# Adequacy of Transport Infrastructure: Urban Roads

## Working Paper

This Working Paper is the fifth in a series of Working Papers which disseminates the results of a large research project into the adequacy of Australia's transport infrastructure over the next 20 years. The assessment covers all four modes of transport - road, rail, air and sea - with the primary focus on freight.

Bureau of Transport and Communications Economics

# WORKING PAPER 14.5

# Adequacy of transport infrastructure
# Urban roads

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## FOREWORD

The National Transport Planning Taskforce (NTPT) was established in October 1993 by the former Minister for Transport and Communications to report on national infrastructure needs and operational improvements required to meet future demands for freight transport.

The Bureau of Transport and Communications Economics was commissioned by the NTPT to carry out assessments of the adequacy of road, rail, seaport and airport infrastructure. In doing this it has attempted to adopt a strategic multimodal orientation. A summary of the Bureau's work is given in *Building for the Job: A Strategy for Australia's Transport Network, Commissioned Work vol. 1* produced by the NTPT.

The project was undertaken under the leadership of Mark Harvey and John Miller. Officers who contributed specific components included Johnson Amoako, Jane Brockington, Peter Collins, Glen D'Este, Bozena Dziatkowiec, Edwina Heyhoe and Chikkegowda Puttaswamy. Other officers of the BTCE, particularly Maurice Haddad, also made valuable contributions.

Details of the research undertaken for each component of the study are provided in a series of six working papers. Each paper describes the methodology used, future demand, and results of the adequacy analysis, and gives options for future research. This paper details the work undertaken to assess the adequacy of urban road infrastructure to meet the needs of freight transport.

The urban adequacy work was undertaken by Mark Harvey with the consultants Travers Morgan collecting data. The dedication of all the Bureau staff involved, the consultants, and the staff of the state road authorities and freight forwarding firms who cooperated in supplying information and constructive comments, has been appreciated.

Russ Reynolds
Research Manager

Bureau of Transport and Communications Economics
Canberra
January 1995

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# ABSTRACT

The aim of this paper is to assess the adequacy of urban road infrastructure to cater for the needs of freight transport over the next 20 years. The concept of adequacy of transport infrastructure and how it might be assessed is discussed in general terms. However, application of the preferred methodology to urban roads has been severely curtailed by data deficiencies and the complex modelling requirements of urban road analysis.

As background, a discussion of some relevant urban road issues is provided including the hierarchical nature of roads in an ideal urban network, and congestion pricing. It is argued that the economically optimal levels of service from urban roads will tend to be less than for intercity roads mainly because of the high cost of providing urban road capacity.

To reduce the assessment task to manageable proportions, a number of major freight corridors were selected in the five mainland state capital cities and relevant data collected from state road authorities. This enabled comparisons to be made between corridors and cities to identify where congestion of most significance for urban freight transport is worst. For each of the five cities, an examination is undertaken of the locations of freight generating activities, major freight flows, and congestion affecting these. The strategic directions being pursued by state planning authorities, including an assessment of how well they address the congestion problems identified, are examined.

It is concluded that, for the most part, the construction of the proposed freeways will ameliorate the bottlenecks affecting freight. But the question is raised as to how far local communities will tolerate continued freeway construction as a long-term solution to congestion. Available benefit–cost ratios are assembled for investment projects affecting the selected corridors. Adequacy of freight forwarders' road terminals is also considered. The paper concludes by considering the future directions of adequacy assessment work for urban roads.

## KEY FINDINGS

About half the total tonnage of road freight is intra-urban movement in the eight capital cities.

Sydney has the worst freight traffic congestion problems, followed by Melbourne, then Brisbane.

Freight moving through major urban areas is hampered by lack of good continuous networks of limited access primary roads. Such networks would enable swift transit between the major origins and destinations of freight traffic in urban areas: the ends of major highways, industrial areas, ports, rail terminals and airports. In all the five mainland state capitals except Adelaide, sections of such networks exist at freeway standards and there are plans to link these together. Common features of these plans include ring roads which connect the major highways and pass through industrial areas, and bypass routes to divert traffic around central business districts (CBDs).

The plans of the state authorities to upgrade and widen existing roads and to construct new freeways will ameliorate many of the congestion problems identified in the study. Some bottlenecks that the plans do not appear to address adequately include:

- in Sydney, the end of the Hume Highway and the linking of Parramatta Road and the Botany–Mascot area;
- in Brisbane, the number of river crossings; and
- in Adelaide, access to the north–west from the south and south–east including the Princes Highway West.

Construction of new freeways may face strong community opposition, leading governments to choose higher cost solutions such as longer alternative routes and tunnels or simply to allow congestion to continue and so regulate itself. Road pricing is another option.

For road freight terminals, adequacy of infrastructure is not likely to be an issue.

# CHAPTER 1 INTRODUCTION

The Bureau of Transport and Communications Economics was asked by the National Transport Planning Taskforce (NTPT) to undertake an assessment of the adequacy of transport infrastructure in Australia for the next 20 years. The assessment covers all four modes of transport—road, rail, sea and air—with the primary focus on freight. The analysis takes passenger transport into account where it uses the same infrastructure as freight and impacts on congestion levels.

The full results of the work are presented in the Bureau's report to the NTPT, which concentrates on the findings of the study, and provides only as much methodology as is necessary to understand the findings. The BTCE has prepared a series of six working papers to explain the methodology in detail and to provide further discussion of the findings and information requirements of the study. The working papers cover each mode, urban roads and intermodal issues.

This working paper, the fifth in the series, contains the assessment for urban road infrastructure for freight. Intercity and urban roads have been treated separately because the data availability and modelling requirements are very different. Less data are available on characteristics and usage of urban roads and modelling them is far more complex and data-intensive. The models developed for the rural road assessment are not transferable to urban roads because they apply only to uninterrupted flows of traffic and do not take into account the network effects so prevalent in urban road systems. For these reasons, it has not been possible to assess the adequacy of urban roads for freight in anything approaching the depth in which intercity roads were assessed. The main features of the urban road assessment are identification of the main bottlenecks that impede freight flows, discussion of the strategic planning directions being pursued by state authorities in so far as they affect the major freight flows, and a general discussion of relevant urban road issues.

To reduce the task to manageable proportions, the Bureau limited its assessment of the adequacy of urban roads for freight transport to the five mainland state capital cities, since these cities have the worst urban congestion problems. Within each of these cities, a number of major routes important for freight traffic were selected. These tend to be the routes linking main highways with each other and with freight-generating centres such as industrial areas, ports and airports. It is acknowledged that bottlenecks affecting significant amounts of freight traffic and large investment needs occur in other parts of the urban areas considered and in other cities. These will often be of more importance to the pick-up and delivery phase of the freight transport process.

## NEED FOR A STRATEGIC APPROACH

The strategic nature of this study needs to be emphasised. The study does put forward some dollar values of investments likely to be warranted, but these should be regarded as broad orders of magnitude only. It would be a grave misrepresentation to interpret the findings as setting out a recommended investment program. The aim was not to produce a program of specific infrastructure projects and itemised costing but to highlight areas where a full scale cost–benefit analysis would most probably indicate that investment in additional infrastructure is warranted within the 20–year period. The study points to areas where detailed evaluations might usefully be undertaken as well as to areas where this is not the case. The results of the study should therefore be valuable in alerting governments to parts of the national transport network infrastructure that are likely to require attention over the next 20 years and the likely magnitude of the financial resources required.

## OUTLINE OF REPORT

Chapter 2, which is common to most of the working papers in the series, contains an explanation of the conceptual framework within which the adequacy assessments have been undertaken. Although it has been possible to implement the methodology contained in chapter 2 only to a very limited extent for urban roads, it is still useful to clarify the concept of adequacy, in particular its relationship to cost–benefit analysis, and the chapter underpins the latter discussion on future directions for adequacy assessment work.

In chapter 3 some relevant urban roads issues are discussed as background to subsequent assessment. The actual assessments are contained in chapter 4 which also includes demand projections and an examination of each of the five cities in turn. In chapter 5 the adequacy of road freight terminals is addressed. The concluding chapter 6 includes a discussion of future directions for adequacy assessment work in urban road infrastructure for freight.

# CHAPTER 2 ASSESSING INFRASTRUCTURE ADEQUACY

In this chapter we address questions of the meaning of 'adequacy' of transport infrastructure and how this might be assessed. Two definitions of adequacy have been employed by the Bureau, one technical and the other economic. How the Bureau has applied these definitions to the different modes has been shaped by the characteristics of the modes and availability of data and models. The depth in which the Bureau has been able to analyse adequacy is therefore very uneven between modes. Even where only a limited assessment has been possible, however, it is still important to bear in mind the ideal, and this serves as the basis for subsequent discussions about future directions that might be taken in adequacy assessment work. Definitions of adequacy are discussed in the first part of the chapter, and in the second part some of the practical issues faced in attempting to apply these definitions are reviewed.

## DEFINING ADEQUACY

### The concept of adequacy

'Adequacy' of transport infrastructure refers to whether or not additional investment is required in the infrastructure. The requirement to invest is a consequence of the infrastructure providing a poor level of service, such as high operating costs, long service times or unreliability. Poor service can have a variety of causes including shortages of capacity, physical deterioration and obsolescence due to changes in technology, demand, input prices or safety requirements.

Specifying just what is meant by a 'poor' level of service is not straightforward. If efficient use of resources is the objective, whether service can be considered poor and the infrastructure requires upgrading is an economic question involving a weighing up of the capital cost of investing against the benefits in terms of improved levels of service. The technique for doing this is social cost–benefit analysis. However, undertaking a cost–benefit analysis is a complex, data-intensive and time consuming task. Simpler and quicker means are needed to identify investment projects where detailed assessment is likely to be warranted, and to make decisions about smaller investments where application of cost–benefit analysis techniques would not be worthwhile. The common procedure is to employ a 'rule of thumb' whereby upgrading is considered necessary when the quality of service provided by a piece of infrastructure deteriorates below some minimum acceptable level.

## Technical adequacy

From the notion of 'rules of thumb' providing a rough indication of whether investment is needed, the Bureau has derived its definition of 'technical adequacy'. Transport infrastructure is deemed to be technically adequate if its physical or performance characteristics are above minimum acceptable levels. The definition can be applied either to physical or performance characteristics. Examples of physical characteristics for urban roads are vehicles per day per lane and intersections per kilometre. For performance characteristics, the minimum could be specified either in technical terms, for example, average or peak hour speeds; or in cost terms, for example vehicle operating and time costs per kilometre.

Given that infrastructure adequacy is essentially an economic question, determining the level of minimum technical standards should be done bearing in mind the standard that is likely to be warranted on economic grounds. One approach is to assume that, *on average across the country,* current standards for infrastructure of a given type are roughly right in economic terms. The physical or performance characteristics of a large number of sections of infrastructure can then be compared and those with the poorest standards deemed to be technically inadequate. Precisely where to draw the line between adequate and inadequate remains a matter for judgment. In the absence of information about economically warranted standards, natural breaks in the continuum of standards and perceptions about reasonable standards could be drawn upon.

## Economic adequacy

An assessment of adequacy using a technical definition can only be regarded as providing a rough guide to whether upgrading is economically justified. A piece of infrastructure which is inadequate in the technical sense, could be adequate in the economic sense if the cost of upgrading was high in relation to the benefits. Conversely, if the benefits of upgrading exceeded the costs, it would be economic to invest even where the infrastructure was technically adequate.

The second approach to defining infrastructure adequacy employed by the Bureau in its assessment of national transport infrastructure is 'economic adequacy' which is based on social cost–benefit analysis. Transport infrastructure is deemed to be economically adequate at a point in time if

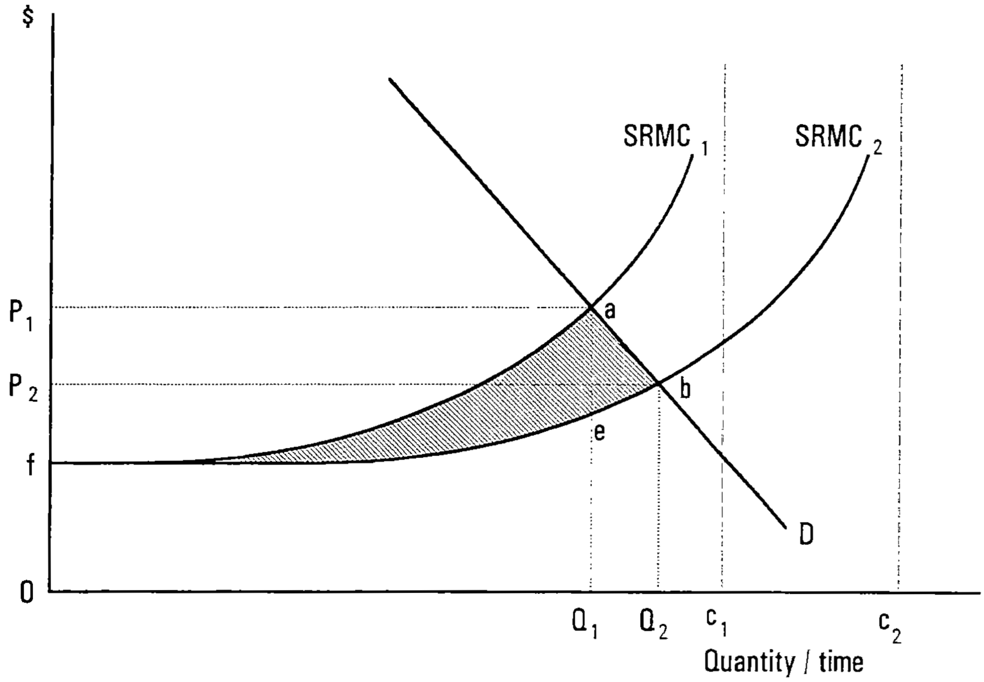


**Figure 2.1 Benefits from capacity expansion**

investment to improve the level of service provided is not economically warranted. An investment is economically warranted at a point in time if:

1 the present value of benefits exceeds the present value of costs; *and*

2 there is no net welfare gain from delaying the investment.

The first condition is intended to ensure that the resources invested will earn at least what they could if used elsewhere in the economy and the second condition aims to ensure optimal timing.

To explain the economic concept of adequacy in more detail, Figure 2.1 shows a demand curve and two 'short-run marginal social cost' (SRMC) curves for the use of a piece of infrastructure. Quantity provided or demanded per period of time is graphed on the horizontal axis and 'generalised social cost' of infrastructure use on the vertical axis. This 'generalised social cost' consists of all the costs associated with use of the infrastructure regardless of to whom they accrue. In the case of urban roads, generalised social costs would include the costs of road provision and maintenance, vehicle operation, time for passengers and freight, and externalities such as air pollution, noise and visual disamenity. Valuing time and externalities entails significant measurement problems which are not addressed in this conceptual discussion.

The marginal cost of infrastructure use is the cost imposed by an *additional* user. The short-run refers to the time frame in which it is not possible to invest to change the infrastructure. Capital costs and fixed operating costs of infrastructure are excluded because they will not be affected in the short term by infrastructure usage. The short-run marginal social cost curve, $SRMC_1$ rises as usage rises towards maximum capacity ($c_1$) and operating costs, delays and unreliability increase. If the maximum capacity was increased, say to $c_2$, the short-run marginal cost curve would shift to the right—to $SRMC_2$.

The demand curve ($D$) shows the quantity demanded of infrastructure usage at each level of generalised cost incurred by users. Users incur their own costs plus taxes and charges associated with use of the infrastructure. To simplify the exposition, it is assumed that taxes and charges are levied in amounts such that user pays the short-run marginal social cost of the resources consumed. This is the economically optimal price. As a result of the capacity expansion, users gain from a reduction in generalised cost from $P_1$ to $P_2$ and so increase their use from $Q_1$ to $Q_2$. The net gain to society from expanding infrastructure capacity is equal to the shaded area (*abf*) in figure 2.1.[1] Clearly, the shaded area and hence the benefits from expanding capacity will be greater in size, the higher demand is in relation to capacity.

A social cost–benefit analysis would compare the capital cost of the capacity expansion with the discounted present value of gains per period time. The first condition in the above definition of economic adequacy requires that the latter exceed the former before capacity could be considered inadequate.

If infrastructure could be expanded in finely divisible amounts, one would keep on adding to capacity as long as the present value of benefits from one dollar's worth of additional expenditure on capacity exceeded one dollar. In practice, however, capacity can often be expanded only in sizeable lumps. In many cases this is due to economies of scale in construction as it is cheaper to reach a given capacity level with one large capital work than to do so via a series of smaller investments increasing capacity in steps. In other cases, this is attributable to technical characteristics, for example, the number of lanes on a road must be an integer.

**The optimal time to invest**

Although capacity may be lumpy, the time at which to invest is divisible. This leads to the second condition in the definition of economic adequacy which ensures optimal timing. Even when the present value of benefits exceeds costs,

1 The area between the two SRMC curves from $0$ to $Q_1$ (*aef*) represents the saving in costs on existing throughput. The area from $Q_1$ to $Q_2$ (*abe*) is the gain to society associated with the generated demand. It is the difference between the gain to users represented by the height of the demand curve and the social cost of meeting the additional demand represented by the height of the $SRMC_2$ curve.

it may still be preferable to delay an investment. Assuming that the upgrade will be permanent, if the investment project was delayed by one year, society would forgo the benefits from the project for that year. As an offset, society could gain by investing the funds required for one year elsewhere and earn interest. Assuming perfect capital markets so that the interest rate equals the discount rate which in turn equals the opportunity cost of capital, society would gain $rK$ where $r$ is the discount rate and $K$ the capital cost of investment. Hence an investment would be better delayed so long as $B(t) < rK$ where $B(t)$ is the benefits in year $t$.[2] If demand is growing over time, annual benefits will grow as well, so the time will eventually be reached when investment is warranted. This is illustrated in figure 2.2. Time is graphed on the horizontal axis and annual benefits and costs on the vertical axis. Two annual benefit curves are shown along with the value of $rK$. The annual benefit curves have been drawn as rising at an increasing rate because, as the demand curve in figure 2.1 moves rightward over time, the distance between the $SRMC_1$ and $SRMC_2$ curves increases. If the annual benefit curve labelled $A$ applied, the investment would be warranted immediately. In this case, the optimal time to invest occurred in the past. In the case of the $B$ curve, it would be better to delay the investment until time $T_B$.[3]

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2 This condition is sometimes expressed as: a project should be delayed if the 'first year rate of return' is below the discount rate, that is, $\frac{B(1)}{K} < r$.

3 It is assumed that the benefit function is continuous and monotonically increasing. With investment occurring at time $T$ and continuous compounding, the net present value of benefits and costs is: $NPV = \int_T^\infty B(t)e^{-rt}\,dt - Ke^{-rT}$. This equation must be differentiated with respect to $T$ and set equal to zero to obtain the optimum time to invest: $\frac{dNPV}{dT} = -B(T)e^{-rT} + rKe^{-rT} = 0$; which reduces to: $B(T) = rK$. The second order condition for a maximum is that, in the region of the optimum: $-e^{-rt}\frac{dB}{dt} < 0$ which holds if $\frac{dB}{dt} > 0$. Thus the annual gain from implementing the project must be growing over time. The optimal timing condition derived here assumes that the project has an infinite life. There may be periodic maintenance costs and replacement costs which occur at definite times following initial construction. Deferral of the initial investment also defers these. NPV could then be expressed as:

$NPV = \int_T^\infty B(t)e^{-rt}dt - Ke^{-rT} - k_1e^{-r(T+x_1)} - k_2e^{-r(T+x_2)} - \ldots - k_ne^{-r(T+x_n)}$ where the $k$'s are periodic maintenance of replacement expenditures each one occurring $x$ years after time $T$. The optimum timing condition then becomes: $B(T) = r\left(K + k_1e^{-rx_1} + k_2e^{-rx_2} + \ldots + k_ne^{-rx_n}\right)$. Thus one could use the simple optimal timing condition derived previously but augment $K$ by an amount equal to the present value of these periodic maintenance and replacement costs. For maintenance costs which occur every year and are the same for each, it is simpler to reduce annual benefits by the amount.

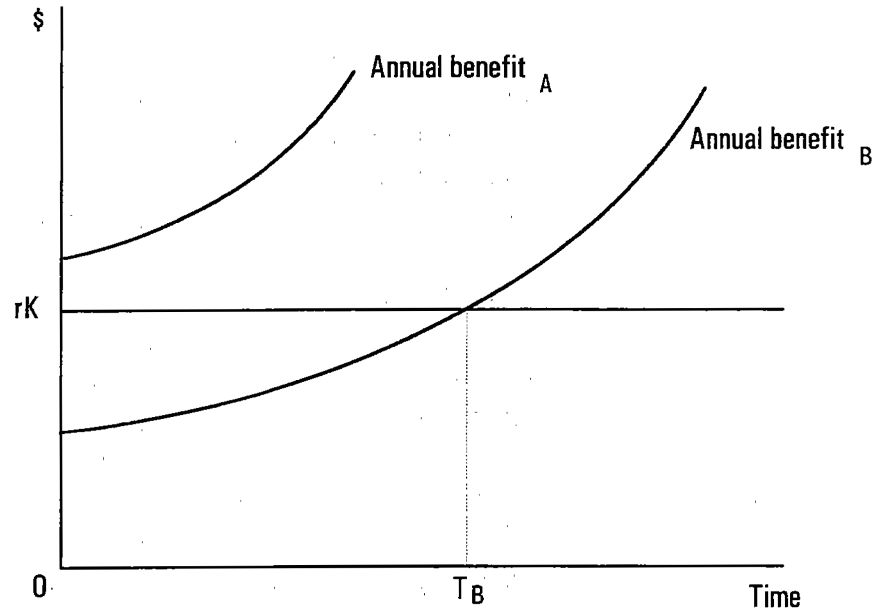


**Figure 2.2 Optimal timing of investments**

In order to explore some of the relationships, it is assumed that annual benefits are growing at a constant rate over time, that is, $b(1+g)^t$ where $b$ is the benefit in year zero from undertaking the investment and $g$ is the annual growth rate in benefits.[4] Substituting the formula for annual benefit into the optimal timing condition, the optimal time to invest is $\frac{ln(rK/b)}{ln(1+g)}$. From this it can be seen that a higher discount rate and capital cost will delay the optimum time while higher benefits and growth in benefits will bring it forward.

The benefit-cost ratio (BCR) (the present value of benefits divided by the present value of capital costs) from the investment under the assumption that benefits grow at a constant rate is $\frac{b(1+g)^T}{K[r-ln(1+g)]}$ where $T$ is the time of implementation. Thus the BCR grows over time at the growth rate. If the investment is undertaken at the optimal time, the formula for the BCR reduces

4 If the demand curve shifts rightward at a constant growth rate, benefits from infrastructure expansion will in fact rise faster because the gap between marginal costs with and without the investment rises as figure 2.1 shows.

to $\frac{1}{1 - ln(1+g)/r}$. The $b$ and $K$ terms drop out of the equation altogether. From this equation it can be seen that with a positive growth rate and optimal timing, the BCR can never lie below one. A project having a BCR below one, would, with optimal timing, be delayed into the future by which time its BCR would have risen above one. At the optimal time, how far the BCR lies above one, will depend on the size of the growth rate relative to the discount rate. If the project has its optimal time in the past, as illustrated by the annual benefit curve $A$ in figure 2.2, the BCR will be higher still, depending on how late the project is. Application of the optimal timing criterion to identify investment projects and timings therefore means that BCRs will be above one and significantly so where growth rates in benefits are high relative to the discount rate and where there is already substantial underinvestment.

### Non-capacity expanding investments

The SRMC curves in figure 2.1 were drawn such that the investment shifts the SRMC curve to the right. Short-run marginal costs at low outputs remain unchanged. The improvements in service levels eventuate because there is more capacity to handle any given volume of demand. Some investments will shift the SRMC curve downwards as well as, or instead of, to the right. An example would be an investment to save on variable maintenance costs. Even if there is no congestion whatsoever, the principles for assessing whether the investment is warranted and estimating the optimal time are the same. In terms of figure 2.1, the demand curve would pass through the flat parts of the SRMC curves. The annual benefit would still be measured by the area bounded by the two SRMC curves and the demand curve.

### Non-optimal pricing

To simplify the exposition, it was assumed in the discussion of figure 2.1 that taxes and charges were levied in amounts such that users always paid the short-run marginal social cost. This is the optimum pricing rule to achieve economic efficiency because the marginal user, that is, the user on the borderline of deciding whether or not to use infrastructure, is faced with the full cost he or she imposes on society. In practice, prices will never perfectly reflect marginal costs and may be quite different. Where prices differ from marginal costs, measurement of benefits from infrastructure upgrading will be more complicated than just the shaded area in figure 2.1.[5] If prices are above

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5 Benefits in the form of increased willingness–to–pay would be measured with reference to the demand curve and actual generalised costs incurred including taxes and charges. Benefits in the form of net cost savings would be measured as the areas under the marginal social cost curves.

marginal costs, infrastructure will be underutilised compared with the most efficient level, and less investment will be required. Conversely, if infrastructure is underpriced, there will be more congestion than the most efficient level and additional investment will be required.

## APPLYING THE DEFINITIONS

The extent to which the Bureau has been able to apply the definitions of technical and economic adequacy to each mode of transport in the adequacy assessments described in the present series of working papers has depended on the availability of data and the availability of models to forecast future levels of service as demand grows and infrastructure is upgraded.

### Demand projections

The present study aims to assess adequacy over the 20-year period 1995–96 to 2014–15 inclusive. Demand projections over this period are therefore an important first step and this is dealt with for urban roads in a later chapter. Data on recent levels of utilisation are vital for making demand projections and some forecasting techniques also require time series data.

As demand rises towards capacity, levels of service will fall, which will choke off some of the demand. Investment in new capacity can have the opposite effect, stimulating demand. In order to keep the effects of demand growth, that is, rightward movement of the demand curve, separate from effects of congestion on demand, that is, movements along the demand curve, it has been assumed when making the demand projections that service levels provided by the infrastructure remain unchanged. Figure 2.3 illustrates this. A demand curve is shown moving rightward over five time periods. The price level $P$ represents the generalised cost at time 1 when the demand curve is at $D_1$. Over time, as demand grows, if the generalised cost remained at $P$, quantity demanded would follow the series of $Q$'s along the horizontal axis. This would be the quantities the demand projections aim to estimate. If changes in service levels were taken into account, the quantities would be found at the intersections of the demand and cost curves.

### Data requirements

An essential component of the research has been a comprehensive program of data collection on the infrastructure being studied. The difficulties encountered by the Bureau in this part of the work have uncovered major deficiencies that exist in knowledge about the physical and performance characteristics and the usage of transport infrastructure in Australia.

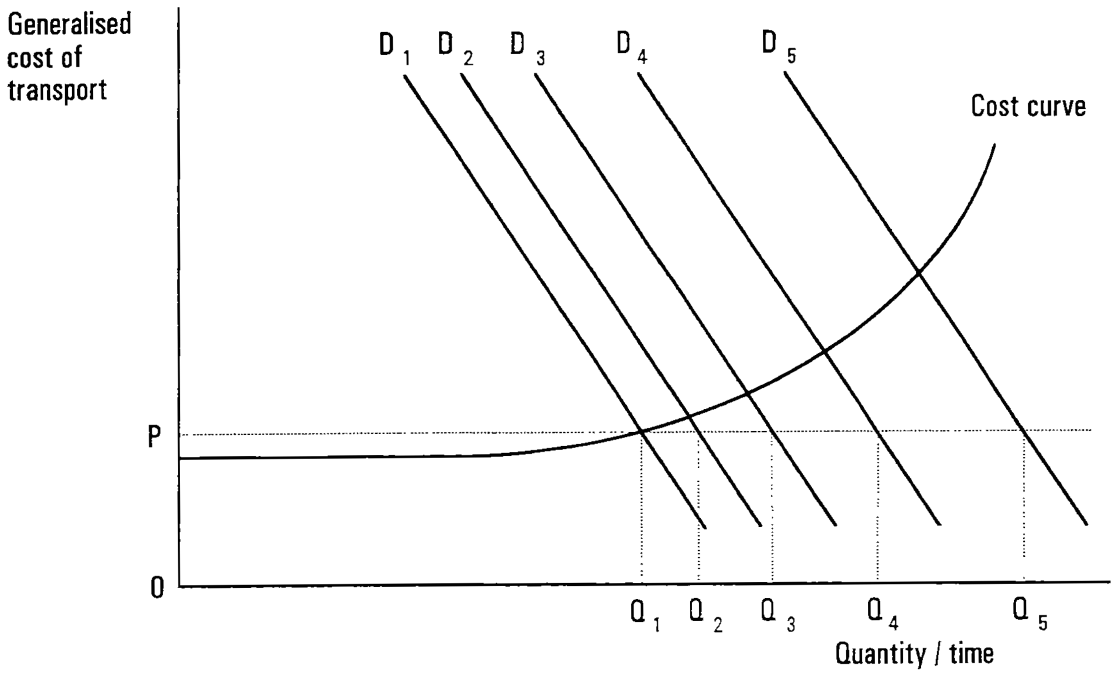


**Figure 2.3 Quantity of travel demanded at a constant level of service**

*Technical assessments*

The basic data required are some physical characteristics of each individual piece of infrastructure and details on levels of utilisation. With this information a technical assessment can be carried out by comparing the physical characteristics of each section of infrastructure against predetermined standards or against one another to highlight the worst infrastructure. Utilisation data are essential where physical characteristics are expressed in relation to throughput, for example, vehicles per day per lane. It might be useful to consider the results of the technical assessment alongside data on utilisation because a piece of infrastructure of low standard but poor utilisation may not be inadequate in the economic sense.

A more sophisticated form technical assessment is based on performance characteristics such as delays, times taken, reliability or operating costs. This requires either data on current service levels or a model which will estimate them. A model normally requires much more detailed data on physical characteristics and utilisation than would be needed for a technical assessment of physical characteristics. Projection of future service levels if forecast demand was to be loaded onto existing infrastructure would also require modelling.

A technical assessment may be employed to identify investment projects and, if the projects can be costed, estimates of the costs of likely future investment needs can be derived. The investments identified would be those which would bring the level of service up to a specified standard.

### *Economic assessments*

A problem with moving from a technical to an economic definition of adequacy is that economic adequacy cannot be assessed without specifying how the infrastructure is to be upgraded in order to estimate the costs and benefits of doing so. If alternative ways of achieving the same service improvement are available, all alternatives need to be analysed and compared. As already noted, the technical assessment can assist in identifying projects.

In the present strategic exercise, full scale cost–benefit assessments of potential infrastructure investments are not feasible. The economic assessment work undertaken must necessarily be rudimentary in nature and so only provides a broad guide as to whether investments are warranted. If the data and models are available to predict levels of service provided by infrastructure such as would be required for a technical assessment of performance characteristics, a basic economic analysis is possible provided some additional information requirements are met. These additional requirements include capital costs of investment projects and data on operating costs including values of time and reliability where these are major benefits from investment projects.

## CONCLUSION

The approach to assessing infrastructure adequacy outlined above offers great flexibility in terms of the depth of analysis, and this is essential given the variations in data availability and ease of modelling between the modes. At the lowest level is the technical review of the physical characteristics of infrastructure. The next level is a technical assessment of adequacy based on current and projected infrastructure performance in terms of service levels. This has the advantage that it can formally incorporate demand projections. In some cases, by using the technical assessment to identify potential projects and estimating the costs of these projects, it has been possible to forecast future investment needs. Finally, if it is possible to specify investment projects and estimate costs and benefits, there is the economic assessment. This too may be undertaken in varying degrees of depth ranging from a 'back of the envelope' calculation to a major cost–benefit study. The study described in the present series of working papers, with its strategic focus, would not aim to go beyond cost–benefit studies at a rudimentary level.

# CHAPTER 3 OVERVIEW OF SOME RELEVANT URBAN ROAD ISSUES

## INTRODUCTION

As background to the adequacy assessment in the next chapter, this chapter contains a review of a number of relevant urban road issues. The first concerns the hierarchical nature of distribution networks and the importance of having a good network of continuous limited access primary roads to enable swift transit between the main freight-generating centres. The characteristics of urban and intercity roads are then contrasted to show why levels of service on urban roads are justifiably lower and why different analytical techniques are required for the two road types. Road congestion pricing is briefly reviewed as many authors advocate it as a necessary component of strategies to deal with growing problems of urban congestion. Finally, arguments for favouring freight over commuters in urban road investment, and interactions between land use and infrastructure investment are briefly discussed.

## HIERARCHICAL NATURE OF DISTRIBUTION NETWORKS

For long-distance freight, urban roads provide the link between the linehaul, whether by road, rail, air or sea and the premises of the consignors and consignees in the main centres of economic activity.

Buchanan et al. (1963 pp. 170-171) wrote:

> The function of the distributary network is to canalise the longer movements from locality to locality. The links of the network should therefore be designed for swift, efficient movement. This means that they cannot also be used for giving direct access to buildings, nor even to minor roads serving the buildings, because the consequent frequency of the junctions would give rise to traffic dangers and disturb the efficiency of the road. It is therefore necessary to introduce the idea of a 'hierarchy' of distributors, whereby important distributors feed down through distributors of lesser category to the minor roads which give access to the buildings. The system may be likened to the trunk, limbs, branches, and finally the twigs (corresponding to the access roads) of a tree.

It is the top level distributors that this paper concentrates on. The reason is simply to keep the task at a manageable level however, it is acknowledged that bottlenecks affecting significant amounts of freight traffic and large investment needs occur on lower level roads in cities. These will generally relate to the initial pick-up and final delivery phase of the freight transport process. If good primary and secondary level links are provided, congestion on lower level roads should be less as through traffic will keep more to the higher level roads. Cox (1994) argues that road networks in major Australian cities are deficient in providing good networks of primary roads.

Strategic planning for urban networks includes examining land use patterns and identifying major transport corridors to determine where high standard roads are most needed. Such planning is important because cost–benefit analysis alone will not find the most efficient solutions. It is necessary to first specify those solutions before they can be evaluated.

## CHARACTERISTICS OF URBAN COMPARED WITH INTERCITY ROADS

### Levels of service

Due to the slower speeds at which traffic moves on urban roads (because of congestion and interruptions at intersections and traffic signals), the cost of travelling a kilometre through an urban area will usually be higher than on an intercity highway. For a typical six-axle articulated semi-trailer travelling between Sydney and Melbourne, only 2 per cent of the distance travelled would be in urban areas at corridor ends, but it is estimated that this would account for some 8 per cent of the total trip time and 4.5 per cent of the linehaul cost of the trip.

There is little doubt that the worst bottlenecks in the freight transport system occur on urban roads. However, it does not necessarily follow that vast amounts should be spent to eliminate these problems. As noted previously, infrastructure adequecy is primarily an economic question that involves weighting up the benefits form reducing congestion against the costs. The very high traffic levels on urban roads make for large benefits from investments in urban roads. Average annual daily traffic (AADT) levels of 60 000 to 100 000 are typical on major freeways while major arterials carry between 20 000 and 40 000 per day (Cox 1994). For the intercity highways examined in the Bureau's assessment of adequacy, the distance-weighted average of AADT levels was estimated at 3 583 vehicles per day for 1995–96 (BTCE 1994). However, for a number of reasons, for any given AADT level, the optimal level of capacity to provide on an urban road will usually be much lower than for a intercity highway.

First, the distribution of the demand for urban road space on a hourly basis throughout the year tends to be much more even than for intercity roads. For example, on intercity roads, the hour of the year with the heaviest traffic will often have a volume of over 20 per cent of the AADT level, while on urban roads the highest hourly volume of the year is likely to be less than 10 per cent of the AADT level. The result is that vehicle operating and time costs for a stream of traffic on an urban road would be less than that for a stream of traffic of identical AADT level and vehicle composition on an intercity road of the same capacity. A more even distribution of hourly volumes means that road space is more efficiently utilised, so less road capacity is needed to handle the same level of AADT.

Second, the mix of heavy and light commercial vehicles is markedly different, with light vehicles predominating in urban areas. Travers Morgan (1991) reported data showing light commercial vehicles (goods vans, utilities, 4wds) accounting for around 70 per cent of commercial vehicle AADT levels in Sydney. This follows from the fact that most commercial vehicles in urban areas are not through traffic but are engaged in local distribution. Lower percentages of heavy commercial vehicles with their higher operating costs would lead to lower benefits from road improvements. Hence a lower level of service from a road is likely to be warranted for a given AADT level.[1]

The third and most important factor that lowers the level of economically justified road capacity for a given AADT level in an urban area is that the costs of providing road capacity are much higher. This occurs first because of the opportunity cost of land and second because of the greater density of crossings of other roads, railway lines and of service conduits such as electricity, gas, telecommunications, water and sewage. The cost of relocating service conduits can greatly add to costs of road works in urban areas. Providing 'grade separation' so a road passes over or under another road or railway line is expensive.

The high costs of increasing the capacity of urban compared with intercity roads means that, even with optimum investment, higher levels of congestion are inevitable. This is particularly so in absence of congestion pricing (discussed below). Researchers have estimated total costs of congestion in cities by comparing current vehicle operating and time costs with those that would

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1 There is no evidence to suggest that proportions of commercial vehicles and private cars, in general, differ greatly one way or the other between urban and intercity roads. For the Bureau's assessment of intercity highway infrastructure, based on distance weighted averages of AADTs, the percentage of commercial vehicles is 17.3 per cent but there is enormous variation around this average both for individual sections and for corridor averages. Travers Morgan (1991) reported commercial vehicles as accounting for 15.6 per cent of AADTs in Sydney (16.4 per cent if buses and coaches are included).

prevail if all traffic could travel at the maximum speeds possible (that is, in the absence of impedance from other vehicles). Miles (1992) produced an estimate of $2 billion for Melbourne. Figures of this type are of little practical value. The optimal level of congestion would only be zero if the cost of eliminating it was zero.

### Externalities

Externalities other than congestion, such as noise, vibration, emissions and visual disamenity, are much more costly in urban areas because there are more people to suffer from them and they are often associated with congestion. While a road improves access for users of that road, it can reduce it for drivers on other routes and pedestrians—another form of externality. Often urban road investments will shift externality costs from one place to another. This, as well as resumption of land occupied by houses, gives rise to significant political sensitivities in respect of urban road investments.

### Network effects

When assessing projects to upgrade sections of intercity highways, it is usually only necessary to consider the section of road in question. This is rarely the case for urban roads where network effects from changes to the road system are significant. A change to one road leads to changes in route patterns affecting traffic levels and hence congestion on other roads. A benefit–cost analysis should take these effects into account. Evaluation of urban road investments is therefore a much more complex task than for intercity road investments.

Predicting network effects in urban traffic is undertaken via complex urban road models which allocate traffic in accordance with Wardrop's principles. If a number of alternative routes are available for trips between a given origin and destination, the traffic adjusts itself in such a way as to even up the travel times or generalised costs of travelling on these alternative routes (Blunden and Black 1984).

A practical consequence of this, which causes concern to urban planners and residents, is that traffic will use indirect routes ('rat runs') through minor roads and residential streets to avoid congestion on main arterials. State and local authorities have in places employed traffic calming devices such as speed humps and banning of heavy vehicles to discourage this.

## CONGESTION PRICING

It is widely argued that resource allocation would be improved in urban areas if congestion pricing was introduced. The road pricing issue has been discussed and advocated at length elsewhere (Broe 1994; Cox 1994; Industry Commission 1994a, & 1994b); it is not covered in any detail here except to explain it briefly and point out the effects of non-optimal pricing on investment needs. As noted in chapter 2, economic theory asserts that under certain assumptions, the pricing rule to achieve maximum economic efficiency of resource use is that prices should equal short-run marginal social costs. The short-run marginal cost is the cost imposed by an additional user when capacity cannot be adjusted. The word 'social' is employed to indicate that the relevant cost is that imposed on society as a whole and so includes costs of externalities. In the long run, when capacity can be adjusted through investments, optimum investment in capacity would ensure that short-run marginal social cost was equal to long-run marginal social cost.

When a road is congested, each user incurs the private cost of congestion and bases his or her decision to use the road on this cost. However, there is an unpriced externality. The user is not made to take account of the cost he or she imposes on other users, so the marginal private cost is below the marginal social cost. The result is excessive congestion and demands for infrastructure spending.

The preferred solution according to economic theory is to levy a congestion tax on each road user equal to the difference between the private and social marginal cost. Road users are already heavily taxed through fuel excise and registration charges but these are insufficient to bring private up to social marginal costs on congested roads. Meyrick estimated the net welfare gain from introduction of a congestion levy in Sydney to be of the order of $20 million per year (Cox 1994). This estimate takes into account the considerable amount of spatial and temporal averaging that would be necessary with any practical system of congestion pricing.

Despite strong advocacy of road pricing in the literature and the existence of the technology to do it, implementation of congestion pricing in urban areas has failed reach the political agenda. The reason is that road users as a whole lose. Society as a whole is better off as the government's gain exceeds road users' losses, but the *average* user is made worse off. Some users are made better off. These would tend to be users who have relatively high vehicle operating costs or high values of time. According to the Industry Commission (1994a), gainers would include most commercial vehicles, businesses benefiting from more timely and certain delivery and users and providers of high occupancy vehicles such as buses and carpools. The Commission went on to point out that the benefits to business could be passed on in the form of better services and lower prices which will benefit all sections of the community.

For political reasons, congestion pricing in urban areas is unlikely to be implemented for some time, but as urban congestion grows and traffic engineers and economists continue to advocate it, road pricing remains a long-term possibility. In the absence of road pricing, a range of 'second best' measures are available, including making parking more difficult and costly, subsidisation of public transport (though the efficacy of this is debatable) and express lanes for high occupancy vehicles.

## NETWORK PATTERNS

Past investment in urban roads in major Australian cities has resulted in a pattern of major urban arterials radiating out from the central business district (CBD). As will be shown in the next chapter, where the broad strategic plans of the major cities are outlined, there is now a trend away from radial routes towards ring roads and roads designed to divert traffic around CBDs. Ogden (pers. comm. to NTPT 1994) argued that these are particularly beneficial to freight movements.

Australia lags well behind overseas cities in turning to ring roads to relieve congestion in the centre. Thirty years ago, Buchanan et al. (1963 p.169) wrote sceptically:

> In some cases it appears that ring roads have been intuitively adopted in the first instance as part of the plan, and at a later date 'origin–and–destination' surveys have been taken to demonstrate that they would carry enough traffic to justify their construction. The results of such surveys are nearly always favourable to the ring road, for the simple reason that practically any new road cut through a densely developed area will, as a drain cut across a sodden field fills with water, attract enough vehicles to justify its existence in terms of flow. But if a wider view is taken the actual contribution to the relieving the centre is extremely uncertain.

Buchanan et al. went on to explain that they were not arguing that a ring road cannot be a beneficial feature of a network but that they were objecting to 'slavish adoption of a ring as a standardised pattern'. The pattern of the network must depend on the disposition of the areas, the types and quantities of traffic they generate and the relations that exist between areas and between areas and outside. The pattern may eventually comprise a ring but this should be allowed to work itself out. Travers Morgan et al. (1991) reported that

> Surveys have shown that, outside the peak hours, the principal areas of congestion and delay for commercial and other traffic [in Sydney] are on radial routes to the CBD, Port Jackson and Port Botany.

Thus ring roads may not be all that is needed to reduce congestion costs for freight transport. Access to the industrial areas, airports, ports and rail terminals will not always be provided by ring roads.

**FREIGHT VERSUS COMMUTERS**

The present study has its primary focus on freight. It has already been suggested that road congestion pricing would benefit freight traffic at the expense of commuter traffic, but this is a byproduct of the policy not an intention. Some authors (Cox 1994; Ogden 1992) argue that freight transport through urban areas has not been accorded the attention it warrants. Road networks, it is claimed, have been primarily designed for the movement of commuters (Taylor et al. 1994). There is now an increasing awareness of freight in developing strategic plans for Australia's major cities.

The NSW Roads and Traffic Authority commissioned consultants to undertake a very substantial study, *Road transport: future directions* (Travers Morgan et al. 1991). The study covered both rural and urban roads. Some of its findings and recommendations concerning goods movement in Sydney include:

- There is a need for a comprehensive road plan which relates to commercial and industrial location, road capacity, removal of bottlenecks, and growth;
- Evaluation of road development should be based more on commercial/service/freight movements and less on the journey to work;
- Trip time reliability is growing in importance with increasing 'just–in–time' operations and increasing traffic congestion;
- While traffic congestion is of concern to all users, the road transport industry tends to view delays at wharves, freight terminals and depots, which are not experienced by private motorists, as more significant than existing delays on arterial roads. However, increasing all–day travel demands will give rise to increasing delays on roads while microeconomic reforms can be expected to reduce delays at ports and depots.

The traditional benefit–cost methodology for assessing investment projects adds benefits and costs regardless of to whom they accrue and so is not inherently biased towards freight or commuters. The greater numbers of commuters, however, ensure their interests carry a great deal of weight. Freight 'stakeholders', in consultations with the NSW Roads and Traffic Authority, put forward the view that counting the value of private travel time encourages car travel, congestion and city growth (RTA 1992). In a similar vein Cox (1994) argued that road expenditures should be prioritised on the basis of benefits to business users only.

In cost–benefit analyses, time savings evaluated for freight vehicles include vehicle and driver related costs but not time savings for the freight itself. The reason is that the value of time for freight is generally considered not to be large. Taylor et al. (1994) suggest that lack of data on freight vehicle movements is a problem. Transport planners have used passenger vehicles and peak commuter traffic to plan networks and have forecast traffic growth rates assuming that freight traffic is some percentage of passenger car traffic.

There is no obvious economic efficiency argument for artificially weighting project evaluations in favour of freight against commuters. If freight transport is indeed receiving inadequate consideration in planning processes, one reason might be the way project evaluation techniques have been applied. Benefit–cost analysis as a decision tool will not lead to allocation of investment funds in the most efficient manner unless the projects yielding the highest returns are identified. So long as planners are open to considering a wide range of projects including those particularly beneficial for goods movements, freight transport will not be discriminated against. There may be equity and macroeconomic arguments, however. Commuters on radial routes are a limited proportion of the populations of cities. Benefits accruing directly to business are likely to be spread over a greater number of people as they lead to lower prices, higher earnings and higher profits. There also may be benefits in terms of macroeconomic objectives such as employment and the balance of trade.

## URBAN TRANSPORT AND LAND USE

In urban areas transport interacts strongly with patterns of land use. The location of activities influences the demand for transport infrastructure while the supply of infrastructure influences land use. Activities generating freight transport in urban areas will have varying degrees of ease of relocation. Activities which need to be close to customers such as retailing have little scope to avoid high transport costs through relocation. Airports, seaports and rail terminals will usually be costly to relocate. Activities such as manufacturing for which ready access to labour and material inputs are highly important are more readily able relocate to take advantage of lower land prices in outer suburbs. High transport costs would be an incentive to relocate. In the long term, congestion-induced relocation may be a cheaper option from the point of view of society as whole than investment in road infrastructure to reduce congestion. Planning urban road infrastructure on the assumption that existing land use patterns are fixed could lead to wastage of resources. To restate an earlier point, benefit–cost analysis will not find the most efficient solutions unless those solutions are first identified.

## CONCLUSION

An ideal urban road network in a large city would consist of a hierarchy of roads. At the top of the hierarchy would be a network of continuous, limited access primary roads which would enable rapid movement between different parts of the city. It has been suggested that major Australian cities are deficient in this regard and this adds to costs of freight distribution. Urban roads have much higher traffic volumes than intercity roads and so higher standard roads are warranted. However, there are other factors working in the opposite direction, namely the much higher costs of road construction, more uniform distribution of hourly volumes and lower proportions of heavy commercial vehicles relative to light commercial vehicles. The result is that it is not economic to invest in urban roads to provide levels of service comparable to intercity roads. A high degree of congestion on urban roads is therefore often consistent with optimal investment and especially so in the absence of congestion pricing. Another contrast between urban and intercity roads is that modelling urban roads is far more complex and demanding than for intercity roads due to the large numbers of intersections and traffic signals and network effects.

Resource allocation would be improved if congestion levies were imposed in urban areas to make users take into account the externality of congestion that they impose on other road users. Commercial vehicles having high values of time and operating costs would be made better off. Absence of congestion pricing leads to higher congestion levels and investment needs than otherwise. At present, introduction of congestion pricing is not on the political agenda.

It is claimed that urban road networks have, in the past, been designed with undue emphasis on commuters relative to freight transport. The currently used benefit–cost techniques are not inherently biased against freight but this could result if projects of importance to freight are not identified and evaluated. There is now increasing awareness among planners of the importance of freight. Ring roads are seen as being of particular benefit to freight traffic but they should only be considered where they coincide with major transport corridors. The interactions between transport and land use should also be considered when planning urban networks.

# CHAPTER 4 ADEQUACY OF URBAN ROAD INFRASTRUCTURE FOR FREIGHT

## INTRODUCTION

This chapter contains assessments of the adequacy of urban road infrastructure for freight in the five mainland state capital cities, Australia's largest urban areas. Data deficiencies and the characteristics of urban roads which make modelling them so complex, have meant that the assessments are of a technical nature only. For the same reasons, the demand projections are limited to forecasts of population growth and traffic on major approaches. Bottlenecks affecting freight have been located by selecting major freight corridors in each of the cities and collecting data on them from state authorities. Information about congestion affecting freight has also been assembled from other sources. The strategic plans of state authorities for the city networks in so far as they affect the major freight corridors are briefly reviewed to ascertain how well the plans will alleviate the bottlenecks identified. Demand is discussed first, followed by a comparison of the cities using the data collected on freight corridors. Each city is then examined in detail. The chapter concludes with a brief economic discussion using to benefit-cost ratios estimated by others.

## DEMAND

Most of the nation's road freight travels on urban roads for part or all of the journey. Table 4.1 shows 1994–95 estimated tonnages of freight travelling on urban roads for the eight capital cities and a further seven major regional centres. For each city, tonnages are shown for intra-urban freight and freight entering and leaving and thereby using urban roads for part of the journey. About half the total tonnage of road freight is intra-urban movement in the eight capital cities and 58 per cent is intra-urban movement in all the 15 cities. A further 11 per cent has its origin and/or destination in these cities so some 70 per cent of road freight passes through the major urban areas.

TABLE 4.1 ROAD FREIGHT WITHIN, ENTERING AND LEAVING URBAN AREAS, 1994–95

*(million tonnes)*

| | *Internal* | *External inward* | *External outward* |
|---|---|---|---|
| Sydney | 198.4 | 22.4 | 28.0 |
| Melbourne | 184.5 | 18.6 | 15.4 |
| Brisbane | 86.5 | 8.2 | 8.9 |
| Adelaide | 64.3 | 6.2 | 4.7 |
| Perth | 63.5 | 4.0 | 2.8 |
| Newcastle | 31.1 | 9.0 | 7.8 |
| Wollongong | 18.7 | 10.1 | 4.4 |
| Gold Coast | 14.2 | 2.6 | 1.5 |
| Cairns | 13.5 | 0.5 | 0.3 |
| Townsville | 13.4 | 0.8 | 0.4 |
| Canberra | 12.6 | 4.3 | 0.3 |
| Hobart | 10.8 | 0.9 | 0.3 |
| Launceston | 6.9 | 2.9 | 0.4 |
| Darwin | 6.2 | 0.3 | 0.4 |
| Alice Springs | 2.4 | 0.4 | 0.0 |
| TOTAL URBAN[a] | 727.0 | 91.2 | 75.6 |
| Rest of Australia | 390.9 | 48.3 | 63.9 |
| TOTAL[b] | 1117.9 | 139.5 | 139.5 |

a. The table does not give a complete picture of the freight on urban roads because some 'rest of Australia' freight would still pass through urban areas. For example, freight between Gosford just north of Sydney and the NSW south coast would pass through Sydney on the way.

b. Total external inward freight must equal total external outward freight. Total road freight is 1117.9 + 139.5 = 1257.4M tonnes.

*Source*: Derived from figures supplied by the Centre for Transport Policy Analysis Wollongong.

The prevalence of network effects in urban areas, that is, the interrelationships between traffic levels on different roads, makes long-term forecasting of future traffic levels on specific roads particularly difficult. The task would require computer network models of each city and assumptions about future land use changes and construction projects. The best that can be done within the constraints of the present task is to examine population forecasts, which will give an indication of internal traffic growth, and the traffic growth forecast, developed for the intercity roads assessment, for the approaches to urban areas Table 4.2 shows the projected 1995 populations and expected future population growth rates for the five mainland capital cities. Perth and Brisbane are expected to grow the most and Sydney and Melbourne have identical forecast growth rates.

TABLE 4.2 CITY POPULATION PROJECTIONS, 1994–2014

| *City* | *Projected 1995 population (millions)* | *2014 medium growth forecast (millions)* | *Medium annual growth forecast (per cent per annum)* |
|---|---|---|---|
| Sydney | 3.45 | 3.99 | 0.8 |
| Melbourne | 2.94 | 3.42 | 0.8 |
| Brisbane | 1.34 | 1.89 | 1.8 |
| Perth | 1.25 | 1.88 | 2.0 |
| Adelaide | 1.00 | 1.12 | 0.6 |

*Source*: Travers Morgan consultants (1994).

TABLE 4.3 FORECAST TRAFFIC GROWTH ON APPROACHES TO CITIES, 1995–96 TO 2014–15

| *City* | *Corridor* | *Medium annual traffic growth forecast (per cent per annum)* |
|---|---|---|
| Sydney | Sydney–Melbourne | 2.1 |
| | Sydney–Brisbane | 1.7 |
| Melbourne | Melbourne–Sydney | 1.9 |
| | Melbourne–Adelaide | 3.2 |
| Brisbane | Brisbane–Sydney via Warwick (New England Highway) | 2.6 |
| | Brisbane–Sydney via Beenleigh (Pacific Highway) | 2.2 |
| | Brisbane–Melbourne | 2.7 |
| | Brisbane–Cairns | 3.7 |
| Perth | Perth–Darwin | 3.2 |
| | Perth–Adelaide | 1.4 |
| Adelaide | Adelaide–Sydney | 1.9 |
| | Adelaide–Melbourne | 2.0 |
| | Adelaide–Perth | 1.2 |

*Source*: Travers Morgan consultants (1994).

Table 4.3 shows the forecast growth rates for traffic on the approaches to the capital cities. The highest growth rates occur on the northern approaches to Brisbane and Perth and the western approach to Melbourne, followed by the other approaches to Brisbane.

## CITY ASSESSMENTS

To assess the adequacy of urban road infrastructure for freight, the Bureau, in consultation with state road authorities, selected a number of corridors which are particularly important for the movement of freight within the five mainland state capital cities. The selected corridors include the main routes linking the major intercity highways with each other and with freight-generating locations such as industrial areas, freight forwarder terminals, ports and airports. The corridors are listed in appendix I and are shown in figures 4.2, 4.5, 4.7, 4.9 and 4.11.

A range of data on the corridors was collected from state road authorities and this is presented in detail in appendix I. Table 4.4 shows some of the characteristics of the selected corridors averaged for each city, with population shown to indicate the relative sizes of the cities.

TABLE 4.4 FREIGHT CORRIDOR COMPARISON BETWEEN CITIES, 1994

| | *Sydney* | *Melbourne* | *Brisbane* | *Perth* | *Adelaide* |
|---|---|---|---|---|---|
| **Population 1995 (millions)** | 3.45 | 2.94 | 1.34 | 1.25 | 1.00 |
| **Infrastructure** | | | | | |
| Total corridor length (km) | 230 | 174 | 193 | 95 | 142 |
| Number of intersections per km[a] | 2.9 | 3.1 | 2.3 | 3.8 | 5.2 |
| **Demand**[b] | | | | | |
| Average number of vehicles per day | 56 900 | 69 500[c] | 44 600 | 29 300 | 33 700 |
| Average number of heavy vehicles per day | 3 800 | 6 400[c] | 3 300 | n.a. | 3100 |
| Average percentage of heavy vehicles | 7.0 | 9.1[c] | 7.8 | n.a. | 8.9 |
| **Performance** | | | | | |
| Weighted average AM peak speed (km/hour)[d] | 46 | 58 | 62 | n.a. | n.a. |

a. Intersections per kilometre refers to all intersections where delays to through traffic would be significant. It includes all signalised intersections, roundabouts and priority intersections where the traffic on the route must give way, but excludes grade separated interchanges and priority intersections where the traffic on the route experiences no (or very little) delay.

b. The corridor AADTs from which the traffic levels were calculated are representative values, not averages for the entire lengths of corridors.

c. The Melbourne traffic level is biased upward because for some corridors only maximum rather than average traffic levels were available.

d. The corridor speeds from which the weighted average speeds were calculated are based on field measurements at various points along the corridor. As such they are indicative only and are not average values for the entire lengths of corridors.

*Source:* Data collected from state road authorities by Travers Morgan consultants (1994).

The number of intersections per kilometre is a measure of the quality of a road in allowing uninterrupted flow. Brisbane, followed by Sydney, leads the way in providing continuous routes of particular benefit to freight traffic. Adelaide has no freewayswhatsoever and this shows in the high number of intersections per kilometre. Traffic levels are highest in the Sydney and Melbourne corridors followed by Brisbane, Adelaide and Perth. Sydney traffic moves slower than Melbourne followed by Brisbane. This would be a reflection of both differing traffic levels and qualities of road networks, Brisbane having the highest standard network of the three cities and the lowest traffic volumes.

It has not been possible to undertake any modelling or project evaluation work for urban roads as was done for rural roads for two reasons. First, data on many of the corridors are limited. Second, urban roads are far more complicated to model because of the numerous intersections and traffic signals and because any changes to the infrastructure lead to complex network effects.

The following is a review of freight-generating locations and major freight flows, and congestion as it affects these flows for each of the five cities. The discussion also includes an assessment of how well the strategic directions being pursued by state planning authorities address the congestion problems identified.

## SYDNEY

### Freight-generating locations and freight flows

Sydney is Australia's largest urban area. Figure 4.1 shows Sydney's main industrial areas. Concentrations of heavy industry occur around Silverwater and Homebush directly west of the city and around Chullora and Bankstown. Areas of light industry are scattered around the metropolitan area with major concentrations in the Port Botany–Mascot areas and Fairfield. A concentration of freight forwarder terminals exists in the area north of Mascot and others are scattered westward but generally close to the Great Western and Hume Highways. Other major freight generators are Port Botany, Port Jackson, Kingsford Smith Airport, and the rail terminal at Chullora (to be moved to Enfield). The New South Wales Roads and Traffic Authority's maps show that the largest truck flows occur along the three main external highways and connecting access roads (the Pacific, Hume and Great Western Highways, the M4, Parramatta Road, the Hornsby–Liverpool corridor and the M5), Botany Road north of Port Botany and the Pacific Highway and Victoria Road just north of the CBD (RTA 1994).

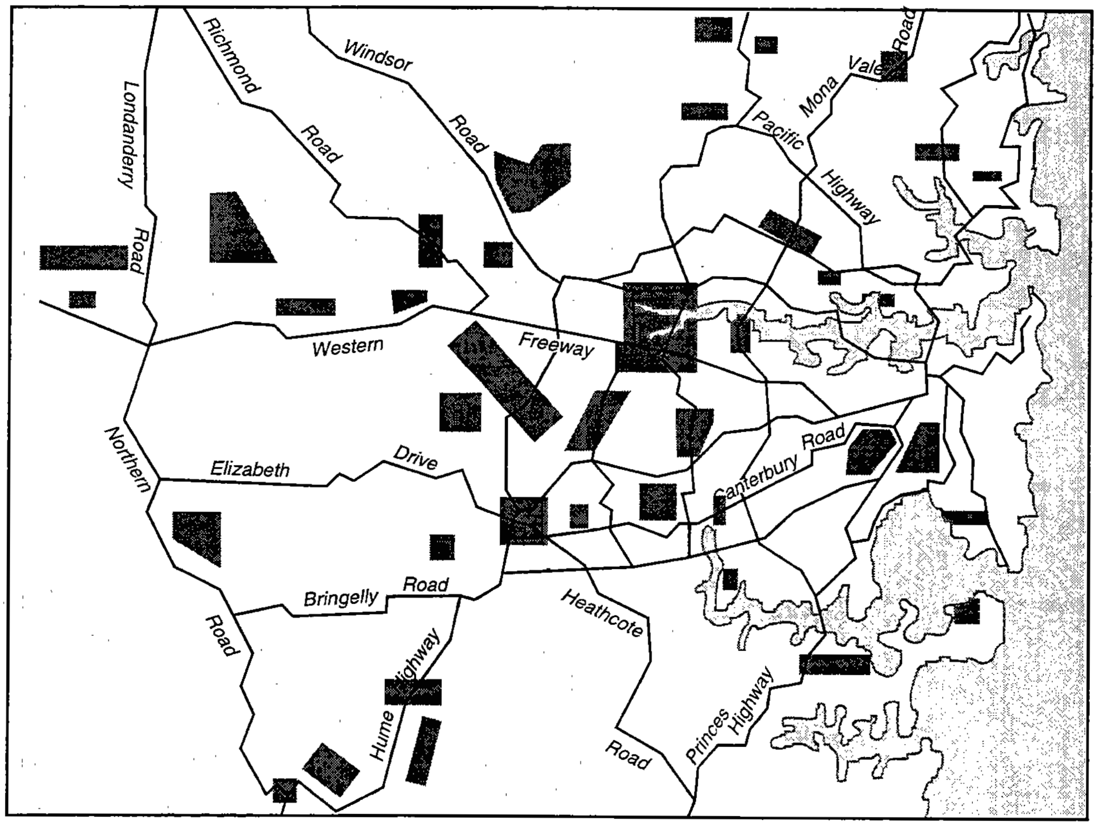


**Figure 4.1** **Sydney industrial areas**

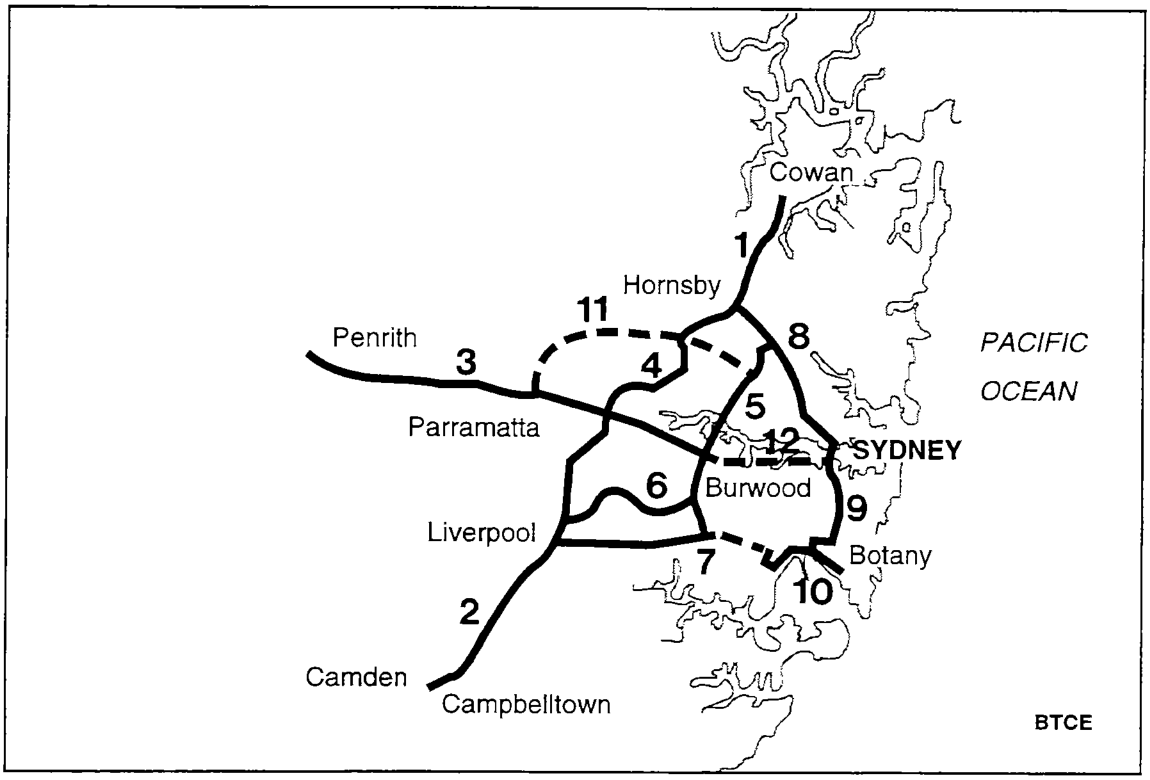


**Figure 4.2** **Selected freight corridors in Sydney**

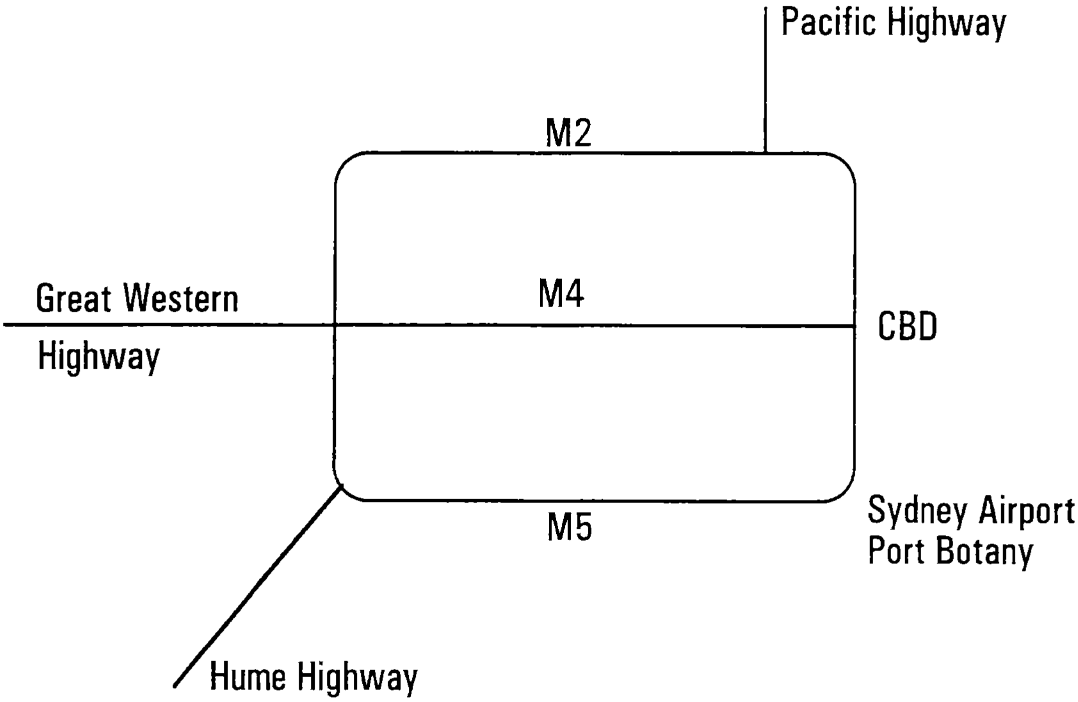


**Figure 4.3** **Schematic map of proposed Sydney freeway system**

### Congestion

The Future Directions (Travers Morgan et al. 1991) study reported that major areas of congestion affecting trucks were:

- the inner south west;
- middle west and south west (Parramatta–Granville, Liverpool–Bankstown);
- access to and from the north (Hornsby–city/ports, Hornsby–middle west); and
- assess between Port Botany and the main western industrial areas.

Broe (1994) listed Parramatta Road, Pennant Hills Road, the Hume and Pacific Highways, Botany Road, O'Riordan Street (Mascot), Mascot–Harbour Bridge–North Shore movements, and south–west–south east movements as the worst congestion locations.

Figure 4.2 shows the urban freight corridors selected for Sydney. The corridors are numbered and the corresponding data are provided in appendix I.

The speed data indicate that congestion is most severe:

- between where the M4 freeway ceases and the Port Botany/Mascot area;
- along the north–south route between the suburbs of Gordon and Ryde;
- along Southern Cross Drive between East Sydney and Dowling Street;
- on the Hornsby–Liverpool corridor between Castle Hill Road and Liverpool;
- at the intersection with Woodville Road on the Hume Highway;
- along the M4 approaching Parramatta;
- at the end of the F3 freeway at Hornsby; and
- along the Pacific Highway between Hornsby and Chatswood.

The picture that emerges is that the worst congestion affecting freight traffic occurs between the M5 and Port Botany, along the ends of the Pacific and Hume Highways and the Hornsby–Liverpool corridor linking them, on north–south arterial roads to the north of Port Botany, along the east–west corridor close to Parramatta, and along the north–south corridor between Gordon and Ryde. Access to Port Botany is particularly a problem, having 8.6 signalised intersections per kilometre between the M4 and General Holmes Drive.

### Strategic directions

The Future Directions (Travers Morgan et al. 1991) study put forward the concept of a 'priority freight route network'. The aim of the concept was to provide linkages between the main external highways and most major freight origins and distribution points, including rail freight terminals and ports. The network would combine existing freeways and access–controlled roads with new projects.

In 1993 the NSW Government released its *Integrated Transport Strategy for Greater Sydney*. The strategy defined a series of public transport and freight corridors, which would serve as 'the basis for the initial identification of transport investment opportunities'. There were three freight corridors, Hornsby–Liverpool (linking the Pacific and Hume Highways), Port Botany–Hume Highway and one starting at Macquarie and heading off into the north–west. The strategy backed away from the Future Directions option of developing a priority freight route network stating that it requires 'more concerted consideration' (NSW Government 1993).

The basic pattern proposed by the RTA for Sydney, illustrated schematically in figure 4.3, involves an orbital system of freeways linking the three main highways, the CBD and the Botany/Mascot areas. This ring is bisected in the east–west direction by the M4. The M2 and M5 motorways together with the western side of the ring follow two of the three freight corridors set out by the Integrated Transport Strategy.

At present only unconnected strips of this system exist. The M4 and M5 are toll roads managed and maintained by private firms. The 6.8 km link between the Hume Highway and the M5 was opened in June 1994 at a cost of $65 million. Work costing $490 million has just commenced on the M2 between Baulkam Hills and North Ryde. This will be a privately funded tollway. The RTA recently released an Environmental Impact Statement (EIS) for the M5 East, a 13.5 km extension of the M5 which will connect it to General Holmes Drive and hence Port Botany. An EIS has been prepared for extending the M5 westward to the proposed Sydney West Airport. In the longer term, land has been reserved for:

- the M6 linking General Holmes Drive with the Princes Highway and hence Wollongong;
- the Cooks River Valley Road between the M5 East and Chullora which will not go ahead if the M5 East proceeds;
- the Eastern Distributor (E3) closing up the gap in the eastern side of the ring south–east of the CBD; and
- a freeway standard link from the National Highway F3 to the proposed North West Transport Link (M2–the northern section of the ring).

In January 1994 consultants completed a Liverpool-Hornsby Highway Strategy Study (Maunsell-Denis Johnstone & Associates 1994). At present the main route between the Pacific Highway and suburbs in Sydney's central–west and the Hume Highway is via Pennant Hills Road. This road has one of the largest truck flows and heavy congestion. The study investigated a number of options and recommended a route to the west of Prospect Reservoir to form the western side of the orbital freeway system. For the connection with the Pacific Highway on the northern side, the study recommended using an upgraded Pennant Hills Road to connect with the M2 in the medium term with provision made for a new route in the longer term.

When completed the ring road will address many of the congestion problems identified here, in particular the Hornsby–Liverpool and M5–Port Botany corridors and north of Botany. The F3–M2 link mentioned above would relieve congestion on the Pacific Highway to the north of the city. Problems not addressed by these projects include congestion at the end of the Hume Highway and the provision of a direct limited access link between Parramatta Road west of the city and the Botany–Mascot area.

## MELBOURNE

### Freight-generating locations and freight flows

Melbourne is Australia's second largest metropolitan area. Figure 4.4 shows the locations of industrial activity in Melbourne. The areas can be described as comprising a ring around the CBD, an area south–west of the CBD and scattered areas to the north and east/south–east some distance from the centre. Commercial activity in the south–eastern region is reported to be growing rapidly (Vicroads 1994b). Other major freight generators are the Port of Melbourne and South Dynon rail terminal both close to the CBD, Melbourne Airport 23 km north–west of the city and the Port of Hastings to the south–east. A large proportion of the freight forwarder terminals in Melbourne are located just west of the CBD in suburbs such as West Melbourne, Footscray and Yarraville. Others are located in Campbellfield to the north, next to the Hume Highway. Some of the air and sea freight forwarders are located just north or west of the CBD. Two national highways terminate at Melbourne, the Hume from Sydney and the Western from Adelaide.

With the rail terminal, port, and many freight forwarder terminals as well as industrial areas located close to the CBD, truck movements largely follow a radial pattern. The Metropolitan National Roads Study (RCA 1987 p.18) stated that:

> The highest truck volumes generally occur on roads within or approaching the inner area and are mostly radial movements. Very high volumes are also recorded on key radial routes in the middle and outer suburbs and on sections of certain circumferential routes which are used by radially-orientated traffic. ... These radial movements result in very heavy flows on a number of roads in the inner area, particularly the Docks, West Melbourne and South Melbourne.

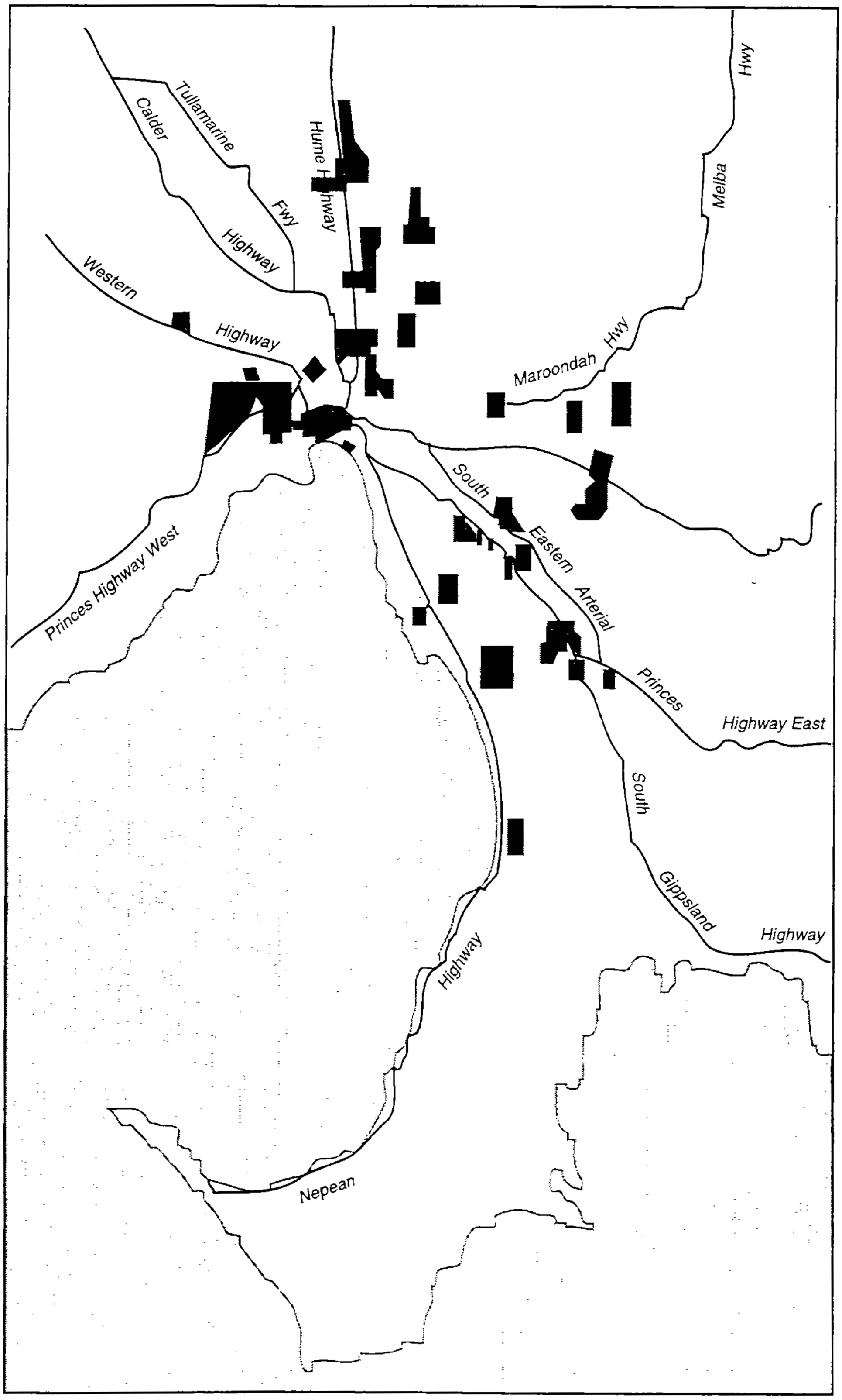


**Figure 4.4 Melbourne industrial areas**

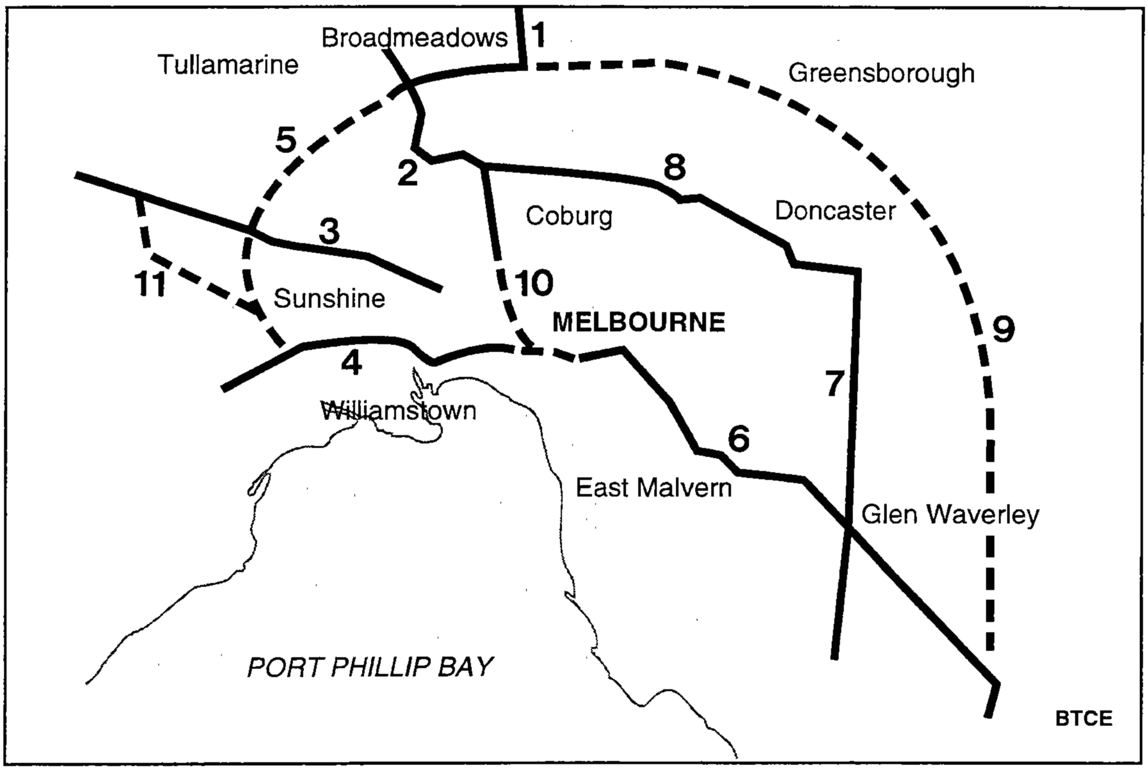


**Figure 4.5 Selected freight corridors in Melbourne**

## Congestion

Broe's (1994) list of the worst locations for congestion affecting freight comprises: the South–East Arterial; the Tullamarine Freeway; a variety of inner roads (Kings Way, Queens Road, Punt Road, Alexandra Avenue, Footscray/Dudley Street intersection); the Nepean Highway; and Dandenong Road. *The Traffic in Melbourne Study* (Vicroads 1993 p.2) noted that 'There is severe congestion on incomplete radial freeways and ring roads. Traffic is forced to use the central city area'.

Figure 4.5 shows the selected freight corridors for Melbourne, and the data collected are in appendix I. According to this analysis, the worst areas of congestion occur along the corridors between the north–west (including where the Hume Highway enters) and the south–east and between the CBD/west and the south–east.

The picture that emerges for congestion as it affects freight in Melbourne differs from Sydney. In Sydney a far higher proportion of the freight flows affected by congestion are circumferential, for example, north to west via Pennant Hills Road and south–west to south–east via the M4, and a ring road presents itself as an obvious solution. In Melbourne, where freight traffic is more radial in nature, ring roads might not be expected to have as high a priority in meeting the needs of freight traffic. However, the Metropolitan National Roads Study (RCA 1987) saw construction of a ring road as encouraging relocation of industry to the corridor created.

Easy access between the rail terminal and port is now provided by a special 600 m 4–lane road completed in December 1993 and paid for under the One Nation package. The road shortens the distance from the port to the rail terminal by 2 km and avoids two signalised intersections and three low clearance bridges.

**Strategic direction**

The Metropolitan Arterial Road Access Study (MOT 1987) stressed the need to improve access to the port and to develop key freight distribution routes, including linking interstate transport corridors, docklands, Melbourne Airport and industrial areas. Shortly after, the Metropolitan National Roads Study (RCA 1987) identified five principal freight corridors:

- Hume Highway–Docks (via airport);
- Hume Highway–Princes Highway West (via airport);
- Princes Highway East/south east suburbs–Docks;
- Princes Highway West–Docks; and
- Princes Highway East/south east suburbs–Hume Highway/northern suburbs.

The second and fifth corridors are circumferential and the others are radial, centred on the port.

Vicroads released its *Linking Melbourne* strategy (Vicroads 1994b) in February 1994. A prime element of the strategy is to 'Link and upgrade strategic roads to provide a continuous principal road network which contributes to trade, economic and metropolitan development' (Vicroads 1994b p.3). The strategy identifies strategic routes, substandard links and missing links together with a series of 'key actions'. The missing links, including the outer ring road, are shown by dashed lines in figure 4.5. The western side of the outer ring road is now under construction but the eastern side is missing with no land reserved for part of it in the north–east. Plans will be developed for the eastern side of the ring. The Tullamarine corridor is to be upgraded and linked to the West Gate Freeway which in turn will be linked to the South–Eastern Arterial. The latter will be upgraded as far as Toorak Road. This will provide a route between the north and south–east bypassing the city as well as improving access to the rail terminal and port. The project will include a tunnel under the Yarra River and the Domain parkland and is expected to cost roughly $1.05

billion. The *Linking Melbourne* strategy also proposes a number of projects to improve major corridors to the east and south–east.

The western approach to Melbourne from Adelaide, the Western Highway, has a particularly high forecast growth rate, 3.2 per cent per annum (table 4.3). A link between the Western Highway and the south–western section of the outer ring road is proposed (shown by a dashed line in figure 4.5) but no land is reserved. In the long term, it is intended to undertake an investigation of a major north–south corridor in the outer west linking the Princes West, Western and Calder Highways.

Overall, the strategies proposed for Melbourne appear to address the congestion problems identified as affecting freight movements.

## BRISBANE

### Freight-generating locations and freight flows

The south–east Queensland region has one the highest growth rates of population in the country. Major industrial areas are shown in figure 4.6. The main areas are around the mouth of the Brisbane River close to the airport and port, in the suburbs to the north, and a range of suburbs to the south and west. Road and rail freight forwarder terminals are concentrated in Acacia Ridge close to the rail terminal and the nearby suburbs of Coopers Plains, Salisbury and Rocklea. With rail and freight forwarder terminals and a high industrial concentration, this area is the main origin and destination of freight traffic for Brisbane.

Two major highways enter Brisbane, the Bruce from the north and the Pacific from the south. The Cunningham Arterial from the west takes traffic from the Newel and New England Highways into Brisbane as well as intrastate traffic from Queensland centres west of Brisbane. This road also passes through some of the main industrial areas.

### Congestion

Broe (1994) lists the worst congestion locations as Ipswich Road, Kessels Road (especially the intersection with Mains Road), the South East Freeway, Kingsford Smith Drive, Ann Street in Fortitude Valley, and the Gateway Arterial (especially at the toll booths). Ipswich Road is used by traffic between the Cunningham Arterial and destinations north and west of the CBD, passing through Fortitude Valley. Kessels Road is the link between the Cunningham Arterial and the South East Freeway and the Gateway Arterial. The Gateway Arterial provides a way for traffic between the north and south or western

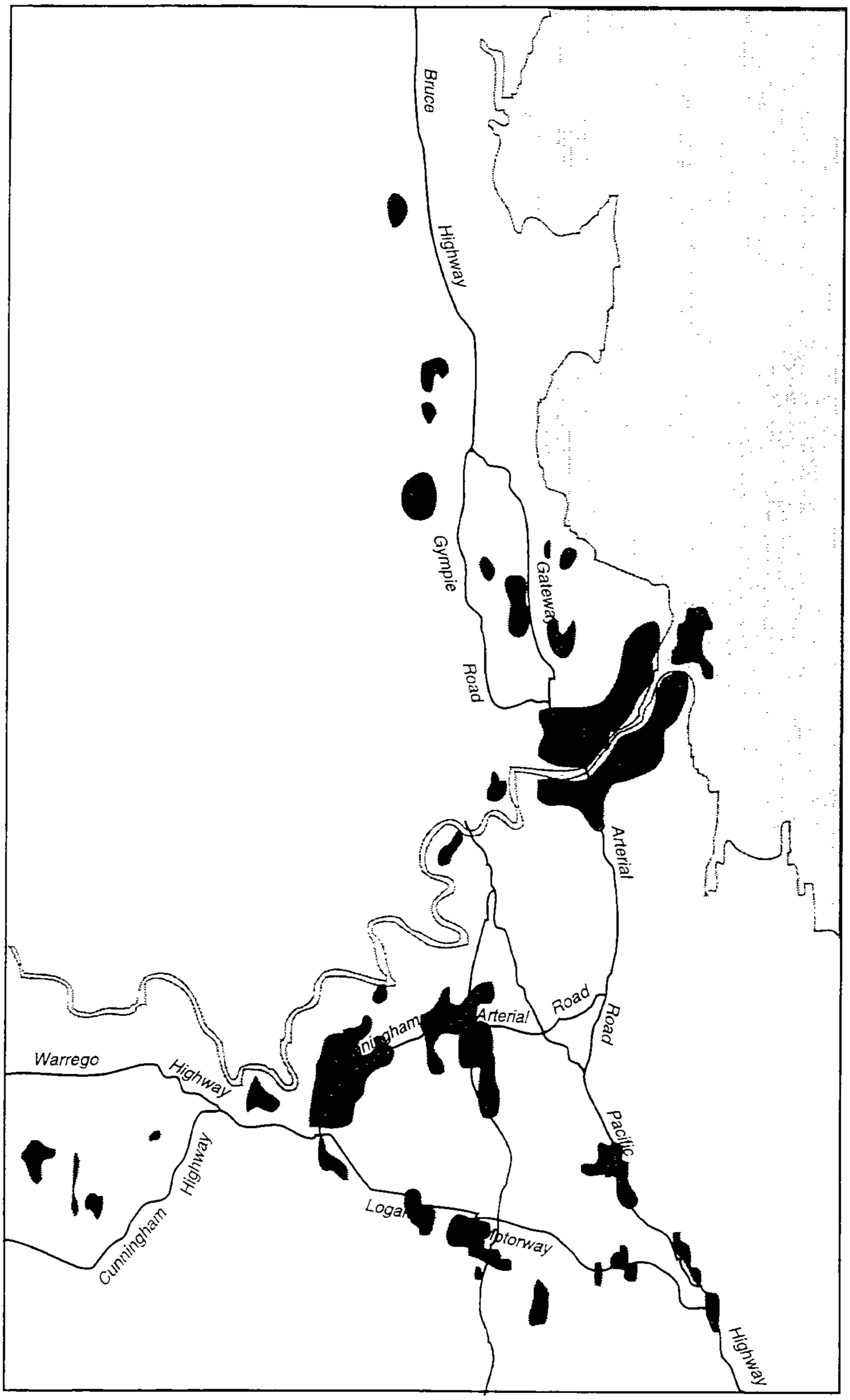


**Figure 4.6 Brisbane industrial areas**

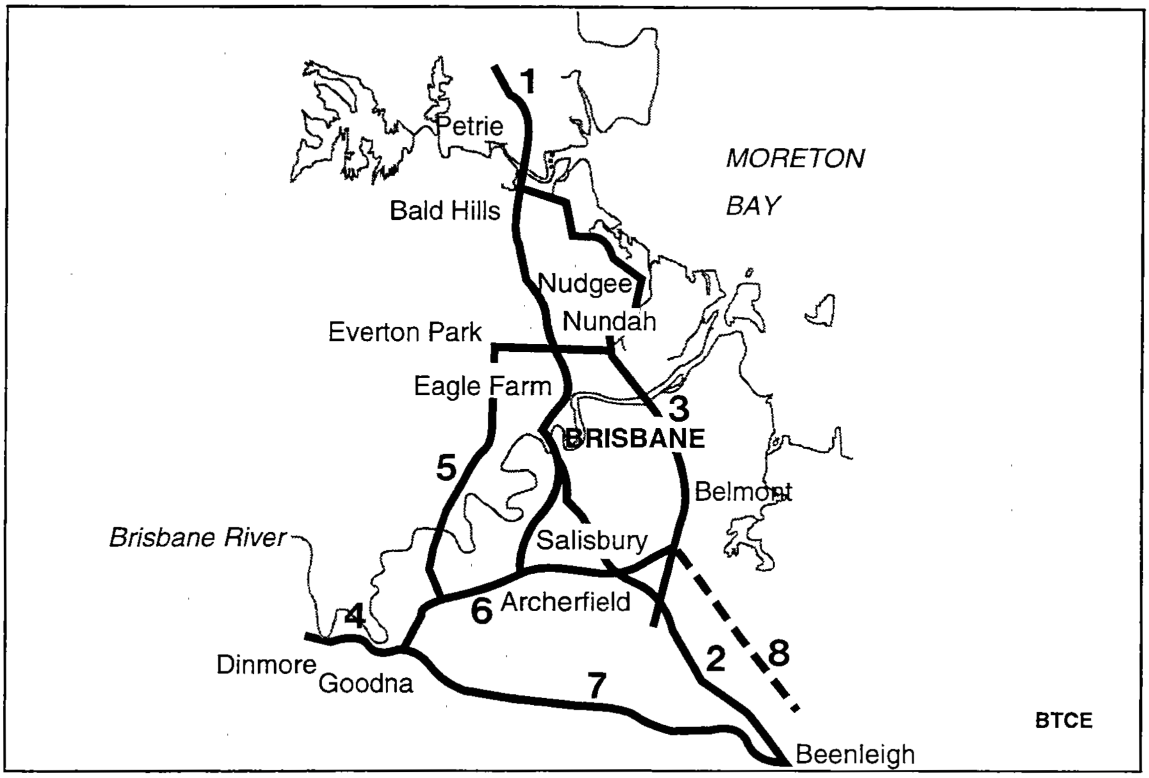


**Figure 4.7 Selected freight corridors in Brisbane**

areas to bypass the CBD as well as gain access to the port and airport. Kingsford Smith Drive links the CBD (including Fortitude Valley) with the airport, Hamilton wharves, and an industrial area.

The selected freight corridors for Brisbane are shown in figure 4.7. According to the data collected on these (see appendix I), the worst congestion areas are along much of the Western Arterial which connects the south–west (including access to major highways to the south and west) and the north (including access to the Bruce Highway), along the main northern entry to the CBD, and along the Cunningham Arterial–Gateway Arterial link. In all cases there are significant numbers of signalised intersections.

Brisbane's urban freight problem could be summed up as one of catering for high volumes of truck movements between two areas: the west and south on one side where there are industrial areas and major external routes, and the north and east where there are more industrial areas, the airport, port and access to the Bruce Highway. The CBD and Brisbane River stand between the two areas (except for traffic to Fisherman Islands). Freight traffic is effectively limited to two bridges across the river, the Story and Gateway Bridges. A route between the Cunningham Arterial and the Bruce Highway exists to the west of the city using the Western Arterial and Stafford but this involves negotiating a considerable number of intersections. Traffic between the Cunningham Arterial and the Pacific Highway coming or going southward is able to bypass congested areas using the Logan Motorway.

**Strategic direction**

In September 1993 the Queensland Department of Transport released a Metropolitan Freight Strategy (Queensland Transport 1993 p.4) aiming to 'increase industries' national and international competitiveness, while restricting the external effects of freight movements. Among other things, the strategy identified a 'primary freight network'. The Ipswich Road–Story Bridge–Fortitude Valley route is excluded because of the external effects generated passing through inner suburbs and part of the CBD. A series of projects was put forward and estimated to cost a total of $241 million. The largest single item at a cost of $90 million is the Southern Brisbane Bypass which would connect the southern end of the Gateway Arterial with a point roughly midway along the Logan Motorway, thus encouraging trucks moving between the west and the Gateway Arterial to avoid residential and commercial suburbs in southern Brisbane along the Kessels Road route. Other projects include a new alignment for Port Road (leading to Fisherman Islands ($56 million) and increasing from four to six lanes the Pacific Highway between Beenleigh and Redland Bay Road ($31 million) and the Bruce Highway within the Brisbane city area ($25 million).

Brisbane's freight strategy is part of a wider metropolitan road network strategy which proposes, among other things, a system of bypasses and three ring roads. The Gateway Arterial forms the eastern sides of both the middle and outer rings. A long–term possible project is the Western Bypass which would connect the Cunningham Arterial with the Bruce Highway, forming the western and northern sides of the outer ring. A proposal for an Airport Motorway linking the airport with the middle ring and the inner ring and hence the CBD was recently rejected by the Queensland Government following strong opposition from local residents. A decision has been taken to construct the South Coast Motorway running 55 km from the southern end of the Gateway Arterial to a point on the Pacific Highway. This will relieve congestion on the northern end of the Pacific Highway. The project will cost some $500 million and includes a 3 km tunnel under a sensitive koala habitat.

A basic problem Brisbane faces is the number of river crossings. The Queensland Government wishes to discourage freight traffic from using the Ipswich Road–Story Bridge–Fortitude Valley route because it passes through inner suburbs and part of the CBD. The route has been excluded from the 'Primary Freight Network' identified in the Metropolitan Freight Strategy. The

Gateway Bridge suffers from some congestion already and most of the other river crossings lead directly to the CBD. The Western Bypass would create a new river crossing but this is not at present a high priority project and may not divert a great deal of traffic away from the Gateway Bridge.

## PERTH

### Freight-generating locations and freight flows

Perth has the highest projected population growth rate of the state capitals and this is a continuation of the trend in the recent past. Industrial areas are shown in figure 4.8. They tend to be scattered in a semicircular band around the city with the main areas, from north to south: Bayswater; around Kewdale where the rail terminal and airport are located; Canningvale; Spearwood; and Kwinana. The latter area includes heavy industries. Road and rail freight forwarder terminals are predominantly located in the Kewdale area including suburbs of Rivervale and Welshpool and further west at Forestfield.

Two National Highways, the Great Eastern from Adelaide and the Great Northern from Darwin, terminate at Perth. The latter joins the former at Midland to the west of Perth. The heaviest freight flows in Perth occur in an east–west direction as traffic from the two national highways moves in along Guildford Road and Riverside Drive to the north of the river and along the Great Eastern, Roe, Leach and Canning Highways to the south. High truck flows also occur on roads in the Kewdale and Fremantle areas.

### Congestion

Broe's (1994) points of worst congestion are: Riverside Drive which runs along the Swan River beside the CBD; Wanneroo Road and the Mitchell Freeway; the two coastal northbound routes; the Albany, Leach, Canning and Stirling Highways; and Welshpool Road which runs through the Kewdale area to the Leach and Albany Highways. From a freight perspective the congestion points on the south side are of more concern.

The selected freight corridors are shown in figure 4.9 and the data in appendix I. Unfortunately data on speed are not available for Perth. The Stirling and Albany Highways and the Great Eastern Highway entry to Perth have relatively high AADT levels and high numbers of signalised intersections per kilometre.

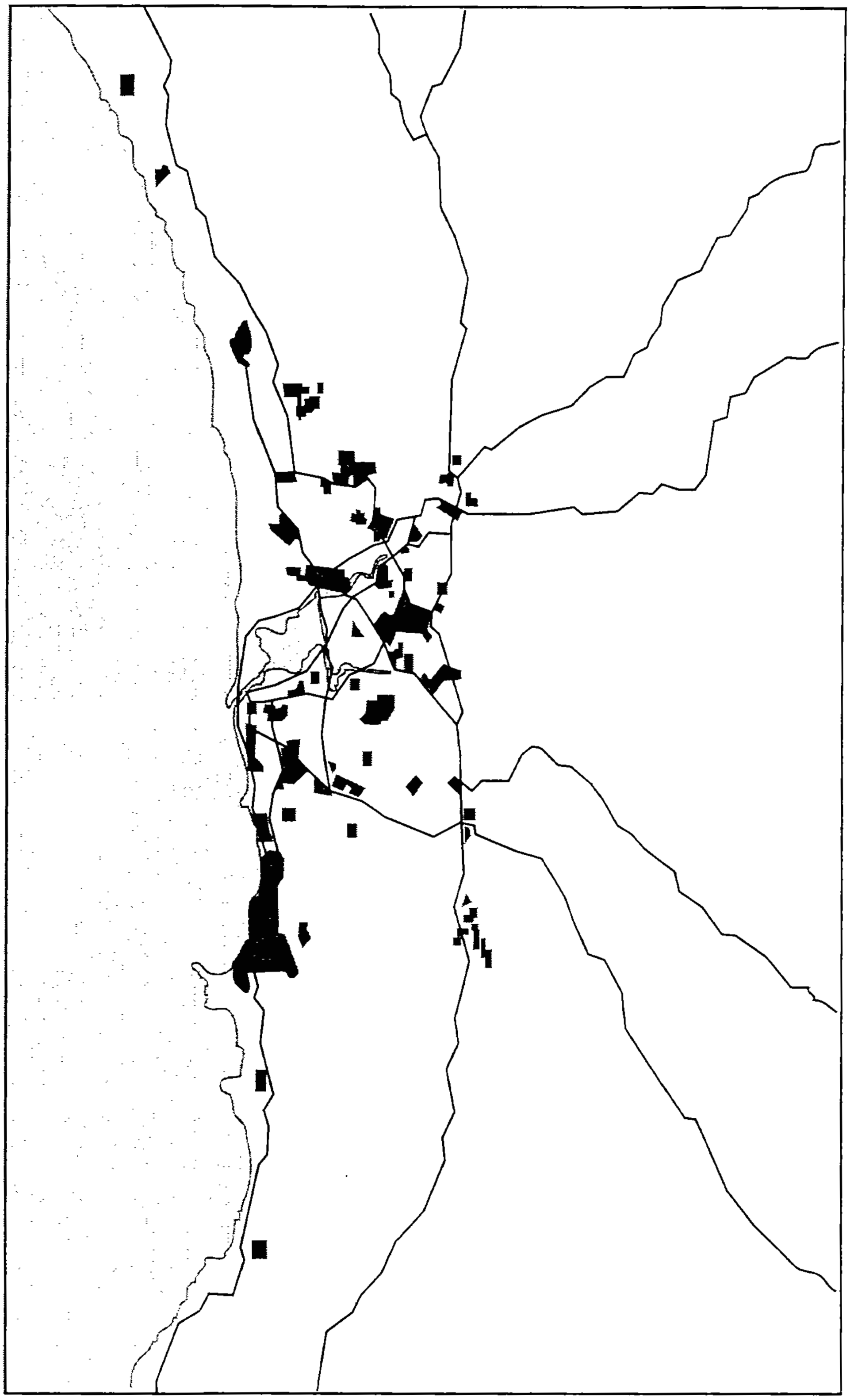

**Figure 4.8 Perth industrial areas**

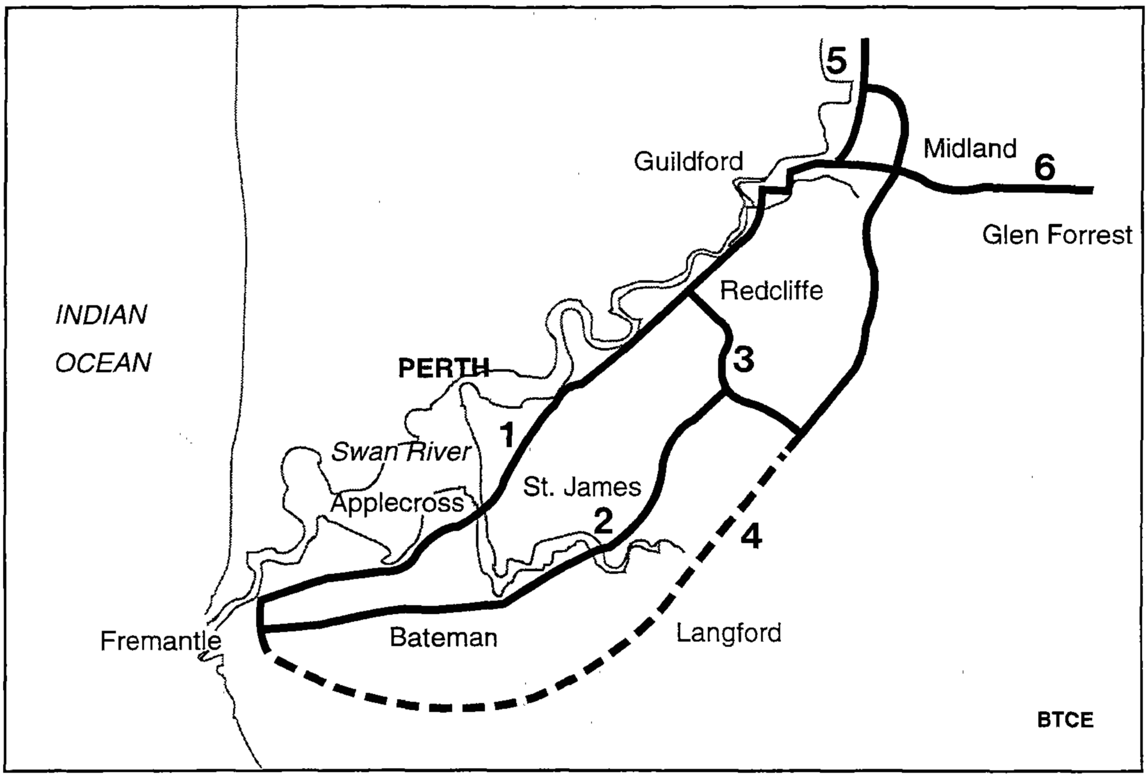


**Figure 4.9 Selected freight corridors in Perth**

### Strategic direction

The long-term strategy for Perth involves creation of a ring road by extending the Roe Highway all the way round to Fremantle, shown by the dashed line in figure 4.9. This will provide a freeway standard link between the national highways, industrial areas in the south and the port. It should provide a way for trucks to avoid the congestion along the Canning and Leach Highways. Extending the Reid Highway in the north to join the Roe Highway will complete the ring and improve access to some of the industrial areas in the north. Other planned new roads include ones parallel to parts of Welshpool Road and the Albany Highway, and from the Mitchell Freeway towards Fremantle, supplementing the Stirling Highway link. A freeway to bypass the CBD and divert traffic from Riverside Drive is under investigation. These actions would do much to remedy the congestion problems identified.

The WA Departments of Transport and of Main Roads have prepared a draft commercial vehicle strategy, which includes designating a series of 'High Value Vehicle' routes which includes the freeways in figure 4.9.

## ADELAIDE

### Freight-generating locations and freight flows

As shown in figure 4.10, most industry in Adelaide is located in the north in areas along Grand Junction Road, at Port Adelaide and along Port Wakefield and North Roads. Another significant industrial area is Lonsdale in the south–west. Road and rail freight forwarders are located in the industrial areas to the north and west of the CBD. The airport and air freight forwarders are situated west of the CBD. National Rail Corporation's rail terminal at Islington is north–west of the CBD close to the main industrial areas.

Three major interstate corridors terminate at Adelaide. The Princes Highway from Melbourne enters from the south–east and exits the city from the north along Port Wakefield road on the way to Perth, and the Sturt Highway exits along Main North Road to Sydney. Most commercial vehicle travel occurs on the main access roads to and from the north–western suburbs where most heavy industry and the key transport terminals are located. Sections of South, Grand Junction and Port Wakefield Roads in these areas have the largest commercial vehicle volumes.

### Congestion

Adelaide's road network is generally in the form of a north–south/east–west grid pattern which provides an informal system of inner and outer ring routes. These ring routes help to ensure an absence of significant flows of heavy vehicle traffic through the CBD. Although there are a number of relatively high standard limited access roads in the outer suburbs, Adelaide has no roads of freeway standard. Consequently most journeys are frequently interrupted by the need to stop at intersections.

Broe (1994) lists the congestion points for Adelaide as: South Road; the intersections South/Grand Junction, South/Regency, and South/Port Roads; and Churchill, Cormack and Main North Roads. Thus the main congested areas of Adelaide occur in two areas, the first is the area where Port Wakefield, Main North and South Road join Grand Junction Road to the north of the CBD, and the second is along South Road to the west of the CBD. Other congested areas include the intersection of Portrush, Glen Osmond and Cross Roads in the south–east and along Cross Road west of the Unley Road intersection where the road is narrow and rough (DRTSA pers comm 7 June 1994).

The selected corridors in Adelaide are shown in figure 4.11 and the data collected in appendix I. The speeds, obtained through modelling not actual measurements, show little variation across the corridors and links. Numbers of

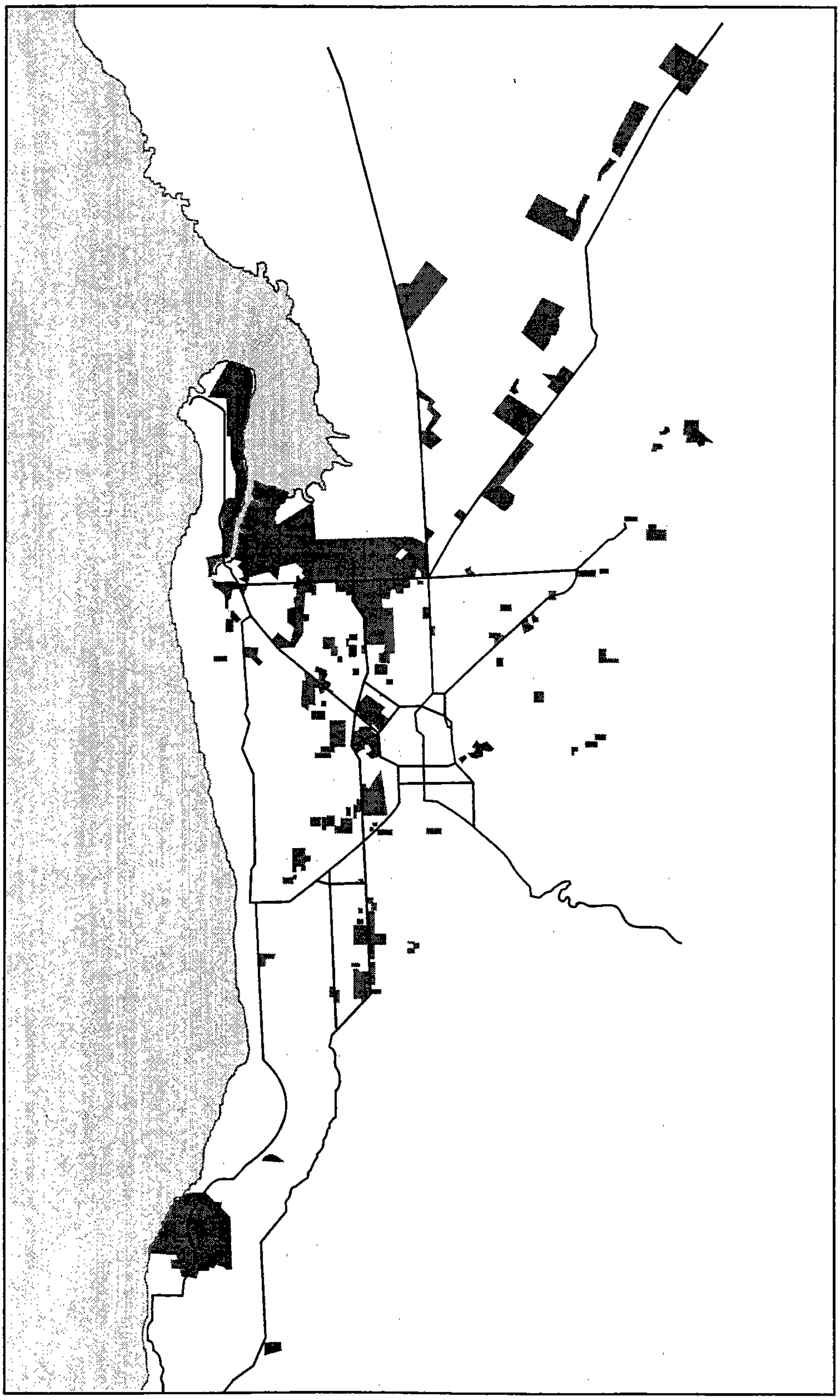

**Figure 4.10 Adelaide industrial areas**

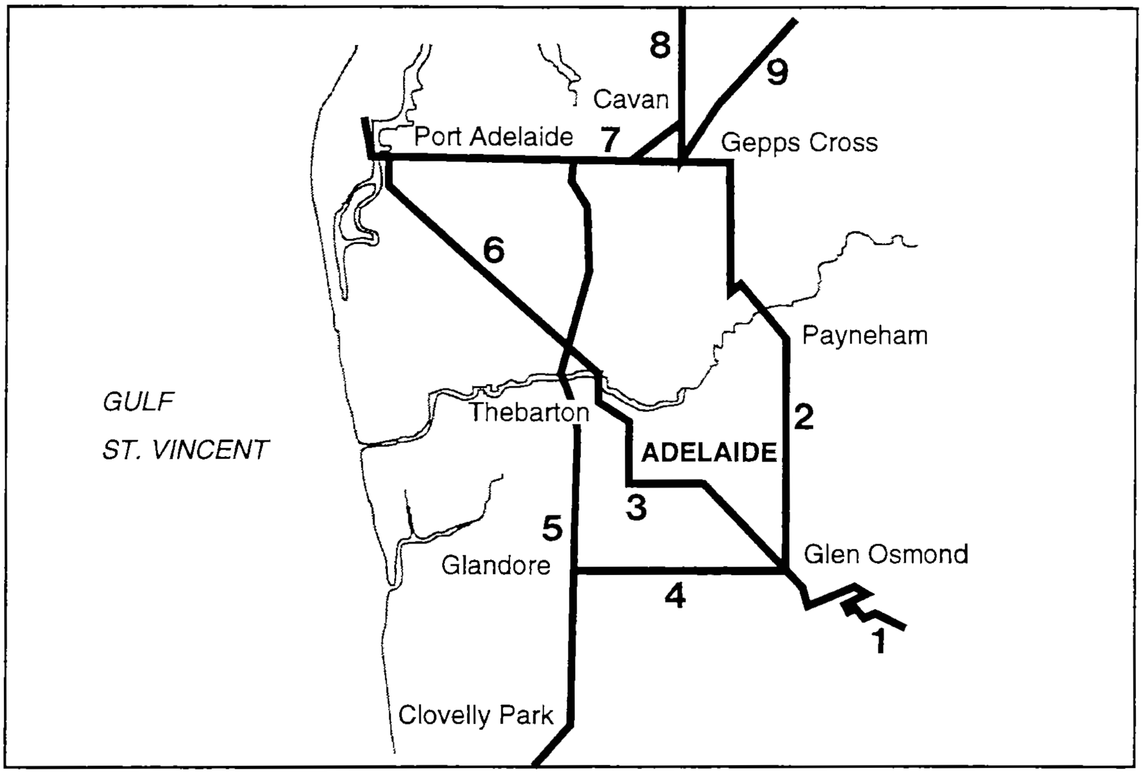


**Figure 4.11 Selected freight corridors in Adelaide**

signalised intersections per kilometre are high on all but the highway connections outside the ring.

Accessibility of the industrial north–western areas to and from the north is relatively good compared with other directions, largely due to the close proximity of the national highway routes to Sydney, Darwin and Perth. Access of this area to and from the south is mainly via the congested South Road, west of the city. Access to and from the Princes Highway West from Melbourne in the south–east direction is a problem for freight.

## Strategic direction

Accessibility to the port and the northern industrial area from the north will be improved by a new road currently being constructed between Port Wakefield and Grand Junction Roads to the west of the congested Gepps Cross/Cavan area. Long-term proposals exist to link this new road with Montague Road to the east and with Port Adelaide to the west. Reducing congestion along South Road is problematic because it has already been upgraded to the maximum extent possible without grade separation. A proposal to upgrade a parallel route, via Park and Railway Terraces, would relieve this congestion, as well as provide a more attractive western bypass of the city. A proposed widening along the existing relatively narrow section of Portrush Road will improve access to the north from the Princes Highway West, but in the absence of freeways, the options to improve flows are limited.

Unlike the other cities discussed, Adelaide does not have any plans to construct freeway systems. The actions proposed to improve access to the north from the south–east involve upgrading existing roads. Adelaide appears to be running out of options. However, Adelaide has the lowest forecast population growth rate of the five capital cities and its current congestion problems are small compared with Sydney and Melbourne.

### Conclusions

The foregoing city by city discussion supports the contention that freight transport moving through major urban areas is hampered by the lack of good continuous networks of primary roads linking ends of major highways and freight-generating locations such as industrial areas, ports, rail terminals and airports. In all the five mainland state capitals except Adelaide, sections of such networks exist at freeway standards and there are plans to link these together. Common features of these plans include ring roads, which connect the major highways and pass through industrial areas, and bypass routes to divert traffic around CBDs.

It is simplistic to view freeways as the long-term panacea for urban congestion problems. At present, congestion on major freeways appears to be limited to some end-points. In the longer term, if these networks of freeways become congested, construction of more freeways as a solution will be seriously questioned. Even completing the existing plans may be difficult due to community opposition. The Airport Motorway in Brisbane, mentioned above, is an example. Such sensitivities may lead governments to choose higher cost solutions involving longer alternative routes and tunnels or simply to allow congestion to act as its own regulator. Another option is to introduce road pricing which will restrict demand to high value users.

## COSTS AND BENEFITS OF URBAN ROAD INVESTMENT

It has not been possible to make forecasts of urban road investment needs in the selected freight corridors. Costs of investments were not available from state authorities and the Bureau believed it could not make reasonable estimates by itself. Costs of urban road infrastructure are highly variable due to the costs of relocating services (water, electricity, telecommunications), differing land values and the varied nature of the works. Few project costs are available for Sydney, and this city is expected to have the heaviest demand for expenditure on major urban road projects. Associated with the selected freight corridors, a total of $2 billion worth of projects have been identified for Melbourne,

$1–$1.2 billion for Brisbane, $243 million for Adelaide and $272 million for Perth. Much of this investment relates to relatively small projects involving widening and grade separation and does not cover many of the larger major freeway projects alluded to in the previous section. The total amount likely to be invested in major corridors through urban areas over the next 20 years can be expected to run into several billions of dollars. It should be noted that the discussion here has only been concerned with major corridors of significance to freight. There will also be heavy demands for spending on other corridors and arterials and on minor roads.

The Bureau has not attempted any cost–benefit analyses of urban road projects because of data deficiencies and the complexities of modelling network effects and intersections. Benefit-cost ratios (BCRs) estimated by others for urban road projects affecting the selected freight corridors have been assembled. None were available for Sydney or Adelaide. For Melbourne, ratios ranged from 2.4 to 6, for Brisbane, 4 to 15 and for Perth, 1.3 to 16. Taking midpoints where only ranges are available and weighting projects by costs, average benefit-cost ratios were 3 for Melbourne, 8 for Brisbane and 5 for Perth. Details of the projects and BCRs are set out in table 4.5. These ratios have been estimated by state authorities or their consultants using their own methodologies and assumptions and have not been standardised. The Allen Consulting Group (1993) collected a number of case studies and standardised them using a common discount rate. Their results are reproduced as table 4.6. BCRs from their case studies ranged from 1.1 to 20 with averages for the various classes of urban roads between 4.8 and 7.0. This was contrasted with a range of 0.6–6.9 and an average of 2.1 for rural national highway projects. The group also pointed to evidence from the United States and from NAASRA (1987) and BTE (1984) to the same effect, that road projects in urban areas yield higher returns than in rural areas.

The Allen Group argued that the higher returns from urban investments suggest a past misallocation of resources. The evidence shows that there are some projects yielding very high BCRs in urban areas as well as some with low BCRs. Just because there are some projects with very high BCRs in urban areas, however, it does not follow that overall levels of spending on urban and rural roads are out of kilter. If economic efficiency was the sole objective, projects having the highest BCRs would receive priority. Once these had been financed, funds would be allocated to projects with lower BCRs and this would continue until available funds were exhausted. How funds are ultimately divided up between urban and rural projects would depend greatly on the rate at which BCRs diminish for the two groups of projects as more funds were allocated to them. The supply of projects with high BCRs in urban areas is likely to be quite limited.

TABLE 4.5 PROJECTS AND BENEFIT–COST RATIOS FOR SELECTED CORRIDORS

| *City / link number* | *Corridor* | *Project description* | *Cost ($M)* | *BCR* |
|---|---|---|---|---|
| **Melbourne** | | | | |
| 2 | Tullamarine Freeway–Airport to city | widening of freeway | 64 | 2.4 |
| 6A | South Eastern Arterial | widening between High St. and Warrigal Rd. | 15 | 2.4 |
| 6B | South Eastern Arterial | grade separation of major intersections | 75 | 2.4 |
| 7A | Springvale Road | Springvale Bypass, provide 4 lanes divided | 28 | 9.5* |
| 9 | Eastern Ring Road (new corridor) | construction in Scoresby Transport Corridor | 550 | 5.0* |
| 10 | City Western Bypass (new corridor) | City Western Bypass including Domain Tunnel | 1050 | 2.4 |
| ***Total*** | | | 1782 | 3.3 |
| **Brisbane** | | | | |
| 1A | Main northern entry–Caboolture to Brisbane | widening 20 km from 4 to 6 lanes | 60* | 6.0 |
| 1B | Main northern entry–Caboolture to Brisbane | interchange at intersection of Beams and Gympie Roads | 20 | 4.0 |
| 5B | Western Arterial–Darra to Nundah | 20 to 50 km of 2 lane road | 250* | 10.5* |
| 6 | Griffith Arterial–Cunningham Arterial to Gateway Arterial | grade separation at Kessels Rd/ Riawena Rd | 20 | 4.0 |
| 7 | Logan Motorway–Goodna to Logan River | upgrade 20 km of 2 lane road | 60* | 6.0 |
| 8 | South Coast Motorway (new corridor) | 55 km of 4 lane divided road | 500 | 8.0 |
| ***Total*** | | | 910 | 8.2 |
| **Perth** | | | | |
| 2 | Leach Highway–Fremantle to Tonkin Highway | widening Shelley Bridge | 7 | 16.0 |
| 3 | Tonkin Highway–Great Eastern Highway to Roe Highway | grade separation at Collier Road | 8 | 7.0 |
| 3 | Tonkin Highway–Great Eastern Highway to Roe Highway | grade separation at Leach Highway | 5 | 6.5 |
| 4B | Roe Highway–Fremantle to Great Northern Highway at Midland | 4 lane divided road between Welshpool Rd and North Lake Rd | 127 | 9.0* |
| 5 | Great Northern Highway to Great Eastern Hwy | construct second 2 lane carriageway between Roe Highway and West Swan Rd | 28 | 7.0 |
| 6 | Great Eastern Highway–Glen Forrest to Guildford | construct second 2 lane carriageway between Mundaring and Sawyers Valley | 5 | 2.7* |
| 6 | Great Eastern Highway–Glen Forrest to Guildford | Orange route near Midland–new divided road link to Toodyay Rd and single carriageway to Great Eastern Highway | 93 | 1.3 |
| ***Total*** | | | 272 | 6.1 |

*Note:* * Midpoint of range

*Source*: Collected byTravers Morgan consultants (1994) from state authorities.

TABLE 4.6 ALLEN CONSULTING GROUP'S BENEFIT–COST RATIOS

| *Investment type* | *Number of case studies* | *Cost of case studies ($million)* | *BCR range* | *Average cost weighted BCR* |
|---|---|---|---|---|
| *Rural roads* | | | | |
| National | 17 | 373.7 | 0.6–6.9 | 2.1 |
| Arterial | 34 | 373.7 | 0.4–3.8 | 2.0 |
| *Urban roads* | | | | |
| Freeways | 13 | 1 143.9 | 1.7–10.8 | 4.8 |
| All arterials | 49 | 420.9 | 1.1–20.0 | 6.0 |
| National | 9 | 160.4 | 2.6–11.8 | 7.0 |
| Inner urban | 7 | 222.8 | 1.1–8.1 | 4.9 |
| Outer urban | 33 | 199.1 | 2.0–20.0 | 6.2 |

*Source:* Allen Consulting Group (1993) p. 63.

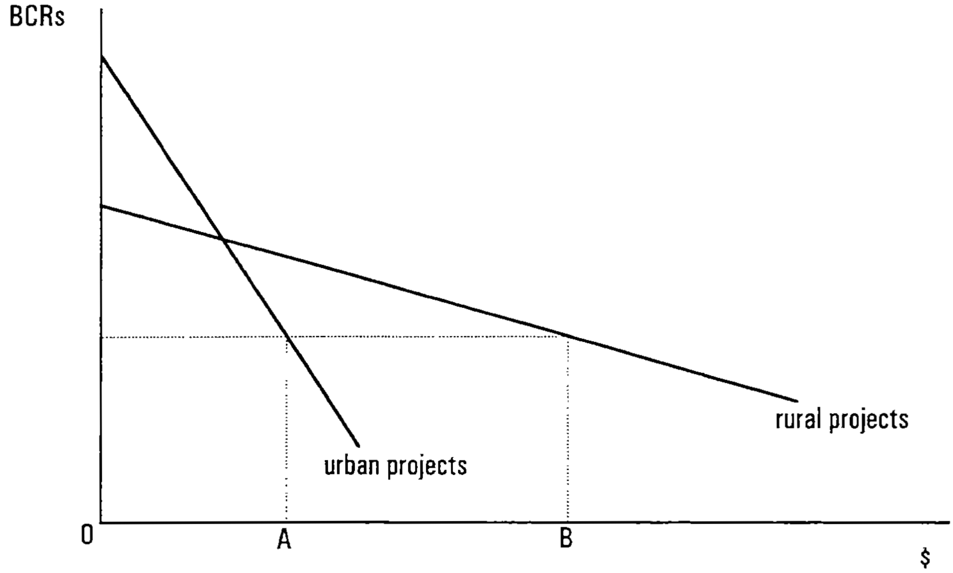


**Figure 4.12 Optimal allocation of funds between urban and rural projects**

Figure 4.12 illustrates this argument. BCRs are plotted on the vertical axis and project costs on the horizontal axis. The two downward sloping lines represent the BCRs of urban and rural projects arranged in descending order. The lines have been drawn so that there are urban projects available with higher BCRs than for rural projects but the supply of urban projects with BCRs at intermediate levels is much less than for rural roads at the same BCR levels. In order to spend a given budget in the optimal manner, one would arrange the projects in descending order of BCR and work down the list until funds were exhausted. At this point, the urban road project that just misses out would have a BCR the same as the rural road project that just misses out. In figure 4.12 the total budget is OA+OB and the optimal allocation of funds is OA to urban and OB to rural. Hence it could be preferable from an efficiency viewpoint to allocate more funds to rural roads than urban roads despite the fact that many urban projects have higher BCRs than rural projects.

## CONCLUSION

Some 70 per cent of road freight passes through the urban areas of the eight capital cities and seven major regional centres for all or part of its journey. To assess the adequacy of urban road infrastructure for freight this study restricted its analysis to the five mainland state capitals. Within each city a number of major corridors of particular importance to freight transport were selected. Data deficiencies and the difficulties of dealing with the network effects in urban areas meant that it was not possible to make projections of traffic levels on these routes. Perth and Brisbane have the highest population forecasts and Adelaide the lowest. The approaches to Brisbane generally have the highest traffic growth forecasts.

On the basis of the selected corridors, Brisbane leads the way in providing continuous routes, followed by Sydney. Adelaide, which has no freeways, is worst in this regard. Sydney, Melbourne and Brisbane, in that order, have the highest traffic levels and slowest speeds.

For each of the five cities examined, the main congestion points affecting freight transport were identified and the strategic investment plans of state authorities reviewed to assess the extent to which they would alleviate congestion problems. Sydney's main freight congestion occurs at the ends of the Hume and Pacific Highways, roads leading to the Botany–Mascot area and major north–south routes. The proposed orbital freeway system will abate most of these problems. Exceptions appear to be the end of the Hume Highway and access from Parramatta Road to the Botany–Mascot area.

Freight congestion in Melbourne is greatest just outside the CBD where the port, rail terminal and significant industrial areas are located. A proposed CBD bypass and ring road will improve freight flows though these congested areas.

Brisbane's problem is moving freight between the south and west where major corridors enter the city and where the rail terminal and major industrial areas are situated, and the north–east where the port, airport and access to the Bruce Highway are located. A plan involving ring roads and CBD bypasses is proposed, but this does not appear to adequately address the problem of too few river crossings.

The main freight congestion in Perth occurs along several major east–west corridors used by traffic from the main highways from Adelaide and Darwin and around the industrial Kewdale area. A proposed ring road and CBD bypass should ameliorate the congestion problems identified.

Adelaide's main freight congestion problem is access from the south and south–west where the highway from Melbourne enters, to the industrial north–west. Without any plans to construct freeways, Adelaide is running out of options to deal with this problem through upgrading existing roads. However, the city has the lowest forecast population growth.

This brief review of state authorities' plans shows that freeways comprising ring roads and CBD bypasses are major elements in strategies to reduce congestion inhibiting freight flows in most of the main cities. However, there are community concerns about continued freeway construction and governments may eventually have to look to alternative strategies such as road pricing.

Reviews of BCRs of urban road projects show that there are some projects having very high returns. However, this should not be taken to mean that a major redirection of funding away from rural to urban roads is called for. The supply of these high yielding projects may be quite limited.

# CHAPTER 5 ROAD FREIGHT TERMINALS

The type of terminals discussed here are those that receive and dispatch interstate freight for local pickup and delivery, not the warehouses of manufacturers and retailers. Due to the number of terminals and the fact that they are privately owned, the comprehensive analysis undertaken for rail terminals is not possible. However, such an analysis is not necessary to make a statement about adequacy. Because they are relatively inexpensive to construct and the optimum size is not large, adequacy of capacity is not an issue. The following section is based on discussions with senior managers of three of the largest operators of terminals, Brambles, Mayne Nickless and TNT.

Freight consignments large enough to fill entire trucks will go door–to–door and so will not use a terminal. Thus for a large part of interstate road traffic, freight terminals are irrelevant. For smaller loads, consignors employ freight forwarders to arrange pick-up and delivery (PUD) and to consolidate smaller loads into single loads for the linehaul by road, rail, air or sea. Freight forwarders aim to minimise costs by blending heavy and light freight so as to take maximum advantage of the weight and cubic capacities of linehaul equipment.

For non–bulk road freight passing through freight forwarders' terminals, there are two types of operation, express and less–than–container–load (LCL) freight. Express freight is highly time sensitive, having guaranteed delivery times, and consists of small parcels, typically around 20 kilograms. LCL freight is much less time sensitive and tends to come in larger consignments, typically 100 kilograms.

The two types of freight require different terminals. For LCL, all that is required is a covered area for loading, unloading and storage, office accommodation, forklifts and parking areas for trucks and employees' cars.[1] In addition to these, express freight terminals require computerised sorting systems and so are more expensive to construct. The PUD fleets for express

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1 For example, Brambles terminal at Reevesby in the Sydney urban area has an area of 3 acres of which about one–third is covered and the rest is parking for employees' cars and trucks.

freight tend to consist of 2–4 tonne trucks and for LCL, 6–8 tonne trucks. Typically an express PUD truck would make of the order of 50 stops per day and an LCL truck, 20–25 stops per day.

For LCL freight, linehaul costs account for roughly half the costs, PUD for 35–40 per cent and the remainder are terminal, administrative and overhead costs. For express freight, linehaul accounts for 25–30 per cent and PUD for 35–40 per cent of costs. Administration and overheads include billing, account collection, computers, and data input. These are greater for express freight.

The optimum size of terminal is not great. Economies of scale are outweighed above a certain size by the increasing complexity of routing PUD fleets to minimise costs. Freight forwarders also believe there are industrial relations disadvantages once terminals rise above the size where the manager can be acquainted with each individual employee. The typical LCL terminal would operate a PUD fleet of 25–30 trucks and the typical express terminal, a fleet of 50–80 trucks. This means that the major Australian cities can sustain a fair number of terminals—unlike air and rail where the economies of scale are such that only one airport or rail terminal is usually required.

Since LCL terminals are so simple to construct, it is not difficult for them to relocate, expand, contract, split up or combine, provided the land is available at a reasonable price at suitable locations. In Sydney, freight terminals have demonstrated considerable mobility over the last few decades. Express terminals are not so mobile but sorting equipment is unlikely to have an economic life much beyond 10 years due to technological obsolescence.

Freight forwarders aim to locate their terminals so that they have good access to the main highways while being not too far from customers. Young, Ritchie and Ogden (1980) in a study of factors affecting the location of freight facilities found that the four main influences were:

- proximity to arterial roads, freeways and services;
- proximity to customers and other facilities operated by the same firm;
- site availability; and
- labour availability.

Of these, the first had by far the greatest impact. Ogden (1992) noted that in the United States, it is common for terminals to be located on or near a circumferential freeway or 'beltway', often near the interchange with an intercity freeway. This may become the case in major Australian cities as ring roads are developed.

Access to main highways is particularly important for express freight. The PUD fleet cannot leave until after the last incoming linehaul truck has been unloaded. Being close to customers minimises PUD costs and is also important for marketing reasons. Consignors will often prefer the forwarder with the closest terminal. The site must also be of adequate size, shape and terrain and be zoned to permit working at night (Ogden 1992). Costs of land may rule out sites which would otherwise be ideal. To promote efficiency of freight transport, planners need to bear these considerations in mind and ensure that suitable sites are available for terminals.

The foregoing discussion suggests that for road freight terminals adequacy of infrastructure is not likely to be an issue. This conclusion is not based on analysis of data but on the fact that road terminal operations are relatively cheap and easy to construct and the optimum size is not large. Shortages of capacity are unlikely ever to be a problem except for temporary or unexpected surges in demand.

The previous assessment dealt only with congestion on major roads used by freight traffic and not with bottlenecks affecting freight on urban roads in general. Freight forwarders have indicated concerns to the Bureau about local government imposed restrictions on parking and the movement of goods affecting both PUD and linehaul operations. In some areas local authorities have imposed curfews on heavy vehicles or completely banned trucks above 2.5 tonnes. In some shopping malls deliveries are only allowed before 6:00 a.m. and after 6:00 p.m. In clearways, parking is only permitted after 10:00 a.m. which can mean that trucks making deliveries cannot complete their deliveries in the order that will minimise time and distance travelled. Bottlenecks affecting PUD operations on urban road networks are a possible area of investigation for future work on adequacy of urban road infrastructure.

# CHAPTER 6 CONCLUSION

## SUMMARY OF MAIN FINDINGS

Urban roads are a vital part of the transport system. Much of the nation's economic activity goes on in urban areas and this is where a large proportion of total freight transported begins and ends its journey. Some 70 per cent of road freight passes through the urban areas of the eight capital cities and seven major regional centres for all or part of its journey. About half the total tonnage of road freight is intra-urban movement in the eight capital cities.

Past investment in urban roads in major Australian cities has resulted in a pattern of major urban arterials radiating out from the central business district (CBD). There is now increasing awareness among urban road planners of the economic importance of providing for freight transport and this is leading to increased focus on ring roads.

Urban roads have much higher traffic volumes than intercity highways and so higher standard roads are warranted. However, there are other factors working in the opposite direction, namely the much higher costs of road construction, more uniform distribution of hourly volumes and lower proportions of heavy commercial vehicles relative to light commercial vehicles. Consequently it is generally not economic to invest in urban roads to the extent where they provide similar levels of service as intercity roads. A high degree of congestion on urban roads may be quite consistent with optimal investment and particularly so in the absence of congestion pricing.

Sydney has the worst congestion problems affecting freight traffic, followed by Melbourne, then Brisbane. Freight moving through major urban areas is hampered by the lack of good continuous networks of limited access primary roads. Such networks would enable swift transit between the major origins and destinations of freight traffic in urban areas: the ends of major highways, industrial areas, ports, rail terminals and airports. In all the five mainland state capitals except Adelaide, sections of such networks exist at freeway standards and there are plans to link these together. Common features of these plans include ring roads, which connect the major highways and pass through industrial areas, and bypass routes to divert traffic around CBDs.

The plans of the state authorities to upgrade and widen existing roads and to construct new freeways will ameliorate many of the congestion problems identified in the study. Some bottlenecks that the plans do not appear to adequately address include:

- in Sydney, the end of the Hume Highway and the linking of the Parramatta Road and the Botany–Mascot area;
- in Brisbane, the number of river crossings; and
- in Adelaide, access to the north–west from the south and south–east including the Princes Highway West.

Construction of new freeways may face strong community opposition, leading governments to choose higher cost solutions such as longer alternative routes and tunnels or simply to allow congestion to continue and so regulate itself. Road pricing is another option but is yet to reach the political agenda.

Some urban road projects have very high BCRs. However, this should not be taken to mean that a major redirection of funding away from intercity to urban roads is called for. The supply of these high yielding projects may be quite limited.

For road freight terminals, adequacy of infrastructure is not likely to be an issue. This conclusion follows, not from analysis of data, but from the fact that road freight terminals are relatively inexpensive to set up and their optimal size is not large. Terminal capacity can therefore respond fairly rapidly to changes in demand. Efficiency in the freight transport system will be promoted if planners ensure that suitable sites are available with good access to major intercity highways and to consignors and consignees. As ring roads develop, sites on or close to these may become favoured sites for road terminals as in the United States.

## FUTURE DIRECTIONS FOR URBAN ROADS ADEQUACY ASSESSMENT

A methodological framework for assessing adequacy of transport infrastructure was developed in chapter 2. For urban roads, the degree to which the framework was able to be implemented was quite limited. It was not possible to make demand projections to 2014–15 for individual roads because of inadequate traffic level data on many corridors and the complexities of network effects. This meant that the technical assessment could only be carried out at present and not future traffic levels. The technical assessment was further restricted in many cases by inadequate data on speeds and road lane numbers for many corridors. Similarly, lack of data and modelling capabilities meant that the economic assessment was limited to assembling benefit-cost ratios for a range of projects assessed by state authorities and their consultants.

Collecting original data on urban roads and developing urban road models, the two prerequisites for a more rigorous assessment of adequacy, are both beyond the capacity of the Bureau. Network models are complex and data-intensive, requiring information on traffic origins and destinations over the whole network, and vehicle operating costs or speeds as a function of traffic volume for each link in the network. To develop a network model even for a single city is a huge undertaking. The Bureau does not have models to predict the effects of intersections and signals on traffic flows. Given the scale of the work and the number of cities involved, this type of research is rightly the domain of the state authorities concerned with urban road planning.

Future Bureau efforts to assess adequacy of urban road infrastructure should therefore include close consultation with state road authorities, making the best use of their work in areas such as data collection, modelling, strategic planning and project identification and evaluation. State authorities might be persuaded to undertake some additional adequacy assessment work themselves if they considered it in their interests to draw attention to their urban infrastructure investment needs.

# APPENDIX I CORRIDOR DATA

**SYDNEY CORRIDORS**

| Corridor/ link no. | 1 | 2 | 3A | 3B | 4A | 4B | 5A | 5B | 6 |
|---|---|---|---|---|---|---|---|---|---|
| Corridor | F3 northern entry–Gosford to Hornsby | F5 southern entry–Cambelltown to Liverpool | M4–Penrith to Burwood | M4–Penrith to Burwood | Route 7–Hornsby to Liverpool | Route 7–Hornsby to Liverpool | Route 3–Gordon to Hurstville | Route 3–Gordon to Hurstville | Hume Highway–Liverpool to Chullora |
| Link | F3 northern entry to Hornsby | F5 southern entry to Liverpool | Penrith to Parramatta | Parramatta to Burwood | Hornsby to M4 | M4 to Liverpool | Gordon to M4 | M4 to Hurstville | Liverpool to Chullora |
| Length (km) | 24 | 17 | 36 | 10 | 21 | 15 | 15 | 12 | 16 |
| AADT | 55 000 | 45 000 | 75 000 | 80 000 | 40 000 | 25 000 | 60 000 | 50 000 | 62 000 |
| Cars | 50 500 | 40 800 | 68 200 | 75 500 | 35 100 | 22 800 | 58 170 | 47 130 | 58 200 |
| Heavy vehicles | 4 500 | 4 200 | 6 800 | 4 500 | 4 900 | 2 200 | 1 830 | 2 870 | 3 800 |
| % heavy vehicles | 8 | 9 | 9 | 6 | 12 | 9 | 3 | 6 | 6 |
| Average a.m. peak speed (km/hour) | 60 | 80 | 40 | 60 | 30 | 40 | 25 | 40 | 40 |
| Intersections | 6 | 4 | 12 | 4 | 96 | 53 | 67 | 61 | 83 |
| No. signalised | 1 | 2 | 0 | 0 | 44 | 24 | 24 | 27 | 37 |
| Intersections/km | 0.25 | 0.24 | 0.33 | 0.40 | 4.57 | 3.53 | 4.47 | 5.08 | 5.19 |
| Congestion now | end of freeway | none | west of Church St | Homebush Bay Dr and east of Church St | between Castle Hill Rd and M4 | entire length | Gordon to Ryde | Intersection with Hume Hwy | Intersection with Woodville Rd |
| Congestion in five years | end of freeway | none | n.a. | none | between James Ruse Dr and M4 | entire length | Gordon to Ryde | none | Intersection with Woodville Rd |
| Proposed future route development | no major proposals | no major proposals | widening to 6 lanes west of Church St | widening to 6 lanes at Homebush Bay Dr & east of Church St | continued widening of Pennant Hills Rd | continued widening of Cumberland Hwy | no major proposals | major upgrading approaches to Hume Hwy | Tunnel under Woodville Rd |
| Status | | | investigation, funds committed | investigation, funds committed | under construction | investigation, funds committed | | investigation, funds committed | investigation, funds not committed |
| Cost | | | n.a. | n.a. | n.a. | n.a. | | n.a. | n.a. |

**SYDNEY CORRIDORS (CONTINUED)**

| Corridor/ link no. | 7A | 7B | 8A | 8B | 9 | 10 | 11 (new route) | 12 |
|---|---|---|---|---|---|---|---|---|
| Corridor | M5–Liverpool to Gen Holmes Dr | M5–Liverpool to Gen Holmes Dr | Pacific Hwy–Hornsby to East Sydney | Pacific Hwy–Hornsby to East Sydney | Southern Cross Dr East Sydney to Brighton | Foreshore Rd – Botany to Port Botany | F2–Blacktown to Epping | City West Link–Burwood–City |
| Link | M5 from Liverpool to Beverly Hills | Beverly Hills to Gen Holmes Dr | Hornsby to Chatswood | Chatswood to East Sydney | East Sydney to Brighton | Botany to Port Botany | Blacktown–Epping | Burwood–City |
| Length (km) | 14 | 5 | 14 | 10 | 16 | 5 | | |
| AADT | 56 000 | 43 000 | 50 000 | 100 000 | 60 000 | 29 000 | | |
| Cars | 52 440 | 40 400 | 47 700 | 98 000 | 58 000 | 26 910 | | |
| Heavy vehicles | 3 560 | 2 600 | 2 300 | 2 000 | 2 000 | 2 090 | | |
| % heavy vehicles | 6 | 6 | 5 | 2 | 3 | 7 | | |
| Average a.m. peak speed (km/hour) | 70 | 25 | n.a. | 50 | 25 | 60 | | |
| Intersections | 6 | 43 | 103 | 59 | 60 | 6 | | |
| No. signalised | 1 | 15 | 41 | 35 | 17 | 5 | | |
| Intersections/km | 0.43 | 8.60 | 7.36 | 5.9 | 3.75 | 1.20 | | |
| Congestion now | none | entire length | entire length | none | East Sydney to Dowling St | none | | |
| Congestion in five years | none | entire length | entire length | none | East Sydney to Dowling St | none | | |
| Proposed future route development | duplication between Fairford and King George Rds | extend M5 from Beverly Hills to Gen Holmes Dr | no major proposals | no major proposals | Eastern distributor | no major proposals | construct M2 from Abbot Rd to Channel 10 | Five Dock to city/ extend M4 from Burwood to Five Dock |
| Status | investigation, funds not committed | investigation, funds not committed | | | investigation, funds not committed | | investigation, funds committed | under construction/ investigation, funds not committed |
| Cost | n.a. | n.a. | n.a. | | n.a. | | n.a. | n.a. |

**MELBOURNE CORRIDORS**

| Corridor/ link no. | 1 | 2 | 3 | 4A | 4B | 5A | 5B | 6A |
|---|---|---|---|---|---|---|---|---|
| Corridor | Hume Hwy—Northern entry to Bell St | Tullamarine Fwy–Airport to City | Western hwy–Western entry to City | West Gate/ Princes Fwy–SW entry to City | West Gate/ Princes Fwy–SW entry to City | Western Ring Road | Western Ring Road | South Eastern Arterial |
| Link | Hume Hwy—Northern entry to Bell St | Tullamarine Fwy–Airport to City | Western Hwy–Western entry to City | Princes Fwy section | West Gate Fwy section | completed section between Hume & Tulla-marine Fwys | uncompleted section between Tullamarine & Princes Fwys | East of Springvale Rd |
| Length (km) | 6 | 20 | 14 | 22 | 14 | 8 | | 15 |
| AADT | 34 088 | 113 847 | 46 357 | 62 691 | 109 928 | 53 340 | | 94 517 |
| Cars | 29 723 | 103 707 | 42 701 | 55 215 | 98 417 | 44 888 | | 84 935 |
| Heavy vehicles | 4 365 | 10 140 | 3 656 | 7 477 | 11 511 | 8 452 | | 9 582 |
| % heavy vehicles | 13 | 9 | 8 | 12 | 10 | 16 | | 10 |
| Average a.m. peak speed (km/hour) | n.a. | n.a. | n.a. | 88 | 89 | n.a. | | 65 |
| Intersections | 25 | 10 | 93 | 6 | 9 | 3 | | 7 |
| No. signalised | 5 | 0 | 23 | 0 | 0 | 0 | | 0 |
| Intersections/km | 4.17 | 0.50 | 6.64 | 0.27 | 0.64 | 0.38 | | 0.47 |
| Congestion now | n.a. | n.a. | n.a. | n.a. | City end | n.a. | | n.a. |
| Congestion in five years | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | | n.a. |
| Proposed future route development | alternative access to Hume Fwy | widening from Bulla Rd to City/ new link bypassing Essendon | no major proposals | no major proposals | connect West Gate Fwy with SE Fwy (Domain tunnel) | no major proposals | | widening east of Springvale Rd |
| Status | suggestion only | investigation, funds committed/ investigation, funds not committed | | | investigation, funds committed | | | under construction |
| Cost | | $65m/ 150m | | | incl in corr.10 | | | $15m |

**MELBOURNE CORRIDORS (CONTINUED)**

| Corridor/ link no. | 6B | 7A | 7B | 8A | 8B | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|
| Corridor | South Eastern Arterial | Springvale Rd | Springvale Rd | Bell St/ Manningham Rd/ Doncaster Rd | Bell St/ Manningham Rd/ Doncaster Rd | Eastern Ring Road (new corridor) | City Western Bypass (new corridor) | Western Fwy to Western Ring Road (new corridor) |
| Link | west of Springvale Rd | south of SE Arterial | north of SE Arterial | Doncaster Rd section | Bell St/ Manningham Rd section | Hume Fwy East & south to SE Arterial | Connection between Tullamarine & West Gate Fwys | Western Fwy link to Western Ring Road |
| Length (km) | 21 | 13 | 14 | 6 | 15 | | | |
| AADT | 66 881 | 36 964 | 51 329 | n.a. | 56 648 | | | |
| Cars | 61 074 | 34 767 | 48 202 | n.a. | 53 162 | | | |
| Heavy vehicles | 5 807 | 2 197 | 3 126 | n.a. | 3 486 | | | |
| % heavy vehicles | 9 | 6 | 6 | n.a. | 6 | | | |
| Average a.m. peak speed (km/hour) | 44 | 42 | 41 | 38 | 37 | | | |
| Intersections | 11 | 75 | 107 | 41 | 173 | | | |
| No. signalised | 1 | 19 | 25 | 13 | 40 | | | |
| Intersections/km | 0.52 | 5.77 | 7.64 | 6.83 | 8.24 | | | |
| Congestion now | major congestion | n.a. | n.a. | n.a. | n.a. | | | |
| Congestion in five years | n.a. | n.a. | n.a. | n.a. | n.a. | | | |
| Proposed future route development | grade separation of all inner SE Fwy intersections | Springvale Bypass | no major proposals | Eastern Fwy extension & Ringwood Bypass/ continuation of Ringwood Bypass | no major proposals | Dalton rd to Plenty rd/ Mahoneys rd to Dalton Rd/ Scoresby Transport Corridor | City Western Bypass | link between Western Fwy & Western Ring Rd |
| Status | under construction | under construction | | under construction/ investigation, funds committed | | under construction/ investigation, funds committed/ investigation, funds not committed | investigation, funds committed | investigation, funds not committed |
| Cost | $75m | $28m | | | | $30m/$92m/$550m | $1050m | $110m |

**BRISBANE CORRIDORS**

| Corridor/ link no. | 1A | 1B | 2A | 2B | 3A | 3B | 4 |
|---|---|---|---|---|---|---|---|
| Corridor | Main northern entry–Caboolture to Brisbane | Main northern entry–Caboolture to Brisbane | Main southern entry–Logan River to Brisbane City | Main southern entry–Logan River to Brisbane City | Gateway arterial–Eight Mile Plains to Bald Hills | Gateway arterial–Eight Mile Plains to Bald Hills | Main western entry–Dinmore to South East arterial |
| Link | Caboolture to Bald Hills | Bald Hills to city | Logan River to Eight Mile Plains | Eight Mile Plains to Brisbane City | Eight Mile Plains to Brisbane River | Brisbane River to Bald Hills | Dinmore to Brisbane |
| Length (km) | 16 | 15 | 14 | 16 | 14 | 22 | 26 |
| AADT | 52 000 | 52 000 | 113 000 | 90 000 | 35 000 | 26 000 | 42 000 |
| Cars | n.a. | 48 880 | n.a. | 85 500 | 32 200 | 23 000 | 36 960 |
| Heavy vehicles | n.a. | 3 120 | n.a. | 4 500 | 2 800 | 3 000 | 5 040 |
| % heavy vehicles | n.a. | 6 | n.a. | 5 | 8 | 12 | 12 |
| Average a.m. peak speed (km/hour) | n.a. | 38 | n.a. | 68 | 80 | 80 | 80 |
| Intersections | 5 | 93 | 12 | 9 | 6 | 9 | 98 |
| No. signalised | 1 | 22 | 0 | 0 | 0 | 0 | 24 |
| Intersections/km | 0.31 | 6.20 | 0.86 | 0.56 | 0.43 | 0.41 | 3.77 |
| Congestion now | Between Gateway Arterial & Anzac Ave | Beams Rd | entire link | Ramp metering at entry points | toll booth at Gateway Bridge | Between Gateway Bridge and Airport Dr | n.a. |
| Congestion in five years | Between Gateway arterial & Anzac Ave | entire link | n.a. | Ramp metering at entry points | toll booth at Gateway Bridge | Between Gateway Bridge and Airport Dr | n.a. |
| Proposed future route development | widen from 4 to 6 lanes | construct interchange at Beams Rd | provide 6 lanes between Gateway arterial and Shailer Park | no major proposals | grade separation of Miles Platting rd/ connections to future Eastern Corridor and Logan Motorway | complete 4 lanes for the entire length | upgrade to motorway standard from Dinmore to Rocklea |
| Status | suggestion only | investigation, funds not committed | under construction | | under construction/ investigation, funds not committed | under construction | under construction |
| Cost | $40m–$60m | $20m | n.a. | | n.a. | n.a. | n.a. |

**BRISBANE CORRIDORS (CONTINUED)**

| Corridor/ link no. | 5A | 5B | 5C | 6 | 7 | 8 |
|---|---|---|---|---|---|---|
| Corridor | Western Arterial–Darra to Nundah | Western Arterial–Darra to Nundah | Western Arterial–Darra to Nundah | Griffith Arterial–Cunningham Arterial to Gate-way Arterial | Logan Motorway–Goodna to Logan River | South Coast Motorway (new corridor)–Gateway arterial to Logan Rd |
| Link | Darra to Jindalee | Jindalee to Everton Park | Everton Park to Nundah | Archerfield to Wishart | Goodna to Logan River | Gateway Arterial to Logan Rd |
| Length (km) | 6 | 15 | 9 | 11 | 29 | |
| AADT | 35 000 | 45 000 | 20 000 | 40 000 | 11 000 | |
| Cars | 32 900 | 42 700 | 19 200 | 35 600 | 10 300 | |
| Heavy vehicles | 2 100 | 2 300 | 800 | 4 400 | 700 | |
| % heavy vehicles | 6 | 5 | 4 | 11 | 6 | |
| Average a.m. peak speed (km/hour) | 72 | 32 | 40 | 38 | n.a. | |
| Intersections | 10 | 85 | 69 | 39 | 9 | |
| No. signalised | 2 | 15 | 18 | 11 | 0 | |
| Intersections/km | 1.67 | 5.67 | 7.67 | 3.55 | 0.31 | |
| Congestion now | n.a. | Mt Coot–tha Roundabout | whole length | entire link | toll booths | |
| Congestion in five years | n.a. | Mt Coot–tha Roundabout | n.a. | entire link | n.a. | |
| Proposed future route development | no major proposals | alternative corridor to the west | upgrading selected sections | grade separation at major intersections | upgrade to 4 lanes | New route east of Pacific Hwy |
| Status | | suggestion only | some under con-struction, others being investigated, funds committed | investigation, funds not committed | | investigation, funds not committed |
| Cost | | $200–300m | | $20m | $40–80m | $500m |

**PERTH CORRIDORS**

| Corridor/ link no. | 1A | 1B | 2 | 3 | 4A |
|---|---|---|---|---|---|
| Corridor | Canning/ Great Eastern Hwy central access–Fremantle to Guildford | Canning/ Great Eastern Hwy central access–Fremantle to Guildford | Leach Hwy–Fremantle to Tonkin Hwy | Tonkin Hwy–Great Eastern Hwy to Roe Hwy | Roe Hwy–Fremantle to Great Northern Hwy at Midland |
| Link | Stirling Hwy to Albany Hwy | Albany Hwy to Guildford | Stirling hwy to Tonkin Hwy | Great Eastern hwy to Roe Hwy | Fremantle bypass to South St |
| Length (km) | 15 | 11 | 21 | 7 | |
| AADT | 31 500 | 40 000 | 35 500 | 34 000 | |
| Cars | 30 700 | 38 550 | 34 050 | 32 600 | |
| Heavy vehicles | 800 | 1 450 | 1 450 | 1 400 | |
| % heavy vehicles | 3 | 4 | 4 | 4 | |
| Average a.m. peak speed (km/hour) | n.a. | n.a. | n.a. | n.a. | |
| Intersections | 114 | 58 | 63 | 4 | |
| No. signalised | 20 | 13 | 22 | 3 | |
| Intersections/km | 7.60 | 5.27 | 3.00 | 0.57 | |
| Congestion now | western approaches to Kwinana Fwy | eastern approaches to Albany Hwy | n.a. | n.a. | |
| Congestion in five years | n.a. | n.a. | n.a. | n.a. | |
| Proposed future route development | no major proposals | no major proposals | widen Shelly Bridge to 6 lanes | grade separation at Leach Hwy/ & at Collier Rd | planned |
| Status | | | investigation, funds committed | investigation, funds committed | investigation, funds not committed |
| Cost | | | $6.8m | $4.8m/$7.9m | n.a. |

**PERTH CORRIDORS (CONTINUED)**

| Corridor/ link no. | 4B | 4C | 4D | 5 | 6 |
|---|---|---|---|---|---|
| Corridor | Roe Hwy–Fremantle to Great Northern Hwy at Midland | Roe Hwy–Fremantle to Great Northern Hwy at Midland | Roe Hwy–Fremantle to Great Northern Hwy at Midland | Great Northern Hwy to Great Eastern Hwy | Great Eastern Hwy–Glen Forrest to Guildford |
| Link | South St to Tonkin Hwy | Tonkin Hwy to Great Eastern Hwy | Great Eastern Hwy to Great Northern Hwy | Great Northern Hwy to Great Eastern Hwy | Glen Forrest to Guildford |
| Length (km) | | 11 | 4 | 12 | 14 |
| AADT | | 28 500 | 21 000 | 8 500 | 27 500 |
| Cars | | 27 600 | 20 450 | 8 150 | 26 850 |
| Heavy vehicles | | 900 | 550 | 350 | 650 |
| % heavy vehicles | | 3 | 3 | 4 | 2 |
| Average a.m. peak speed (km/hour) | | n.a. | n.a. | n.a. | n.a. |
| Intersections | | 8 | 4 | 53 | 61 |
| No. signalised | | 4 | 4 | 4 | 9 |
| Intersections/km | | 0.73 | 1.00 | 4.42 | 4.36 |
| Congestion now | | n.a. | n.a. | n.a. | n.a. |
| Congestion in five years | | n.a. | n.a. | n.a. | n.a. |
| Proposed future route development | construction between Tonkin Hwy & Welshpool St/ between Welshpool and South Sts | no major proposals | no major proposals | construct second carriageway | construct second carriageway/ Orange route near Midland |
| Status | under construction/ investigation, funds committed | | | investigation, funds committed | investigation, funds committed |
| Cost | $127m | | | $28m | $5.1m/$92.7m |

**ADELAIDE CORRIDORS**

| Corridor/ link no. | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Corridor | Eastern entry to Glen Osmond | Glen Osmond to Gepps Cross | Glen Osmond to South Adelaide | Glen Osmond to Emerson | Noarlunga to Cavan, north of Gepps Cross |
| Link | Murray Bridge to Glen Osmond | Glen Osmond to Gepps Cross | Glen Osmond to Mile End via Greenhill & Richmond Rds | Glen Osmond to Emerson via Cross Rd | Noarlunga to Cavan, north of Gepps Cross, via South Rd |
| Length (km) | 9 | 15 | 7 | 6 | 23 |
| AADT | 26 000 | 24 000 | 32 000 | 22 000 | 41 000 |
| Cars | 23 900 | 22 300 | 30 300 | 21 000 | 37 000 |
| Heavy vehicles | 2 100 | 1 700 | 1 700 | 1 000 | 4 000 |
| % heavy vehicles | 8 | 7 | 5 | 5 | 10 |
| Average a.m. peak speed (km/hour) | 40 | 35 | 35 | 35 | 35 |
| Intersections | 2 | 156 | 56 | 55 | 188 |
| No. signalised | 1 | 27 | 14 | 11 | 35 |
| Intersections/km | 0.22 | 10.40 | 8.00 | 9.17 | 8.17 |
| Congestion now | intersection with Portrush & Cross Rds | between Greenhill and Magil Rds and major intersections | all major intersections | between Duthy St & South Rd and intersection with Unley and Goodwood Rds | between Henly Beach & Torrens Rds and all major intersections |
| Congestion in five years | intersection with Portrush & Cross Rds | between Greenhill and Magil Rds and major intersections | all major intersections | between Duthy St & South Rd and intersection with Unley and Goodwood Rds | between Port & Torrens Rds and all major and some minor intersections |
| Proposed future route development | new alignment for Mt Barker Rd/ grade separation at intersection with Portrush and Cross Rds | widening between Greenhill and Magill Rds/ grade separation at intersection with Main North and Port Wakefield Rds | grade separation at intersection with Greenhill Rd | rehabilitation between West Tce & South Rd | new links between Grand Junction and Port Wakefield Rds/ between Reynella and Sturt/ widening between Torrens and Port Rds |
| Status | investigation, funds not committed/ suggestion only | investigation, funds not committed/ suggestion only | suggestion only | under construction | construction/ investigation, funds committed/ investigation funds not committed |
| Cost | $140m/ $10m | $18m/ n.a. | $30m | $5m | $35m/$70m/$12m |

## ADELAIDE CORRIDORS (CONTINUED)

| Corridor/ link no. | 6 | 7 | 8 | 9A | 9B |
|---|---|---|---|---|---|
| Corridor | Port Adelaide to City | Port Adelaide to Gepps Cross | Northern entry to Gepps Cross | North–east entry to Gepps Cross | North–east entry to Gepps Cross |
| Link | Pt Adelaide to City via Port Rd | Port Adelaide to Gepps Cross via Grand Junction Rd | Northern entry to Gepps Cross (Wakefield Rd) | Gawler to Elizabeth | Elizabeth to Gepps Cross |
| Length (km) | 12 | 9 | 29 | 15 | 17 |
| AADT | 36 000 | 40 000 | 40 000 | 20 000 | 38 000 |
| Cars | 33 250 | 35 350 | 35 150 | 18 500 | 35 500 |
| Heavy vehicles | 2 750 | 4 650 | 4 850 | 1 500 | 2 500 |
| % heavy vehicles | 8 | 12 | 12 | 8 | 7 |
| Average a.m. peak speed (km/hour) | 40 | 40 | 40 | n.a. | 40 |
| Intersections | 107 | 56 | 43 | 44 | 34 |
| No. signalised | 27 | 12 | 7 | 7 | 14 |
| Intersections/km | 8.92 | 6.22 | 1.48 | 2.93 | 2.00 |
| Congestion now | intersection with Adam St/Park Tce & Phillips St | n.a. | n.a. | n.a. | intersection with Main North/Saints Rds/Grove Way |
| Congestion in five years | intersection with Adam St/Park Tce & Phillips St | n.a. | n.a. | n.a. | intersection with Main North/Saints Rds/Grove Way |
| Proposed future route development | Replace bridge over Torrens River | Third port river crossing | no major proposals | no major proposals | widening between Hogarth Rd and Grove Way/ between Grove Way and Montague Rd |
| Status | investigation, funds committed | investigation, funds not committed | | | investigation, funds committed/investigation, funds not yet committed |
| Cost | $5m | $40m | | | $18m |

# REFERENCES

## ABBREVIATIONS

| | |
|---|---|
| BTE | Bureau of Transport Economics |
| BTCE | Bureau of Transport and Communications Economics |
| MOT | Ministry of Transport (Victoria) |
| NAASRA | National Association of Australian Road Authorities |
| RTA | Roads and Traffic Authority (New South Wales) |
| RCA | Road Construction Authority (Victoria) |

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## ABBREVIATIONS

| | |
|---|---|
| AADT | annual average daily traffic |
| BCR | benefit–cost ratio |
| BTE | Bureau of Transport Economics |
| BTCE | Bureau of Transport and Communications Economics |
| CBD | central business district |
| DRTSA | Department of Road Transport, South Australia |
| LCL | less–than–container–load |
| MOT | Ministry of Transport (Victoria) |
| NAASRA | National Association of Australian Road Authorities |
| NPV | net present value |
| NTPT | National Transport Planning Taskforce |
| PUD | Pick-up and Delivery |
| RTA | Roads and Traffic Authority (New South Wales) |
| RCA | Road Construction Authority (Victoria) |
| SRMC | short-run marginal social cost |