Number Plate Survey Methodology for Long - Distance Traffic Flows

Occasional Paper

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Occasional Paper 81

Number Plate Survey Methodology for Long-distance Traffic Flows

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FOREWORD

The lack of comprehensive data on transport operations is a long-standing problem in transport research. Information on road transport in particular has proved difficult to obtain. This Paper documents a study which was aimed at developing and testing a technique to estimate long-distance passenger and freight movements based on direct observation of vehicle movements.

The study was carried out under the direction of Mr L. Kempen. Dr N. Ada, Mr D. Cosgrove, Mr D. Hamer, Mr P. McDonald, Mr J. Murphy and Mr C. Stevenson made significant contributions.

R. W. L. Wyers
Assistant Director
Systems and Information Branch

Federal Bureau of Transport Economics
Canberra
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Officers of the Federal Bureau of Transport Economics who carried out the fieldwork for the heavy vehicle survey.

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SUMMARY

This Paper documents a study which addressed the development and testing of a technique for estimating passenger and freight movements over long distances based on direct observation of vehicle movements.

The technique adopted was based on a number plate survey. This involves identifying vehicle movements by matching vehicle sightings at various survey locations using the number plate as the primary means of vehicle identification. Pilot testing showed it was very difficult to accurately record details of all vehicles when traffic was heavy. Consequently, the full-scale testing of the technique was restricted to heavy vehicles and, as a result, the emphasis in this study was on freight traffic.

Due to cost considerations and the experimental nature of the study the full-scale test used only three survey locations; the minimum number which would provide a valid test of the methodology. The full-scale test involved a 24-hour survey of southbound heavy vehicles at Marulan, Yass and Wodonga on the Hume Highway. During this heavy vehicle survey, observers attempted to record details of the vehicle including vehicle type, number of axles and commodity if applicable, in addition to the registration number.

The overall survey methodology was found to be workable. The quality of the data collected in the survey was quite good although there were some difficulties at night, largely due to fog. It was usually possible to get the required details, including the number plate, if the night-time recording position had adequate street lighting and was at a place where the vehicles would slow down, such as at an intersection. During the day, recording was much less difficult but it was important to be well away from the congestion of local traffic in town centres.

By matching the vehicle sightings at the different survey locations they were categorised into trips. The most important criterion for matching vehicles was the recorded registration number, but other details of the vehicle description and time of recording were also

used. The matching process adopted was a complex procedure involving computer based sorting and extensive clerical checking which relied upon some degree of judgement.

Because only three survey locations were used it was recognised that estimates of region to region traffic flows derived from the survey would not be very informative as the region boundaries were not well defined. This highlights the major limitation of the methodology, which is the fact that the survey activity is labour intensive and thereby very costly. The number of origin and destination regions that can be defined is related to the number of locations at which the survey is conducted, which in turn has a direct bearing on the staffing requirement. In addition, if the area under study has a complex pattern of probable routes, additional survey locations may be required. Nevertheless, it is felt that the methodology offers a potentially useful approach for studies of freight movements over corridors and medium size areas involving distances of the order of several hundred kilometres.

Notwithstanding the experimental and limited nature of the survey, some of the insights into heavy vehicle traffic on the Hume Highway gained by analysing the results are considered reliable.

The study confirmed the well known fact that the volume and proportion of heavy vehicle traffic varies considerably by time of day. For example, large numbers of semi-trailers passed southbound through Marulan between 4.00 p.m. and 10.00 p.m. accounting for nearly one-half of total traffic at that time. In fact, most of the long-distance traffic travelling through Marulan, Yass and Wodonga occurred in a short span of hours, going through Marulan between 4.00 p.m. and 10.00 p.m., through Yass between 6.00 p.m. and 11.00 p.m. and through Wodonga between 10.00 p.m. and 4.00 a.m. The long-distance traffic was dominated by semi-trailers which carried out nearly 90 per cent of these trips. Semi-trailers were significantly less important on the shorter distance trips.

Estimates of travel time (and hence average speed) were calculated from the recorded time of sighting at the various survey locations. It was clear that a considerable number of heavy vehicles would have had to consistently exceed the speed limit. It was also found that heavy vehicles tended to travel faster at night.

CHAPTER 1 INTRODUCTION

BACKGROUND

The lack of comprehensive data on transport operations is a long-standing problem in transport research. Information on road transport is particularly difficult to obtain because of the large number and diverse nature of participants in that industry. Most of the information available is at a broad level. Information on the stock of vehicles is available from the Australian Bureau of Statistics (ABS) triennial Motor Vehicle Census (ABS 1986a). The triennial ABS Survey of Motor Vehicle Use provides information relating to the operation of vehicles (ABS 1986b). Detailed data on structural and financial aspects of the industry have generally not been available although there has been recent work in this area. In 1984 the Federal Bureau of Transport Economics (BTE) carried out a survey which provided a profile of commercial trucking operations in Australia (BTE 1986). The Bureau also conducted a review of the Australian long-distance coach industry (BTE 1985). The ABS conducted the Transport Industry Survey for 1983-84 (ABS 1986c, 1987).

Notwithstanding these developments the requirement for detailed transport activity data remains unsatisfied. The basic requirement is for disaggregate information on freight movements by origin, destination, commodity and mode. Corresponding data on passenger movements are also required but have usually been given less emphasis. These data are necessary to properly address issues such as modal pricing, assessment of modal competition, decisions on transport infrastructure, and area and corridor studies.

The Bureau has carried out a number of studies of interregional freight flows. These have included studies for individual modes (BTE 1977a, 1979, 1982a, 1983), specific commodities (BTE 1981, 1982b) and area studies (BTE 1973, 1977b).

A comprehensive picture of 1971-72 interregional freight flows was presented in BTE (1976). These estimates were based on data from various sources and relied on some modelling assumptions. Basically,

estimates of total freight were derived from statistics of production which were generally available from official statistical or regulatory sources. Production was allocated to regions on the basis of knowledge of the industries, with pro-rata methods based on population census employment figures as necessary. With some major exceptions, gravity-type models were used to allocate freight to 'consuming' or 'importing' regions. The exceptions were commodities primarily for export or for use in localised processing plants. Independent estimates were made of movements by rail, sea, air and pipeline. Finally, road freight movements were calculated as the balance. The estimates were updated for 1975-76 in BTE (1978).

A notable feature of these two studies is the fact that estimates of road movements were derived indirectly rather than being obtained from the road freight industry or by direct measurement. The Bureau has investigated alternative methods for collecting such data. Truck operators generally do not maintain records which would allow them to readily supply data on, for example, total freight movements by commodity, origin and destination for a financial year. The Bureau also conducted a pilot survey of the manufacturing industry (BTE 1984, unpublished) to see whether manufacturing businesses could provide details of freight consignments by mode and destination. However, the results were disappointing.

AIM OF THE STUDY

Against this background the Bureau decided to conduct the study documented in this Paper, which was aimed at developing and testing a technique to estimate passenger and freight movements over long distances based on direct observation of vehicle movements. The study sought to test this methodology in terms of feasibility, limitations and cost.

It was intended that the study cover passenger traffic as well as freight. However, it became evident that freight flow analysis was more tractable than passenger traffic. Consequently, most of the emphasis in the study was directed to freight traffic.

STRUCTURE OF THIS PAPER

This chapter has outlined the background and aim of the study. The development and pilot testing of the survey techniques prior to the full-scale testing is described in Chapter 2. The full-scale test involved a 24-hour survey of heavy vehicles carried out at three locations, Marulan, Yass and Wodonga, on the Hume Highway. The rationale and organisation of this survey is set out in Chapter 3.

Aspects of data quality for the survey are addressed and analysed in Chapter 4. Chapter 5 describes the characteristics of daily traffic at each of the three survey locations on the Hume Highway.

The major objective of the survey was to deduce the movement of vehicles between the three survey points. Chapter 6 describes the process used to identify vehicle movements, which relied heavily on matching registration number plates. The resultant estimates of traffic flow are set out and analysed in Chapter 7. Concluding remarks are in Chapter 8.

CHAPTER 2 DEVELOPMENT OF TRAFFIC SURVEY TECHNIQUES

This chapter briefly describes some of the techniques that have been used to collect origin-destination information on traffic flows and describes the pilot surveys conducted by the Bureau in developing the survey technique tested in this study.

DATA COLLECTION TECHNIQUES

There are a number of techniques for collecting origin-destination information for a particular route. A description of the major techniques can be found in Daff (1984), on which the following summary is based.

Number plate technique

The number plate technique involves the placement of roadside observers at various points on the route under study. The observers note the number plates of passing vehicles and any other desired information such as vehicle type, number of axles and time of passing. The routes taken by individual vehicles are later deduced by matching the observations from the different observers.

Elevated observer technique

Using the elevated observer technique, one or more observers are positioned with a view of a series of intersections or streets and trace the routes of individual vehicles which enter their field of view. This technique is commonly used to record turning movements at an intersection. It has the disadvantage that, on a road network with a high volume of traffic, observers may be unable to track all the vehicles. This could be overcome by only selecting a sample of the vehicles. A more serious objection from the point of view of this study is that the observers must be able to view the entire study area. This is obviously impractical for a study over the length of a major highway.

Roadside interview technique

In the roadside interview technique, vehicles are directed to stop and the drivers requested to complete a questionnaire giving details of their trip. It is generally argued that high response rates result from interview surveys. Unfortunately this technique is very labour intensive. In areas of high traffic volume bottlenecks can form, causing long time delays and inconveniencing the public. This can also alter the traffic flow if motorists avoid the blockage by taking other routes. Another difficulty is that in some States only police are empowered to direct vehicles to stop.

Postcard reply technique

The postcard reply technique is similar to the roadside interview technique except that drivers are requested to complete a self-administered questionnaire and mail it in a reply paid envelope to the survey agency. Experience indicates this technique generally has a low response rate.

Headlights-on technique

In the headlights-on technique drivers at a particular point are requested to switch on their headlights and observers stationed further down the road system note the distribution of these vehicles. This technique was used in a study at Wangaratta on the Hume Highway (Vincent 1984). Adjustments can be made to allow for the fact that some drivers travel in daytime with headlights on. However, it is obviously impractical for a study in both daytime and night-time conditions.

Windscreen-sticker technique

The windscreen-sticker technique is similar to the headlights-on technique, except that the vehicles are identified by stickers attached to the windscreen. Multiple origins can be identified if different coloured stickers are used. The disadvantage of this technique is that vehicles have to be stopped in order to attach the stickers. Furthermore, there may be little difference between recording details of a windscreen sticker and those of a number plate.

Car following technique

The car following technique involves an observer in a car following a selected vehicle through the study area. This is similar to the elevated observer technique, but can extend the study over a somewhat larger area. It requires either a large number of observers in cars or allows only a small number of vehicles to be studied. For a study

area involving considerable distances this technique is clearly impractical on cost considerations.

Registration address technique

In the registration address technique vehicle registration numbers are recorded and their origin or destination is deduced from their registered address. Alternatively a questionnaire is sent to the registered address in order to collect information on the trip details. For commercial vehicles the registered address often bears no relationship to the trip origin or destination, particularly for vehicles engaged in long distance travel. Furthermore, a mail questionnaire would be subject to a low response rate in the same way as the postcard reply technique. An added complication is that by the time a particular driver received a questionnaire the exact details of the trip may have been forgotten.

PILOT TESTING

The technique chosen for detailed testing in this study was the number plate method. It was felt that this method was capable of collecting adequate data for each vehicle. Another advantage of this technique is that it is less labour intensive and easier to administer than most of the other techniques described. However, little research appears to have been conducted using the number plate technique for a full 24-hour period over long distances. A whole range of practical issues needed to be addressed before attempting a full-scale test survey, including:

- Is it possible to read the number plate of a moving vehicle accurately enough to match it reliably with other sightings of the same vehicle?
- Should all or part of the number plate be recorded?
- Is it better to record details of all vehicles or take a sample?
- How much data and what data items can be recorded accurately and under what conditions?
- What is the best method of recording the data?
- How long can an observer record before fatigue or boredom causes unacceptable loss of accuracy?

First pilot survey

To answer some of these questions a pilot survey was conducted at the junction of the Hume and Federal Highways on Monday 24 February 1986.

The pilot survey consisted of two recording sessions each of three hours. One session was in the late morning, the other in the early afternoon. The morning was cloudy and cold and light rain fell for a short period of time but conditions cleared in the afternoon. Visibility was quite good for the whole time.

The junction of the Hume and Federal Highways is a 'Y' shaped intersection. During the pilot survey, vehicles were observed at three stations. Only one direction of traffic was covered at any one time. These stations were less than 500 metres apart and were located so that all traffic had to pass through two of the three stations. This made it quite easy to match vehicle sightings and enabled the accuracy of the data recorded to be assessed. Some 3400 vehicle sightings were recorded in the pilot survey, involving approximately 1700 different vehicles.

Attempts were made to collect data in respect of all vehicles that passed the observation stations. The actual data items depended on the type of vehicle. State of registration and the registration number were sought for all vehicles. Vehicle type identified included motor cycles, cars, light commercials, rigid trucks, semi-trailers and buses. The number of occupants was recorded for cars and motor cycles. The number of axles and details of the commodity carried, if applicable, were recorded for trucks. Vehicles towing an additional trailer (including, for example, a caravan) were identified as such. A note of the time of day was taken at approximately five minute intervals.

Two methods of recording were tested. The first involved one person observing the vehicles and calling out details to another person who wrote them down on a coding sheet. The second involved only one person using a tape recorder. The tape recorder method was found to be much easier and more accurate.

For the majority of vehicles it was quite easy to read the number plate. However, it was rather more difficult to be sure of the State of registration. The major difficulty in recording number plates (and other vehicle details) was not the speed of the vehicles but their frequency. When groups of vehicles went past it was difficult keeping up with the recording task and one or more of the vehicles in the group could be obscured.

In general it was easier to read the front number plate as the vehicle was approaching. The number plates on motor cycles were very hard to read because of their small size and the fact that they are at the

rear. Of course, the number plates on the front and rear of semi-trailers are often different. In addition to it being easier to read the front plate as the vehicle was approaching, it was noticed that the rear plate was usually dirtier than the front.

The use of binoculars to assist in reading number plates was also tested and found to be beneficial. It was noticed, however, that extended use of binoculars created eyestrain.

Another technique that can potentially improve the accuracy of recording number plates is to record only part of the plate, such as the last four characters. In theory, this could make the matching process less accurate, but the effect might be very small. It was found that this technique conferred no appreciable advantage. If the number plate could be read at all, it was just as easy to record the full number.

Number plate surveys are sometimes based on a sample of the traffic. Daff (1984) points out that it is usual to sample on the basis of the last digit of the number plate. Sampling was not considered to be a viable option for this study. It does not really help with the problem of reading number plates because the number plate must be seen clearly in order to decide whether or not to include a particular vehicle in the sample. In addition, when traffic is not very heavy, a lot of the survey time would be unproductive. Obviously, the sampling has to be on the basis of an observable unchanging feature of the vehicle. This is the only way to ensure that a vehicle selected at one observation point would also be selected at any other observation point through which it passed.

The pilot survey provided a number of other findings. It was not easy to count the occupants in cars. From a distance it was easy to confuse a head restraint and an occupant. Tinted windows and sunlight glare off windscreens added to the difficulty.

Difficulties were experienced in identifying vehicles in the light commercial category. The definition used in the pilot survey attempted to exclude passenger vans by reference to whether or not the rear compartment was fitted with seats. Passenger vans were then counted as cars. This definition proved very difficult to implement.

The observers found the work very demanding. It was necessary for each person to take regular breaks. Endurance also seemed to be influenced by the frequency of vehicles and the perceived success rate. Heavy traffic together with a relatively high number of missed observations resulted in lower endurance.

The observation stations in the pilot survey were positioned so that each vehicle had to pass two stations. It was generally easy to match vehicle sightings at the different stations because the stations were less than 500 metres apart. Comparison of the number plate records for the same vehicles at the different stations showed that it was difficult to visually distinguish between 'O', 'D' and 'Q'; 'I' and 'T'; 'M' and 'W'; and '8' and '3'. Problems with pronounciation also caused confusion between the letters 'M' and 'N'; 'G' and 'J'; 'B', 'P' and 'V'; and 'Y' and 'I'.

Second pilot survey

Overall, the results of the first pilot survey were encouraging. However, there was considerable difficulty in collecting details of all vehicles when traffic was heavy. The need for detailed data on freight movements has generally been given greater emphasis than the need for data on passenger movements. Accordingly, it was decided to focus the survey work on heavy vehicles. It was still necessary to test whether recording could be successfully carried out at night. This is particularly important for measuring freight movements because a significant proportion of long distance road freight movements occurs at night.

A second pilot survey was conducted to test night-time recording of heavy vehicles. This survey was carried out at Yass on Monday 24 March 1986 between 6.30 p.m. and 9.00 p.m. by a team of three persons with a tape recorder.

Two roadside locations were tested. The first was on the Hume Highway at an intersection in the centre of town. The intersection was controlled by traffic lights which served to slow the traffic and assist recording. The location was also reasonably well lit by street lighting. It was found that it was much easier to record the rear number plate. Looking into the headlights trying to read the front number plate was very difficult. Generally, most details of the vehicle could be recorded just before or as it was passing the observation point and the rear number plate picked up as the vehicle was moving away. When groups of heavy vehicles went past all members of the observation team were busy. Having one person equipped with binoculars and given the responsibility for recording only number plates seemed to work well although this task was best rotated because it was hard on the eyes. It was also important to verbally label the sequence of heavy vehicles in a group because the records on the tape would consist of a list of vehicle descriptions followed by a list of registration numbers. Some 130 heavy vehicles were observed at this location with a high degree of success.

The other location tested was on the Hume Highway just outside Yass. This location was poorly lit. It proved virtually impossible to record number plates under these circumstances.

CONCLUSIONS FROM THE PILOT TESTS

The main conclusion of the pilot surveys was that a number plate based survey of heavy vehicles on a major highway was feasible. Data can be collected both in daylight and at night with sufficient accuracy to allow vehicles to be matched at different points along the highway.

The first location tested in the second pilot survey was suitable for night-time recording. However, the amount of traffic in town during the day, both local heavy vehicle and passenger traffic, would make it difficult to carry out the survey in the middle of a town during the day. The locations used during the day and night do not have to be the same. A location outside a town is more suitable during daylight while one inside a well lit area is more suitable at night.

Daytime recording locations should have:

- a clear view of the road used by approaching vehicles;
- sufficient room on the side of the road for the recording station; and
- minimal local traffic.

Night-time recording locations should:

- be well lit;
- have a clear view in both directions of the route the traffic will take; and
- have a feature such as traffic lights, corners or steep hills that cause the vehicle to slow down or stop.

The pilot surveys clearly showed that the use of tape recorders was the best way to collect the data. It was also clear that the recording task was quite demanding and that teams of three persons each were necessary to allow adequate rest.

CHAPTER 3 ORGANISATION OF THE HEAVY VEHICLE SURVEY

As outlined in Chapter 2, the pilot testing of techniques led to the decision to focus the survey activity on heavy vehicles. This chapter describes the arrangements for the 24-hour heavy vehicle survey conducted on the Hume Highway which was the full-scale test of the survey technique.

SURVEY CONSTRAINTS

The major factors to be considered in any survey activity are costs and timing requirements. The New South Wales Ministry of Transport (MoT) conducts a one-week survey every quarter at the Marulan and Berowra vehicle checking stations. During this survey week, data additional to the normally collected vehicle type and axle weight details are obtained from the vehicle driver. These include information on type of commodity for freight vehicles, number of passengers for buses, and origin and destination areas. One of these surveys was timed to commence on Monday 2 June 1986. Because this survey would provide a useful check on the Bureau's survey, it was considered important that the 24-hour heavy vehicle survey be conducted at the same time.

The pilot surveys indicated that the staff requirements for the survey would be considerable. In general, three persons per shift would be required at each survey location to cover traffic in one direction only. Survey personnel could not be expected to operate effectively for longer than six-hour shifts. Because survey conditions were more favourable at the Marulan vehicle checking station (largely because the vehicles are stopped), it was felt that only two persons per shift would be necessary at that location.

It was also necessary to carry out the survey at each location for longer than 24 hours in order to obtain a reliable picture of traffic flows for a 24-hour period. The reasons are explained more fully in the next section but hinge on the need to account for variations in vehicle travel time between survey locations.

Because the survey was exploratory and developmental in nature it was considered important to minimise the cost. This was done by using the minimum number of survey locations which would still provide a valid test of the methodology. As a consequence the estimates of region-to-region traffic flow derived from the survey were not very informative because the regions were not clearly delineated. It was also considered important to maximize the use of Bureau officers. Bureau staff could be trained quickly so as to meet the tight timing constraint and could be allocated to the project without incurring additional expenditure. For these reasons it was decided to use the limited staffing resources of the Bureau rather than employ temporary staff to conduct the survey.

In light of these considerations it was decided to conduct the survey at only three locations on the Hume Highway measuring only one direction (southbound) traffic.

SURVEY SITES AND TIMES

The choice of survey locations directly determines the regions between which estimates of traffic flow can be determined. The southbound Marulan vehicle checking station was one obvious location because the survey could be carried out there with fewer staff resources and to take advantage of the opportunity to compare results with the concurrent MoT survey.

Consideration of the likely origins and destinations of freight traffic that would travel south on the Hume Highway led to the decision to place the other two survey locations south of Yass and south of Wodonga. This would determine four regions:

- Region A (north of Marulan) which would include Sydney;
- Region B (between Marulan and Yass) which would include Canberra and Goulburn;
- Region C (between Yass and Wodonga) which would include the western States and Albury; and
- Region D (south of Wodonga) which would include Melbourne.

In fact two locations were used at Yass. For daytime observation a location about four kilometres south of Yass was used. This location was far enough out of Yass to minimise the difficulties caused by a high volume of local traffic and, being on a substantial rise, afforded a good view of oncoming traffic as well as slowing it down. At night, the survey location was shifted to the main intersection in Yass to take advantage of the street lighting and the fact that the intersection would slow the traffic down.

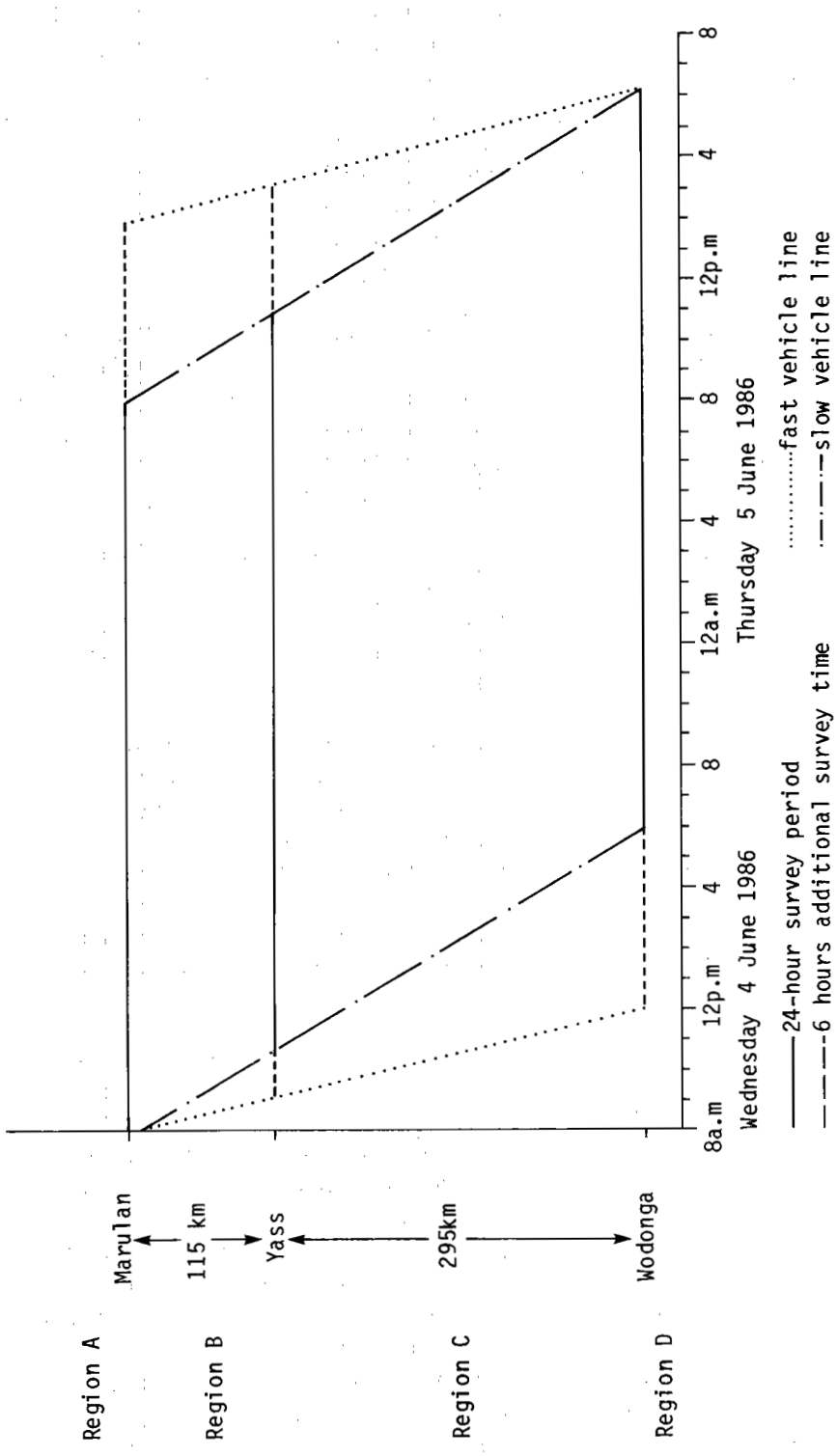
Permission was obtained from the local police to set up the Wodonga survey point at the northern end of the Wodonga bypass freeway. This location was suitable both for daytime and night-time observation. In fact, daytime observation was carried out some 100 metres from the start of the freeway. At night, the observation point was right on the intersection to take advantage of the street lighting and the fact that the traffic lights stopped the traffic. Traffic entering the freeway from the causeway (bypassing Wodonga) and traffic exiting Wodonga and entering the freeway were recorded.

The survey commenced at 8.00 a.m. on Wednesday 4 June 1986 at the southbound Marulan vehicle checking station. This starting time was chosen because it is a time with relatively low volume of traffic through the vehicle testing station, and because it was convenient in terms of the travel from Canberra by Bureau staff as well as the travel requirements thereby imposed for the Yass and Wodonga sites.

Figure 3.1 shows, among other things, the start and finish times at each survey location. Thirty hours of observation were carried out at each location and a specific 24-hour subset defined. To appreciate the reasons underlying the choice of times it is helpful to think of the survey as three separate surveys.

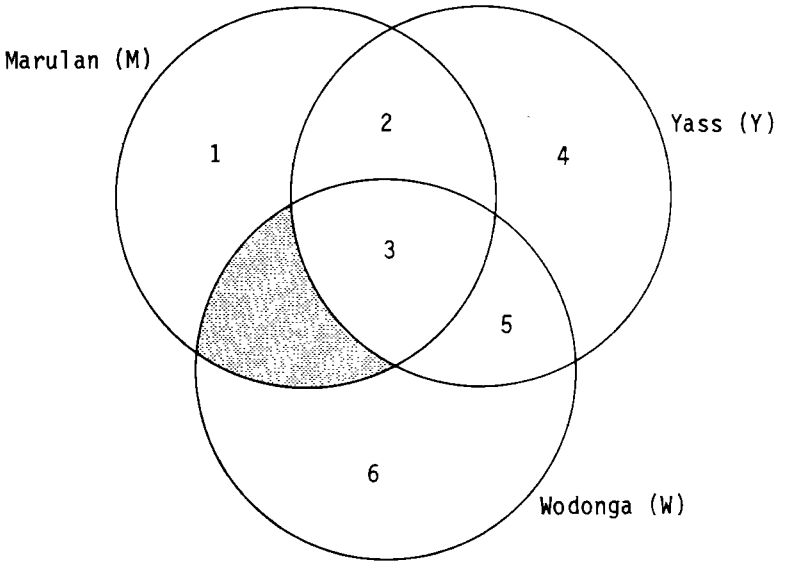
The 24-hour survey at Marulan was primarily designed to provide an estimate of one day's traffic originating in Region A. Likewise, the 24-hour survey at Yass was intended to estimate one day's traffic originating in Region B and the 24-hour survey at Wodonga was intended to pick up one day's traffic originating in Region C. The presence and placement of the extra six hours of observation at each survey location arises from variations in vehicle travel time and was intended to facilitate correct identification of origin, as well as destination, regions.

As indicated in Figure 3.2 there are six origin-destination 24-hour flows that can be estimated from the survey. The formulae are given in set notation; M, Y, W represent all vehicles recorded at Marulan, Yass and Wodonga respectively; M^*, Y^*, W^* represent those vehicles recorded in the relevant 24-hour subsets, and -, $\cap$, $\cup$ are the set operations of subtraction, intersection and union respectively. For example, the estimate of daily traffic from Region A to Region B (M^*-Y) is those vehicles recorded in the 24-hour period at Marulan that were not picked up at Yass. The estimate for Region B to Region C ($Y^*-(M \cup W)$) is those vehicles recorded in the 24-hour period at Yass but not picked up in either Marulan or Wodonga. The estimate for Region B to Region D ($Y^* \cap W-M$) is those vehicles recorded in the 24-hour period at Yass and recorded at Wodonga but not at Marulan.



Source BTE heavy vehicle survey (1986).

Figure 3.1 Heavy vehicle survey times



1	Region A to Region B	$M^* - Y$
2	Region A to Region C	$M^* \cap Y - W$
3	Region A to Region D	$M^* \cap W$
4	Region B to Region C	$Y^* - (M \cup W)$
5	Region B to Region D	$Y^* \cap W - M$
6	Region C to Region D	$W^* - (M \cup Y)$

Note All vehicles recorded in both Marulan and Wodonga are assumed to have travelled through Yass.

Source **BTE heavy vehicle survey (1986).**

Figure 3.2 Formulae for origin-destination flows

The survey start times at Yass and Wodonga were 9.00 a.m. and 12 noon respectively. These correspond to the fast vehicle line (see Figure 3.1) for a vehicle travelling at an average speed somewhat in excess of 100 kilometres per hour. This ensured that a vehicle travelling through Marulan at the start of the survey (8.00 a.m.) would be picked up at Yass and Wodonga if it travelled through those survey locations.

The 24-hour period at Marulan was set at 8.00 a.m. Wednesday to 8.00 a.m. Thursday. To ensure that slow vehicles travelling through Marulan at the end of this 24-hour period would be picked up at Yass and Wodonga, these latter stations had to be open longer than 24 hours. This is shown by the slow vehicle line for a vehicle averaging somewhat less than 50 kilometres per hour. An extra six-hour shift was used at Wodonga.

Clearly, the 24-hour period at Wodonga for estimating traffic originating in Region C should be the last 24 hours of the 30-hour period. This maximises the likelihood that a vehicle observed at the start of this period would have been picked up at Marulan and/or Yass if it had travelled through those survey locations. This does mean, however, that Marulan and Yass survey locations had to operate longer to ensure that a fast vehicle travelling through Marulan and/or Yass and reaching Wodonga just before the close of the survey at Wodonga was also recorded at the earlier locations. For simplicity it was decided to operate all survey locations for 30 hours.

The placement within the 30 hours 9.00 a.m. Wednesday to 3.00 p.m. Thursday of the 24-hour period at Yass, for estimating traffic originating in Region B, is not as clearcut. Ideally, the start of this period should be as late as possible to minimise the chance that it includes a slow vehicle that passed Marulan before the survey commenced at Marulan. Conversely, it should be as early as possible to minimise the chance that it includes a slow vehicle that passed Wodonga after surveying there ceased. Having regard to the relative distances between Yass and Marulan, and Yass and Wodonga, it was decided to commence the 24-hour period at 11.00 a.m. Wednesday, two hours after the commencement of the survey at Yass.

DATA COLLECTION

The heavy vehicle survey collected data from vehicle observations including time of day, vehicle type, number of axles, commodity (where applicable) and registration numbers. The data were recorded directly onto coding sheets at Marulan. At Yass and Wodonga, tape recorders were used to capture the data which were subsequently transcribed onto coding sheets. A copy of the coding sheet is at Appendix I.

Time of day was recorded to enable analysis of traffic flow patterns and trip times as well as providing additional information to assist in matching vehicle observations between the three survey locations. A time reading was not made for each vehicle observation. Staff were instructed to make a time recording at about every five minutes.

The first pilot survey emphasised the need to use a simple vehicle-type classification. The major difficulty encountered in the pilot survey was with light commercial vehicles. Such vehicles are not required to enter the Marulan vehicle checking station and the fact that they would not be covered in the survey was reflected in the definitions adopted.

The vehicle types identified were coaches, other buses, rigid trucks and semi-trailers. Rigid trucks towing additional trailers were separately identified.

Buses were defined to exclude light commercials. Coaches comprised long distance and charter buses. Other buses included local, school and military buses.

A truck was defined as:

- not a sedan, station wagon, utility, light commercial or bus;
- any other vehicle with three or more axles;
- any other vehicle with two axles and four tyres on the rear axle (dual tyres); and
- any prime mover travelling alone (not already covered).

The last point in the definition was only necessary to account for the unlikely occurrence of a two axle, non-dual tyre prime mover travelling alone. However, it served to emphasise the inclusion of prime movers travelling alone as trucks and simplified the observational task. Prime movers travelling alone were, in fact, recorded as semi-trailers.

The number of axles was recorded for each vehicle and recorded separately for additional trailers. For example, a three axle rigid truck towing a two axle additional trailer was recorded as such and not as a five axle rigid truck or semi-trailer. Of course the trailer which forms the integral part of a semi-trailer was not considered to be an additional trailer.

For trucks carrying freight, or capable of carrying freight, a broad commodity classification was used. The four categories were bulk solid, bulk liquid, non-bulk and livestock. Generally, body type or trailer type was used as a proxy for commodity. For example, tippers were described as bulk solid, tankers as bulk liquid and flat-tops and pantechnicons as non-bulk. A more detailed commodity classification (see Appendix II) was used at Marulan where vehicles could be more

readily observed, but the staff at Yass and Wodonga were instructed to describe the load as they saw it.

The most important data items for the survey were the registration numbers. For buses and rigid trucks without additional trailers staff were instructed to record either the front or rear registration number (which, of course, should be identical). For other vehicles, especially semi-trailers, the rear number was considered the more important but staff at Marulan and those operating in daylight at Yass or Wodonga were asked to also attempt to record the front number. Reading front registration number plates into the glare of oncoming headlights was found in the second pilot test to be very tiring, if not impossible.

The New South Wales Department of Main Roads (DMR) operates permanent automatic counting stations fairly close to the survey locations at Marulan and Yass. Data from these stations were used to describe the heavy vehicle traffic as a function of total traffic. No suitable counting station was close to the Wodonga survey location. In addition to their other duties, the staff at Wodonga operated a hand-held counter to obtain total hourly vehicle volumes.

STAFFING ARRANGEMENTS

A total of 31 Bureau officers assisted with the fieldwork. The two persons per shift at Marulan and the three persons per shift at Yass were relieved at the end of each six-hour shift. Five shifts operated at Marulan and Yass.

Because of the distance to Wodonga it was not feasible to operate the survey there on a relief basis from Canberra. Instead, two teams of three officers each were stationed in Albury-Wodonga and shared the workload on an alternate shift basis. Six shifts were used, one of three hours followed by four of six hours and a final shift of three hours.

To ensure that the fieldwork would proceed smoothly the local police at Yass and Wodonga, DMR and the Victorian Road Construction Authority were advised as to the nature and timing of the survey. One incident involving the 9.00 p.m. to 3.00 a.m. Yass shift confirmed the importance of notifying local authorities. These staff were visited by police after a concerned citizen telephoned the police station and reported three suspicious looking men loitering around the bank!

All staff involved in the fieldwork were extensively briefed to ensure that they understood the data definitions and collection requirements.

The briefing covered the logistics of providing the relief shifts to Marulan and Yass as well as dealing with contingencies such as staff being unavailable due to illness.

Except at Marulan, where the survey was conducted at the vehicle testing station, observations were taken from a parked car. Safety aspects such as how and where to park the survey vehicles were also covered in the briefing. Large signs stating 'Traffic Survey in Progress' were provided to display at the front and rear of the survey vehicles during daylight hours.

CHAPTER 4. QUALITY OF DATA FROM THE HEAVY VEHICLE SURVEY

The purpose of this chapter is to investigate aspects of the quality of the data collected in the heavy vehicle survey. This data quality needs to be assessed in terms of the adequacy of the data for describing vehicle populations at the different survey locations and for estimating traffic flows along the highway through a vehicle matching process.

The survey data were primarily used to analyse traffic flows by identifying the same vehicle at different survey locations. For this analysis, complete and accurate recording of vehicle registration plates was particularly important. A secondary use of the data was the description of vehicle populations at each survey location in isolation. For this analysis the completeness and accuracy of recorded vehicle details, such as vehicle type and number of axles, are important.

DATA EDITING

At Marulan, the vehicle details were written directly onto prepared coding sheets. At the Yass and Wodonga survey locations tape recorders were used and the data were subsequently transcribed onto coding sheets. Before any analysis was done the data were subjected to detailed editing. The editing process is illustrated in Figure 4.1.

Prior to keying the data to magnetic tape, the coding sheets were examined for obvious transcription errors, legibility and consistency of notation. For example, the consistent use of 'Ø' for the number zero, to distinguish it from the letter 'O', was clerically checked. Space was allowed on the forms for the survey personnel to comment on anything unusual or on items of which they were unsure. A further clerical check of the data was accomplished by comparing the comments made about a vehicle with its recorded details.

The data were keyed to magnetic tape using double punching to minimise errors. Because the Marulan coding sheets were completed on-site,

sometimes hurriedly, they were somewhat less legible than those for the other survey locations and the keypunch operators could have had difficulty reading parts of them. So a complete clerical check of all details was made on the sightings recorded at Marulan. Computer tests were then run on the data file to determine whether the entered values for each vehicle's number of axles, broad commodity type and time of day sighted were within valid ranges. Tests were also performed to ensure that each vehicle had only one vehicle type recorded and not more than one commodity code.

Registration plate records were also searched for any inconsistencies. These consisted of number plates with more than six characters and rigid vehicles with differing front and rear recorded number plates.

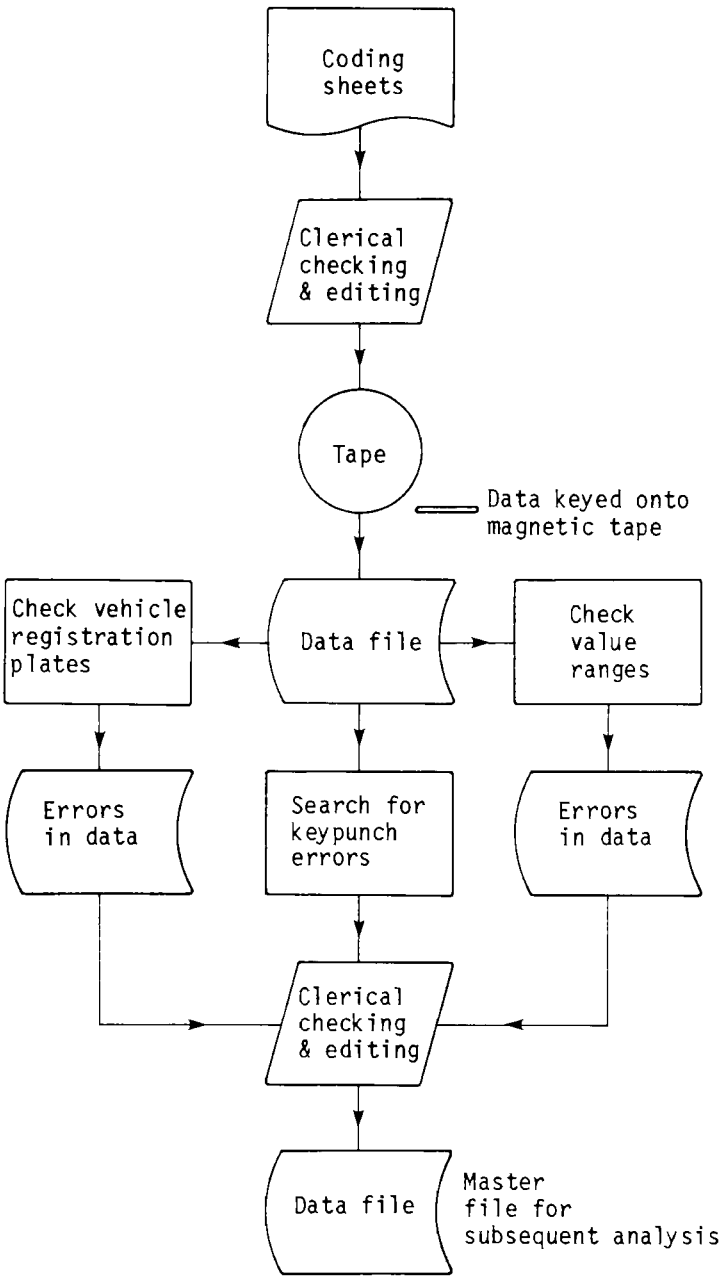
The editing process resulted in changes to the punched data affecting 7.3 per cent of the 4416 vehicle sightings recorded in the survey. On average, only one item of data needed to be changed for each of these vehicle sightings. That is, approximately 0.3 per cent of the original survey data was altered.

QUALITY OF THE SURVEY DATA

In terms of describing the composition and distribution of traffic at the three separate survey locations, the quality of the data collected in the survey was good. The details important for describing the vehicle populations at each site are the vehicle type, number of axles and the commodity type for freight vehicles.

These characteristics were recorded for the majority of the surveyed vehicles. A vehicle type was recorded for all but 0.5 per cent of vehicles. Most of these comprised vehicles for which data was lost due to problems with the tape recorder at the Wodonga survey station. A vehicle type of semi-trailer was imputed for these vehicles. The number of axles was missed for only 0.1 per cent of the vehicles which passed through Marulan, 1.1 per cent of the vehicles at Yass and 3.0 per cent of the vehicles at Wodonga. The broad commodity type of the freight being carried was not recorded for 0.5 per cent of the freight vehicles surveyed at Marulan, 8.7 per cent of the freight vehicles at Yass and 5.9 per cent of the freight vehicles at Wodonga.

Survey personnel were instructed to record the time of day approximately every five minutes. Throughout most of the survey period this five minute (or better) recording interval was maintained, yet some lapses did occur. There were a few cases, mainly at night or in the early morning, when recorded times were separated by up to thirty minutes despite the presence of a fair amount of traffic. This



Source BTE heavy vehicle survey (1986).

Figure 4.1 Flowchart of data editing

does affect, to some extent, the accuracy of the travel time estimates in Chapter 7.

Survey staff were instructed to afford low priority to recording the specific commodity. If very busy, they were to give preference to recording the other required details. The data on specific commodities carried by freight vehicles were therefore not very complete. Survey personnel did not identify the specific commodity for 42.8 per cent, 61.9 per cent and 55.3 per cent of freight vehicles at the Marulan, Yass and Wodonga sites respectively. However, this was due mainly to the inability to see the freight when it was covered by a tarpaulin or in an enclosed van.

The prime objective of the survey was to estimate traffic flows along the highway by matching vehicle sightings at different survey locations. The most important details recorded for this purpose were the vehicles' registration plates. The rear plate was the more crucial since front plates are very difficult to read at night.

Overall, a high proportion of vehicles had their rear number plate recorded. A complete rear number plate was recorded for 95.6 per cent of all vehicles at Marulan, 72.9 per cent of all vehicles at Yass and 86.7 per cent of all vehicles at Wodonga. Tables 4.1 and 4.2 show the proportions of vehicles for which full or partial number plates were recorded. In a small number of cases survey personnel recorded that the vehicle appeared to be lacking one or both of its number plates, making registration number recording impossible. Characters from number plates were occasionally missed by the survey personnel because the plate was obscured by other parts of the vehicle, dirty or poorly lit at night. Some plates were so dirty that they were totally unreadable.

DEMERIT REPRESENTATION OF DATA COMPLETENESS

The completeness of the data may be evaluated and summarised through the use of a demerit system. In such a system, the failure to record vehicle details incurs an appropriate number of demerit points. Such a summary method helps in assessing the methodology of the survey because it allows the difficulty of data recording to be analysed in terms of the conditions at the survey locations.

The details of the demerit system are largely arbitrary. The values assigned to various omissions in recording were chosen to reflect the priority placed upon the different data items. Demerit points were allocated for the failure to obtain the broad commodity type for a freight vehicle, the failure to record the number of axles or, most

TABLE 4.1 PROPORTION OF VEHICLES BY COMPLETENESS OF REGISTRATION NUMBER RECORDING AND SURVEY LOCATION: SEMI-TRAILERS AND RIGID TRUCKS WITH TRAILERS

(per cent)

Number plate data recorded	*Survey location*		
	Marulan	*Yass*	*Wodonga*
Full front and rear plates	92.8	21.0	23.9
Full rear plate	1.7	48.8	61.2
Full front plate	2.2	2.1	1.2
Partial plates	3.2	20.0	7.6
No characters	0.1	8.1	6.1
Total	100.0	100.0	100.0
Number of vehicles	1 393	1 151	805

Source BTE heavy vehicle survey (1986).

TABLE 4.2 PROPORTION OF VEHICLES BY COMPLETENESS OF REGISTRATION NUMBER RECORDING AND SURVEY LOCATION: BUSES AND RIGID TRUCKS WITHOUT TRAILERS

(per cent)

Number plate data recorded	*Survey location*		
	Marulan	*Yass*	*Wodonga*
Full plate	99.5	83.2	91.0
Partial plate	0.5	10.4	4.5
No characters	0.0	6.4	4.5
Total	100.0	100.0	100.0
Number of vehicles	411	345	311

Source BTE heavy vehicle survey (1986).

importantly, the failure to record details of a vehicle's rear registration plate. Having characters recorded from the front number plate was helpful in the matching process, especially if some or all of the characters had been missed from the rear. Thus, demerits accrued by missing characters from the rear registration plate were negated to some extent if characters from the front plate were recorded. Details of the demerit points are in Table 4.3. A vehicle for which no particulars were recorded would receive the maximum demerit score of 30 points.

A zero demerit score, indicating very high data completeness, occurred in 97.3 per cent, 70.4 per cent and 84.7 per cent of all vehicles for the Marulan, Yass and Wodonga survey locations respectively. Any

TABLE 4.3 STRUCTURE OF DEMERIT POINTS

Data item	*Demerit points*
Broad commodity	1
Number of axles	4
Rear registration plate	
Number of characters missed	
1	1
2	5
3	12
4	20
5	24
6	25
Front registration plate[a]	
Number of characters recorded	
1	0
2	0
3	-1
4	-5
5	-10
6	-12

a. The number of demerit points incurred for failing to record characters of the rear registration plate are offset to the extent shown if details of the front registration plate were recorded.

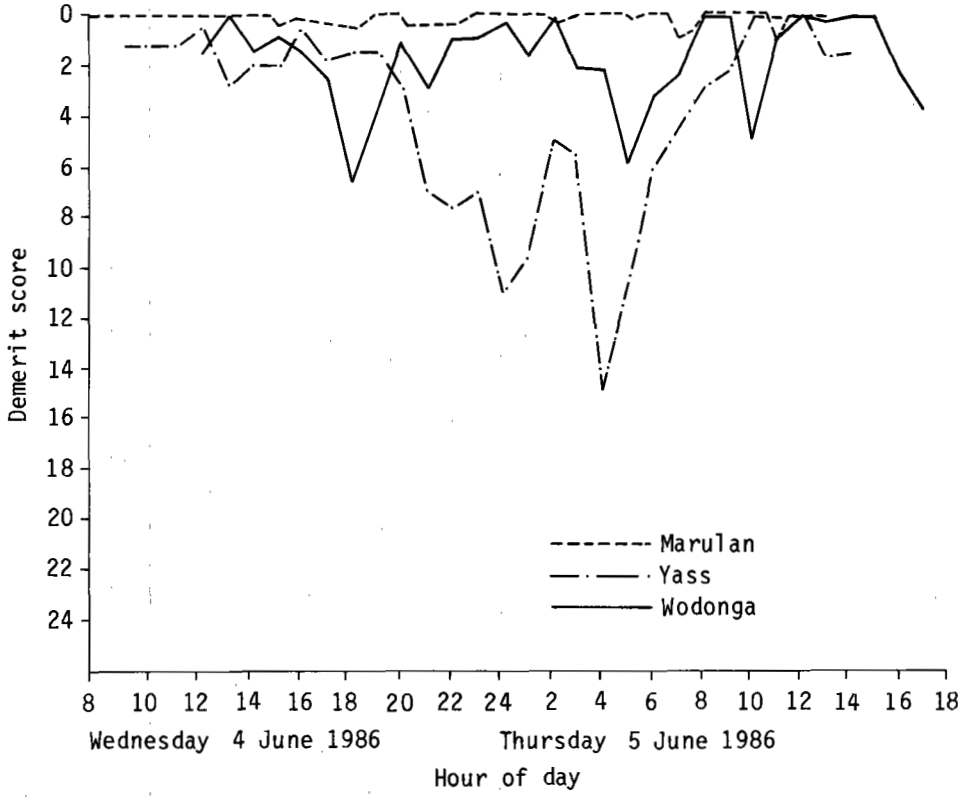
vehicle recording with a demerit score of below about 12 generally had enough information recorded to allow accurate matching (see Chapter 7). At Marulan 98.1 per cent of vehicles had less than 12 demerits, as did 83.2 per cent at Yass and 90.4 per cent at Wodonga. Maximum demerits; that is, a lack of any details suitable for matching; occurred in approximately 0.1 per cent of sightings at Yass and 1.6 per cent of sightings at Wodonga. There were no cases of maximum demerit score at Marulan.

A graph of the mean demerit score per hour against time is shown in Figure 4.2. This summarises the relative performance between the three survey stations and highlights the times of the day when data recording was hampered by prevailing conditions.

Marulan recorded very few demerits due to the favourable conditions. Because Marulan was expected to be the most favourable of the survey locations, the shifts there consisted of two survey personnel, whereas the Yass and Wodonga sites had three people per shift. Most declines in data completeness at Marulan coincided with the opening of a second lane at the vehicle checking station, since this necessitated each person working alone.

The demerit curve for Yass exhibits quite large peaks, most of which occurred at night. At Yass, the daytime counting position was outside the town and the night-time position was in the middle of town to take advantage of street lighting. During each change in survey position recording proved to be difficult. Recording the vehicles at night in Yass also proved quite difficult for many of the survey personnel, due to the site not being ideal. The level of lighting was not sufficient and, for much of the night, fog further reduced visibility. Many vehicles were travelling faster than those during the day, especially after 1.00 a.m. During these early hours of the morning, when the volume of cars was low, the trucks sped up considerably and some did not even appear to slow down for the traffic lights adjacent to the survey position.

The Wodonga station also incurred sizeable peaks in demerits. The actual recording position in Wodonga was such that visibility was poor at dusk and dawn. Problems with the tape recorder early on the Thursday morning caused the loss of data for an estimated 18 vehicles. The rise in demerits towards the end of the survey could have been due to staff fatigue, since the survey at Wodonga was carried out by only two teams working in rotation. At Marulan and Yass the teams were relieved from Canberra after each shift of six hours.



Source BTE heavy vehicle survey (1986).

Figure 4.2 Completeness of data by hour: Marulan, Yass and Wodonga survey locations

No significant relationship was found between demerits and traffic volume. Poor visibility seemed to be the major factor influencing the quality of the data.

INCONSISTENCIES WITHIN THE DATA

Complete data do not necessarily imply that everything recorded is accurate. For example, a truck may be recorded at Yass as being a bulk solid carrier, yet be recorded as carrying non-bulk freight at Wodonga. A measure of the accuracy of the recorded data may be gained by looking at vehicles which were sighted at more than one survey location. After a vehicle has been matched, its different descriptions can be compared to search for any vehicle details that are not consistent across the sightings.

Using this technique it was found that discrepancies between recorded vehicle type occurred for 2.3 per cent of the vehicles matched between all three survey locations. Discrepancies were also noted between the number of axles for 7.7 per cent of these matched vehicles and between the broad commodity type for 2.3 per cent of the freight vehicles matched between the three locations.

As an example, one car carrier was recorded as a three axle rigid truck with a two axle additional trailer at Marulan, as a five axle semi-trailer at Yass, and as a six axle semi-trailer at Wodonga.

CHAPTER 5 TRAFFIC CHARACTERISTICS AT MARULAN, YASS AND WODONGA

This chapter describes the major characteristics of southbound traffic at each of the three locations, Marulan, Yass and Wodonga. As explained in Chapter 3, a specific period of 24 hours was defined for each survey location as a basis for estimates of daily traffic flow between regions. The estimates of daily traffic composition presented in this chapter are also based on those 24-hour subsets.

TRAFFIC COMPOSITION

During the 30 hours of surveying, a total of 1804, 1496 and 1116 heavy vehicles were recorded at Marulan, Yass and Wodonga respectively. The total number of heavy vehicles at each survey location by hour of the day shows peak traffic volumes occurring late afternoon and early evening at Marulan, early to late evening at Yass and early morning at Wodonga (see Figure 5.1). If travel time is taken into account this pattern is consistent with a wave of traffic moving south on the Hume Highway. This topic is addressed in more detail in Chapter 7.

By vehicle type

A total of 1485, 1239 and 950 heavy vehicles were recorded in the relevant 24-hour survey periods at Marulan, Yass and Wodonga respectively. Table 5.1 shows the breakdown by type of vehicle. Semi-trailers were consistently and by far the dominant vehicle type, accounting for nearly three out of four vehicles. Six axle semi-trailers accounted for nearly three out of every five vehicles.

Rigid trucks made up approximately one-fifth of all vehicles. Most rigid trucks had two axles. Nearly one in six rigid trucks was towing an additional trailer. Most of these trailers had two axles.

Very few buses were recorded, comprising only 2 or 3 per cent of all heavy vehicles.

By commodity

Vehicles carrying freight or capable of carrying freight were assigned to a commodity classification on the basis of body type or trailer

TABLE 5.1 HEAVY VEHICLES BY VEHICLE TYPE, NUMBER OF AXLES AND SURVEY LOCATION

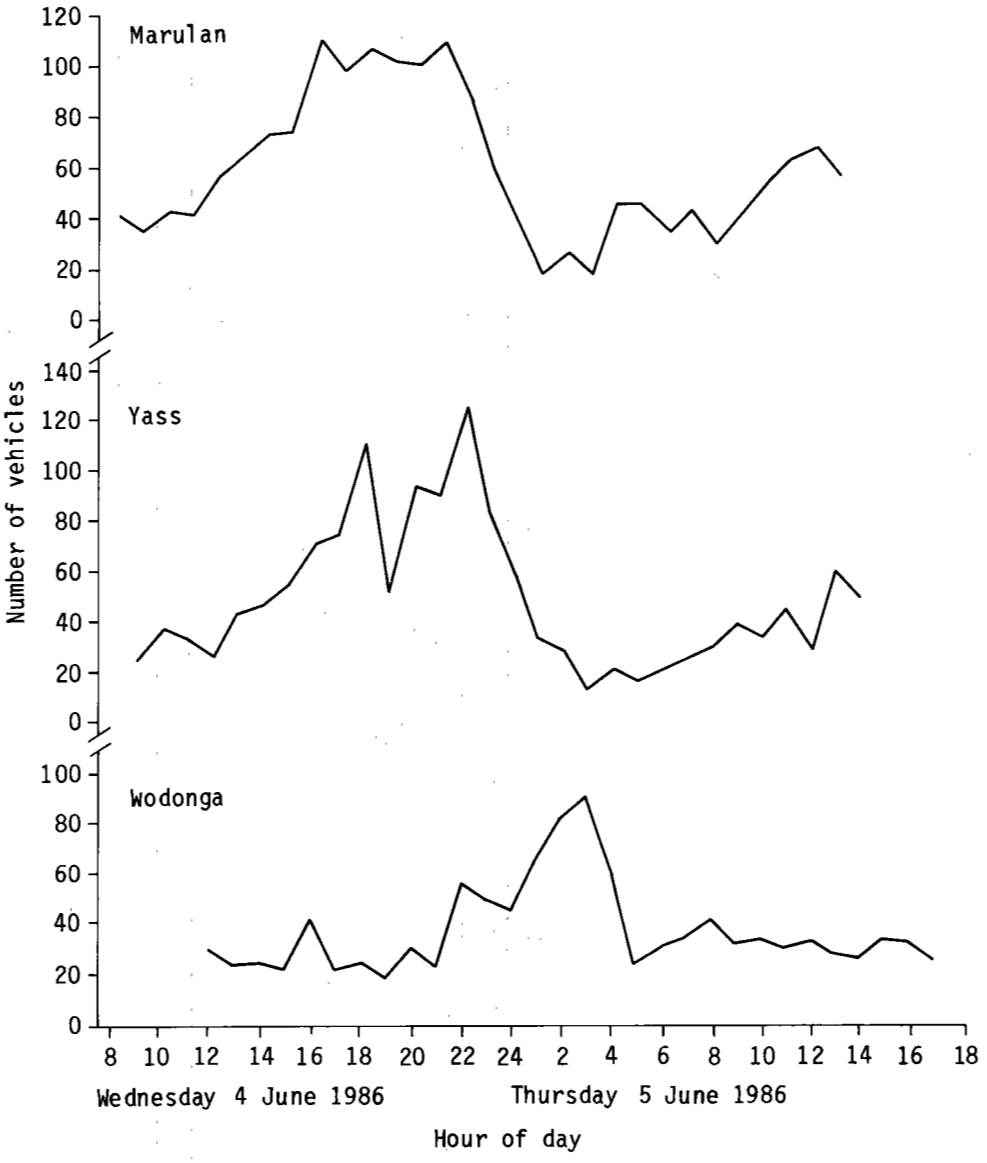
Vehicle type (number of axles)	*Survey location*					
	Marulan		*Yass*		*Wodonga*	
	(vehicles)	*(per cent)*	*(vehicles)*	*(per cent)*	*(vehicles)*	*(per cent)*
Buses						
Two axles	16	1.1	16	1.3	8	0.8
Three axles	31	2.1	22	1.8	6	0.6
Unknown	0	0.0	2	0.2	4	0.4
Total	47	3.2	40	3.2	18	1.9
Rigid trucks						
Two axles	213	14.3	180	14.5	159	16.7
Three axles	83	5.6	55	4.4	71	7.5
Four axles	32	2.2	11	0.9	7	0.7
Unknown	1	0.1	9	0.7	6	0.6
Total	329	22.2	255	20.6	243	25.6

TABLE 5.1 (Cont.) HEAVY VEHICLES BY VEHICLE TYPE, NUMBER OF AXLES AND SURVEY LOCATION

Vehicle type (number of axles)	*Survey location*					
	Marulan		*Yass*		*Wodonga*	
	(vehicles)	*(per cent)*	*(vehicles)*	*(per cent)*	*(vehicles)*	*(per cent)*
Semi-trailers						
Two axles[a]	1	0.1	0	0.0	2	0.2
Three axles[b]	23	1.5	23	1.9	25	2.6
Four axles	80	5.4	55	4.4	51	5.4
Five axles	133	9.0	100	8.1	76	8.0
Six axles	872	58.7	760	61.3	509	53.6
Seven axles	0	0.0	0	0.0	4	0.4
Eight axles	0	0.0	1	0.1	0	0.0
Unknown	0	0.0	5	0.4	22	2.3
Total	1 109	74.7	944	76.2	689	72.5
Total (vehicles)	1 485	100.0	1 239	100.0	950	100.0

a. Prime movers travelling alone.
b. Includes prime movers travelling alone.

Source BTE heavy vehicle survey (1986).



Source BTE heavy vehicle survey (1986).

Figure 5.1 Heavy vehicle traffic volume by hour: Marulan, Yass and Wodonga

type. Thus, tippers were classified as bulk solid, stock carriers as livestock and all pantechnicons and flat-top semi-trailers as non-bulk. Tankers were recorded as bulk liquid notwithstanding the fact that some tankers are designed to carry bulk solids such as flour. Not all vehicles are designed to carry freight. Buses were excluded from the commodity classification. Vehicles such as fire trucks, tow trucks and prime movers travelling alone had commodity classified as not applicable.

The breakdown by commodity is shown in Table 5.2. Reflecting the difficulty identifying bulk solid tankers, the headings 'tipper' and 'tanker' have been used in place of 'bulk solid' and 'bulk liquid'. It should also be stressed that in many cases it was not possible to see whether the truck was empty or loaded.

The major feature of Table 5.2 is the dominance of non-bulk carriers. These trucks outnumbered other trucks by four or five to one. Higher proportions of tippers were sighted at Marulan and Wodonga than at Yass. These appeared to be involved with nearby road works. It is understood that the survey coincided with a market day at Goulburn. The numbers of livestock carriers sighted at Marulan and Yass may therefore be somewhat higher than normal.

TRAFFIC VOLUMES

At Marulan

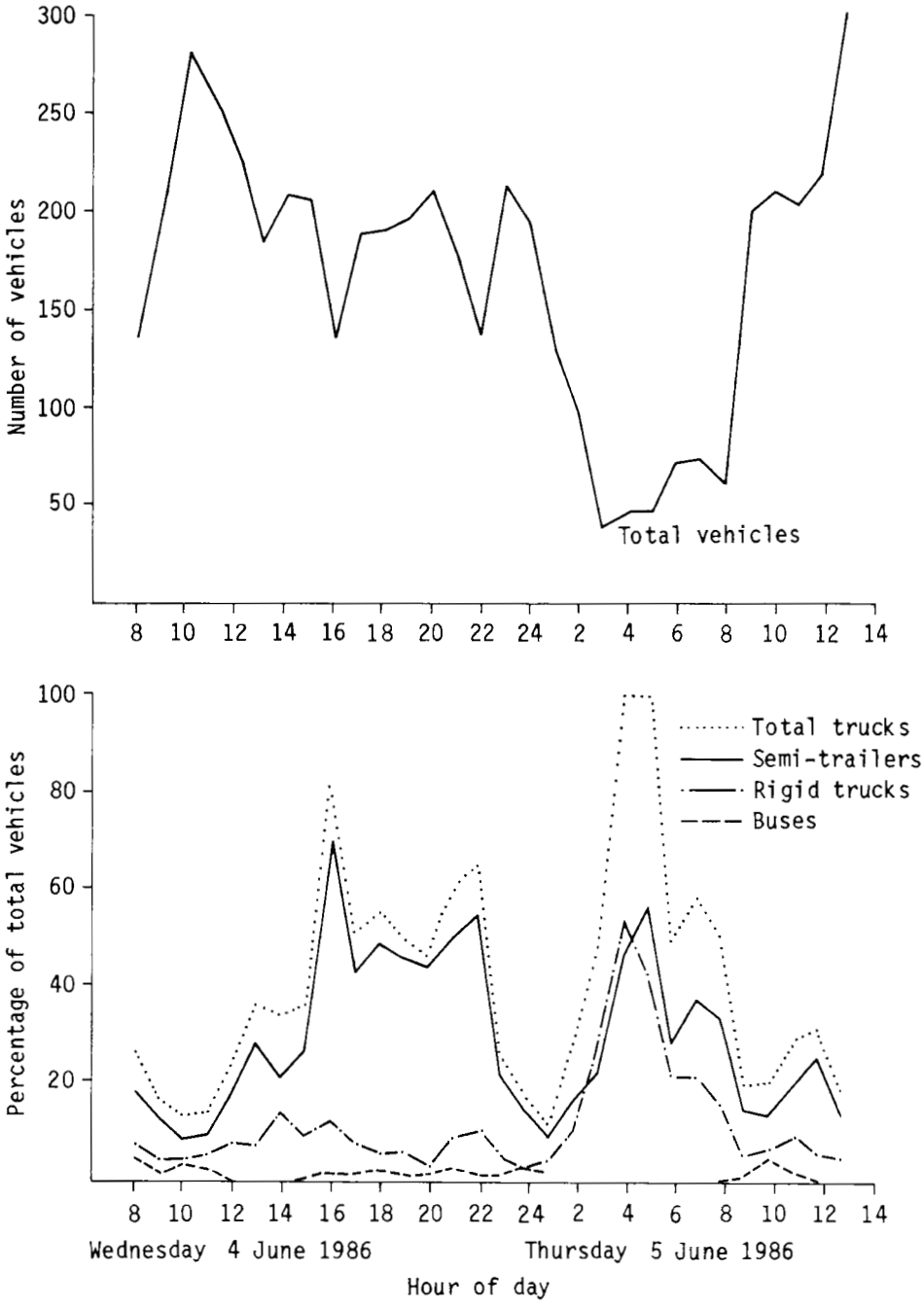
Total hourly traffic volumes were obtained to facilitate analysis of traffic composition in terms of all vehicles, not just heavy vehicles. The DMR operates a permanent automatic axle counting station on the Hume Highway approximately 5 kilometres north of the Marulan vehicle checking station. To convert these counts to vehicle counts, it was assumed that vehicles passing southbound through the checking station had to pass the automatic traffic counter. The number of axles passing through the Marulan station were subtracted from the DMR axle counts and the remainder divided by two, which represented the number of vehicles (mainly cars) not passing through the checking station.

The total hourly vehicle count and traffic composition for Marulan is shown in Figure 5.2. The volume of traffic peaked during mid-morning, decreased during mid-afternoon and dropped rapidly after midnight before rising again the next morning. The traffic composition graph shows that the mid-morning traffic peak included only one truck in every four vehicles. Large numbers of semi-trailers (nearly two out of every four vehicles) passed through Marulan between 4 p.m. and 10 p.m.

TABLE 5.2 TRUCKS BY SURVEY LOCATION, TRUCK TYPE AND COMMODITY
(per cent)

Survey location and truck type	*Commodity*							*Number of trucks*
	Tipper	*Tanker*	*Non-bulk*	*Livestock*	*Not applicable*	*Unknown*	*Total*	
Marulan								
Rigid trucks	6.7	2.1	85.4	2.4	1.2	2.1	100.0	329
Semi-trailers	9.2	8.1	80.3	1.7	0.5	0.2	100.0	1 109
Total	8.6	6.7	81.5	1.9	0.6	0.6	100.0	1 438
Yass								
Rigid trucks	7.1	2.0	69.4	3.1	0.4	18.0	100.0	255
Semi-trailers	3.9	7.1	82.1	2.3	0.2	4.3	100.0	944
Total	4.6	6.0	79.4	2.5	0.3	7.3	100.0	1 199
Wodonga								
Rigid trucks	17.3	7.8	65.4	1.6	0.4	7.4	100.0	243
Semi-trailers	3.0	6.5	82.1	0.9	1.3	6.1	100.0	689
Total	6.8	6.9	77.8	1.1	1.1	6.4	100.0	932

Source BTE heavy vehicle survey (1986).



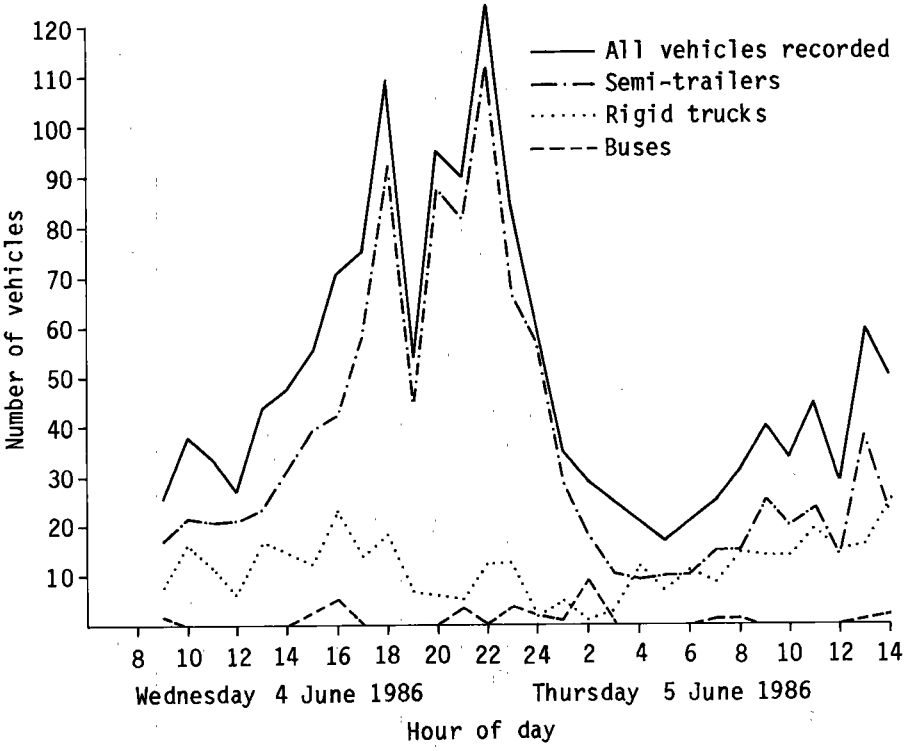
Sources BTE heavy vehicle survey (1986).
Traffic counts, DMR (forthcoming).

Figure 5.2 Total vehicles and traffic composition by hour: Marulan

The early morning traffic was virtually all heavy vehicles. The proportions of semi-trailers and rigid trucks were approximately equal. A significant proportion of these vehicles carried either building materials or were tippers. The significant level of road construction being carried out near Marulan may account for some of this traffic.

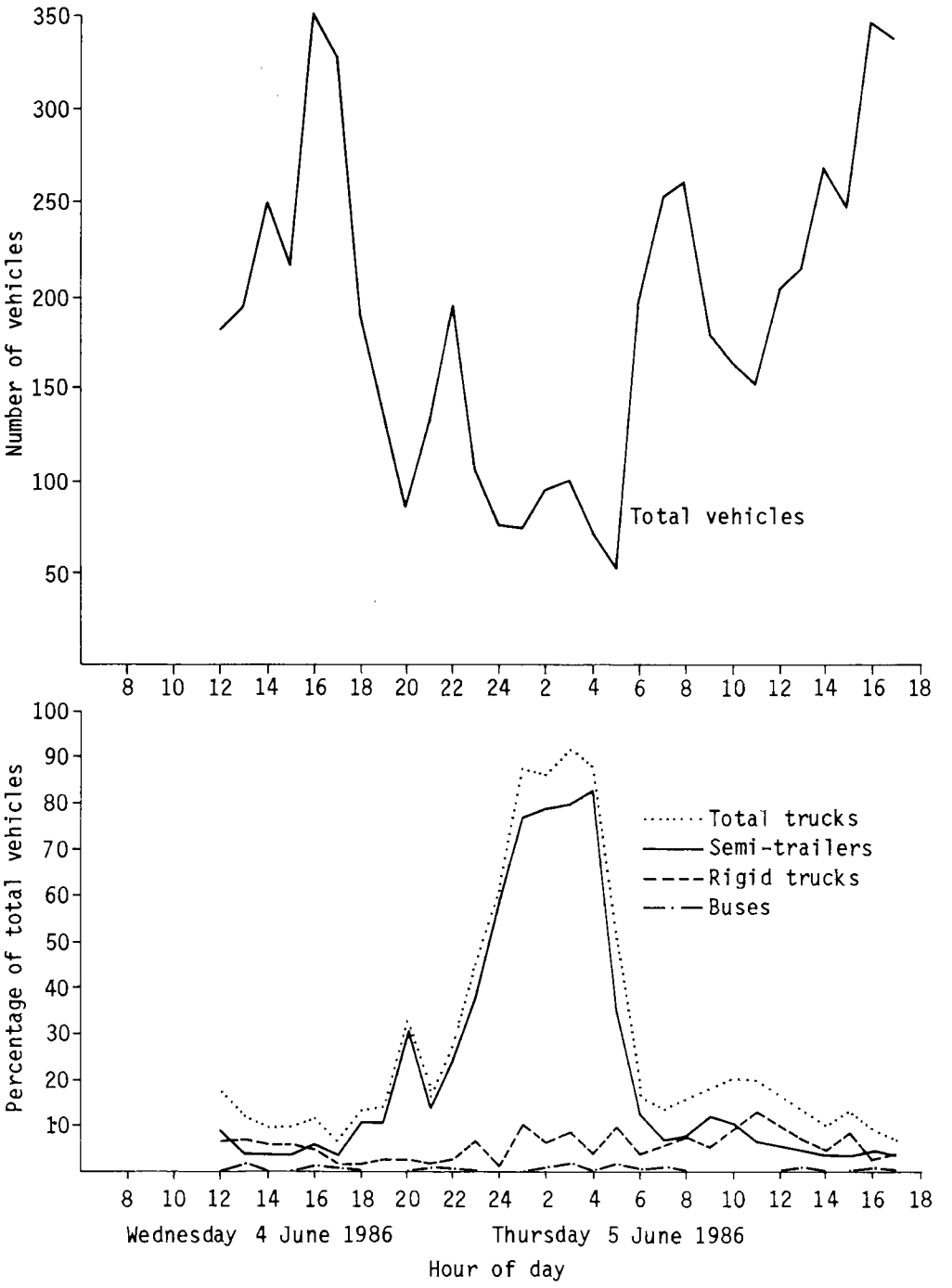
At Yass

An automatic traffic counter is located about 7 kilometres south of Yass on the Hume Highway. After the survey was conducted it was found that directional traffic counts were unobtainable. It was therefore not possible to estimate total traffic counts for Yass. Figure 5.3 shows the recorded heavy vehicle composition by hour for Yass. Traffic volumes peaked during the early to late evening, diminished in the early morning and rose throughout the next day.



Source BTE heavy vehicle survey (1986).

Figure 5.3 Heavy vehicle traffic volume by type and hour: Yass



Source BTE heavy vehicle survey (1986).

Figure 5.4 Total vehicles and traffic composition by hour: Wodonga

The peak volume of heavy vehicle traffic was composed of approximately 90 per cent semi-trailers. The timing of this traffic is consistent with the likelihood that many of these trucks would have travelled through Marulan. Interestingly, there is a marked drop in the number of semi-trailers in Yass in the hour from 7 p.m. A possible explanation is that the drivers stop for dinner between Marulan and Yass, perhaps at Goulburn.

The volume of rigid trucks at Yass remained relatively constant during the day but diminished at night.

At Wodonga

No suitable traffic counting station was situated in the vicinity of the Wodonga survey location so staff at this location carried out the necessary counts. Figure 5.4 shows the total hourly vehicle count and traffic composition for Wodonga. Traffic volumes peaked during the late afternoon and morning, corresponding to typical city peak hours.

A considerable number of semi-trailers (nearly 80 per cent of total traffic at that time) passed the Wodonga survey location in the early hours of the morning. Again, the timing of this traffic is consistent with many of these trucks having travelled through Yass (and previously through Marulan).

CHAPTER 6 IDENTIFICATION OF VEHICLE MOVEMENTS

The success of the heavy vehicle survey relied heavily on the ability to match vehicles from different recording locations. This enabled the vehicle sightings to be categorised into trips from one region to another, according to the survey locations they were known to have passed.

The most important criterion for matching vehicles was the recorded registration number, but other details of the vehicle description and time of recording were also used. This chapter explains the procedure that was adopted to match vehicle sightings and includes an examination of the accuracy of the methodology.

BACKGROUND

The first pilot survey (see Chapter 2) gave valuable insights into the complexities of matching number plates and the consequences of characters being read incorrectly or missed entirely. The major finding was that the inability to match number plates was due largely to characters not being recorded rather than misread.

As outlined in Chapter 4, the completeness and correctness of the data collected in the survey varied according to the conditions at each of the three survey locations. It was necessary to develop a methodology which took into account the quality of the data. While there was evidence in the literature that the number plate technique had been used, little could be found on how to actually match the vehicle sightings between locations. Another important consideration was the fact that the number of vehicle sightings was not excessively large, which allowed various different computerised methods of searching for possible matches to be tried without excessive use of processing time. For these reasons a heuristic approach was taken to the matching process whereby the problem was broken down into separate steps and a method developed for solving each one.

Definitions

To simplify the description of the methodology there are some terms that need to be defined. The term 'match' is used to simply indicate that a vehicle was identified as having been sighted more than once, either at different locations or more than one sighting at the same location. Two types of matches are defined; perfect and imperfect. A 'perfect match' is one where the recorded number plates from the two sightings correspond exactly and at least four characters out of the possible six have been recorded. It may be either the front number plates or the rear number plates that correspond, and it is possible that the front plates form a perfect match while the rear plates do not (or vice versa). Possible discrepancies between other details of the vehicle description do not affect whether or not a match is perfect.

Any other case where two sightings are identified as the same vehicle but the recorded number plates do not correspond exactly is considered to be an 'imperfect match'. These could range from pairs of sightings differing only by one character in the number plate to pairs that might only have been matched on the basis of one or two elements in the description.

Matches were considered to represent trips from one region to another. These trips correspond to the combinations of the different locations the vehicle was known to have passed through. There are ten possible trip categories. If a record was matched at all three locations it was referred to as Marulan-Yass-Wodonga. Those matched at two were described as Marulan-Yass, Yass-Wodonga or Marulan-Wodonga. If it occurred that a record was matched with another record at the same survey location it was referred to as a 'regular' vehicle, signifying that it made more than one trip through that location in less than 30 hours. Otherwise, vehicles that only appeared once fell into the categories Marulan-Only, Yass-Only and Wodonga-Only.

There were instances where vehicles were actually candidates for more than one of these categories. Some vehicles were sighted at Marulan, Yass and then again at Marulan, usually around 24 hours after the first sighting at Marulan. The implication was that the vehicle was making a second trip. It may well have passed through Yass again but after the survey had ended. In these cases the records were categorised into the two distinct trips that were made; in this case one Marulan-Yass and one Marulan-Only. It should be noted that this would not invalidate the estimates of daily traffic flow (trips per day) because the second (incomplete) trip would fall outside the 24-hour period used for estimating the total daily traffic.

Assumptions

The process of identifying matches was aided by a number of assumptions. One assumption was that if a vehicle passed through Marulan and Wodonga it must have passed through Yass.

A minimum travel time between survey locations was also assumed which greatly assisted the matching process. The minimum times chosen were fifty minutes between Marulan and Yass, and two hours and fifty minutes between Yass and Wodonga. No upper limit was applied to travel times and no possible matches were discarded for reason of long travel time alone.

Another assumption was that no vehicles would be matched inadvertently due to errors in the recorded data. That is, the possibility that misreading characters in one number plate causing it to be matched with a different plate was ignored. The fact that no perfect matches were found with infeasible travel times supports the reasonableness of this assumption.

There were also other assumptions that came into consideration when vehicle description was used to decide on a possible match. It was considered possible to confuse semi-trailers with rigid trucks, but certain body types were considered to be impossible to mistake. A tanker, for instance, would not be matched with another sighting which conflicted in the description of body type. The same principle also applied to buses and specialised vehicles like cement mixers.

In setting up the computer records, care was taken to distinguish between short number plates and missed characters. Short number plates were left justified with blank fill, but if characters had been missed by the recorder they were filled in with asterisks. If buses or rigid trucks without additional trailers had only one of the front or rear number plates recorded, the other was assumed to be the same.

METHODOLOGY

The methodology can be broadly divided into two main steps. The first was the identification of all perfect matches and the dividing of the data set into a group of files according to the trips the perfect matches represent. The second step was to compare combinations of these files to find imperfect matches and thus re-categorise records into appropriate trips.

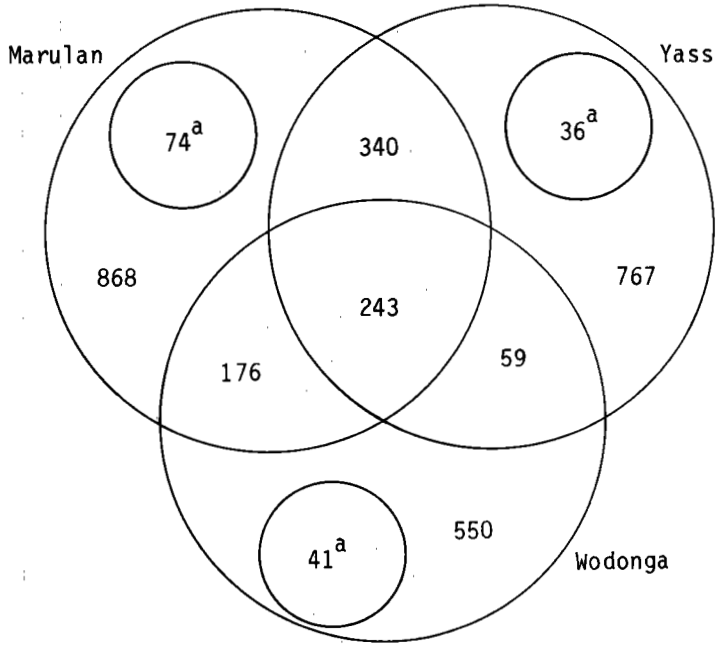
Identification of perfect matches

All records for all three survey locations were combined into one

master file and sorted in order of rear number plate. The perfect matches on the rear plates were then picked out and allocated to one of the ten possible trip categories. The process was repeated with the master file sorted in order of front number plate. This produced a set of files that represented all perfect matches on the front plates. The number of these was, of course, considerably less as emphasis had been placed on recording rear number plates.

Perfect matching on the rear plates produced 1228 matches (where a match between all three survey locations is considered to be two matches). Perfect matching on front plates however, only produced a further 34. There was some overlap between the front and rear sets of perfect matches. Five pairs of records that had been categorised as passing through two survey locations as a result of perfect matching on the rear plates were redefined as passing through three survey locations when front plates were considered.

The resultant breakdown of trips obtained by picking out perfect matches only is shown in Figure 6.1. In the case of 'regular'



a. Vehicles that appeared more than once at the same survey location.

Source BTE heavy vehicle survey (1986).

Figure 6.1 Classification of trips after finding perfect matches only

vehicles, that is, those that reappeared at the same survey location more than once, the number of vehicles is indicated rather than the total number of sightings.

It should be emphasised that at this point none of the figures were considered final and could move up or down as a result of finding imperfect matches. In particular, the 176 Marulan-Wodonga vehicles would eventually become Marulan-Yass-Wodonga vehicles with a corresponding decrease of Yass-Only vehicles.

Identification of imperfect matches

Using the files created from this first step as a base, the second step commenced. The priority for finding imperfect matches began with taking records matched at two stations and seeing if a match appeared at the third. This was followed by the three possible combinations of any two stations. The other possibility was to check records within a single station for an imperfect match signifying a 'regular' vehicle. Splitting the data into ten files might appear to be a cumbersome approach as it implies several combinations of files which need to be tested for imperfect matches. However, using small files proved to be efficient in terms of computing time and enhanced the scope for manual checking.

It soon became apparent that using some system of identifying commonly confused characters and treating them as one of a set rather than being unique, would not be effective. The first pilot survey showed that commonly confused characters only accounted for a small proportion of imperfect matches. Such a method would also produce inappropriate matches. For example, the number plate 'MQP 883' could be matched with over 300 other possible plates when allowance is made for the fact the 'M' may be mistaken with an 'N' or 'W', the 'Q' with an 'O', 'C' or 'U', the '8' with a '6' and so on. Any matches found this way would require additional checking to decide between any multiple matches that had occurred.

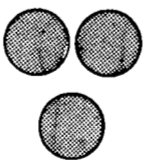
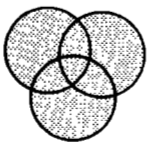
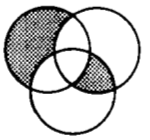
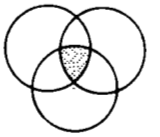
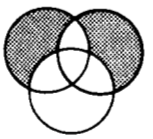
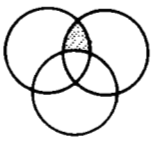
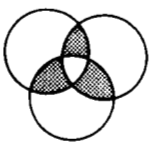
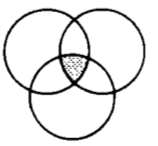
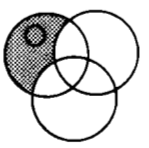
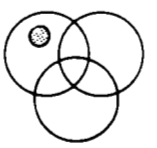
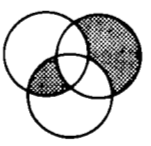
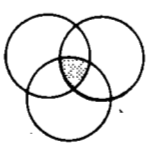
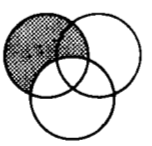
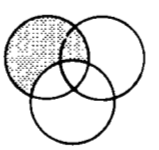
One of the features of this particular data set was that the distribution of characters within number plates was by no means random. A high proportion of number plates beginning with 'IS', 'IT' and 'IU' were observed. Vehicles with these plates are registered for interstate use. Trailer plates (one letter and five digits), buses ('TV' or 'MO' and up to 3 digits) and Commonwealth Government vehicles ('Z' plates) also contributed to the uneven groupings of certain letter/digit combinations.

One implication of this is that there is a reasonable chance of two unique vehicles having number plates that differ by only one character. For example, the following vehicles with identical descriptions were all recorded as passing through Marulan in the space of a few hours: 'IT 9916', 'IT 9918' and 'IT 9919'. This highlights the complications that would have arisen if recordings at the other survey locations were accepted on the basis of a difference in only one character. Therefore any set of matches obtained by some set of rules or tests, no matter how complex, would still need to be checked clerically to ensure that a valid match had been made.

The procedure adopted was along the following lines. The two files to be compared were sorted by time of sighting. A record was taken from the first file, for example, Marulan-Only records. Then the second file, such as Yass-Wodonga records, was scanned for any records within a feasible time period that contained plates with at least three characters corresponding exactly (that is, the same letter or digit in the same position). This produced a set of records that varied in number from zero to around 50 in some cases. The computer program displayed these on a terminal and a selection was made by examining the possibilities. Selections were made on the basis of all the coded information recorded, not just number plate. Factors such as vehicle type, commodity and number of axles were taken into consideration. As the additional written comments were not encoded on the computer files, these were not used at this stage. Those records that were matched in this way were written onto a separate file where they could be checked for the possibility of any duplicate matches before being combined with any other records that had been classified as the same trip type. When comparing some of the larger files this process could involve lengthy sessions at a computer terminal selecting matches from the options presented.

The priority that was adopted for comparing files is set out in Figure 6.2 which summarises the matching process. It should be noted that, given the distance between Marulan and Wodonga, it was assumed that once a vehicle was identified at all three survey locations it could not appear again. There were cases however, where vehicles were discovered to have made a second trip through either Marulan or Yass or both. The end result at this stage of the matching is shown in Figure 6.3.

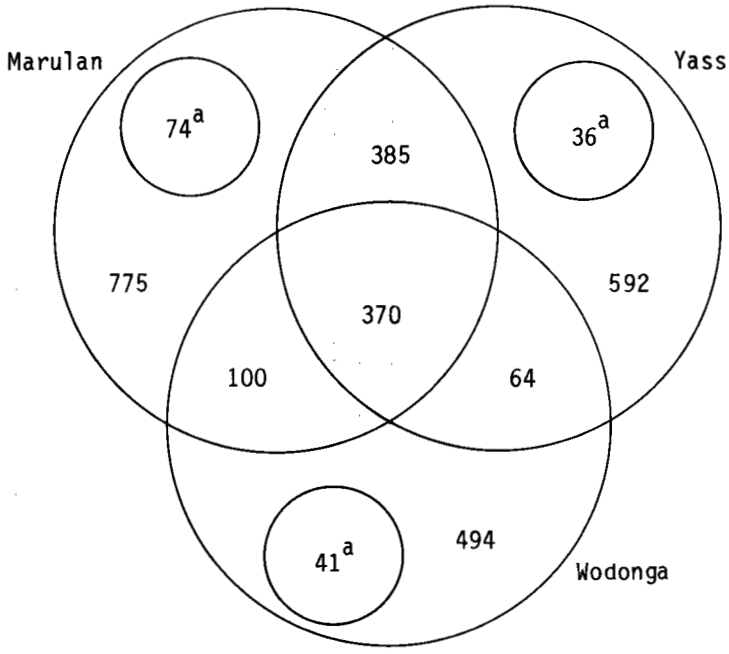
At this point there remained 100 records still categorised as Marulan-Wodonga which required a match at Yass. These were dealt with by clerically scanning the list within the feasible time period (fifty minutes after the Marulan time until two hours and fifty minutes

Step	Records compared	Trips identifed	Description
1.			Find all perfect matches on front or rear plates for all trip categories
2.			Find imperfect matches at third location for those already matched between two locations
3.			Find imperfect matches between any two single locations
4.			Compare imperfect matches between two locations to detect imperfect matches between all three
5.			Find imperfect matches representing 'regular' vehicles
6.			Clerically match Marulan-Wodonga records with Yass records
7.			Compare records matched between two locations with each location separately to identify multiple trips

Note For each step the shaded area in the left hand diagram indicates those records examined to see whether or not the trips they represent should be in the shaded area of the right hand diagram.

Source BTE heavy vehicle survey (1986).

Figure 6.2 Outline of matching procedure: order of steps taken



a. Vehicles that appeared more than once at the same survey location.

Source BTE heavy vehicle survey (1986).

Figure 6.3 Classification of trips after finding imperfect matches

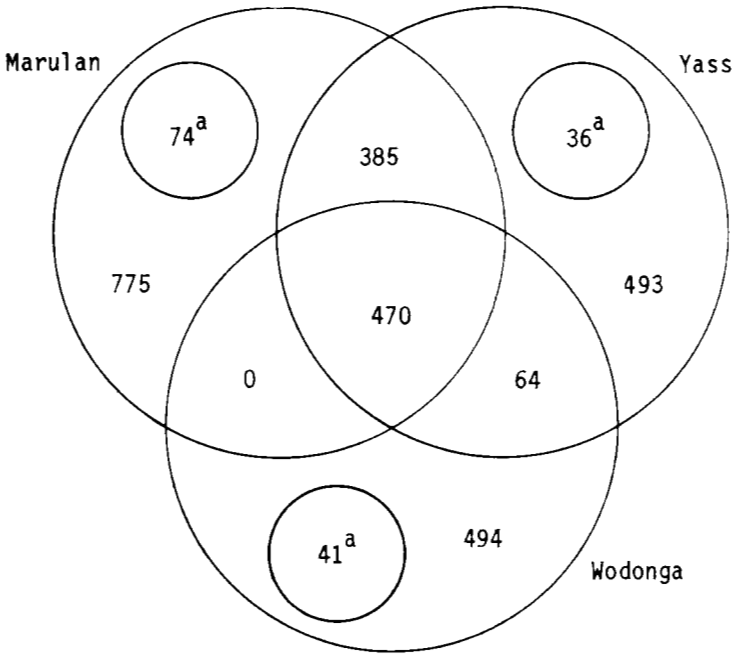
before the Wodonga time). In some cases a match was made by a unique feature of the vehicle that stood out from those in the time period. This might have been a relatively rare vehicle type such as a bus or tanker, a low number of axles on a semi-trailer, or even one or two unique characters in the number plate. About 30 matches were found in this way. For the rest, where no readily identifiable matches could be found, a subset was extracted of records with insufficient detail recorded to cause any conflict with the Marulan-Wodonga records. These were largely vehicles identified as having 5 or 6 axles, carrying some sort of non-bulk commodity and having no characters at all recorded from the number plates. Matches were then made on the basis of the most likely time the vehicle would have passed through Yass based on its times at Marulan and Wodonga. In some cases the additional written comments were useful, particularly to differentiate tarpaulin covered vehicles from pantechnicons.

As a check on the matching process, the total number of vehicles recorded as passing through each survey location had to remain constant. So, for example, the total of all trips that involved passing through Marulan always had to remain at 1804. This ensured every record had been accounted for and that no double counting had occurred.

Travel times were also checked to ensure that they were all above the minimum time specified. This was more important in the case of perfect matches, as imperfect matches had only been selected having regard to feasible time differences.

There were a small number of cases of prime movers appearing with different trailers and trailers with different prime movers. It was assumed that a change of prime mover was considered to be part of the same trip but a change of trailer was not.

The final breakdown of matches is shown in Figure 6.4. It should be stressed that these results are based on the full 30 hours of



a. Vehicles that appeared more than once at the same survey location.

Source BTE heavy vehicle survey (1986).

Figure 6.4 Final classification of trips

recording at each of the three survey locations and do not represent estimates of daily traffic flow. Estimates of traffic flow are presented in Chapter 7.

VALIDATION OF THE MATCHING PROCESS

Because the number of matched vehicles is considered as an estimate of the actual number of vehicles that travelled between two regions, it is important to have an appreciation of the level of accuracy of the estimate. There are a number of reasons why the results of matching may not be completely accurate.

One important reason is that due to the lack of completeness in the recorded data, there were records for which there was no way of deciding if they were a possible match. The system of demerit scores discussed in Chapter 5 provided a good indication of the extent of incompleteness. A demerit score of more than 12 points was a likely indication that there was insufficient detail to match a record with any other. The numbers of these records was four, 212 and 90 at Marulan, Yass and Wodonga respectively. In particular, 17 vehicles were missed completely at Wodonga in the early hours of the morning, at a time when the traffic was dominated by vehicles that had passed through Marulan. There were also some 19 vehicles, for which no recordings were made at Yass seen parked at truck stops, when the survey personnel moved to the centre of town for night-time recording.

It is possible to gauge the inaccuracy due to data incompleteness by taking a subset of the data and using the assumption that vehicles matched at Marulan and Wodonga must appear at Yass. If it is assumed that the survey had been conducted over just two points, Marulan and Wodonga, then it can be seen from Figure 6.1 that 419 perfect matches would have been identified. This number is the sum of the 176 Marulan-Wodonga perfect matches and the 243 matched perfectly at all three survey locations. These 419 records can be treated as records from a single point that must appear at a second point which is represented by Yass. Of these, 243 records were perfect matches at this second point. A further 76 matches were revealed by the standard method of finding imperfect matches described in the previous section. This leaves 100 matches which had to be found by mainly arbitrary, clerical methods. This implies that the matching procedure detects 319 out of 419 or around 76 percent of actual trips.

However, it is not correct to apply this figure to all estimates of traffic flow. If anything, the estimated 76 per cent coverage would be a bottom limit. Night-time conditions at Yass proved to be the

worst for data recording. As shown in Chapter 7 the majority of vehicles travelling through all three survey locations did so overnight. Of course, the extent to which the estimate of long-distance traffic flow (Marulan to Wodonga) is understated must be balanced by overestimating some or all of the shorter distance flows.

The heavy vehicle survey was conducted at the same time as the New South Wales MoT was carrying out an origin-destination and commodity survey at the Marulan vehicle checking station. While the MoT survey did not record time beyond the hour, the order of the records was preserved and it was generally possible to compare the MoT survey records with the heavy vehicle survey records and identify descriptions relating to the same vehicle. The totals for the 30-hour period showed that MoT had recorded 152 vehicles less than the heavy vehicle survey. There was also a slight complication when two lanes were operating at the checking station in that there was no way of knowing the correct order that vehicles passed through.

The two data sets were compared for consistency between origin and destination pairs. The MoT survey classified origins and destinations by area, for example dividing New South Wales into Sydney, Canberra, and other large regions. While these regions did not correspond to those defined in the heavy vehicle survey it was still possible to compare the two sets of results. For example, if a vehicle was in the MoT survey as travelling from Sydney to Melbourne then it would be expected to have been categorised as Marulan-Yass-Wodonga.

The results of this comparison are shown in Table 6.1. The table shows, for example, that 268 vehicles had a stated destination in the MoT survey of Australian Capital Territory. Of these, 89 per cent were consistent with their sightings in the heavy vehicle survey as they were recorded only at Marulan. The remaining 11 per cent were also recorded as passing through Yass. Overall, the results were fairly consistent with the major discrepancies explainable in survey operational and definitional terms. The main difference was that the MoT categorised a higher proportion of vehicles as travelling at least as far as Wodonga. One of the reasons for this was the difficulties caused by data incompleteness discussed in the previous section. Another reason was the siting of the survey location at Wodonga at the start of the Wodonga bypass freeway. A number of vehicles that entered Wodonga, perhaps for a truck stop, before proceeding south would have been missed.

There also appeared cases where, according to the heavy vehicle survey, vehicles travelled further than indicated in the MoT survey.

TABLE 6.1 COMPARISON BETWEEN HEAVY VEHICLE SURVEY AND NEW SOUTH WALES MINISTRY OF TRANSPORT SURVEY
(per cent)

Vehicle matchings in heavy vehicle survey	*Stated destination region (MoT survey)*					
	Australian Capital Territory	*Southern Tablelands*	*South-West Riverina*	*South Australia and Western Australia*	*Victoria*	*All regions*
Consistent with MoT survey						
Marulan-Only	89	79	..	..	..	34
Marulan-Yass	..	19	62	66	..	10
Marulan-Yass-Wodonga	..	..	..	..	61	30
Total	89	98	62	66	61	75
Inconsistent with MoT survey						
Marulan-Only	..	..	38	19	19	12
Marulan-Yass	11	..	..	..	20	12
Marulan-Yass-Wodonga	0	2	0	15	..	1
Total	11	2	38	34	39	25
Number of vehicles	268	289	73	62	671	1 363

.. Not applicable.

Sources BTE estimates derived from BTE heavy vehicle survey (1986). New South Wales MoT survey, June (1986).

This is quite feasible as the MoT survey relied on drivers' responses to the question as to their destination. If a vehicle was making a stop at Canberra to pick up or deliver freight before proceeding on through Yass it is legitimate for the driver to consider the destination as Canberra. This emphasises the importance of carefully defining terms such as 'origin' and 'destination' in surveys.

CHAPTER 7 ESTIMATES OF DAILY TRIPS

This chapter presents estimates of the numbers of southbound heavy vehicle trips per day on the Hume Highway. The estimates are based on the vehicle movements identified from the heavy vehicle survey, as outlined in Chapter 6. An analysis of trips in terms of vehicle type, commodity carried and travel times is also included, together with an examination of the accuracy of the estimates.

DEFINITIONS

To clarify the estimates presented in this chapter, it is necessary to carefully define the two terms 'regions' and 'daily trips', and to specify how conflicting vehicle descriptions were resolved.

Regions

Trip types are defined in terms of a vehicle moving from one region to another. As pointed out in Chapter 3, the placement of the three survey locations at Marulan, Yass and Wodonga determined four regions for southbound traffic on the Hume Highway:

- Region A (north of Marulan);
- Region B (between Marulan and Yass);
- Region C (between Yass and Wodonga); and
- Region D (south of Wodonga).

Because only three survey locations were used it was recognised that the estimates of region-to-region traffic flow would not be very informative as the region boundaries were not well defined. For example, traffic from Region A to Region C could include traffic from Sydney to Perth. Nevertheless, it was hoped that the long-distance Region A to Region D trip estimates would give a reasonable approximation of Sydney to Melbourne traffic. As pointed out in Chapter 6, a significant proportion of Sydney to Melbourne traffic was missed because the heavy vehicles did not go through the survey location at Wodonga. For these reasons the estimates presented in this chapter are intended to indicate only the types of analyses supported by the survey methodology.

Daily trips

The heavy vehicle survey involved 30 hours of recording at each of the three survey locations. As shown in Chapter 4, specific 24-hour subsets were defined so as to provide the optimal basis for estimating one day's traffic originating in each of the regions. The maximum difference of ten hours between these 24-hour periods was effectively ignored and the trip estimates are presented as estimates of typical, mid-week daily trip numbers for that time of year.

Vehicle characteristics

In a small proportion of cases there were inconsistencies in elements of the vehicle description recorded at two or three of the survey locations. A relatively common inconsistency was a discrepancy between the recorded number of axles which affected 7.7 per cent of vehicles matched between all three survey locations (see Chapter 4). These inconsistencies were resolved in the following manner. If the trip involved sightings at all three survey locations and two of those were in agreement, that majority description was adopted. In the other cases preference was given to the description recorded at Marulan if relevant; otherwise the description at Wodonga was adopted. This order of preference reflects the generally decreasing quality of data and increasing difficulty of survey conditions at Marulan, Wodonga and Yass respectively.

TYPES OF TRIPS

Table 7.1 shows the number of daily trips classified by vehicle and trip type. As might be expected for southbound traffic on the Hume Highway, a large proportion of trips (over 60 per cent) originated in Region A (north of Marulan). Trips from Region A to Region D (going through Marulan, Yass and Wodonga) made up nearly 20 per cent of all trips recorded. This long-distance traffic was also dominated by semi-trailers, which carried out nearly 90 per cent of these trips compared to an all trips average for semi-trailers of under 70 per cent.

Table 7.2 shows the number of daily trips carried out by rigid trucks and semi-trailers classified by commodity and trip type. Non-bulk traffic dominated, accounting for 76 per cent of all trips and 90 per cent of the long-distance Region A to Region D trips. The other three identifiable commodity types, tipper, tanker and livestock, are relatively more prevalent in the shorter distance trips which involve a vehicle being sighted at only one of the survey locations. As noted in Chapter 5, the relatively high proportion of tippers sighted at Marulan and Wodonga appeared to have been involved with nearby road works.

TABLE 7.1 DAILY TRIPS BY VEHICLE TYPE, NUMBER OF AXLES AND TRIP TYPE

Vehicle type	Trip type						Total	
	Region A-Region B	Region A-Region C	Region A-Region D	Region B-Region C	Region B-Region D	Region C-Region D	(trips)	(per cent)
Buses	29	12	6	22	0	12	81	3.3
	(4.2)	(3.6)	(1.3)	(5.0)	(0.0)	(2.7)		
Rigid trucks								
Two axles	157	22	32	127	7	123	468	19.4
Three axles	56	16	14	33	4	58	181	7.5
Four axles	26	5	0	4	0	6	41	1.7
Unknown	2	0	0	3	0	4	9	0.4
Total	241	43	46	167	11	191	699	28.9
	(34.6)	(13.0)	(10.0)	(38.0)	(25.6)	(42.4)		
Semi-trailers								
Two axles	0	1	0	0	0	2	3	0.1
Three axles	9	4	9	6	2	10	40	1.7
Four axles	37	17	27	15	5	17	118	4.9
Five axles	67	22	44	24	4	27	188	7.8
Six or more axles	314	231	326	203	21	171	1 266	52.4
Unknown	0	0	0	2	0	21	23	1.0
Total	427	275	406	250	32	248	1 638	67.7
	(61.3)	(83.3)	(88.6)	(56.9)	(74.4)	(55.0)		

TABLE 7.1 (Cont.) DAILY TRIPS BY VEHICLE TYPE, NUMBER OF AXLES AND TRIP TYPE

	Trip type						*Total*	
Vehicle type	*Region A-Region B*	*Region A-Region C*	*Region A-Region D*	*Region B-Region C*	*Region B-Region D*	*Region C-Region D*	*(trips)*	*(per cent)*
Total (heavy vehicles)	697	330	458	439	43	451	2 418	100.0
	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)		
Per cent	(28.8)	(13.6)	(18.9)	(18.2)	(1.8)	(18.7)	(100.0)	

Note Figures in parentheses are percentages.

Source BTE heavy vehicle survey (1986).

TABLE 7.2 DAILY TRIPS BY COMMODITY CARRIED AND TRIP TYPE: RIGID TRUCKS AND SEMI-TRAILERS

Commodity	*Trip type*						*Total*	
	Region A-Region B	*Region A-Region C*	*Region A-Region D*	*Region B-Region C*	*Region B-Region D*	*Region C-Region D*	*(trips)*	*(per cent)*
Tipper	87	22	11	35	2	51	208	8.9
Tanker	57	18	22	33	0	45	175	7.5
Non-bulk	493	268	416	281	40	286	1 784	76.3
Livestock	18	8	1	22	1	8	58	2.5
Not applicable	6	2	2	2	0	7	19	0.8
Unknown	7	0	0	44	0	42	93	4.0
Total	668	318	452	417	43	439	2 337	100.0
Per cent	(28.6)	(13.6)	(19.3)	(17.8)	(1.8)	(18.8)	(100.0)	

Source BTE heavy vehicle survey (1986).

Further insight into these short trips can be gained by looking at vehicles which made more than one trip in the 24-hour survey period. In most cases this involved vehicles being sighted more than once at only one survey location. The trip pattern of vehicles passing through only one survey location is shown in Table 7.3. The vehicles denoted by 'double appearances' only contributed one trip each to the number of daily trips because the additional sightings were outside the 24-hour reference periods. In most of these cases the two sightings were about 24 hours apart. The vehicles denoted by 'multiple appearances' each contributed two or more to the estimates of daily trips. One vehicle at Marulan was sighted four times in the 24-hour reference period and therefore accounted for four trips. This vehicle was also sighted on three more occasions in the next six hours.

The heavy vehicle traffic volume by hour of day was analysed in Chapter 5. The hourly traffic volume at each of the three survey locations (see Figure 5.1) was consistent with a wave of traffic moving south on the Hume Highway. Figure 7.1 shows these hourly volumes broken down by the various trip types. The dominant feature is the wave of long-distance Region A to Region D traffic which peaks between 4.00 p.m. and 10.00 p.m. at Marulan, 6.00 p.m. and 11.00 p.m. at Yass, and 10.00 p.m. and 4.00 a.m. at Wodonga.

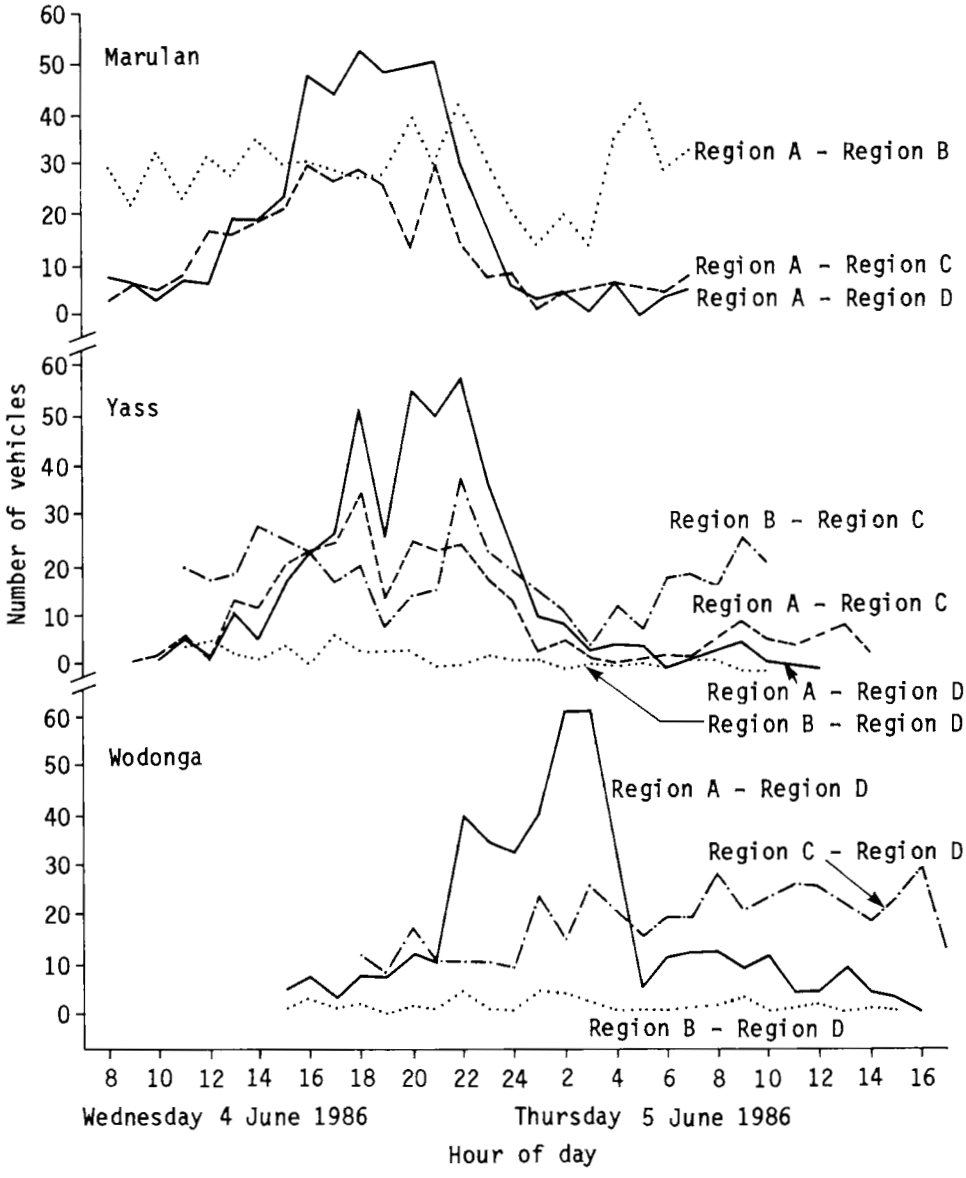
TRAVEL TIMES

From the recorded times of sightings it was possible to calculate travel times between the survey locations. Using the distances between the survey locations (about 115 kilometres from Marulan to Yass and about 295 kilometres from Yass to Wodonga) these travel times can be expressed in terms of average speed. Survey personnel recorded time checks every five minutes or more frequently, although there were a few lapses. These would not, however, significantly effect the broad conclusions about travel times presented in this section.

The distributions of travel times for vehicles travelling from Marulan to Wodonga, Marulan to Yass and Yass to Wodonga are shown in Figures 7.2 to 7.4. Each figure includes all the vehicles that covered that section of the Hume Highway, regardless of trip type. The figures include a scale which denotes the equivalent average speed.

In many cases vehicles would have broken their journey so that the lower average speeds are not indicative of the speeds maintained while travelling. The higher average speeds would also understate the speed maintained on the open road because of travel in built-up areas. At the time of the survey a maximum speed limit of 80 kilometres per hour

applied in New South Wales to trucks with a laden weight exceeding 4.5 tonnes. Clearly, a significant number of vehicles would have exceeded the speed limit. An analysis of travel time against time of day also shows that vehicles travelling at night-time tend to travel faster than those travelling during the day (see Table 7.4).



Source BTE heavy vehicle survey (1986).

Figure 7.1 Heavy vehicle traffic volume by trip type and hour: Marulan, Yass and Wodonga

TABLE 7.3 TRIP PATTERN OF VEHICLES PASSING THROUGH ONLY ONE SURVEY LOCATION

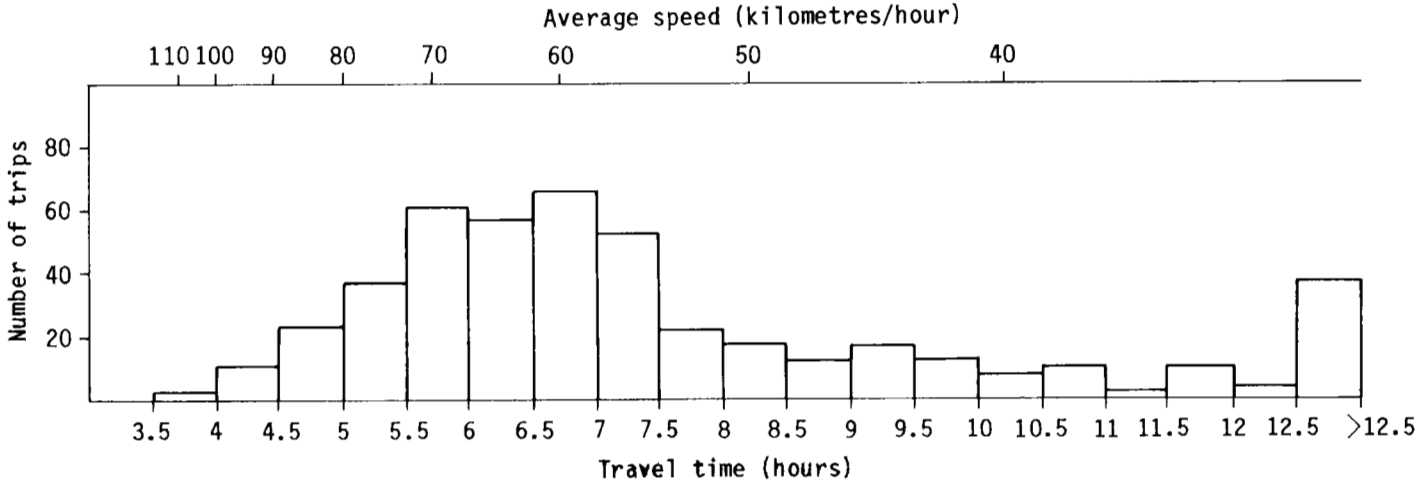
Survey location and trip pattern	*Number of vehicles*	*Number of trips in 24 hours*	*Number of sightings outside 24-hour survey period*
Marulan			
Single appearance[a]	595	595	..
Double appearances[b]	52	52	52
Multiple appearances[c]	19	50	16
Total	666	697	68
Yass			
Single appearance[a]	391	391	..
Double appearances[b]	17	17	19
Multiple appearances[c]	13	31	10
Total	421	439	29
Wodonga			
Single appearance[a]	392	392	..
Double appearances[b]	22	22	22
Multiple appearances[c]	16	37	4
Total	430	451	26

a. Vehicles sighted only once, which was in the relevant 24-hour reference period.
b. Vehicles sighted once during the 24-hour reference period and at least once outside the reference period.
c. Vehicles sighted more than once during the 24-hour reference period.
.. Not applicable.

Source BTE heavy vehicle survey (1986).

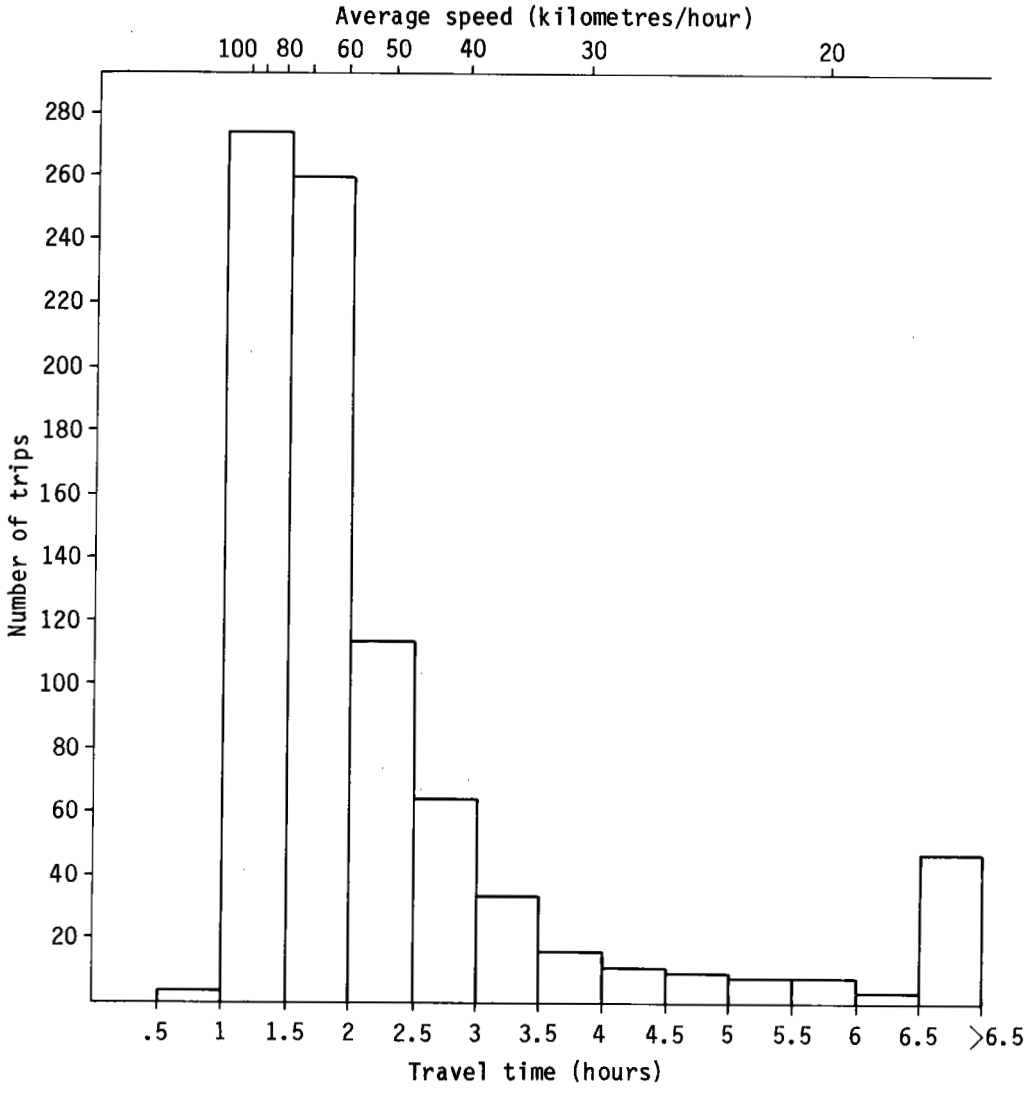
VEHICLES REGISTERED FOR INTERSTATE USE

Prior to the introduction of the Federal interstate vehicle registration scheme in 1987, five States (New South Wales, Victoria, South Australia, Western Australia and Tasmania) had provision for



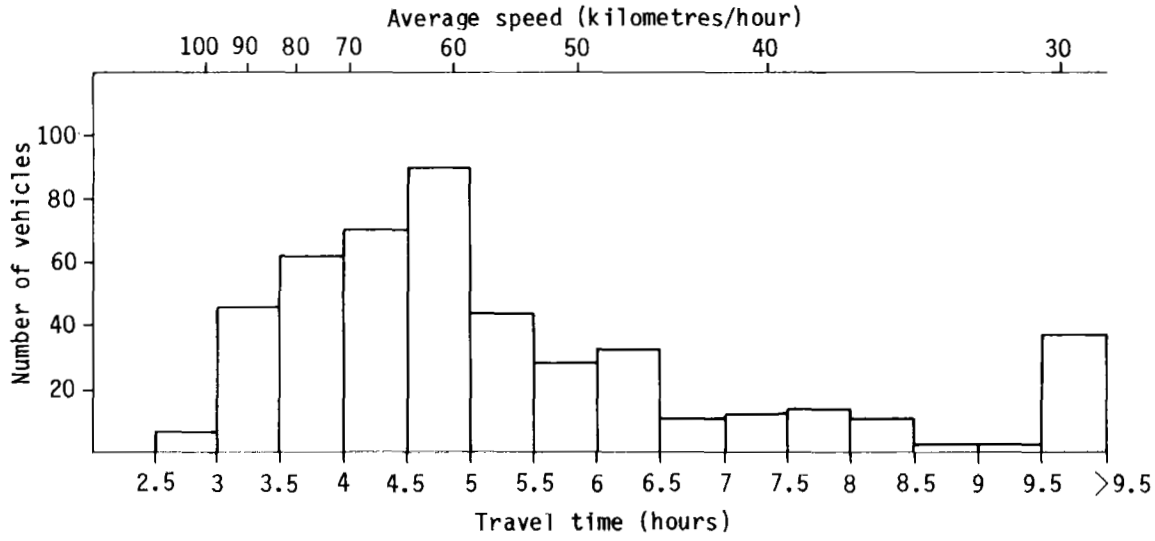
Source BTE heavy vehicle survey (1986).

Figure 7.2 Distribution of heavy vehicle travel times: Marulan to Wodonga



Source BTE heavy vehicle survey (1986).

Figure 7.3 Distribution of heavy vehicle travel times: Marulan to Yass



Source BTE heavy vehicle survey (1986).

Figure 7.4 Distribution of heavy vehicle travel times: Yass to Wodonga

registering vehicles for interstate use (IS vehicles). These vehicles can be identified by the reserved registration number ranges listed in Appendix III. In most cases it was possible to identify whether or not a vehicle was an IS vehicle, but in about 8 per cent of cases, insufficient detail had been recorded. Most of these were vehicles sighted only at Yass.

The number of daily trips by trip type for IS vehicles and other vehicles are shown in Table 7.5. As might be expected, a relatively high proportion (78 per cent) of the long-distance Region A to Region D trips were carried out by IS vehicles. IS vehicles making trips from Region A to Region C would include vehicles travelling north of Marulan to western States. The number of IS vehicles making trips between Region A and Region B (sighted only at Marulan) appears somewhat high as travel to or from the Australian Capital Territory is not considered interstate for the purposes of interstate registration, but this figure may include vehicles that were missed in Yass and bypassed the survey location at Wodonga or were sighted at Wodonga with insufficient details being recorded to match with the earlier sightings.

TABLE 7.4 COMPARISON OF TRAVEL TIMES FOR NIGHT-TIME AND OTHER TRAFFIC: HEAVY VEHICLES TRAVELLING FROM MARULAN TO WODONGA

	Time through Marulan			
	Between 6.00 p.m. and midnight		*Other times*	
Travel time (hours)	*(number)*	*(per cent)*	*(number)*	*(per cent)*
Up to 4	1	0.4	0	0.0
4 to 4.5	9	3.6	1	0.5
4.5 to 5	20	8.1	8	3.8
5 to 5.5	28	11.3	13	6.2
5.5 to 6	37	15.0	22	10.4
6 to 6.5	26	10.5	34	16.1
More than 6.5	126	51.0	133	63.0
Total	247	100.0	211	100.0

Source BTE heavy vehicle survey (1986).

TABLE 7.5 DAILY TRIPS BY TYPE OF REGISTRATION AND TRIP TYPE

	Trip type						
Registration	*Region A-Region B*	*Region A-Region C*	*Region A-Region D*	*Region B-Region C*	*Region B-Region D*	*Region C-Region D*	*Total*
IS vehicles	127	165	357	73	18	131	871
Other vehicles	568	165	101	258	24	246	1 362
Unknown	2	0	0	108	1	74	185
Total	697	330	458	439	43	451	2 418

Source BTE heavy vehicle survey (1986).

ACCURACY OF ESTIMATES

Evidence was presented in Chapter 6 that the number of long-distance Region A to Region D trips may have been underestimated. As a consequence the number of trips in some of the shorter distance categories may have been overstated. The analysis, in the previous section, of trips carried out by IS vehicles is consistent with this view. A further check can be carried out by comparing the daily trip estimates with the information collected in the New South Wales MoT survey on the same day. Table 7.6 shows stated destination for vehicles travelling south through the Marulan vehicle checking station. As noted in Chapter 6, a number of vehicle records appeared to have been missed in the MoT survey. This accounts for the difference between the total of 1364 in Table 7.6 and the 1485 daily trips originating in Region A shown in the first three columns of Table 7.1. Even so, the MoT survey shows 609 vehicles travelling to Melbourne with another 42 going to other places in Victoria, compared to the heavy vehicle survey estimate of 458 Region A to Region D trips.

Clearly, the estimate of daily trips from Region A to Region D understates the true level of heavy vehicle traffic travelling from north of Marulan to south of Wodonga. In theory, this may be due to problems with data recording at the Wodonga survey location, or due to significant numbers of vehicles taking a route that did not go through the Wodonga survey location. The generally good level of data recording in the heavy vehicle survey suggests that the shortfall is primarily due to vehicles not passing through the Wodonga survey location.

EXTRAPOLATION TO YEARLY ESTIMATES

The daily trip estimates presented in this chapter were based on a 24-hour survey and interpreted as estimates for a typical, mid-week day for that time of year. To extrapolate the estimates to yearly figures would require some data on the variation in day-to-day traffic. Detailed data suitable for this purpose are collected by DMR at the Marulan vehicle checking station. However, suitable data might not generally be available for surveys on other routes. For this reason, and because of the limitations of the region-to-region estimates derived from the heavy vehicle survey, estimates indicative of one year's activity are not presented.

TABLE 7.6 VEHICLES BY DESTINATION: SOUTHBOUND TRAFFIC THROUGH MARULAN VEHICLE CHECKING STATION, 24 HOURS FROM 8.00 A.M. WEDNESDAY 4 JUNE 1986

Destination	*Number of vehicles*
Australian Capital Territory	268
Southern Tablelands	238
Midwestern Plains	3
Riverina	80
Melbourne	609
Victoria	42
Adelaide and South Australia	70
Perth	4
Unknown[a]	49
Total	1 363

a. Vehicles with recorded origin and destination inconsistent with southbound travel on the Hume Highway.

Source BTE estimates based on New South Wales MoT survey, June 1986.

CHAPTER 8 CONCLUDING REMARKS

The aim of this study was to develop and test methodology for estimating long-distance passenger and freight movements based on direct observation of vehicle movements. The central part of the methodology chosen was a number plate survey which could be carried out over a full day at various locations on the road network under study, in order to identify vehicle movements between the regions delineated by the survey locations. Covering passenger as well as freight traffic was, however, found to be too difficult a survey task. Consequently, the methodology developed was restricted to heavy vehicles.

Due to cost constraints and the experimental nature of the study, this heavy vehicle survey was conducted at only three locations on the Hume Highway (Marulan, Yass and Wodonga) covering southbound traffic only. The methodology was found to be workable. There were a number of factors that made the survey task easier than might otherwise be the case. The most important of these was having one survey location at the Marulan vehicle checking station. In addition, weather conditions were reasonably good. Although there were some problems with fog, there was no rain during the survey period. On the other hand, the survey was conducted in winter and it would be expected that longer hours of daylight and more comfortable conditions for survey personnel in summer would improve the quality of the data collected.

The major limitation of the methodology is that it is labour intensive and thereby very costly. The number of regions to be identified in a study using this survey methodology has a direct bearing on the number of survey locations required. If the area under study has a complex pattern of probable routes, additional survey locations may be required. The number of survey locations determines the staffing requirement, which was found to be three persons per six-hour shift for traffic in one direction. If both directions of traffic are to be covered it may be feasible to use five rather than six persons per shift.

The furthest distance between survey locations also has a bearing on the staffing requirement. In order to provide estimates for a 24-hour

traffic flow it is necessary to carry out the survey at each location for longer than 24 hours, to take into account variations in travel time. This additional surveying requirement would increase with the distance between survey locations.

There is an additional conceptual difficulty in defining a daily trip which was not specifically addressed in this study. For heavy vehicle traffic between Marulan and Wodonga it is reasonable to assume that most vehicles travel more or less straight through. Over longer distances this assumption may not be valid. If one was studying traffic from Melbourne to Brisbane, for example, it would be necessary to conduct the survey for, say, 48 hours to provide estimates for one day. Then there is the problem of distinguishing between vehicles that have taken a long rest break and those that have actually made more than one trip.

If the method was to be employed to develop estimates of annual traffic movements, several such surveys would need to be conducted on different days in the year unless appropriate information on variations in day-to-day traffic were available from other sources. In the former case the cost would increase in proportion to the number of surveys required, while in the latter case some judgement would be implicit in using the additional information.

Overall, the methodology offers a potentially useful approach for studies of freight movements over corridors and medium size areas involving distances of the order of several hundred kilometres.

APPENDIX I HEAVY VEHICLE SURVEY CODING SHEET

Time	Number of axles					Truck commodity				Registration numbers		Comments
	Bus		Truck		Add. trailer							
	Coach	Other	Rigid	Semi		Bulk solid	Bulk liquid	Non-bulk	Livestock	Front	Back	

APPENDIX II HEAVY VEHICLE SURVEY DETAILED COMMODITY CLASSIFICATION

Bulk Solid

C Coal and coke
W Wheat and other grains
G Gravel, sand, loam and so on
O Other, such as minerals (please comment)
E Empty or load not visible
? Unidentified

Bulk Liquid

M Milk
P Petrol
C Chemicals
O Other (please comment)
? Unidentified

Non-bulk

P Produce (agriculture and groceries)
R Refrigerated goods
B Building materials
M Metal products
F Furniture
C Cars
O Other, including machinery, tools of trade, containers
E Empty
? Unidentified

Livestock

C Cattle
S Sheep
P Pigs
O Other, such as poultry
E Empty
? Unidentified

APPENDIX III REGISTRATION NUMBERS IDENTIFYING VEHICLES REGISTERED FOR INTERSTATE USE

New South Wales

ISA000 - ISZ999

Victoria

IS0000 - IS9999
IT0000 - IT9999
IU0000 - IU3397

South Australia

IS0000 - IS2899
RIS000 - RIS999
SIS000 - SIS999
TIS000 - TIS999
RIH000 - RIH999
SIH000 - SIH999
RI0000 - RI9999
TIH000 - TIH999

Western Australia

UIS000 - UIS999
6IS000 - 6IS999

Tasmania

IS0000 - IS9999
IT0000 - IT9999

Note Prior to the introduction of the Federal interstate vehicle registration scheme in 1987, Queensland, Northern Territory and the Australian Capital Territory had no provision for registering vehicles for interstate use.

REFERENCES

Abbreviations

ABS	Australian Bureau of Statistics
AGPS	Australian Government Publishing Service
BTE	Federal Bureau of Transport Economics
DMR	Department of Main Roads, New South Wales

ABS (1986a), *Motor Vehicle Census, Australia, 30 September 1985,* Cat.No. 9309.0, Canberra.

__ (1986b), *Survey of Motor Vehicle Use, Twelve Months ended 30 September 1985,* Cat.No. 9208.0, Canberra.

__ (1986c), *Transport Establishments: Details of Operations by Industry Class, Australia, 1983-84,* Cat.No. 9104.0, Canberra.

__ (1987), *Road Freight Transport Activity of Private Enterprises by Industry Division, Australia and States, 1983-84,* Cat.No. 9107.0, Canberra.

BTE (1973), *Freight Transport to North West Australia 1975-1990,* Report 7, AGPS, Canberra.

__ (1976), *Estimates of Australian Interregional Freight Movements, 1971-72,* Information Bulletin, AGPS, Canberra.

__ (1977a), *Australian Sea Freight Movements, 1975-76,* Information Bulletin, AGPS, Canberra.

__ (1977b), *Darwin and Northern Territory Freight Transport Study,* Report 32, AGPS, Canberra.

__ (1978), *Estimates of Australian Interregional Freight Movements, 1975-76,* Information Bulletin, AGPS, Canberra.

__ (1979), *Australian Rail Freight Movements, 1975-76,* Information Bulletin, AGPS, Canberra.

__ (1981), *Estimates of the Task of Transporting Principal Rural Products in Australia,* 1975-76, Information Paper 5, AGPS, Canberra.

__ (1982a), *Estimates of Freight Travelling to and from Sydney along the Hume and Pacific Highways,* Information Paper 6, AGPS, Canberra.

__ (1982b), *Transport of Slaughter Cattle in Australia,* Report 50, AGPS, Canberra.

__ (1983), *Australian Rail Freight Movements 1979-80,* Information Paper 8, by T. G. Mikosza and J. A. Ascione, AGPS, Canberra.

__ (1984), Pilot Survey of Manufacturers, 1984.

__ (1985), *Australian Long Distance Coach Industry Review,* Occasional Paper 74, AGPS, Canberra.

__ (1986), *Survey of Trucking Operations 1982-83: Methodology and Results,* Occasional Paper 75, AGPS, Canberra.

Daff, M. (1984), Origin and Destination Surveys with Emphasis on the Number Plate Method, in *Traffic Survey Methods,* ed. M. A. P. Taylor, Monash University, Melbourne.

DMR (forthcoming), automatic traffic count data for *Traffic Volumes and Supplementary Data, 1988, Southern Division, Sydney.*

Vincent, E. N. (1984), A Rural Origin-Destination Survey, in *Traffic Survey Methods,* ed. M. A. P. Taylor, Monash University, Melbourne.

ABBREVIATIONS

ABS	Australian Bureau of Statistics
AGPS	Australian Government Publishing Service
BTE	Federal Bureau of Transport Economics
DMR	New South Wales Department of Main Roads
IS vehicle	Vehicle registered for interstate use
MoT	New South Wales Ministry of Transport

NOTATION

M,Y,W	Vehicles recorded in the heavy vehicle survey at Marulan, Yass and Wodonga respectively
M*,Y*,W*	Vehicles recorded in the defined 24-hour periods in the heavy vehicle survey at Marulan, Yass and Wodonga respectively
-	Subtraction of sets
$\cap$	Intersection of sets
$\cup$	Union of sets