) FROM 149 ST.

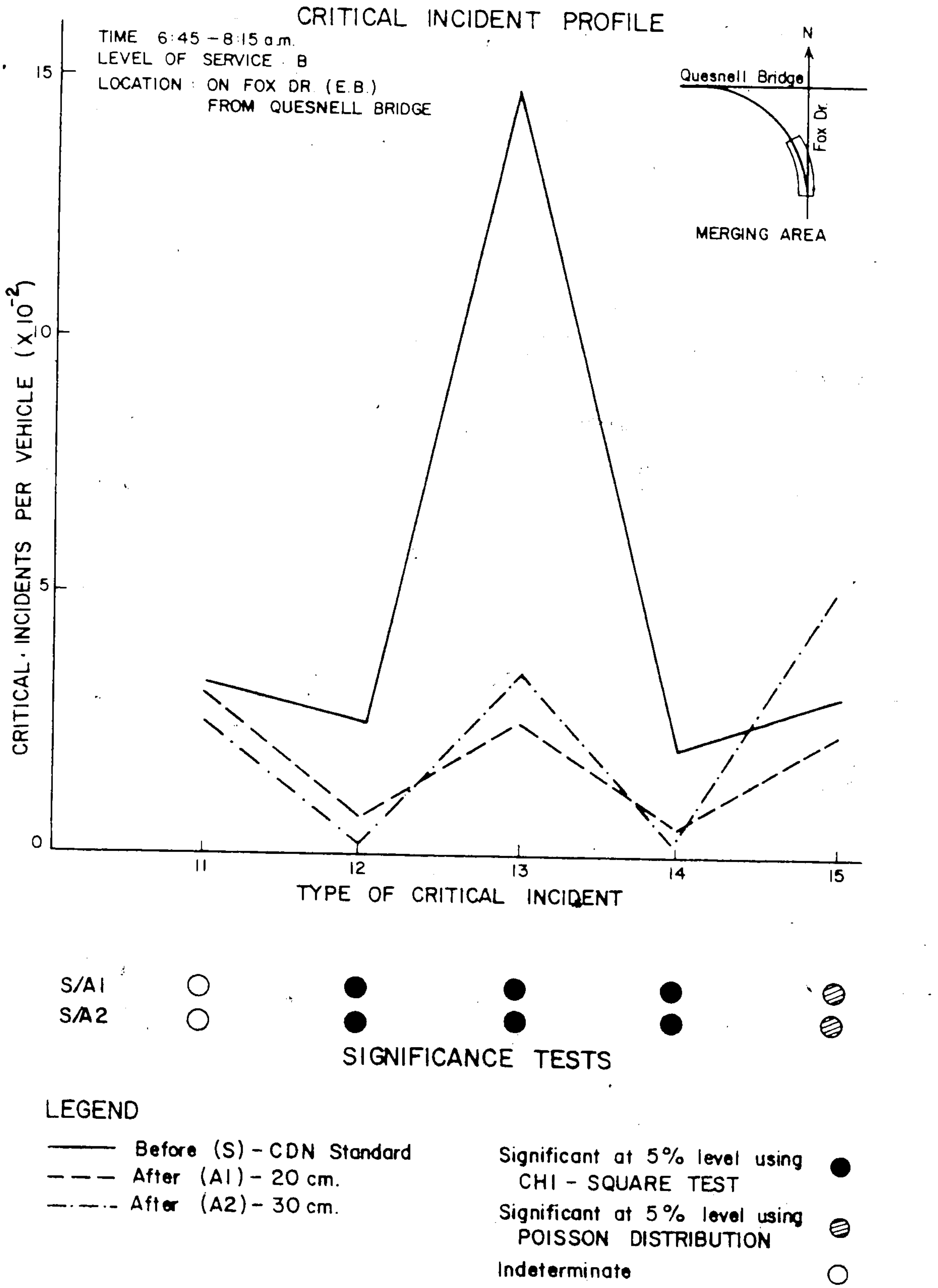


Fig. 44 CRITICAL INCIDENT PROFILE & THE SIGNIFICANCE TESTS ON FOX DR. (E.B.) FROM QUESNELL BRIDGE

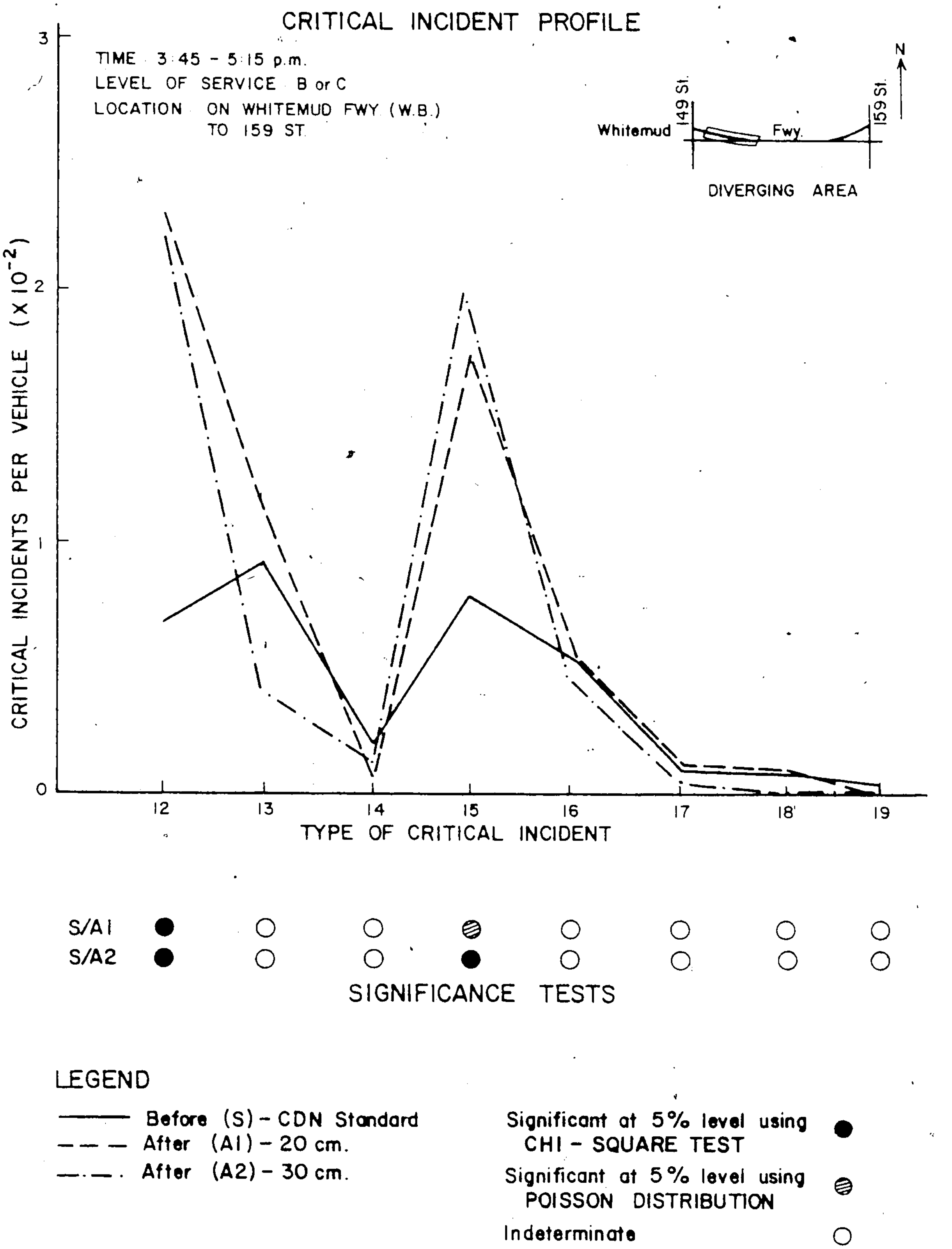
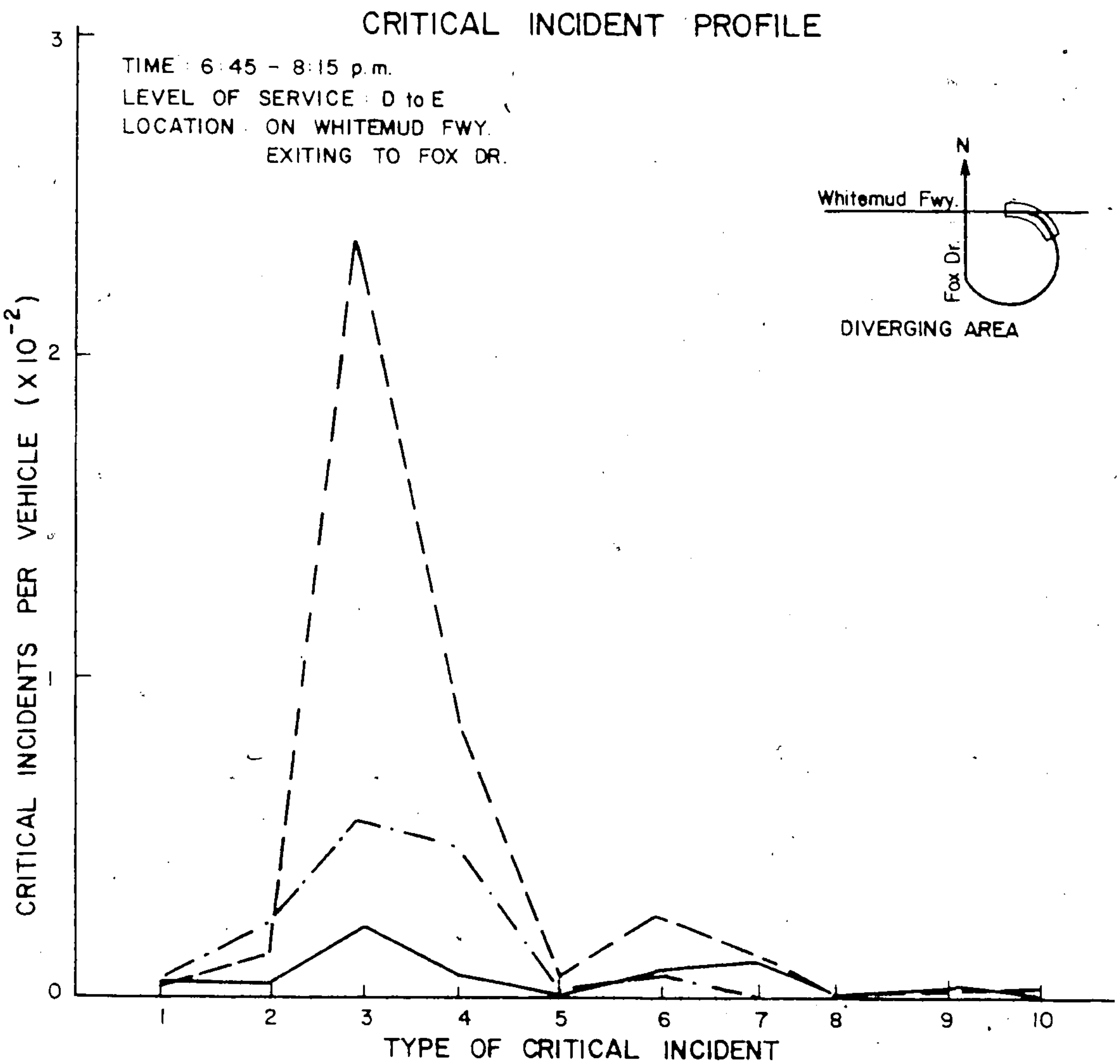


Fig. 45 CRITICAL INCIDENT PROFILE & THE SIGNIFANCE TESTS ON WHITEMUD FWY. (W.B.) TO 159 ST.



	1	2	3	4	5	6	7	8	9	10
S/A1	○	○	○	○	○	○	○	○	○	○
S/A2	○	○	○	○	○	○	○	○	○	○

SIGNIFICANCE TESTS

LEGEND

- ——— Before (S) – CDN Standard
- — — — After (A1) – 20 cm.
- —·—·– After (A2) – 30 cm.

- Significant at 5% level using CHI – SQUARE TEST ●
- Significant at 5% level using POISSON DISTRIBUTION ◍
- Indeterminate ○

Fig. 46 CRITICAL INCIDENT PROFILE & THE SIGNIFICANCE TESTS ON WHITEMUD FWY. EXITING TO FOX DR.

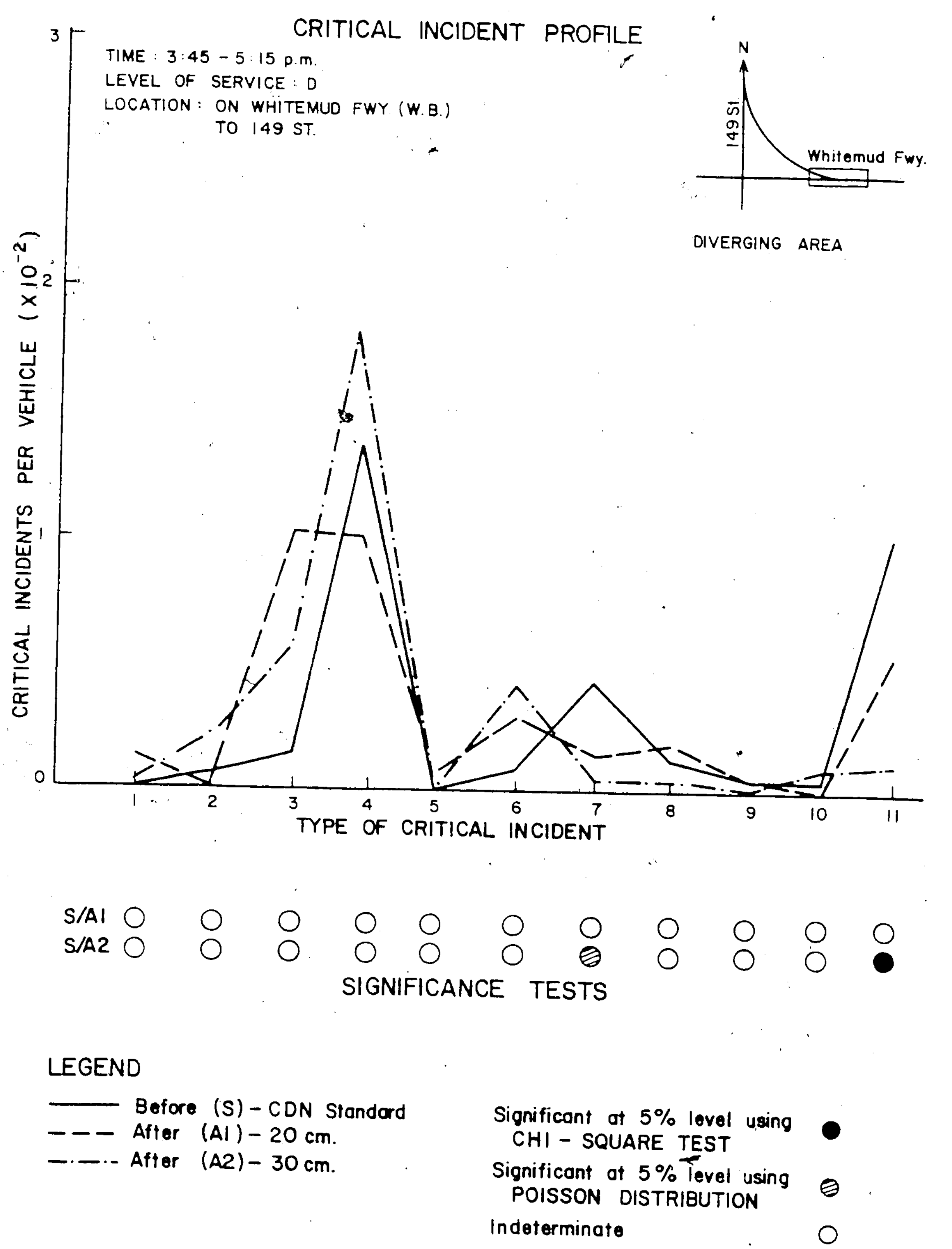


Fig. 47 CRITICAL INCIDENT PROFILE & THE SIGNIFICANCE TESTS ON WHITEMUD FWY. (W. B.) TO 149 ST.

of test marking pattern 2, the reduction in critical incidents by types was calculated and compared with the critical values given by the curves. If the reduction exceeded the critical values given by the curves, then the difference was significant at the 5% level; if the calculated reduction laid between the corresponding values given by the curves, then the difference was significant at 5% level only from the liberal side and insignificant at 5% level from the conservative side; if the calculated value was less than the values given by the curves, the difference was totally insignificant at the 5% level. Results of the significance test at a 5% level was recorded in Appendix F and also presented in Figures 41 to 47.

D. Conclusion

The best marking pattern alternatives, i.e. those that minimized the number of critical incidents could be identified from the result of statistical tests. Data collected for the diverging areas (location 5 to location 7) were not conclusive. (It should be noted that locations with less than 50% of the critical incidents which had statistically significant data would be considered as inconclusive or indeterminate).

Specific Conclusions (by test locations)

Based on the assumption that the effectiveness of a test marking pattern at a test location deminishes with increasing number of critical incident experienced and vice versa, some conclusions were arrived at through the results of the significance tests. They are summarized in Table 4 in which, for each test location, and for the types of critical incident which indicated significant changes in drivers' responses, test marking patterns are arranged in the order of preference. It was found that :

1. Data collected for the diverging areas (test locations 5 to 7 inclusive) was not conclusive.
2. For locations 1, 2 and 4, continuity line markings of 20 cm wide were preferred to those of 30 cm wide which in turn was preferred to that of current Canadian Standard (10 cm);
3. For location 3, a continuity line marking of 30 cm wide with closed section was preferred to that of 30 cm with open section, which was preferred to that of 20 cm wide with open section, which was preferred to the current Canadian Standard(10 cm wide with open section).

General Conclusions

SPECIFIC CONCLUSIONS ARE GENERALIZED IN TABLE 10 :

1. For diverging situations, no concrete conclusion could be drawn from the data collected;
2. For the merging situation:
   a. where the entering ramp becomes a continuous lane (location 1 and location 4), continuity line marking of 20 cm was preferred;
   b. where the entering ramp is a taper (location 3), a closed section with continuity line marking of 30 cm

TEST LOCATION	TYPE OF CRITICAL INCIDENT[1]	ALTERNATIVE MARKING PATTERNS ARRANGED IN THE ORDER OF PREFERENCE AS INDICATED BY THE STATISTICAL TESTS			
		1	2	3	4
1. ON QUESNELL BRIDGE (W.B.) ENTERING FROM FOX DRIVE (MERGING)	11	20 cm	30 cm	CAN. STD.	-
	12	30 cm*	20 cm/ CAN. STD.	20 cm/ CAN. STD.	-
	16	20 cm/30 cm	20 cm/30 cm	CAN. STD.	-
	Conclusion	20 cm	30 cm	CAN. STD.	-
2. ON THE RAMP FROM FOX DRIVE TO QUESNELL BRIDGE (MERGING)	18	30 cm	20 cm	CAN. STD.	-
	19	20 cm	30 cm/ CAN. STD.	30 cm/ CAN. STD.	-
	20	20 cm/30 cm	20 cm/30 cm	CAN. STD.	-
	Conclusion	20 cm	30 cm	CAN. STD.	-
N. B. Only closed sections were used for this location.					
3. ON WHITEMUD FREEWAY (E.B.) FROM 149 ST. (MERGING)	3	20 cm(0)*/ 30 cm(C)*/ 30 cm(0)*	20 cm(0)[illegible] 30 cm(C)[illegible] 30 cm(0)*	20 cm(0)*/ 30 cm(C)*/ 30 cm(0)*	CAN.STD.
	5	30 cm(C)	30 cm(0)*/ 20 cm(0)*	30 cm(0)*/ 20 cm(0)*	CAN. STD.
	6	30 cm(C)*/ CAN. STD.*	30 cm(C)*/ CAN. STD.*	30 cm(0)*/ 20 cm(0)	30 cm(0)*/ 20 cm(0)
	8	30 cm(C)	30 cm(0)	20 cm(0)	CAN. STD.
	9	30 cm(0)	30 cm(C)	20 cm(0)*	CAN. STD.
	Conclusion	30 cm(C)	30 cm(0)	20 cm(0)	CAN. STD.
4. ON FOX DRIVE (E.B.) FROM QUESNELL BRIDGE (MERGING)	12	30 cm/20 cm	30 cm/20 cm	CAN. STD.	-
	13	20 cm	30 cm	CAN. STD.	-
	14	30 cm/20 cm	30 cm/20 cm	CAN. STD.	-
	15	20 cm*	CAN. STD.*	30 cm*	
	Conclusion	20 cm	30 cm	CAN. STD.	-

Legends: / ; Inconclusive as which is preferred
* ; Only satisfies tite liberal test
(0) : Open section
(C) ; Closed section

1 Refer to Fig. 2 to Fig. 40

Table 4 CRITICAL INCIDENT SURVEY - CONCLUSIONS FROM STATISTICAL SIGNIFICANT TESTS

	Traffic Configuration	Movement	No Marking	Canadian Standard	20cm	20cm Open	20cm Closed	30cm	30cm Open	30cm Closed
			MARKING PATTERN ALTERNATIVES							
DIVERGING	AUXILLIARY LANE	EXITING	No significant result	No significant result	Not applicable	No significant result	No significant result	Not applicable	No significant result	No significant result
DIVERGING	AUXILLIARY LANE	THROUGH	No significant result	No significant result	Not applicable	No significant result	No significant result	Not applicable	No significant result	No significant result
DIVERGING	EXITING (DECELERATION) RAMP		No significant result	Not applicable	No significant result	No significant result	Not applicable	No significant result	No significant result	Not applicable
MERGING	ENTERING RAMP CONTINUES	ENTERING	No significant result		Mostly preferred	No significant result	No significant result	No significant result	No significant result	No significant result
MERGING	ENTERING RAMP CONTINUES	THROUGH	No significant result		Mostly preferred	No significant result	No significant result	No significant result	No significant result	No significant result
MERGING	ENTERING (ACCELERATION) RAMP		No significant result		No significant result	Thirdly preferred	No significant result	No significant result		Mostly preferred
MERGING	LANE DROP		Not applicable		No significant result	No significant result	Mostly preferred	No significant result	No significant result	

LEGEND

- MOSTLY PREFERRED
- RELATIVELY PREFERRED
- THIRDLY PREFERRED
- LEAST PREFERRED
- NO SIGNIFICANT RESULT
- NOT APPLICABLE

TABLE 5. GENERAL CONCLUSIONS FROM CRITICAL INCIDENT SURVEY

is preferred;

c. where the shoulder lane is dropped (location 2), a separation line marking of 20 cm wide with closed section is preferred.

V. VEHICLE TRAJECTORY SURVEY

A. Introduction

The Vehicle Trajectory Survey involved a filming technique. It consisted of three phases: data collection, data extraction, and data analysis.

During the phase of data collection, traffic at the test locations was recorded by a 16 mm movie camera mounted on a tripod. After the application of each new test marking pattern, at least three days were allowed before the survey was conducted in order to reduce the novelty effect. Test locations were only filmed during their peak periods on weekdays. The survey was carried out in summer, 1978, spanning a period of over four months (from May to September).

As the traffic was filmed from perspectives other than the plan view, the trajectories of vehicles were extracted from the 16 mm films with the following procedures:

1. Projection of movie films on a screen;
2. Calibration of a length measured on the screen with the length measured on the roadway;
3. Digitization of the positions of vehicles by one second increments;
4. Tracing of vehicle travel paths.

The travel path of a vehicle was defined by the lateral and longitudinal displacements by second with respect to a reference line and a reference point on the roadway. When the displacements were known, higher derivatives of velocities and accelerations were readily obtainable. For this particular purpose, only the variance of lateral displacement and the variance of longitudinal velocity were selected among the vehicle dynamics for statistical significance analysis. However, the means of longitudinal velocity were evaluated on 'common sense' basis.

B. Data Collection Procedures

The traffic at a test location was recorded by means of a 16 mm movie camera, with a zoom lens mounted on a tripod. Movie films used were 100 ft long, or two and a half minute in duration - when shooting at the speed of 24 f.p.s. Several precautions were taken in locating the movie camera:

1. The drivers' attention would not be distracted;
2. The distances between the equipment and the test sites were to be as long as possible so that the error in measurement introduced by the 'perspective effect' might be reduced;
3. All the critical points of the test locations were captured within the frame of the pictures;
4. The camera was not directed toward the sun;
5. The position of the camera at each location was fixed for all test marking patterns so that the positions of the reference line and reference point remained essentially unchanged.

Other precautions taken included:

1. After the application of each new alternative marking pattern, at least three days were allowed before the survey was conducted in order to reduce the novelty effect;
2. Data was only collected during the peak period of each test location;
3. Traffic would only be filmed when there was a continuous flow and yet no queuing.

C. Data Extraction

The process of data extraction consisted of two stages:

1. Tracing of vehicle trajectories which were defined by the lateral and longitudinal displacements of vehicles by second.
2. Calculation of higher derivatives of displacements, including velocities and accelerations.

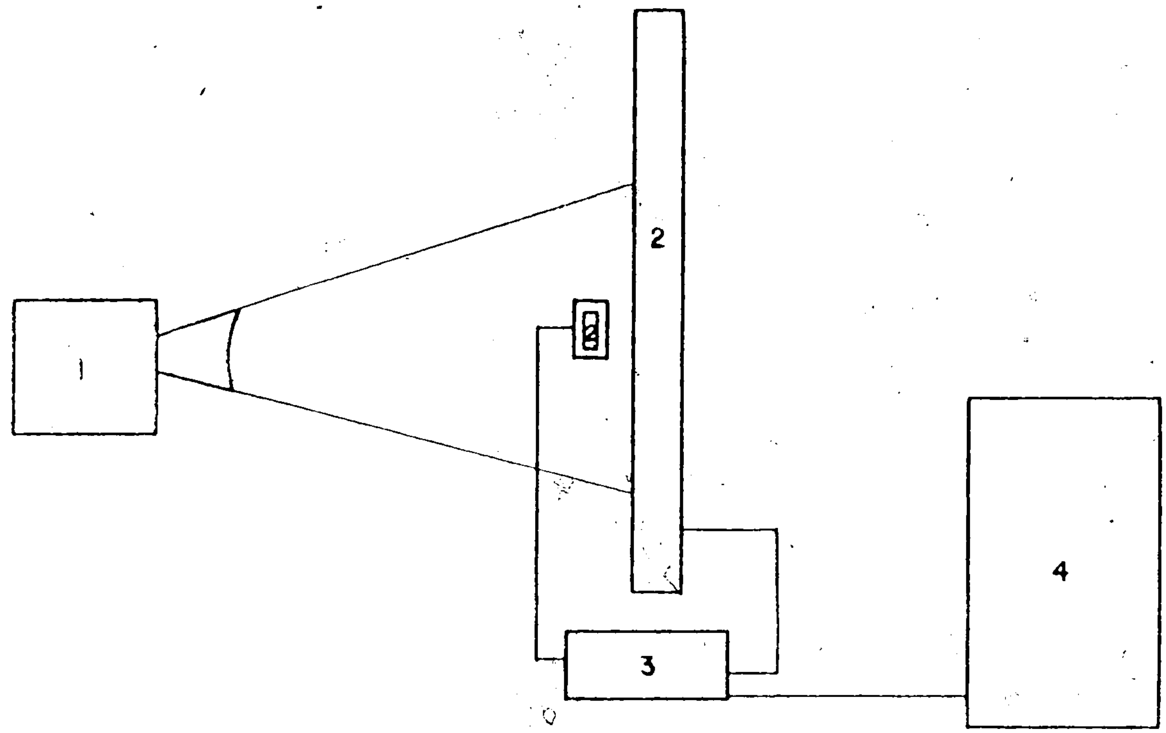
The equipment used included:

1. Lafayette Stop Motion Analyzer;
2. Bendix Platen and Cursor;
3. HP 9864A Digitizer;
4. HP 9825A Mini-computer;
5. AMDAHL 470/V6 computer system.

The arrangement of the equipment was represented schematically in Figure 48.

<u>Tracing of Vehicle Trajectories</u>

As the traffic was filmed from perspectives other than the plan view, any measurement obtained from the movie film



Legend:

1. Lafayette Stop Motion Analyzer
2. Bendix Plateu and Cursor
3. HP 9864A Digitizer
4. HP 9825A Minicomputer

Fig. 48 SCHEMATIC REPRESENTATION OF THE ARRANGEMENT OF EQUIPMENT USED IN THE PROCESS OF DATA EXTRACTION was distorted due to the perspective effect. In order to obtain true measurements both laterally and longitudinally, perspective correction factors along the roadway had to be known. To obtain the lateral perspective correction factors along the roadway of a test location, the movie film was projected on the Bendix Platen by means of the Lafayette Stop Motion Analyser. The former was connected to the Digitizer which in turn was attached to the Mini-computer (Program 1, Appendix H) A vehicle (e.g. GM panel truck) with known distance between its headlights was selected. The motion of the vehicle through the test section was stopped at every fifth frame (or about one fifth of a second) and the positions of the headlights were registered by the Cursor and converted into coordinates (lateral and longitudinal displacements) by the Digitizer. The corresponding distance between the headlights was then calculated by the Minicomputer. The ratio between the real length and the length measured on the Platen was then calculated. To obtain the longitudinal perspective correction factors along the roadway of a test location, the position of the lamp posts at the test location were digitized and the distances between them computed. The ratio of the real distance between two lamp posts as measured on the roadway and the corresponding distance obtained from the projection on the Platen was then calculated. A linear regression was then established by using the positions of the lamp posts and the distances between them.

After the calibrations were done, the digitization of travel paths of vehicles could be started. A convenient point of a vehicle (e.g. the right front wheel of a vehicle) was chosen. Its position with respect to the roadside or its nearest separation line and an arbitrary point on the roadway was digitized at the end of each second (or at every 25th frame). The corresponding lateral and longitudinal displacements were obtained by multiplying the distances measured from the film with their corresponding perspective correction factors. Thirty or less vehicle trajectories were obtained for each test marking pattern. The process in data extraction were SUMMERIZED IN FIG.49.

Calculation of Parameters

Higher derivatives of lateral and longitudinal displacements, namely, lateral velocities, accelerations and longitudinal velocities and accelerations were calculated by means of the following relationships:

Lateral velocity,

$$Vx(i+1)=(X(i+1)-Xi)/t$$

Lateral acceleration,

$$Ax(i+2)=(Sq(Vx(i+1)-Sq(Vxi))/2Xi$$

where i=1 to n;

Longitudinal velocity,

$$Vy(i+1)=(Y(i+1)-Yi)/t$$

Longitudinal acceleration,

$$Ay(i+2)=(Sq(Vy(i+1)-Sq(Vyi))/2Yi$$

where i=0 to n.

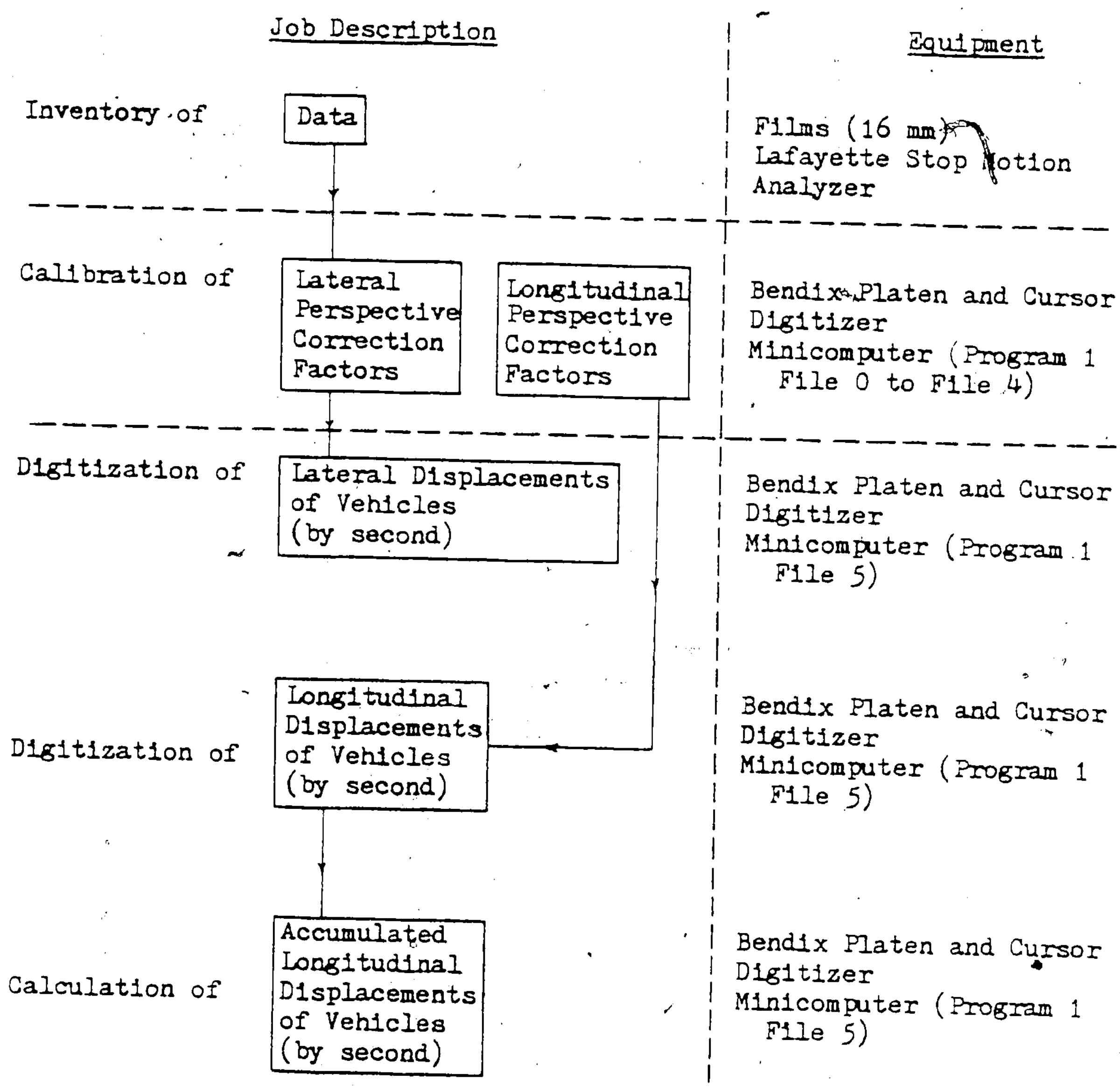


Fig. 49 Vehicle Trajectory Survey - Data Extraction

The parameters were calculated and tabulated by Program 2a and plotted by Program 2b (Appendix I) which were run under AMDAHL 470/V6, using the MTS operation system. Data inventory and plottings are kept separately,but samples of them are found in Appendix J.

D. Data Analysis

Variance Analysis

The parameters selected for the comparison of effectiveness of the test marking patterns were lateral displacement and longitudinal velocity. They were able to reflect the primary characteristics of drivers' behaviours at these critical areas of merging and diverging.

F-tests were applied to the average variances of lateral displacements and longitudinal velocities among the test marking patterns. The results were tabulated in Appendix K. Based on the assumption that a reduction in the range of observed drivers' behaviours (reflected in the variance of lateral displacement and longitudinal velocity) implied a decrease in the probability of occurence of performance more deviant than those observed, the order of preference of test marking pattern for each test location was inferred according to the results of the variance analysis which were summerized in Table 6 to Table 7.

Comparison of Means of Longitudinal Velocities

The behaviours of drivers, in terms of the means of longitudinal velocities, for each test marking pattern were

TYPE/ LOCATION/ DIRECTION	TRAFFIC MOVEMENT	ORDER OF PREFERENCE			
		1	2	3	4
1. ENTRY LANE/ FOX DR. TO WHITEMUD FWY./ W.B.	MERGING	20 cm	30 cm	CAN. STD.	-
	THROUGH	CAN. STD./ 20 cm	CAN. STD./ 20 cm	30 cm	-
2. MERGE/ ON THE RAMP FROM FOX DR. TO WHITEMUD FWY/W.B.	-	30 cm	20 cm/ CAN. STD.	20 cm CAN. STD.	-
3. MERGE/ FROM 149 ST. TO WHITEMUD FWY. S.B.	-	30 cm(open)	30 cm(closed) or 20 cm(open) or CAN. STD.	30 cm(closed) or 20 cm(open) or CAN. STD.	30 cm(closed) or 20 cm(open) or CAN. STD.
4. ENTRY LANE/ FROM WHITEMUD FWY. TO FOX DR. E.B.	MERGING	20 cm or 30 cm	20 cm or 30 cm	CAN. STD.	-
	THROUGH	(NOT SIGNIFICANT)			
5. EXITING LANE/ FROM WHITEMUD FWY. TO 159 ST. N.B.	DIVERGING	(NOT SIGNIFICANT)			
	THROUGH	20 cm	30 cm	-	-
6. DIVERGE/ FROM WHITEMUD FWY. TO FOX DR. E.B.	-	(NOT SIGNIFICANT)			
7. DIVERGE/ FROM WHITEMUD FWY. TO 149 ST. N.B.	-	20 cm or 30 cm	20 cm or 30 cm	CAN. STD.	-

Table 6 VEHICLE TRAJECTORY SURVEY - CONCLUSIONS OF VARIANCE ANALYSIS OF LATERAL DISPLACEMENT

TYPE/ LOCATION/ DIRECTION	TRAFFIC MOVEMENT	ORDER OF PREFERENCE 1	2	3	4
1. ENTRY LANE/ FOX DR. TO WHITEMUD FWY./ W.B.	MERGING	20 cm	CAN. STD./30cm	CAN. STD./30 cm	–
	THROUGH	CAN. STD.	20 cm or 30 cm	20 cm or 30 cm	–
2. MERGE/ ON THE RAMP FROM FOX DR. TO WHITEMUD FWY./W.B.	–	(NOT SIGNIFICANT)			
3. MERGE/ FROM 149 ST. TO WHITEMUD FWY./S.B.	–	20 cm(open) or 30 cm(open) or 30 cm(closed)	20 cm(open) or 30 cm(open) or 30 cm(closed)	20 cm(open) or 30 cm(open) or 30 cm(closed)	CAN. STD.
4. ENTRY LANE/ FROM WHITEMUD FWY. TO FOX DR./E.B.	MERGE	30 cm	20 cm or CAN. STD.	20 cm or CAN. STD.	–
	THROUGH	(NOT SIGNIFICANT)			
5. EXITING LANE/ FROM WHITEMUD FWY. TO 159 ST./ N.B.	MERGING	(NOT SIGNIFICANT)			
	THROUGH	(NOT SIGNIFICANT)			
6. DIVERGE/ FROM WHITEMUD FWY. TO FOX DR./E.B.	–	30 cm or CAN. STD.	30 cm or CAN. STD.	20 cm	–
7. DIVERGE/ FROM WHITEMUD FWY. TO 149 ST./ N.B.	–	CAN. STD. or 30 cm	CAN. STD. or 30 cm	20 cm	–

Table 7 VEHICLE TRAJECTORY SURVEY - CONCLUSIONS OF VARIANCE ANALYSIS OF LONGITUDINAL VELOCITY

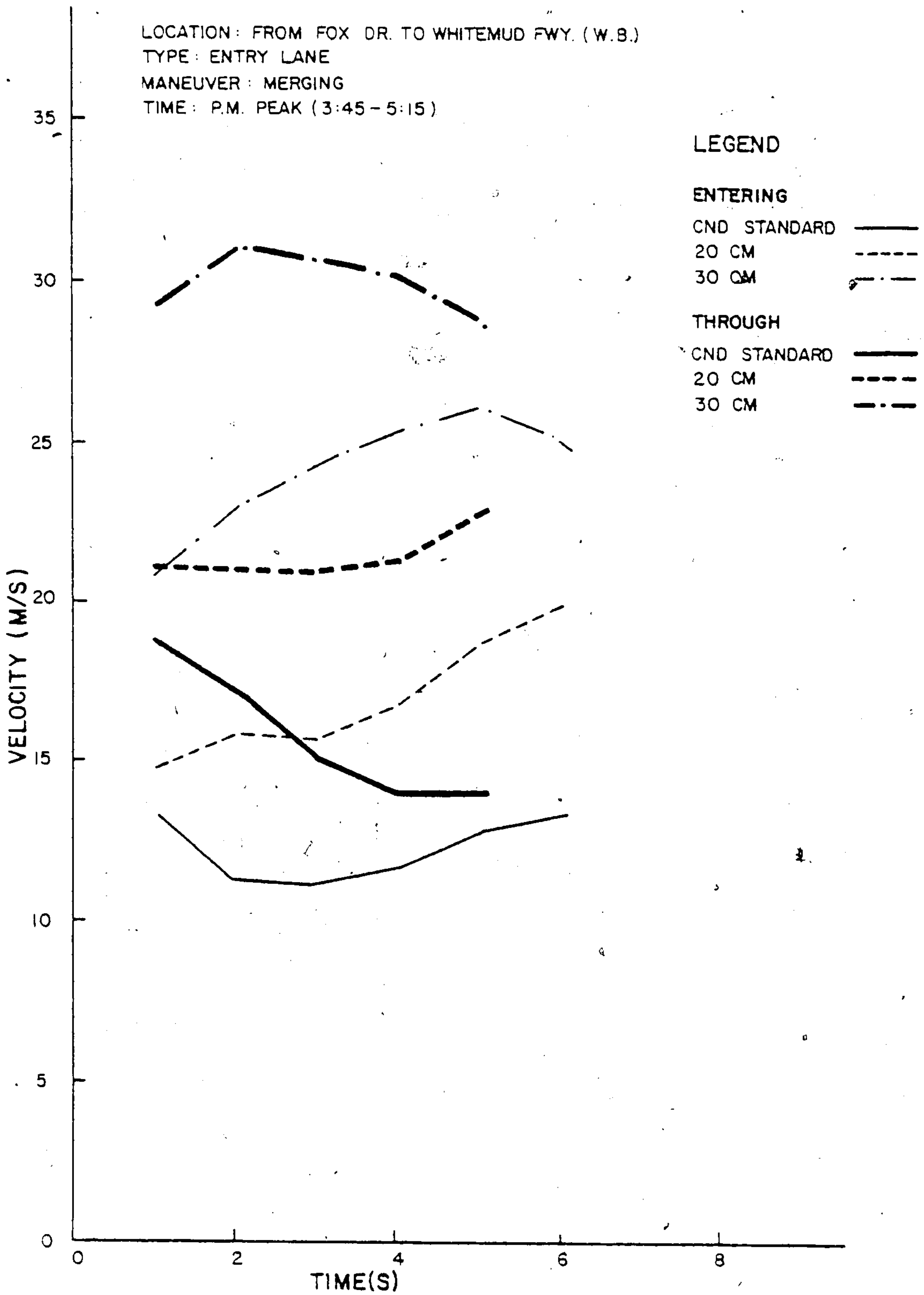
compared to the "ideal behaviours" (under the ideal conditions) as described in the following:

1. In the case of merging situatons,
   a. The speed of the thru traffic should remain constant.
   b. The speed of the merging traffic should increase from the ramp speed to the speed of the through traffic at the point of merging.
2. In the case of diverging,
   a. The speed of the thru traffic should remain constant.
   b. The speed of the diverging traffic should decrease from the thru speed to ramp speed at the entrance of the exit ramp.

The means of longitudinal velocities for each test marking pattern were plotted in Figure 50 to 56. The comparisons of mean of longitudinal velocity were summarized in Table 8. Conclusions based on these comparisons were summarized in Table 9. It should be noted that the element of subjectiveness did come in while inferring the order of preference of marking pattern for a particular test location.

General Conclusions

Conclusions arrived at previously through three different parameters, namely, the variance of lateral displacement, the variance of longitudinal velocity, and the means of longitudinal velocity were summarized by locations.



LONGITUDINAL VELOCITY

Fig. 50 VEHICLE TRAJECTORY SURVEY - MEAN OF LONGITUDINAL VELOCITY (ON QUESNELL BRIDGE ENTERING FOX DRIVE)

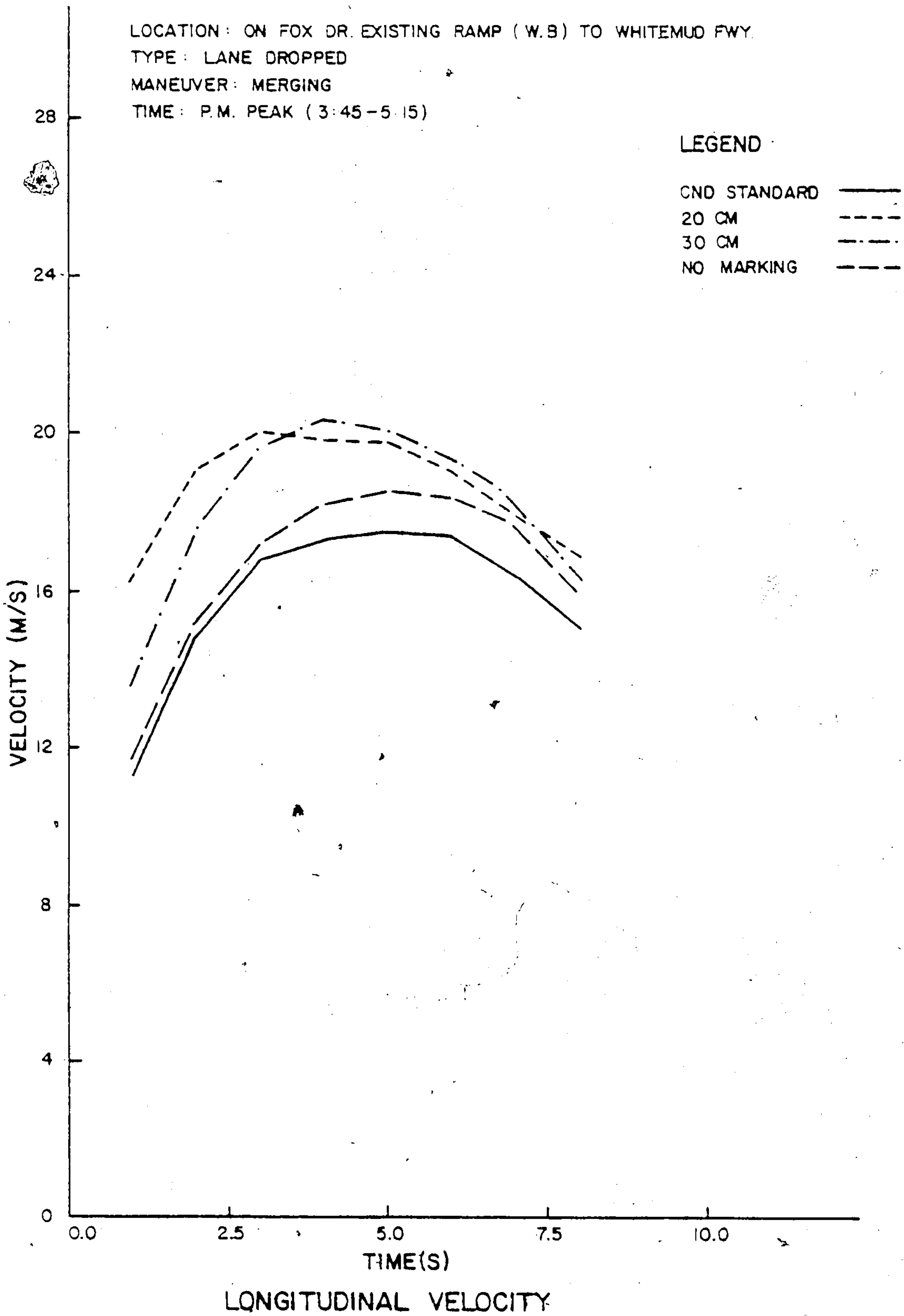
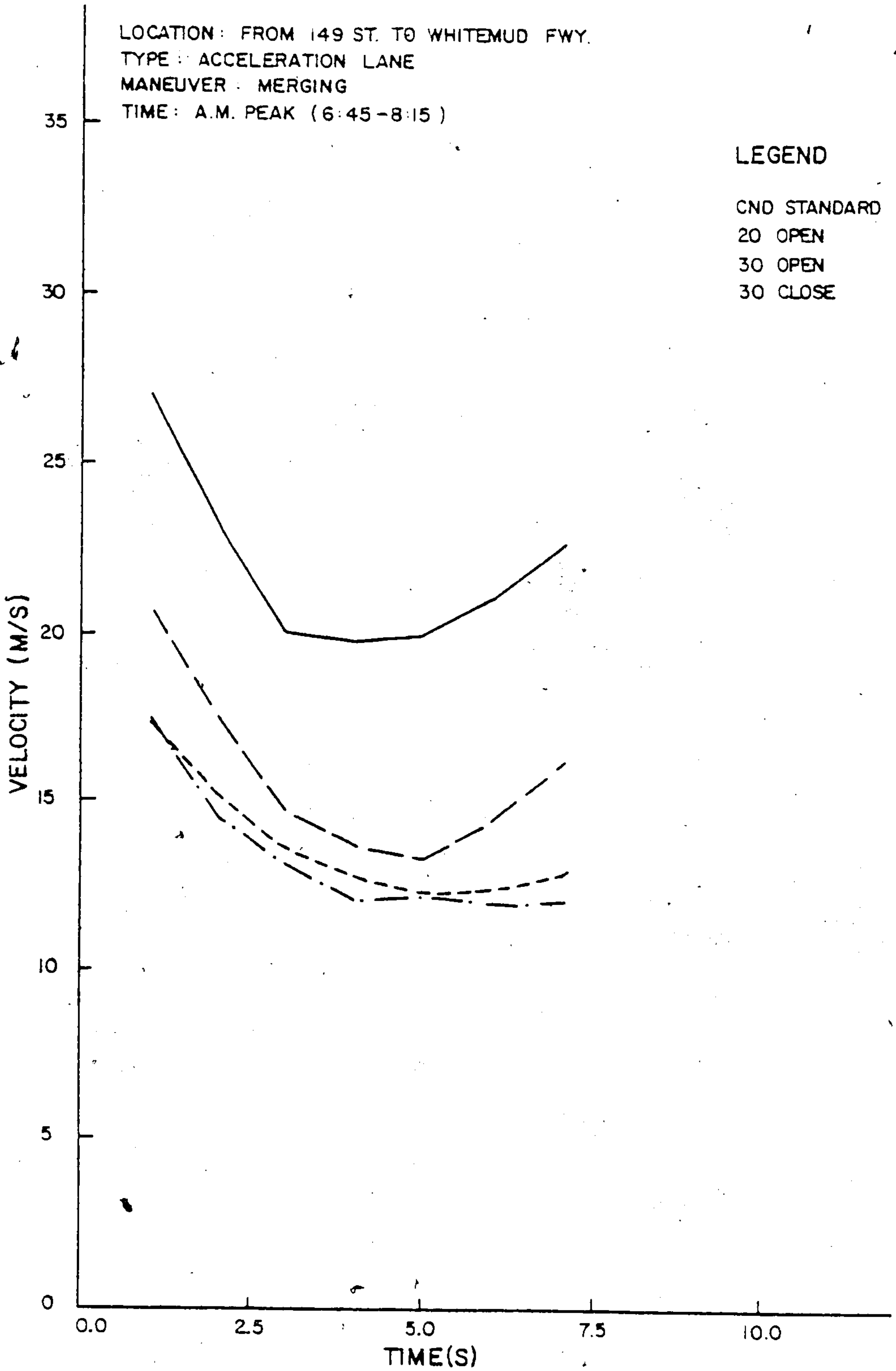
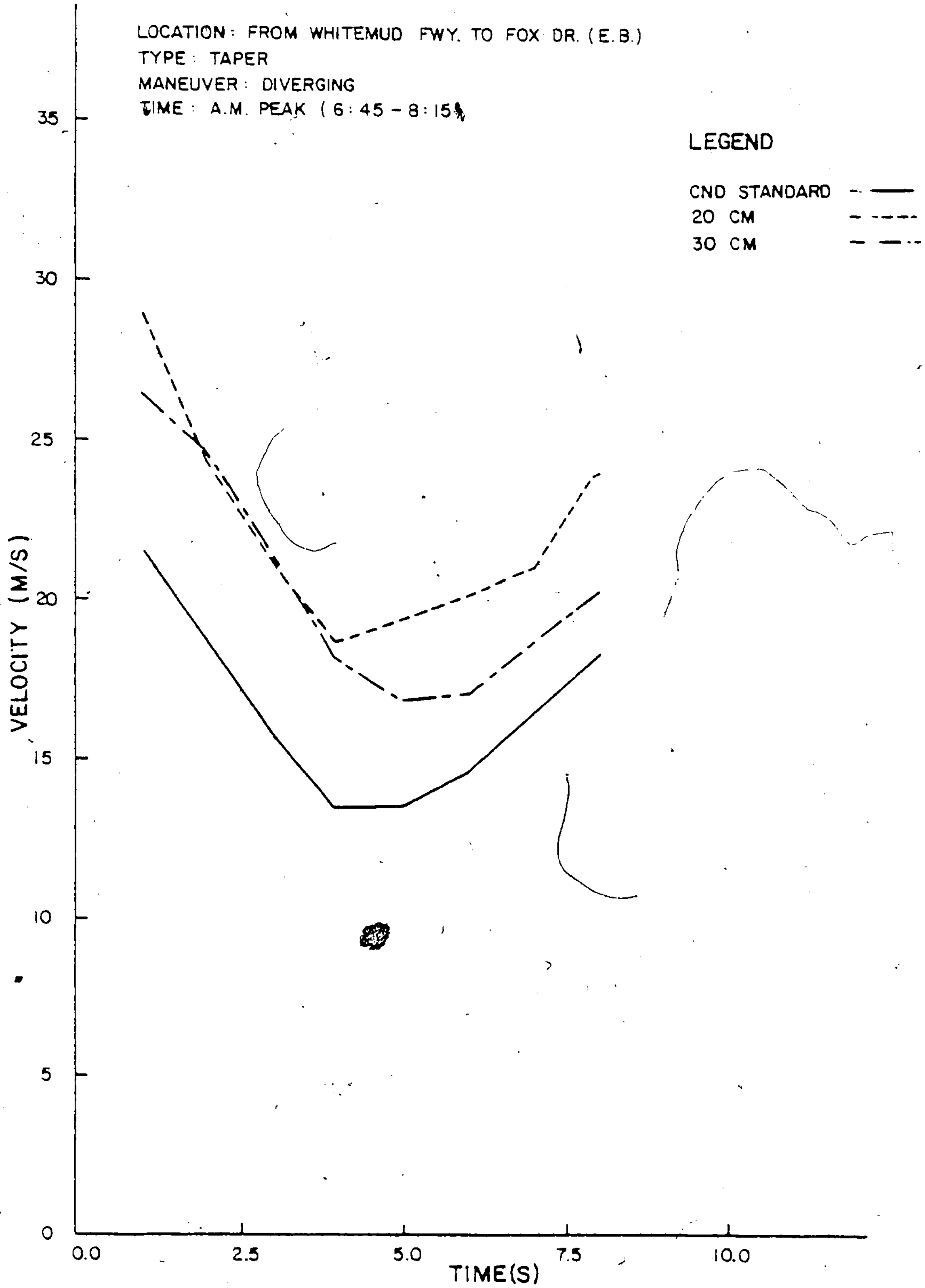


Fig. 51 VEHICLE TRAJECTORY SURVEY - MEAN OF LONGITUDINAL VELOCITY (ON THE RAMP FROM FOX DRIVE TO QUESNELL BRIDGE)



LONGITUDINAL VELOCITY

Fig. 52 VEHICLE TRAJECTORY SURVEY - MEAN OF LONGITUDINAL VELOCITY (ON WHITEMUD FREEWAY (E.B.) FROM 149 ST.)



LONGITUDINAL VELOCITY

Fig. 53 VEHICLE TRAJECTORY SURVEY - MEAN OF LONGITUDINAL VELOCITY (ON FOX DRIVE (E.B.) FROM QUESNELL BRIDGE)

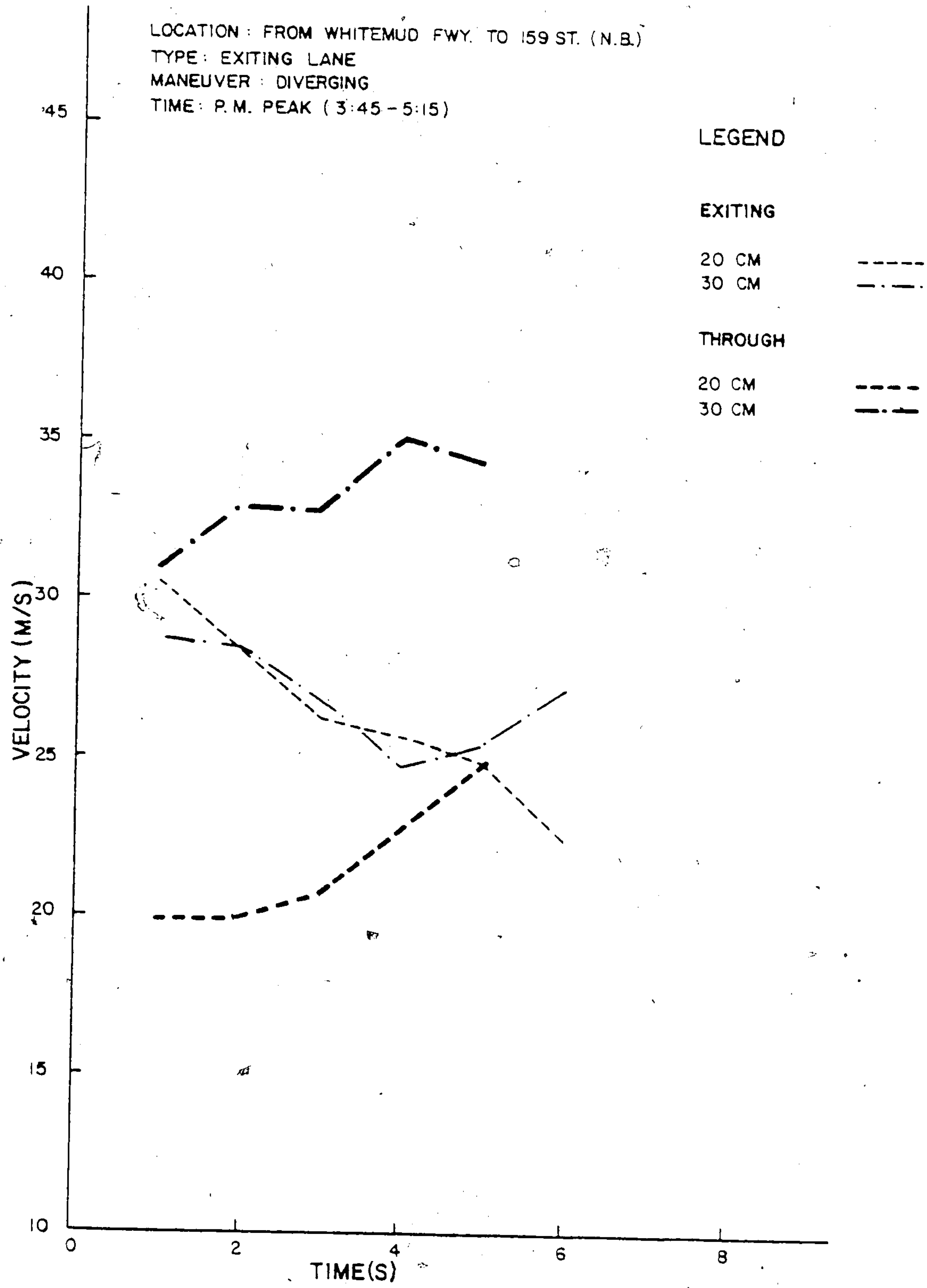
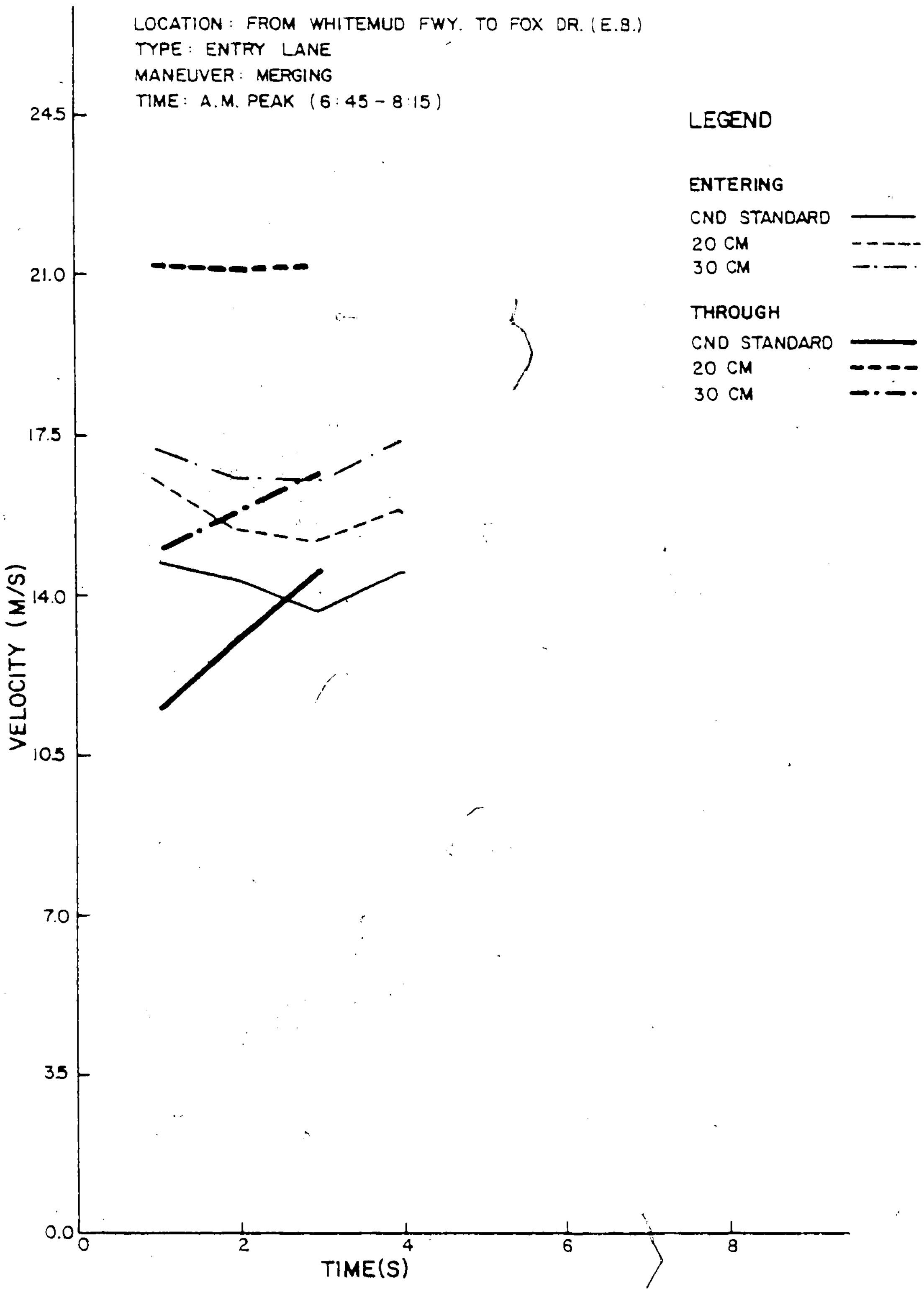
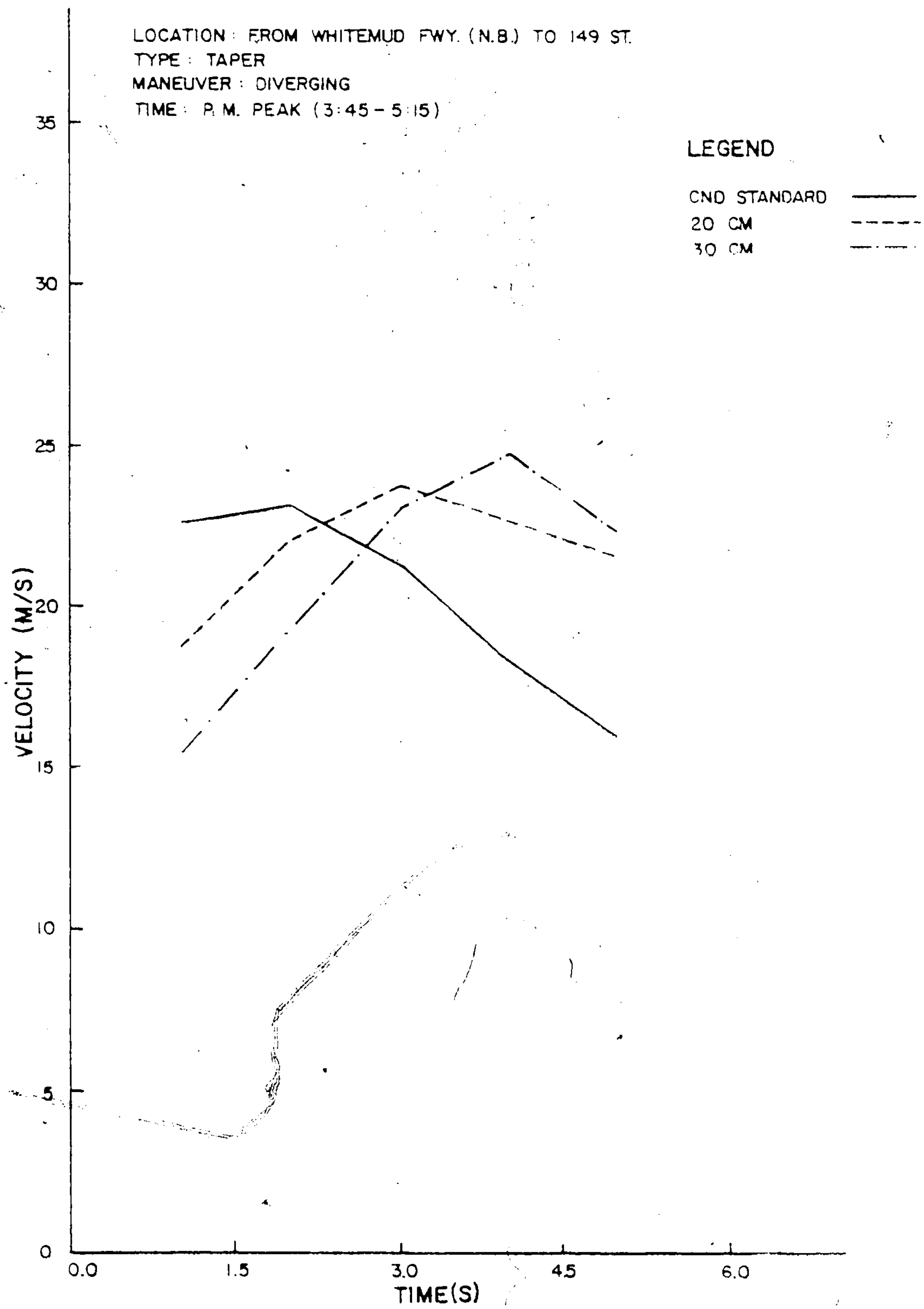


Fig. 54 VEHICLE TRAJECTORY SURVEY - MEAN OF LONGITUDINAL VELOCITY (ON WHITEMUD FREEWAY (W.B.) TO 159 ST.)



LONGITUDINAL VELOCITY

Fig. 55 VEHICLE TRAJECTORY SURVEY - MEAN OF LONGITUDINAL VELOCITY (ON WHITEMUD FREEWAY EXITING TO FOX DRIVE)



LONGITUDINAL VELOCITY

Fig. 56 VEHICLE TRAJECTORY SURVEY - MEAN OF LONGITUDINAL VELOCITY (ON WHITEMUD FREEWAY (W.B.) TO 149 ST.)

TYPE/ LOCATION/ DIRECTION	MARKING PATTERN	TRAFFIC MOVEMENT	LONG VELOCITY AT THE BEGINNING V_1	LONG. AVERAGE AT THE END V_2	AVERAGE LONG. VELOCITY V(M/S)	DECREASES IN VEL. V_1-V_2	DIFFERENT IN VEL. AT THE END THRU-ENTRY	REMARK
ENTRY LANE/ FOX DR. TO WHITEMUD FWY/ W.B.	CAN. STD.	ENTRY	13.43	12.85	12.11	0.58	1.19	Order of preference: 30 cm, 20 cm, CAN. STD. Although the difference in speeds at the end of observation period is smallest for CAN. STD. both the entry and thru traffic experienced deceleration which was undersirable.
		THRU	18.32	14.04	15.85	4.78		
	20 cm	EXIT	14.76	18.75	16.38	-3.99	4.21	
		THRU	21.14	22.96	21.50	-1.82		
	30 cm	ENTRY	20.76	26.11	23.86	-5.35	2.51	
		THRU	29.14	28.62	29.90	0.52		
MERGING/ ON THE RAMP FROM FOX DR. TO WHITEMUD FWY/W.B.	CAN. STD.	-	11.21	15.15	15.79	-3.94	-	Order of preference : 20 cm, 30 cm, CAN. STD. The average speed was highest and experienced least deceleration in the case of 20 cm marking.
	20 cm	-	16.23	16.93	18.57	-0.7	-	
	30 cm	-	13.50	16.40	18.11	-2.90	-	
MERGING/ FROM 149 ST., TO WHITEMUD FWY/S.B.	CAN. STD.	-	27.02	22.76	22.02	4.26	-	Order of preference : CAN. STD., 30 cm (closed), 20 cm (open), 30 cm (open) The average speed was highest in the case of CAN. STD. marking.
	20 cm (open)	-	17.45	12.95	13.87	4.50	-	
	30 cm (open)	-	17.63	12.16	13.45	5.47	-	
	30 cm (closed)	-	20.75	16.27	15.87	4.48	-	
ENTRY LANE/ FROM WHITEMUD FWY TO FOX DR./E.B.	CAN. STD.	ENTRY	14.77	14.51	14.32	0.26	0.16	Order of preference : 30 cm, CAN. STD., 20 cm The average speed of the entering and thru traffic was closest to speed limit of 17 m/s in the case of 30 cm marking.
		THRU	11.61	14.67	13.14	-3.06		
	20 cm	ENTRY	16.60	15.93	15.81	0.67	5.31	
		THRU	21.26	21.24	21.23	0.02		
	30 cm	ENTRY	17.24	17.45	16.97	-0.21	-0.67	
		THRU	15.05	16.78	15.90	-1.72		
EXITING LANE/ FROM WHITEMUD FWY TO 159 ST./N.B.	20 cm	EXIT	30.49	22.45	21.99	8.03	-	Order of preference : 30 cm, 20 cm. The high speed of the thru traffic in the case of 30 cm marking reflects drivers' confidence
		THRU	19.88	24.74	21.59	-4.86		
	30 cm	EXIT	28.81	27.30	26.47	1.51	-	
		THRU	30.97	34.26	33.21	-3.29		
DIVERGING/ FROM WHITEMUD FWY TO FOX DR./E.B.	CAN. STD.	-	21.55	18.30	16.57	3.25	-	Order of preference : 20 cm, 30 cm, CAN. STD. The higher average speed of the exiting traffic indicated the drivers' confidence in maneuvering at the critical area.
	20 cm	-	29.00	24.06	22.20	4.94	-	
	30 cm	-	26.51	20.19	20.46	6.32	-	
DIVERGING/ FROM WHITEMUD FWY TO 149 ST./N.B.	CAN. STD.	-	22.70	16.00	20.34	6.70	-	Order of preference : 20 cm, 30 cm, CAN. STD. The highest average speed of the exiting traffic indicated the drivers' confidence in maneuvering at the critical area.
	20 cm	-	18.82	21.62	21.82	-2.80	-	
	30 cm	-	15.47	22.42	21.07	-6.95	-	

Table 8 VEHICLE TRAJECTORY SURVEY - COMPARISON OF MEAN OF LONGITUDINAL VELOCITY

TYPE/ LOCATION DIRECTION	TRAFFIC MOVEMENT	ORDER OF PREFERENCE			
		1	2	3	4
1. ENTRY LANE/ FOX DR. TO WHITEMUD FWY/ W.B.	-	30 cm	20 cm	CAN. STD.	-
2. MERGE/ ON THE RAMP FROM FOX DR. TO WHITEMUD FWY/W.B.	-	20 cm	30 cm	CAN. STD.	-
3. MERGE/ FROM 149 ST. TO WHITEMUD FWY S.B.	-	CAN. STD.	30 cm(closed)	20 cm(open)	30 cm(open)
4. ENTRY LANE/ FROM WHITEMUD FWY. TO FOX DR. E.B.	-	30 cm	CAN. STD.	20 cm	-
5. EXITING LANE/ FROM WHITEMUD FWY. TO 159 ST. N.B.	-	30 cm	20 cm	-	-
6. DIVERGE/ FROM WHITEMUD FWY. TO FOX DR. E.B.	-	20 cm	30 cm	CAN. STD.	-
7. DIVERGE/ FROM WHITEMUD FWY. TO 149 ST. N.B.	-	30 cm or 20 cm	30 cm or 20 cm	CAN. STD.	-

Table 9 VEHICLE TRAJECTORY SURVEY - CONCLUSIONS OF COMPARISON OF MEAN LONGITUDINAL VELOCITY

They were then generalized to traffic situations and tabulated in Table 10, Table 11 and Table 12.

	Traffic Configuration	Movement	No Marking	Canadian Standard	20 cm	20 cm Open	20 cm Closed	30 cm	30 cm Open	30 cm Closed
			Marking Pattern Alternatives							
DIVERGING	AUXILLIARY LANE	EXITING	No significant result	No significant result	Not applicable	No significant result	No significant result	Not applicable	No significant result	No significant result
		THROUGH	No significant result	No significant result	Mostly preferred	No significant result	No significant result	Relatively preferred	No significant result	No significant result
	EXITING (DECELERATION) RAMP		No significant result	Thirdly preferred	No significant result	No significant result	Mostly preferred	No significant result	No significant result	Relatively preferred
MERGING	ENTERING RAMP CONTINUES	ENTERING	No significant result	Thirdly preferred	Mostly preferred	No significant result	No significant result	Least preferred	No significant result	No significant result
		THROUGH	No significant result	Mostly preferred	Mostly preferred	No significant result	No significant result	Least preferred	No significant result	No significant result
	ENTERING (ACCELERATION) RAMP		No significant result	Least preferred	No significant result	Relatively preferred	No significant result	No significant result	Mostly preferred	Least preferred
	LANE DROP		No significant result	Least preferred	No significant result	No significant result	Least preferred	No significant result	No significant result	Mostly preferred

LEGEND
- MOSTLY PREFERRED
- RELATIVELY PREFERRED
- THIRDLY PREFERRED
- LEAST PREFERRED
- NO SIGNIFICANT RESULT
- NOT APPLICABLE

TABLE 10. GENERAL CONCLUSIONS FROM VARIANCE ANALYSIS OF LATERAL DISPLACEMENT

	Traffic Configuration	Movement	No Marking	Canadian Standard	20 cm	20 cm Open	20 cm Closed	30 cm	30 cm Open	30 cm Closed
Diverging	Auxilliary Lane	Exiting	No significant result	No significant result	Not applicable	No significant result	No significant result	Not applicable	No significant result	No significant result
		Through	No significant result	No significant result	Not applicable	No significant result	No significant result	Not applicable	No significant result	No significant result
	Exiting (Deceleration) Ramp		No significant result	Mostly preferred	No significant result	No significant result	Thirdly preferred	No significant result	No significant result	Mostly preferred
Merging	Entering Ramp Continues	Entering	No significant result	Thirdly preferred	Mostly preferred	No significant result	No significant result	Mostly preferred	No significant result	No significant result
		Through	No significant result	Mostly preferred	Thirdly preferred	No significant result	No significant result	Thirdly preferred	No significant result	No significant result
	Entering (Acceleration) Ramp		No significant result	Thirdly preferred	No significant result	Mostly preferred	No significant result	No significant result	Mostly preferred	Mostly preferred
	Lane Drop		Not applicable	Not applicable	No significant result	No significant result	Not applicable	No significant result	No significant result	Not applicable

LEGEND

- ▩ MOSTLY PREFERRED
- ▢ RELATIVELY PREFERRED
- ▤ THIRDLY PREFERRED
- ☐ LEAST PREFERRED
- ⧄ NO SIGNIFICANT RESULT
- ⊟ NOT APPLICABLE

TABLE II. GENERAL CONCLUSIONS FROM VARIANCE ANALYSIS OF LONGITUDINAL VELOCITIES

	Traffic Configuration	Movement	No Marking	Canadian Standard	20 cm	20 cm Open	20 cm Closed	30 cm	30 cm Open	30 cm Closed
Diverging	Auxilliary Lane	Exiting	No significant result	No significant result	Least preferred	No significant result	No significant result	Mostly preferred	No significant result	No significant result
		Through	No significant result	No significant result	Least preferred	No significant result	No significant result	Mostly preferred	No significant result	No significant result
	Exiting (Deceleration) Ramp		No significant result	Thirdly preferred	No significant result	No significant result	Mostly preferred	No significant result	No significant result	No significant result
Merging	Entering Ramp Continues	Entering	No significant result	Least preferred	Least preferred	No significant result	No significant result	Mostly preferred	No significant result	No significant result
		Through	No significant result	Least preferred	Least preferred	No significant result	No significant result	Mostly preferred	No significant result	No significant result
	Entering (Acceleration) Ramp		No significant result	Mostly preferred	No significant result	Thirdly preferred	No significant result	No significant result	No significant result	No significant result
	Lane Drop		Not applicable	Thirdly preferred	No significant result	No significant result	Mostly preferred	No significant result	No significant result	No significant result

LEGEND

- ■ MOSTLY PREFERRED
- □ RELATIVELY PREFERRED
- THIRDLY PREFERRED
- LEAST PREFERRED
- ◪ NO SIGNIFICANT RESULT
- ⊟ NOT APPLICABLE

TABLE 12. GENERAL CONCLUSIONS FROM THE COMPARISON OF MEANS OF LONGITUDINAL VELOCITIES

VI. CONCLUSIONS AND EVALUATON

A. Methods of Evaluation

The Critical Incident Survey, as a method of evaluation of pavement marking, was, indeed, non-accident dependent, objective, accurate, able to reflect the causes of potential accidents; and able to take into account the factor of capacity. As far as the complexity and installation of instrumentation were concern, it was the simplest. It was proved to be successful in identifying the best test marking pattern for test locations of merging maneuver. However, for the test locations of diverging maneuver, no conclusion of statistical significance could be drawn from the data collected, thus, either a longer period of data collection or a supplementary method of evaluation was warranted.

The Vehicle Trajectory Survey was used as another method of evaluation of pavement marking. Unlike Ackroyd and Madden's instrumentation of Time-Lapse cinephotography (5,6), the direct employment of 16 mm. movie camera did simplify the process of data collection. The phase of data extraction was time consuming and involved extensive motion analyzing equipment.

It was found that the selection of appropriate traffic performance measures was the most critical task. These measures must reflect variations in drivers' responses to the marking patterns. Unfortunately, definitive guidelines are difficult to establish because of the number of combinations of geometric situations, potential treatments / systems, weather conditions, and traffic performance measures are unlimited. Lateral displacement and longitudinal velocity were selected as parameters of measurement because they reflect adequately the behaviour of drivers at these critical areas of merging and diverging.

These methods of evaluation were not weighed in terms of significance. They measured different aspects of driver's responses to the marking patterns. The results obtained should, generally, confirm each other.

B. Comparison of Results

Table 13 summarizes the first preference of marking pattern indicated by the four parameters, which included : number of critical incidents; variance of lateral displacement; variance of longitudinal velocity; and the mean of longitudinal velocity. It could then generally be inferred that :

1. The effects of pavement marking on the drivers are more obvious at complex situatons like those of merging and diverging.
2. Wider marking (20/30 cm) was preferred to current Canadian Standard (10 cm) for the continuity lines in merging and diverging areas;
3. Closed sections were preferred to open sections in merging and diverging areas.

Traffic Configuration	Traffic Movement	Critical Incident Survey	Vehicle Trajectory Survey		
			Variance Analysis		Comparison of Mean
			Lateral Displacement	Longitudinal Velocity	Longitudinal Velocity
Auxilliary Lane	Exit	--	--	--	30 cm
	Thru	--	20 cm	--	30 cm
Exiting Ramp	--	--	20 cm/30 cm c / c	30 cm/Can. Std. c	20 cm c
Entering Ramp Continues	Enter	20 cm	20 cm	20 cm/30 cm	30 cm
	Thru	20 cm	20 cm/Can. Std.	Can. Std.	30 cm
Acceleration Ramp	--	30 cm c	30 cm	20cm/30cm/30cm 0 / 0 / 0	Can. Std.
Lane Drop	--	20 cm c	30 cm c	--	20 cm c

Legend: c = closed

0 = Open

Table 13 A COMPARISON OF CONCLUSIONS FROM THE METHODS OF EVALUATION OF MARKING AT MERGING AND DIVERGING AREAS.

VII. RECOMMENDATIONS

The followings are recommended for i plementation:

1. Continuity lines of 20 or 30 cm at merging and diverging areas are recommeded for Canadian applications;
2. Closed sections are preferred to open sections for these critical areas.

The followings are recommendated for further investigation:

1. As for this study, data was only collected during peak periods at the test locations, when the accident rates were highest and vehicular interactions were maximum; and, of course, taking the advantage that large amount of data could be collected during a short time. However, the effectiveness of the pavement marking might be different at low traffic volume. Further study during the off-peak periods might bring more insight into the effectiveness of pavement marking at these areas.
2. During the study, the applications of 30 cm wide markings were not satisfactory due to some technical problems. Furthermore, the comparison between 20 cm and 30 cm markings were not conclusive in many cases. Therefore, further investigation in the differences of effects which these marking patterns might have on the drivers is recommended.
3. As for the Critical Incident Survey, no concrete conclusion could be drawn from the data for diverging situations. The survey could be further pursued, for

example, by lengthening the observation to three hours. Generally, this method is efficient in measuring highway improvements and is recommended as a method of evaluation of other highway safety improvements.

4. As for the Vehicular Trajectory Survey, its accuracy of measurement and its sensitivity are indeed attractive; however, the complexity of data analysis have to be re-accessed before this method of evaluation could be used efficiently and economically.

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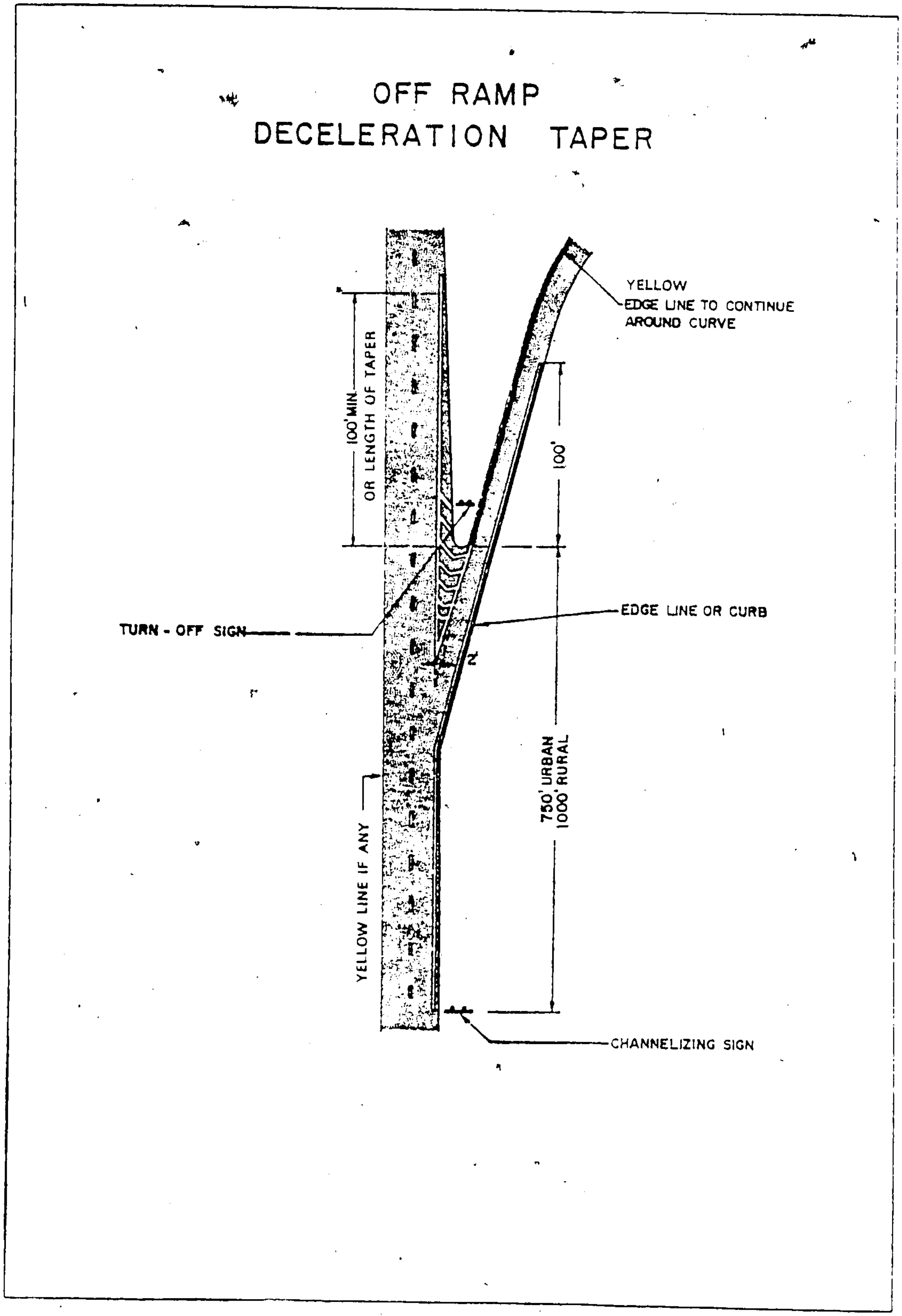
APPENDIX A

Canadian Pavement Marking Standard

at the Merging and Diverging Areas

Source: Uniform Traffic Control Device Manual, Canada, October, 1970.



OFF RAMP
DECELERATION TAPER
YELLOW
EDGE LINE TO CONTINUE
AROUND CURVE
100' MIN
OR LENGTH OF TAPER
100'
EDGE LINE OR CURB
TURN - OFF SIGN
2'
750' URBAN
1000' RURAL
YELLOW LINE IF ANY
CHANNELIZING SIGN

FIGURE 30

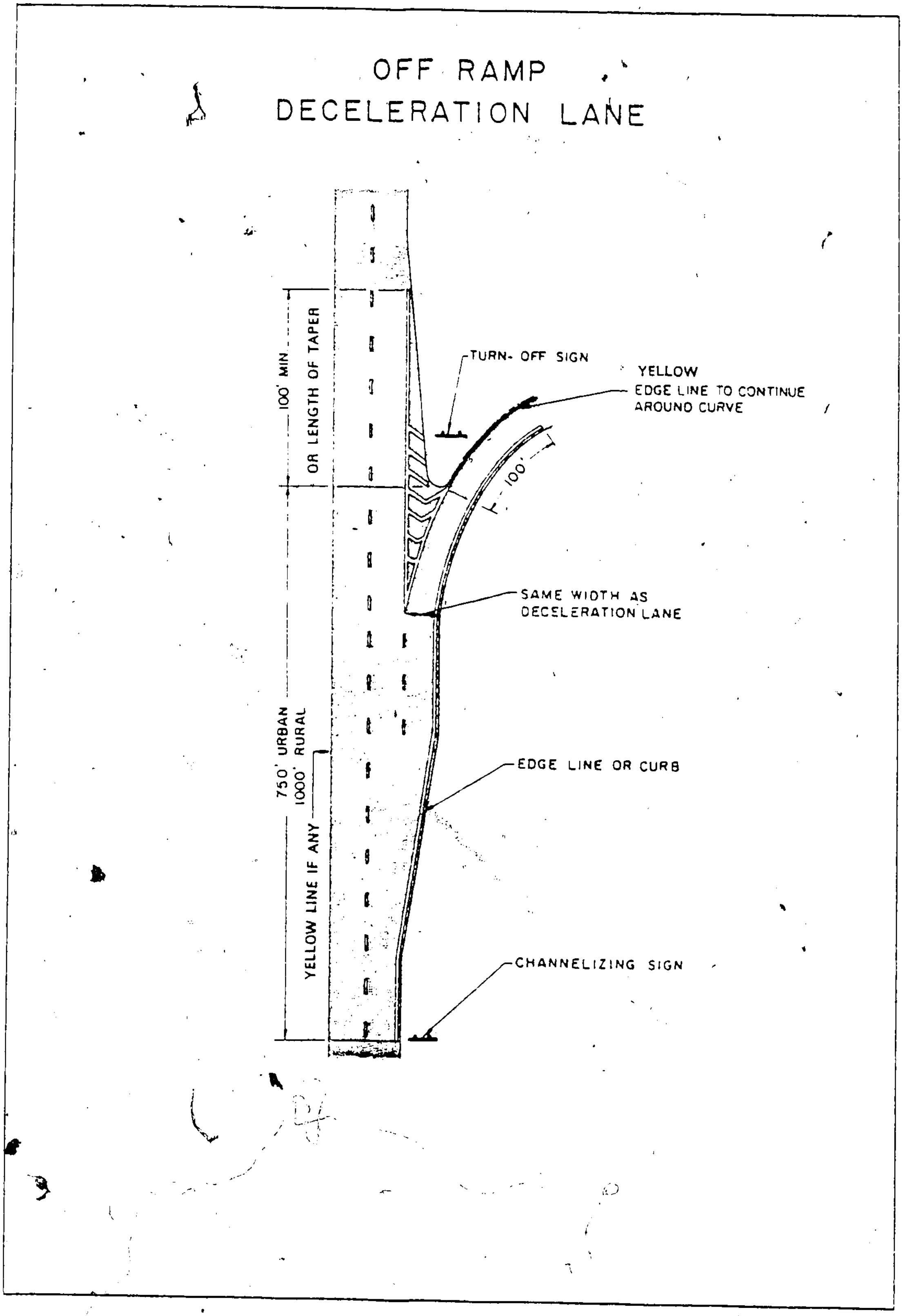

OFF RAMP
DECELERATION LANE
TURN- OFF SIGN
YELLOW
EDGE LINE TO CONTINUE
AROUND CURVE
100'
SAME WIDTH AS
DECELERATION LANE
EDGE LINE OR CURB
CHANNELIZING SIGN
100' MIN
OR LENGTH OF TAPER
750' URBAN
1000' RURAL
YELLOW LINE IF ANY

FIGURE 31

ON RAMP ACCELERATION TAPER

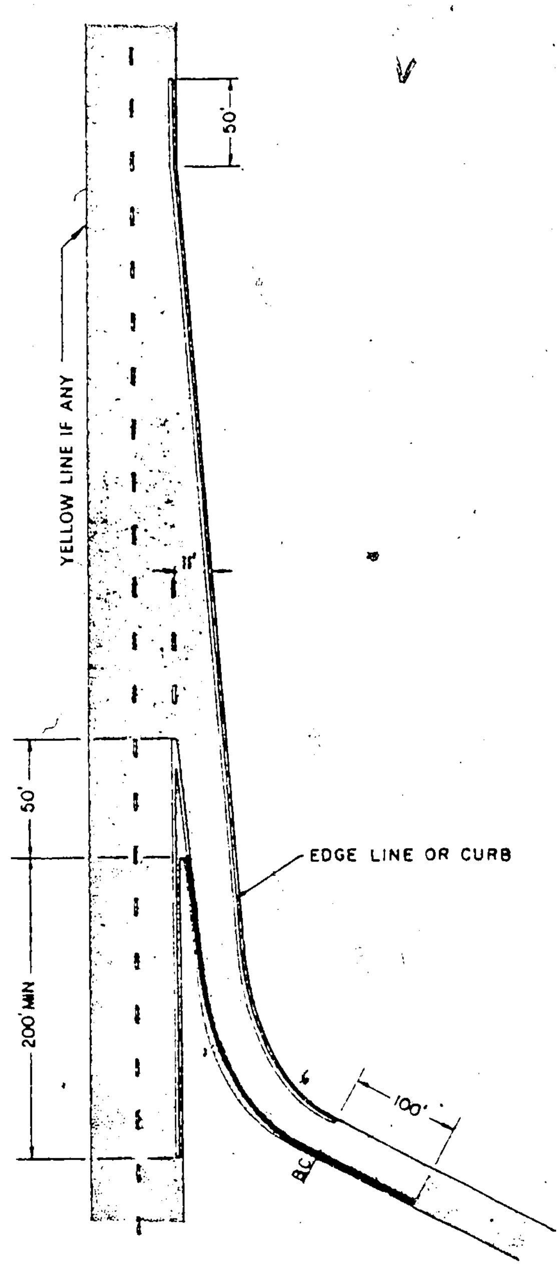


FIGURE 32

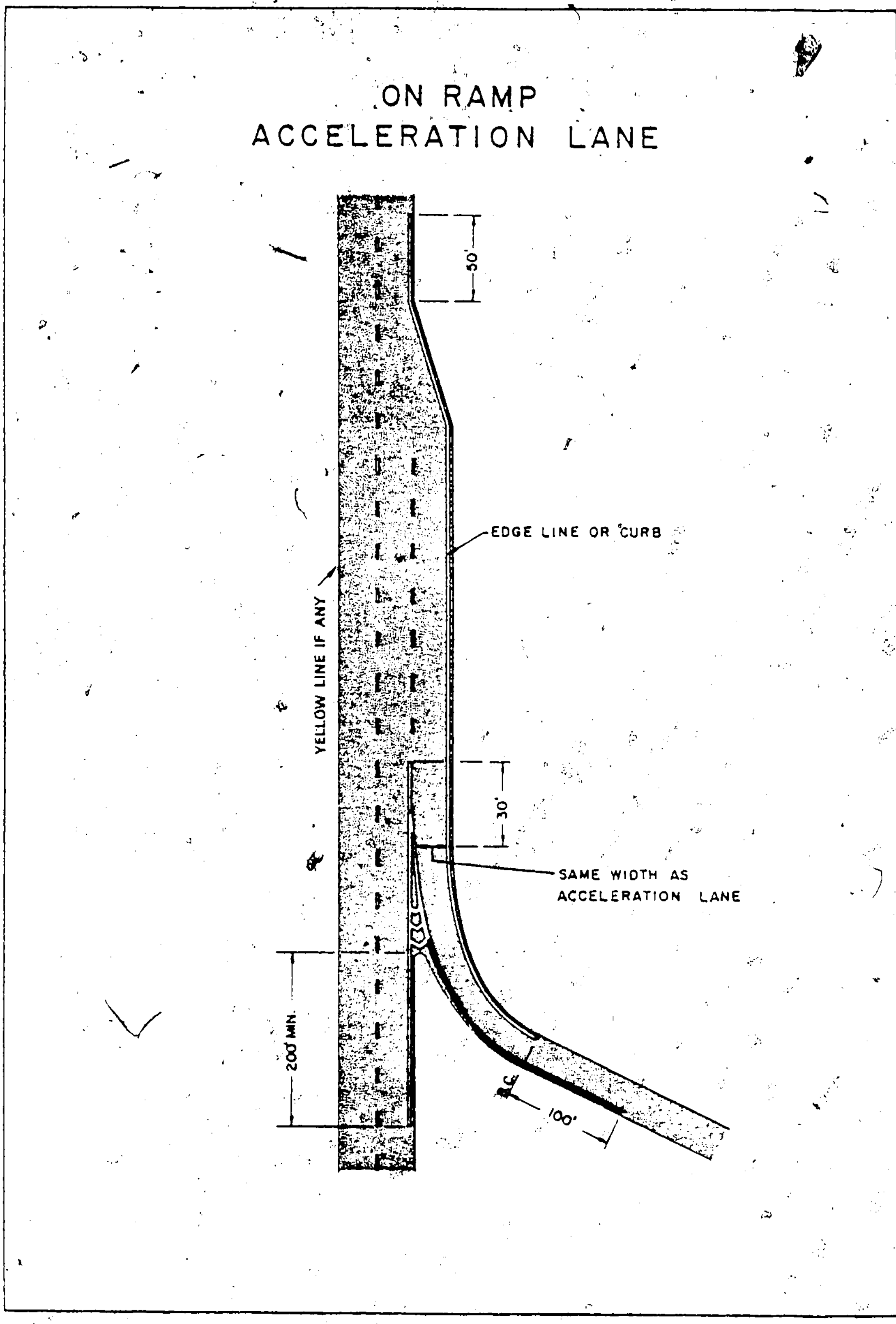
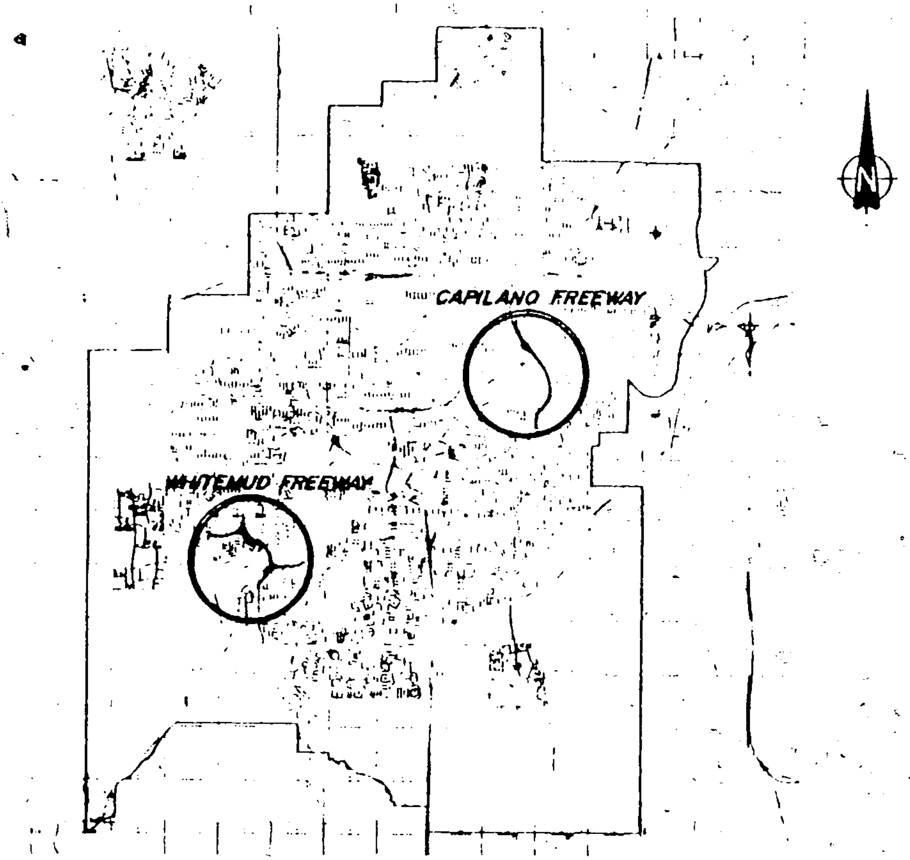

ON RAMP
ACCELERATION LANE
50'
EDGE LINE OR CURB
YELLOW LINE IF ANY
30'
SAME WIDTH AS
ACCELERATION LANE
200' MIN.
100'

FIGURE 33

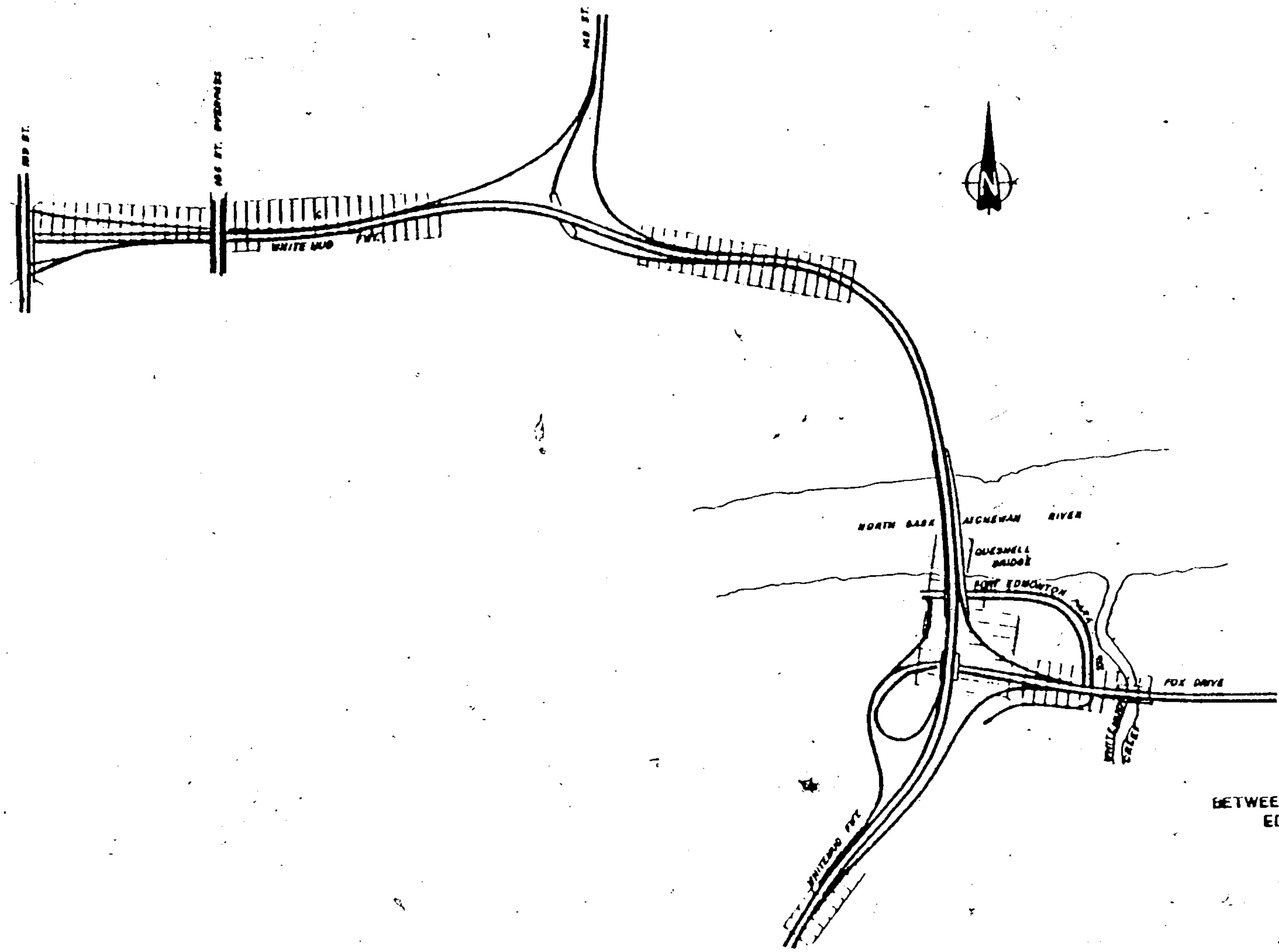
APPENDIX B

Plans Showing the Test Locations in Metropolitan Edmonton.



N.B. Only pilot study was done at Capilano Freeway.

AREA MAP OF
EDMONTON, ALBERTA
INDICATING PROJECT 109 TEST AREAS

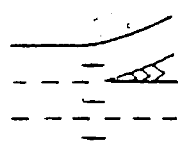
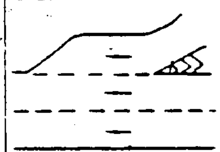
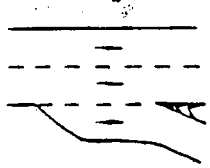
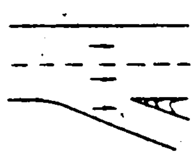
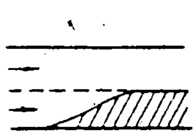
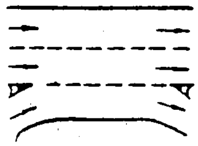


LEGEND:
ǀǀǀǀǀǀ TEST LOCATION

WHITEMUD FREEWAY
BETWEEN 159 ST. AND FOX DRIVE
EDMONTON, ALBERTA

APPENDIX C

Test Locations.

TRAFFIC CONFIGURATION	LOCATION	BEFORE	T	AFTER 1	T	AFTER 2	T	AFTER 3
	1. On Quesnell Bridge (N.B.) from Fox Drive 2. On Fox Drive (E.B.) from Quesnell Bridge	S S	3 3	20 20	3 3	30 30	- -	- -
	1. [illegible]temud Fwy. (W. of [illegible]14) from 149 St.**	S	3	Open-20	3	Open-30	3	Close-30
	1. On Whitemud Fwy. exiting to Fox Drive	S	3	Close-30	-	-	-	-
	1. On Wtd. Fwy. to 149 St.**	S	3	Close-20	3	Close-30	-	-
	1. On Fox Drive to Whitemud Fwy. (N.B.)	S	3	20	3	30	-	-
	1. On exiting ramp from Fox Drive to Whitemud Fwy.**	S	3	Close-20	3	Close-30	-	-
	1. On Whitemud Fwy. between 149 St. and 159 St. N.B.	S	3	20	3	30	-	-

Legend:

1. T = Time interval between alternatives (weeks)
2. **= Indication of a change of configuration
3. S = Standard pavement marking

APPENDIX D

Schedule of Activities During the Stage of Data Collection.

TEST LOCATION	TEST[a] PATTERN	MARKING SCHEDULE	VEHICLE TRAJEC-TORIES SURVEY	CRITICAL INCIDENTS SURVEY[b]			VIDEO-TAPING
				D_1	D_2	D_3	
ON QUESNELL BRIDGE FROM FOX DR. (W.B.)	10 cm	May 29	June 23	June 21	June 29	July 4	June 22
	20 cm	July 5	Aug. 11	Aug. 1	Aug. 3	Aug. 8	July 28
	30 cm	Aug. 7	Aug. 29	Aug. 29	Aug. 30	Aug. 31	Sept. 8
ON FOX DR. FROM QUESNELL BRIDGE (E.B.)	10 cm	May 29	June 19	June 19	June 23	June 26	June 22
	20 cm	July 5	July 14	July 14	July 24	July 26	July 28
	30 cm	Aug. 7	Sept. 11	Aug. 28	Aug. 30	Aug. 31	Sept. 8
ON WHITEMUD FREEWAY TO 159 ST. (W.B.)	10 cm	May 29	May 30	June 14	June 22	June 26	June 22
	20 cm	July 5	Aug. 1	July 19	Aug. 3	Aug. 8	July 28
	30 cm	Aug. 7	Sept. 12	Aug. 29	Aug. 30	Aug. 31	Sept. 8
ON WHITEMUD FREEWAY TO FOX DR. (E.B.)	10 cm o	May 29	June 23	June 23	June 26	June 29	June 22
	20 cm •	July 5	July 18	July 18	July 21	July 25	July 28
	30 cm •	Aug. 7	Aug. 25	Aug. 30	Aug. 31	Sept. 5	Sept. 8
ON WHITEMUD FREEWAY TO 149 ST. (W.B.)	10 cm o	May 29	June 20	June 19	June 20	June 23	June 22
	20 cm •	July 5	July 17	July 17	July 24	July 26	July 28
	30 cm •	Aug. 7	Aug. 28	Aug. 29	Aug. 30	Aug. 31	Sept. 8
ON FOX DR. TO QUESNELL BRIDGE (W.B.)	10 cm •	May 29	June 26	June 13	June 19	June 22	June 22
	20 cm •	July 5	Aug. 2	July 25	Aug. 1	Aug. 3	July 28
	30 cm •	Aug. 7	Sept. 26	Sept. 19	Sept. 20	Sept. 26	Sept. 8
ON WHITEMUD FREEWAY FROM 149 ST. (E.B.)	10 cm o	May 29	June 15	June 15	June 20	June 21	June 22
	20 cm o	July 5	July 13	July 17	July 20	July 28	July 28
	30 cm o	Aug. 7	Aug. 25	Aug. 25	Aug. 28	Aug. 29	-
	30 cm •	Sept. 7	Sept. 12	Sept. 12	Sept. 13	Sept. 14	Sept. 8

SCHEDULE OF ACTIVITIES DURING THE STAGE OF DATA COLLECTION*

Note :

a 10 cm marking patterns are of contempory Canadian Standard

b for critical incidents survey, 3 sets of data were collected for each alternative marking pattern

o open section

• closed section

- not done

* as implemented

APPENDIX E

Sample of Data Collection Form.

Sample of Data Collection Form.

MERGING AREA

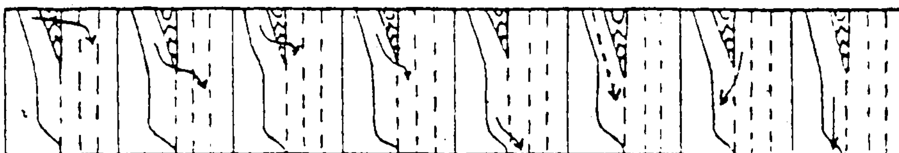
Date : ____________________ Done by: ____________________

Location : ____________________

Time : Start ____________________ End ____________________

Weather Condition : ____________________

Traffic Volume : ____________________



R-G(C)-2		R-G(A)-2		R-G(B)-1		R-G(A)-1		R-S_1-1		R-H-1		1-G(A)-R		R-S_2-1					
C_1	C_2	C_1	C_2	C_1	C_2	C_1	C_2	C_1	C_2	C_1	C_2	C_1	C_2	C_1	C_2	C_1	C_2	C_1	C_2

APPENDIX F

Critical Incident Survey - Data Inventory.

TABLE 1: Data Inventory Sheet #1 For Critical Incident Survey

Location: On Quesnell Bridge (W.B.) entering from Fox Drive

Time: 3:45 - 5:15 p.m.

Maneuver: Merging

Level of Service: D to E

Alternative		S				A1				A2				% of Critical Incident Reduction		
Type of Critical Incident	Survey Vol.	1 2069	2 2099	3 2149	Mean	1 2139	2 1899	3 2350	Mean	1 2181	2 2215	3 2175	Mean	S/A1	S/A2	A1/A2
11	# #/vol(10^-2)	43 2.08	54 2.57	64 2.98	54 2.54	11 .54	12 .63	12 .51	12 .56	30 1.38	25 1.13	14 .64	23 1.05	[78] N/A	[57] N/A	[-92] N/A
12	# #/vol(x10^-2)	28 1.35	10 .48	2 .09	13 .64	19 .93	19 1.0	6 .26	15 .73	6 .28	6 .27	9 .41	7 .32	-15 N/A	(46) N/A	(54) N/A
13	# #/vol(x10^-2)	1 .05	0 0	1 .05	1 .03	0 0	0 0	1 .04	0 .01	1 .05	2 .09	2 .09	2 .08	I N/A	I N/A	I N/A
15	# #/vol(x10^-2)	2 .10	2 .10	0 0	1 .06	17 .83	11 .58	12 .51	13 .64	7 .32	15 .68	12 .55	11 .52	I N/A	I N/A	I N/A
16	# #/vol(x10^-2)	6 .29	21 1.00	48 2.23	25 1.17	0 0	1 .05	2 .09	1 .05	8 .37	5 .23	9 .41	7 .34	[96] N/A	[72] N/A	I N/A
17	# #/vol(x10^-2)	[illegible] .92	15 .71	12 .56	15 .73	7 .34	19 1.0	24 1.0	17 .78	12 .55	21 .95	13 .60	15 .7	13 N/A	0 N/A	12 N/A

NOTE: S = Contemporary Canadian Standard

A1 = 20 cm

A2 = 30 cm

TABLE 2 Data Inventory Sheet #2 for Critical Incident Survey

Location: On the ramp from Fox Drive to Quesnell Bridge (W.B.)

Time: 3:45 - 8:15 p.m.

Maneuver: Merging (lane dropping)

Level of Service: E

Alternative		S				A1				A2				% of Critical Incident Reduct.		
Type of Critical Incident	Survey Vol	1 1936	2 2393	3 1824	Mean	1 2015	2 1933	3 1804	Mean	1 2138	2 2241	3 2141	Mean	S/A1	S/A2	A1/A2
18	#	127	189	78	146	77	56	122	85	22	26	59	36	[42]	[76]	[58
	#/vol.(10^{-2})	6.65	7.90	4.28	6.28	3.82	2.90	6.76	4.49	1.03	1.16	2.76	1.65	N/A	N/A	N/A
19	#	66	61	21	49	22	7	16	15	42	63	31	45	[69]	8	[-20
	#/vol.(10^{-2})	3.41	2.55	1.15	2.37	1.09	.36	.87	.77	1.96	2.81	1.45	2.07	N/A	N/A	N/A
20	#	112	153	67	111	84	41	76	67	67	69	45	60	[40]	[46]	10
	#/vol.(10^{-2})	5.79	6.39	3.67	5.28	4.17	2.12	4.21	3.5	3.13	3.08	2.10	2.77	N/A	N/A	N/A

NOTE: S = Contemporary Canadian Standard

A1 = 20 cm

A2 = 30 cm

TABLE 3 Data Inventory Sheet #3 for Critical Incident Survey

Location: On Whitemud Freeway (E.B.) from 149 Street
Time: 6:45 - 8:15 a.m.

Maneuver: Merging
Level of Service: D to E

Alternative		S				A1				A2				A3				% of Critical Incident Reduction					
Type of Critical Incident	Survey Vol.	1 689	2 1086	3 1109	Mean	1 900	2 983	3 998	Mean	1 938	2 986	3 1011	Mean	1 1036	2 1054	3 1065	Mean	S/A1	S/A2	S/A3	A1/A2	A1/A3	A2/A3
2	#	0	2	0	1	0	0	0	0	0	0	0	0	1	1	0	1	I	I	I	I	I	I
	#/vol.(10^{-2})	0	.18	0	.06	0	0	0	0	0	0	0	0	.09	.09	0	.06	N/A	N/A	N/A	N/A	N/A	N/A
3	#	8	11	0	6	4	1	1	2	6	5	0	4	6	1	0	2	(67)	(33)	(67)	I	I	I
	#/vol.(10^{-2})	1.16	1.01	0	.72	.41	.10	.10	.20	.64	.51	0	.38	.58	.09	0	.22	N/A	N/A	N/A	N/A	N/A	N/A
4	#	0	0	0	0	11	5	12	9	6	4	8	6	11	7	8	9	I	I	I	33	0	-50
	#/vol.(10^{-2})	0	0	0	0	1.12	.51	1.20	.94	.64	.41	.79	.61	1.06	.66	.75	.82	N/A	N/A	N/A	N/A	N/A	N/A
5	#	23	28	17	23	13	19	7	13	12	14	10	12	15	6	6	9	(44)	(48)	[61]	8	31	25
	#/vol.(10^{-2})	3.34	2.58	1.53	2.48	1.33	1.93	.70	1.32	1.28	1.42	.99	1.23	1.45	.57	.56	.86	N/A	N/A	N/A	N/A	N/A	N/A
6	#	2	3	20	8	24	15	19	19	14	5	12	10	12	0	8	7	[-138]	(-25)	13	(47)	(63)	30
	#/vol.(10^{-2})	.29	.28	1.80	.79	2.45	1.53	1.90	1.96	1.49	.51	1.19	1.06	1.16	0	.75	.64	N/A	N/A	N/A	N/A	N/A	N/A
7	#	0	1	4	2	1	3	0	2	0	0	3	1	1	0	1	1	I	I	I	I	I	I
	#/vol.(10^{-2})	0	.09	.36	.15	.10	.31	0	.14	0	0	.03	.01	.09	0	.09	.06	N/A	N/A	N/A	N/A	N/A	N/A
8	#	67	172	188	142	44	57	34	45	26	27	13	22	47	35	27	36	[68]	[85]	[75]	[51]	20	[64]
	#/vol.(10^{-2})	9.72	15.8	17.0	14.2	4.49	5.80	3.40	4.56	2.77	2.74	1.29	2.27	4.54	3.32	2.54	3.46	N/A	N/A	N/A	N/A	N/A	N/A
9	#	18	50	90	53	29	46	39	38	27	30	37	31	36	31	30	32	(28)	[42]	[40]	18	16	-3
	#/vol.(10^{-2})	2.61	4.60	8.12	15.3	3.00	4.68	3.90	3.86	2.88	3.04	3.66	3.19	3.47	2.94	2.82	3.08	N/A	N/A	N/A	N/A	N/A	N/A

NOTE: S = Contemporary Canadian Standard

A1 = 20 cm open section

A2 = 30 cm open section

A3 = 30 cm closed section

TABLE 4 Data Inventory Sheet #4 for Critical Incident Survey

Location: On Fox Drive (E.B.) from Quesnell Bridge — Maneuver: Merging

Time: 6:45 - 8:15 a.m. — Level of Service: B

Alternative		S				A1				A2				% of Critical Incident Reduction		
Type of Critical Incident	Survey Vol	1 381	2 454	3 502	Mean	1 408	2 437	3 439	Mean	1 404	2 414	3 428	Mean	S/A1	S/A2	A1/A2
11	# #/vol.(x10⁻²)	9 2.36	17 3.74	16 3.19	14 3.10	14 3.43	14 3.20	11 2.51	13 3.05	18 4.46	4 1.00	8 1.87	10 2.44	7 N/A	29 N/A	23 N/A
12	# #/vol.(x10⁻²)	9 2.36	14 3.08	9 1.79	11 2.41	4 .98	2 .46	3 .68	3 .71	2 .50	0 0	0 0	1 .17	[72] N/A	[91] N/A	1 N/A
13	# #/vol.(x10⁻²)	72 18.9	53 11.7	66 13.1	64 14.6	16 3.92	13 2.97	2 .46	10 2.45	10 2.48	5 1.21	30 7.01	15 3.57	[84] N/A	[77] N/A	(-50) N/A
14	# #/vol.(x10⁻²)	19 4.99	3 .66	1 .20	8 1.95	1 .25	3 .69	1 .23	2 .39	0 0	0 0	2 .47	1 .16	[75] N/A	[88] N/A	1 N/A
15	# #/vol.(x10⁻²)	11 2.89	12 2.64	18 3.59	14 3.04	13 3.19	13 2.97	3 .68	10 2.28	25 6.19	24 5.80	17 3.97	22 5.32	(29) N/A	(-57) N/A	[-120] N/A

NOTE: S = Contemporary Canadian Standard

A1 = 20 cm

A2 = 30 cm

TABLE 5 Data Inventory Sheet #5 For Critical Incident Survey

Location: on Whitemud Freeway (W.B.) to 159 Street — Maneuver: Diverging

Time: 3:45 - 5:15 p.m. — Level of Service: B or C

Alternative		S				A1				A2				% of Critical Incident Reduction		
Type of Critical Incident	Survey Vol.	1 965	2 882	3 903	Mean	1 842	2 743	3 880	Mean	1 883	2 918	3 891	Mean	S/A1	S/A2	A1/A2
12	# #/vol.(10^{-2})	14 1.45	3 .34	2 .22	6 .67	15 1.78	21 2.83	20 2.27	19 2.29	12 1.36	15 1.63	31 3.48	19 2.16	[-216] N/A	[-216] N/A	0 N/A
13	# #/vol.(10^{-2})	7 0.73	10 1.13	8 .89	8 .92	6 .71	10 1.35	10 1.14	9 1.07	3 .34	8 .87	0 .0	4 .40	-13 N/A	50 N/A	(56) N/A
14	# #/vol.(10^{-2})	0 0	2 .23	3 .33	2 .19	0 0	1 .13	1 .11	1 .08	1 .11	2 .22	1 .11	1 .15	I N/A	I N/A	I N/A
15	# #/vol.(10^{-2})	17 1.76	1 .11	5 .55	8 .81	11 1.31	15 2.02	18 2.05	15 1.79	13 1.14	15 1.63	28 3.14	19 1.97	[-88] N/A	[-138] N/A	-40 N/A
16	# #/vol.(10^{-2})	5 0.52	6 .68	4 .44	5 .55	9 1.07	3 .40	2 .23	5 .57	3 .34	9 .98	0 0	4 .44	0 N/A	20 N/A	20 N/A
17	# #/vol.(10^{-2})	0 0	1 .11	2 .22	1 .11	1 .12	2 .27	0 0	1 .13	1 .11	0 0	0 0	0 .04	I N/A	I N/A	I N/A
18	# #/vol.(10^{-2})	3 0.31	0 0	0 0	1 .10	1 .12	1 .13	1 .11	1 .12	0 0	0 0	0 0	0 0	I N/A	I N/A	I N/A
19	# #/vol.(10^{-2})	0 0	0 0	1 .11	0 .04	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	I N/A	I N/A	I N/A

NOTE: S = Contemporary Canadian Standard

A1 = 20 cm

A2 = 30 cm

TABLE 6 Data Inventory Sheet #6 for Critical Incident Survey

Location: On Whitemud Freeway (E.B.) to Fox Drive
Time: 6:45 - 8:15 a.m.

Maneuver: Diverging
Level of Service: D to E

Alternative		S				A1				A2				% of Critical Incident Reduction		
Type of Critical Incident	Survey Vol.	1 1837	2 1931	3 1809	Mean	1 1870	2 1711	3 1871	Mean	1 1867	2 1820	3 2083	Mean	S/A1	S/A2	S/A3
1	#	0	0	2	1	1	1	0	1	1	2	1	1	I	I	I
	#/vol.(10^{-2})	0	0	.11	.04	.05	.06	0	.03	.05	.11	.05	.67			
2	#	0	1	1	1	2	4	2	3	2	8	3	4	I	I	I
	#/vol.(10^{-2})	0	.05	.06	.04	.11	.23	.11	.15	.11	.44	.14	.23			
3	#	4	3	6	4	28	68	30	42	8	12	12	11	I	I	I
	#/vol.(10^{-2})	.22	.16	.33	.24	1.50	3.97	1.60	2.36	.43	.66	.58	.56			
4	#	4	0	0	1	7	15	26	16	8	6	14	9	I	I	I
	#/vol.(10^{-2})	.22	0	0	.07	.37	.88	1.39	.88	.43	.33	.67	.48			
5	#	0	0	0	0	4	1	0	2	0	0	1	0	I	I	I
	#/vol.(10^{-2})	0	0	0	0	.21	.06	0	.09	0	0	.05	.02			
7	#	1	1	4	2	4	1	11	5	0	2	4	2	I	I	I
	#/vol.(10^{-2})	.05	.05	.22	.11	.21	.06	.59	.29	0	.11	.19	.10			
8	#	0	4	3	2	2	4	2	3	0	0	0	0	I	I	I
	#/vol.(10^{-2})	0	.21	.17	.13	.11	.23	.11	.15	0	0	0	0			
9	#	0	0	0	0	0	0	0	0	0	0	0	0	I	I	I
	#/vol.(10^{-2})	0	0	0	0	0	0	0	0	0	0	0	0			
10	#	1	1	0	1	0	1	0	0	0	0	0	0	I	I	I
	#/vol.(10^{-2})	.05	.05	0	.03	0	.06	0	.02	0	0	0	0			
11	#	0	0	0	0	1	0	0	0	0	0	0	0	I	I	I
	#/vol.(10^{-2})	0	0	0	0	.05	0	0	.02	0	0	0	0			

NOTE: S = Contemporary Canadian Standard
A1 = 20 cm closed section
A2 = 30 cm closed section

TABLE 7 Data Inventory Sheet #7 for Critical Incident Survey

Location: On Whitemud Freeway (W.B.) to 149 Street
Time: 3:45 - 5:15 p.m.

Maneuver: Diverging
Level of Service: D

Alternative		S				A1				A2				% Critical Incident Reduction		
Type of Critical Incident	Survey Vol.	1 1323	2 1266	3 1372	Mean	1 1225	2 1197	3 1181	Mean	1 1178	2 1218	3 1207	Mean	S/A1	S/A2	A1/A2
1	#	0	0	0	0	2	2	1	2	1	0	0	0	I	I	I
	#/vol.(10⁻²)	0	0	0	0	.16	.17	.08	.14	.08	0	0	.02	N/A	N/A	N/A
2	#	1	0	2	1	0	0	0	0	3	4	1	3	I	I	I
	#/vol.(10⁻²)	0.08	0	0.15	.08	0	0	0	0	.25	.33	.08	.22	N/A	N/A	N/A
3	#	5	0	1	2	5	9	23	12	7	8	6	7	I	I	I
	#/vol.(10⁻²)	0.38	0	0.07	.15	.41	0.75	1.95	1.04	.59	.66	.50	.58	N/A	N/A	N/A
4	#	15	16	24	18	2	15	19	12	14	26	25	22	33	-22	[-83]
	#/vol.(10⁻²)	1.13	1.26	1.75	1.38	.16	1.25	1.61	1.01	1.19	2.13	2.07	1.80	N/A	N/A	N/A
5	#	0	0	0	0	1	1	1	1	0	0	0	0	I	I	I
	#/vol.(10⁻²)	0	0	0	0	.08	.08	.08	.08	0	0	0	0	N/A	N/A	N/A
6	#	2	1	1	1	6	4	2	3	6	6	4	5	I	I	I
	#/vol.(10⁻²)	0.15	0.08	.07	.10	.49	.33	.17	.33	.51	.49	.33	.44	N/A	N/A	N/A
7	#	3	13	2	6	1	0	4	2	1	1	0	1	13.9	(83.3)	I
	#/vol.(10⁻²)	0.23	1.03	.15	.47	.08	0	.39	.16	.08	.08	0	.05	N/A	N/A	N/A
8	#	3	1	2	2	2	2	3	2	1	0	1	1	I	I	I
	#/vol.(10⁻²)	0.23	0.08	.15	.15	.16	.17	.25	.19	.08	0	.08	.05	N/A	N/A	N/A
9	#	0	2	1	1	0	1	2	1	0	0	0	0	I	I	I
	#/vol.(10⁻²)	0	0.16	.07	.08	0	.08	.17	.08	0	0	0	0	N/A	N/A	N/A
10	#	1	2	0	1	0	0	0	0	2	0	3	2	I	I	I
	#/vol.(10⁻²)	0.08	0.16	0	.08	0	0	0	0	.17	0	.25	.14	N/A	N/A	N/A
11	#	13	22	4	13	6	4	14	8	1	1	4	2	38	[85]	(75)
	#/vol.(10⁻²)	0.98	1.74	.29	1.09	.49	.33	1.19	.67	.08	.08	.33	.16	N/A	N/A	N/A

NOTE: S = Contemporary Canadian Standard
A1 = 20 cm closed section
A2 = 30 cm closed section

APPENDIX G

Critical Incident Survey - Curves of Statistical Significance Tests.

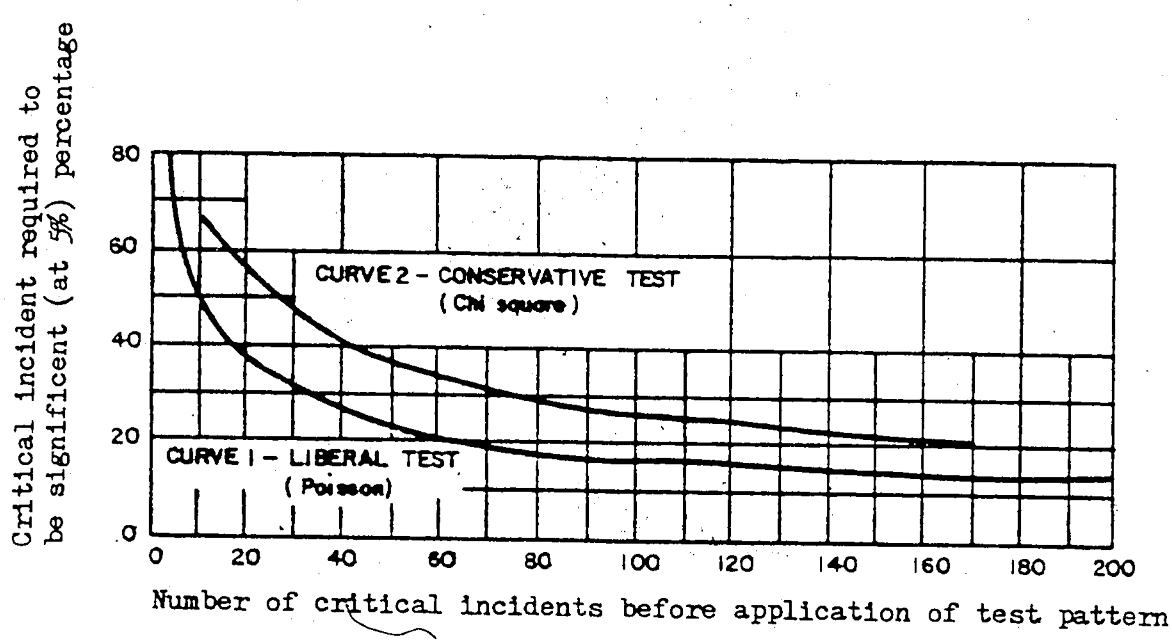


Fig. 1 CURVES OF SIGNIFICANCE TEST FOR CRITICAL INCIDENT REDUCTION

APPENDIX H

Program 1.

Date Extraction

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Faculty of Physical Education,
University of Alberta.
Hansel Wang, Department of Civil Engineering,
University of Alberta.

Purpose

The purpose of Program 1 is to compute the vehicle positioning, by second, by transforming the positions of the vehicles registered by the cursor into lateral and longitudinal displacements.

Program Structure

The program is constituted of 3 subprograms (A. B. and C.), which occupied 5 files.

Subprogram A in File 0 compute the lateral perspective correction factors. The program uses a known reference line that is digitized throughout the desired range, computes the correction factors, smoothes them by using a single exponential/rejection technique and stores the smoothed correction factors and the corresponding y values in File 1 and File 2 respectively.

Subprogram B in File 3 finds longitudinal perspective correction factors. The positions and distances between lamp posts are used to establish a linear regression. The coefficients of the obtained equation are stored in File 4.

Subprogram C in File 5 is the analysis program. The lateral displacement is obtained by scanning the y array and finding the corresponding correction factor which is then multiplied by the distance measured on the Platen to give the real distance. The longitudinal displacement is obtained by using the y value to find the corresponding perspective correction factor from the regression equation.

```
0: dim C[100],Y[100],S[100],L[100],Z[100],X[100],O[100],T[100]
1: prt "CIVIL ENGG.";spc 2
2: 1→I
3: ent "REAL SIZE OF REFERENCE [cm]",R
4: prt "REAL SIZE [cm]=",R;spc
5: enp "PERMISSIBLE      DEVIATION % =",r0;spc 2
6: dsp "DIGITIZE REFERENCE  #",I
7: red 4,X,Y;2.54X→X;2.54Y→Y;beep
8: red 4,A,B;2.54A→A;2.54B→B;beep
9: if X-A=0;I-1→I;gto 15
10: √((A-X)^2+(Y-B)^2)→D
11: R/D→C[I]
12: if I>1;if C[I-1]>C[I]+C[I]r0/100;dsp "REJECTED+";wait 2000;beep;gto 6
13: if I>1;if C[I-1]<C[I]-C[I]r0/100;dsp "REJECTED-";wait 2000;beep;gto 6
14: B→Y[I];I+1→I→r3;gto 6
15: prt "C FACTOR";spc
16: for A=1 to I
17: prt C[A]
18: if A=1;C[A]→S[A];gto 20
19: .5C[A+1]+.5C[A]→S[A]
20: next A
21: spc ;prt "SMOOTHED C FAC";spc
22: for B=1 to I-1
23: fmt 2f7.2;wrt 16,"Y",Y[B]," ",S[B]
24: next B
25: spc 2;prt "CALIBRATION DONE";spc
26: r3→F
27: rcf 1,Y[*]
28: rcf 2,S[*]
29: prt "*****************";spc
*24181
```

```
0: beep;dsp "LONGDITUDINAL DISP. Calibration";wait 2000;beep
1: dim O[2,30]
2: prt "<<<<<<<<>>>>>>>>"
3: spc ;prt "LONG DISP.CAL";spc
4: ent "# of REFERENCE POINTS ?",r0
5: dsp "DIGITIZE REFERENCE #",1;red 4,E,F;beep
6: 2.54E→E;2.54F→F
7: for K=1 to r0-1
8: dsp "DIGITIZE REFERENCE #",K+1;red 4,G,H;beep
9: 2.54G→G;2.54H→H
10: √((G-E)^2+(H-F)^2)→r1
11: ent "REAL DISTANCE IN METERS",r2
12: r2/(r1/100)→O[2,K]
13: (H+F)/2→O[1,K]
14: G→E;H→F
15: next K
16: 0→B→Q→R→E→S→Z→J
17: for Q=1 to r0-1
18: O[1,Q]+S→S;O[2,Q]+Z→Z
19: next Q
20: S/(r0-1)→X;Z/(r0-1)→Y
21: for A=1 to r0-1
22: prt O[1,A];prt O[2,A];spc
23: (O[1,A]-X)(O[2,A]-Y)+B→B
24: (O[1,A]-X)^2+J→J
25: (O[2,A]-Y)^2+R→R
26: next A
27: B/√(JR)→E
28: prt "Sx =",√(J/(r0-2))→r2
29: prt "Sy =",√(R/(r0-2))→r3
30: spc ;prt "CORRELATION";spc ;prt "r =",E
31: Er3/r2→r4;Y-r4X→r5
32: Er2/r3→r6;X-r6Y→r7
33: spc ;prt "REGRESSION";spc
34: r3√(1-E^2)→r8
35: fmt 4f6.1;wrt 16,"Y=",r5,"+",r4,"x";spc
36: prt "St.Err.of Est.",r8
37: spc ;prt "LONG CAL DONE";spc
38: rcf 4,r4,r5
39: prt "<<<<<<<<>>>>>>>>";spc 2
40: end
*13680
```

```
0: dim A$[50],B$[20];1→U
1: ent "LOCATION",A$[U]
2: prt "++++++++++++++++"
3: prt A$[U];prt "++++++++++++++++";spc
4: ldf 4,r4,r5
5: 1→U
6: ent "COMMENTS",B$[U]
7: prt "****************";spc
8: prt B$[U];spc ;prt "****************";spc
9: dim C[100],Y[100],S[100],L[100],Z[100],X[100],O[2,20],T[100]
10: ldf 1,Y[*]
11: for P=1 to 100
12: if Y[P]=0;P→r3;jmp 2
13: next P
14: ldf 2,S[*]
15: dsp "LATERAL DISTANCE COMPUTATIONS";beep;wait 1500;beep
16: 1→I→N
17: dsp "DIGITIZE POSITION  ",N;red 4,X,Y;2.54X→X;2.54Y→Y;beep
18: X→X[N];Y→Z[N]
19: dsp "DIGITIZE ROADSIDE";red 4,A,B;2.54A→A;2.54B→B;beep
20: if X-A=0;gto 28
21: √((X-A)^2+(Y-B)^2)→D
22: if Y<Y[I];dsp "OUT OF RANGE -";wait 2000;beep;gto 17
23: if Y>Y[I];if Y>Y[r3-1];dsp "OUT OF RANGE +";wait 2000;beep;gto 17
24: if Y=Y[I];S[I]→C;gto 27
25: if Y>Y[I];if Y<Y[I+1];S[I]→C;gto 27
26: I+1→I;gto 24
27: DC→L[N];N+1→N;1→I;gto 17
28: 1→I
29: prt "→LATERAL DIST.→";spc
30: for Z=1 to N-2
31: prt L[Z]/100
32: next Z
33: 0→D
34: dsp "LONG DISPLACEMENT";beep;wait 1500;beep
35: spc ;prt "→→LONG DISP.→→";spc
36: ent "# OF POSITIONS ?",r11
37: dsp "DIGITIZE POSITION #",1;red 4,A,B;beep
38: 2.54A→A;2.54B→B
39: for R=1 to r11-1
40: dsp "DIGITIZE POSITION #",R+1;red 4,X,Y;beep
41: 2.54X→X;2.54Y→Y
42: √((X-A)^2+(Y-B)^2)→L
43: r5+r4((B+Y)/2)→C
44: prt "LONG",CL/100
45: CL/100+D→D;prt "ACC",D;spc
46: X→A;Y→B
47: next R
48: ent "LONG DISP. O.K. ? (1=Yes)",E
49: if E≠1;0→D;prt "REPEAT";gto 35
50: dsp "PRESS 'RUN' TO CONTINUE NEXT CAR"
51: end
*11492
```

APPENDIX I

program 2.

Computation of Parameters

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University of Alberta.

Hansel Wang, Department of Civil Engineering,

University OF ALBERTA.

PURPOSE

The purpose of Program 2 is to compute the velocities and accelerations from the lateral and longitudinal displacements and subsequently display them graphically.

program Structure

The program consists of two subprograms A, and B. Subprogram 2A is written in algol, from the input data of lateral and longitudinal displacements, the velocities and accelerations (by second) of a vehicle are computed. The parameters thus obtained will be kept in a data file.

Subprogram 2B is written in fortran. It reads in the parameters computed by subprogram 2A and by calling the Subroutine CGPL in * Applot, the parameters will then be plotted.

```
BEGIN

  COMMENT DATA DEFINITION STARTS HERE;

  COMMENT  CARX(x,y,z) is lateral displacement,
           CARY(x,y,z) is longitudinal displacement,
           both of them are three dimension arrays,
           where x = alternative no.
                 y = car no.
                 z = at t sec                      ;

  REAL ARRAY CARX, CARY  (1::10,1::30,1::15);

  COMMENT LATV(x,y,z) is the lateral velocity
          LONGV(x,y,z) is the longitudinal velocity
          LATA(x,y,z)  is the lateral acceleration
          LONGA(x,y,z) is the longitudinal acceleration;

  REAL ARRAY LATV, LATA (1::10,1::30,1::15);
  REAL ARRAY LONGV, LONGA (1::10,1::30,1::15);

  COMMENT TIME(x,y) is the time consumed for each car
          DENSITY (x,y) is the density for each car
                  where x is the alternative no.
                        y is the car no.           ;

  INTEGER ARRAY TIME, DENSITY (1::10, 1::50);
  REAL ARRAY MDLAT, MDLONG (1::10, 1::15);
  REAL ARRAY STDLAT, STDLONG (1::10, 1::15);
  REAL ARRAY MVLAT, MVLONG, MALAT, MALONG (1::10, 1::15);
  REAL ARRAY STVLAT, STVLONG, STALAT, STALONG (1::10, 1::15);
  REAL ARRAY MEANDX, MEANVX, MEANAX (1::15);
  REAL ARRAY MEANDY, MEANVY, MEANAY (1::15);
  STRING (80) ARRAY X (1::9);
  STRING (80) ARRAY Y  (1::14);

  COMMENT TOM IS THE TYPE OF MANUEVER
          AP means A.M. or P.M.
          ANO is the alternative number;

  INTEGER TOM, AP, ANO;

  INTEGER ARRAY CN  (1::10);
  INTEGER ALT, TS, TEMP , I, J, K, AN, LOC;

  COMMENT NOOFALT is the number of alternatives used in
                  each location;
  INTEGER NOOFALT;
  STRING ( 80 ) ALTR ;
  INTEGER CT1, CT2, CT3, CT4,CT5,CT6;
  REAL SUM1,SUM2,SUM3,SUM4,SUM5,SUM6;
  STRING (50)  ARRAY TYPE, APPEAR (1::3) ;

 ALGOL, ' '

 PROCEDURE PRINT_FRONT_PAGE;
 BEGIN
   IOCONTROL( 3);
   FOR A:=1 UNTIL 21 DO WRITE("  ");
   PUT (6,"50X,A25","THE UNIVERSITY OF ALBERTA");
```

```
      WRITE ("   ");
      WRITE ("   ");
      PUT (6,"47X,A11","DEPARTMENT OF CIVIL ENGINEERING");
      WRITE ("   ");
      WRITE ("   ");
      PUT (6,"29X,A40,A30",
           "EVALUATION OF PAVEMENT MARKING PATTERNS ",
           "IN MERGING AND DIVERGING AREAS");
      WRITE ("   ");
      WRITE ("   ");
      PUT (6,"55X,A14","DATA INVENTORY");
    END;

  $TITLE,' '

    PROCEDURE PRINT_INFO;
    BEGIN
      PUT (6,"4X,A27,X,A80","LOCATION : ",X(LOC));
      WRITE ("   ");
      PUT (6,"4X,A27,X,A20","TYPE OF MANEUVER : ",TYPE(MAN));
      WRITE("   ");
      PUT (6,"4X,A27,X,A50","TIME : ",APPEAK(AP));
      WRITE("   ");
      PUT (6,"4X,A27,X,A80",
           "PAVEMENT MARKING PATTERN : ",
           Y(ALT));
    END PRINTINFO;


  $TITLE,'  READ AND PRINT DISPLAEMENTS'

    PROCEDURE READ_DATA(INTEGER VALUE AN1);
      FOR JJ:=1 UNTIL CN(AN1) DO
        BEGIN

          READ (DENSITY(AN1,JJ),TIME(AN1,JJ));
          FOR TS:= 1 UNTIL TIME(AN1,JJ) DO
            READON (CARX(AN1,JJ,TS));
          FOR TS:=1 UNTIL TIME(AN1,JJ) DO
              READON (CARY(AN1,JJ,TS));

        END;



    PROCEDURE PRINT_DISPLACEMENTS(INTEGER VALUE AN2);
      BEGIN
        PRINT_PAGE_HEAD(1,AN2);
        FOR I:=1 UNTIL CN(AN2) DO
          BEGIN
            PUT (6,"2X,12,12X",I);
            FOR TS:=1 UNTIL 15 DO
              IF  CARX(AN2,I,TS) ~= 0
                  THEN   PUTON (6,"X,F6.2", CARX (AN2,I,TS) )
                  ELSE   PUTON (6,"7X");
            PUTON(6,"3X,I3",DENSITY(AN2,I));
          END;
          PRINT_MEANS(MDLAT(*,*),AN2);
          PRINT_DEVIATIONS (STDLAT(*,*),AN2);
```

```
          PRINT_PAGE_HEAD(2,AN2);
          FOR I:=1 UNTIL CN(AN2) DO
            BEGIN
              PUT (6,"2X,I2,12X", I );
              FOR IS:=1 UNTIL 15 DO
                IF CARY (AN2,I,IS) ~= 0
                    THEN  PUTON (6,"X,F6.2", CARY (AN2,I,IS) )
                    ELSE  PUTON (6,"7X");
              PUTON(6,"1X,I1",DENSITY(AN2,I));
            END;

        WRITE (" ");
        WRITE (" MEAN");
        PUTON (6,"11X");
        FOR I:=1 UNTIL 15 DO PUTON (6,"X,F6.2",MULONG(AN2,I));
        WRITE (" ");
        WRITE ("STANDARD");
        PUT (6,"A9,7X","DEVIATION");
        FOR I:=1 UNTIL 15 DO PUTON(6,"X,F6.2",STLONG(AN2,I));

      END;
    @TITLE,'
    PROCEDURE PRINT_PAGE_HEAD(INTEGER VALUE P; INTEGER VALUE Q );
     BEGIN
      STRING (95) TITLE;
      IOCONTROL(3);
      PUT (6,"107X,A21","---------------------");
      PUT (6,"107X,A21","UNIVERSITY OF ALBERTA");
      PUT (6,"107X,A21","DEPT. OF CIVIL  ENG.");
      PUT (6,"107X,A21","PROJECT    #    1 0 9");
      PUT (6,"107X,A21","---------------------");
      PRINT_INFO;
      WRITE (" ");
      CASE P OF
        BEGIN
          TITLE := "LATERAL DISPLACEMENT (M.) OF VEHICLE";
          TITLE := "LONGITUDINAL DISPLACEMENT (M.) OF VEHICLE";
          TITLE := "LATERAL VELOCITIES (M/SEC) OF VEHICLE";
          TITLE := "LONGITUDINAL VELOCITIES (M/SEC) OF VEHICLE";
          TITLE := "LATERAL ACCELERATIONS (M/S-S) OF VEHICLE";
          TITLE := "LONGITUDINAL ACCELERATIONS (M/S-S) OF VEHICLE";
        END;
      CASE P OF
      BEGIN
        TITLE(36|50) :=
            " WITH RESPECT TO A REFERENCE LINE ON THE ROADWAY ";
        TITLE(41|50) :=
            " WITH RESPECT TO A REFERENCE POINT ON THE ROADWAY";
        TITLE (50|20) := "                 ";
        TITLE (50|20) := "                 ";
        TITLE (50|20) := "                 ";
        TITLE (50|20) := "                 ";
      END;
      WRITE ("  ");
      FOR JJ:=1 UNTIL 126 DO WRITEON ("*");
      PUT (6,"2X,A1,124X,A1","*","*");
      PUT(6,"2X,A9,I2,A1,I1,1X,A95,16X,A1","* TABLE",Q,".",
            P,TITLE,"*");
      PUT (6,"2X,A1,10X,A10,A21,A11,72X,A1",
            "*","AFTER EACH",
```

```
          " CONSECUTIVE INTERVAL",
          " (1 SECOND)","*");
      PUT (6,"2X,A1,124X,A1","*","*");
      WRITE (" ");
      FOR JJ:=1 UNTIL 126 DO WRITEON ("*");
      WRITE ("  CAR  ");
      PUT(6,"A8,127,I1","SURVEYED",1);
      FOR JJ:=2 UNTIL 15 DO PUTON (6,"5X,I2",JJ);
      PUTON (6,"3X,A7","DENSITY");
      PUT(6,"X,A6,43X,A10,61X,A10","NUMBER","( SECOND )","(VEH./KM)");
      WRITE ("-");
      FOR JJ:=1 UNTIL 128 DO WRITEON ("-");
    END;

 @TITLE,'  CALCULATE AND PRINT VELOCITIES'

   PROCEDURE CALCULATE_VELOCITIES(INTEGER VALUE AN3);
     FOR I:=1 UNTIL CN(AN3) DO
     BEGIN
       LATV(AN3,I,1):=CARX(AN3,I,1);
       TS:=1;
       WHILE CARX(AN3,I,TS+1) ¬= 0 DO
       BEGIN
         LATV(AN3,I,TS+1) := CARX(AN3,I,TS+1) -CARX(AN3,I,TS);
         TS := TS + 1 ;
       END;
       LONGV(AN3,I,1):=CARY(AN3,I,1);
       TS := 1 ;
       WHILE CARY(AN3,I,TS+1) ¬= 0 DO
       BEGIN
         LONGV(AN3,I,TS+1) :=CARY(AN3,I,TS+1) - CARY(AN3,I,TS);
         TS := TS + 1 ;
       END;
     END;


   PROCEDURE PRINT_VELOCITIES(INTEGER VALUE AN4);
     BEGIN
       PRINT_PAGE_HEAD (3,AN4);
       FOR I := 1 UNTIL CN(AN4) DO
         BEGIN
         PUT(6,"2X,I2,12X",I);
         FOR TS:=2 UNTIL 15 DO
           IF LATV(AN4,I,TS) ¬= 0
              THEN  PUTON (6,"X,F6.2",LATV(AN4,I,TS))
              ELSE  PUTON (6,"7X");
         PUTON(6,"9X,I1",DENSITY(AN4,I));
         END;
       MEANSONE  (MVLAT(*,*),AN4);
       DEVIATIONSONE (STVLAT(*,*),AN4);

       PRINT_PAGE_HEAD(4,AN4);
       FOR I:=1 UNTIL CN(AN4) DO
         BEGIN
         PUT(6,"2X,I2,12X",I);
         FOR TS:=1 UNTIL 15 DO
           IF LONGV(AN4,I,TS) ¬= 0
             THEN  PUTON (6,"X,F6.2",LONGV(AN4,I,TS))
             ELSE  PUTON (6,"7X");
         PUTON(6,"3X,I3",DENSITY(AN4,I));
```

```
            END;
        PRINT_MEANS (AVLONG(*,*),ANG);
        PRINT_DEVIATIONS (STVLONG(*,*),ANG);
    END;
%TITLE,'   CALCULATE AND PRINT ACCELERATIONS'

    PROCEDURE CALCULATE_ACCELERATIONS (INTEGER VALUE ANS);
      FOR I:=1 UNTIL CN(ANS) DO
        BEGIN
          TS := 2 ;
          WHILE LATV (ANS,I,TS+1) ¬= 0 DO
            BEGIN
              LATA (ANS,I,TS+1) := (  LATV(ANS,I,TS+1)**2
                       -(LATV(ANS,I,TS)**2))/(2*LATV(ANS,I,TS+1));
              TS := TS + 1 ;
            END;
          TS := 1 ;
          WHILE LONGV(ANS,I,TS+1) ¬= 0 DO
            BEGIN
              LONGA(ANS,I,TS+1) := (  LONGV(ANS,I,TS+1)**2
                       -(LONGV(ANS,I,TS)**2))/(2*LONGV(ANS,I,TS+1));
              TS := TS + 1 ;
            END;
        END;


    PROCEDURE PRINT_ACCELERATIONS(INTEGER VALUE ANG);
      BEGIN
        PRINT_PAGE_HEAD (5,ANG);
        FOR I:=1 UNTIL CN(ANG) DO
          BEGIN
            PUT(6,"2X,I2,12X",I);
            FOR TS:=3 UNTIL 15 DO
              IF LATA(ANG,I,TS) ¬= 0
                THEN  PUTON (6,"X,F6.2", LATA(ANG,I,TS) )
                ELSE  PUTON (6,"7X");
            PUTON(6,"15X,I P",DENSITY(ANG,I));
          END;
        MEANSTWO (MALAT(*,*),ANG);
        DEVIATIONSTWO (STALAT(*,*),ANG);

        PRINT_PAGE_HEAD (6,ANG);
        FOR I:=1 UNTIL CN(ANG) DO
          BEGIN
            PUT(6,"2X,I2,12X",I);
            FOR TS:= 2 UNTIL 15 DO
              IF LONGA(ANG,I,TS) ¬= 0
                THEN  PUTON (6,"X,F6.2",LONGA(ANG,I,TS))
                ELSE  PUTON (6,"7X");
            PUTON(6,"9X,I3",DENSITY(ANG,I));
          END;
        MEANSONE (MALONG(*,*),ANG);
        DEVIATIONSONE (STALONG(*,*),ANG);
      END;




%TITLE,'   CALCULATE MEANS   '
```

```
PROCEDURE CALCULATE_MEANS (INTEGER VALUE AN7);
  FOR J:=1 UNTIL 15 DO
  BEGIN
    INTEGER C1,C2,C3,C4,C5,C6;
    REAL S1,S2,S3,S4,S5,S6;
    REAL T1,T2,T3,T4,T5,T6;
    C2:=C1:=C3:=C4:=C5:=C6:=0;
    S1:=S2:=S3:=S4:=S5:=S6:=0;
    T1:=T2:=T3:=T4:=T5:=T6:=0;
    FOR I:=1 UNTIL CN(AN7) DO
      BEGIN
        IF CARX(AN7,I,J) ¬= 0 THEN
          BEGIN
            S1 :=S1+CARX(AN7,I,J);
            T1 :=T1+ (CARX(AN7,I,J)**2);
            C1 :=C1+1;
          END;
        IF CARY(AN7,I,J) ¬= 0 THEN
          BEGIN
            S2 := S2 + CARY (AN7,I,J) ;
            T2 := T2 + (CARY(AN7,I,J)**2);
            C2 := C2 + 1 ;
          END;

        IF LATV(AN7,I,J) ¬= 0 THEN
          BEGIN
            S3 := S3 + LATV(AN7,I,J) ;
            T3 := T3 + (LATV(AN7,I,J)**2);
            C3 := C3 + 1 ;
          END;

        IF LONGV(AN7,I,J) ¬= 0 THEN
          BEGIN
            S4 := S4 + LONGV(AN7,I,J) ;
            T4 := T4 + (LONGV(AN7,I,J)**2);
            C4 := C4 + 1 ;
          END;

        IF LATA (AN7,I,J) ¬= 0 THEN
          BEGIN
            S5 := S5 + LATA(AN7,I,J) ;
            T5 := T5 + (LATA(AN7,I,J)**2);
            C5 := C5 + 1 ;
          END;

        IF LONGA (AN7,I,J) ¬= 0 THEN
          BEGIN
            S6 := S6 + LONGA (AN7,I,J) ;
            T6 := T6 + (LONGA(AN7,I,J)**2);
            C6 := C6 + 1 ;
          END;
      END;

%TITLE,' ';
    IF S1 ¬= 0 THEN MDLAT  (AN7,J) := S1 / C1 ;
    IF S2 ¬= 0 THEN MDLONG (AN7,J) := S2 / C2 ;
    IF S3 ¬= 0 THEN MVLAT  (AN7,J) := S3 / C3 ;
    IF S4 ¬= 0 THEN MVLONG (AN7,J) := S4 / C4 ;
```

```
      IF S5 ¬= 0 THEN MALAT  (AN7,J) := S5 / C5 ;
      IF S6 ¬= 0 THEN MALONG (AN7,J) := S6 / C6 ;

      IF T1 ¬= 0 THEN
         STDLAT  (AN7,J) := SQRT (ABS( (T1/C1) - (MDLAT (AN7,J)**2)));
      IF T2 ¬= 0 THEN
         STDLONG (AN7,J) := SQRT (ABS( (T2/C2) - (MDLONG(AN7,J)**2)));
      IF T3 ¬= 0 THEN
         STVLAT  (AN7,J) := SQRT (ABS( (T3/C3) - (MVLAT (AN7,J) **2)));
      IF T4 ¬= 0 THEN
         STVLONG (AN7,J) := SQRT (ABS( (T4/C4) - (MVLONG(AN7,J)** 2)));
      IF T5 ¬= 0 THEN
         STALAT  (AN7,J) := SQRT (ABS( (T5/C5) - (MALAT (AN7,J)**2)));
      IF T6 ¬= 0 THEN
         STALONG (AN7,J) := SQRT (ABS( (T6/C6) - (MALONG(AN7,J)**2)));

    END;



  TITLE,'  '

   PROCEDURE PRINT_MEANS(REAL ARRAY MNS (*,*); INTEGER VALUE AN8);
      BEGIN
       WRITE (" ");
       WRITE(" MEAN");
       PUTON (6,"11X");
       FOR I:=1 UNTIL 15 DO
          PUTON (6,"X,F6.2",MNS(AN8,I));
    END;

   PROCEDURE PRINT_DEVIATIONS (REAL ARRAY STD (*,*);
                               INTEGER VALUE AN11);
      BEGIN
         WRITE (" ");
         WRITE ("STANDARD");
         PUT (6,"A9,7X","DEVIATION");
         FOR I:=1 UNTIL 15 DO PUTON(6,"X,F6.2",STD(AN11,I));
      END;

  PROCEDURE MEANSONE (REAL ARRAY MNSONE(*,*);INTEGER VALUE ANONE8);
    BEGIN
      WRITE (" ");
      WRITE (" MEAN");
      PUTON (6,"11X");
      FOR I:=2 UNTIL 15 DO
          PUTON (6,"X,F6.2",MNSONE(ANONE8,I));
     END;
  PROCEDURE DEVIATIONSONE (REAL ARRAY STDONE (*,*);INTEGER VALUE ANONE11);
    BEGIN
       WRITE("  ");
       WRITE("STANDARD");
       PUT (6,"A9,7X","DEVIATION");
       FOR I:=2 UNTIL 15 DO PUTON(6,"X,F6.2",STDONE(ANONE11,I));
    END;
  PROCEDURE MEANSTWO (REAL ARRAY MNSTWO(*,*);INTEGER VALUE ANTWO1);
    BEGIN
      WRITE ("  ");
```

```
      WRITE (" MEAN");
      PUTON (6,"11X");
      FOR I:=1 UNTIL 15 DO
        PUTON(6,"X,F6.2",MEANNO(ANSWER6,I));
    END;
  PROCEDURE DEVIATIONSTWO(REAL ARRAY STDTWO(*,*);INTEGER VALUE ANSWER);
    BEGIN
      WRITE("   ");
      WRITE ("STANDARD");
      PUT (6,"A9,7X","DEVIATION");
      FOR I:=1 UNTIL 15 DO PUTON(6,"X,F6.2",STDTWO(ANTWOLL,I));
    END;
  @TITLE,'    '

    PROCEDURE WRITE_DATA (INTEGER VALUE AN9);
      BEGIN
        PUT (4,"I2,X,I3,X,I2",LOC,ALT,CN(AN9));
        FOR A := 1 UNTIL 30 DO
        BEGIN
          PUT (4,"X,F6.2",CARX(AN9,A,1));
          FOR B := 2 UNTIL 15 DO
            PUTON (4,"X,F6.2,",CARX(AN9,A,B));
        END;
        FOR A:=1 UNTIL 30 DO
        BEGIN
          PUT (4,"X,F6.2",CARY(AN9,A,1));
          FOR B:=2 UNTIL 15 DO
            PUTON (4,"X,F6.2",CARY(AN9,A,B));
        END;
        FOR A := 1 UNTIL  30 DO
        BEGIN
          PUT (4,"X,F6.2,",LATV(AN9,A,1));
          FOR B := 2 UNTIL 15 DO
            PUTON (4,"X,F6.2",LATV(AN9,A,B));
        END;
        FOR A:=1 UNTIL 30 DO
        BEGIN
          PUT (4,"X,F6.2",LONGV(AN9,A,1));
          FOR B := 2 UNTIL 15 DO
            PUTON (4,"X,F6.2",LONGV(AN9,A,B));
        END;
        FOR A := 1 UNTIL 30 DO
        BEGIN
          PUT (4,"X,F6.2",LATA(AN9,A,1));
          FOR B := 2 UNTIL 15 DC
            PUTON (4,"X,F6.2",LATA(AN9,A,B));
        END;
        FOR A:=1 UNTIL 30 DO
        BEGIN
          PUT (4,"X,F6.2",LATA(AN9,A,1));
          FOR B:=2 UNTIL 15 DO
            PUTON (4,"X,F6.2",LONGA(AN9,A,I));
        END;
    END;
  @TITLE,'  INITIATION'

    PROCEDURE INITIATION;
      BEGIN
        FOR I := 1 UNTIL 15 DO
          BEGIN
```

```
        FOR I := 1 UNTIL 10 DO
        BEGIN
          FOR K := 1 UNTIL 10 DO
            BEGIN
              CARX(I,K,J):=CARY(I,K,J):=0;
              LATV(I,K,J):=LONGV(I,K,J):=0;
              LATA(I,K,J):=LONGA(I,K,J):=0;
            END;
          MDLAT(I,J):=MDLONG(I,J):=0;
          MVLAT(I,J):=MVLONG(I,J):=0;
          MALAT(I,J):=MALONG(I,J):=0;
          STDLAT(I,J):=STDLONG(I,J):=0;
          STVLAT(I,J):=STVLONG(I,J):=0;
          STALAT(I,J):=STALONG(I,J):=0;
        END;
        MEANDX(J):=MEANVX(J):=MEANAX(J):=0;
        MEANDY(J):=MEANVY(J):=MEANAY(J):=0;
      END;
     X(1):="ON QUESNELL BRIDGE (WEST BOUND) FROM FOX DRIVE";
     X(2):="ON FOX DRIVE (EAST BOUND) FROM QUESNELL BRIDGE";
     X(3):="ON WHITEMUD FREEWAY (EAST BOUND) WEST OF STATION 114 FROM
 149 ST";
     X(4):="ON WHITEMUD FREEWAY (EAST BOUND) TO FOX DRIVE";
     X(5):="ON WHITEMUD FREEWAY(WEST BOUND) TO 149 ST";
     X(6):="ON FOX DRIVE (WEST BOUND) TO QUESNELL BRIDGE";
     X(7):="ON FOX DRIVE EXITING RAMP (WEST BOUND) TO QUESNELL BRIDGE";
     X(8):="ON WHITEMUD FREEWAY (WEST BOUND) TO 159 ST";
     X(9):="ON WHITEMUD FREEWAY (WEST BOUND) TO FOX DRIVE";

     Y(1):="CANADIAN STANDARD (1)                                  ";
     Y(2):="CANADIAN STANDARD (2)                                  ";
     Y(3):="20 CM.           (1)                                   ";
     Y(4):="20 CM.           (2)                                   ";
     Y(5):="20 CM. OPEN      (1)                                   ";
     Y(6):="20 CM. OPEN      (2)                                   ";
     Y(7):="20 CM. CLOSE     (1)                                   ";
     Y(8):="20 CM. CLOSE     (2)                                   ";
     Y(9):="30 CM.           (1)                                   ";
     Y(10):="30 CM.          (2)                                   ";
     Y(11):="30 CM. OPEN     (1)                                   ";
     Y(12):="30 CM. OPEN     (2)                                   ";
     Y(13):="30 CM. CLOSE    (1)                                   ";
     Y(14):="30 CM. CLOSE    (2)                                   ";

     TYPE (1) := "MERGING" ;
     TYPE (2) := "DIVERGING";
     TYPE (3) := "THROUGH MOVEMENT";
     APPEAK (1) := "A.M. PEAK 6:45 - 8:15 ";
     APPEAK (2) := "P.M. PEAK 3:45 - 5:15 ";

     END;
 @TITLE,'  '
   PROCEDURE PRINT_MEANS_OF_MEANS;
     BEGIN
       IOCONTROL(3);
       PUT (6,"107X,A21","---------------------");
       PUT (6,"107X,A21","UNIVERSITY OF ALBERTA");
       PUT (6,"107X,A21","DEPT. OF  CIVIL  ENG.");
       PUT (6,"107X,A21","PROJECT    #    1 0 9");
       PUT (6,"107X,A21","---------------------");
```

```
        WRITE ("  ");
        FOR JJ:=1 UNTIL 126 DO WRITECH ("*");
        PUT (6,"2X,A1,124X,A1","*","*");
        PUT (6,"2X,A1,2X,A37,A9,76X,A1",
             "*","TABLE OF STANDARD DEVIATION AND MEANS",
             " OF MEANS",
             "*");
        PUT (6,"2X,A1,124X,A1","*","*");
        WRITE ("  ");
        FOR JJ:=1 UNTIL 126 DO WRITECH ("*");
        WRITE ("  ");
        PUT (6,"20X,I1",0);
        FOR JJ:=1 UNTIL 15 DO PUTON (6,"5X,I2",JJ);
        PUT (6,"50X,A10","( SECOND )");
        WRITE ("-");
        FOR JJ:=1 UNTIL 128 DO WRITECH("-");
        WRITE ("  ");
        WRITE ("MEANS OF");
        PUT (6,"A16","LATERAL       ");
        FOR I:=1 UNTIL 15 DO
          PUTON (6,"X,F6.2",MEANDX(I));
        WRITE ("DISPL. MEANS");
        WRITE (" ");
        WRITE ("MEANS OF");
        PUT (6,"A16","LONGITUDINAL");
        FOR I:=1 UNTIL 15 DO
          PUTON (6,"X,F6.2",MEANDY(I));
        WRITE ("DISPL. MEANS");
        WRITE (" ");
        WRITE ("MEANS OF");
        PUT (6,"A16","LATERAL");
        FOR I:=1 UNTIL 15 DO
          PUTON (6,"X,F6.2",MEANVX(I));
        WRITE ("VELOCITY MEANS");
        WRITE ("  ");
        WRITE ("MEANS OF ");
        PUT (6,"A16","LONGITUDINAL");
        FOR I:=1 UNTIL 15 DO
          PUTON (6,"X,F6.2",MEANVY(I));
        WRITE ("VELOCITY MEANS");
        WRITE (" ");
        WRITE ("MEANS OF");
        PUT (6,"A16","LATERAL");
        FOR I:=1 UNTIL 15 DO

          PUTON (6,"X,F6.2",MEANAX(I));
        WRITE ("ACC. MEANS");
        WRITE (" ");
        WRITE ("MEANS OF ");
        PUT (6,"A16","LONGITUDINAL");
        FOR I:=1 UNTIL 15 DO
          PUTON (6,"X,F6.2",MEANAY(I));
        WRITE ("ACC. MEANS");
      END;
  $TITLE,'  '
  PROCEDURE WRITE_DEVIATIONS;
   BEGIN

    FOR K:=1 UNTIL 10 DO
      BEGIN
```

```
        PUT(4,"X,F6.2",STDLAT(K,1));
        FOR I:=2 UNTIL 15 DO
             PUTON(4,"X,F6.2",STDLAT(K,I));
     END;

     FOR K:=1 UNTIL 10 DO
       BEGIN
        PUT (4,"X,F6.2",STDLONG(K,1));
        FOR I:=2 UNTIL 15 DO
             PUTON(4,"X,F6.2",STDLONG(K,I));
       END;

     FOR K:=1 UNTIL 10 DO
       BEGIN
        PUT(4,"X,F6.2",STVLAT(K,1));
        FOR I:=2 UNTIL 15 DO
             PUTON (4,"X,F6.2",STVLAT(K,I));
       END;

     FOR K:=1 UNTIL 10 DO
       BEGIN
        PUT (4,"X,F6.2",STVLONG(K,1));
        FOR I:=2 UNTIL 15 DO
             PUTON(4,"X,F6.2",STVLONG(K,I));
       END;

     FOR K:=1 UNTIL 10 DO
       BEGIN
        PUT (4,"X,F6.2",STALAT(K,1));
        FOR I:=2 UNTIL 15 DO
             PUTON (4,"X,F6.2",STALAT(K,I));
       END;
     FOR K:=1 UNTIL 10 DO
       BEGIN
        PUT (4,"X,F6.2",STALONG(K,1));
        FOR I:=2 UNTIL 15 DO
            PUTON(4,"X,F6.2",STALONG(K,I));
       END;

   END;
   @TITLE,'  '
    PROCEDURE WRITE_MEANS;
      BEGIN
        FOR K:=1 UNTIL 10 DO
          BEGIN
               PUT (4,"X,F6.2",MDLAT(K,1));
               FOR I:=2 UNTIL 15 DO
                    PUTON(4,"X,F6.2",MDLAT(K,I));
          END;

       FOR K:=1 UNTIL 10 DO
         BEGIN
             PUT (4,"X,F6.2",MDLONG(K,1));
             FOR I:=2 UNTIL 15 DO
                  PUTON(4,"X,F6.2",MDLONG(K,I));
         END;

       FOR K:=1 UNTIL 10 DO
         BEGIN
             PUT (4,"X,F6.2",MVLAT(K,1));
```

```
                FOR I:=2 UNTIL 15 DO
                    PUTON (4,"X,F6.2",MVLAT(K,I));
            END;

         FOR K:=1 UNTIL 10 DO
           BEGIN
                PUT (4,"X,F6.2",MVLONG(K,1));
                FOR I:=2 UNTIL 15 DO
                    PUTON (4,"X,F6.2",MVLONG(K,I));
            END;

         FOR K:=1 UNTIL 10 DO
           BEGIN
                PUT (4,"X,F6.2",MALAT(K,1));
                FOR I:=2 UNTIL 15 DO
                    PUTON (4,"X,F6.2",MALAT(K,I));
            END;

         FOR K:=1 UNTIL 10 DO
           BEGIN
                PUT (4,"X,F6.2",MALONG(K,1));
                FOR I:=2 UNTIL 15 DO
                    PUTON (4,"X,F6.2",MALONG(K,I));
            END;
         END;
#TITLE,'   MAIN PROGRAM'


      INITIATION;

      PRINT_FRONT_PAGE;

      READ ( NOOPALT );

      PUT (4,"I2",NOOPALT);

      FOR ANO:=1 UNTIL NOOPALT DO
      BEGIN


        GET (5,"I2,I2,I2",LOC,ALT,CR(ANO));

        GET(5,"I1,I1",TCM,AP);

        READ_DATA(ANO);

        CALCULATE_VELOCITIES(ANO);

        CALCULATE_ACCELERATIONS(ANO);

        CALCULATE_MEANS(ANO);

        PRINT_DISPLACEMENTS(ANO);

        PRINT_VELOCITIES    (ANO);

        PRINT_ACCELERATIONS(ANO);

        WRITE_DATA(ANO);
```

```
   END;
WRITE_MEANS;
WRITE_DEVIATIONS;
WRITE(,' ')
  COMMENT
        STARTS HERE :
                     CALCULATE MEAN OF MEANS,
                     PRINT MEAN OF MEANS,
                     AND WRITE OUT MEANS TO FILE;


  FOR I:=1 UNTIL 15 DO
  BEGIN
    SUM1:=SUM2:=SUM3:=SUM4:=SUM5:=SUM6:=0;
    CT1:=CT2:=CT3:=CT4:=CT5:=CT6:=0;
    FOR J:=1 UNTIL 10 DO
      BEGIN
        IF MDLAT(J,I) ¬= 0 THEN
          BEGIN
            SUM1:=SUM1 + MDLAT(J,I) ;
            CT1:= CT1 + 1 ;
          END;
       IF MDLONG(J,I) ¬= 0 THEN
          BEGIN SUM2:= SUM2 + MDLONG(J,I) ;
                CT2 := CT2 + 1;
           END;
       IF MVLAT(J,I) ¬= 0 THEN
          BEGIN SUM3 := SUM3 + MVLAT(J,I);
                CT3 := CT3 + 1 ; END;
       IF MVLONG(J,I) ¬= 0 THEN
          BEGIN SUM4 := SUM4 + MVLONG(J,I);
                CT4 := CT4 + 1 ; END;
       IF MALAT(J,I) ¬= 0 THEN
          BEGIN SUM5 := SUM5 + MALAT(J,I);
                CT5 := CT5 + 1 ; END;
       IF MALONG(J,I) ¬= 0 THEN
          BEGIN SUM6 := SUM6 + MALONG(J,I);
                CT6 := CT6 + 1 ; END;
      END;
    IF SUM1 ¬= 0 THEN MEANDX(I):= SUM1 / CT1;
    IF SUM2 ¬= 0 THEN MEANDY(I):= SUM2 / CT2;
    IF SUM3 ¬= 0 THEN MEANVX(I):= SUM3 / CT3;
    IF SUM4 ¬= 0 THEN MEANVY(I):= SUM4 / CT4;
    IF SUM5 ¬= 0 THEN MEANAX(I):= SUM5 / CT5;
    IF SUM6 ¬= 0 THEN MEANAY(I):= SUM6 / CT6;
    END;
    PUT (4,"F6.2",MEANDX(1));
    FOR I:=2 UNTIL 15 DO PUTON (4,"X,F6.2",MEANDX(I));
    PUT (4,"F6.2",MEANDY(1));
    FOR I:=2 UNTIL 15 DO PUTON (4,"X,F6.2",MEANDY(I));
    PUT (4,"F6.2",MEANVX(1));
    FOR I:=2 UNTIL 15 DO PUTON (4,"X,F6.2",MEANVX(I));
    PUT (4,"F6.2",MEANVY(1));
    FOR I:=2 UNTIL 15 DO PUTON (4,"X,F6.2",MEANVY(I));
    PUT (4,"F6.2",MEANAX(1));
    FOR I:=2 UNTIL 15 DO PUTON (4,"X,F6.2",MEANAX(I));
    PUT (4,"F6.2",MEANAY(1));
    FOR I:=2 UNTIL 15 DO PUTON (4,"X,F6.2",MEANAY(I));
```

```
        PRINT_MEANS_OF_MEANS;

        IOCONTROL(3);
        WRITE (" ");

    END.
END OF FILE
```

```
      REAL*4   CARX(10,30,15),CARY(10,30,15)
      INTEGER  CN,TSEC
      DIMENSION  CN(10),TSEC(10)
      REAL*4   LATV(10,30,15),LONGV(10,30,15)
      REAL*4   LATA(10,30,15),LONGA(10,30,15)
      REAL*4   MDLAT(10,15),MDLONG(10,15)
      REAL*4   MVLAT(10,15),MVLONG(10,15)
      REAL*4   MALAT(10,15),MALONG(10,15)
      REAL*4   STDLAT(10,15),STDLNG(10,15)
      REAL*4   STVLAT(10,15),STVLNG(10,15)
      REAL*4   STALAT(10,15),STALNG(10,15)
      REAL*4   MEAND(15),MEANV(15),MEANA(15)
      INTEGER  ALT,ALTNO,ALTC
      REAL*4   X,Y
      INTEGER  ALTR
      REAL*4   INCMT
      INTEGER AN
      DIMENSION ALPH1(20),ALPH2(20),ALPH3(20),ALPH4(20),
     *ALPH5(20),ALPH6(20)
      DIMENSION YSH(15),YSL(15)
      DIMENSION YP(15),XP(15)
      DIMENSION IOP(10)
      DIMENSION S(6,6)
      DATA IOP/0,1,0,999,0,0,0,0,0,0/
C-----------------------------------------------------------C
C      REQUEST INTERACTIVE PLOTTING MODE                    C
C-----------------------------------------------------------C
C      CALL CGPEP2(7,IOP)                                   C
C-----------------------------------------------------------C
C-----------------------------------------------------------C
C      READ NO OF ALTERNATIVES                              C
C-----------------------------------------------------------C
      READ(5,99) ALTNO
 99   FORMAT (I3)
      DO 1330 AN=1,ALTNO
      CONTINUE
C***********************************************************C
C                                                           C
C      READ DATA                                            C
C                                                           C
C***********************************************************C
C
C
C-----------------------------------------------------------C
C      READ TITLE INFORMATION                               C
C-----------------------------------------------------------C
      READ (5,50) IOC,ALTR,CN(AN)
 50   FORMAT (I3,I4,I3)
C-----------------------------------------------------------C
C      READ IN DATA OF CARS OF ONE ALTERNATIVES             C
C-----------------------------------------------------------C
C
C
C-----------------------------------------------------------C
C      READ DISPLACEMENTS                                   C
C-----------------------------------------------------------C
 1100 J=CN(AN)
      DO 1104 K=1,30
 1104 READ (5,1110) (CARX(AN,K,I),I=1,15)
 1110 FORMAT (1X,15F7.2)
```

```
      DO 1106 K=1,10
1106  REAL (5,1108) (CARY(AN,K,I),I=1,15)
1108  FORMAT (1X,15F7.2)
1120  CONTINUE
1130  CONTINUE
C-----------------------------------------------------------C
C        READ VELOCITIES                                    C
C-----------------------------------------------------------C
1200  DO 1204 K=1,30
1204  REAL (5,1210) (LATV(AN,K,I),I=1,15)
1210  FORMAT (1X,15F7.2)
      DO 1214 K=1,30
1214  READ (5,1216) (LONGV(AN,K,I),I=1,15)
1216  FORMAT (1X,15F7.2)
1220  CONTINUE
1230  CONTINUE
C-----------------------------------------------------------C
C        READ ACCELERATIONS                                 C
C-----------------------------------------------------------C
1300  DO 1304 K=1,30
1304  READ (5,1310) (LATA(AN,K,I),I=1,15)
1310  FORMAT (1X,15F7.2)
      DO 1314 K=1,30
1314  READ (5,1316) (LONGA(AN,K,I),I=1,15)
1316  FORMAT (1X,15F7.2)
1330  CONTINUE
C-----------------------------------------------------------C
C        READ MEANS                                         C
C-----------------------------------------------------------C
1400  DO 1402 K=1,10
1402  REAL (5,1404) (MDLAT(K,I),I=1,15)
1404  FORMAT (1X,15F7.2)
C
1410  DO 1412 K=1,10
1412  READ (5,1414) (MDLONG(K,I),I=1,15)
1414  FORMAT (1X,15F7.2)
C
1420  DO 1422 K=1,10
1422  REAL (5,1424) (MVLAT(K,I),I=1,15)
1424  FORMAT (1X,15F7.2)
C
1430  DO 1432 K=1,10
1432  FEAD (5,1434) (MVLONG(K,I),I=1,15)
1434  FORMAT (1X,15F7.2)
C
1440  DO 1442 K=1,10
1442  REAL (5,1444) (MALAT(K,I),I=1,15)
1444  FORMAT (1X,15F7.2)
C
1450  DO 1452 K=1,10
1452  READ (5,1454) (MALONG(K,I),I=1,15)
1454  FORMAT (1X,15F7.2)
C-----------------------------------------------------------C
C        READ STANDARD DEVIATIONS                           C
C-----------------------------------------------------------C
1500  DO 1502 K=1,10
1502  REAL (5,1504) (SDLAT(K,I),I=1,15)
1504  FORMAT (1X,15F7.2)
C
1510  DO 1512 K=1,10
```

```
 1512  READ (5,1514)(STDLNG(K,I),I=1,15)
 1514  FORMAT (1X,15F7.2)
C
 1520  DO 1522 K=1,10
 1522  READ (5,1524)(STVLAT(K,I),I=1,15)
 1524  FORMAT (1X,15F7.2)
C
 1530  DO 1532 K=1,10
 1532  READ (5,1534)(STVLNG(K,I),I=1,15)
 1534  FORMAT (1X,15F7.2)
C
 1540  DO 1542 K=1,10
 1542  READ (5,1544)(STALAT(K,I),I=1,15)
 1544  FORMAT (1X,15F7.2)
C
 1550  DO 1552 K=1,10
 1552  READ (5,1554)(STALNG(K,I),I=1,15)
 1554  FORMAT (1X,15F7.2)
       READ (4,44)ALPH1
       READ (4,44)ALPH2
       READ (4,44)ALPH3
       READ (4,44)ALPH4
       READ (4,44)ALPH5
       READ (4,44)ALPH6
   44  FORMAT (20A4)
       READ (4,45)I1,I2
       READ (4,46)KD,KV,KA
       READ (4,45)KR,KS
   46  FORMAT (3I1)
       READ (4,47)((S(I,J),J=1,6),I=1,6)
   47  FORMAT (6E15.0)
   45  FORMAT (2I1)
       REAL XX(15)/1.0,2.0,3.0,4.0,5.0,6.0,7.0,8.0,9.0,10.0,
      *11.0,12.0,13.0,14.0,15.0/
       DO 9000 AN=I1,I2
C--------------------------------------------------------------------C
C      PLOT LAT.DISPLACEMENT                                         C
C--------------------------------------------------------------------C
C--------------------------------------------------------------------C
C      PLOT ONE CURVE FOR EACH CAR (LAT. DISP.)                      C
C--------------------------------------------------------------------C
       NC=CN(AN)
       IF (KD.LT.1) GOTO 299
       IF (KR.LT.1) GOTO 102
       DO 100 NP=1,NC
       NFF=2
       ND=0
       DO 101 I=1,15
       YY=CAPX(AN,NP,I)
       IF (YY.EQ.0.0) GOTO 101
       ND=ND+1
       YP(ND)=YY
       XP(ND)=XX(I)
  101  CONTINUE
       IF (NP.LT.2) NFF=1
       CALL CGPL (XP,YP,YP,ND,NFF,1,1,4,1,S(1,1),S(1,2),S(1,3),
      *S(1,4),S(1,5),S(1,6),ALPH1,6)
  100  CONTINUE
C--------------------------------------------------------------------C
C      PLOT MEAN AND STANDARD DEVIATIONS                             C
```

```
C-----------------------------------------------------------------C
      ND=0
  102 CONTINUE
      IF (KS.LT.1) GOTO 199
      DO 1012 I=1,15
      YY=MCLAT(AN,I)
      IF (YY.EQ.0.0) GOTO 1012
      ND=ND+1
      YP(ND)=YY
      XP(ND)=XX(I)
      YSD=STDLAT(AN,I)
      YSH(ND)=YY+YSD
      YSL(ND)=YY-YSD
 1012 CONTINUE
      CALL CGPL (XP,YP,YP,ND,1,1,1,14,1,S(1,1),S(1,2),S(1,3),
     *S(1,4),S(1,5),S(1,6),ALPH1,6)
      CALL CGPL (XP,YSH,YSH,ND,2,1,1,4,1,S(1,1),S(1,2),S(1,3),
     *S(1,4),S(1,5),S(1,6),ALPH1,6)
      CALL CGPL (XP,YSL,YSL,ND,3,1,1,4,1,S(1,1),S(1,2),S(1,3),
     *S(1,4),S(1,5),S(1,6),ALPH1,6)
C-----------------------------------------------------------------C
C      PLOT LONG.DISPLACEMENT                                     C
C-----------------------------------------------------------------C
C-----------------------------------------------------------------C
C      PLOT ONE CURVE FOR EACH CAR (LONG. DISP.)                  C
C-----------------------------------------------------------------C
  199 CONTINUE
      IF (KB.LT.1) GOTO 203
      DO 200 NF=1,NC
      NFF=2
      ND=0
      DO 201 I=1,15
      YY=CARY(AN,NF,I)
      IF (YY.EQ.0.0) GOTO 201
      ND=ND+1
      YP(ND)=YY
      XP(ND)=XX(I)
  201 CONTINUE
      IF (NF.LT.2) NFF=1
      CALL CGPL (XP,YP,YP,ND,NFF,1,1,4,1,S(2,1),S(2,2),S(2,3),
     *S(2,4),S(2,5),S(2,6),ALPH2,6)
  200 CONTINUE
C-----------------------------------------------------------------C
C      PLOT MEAN AND STANDARD DEVIATIONS                          C
C-----------------------------------------------------------------C
  203 CONTINUE
      IF (KS.LT.1) GOTO 299
      ND=0
      DO 202 I=1,15
      YY=MCLONG(AN,I)
      IF (YY.EQ.0.0) GOTO 202
      ND=ND+1
      YP(ND)=YY
      XP(ND)=XX(I)
      YSD=STDLNG(AN,I)
      YSH(ND)=YY+YSD
      YSL(ND)=YY-YSD
  202 CONTINUE
      CALL CGPL (XP,YP,YP,ND,1,1,1,14,1,S(2,1),S(2,2),S(2,3),
     *S(2,4),S(2,5),S(2,6),ALPH2,6)
```

```
      CALL CGPL (XP,YSH,YSH,ND,2,1,1,4,1,S(2,1),S(2,2),S(2,3),
     *S(2,4),S(2,5),S(2,6),ALPH2,6)
      CALL CGPL (XP,YSL,YSL,ND,3,1,1,4,1,S(2,1),S(2,2),S(2,3),
     *S(2,4),S(2,5),S(2,6),ALPH2,6)
C-----------------------------------------------------------C
C       PLOT LAT.VELOCITY                                    C
C-----------------------------------------------------------C
C-----------------------------------------------------------C
C       PLOT ONE  CURVE FOR EACH CAR (LAT. VEL.)             C
C-----------------------------------------------------------C
  299 CONTINUE
      IF (KS.LT.1) GOTO 30?
      IF (KV.LT.1) GOTO 499
      DO 300 NF=1,NC
      NFF=2
      ND=0
      DO 301 I=1,15
      YY=LATV(AN,NF,I)
      IF (YY.EQ.0.0) GOTO 301
      ND=ND+1
      YP(ND)=YY
      XP(ND)=XX(I)
  301 CONTINUE
      IF (NF.LT.2) NFF=1
      CALL CGPL (XP,YP,YP,ND,NFF,1,1,4,1,S(3,1),S(3,2),S(3,3),
     *S(3,4),S(3,5),S(3,6),ALPH3,6)
  300 CONTINUE
C-----------------------------------------------------------C
C       PLOT MEAN AND STANDARD DEVIATIONS                    C
C-----------------------------------------------------------C
  303 CONTINUE
      IF (KS.LT.1) GOTO 399
      ND=0
      DO 302 I=1,15
      YY=MVLAT(AN,I)
      IF (YY.EQ.0.0) GOTO 302
      ND=ND+1
      YP(ND)=YY
      XP(ND)=XX(I)
      YSD=STVLAT(AN,I)
      YSH(ND)=YY+YSD
      YSL(ND)=YY-YSD
  302 CONTINUE
      CALL CGPL (XP,YP,YP,ND,1,1,1,14,1,S(3,1),S(3,2),S(3,3),
     *S(3,4),S(3,5),S(3,6),ALPH3,6)
      CALL CGPL (XP,YSH,YSH,ND,2,1,1,4,1,S(3,1),S(3,2),S(3,3),
     *S(3,4),S(3,5),S(3,6),ALPH3,6)
      CALL CGPL (XP,YSL,YSL,ND,3,1,1,4,1,S(3,1),S(3,2),S(3,3),
     *S(3,4),S(3,5),S(3,6),ALPH3,6)
C-----------------------------------------------------------C
C       PLOT LONG.VELOCITY                                   C
C-----------------------------------------------------------C
C-----------------------------------------------------------C
C       PLOT ONE  CURVE FOR EACH CAR (LONG VEL.)             C
C-----------------------------------------------------------C
  399 CONTINUE
      IF (KR.LT.1) GOTO 401
      DO 400 NF=1,NC
      NFF=2
      ND=0
```

```
      DO 401 I=1,15
      YY=LONGV(AN,NF,I)
      IF (YY.EQ.0.0) GOTO 401
      ND=ND+1
      YP(ND)=YY
      XP(ND)=XX(I)
  401 CONTINUE
      IF (NF.LT.2) NFF=1
      CALL CGPL (XP,YP,YP,ND,NFF,1,1,4,1,S(4,1),S(4,2),S(4,3),
     *S(4,4),S(4,5),S(4,6),ALPH4,6)
  400 CONTINUE
C-------------------------------------------------------------------C
C       PLOT MEAN AND STANDARD DEVIATIONS                           C
C-------------------------------------------------------------------C
  403 CONTINUE
      IF (KS.LT.1) GOTO 499
      ND=0
      DO 402 I=1,15
      YY=MVLONG(AN,I)
      IF (YY.EQ.0.0) GOTO 402
      ND=ND+1
      YP(ND)=YY
      XP(ND)=XX(I)
      YSD=STVLNG(AN,I)
      YSH(ND)=YY+YSD
      YSL(ND)=YY-YSD
  402 CONTINUE
      CALL CGPL (XP,YP,YP,ND,1,1,1,14,1,S(4,1),S(4,2),S(4,3),
     *S(4,4),S(4,5),S(4,6),ALPH4,6)
      CALL CGPL (XP,YSH,YSH,ND,2,1,1,4,1,S(4,1),S(4,2),S(4,3),
     *S(4,4),S(4,5),S(4,6),ALPH4,6)
      CALL CGPL (XP,YSL,YSL,ND,3,1,1,4,1,S(4,1),S(4,2),S(4,3),
     *S(4,4),S(4,5),S(4,6),ALPH4,6)
C-------------------------------------------------------------------C
C       PLOT LAT.ACCELERATION                                       C
C-------------------------------------------------------------------C
C-------------------------------------------------------------------C
C       PLOT ONE CURVE FOR EACH CAR (LAT. ACC.)                     C
C-------------------------------------------------------------------C
  499 CONTINUE
      IF (KA.LT.1) GOTO 699
      IF (KR.LT.1) GOTO 503
      DO 500 NF=1,NC
      NFF=2
      ND=0
      DO 501 I=1,15
      YY=LATA(AN,NF,I)
CCC   IF (YY.EQ.0.0) GOTO 501
      ND=ND+1
      YP(ND)=YY
      XP(ND)=XX(I)
  501 CONTINUE
      IF (NF.LT.2) NFF=1
      CALL CGPL (XP,YP,YP,ND,NFF,1,1,4,1,S(5,1),S(5,2),S(5,3),
     *S(5,4),S(5,5),S(5,6),ALPH5,6)
  500 CONTINUE
C-------------------------------------------------------------------C
C       PLOT MEAN AND STANDARD DEVIATIONS                           C
C-------------------------------------------------------------------C
  503 CONTINUE
```

```
      IF (KS.LT.1) GOTO 599
      ND=0
      DO 502 I=1,15
      YY=MALAT(AN,I)
CCC   IF (YY.EQ.0.0) GOTO 502
      ND=ND+1
      YP(ND)=YY
      XP(ND)=XX(I)
      YSD=STALAT(AN,I)
      YSH(ND)=YY+YSD
      YSL(ND)=YY-YSD
  502 CONTINUE
      CALL CGPL (XP,YP,YP,ND,1,1,1,14,1,S(5,1),S(5,2),S(5,3),
     *S(5,4),S(5,5),S(5,6),ALPH5,6)
      CALL CGPL (XP,YSH,YSH,ND,2,1,1,4,1,S(5,1),S(5,2),S(5,3),
     *S(5,4),S(5,5),S(5,6),ALPH5,6)
      CALL CGPL (XP,YSL,YSL,ND,3,1,1,4,1,S(5,1),S(5,2),S(5,3),
     *S(5,4),S(5,5),S(5,6),ALPH5,6)
C-----------------------------------------------------------C
C       PLOT LONG.ACCERATION                                C
C-----------------------------------------------------------C
C-----------------------------------------------------------C
C       PLOT ONE CURVE FOR EACH CAR (LONG. ACC.)            C
C-----------------------------------------------------------C
  599 CONTINUE
      IF (KR.LT.1) GOTO 603
      DO 600 NF=1,NC
      NPF=2
      ND=0
      DO 601 I=1,15
      YY=LONGA(AN,NF,I)
CCC   IF (YY.EQ.0.0) GOTO 601
      ND=ND+1
      YP(ND)=YY
      XP(ND)=XX(I)
  601 CONTINUE
      IF (NF.LT.2) NPF=1
      CALL CGPL (XP,YP,YP,ND,NPF,1,1,4,1,S(6,1),S(6,2),S(6,3),
     *S(6,4),S(6,5),S(6,6),ALPH6,6)
  600 CONTINUE
C-----------------------------------------------------------C
C       PLOT MEAN AND STANDARD DEVIATIONS                   C
C-----------------------------------------------------------C
  603 CONTINUE
      IF (KS.LT.1) GOTO 699
      ND=0
      DO 602 I=1,15
      YY=MALONG(AN,I)
CCC   IF (YY.EQ.0.0) GOTO 602
      ND=ND+1
      YP(ND)=YY
      XP(ND)=XX(I)
      YSD=STALNG(AN,I)
      YSH(ND)=YY+YSD
      YSL(ND)=YY-YSD
  602 CONTINUE
      CALL CGPL (XP,YP,YP,ND,1,1,1,14,1,S(6,1),S(6,2),S(6,3),
     *S(6,4),S(6,5),S(6,6),ALPH6,6)
      CALL CGPL (XP,YSH,YSH,ND,2,1,1,4,1,S(6,1),S(6,2),S(6,3),
     *S(6,4),S(6,5),S(6,6),ALPH6,6)
```

```
      CALL CGPL (XP,YSL,YSL,ND,3,1,1,4,1,S(6,1),S(6,2),S(6,3),
     *S(5,4),S(6,5),S(6,6),ALPH6,6)
  699 CONTINUE
 9000 CONTINUE
      CALL CGPL (XP,YP,YP,ND,0,1,1,12,1,0.0,3.0,5.0,
     *-10.0,4.0,8.0,ALPH6,6)
      STOP
      END
END OF FILE
```

APPENDIX J

Vehicle Trajectory Survey - Sample of Data Inventory and plottings.

UNIVERSITY OF ALBERTA
DEPT. OF CIVIL ENG.
PROJECT # [illegible]

LOCATION : CP WHITEMUD FREEWAY (EAST BOUND) TO FOX DRIVE

TYPE OF MANEUVER : DIVERGING

TIME : A.M. PEAK 6:45 – 9:15

PAVEMENT MARKING PATTERN : 10 CM. CLOSE (1)

TABLE 3.1 LATERAL DISPLACEMENT (M.) OF VEHICLE WITH RESPECT TO A REFERENCE LINE ON THE ROADWAY AFTER EACH CONSECUTIVE INTERVAL (1 SECOND)

CAR SURVEYED NUMBER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	DENSITY (VEH./KM)
	(SECOND)															
1	2.05	2.31	2.46	2.57	3.19	3.97	4.60	5.58	6.56	7.67	8.74					20
2	2.45	2.57	2.38	2.11	2.03	1.94	2.19	2.38	2.75	2.57						20
3	2.20	2.42	2.30	2.38	2.41	2.61	2.58	2.48	2.59	2.54	2.71	2.76				20
4	2.88	2.40	2.11	2.08	2.22	2.40	2.58	2.56	2.59	2.90	3.27					20
5	2.43	2.49	2.44	2.23	2.24	2.21	2.19	2.26	2.25	2.54	2.45					15
6	2.10	2.06	2.07	1.98	1.94	2.91	2.96	2.26	2.82	2.33	2.46					14
7	2.01	1.74	1.64	1.60	1.66	1.83	2.02	1.97	1.90	1.91	2.05	2.24				15
8	1.47	1.69	1.43	1.46	1.27	1.55	1.35	1.51	1.42	1.56	1.59	2.01	2.24			23
9	2.98	2.33	2.30	2.47	3.94	3.39	4.18	5.92	6.19	6.93	9.08					15
10	2.46	2.29	2.24	2.06	2.22	2.39	2.52	2.59	2.45	2.41	2.44	3.02				20
11	2.64	2.49	2.22	2.12	2.37	2.39	2.10	1.86	1.74	2.22	2.36	2.97				20
12	1.84	1.75	1.58	1.64	1.79	1.60	1.87	2.07	2.24	2.58	2.65	2.66	2.44			20
13	2.86	2.01	1.93	1.58	1.47	2.00	2.28	2.37	2.38	2.77	2.75	2.92	3.95			21
14	1.86	1.61	1.68	1.60	1.98	1.94	2.19	2.35	2.51	2.82	2.86	2.49	3.05			13
15	2.48	2.18	2.24	2.36	2.40	2.48	2.64	2.72	2.61	2.88	2.67	2.81	3.08			19
16	2.31	1.88	2.26	2.59	2.73	2.74	3.13	2.96	2.91	2.70	2.64	2.76	3.32			19
17	1.89	1.97	1.90	1.65	1.76	1.81	1.75	1.89	1.99	1.81	1.75	1.78	2.94			25
	1.51	1.93	1.87	1.74	1.70	1.67	1.59	1.53	1.41	1.55	1.65	1.70	1.85			[illegible]
	2.49	2.27	2.22	2.39	2.64	2.71	2.79	2.56	2.85	2.50	2.43	2.38	2.71			[illegible]
	2.43	2.08	2.15	2.02	1.92	2.12	2.11	2.29	2.14	2.43	2.63					23
	2.22	2.48	2.40	2.48	2.56	2.51	2.60	2.66	2.72	2.52	2.60					20
22	2.36	2.44	2.42	2.50	2.47	2.59	2.44	2.43	2.41	2.39	2.63					20
23	2.15	2.27	2.22	2.45	2.50	2.52	2.53	2.71	2.93	2.93	2.90					20
24	2.65	2.48	2.20	2.39	2.43	2.59	2.49	2.58	2.80	3.13	2.90					20
25	1.75	1.74	1.68	1.40	1.81	1.76	1.90	2.00	2.11	2.91	2.12	2.19	2.21			23
26	2.45	2.42	2.29	2.98	2.18	2.25	2.40	2.49	2.63	2.60	2.65	2.76	2.52			[illegible]
27	2.48	2.51	2.15	2.08	2.22	2.27	2.30	2.48	2.72	3.01	4.12	3.69				25
28	1.02	2.51	2.26	2.08	2.07	2.82	2.65	2.94	3.11	3.09						9
29	1.91	1.63	1.55	1.64	1.45	1.79	1.99	2.27	2.26	2.58						23
30	2.12	1.95	1.58	1.73	1.77	2.14	2.22	2.57	2.43	2.73	[illegible]					12
MEAN	2.19	2.17	2.06	2.05	2.17	[illegible]	2.40	2.58	2.66	2.71	[illegible]	2.56	2.61	0.00	0.00	
STANDARD DEVIATION	[illegible]	[illegible]	[illegible]	[illegible]	0.43	0.51	0.68	0.81	1.17	[illegible]	[illegible]	0.39	0.40	0.00	[illegible]	

UNIVERSITY OF ALBERTA
DEPT. OF CIVIL ENG.
PROJECT # 1 9 9

LOCATION : ON WHITEMUD FREEWAY (EAST BOUND) TO FOX DRIVE

TYPE OF MANEUVRE : DIVERGING

TIME : A.M. PEAK 7:45 - 8:15

PAVEMENT MARKING PATTERN : 30 CM. CLOSE (1)

TABLE 3.3 LATERAL VELOCITIES (M/SEC) OF VEHICLE AFTER EACH CONSECUTIVE INTERVAL*(1 SECOND)

CAR SURVEYED NUMBER	1	2	3	4	5	6 (SECOND)	7	8	9	10	11	12	13	14	15	DENSITY (VEH./KM)
1	0.26	0.14	0.10	0.61	0.78	0.63	0.97	0.98	1.11	1.07						20
2	0.11	-0.18	-0.27	-0.07	-0.09	0.25	0.19	0.36	-0.18							20
3	0.22	-0.11	0.07	0.02	0.19	-0.02	-0.10	0.11	-0.05	0.17	0.05					20
4	0.31	-0.29	-0.02	0.14	0.17	0.18	-0.01	0.02	0.21	0.47						20
5	0.05	-0.05	-0.21	0.01	-0.02	-0.02	0.07	-0.01	0.29	0.31						15
6	-0.03	0.00	-0.18	0.05	0.07	0.05	0.19	0.05	0.01	0.13						18
7	-0.27	-0.09	-0.03	0.05	0.17	0.19	-0.05	-0.07	0.01	0.14	0.18					15
8	0.21	-0.25	0.02	-0.18	0.27	-0.19	0.15	-0.09	0.14	0.02	0.42	-0.22				21
9	0.25	-0.02	0.17	0.56	0.35	0.79	0.84	1.16	0.74	1.15						15
10	-0.17	-0.05	-0.17	0.15	0.17	0.13	0.06	-0.14	-0.03	0.02	0.58					20
11	-0.15	-0.26	-0.10	0.25	-0.06	-0.19	-0.24	-0.11	0.48	0.13	0.51					20
12	-0.09	-0.17	0.06	0.14	-0.10	0.18	0.19	0.17	0.34	0.06	0.01	0.32				20
13	-0.05	-0.07	-0.35	0.29	0.13	0.27	0.09	0.01	0.19	-0.02	0.17	0.13				20
14	-0.25	0.07	-0.07	0.37	-0.03	0.25	0.16	0.15	0.10	0.03	-0.36	0.56				18
15	-0.29	0.05	0.11	0.03	0.07	0.16	0.07	-0.11	0.27	-0.21	0.14	0.26				15
16	-0.43	0.38	0.32	0.13	0.01	0.39	-0.17	-0.05	-0.21	-0.05	0.11	0.26				15
17	0.07	-0.17	-0.15	0.11	0.05	-0.06	0.14	0.09	-0.17	-0.06	0.02	0.26				25
18	0.42	-0.06	-0.13	-0.03	-0.02	-0.07	-0.06	-0.11	0.14	0.09	0.05	0.15				25
19	-0.20	-0.05	0.17	0.25	0.06	0.07	-0.22	0.29	-0.35	-0.06	-0.05	0.32				7
20	0.04	-0.32	-0.12	-0.10	0.19	-0.01	0.18	-0.14	0.29	0.19						23
21	0.15	0.01	0.07	0.08	-0.05	0.09	0.05	0.06	-0.19	0.07						20
22	0.07	-0.01	0.07	-0.13	0.22	-0.15	-0.00	-0.02	-0.01	0.23						20
23	0.12	-0.05	0.22	0.05	0.02	0.00	0.18	0.22	-0.10	0.15						20
24	-0.17	-0.19	0.11	0.03	0.15	-0.10	0.09	0.22	0.32	-0.14						20
25	-0.01	-0.05	-0.28	0.41	-0.05	0.13	0.18	0.02	-0.09	0.10	-0.06	0.02				20
26	-0.02	-0.22	-0.13	0.11	0.06	0.14	0.09	0.14	-0.02	0.04	0.11	-0.23				23
27	0.03	-0.36	-0.10	0.18	0.05	0.06	0.13	0.24	0.39	0.10	-0.56					28
28	-0.51	-0.25	0.21	-0.00	0.34	-0.17	0.29	0.17	-0.07							25
29	-0.27	-0.07	0.09	-0.15	0.34	0.19	0.23	0.03	0.42							28
30	-0.17	-0.16	0.14	0.04	0.36	0.07	0.34	-0.09	0.25	0.26						23
																12
MEAN	-0.02	-0.10	-0.01	0.11	0.12	0.10	0.13	0.11	0.15	0.16	0.16	0.21	0.00	0.00		
STANDARD DEVIATION	0.22	0.15	0.16	0.19	0.18	0.21	0.24	0.28	0.30	0.30	0.24	0.19	0.00	0.00		

UNIVERSITY OF ALBERTA
DEPT. OF CIVIL ENG.
PROJECT # 109

LOCATION : ON WHITEMUD FREEWAY (EAST BOUND) TO FOX DRIVE

TYPE OF MANEUVRE : DIVERGING

TIME : A.M. PEAK 6:45 - 8:15

PAVEMENT MARKING PATTERN : 10 CM. CLOSE (1)

TABLE 3.5 LATERAL ACCELERATIONS (M/S-S) OF VEHICLE AFTER EACH CONSECUTIVE INTERVAL (1 SECOND)

CAR SURVEYED NUMBER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	DENSITY (VEH./KM)
						(SECOND)										
1	-0.15	-0.04	0.30	0.14	-0.16	0.28	0.00	0.12	-0.04							20
2	-0.05	-0.06	0.41	-0.00	0.10	-0.06	0.13	0.29								20
3	0.14	-0.04	-0.09	0.09	0.65	-0.04	0.00	0.09	0.07	-0.26						20
4	0.01	1.38	0.06	0.03	0.00	0.80	0.00	0.10	0.48							20
5	0.01	-0.09	-2.19	-0.01	0.01	0.03	0.23	0.14	0.01							15
6	-0.07	-0.09	-0.27	0.00	-0.02	0.09	-0.30	-0.17	0.06							18
7	0.31	0.10	0.01	0.07	0.01	0.33	-0.01	-0.23	0.06	0.04						15
8	-0.03	-1.11	-0.09	0.07	0.09	-0.04	0.09	0.04	-0.31	0.20	-0.26					23
9	1.02	0.08	0.25	-0.28	0.31	0.04	0.28	-0.55	0.33							15
10	0.26	-0.08	-0.02	0.00	-0.04	-0.08	-0.05	0.22	-0.01	0.28						20
11	-0.09	0.31	0.10	0.41	-0.08	-0.03	0.18	0.22	-0.75	0.23						20
12	-0.06	-0.21	0.06	0.04	0.06	0.00	-0.03	0.12	-0.79	-0.23	0.16					20
13	-0.02	-0.16	-0.06	-0.25	0.10	-0.39	-0.39	0.19	3.79	0.08	-0.04					20
14	-0.41	-0.00	0.18	1.78	0.12	-0.11	-0.00	0.11	-1.18	-0.18	0.15					18
15	-0.72	0.04	-0.15	0.02	0.06	-0.12	-0.02	0.11	0.06	-0.08	0.09					19
16	-0.05	-0.05	-0.31	-0.97	0.19	0.36	0.26	-0.09	0.33	0.04	0.10					19
17	-0.06	0.02	-0.04	-0.09	-0.00	0.05	-0.04	-0.06	0.23	-0.04	0.12					25
18	1.43	-0.05	0.49	0.01	-0.03	0.02	-0.04	0.01	-0.04	-0.07	0.06					25
19	0.41	0.07	0.06	-0.41	0.00	-0.10	0.05	-0.05	0.84	0.02	0.16					7
20	-0.16	0.35	0.03	0.07	1.99	0.08	0.03	0.10	-0.11							23
21	-0.63	0.03	0.00	0.03	0.03	-0.03	0.00	-0.09	-0.20							20
22	0.15	0.03	-0.04	0.07	0.08	1.12	-0.00	0.00	0.11							20
23	0.11	0.10	-0.50	-0.05	-0.01	0.08	0.03	0.19	0.04							20
24	-0.02	-0.12	-0.13	0.07	0.07	-0.01	0.09	0.09	0.31							20
25	-0.02	-0.13	0.10	1.65	0.06	0.03	-0.52	-0.04	0.00	-0.07	-0.04					23
26	-0.10	0.10	-0.02	-0.06	0.05	-0.07	0.04	0.31	0.01	0.04	-0.09					28
27	-0.17	0.53	0.05	-0.29	0.01	0.05	0.07	0.04	-0.32	0.27						25
28	0.39	-0.03	2.41	0.17	0.27	0.09	-0.16	0.71								28
29	0.44	0.00	-0.07	0.11	-0.18	0.02	-0.64	0.20								23
30	-0.14	-0.38	-0.26	0.18	-0.81	0.16	0.73	0.10	0.00							12
MEAN	0.05	0.01	-0.00	0.08	0.09	0.08	-0.00	0.07	0.10	0.01	0.03	0.00	0.00			
STANDARD DEVIATION	0.40	0.36	0.62	0.49	0.41	0.27	0.23	0.20	0.81	0.16	0.13	0.09	0.00			

UNIVERSITY OF ALBERTA
DEPT. OF CIVIL ENG.
PROJECT # 1 0 9

LOCATION : ON WHITEMUD FREEWAY (EAST BOUND) TO FOX DRIVE

TYPE OF MANEUVRE : DIVERGING

TIME : A.M. PEAK 6:45 - 8:15

PAVEMENT MARKING PATTERN : 30 CM. CLOSE (1)

TABLE 3.2 LONGITUDINAL DISPLACEMENT (M.) OF VEHICLE WITH RESPECT TO A REFERENCE POINT ON THE ROADWAY AFTER EACH CONSECUTIVE INTERVAL (1 SECOND)

CAR SURVEYED NUMBER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	DENSITY (VEH./KM)
	(SECOND)															
1	29.41	57.12	82.64	102.39	123.46	138.33	155.97	174.89	196.13	218.82	241.67					20
2	27.02	52.62	74.56	90.39	107.82	129.25	149.57	172.24	198.05	226.08						20
3	28.00	51.66	74.19	93.98	109.32	126.67	148.05	172.78	198.14	226.14	256.78	290.32				20
4	28.86	55.61	75.56	95.06	112.07	128.39	147.85	169.56	193.81	220.22	247.14					20
5	29.80	54.12	75.48	95.41	114.75	134.42	157.58	181.75	205.75	232.78	262.78					15
6	29.09	54.55	74.07	93.56	114.08	130.78	150.70	171.49	194.42	218.77	245.21					18
7	25.39	46.05	68.30	86.27	101.67	119.86	137.92	157.78	181.13	205.19	230.75	258.87				15
8	23.17	46.73	65.47	81.42	99.17	113.24	128.45	145.28	162.78	179.89	199.59	221.88	244.36			23
9	25.74	54.00	77.93	97.89	114.58	132.11	151.12	166.95	185.47	207.10	231.47					15
10	23.55	46.64	66.62	84.76	99.69	117.20	135.14	155.68	173.50	195.25	220.25	246.13				20
11	23.89	45.49	66.97	81.97	96.72	113.64	133.38	152.44	170.81	186.77	206.36	229.38				20
12	24.42	49.87	69.52	86.34	105.48	118.71	133.42	147.74	165.20	186.38	210.49	232.73	252.42			20
13	24.05	45.21	65.59	82.92	97.17	113.98	129.70	148.66	166.23	186.32	209.83	233.85	260.67			20
14	24.39	50.20	70.06	84.87	102.52	120.31	136.55	151.89	170.42	192.59	216.36	242.42	268.54			18
15	25.57	48.28	68.75	85.08	99.46	117.25	132.36	150.70	170.74	192.94	215.23	239.35	264.00			19
16	23.89	48.88	72.75	90.44	105.66	129.32	138.34	158.73	178.67	201.11	227.53	250.91	270.06			19
17	21.45	45.89	64.64	82.00	96.25	110.46	126.28	144.78	163.99	182.95	205.23	226.42	251.10			25
18	28.49	51.87	73.32	90.89	105.19	121.23	136.16	154.41	171.63	189.22	210.62	230.21	252.34			25
19	23.37	47.58	65.64	83.45	98.50	112.72	131.35	148.79	168.73	191.37	215.56	239.64	264.30			7
20	28.60	54.11	76.16	95.46	111.77	130.73	152.10	173.78	196.92	223.70	253.67					21
21	27.85	55.36	79.14	98.17	114.30	133.62	154.20	178.30	205.06	234.08	265.37					20
22	28.00	56.23	78.19	95.17	111.88	131.42	153.73	176.60	209.92	227.09	255.78					20
23	27.87	53.09	75.86	96.89	112.58	132.44	153.08	174.94	199.42	226.82	254.64					20
24	28.49	52.99	73.77	93.89	111.36	128.55	149.59	172.19	195.82	223.25	252.81					20
25	24.28	46.95	69.75	87.13	103.50	118.83	135.69	155.58	175.61	199.84	224.21	250.78	280.28			21
26	-22.35	46.22	66.78	92.66	100.58	114.77	132.22	148.22	167.55	189.53	214.89	239.00	266.86			20
27	27.11	51.42	71.78	89.64	105.96	125.19	141.39	161.23	189.45	201.78	231.07	260.87				25
28	32.69	58.48	81.25	98.31	119.00	137.11	157.94	181.71	209.38	237.06						20
29	27.98	56.95	82.23	101.66	119.57	138.30	159.61	184.61	213.86	246.71						21
30	28.73	52.25	74.09	96.89	116.92	134.09	154.13	177.09	204.25	231.24	261.78					12
MEAN	26.51	51.18	72.70	90.83	107.70	124.79	143.51	163.71	185.49	209.43	232.18	243.32	261.35	0.00	0.00	
STANDARD DEVIATION	2.51	3.97	5.14	6.27	7.47	8.44	10.25	12.52	15.62	19.06	20.39	16.37	9.94	0.00	0.00	

UNIVERSITY OF ALBERTA
DEPT. OF CIVIL ENG.
PROJECT # 1 0 9

LOCATION : ON WHITEMUD FREEWAY (EAST BOUND) TO FOX DRIVE

TYPE OF MANEUVRE : DIVERGING

TIME : A.M. PEAK 6:45 - 8:15

PAVEMENT MARKING PATTERN : 30 CM. CLOSE (1)

TABLE 3.4 LONGITUDINAL VELOCITIES (M/SEC) OF VEHICLE AFTER EACH CONSECUTIVE INTERVAL (1 SECOND)

CAR SURVEYED NUMBER	1	2	3	4	5	6 (SECOND)	7	8	9	10	11	12	13	14	15	DENSITY (VEH./KM)
1	29.41	27.70	25.53	19.75	21.06	14.86	17.64	18.92	21.24	22.69	24.85					20
2	27.02	25.59	21.94	15.83	17.43	21.43	20.31	22.67	25.81	28.03						20
3	28.00	23.65	22.53	19.78	15.34	17.35	21.37	24.73	25.36	28.00	30.64	34.04				20
4	28.86	26.75	19.95	19.50	17.01	16.32	19.45	21.70	24.25	26.41	26.92					20
5	29.80	24.31	21.36	19.93	19.34	19.66	23.16	24.17	24.00	27.03	30.00					15
6	29.09	25.46	19.52	19.40	20.52	16.70	19.92	20.79	22.92	24.35	26.44					13
7	25.39	20.66	22.25	17.97	15.40	18.18	18.06	19.86	23.34	24.06	25.56	28.12				15
8	23.17	23.56	18.74	15.95	17.94	13.87	15.20	16.84	17.49	17.11	19.70	22.29	22.48			23
9	25.74	28.25	23.83	20.06	16.68	17.53	19.00	15.83	18.52	21.83	24.17					15
10	23.55	23.09	19.97	18.17	14.90	17.50	17.94	20.74	17.62	21.75	25.00	25.88				20
11	23.89	21.60	21.48	15.00	14.75	16.92	19.74	19.06	18.37	15.96	19.59	23.02				20
12	24.42	25.45	19.65	16.81	19.14	13.23	14.70	14.32	17.45	21.18	24.11	22.23	19.70			20
13	24.05	21.16	20.37	17.33	14.25	16.80	15.72	18.96	17.56	20.09	23.50	24.02	26.82			20
14	24.39	25.80	19.86	14.80	17.65	17.78	16.24	15.33	18.53	22.10	23.83	26.06	26.12			18
15	25.57	22.70	20.48	16.32	14.30	17.79	15.10	18.34	20.04	22.70	22.28	24.12	24.64			19
16	23.89	24.99	23.87	17.68	15.22	14.66	18.01	20.39	19.94	22.44	26.42	23.30	19.15			19
17	23.45	22.45	18.75	17.36	14.24	14.21	15.81	18.50	19.21	13.95	22.28	21.19	24.68			25
18	28.49	23.37	21.45	17.56	14.30	16.03	14.93	18.25	17.22	17.59	21.39	19.59	22.12			25
19	23.37	24.21	18.06	17.81	15.05	14.22	18.63	17.34	20.03	22.64	24.19	24.08	24.66			7
20	28.60	25.50	22.05	19.30	16.31	18.95	21.37	21.68	23.14	26.77	29.97					23
21	27.85	27.50	23.79	19.03	16.12	19.31	20.58	24.10	26.75	29.02	31.29					20
22	28.00	28.23	21.96	16.98	16.71	19.53	22.31	22.87	24.31	26.08	28.78					20
23	27.87	25.22	22.77	21.03	15.68	19.86	20.64	21.86	24.48	27.40	27.41					20
24	28.49	24.50	20.78	20.12	17.46	17.19	21.03	22.51	23.72	27.43	29.55					20
25	24.28	21.77	23.70	17.37	16.37	15.32	16.77	19.98	20.93	24.23	24.37	26.56	29.59			23
26	22.35	23.87	20.56	15.88	17.92	14.19	17.45	16.00	19.33	21.98	25.35	24.12	27.85			23
27	27.11	24.31	20.36	17.86	16.31	19.23	18.20	17.83	19.22	23.33	27.29	29.90				25
28	32.69	25.78	22.77	17.06	20.69	18.11	20.83	23.77	27.67	27.67						24
29	27.98	28.97	25.28	19.43	17.91	18.73	21.31	25.00	29.25	32.87						23
30	28.73	23.52	21.84	22.81	20.03	17.07	20.13	23.47	26.65	26.98	30.54					12
MEAN	26.51	24.66	21.51	18.13	16.87	17.08	18.72	20.19	21.78	23.94	25.77	24.90	24.34	0.00	0.00	
STANDARD DEVIATION	2.51	2.12	1.36	1.82	1.99	2.03	2.35	2.93	3.46	3.82	3.24	3.42	3.09	0.00	0.00	

UNIVERSITY OF ALBERTA
DEPT. OF CIVIL ENG.
PROJECT # 1 0 9

LOCATION : ON WHITEMUD FREEWAY (EAST BOUND) TO FOX DRIVE

TYPE OF MANEUVRE : DIVERGING

TIME : A.M. PEAK 6:45 - 8:15

PAVEMENT MARKING PATTERN : 30 CM. CLOSE (1)

TABLE 3.6 LONGITUDINAL ACCELERATIONS (M/S-S) OF VEHICLE AFTER EACH CONSECUTIVE INTERVAL (1 SECOND)

CAR SURVEYED NUMBER	1	2	3	4	5	6 (SECOND)	7	8	9	10	11	12	13	14	15	DENSITY (VEH./KM)
1	-1.75	-2.27	-6.62	1.26	-7.47	2.55	1.23	2.19	1.40	2.07						20
2	-1.45	-3.96	-7.28	1.52	3.63	-1.16	2.23	2.94	2.13							20
3	-4.76	-1.14	-2.92	-5.09	1.90	3.63	3.13	0.62	2.51	2.52	3.23					20
4	-2.19	-7.95	-0.45	-2.67	-0.69	2.86	2.14	2.40	2.07	0.51						20
5	-6.09	-3.16	-1.48	-0.58	0.30	3.23	0.98	-0.17	2.86	2.82						15
6	-3.88	-6.84	-0.03	1.00	-4.25	2.95	0.85	2.04	1.37	2.00						18
7	-5.27	1.53	-4.78	-2.77	2.55	-0.11	1.70	3.22	0.70	1.45	2.44					15
8	0.38	-5.43	-3.02	1.87	-4.66	1.28	1.55	0.63	-0.38	2.41	2.43	0.18				21
9	2.40	-4.04	-4.11	-3.73	0.82	1.42	-3.49	2.49	3.05	2.22						15
10	-0.45	-3.37	-1.88	-3.62	2.41	0.42	2.61	-3.39	3.73	3.03	0.86					20
11	-2.41	-0.12	-7.87	-0.25	2.03	2.61	-0.69	-0.70	-2.59	3.29	3.17					20
12	1.00	-6.65	-3.06	2.17	-7.23	1.40	-0.39	2.85	3.39	2.75	-1.94	-2.70				20
13	-3.08	-0.79	-3.31	-3.40	2.34	-1.11	2.96	-1.44	2.36	3.17	0.59	2.66				20
14	1.36	-6.82	-5.91	2.61	0.13	-1.62	-0.92	2.92	3.27	1.66	2.13	0.05				18
15	-3.04	-2.35	-4.69	-2.07	3.99	-2.94	2.95	1.62	2.05	0.08	1.76	0.52				19
16	1.07	-1.13	-7.28	-2.65	-0.57	3.04	2.23	-0.45	2.36	3.69	-3.23	-4.69				19
17	-1.02	-4.06	-1.44	-3.46	-0.03	1.52	2.48	0.69	-0.25	3.07	-1.11	3.24				25
18	-5.66	-2.01	-4.30	-3.64	1.64	-1.15	3.01	-1.06	0.36	3.47	-1.89	2.39				25
19	0.82	-7.19	-0.25	-3.01	-0.85	3.88	-1.32	2.50	2.45	1.50	-0.11	0.57				7
20	-3.27	-3.73	-2.94	-3.26	2.46	2.27	0.31	1.40	3.38	3.02						23
21	-0.34	-4.02	-5.33	-3.18	2.93	1.22	3.26	2.52	2.17	2.19						20
22	0.22	-7.16	-5.71	-0.27	2.62	2.59	0.55	1.40	1.70	2.58						20
23	-2.78	-2.58	-1.80	-6.27	3.74	0.76	1.18	2.47	2.76	0.41						20
24	-4.31	-4.05	-0.66	-2.87	-0.27	3.49	1.42	1.17	3.46	2.03						20
25	-2.65	1.86	-7.49	-1.01	-1.09	1.38	2.95	0.04	1.83	3.13	2.10	2.78				23
26	1.47	-3.57	-5.36	1.92	-4.22	2.95	-1.51	3.04	2.49	3.13	-1.26	3.48				23
27	-2.95	-4.34	-2.67	-1.62	2.69	-1.04	-0.38	1.33	3.74	3.67	2.40					25
28	-7.82	-3.22	-6.66	3.31	-2.76	2.54	2.75	3.62	0.00							28
29	0.97	-3.95	-6.73	-1.58	0.80	2.42	3.41	3.94	3.42							23
30	-5.78	-1.74	0.94	-2.97	-3.21	2.82	3.10	2.99	0.31	3.35						12
MEAN	-2.04	-3.50	-3.84	-1.47	-0.03	1.47	1.34	1.46	2.00	2.30	0.71	0.77	0.00	0.00		
STANDARD DEVIATION	2.62	2.44	2.50	2.43	3.06	1.77	1.71	1.68	1.48	1.04	1.99	2.46	0.00	0.00		

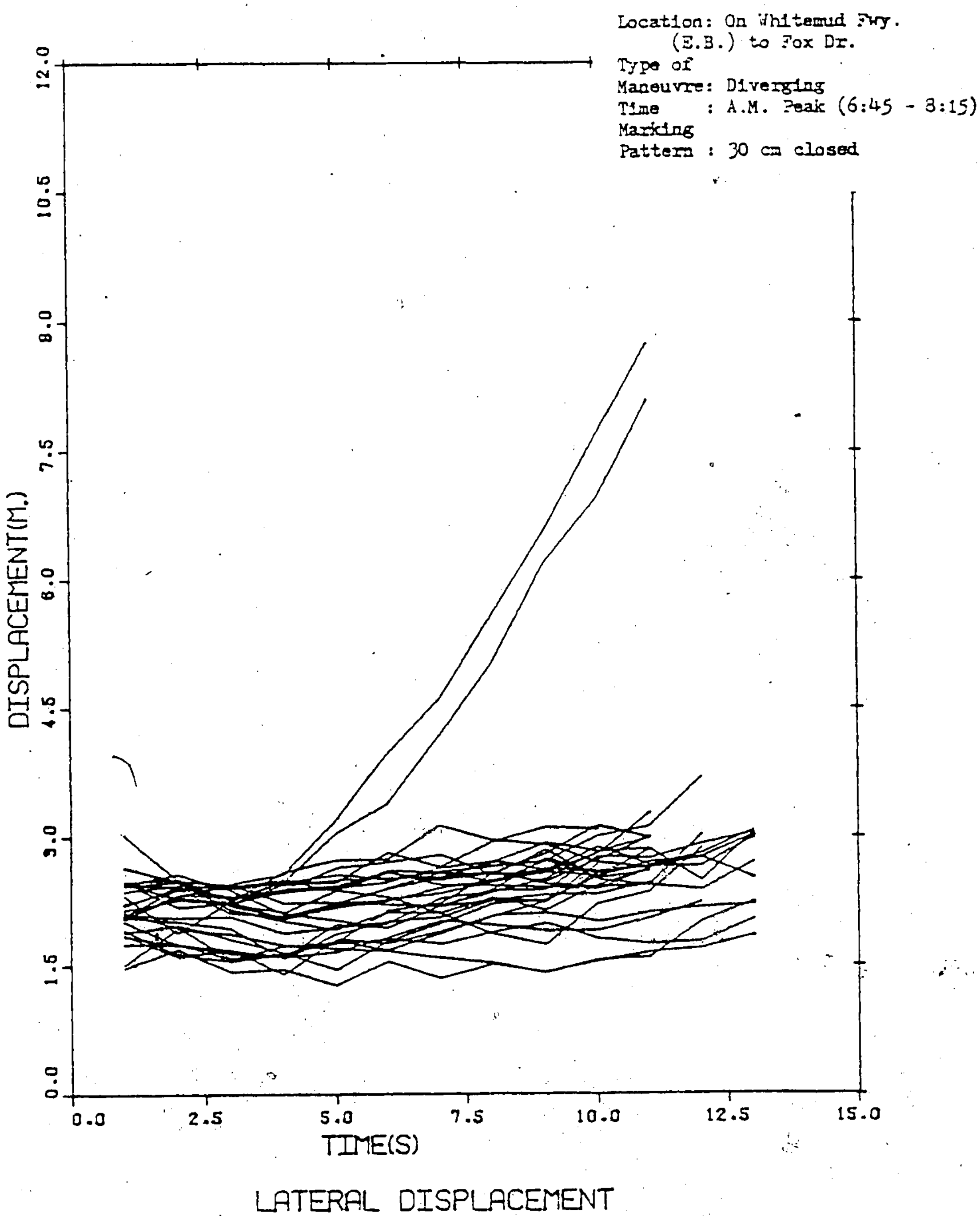


Figure 1

An example of individual vehicle trajectories: lateral displacement.

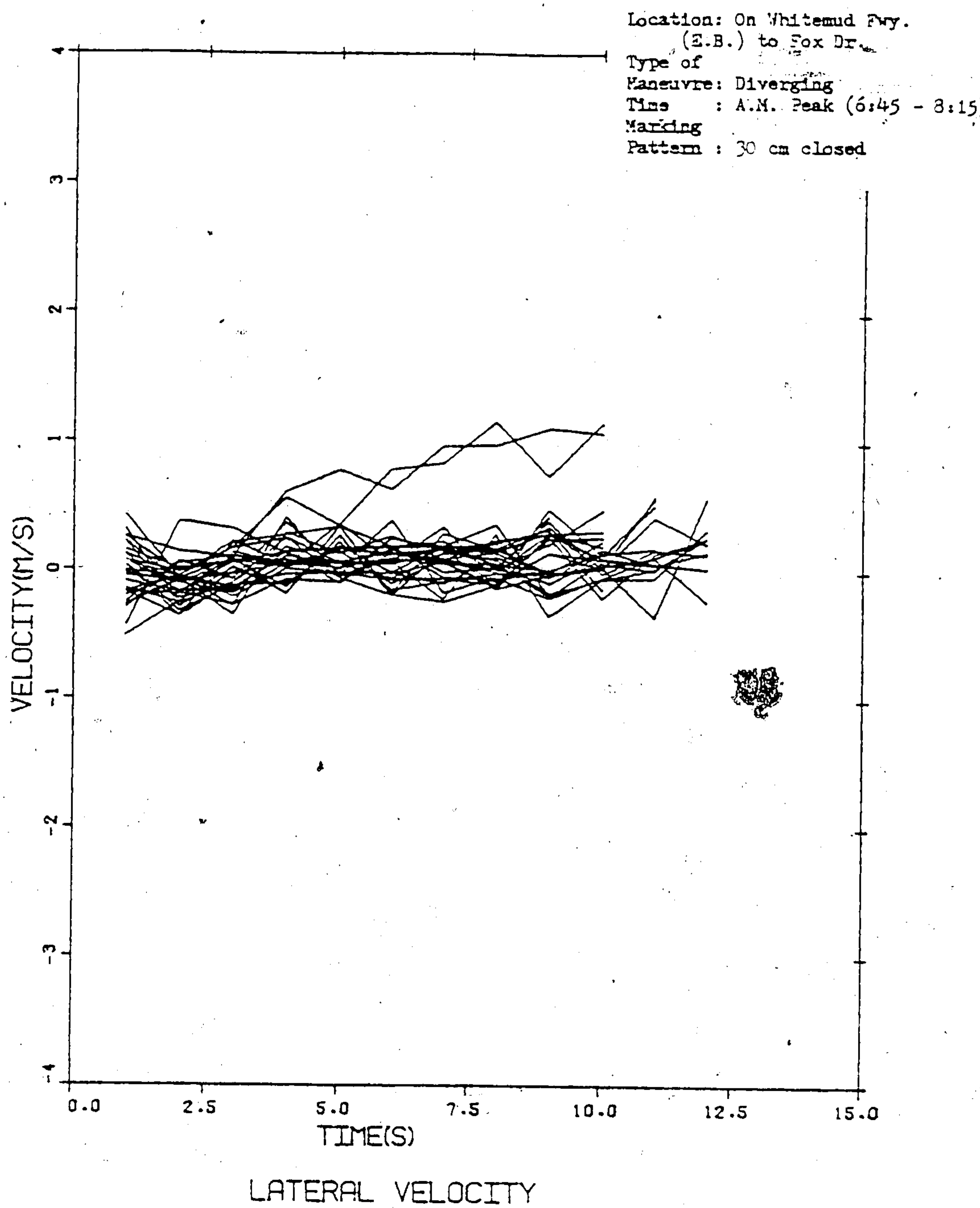


Figure 2

An example of individual vehicle trajectories: lateral velocity.

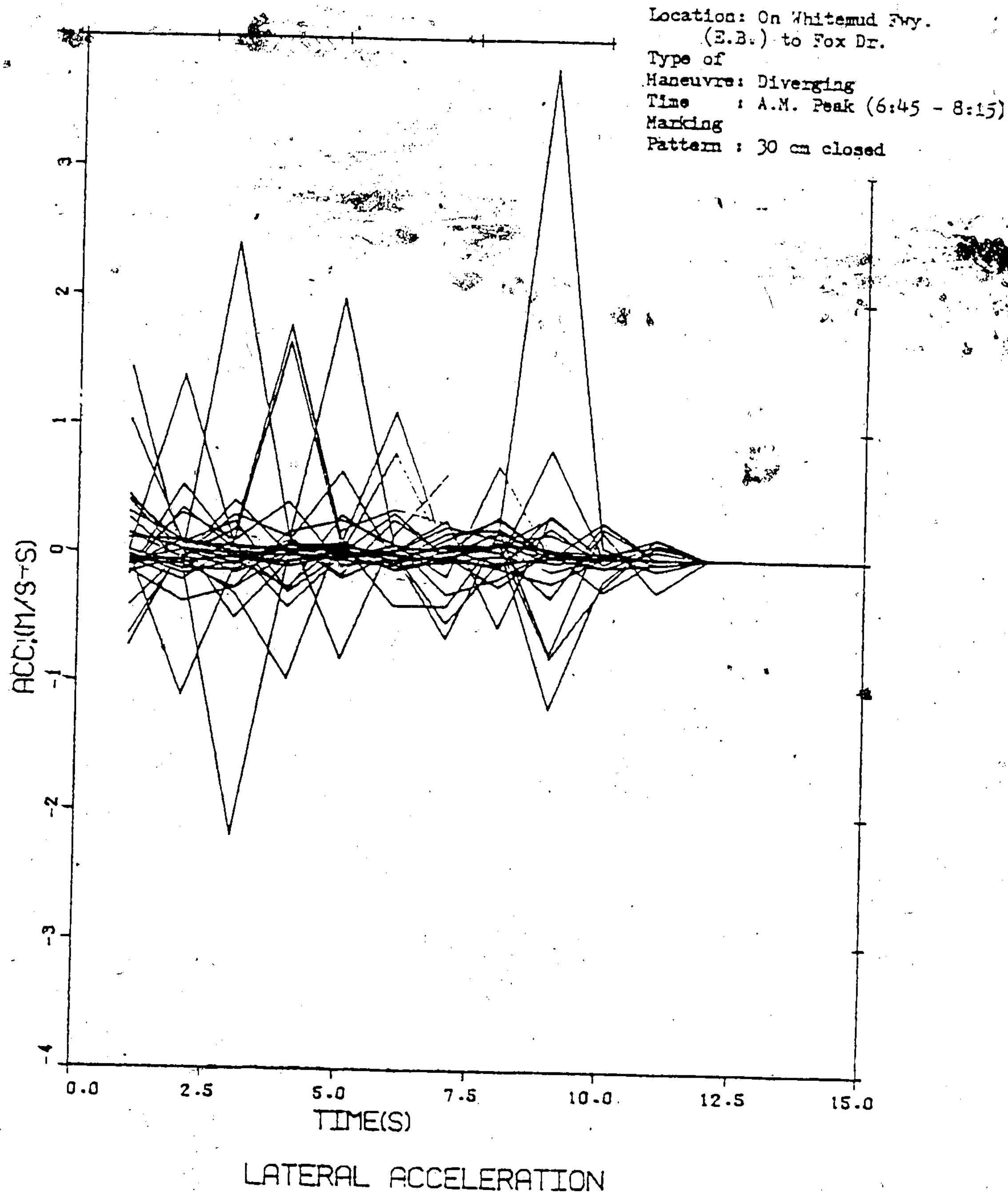


Figure 3

An example of individual vehicle trajectories: lateral acceleration.

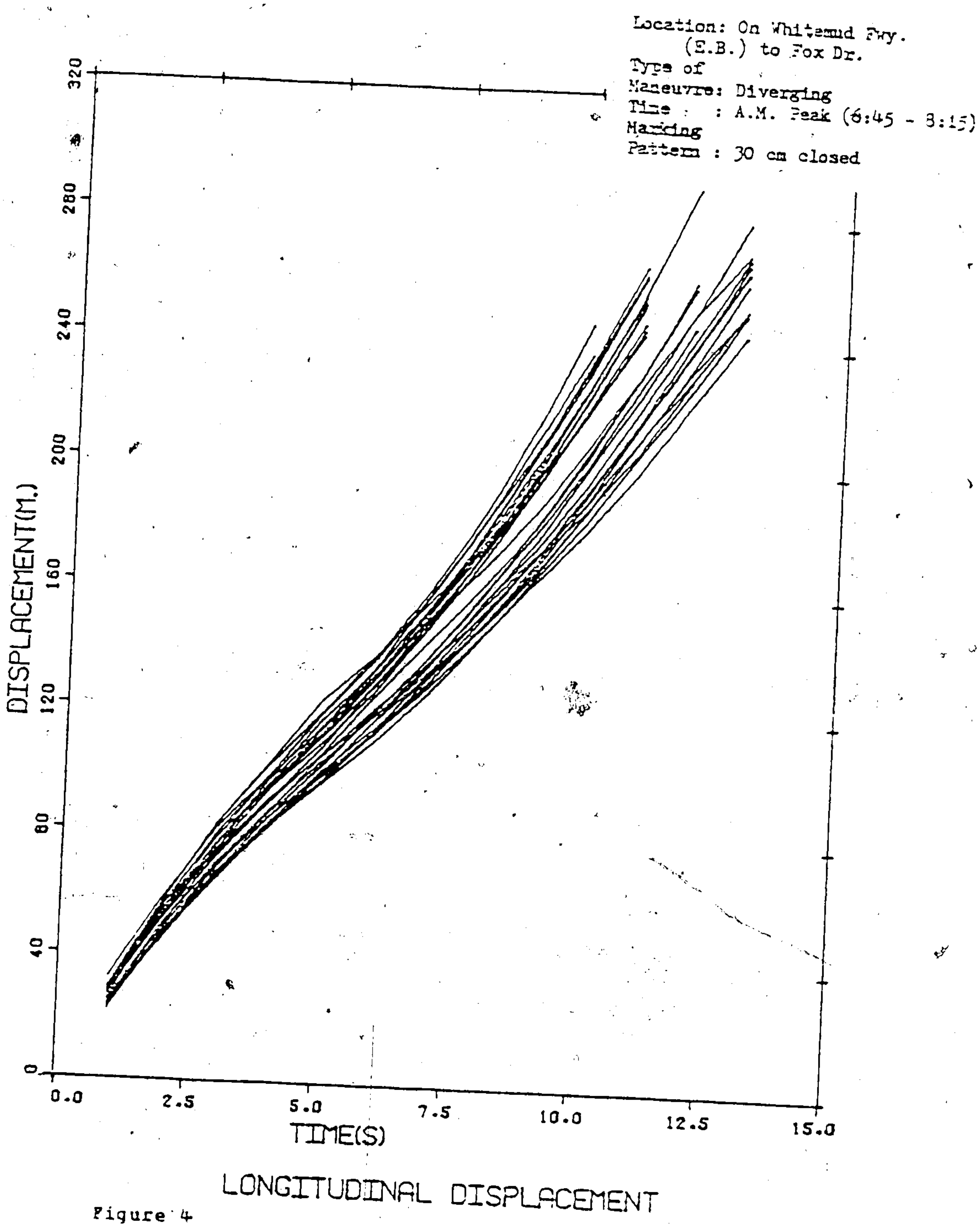
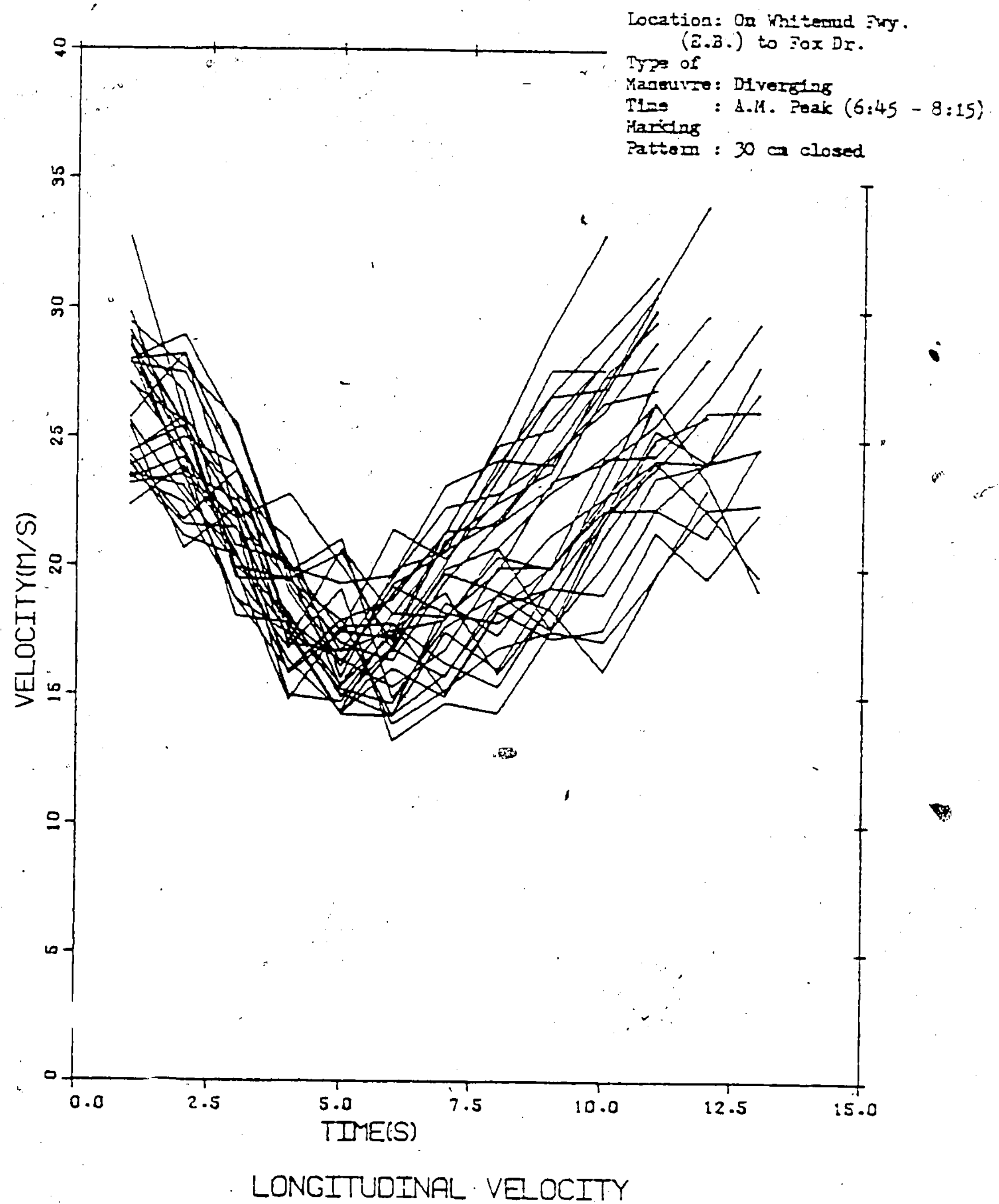


Figure 4

An example of individual vehicle trajectories: longitudinal displacement.



Figure

An example of individual vehicle trajectories: longitudinal velocity.

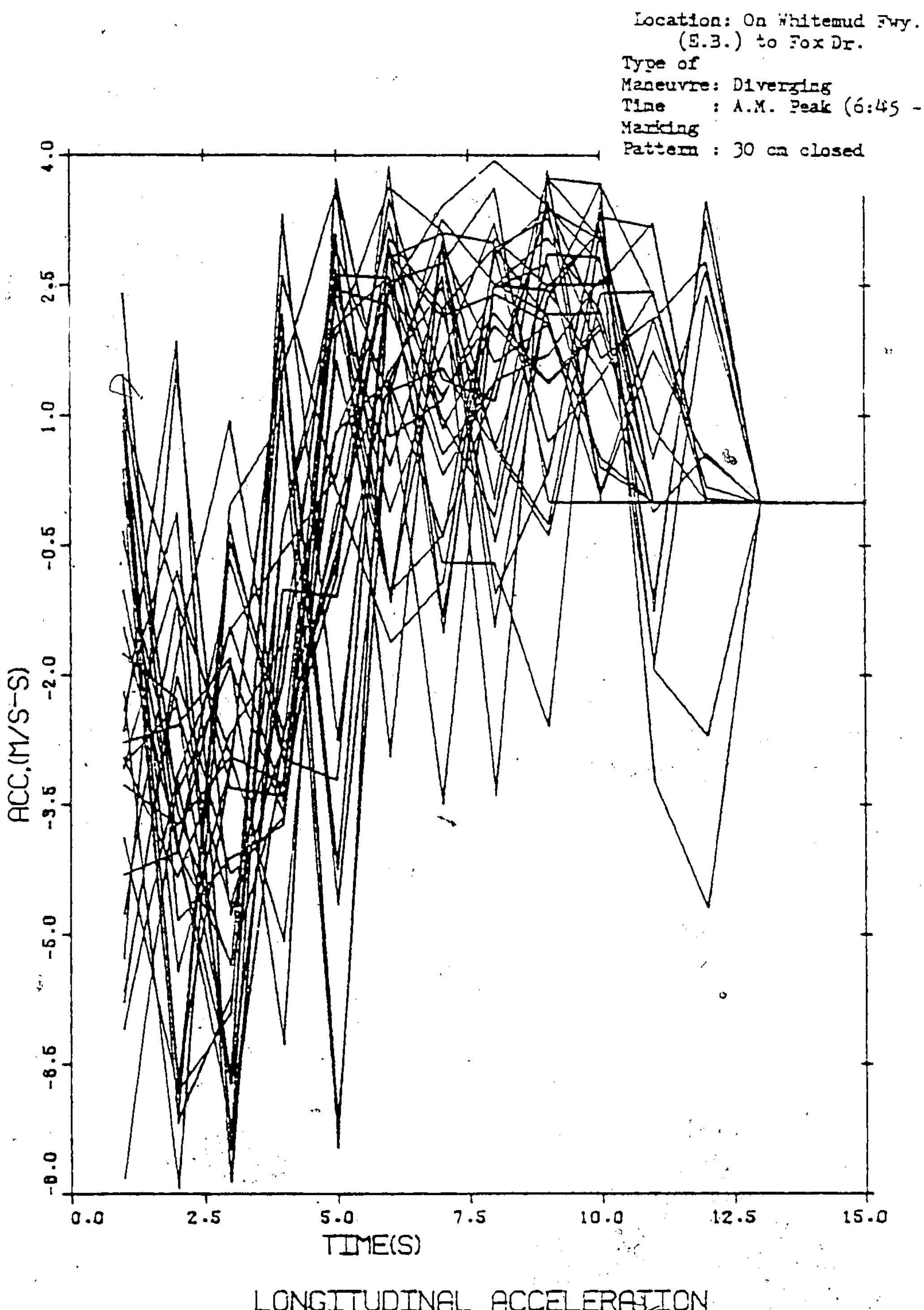


Figure 6 An example of individual vehicle trajectories: longitudinal acceleration.

APPENDIX K

Vehicle Trajectory Survey - Variance Analysis of Lateral Displacement and Longitudinal Velocity

LOCATION: FOX DR. TO WHITEMUD FWY. W.B.
MANEUVER: MERGING
TIME: P.M. PEAK (3.45 - 5.15)

TEST MARKING PATTERN	TRAFFIC MOVEMENT	LATERAL DISPLACEMENT (M)/STANDARD DEVIATION/VARIANCE SECOND AFTER THE BEGINNING OF THE OBSERVATION PERIOD 1	2	3	4	5	6	MEAN VARIANCE
CANADIAN STANDARD	ENTRY	2.98 0.59 0.35	3.03 0.99 0.98	3.18 1.17 1.77	3.39 1.71 2.92	3.82 2.15 4.62	4.31 2.52 6.35	- - 2.83
	THRU	2.77 0.20 0.04	2.94 0.28 0.08	2.97 0.24 0.06	2.94 0.31 0.10	2.85 0.29 0.08	- - -	- - 0.07
20 cm	ENTRY	2.73 0.45 0.20	2.73 0.45 0.20	2.73 0.60 0.36	2.86 0.79 0.62	3.04 0.91 0.83	3.38 1.19 1.42	- - 0.61
	Thru	3.34 0.25 0.07	3.40 0.25 0.06	3.20 0.28 0.08	3.10 0.44 0.19	2.93 0.84 0.71	- - -	- - 0.22
30 cm	ENTRY	3.18 0.64 0.41	3.34 0.96 0.92	3.57 1.24 1.54	3.89 1.46 2.13	4.38 1.74 3.03	4.38 2.01 4.04	- - 2.01
	THRU	3.56 0.37 0.14	3.23 0.40 0.16	3.11 0.87 0.22	3.22 0.64 0.41	3.65 1.01 1.02	- - -	- - 0.39

ENTERING TRAFFIC		THROUGH TRAFFIC	
COMPARISON OF MEAN VARIANCE BETWEEN MARKING PATTERN	F - TEST (5% SIGNIFICANT LEVEL)	COMPARISON OF MEAN VARIANCE BETWEEN MARKING PATTERN	F - TEST (5% SIGNIFICANT LEVEL)
CANADIAN STANDARD - 20 cm	●	CANADIAN STANDARD - 20 cm	o
CANADIAN STANDARD - 30 cm	o	CANADIAN STANDARD - 30 cm	●
20 cm - 30 cm	●	20 cm - 30 cm	o

Legend: ● significant
o not significant

Table 1 VEHICLE TRAJECTORY SURVEY - VARIANCE ANALYSIS OF LATERAL DISPLACEMENT

LOCATION: ON THE RAMP FROM FOX DR. TO WHITEMUD FWY. W.B.
MANEUVER: MERGING
TIME: P.M. PEAK (3.45 - 5.15)

TEST MARKING PATTERN	TRAFFIC MOVEMENT	LATERAL DISPLACEMENT (M)/STANDARD DEVIATION/ VARIANCE/SECOND AFTER THE BEGINNING OF THE OBSERVATION PERIOD								MEAN VARIANCE
		1	2	3	4	5	6	7	8	
NO MARKING	-	4.56	4.81	4.88	4.65	4.73	4.73	4.54	4.42	-
		1.64	1.56	1.53	1.53	1.55	1.51	1.43	1.45	-
		2.69	2.43	2.34	2.34	2.40	2.28	2.04	2.10	2.33
CANADIAN STANDARD	-	5.64	5.45	5.30	5.39	5.47	5.67	5.82	5.68	-
		1.48	1.66	1.52	1.57	1.59	1.60	1.48	1.34	-
		2.19	2.76	2.31	2.46	2.53	2.56	2.19	1.80	2.35
20 cm closed	-	3.93	4.46	4.94	4.97	5.13	5.35	5.40	5.57	-
		1.96	1.70	1.71	1.66	1.64	1.51	1.37	1.34	-
		3.84	2.89	2.92	2.76	2.69	2.28	1.88	1.80	2.63
30 cm closed	-	5.68	4.87	4.94	4.94	5.21	5.40	5.31	5.50	-
		1.14	0.98	1.04	0.99	1.00	0.87	0.86	0.84	-
		1.30	0.96	1.08	0.98	1.00	0.76	0.74	0.71	0.94

COMPARISON OF MEAN VARIANCE BETWEEN MARKING PATTERN	F - TEST (5% SIGNIFICANT LEVEL)
20 cm closed - CANADIAN STANDARD	o
CANADIAN STANDARD - 30 cm closed	•
20 cm closed - 30 cm closed	•

Legend:
- • significant
- o not significant

Table 2 VEHICLE TRAJECTORY SURVEY - VARIANCE ANALYSIS OF LATERAL DISPLACEMENT

LOCATION: FROM 149 ST. TO WHITEMUD FWY. S.B.
MANEUVER: MERGING
TIME: A.M. PEAK (6.45 - 8.15)

TEST MARKING PATTERN	TRAFFIC MOVEMENT	LATERAL DISPLACEMENT (M)/STANDARD DEVIATION/VARIANCE AFTER THE BEGINNING OF THE OBSERVATION PERIOD							MEAN VARIANCE
		1	2	3	4	5	6	7	
CANADIAN STANDARD	-	3.82	4.07	4.53	5.09	5.66	6.10	6.54	-
		0.61	0.75	1.11	1.76	2.39	2.61	2.71	-
		0.37	0.56	1.23	3.10	5.71	6.81	7.34	3.59
20 cm open	-	4.16	4.40	4.65	5.18	5.43	5.79	6.16	-
		0.75	0.98	1.46	1.82	2.14	2.23	2.23	-
		0.56	0.96	2.13	3.31	4.58	4.97	4.97	3.07
30 cm open	-	3.75	4.04	4.16	4.25	4.78	5.34	5.85	-
		0.43	0.56	0.62	0.95	1.35	1.79	2.12	-
		0.18	0.31	0.38	0.90	1.82	3.20	4.49	1.62
30 cm closed	-	4.44	4.73	5.15	5.55	6.00	6.45	6.87	-
		0.59	0.91	1.36	1.61	1.88	2.03	2.24	-
		0.35	0.83	1.85	2.59	3.53	4.12	5.02	2.55

COMPARISON OF MEAN VARIANCE BETWEEN MARKING PARRERN	F - TEST (5% SIGNIFICANT LEVEL)
CANADIAN STANDARD - 20 cm open	o
CANADIAN STANDARD - 30 cm open	•
CANADIAN STANDARD - 30 cm closed	o
20 cm open - 30 cm open	•
20 cm open - 30 cm closed	o
30 cm closed - 30 cm open	o

Legend: • significant
o not significant

Table 3 VEHICLE - TRAJECTORY SURVEY - VARIANCE ANALYSIS OF LATERAL DISPLACEMENT

LOCATION: FROM WHITEMUD FWY. TO FOX DR. E. B.
MANEUVER: DIVERGING
TIME: A.M. PEAK (6.45 - 8.15)

TEST MARKING PATTERN	TRAFFIC MOVEMENT	LATERAL DISPLACEMENT (M)/STANDARD DEVIATION/ VARIANCE/SECOND AFTER THE BEGINNING OF THE OBSERVATION PERIOD 1	2	3	4	5	6	7	8	MEAN VARIANCE
CANADIAN STANDARD	-	2.08	1.94	1.95	1.97	2.25	2.56	2.82	3.02	-
		0.38	0.39	0.43	0.44	0.50	0.65	0.82	1.15	-
		0.14	0.15	0.18	0.19	0.25	0.42	0.67	1.32	0.42
20 cm	-	2.26	2.15	1.97	2.22	2.43	2.58	2.74	2.85	-
		0.51	0.41	0.36	0.39	0.49	0.62	0.27	0.95	-
		0.26	0.17	0.13	0.15	0.24	0.38	0.07	0.90	0.29
30 cm	-	2.19	2.17	2.06	2.05	2.17	2.29	2.40	2.54	-
		0.33	0.30	0.30	0.36	0.43	0.51	0.64	0.81	-
		0.11	0.09	0.09	0.13	0.18	0.26	0.41	0.66	0.24

COMPARISON OF MEAN VARIANCE BETWEEN MARKING PATTERN	F - TEST (5% SIGNIFICANT LEVEL)
CANADIAN STANDARD - 20 cm	o
CANADIAN STANDARD - 30 cm	o
20 cm - 30 cm	o

Legend: • significant
o not significant

Table 4 VEHICLE TRAJECTORY SURVEY - VARIANCE ANALYSIS OF LATERAL DISPLACEMENT

LOCATION: FROM WHITEMUD FWY. TO 159 ST. N.B.
MANEUVER: DIVERGING
TIME: P.M. PEAK (3.45 - 5.15)

TEST MARKING PATTERN	TRAFFIC MOVEMENT	LATERAL DISPLACEMENT (M)/ STANDARD DEVIATION/VARIANCE SECOND AFTER THE BEGINNING OF THE OBSERVATION PERIOD 1	2	3	4	5	6	MEAN VARIANCE
20 cm	EXITING	3.00	2.97	2.88	2.96	3.05	2.97	-
		1.06	0.88	0.70	0.60	0.62	0.64	-
		1.12	0.77	0.49	0.36	0.38	0.41	0.59
	THRU	2.15	2.18	2.20	2.25	2.23	-	-
		0.91	0.76	0,60	0.43	0.35	-	-
		0.83	0.58	0.76	0.18	0.12	-	0.41
30 cm	EXITING	2.77	2.89	2.96	2.92	2.85	2.63	-
		0.70	0.73	0.68	0.68	0.64	0.58	-
		0.49	0.53	0.46	0.46	0.41	0.34	0.45
	THRU	2.41	2.27	2.22	2.19	2.19	-	-
		0.34	0.30	0.30	0.37	0.29	-	-
		0.12	0.09	0.09	0.14	0.08	-	0.10

EXITING TRAFFIC		THROUGH TRAFFIC	
COMPARISON OF MEAN VARIANCE BETWEEN MARKING PATTERN	F - TEST (5% SIGNIFICANT LEVEL)	COMPARISON OF MEAN VARIANCE BETWEEN MARKING PATTERN	F - TEST (5% SIGNIFICANT LEVEL)
20 cm - 30 cm	o	20 cm - 30 cm	●

Legend: ● significant
o not significant

Table 5 VEHICLE TRAJECTORY SURVEY - VARIANCE ANALYSIS OF LATERAL DISPLACEMENT

LOCATION: FROM WHITEMUD FWY. TO FOX DR. E.B.
MANEUVER: MERGING
TIME: A.M. PEAK (6.45 - 8.15)

TEST MARKING PATTERN	TRAFFIC MOVEMENT	LATERAL DISPLACEMENT (M)/STANDARD DEVIATION/VARIANCE SECOND AFTER THE BEGINNING OF THE OBSERVATION PERIOD 1	2	3	4	MEAN VARIANCE
CANADIAN STANDARD	ENTERING	3.85 0.89 0.79	3.55 0.93 0.86	3.17 1.50 2.25	2.63 1.80 3.24	- - 1.79
	THRU	4.75 0.98 0.96	4.91 0.83 0.69	6.10 0.94 0.88	- - -	- - 0.84
20 cm	ENTERING	3.44 0.49 0.24	3.20 0.48 0.23	2.88 0.62 0.38	2.48 0.90 0.81	- - 0.42
	THRU	4.03 0.46 0.21	4.57 0.72 0.52	5.78 0.82 0.67	- - -	- - 0.47
30 cm	ENTERING	3.63 0.37 0.14	3.80 0.51 0.26	3.49 0.60 0.36	3.04 0.73 0.53	- - 0.32
	THRU	4.03 0.74 0.54	4.14 0.80 0.64	4.95 0.88 0.77	- - -	- - 0.65

ENTRRTING TRAFFIC		THROUGH TRAFFIC	
COMPARISON OF MEAN VARIANCE BETWEEN MARKING PATTERN	F - TEST (5% SIGNIFICANT LEVEL)	COMPARISON OF MEAN VARIANCE BETWEEN MARKING PATTERN	F - TEST (5% SIGNIFICANT LEVEL)
CANADAIAN STANDARD - 20 cm	●	CANADIAN STANDARD - 20 cm	o
CANDAIAN STANDARD - cm	●	CANADIAN STANDARD - 30 cm	o
20 cm - 30 cm	o	20 cm - 30 cm	o

Legend: ● significant
o not significant

Table 6 VEHICLE TRAJECTORY SURVEY - VARIANCE ANALYSIS OF LATERAL DISPLACEMENT

LOCATION: FROM WHITEMUD FWY. TO 149 St. N.B.
MANEUVER: DIVERGING
TIME: P.M. PEAK (3.45 - 5.15)

TEST MARKING PATTERN	TRAFFIC MOVEMENT	LATERAL DISPLACEMENT (M)/STANDARD DEVIATION/VARIANCE SECOND AFTER THE BEGINNING OF THE OBSERVATION PERIOD 1	2	3	4	5	MEAN VARIANCE
CANADIAN STANDARD	-	2.67	2.57	2.43	2.48	2.47	-
		0.96	0.84	0.76	0.65	0.66	-
		0.92	0.71	0.58	0.42	0.44	0.61
20 cm CLOSED	-	2.69	2.64	2.51	2.52	2.60	-
		0.34	0.47	0.52	0.68	0.84	-
		0.12	0.22	0.27	0.46	0.71	0.23
30 cm CLOSED	-	2.72	2.72	2.65	2.56	2.54	-
		0.30	0.29	0.38	0.45	0.49	-
		0.09	0.08	0.14	0.20	0.24	0.15

COMPARISON OF MEAN VARIANCE BETWEEN MARKING PATTERN	F - TEST (5% SIGNIFICANT LEVEL)
CANADIAN STANDARD-20 cm	●
CANDAIN STANDARD-30 cm	●
20 cm - 30 cm	o

Legend: - ● significant
o not significant

Table 7 VEHICLE TRAJECTORY SURVEY - VARIANCE ANALYSIS OF LATERAL DISPLACEMENT

LOCATION: FOX DR. TO WHITEMUD FWY. W.B.
MANEUVER: MERGING
TIME: P.M. PEAK (3.34 - 5.15)

TEST MARKING PATTERN	TRAFFIC MOVEMENT	LATERAL DISPLACEMENT (M)/STANDARD DEVIATION/VARIANCE SECOND AFTER THE BEGINNING OF THE OBSERVATION PERIOD 1	2	3	4	5	MEAN VARIANCE
CANADIAN STANDARD	ENTRY	13.43 3.92 15.37	11.22 4.55 20.70	11.22 4.22 17.81	11.74 4.06 16.40	12.85 4.31 18.58	- - 17.79
	THRU	18.82 2.07 4.28	17.26 1.38 1.90	13.14 1.10 1.21	14.01 1.37 1.88	14.04 1.15 1.32	- - 2.12
20 cm	ENTRY	14.76 2.20 4.84	15.86 1.92 3.69	15.71 2.57 6.60	16.80 3.27 10.69	18.75 2.75 7.56	- - 6.67
	THRU	21.14 2.94 8.64	21.04 2.59 6.71	21.01 1.91 3.65	21.39 3.41 11.63	22.96 3.94 15.32	- - 9.23
30 cm	ENTRY	20.76 4.88 23.81	22.85 5.25 27156	24.25 5.12 26.21	25.35 5.37 28.84	26.11 5.36 28.73	- - 27.03
	THRU	29.14 3.14 9.86	31.01 2.77 7.67	30.70 2.75 7.56	30.05 3.82 14.59	28.62 4.28 18.32	- - 11.60

ENTERING TRAFFIC		THROUGH TRAFFIC	
COMPARISON OF MEAN VARIANCE BETWEEN MARKING PATTERN	F - TEST (5% SIGNIFICANT LEVEL)	COMPARISON OF MEAN VARIANCE BETWEEN MARKING PATTERN	F - TEST (5% SIGNIFICANT LEVEL)
CANADIAN STANDARD - 20 cm	●	CANADIAN STANDARD - 20 cm	●
30 cm - CANADIAN STANDARD	o	30 cm - CANADIAN STANDARD	●
30 cm - 20 cm	●	30 cm - 20 cm	o

Legend: ● significant
o not significant

Table 8 VEHICLE TRAJECTORY SURVEY - VARIANCE ANALYSIS OF LONGITUDINAL VELOCITY

LOCATION: ON THE RAMP FROM FOX DR. TO WHITEMUD FWY. W. B.
MANEUVER: MERGING
TIME: P.M. PEAK (3.45 - 5.15)

TEST MARKING PATTERN	TRAFFIC MOVEMENT	LONGITUDINAL VELOCITY (M)/STANDARD DEVIATION/ VARIANCE/SECOND AFTER THE BEGINNING OF THE OBSERVATION PERIOD 1	2	3	4	5	6	7	8	MEAN VARIANCE
NO MARKING		11.57	15.14	17.14	18.19	18.48	18.33	17.64	15.95	-
	-	1.88	1.84	2.10	2.52	2.26	1.86	1.69	1.79	-
		3.53	3.39	4.41	6.35	5.10	3.46	2.86	3.20	4.04
CANADIAN STANDARD		11.21	14.80	16.69	17.26	17.48	17.35	16.39	15.15	15.79
	-	1.75	1.75	2.01	1.56	1.74	1.69	1.86	1.08	-
		2.96	3.06	4.04	2.43	3.03	2.86	3.46	1.17	2.87
20 cm closed		16.23	18.96	19.97	19.78	19.76	19.03	17.89	16.93	18.57
	-	1.70	2.03	2.71	2.47	2.71	1.99	1.77	2.28	-
		2.89	4.12	7.34	6.10	7.34	3.96	3.13	5.20	5.01
30 cm closed		13.50	17.46	19.59	20.29	20.03	19.37	18.26	16.40	-
	-	1.57	1.58	2.01	2.01	1.79	1.80	1.73	1.51	-
		2.46	2.50	4.04	4.04	3.20	3.24	3.00	2.28	3.09

COMPARISON OF MEAN VARIANCE BETWEEN MARKING PATTERN	F - TEST (5% SIGNIFICANT LEVEL)
20 cm closed - CANADIAN STANDARD	o
30 cm closed - CANADIAN STANDARD	o
20 cm closed - 30 cm closed	o

Legend: • significant
o not significant

Table 9 VEHICLE TRAJECTORY SURVEY - VARIANCE ANALYSIS OF LONGITUDINAL VELOCITY

LOCATION: FROM 149 ST. TO WHITEMUD FWY. S.B.
MANEUVER: MERGING
TIME: A.M. PEAK (6.45 - 8.15)

TEST MARKING PATTERN	TRAFFIC MOVEMENT	LONGITUDINAL VELOCITY (M)/STANDARD DEVIATION/VARIANCE/SECOND AFTER THE BEGINNING OF THE OBSERVATION PERIOD 1	2	3	4	5	6	7	MEAN VARIANCE
CANADIAN STANDARD	-	27.02	23.22	20.04	19.82	20.03	21.12	22.76	-
		5.58	4.91	3.73	3.54	4.19	4.27	4.25	-
		31.13	24.11	13.53	12.53	17.56	18.23	18.06	19.36
20 cm open	-	17.45	15.27	13.69	12.88	12.35	12.48	12.95	13.87
		2.82	3.29	3.02	2.30	2.26	1.90	2.18	-
		7.95	10.82	9.12	5.29	5.11	3.61	4.75	6.67
30 cm open	-	17.63	14.65	13.18	12.16	12.29	12.09	12.15	13.45
		2.31	2.42	2.32	2.42	2.48	2.04	1.62	-
		5.34	5.86	5.38	5.86	6.15	4.16	2.62	5.05
30 cm closed	-	20.75	17.50	14.77	13.80	13.43	14.56	16.29	-
		3.83	3.33	2.90	2.66	2.38	2.21	2.66	-
		14.67	11.09	8.41	7.08	5.66	4.88	7.08	8.47

COMPARISON OF MEAN VARIANCE BETWEEN MARKING PATTERN	F - TEST (5% SIGNIFICANT LEVEL)
CANADIAN STANDARD - 20 cm open	•
CANADIAN STANDARD - 30 cm open	•
CABADIAN STANDARD - 30 cm closed	•
20 cm open - 30 cm open	o
30 cm closed - 20 cm open	o
30 cm closed - 30 cm open	o

Legend: • significant
o not significant

Table 10 VEHICLE TRAJECTORY SURVEY - VARIANCE ANALYSIS OF LONGITUDINAL VELOCITY

LOCATION: FROM WHITEMUD FWY. TO FOX DR. E.B.
MANEUVER: DIVERGING
TIME: A.M. PEAK (6.45 - 8.15)

TEST MARKING PATTERN	TRAFFIC MOVEMENT	LONGITUDINAL VELOCITY (M)/STANDARD DEVIATION/ VARIANCE/SECOND AFTER THE BEGINNING OF THE OBSERVATION PERIOD 1	2	3	4	5	6	7	8	MEAN VARIANCE
CANADIAN STANDARD	-	21.55	18.71	18.78	13.46	13.60	14.66	16.47	18.30	16.57
		2.41	1.86	1.67	1.25	2.31	3.05	2.92	3.73	-
		5.81	3.46	2.79	1.56	5.34	9.30	8.53	13.91	6.34
20 cm	-	29.00	24.30	21.19	18.62	19.20	20.13	21.00	24.06	22.20
		2.80	2.49	2.48	2.11	2.47	3.70	3.71	4.35	-
		7.84	6.20	6.15	4.45	6.10	13.69	13.76	18.92	9.64
30 cm	-	26.51	24.66	21.51	18.13	16.87	17.08	18.72	20.19	20.46
		2.51	2.12	1.86	1.82	1.99	2.03	2.35	2.93	-
		6.30	4.49	3.46	3.31	3.96	4.12	5.52	8.58	4.97

COMPARISON OF MEAN VARIANCE BETWEEN MARKING PATTERN	F - TEST (5% SIGNIFICANT LEVEL)
20 cm - CANADIAN STANDARD	o
CANADIAN STANDARD - 30 cm	o
20 cm - 30 cm	o

Legend: • significant
o not significant

Table 11 VEHICLE TRAJECTORY SURVEY - VARIANCE ANALYSIS OF LONGITUDINAL VELOCITY

LOCATION: FROM WHITEMUD FWY. TO 159 ST. N.B.
MANEUVER: DIVERGING
TIME: P.M. PEAK (3.45 - 5.15)

TEST MARKING PATTERN	TRAFFIC MOVEMENT	LONGITUDINAL VELOCITY (M)/STANDARD DEVIATION/VARIANCE SECOND AFTER THE BEGINNING OF THE OBSERVATION PERIOD 1	2	3	4	5	6	MEAN VARIANCE
20 cm	EXITING	30.49	28.42	26.21	25.71	24. 9	22.45	21.99
		5.27	4.20	4.71	4.27	3.39	2.96	-
		27.77	17.64	22.18	18.23	11.49	8.76	17.6806
	THRU	19.88	19.90	20.69	22.72	24.74	-	21.59
		3.58	3.52	3.42	3.76	4.17	-	-
		12.82	12.39	11.70	14.14	17.39	-	13.69
30 cm	EXITING	28.81	28.48	26.87	24.80	25.54	27.30	26.97
		4.40	3.87	2.93	3.21	2.66	3.89	-
		19.36	14.98	8.58	10.30	7.08	15.13	12.57
	THRU	30.97	32.9	32.83	35.02	34.26	-	33.21
		3.56	4.38	4.11	3.60	3.29	-	-
		12.67	19.18	16.89	12.96	10.82	-	14.51

EXITING TRAFFIC		THROUGH TRAFFIC	
COMPARISON OF MEAN VARIANCE BETWEEN MARKING PATTERN	F - TEST (5% SIGNIFICANT LEVEL)	COMPARISON OF MEAN VARIANCE BETEEEN MARKING PATTERN	F - TEST (5% SIGNIFICANT LEVEL)
20 cm - 30 cm	o	30 cm - 20 cm	o

Legend: ● significant
o not significant

Table 12 VEHICLE TRAJECTORY SURVEY - VARIANCE ANALYSIS OF LONGITUDINAL VELOCITY

LOCATION: FROM WHITEMUD FWY. TO FOX DR. E.B.
MANEUVER: MERGING
TIME: A.M. PEAK (6.45 - 8.15)

TEST MARKING PATTERN	TRAFFIC MOVEMENT	LONGITUDINAL VELOCITY (M)/STANDARD DEVIATION/VARIANCE SECOND AFTER THE BEGINNING OF THE OBSERVATION PERIOD 1	2	3	4	MEAN VARIANCE
CANADIAN STANDARD	ENTRY	14.77 2.66 7.08	14.35 3.55 12.60	13.65 3.46 11.97	14.51 3.73 13.91	- - 11.39
	THRU	11.61 1.08 1.17	13.15 1.05 1.10	14.67 1.20 1.44	- - -	- - 1.24
20 cm	ENTRY	16.60 3.31 10.96	15.51 3.17 10.05	15.21 3.23 10.43	15.93 3.46 11.97	- - 8.11
	THRU	21.26 1.29 1.66	21.19 1.11 1.23	21.24 1.06 1.12	- - -	- - 1.34
30 cm	ENTRY	17.24 1.98 3.92	16.62 1.92 3.69	16.58 1.90 3.61	17.45 2.35 5.52	- - 4.18
	THRU	15.05 1.29 1.66	15.97 0.99 0.98	16.78 1.57 2.46	- - -	- - 1.70

ENTERING TRAFFIC		THROUGH TRAFFIC	
COMPARISON OF MEAN VARIANCE BETWEEN MARKING PATTERN	F - TEST (5% SIGNIFICANT LEVEL)	COMPARISON OF MEAN VARIANCE BETWEEN MARKING PATTERN	F - TEST (5% SIGNIFICANT LEVEL)
CANADIAN STANDARD - 20 cm	o	20 cm - CANADIAN STANDARD	o
CANADIAN STANDARD - 30 cm	●	30 cm - CANADIAN STANDARD	o
20 cm - 30 cm	●	30 cm - 20 cm	o

Legend: ● significant
o not significant

Table 13 VEHICLE TRAJECTORY SURVEY - VARIANCE ANALYSIS OF LONGITUDINAL VELOCITY

LOCATION: FROM WHITEMUD FWY. TO 149 ST. N.B.
MANEUVER: DIVERGING
TIME: P.M. PEAK (3.45 - 5.15)

TEST MARKING PATTERN	TRAFFIC MOVEMENT	LONGITUDINAL VELOCITY (M)/ STANDARD DEVIATION/ VARIANCE SECOND AFTER THE BEGINNING OF THE OBSERVATION PERIOD 1	2	3	4	5	MEAN VARIANCE
CANADIAN STANDARD	-	22.70 2.11 4.45	23.24 3.03 9.18	21.37 2.62 6.86	18.40 1.97 3.88	16.00 2.28 5.20	20.34 - 5.92
20 cm	-	18.82 3.76 14.14	22.11 3.62 13.10	23.80 2.97 8.82	22.73 2.62 6.86	21.62 3.28 10.75	21.82 - 10.74
30 cm	-	15.47 2.23 4.97	19.28 2.16 4.67	23.05 2.39 5.71	24.81 2.98 8.88	22.42 2.02 4.08	21.01 - 5.66

COMPARISON OF MEAN VARIANCE BETWEEN MARKING PATTERN	F - TEST (5% SIGNIFICANT LEVEL)
20 cm - CANADIAN STANDARD	o
CANADIAN STANDARD - 30 cm	o
20 cm - 30 cm	•

Legend: • significant
o not significant

Table 14 VEHICLE TRAJECTORY SURVEY - VARIANCE ANALYSIS OF LONGITUDINAL VELOCITY

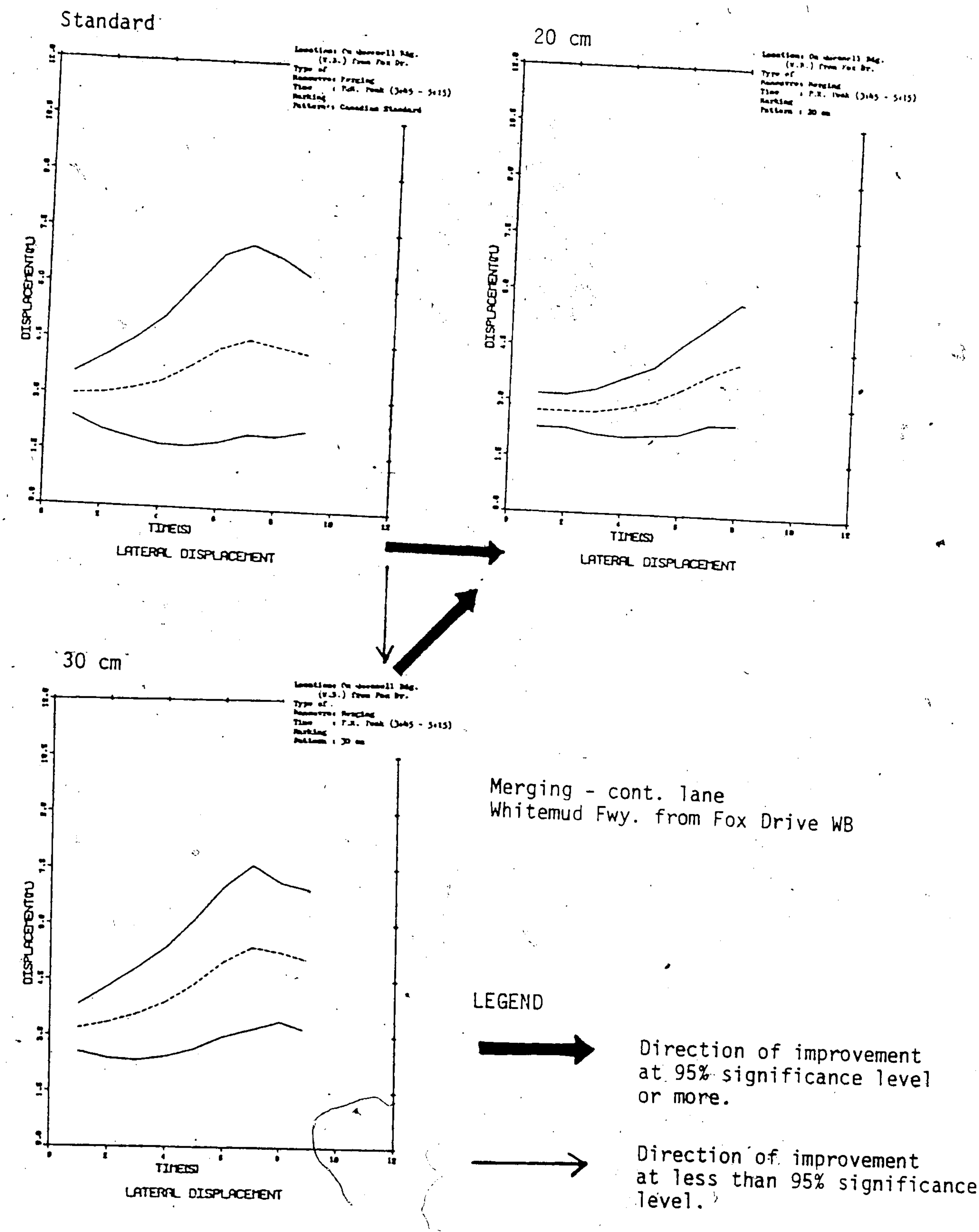


Figure 1

Average lateral displacement ±1 standard deviation.

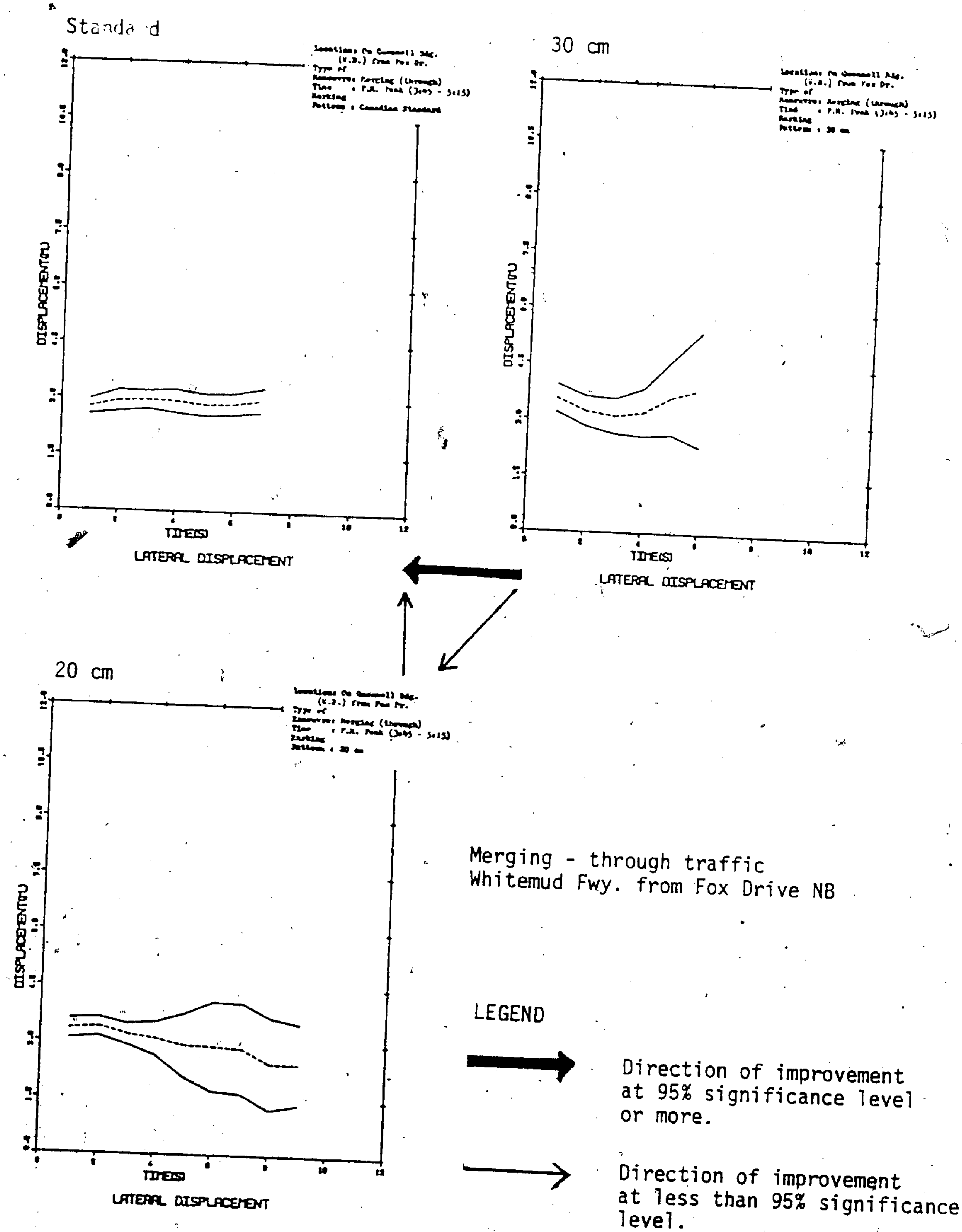
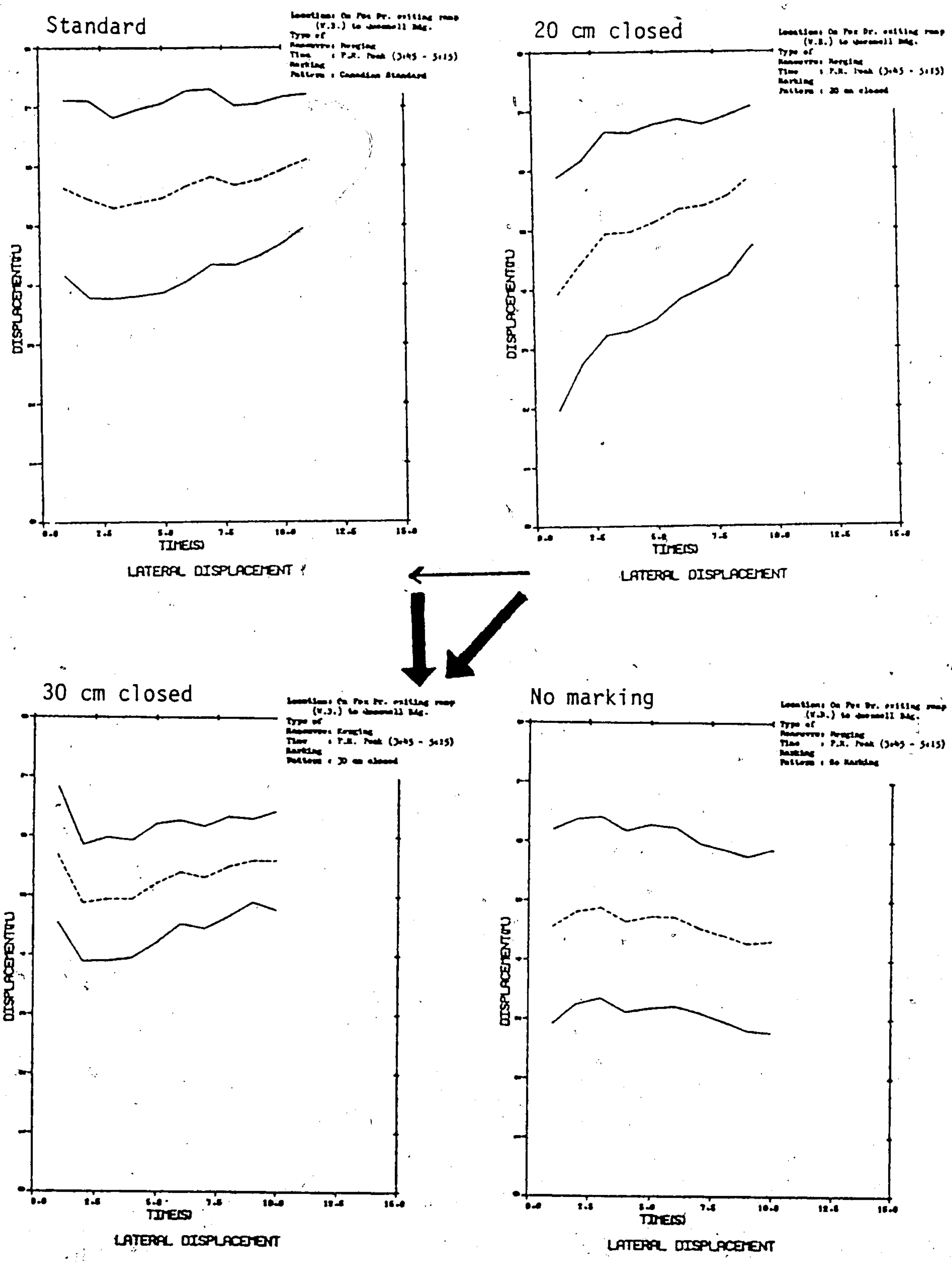


Figure 2

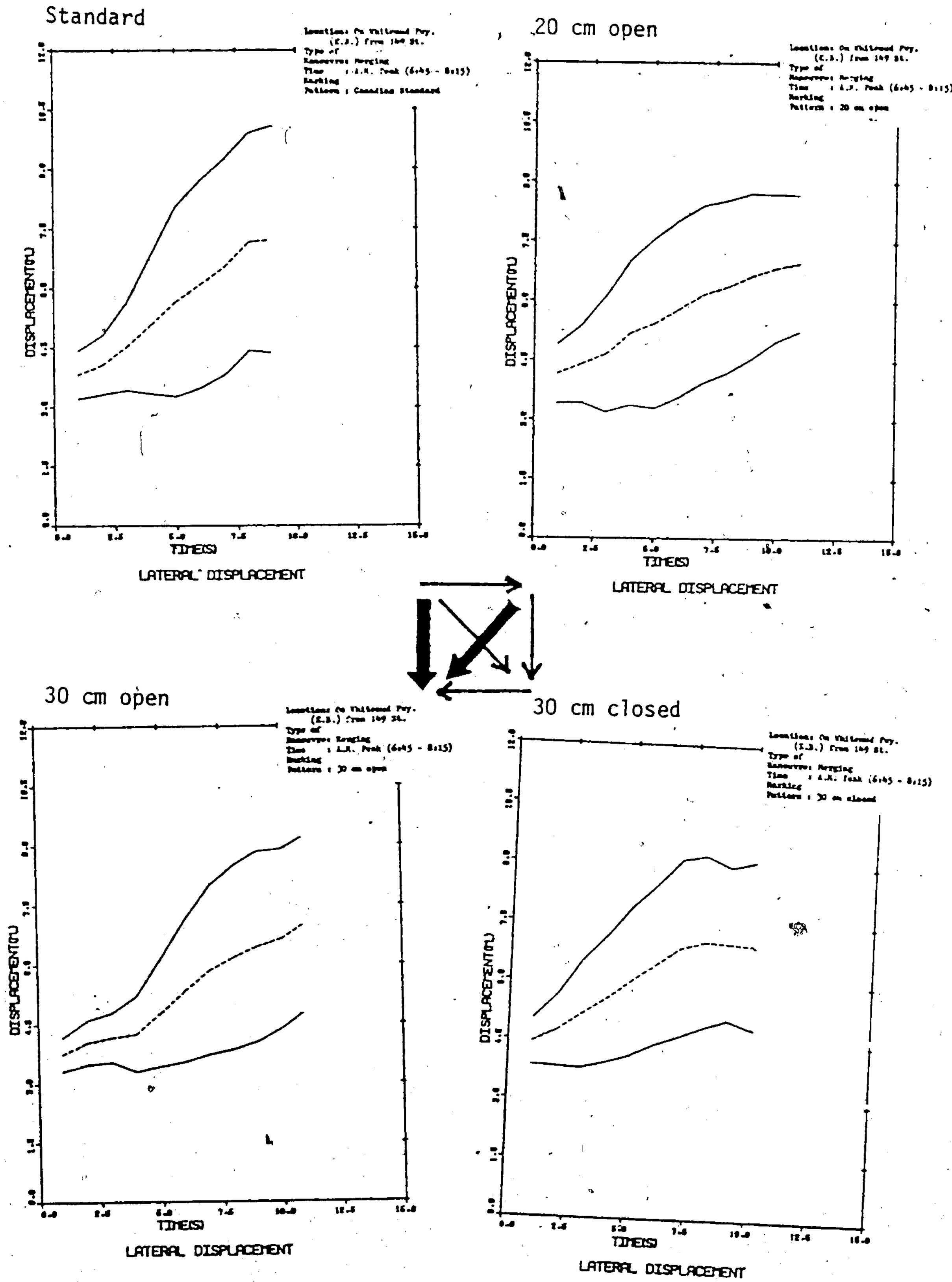
Average lateral displacement ±1 standard deviation.



Merging
Fox Drive ramp to Whitemud Fwy. NB

Figure 3

Average lateral displacement ±1 standard deviation.



Merging
Whitemud Fwy. from 149 St. SB

Figure 4

Average lateral displacement ±1 standard deviation.

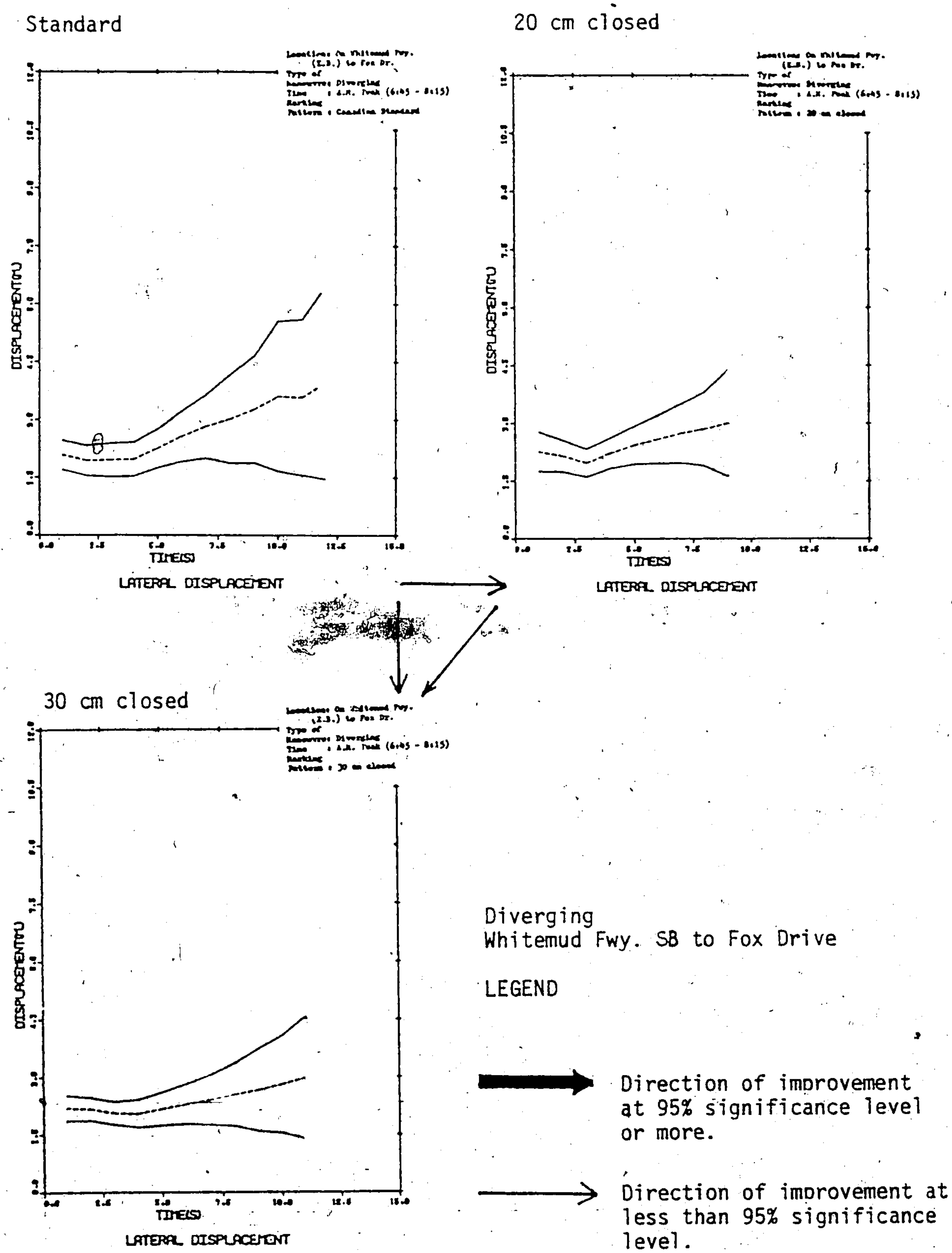
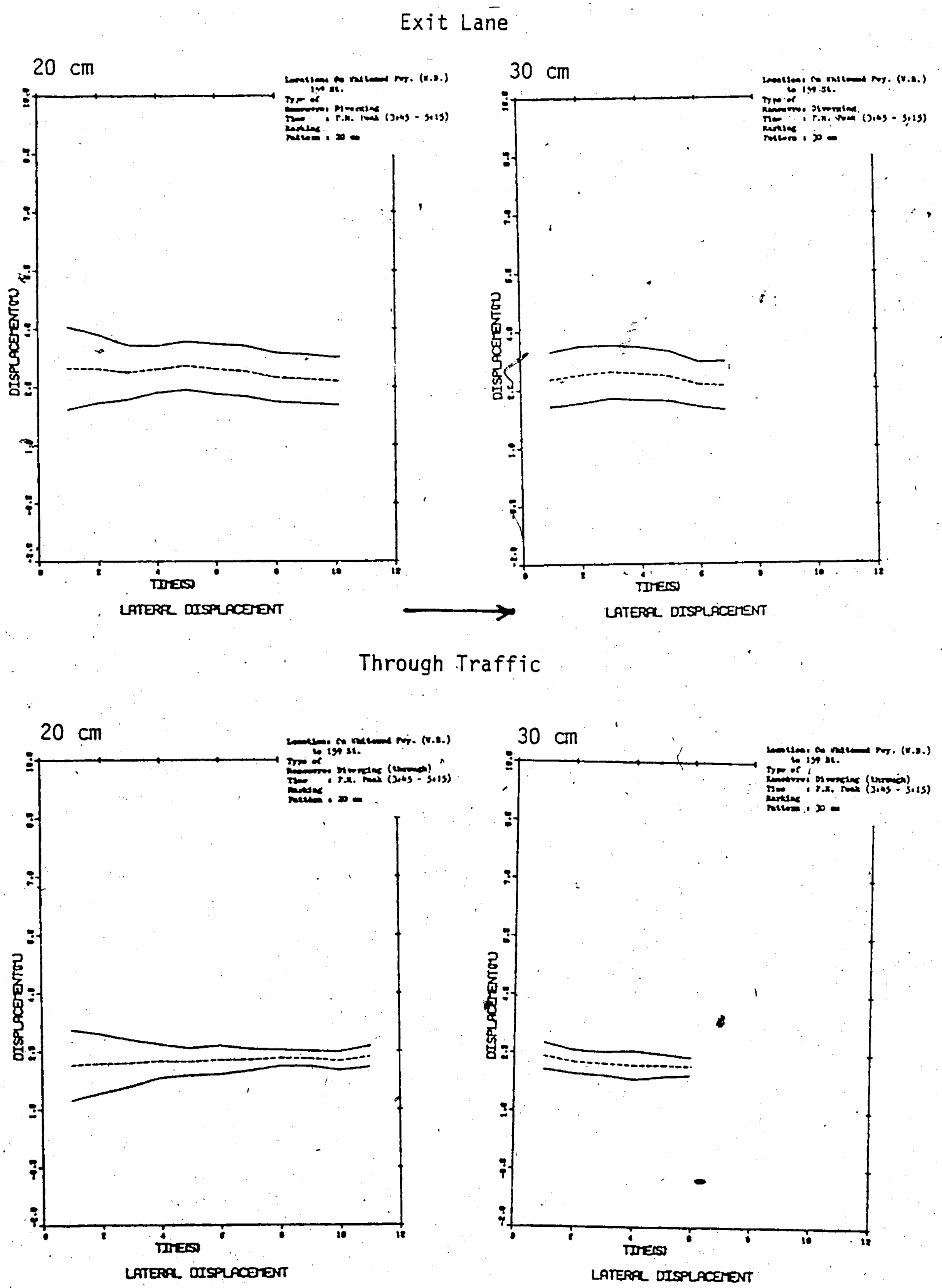


Figure 5

Average lateral displacement ±1 standard deviation.



Diverging - cont. lane and through traffic
Whitemud Fwy. to 159 St. NB

Figure 6 Average lateral displacement ±1 standard deviation.

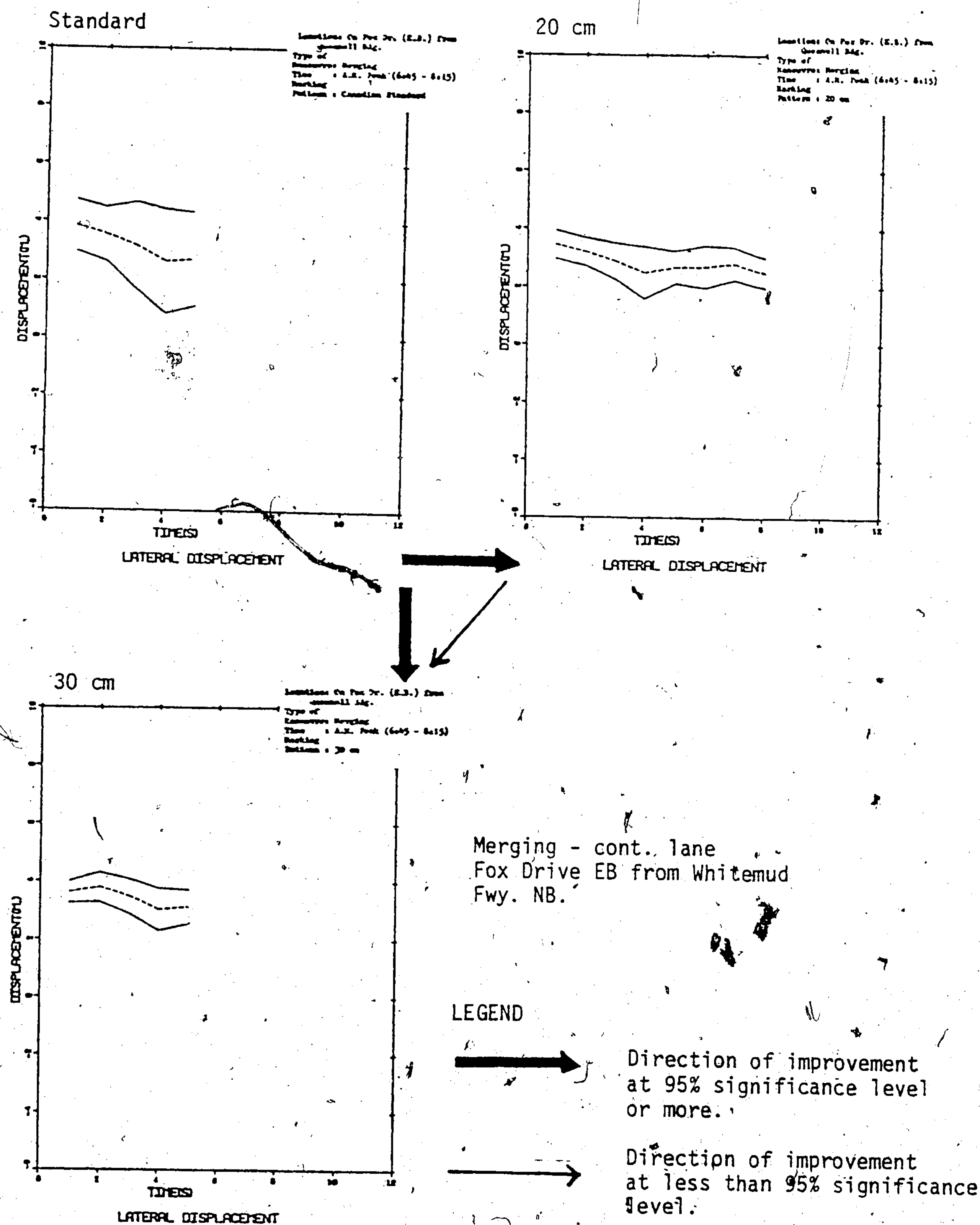


Figure 7

Average lateral displacement ±1 standard deviation.

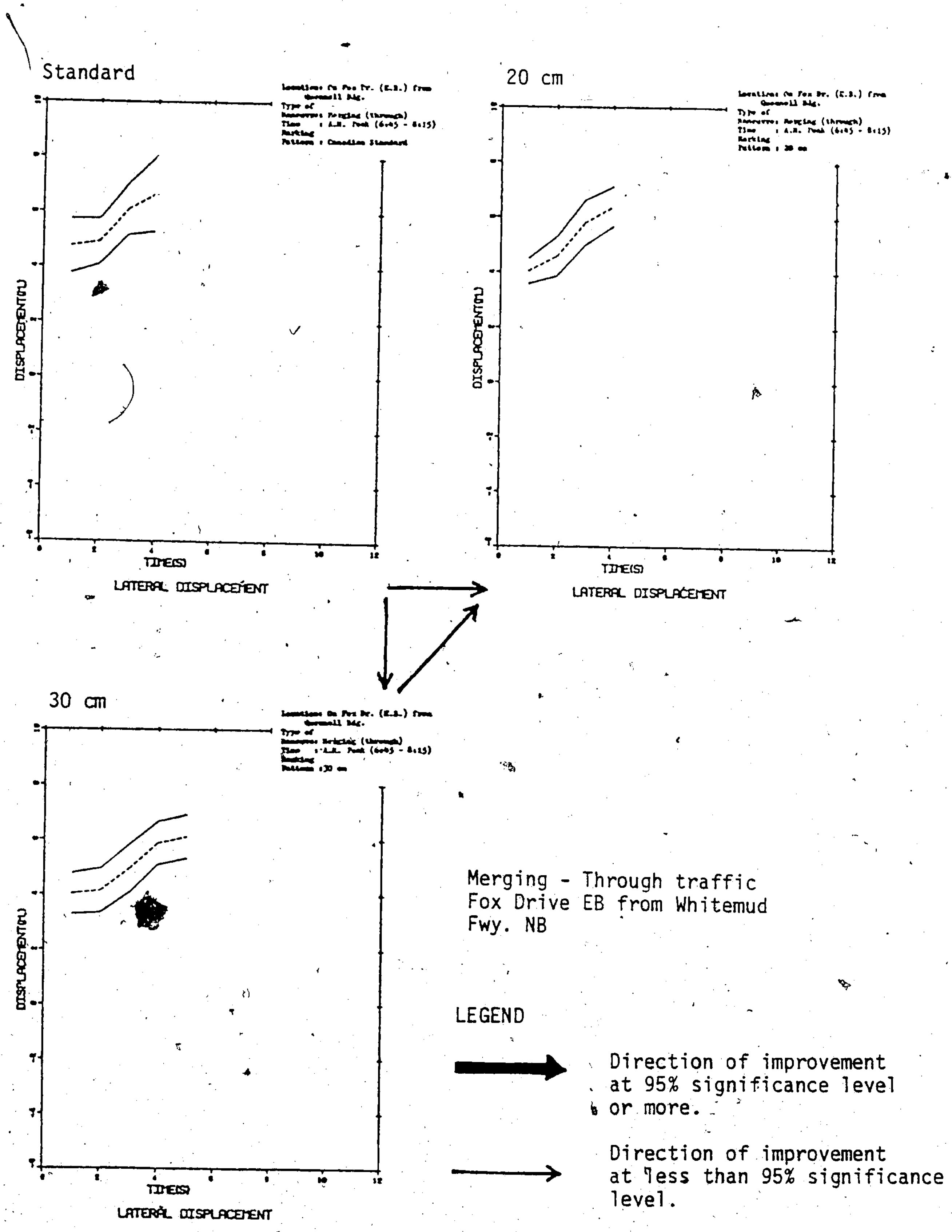


Figure 8

Average lateral displacement ±1 standard deviation.

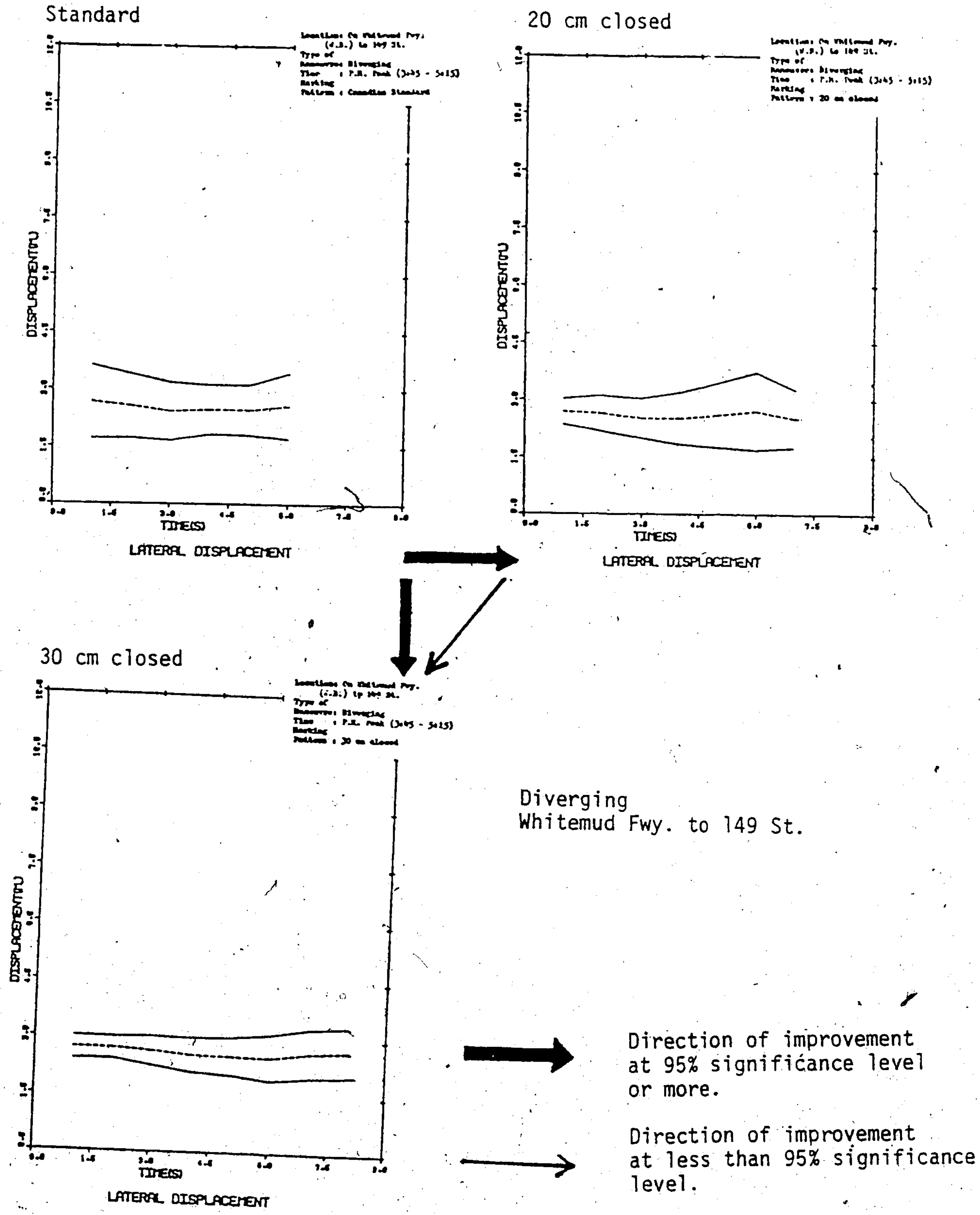


Figure 9

Average lateral displacement ±1 standard deviation.

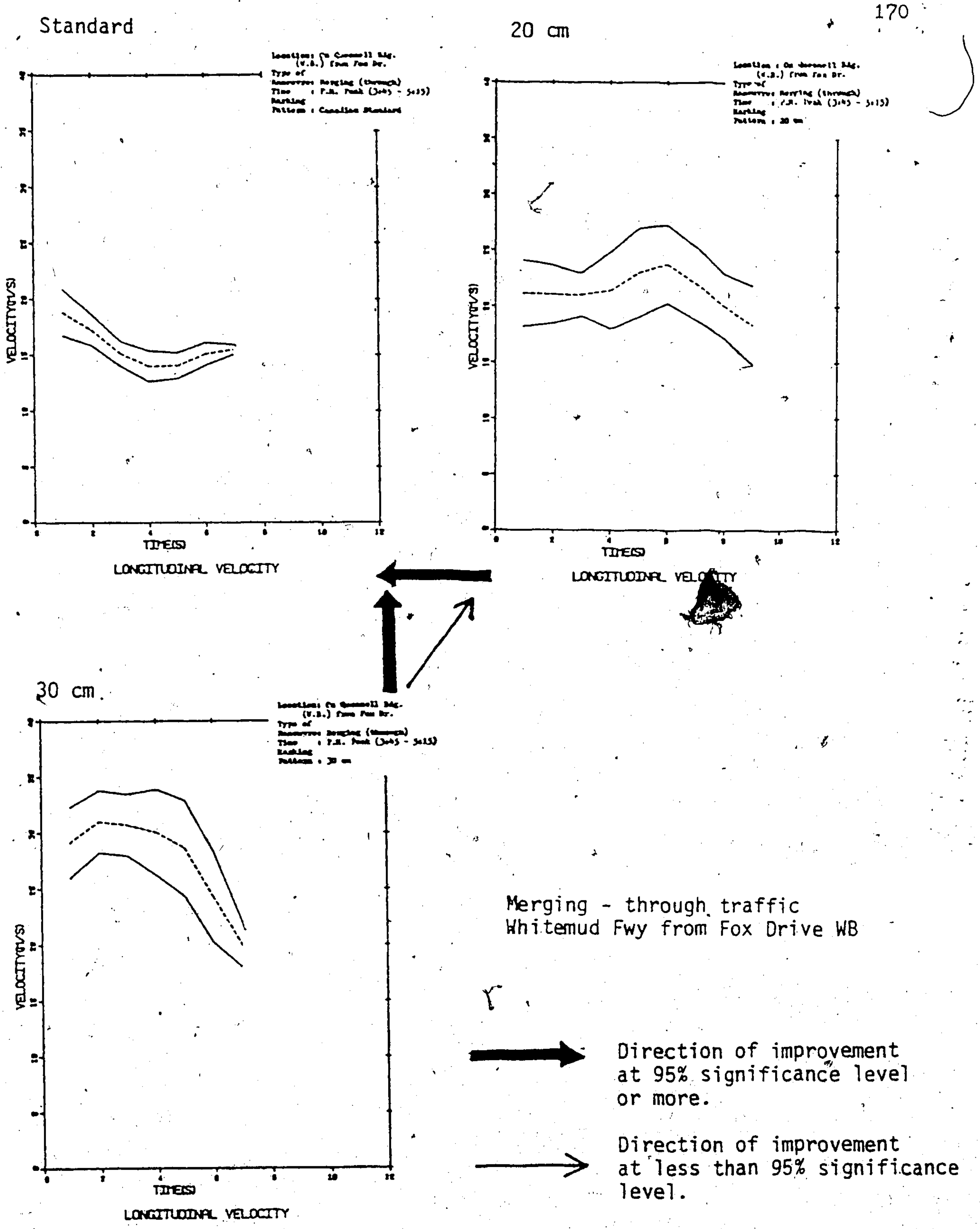


Figure 10

Average longitudinal velocity ±1 standard deviation.

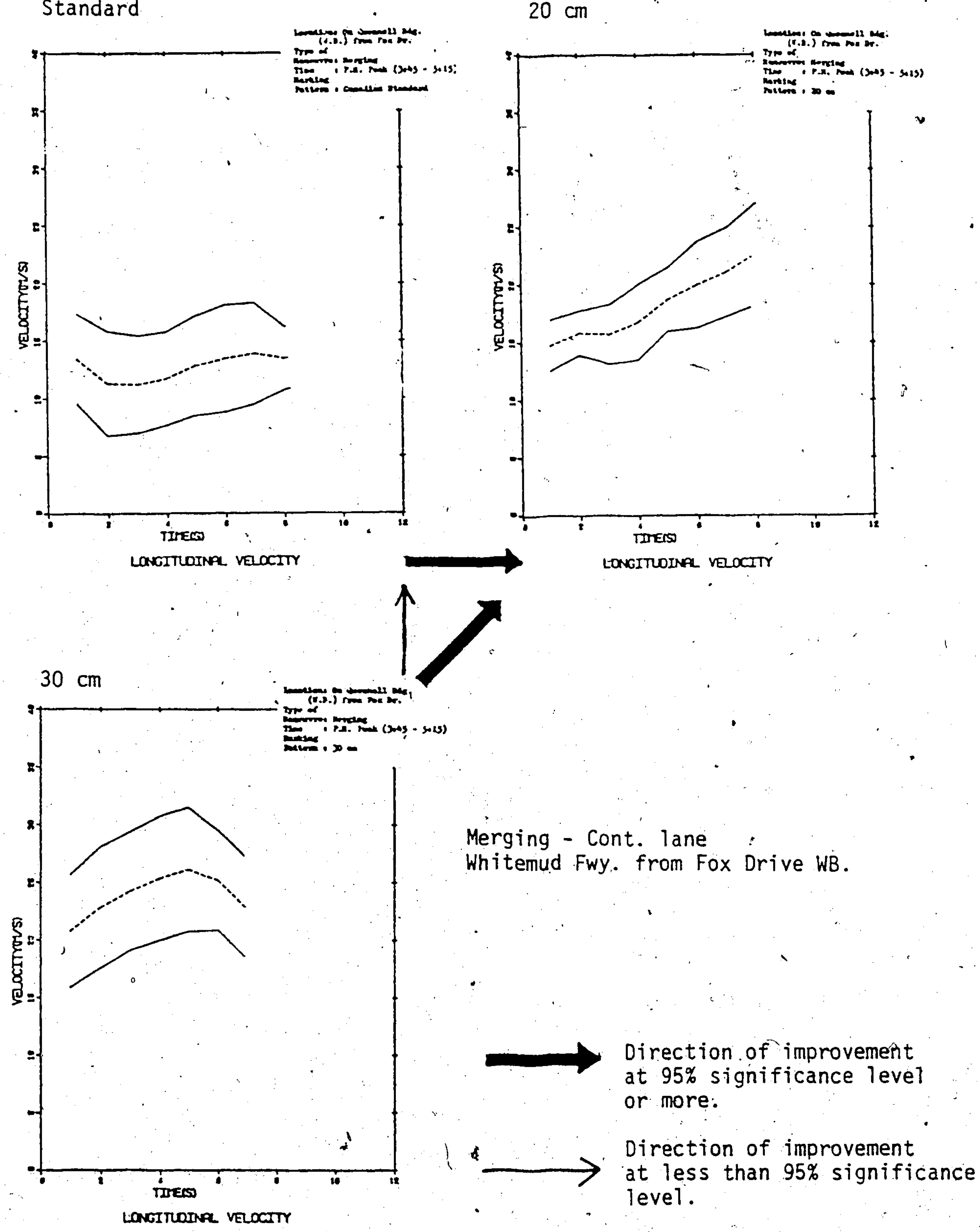
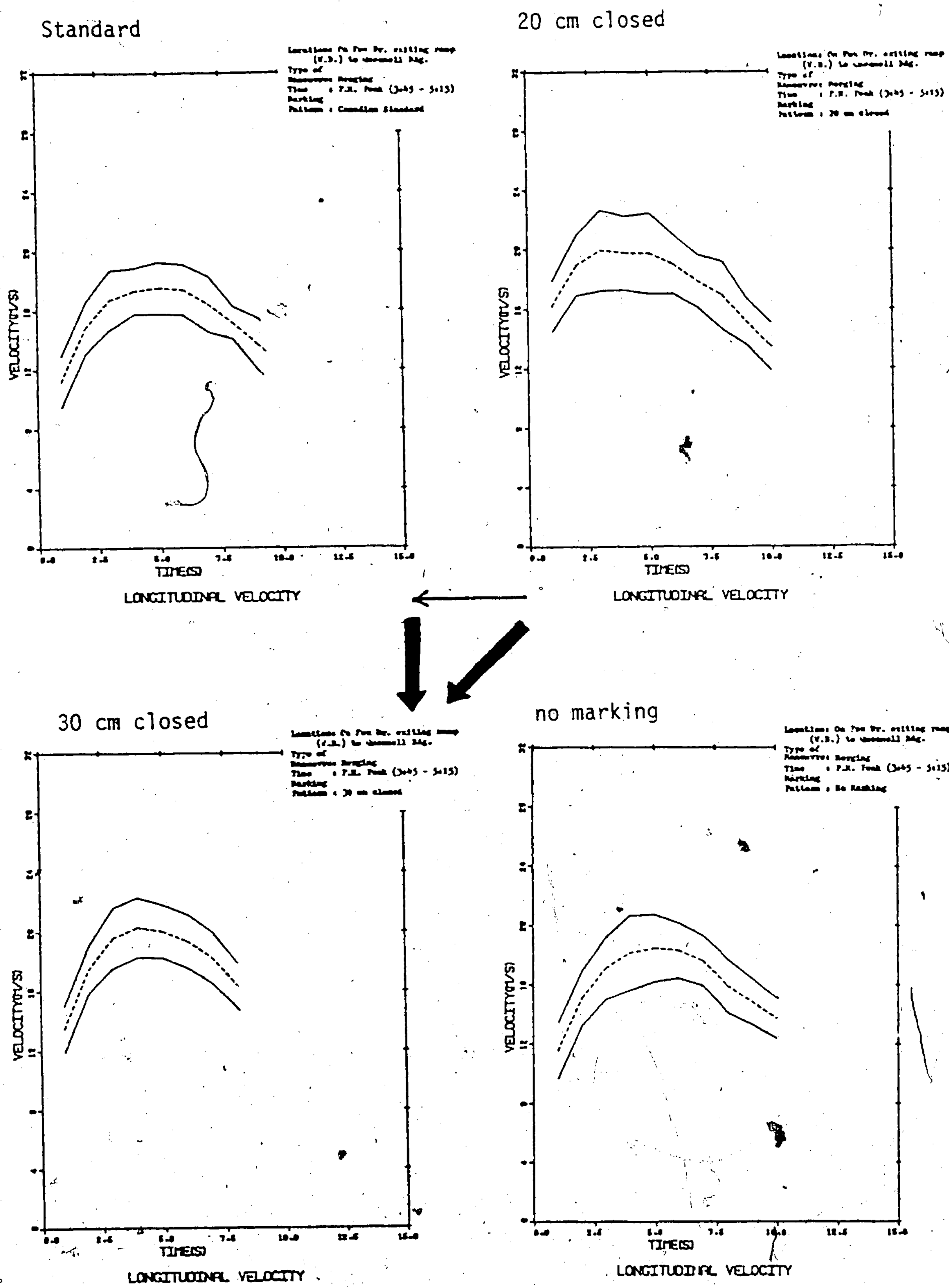


Figure 11

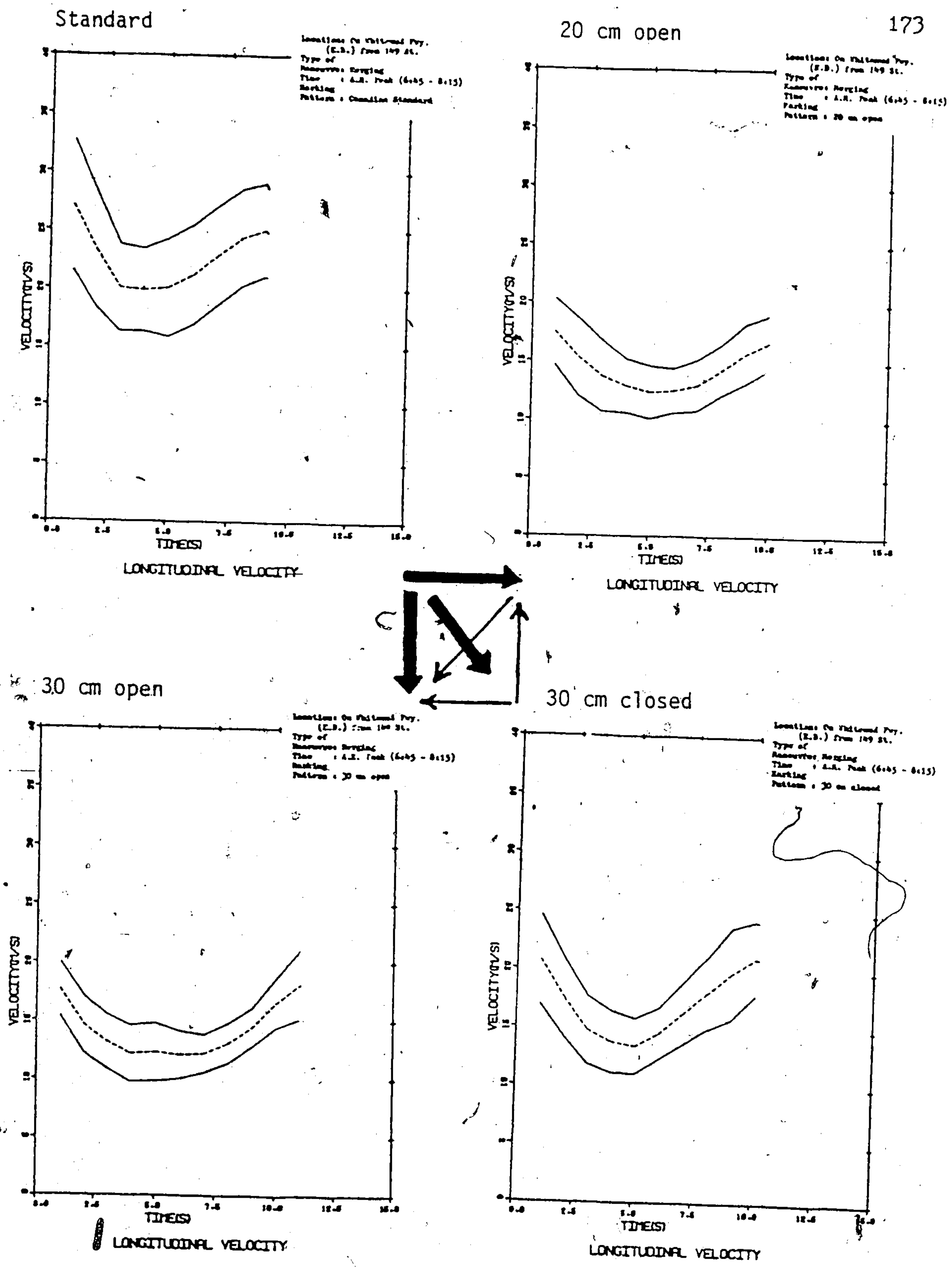
Average longitudinal velocity ±1 standard deviation.



Merging
Fox Drive ramp to Whitemud Fwy. NB.

Figure 12

Average longitudinal velocity ±1 standard deviation.



Merging
Whitemud Fwy. from 149 St. SB

Figure 13

Average longitudinal velocity ±1 standard deviation.

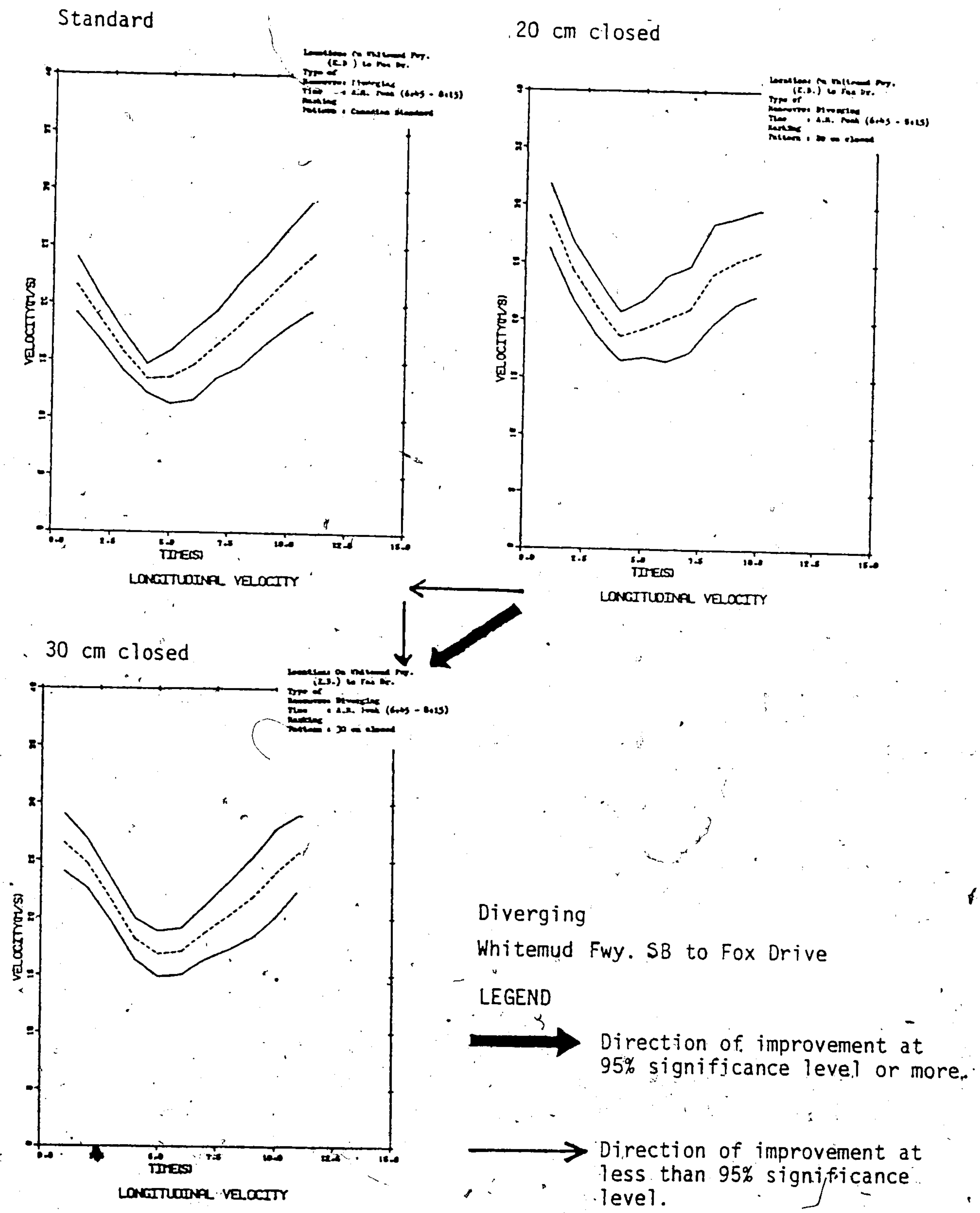
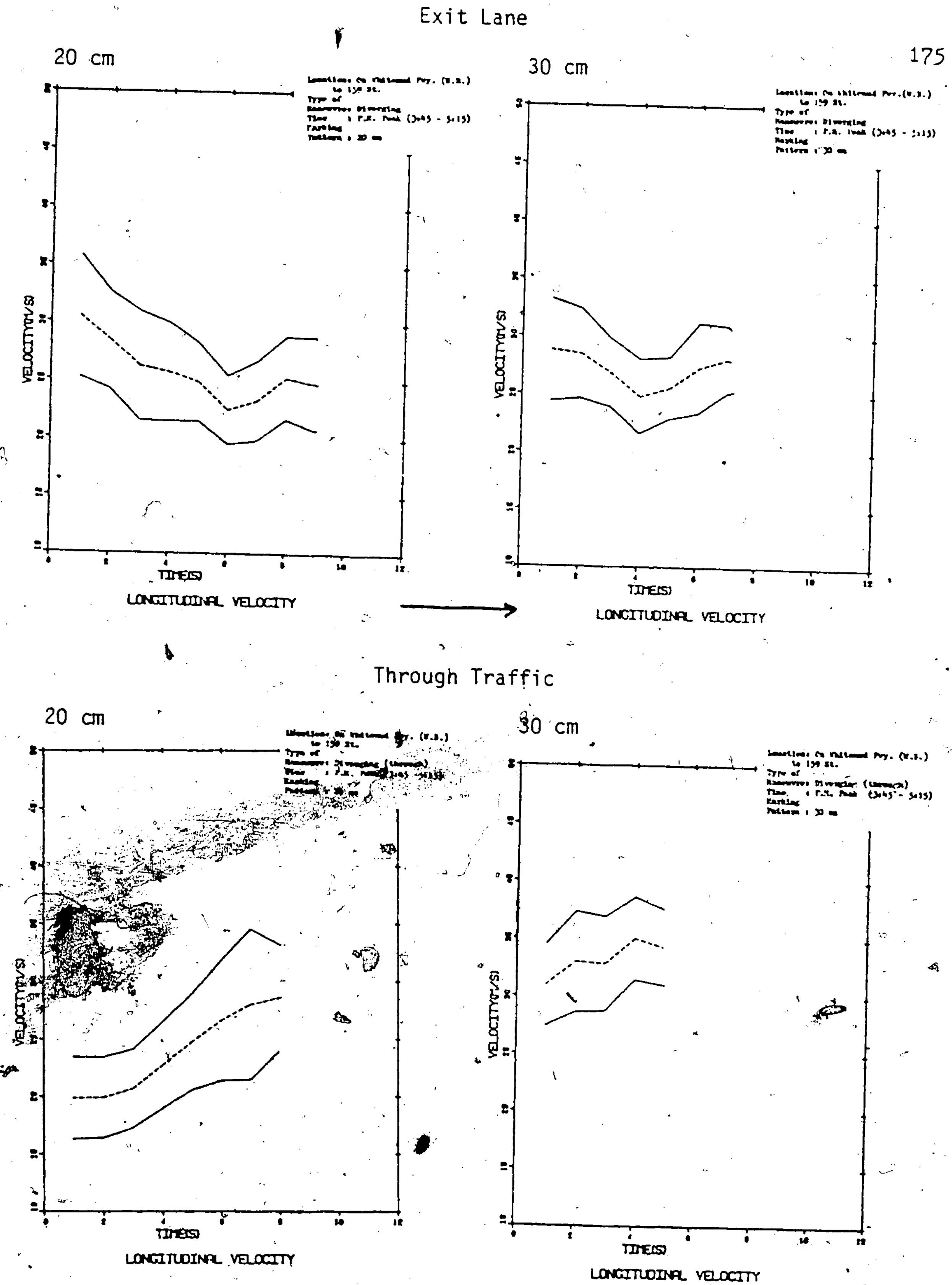


Figure 14

Average longitudinal velocity ±1 standard deviation.



Diverging - cont. lane and through traffic.
Whitemud Fwy. to 159 St. NB

Figure 15

Average longitudinal velocity ±1 standard deviation.

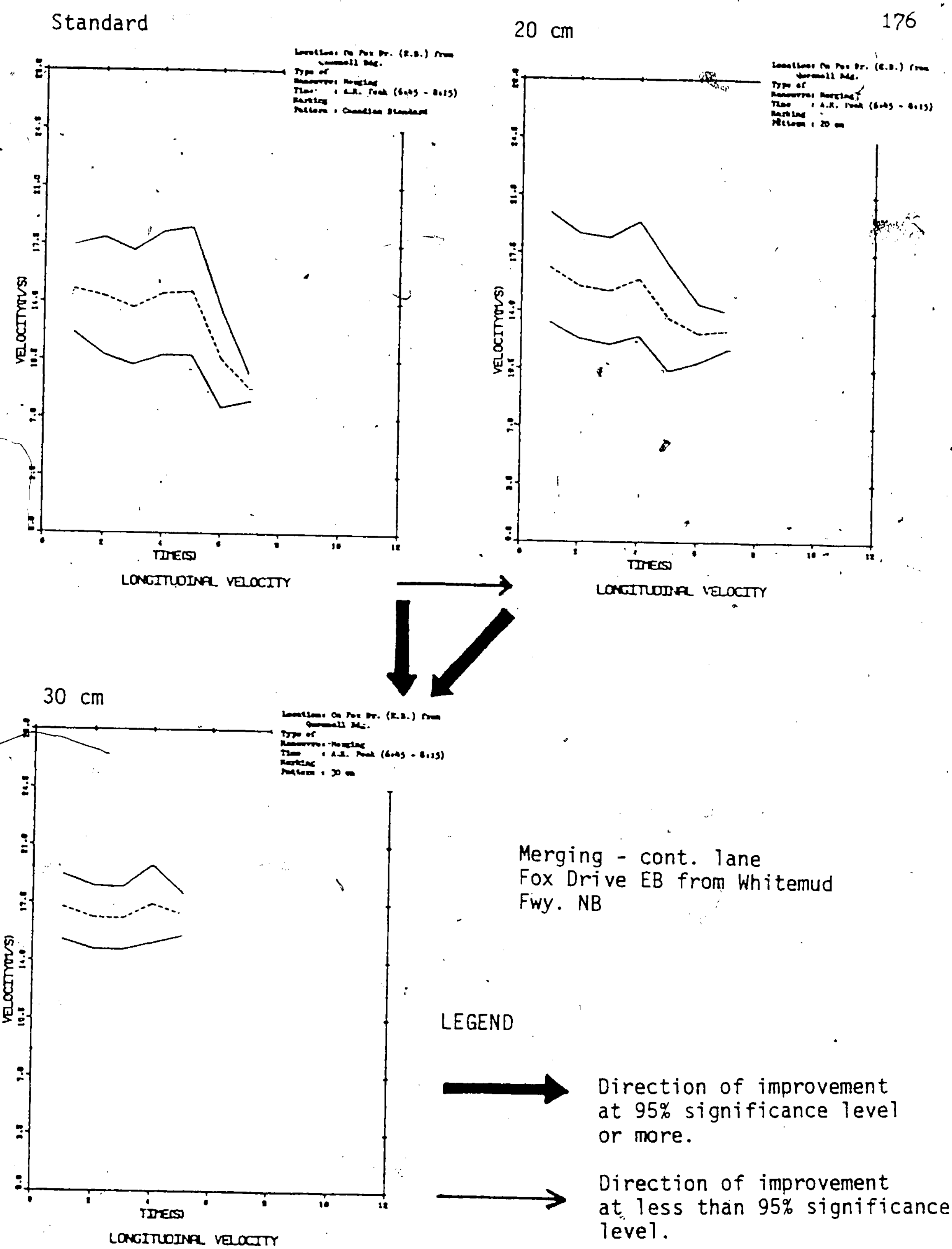


Figure 16

Average longitudinal velocity ±1 standard deviation.

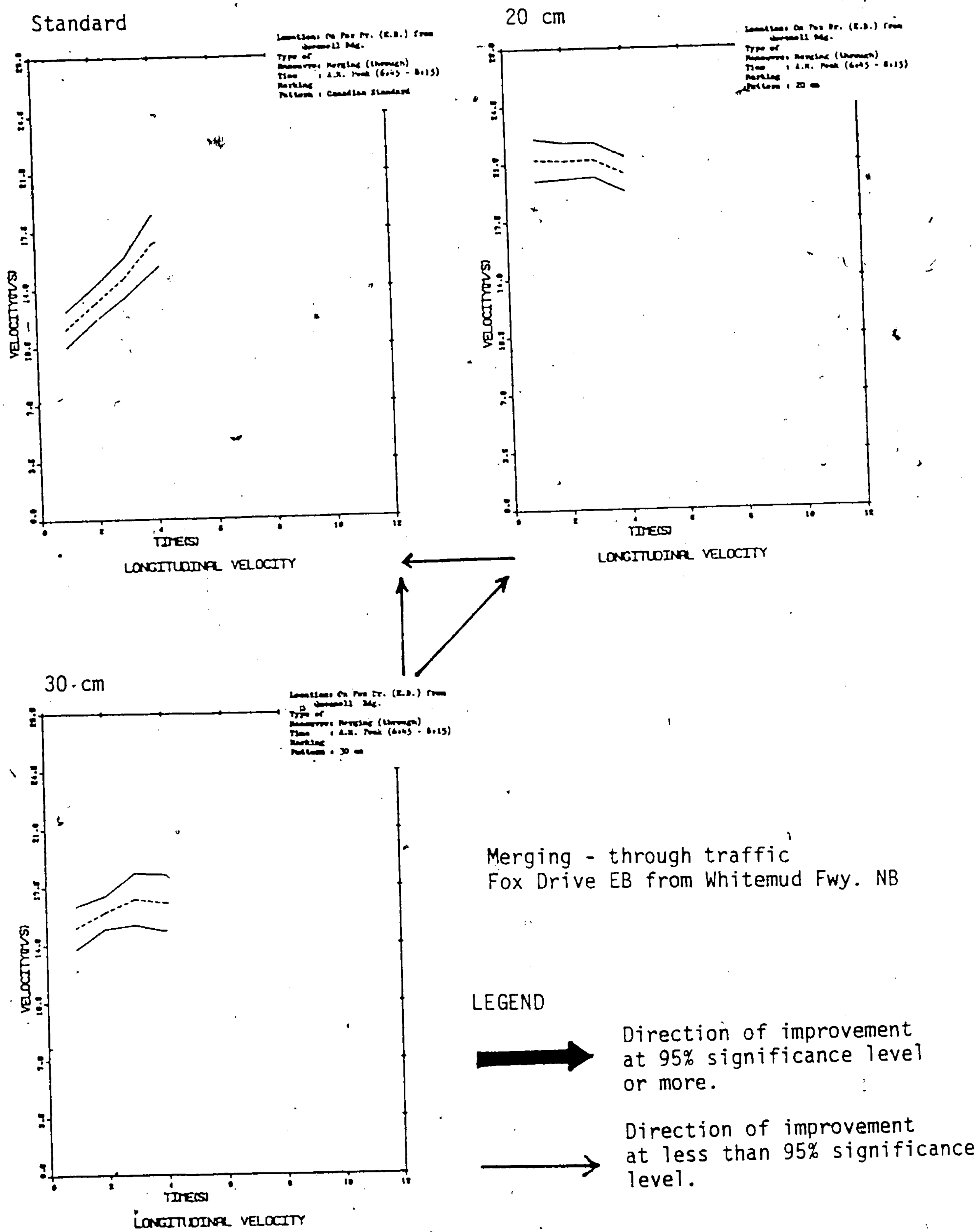


Figure 17

Average longitudinal velocity ±1 standard deviation.

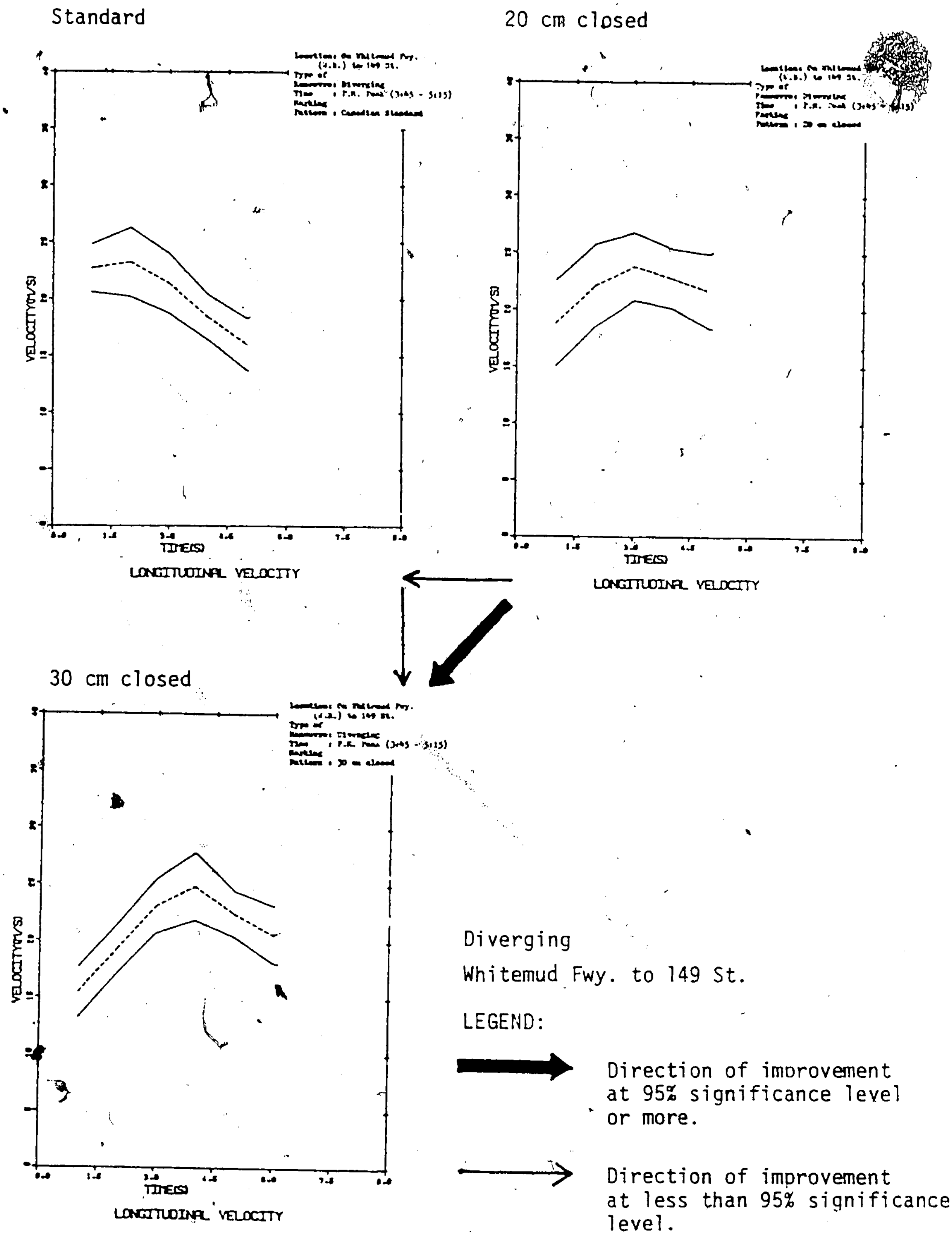


Figure 18

Average longitudinal velocity ±1 standard deviation.