Assessment of the Australian Road System: Economic Assessment Model for Rural Arterial Roads

Occasional Paper

This Occasional Paper describes an economic assessment of rural arterial roads in Australia based on a road deficiency analysis. Benefit cost analysis was undertaken using the NIMPAC road planning model and an additional set of programs developed by the BTE to carry out economic evaluation. The principal objective of the analysis was to examine the economic returns from investment in rural arterial roads in different States and in different types of project construction work.

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FOREWORD

In May 1982, the then Minister for Transport directed the Bureau of Transport Economics (BTE) to undertake an assessment of the Australian road system. The BTE reported on a previous assessment in 1979 following similar reports prepared by the former Commonwealth Bureau of Roads in 1969, 1973 and 1975.

In satisfying the 1982 Ministerial reference a number of discrete but related investigations were carried out. Each investigation is being reported in a separate BTE publication.

Information from these publications and from other sources are brought together to provide a general assessment of the state and future of the road system in BTE Report 56 'Assessment of the Australian Road System: 1984'.

This Occasional Paper describes an economic assessment of rural arterial roads in Australia based on a road deficiency analysis. Benefit cost analysis was undertaken using the NIMPAC road planning model and an additional set of programs developed by the BTE to carry out economic evaluation. The principal objective of the analysis was to examine the economic returns from investment in rural arterial roads in different States and in different types of project construction work.

The economic assessment of rural arterial roads reported in this Paper was undertaken by a team in the Economic Assessment Branch which was headed by Dr. R. Mellor and included M. Poole, B. Honu and S. Taylor.

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SUMMARY

An economic assessment of rural arterial roads in Australia was carried out as part of the 1984 Assessment of the Australian Road System by the Bureau of Transport Economics (BTE). A disaggregate methodology based on a list of improvement projects generated from a road deficiency analysis was employed. The BTE developed a set of economic evaluation programs which were linked to the NIMPAC road planning model, to produce benefit cost ratios for individual road sections.

The analysis showed that there are considerable returns to be derived from further investment in rural arterial roads in Australia. For the five year period 1985-86 to 1989-90 an average benefit cost ratio of 2.6 was obtained for Australia as a whole for the set of improvement projects generated by the NIMPAC model, using the current assessment and design standards and the 1980-81 funding level. Not all of the expenditure produced by this process has a high economic return. Sixty four per cent of expenditure produced a benefit cost ratio greater than one, whilst the remaining 36 per cent was below that level.

For each State four different sets of assessment and design standards were devised to produce work programs with expenditure levels ranging from 25 per cent below to 50 per cent above the funds applied to rural arterial roads in 1980-81. An important finding of the study was that average benefit cost ratios and the proportion of expenditure generated with a benefit cost ratio greater than one was fairly constant over the range of standards used. In other words, it appears that the average return on rural arterial road investment in each State would not change significantly if the funding level was increased or decreased within the range considered.

The assessment work indicated that higher economic returns are likely to be derived from investment in rural arterial roads in New South Wales, Queensland and Victoria than in the other three States and the Northern Territory. Benefits from upgrading rural arterial roads are highly correlated with traffic levels. Therefore, traffic levels and traffic growth are probably the most important determinants of economic returns, although construction costs are also significant.

The benefits that are derived from improving rural arterial roads accrue to both road users and road authorities. Savings in maintenance costs, which are the major benefit to road authorities, are always small (generally less than 3 per cent of total benefits). Benefits to road users are dominated by reductions in vehicle operating costs and travel time savings. For Australia as a whole, vehicle operating costs represent 51 per cent of total benefits from road improvements and travel time savings 45 per cent. The contribution to economic benefits from reductions in accident costs is always quite small (2.6 per cent for Australia as a whole and less than 4 per cent for each of the States).

CHAPTER 1—INTRODUCTION

BACKGROUND

Economic assessment of rural arterial roads was first carried out on a comprehensive national basis in Australia in the late 1960s. This followed the establishment in 1964 of the Commonwealth Bureau of Roads (CBR) which had the statutory function of advising the Commonwealth Government on financial assistance to the States for roads and road transport.

Rural arterial roads were evaluated along with other categories of road in the 1969 CBR report on Commonwealth financial assistance to the States for roads (CBR 1969). The procedure adopted was to estimate the cost of road needs identified by engineering deficiency criteria, and also to estimate economically warranted levels of construction expenditure based on benefit cost analysis. The same basic process was utilised in subsequent reports (CBR 1973, CBR 1975 and BTE 1979). The disaggregate methodology used, which worked upwards from individual sections of road, involved extensive data collection and use of a computerised road assessment and costing model.

There is no universally accepted procedure for assessing the potential returns from investment in road infrastructure. Different countries have developed different approaches supported by various large scale computer models. In Britain there have been a number of investigations into road assessment procedures including the trunk road assessment study (Advisory Committee on Trunk Road Assessment 1978). The COBA model (Great Britain Department of Environment 1972), which calculates benefit cost ratios for improvement projects on given road sections, is in common use in the United Kingdom. In the United States a number of road evaluation models have been developed at both State and federal levels, and comprehensive research programs on road investment procedures undertaken; an example is the software package Performance Investment Analysis Process (PIAP) (US Department of Transport 1978). The Highway Design Model (HDM) (Moavenzadeh et al. 1977) is used extensively by the World Bank for highway project evaluation.

The basic methodology adopted in the economic assessment work reported in this Paper, followed the approach used by the CBR and BTE in previous studies. The physical state of road sections was compared with minimum acceptable standards, deficiencies identified, the cost of upgrading deficient sections calculated, the benefits flowing from these improvements determined, and hence benefit cost ratios derived. A major criticism of this approach has been the application of a rigid set of assessment and design standards formulated by road engineers. An important step forward in the current study was the application of a range of standards which generated differing investment programs (mixes of project types) and various funding levels. This process made it possible to examine how economic returns change as standards and funding levels are varied.

The economic assessment discussed in this Paper represents only part of the analysis of rural arterial roads that was carried out for the 1984 BTE Assessment of the Australian Road System. The overall assessment has a broader base, incorporating physical performance criteria as well as economic criteria, and also addresses some distributional and institutional matters (BTE 1984a).

The use of a disaggregate methodology employing project based assessment is dependent on the availability of a detailed inventory on the condition of the rural arterial network, and also on an appropriate road assessment and costing model. The data bank of rural arterial roads that was used in the assessment process was compiled by each State Road Authority (SRA) for the purpose of the National Association of Australian State Road Authorities (NAASRA) Roads Study (NAASRA 1984a). The assessment model used is the latest in a series of Australian computer based road planning models, NAASRA Improved Model for Project Assessment and Costing (NIMPAC). The BTE developed a suite of computer programs to undertake economic analysis of road improvements based on the cost data produced by the NIMAPC model. The most important of these programs draws together the cost and benefit streams from a base case and an improvement case NIMPAC analysis to produce benefit cost ratios for individual sections of road.

The major objective of the analysis was to examine the economic returns from investment in rural arterial roads in different States, and in different types of project construction work. The budget period of interest was the five years 1985-86 to 1989-90. As indicated above, a range of standards which generated different investment programs and various funding levels, were employed to make it possible to examine how economic returns vary as standards and funding levels change. In addition, the relative importance of the components of the benefits that flow from rural arterial road improvements (reductions in vehicle operating costs and accident costs, travel time savings and savings in maintenance costs) were investigated.

STRUCTURE OF THE PAPER

This Paper is structured in the following manner. Chapter 2 presents a description of important physical characteristics of rural arterial roads in Australia. The methodology that was adopted for the economic assessment work is described in detail in Chapter 3. Some of the more technical aspects of the NIMPAC road management model are set out in Chapter 4. This chapter also presents an overview of the extended NIMPAC economic evaluation system. Chapter 5 is devoted to reporting on the results of the economic assessment, with particular emphasis on the economic returns from investment programs by State and by type of construction work. Chapter 6 provides an overview of the analysis carried out and presents some concluding remarks. Additional descriptive material relating to the rural arterial network, and more detailed analysis of the economic assessment work, particularly on a State basis, are incorporated in Appendixes to the Paper.

CHAPTER 2—DESCRIPTION OF RURAL ARTERIAL ROADS

This chapter presents data on a number of important physical characteristics of rural arterial roads in the six States and the Northern Territory of Australia. It provides background to the economic analysis described in subsequent chapters of the Paper.

Under the National Association of Australian State Road Authorities (NAASRA) classification, all roads are divided into nine functional classes. Functional classes 1 to 5 apply to rural roads and are respectively, arterial, sub-arterial, collector, local and special roads. Functional classes 6 to 9 apply to urban roads[1]. For the purposes of this Paper roads of functional classes 1, 2 and 3 are aggregated to form rural arterial roads. Rural arterial roads provide an important transport link between cities and rural regions for either personal travel or for the transportation of produce and other commodities.

National highways are included in the NAASRA definition of functional class 1 roads. However, because of the higher rate of expenditure on these roads and the special administrative provisions which apply to them, they were excluded from the assessment described in this study. National highways are therefore not included in the rural arterial roads data discussed in this chapter. In addition, bridges are excluded from the data since bridges are not subject to economic assessment (see Chapter 3 for reasons).

Rural arterial roads form only 12.2 per cent (97 300 kilometres) of the total road length in Australia (Table 2.1). The proportion of rural arterial roads in the total road length varies between States, from 9.6 per cent in Victoria to 15.2 per cent in Tasmania, and 15.3 per cent in New South Wales.

Differences also exist in the distribution of rural arterial road length by both functional and area classes[2], as shown in Tables 2.2 and 2.3. Functional class 3 roads constitute the largest portion of the rural arterial network. In the Northern Territory rural arterial roads are exclusively of functional class 3, whereas in the States this functional class makes up between 71.5 per cent (South Australia) and 54.1 per cent (Tasmania) of the total rural road length. The predominance of area class 5 roads in all cases (more than 90 per cent of the length of the rural arterial network) is clearly shown in Table 2.3.

The differences exhibited by the States and the Northern Territory in Tables 2.2 and 2.3 can be explained to a large extent by differences in development, and population density and distribution among the States.

ROAD STEREOTYPES

Rural arterial roads embrace a variety of roads which differ in respect of physical conditions such as surface type and number of lanes. These conditions influence operating characteristics such as rideability, wet weather deterioration and closure. Therefore the rural arterial network was divided into road stereotypes which are

1. See BTE (1979, p387) for a detailed functional classification of roads, and BTE (1984a) for a discussion of the classification.
2. Rural arterial roads are classified as belonging to area class 4 if the road is in town and to area class 5 if it is out of town.

TABLE 2.1—ROAD LENGTH, AUSTRALIA: 1981

State or Territory	Road category											
	National highway		Rural arterial		Rural local		Urban arterial		Urban local		Total	
	Length (km)	(per cent)	Length (km)	(per cent)	Length (km)	(per cent)	Length (km)	(per cent)	Length (km)	(per cent)	Length (km)	(per cent)
New South Wales	1 300	0.7	30 000	15.3	150 000	76.7	2 200	1.1	12 000	6.1	195 500	100.0
Victoria	700	0.4	15 400	9.6	129 400	80.9	2 500	1.6	12 000	7.5	160 000	100.0
Queensland	3 900	2.4	19 300	11.8	130 800	80.2	1 100	0.7	8 000	4.9	163 100	100.0
South Australia	2 600	2.6	10 400	10.2	83 200	81.7	600	0.6	5 000	4.9	101 800	100.0
Western Australia	4 700	3.4	16 400	11.8	112 800	81.3	800	0.6	4 000	2.9	138 700	100.0
Tasmania	300	1.8	2 600	15.2	12 900	75.4	300	1.8	1 000	5.8	17 100	100.0
Northern Territory	2 700	12.9	3 100	14.8	14 700	70.0	–	–	500	2.4	21 000	100.0
Australian Capital Territory	–	–	100	6.7	400	26.7	300	20.0	700	46.7	1 500	100.0
Total	16 200	2.0	97 300	12.2	634 200	79.4	7 800	1.0	43 200	5.4	798 700	100.0

– Nil or rounded to zero.

Notes: 1. In order to produce data on a comparable basis for all categories of road, figures in this table do not correspond exactly to figures in other tables in this chapter (which are derived from the NAASRA Data Bank).

2. Figures may not add to totals due to rounding.

Source: BTE (1984a).

more homogeneous. The four road stereotypes used were unsealed roads, one-lane sealed roads (that is, under 4.6 metres wide), two-lane sealed roads and two-lane sealed roads plus overtaking lane (that is, from 4.6 to 11.6 metres wide), and finally four-lane and divided roads (that is, all sealed rural arterial roads wider than 11.6 metres). These categories are based on an aggregated version of the NAASRA Road Study categories (NAASRA 1984b).

The road stereotype composition of the rural arterial network is given in Table 2.4[1].

TABLE 2.2—RURAL ARTERIAL ROADS, LENGTH BY FUNCTIONAL CLASS: 1981

Functional class	*NSW*	*Vic*	*Qld*	*SA*	*WA* [a]	*Tas*	*NT*
Class 1							
Length (km)	4 061	270	1 980	788	600	–	–
Per cent	(14.4)	(1.9)	(10.5)	(7.9)	(3.7)	–	–
Class 2							
Length (km)	7 000	3 981	4 303	2 056	5 395	1 109	–
Per cent	(24.9)	(27.7)	(22.9)	(20.6)	(33.0)	(45.9)	–
Class 3							
Length (km)	17 082	10 142	12 513	7 130	10 375	1 307	3 094
Per cent	(60.7)	(70.5)	(66.6)	(71.5)	(63.4)	(54.1)	(100.0)
Total							
Length (km)	28 143	14 393	18 796	9 974	16 370	2 416	3 094
Per cent	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)

a. Figures for Western Australia are for 1982.

– Nil or rounded to zero

Notes: 1. Functional classes 1, 2 and 3 are arterial. sub-arterial and collector respectively.

2. Figures may not add to totals due to rounding.

Source: BTE tabulations from the NAASRA Data Bank.

TABLE 2.3—RURAL ARTERIAL ROADS, LENGTH BY AREA CLASS: 1981

Functional class	*NSW*	*Vic*	*Qld*	*SA*	*WA* [a]	*Tas*	*NT*
Class 4							
Length (km)	1 551	706	595	411	239	203	–
Per cent	(5.5)	(4.9)	(3.2)	(4.1)	(1.5)	(8.4)	–
Class 5							
Length (km)	26 592	13 687	18 201	9 563	16 131	2 213	3 094
Per cent	(94.5)	(95.1)	(96.8)	(95.9)	(98.5)	(91.6)	(100.0)
Total							
Length (km)	28 143	14 393	18 796	9 974	16 370	2 416	3 094
Per cent	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)

a. Figures for Western Australia are for 1982.

– Nil or rounded to zero

Note: Area classes 4 and 5 are in town and out of town respectively.

Source: BTE tabulations from the NAASRA Data Bank.

1. Tables 2.4 to 2.7 each provide information on both the original 1981 (1982 for Western Australia) status of rural arterial roads and the projected 1985 status for all States and the Northern Territory. However, the discussion is concentrated on the original status of the roads. Figures for the 1985 inventory (projected using NIMPAC) are provided for comparison.

TABLE 2.4—ROAD STEREOTYPE COMPOSITION OF THE RURAL ARTERIAL NETWORK: 1981 AND 1985

	Unsealed		*Sealed*								
			One-lane[a]		*Two-lane*[b]		*Four-lane and divided*[c]		*Total sealed*		*Total*
	Length (km)	*(per cent)*	*Length (km)*	*(per cent)*	*Length (km)*	*(per cent)*	*Length (km)*	*(per cent)*	*Length (km)*	*(per cent)*	*length (km)*
New South Wales											
1981	8 714	31.0	319	1.1	18 478	65.7	632	2.2	19 429	69.0	28 143
1985	8 102	28.8	326	1.2	19 069	67.8	646	2.3	20 041	71.2	28 143
Victoria											
1981	327	2.3	431	3.0	13 409	93.2	226	1.6	14 066	97.7	14 393
1985	191	1.3	442	3.1	13 530	94.0	230	1.6	14 202	98.7	14 393
Queensland											
1981	4 760	25.3	5 069	27.0	8 940	47.6	27	0.1	14 036	74.7	18 796
1985	3 794	20.2	4 837	25.7	10 134	53.9	31	0.2	15 002	79.8	18 796
South Australia											
1981	1 908	19.1	55	0.6	7 920	79.4	91	0.9	8 066	80.9	9 974
1985	1 691	17.0	55	0.6	8 137	81.6	91	0.9	8 283	83.0	9 974
Western Australia[d]											
1982	4 641	28.4	2 410	14.7	9 244	56.5	75	0.5	11 729	71.6	16 370
1985	4 533	27.7	2 140	13.1	9 622	58.8	75	0.5	11 837	72.3	16 370

TABLE 2.4(Cont)—ROAD STEREOTYPE COMPOSITION OF THE RURAL ARTERIAL NETWORK: 1981 AND 1985

	Unsealed		*Sealed*								*Total*
			One-lane[a]		*Two-lane*[b]		*Four-lane and divided*[c]		*Total sealed*		
	Length (km)	*(per cent)*	*Length (km)*	*(per cent)*	*Length (km)*	*(per cent)*	*Length (km)*	*(per cent)*	*Length (km)*	*(per cent)*	*length (km)*
Tasmania											
1981	216	8.9	29	1.2	2 155	89.2	16	0.7	2 200	91.1	2 416
1985	135	5.6	21	0.9	2 244	92.9	16	0.7	2 281	94.4	2 416
Northern Territory											
1981	1 698	54.9	1 211	39.1	185	6.0	–	–	1 396	45.1	3 094
1985	1 670	54.0	1 239	40.0	185	6.0	–	–	1 424	46.0	3 094

a. Roads with width up to 4.5 metres.
b. These include two lanes with overtaking lane, that is all sealed roads 4.6 to 11.6 metres wide.
c. Roads with width 11.7 metres or more.
d. Figures for Western Australia are for 1982.

– nil or rounded to zero

Note: Figures may not add to totals due to rounding.

Sources: 1981 figures (1982 for Western Australia) were obtained by BTE from the NAASRA Data Bank. 1985 figures are projections using the NIMPAC model.

Excluding the Northern Territory, the bulk of rural arterials are two-lane sealed roads. This category constitutes between a high of 93.2 per cent (13 409 kilometres) in Victoria and a low 47.6 per cent (8940 kilometres) in Queensland. Four-lane and divided roads make up a very small proportion of the rural arterial road length, with no more than about 2 per cent in any State and none at all in the Northern Territory. The table also shows that unsealed roads are concentrated in the States with the most extensive sparsely settled rural areas (New South Wales, Queensland, South Australia, Western Australia and the Northern Territory). This road stereotype serves mainly to provide basic commmunication needs between sparsely settled remote communities. One-lane sealed roads are largely confined to Queensland, Western Australia and the Northern Territory.

The 1981 inventory was updated to 1985, the year prior to the budget period of interest in this Paper (1985-86 to 1989-90). Updating the 1981 inventory in each State involved running the NIMPAC model for four years using current assessment and design standards[1]. The effect of updating the 1981 inventory is generally to increase the length and share of two-lane sealed roads mainly at the expense of unsealed roads.

PHYSICAL CHARACTERISTICS OF ROAD STEREOTYPES

There are many characteristics of a road which either alone or in combination with other factors influence the quality of service provided by the road. Perhaps most important among these are level of roughness, alignment and traffic volume. Information on these characteristics is contained in Tables 2.5 to 2.7 and Appendix I (Tables I.1 to I.8). Again data for the year 1981 and projected data for 1985 are presented.

Roughness level

In the NAASRA data bank, the level of roughness of a road section is measured in NAASRA roughness meter (NRM) counts per kilometre. The higher the NRM count per kilometre the rougher the road section, the less comfortable the ride. Roughness is used as a measure of pavement condition and is a key element in the deficiency assessment analysis (see Chapter 4). The level of roughness also significantly influences vehicle operating cost through its effect on travel speed and wear and tear on vehicles. In Table 2.5 the total sealed length of the rural arterial network is grouped into four roughness ranges[2].

Although States show differences in the sealed road length in each roughness range, there is a general tendency for road length to be concentrated in the 60-119 range. The proportion varies from 67.8 per cent in Tasmania to 55.7 in Victoria and 53.9 in New South Wales. South Australia and Western Australia have the lowest proportion (42.3 per cent and 45.8 per cent respectively), but this is because a very high percentage of the rural arterial road length in these States (52.6 per cent in South Australia and 53.5 per cent in Western Australia) have a lower roughness measure. Queensland has by far the greatest length and proportion with a roughness measure above 160. Generally each road stereotype shows a similar trend to that for all sealed roads. Detailed data are presented in Table I.2.

The differences which were observed in the level of roughness among the States can be explained by a variety of factors. The most important ones are differences in annual average daily traffic (AADT), maintenance practices, financial constraints, climate, degree of tolerance by road users and finally, relative past funding priorities.

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1. Details of the procedure used in projecting the rural arterial road inventory are presented in Chapter 3.
2. Roughness level is measured *only* for sealed roads. See Tables I.1 and I.2 for further details on the classification of road length by roughness levels.

TABLE 2.5—ROUGHNESS LEVELS (SEALED ROADS ONLY): 1981 AND 1985

State	*NRM Ranges* 0-59 Length (km)	0-59 (per cent)	60-119 Length (km)	60-119 (per cent)	120-159 Length (km)	120-159 (per cent)	160+ Length (km)	160+ (per cent)	Total Length (km)	Total (per cent)
New South Wales										
1981	7 390	38.0	10 477	53.9	1 102	5.7	460	2.4	19 429	100.0
1985	2 514	12.5	12 794	63.8	3 783	18.9	950	4.7	20 041	100.0
Victoria										
1981	5 851	41.6	7 833	55.7	311	2.2	71	0.5	14 066	100.0
1985	4 381	30.8	9 012	63.5	776	5.5	33	0.2	14 202	100.0
Queensland										
1981	1 695	12.1	8 229	58.6	2 578	18.4	1 534	10.9	14 036	100.0
1985	1 086	7.2	10 045	67.0	2 741	18.3	1 130	7.5	15 002	100.0
South Australia										
1981	4 243	52.6	3 409	42.3	318	3.9	96	1.2	8 066	100.0
1985	2 814	34.0	4 214	50.9	928	11.2	327	3.9	8 283	100.0
Western Australia[a]										
1982	6 276	53.5	5 368	45.8	72	0.6	13	0.1	11 729	100.0
1985	4 385	37.0	7 435	62.8	17	0.1	–	–	11 837	100.0
Tasmania										
1981	253	11.5	1 491	67.8	399	18.1	57	2.6	2 200	100.0
1985	200	8.8	1 732	76.0	349	15.3	–	–	2 281	100.0
Northern Territory										
1981	476	34.1	920	65.9	–	–	–	–	1 396	100.0
1985	269	18.9	1 155	81.1	–	–	–	–	1 424	100.0

a. Figures for Western Australia are for 1982.

– nil or rounded to zero

Note: Figures may not add to totals due to rounding.

Source: BTE tabulations from the NAASRA Data Bank.

Alignment

In combination with other road characteristics such as road width and/or hazardous roadside features the standard of road alignment has important implications for speed and cost of travel, and road safety.

Aspects of alignment include horizontal curvature, vertical curvature and grades. Table 2.6 contains information on the percentage of curves with a design speed below 70 kilometres per hour (km/h)[1]. More detailed data including the number of horizontal curves in various design speed ranges, are presented in Table I.3. The States displayed a significant amount of variation in horizontal alignment. The proportion of curves with design speeds below 70km/h is much higher in New South Wales (59.7 per cent) and Victoria (46.2 per cent) than in South Australia (19.3 per cent) and Western Australia (14.9 per cent).

Table 2.6 also presents information on upgrades[2] with gradients of 6 per cent or higher, whilst Table I.4 includes a comparison of the number of upgrades within specified slope ranges. New South Wales has significantly more upgrades with gradients of 6 per cent or higher, than other States. These differences, and those displayed for horizontal curves, are largely due to differences in the terrain of the State.

TRAFFIC VOLUME DISTRIBUTION ON ROAD STEREOTYPES

Table 2.7 and Tables I.5 to I.8, provide information on the traffic volume distribution as measured by AADT for the various road stereotypes. Table 2.7 shows the proportion of each road stereotype length in various traffic volume ranges. In 1981, Tasmania had the highest proportion of unsealed rural arterial road carrying 100 or more vehicles per day[3] (64.4 per cent). In the same year 34.3 per cent of unsealed rural arterials in New South Wales and 32.1 per cent in Victoria carried 100 or more vehicles per day. The corresponding figures for Queensland, South Australia and Western Australia were 23.6 per cent, 28.8 per cent and 0.5 per cent respectively. Tables I.5 to I.8, provide further details. In all States except Tasmania a high percentage of one-lane sealed roads carried between 100 and 300 vehicles a day; none of the Northern Territory's one-lane sealed roads carried more than 100 vehicles a day.

MORE DETAILED DATA

More detailed information relating to the physical characteristics of rural arterial roads in the States and Northern Territory is presented in Appendix I. In addition, data relating to expenditure on rural arterial roads for the period 1975-76 to 1981-82, and a breakdown between maintenance and construction work, are included (Tables I.9 and I.10).

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1. In the NAASRA Roads Study all horizontal curves with design speed less than 70km/h are designated as poor (NAASRA 1984b).
2. Whether a grade is called an upgrade or a downgrade depends on the direction of travel when the inventory data were being collected.
3. The NAASRA Roads Study designates all unsealed rural arterial roads with 100 or more vehicles per day as poor (NAASRA 1984b).

TABLE 2.6—ALIGNMENT DATA FOR RURAL ARTERIAL ROADS: 1981 AND 1985

(per cent)

	NSW		Vic		Qld [a]		SA		WA [b]		Tas [a]		NT	
	1981	*1985*	*1981*	*1985*	*1981*	*1985*	*1981*	*1985*	*1982*	*1985*	*1981*	*1985*	*1981*	*1985*
Horizontal curves														
curves with design speed under 70km/h	59.7	56.9	46.2	45.1	..	..	19.3	16.0	14.9	13.7	..	..	–	–
Upgrades														
grades greater than 6 per cent	49.5	49.5	21.4	21.4	..	..	9.3	9.3	6.0	6.0	..	..	–	–

a. There are no alignment data available for Queensland and Tasmania.
b. Figures for Western Australia are for 1982.

– nil or rounded to zero

.. not applicable

Sources: Tables I.3 and I.4.

TABLE 2.7—TRAFFIC VOLUME DISTRIBUTION FOR RURAL ARTERIAL ROADS: 1981 AND 1985

	NSW		*Vic*		*Qld*		*SA*		*WA*[a]		*Tas*		*NT*	
	1981	*1985*	*1981*	*1985*	*1981*	*1985*	*1981*	*1985*	*1982*	*1985*	*1981*	*1985*	*1981*	*1985*
Unsealed roads														
Percentage of length with AADT														
Under 60	50.7	50.4	2.8	26.7	49.6	57.0	51.5	50.8	91.8	84.7	23.6	37.8	98.4	98.0
60-99	15.0	15.7	65.1	67.0	26.9	28.1	19.7	26.8	7.6	15.3	12.0	19.3	1.6	1.9
100+	34.3	33.8	32.1	6.3	23.6	15.0	28.8	22.3	0.5	–	64.4	43.0	–	–
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
One-lane sealed roads[b]														
Percentage of length with AADT														
Under 60	11.3	11.0	0.9	1.5	18.6	17.3	–	–	15.5	8.2	–	–	92.6	79.6
60- 99	11.3	9.2	12.5	25.1	21.1	22.1	–	–	27.3	33.6	–	–	7.4	20.4
100-299	64.9	53.4	58.5	55.9	45.4	40.8	83.6	96.4	52.8	58.1	17.2	9.5	–	–
300+	12.5	26.3	28.1	17.6	14.8	19.8	16.4	3.6	4.4	0.1	82.8	90.6	–	–
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Two-lane sealed roads[c]														
Percentage of length with AADT														
Under 300	29.7	27.4	24.0	23.0	41.9	41.4	34.2	33.4	46.5	39.7	20.2	22.5	100.0	41.6
300- 999	41.3	41.1	43.5	43.5	36.4	36.1	44.1	43.7	38.6	43.3	50.4	49.0	–	58.4
1000-3999	25.3	27.5	28.7	29.2	18.7	19.1	19.7	20.4	10.1	14.7	28.0	27.1	–	–
4000+	3.6	4.0	3.8	4.3	2.9	3.4	2.1	2.4	4.8	2.3	1.4	1.4	–	–
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

TABLE 2.7(Cont)—TRAFFIC VOLUME DISTRIBUTION FOR RURAL ARTERIAL ROADS: 1981 AND 1985

	NSW		*Vic*		*Qld*		*SA*		*WA* [a]		*Tas*		*NT*	
	1981	*1985*	*1981*	*1985*	*1981*	*1985*	*1981*	*1985*	*1982*	*1985*	*1981*	*1985*	*1981*	*1985*
Four-lane and divided sealed roads [d]														
Percentage of length with AADT														
0-1999	51.9	44.1	56.6	52.6	51.9	41.9	28.6	27.5	52.0	50.7	68.8	68.8	..	..
2000-5999	37.8	41.1	35.4	36.1	22.2	22.6	35.2	29.7	41.3	38.7	31.2	31.2	..	..
6000+	10.3	14.7	8.0	11.3	25.9	35.5	36.3	42.9	6.7	10.7	–	–	..	..
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	..	..

a. Figures for Western Australia are for 1982.
b. Roads with width up to 4.5 metres.
c. Includes two lanes with overtaking lane (roads with width 4.6 to 11.6 metres).
d. Roads with width 11.7 metres or more.

– nil or rounded to zero

.. not applicable

Note: Figures may not add to totals due to rounding.

Sources: Tables I.5 to I.8.

CHAPTER 3—ASSESSMENT METHODOLOGY

This chapter describes the methodology that was adopted for the economic assessment of rural arterial roads in Australia. The budget period of interest was the five year period 1985-86 to 1989-90. The main purpose of the assessment was to gain insight into the economic returns from investment in rural arterial roads in different States, and in different types of work. A range of assessment and design standards which generated different investment programs and various funding levels, was employed to make it possible to examine how economic returns vary as standards and funding levels change.

The approach adopted for the evaluation was a disaggregate one based on an assessment of road condition and its ability to service future demands. Benefit cost analysis was employed, taking as its starting point a list of projects generated from a road deficiency analysis.

The use of a disaggregate methodology employing project based assessment is dependent on the availability of an extensive data base relating to road condition, and a road assessment and costing model. Each State Road Authority (SRA) has assembled a detailed inventory of rural arterial roads in its State, in particular for the NAASRA Road Study (NAASRA 1984a). In addition NAASRA commissioned the development of a computerised road planning model, NIMPAC (NAASRA Improved Model for Project Assessment and Costing) to permit an examination of the implications of various road improvement and maintenance strategies. The BTE developed a set of procedures and computer programs which take output from the basic NIMPAC model and undertake economic analysis and evaluation, including the computation of benefit cost ratios, for individual road sections. This economic evaluation system was used to carry out this economic assessment of rural arterial roads.

THE NIMPAC MODEL

NIMPAC is the latest in a series of Australian computer based road planning models. The first major models were developed in the late 1960s by the Main Roads Department, Western Australia (MERIN) (Kaesehagen 1970) and by the former Commonwealth Bureau of Roads (MERRI) (Lack et al. 1968, Fisher et al. 1970); the latter was subsequently upgraded (MODMERRI) (Both, Thompson and Lack 1972).

The NIMPAC model carries out an analysis by proceeding through the following steps:

- the state of each road section is compared with a set of assessment standards (minimum acceptable standards);
- sections not meeting the minimum standards are designated 'deficient';
- design standards are invoked to determine what improvements should be carried out to the deficient sections;
- if no improvement project is generated, the maintenance requirement is determined;
- project, maintenance and road user costs are calculated; and
- the updated state of the road system, taking into account improvement projects, maintenance, projected traffic growth and deterioration, is determined.

The output of the NIMPAC program is a set of road authority and road user costs for each road section. Road authority expenditure is divided into routine maintenance expenditure and the various components of costs associated with improvement projects (for example, surfacing, land acquisition). The major road user costs, travel time and vehicle operating costs, are derived by vehicle type; costs associated with accidents are also produced. Table 3.1 sets out the various costs calculated by the model.

It is possible to vary the assessment and design standards employed by the model, in successive iterations, in order to gauge the effects of these changes on the future condition of the road system and on the various elements of road authority and road user costs.

Some more technical aspects of NIMPAC are presented in Chapter 4. A more extensive description of the model can be found in Bayley (1978) and Cleeland and Both (1982).

TABLE 3.1—COSTS OUTPUT BY NIMPAC

Road authority expenditure		*Road user costs*	
Project costs	*Ongoing costs*	*Operating costs*	*Accident costs*
Pavement Surfacing Shoulders Land acquisition Clearing Earthworks Resheeting Rehabilitation Drainage Miscellaneous Bridges[a] Oncost Resealing/ resurfacing[b]	Routine maintenance roads bridges[a]	Travel time costs cars light commercials rigid trucks semi-trailers road trains Vehicle operating costs[c] cars light commercials rigid trucks semi-trailers road trains	Accidents associated with roads bridges[a]

a. Bridge expenditure is excluded from the current analysis.
b. Resealing/resurfacing is treated as a maintenance cost in the economic evaluation.
c. Vehicle operating costs are also produced and presented under the following components: fuel, oil, tyres, repairs/servicing and depreciation.

BENEFIT COST RATIOS

The measure used in this Paper to evaluate investment in road improvements is the benefit cost ratio. This criterion is defined as the ratio of B to K where:

K = present value of capital investment; and

B = present value of user benefits resulting from investment plus change in present value of recurrent operating and maintenance costs incurred by the road authority.

In terms of the costs derived by NIMPAC, and listed in Table 3.1, capital investment (K) comprises all of the road authority project costs with the exception of resealing[1].

1. Resealing/resurfacing is considered as a maintenance activity.

All other costs set out in Table 3.1, namely routine maintenance costs plus resealing, and road user operating and accident costs, constitute the user benefits (B).

Traditional benefit cost analysis is generally accepted as an appropriate criterion for evaluating road investment. However its application is sometimes criticised because of difficulties in measuring some costs and benefits in monetary terms. Intangible benefits such as the mental and physical comfort of road users, have no market value. Costs and benefits imposed on non-road users are generally difficult to incorporate in the analysis. Increased tourism, defence effects, increased production potential and air and noise pollution effects are relevant factors which are virtually impossible to quantify in monetary values. However, the somewhat restricted set of costs and benefits relating to a road improvement which are generated by NIMPAC, are considered to encompass the most significant aspects for rural arterial roads.

INVENTORY

The starting point for the assessment of rural arterial roads was the 'sectionised'[1] 1981[2] road inventory prepared by each SRA for the purposes of the 1984 NAASRA Roads Study (NAASRA 1984a). These State inventories are in a common format known as the NAASRA Data Bank System (Linsten 1978). There are about 160 data items in this system and they include geographical information, horizontal and vertical alignment, terrain, pavement and surface data, roughness, traffic volume and traffic composition. A complete list of the data items is given in Appendix II. Each road section is regarded as a separate entity and is assessed without reference to any other section in the road system.

Each State's sectionised 1981 rural and outer urban arterial[3] inventory was reduced to rural road sections (area classes 4 and 5) that are classed as primary and secondary arterial roads (functional classes 1, 2 and 3). Bridges were excluded from the inventory as the methodology being used was not considered appropriate to evaluate bridge construction works. National highways were also excluded from the analysis.

UPDATING THE INVENTORY

The budget period of interest in this BTE study was the five years 1985-86 to 1989-90. It was therefore necessary to update each State inventory from June 1981 to produce a 'projected base inventory' as at the beginning of the budget period, that is June 1985.

Each SRA derived a set of 'matching' assessment and design standards (called F100 standards). These standards were devised in such a way that the expenditure generated by NIMPAC (for the 10 year NAASRA analysis period 1982 to 1991) closely approximated a road authority's current expenditure on rural and outer urban arterials, both in total and in respect of the distribution by different types of construction work. Current expenditure was defined as the average, in 1980-81 prices, of expenditure in 1979-80 and 1980-81. Details of the F100 standards are set out in Appendix III. (These standards are designated S2 in the Appendix, as described there and in Chapter 5). Different States adopted different practices in deriving the F100 matching standards but in general, expenditure was not matched on a year

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1. Road sections were formed from a continuous inventory using criteria such as area class (in town or out of town), operational class (number and type of carriageways), pavement type and width, and surface type and width (Bayley 1978, p 2-5-2). As a result physical characteristics are relatively constant within a section.

2. 1982 in the case of Western Australia.

3. Outer urban arterials lie in the area between the inner urban boundary as defined by the Australian Bureau of Statistics for capital cities and major provincial cities for the 1976 Population Census, and the boundary of the relevant statistical division or district.

by year basis, but simply in total for the 10 year period of the NAASRA analysis (1982 to 1991). NIMPAC-generated expenditure varied significantly from year to year in some States.

The inventory updating process was carried out by running NIMPAC on each State's 1981 rural arterial inventory, using the F100 standards (with a view to mirroring current practice), until about four years of current expenditure was spent on project construction in each State. Since the F100 standards did not necessarily generate NIMPAC expenditure which matched actual expenditure on a year by year basis (but only in total for the 10 year NAASRA analysis period), four years of current expenditure was not necessarily generated by NIMPAC in a four year analysis period. The most extreme case was Queensland, where slightly more than four years (average annual) expenditure was generated in the first year (1982). Running the model for two years in Tasmania (1982 and 1983) generated about four years of average annual expenditure. However, in the remaining States and the Northern Territory NIMPAC generated about four years of average annual expenditure in a four year analysis period (three years expenditure in three years NIMPAC analysis from 1982 in the case of Western Australia).

Following the above procedure, a snapshot of the rural arterial road inventory (taking into account improvement projects, maintenance, traffic growth and deterioration) was taken in 1982 for Queensland, in 1983 for Tasmania, and in 1985 for the other States. The model 'aged' those variables that change over time (roughness and travel volume) in Queensland and Tasmania so that these items also related to 1985. This process then produced a projected base 1985 inventory for each State.

An examination was carried out to ensure that the updating process had not caused any substantial change in the distribution of the major inventory items. The change between 1981 and 1985 in most data items such as vertical and horizontal alignment was quite small (see Chapter 2). Roughness was the only item in which there was a significant change during the updating period. There was a tendency for the roughest roads to be improved in the updating process, as one might expect, and hence for the proportion of smooth pavements to increase. However, the average roughness did not fall markedly between 1981 and 1985 in any State, and in fact increased in New South Wales, Victoria and South Australia.

There was also some concern that utilising the NIMPAC model for a short period (no more than four years) in the updating procedure, may cause some distortion due to 'gearing-up' and 'closing-down' effects in the model. It is assumed by the model that in cases where projects are initiated, but not completed, in a NIMPAC analysis period, no work is carried out on the given project. It is possible that this could have some distorting effect on the distribution of project types. As projects on longer road sections take longer to complete, fewer long projects would be expected in the updating period, and consequently more of these projects would occur in the budget period. As might be expected, there is some indication that this effect is slightly greater in Queensland and Tasmania than the other States. However, the fact that this phenomenon did not appear to affect the distribution of inventory items in any State in any significant way, indicates that any resulting distortion is not large.

SAMPLING

The NIMPAC road planning model requires considerable computing capacity as it processes data on a section by section basis and produces large amounts of output data on a year by year basis. There are over 15 000 road sections in Queensland for example (see Table 3.2 for further details). In addition, it was necessary to run the model for up to 40 years to obtain the full stream of benefits flowing from a project (see section 'Evaluation Procedure' below). It was therefore not possible to process the full 1985 rural arterial inventory for all States through NIMPAC and

TABLE 3.2—SAMPLE AND POPULATION DISTRIBUTION, NUMBER AND LENGTH OF SECTIONS

State	Sample	Population	Sample/Population
New South Wales			
No of sections	2 022	3 786	0.53
Length (km)	24 256	28 144	0.86
Victoria			
No of sections	1 574	7 155	0.22
Length (km)	9 787	14 393	0.68
Queensland			
No of sections	1 962	15 285	0.13
Length (km)	6 985	18 796	0.37
South Australia[a]			
No of sections	..	3 427	..
Length (km)	..	9 974	..
Western Australia			
No of sections	1 896	8 028	0.24
Length (km)	9 698	16 370	0.59
Tasmania[a]			
No of sections	..	1 170	..
Length (km)	..	2 416	..
Northern Territory[a]			
No of sections	..	100	..
Length (km)	..	3 094	..

a. Sampling was not necessary in these States.

.. not applicable

Note: In the case of the sample, the length of section is that prior to factoring.

the associated economic evaluation system on the BTE's Perkin-Elmer 3230 computer. As a result, a sample of the inventories for New South Wales, Victoria, Queensland and Western Australia was selected. It was not necessary to sample the South Australian, Tasmanian or Northern Territory inventories.

It is noted that in the updating process it was not necessary to sample the inventories as there was sufficient computing capacity to run NIMPAC on the population of road sections in all States for up to four years. It was only for evaluation purposes, when it was necessary to run the model for up to 40 years to obtain the full stream of benefits, that computer capacity problems arose.

In devising a sample of the rural arterial inventories in New South Wales, Victoria, Queensland and Western Australia, it was recognised that there was sufficient computing capacity to allow for a relatively large sample size (about 13 per cent of road sections and 37 per cent of network length in Queensland and over 20 per cent of sections and 50 per cent of length in the other States). The first step in the sampling process was to stratify the population of rural arterial road sections in each of four States using the following variables:

- area class (in town or out of town);
- functional class (1, 2 or 3);
- length of road section[1] (generally <1 km, 1 to 5 km, $\geqslant 5$ km);

1. In New South Wales the ranges used were <3 km, 3 to 10 km and $\geqslant 10$ km.

- annual average daily traffic[1] (AADT) (generally $< 10\,000$, $\geqslant 10\,000$); and
- general terrain (flat, undulating, hilly or mountainous).

Stratification divides a variable population into more homogeneous sub-populations and hence facilitates the production of more reliable estimates.

The stratification process produced 144 individual cells, and a separate systematic sample was selected from each cell. Relatively long and/or heavily trafficked sections of road have the potential to contribute large amounts to the cost or benefit streams of given improvement projects. As a result long (generally longer than 5 kilometres) and/or heavily trafficked (generally more than 10 000 vehicles a day) sections were completely enumerated (that is, all such sections were included in the sample). Different proportions of road sections (typically 1 in 3 and 1 in 4, but up to 1 in 30 in Queensland) were drawn from other strata depending on the variability of the stratum and the overall sample size required. Details of the sample size in each State, and the population size from which it was drawn, are presented in Table 3.2.

Estimates of population values (including expenditure items) were obtained using a ratio estimation technique (Cochran 1977). For each stratum the total length of all road sections in the population L_h and the total length of road sections included in the sample l_h were calculated[2]. The length of every section in the sample was factored up by the ratio L_h/l_h. The number of curves, grades and crests in a section was also factored up by this ratio. After factoring, the sample of road sections in each stratum had the same total length as the full network length in that stratum.

ACCURACY OF SAMPLING PROCESS

The accuracy of the sampling process was examined by running the NIMPAC model using the F100 matching standards for the five year period[3] 1985-86 and 1989-90 on both the population and sample in each State, and comparing the results.

Road user costs, resealing and road maintenance were estimated quite accurately by the samples in all States, the estimates being within 2 per cent of population values in all cases. This result was in line with expectations as these costs are fairly stable. On the other hand, project expenditure is quite 'lumpy' and hence is more difficult to estimate accurately from a sample.

There was a tendency for the samples to underestimate total expenditure, by 11 to 12 per cent in Victoria and Queensland, about 7 per cent in New South Wales and about 2 per cent in Western Australia. This appears to have occurred because of the higher average section length in the samples (due to the factoring up) and thus the longer time period required for projects to be completed. It would be expected that relatively more projects initiated in the five year analysis period would not be completed in that period in the case of the sample than in the case of the population. However, there is no indication that this underestimation of project expenditure resulted in any bias in the distribution of the resulting benefit cost ratios.

There does not appear to be any particular pattern in the types of construction work which contribute to the underestimation of project expenditure in the case of the sample when compared with the expenditure generated by the total inventory. (Work types are discussed in more detail in Chapter 5.) In New South Wales the work types 'realign and widen' and 'realign' contribute most to the underestimation. The main sources of underestimation of project expenditure in Victoria are 'realign', 'overtaking lanes' and 'rehabilitation', and in Queensland 'rehabilitation' and

1. In Western Australia the ranges used were < 8000 and $\geqslant 8000$.
2. The subscript 'h' indicates the h-th stratum.
3. NIMPAC could be run on the population of road sections for a 5-year period, but not for the 30 to 40 year period necessary to obtain the full stream of benefits flowing from a project.

'rehabilitation and widening'. Work types which result from high traffic levels, 'widening to six or eight lanes' and 'duplication', were generally estimated quite accurately because of heavier sampling (including complete enumeration) at high traffic volumes.

In light of the above discussion and other comparisons that were carried out, including regional analysis, it is considered that the sampling process was quite adequate for the purpose of the current analysis.

EVALUATION PROCEDURE

The evaluation of rural arterial road investment was carried out by identifying the benefits and costs of the provision of road improvements. As indicated earlier in the chapter, the criterion used was the benefit cost ratio.

Benefit cost analysis is carried out by examining the difference between the costs and benefits that arise in a project case and a base case. In the evaluation of rural arterial roads this entailed two NIMPAC runs:

- an improvement or project case which was defined by a given set of assessment and design standards; and
- the base case defined by a set of assessment and design standards which allowed road maintenance and resealing but did not permit the generation of improvement projects.

The NIMPAC model was set to run on the June 1985 rural arterial inventory for each State, and the analysis continued for a 30 year period following the generation of the first project on each road section. If no project was generated in the first 10 years of the analysis (double the budget period of interest) the model was terminated. Prime interest was in the budget period 1985-86 to 1989-90 with limited examination of the following five years to gain some insight into possible expenditure patterns in the future.

The present value of all capital investment on the section over the 30 year period (beginning with the generation of the first project on the section) was calculated in the improvement case. By definition there was no capital investment in the base case. Similarly, the discounted values of road user costs, maintenance and resealing costs over the 30 years were computed for both the improvement and base cases. The discounted benefits were calculated as the present value of the difference in these cost items (between the improvement and base cases), and were then compared with the present value of capital investment. The selection of 30 years as the period for calculation of the benefit and cost streams was made on the basis that this period is sufficiently long for the discounted contribution from later years (the residual effect) to be negligible.

The requirement for discounting benefits and costs to a common base necessitates the selection of an appropriate discount rate. In this study real discount rates of 4, 7 and 10 per cent were used. While the choice of the individual rates is somewhat arbitrary, the rates chosen provide an appropriate range for testing sensitivity to changes in the discount rate. Sensitivity of the evaluation results to the different rates can be seen from the information reported in Chapter 5.

In addition to a road network inventory, NIMPAC requires as data input a set of unit costs and parameters (including unit costs for construction activities, pavement performance parameters and traffic parameters) and model variables (covering road user cost parameters such as the price of fuel, tyres and new vehicles, and maintenance cost parameters). Values for the unit costs and parameters for rural arterial roads were produced by each SRA for the 1984 NAASRA Roads Study, and these SRA estimates were adopted for the BTE evaluations. The maintenance cost parameters used in this study were also the values derived by SRAs for the NAASRA Roads Study. All these costs were expressed in 1980-81 prices.

Road user costs are made up of three components, travel time costs, vehicle operating costs and accident costs. The vehicle operating cost module in NIMPAC (Bayley 1978) estimates five aspects of operating costs for seven different vehicle types: fuel, oil, tyres, repairs and servicing, and depreciation and interest. Unit costs for each of these aspects were obtained from Thoresen and Evans (1982); the values produced were as at March 1981. Accident costs were derived from the same source.

It is particularly difficult to establish satisfactory estimates for the value of travel time (BTE 1982b). The values used in this analysis were based on the work of Thoresen and Evans. There is a substantial difference in the value of time assigned to the occupants of private cars (90 cents per hour) compared to that assigned to occupants of business cars ($11.50 per hour). Therefore the relative share of business and private cars is most important. It was assumed in this assessment that 30 per cent of cars were business cars and that the occupancy rates for private and business cars were 2 and 1.6 respectively. Light commercial vehicles were assumed to have an occupancy rate of 1.3 persons per vehicle with a value of time of $5.60 per person per hour. The various categories of trucks were assumed to carry the driver only and to have values of time from $6.60 to $10.80 per hour. The derived values of travel time for each vehicle type are given in Table 3.3, together with the assumed occupancy rates and the value of time per person per hour on which they were based.

TABLE 3.3—VALUES OF TRAVEL TIME

Vehicle type	*Occupancy rate (persons/vehicle)*	*Value ($/hr/person)*	*Value of travel time ($/hr/person)*
Private car	2.0	.90)	6.80
Business car	1.6	11.50)	
Light commercials	1.3	5.60	7.30
Rigid trucks	1.0	6.60	6.60
Semi-trailers	1.0	7.10	7.10
Road train	1.0	10.80	10.80

The NAASRA Data Bank contains proportions of each vehicle type for each section of road (cars are treated as a single category as there is no breakdown into private and business cars). Because the values of time ascribed to the various vehicle types are very similar (except for road trains) the results of the analysis are relatively insensitive to traffic composition.

In order to examine the economic returns from various road improvement programs, with different total expenditures and with different mixes of project types, four sets of assessment and design standards were employed. State Road Authorities produced upgrading programs for four different funding levels, which were considered a realistic approximation of what road engineers judged to be likely in practice. As described above, one program of road improvements was devised which 'matched' current expenditure[1]; this was defined by the F100 'matching' standards. Similarly, F75, F125 and F150 standards were devised for each State to produce upgrading programs, for the 10 years 1982 to 1991, requiring an average annual rate of approximately 75 per cent, 125 per cent and 150 per cent of the current expenditure[1] applied to rural arterial roads. Since these standards are applied in this study for the budget period 1985-86 to 1989-90 and beyond, with only the F100 standards used in the updating period, F75, F100, F125 and F150 should be interpreted purely as standards, and not as funding levels. As a result they are subsequently designated as S1 (F75),

1. Current expenditure is defined as the average in 1980-81 prices, of expenditure in 1979-80 and 1980-81.

S2 (F100), S3 (F125) and S4 (F150) standards. Details of the standards are given in Appendix III. The funding levels discussed in this Paper are the expenditure levels that NIMPAC generated using the standards as defined in the budget period of interest.

The sectionised rural arterial road inventory for each State includes details of traffic levels, as measured by AADT and growth in AADT. As the benefit stream is heavily dependent on traffic level, the absolute level of AADT and the growth rate will affect benefit cost ratios. The results presented in Chapter 5 use the traffic growth rates included in the NAASRA Data Bank by SRAs. These rates are presented for each State in Table 3.4, together with high and low growth projections of vehicle kilometres travelled that were derived by the BTE (BTE 1984b); these BTE projections of vehicle kilometres travelled relate to all categories of road and not just to rural arterials. Some testing of the effects of applying differing traffic growth rates was carried out. Within the range of interest, (that is. less than about 5 per cent) overall results did not change greatly with different growth rates. Benefits (and hence benefit cost ratios) did increase steadily with increased traffic growth rates but not dramatically so, and the pattern of results (when broken down by work types for example) remained quite consistent.

TABLE 3.4—TRAFFIC GROWTH RATES BY STATE

(per cent per annum)

State	*NAASRA (AADT)*		*BTE (VKT[a])*			
	1986-1991	*1991-2025*	*1985-1990*		*1990-2000*	
			Low	*High*	*Low*	*High*
New South Wales	2.6	1.8	2.5[b]	5.2[b]	2.2[b]	4.4[b]
Victoria	1.8	1.4	1.8	4.7	1.6	5.1
Queensland	4.5	2.5	3.3	6.1	2.5	5.1
South Australia	2.7	1.8	1.3[c]	4.8[c]	1.1[c]	3.8[c]
Western Australia	4.1	2.5	3.1	6.4	2.6	5.3
Tasmania	–	–	2.0	4.4	1.6	3.8
Northern Territory	3.2	2.0	..	..	..	..

a. Vehicle kilometres travelled. These BTE projections of VKT relate to all categories of road and not just to rural arterials.
b. New South Wales includes the Australian Capital Territory.
c. South Australia includes the Northern Territory.

– nil or rounded to zero

.. not applicable

Sources: BTE estimates derived from the NAASRA Data Bank, and BTE (1984b).

MAINTENANCE COSTS

Maintenance cost parameters and coefficients are an input to the NIMPAC model and are used as the basis of the calculation of maintenance costs. For the purposes of this study the maintenance model parameters were specified so as to produce historical levels of maintenance expenditure, and these were the same for each set of assessment and design standards. In other words the road improvement programs generated by NIMPAC, for each of the four sets of standards, were produced on the assumption that the amount of maintenance work carried out was continued at the current level. The historical level of maintenance in each State and the Northern Territory can be seen from Table I.10. No attempt was made to investigate the interaction between maintenance strategies and road improvement strategies.

ASSESSMENT RESULTS

The methodology described in this chapter enabled benefit cost ratios (BCRs) to be produced on a section by section basis, for a given inventory. Distributions of BCRs were derived by State and by type of work performed (see Chapter 5 for definitions of work types), separately for the four sets of standards used. Other characteristics such as average BCR and the proportion of expenditure with a BCR greater than one (and two, and other levels) were also obtained. Just as capital investment was broken down by type of work, the benefits were divided into their components, travel time savings and reductions in vehicle operating, accident, maintenance and resealing costs. A range of the results that were produced by this BTE analysis are reported in Chapter 5.

CHAPTER 4—EXTENDED NIMPAC EVALUATION SYSTEM

The first part of this chapter discusses some of the more technical aspects of the NIMPAC road planning model. An overview of the extended NIMPAC economic evaluation system is presented in the latter part of the chapter.

NIMPAC is a computer model which gives an indication of the macro implications of road management strategies. The planner is able to use NIMPAC to consider the effects of a set of management decisions on direct road user and road authority costs. Decisions on the number and scale of road improvements are simulated by applying a set of assessment and design standards. Flexibility in using these standards, and the modelling of the pavement life cycle by predicting changes in road pavement roughness over time, are important improvements in NIMPAC over earlier Australian computer based road planning models.

EXISTING NIMPAC MODEL

NIMPAC is designed to operate on a set of road sections; in particular it is compatible with the NAASRA Data Bank System (Linsten 1978). As a result of the sectionising process physical characteristics are relatively constant within a section. Each individual road section is examined independently from the remaining sections in the road system, and the information aggregated to provide network results.

The state of an individual road section is compared with a set of minimum acceptable standards, the assessment standards. These standards are designed to simulate decisions which initiate an improvement project on a section of road. Road sections not meeting the minimum set of standards are designated deficient. There are three main areas of roads assessment:

- Need for reconstruction. This occurs when the roughness level[1] for a given road section rises above a maximum acceptable level, indicating that the pavement has deteriorated to an unacceptable degree.
- Width assessment. The standards specify the minimum pavement and surface width permitted for particular ranges of traffic volume (AADT).
- Alignment assessment. A minimum speed for horizontal and vertical curves is specified.

Assessment standards have a first level effect on evaluation because they determine whether or not a given section is deficient; hence they determine the number of improvement projects generated.

When deficiencies are identified design standards are invoked to determine the scale of the road improvement. These standards simulate construction decisions and are based on the projected future traffic level 15 years from the deficiency year. In particular, the relationship between traffic volume and road width and the minimum speed for vertical and horizontal curves define the design standards. The design standards have a second level effect on evaluation as they determine the size, and hence the cost, of improvement projects generated.

Project timing rules may also be used to examine whether it is more appropriate to alter the time when certain projects are carried out. For example, a widening

1. Road pavement roughness is measured by the NAASRA Roughness Meter (NRM).

project on a deteriorated (rough) pavement might be deferred until reconstruction of the pavement is necessary (if that reconstruction would fall due in the near future).

Project, maintenance, resealing and road user costs (vehicle operating, travel time and accident) are calculated for each road section. The existing inventory is then updated to take into account improvement projects, maintenance, traffic growth and deterioration. Each road section is processed successively for each time period using the updated inventory until a specified time period is reached.

The pavement life cycle

The pavement deterioration model within NIMPAC plays a key role in determining road user costs for sealed roads. The deterioration of sealed pavements is measured by road pavement roughness. Roughness (as measured by NRM) in combination with traffic volume is used, inter alia, to estimate vehicle speed which is an important determinant of road user costs.

A sealed pavement has a life cycle that progresses from a high riding comfort road (smooth or low roughness) to a very poor riding comfort road (extreme roughness). The relationship between speed, pavement roughness and traffic volume is given in Figure 4.1. Pavement deterioration is predicted by a quadratic expression relating roughness to time. The parameters of the quadratic pavement deterioration curves to be used by NIMPAC are specified by the user. Unfortunately pavement deterioration rates occurring in practice are not well known, as there is a paucity of data on these relationships. The quadratic curves used in this study, like those employed in the NAASRA Roads Study, are based on the Study of the Economics of Road Vehicle Limits (ERVL) (Stevenson 1976). Examples of the curves used are given in Figure 4.2.

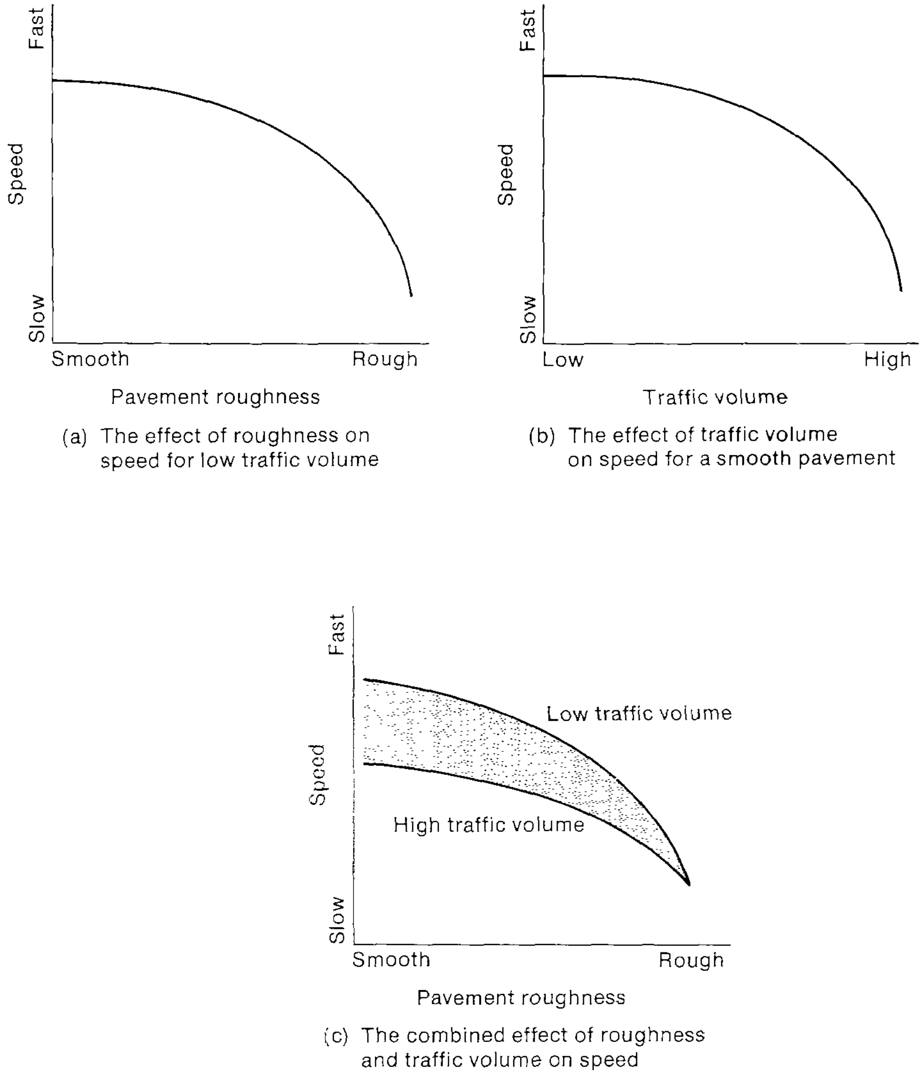
NIMPAC generated projects which increase the width of the road are basically determined by traffic volumes specified in the assessment and design standards. On the other hand, reconstruction and rehabilitation projects are principally determined by roughness (pavement condition). Hence pavement deterioration rates are critical in determining which (reconstruction and rehabilitation) projects are done. In addition, pavement deterioration has an important influence on benefit cost ratios, as it determines how rough the pavement will get in the base case. If pavement deterioration is rapid, roughness at the end of the 30 years analysis period may become very high in the base case. As a result, if a project is carried out on such a section, large reductions in vehicle operating costs and travel time will accrue (although it should be recognised that the effect is reduced by the discounting of future monetary values).

Some testing of the sensitivity of benefit cost ratios to the pavement life curve was undertaken. For example, Victorian rural arterials were analysed using the Western Australian pavement deterioration curve, and vice versa. Using the Western Australian pavement age curve on Victorian data had almost no effect on the average BCR for the State. However, the economic returns for certain work types did change significantly, in particular 'realign and widen' and 'widen and rehabilitate' (increased BCRs) and 'rehabilitate' (decreased BCR). On the other hand, applying the Victorian pavement deterioration curve to the Western Australian data increased the average BCR for the State by about 30 per cent. There was no substantial change in BCRs for work types and the increase in the average BCR occurred because of a change in the project mix (particularly increases in the amount of 'widen and rehabilitate' and 'rehabilitate').

Vehicle operating costs

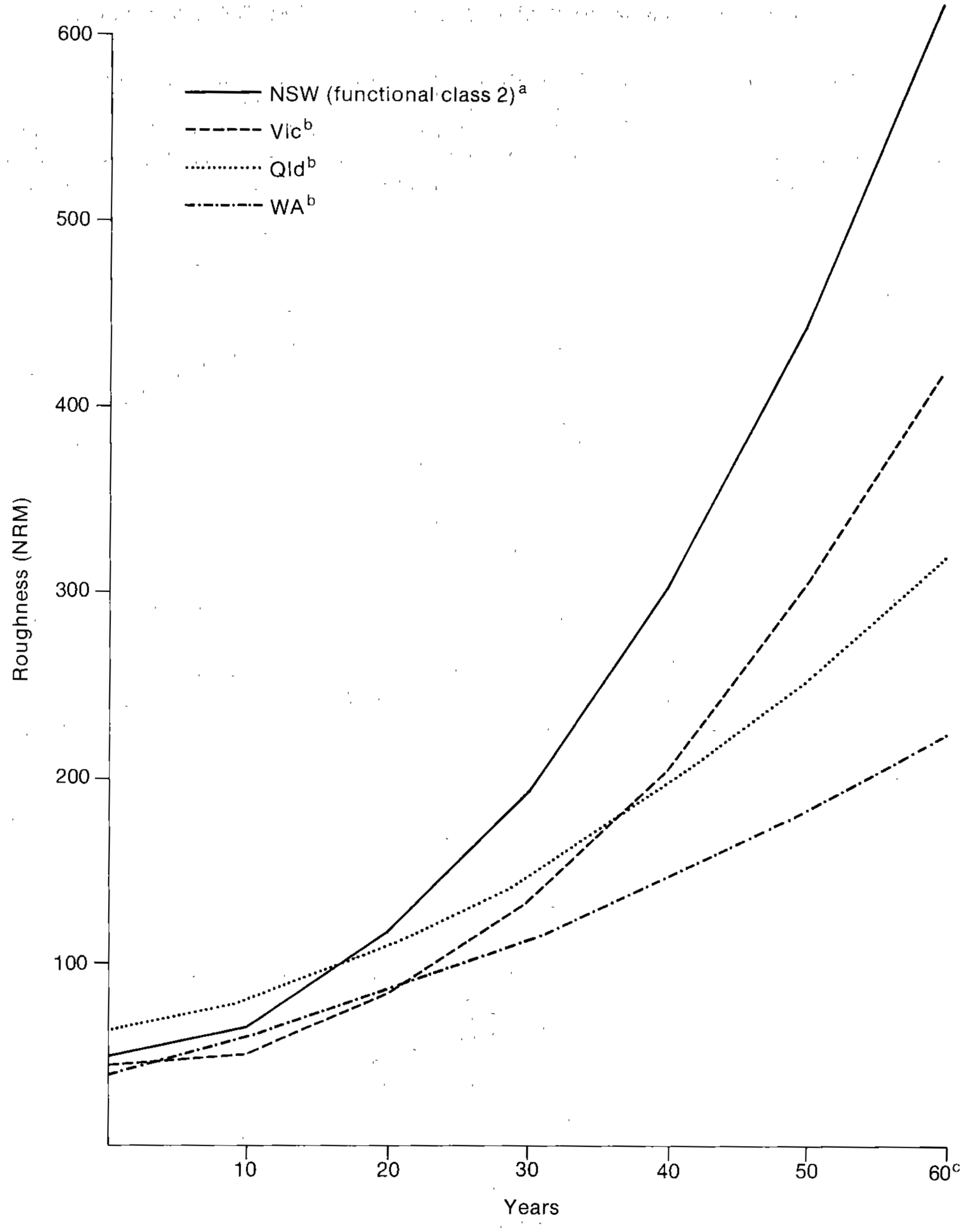
The most significant component of road user costs is vehicle operating costs (see Chapter 5). The vehicle operating cost (VOC) module in NIMPAC estimates five segments of operating cost for seven different vehicle types: fuel, oil, tyres, repairs and servicing, and depreciation and interest. The form of the relationships in the module are based on those in an earlier road model MODMERRI (Both and Bayley 1976).

The coefficients in a number of relationships in the VOC module, especially the effects of roughness on vehicle speed and operating cost, were estimated over a decade ago. In addition the form of, and the values attached to, a number of factors in the relationships are based on overseas studies due to the lack of Australian data. These facts cause some concern about the current accuracy of vehicle operating



Source: Cleeland and Both (1982).

Figure 4.1—The effects of pavement roughness and traffic volume on traffic speed



a. Different curves were used for the different functional classes in New South Wales.

b. Curve applies for all three functional classes.

c. Although the maximum analysis period is 40 years, the curves at 60 years and beyond are used, in the base case, for pavements which were 20 or more years old in 1985. Notice that the curves diverge substantially after about 30 years because of the different quadratic forms used.

Figure 4.2—Pavement deterioration curves for rural arterial roads in selected States

costs generated by NIMPAC. However it is generally considered that the values produced by the module are of the right order of magnitude.

Accident costs

The accident cost module in NIMPAC is fairly simplistic being based on accident rates for different road stereotypes. Since reductions in accident costs are a relatively small proportion of total road user benefits (see Table 5.7), this is not considered to be a major drawback.

EXTENSIONS TO THE NIMPAC MODEL

The BTE has developed a suite of computer programs to undertake economic analysis of road improvements based on the transportation costs derived by NIMPAC (and listed in Table 3.1). The programs are integrated with the existing NIMPAC system. Figure 4.3 presents an overview of the extended NIMPAC economic evaluation system. Details of the system are set out in BTE (1984d).

Sampling of a road network is provided for, where necessary to minimise computing demands, by the program SECRED. The program uses a stratified sample with systematic selection within strata. The sample is factored up so that the aggregate network length is maintained.

To reduce the computing requirements of the extended NIMPAC system, the NIMPAC program was modified to eliminate a number of calculations that were not necessary for the economic evaluation modules. The modified NIMPAC is referred to as NIMPACX in Figure 4.3.

NIMPAC performs its road life cycle simulation over a nominated time period with a specified computation interval. Variations in the computation interval alter the timing and content of the program of road works. A one year interval was used in the analysis for the project case to ensure that no distortions were introduced to the calculation of benefit cost ratios. For the base case NIMPAC run, it was necessary to produce road user costs and road authority recurrent costs for every road section for a 40 year analysis period; the 10 years of the double budget period and 30 years for the streams of benefits and costs flowing from an improvement project. A two year computation interval was found to be satisfactory in the base case since no road improvements are generated.

The next step in the evaluation process illustrated in Figure 4.3 involves the drawing together of the cost and benefit streams of the base and improvement cases through program BCRCAL. A BCR for individual road sections is calculated as the ratio of the present value of user benefits resulting from capital investment plus the change in the present value of maintenance and resealing expenditure incurred by the road authority, to the present value of capital investment (see Chapter 3 for details).

The tabulation reporting program XTAB has been extended to cater for the output from BCRCAL and also to facilitate various comparative analyses which are useful in the evaluation system. The extended XTAB program is named 'XTABX' in Figure 4.3.

The extended NIMPAC economic evaluation system also provides two other new modules. The first is BUDMAT which permits scheduling of expenditures over time to accord with user nominated capital expenditure constraints over a designated period. The second is SELIMP which provides a detailed breakup of capital expenditure by activity (for example, paving, sealing) for improvements which meet any budget constraints imposed. Further details of these programs are provided in BTE (1984d). Neither of these modules was used in the current BTE analysis.

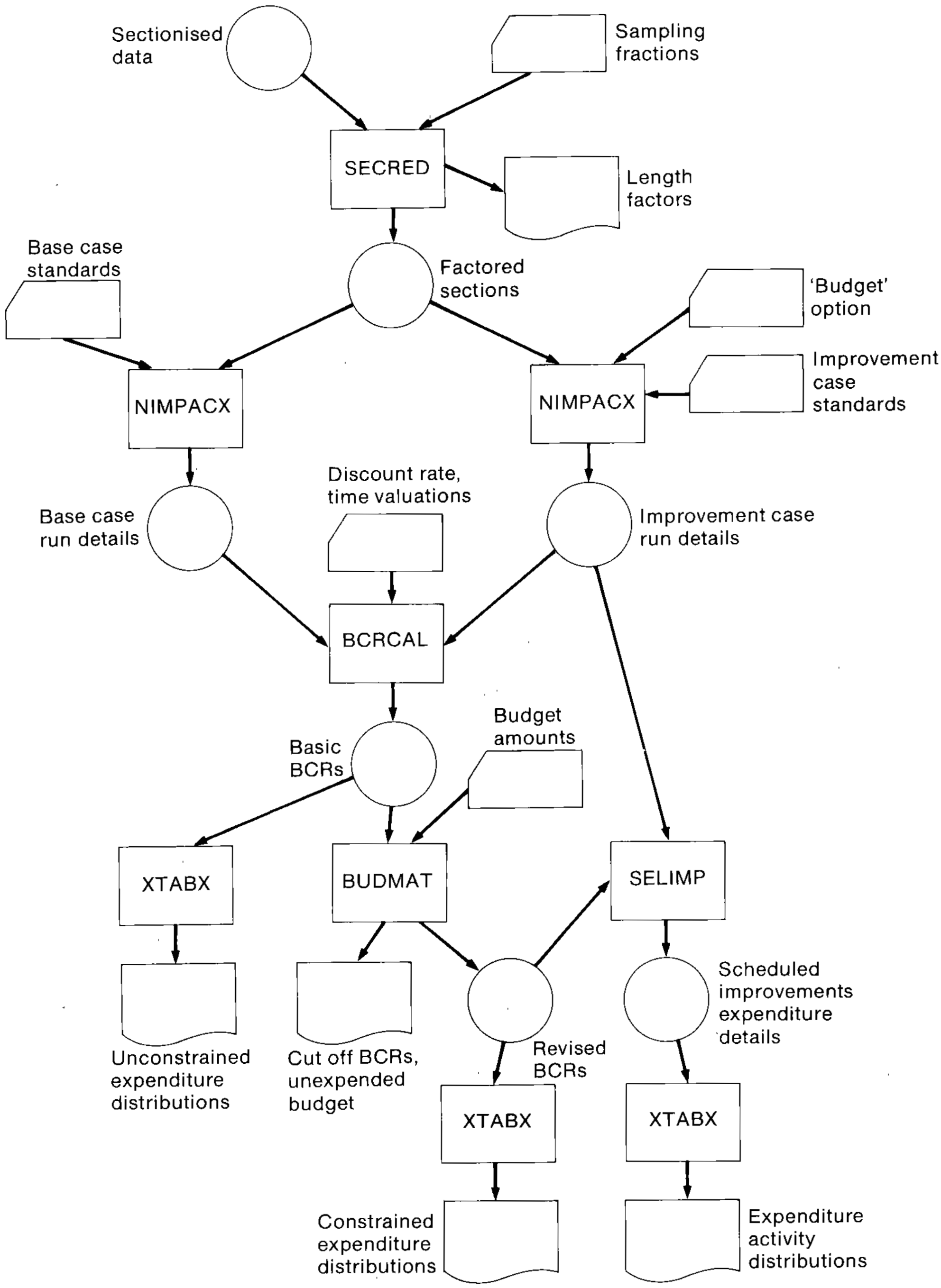


Figure 4.3—Overview of the extended NIMPAC system

CHAPTER 5—ECONOMIC ASSESSMENT

The economic returns on possible future rural arterial road investment programs were determined using the extended version of the NIMPAC road planning model described in Chapter 4. The five years 1985-86 to 1989-90 were the budget period of interest.

The NIMPAC model calculates project, maintenance and road user costs associated with individual road sections, and the BTE extended this capability to produce benefit cost ratios for work programs. The extended model was applied to a sample of road sections in each State to estimate the expected returns from a range of funding levels provided by the application of four sets of assessment and design standards, which are designated as S1, S2, S3 and S4 (see Appendix III for details). Standards S2 generate expenditure in real terms at about the current (1980-81) level. Standards S1 generate a lower level of expenditure, Standards S3 a higher expenditure level and Standards S4 a higher level again. The actual expenditure levels produced by the standards are discussed later in the chapter. To simplify the subsequent discussion 'higher' standards will be used to designate standards that generate higher expenditure levels, and 'lower' standards will refer to those that generate lower expenditure levels.

The model was applied in this way to give an indication of the economic returns that would result from the use of standards that were likely to be applied in practice by SRAs in response to changes in funding levels. This is in recognition of the fact that SRAs have objectives other than pure economic efficiency in determining road investment programs; these include generally meeting community expectations and maintaining a steady flow of work for the workforce in each region.

Detailed results of the economic assessment work are presented, State by State, in Appendixes IV to XI. The discussion in this chapter is based principally on the summary tables given here, which draw together data from all States and the Northern Territory. Reference to the more detailed State tables is made to amplify and illustrate more clearly certain points.

ECONOMIC RETURN ON INVESTMENT

The economic returns on NIMPAC-generated investment in rural arterial roads in the budget period (1985-86 to 1989-90) for each State and each set of standards are shown in Table 5.1. The measures used in the table are the average benefit cost ratio and the proportion of expenditure with a benefit cost ratio greater than one, at a discount rate of 7 per cent.

Looking first at the application of the 'current' (S2) standards, it is apparent that there are substantial returns to be achieved from maintaining the current level of investment in rural arterial roads in Australia during the five year period 1985-86 to 1989-90. The analysis produced an average BCR for Australia of 2.6, with ratios of at least that level in the three most populous States, and between one and two in South Australia, Western Australia and Tasmania.

In moving to higher standards (S3 and S4) which generate higher levels of expenditure, there is very little change in the average benefit cost ratios produced. In other words, additional funds could be allocated to work on rural arterial roads in Australia with essentially the same overall return on investment. On the other hand, moving to a lower standard (S1), and hence lower expenditure, a significant increase in the average benefit cost ratio is achieved overall and in a majority of States.

TABLE 5.1—OVERALL BENEFIT COST RATIO AND PERCENTAGE OF EXPENDITURE ON RURAL ARTERIALS WITH BENEFIT COST RATIO GREATER THAN ONE BY STATE, 7 PER CENT DISCOUNT RATE: 1985-86 TO 1989-90

	New South Wales	*Victoria*	*Queensland*	*South Australia*	*Western Australia*	*Tasmania*[a]	*Northern Territory*	*Australia*
S1 standards								
Per cent of expenditure with BCR > 1	78.7	50.9	88.3	55.1	41.4	..	85.7	78.0[b]
Overall BCR	3.1	3.7	4.9	2.2	1.1	..	1.1	3.7[b]
S2 standards								
Per cent of expenditure with BCR > 1	73.9	62.9	61.4	79.2	44.7	56.9	24.0	64.0 (64.4[b])
Overall BCR	2.6	3.6	3.2	1.8	1.5	1.1	0.7	2.6 (2.7[b])
S3 standards								
Per cent of expenditure with BCR > 1	69.4	67.0	61.0	82.1	46.2	..	12.2	63.0[b]
Overall BCR	2.6	3.4	3.1	2.3	1.9	..	0.5	2.7[b]
S4 standards								
Per cent of expenditure with BCR > 1	68.0	63.4	59.3	79.1	40.3	..	12.0	60.5[b]
Overall BCR	2.8	3.1	2.6	2.2	1.7	..	0.5	2.6[b]

a. Only one set of standards (S2) were used in Tasmania (see discussion under 'Tasmania').
b. Excludes Tasmania.

.. Not applicable

Note: Data in this table are based on upgrading programs generated by the NIMPAC road planning model.

At the current (S2) standards, the proportion of expenditure with a BCR greater than one is generally in the range 60 to 70 per cent. The remaining 30 to 40 per cent of expenditure is devoted to road sections which were identified as deficient according to the S2 standards but for which the benefits of the proposed improvement projects were not sufficient to make the projects economically viable (that is, a BCR greater than one). Surprisingly, this proportion changes little as the standards are modified to generate additional expenditure (up to S4 standards). Moving to lower standards increases the proportion of expenditure with a BCR greater than one in some States and decreases it in others; for Australia as a whole the proportion increases substantially.

It should be recognised that there are two opposing forces operating which affect benefit cost ratios as standards are modified to accommodate changing funding levels. One response to lower funding is simply to delay projects until higher traffic levels are experienced. This will generally increase the benefit cost ratio as greater benefits accrue from upgrading a road section when the traffic volume is higher. If, however, the response to lower funding is to concentrate on maintaining the basic riding quality of the road by doing more rehabilitation and gravel resheeting, which generally have a smaller economic return, then lower funding may result in smaller benefit cost ratios. In practice the response to lower funding will be a mixture of these two, but the emphasis on one or the other will affect the magnitude of the resulting BCRs.

It is clear from Table 5.1 that road authorities do not ration their funds in such a way as to maximise economic returns. As discussed earlier, they have priorities other than maximising economic efficiency as measured by benefit cost ratios. In addition they may take into account costs and benefits not adequately represented by the NIMPAC model.

Economic returns are highest in the three most populous States, New South Wales, Queensland and Victoria. These States have the highest traffic volumes, and road user benefits are highly dependent on traffic volume. However, comparing average BCRs for States may be somewhat misleading because of different distributions of BCRs in different States (see Figure 5.3). There is a larger amount of expenditure with high BCRs in Victoria and Queensland than in the other States and this tends to raise the average BCR (see discussion on 'High benefit cost ratios' below). In addition, some care must be exercised in comparing benefit cost ratios across States because of shortcomings in the NIMPAC model which may have different effects in different States. For example, the relationship between age and roughness is difficult to measure and varies between States (see Figure 4.2), and vehicle operating costs are quite sensitive to the roughness count.

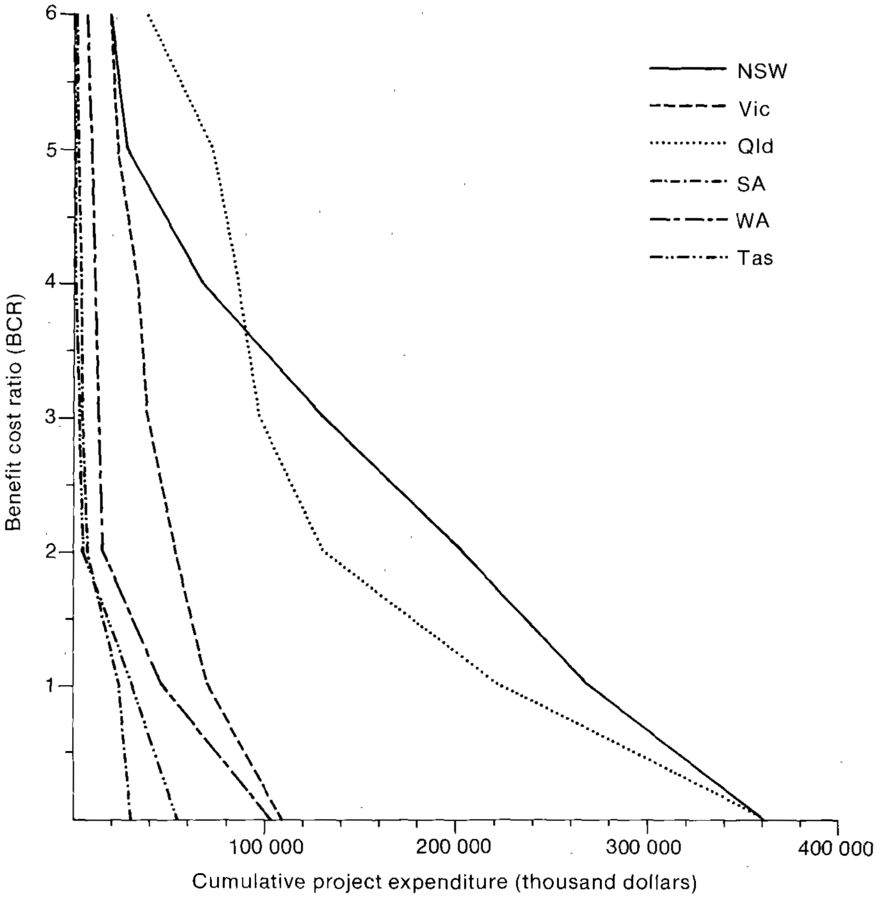
Table 5.1 presents two summary measures of economic returns, but it is useful to examine the complete distribution of benefit cost ratios. Figure 5.1 plots, for S2 standards at a 7 per cent discount rate, the total expenditure for all projects with a benefit cost ratio greater than the BCR value given on the vertical axis. Figure 5.2 shows the same information but with all expenditures expressed as a percentage of total project expenditure. It can be seen from this figure that the proportion of expenditure with a BCR greater than two is higher in New South Wales and Victoria than in the other States. In addition, the percentage of projects with a benefit cost ratio greater than two has a wider range across the States than the percentage of projects with a benefit cost ratio greater than one.

Differences in the distributions of BCRs in the different States can be seen more clearly from the frequency distributions in Figure 5.3. Whilst New South Wales exhibits a relatively even distribution across BCR ranges, Victoria and Queensland tend to have U-shaped distributions, with a large number of projects having either high or low BCRs. South Australia, Western Australia and Tasmania have relatively little expenditure with a BCR greater than two.

High benefit cost ratios

It can be seen from Figure 5.2 that for the S2 standards and a 7 per cent discount rate, nearly 17 per cent of NIMPAC-generated expenditure in Victoria was devoted to projects with a BCR greater than six, whilst for Queensland this figure was 10.5 per cent. There were also a number of projects in the other States with high BCRs. In many cases there are special circumstances pertaining which inflate these BCRs. It is considered that these situations (particularly where the calculated BCR is greater than 10) should simply be interpreted as having large returns but with no specific BCR attached.

There are a number of projects which produce high BCRs, mainly in Queensland and to a lesser extent in New South Wales, which are in area class 4 (that is, in towns). Road improvements tend to be more individualistic in towns and the average cost data applied may not be entirely appropriate. Also 'in town' projects often have



Note: For Queensland, for example, project expenditure totalling $72 million has a BCR greater than 5, a total of $97 million has a BCR grater than 3 and $222 million has a BCR greater than 1.

Figure 5.1—All States cumulative project expenditure (1985-86 to 1989-90) in 1980-81 prices by benefit cost ratio, S2 standards, 7 per cent discount rate

very high traffic volumes and hence have the potential to generate very large benefits. These effects can lead to projects with very high BCRs. Whilst all projects in area class 4 (in towns) do not have especially large BCRs, it is noted that the average BCR for Queensland for projects in area class 5 (out of town) alone is 2.4, compared with the average of 3.2 for projects in both area classes 4 and 5. The corresponding figures for New South Wales are an average BCR of 2.3 for area class 5 (out of town) only and 2.6 for both area classes 4 and 5.

Projects with high BCRs are almost always associated with high traffic volumes. Of projects with a BCR greater than 10 in Victoria, none had an AADT less than 3000, almost all had an AADT in excess of 6000 vehicles a day and more than half had an AADT greater than 10 000. To give some indication of the contribution of these high benefit cost ratios to average BCRs, it is noted that if all projects in Victoria with a BCR greater than 10 had their BCR reduced to 10, the average BCR for the State as a whole would be reduced from 3.6 to 2.9. Also, the average BCR for all projects in Victoria with a BCR less than 10 is 2.2.

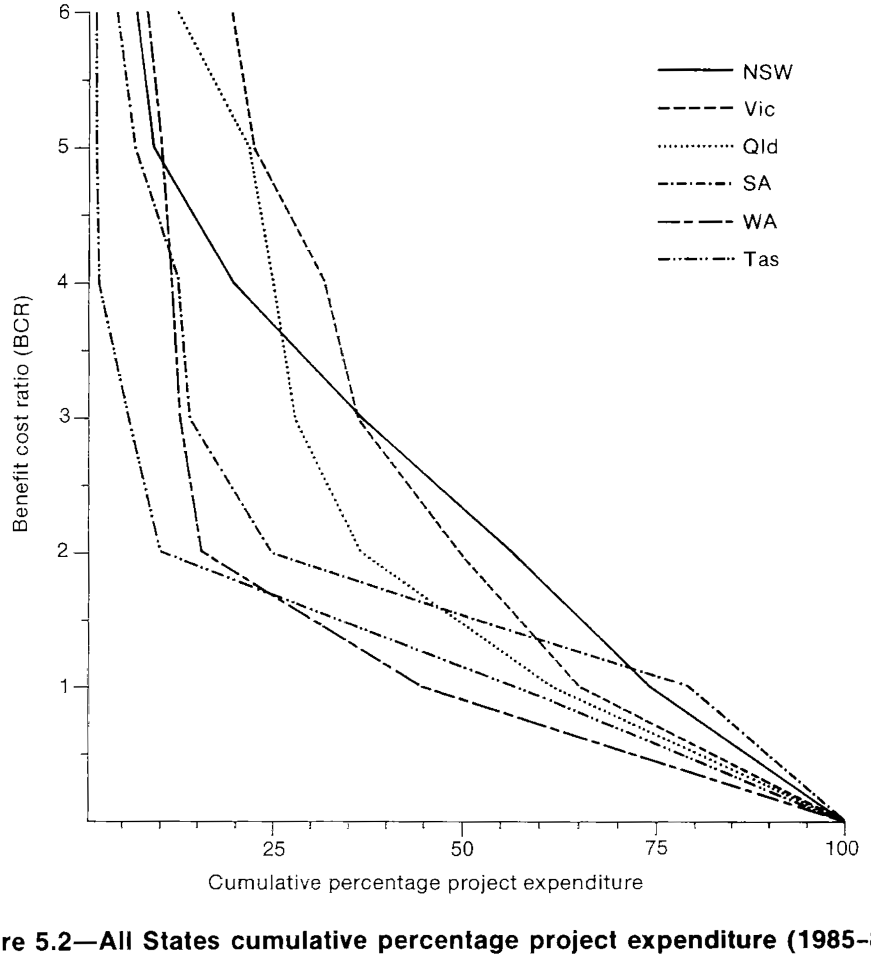


Figure 5.2—All States cumulative percentage project expenditure (1985-86 to 1989-90) by benefit cost ratio, S2 standards, 7 per cent discount rate

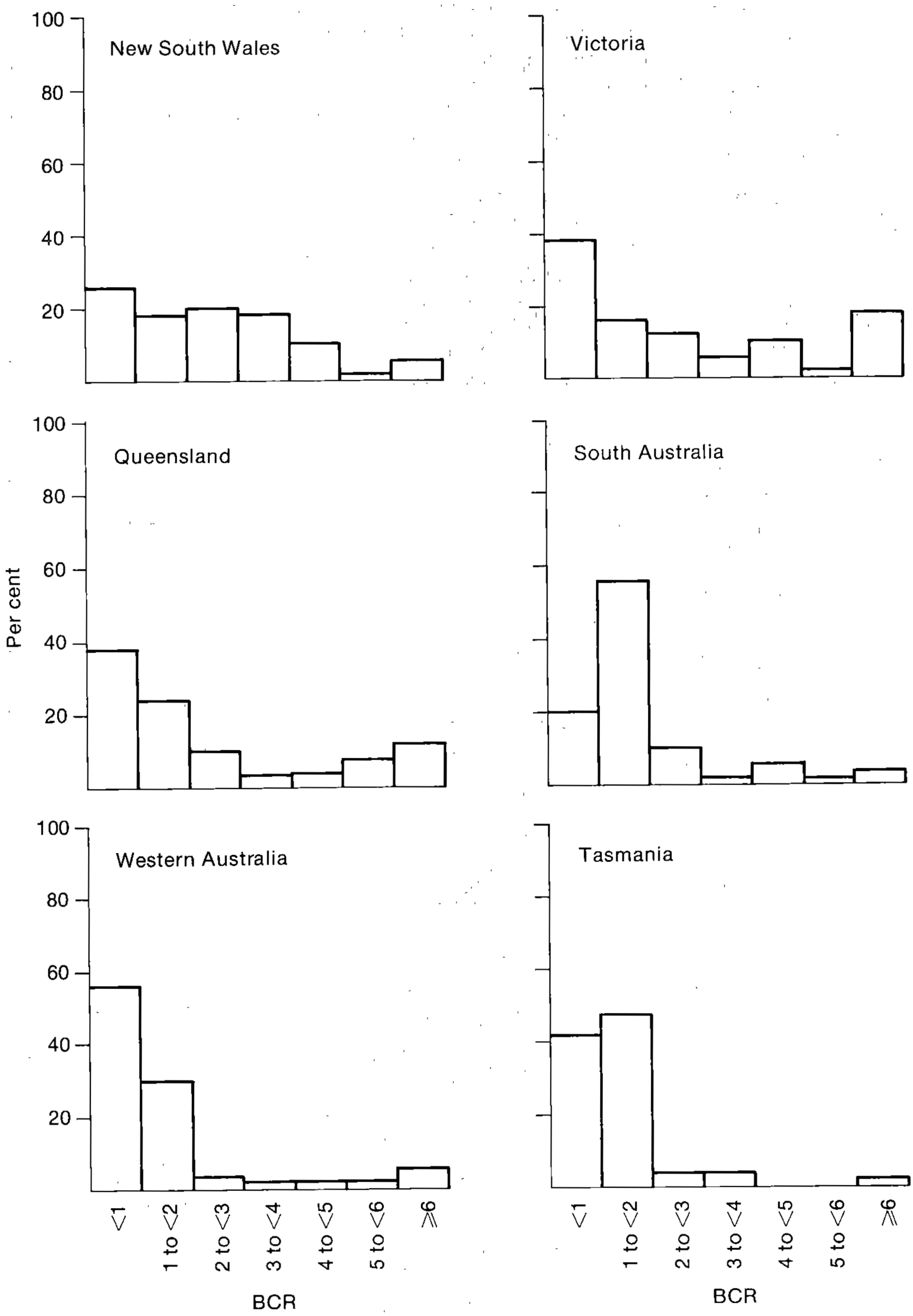


Figure 5.3—Frequency distribution, per cent of expenditure (1985-86 to 1989-90) by benefit cost ratio ranges, all States, S2 standards, 7 per cent discount rate

High BCRs sometimes occur because projects are delayed well past the time when they are economically justified. This is particularly likely to occur when a project is expensive (for example duplication work) as it is sometimes difficult to fit such projects into a program of works when there is a limited budget. BTE analysis (BTE 1984a, Chapter 7) indicates that the benefit cost ratio for upgrading a broad two lane sealed road to a dual carriageway reaches one at about 5000 vehicles a day (for a 7 per cent discount rate). On the other hand, the S2 assessment standards specify, for a two lane road, a maximum traffic volume of 8 000 vehicles a day in New South Wales, 9 000 in South Australia, 10 000 in Tasmania, 13 000 in Victoria, 15 000 in Queensland and 16 000 in Western Australia (see Appendix III). Therefore substantial economic returns would be expected from duplication work, particularly in Victoria and Queensland (there is no duplication in Western Australia under the S2 standards).

Although projects with high BCR values represent only a relatively small proportion of total expenditure they can have a significant effect on average BCRs. At the same time it should be recognised that the shape of the distribution of BCRs in the lower ranges and the proportion of expenditure with a BCR greater than (say) one are not affected by these high BCR projects.

Discount rate

The sensitivity of the benefit cost ratio to the discount rate is shown in Table 5.2. The average benefit cost ratio for each State and the Northern Territory at discount rates of 4, 7 and 10 per cent are presented for the four sets of standards. All project costs are deemed to occur in the year a project is completed, while benefits start from the following year and continue for 30 years. Because the benefits flowing from a project accrue in later time periods than the costs, lower discount rates give higher average benefit cost ratios. The average benefit cost ratios vary quite markedly with discount rate because of the distinct temporal separation of costs and the stream of benefits. The percentage of expenditure with a benefit cost ratio greater than one varies even more as the discount rate changes (see data for individual States in the Appendixes).

WORK TYPES

The mix of project types in a given works program can have an important effect on the total cost of the program and also on the economic returns that flow from this expenditure. Classification of road work performed into a set of categories is difficult and somewhat arbitrary. The classification used in this study was based on that used in the NAASRA Roads Study, and is set out in Table 5.3.

The breakdown of total expenditure into work types is shown for each State and the Northern Territory and for each set of standards in Table 5.4. The changes in the relative importance of different work types as the standards are modified reflect the different strategies adopted by State Road Authorities to possible changes in expenditure levels, bearing in mind the condition of the road system and the terrain in each State. Generally, at lower standards there tends to be more emphasis on rehabilitation and gravel resheeting as the road authorities have a commitment to maintaining the system in a 'reasonable' condition. If additional funds were made available the indications are that there would be a move to more expensive work types such as widening of existing roads, adding lanes and duplication. However, the increased importance of these varies according to the strategy adopted by the individual State.

The average benefit cost ratio and the percentage of expenditure with a BCR greater than one is presented for each work type in Table 5.5 for the S2 standards at a 7 per cent discount rate. The work types (for Australia as a whole) fall into three groupings of BCRs. The high traffic group of 'widening to 6 or 8 lanes', 'duplication'

TABLE 5.2—AVERAGE BENEFIT COST RATIOS FOR RURAL ARTERIALS, VARYING DISCOUNT RATES BY STATE: 1985-86 TO 1989-90

Discount Rate (per cent)	*New South Wales*	*Victoria*	*Queensland*	*South Australia*	*Western Australia*	*Tasmania*	*Northern Territory*	*Australia*
S1 standards								
4	4.0	5.2	7.0	3.2	1.6	..	1.3	5.0[a]
7	3.1	3.7	4.9	2.2	1.1	..	1.1	3.7[a]
10	2.4	2.6	3.6	1.7	0.8	..	0.9	2.8[a]
S2 standards								
4	3.3	5.1	4.7	2.6	1.9	1.4	0.8	3.6 (3.7[a])
7	2.6	3.6	3.2	1.8	1.5	1.1	0.7	2.6 (2.7[a])
10	2.1	2.6	2.3	1.4	1.2	0.9	0.5	2.0 (2.1[a])
S3 standards								
4	3.3	4.8	4.5	3.4	2.5	..	0.6	3.7[a]
7	2.6	3.4	3.1	2.3	1.9	..	0.5	2.7[a]
10	2.1	2.5	2.2	1.7	1.4	..	0.4	2.0[a]
S4 standards								
4	3.7	4.4	3.6	3.1	2.3	..	0.6	3.5[a]
7	2.8	3.1	2.6	2.2	1.7	..	0.5	2.6[a]
10	2.2	2.3	1.9	1.6	1.2	..	0.4	1.9[a]

a. Excludes Tasmania.

.. Not applicable

Note: Benefit cost ratios are based on upgrading programs generated by the NIMPAC model.

and 'overtaking lanes' have very high BCRs. The middle group with BCRs of 2.5 to 3.0 consists of 'realign and widen', 'realign', 'rehabilitate and widen' and 'rehabilitate'. The remaining work types comprise a predominantly low traffic group with BCRs around one; the exception is 'new two lane seal' which has an average BCR of about two.

The proportion of projects with BCRs greater than one follows a similar pattern. The high traffic group has a very high proportion of BCRs greater than one, perhaps indicating that road authorities have somewhat conservative standards for these types of work. The figures showing the proportion of projects with a benefit cost ratio greater than one should be treated with some caution as they can be quite sensitive to the discount rate.

Expenditure level

It should be noted that the expenditure amounts generated by each set of standards in this study are not directly comparable with the expenditure produced by these same standards in the analysis for the NAASRA Roads Study. Also the relativities between the expenditure levels generated by the four sets of standards are not immediately obvious. Firstly, the expenditure of interest here is for a particular five years out of the 10 year NAASRA analysis period (expenditure was not generally matched on a year by year basis in the NAASRA work). Secondly, expenditure on rural arterials only is considered in this study, whilst the NAASRA standards were

TABLE 5.3—DEFINITION OF WORK TYPE FOR ROAD PROJECTS

Abbreviation	*Work type*	*Description*
DUPW	Widening to 6 or 8 lanes	Add lanes to make a 6 or 8 lane road
DUP	Duplicate	Add lanes to make a 4 lane road[a]
OTAK	Overtaking lanes	Add overtaking lanes to a 1 or 2 lane road
2ALW	Realign and widen (2 lane)	Realign and widen within 2 sealed lanes
REAL	Realign (existing width)	Realign existing number of sealed lanes
2W	Rehabilitate and widen (2 lane)	Rehabilitate and widen within 2 sealed lanes
RHAB	Rehabilitate (existing width)	Rehabilitate existing number of sealed lanes
1TO2	Widen to 2 lanes	Add one lane only to a sealed single lane
NEW2	New 2 lane seal	New seal-2 or more lanes in width
NEW1	New 1 lane seal	New seal-1 lane width
GRAV	Gravel resheet	Resheet and/or realign existing unsealed pavement or existing formations
NEWG	New gravel	New gravel pavement (unsealed, paved over 100mm)
FORM	New formation	New formation (paved up to 100mm)
CONV	Miscellaneous	All other work

a. When a carriageway is to be duplicated, all expenditure on the original carriageway prior to completion of the new carriageway is included in DUP. In the original NIMPAC this expenditure was assigned to the relevant work type (widening, rehabilitation etc.).

TABLE 5.4—EXPENDITURE ON RURAL ARTERIALS FOR EACH STANDARD BY WORK TYPE BY STATE: 1985-86 TO 1989-90

($'000 1980-81 prices)

State	*DUPW*	*DUP*	*OTAK*	*2ALW*[a]	*REAL*[a]	*2W*	*RHAB*	*1TO2*	*NEW2*	*NEW1*	*GRAV*	*NEWG*	*FORM*	*CONV*	*Total*
New South Wales															
S1	-	-	-	29 388	54 848	3 904	63 948	-	-	-	21 614	-	-	-	173 702
S2	-	31 472	3 266	65 028	81 550	85 388	64 402	-	3 911	-	27 139	-	-	-	362 156
S3	3 131	22 630	4 784	77 299	75 338	108 557	99 394	1 169	56 124	-	51 904	-	-	-	500 330
S4	3 131	33 227	5 404	90 753	84 058	149 844	113 212	2 084	114 230	-	66 478	2 606	-	-	665 027
Victoria															
S1	2 371	1 054	520	-	-	1 413	11 532	1 957	-	-	3 360	-	-	1 074	23 281
S2	2 112	14 075	1 010	9 782	8 920	28 708	20 443	2 169	-	-	18 532	-	-	1 208	106 959
S3	2 112	22 810	2 705	22 593	15 740	45 593	34 349	7 364	-	-	18 532	-	-	1 337	173 135
S4	2 291	43 619	1 712	50 075	13 711	50 742	31 643	14 281	-	-	19 560	-	-	1 467	229 101
Queensland															
S1	1 717	206	254	..	..	36 852	6 223	10 998	94 388	-	15 277	-	-	5 658	171 571
S2	1 717	7 809	254	..	..	67 095	10 149	33 976	215 991	-	9 895	8 215	-	5 658	360 757
S3	1 717	13 047	254	..	..	170 042	23 718	92 584	256 801	-	7 990	-	-	5 658	571 810
S4	2 660	41 084	254	..	..	240 465	40 512	165 963	288 521	-	2 237	-	-	5 658	787 352
South Australia															
S1	252	5	172	-	-	8 329	3 874	598	-	-	-	-	-	-	13 230
S2	252	5	172	7 361	1 204	3 470	3 212	804	13 718	-	-	-	-	-	30 198
S3	252	7 290	172	18 152	2 457	14 666	3 462	1 358	13 718	-	-	-	-	-	61 527
S4	252	7 714	172	25 212	1 472	26 615	4 720	3 631	13 718	-	-	-	-	-	83 506
Western Australia															
S1	-	-	-	-	-	7 887	-	1 690	-	-	2 891	-	2 285	11 613	26 365
S2	-	-	1 604	421	1 400	35 224	8 694	7 320	10 830	3 892	4 251	-	14 243	14 433	102 311
S3	2 282	8 717	4 000	421	2 055	46 553	8 197	8 900	12 189	3 892	3 571	14 548	19 578	2 128	137 031
S4	2 418	15 102	4 757	2 880	3 367	74 561	13 818	10 015	12 189	23 913	34 352	4 339	8 135	15 719	225 566

TABLE 5.4(Cont)—EXPENDITURE ON RURAL ARTERIALS FOR EACH STANDARD BY WORK TYPE BY STATE: 1985-86 TO 1989-90

($'000 1980-81 prices)

State	*DUPW*	*DUP*	*OTAK*	*2ALW*[a]	*REAL*[a]	*2W*	*RHAB*	*1TO2*	*NEW2*	*NEW1*	*GRAV*	*NEWG*	*FORM*	*CONV*	*Total*
Tasmania															
S2[b]	–	–	–	..	..	45 494	3 859	789	–	–	3 743	–	–	–	53 885
Northern Territory															
S1	–	–	–	–	–	1 501	208	–	–	–	43	–	–	–	1 752
S2	–	–	–	–	–	1 501	5 039	–	–	6 239	2 971	–	–	–	15 749
S3	–	–	–	–	–	1 501	14 208	–	–	6 239	9 138	–	–	–	31 085
S4	–	–	–	–	–	1 501	14 208	–	–	12 171	7 134	–	–	–	35 013

a. Queensland and Tasmania have no alignment data, so this work type was not generated for those States.
b. Only the S2 standards were used in Tasmania (see discussion under 'Tasmania' below).

– nil or rounded to zero

.. not applicable

Note: Data in this table are based on upgrading programs generated by the NIMPAC model. The work types, including the abbreviations used, are defined in Table 5.3

TABLE 5.5—BENEFIT COST RATIOS BY WORK TYPE BY STATE, S2 STANDARDS, 7 PER CENT DISCOUNT RATE: 1985-86 TO 1989-90

State	*DUPW*	*DUP*	*OTAK*	*2ALW*[a]	*REAL*[a]	*2W*	*RHAB*	*1TO2*	*NEW2*	*NEW1*	*GRAV*	*NEWG*	*FORM*	*CONV*	*Total*
New South Wales															
Per cent of expenditure with BCR > 1	..	100.0	100.0	66.5	83.5	66.0	57.5	..	72.1	..	92.6	..	..	..	73.9
Overall BCR	..	3.5	b	2.8	2.9	2.1	2.1	..	2.6	..	2.0	..	..	..	2.6
Victoria															
Per cent of expenditure with BCR > 1	41.1	100.0	100.0	100.0	0.3	92.3	67.4	–	..	..	1.4	..	..	83.3	69.2
Overall BCR	3.5	9.0	b	2.6	0.4	2.6	2.5	0.9	..	..	0.1	..	..	4.5	3.6
Queensland															
Per cent of expenditure with BCR > 1	100.0	100.0	100.0	..	..	88.0	59.7	75.1	53.9	..	2.7	53.4	..	–	61.4
Overall BCR	b	b	b	..	..	5.4	3.4	1.4	2.2	..	0.7	0.9	..	0.4	3.2
South Australia															
Per cent of expenditure with BCR > 1	100.0	100.0	100.0	43.7	100.0	65.6	95.8	–	100.0	..	..	..	..	..	79.2
Overall BCR	4.7	5.0	6.9	1.3	3.7	2.2	3.3	0.8	1.5	..	..	..	..	..	1.8

TABLE 5.5(Cont)—BENEFIT COST RATIOS BY WORK TYPE BY STATE, S2 STANDARDS, 7 PER CENT DISCOUNT RATE: 1985-86 TO 1989-90

State	*DUPW*	*DUP*	*OTAK*	*2ALW*[a]	*REAL*[a]	*2W*	*RHAB*	*1TO2*	*NEW2*	*NEW1*	*GRAV*	*NEWG*	*FORM*	*CONV*	*Total*
Western Australia															
Per cent of expenditure with BCR > 1	..	..	100.0	–	–	60.8	89.5	0.8	73.0	10.8	40.2	..	–	33.8	44.7
Overall BCR	..	..	3.8	0.4	0.1	2.4	6.0	0.5	1.0	0.8	1.1	..	0.2	1.0	1.5
Tasmania															
Per cent of expenditure with BCR > 1	..	..	..	..	..	63.2	44.1	–	..	..	5.0	..	..	..	56.9
Overall BCR	..	..	..	..	..	1.3	1.1	0.5	..	..	0.6	..	..	..	1.1
Northern Territory															
Per cent of expenditure with BCR > 1	..	..	..	..	..	100.0	–	..	..	31.6	10.5	..	..	..	24.0
Overall BCR	..	..	..	..	..	1.2	0.3	..	..	0.9	0.5	..	..	..	0.7

TABLE 5.5(Cont)—BENEFIT COST RATIOS BY WORK TYPE BY STATE, S2 STANDARDS, 7 PER CENT DISCOUNT RATE: 1985-86 TO 1989-90

State	*DUPW*	*DUP*	*OTAK*	*2ALW*[a]	*REAL*[a]	*2W*	*RHAB*	*1TO2*	*NEW2*	*NEW1*	*GRAV*	*NEWG*	*FORM*	*CONV*	*Total*
Australia															
Per cent of expenditure with BCR > 1	69.5	100.0	100.0	68.1	74.5	73.4	60.0	56.8	57.6	23.6	43.1	53.4	–	27.6	64.0
Overall BCR	b	7.2	b	2.6	2.6	2.9	2.5	1.2	2.1	0.8	1.1	0.9	0.2	1.3	2.6

a. Queensland and Tasmania have no alignment data, so this work type was not generated for those States.

b. The model produced BCRs greater than 10 for these cases. However, in many situations there were special circumstances pertaining which inflated the BCRs. Generally it is considered that these cases should simply be interpreted as having large returns but with no specific BCR attached. See also discussion on 'High benefit cost ratios'.

– nil or rounded to zero

.. not applicable

Note: Data in this table are based on upgrading programs generated by the NIMPAC model. The work types, including the abbreviations used, are defined in Table 5.3.

devised for rural and outer urban arterials including bridges. Finally, it must be remembered that the updating of road inventories from 1981 to 1985 was carried out using S2 standards. It was only in the budget period and following years that the different standards were applied. When all these factors are taken into account the expenditure levels generated in this study for the different standards have approximately the same relationship to one another as those in the NAASRA Roads Study.

DISCUSSION ON INDIVIDUAL STATES

New South Wales

Expenditure generated by NIMPAC for rural arterial roads in New South Wales has an overall benefit cost ratio of 2.6 for the S2 standards with a 7 per cent discount rate. About 74 per cent of the expenditure has a benefit cost ratio greater than one. Reducing the level of expenditure by moving to the S1 standards concentrates resources on the work types 'realignment' and 'rehabilitation'. There is a greater proportionate effort devoted to maintaining the road system, but also some delaying of projects until higher traffic levels are reached; the result is an increase in the average BCR to 3.1. On the other hand if the S3 or S4 standards are employed to increase expenditure, there is almost no change in average BCRs or proportion of expenditure on projects with a BCR greater than one (from the S2 standards).

Although the S1 standards result in the highest proportion of expenditure with a benefit cost ratio greater than one, it should be remembered that there is a much greater absolute expenditure on projects with high benefit cost ratios at the higher standards. Indeed if the projects generated by the S4 standards are ranked in decreasing order of BCR and the S1 expenditure level applied, all projects selected would have a benefit cost ratio greater than three.

Victoria

At the 7 per cent discount rate, the analysis produced an overall benefit cost ratio for Victoria of 3.6 for the S2 standards, with a range from 3.7 at S1 to 3.1 at S4 standards. There is a greater percentage of projects with very high BCRs in Victoria than in any other State (Figure 5.2 and earlier discussion on 'High benefit cost ratios') and hence these average BCRs are probably inflated in relation to those for other States. The relatively high benefit cost ratios in Victoria result principally from high traffic densities. The proportion of expenditure on projects with benefit cost ratios greater than one ranged from 51 per cent at the S1 standards to between 63 and 67 per cent for the other standards.

At the S1 standards rehabilitation accounts for almost half of the budget compared with less than 20 per cent in the case of the other standards. The proportion of expenditure on rehabilitation with a BCR greater than one is relatively low (46 per cent) for the S1 standards; it is 67 per cent for the S2 standards (see Table VI.1). This accounts for the relatively low proportion of expenditure in Victoria with a BCR greater than one (51 per cent) at the S1 standards.

Queensland

Under the S2 standards in Queensland, sealing gravel roads is the predominant worktype generated by NIMPAC, accounting for 60 per cent of project expenditure. At a 7 per cent discount rate an overall benefit cost ratio of 3.2 was obtained in Queensland for the S2 standards, with a range from 4.9 at S1 to 2.6 at S4 standards. Higher expenditure in relation to the length of the road network is generated in Queensland than any other mainland State.

Benefit cost ratios for Queensland could be a little understated compared with those for the other States because of the lack of alignment data. The costs in the model are increased to allow for expenditure on realignment. However, as the benefits do not include gains resulting from realignment, it is expected that the benefit cost ratios are understated, although probably not to a large extent.

The average benefit cost ratios for widening a duplicated road to six or eight lanes and providing overtaking lanes are very high for all sets of standards. However, all these projects occur 'in towns', and such projects tend to be rather individualistic. As a result the 'average' standards and costings applied by the model are often inappropriate for such situations. It is considered that those cases should simply be interpreted as having large returns, but with no specific BCR attached to them. Notice also that these very high BCRs will tend to inflate the average BCRs in Queensland (see earlier discussion under 'High benefit cost ratios').

The proportion of expenditure on projects in Queensland with benefit cost ratios greater than one is about the same at the S2, S3 and S4 standards (around 60 per cent) but increases markedly to 88 per cent at the S1 standards. A much higher proportion of new two lane seals (the majority work type) has benefit cost ratios greater than one at the S1 standards (see Table VII.1).

South Australia

Utilising the S2 standards, NIMPAC generates a program of improvements for South Australia which allocates 79 per cent of expenditure to projects with a benefit cost ratio greater than one, higher than for any other State. However, the overall benefit cost ratio for South Australia is relatively low at 1.8. This occurs because of the large number of projects with a BCR between one and two (see Figure 5.3). Project expenditure at the S2 standards is concentrated on new two lane seals (45 per cent of total expenditure) and realignment combined with widening (24 per cent).

If expenditure is increased by moving to the S3 or S4 standards, there is a small increase in the BCRs derived, while the proportion of expenditure on projects with a BCR greater than one remains at about the same level. On the other hand, applying the S1 standards reduces the percentage of projects with a benefit cost ratio greater than one to only 55, principally because no new sealing of two lane roads is carried out. All projects with this work type have a benefit cost ratio greater than one at the other standards. Also, at the S1 standards, 63 per cent of expenditure is devoted to widening, a work type with relatively low economic returns.

Western Australia

Using the S2 standards with a 7 per cent discount rate, the analysis for Western Australia resulted in 45 per cent of expenditure being allocated to projects with a benefit cost ratio greater than one, the lowest percentage for any State. However, the average benefit cost ratio of 1.5 is comparable with those for South Australia and Tasmania. Western Australia has a long length of lightly trafficked road and this leads to many projects with low benefit cost ratios. Western Australian authorities have stressed the importance of other criteria against which roads should be assessed in remote areas, such as provision of access for social as well as defence purposes and the provision of infrastructure for developing areas (particularly export producing developments).

At higher standards benefit cost ratios in Western Australia increase slightly. This results from more emphasis being given to higher trafficked roads with more projects such as duplication and provision of overtaking lanes being done. The proportion of expenditure on projects with a BCR greater than one remains at about the same level at the higher standards.

Tasmania

Tasmania is reported only at the S2 standards and like Queensland has no alignment data[1]. This lack of alignment data leads to some understatement of benefit cost ratios (as discussed earlier for Queensland).

The overall benefit cost ratio for the S2 standards in Tasmania is 1.1 at a 7 per cent discount rate. The proportion of expenditure with a BCR greater than one is 57 per cent.

Northern Territory

At the S2 standards, the Northern Territory has a lower overall benefit cost ratio (0.7) and a lower percentage of projects with a benefit cost ratio greater than one (24 per cent) than any of the States. This is mainly due to low traffic levels in the Territory. Non-quantifiable benefits such as defence and infrastructure development may be considered to be relatively more important in the Northern Territory.

New one lane sealing is the majority work type in the Northern Territory at the S2 standards but at higher standards rehabilitation becomes more important. Widening has an overall benefit cost ratio greater than one, but all other work types have average benefit cost ratios less than one at all standards. The overall BCR at the S1 standards is 1.1 and widening is the predominant work type.

SUBSEQUENT BUDGET PERIOD

This study has concentrated on projects generated in the budget period, the five years 1985-86 to 1989-90. However, to provide an indication of likely developments after that time, NIMPAC generated expenditure was derived for the subsequent five years 1990-91 to 1994-95. Expenditures in the first and second budget periods are shown in Table 5.6.

The table indicates that there is generally more expenditure in the second budget period than the first, except in the case of Queensland. NIMPAC generated a large amount of expenditure in Queensland in the first year of analysis, indicating a backlog of work. For Australia as a whole, the larger expenditure generated in the second budget period indicates that some increase in real expenditure on roads may be needed in the period 1990-91 to 1994-95, over that in the previous five years, if use of the same set of assessment and design standards in carrying out road works in Australia is continued. However, the implied increase may also be partly a reflection of the assumptions of the model, which are subject to greater uncertainty with respect to the more distant period. No economic assessment of NIMPAC generated expenditure for 1990-91 to 1994-95 was undertaken.

SOURCE OF BENEFITS

A breakdown of the benefits into their various components is presented in Table 5.7. The benefits and costs shown in this table relate only to road sections on which there was a project improvement in the budget period 1985-86 to 1989-90. The S2 standards and a 7 per cent discount rate are used.

The dissection of benefits in Table 5.7 shows that upgrading roads leads to very low benefits to road authorities compared with the benefits to road users. Indeed the benefits to road authorities, in terms of savings in maintenance and resealing costs, are not always positive.

Benefits to road users are dominated by travel time savings and reductions in vehicle operating costs, with vehicle operating costs being more significant overall. The contribution of accident reduction to economic benefits is always quite small. This is partly due to the fact that costs of accident deaths are principally valued in NIMPAC

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1. Only the S2 standards were used in the analysis because NAASRA Road Study work indicates that at higher funding levels most of the additional funds would be allocated to improving road alignment. As there is no alignment in the inventory, this cannot be modelled by NIMPAC.

TABLE 5.6—EXPENDITURES IN THE FIRST AND SECOND BUDGET PERIOD BY STATE

($'000 1980-81 prices)

Standard	*New South Wales*	*Victoria*	*Queensland*	*South Australia*	*Western Australia*	*Tasmania*	*Northern Territory*	*Australia*
S1 standards								
First budget period	173 702	23 281	171 571	13 230	26 365	..	1 752	..
Second budget period	498 680	109 041	153 197	22 144	77 539	..	25 551	..
S2 standards								
First budget period	362 156	106 959	360 757	30 198	102 311	53 885	15 749	1 032 017
Second budget period	727 034	200 655	155 677	47 732	142 150	52 399	26 463	1 352 110
S3 standards								
First budget period	500 330	173 135	571 810	61 527	137 031	..	31 085	..
Second budget period	833 053	278 197	247 699	74 964	170 477	..	27 837	..
S4 standards								
First budget period	665 027	229 101	787 352	83 506	225 566	..	35 013	..
Second budget period	931 231	306 072	331 299	99 333	187 509	..	29 626	..

.. not applicable

Note: Data in this table are based on upgrading programs generated by the NIMPAC model. The first and second budget periods are 1985-86 to 1989-90 and 1990-91 to 1994-95 respectively.

TABLE 5.7—COMPONENTS OF BENEFITS BY STATE, S2 STANDARDS, 7 PER CENT DISCOUNT RATE

	New South Wales	*Victoria*	*Queensland*	*South Australia*	*Western Australia*	*Tasmania*	*Northern Territory*	*Australia*
Total discounted benefits[a]	668.7	318.7	828.9	35.9	138.3	49.3	9.7	2 049.2
Total discounted costs[a]	258.6	88.4	257.5	19.6	91.9	43.1	14.8	774.0
Discounted benefits as a percentage of total discounted benefits								
Road user								
Travel time	42.2	54.6	48.2	37.7	26.6	35.5	29.9	45.2
Vehicle operating costs	55.3	42.1	47.8	57.0	67.8	59.4	72.2	51.2
Accident costs	2.1	3.9	2.5	1.6	3.0	3.9	-1.1	2.6
Total	99.6	100.6	98.5	96.4	97.4	98.8	101.0	99.0
Road authority								
Maintenance	0.1	-0.9	2.3	3.8	1.2	0.1	0.4	1.0
Resealing	0.3	0.3	-0.7	-0.2	1.4	1.1	-1.4	-
Total	0.4	-0.6	1.5	3.6	2.6	1.2	-1.0	1.0

a. $ million, 1980-81 prices.

\- nil or rounded to zero

Notes: 1. Data in this table relate only to road sections with projects generated in the budget period (1985-86 to 1989-90).

2. Figures may not add to totals due to rounding.

by discounted lifetime earnings; no value is placed on pain and suffering for example. The efforts of governments to reduce the road toll indicate that the community is probably willing to pay rather more than this value to reduce road accidents.

Reductions in vehicle operating costs are more important than travel time savings in most States and the Northern Territory; the two components are of approximately equal importance in Queensland. Time savings represent a higher proportion of the benefits in the case of Victoria, probably reflecting the higher traffic densities experienced in that State. For a State as a whole the relative size of travel time and vehicle operating cost benefits depends mainly on the distribution of work types. Vehicle operating cost savings are larger than travel time savings in a majority of States for most of the major work types, 'realign and widen', 'realign', 'widen and rehabilitate' and 'gravel resheet'. For rehabilitation projects benefits associated with reductions in vehicle operating costs are much larger than travel time savings in all States. On the other hand, travel time savings are more important in all States except South Australia for duplication work. Clearly, within work types the proportion of travel time to vehicle operating cost benefits can vary considerably because of the special nature of individual projects.

The negative benefits in relation to accidents from upgrading of Northern Territory rural arterial roads is the result of additional lengths of single lane seal to which the model ascribes relatively high accident rates. This effect also occurs in some of the States but the losses on these particular road types are more than offset by accident reductions on other road types.

ROAD STUDY REGIONS

Changes in population and economic activity are not consistent across nor within States. Regional changes are often quite different from national or State averages. A series of regions were defined for the 1984 BTE Assessment of the Australian Road System (BTE 1984a) and details of the regions are given in that Report. Maps of the regions are provided in Figures V.3, VI.3, VII.3, VIII.3, IX.3 and X.2.

Economic returns from possible investment in rural arterial roads for the period 1985-86 to 1989-90 are presented in Table 5.8 for all regions, based on the S2 standards and a 7 per cent discount rate. Population growth for the decade 1971-1981 is also given for each region, together with the percentage of each State's rural arterial network length in each region and the regional expenditure (for 1985-86 to 1989-90) expressed as a percentage of the total expenditure for the State. Further details of the regional analysis are provided in Tables V.5, VI.5, VII.5, VIII.5, IX.5 and X.5.

There is considerable variation in the percentage of regional expenditure with a BCR greater than one. Regions encompassing capital cities register a high percentage because of associated high traffic volumes. The level of population growth over the past decade appears to be a good indicator of whether NIMPAC generates a higher or lower proportion of total State expenditure in a region than its proportion of the length of the rural arterial network, under the S2 standards. Regions with a much higher proportion of expenditure than rural arterial road length such as North Coast (New South Wales), South Gippsland and East Gippsland (Victoria), Mid-North Coast and North (Queensland) and Pilbara (Western Australia) have had high recent population growth. On the other hand, regions with a significantly smaller proportion of expenditure than rural arterial road length such as West (New South Wales), Murray and West (Victoria), South West (Queensland), North (South Australia) and Goldfields and Midlands (Western Australia) had a negative or small positive population growth between 1971 and 1981.

ALLOCATION OF FUNDS AMONG STATES

The prime purpose of this study was to investigate the benefits and costs of the sort of construction projects that are carried out by road authorities at current funding

TABLE 5.8—RETURNS ON RURAL ARTERIAL ROAD INVESTMENT PROGRAMS BY REGION, S2 STANDARDS, 7 PER CENT DISCOUNT RATE: 1985-86 TO 1989-90

State	*Region*[a]	*Location*	*Population growth (1971-1981) (per cent)*	*Region rural arterial length as a percentage of State total*	*Region expenditure as a percentage of State total*	*Percentage of of regional expenditure with BCR > 1*
New South Wales	201	Sydney area	7.6	0.1	–	. .
	202	Hunter	8.5	3.8	2.2	75.6
	203	North Coast	24.9	7.6	36.4	74.9
	204	Illawarra and South Coast	19.3	5.5	6.3	98.0
	205	West	-2.4	83.0	55.1	70.4
	All			100.0	100.0	73.9
Victoria	301	Melbourne area	7.4	4.2	6.7	98.9
	302	South Gippsland	12.2	5.8	14.9	76.2
	303	North	11.5	19.8	16.7	62.5
	304	Murray and West	5.6	56.8	31.8	84.3
	305	Geelong	15.0	6.8	9.9	28.1
	306	East Gippsland	13.6	6.5	20.0	24.7
	All			100.0	100.0	62.9
Queensland	401	Brisbane and Gold Coast	26.8	6.3	2.9	100.0
	402	Darling Downs and Wide Bay	10.8	26.7	21.3	56.3
	403	South West	-8.2	34.6	13.1	40.2
	404	Mid-North Coast	23.1	23.6	45.5	65.9
	405	North	27.9	8.9	17.2	65.5
	All			100.0	100.0	61.4

TABLE 5.8(Cont)—RETURNS ON RURAL ARTERIAL ROAD INVESTMENT PROGRAMS BY REGION, S2 STANDARDS, 7 PER CENT DISCOUNT RATE: 1985-86 TO 1989-90

State	*Region*[a]	*Location*	*Population growth (1971-1981) (per cent)*	*Region rural arterial length as a percentage of State total*	*Region expenditure as a percentage of State total*	*Percentage of of regional expenditure with BCR > 1*
South Australia	501	Adelaide area	10.4	1.2	4.2	100.0
	502	Mid-North	3.4	33.5	51.4	73.9
	503	Murray and South East	12.8	43.8	36.1	79.5
	504	Eyre	8.4	14.0	8.2	100.0
	505	North	-9.5	7.5	–	..
	All			100.0	100.0	79.2
Western Australia	601	Perth area	28.7	0.9	4.3	100.0
	602	South West	8.3	55.0	44.7	56.6
	603	Pilbara	57.6	13.5	37.7	33.1
	604	Kimberley	32.2	7.3	7.5	15.7
	605	Goldfields and Midlands	-0.4	23.3	5.8	25.6
	All			100.0	100.0	44.7

TABLE 5.8(Cont)—RETURNS ON RURAL ARTERIAL ROAD INVESTMENT PROGRAMS BY REGION, S2 STANDARDS, 7 PER CENT DISCOUNT RATE: 1985-86 TO 1989-90

State	*Region*[a]	*Location*	*Population growth (1971-1981) (per cent)*	*Region rural arterial length as a percentage of State total*	*Region expenditure as a percentage of State total*	*Percentage of of regional expenditure with BCR > 1*
Tasmania	701	South	8.0	34.1	45.8	69.2
	702	North	7.3	34.4	26.9	45.7
	703	West	6.3	31.5	27.3	47.3
	All			100.0	100.0	56.9
Northern Territory[b]	801		42.8	100.0	100.0	24.0

a. Maps of regions are given in Appendix Figures V.3, VI.3, VII.3, VIII.3, IX.3 and X.2.
b. The Northern Territory is treated as a single region in this analysis.

\- nil or rounded to zero
.. not applicable

Note: Figures may not add to totals due to rounding.

Sources: BTE (1984a) Table 8.2 and Tables V.5, VI.5, VII.5, VIII.5, IX.5, X.5.

levels, and those that would be undertaken if the funding level was reduced by 25 per cent or increased by up to 50 per cent. However, the data produced can be used to give some indication of how rural arterial funds might be allocated among the States.

If limited funds are to be devoted to rural arterial roads in Australia, economic theory would suggest allocating expenditure among projects, and hence among States, along the following lines:

- determine the highest benefit cost ratio that can be derived from investment in the period of interest on each rural arterial road section in Australia;
- rank sections in order of benefit cost ratio;
- schedule projects on the highest ranking sections until the total budget is exhausted; and
- allocate funds to States so that all scheduled work can be carried out in each State.

This process effectively equalises benefit cost ratios at the margin in each State. All sections with a BCR less than one would be eliminated from the analysis if it was decided to ensure that all expenditure was economically viable.

The first step in the above process was not carried out in the present study. The analysis undertaken was based on the four sets of standards, S1, S2, S3 and S4, used in the assessment work. The set of projects generated at the S4 standard came closest to the theoretical procedure described.

A modification of the procedure outlined, using the S4 standards, is illustrated in Table 5.9 for a 7 per cent discount rate. The most recent available expenditure level (1981-82) in each State was multiplied by 1.5 to give the expected expenditure for the S4 (F150) standards (column (3) of Table 5.9). This expenditure was in turn multiplied by the proportion of expenditure with a BCR greater than one in that State to produce a 'justified' expenditure level for the State (column (5) of Table 5.9). These justified expenditures were summed to give an Australian total, and hence State proportions could be derived. The Australian total derived in this way approximated the current (Australian) expenditure level (column (1) of Table 5.9).

Alternative allocations of funds among States using the same procedure, but based on S2 standards and different discount rates were also derived. The results are summarised in Table 5.10. There are no substantial differences in allocations to States using the different standards and different discount rates.

Comparing the derived allocations with the current distribution of (1981-82) expenditure on rural arterials as shown in column (2) of Table 5.9 indicates that expenditure would need to be increased in New South Wales and reduced a little in Western Australia and Tasmania to improve the allocation in terms of economic efficiency.

TABLE 5.9—DERIVATION OF AN ALLOCATION OF FUNDS AMONG STATES, S4 STANDARDS, 7 PER CENT DISCOUNT RATE

State	(1) 1981-82 expenditure[a] $ million	(2) 1981-82 expenditure[a] per cent	(3) 150% of 1981-82 expenditure (1) x 1.5	(4) Proportion of expenditure with BCR > 1 S4, 7 per cent[b]	(5) Expenditure with BCR > 1 S4, 7 per cent ($ million) (3) x (4)	(6) Per cent by State
New South Wales	108.9	38	163.4	.68	111.1	42
Victoria	35.8	12	53.7	.63	34.0	13
Queensland	81.5	28	122.3	.59	72.5	27
South Australia	12.6	4	18.9	.79	14.9	6
Western Australia	29.9	10	44.9	.40	18.1	7
Tasmania	19.0	7	28.5	.50[c]	14.3	5
Northern Territory	1.6	1	2.4	.12	0.3	–
Australia	289.3	100	434.0	..	265.5	100

a. BTE (1984c).
b. Appendixes V to XI.
c. There are only S2 standards for Tasmania so this figure was extrapolated from the S2 results.

– nil or rounded to zero

.. not applicable

Note: Figures may not add to totals due to rounding.

TABLE 5.10—ALLOCATION OF FUNDS AMONG STATES, S2 AND S4 STANDARDS, 7 PER CENT AND 10 PER CENT DISCOUNT RATES: 1985-86 TO 1989-80

(per cent)

	S2 standards		*S4 standards*	
State	*7 per cent*	*10 per cent*	*7 per cent*	*10 per cent*
New South Wales	43	46	42	44
Victoria	12	12	13	13
Queensland	27	27	27	27
South Australia	5	5	6	6
Western Australia	7	5	7	5
Tasmania	6	5	5	5
Northern Territory	–	–	–	–
Total	100	100	100	100

– nil or rounded to zero

CHAPTER 6—CONCLUDING REMARKS

An economic assessment of rural arterial roads in Australia was undertaken using a disaggregate methodology which incorporated benefit cost analysis. It took as its starting point a list of projects generated from a road deficiency analysis derived from the NIMPAC road planning model. An additional set of modules which perform economic evaluation was developed by the BTE to complement NIMPAC and produce benefit cost ratios for individual road sections.

NIMPAC is a complex computer model which models the life cycle of a road network by analysing individual sections of road. It incorporates a variety of relationships which are linked together, and it is accepted that a number of aspects of the model are somewhat simplified or based on data less reliable than one would like. However, NIMPAC is the most recent in a series of Australian computerised road planning models which date from the late 1960s. Over that period considerable effort has been devoted to critically reviewing and researching various aspects of the models. As a result the macro analysis reported here is based on the latest available techniques and data. An important advantage of using the NIMPAC model in the current assessment was that it provided a uniform procedure for evaluating rural arterial roads across Australia.

RETURN ON INVESTMENT

The most important conclusion from the economic assessment that has been carried out in this study is that there are substantial economic returns to be derived from further investment in rural arterial roads in Australia. If the current assessment and design standards, and funding level, were continued through the five year period 1985-86 to 1989-90, the analysis indicated that an average benefit cost ratio of 2.6 would be obtained for Australia as a whole. New South Wales, Victoria and Queensland would give returns of at least that level, with ratios of between one and two in South Australia, Western Australia and Tasmania. It should be recognised that not all of the expenditure resulting from the current assessment and design standards produces a high economic return. Indeed the proportion of expenditure with a BCR greater than one was generally in the range of 60 to 70 per cent.

The analysis indicated the existence of a large number of potential rural arterial road investment projects with substantial economic returns. However, this does not necessarily imply that governments should allocate funds to these projects. Firstly, the overall returns, in a broad social sense, may be even greater for other public sector projects than for rural arterial roads. Because the evaluation of costs and benefits in other sectors of public investment such as education is even more complex than in the roads area, it is difficult to draw comparisons across sectors. Inevitably a political judgement on the trade-off between sectors must be made. Secondly, the need to ration public sector capital expenditure may mean that projects with a high economic return in many areas, in addition to roads, may not be able to be undertaken.

OTHER FINDINGS

An important finding of the study was that average benefit cost ratios and the proportion of expenditure generated with a BCR greater than one remained remarkably constant as assessment and design standards were modified from the current matching ones (S2) to standards which generate additional expenditure (S3 or S4)[1]. The proportion of expenditure with a BCR greater than one was generally in the range 60 to 70 per cent. If standards were modified to reduce expenditure the average BCRs and proportion of expenditure with a BCR greater than one increased significantly overall but there was considerable variation by State. The proportion of expenditure with a BCR greater than one actually declined in three States.

The analysis indicated that higher economic returns are likely to be derived from investment in rural arterial roads in New South Wales, Queensland and Victoria than in the other three States and the Northern Territory. The differences in returns among the States reflect a variety of factors including differing costs of construction, traffic levels, growth rates and project types.

In examining the returns from investment in different types of construction work, the study suggests a logical subdivision into three groupings of work types which are related to traffic level. The high traffic group containing 'widening to 6 or 8 lanes', 'duplication' and 'overtaking lanes' have very high BCRs. The middle group with BCRs of 2.5 to 3.0 for Australia as a whole, consists of 'realign and widen', 'realign', 'rehabilitate and widen' and 'rehabilitate'. The remaining work types comprise a predominantly low traffic group with BCRs around one; the exception is 'new two lane seal' which has an average BCR of about two.

The factors that contribute to the benefits derived from upgrading rural arterial roads were also considered. Benefits to road authorities, namely savings in maintenance and resealing costs, are always small (and may be negative). The benefits to road users are dominanted by reductions in vehicle operating costs and travel time savings. Reductions in vehicle operating costs are more important than travel time savings in all States and the Northern Territory except Victoria; the two components are of approximately equal importance in Queensland. The contribution to economic benefits of reductions in accident costs is always quite small.

ALLOCATION OF EXPENDITURE AMONG STATES

The data produced in this study were used in Chapter 5 to give an indication of how expenditure on rural arterial roads might be allocated among the States to meet economic efficiency criteria.

Table 6.1 shows the distribution among the States that would have been made on the basis of the warranted programs[2] developed in the 1973, 1975 (CBR) and 1979 (BTE) Road Reports and those obtained for 1985-86 to 1989-90 from the present work. State shares of actual expenditure on road construction work for the periods 1972-73 to 1974-75, 1975-76 to 1979-80 and 1980-81 and 1981-82 are also shown in the table.

The data in Table 6.1 indicate that there has been a redistribution of total expenditure on rural arterial roads in the direction of increased economic efficiency over the last 10 years, but that change has been quite slow. However, in spite of this trend, a consistently smaller proportion of expenditure than desirable has been spent in New South Wales and a consistently higher than desirable proportion has been spent in Western Australia. To improve the distribution of rural arterial road funds in terms of economic efficiency, expenditure would need to be increased in New South Wales and reduced a little in Western Australia.

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1. See Appendix III for an explanation of the derivation of the standards and details of the standards themselves.
2. Warranted programs relate to expenditure for which the discounted future benefits to the community are at least as great as the discounted costs of undertaking the work.

TABLE 6.1—DISTRIBUTION OF RURAL ARTERIAL ROAD EXPENDITURE AMONG STATES, ACTUAL AND WARRANTED: 1972-73 TO 1989-90

(per cent)

State	*Warranted 1973 report*	*Actual 1972-75*	*Warranted 1975 report*	*Actual 1975-80*	*Warranted 1979 report*	*Actual 1980*	*Actual 1981*	*Warranted 1985-90 7 per cent S2*	*Warranted 1985-90 7 per cent S4*
New South Wales	44	32	41	35	44	42	38	43	42
Victoria	13	16	13	17	13	12	12	12	13
Queensland	24	22	25	27	24	23	28	27	27
South Australia	9	8	8	6	10	5	4	5	6
Western Australia	7	13	9	12	6	14	10	7	7
Tasmania	2	4	3	4	2	4	7	6	5
Northern Territory	1	5	1	–	1	1	1	–	–

Note: Rural arterial roads included national highways before 1975.

Sources: CBR (1973 and 1975). BTE (1979 and 1984c). Table 5.9.

APPENDIX I—CHARACTERISTICS OF RURAL ARTERIAL ROADS

In Chapter 2 data were presented on some important characteristics of the rural arterial road network in the six States and the Northern Territory. Many of the tables in that chapter contained only a summary of the available data. This Appendix provides further details on the characteristics of the rural arterial road network in Australia.

Tables I.1 and I.2 present a detailed breakdown of sealed rural arterial road length into six roughness ranges. In Table I.1 the breakdown is for all sealed rural arterial roads whereas Table I.2 shows the breakdown separately for each of the three sealed road stereotypes discussed in Chapter 2, that is, one-lane sealed, two-lane sealed, and four-lane sealed and divided roads.

Tables I.3 and I.4 present data on two aspects of alignment namely horizontal curve speeds and grades. Table I.3 shows for each State, the number of curves with various design curve speeds and the proportion with a design curve speed lower than 70 kilometres per hour. Table I.4 contains the distribution of upgrades by various slope ranges and the percentage of upgrades with slopes of 6 per cent or higher.

In Tables I.5 to I.8 data are presented on the traffic volume distribution for each of the road stereotypes discussed in Chapter 2. For example (Table I.5) in 1981 2290 kilometres of unsealed roads in New South Wales carried less than 30 vehicles a day. This length constitutes 26.3 per cent of the State's unsealed roads (lower half of Table I.5).

Tables I.9 and I.10 contain information on rural arterial road expenditure. Table I.9 shows the proportion of total road expenditure spent on rural arterial roads for the period 1975-76 to 1981-82 and Table I.10 presents data on the distribution of rural arterial road expenditure between construction and maintenance work for this period.

TABLE I.1—ROUGHNESS RANGE BY LENGTH (SEALED ROADS ONLY): 1981 AND 1985

	0-39 NRM counts/km		40-59 NRM counts/km		60-79 NRM counts/km		80-119 NRM counts/km		120-159 NRM counts/km		160+ NRM counts/km		Total	
	Length (km)	*(per cent)*	*Length (km)*	*(per cent)*	*Length (km)*	*(per cent)*	*Length (km)*	*(per cent)*	*Length (km)*	*(per cent)*	*Length (km)*	*(per cent)*	*Length (km)*	*(per cent)*
New South Wales														
1981	752	3.8	6 638	34.2	5 475	28.2	4 998	25.7	1 102	5.7	460	2.4	19 425	100.0
1985	210	1.0	2 304	11.5	6 014	30.0	6 778	33.8	3 783	18.9	950	4.7	20 039	100.0
Victoria														
1981	2 023	14.4	3 828	27.2	4 501	32.0	3 329	23.7	311	2.2	71	0.5	14 063	100.0
1985	2 023	14.2	2 358	16.6	3 706	26.1	5 306	37.4	776	5.5	33	0.2	14 202	100.0
Queensland														
1981	27	0.2	1 668	11.9	3 065	21.8	5 167	36.8	2 578	18.4	1 534	10.9	14 039	100.0
1985	4	–	1 082	7.2	4 562	30.4	5 483	36.5	2 741	18.3	1 130	7.5	15 002	100.0
South Australia														
1981	1 045	13.0	3 197	39.6	1 887	23.4	1 522	18.9	318	3.9	96	1.2	8 066	100.0
1985	632	7.6	2 182	26.3	1 789	21.7	2 416	29.2	928	11.2	327	3.9	8 283	100.0
Western Australia[a]														
1982	604	5.1	5 672	48.8	3 807	32.5	1 561	13.3	72	0.6	13	0.1	11 729	100.0
1985	121	1.0	4 264	36.0	4 692	39.6	2 743	23.2	17	0.1	–	–	11 837	100.0
Tasmania														
1981	–	–	253	11.5	497	22.6	994	45.2	399	18.1	57	2.6	2 200	100.0
1985	–	–	200	8.8	602	26.4	1 131	49.6	349	15.3	–	–	2 281	100.0
Northern Territory														
1981	79	5.7	398	28.5	613	43.9	306	21.9	–	–	–	–	1 396	100.0
1985	35	2.5	234	16.4	338	23.7	817	57.4	–	–	–	–	1 424	100.0

a. Figures for Western Australia are for 1982.

– nil or rounded to zero

Note: Figures may not add to totals due to rounding.

Sources: 1981 figures (1982 for Western Australia) were obtained by the BTE from the NAASRA Data Bank. 1985 figures are projections using the NIMPAC model.

TABLE I.2—ROUGHNESS OF ROAD STEREOTYPES: 1981

	0-39 NRM counts/km		*40-59 NRM counts/km*		*60-79 NRM counts/km*		*80-119 NRM counts/km*		*120-159 NRM counts/km*		*160+ NRM counts/km*		*Total*	
	Length (km)	*(per cent)*	*Length (km)*	*(per cent)*	*Length (km)*	*(per cent)*	*Length (km)*	*(per cent)*	*Length (km)*	*(per cent)*	*Length (km)*	*(per cent)*	*Length (km)*	*(per cent)*
One-lane														
New South Wales	–	–	135	42.3	71	22.3	87	27.3	25	7.8	1	0.3	319	100.0
Victoria	81	18.8	54	12.5	173	40.1	76	17.6	33	7.7	14	3.2	431	100.0
Queensland	12	0.2	538	10.6	959	18.9	1 986	39.2	1 012	20.0	562	11.1	5 069	100.0
South Australia	1	1.8	–	–	29	52.7	20	36.4	5	9.1	–	–	55	100.0
Western Australia[a]	109	4.5	1 485	61.7	608	25.2	202	8.4	3	0.1	–	–	2 410	100.0
Tasmania	–	–	1	3.4	6	20.7	3	10.3	19	65.5	–	–	29	100.0
Northern Territory	35	2.9	324	26.8	563	46.5	289	23.9	–	–	–	–	1 211	100.0
Two-lane														
New South Wales	750	4.1	6 337	34.3	5 289	28.6	4 731	25.6	972	5.3	395	2.1	18 474	100.0
Victoria	1 903	14.2	3 739	27.9	4 257	31.7	3 201	23.9	258	1.9	51	0.4	13 409	100.0
Queensland	15	0.2	1 130	12.6	2 104	23.5	3 172	35.5	1 560	17.4	959	10.7	8 940	100.0
South Australia	1 043	13.2	3 174	40.1	1 834	23.2	1 475	18.6	295	3.7	99	1.3	7 920	100.0
Western Australia[a]	495	5.4	4 166	45.1	3 174	34.3	1 337	14.5	60	0.6	12	0.1	9 244	100.0
Tasmania	–	–	250	11.6	482	22.4	990	45.9	376	17.4	57	2.6	2 155	100.0
Northern Territory	44	32.8	74	40.0	50	27.0	17	9.2	–	–	–	–	185	100.0

TABLE I.2(Cont)—ROUGHNESS OF ROAD STEREOTYPES: 1981

	0-39 NRM counts/km		40-59 NRM counts/km		60-79 NRM counts/km		80-119 NRM counts/km		120-159 NRM counts/km		160+ NRM counts/km		Total	
	Length (km)	*(per cent)*	*Length (km)*	*(per cent)*	*Length (km)*	*per cent)*	*Length (km)*	*(per cent)*	*Length (km)*	*(per cent)*	*Length (km)*	*(per cent)*	*Length (km)*	*(per cent)*
Four-lane and divided														
New South Wales	2	0.3	107	26.4	113	17.9	183	29.0	105	16.6	62	9.8	632	100.0
Victoria	40	17.7	36	15.9	72	31.9	53	23.5	20	8.8	5	2.2	226	100.0
Queensland	-	-	-	-	1	3.7	8	29.6	6	22.2	12	44.4	27	100.0
South Australia	2	2.2	23	25.3	23	25.3	20	22.0	19	20.9	4	4.4	91	100.0
Western Australia[a]	-	-	17	2.7	24	32.0	22	29.3	10	13.3	2	2.7	75	100.0
Tasmania	-	-	1	6.3	7	43.8	5	31.3	3	18.8	-	-	16	100.0
Northern Territory	-	..	-	..	-	..	-	..	-	..	-	..	-	..

a. Figures for Western Australia are for 1982.

\- nil or rounded to zero

.. not applicable

Note: Figures may not add to totals due to rounding.

Source: BTE tabulations from the NAASRA Data Bank.

TABLE I.3—ALIGNMENT, HORIZONTAL CURVES: 1981 AND 1985

Design speed (km/h)	*NSW*		*Vic*		*Qld*[a]		*SA*		*WA*[b]		*Tas*[a]		*NT*	
	1981	*1985*	*1981*	*1985*	*1981*	*1985*	*1981*	*1985*	*1982*	*1985*	*1981*	*1985*	*1981*	*1985*
							(number)							
Under 40	12 286	11 066	2 206	1 245	..	..	170	157	195	185	..	..	–	–
40–49	1 086	1 435	1 949	1 658	..	..	152	122	176	161	..	..	–	–
50–59	1 433	1 337	2 019	1 610	..	..	382	396	257	235	..	..	–	–
60–69	1 956	2 149	1 925	3 223	..	..	467	448	537	495	..	..	–	–
70–79	2 426	2 221	2 260	2 212	..	..	509	500	625	687	..	..	–	–
80–89	3 062	3 830	2 380	2 402	..	..	705	697	1 303	1 341	..	..	1	1
90–99	3 304	3 247	2 496	2 587	..	..	1 712	1 739	1 987	1 992	..	..	5	5
100+	2 522	2 857	2 104	2 227	..	..	2 960	2 946	2 715	2 731	..	..	28	28
Total	28 075	28 082	17 159	17 164	..	..	7 057	7 005	7 795	7 827	..	..	34	34
							(per cent)							
Percentage of curves with design speed under 70km/h	59.7	56.7	46.2	45.1	..	..	19.3	16.0	14.9	13.7	..	..	–	–

a. There are no alignment data for Queensland and Tasmania.
b. Figures for Western Australia are for 1982.

– nil or rounded to zero

.. not applicable

Sources: 1981 figures (1982 for Western Australia) were obtained by the BTE from the NAASRA Data Bank. 1985 figures are projections using the NIMPAC model.

TABLE I.4—ALIGNMENT, UPGRADES: 1981 AND 1985

Grade (per cent)	*NSW* 1981	*NSW* 1985	*Vic* 1981	*Vic* 1985	*Qld*[a] 1981	*Qld*[a] 1985	*SA* 1981	*SA* 1985	*WA*[b] 1982	*WA*[b] 1985	*Tas*[a] 1981	*Tas*[a] 1985	*NT* 1981	*NT* 1985
							(number)							
2-3.9	789	790	2 813	2 815	..	..	3 300	3 300	3 589	3 616	..	..	3	3
4-5.9	1 890	1 890	1 595	1 596	..	..	932	932	1 108	1 117	..	..	–	–
6-7.9	1 590	1 594	867	868	..	..	342	342	256	258	..	..	–	–
8-9.9	731	731	243	243	..	..	73	73	39	39	..	..	–	–
10+	306	306	91	91	..	..	19	19	6	6	..	..	–	–
Total	5 306	5 311	5 609	5 613	..	..	4 666	4 666	4 998	5 036	..	..	3	3
							(per cent)							
Percentage of grades above 6 per cent	49.5	49.5	21.4	21.4	..	..	9.3	9.3	6.0	6.0	..	..	–	–

a. There are no alignment data for Queensland and Tasmania.
b. Figures for Western Australia are for 1982.

– nil or rounded to zero

.. not applicable

Sources: 1981 figures (1982 for Western Australia) were obtained by the BTE from the NAASRA Data Bank. 1985 figures are projections using the NIMPAC model.

TABLE I.5—TRAFFIC VOLUME DISTRIBUTION, UNSEALED ROADS: 1981 AND 1985

AADT range	*NSW* 1981	*NSW* 1985	*Vic* 1981	*Vic* 1985	*Qld* 1981	*Qld* 1985	*SA* 1981	*SA* 1985	*WA*[a] 1982	*WA*[a] 1985	*Tas* 1981	*Tas* 1985	*NT* 1981	*NT* 1985
	Road length (kilometres)													
0– 29	2 290	1 898	–	–	1 285	1 270	340	406	3 154	2 889	–	–	1 571	1 343
30– 59	2 127	2 186	9	51	1 072	891	642	453	1 107	949	51	51	99	295
60– 99	1 307	1 276	213	128	1 280	1 065	376	455	355	695	25	26	28	32
100–149	965	1 105	47	12	640	296	369	346	25	–	75	58	–	–
150–299	1 644	1 630	40	–	413	234	149	31	–	–	49	–	–	–
300–599	208	7	–	–	36	20	30	–	–	–	6	–	–	–
600–999	18	–	2	–	19	4	2	–	–	–	5	–	–	–
1000+	55	–	16	–	15	14	–	–	–	–	4	–	–	–
Total	8 714	8 102	327	191	4 760	3 794	1 908	1 691	4 641	4 533	216	135	1 698	1 670
	(per cent)													
0–29	26.3	23.4	–	–	27.0	33.5	17.8	24.0	68.0	63.7	–	–	92.5	80.4
30–99	39.4	42.7	67.9	93.7	49.4	51.5	53.4	53.7	31.5	36.3	35.6	57.0	7.5	19.6
100+	34.4	33.8	32.1	6.3	23.6	15.0	28.8	22.3	0.5	–	64.4	43.0	–	–

a. Figures for Western Australia are for 1982.

– nil or rounded to zero

Note: Figures may not add to totals due to rounding.

Sources: 1981 figures (1982 for Western Australia) were obtained by the BTE from the NAASRA Data Bank. 1985 figures are projections using the NIMPAC model.

TABLE I.6—TRAFFIC VOLUME DISTRIBUTION, ONE LANE SEALED ROADS: 1981 AND 1985

AADT range	NSW 1981	NSW 1985	Vic 1981	Vic 1985	Qld 1981	Qld 1985	SA 1981	SA 1985	WA[a] 1982	WA[a] 1985	Tas 1981	Tas 1985	NT 1981	NT 1985
							Road length (kilometres)							
0- 29	23	23	–	–	99	91	–	–	31	31	–	–	682	451
30- 59	13	13	4	6	845	746	–	–	342	146	–	–	439	535
60- 99	36	30	54	111	1 072	1 068	–	–	657	717	–	–	90	253
100-149	10	16	29	46	924	615	–	–	665	615	3	–	–	–
150-299	197	158	223	201	1 378	1 357	42	42	608	629	2	2	–	–
300-599	19	38	35	28	478	659	7	11	107	–	17	13	–	–
600-999	21	27	28	13	167	170	2	–	–	2	6	6	–	–
1000+	–	21	58	37	106	131	–	2	–	–	1	–	–	–
Total	319	326	431	442	5 069	4 837	55	55	2 410	2 140	29	21	1 211	1 239
							(per cent)							
0- 29	7.2	7.1	–	–	2.0	1.9	–	–	1.3	1.4	–	–	56.3	36.4
30- 99	15.4	13.2	13.5	26.5	37.8	37.5	–	–	41.5	40.3	–	–	43.7	63.6
100-299	64.9	53.4	58.5	55.9	45.4	40.8	83.6	96.4	52.8	58.1	17.2	9.5	–	–
300+	12.5	26.3	28.1	17.6	14.8	19.8	16.4	3.6	4.4	0.1	82.8	90.6	–	–

a. Figures for Western Australia are for 1982.

– nil or rounded to zero

Notes: 1. Roads with width up to 4.5 metres are classified as one lane.
2. Figures may not add to totals due to rounding.

Sources: 1981 figures (1982 for Western Australia) were obtained by the BTE from the NAASRA Data Bank. 1982 figures are projections using the NIMPAC model.

TABLE I.7—TRAFFIC VOLUME DISTRIBUTION, TWO LANE SEALED ROADS: 1981 AND 1985

AADT range	NSW		Vic		Qld		SA		WA[a]		Tas		NT	
	1981	*1985*	*1981*	*1985*	*1981*	*1985*	*1981*	*1985*	*1982*	*1985*	*1981*	*1985*	*1981*	*1985*
	Road length (kilometres)													
0– 29	260	301	–	–	148	106	–	25	6	6	–	–	2	2
30– 59	544	489	7	30	208	175	145	121	227	96	10	10	–	–
60– 99	725	682	129	127	418	736	237	205	587	600	15	15	–	–
100– 299	3 966	3 744	3 081	2 950	2 975	3 181	2 326	2 368	3 479	3 116	410	479	183	75
300– 599	4 632	4 763	3 294	3 344	2 022	2 240	2 133	2 087	2 853	3 262	408	418	–	108
600– 999	3 003	3 068	2 542	2 536	1 231	1 418	1 357	1 471	716	902	678	682	..	–
1000–1999	2 967	3 308	2 683	2 703	1 156	1 303	1 136	1 228	929	1 077	459	463	–	–
2000–3999	1 706	1 944	1 169	1 253	519	632	422	436	358	341	144	146	–	–
4000–5999	411	431	319	297	104	145	75	98	72	170	16	16	–	–
6000+	260	335	185	290	159	198	89	98	17	52	15	15	–	–
Total	18 474	19 065	13 409	13 530	8 940	10 134	7 920	9 244	9 644	9 622	2 155	2 244	185	185
	(per cent)													
0– 299	29.7	27.4	24.0	23.0	41.9	41.4	34.2	33.4	46.5	39.7	20.2	22.5	100.0	41.6
300– 999	41.3	41.1	43.5	43.5	36.4	36.1	44.1	43.7	38.6	43.3	50.5	49.0	–	58.4
1000–3999	25.3	27.5	28.7	29.2	18.7	19.1	19.7	20.4	10.1	14.7	28.0	27.1	–	–
4000+	3.6	4.0	3.8	4.3	2.9	3.4	2.1	2.4	4.8	2.3	1.4	1.4	–	–

a. Figures for Western Australia are for 1982.

.. nil or rounded to zero

Notes: 1. Roads with width 4.6 metres to 11.6 metres are classified as two lane.
2. Figures may not add to totals due to rounding.

Sources: 1981 figures (1982 for Western Australia) were obtained by the BTE from the NAASRA Data Bank. 1985 figures are projections using the NIMPAC model.

TABLE I.8—TRAFFIC VOLUME DISTRIBUTION, FOUR LANE AND DIVIDED ROADS: 1981 AND 1985

Road length (kilometres)

AADT range	*NSW*		*Vic*		*Qld*		*SA*		*WA*[a]		*Tas*	
	1981	*1985*	*1981*	*1985*	*1981*	*1985*	*1981*	*1985*	*1982*	*1985*	*1981*	*1985*
0- 1999	328	285	128	121	14	13	26	25	39	38	11	11
2000- 3999	121	139	52	57	4	4	20	16	26	13	5	5
4000- 5999	118	127	28	26	2	3	12	11	5	16	–	–
6000- 9999	43	53	12	18	5	4	28	32	5	8	–	–
10000-14999	19	29	2	2	1	2	1	3	–	–	–	–
15000+	3	13	4	6	1	5	4	4	–	–	–	–
Total	632	646	226	230	27	31	91	91	75	75	16	16

a. Figures for Western Australia are for 1982.

– nil or rounded to zero

Note: Roads with width 11.7 metres or more are classified as four lane and divided. There are no four lane and divided roads in the Northern Territory.

Sources: 1981 figures (1982 for Western Australia) were obtained by the BTE from the NAASRA Data Bank. 1985 figures are projections using the NIMPAC model.

TABLE I.9—EXPENDITURE ON RURAL ARTERIAL ROADS: 1975-76 TO 1981-82

State	*1975-76*	*1976-77*	*1977-78*	*1978-79*	*1979-80*	*1980-81*	*1981-82*	*Total*	*Average annual growth rate (per cent)*
New South Wales									
All roads[a]	948.2	845.9	923.7	900.3	752.9	817.8	797.5	5 986.3	-2.8
Rural arterials[a]	188.3	167.5	182.0	182.4	195.6	183.6	161.9	1 261.3	-2.5
Per cent on rural arterials	19.9	19.8	19.7	20.3	26.0	22.5	20.3	21.1	. .
Victoria									
All roads[a]	533.5	519.8	526.9	508.0	480.3	474.9	462.0	3 505.4	-2.4
Rural arterials[a]	95.6	88.2	80.2	76.6	69.3	59.5	61.6	531.0	-7.1
Per cent on rural arterials	17.9	17.0	15.2	15.1	14.5	12.5	13.3	15.1	. .
Queensland									
All roads[a]	418.6	415.7	403.0	398.2	396.7	388.2	381.6	2 802.0	-1.5
Rural arterials[a]	116.7	127.8	107.1	100.2	97.9	87.4	104.4	741.5	-1.8
Per cent on rural arterials	27.9	30.7	26.6	25.2	24.7	22.5	27.4	26.5	. .
South Australia									
All roads[a]	176.0	182.9	177.2	179.6	160.4	157.6	151.8	1 185.5	-2.4
Rural arterials[a]	30.2	30.2	33.6	33.5	32.0	27.3	29.3	216.1	-0.5
Per cent on rural arterials	17.3	16.5	20.6	18.6	19.9	17.3	19.3	18.2	. .
Western Australia									
All roads[a]	225.2	224.7	223.1	237.4	225.6	211.6	204.4	1 552.0	-1.6
Rural arterials[a]	43.9	49.3	47.7	51.8	60.5	54.2	46.4	353.8	+0.9
Per cent on rural arterials	19.5	21.9	20.8	21.8	26.8	25.6	22.7	22.8	. .

TABLE I.9(*Cont*)—EXPENDITURE ON RURAL ARTERIAL ROADS: 1975-76 TO 1981-82

State	*1975-76*	*1976-77*	*1977-78*	*1978-79*	*1979-80*	*1980-81*	*1981-82*	*Total*	*Average annual growth rate (per cent)*
Tasmania									
All roads[a]	106.3	121.2	107.1	99.7	89.5	90.3	91.2	705.3	-2.5
Rural arterials[a]	14.7	14.9	17.0	19.1	17.1	15.6	23.7	122.1	+8.3
Per cent on rural arterials	13.9	12.3	15.9	19.1	19.0	17.3	26.0	17.3	..
Northern Territory									
All roads[a]	42.6	41.4	41.0	49.4	60.7	55.8	56.5	347.4	+4.8
Rural arterials[a]	5.6	3.8	3.2	0.3	6.9	4.9	3.3	28.0	-8.4
Per cent on rural arterials	13.1	9.2	7.8	0.6	11.4	8.8	5.8	8.1	..

a. $ million, 1980-81 prices.

.. not applicable.

Note: Expenditures include expenditure by all levels of government (Commonwealth, State and local). Total expenditure on all roads includes expenditure on planning and research and expenditure on bridges. See BTE (1983) for qualifications to the figures contained in this table.

Sources: BTE (1983 and 1984c).

TABLE I.10—MAINTENANCE AND CONSTRUCTION EXPENDITURE, RURAL ARTERIAL ROADS: 1975-76 TO 1981-82

	1975-76		*1976-77*		*1977-78*		*1978-79*		*1979-80*		*1980-81*		*1981-82*		*Total*	
	($m)	*(per cent)*	*($m)*	*(per cent)*	*($m)*	*(per cent)*	*($m)*	*(per cent)*	*($m)*	*(per cent)*	*($m)*	*(per cent)*	*($m)*	*(per cent)*	*($m)*	*(per cent)*
New South Wales																
Construction	114.7	60.9	88.1	52.6	91.9	50.5	103.4	56.7	118.0	60.3	108.8	59.3	96.8	59.8	721.7	57.2
Maintenance	73.6	39.1	79.4	47.4	90.1	49.5	79.0	43.3	77.6	39.7	74.8	40.7	65.1	40.2	539.7	42.8
Total	188.3	100.0	167.5	100.0	182.0	100.0	182.4	100.0	195.6	100.0	183.6	100.0	161.9	100.0	1261.4	100.0
Victoria																
Construction	57.3	59.9	52.9	60.0	49.9	62.2	44.4	58.0	37.5	54.1	32.0	53.8	31.8	51.6	305.8	57.6
Maintenance	38.3	40.1	35.3	40.0	30.3	37.8	32.2	42.0	31.8	45.9	27.5	46.2	29.8	48.4	225.2	42.4
Total	95.6	100.0	88.2	100.0	80.2	100.0	76.6	100.0	69.3	100.0	59.5	100.0	61.6	100.0	531.0	100.0
Queensland																
Construction	76.6	65.6	92.7	72.5	78.1	72.9	70.4	70.3	69.6	71.1	59.4	68.0	72.4	69.4	519.2	69.9
Maintenance	40.1	34.4	35.1	27.5	29.0	27.1	29.8	29.7	28.3	28.9	28.9	32.0	31.9	30.6	223.1	30.1
Total	116.7	100.0	127.8	100.0	107.1	100.0	100.2	100.0	97.9	100.0	87.4	100.0	104.3	100.0	742.3	100.0
South Australia																
Construction	13.2	43.7	15.8	52.3	17.8	53.0	17.3	51.6	16.2	50.6	12.1	44.3	11.2	38.2	103.6	48.0
Maintenance	17.0	56.3	14.4	47.7	15.8	47.0	16.2	48.4	15.8	49.4	15.2	55.7	18.1	61.8	112.4	52.0
Total	30.2	100.0	30.2	100.0	33.6	100.0	33.5	100.0	32.0	100.0	27.3	100.0	29.3	100.0	216.0	100.0
Western Australia																
Construction	30.9	70.4	32.3	65.5	32.5	68.1	34.6	66.8	41.8	69.1	37.3	68.8	26.6	57.3	236.0	66.7
Maintenance	13.0	29.6	17.0	34.5	15.2	31.9	17.2	33.2	18.7	30.9	16.9	31.2	19.8	42.7	117.8	33.3
Total	43.9	100.0	49.3	100.0	47.7	100.0	51.8	100.0	60.5	100.0	54.2	100.0	46.4	100.0	353.8	100.0

TABLE I.10(Cont)—MAINTENANCE AND CONSTRUCTION EXPENDITURE, RURAL ARTERIAL ROADS: 1975-76 TO 1981-82

	1975-76		*1976-77*		*1977-78*		*1978-79*		*1979-80*		*1980-81*		*1981-82*		*Total*	
	($m)	*(per cent)*	*($m)*	*(per cent)*	*($m)*	*(per cent)*	*($m)*	*(per cent)*	*($m)*	*(per cent)*	*($m)*	*(per cent)*	*($m)*	*(per cent)*	*($m)*	*(per cent)*
Tasmania																
Construction	8.6	58.5	9.1	61.1	11.4	67.1	12.5	65.4	10.8	63.2	9.9	63.5	16.9	72.2	79.2	65.0
Maintenance	6.1	41.5	5.8	38.9	5.6	32.9	6.6	34.6	6.3	36.8	5.7	36.5	6.5	27.8	42.6	35.0
Total	14.7	100.0	14.9	100.0	17.0	100.0	19.1	100.0	17.1	100.0	15.6	100.0	23.4	100.0	121.8	100.0
Northern Territory																
Construction	0.2	3.6	0.3	7.9	0.4	12.5	0.2	66.7	3.3	47.8	2.1	42.9	1.4	42.4	7.9	28.2
Maintenance	5.4	96.4	3.5	92.1	2.8	87.5	0.1	33.3	3.6	52.2	2.8	57.1	1.9	57.6	20.1	71.8
Total	5.6	100.0	3.8	100.0	3.2	100.0	0.3	100.0	6.9	100.0	4.9	100.0	3.3	100.0	28.0	100.0

Notes: 1. Expenditure is expressed in 1980-81 prices, and includes expenditure by all levels of government (Commonwealth, State and local).
2. Figures may not add to totals due to rounding.

Sources: BTE (1983 and 1984c).

APPENDIX II—NAASRA DATA BANK ROAD INVENTORY ITEMS

The NAASRA Data Bank System (Linsten 1978) has provision for the 158 data items listed below. The items include geographical information, horizontal and vertical alignment, terrain, pavement and surface data, roughness, traffic volume and traffic composition.

IDENTIFIERS

1 Record type
2 Route identifier
3 Road number
4 Permanent reference point 1
5 Permanent reference point 2
6 Nominal year of inventory
7 Section number
8 Code to indicate required cost group
9 Link sequence number
10 Distance from PRP1 (km)
11 Carriageway identifier

GEOGRAPHICAL AND LEGAL CLASSIFICATION ITEMS

12 State or Territory identifier
13 SRA Division number
14 Local government area
15 ABS statistical area
16 Functional class
17 State legal class
18 Commonwealth legal class
19 Area class (as used by NIMPAC)
20 Land use
21 General terrain

GEOMETRIC AND MATERIAL CLASSIFICATION DATA

22 Length of road section (km)
23 Formation type
24 Formation width (m)
25 Pavement type
26 Pavement width (m)
27 Surface type

28 Surface width (m)
29 Shoulder type—left
30 Shoulder width (m)—left
31 Shoulder type—right
32 Shoulder width (m)—right
33 Outer separator width (m)
34 Median width (m)
35 Safety barrier in median
36 Slow vehicle lane—left
37 Slow vehicle lane—right

HORIZONTAL CURVES

38 Proportion of length with curve speed less than 40 km/h
39 Number of curves with curve speed less than 40 km/h
40 Proportion of length with curve speed in the range 40-49 km/h
41 Number of curves with curve speed in the range 40-49 km/h
42 Proportion of length with curve speed in the range 50-59 km/h
43 Number of curves with curve speed in the range 50-59 km/h
44 Proportion of length with curve speed in the range 60-69 km/h
45 Number of curves with curve speed in the range 60-69 km/h
46 Proportion of length with curve speed in the range 70-79 km/h
47 Number of curves with curve speed in the range 70-79 km/h
48 Proportion of length with curve speed in the range 80-89 km/h
49 Number of curves with curve speed in the range 80-89 km/h
50 Proportion of length with curve speed in the range 90-99 km/h
51 Number of curves with curve speed in the range 90-99 km/h
52 Proportion of length with curve speed in the range 100-109 km/h
53 Number of curves with curve speed in the range 100-109 km/h
54 Proportion of length with straight alignment
55 Proportion of length with flat alignment (that is, grades less than 2 per cent).

UPGRADES

56 Proportion of length with upgrades in the range 2-3 per cent
57 Number of upgrades in the range 2-3 per cent
58 Proportion of length with upgrades in the range 4-5 per cent
59 Number of upgrades in the range 4-5 per cent
60 Proportion of length with upgrades in the range 6-7 per cent
61 Number of upgrades in the range 6-7 per cent
62 Proportion of length with upgrades in the range 8-9 per cent
63 Number of upgrades in the range 8-9 per cent
64 Proportion of length with upgrades greater than or equal to 10 per cent
65 Number of upgrades greater than or equal to 10 per cent

DOWNGRADES

66 Proportion of length with downgrades in the range 2-3 per cent
67 Number of downgrades in the range 2-3 per cent
68 Proportion of length with downgrades in the range 4-5 per cent
69 Number of downgrades in the range 4-5 per cent
70 Proportion of length with downgrades in the range 6-7 per cent
71 Number of downgrades in the range 6-7 per cent
72 Proportion of length with downgrades in the range 8-9 per cent
73 Number of downgrades in the range 8-9 per cent
74 Proportion of length with downgrades greater than or equal to 10 per cent
75 Number of downgrades greater than or equal to 10 per cent

VERTICAL CURVES (VCs)

76 Proportion of length with curve speed less than 50 km/h
77 Number of summit VCs with curve speed less than 50 km/h
78 Proportion of length with curve speed in the range 50-59 km/h
79 Number of summit VCs with curve speed in the range 50-59 km/h
80 Proportion of length with curve speed in the range 60-69 km/h
81 Number of summit VCs with curve speed in the range 60-69 km/h
82 Proportion of length with curve speed in the range 70-79 km/h
83 Number of summit VCs with curve speed in the range 70-79 km/h
84 Proportion of length with curve speed in the range 80-89 km/h
85 Number of summit VCs with curve speed in the range 80-89 km/h
86 Proportion of length with curve speed in the range 90-99 km/h
87 Number of summit VCs with curve speed in the range 90-99 km/h
88 Proportion of length with curve speed in the range 100-109 km/h
89 Number of summit VCs with curve speed in the range 100-109 km/h
90 Proportion of length with curve speed greater than or equal to 110 km/h
91 Number of summit VCs with curve speed greater than or equal to 110 km/h
92 Proportion of length which has no vertical or horizontal curves

ROAD RIDEABILITY DATA

93 Pavement data type
94 Year of reconstruction or paving/resheeting
95 'Present' serviceability rating
96 Year of surfacing/resurfacing
97 Surface rating
98 Year of NRM reading/P.S. rating
99 NAASRA roughness meter reading (counts/km)

DRAINAGE-RELATED DATA

100 Proportion of length which has rippable adjacent material
101 Proportion of length which has untrafficable adjacent material

102 Proportion of length which has adequate minor drainage

CULVERTS

103 Total waterway area for culverts in the section (m^2)

104 Number of culverts in the section

FLOODWAYS

105 Total length of floodway in the section (m)

106 Number of floodways

107 Number of ferries

108 Number of fords

109 Number of causeways

BRIDGES

110 Number of bridges over water

111 Number of bridges not over water

TRAFFIC OPERATION DATA

112 Number of carriageways

113 Operational class

114 Degree of access control

115 Legal speed limit (km/h)

116 Proportion of length for which kerbs exist—left

117 Proportion of length for which kerbs exist—right

118 Proportion of length for which kerbs exist—left and right

119 Standing allowed A.M. peak—left

120 Standing allowed P.M. peak—left

121 Standing allowed Off-peak—left

122 Standing allowed A.M. peak—right

123 Standing allowed P.M. peak—right

124 Standing allowed Off-peak—right

125 Type of off-centre operation

126 Number of lanes involved in off-centre operation

127 Priority lane type

128 Priority lane width (m)

129 Right of way width (m)

PEDESTRIAN CROSSING DATA

130 Number of unsignalised pedestrian crossings

131 Number of pedestrian crossings with signs only

132 Number of pedestrian crossings with flashing lights

133 Number of pedestrian crossings with pedestrian-operated stop-go signals

INTERSECTIONS

134 Number of intersections with no traffic control
135 Number of intersections with 'give-way to right rule'
136 Number of intersections with stop/give-way signs
137 Number of intersections with stop/go signals

RAIL CROSSINGS

138 Number of railway level crossings with no warning device
139 Number of railway level crossings with signs/markings only
140 Number of railway level crossings with wig-wags or flashing lights
141 Number of railway level crossings with boom barriers
142 Number of railway level crossings with gates

TRAFFIC DATA

143 Year of annual average daily traffic (AADT)
144 Annual average daily traffic for year of AADT (vehicles/day)

TRAFFIC GROWTH

145 Year 1 of traffic forecast
146 Traffic forecast for year 1 (vehicles/day)
147 Year 2 of traffic forecast
148 Traffic forecast for year 2 (vehicles/day)
149 Year 3 of traffic forecast
150 Traffic forecast for year 3 (vehicles/day)

TRAFFIC COMPOSITION

151 Proportion of AADT which is cars
152 Proportion of AADT which is light commercials
153 Proportion of AADT which is rigid trucks
154 Proportion of AADT which is semi-trailers
155 Proportion of AADT which is road trains
156 Number of buses/weekday
157 Number of trams/weekday
158 Area class (as defined in data bank manual)

APPENDIX III—ASSESSMENT AND DESIGN STANDARDS

The following tables present a summary of the four sets of assessment and design standards employed for each State.

One set of standards was devised for each State in such a way that it generated a program of road improvements which 'matched' the current expenditure[1] on rural arterial roads, both in total and in the distribution by work type; this set was designated the S2 standards and is identical to the NAASRA F100 standards. Similarly, S1, S3 and S4 standards, which are identical to the NAASRA F75, F125 and F150 standards respectively, were devised for each State to produce upgrading programs, for the NAASRA 10 year analysis period 1982-1991, requiring an average annual rate of approximately 75 per cent, 125 per cent and 150 per cent of the current expenditure[1] applied to rural arterial roads. Since these standards are applied in the current study for the budget period 1985-86 to 1989-90 and beyond, with the S2 standards always applied in the updating period, the funding levels generated by NIMPAC in this Paper are not comparable to those in the NAASRA Roads Study. Details of the funding levels generated are discussed in Chapter 5. To simplify discussion 'higher' standards will be used to designate standards that generate higher expenditure levels and 'lower' standards will refer to those that generate lower expenditure levels.

The table for each State has a common format to allow comparison. However, for Western Australia there is a variety of maximum traffic levels for two lane sealed roads, and hence a finer classification was used in Western Australia for this part of the assessment standards.

Assessment standards determine whether or not a given section is deficient; hence they determine the number of improvement projects generated. The two major areas of assessment are surface width and pavement roughness. More projects will be initiated if the maximum traffic level for a particular road stereotype or the maximum pavement roughness is lowered. Thus, higher standards will tend to have lower maximum traffic and lower maximum roughness levels.

The extent of changes between the four sets of standards varies between States. For example, the only difference in maximum traffic levels in South Australia (Table III.4) are for the S1 standards for unsealed and one lane roads. In New South Wales the same maximum traffic level is specified for all standards for all roads more than 9.1 metres wide (Table III.1). A similar situation applies to roads wider than 6.4 metres in the Northern Territory (Table III.7).

Three aspects of design standards are presented in the tables, design for curve speed, surface width design and the provision of overtaking lanes. Design standards determine the scale of projects, so more expenditure can be generated by specifying a higher minimum curve speed, or by designing a superior road stereotype or adding an overtaking lane at a lower traffic level. Standards producing higher funding levels will tend to have these characteristics. Design standards are based on the projected future traffic level 15 years from the deficiency year.

Periodic resealing and the scheduling of projects are determined by project timing rules. Widening, realigning or bituminous concrete resurfacing can be delayed by

1. Current expenditure is defined as the average, in 1980-81 prices, of expenditure in 1979-80 and 1980-81.

undertaking these projects only if pavement roughness is below a certain level. While more expenditure could be generated by resealing more frequently, it is not always clear what effect changing project scheduling rules will have on expenditure generated. This depends on the interaction between the various aspects of the standards.

TABLE III.1—ASSESSMENT AND DESIGN STANDARDS, NEW SOUTH WALES

	S1	*S2*	*S3*	*S4*
Assessment standards (initiation of projects)				
Maximum traffic (vehicles/day)				
1 lane gravel (up to 4.5m)	2 000	307	240	210)
2 lane gravel (over 4.5m)	2 000	307	240	210
1 lane seal (up to 4.5m)	3 000	500	500	500
2 lane seal (4.6 to 6.4m)	7 000	5 000	4 000	5 000
2 lane seal (6.5 to 9.1m)	11 300	8 000	12 300	12 000
3 lane seal (9.2 to 11.6m)	15 000	15 000	15 000	15 000
4 lane seal (11.7 to 18.2m)	40 000	40 000	40 000	40 000
4 lane divided seal (up to 9.1m x 2)	40 000	40 000	40 000	40 000
6 lane divided seal (9.2 to 11.6m x 2)	999 999	999 999	999 999	999 999
Maximum pavement roughness (NRM)	189	174	168	162
Design standards (scale of projects)				
Curve speed (km/h)				
Flat terrain	100	100	100	100
Undulating terrain	100	100	100	100
	(80)	(80)	(80)	(80)
Hilly terrain	80	80	80	80
	(60)	(60)	(60)	(60)
Mountainous terrain	50	50	50	50
	(40)	(40)	(40)	(40)
Maximum traffic (vehicles/day)				
1 lane gravel (4m)	–	–	–	–
2 lane gravel (6m)	2 000	307	240	210
1 lane seal (4m)	2 000	307	240	210
2 lane seal (6m)	3 000	500	500	500
2 lane seal (7m)	11 300	8 000	12 300	12 000
4 lane divided (14m)	40 000	40 000	40 000	40 000
6 lane divided (21m)	50 000	50 000	50 000	50 000
Add overtaking lanes[a]				
3 per cent grade if traffic exceeds	7 833	7 833	5 333	5 333
6 per cent grade if traffic exceeds	6 833	6 833	4 333	4 333

TABLE III.1(Cont)—ASSESSMENT AND DESIGN STANDARDS, NEW SOUTH WALES

	S1	*S2*	*S3*	*S4*
Project timing rules (scheduling of projects)				
If pavements smoother than (NRM)				
Widen pavements	35	35	80 (90)	100 (110)
Realign isolated curves	–	–	–	–
Bituminous concrete resurface	130 (170)	130 (170)	130 (170)	130 (170)
Resealing frequency (years)	10	10	10	10
Bituminous concrete resurfacing frequency (years)	15	15	15	15

a. This applies to road sections where the proportion of commercial vehicles to total vehicles is in the range 11 per cent to 20 per cent.

\- nil

Note: Secondary arterial values are in brackets when differing from primary arterial figures.

TABLE III.2—ASSESSMENT AND DESIGN STANDARDS, VICTORIA

	S1	S2	S3	S4
Assessment standards (initiation of projects)				
Maximum traffic (vehicles/day)				
1 lane gravel (up to 4.5m)	100	60	60	60
2 lane gravel (over 4.5m)	100	60	60	60
1 lane seal (up to 4.5m)	600	400	200	100
2 lane seal (4.6 to 6.4m)	5 000	3 500	2 500	2 000
2 lane seal (6.5 to 9.1m)	18 000	13 000	9 000	7 000
3 lane seal (9.2 to 11.6m)	20 000	15 000	11 000	9 000
4 lane seal (11.7 to 18.2m)	75 000	60 000	45 000	30 000
4 lane divided seal (up to 9.1m x 2)	75 000	60 000	45 000	30 000
6 lane divided seal (9.2 to 11.6m x 2)	999 999	999 999	999 999	999 999
Maximum pavement roughness (NRM)	140	120	110	110
	(180)	(160)	(150)	(150)
Design standards (scale of projects)				
Curve speed (km/h)				
Flat terrain	110	110	110	110
	(0)	(100)	(100)	(100)
Undulating terrain	100	100	100	100
	(0)	(80)	(80)	(90)
Hilly terrain	90	90	90	90
	(0)	(60)	(60)	(80)
Mountainous terrain	80	80	80	80
	(0)	(40)	(40)	(50)

TABLE III.2(Cont)—ASSESSMENT AND DESIGN STANDARDS, VICTORIA

	S1	*S2*	*S3*	*S4*
Maximum traffic (vehicles/day)[a]				
1 lane gravel (4m)	-	-	-	-
2 lane gravel (6m)	-	-	-	-
1 lane seal (4m)	70	70	70	70
2 lane seal (6m)	150	150	150	150
2 lane seal (7m)	3 500	3 500	3 500	3 500
4 lane divided (14m)	90 000	90 000	90 000	90 000
6 lane divided (21m)	95 000	95 000	95 000	95 000
Add overtaking lanes[b]				
3 per cent grade if traffic exceeds	5 000	5 000	5 000	5 000
6 per cent grade if traffic exceeds	3 000	3 000	3 000	3 000
Project timing rules (scheduling of projects)				
If pavements smoother than (NRM)				
Widen pavements	70 (90)	70 (90)	70 (90)	70 (90)
Realign isolated curves	-	-	-	-
Bituminous concrete resurface	100 (120)	100 (120)	100 (120)	100 (120)
Resealing frequency (years)	8 (10)	8 (10)	8 (10)	8 (10)
Bituminous concrete resurfacing frequency (years)	15	15	15	15

a. Given a design speed of 100 km/h.

b. This applies to road sections where the proportion of commercial vehicles to total vehicles is less than 20 per cent.

\- nil

Note: Secondary arterial values are in brackets when differing from primary arterial figures.

TABLE III.3—ASSESSMENT AND DESIGN STANDARDS, QUEENSLAND

	S1	*S2*	*S3*	*S4*
Assessment standards (initiation of projects)				
Maximum traffic (vehicles/day)				
1 lane gravel (up to 4.5m)	300	75	60	50
2 lane gravel (over 4.5m)	300	75	60	50
1 lane seal (up to 4.5m)	350	225	225	225
2 lane seal (4.6 to 6.4m)	1 500	1 000	1 000	1 000
2 lane seal (6.5 to 9.1m)	25 000	15 000	10 000	7 500
3 lane seal (9.2 to 11.6m)	25 000	15 000	10 000	7 500
4 lane seal (11.7 to 18.2m)	50 000	50 000	40 000	40 000
4 lane divided seal (up to 9.1m x 2)	50 000	50 000	40 000	40 000
6 lane divided seal (9.2 to 11.6m x 2)	999 999	999 999	999 999	999 999
Maximum pavement roughness (NRM)[a]	200	185	170	150
	(220)	(205)		
Design standards (scale of projects)				
Curve speed (km/h)[b]				
Flat terrain	100	100	100	100
Undulating terrain	70	70	70	70
Hilly terrain	60	60	60	60
Mountainous terrain	50	50	50	50
Maximum traffic (vehicles/day)				
1 lane gravel (4m)	–	–	–	–
2 lane gravel (6m)	110	70	60	50
1 lane seal (4m)	–	–	–	–
2 lane seal (6m)	1 000	1 000	1 000	1 000
2 lane seal (7m)	23 000	12 000	10 000	7 500
4 lane divided (14m)	40 000	40 000	40 000	40 000
6 lane divided (21m)	60 000	60 000	60 000	50 000
Add overtaking lanes[c]				
3 per cent grade if traffic exceeds	2 333	2 333	2 333	2 333
6 per cent grade if traffic exceeds	1 333	1 333	1 333	1 333

TABLE III.3(Cont)—ASSESSMENT AND DESIGN STANDARDS, QUEENSLAND

	S1	*S2*	*S3*	*S4*
Project timing rules (scheduling of projects)				
If pavements smoother than (NRM)				
Widen pavements	45	45	45	45
Realign isolated curves	–	–	–	–
Bituminous concrete resurface	125	125	125	125
Resealing frequency (years)	9	9	9	9
Bituminous concrete resurfacing frequency (years)	18 (20)	18 (20)	18 (20)	18 (20)

a. For primary arterials only the functional class 2 value is given.
b. Not applicable due to the lack of alignment data.
c. This applies to road sections where the proportion of commercial vehicles to total vehicles is in the range 11 per cent to 20 per cent.

– nil

Note: Secondary arterial values are in brackets when differing from primary arterial figures.

TABLE III.4—ASSESSMENT AND DESIGN STANDARDS, SOUTH AUSTRALIA

	S1	*S2*	*S3*	*S4*
Assessment standards (initiation of projects)				
Maximum traffic (vehicles/day)				
1 lane gravel (up to 4.5m)	600	150	150	150
2 lane gravel (over 4.5m)	600	150	150	150
1 lane seal (up to 4.5m)	600	150	150	150
2 lane seal (4.6 to 6.4m)	4 000	4 000	4 000	4 000
2 lane seal (6.5 to 9.1m)	9 000	9 000	9 000	9 000
3 lane seal (9.2 to 11.6m)	9 000	9 000	9 000	9 000
4 lane seal (11.7 to 18.2m)	999 999	999 999	999 999	999 999
4 lane divided seal (up to 9.1m x 2)	18 000	18 000	18 000	18 000
6 lane divided seal (9.2 to 11.6m x 2)	18 000	18 000	18 000	18 000
Maximum pavement roughness (NRM)[a]	200	200	200	200
	(230)	(230)	(180)	(160)
Design standards (scale of projects)				
Curve speed (km/h)				
Flat terrain	–	115	115	115
Undulating terrain	–	115	115	115
Hilly terrain	–	95	95	95
		(50)	(50)	(50)
Mountainous terrain	–	95	95	95
		(50)	(50)	(50)
Maximum traffic (vehicles/day)[b]				
1 lane gravel (4m)	–	–	–	–
2 lane gravel (6m)	–	–	–	–
1 lane seal (4m)	–	–	–	–
2 lane seal (6m)	500	500	500	500
2 lane seal (7m)	5 000	5 000	5 000	5 000
4 lane divided (14m)	999 999	999 999	999 999	999 999
6 lane divided (21m)	–	–	–	–
Add overtaking lanes[c]				
3 per cent grade if traffic exceeds	999 999	999 999	999 999	999 999
6 per cent grade if traffic exceeds	999 999	999 999	999 999	999 999

TABLE III.4(Cont)—ASSESSMENT AND DESIGN STANDARDS, SOUTH AUSTRALIA

	S1	*S2*	*S3*	*S4*
Project timing rules (scheduling of projects)				
If pavements smoother than (NRM)				
Widen pavements[a]	-	-	-	-
Realign isolated curves	-	-	-	-
Bituminous concrete resurface[a]	170 (200)	170 (200)	170 (150)	170 (130)
Resealing frequency (years)	10	12	12	10
Bituminous concrete resurfacing frequency (years)	13	15 (20)	15 (20)	13 (17)

a. For primary arterials only the value for functional class 2 is given.
b. Given a design speed of 89km/h.
c. This applies to road sections where the proportion of commercial vehicles to total vehicles is less than 30 per cent.

\- nil

Note: Secondary arterial values are in brackets when differing from primary arterial figures.

TABLE III.5—ASSESSMENT AND DESIGN STANDARDS, WESTERN AUSTRALIA

	S1	*S2*	*S3*	*S4*
Assessment standards (initiation of projects)				
Maximum traffic (vehicles/day)				
1 lane gravel (up to 4.5m)	105	90	85	55
2 lane gravel (over 4.5m)	105	90	85	55
1 lane seal (up to 4.5m)	290	255	250	245
2 lane seal (4.6 to 5.3m)	584	550	530	450
2 lane seal (5.4 to 5.9m)	990	935	725	580
2 lane seal (6.0 to 6.4m)	1 838	1 740	1 130	850
2 lane seal (6.5 to 6.9m)	3 875	3 675	2 120	1 500
2 lane seal (7.0 to 9.1m)	22 000	16 000	6 600	6 000
3 lane seal (9.2 to 11.6m)	60 000	54 000	23 000	21 000
4 lane seal (11.7 to 18.2m)	90 000	72 000	40 000	37 000
4 lane divided seal (up to 9.1m x 2)	90 000	72 000	40 000	37 000
6 lane divided seal (9.2 to 11.6m x 2)	999 999	999 999	999 999	999 999
Maximum pavement roughness (NRM)	126	110	108	104
	(138)	(120)	(118)	(114)
Design standards (scale of projects)				
Curve speed (km/h)				
Flat terrain	100	100	100	100
	(90)	(90)	(90)	(90)
Undulating terrain	80	80	80	80
	(70)	(70)	(70)	(70)
Hilly terrain	70	70	70	70
Mountainous terrain	70	70	70	70

TABLE III.5(Cont)—ASSESSMENT AND DESIGN STANDARDS, WESTERN AUSTRALIA

	S1	*S2*	*S3*	*S4*
Maximum traffic (vehicles/day)				
1 lane gravel (4m)	-	-	-	-
2 lane gravel (6m)	120	95	90	70
1 lane seal (4m)	150	150	150	150
2 lane seal (6m)	1 100	1 000	1 000	1 000
2 lane seal (7m)	5 000	5 000	5 000	5 000
4 lane divided (14m)	60 000	54 000	23 000	21 000
6 lane divided (21m)	999 999	999 999	40 000	37 000
Add overtaking lanes[a]				
3 per cent grade if traffic exceeds	4 666	2 333	2 333	2 333
6 per cent grade if traffic exceeds	2 666	1 333	1 333	1 333
Project timing rules (scheduling of projects)				
If pavements smoother than (NRM)				
Widen pavements	102	87	86	82
	(113)	(96)	(95)	(91)
Realign isolated curves	102	87	86	82
	(113)	(96)	(95)	(91)
Bituminous concrete resurface	114	98	97	93
	(125)	(108)	(106)	(102)
Resealing frequency (years)	16	16	16	16
	(24)	(24)	(24)	(24)
Bituminous concrete resurfacing frequency (years)	21	21	21	21
	(29)	(29)	(29)	(29)

a. This applies to road sections where the proportion of commercial vehicles to total vehicles is in the range 11 per cent to 20 per cent.

\- *nil*

Note: Secondary arterial values are in brackets when differing from primary arterial figures.

TABLE III.6—ASSESSMENT AND DESIGN STANDARDS, TASMANIA

	S2[a]
Assessment standards (initiation of projects)	
Maximum traffic (vehicles/day)	
1 lane gravel (up to 4.5m)	120)
2 lane gravel (over 4.5m)	120
1 lane seal (up to 4.5m)	300
2 lane seal (4.6 to 6.4m)	10 000
2 lane seal (6.5 to 9.1m)	10 000
3 lane seal (9.2 to 11.6m)	10 000
4 lane seal (11.7 to 18.2m)	999 999
4 lane divided seal (up to 9.1m x 2)	999 999
6 lane divided seal (9.2 to 11.6m x 2)	999 999
Maximum pavement roughness (NRM)	140
Design standards (scale of projects)	
Curve speed (km/h)[b]	
Flat terrain	100 (60)
Undulating terrain	70 (60)
Hilly terrain	70 (60)
Mountainous terrain	70 (50)
Maximum traffic (vehicles/day)[c]	
1 lane gravel (4m)	–
2 lane gravel (6m)	120
1 lane seal (4m)	–
2 lane seal (6m)	3 000
2 lane seal (7m)	10 000
4 lane divided (14m)	999 999
6 lane divided (21m)	999 999
Add overtaking lanes[d]	
3 per cent grade if traffic exceeds	2 333
6 per cent grade if traffic exceeds	1 333
Project timing rules (scheduling of projects)	
If pavements smoother than (NRM)	
Widen pavements	–
Realign isolated curves	–
Bituminous concrete resurface	80
Resealing frequency (years)	10
Bitumimous concrete resurfacing frequency (years)	15

a. Only one set of standards (S2) was used in Tasmania.
b. Not applicable due to the lack of alignment data.
c. Given a design speed greater than 60 km/h.
d. This applies to road sections where the proportion of commercial vehicles to total vehicles is in the range 11 per cent to 20 per cent.

– nil

Note: Secondary arterial values are in brackets when differing from primary arterial figures.

TABLE III.7-ASSESSMENT AND DESIGN STANDARDS, NORTHERN TERRITORY

	S1	S2	S3	S4
Assessment standards (initiation of projects)				
Maximum traffic (vehicles/day)				
1 lane gravel (up to 4.5m)	90	55	50	38
2 lane gravel (over 4.5m)	90	55	50	38
1 lane seal (up to 4.5m)	260	200	180	155
2 lane seal (4.6 to 6.4m)	260	200	180	155
2 lane seal (6.5 to 9.1m)	2 000	2 000	2 000	2 000
3 lane seal (9.2 to 11.6m)	2 000	2 000	2 000	2 000
4 lane seal (11.7 to 18.2m)	999 999	999 999	999 999	999 999
4 lane divided seal (up to 9.1m x 2)	999 999	999 999	999 999	999 999
6 lane divided seal (9.2 to 11.6m x 2)	999 999	999 999	999 999	999 999
Maximum pavement roughness (NRM)[a]	124	122	110	109
Design standards (scale of projects)				
Curve speed (km/h)				
Flat terrain	130	130	130	130
Undulating terrain	130	130	130	130
Hilly terrain	130	130	130	130
Mountainous terrain	130	130	130	130
Maximum traffic (vehicles/day)				
1 lane gravel (4m)	90	55	50	38
2 lane gravel (6m)	90	55	50	38
1 lane seal (4m)	260	200	180	155
2 lane seal (6m)	–	–	–	–
2 lane seal (7m)	2 000	2 000	2 000	2 000
4 lane divided (14m)	999 999	999 999	999 999	999 999
6 lane divided (21m)	–	–	–	–
Add overtaking lanes				
3 per cent grade if traffic exceeds	999 999	999 999	999 999	999 999
6 per cent grade if traffic exceeds	999 999	999 999	999 999	999 999

TABLE III.7(Cont)—ASSESSMENT AND DESIGN STANDARDS, NORTHERN TERRITORY

	S1	*S2*	*S3*	*S4*
Project timing rules (scheduling of projects)				
If pavements smoother than (NRM)				
Widen pavements	–	–	–	–
Realign isolated curves	–	–	–	–
Bituminous concrete resurface	–	–	–	–
Resealing frequency (years)	10	10	10	10
Bituminous concrete resurfacing frequency (years)	15	15	15	15

a. For primary arterials only the values for functional class 2 are given.

– nil

Note: Secondary arterial values are in brackets when differing from primary arterial figures.

APPENDIX IV—CUMULATIVE DISTRIBUTIONS OF BENEFIT COST RATIOS

This appendix contains figures IV.1, IV.2 and IV.3 which show the percentage of project expenditure in all States with benefit cost ratios greater than given levels at the 4 per cent, 7 per cent and 10 per cent discount rates respectively.

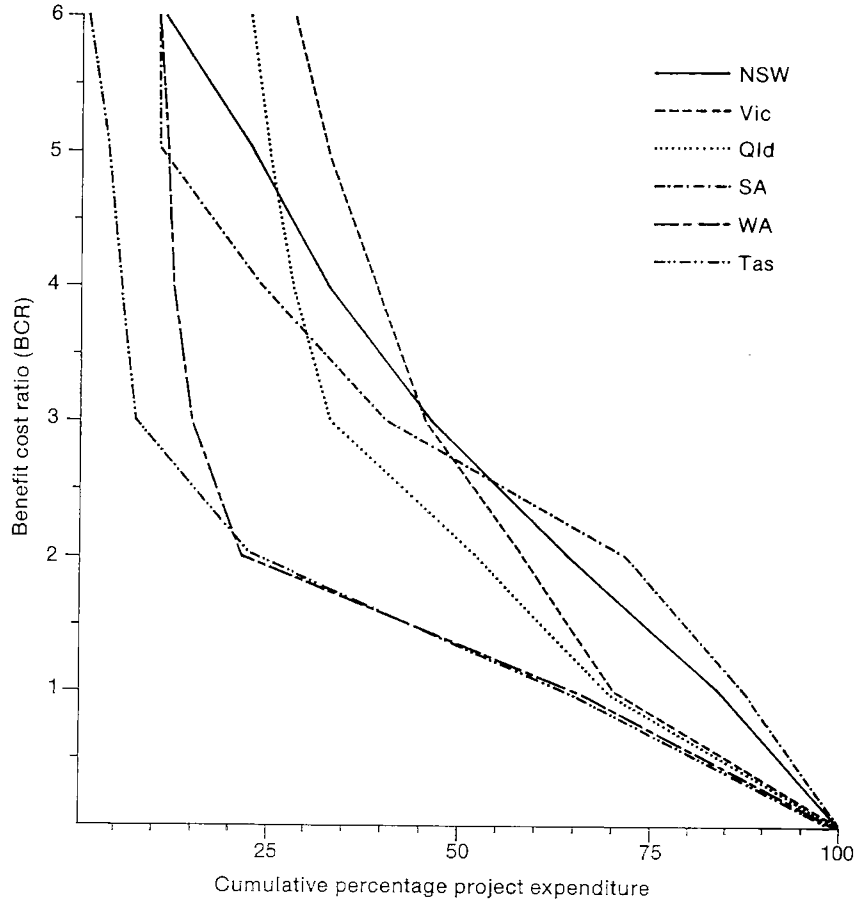


Figure IV.1—All States cumulative percentage project expenditure (1985-86 to 1989-90) by benefit cost ratio, S2 standards, 4 per cent discount rate

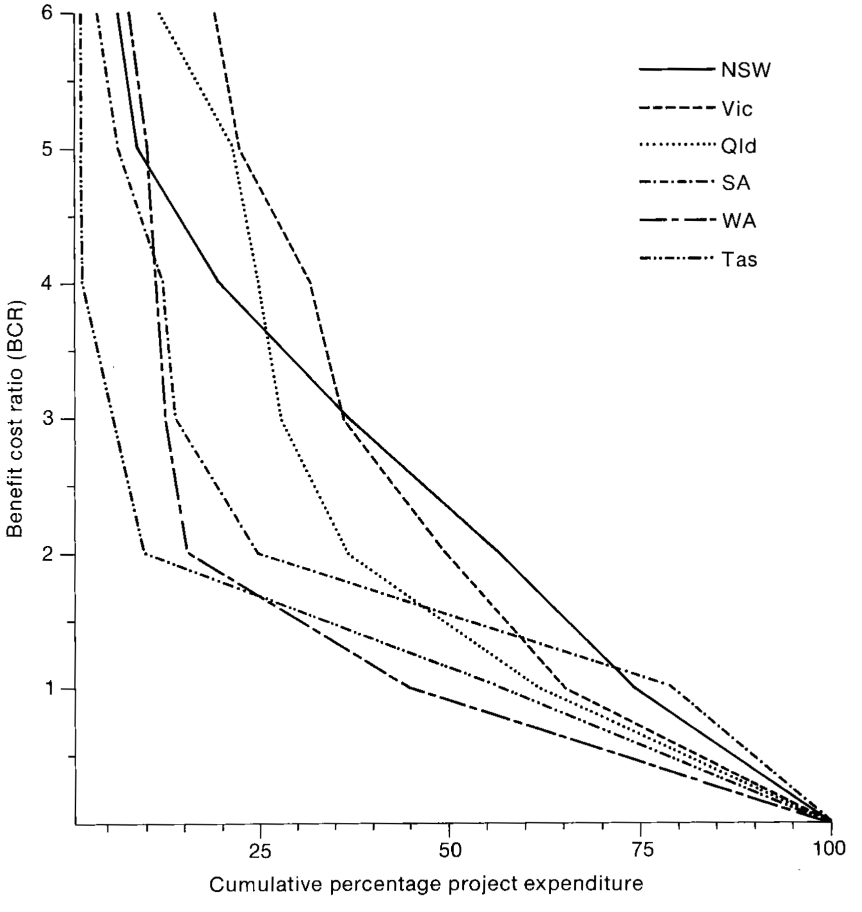


Figure IV.2—All States cumulative percentage project expenditure (1985-86 to 1989-90) by benefit cost ratio, S2 standards, 7 per cent discount rate

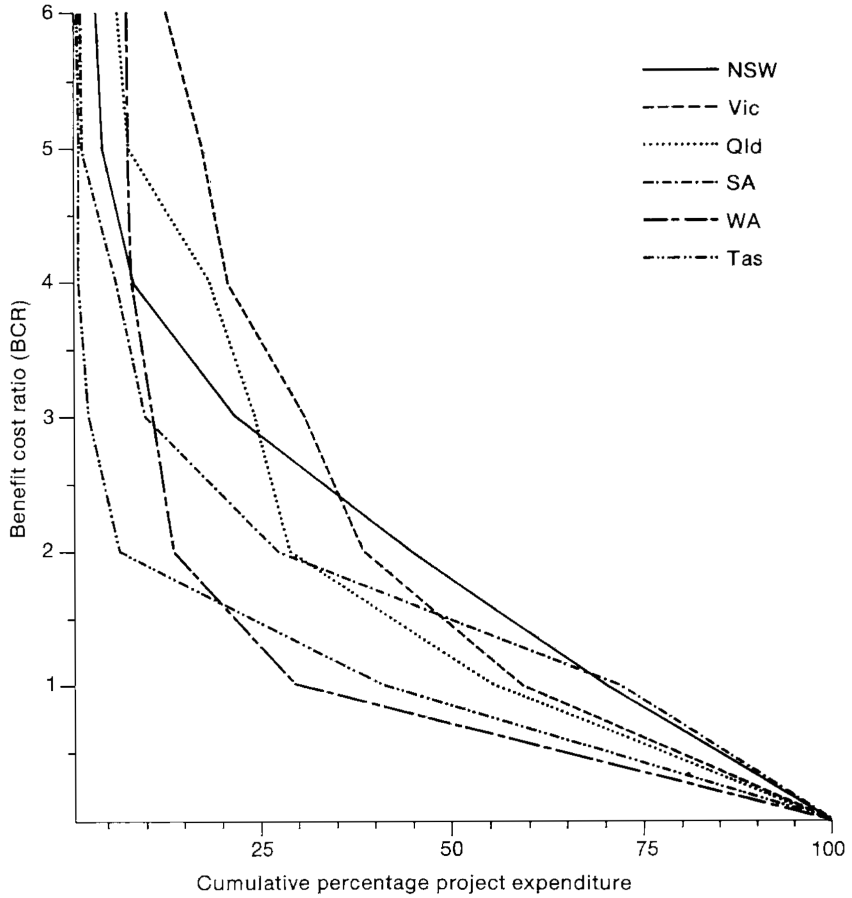


Figure IV.3—All States cumulative percentage project expenditure (1985-86 to 1989-90) by benefit cost ratio, S2 standards, 10 per cent discount rate

APPENDIX V—NEW SOUTH WALES ECONOMIC RETURNS

This appendix contains detailed information (figures and tables) concerning the economic returns from NIMPAC-generated expenditure on the New South Wales rural arterial road system. There is a set of 3 figures and 5 tables.

Figure V.1 plots the level of S2 expenditure at which BCRs are greater than given levels at the three discount rates. Figure V.2 uses the same concept to allow comparisons between the alternative standards (S1, S2, S3 and S4) at the 7 per cent discount rate. Figure V.3 is a map of road study regions in the State.

Table V.1 provides the average BCRs and the percentage of expenditure with BCRs greater than one by work type. Table V.2 gives the level of discounted costs and benefits and the sources of benefits by type of work performed. Table V.3 lists the percentage of expenditure with BCRs greater than one for the three discount rates at each set of standards. Table V.4 allows comparisons to be made between expenditure in the first (1985-86 to 1989-90) and second (1990-91 to 1994-95) budget periods by work type for the four alternative standards. Table V.5 provides the percentage of expenditure with BCRs greater than one for each of the BTE defined road study regions.

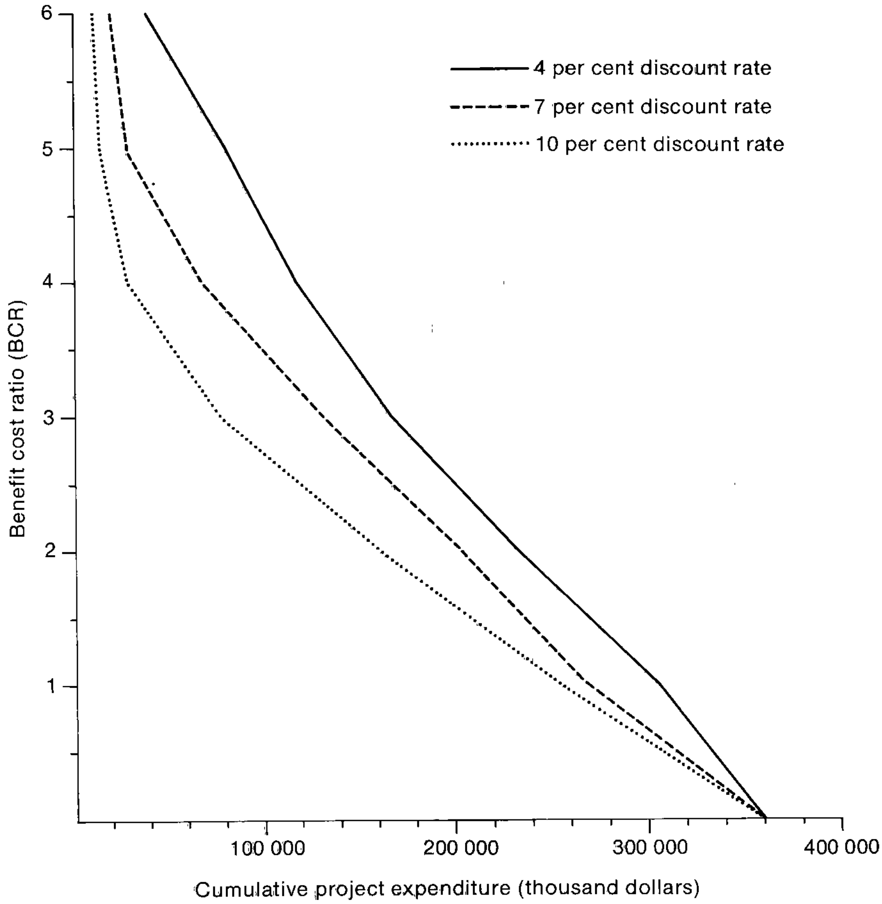


Figure V.1—New South Wales cumulative project expenditure (1985-86 to 1989-90) in 1980-81 prices by benefit cost ratio, S2 standards, all discount rates

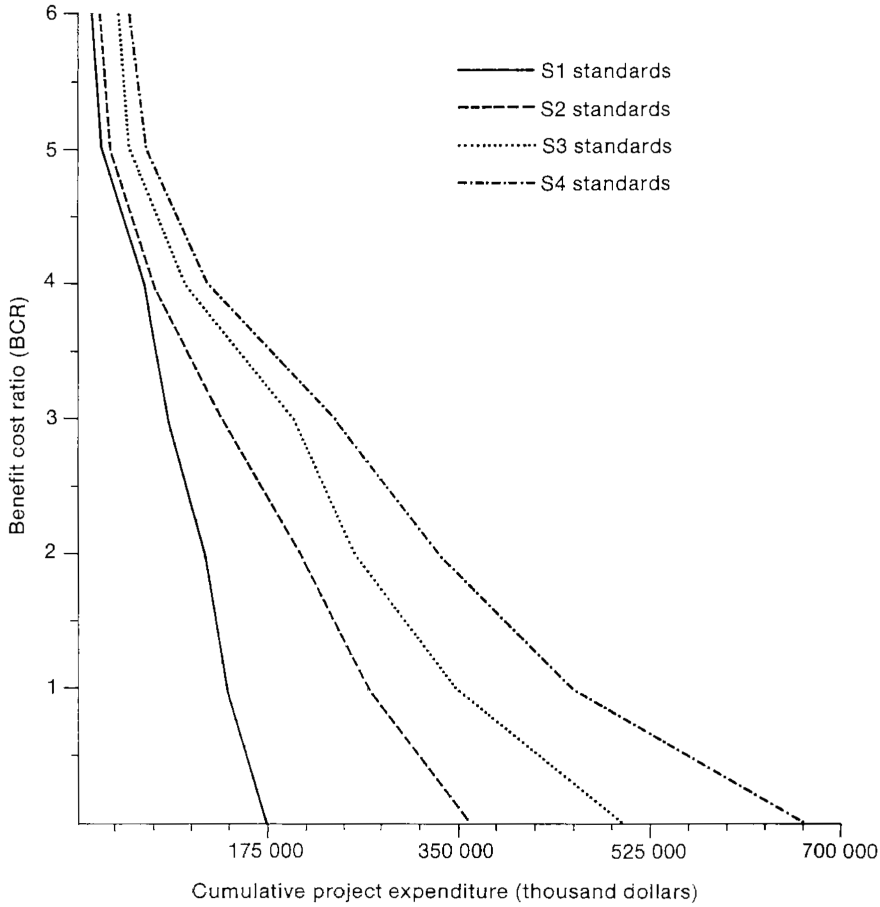
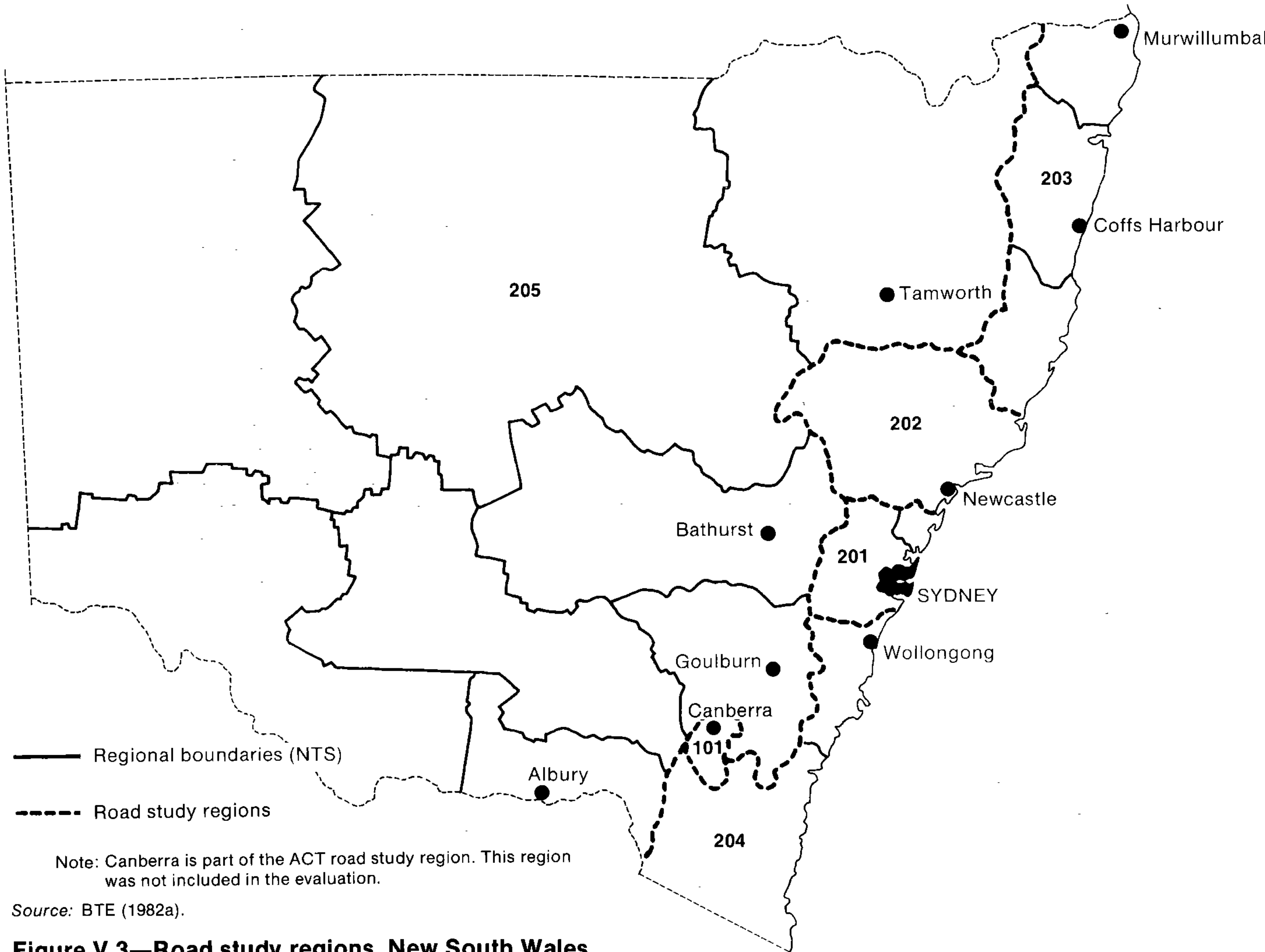


Figure V.2—New South Wales cumulative project expenditure (1985-86 to 1989-90) in 1980-81 prices by benefit cost ratio, all standards, 7 per cent discount rate



Note: Canberra is part of the ACT road study region. This region was not included in the evaluation.

Source: BTE (1982a).

Figure V.3—Road study regions, New South Wales

TABLE V.1—BENEFIT COST RATIOS BY WORK TYPE, 7 PER CENT DISCOUNT RATE, NEW SOUTH WALES

	DUPW	*DUP*	*OTAK*	*2ALW*	*REAL*	*2W*	*RHAB*	*1TO2*	*NEW2*	*NEW1*	*GRAV*	*NEWG*	*FORM*	*CONV*	*Total*
S1 standards															
Per cent of expenditure with BCR> 1	..	..	..	100.0	80.7	100.0	68.0	..	..	..	72.7	..	..	..	78.7
Overall BCR	..	..	..	4.9	3.1	5.9	2.6	..	..	..	2.1	..	..	..	3.1
S2 standards															
Per cent of expenditure with BCR > 1	..	100.0	100.0	66.5	83.5	66.0	57.5	..	72.1	..	92.6	..	..	..	73.9
Overall BCR	..	3.5	a	2.8	2.9	2.1	2.1	..	2.6	..	2.0	..	..	..	2.6
S3 standards															
Per cent of expenditure with BCR > 1	99.3	100.0	100.0	64.3	87.8	67.0	62.9	–	56.0	..	65.8	..	..	..	69.4
Overall BCR	7.3	8.0	4.6	3.1	3.1	2.3	2.5	0.6	1.5	..	1.2	..	..	..	2.6
S4 standards															
Per cent of expenditure with BCR > 1	100.0	100.0	100.0	63.4	88.1	66.4	67.5	43.9	65.0	..	37.8	100.0	..	..	68.0
Overall BCR	7.3	8.4	a	2.9	3.0	2.3	2.5	2.2	1.8	..	0.9	2.1	..	..	2.8

a. The model produced BCRs greater than 10.0 for these cases. However there were special circumstances pertaining which inflated the BCRs. It is considered that these cases should simply be interpreted as having large returns, but with no specific BCR attached.

– nil or rounded to zero

.. not applicable

TABLE V.2—COMPONENTS OF BENEFITS, S2 STANDARDS, 7 PER CENT DISCOUNT RATE, NEW SOUTH WALES

	DUPW	*DUP*	*OTAK*	*2ALW*	*REAL*	*2W*	*RHAB*	*1TO2*	*NEW2*	*NEW1*	*GRAV*	*NEWG*	*FORM*	*CONV*	*Total*
Total discounted benefits[a]	..	87.2	22.3	116.1	160.3	115.5	87.6	..	6.9	..	72.8	..	..	..	668.7
Total discounted costs[a]	–	24.7	2.2	41.4	55.0	53.8	42.3	–	2.7	–	36.6	–	–	–	258.6
Discounted benefits as a percentage of total discounted benefits															
Road user															
Travel time	..	52.2	27.3	40.2	34.8	40.0	41.6	..	56.1	..	57.1	..	..	..	42.2
Vehicle operating costs	..	40.7	70.2	56.3	64.7	56.5	57.5	..	37.5	..	42.9	..	..	..	55.3
Accident costs	..	7.8	2.3	3.0	–	2.9	–	..	0.2	..	0.1	..	..	..	2.1
Total	..	100.7	99.8	99.5	99.4	99.4	99.1	..	93.8	..	100.0	..	..	..	99.6
Road authority															
Maintenance	..	–0.9	–0.1	0.2	0.2	0.2	0.2	..	7.6	..	0.2	..	..	..	0.1
Resealing	..	0.2	0.3	0.3	0.4	0.4	0.7	..	–1.4	..	–0.2	..	..	..	0.3
Total	..	–0.7	0.2	0.5	0.6	0.6	0.9	..	6.2	..	–	..	..	..	0.4

a. $ million, 1980-81 prices.

– nil or rounded to zero

.. not applicable

Note: These figures are for road sections with projects generated in the budget period (1985-86 to 1989-90).

TABLE V.3—EXPENDITURES WITH BCR > 1 BY WORK TYPE, VARYING DISCOUNT RATES, NEW SOUTH WALES

(per cent)

Discount rate (per cent)	*DUPW*	*DUP*	*OTAK*	*2ALW*	*REAL*	*2W*	*RHAB*	*1TO2*	*NEW2*	*NEW1*	*GRAV*	*NEWG*	*FORM*	*CONV*	*Total*
S1 standards															
4	..	..	..	100.0	80.7	100.0	81.8	..	..	..	77.2	..	..	..	84.3
7	..	..	..	100.0	80.7	100.0	68.0	..	..	..	72.7	..	..	..	78.7
10	..	..	..	100.0	80.7	100.0	64.5	..	..	..	71.3	..	..	..	77.3
S2 standards															
4	..	100.0	100.0	77.5	83.5	90.4	70.8	..	72.1	..	95.1	..	..	..	84.1
7	..	100.0	100.0	66.5	83.5	66.0	57.5	..	72.1	..	92.6	..	..	..	73.9
10	..	100.0	100.0	65.6	78.3	57.5	56.4	..	72.1	..	87.8	..	..	..	69.9
S3 standards															
4	99.3	100.0	100.0	73.6	87.8	89.1	76.6	–	72.9	..	74.9	..	..	..	81.2
7	99.3	100.0	100.0	64.3	87.8	67.0	62.9	–	56.0	..	65.8	..	..	..	69.4
10	98.6	100.0	100.0	64.3	82.1	57.0	61.1	–	50.8	..	50.4	..	..	..	63.8
S4 standards															
4	100.0	100.0	100.0	76.1	89.0	83.7	80.0	43.9	77.4	..	45.5	100.0	..	..	78.8
7	100.0	100.0	100.0	63.4	88.1	66.4	67.5	43.9	65.0	..	37.8	100.0	..	..	68.0
10	99.3	100.0	100.0	63.4	83.9	57.8	65.5	43.9	58.4	..	29.9	100.0	..	..	63.3

– nil or rounded to zero

.. not applicable

TABLE V.4—EXPENDITURES IN THE FIRST AND SECOND BUDGET PERIOD BY WORK TYPE, NEW SOUTH WALES

($'000 1980-81 prices)

Work type	*S1 Standards*		*S2 Standards*		*S3 Standards*		*S4 Standards*	
	First Budget Period	*Second Budget Period*	*First Budget Period*	*Second Budget Period*	*First Budget Period*	*Second Budget Period*	*First Budget Period*	*Second Budget Period*
DUPW	–	–	–	2 551	3 131	10 346	3 131	10 338
DUP	–	12 028	31 472	39 314	22 630	12 410	33 227	14 144
OTAK	–	–	3 266	–	4 784	25 963	5 404	25 987
2ALW	29 388	36 534	65 028	109 497	77 299	121 863	90 753	135 409
REAL	54 848	117 346	81 550	87 224	75 338	73 551	84 058	68 456
2W	3 904	63 658	85 388	243 367	108 557	304 184	149 844	338 726
RHAB	63 948	225 003	64 402	169 660	99 394	159 872	113 212	220 102
1TO2	–	1 307	–	3 107	1 169	3 101	2 084	4 369
NEW2	–	–	3 911	29 965	56 124	26 517	114 230	4 619
NEW1	–	–	–	–	–	–	–	–
GRAV	21 614	42 804	27 139	42 349	51 904	91 050	66 478	107 818
NEWG	–	–	–	–	–	4 166	2 606	1 263
FORM	–	–	–	–	–	–	–	–
CONV	–	–	–	–	–	–	–	–
Total	173 702	498 680	362 156	727 034	500 330	833 053	665 027	931 231

– Nil or rounded to zero

Note: The first and second budget periods are 1985-86 to 1989-90 and 1990-91 to 1994-95 respectively.

TABLE V.5—EXPENDITURES WITH BCR > 1 BY ROAD STUDY REGIONS, 7 PER CENT DISCOUNT RATE, NEW SOUTH WALES: 1985-86 TO 1989-90

	Road study region[a]					
	201	*202*	*203*	*204*	*205*	*Total*
Length of network (km)	23	1 062	2 132	1 557	23 367	28 141
Per cent by region	0.1	3.8	7.6	5.5	83.0	100.0
S1 standards						
Expenditure in first budget period[b]	–	469	72 370	13 145	87 718	173 702
Per cent by region	–	0.3	41.7	7.6	50.5	100.0
Per cent in region with BCR > 1	..	100.0	78.6	100.0	75.5	78.7
S2 standards						
Expenditure in first budget period[b]	–	8 110	131 746	22 763	199 537	362 156
Per cent by region	–	2.2	36.4	6.3	55.1	100.0
Per cent in region with BCR > 1	..	75.6	74.9	98.0	70.4	73.9
S3 standards						
Expenditure in first budget period[b]	–	19 618	147 358	33 470	299 884	500 330
Per cent by region	–	3.9	29.5	6.7	59.9	100.0
Per cent in region with BCR > 1	..	46.0	74.4	90.9	66.0	69.4
S4 standards						
Expenditure in first budget period[b]	182	23 508	176 714	40 954	423 669	665 027
Per cent by region	–	3.5	26.6	6.2	63.7	100.0
Per cent in region with BCR > 1	100.0	53.7	73.5	76.2	65.6	68.0

a. 201–Sydney, 202–Hunter, 203–North Coast, 204–Illawarra and South, 205–West.
b. $'000, 1980-81 prices.

– nil or rounded to zero

.. not applicable

APPENDIX VI—VICTORIAN ECONOMIC RETURNS

This appendix contains detailed information (figures and tables) concerning the economic returns from NIMPAC-generated expenditure on Victoria's rural arterial road system. There is a set of 3 figures and 5 tables.

Figure VI.1 plots the level of S2 expenditure at which BCRs are greater than given levels at the three discount rates. Figure VI.2 uses the same concept to allow comparisons between the alternative standards (S1, S2, S3 and S4) at the 7 per cent discount rate. Figure VI.3 is a map of road study regions in the State.

Table VI.1 provides the average BCRs and the percentage of expenditure with BCRs greater than one by work type. Table VI.2 gives the level of discounted costs and benefits and the sources of benefits by type of work performed. Table VI.3 lists the percentage of expenditure with BCRs greater than one for the three discount rates at each set of standards. Table VI.4 allows comparisons to be made between expenditure in the first (1985-86 to 1989-90) and second (1990-91 to 1994-95) budget periods by work type for the four alternative standards. Table VI.5 provides the percentage of expenditure with BCRs greater than one for each of the BTE defined road study regions.

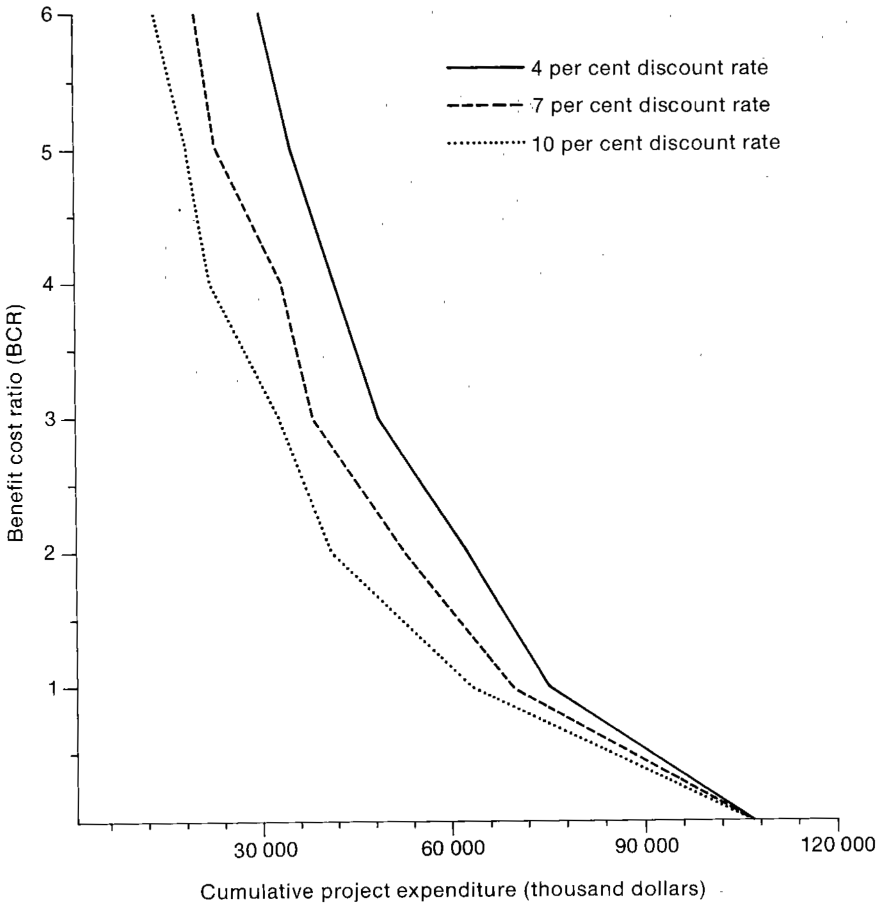


Figure VI.1—Victoria cumulative project expenditure (1985-86 to 1989-90) in 1980-81 prices by benefit cost ratio, S2 standards, all discount rates

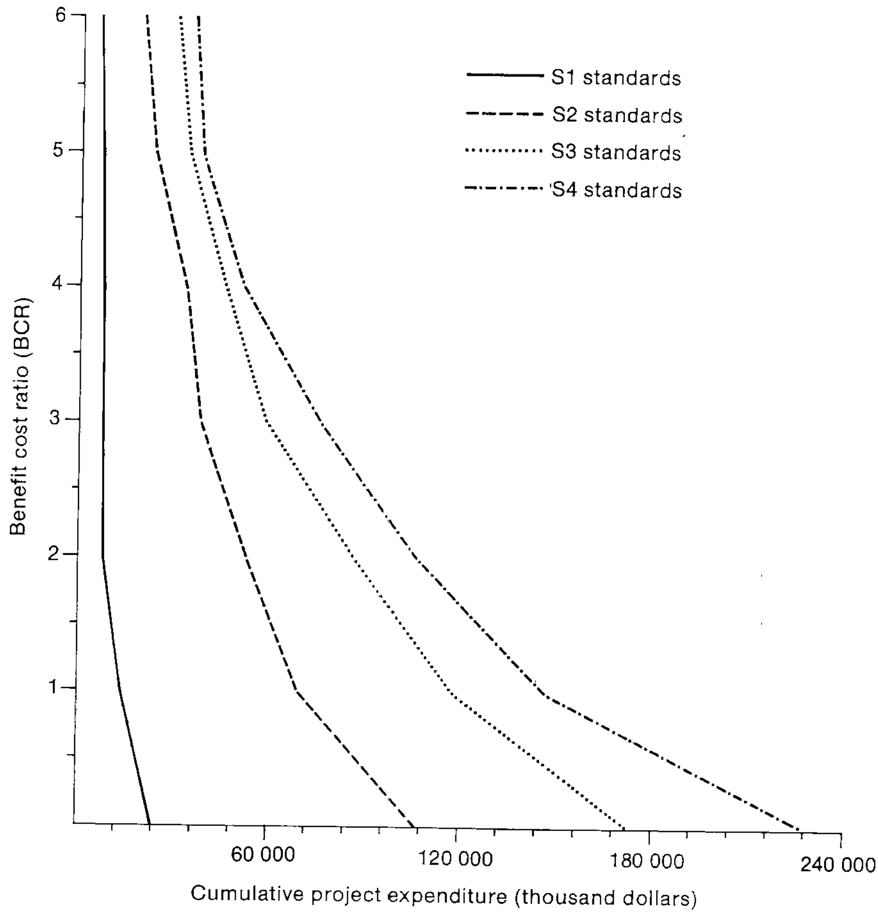
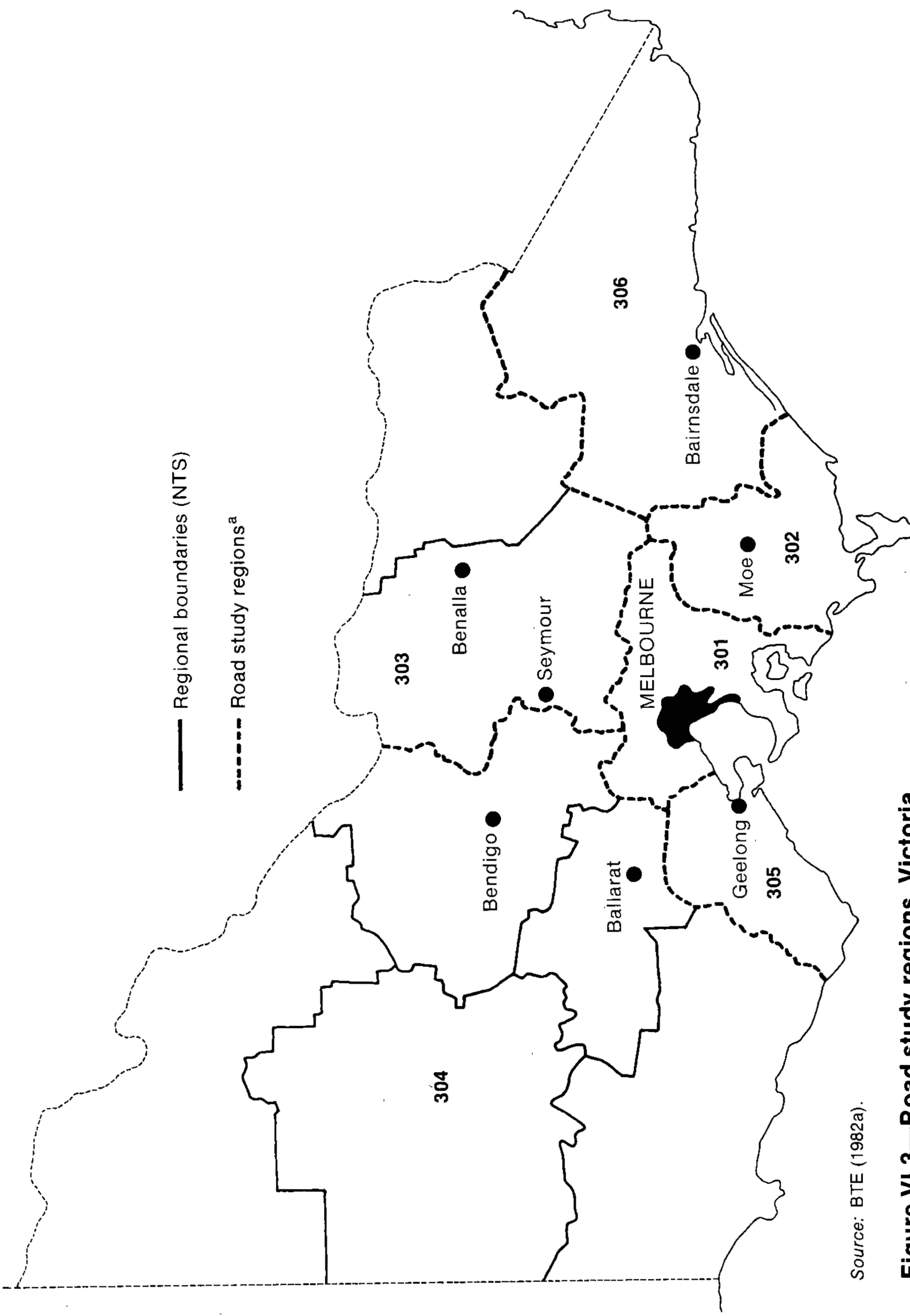


Figure VI.2—Victoria cumulative project expenditure (1985-86 to 1989-90) in 1980-81 prices by benefit cost ratio, all standards, 7 per cent discount rate



Source: BTE (1982a).

Figure VI.3—Road study regions, Victoria

TABLE VI.1—BENEFIT COST RATIOS BY WORK TYPE, 7 PER CENT DISCOUNT RATE, VICTORIA

	DUPW	*DUP*	*OTAK*	*2ALW*	*REAL*	*2W*	*RHAB*	*1TO2*	*NEW2*	*NEW1*	*GRAV*	*NEWG*	*FORM*	*CONV*	*Total*
S1 standards															
Per cent of expenditure with BCR > 1	17.1	100.0	100.0	..	..	95.0	46.4	100.0	..	..	7.9	..	..	88.6	50.9
Overall BCR	2.5	5.3	a	..	..	2.7	3.4	1.2	..	..	0.4	..	..	4.0	3.7
S2 standards															
Per cent of expenditure with BCR > 1	41.1	100.0	100.0	100.0	0.3	92.3	67.4	–	..	..	1.4	..	..	83.3	62.9
Overall BCR	3.5	9.0	a	2.6	0.4	2.6	2.5	0.9	..	..	0.1	..	..	4.5	3.6
S3 standards															
Per cent of expenditure with BCR > 1	41.1	100.0	100.0	62.9	27.4	85.6	80.6	40.2	..	..	1.4	..	..	90.1	67.0
Overall BCR	3.6	7.5	a	1.5	1.0	2.6	3.2	1.0	..	..	0.1	..	..	5.5	3.4
S4 standards															
Per cent of expenditure with BCR > 1	45.7	98.0	100.0	41.7	45.8	84.1	78.9	25.0	..	..	1.4	..	..	67.6	63.4
Overall BCR	3.4	5.3	7.8	1.2	1.3	2.5	3.1	0.9	..	..	0.1	..	..	6.6	3.1

a. The model produced BCRs greater than 10.0 for these cases. However there were special circumstances pertaining which inflated the BCRs. It is considered that these cases should simply be interpreted as having large returns, but with no specific BCR attached.

– nil or rounded to zero

.. not applicable

TABLE VI.2—COMPONENTS OF BENEFITS, S2 STANDARDS, 7 PER CENT DISCOUNT RATE, VICTORIA

	DUPW	*DUP*	*OTAK*	*2ALW*	*REAL*	*2W*	*RHAB*	*1TO2*	*NEW2*	*NEW1*	*GRAV*	*NEWG*	*FORM*	*CONV*	*Total*
Total discounted benefits[a]	9.5	169.6	12.2	15.3	2.4	47.5	50.0	1.3	–	–	1.1	–	–	9.7	318.7
Total discounted costs[a]	2.7	18.9	0.7	6.0	5.7	18.0	20.2	1.4	–	–	12.6	–	–	2.1	88.4
Discounted benefits as percentage of total discounted benefits															
Road user															
Travel time	49.0	76.4	46.7	22.1	57.7	32.3	20.2	75.3	..	..	50.3	..	..	22.1	54.6
Vehicle operating costs	48.7	17.7	53.3	76.5	37.0	64.5	82.3	20.8	..	..	49.7	..	..	79.5	42.1
Accident costs	2.2	6.3	–	1.3	–	2.7	–	2.1	..	..	–	..	..	0.9	3.9
Total	99.8	100.5	100.0	99.8	94.7	99.6	102.5	98.2	..	..	100.0	..	..	102.5	100.6

TABLE VI.2(Cont)—COMPONENTS OF BENEFITS, S2 STANDARDS, 7 PER CENT DISCOUNT RATE, VICTORIA

	DUPW	*DUP*	*OTAK*	*2ALW*	*REAL*	*2W*	*RHAB*	*1TO2*	*NEW2*	*NEW1*	*GRAV*	*NEWG*	*FORM*	*CONV*	*Total*
Road authority															
Maintenance	0.1	-0.5	–	0.2	0.3	0.3	-4.0	0.2	..	..	–	..	..	-4.1	-0.9
Resealing	0.1	–	–	–	5.0	0.1	1.5	1.6	..	..	–	..	..	1.5	0.3
Total	0.2	-0.5	–	0.2	5.3	0.4	-2.5	1.8	..	..	–	..	..	-2.6	-0.6

a. $ million, 1980-81 prices.

– nil or rounded to zero

.. not applicable

Note: These figures are for road sections with projects generated in the budget period (1985-86 to 1989-90).

TABLE VI.3—EXPENDITURES WITH BCR > 1 BY WORK TYPE, VARYING DISCOUNT RATES, VICTORIA

(per cent)

Discount rate (per cent)	*DUPW*	*DUP*	*OTAK*	*2ALW*	*REAL*	*2W*	*RHAB*	*1TO2*	*NEW2*	*NEW1*	*GRAV*	*NEWG*	*FORM*	*CONV*	*Total*
S1 standards															
4	17.1	100.0	100.0	..	..	95.0	57.5	100.0	..	..	7.9	..	..	88.6	56.4
7	17.1	100.0	100.0	..	..	95.0	46.4	100.0	..	..	7.9	..	..	88.6	50.9
10	17.1	100.0	100.0	..	..	95.0	37.1	–	..	..	–	..	..	80.0	36.3
S2 standards															
4	41.1	100.0	100.0	100.0	21.7	95.9	70.3	100.0	..	..	1.4	..	..	88.9	68.3
7	41.1	100.0	100.0	100.0	0.3	92.3	67.4	–	..	..	1.4	..	..	83.3	62.9
10	41.1	100.0	100.0	59.6	0.3	84.8	65.1	–	..	..	–	..	..	75.6	56.5
S3 standards															
4	41.1	100.0	100.0	62.9	39.4	94.2	82.4	84.9	..	..	1.4	..	..	90.1	72.6
7	41.1	100.0	100.0	62.9	27.4	85.6	80.6	40.2	..	..	1.4	..	..	90.1	67.0
10	41.1	95.1	100.0	44.4	27.4	77.8	79.2	40.2	..	..	–	..	..	78.9	61.4
S4 standards															
4	45.7	100.0	100.0	45.0	87.6	88.7	80.8	32.9	..	..	1.4	..	..	67.6	68.7
7	45.7	98.0	100.0	41.7	45.8	84.1	78.9	25.0	..	..	1.4	..	..	67.6	63.4
10	37.9	93.5	100.0	26.9	31.4	75.1	77.5	25.0	..	..	–	..	..	57.5	55.9

– nil or rounded to zero

.. not applicable

TABLE VI.4—EXPENDITURES IN THE FIRST AND SECOND BUDGET PERIOD BY WORK TYPE, VICTORIA

($'000 1980-81 prices)

Work type	S1 Standards		S2 Standards		S3 Standards		S4 Standards	
	First Budget Period	Second Budget Period	First Budget Period	Second Budget Period	First Budget Period	Second Budget Period	First Budget Period	Second Budget Period
DUPW	2 371	1 361	2 112	774	2 112	2 566	2 291	1 069
DUP	1 054	2 908	14 075	16 801	22 810	46 295	43 619	68 321
OTAK	520	2 959	1 010	9 051	2 705	3 242	1 712	3 242
2ALW	–	16 179	9 782	28 552	22 593	26 973	50 075	48 471
REAL	–	5 972	8 920	14 899	15 740	23 512	13 711	20 116
2W	1 413	43 241	28 708	73 178	45 593	97 365	50 742	95 286
RHAB	11 532	30 611	20 443	43 673	34 349	64 046	31 643	55 253
1TO2	1 957	2 193	2 169	11 050	7 364	11 474	14 281	12 016
NEW2	–	–	–	–	–	–	–	–
NEW1	–	203	–	1 887	–	1 887	–	1 514
GRAV	3 360	3 268	18 532	698	18 532	698	19 560	737
NEWG	–	–	–	–	–	–	–	–
FORM	–	–	–	–	–	–	–	–
CONV	1 074	146	1 208	92	1 337	139	1 467	47
Total	23 281	109 041	106 959	200 655	173 135	278 197	229 101	306 072

– Nil or rounded to zero

Note: The first and second budget periods are 1985–86 to 1989–90 and 1990–91 to 1994–95 respectively.

TABLE VI.5—EXPENDITURES WITH BCR > 1 BY ROAD STUDY REGIONS, 7 PER CENT DISCOUNT RATE, VICTORIA: 1985-86 TO 1989-90

	Road study region[a]						
	301	*302*	*303*	*304*	*305*	*306*	*Total*
Length of network (km)	601	838	2 849	8 171	985	941	14 385
Per cent by region	4.2	5.8	19.8	56.8	6.8	6.5	100.0
S1 standards							
Expenditure in first budget period[b]	2 995	6 743	5 246	3 264	3 895	1 140	23 283
Per cent by region	12.9	29.0	22.5	14.0	16.7	4.9	100.0
Per cent in region with BCR > 1	90.9	57.7	57.7	58.7	0.8	23.4	50.9
S2 standards							
Expenditure in first budget period[b]	7 128	15 961	17 845	33 999	10 604	21 422	106 959
Per cent by region	6.7	14.9	16.7	31.8	9.9	20.0	100.0
Per cent in region with BCR > 1	98.9	76.2	62.5	84.3	28.1	24.7	62.9
S3 standards							
Expenditure in first budget period[b]	28 339	26 771	22 746	57 899	13 411	23 965	173 131
Per cent by region	16.4	15.5	13.1	33.4	7.7	13.8	100.0
Per cent in region with BCR > 1	70.2	70.3	67.6	85.3	34.9	32.7	67.0

TABLE VI.5(Cont)—EXPENDITURES WITH BCR > 1 BY ROAD STUDY REGIONS, 7 PER CENT DISCOUNT RATE, VICTORIA: 1985-86 TO 1989-90

	Road study region[a]						
	301	*302*	*303*	*304*	*305*	*306*	*Total*
S4 standards							
Expenditure in first budget period[b]	49 233	39 096	30 225	64 378	15 055	31 114	229 101
Per cent by region	21.5	17.1	13.2	28.1	6.6	13.6	100.0
Per cent in region with BCR > 1	49.3	71.3	63.9	82.0	44.8	45.7	63.4

a. 301—Melbourne, 302—South Gippsland, 303—North, 304—Murray and West, 305—Geelong, 306—East Gippsland.
b. $'000, 1980-81 prices.

APPENDIX VII—QUEENSLAND ECONOMIC RETURNS

This appendix contains detailed information (figures and tables) concerning the economic returns from NIMPAC-generated expenditure on Queensland's rural arterial road system. There is a set of three figures and five tables.

Figure VII.1 plots the level of S2 expenditure at which BCRs are greater than given levels at the three discount rates. Figure VII.2 uses the same concept to allow comparisons between the alternative standards (S1, S2, S3 and S4) at the 7 per cent discount rate. Figure VII.3 is a map of road study regions in the State.

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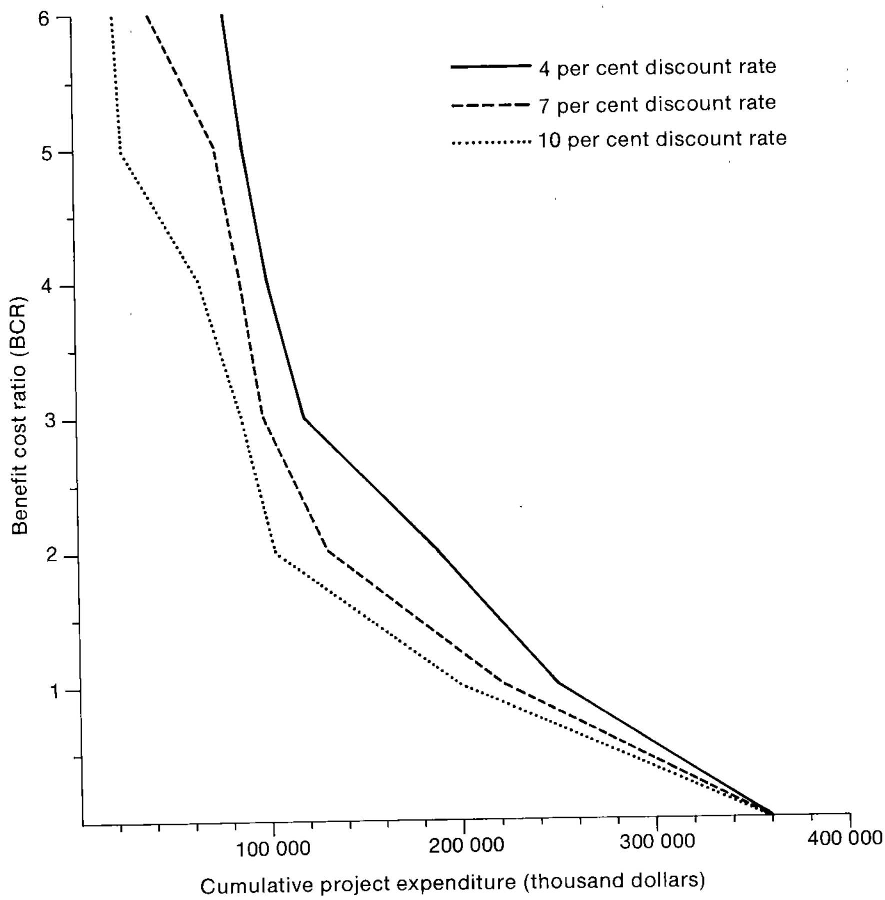


Figure VII.1—Queensland cumulative project expenditure (1985-86 to 1989-90) in 1980-81 prices by benefit cost ratio, S2 standards, all discount rates

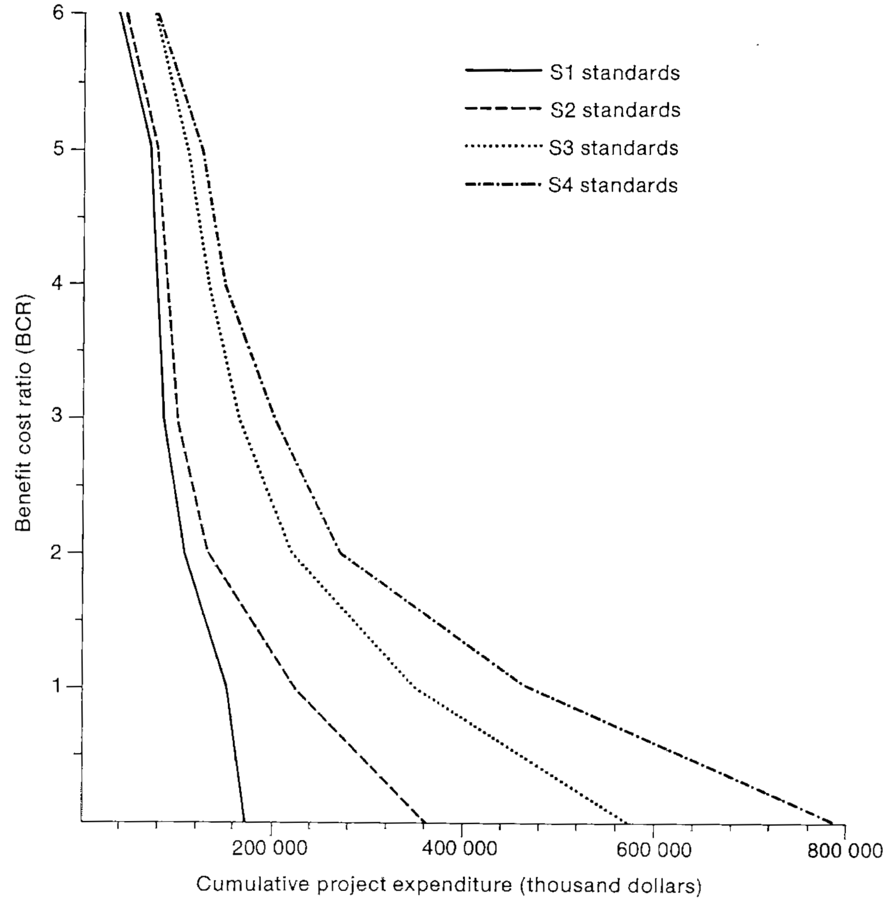
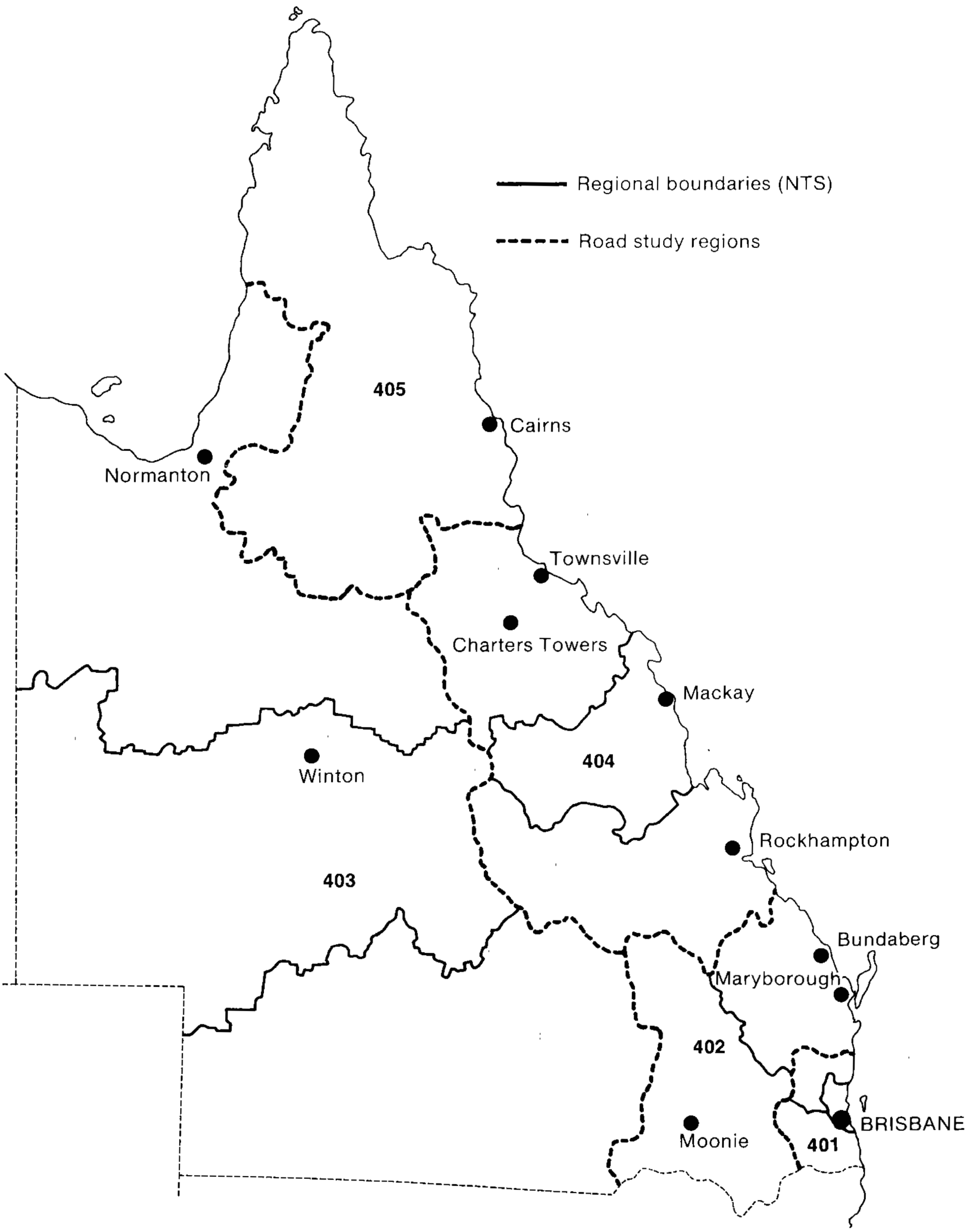


Figure VII.2—Queensland cumulative project expenditure (1985-86 to 1989-90) in 1980-81 prices by benefit cost ratio, all standards, 7 per cent discount rate



Source: BTE (1982a).

Figure VII.3—Road study regions, Queensland

TABLE VII.1—BENEFIT COST RATIOS BY WORK TYPE, 7 PER CENT DISCOUNT RATE, QUEENSLAND

	DUPW	*DUP*	*OTAK*	*2ALW*[a]	*REAL*[a]	*2W*	*RHAB*	*1TO2*	*NEW2*	*NEW1*	*GRAV*	*NEWG*	*FORM*	*CONV*	*Total*
S1 standards															
Per cent of expenditure with BCR > 1	100.0	100.0	100.0	..	..	90.7	88.8	89.9	98.2	..	50.3	..	..	–	88.3
Overall BCR	b	b	b	..	..	9.8	5.1	1.7	4.0	..	1.3	..	..	0.4	4.9
S2 standards															
Per cent of expenditure with BCR > 1	100.0	100.0	100.0	..	..	88.0	59.7	75.1	53.9	..	2.7	53.4	..	–	61.4
Overall BCR	b	b	b	..	..	5.4	3.4	1.4	2.2	..	0.7	0.9	..	0.4	3.2
S3 standards															
Per cent of expenditure with BCR > 1	100.0	100.0	100.0	..	..	90.8	33.3	53.5	47.5	..	2.6	..	..	–	61.0
Overall BCR	b	b	b	..	..	4.5	1.8	1.3	1.9	..	0.6	..	..	0.4	3.1
S4 standards															
Per cent of expenditure with BCR > 1	100.0	100.0	100.0	..	..	88.0	29.3	47.2	42.1	..	3.3	..	..	–	59.3
Overall BCR	b	7.7	b	..	..	3.3	1.2	1.1	1.7	..	0.7	..	..	0.4	2.6

a. The Queensland inventory did not contain alignment data, so no projects of this type were recorded.

b. The model produced BCRs greater than 10.0 for these cases. However there were special circumstances pertaining which inflated the BCRs. It is considered that these cases should simply be interpreted as having large returns, but with no specific BCR attached.

– nil or rounded to zero

.. not applicable

TABLE VII.2—COMPONENTS OF BENEFITS, S2 STANDARDS, 7 PER CENT DISCOUNT RATE, QUEENSLAND

	DUPW	*DUP*	*OTAK*	*2ALW*[a]	*REAL*[a]	*2W*	*RHAB*	*1TO2*	*NEW2*	*NEW1*	*GRAV*	*NEWG*	*FORM*	*CONV*	*Total*
Total discounted benefits[b]	76.2	127.5	7.5	..	..	235.5	23.3	29.6	306.3	–	15.6	5.9	–	1.5	828.9
Total discounted costs[b]	1.2	9.9	0.2	..	..	44.0	6.9	21.2	141.2	–	23.0	6.4	–	3.5	257.5
Discounted benefits as a percentage of total discounted benefits															
Road user															
Travel time	76.0	59.3	70.7	..	..	49.9	21.1	57.2	36.2	..	42.7	24.6	..	121.3	48.2
Vehicle operating costs	22.7	35.2	27.4	..	..	46.0	77.7	37.3	59.4	..	54.9	72.9	..	4.5	47.8
Accident costs	1.2	5.6	1.8	..	..	3.9	–	6.2	0.4	..	0.1	-0.2	..	–	2.5
Total	100.0	100.2	99.9	..	..	99.7	98.8	100.7	96.0	..	97.7	97.4	..	125.8	98.5
Road authority															
Maintenance	–	-0.3	–	..	..	0.1	0.2	0.2	5.9	..	4.2	7.9	..	-25.8	2.3
Resealing	–	0.1	0.1	..	..	0.2	1.0	-1.0	-2.0	..	-1.9	-5.3	..	–	-0.7
Total	–	-0.2	0.1	..	..	0.3	1.2	-0.7	4.0	..	2.3	2.6	..	-25.8	1.5

a. The Queensland inventory did not contain alignment data so no projects of this type were recorded.
b. $ million, 1980-81 prices.

– nil or rounded to zero

.. *not applicable*

Notes: 1. These figures are for road sections with projects generated in the budget period (1985-86 to 1989-90).
2. Figures may not add to totals due to rounding.

TABLE VII.3—EXPENDITURES WITH BCR > 1 BY WORK TYPE, VARYING DISCOUNT RATES, QUEENSLAND

(per cent)

Discount rate (per cent)	*DUPW*	*DUP*	*OTAK*	*2ALW*[a]	*REAL*[a]	*2W*	*RHAB*	*1TO2*	*NEW2*	*NEW1*	*GRAV*	*NEWG*	*FORM*	*CONV*	*Total*
S1 standards															
4	100.0	100.0	100.0	..	..	99.2	88.8	99.6	100.0	..	63.4	..	..	–	92.8
7	100.0	100.0	100.0	..	..	90.7	88.8	89.9	98.2	..	50.3	..	..	–	88.3
10	100.0	100.0	100.0	..	..	86.8	88.8	43.3	92.9	..	49.0	..	..	–	81.4
S2 standards															
4	100.0	100.0	100.0	..	..	96.5	59.7	82.9	62.4	..	15.2	53.4	..	–	69.1
7	100.0	100.0	100.0	..	..	88.0	59.7	75.1	53.9	..	2.7	53.4	..	–	61.4
10	100.0	100.0	100.0	..	..	87.3	59.7	52.6	48.0	..	2.0	40.1	..	–	55.3
S3 standards															
4	100.0	100.0	100.0	..	..	95.1	33.3	66.4	55.4	..	20.3	..	..	–	68.2
7	100.0	100.0	100.0	..	..	90.8	33.3	53.5	47.5	..	2.6	..	..	–	61.0
10	100.0	100.0	100.0	..	..	87.9	33.3	37.0	41.4	..	–	..	..	–	54.7
S4 standards															
4	100.0	100.0	100.0	..	..	93.7	30.5	62.5	50.7	..	42.2	..	..	–	67.6
7	100.0	100.0	100.0	..	..	88.0	29.3	47.2	42.1	..	3.3	..	..	–	59.3
10	100.0	100.0	100.0	..	..	80.5	27.6	32.1	36.9	..	–	..	..	–	51.9

a. The Queensland inventory did not contain alignment data so no projects of this type were recorded.

– nil or rounded to zero

.. not applicable

TABLE VII.4—EXPENDITURES IN THE FIRST AND SECOND BUDGET PERIOD BY WORK TYPE, QUEENSLAND

($'000 1980-81 prices)

Work type	*S1 Standards*		*S2 Standards*		*S3 Standards*		*S4 Standards*	
	First Budget Period	*Second Budget Period*	*First Budget Period*	*Second Budget Period*	*First Budget Period*	*Second Budget Period*	*First Budget Period*	*Second Budget Period*
DUPW	1 717	1 139	1 717	1 139	1 717	2 086	2 660	4 899
DUP	206	–	7 809	6 887	13 047	33 545	41 084	40 306
OTAK	254	701	254	701	254	701	254	701
2ALW[a]	..	..	..	..	..	..	..	..
REAL[a]	..	..	..	..	..	..	..	..
2W	36 852	79 322	67 095	78 178	170 042	92 796	240 465	153 553
RHAB	6 223	10 296	10 149	11 299	23 718	20 464	40 512	30 184
1TO2	10 998	28 221	33 976	40 440	92 584	78 454	165 963	88 444
NEW2	94 388	8 322	215 991	–	256 801	8 629	288 521	10 490
NEW1	–	–	–	–	–	–	–	–
GRAV	15 277	13 257	9 895	15 978	7 990	11 024	2 237	2 722
NEWG	–	11 939	8 215	1 055	–	–	–	–
FORM	–	–	–	–	–	–	–	–
CONV	5 658	–	5 658	–	5 658	–	5 658	–
Total	171 574	153 197	360 757	155 677	571 810	247 699	787 352	331 299

a. The Queensland inventory did not contain alignment data so no projects of this type were recorded.

– Nil or rounded to zero

.. Not applicable

Note: The first and second budget periods are 1985-86 to 1989-90 and 1990-91 to 1994-95 respectively.

TABLE VII.5—EXPENDITURES WITH BCR > 1 BY ROAD STUDY REGIONS, 7 PER CENT DISCOUNT RATE, QUEENSLAND: 1985-86 TO 1989-90

	Road study region[a]					
	401	*402*	*403*	*404*	*405*	*Total*
Length of network (km)	1 183	5 033	6 510	4 440	1 672	18 838
Per cent by region	6.3	26.7	34.6	23.6	8.9	100.0
S1 standards						
Expenditure in first budget period[b]	7 435	24 760	14 563	99 389	25 424	171 571
Per cent by region	4.3	14.4	8.5	57.9	14.8	100.0
Per cent in region with BCR > 1	100.0	82.7	50.5	92.1	96.9	88.3
S2 standards						
Expenditure in first budget period[b]	10 540	76 673	47 307	164 154	62 083	360 757
Per cent by region	2.9	21.3	13.1	45.5	17.2	100.0
Percent in region with BCR > 1	100.0	56.3	40.2	65.9	65.5	61.4
S3 standards						
Expenditure in first budget period[b]	27 725	141 461	92 292	219 318	91 014	571 810
Per cent by region	4.8	24.7	16.1	38.4	15.9	100.0
Per cent in region with BCR > 1	84.8	57.7	24.7	70.6	72.7	61.0
S4 standards						
Expenditure in first budget period[b]	62 552	191 987	143 178	293 605	96 030	787 352
Per cent by region	7.9	24.4	18.2	37.3	12.2	100.0
Per cent in region with BCR > 1	87.9	54.4	21.2	70.3	74.1	59.3

a. 401—Brisbane/Gold Coast, 402—Darling Downs and Wide Bay/Burnett, 403—South West, 404—Fitzroy/Mackay/Townsville, 405—Northern.

b. $'000, 1980-81 prices.

APPENDIX VIII—SOUTH AUSTRALIAN ECONOMIC RETURNS

This appendix contains detailed information (figures and tables) concerning the economic returns from NIMPAC-generated expenditure on South Australia's rural arterial road system. There is a set of three figures and five tables.

Figure VIII.1 plots the level of S2 expenditure at which BCRs are greater than given levels at the three discount rates. Figure VIII.2 uses the same concept to allow comparisons between the alternative standards (S1, S2, S3 and S4) at the 7 per cent discount rate. Figure VIII.3 is a map of the road study regions in the State.

Table VIII.1 provides the average BCRs and the percentage of expenditure with BCRs greater than one by work type. Table VIII.2 gives the level of discounted costs and benefits and the sources of benefits by type of work performed. Table VIII.3 lists the percentage of expenditure with BCRs greater than one for the three discount rates at each set of standards. Table VIII.4 allows comparisons to be made between expenditure in the first (1985-86 to 1989-90) and second (1990-91 to 1994-95) budget periods by work type for the four alternative standards. Table VIII.5 provides the percentage of expenditure with BCRs greater than one for each of the BTE defined road study regions.

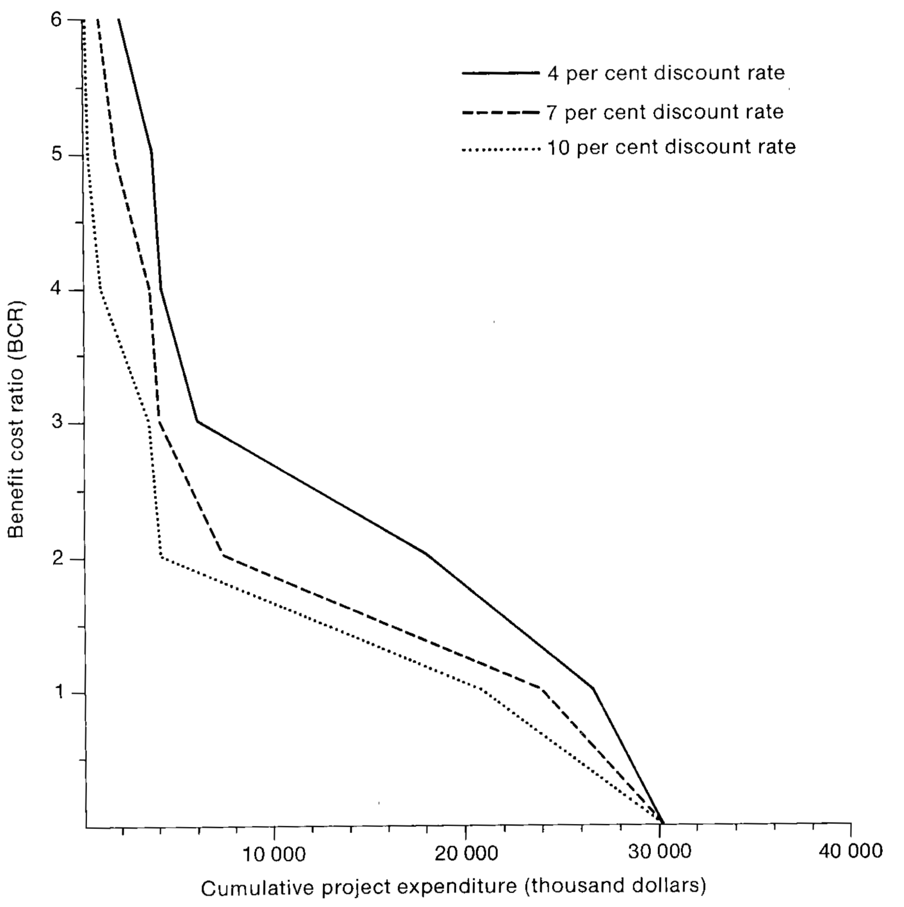


Figure VIII.1—South Australia cumulative project expenditure (1985-86 to 1989-90) in 1980-81 prices by benefit cost ratio, S2 standards, all discount rates

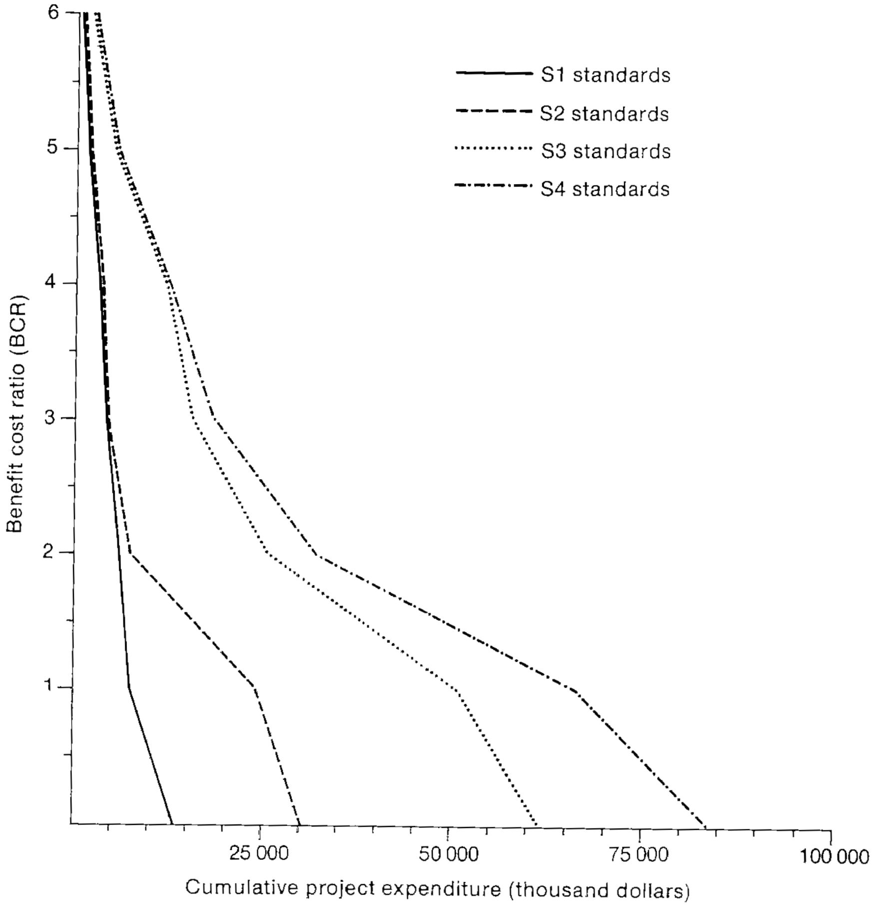
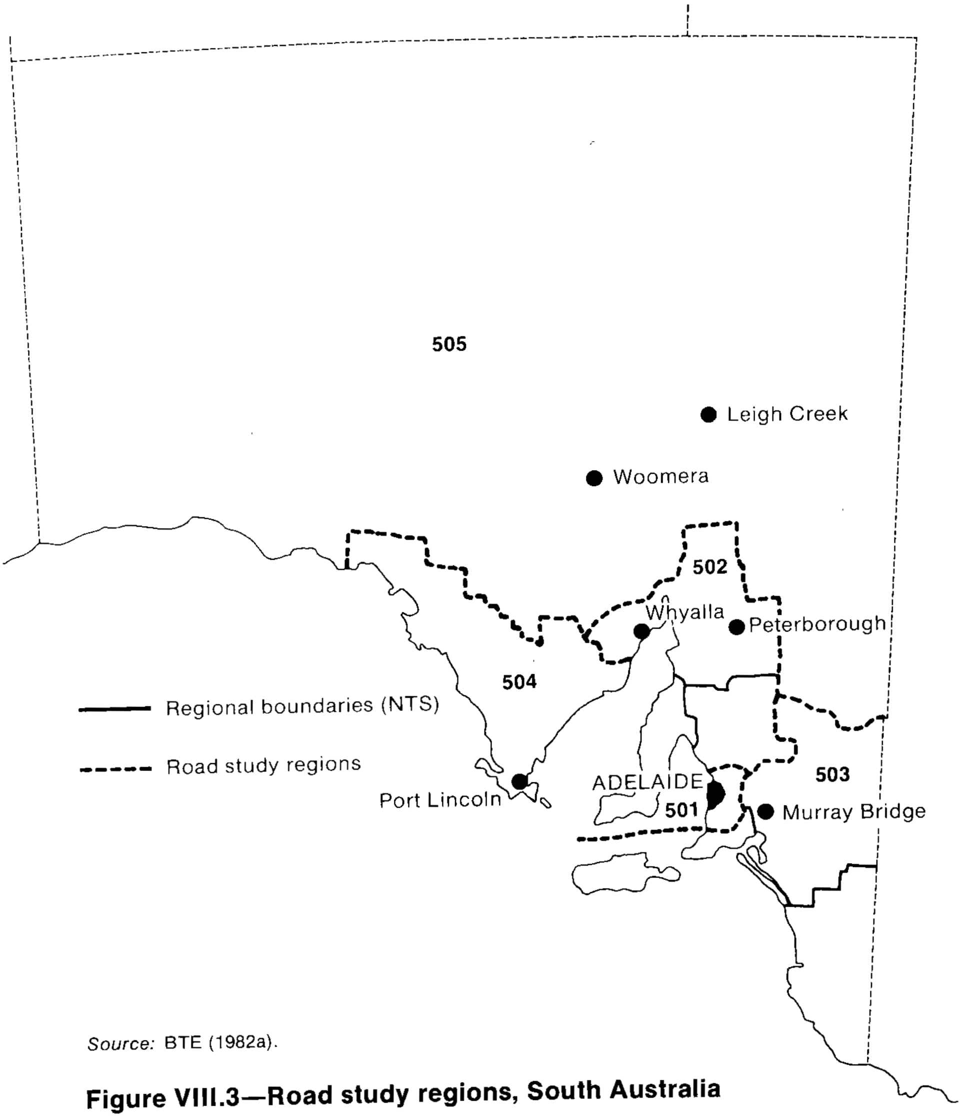


Figure VIII.2—South Australia cumulative project expenditure (1985-86 to 1989-90) in 1980-81 prices by benefit cost ratio, all standards, 7 per cent discount rate



Source: BTE (1982a).

Figure VIII.3—Road study regions, South Australia

TABLE VIII.1—BENEFIT COST RATIOS BY WORK TYPE, 7 PER CENT DISCOUNT RATE, SOUTH AUSTRALIA

	DUPW	*DUP*	*OTAK*	*2ALW*	*REAL*	*2W*	*RHAB*	*1TO2*	*NEW2*	*NEW1*	*GRAV*	*NEWG*	*FORM*	*CONV*	*Total*
S1 standards															
Per cent of expenditure with BCR > 1	100.0	100.0	100.0	..	..	37.4	96.5	–	..	..	..	..	..	..	55.1
Overall BCR	4.7	5.0	6.9	..	..	1.6	3.5	0.9	..	..	..	..	..	..	2.2
S2 standards															
Per cent of expenditure with BCR > 1	100.0	100.0	100.0	43.7	100.0	65.6	95.8	–	100.0	..	..	..	..	..	79.2
Overall BCR	4.7	5.0	6.9	1.3	3.7	2.2	3.3	0.8	1.5	..	..	..	..	..	1.8
S3 standards															
Per cent of expenditure with BCR > 1	100.0	100.0	100.0	63.3	100.0	79.4	96.1	12.1	100.0	..	..	..	..	..	82.1
Overall BCR	4.7	4.1	6.9	2.0	2.8	2.3	3.3	0.9	1.5	..	..	..	..	..	2.3
S4 standards															
Per cent of expenditure with BCR > 1	100.0	100.0	100.0	68.2	100.0	76.9	93.9	15.8	100.0	..	..	..	..	..	79.1
Overall BCR	4.7	4.0	6.9	2.2	1.9	1.9	3.0	0.9	1.5	..	..	..	..	..	2.2

– nil or rounded to zero

.. not applicable

TABLE VIII.2—COMPONENTS OF BENEFITS, S2 STANDARDS, 7 PER CENT DISCOUNT RATE, SOUTH AUSTRALIA

	DUPW	*DUP*	*OTAK*	*2ALW*	*REAL*	*2W*	*RHAB*	*1TO2*	*NEW2*	*NEW1*	*GRAV*	*NEWG*	*FORM*	*CONV*	*Total*
Total discounted benefits[a]	0.7	–	0.8	6.3	2.7	5.0	6.8	0.4	13.3	..	..	..	..	..	35.9
Total discounted costs[a]	0.1	–	0.1	4.7	0.7	2.3	2.1	0.5	9.0	–	–	–	–	–	19.6
Discounted benefits as a percentage of total discounted benefits															
Road user															
Travel time	20.4	43.3	26.0	55.0	35.2	50.0	32.4	59.3	29.2	..	..	..	..	..	37.7
Vehicle operating costs	75.9	53.4	70.3	41.7	64.5	45.4	66.7	34.6	61.1	..	..	..	..	..	57.0
Accident costs	3.2	3.3	3.4	3.0	–	4.7	–	5.8	0.7	..	..	..	..	..	1.6
Total	99.6	100.0	99.6	99.6	99.7	100.1	99.1	99.7	90.9	..	..	..	..	..	96.4

TABLE VIII.2(Cont)—COMPONENTS OF BENEFITS, S2 STANDARDS, 7 PER CENT DISCOUNT RATE, SOUTH AUSTRALIA

	DUPW	*DUP*	*OTAK*	*2ALW*	*REAL*	*2W*	*RHAB*	*1TO2*	*NEW2*	*NEW1*	*GRAV*	*NEWG*	*FORM*	*CONV*	*Total*
Road authority															
Maintenance	-0.3	–	–	–	–	-0.3	0.2	0.3	10.3	..	..	..	..	..	3.8
Resealing	0.7	–	0.3	0.4	0.3	0.2	0.7	–	-1.2	..	..	..	..	..	-0.2
Total	0.4	–	0.3	0.4	0.3	-0.1	0.9	0.3	9.1	..	..	..	..	..	3.6

a. $ million, 1980-81 prices.

– nil or rounded to zero

.. not applicable

Notes: 1. These figures are for road sections with projects generated in the budget period (1985-86 to 1989-90).
2. Figures may not add to totals due to rounding.

TABLE VIII.3—EXPENDITURES WITH BCR > 1 BY WORK TYPE, VARYING DISCOUNT RATES, SOUTH AUSTRALIA

(per cent)

Discount rate (per cent)	*DUPW*	*DUP*	*OTAK*	*2ALW*	*REAL*	*2W*	*RHAB*	*1TO2*	*NEW2*	*NEW1*	*GRAV*	*NEWG*	*FORM*	*CONV*	*Total*
S1 standards															
4	100.0	100.0	100.0	..	..	89.2	100.0	100.0	..	..	..	..	..	..	93.2
7	100.0	100.0	100.0	..	..	37.4	96.5	–	..	..	..	..	..	..	55.1
10	100.0	100.0	100.0	..	..	35.1	89.7	–	..	..	..	..	..	..	51.6
S2 standards															
4	100.0	100.0	100.0	52.0	100.0	96.6	100.0	100.0	100.0	..	..	..	..	..	87.9
7	100.0	100.0	100.0	43.7	100.0	65.6	95.8	–	100.0	..	..	..	..	..	79.2
10	100.0	100.0	100.0	43.7	100.0	61.7	87.6	–	79.9	..	..	..	..	..	68.8
S3 standards															
4	100.0	100.0	100.0	80.5	100.0	98.7	100.0	100.0	100.0	..	..	..	..	..	94.0
7	100.0	100.0	100.0	63.3	100.0	79.4	96.1	12.1	100.0	..	..	..	..	..	82.1
10	100.0	100.0	100.0	63.3	100.0	78.5	88.5	–	79.9	..	..	..	..	..	76.7
S4 standards															
4	100.0	100.0	100.0	86.0	100.0	94.7	96.8	100.0	100.0	..	..	..	..	..	93.9
7	100.0	100.0	100.0	68.2	100.0	76.9	93.9	15.8	100.0	..	..	..	..	..	79.1
10	100.0	100.0	100.0	62.5	100.0	62.6	79.6	11.3	79.9	..	..	..	..	..	68.4

– nil or rounded to zero

.. not applicable

TABLE VIII.4—EXPENDITURES IN THE FIRST AND SECOND BUDGET PERIOD BY WORK TYPE, SOUTH AUSTRALIA

($'000 1980-81 prices)

Work type	S1 Standards		S2 Standards		S3 Standards		S4 Standards	
	First Budget Period	Second Budget Period	First Budget Period	Second Budget Period	First Budget Period	Second Budget Period	First Budget Period	Second Budget Period
DUPW	252	429	252	429	252	429	252	429
DUP	5	1 200	5 172	1 211	7 290	3 668	7 714	7 754
OTAK	172	–	7361	–	172	–	172	–
2ALW	–	–	1 204	12 312	18 152	18 538	25 212	22 172
REAL	–	–	3 470	2 744	2 457	2 744	1 472	10 693
2W	8 329	15 281	3 212	6 530	14 666	22 067	26 615	32 322
RHAB	3 874	4 951	804	2 479	3 462	3 608	4 720	4 038
1TO2	598	283	13 718	390	1 358	2 273	3 631	288
NEW2	–	–	–	21 637	13 718	21 637	13 718	21 637
NEW1	–	–	–	–	–	–	–	–
GRAV	–	–	–	–	–	–	–	–
NEWG	–	–	–	–	–	–	–	–
FORM	–	–	–	–	–	–	–	–
CONV	–	–	–	–	–	–	–	–
Total	13 230	22 144	30 198	47 732	61 527	74 964	83 506	99 333

– Nil or rounded to zero

Note: The first and second budget periods are 1985-86 and 1989-90 and 1990-91 and 1994-95 respectively.

TABLE VIII.5—EXPENDITURES WITH BCR > 1 BY ROAD STUDY REGIONS, 7 PER CENT DISCOUNT RATE, SOUTH AUSTRALIA: 1985-86 TO 1989-90

	Road study region[a]					
	501	*502*	*503*	*504*	*505*	*Total*
Length of network (km)	117	3 341	4 368	1 399	749	9 974
Per cent by region	1.2	233.5	43.8	14.0	7.5	100.0
S1 standards						
Expenditure in the first budget period[b]	1 278	7 539	4 277	136	-	13 230
Per cent by region	9.7	57.0	32.3	1.0	-	100.0
Per cent in region with BCR > 1	100.0	46.4	55.6	100.0	..	55.1
S2 standards						
Expenditure in the first budget period[b]	1 278	15 534	10 903	2 483	-	30 198
Per cent by region	4.2	51.4	36.1	8.2	-	100.0
Per cent in region with BCR > 1	100.0	73.9	79.5	100.0	..	79.2
S3 standards						
Expenditure in the first budget period[b]	1 456	26 972	30 288	2 811	-	61 527
Per cent by region	2.4	43.8	49.2	4.6	-	100.0
Per cent in region with BCR > 1	100.0	75.4	85.5	100.0	..	82.1
S4 standards						
Expenditure in the first budget period[b]	1 456	38 512	40 727	2 811	-	83 506
Per cent by region	1.7	46.1	48.8	3.4	-	100.0
Per cent in region with BCR > 1	100.0	74.5	81.2	100.0	..	79.1

a. 501—Adelaide, 502—Mid North, 503—Murray and South East, 504—Eyre, 505—Remainder of South Australia.

b. $'000, 1980-81 prices.

\- nil or rounded to zero

.. not applicable

APPENDIX IX—WESTERN AUSTRALIAN ECONOMIC RETURNS

This appendix contains detailed information (figures and tables) concerning the economic returns from NIMPAC-generated expenditure on the Western Australian rural arterial road system. There is a set of three figures and five tables.

Figure IX.1 plots the level of S2 expenditure at which BCRs are greater than given levels at the three discount rates. Figure IX.2 uses the same concept to allow comparisons between the alternative standards (S1, S2, S3 and S4) at the 7 per cent discount rate. Figure IX.3 is a map of road study regions in the State.

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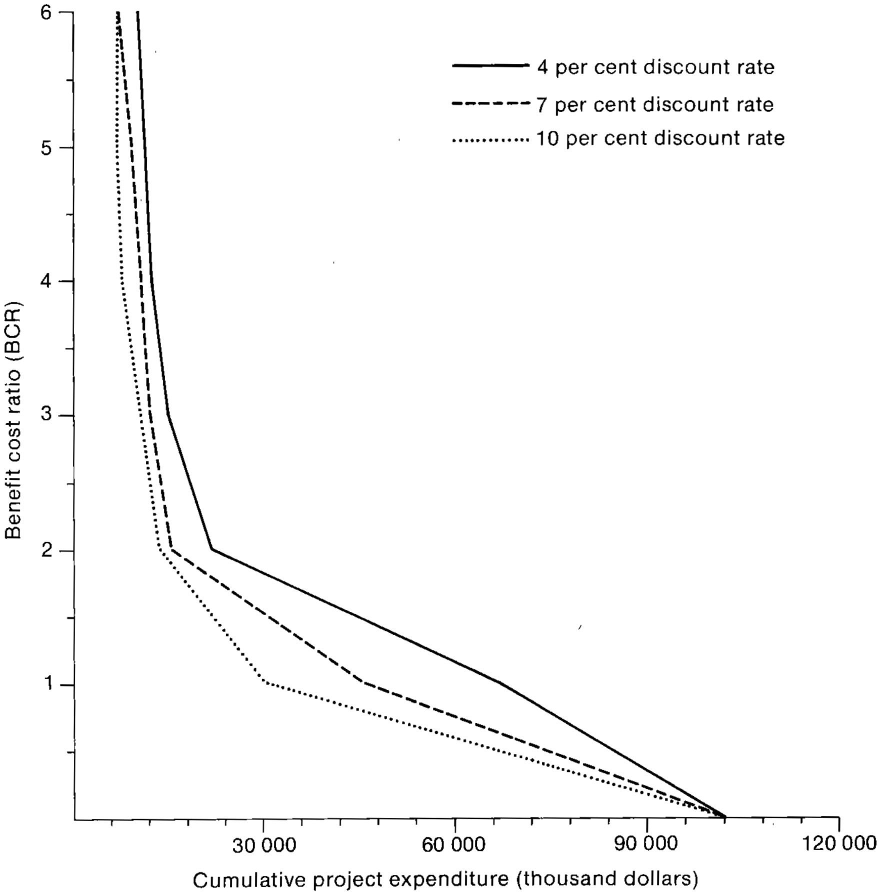


Figure IX.I—Western Australia cumulative project expenditure (1985-86 to 1989-90) in 1980-81 prices by benefit cost ratio, S2 standards, all discount rates

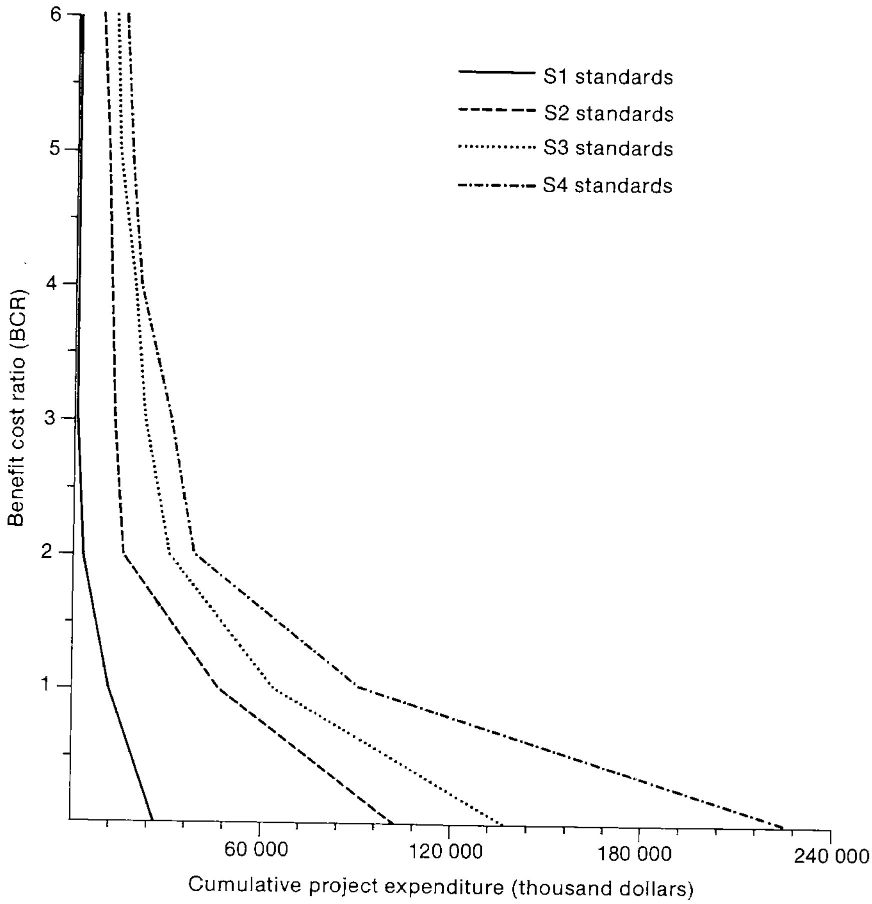
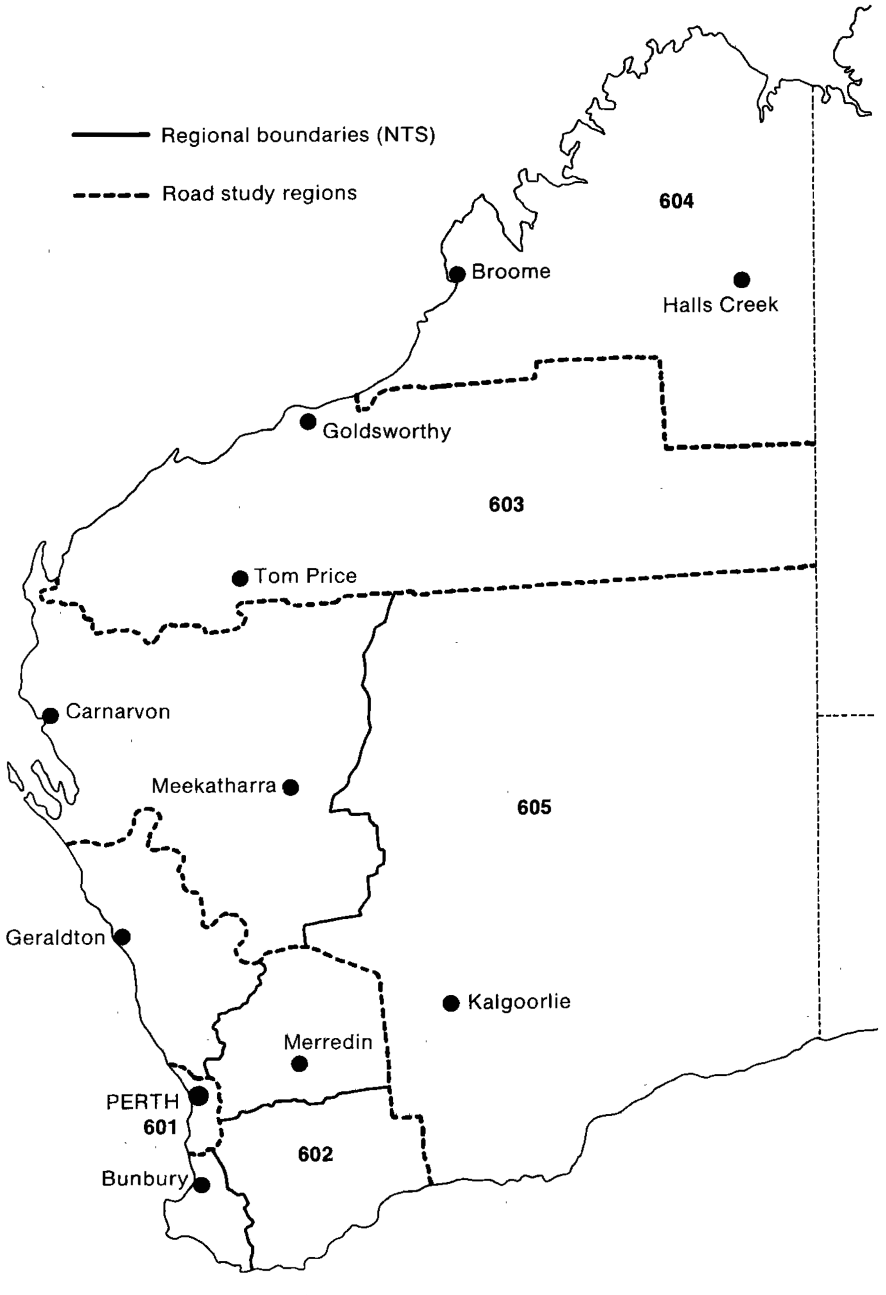


Figure IX.2—Western Australia cumulative project expenditure (1985-86 to 1989-90) in 1980-81 prices by benefit cost ratio, all standards, 7 per cent discount rate



Source: BTE (1982a).

Figure IX.3—Road study regions, Western Australia

TABLE IX.1—BENEFIT COST RATIOS BY WORK TYPE, 7 PER CENT DISCOUNT RATE, WESTERN AUSTRALIA

	DUPW	*DUP*	*OTAK*	*2ALW*	*REAL*	*2W*	*RHAB*	*1TO2*	*NEW2*	*NEW1*	*GRAV*	*NEWG*	*FORM*	*CONV*	*Total*
S1 standards															
Per cent of expenditure with BCR > 1	..	..	..	..	..	41.7	..	–	..	..	88.1	..	–	43.8	41.4
Overall BCR	..	..	..	..	..	1.9	..	0.5	..	..	1.4	..	0.2	1.0	1.1
S2 standards															
Per cent of expenditure with BCR > 1	..	..	100.0	–	–	60.8	89.5	0.8	73.0	10.8	40.2	..	–	33.8	44.7
Overall BCR	..	..	3.8	0.4	0.1	2.4	6.0	0.5	1.0	0.8	1.1	..	0.2	1.0	1.5
S3 standards															
Per cent of expenditure with BCR > 1	79.9	100.0	100.0	–	–	58.3	66.8	0.7	64.8	10.8	58.4	28.0	–	77.6	46.2
Overall BCR	4.0	6.7	5.4	0.4	0.1	2.1	2.3	0.5	0.9	0.7	1.1	1.0	0.2	1.6	1.9
S4 standards															
Per cent of expenditure with BCR > 1	81.0	100.0	100.0	–	–	53.8	70.9	0.6	64.8	29.3	0.3	89.1	–	1.6	40.3
Overall BCR	3.9	6.3	4.7	0.7	0.3	1.6	2.0	0.5	0.9	0.9	0.6	1.4	0.1	0.7	1.7

– nil or rounded to zero

.. not applicable

TABLE IX.2—COMPONENTS OF BENEFITS, S2 STANDARDS, 7 PER CENT DISCOUNT RATE, WESTERN AUSTRALIA

	DUPW	*DUP*	*OTAK*	*2ALW*	*REAL*	*2W*	*RHAB*	*1TO2*	*NEW2*	*NEW1*	*GRAV*	*NEWG*	*FORM*	*CONV*	*Total*
Total discounted benefits[a]	–	–	3.8	0.1	0.1	63.5	34.8	3.3	7.6	2.2	6.3	–	3.8	12.9	138.3
Total discounted costs[a]	–	–	1.0	0.3	1.4	25.9	5.8	6.4	7.8	2.8	5.7	–	21.4	13.4	91.9
Discounted benefits as percentage of total discounted benefits															
Road user															
Travel time	..	..	28.9	33.8	34.5	24.2	21.9	98.7	31.0	32.8	42.5	..	15.9	24.3	26.6
Vehicle operating costs	..	..	69.0	55.1	18.4	68.9	77.6	-19.8	59.6	71.1	57.4	..	70.3	66.8	67.8
Accident costs	..	..	2.7	2.9	–	5.8	–	18.6	0.6	-2.8	-0.1	..	-0.7	-1.6	3.0
Total	..	..	100.6	91.9	52.9	98.9	99.5	97.5	91.1	101.1	99.8	..	85.5	89.4	97.4

TABLE IX.2(Cont)—COMPONENTS OF BENEFITS, S2 STANDARDS, 7 PER CENT DISCOUNT RATE, WESTERN AUSTRALIA

	DUPW	*DUP*	*OTAK*	*2ALW*	*REAL*	*2W*	*RHAB*	*1TO2*	*NEW2*	*NEW1*	*GRAV*	*NEWG*	*FORM*	*CONV*	*Total*
Road authority															
Maintenance	..	..	-1.3	-2.2	-2.3	-1.3	-0.7	-3.8	11.6	-0.9	0.6	..	14.5	11.7	1.2
Resealing	..	..	0.7	10.3	49.4	2.4	1.1	6.3	-2.6	-0.2	-0.4	..	-	-1.0	1.4
Total	..	..	-0.6	8.1	47.1	1.1	0.5	2.5	8.9	-1.1	0.2	..	14.5	10.6	2.6

a. $ million, 1980-81 prices.

\- nil or rounded to zero

.. not applicable

Notes: 1. These figures are for road sections with projects generated in the budget period (1985-86 to 1989-90).
2. Figures may not add to totals due to rounding.

TABLE IX.3—EXPENDITURES WITH BCR > 1 BY WORK TYPE, VARYING DISCOUNT RATES, WESTERN AUSTRALIA

(per cent)

Discount rate (per cent)	*DUPW*	*DUP*	*OTAK*	*2ALW*	*REAL*	*2W*	*RHAB*	*1TO2*	*NEW2*	*NEW1*	*GRAV*	*NEWG*	*FORM*	*CONV*	*Total*
S1 standards															
4	..	..	..	..	..	64.7	..	-	..	..	79.2	..	-	100.0	72.1
7	..	..	..	..	..	41.7	..	-	..	..	88.1	..	-	43.8	41.4
10	..	..	..	..	..	22.4	..	-	..	..	68.6	..	-	1.5	14.9
S2 standards															
4	..	..	100.0	-	-	78.5	89.5	23.9	73.0	63.3	85.8	..	-	97.8	65.4
7	..	..	100.0	-	-	60.8	89.5	0.8	73.0	10.8	40.2	..	-	33.8	44.7
10	..	..	100.0	-	-	51.8	81.7	0.8	-	-	37.2	..	-	11.3	29.5
S3 standards															
4	79.9	100.0	100.0	-	-	76.8	71.0	19.7	76.0	10.8	75.2	100.0	10.2	88.8	64.7
7	79.9	100.0	100.0	-	-	58.3	66.8	0.7	64.8	10.8	58.4	28.0	-	77.6	46.2
10	79.9	100.0	100.0	-	-	46.2	54.8	0.7	-	-	53.9	11.2	-	12.0	32.4
S4 standards															
4	81.0	100.0	100.0	50.8	-	73.6	73.4	17.5	76.0	76.6	24.8	100.0	-	38.9	60.5
7	81.0	100.0	100.0	-	-	53.8	70.9	0.6	64.8	29.3	0.3	89.1	-	1.6	40.3
10	81.0	100.0	97.4	-	-	28.3	62.3	-	-	6.8	-	89.1	-	1.6	25.3

\- nil or rounded to zero

.. not applicable

TABLE IX.4—EXPENDITURES IN THE FIRST AND SECOND BUDGET PERIOD BY WORK TYPE, WESTERN AUSTRALIA

($'000 1980-81 prices)

Work type	S1 Standards		S2 Standards		S3 Standards		S4 Standards	
	First Budget Period	Second Budget Period	First Budget Period	Second Budget Period	First Budget Period	Second Budget Period	First Budget Period	Second Budget Period
DUPW	-	-	-	-	2 282	195	2 418	681
DUP	-	-	-	1 331	8 717	18 601	15 102	26 400
OTAK	-	255	1 604	2 060	4 000	3 074	4 757	2 425
2ALW	-	421	421	5 519	421	5 632	2 880	3053
REAL	-	1 403	1 400	2 469	2 055	2 545	3 367	1 142
2W	7 887	33 071	35 224	65 644	46 553	72 073	74 561	79 575
RHAB	-	11 588	8 964	32 024	8 197	29 747	13 818	38 180
1TO2	1 690	7 657	7 320	13 389	8 900	13 840	10 015	14 606
NEW2	-	2 928	10 830	-	12 189	-	12 189	-
NEW1	-	-	3 892	1 112	3 892	1 108	23 913	-
GRAV	2 891	9 133	4 251	5 064	3 571	5 256	34 352	4 772
NEWG	-	-	-	-	14 548	-	4 339	670
FORM	2 285	6 830	14 243	9 822	19 578	16 757	8 135	11 196
CONV	11 613	4 252	14 433	3 716	2 128	1 650	15 719	4 810
Total	26 365	77 539	102 311	142 150	137 031	170 477	225 566	187 509

\- Nil or rounded to zero

Note: The first and second budget periods are 1985-86 and 1989-90 to 1994-95 respectively.

TABLE IX.5—EXPENDITURES WITH BCR > 1 BY ROADS STUDY REGIONS, 7 PER CENT DISCOUNT RATE, WESTERN AUSTRALIA: 1985-86 TO 1989-90

	Road study region[a]					
	601	*602*	*603*	*604*	*605*	*Total*
Length of network (km)	153	8 985	2 202	1 191	3 807	16 338
Per cent by region	0.9	55.0	13.5	7.3	23.3	100.0
S1 standards						
Expenditure in first budget period[b]	455	9 676	14 467	1 202	565	26 365
Per cent by region	1.7	36.7	54.9	4.6	2.1	100.0
Per cent in region with BCR > 1	100.0	24.4	43.9	100.0	100.0	41.4
S2 standards						
Expenditure in first budget period[b]	4 381	45 741	38 615	7 658	5 916	102 311
Per cent by region	4.3	44.7	37.7	7.5	5.8	100.0
Per cent in region with BCR > 1	100.0	56.6	33.1	15.7	25.6	44.7
S3 standards						
Expenditure in first budget period[b]	9 797	64 829	46 806	7 658	7 941	137 031
Per cent by region	7.1	47.3	34.2	5.6	5.8	100.0
Per cent in region with BCR > 1	95.3	55.6	30.3	15.7	32.6	46.2
S4 standards						
Expenditure in first budget period[b]	13 956	107 031	74 034	19 632	10 913	225 566
Per cent by region	6.2	47.4	32.8	8.7	4.8	100.0
Per cent in region with BCR > 1	96.7	48.6	25.6	12.4	46.9	40.3

a. 601—Perth, 602—South West, 603—Pilbara, 604—Kimberly, 605—Goldfields and Midlands.
b. $'000, 1980-81 prices.

APPENDIX X—TASMANIAN ECONOMIC RETURNS

This appendix contains detailed information (figures and tables) concerning the economic returns from NIMPAC-generated expenditure on Tasmania's rural arterial road system. There is a set of two figures and five tables.

Only one set of standards (S2) was used in the Tasmanian analysis. Work for the NAASRA Roads Study indicated that at higher standards most of the additional funds would be devoted to improving road alignment. As there is no alignment data in the inventory for Tasmania, this cannot be modelled by NIMPAC.

Figure X.1 plots the level of S2 expenditure at which BCRs are greater than given levels at the three discount rates. Figure X.2 is a map of road study regions in the State.

Table X.1 provides the average BCRs and the percentage of expenditure with BCRs greater than one by work type. Table X.2 gives the level of discounted costs and benefits and the sources of benefits by type of work performed. Table X.3 lists the percentage of expenditure with BCRs greater than one for the three discount rates for the S2 standards. Table X.4 allows comparisons to be made between the first (1985-86 to 1989-90) and second (1990-91 to 1994-95) budget period expenditure by work type. Table X.5 provides the percentage of expenditure with BCRs greater than one for each of the BTE defined road study regions.

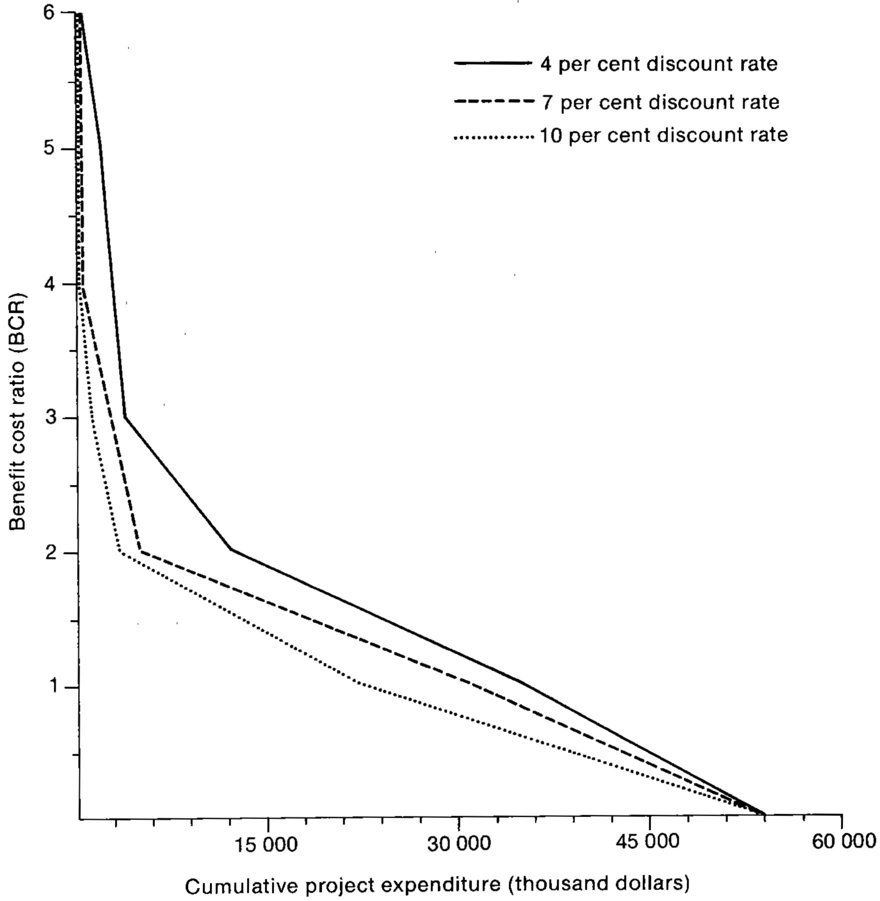
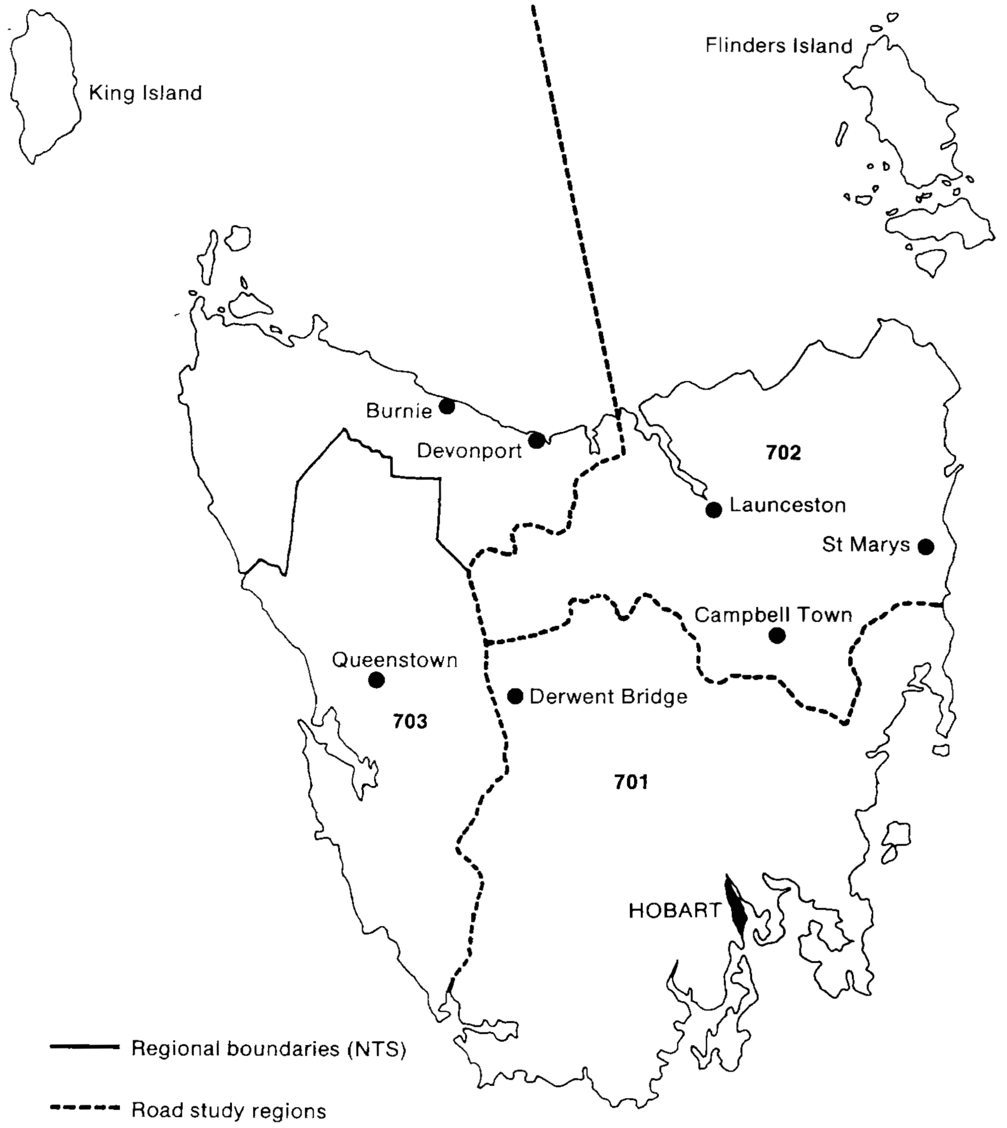


Figure X.1—Tasmania cumulative project expenditure (1985-86 to 1989-90) in 1980-81 prices by benefit cost ratio, S2 standards, all discount rates



Source: BTE (1982a).

Figure X.2—Road study regions, Tasmania

TABLE X.1—BENEFIT COST RATIOS BY WORK TYPE, 7 PER CENT DISCOUNT RATE, TASMANIA

	DUPW	*DUP*	*OTAK*	*2ALW*[a]	*REAL*[a]	*2W*	*RHAB*	*1TO2*	*NEW2*	*NEW1*	*GRAV*	*NEWG*	*FORM*	*CONV*	*Total*
S2 standards[b]															
Per cent of expenditure with BCR > 1	..	..	..	..	..	63.2	44.1	–	..	..	5.0	..	..	..	56.9
Overall BCR	..	..	..	..	..	1.3	1.1	0.5	..	..	0.6	..	..	..	1.1

a. As there are no alignment data in the Tasmanian inventory, these work types are not generated.
b. There are no other standards for Tasmania.

– nil or rounded to zero

.. not applicable

TABLE X.2—COMPONENTS OF BENEFITS, S2 STANDARDS, 7 PER CENT DISCOUNT RATE, TASMANIA

	DUPW	*DUP*	*OTAK*	*2ALW*[a]	*REAL*[a]	*2W*	*RHAB*	*1TO2*	*NEW2*	*NEW1*	*GRAV*	*NEWG*	*FORM*	*CONV*	*Total*
Total discounted benefits[b]	..	..	..	..	..	42.2	3.2	0.3	..	..	3.7	..	..	..	49.3
Total discounted costs[b]	–	–	–	..	..	33.7	3.0	0.6	–	–	5.8	–	–	–	43.1
Discounted benefits as percentage of total discounted benefits															
Road user															
Travel time	..	..	..	..	..	35.2	22.2	63.4	..	..	47.9	..	..	..	35.5
Vehicle operating costs	..	..	..	..	..	59.0	75.0	30.9	..	..	52.3	..	..	..	59.4
Accident costs	..	..	..	..	..	4.6	–	6.4	..	..	–	..	..	..	3.9
Total	..	..	..	..	..	98.8	97.2	101.0	..	..	100.3	..	..	..	98.8

TABLE X.2(Cont)—COMPONENTS OF BENEFITS, S2 STANDARDS, 7 PER CENT DISCOUNT RATE, TASMANIA

	DUPW	*DUP*	*OTAK*	*2ALW*[a]	*REAL*[a]	*2W*	*RHAB*	*1TO2*	*NEW2*	*NEW1*	*GRAV*	*NEWG*	*FORM*	*CONV*	*Total*
Road authority															
Maintenance	..	..	..	..	..	0.1	0.3	0.3	..	..	-0.3	..	..	..	0.1
Resealing	..	..	..	..	..	1.1	2.6	-1.3	..	..	–	..	..	..	1.1
Total	..	..	..	..	..	1.2	2.8	-1.0	..	..	-0.3	..	..	..	1.2

a. As there are no alignment data in the Tasmanian inventory, these work types are not generated.
b. $ million, 1980-81 prices.

\- nil or rounded to zero

.. not applicable

Notes: 1. These figures are for road sections with projects generated in the budget period (1985-86 to 1989-90).
2. Figures may not add to totals due to rounding.

TABLE X.3—EXPENDITURES WITH BCR > 1 BY WORK TYPE, VARYING DISCOUNT RATES, TASMANIA

(per cent)

Discount rate (per cent)	*DUPW*	*DUP*	*OTAK*	*2ALW*[a]	*REAL*[a]	*2W*	*RHAB*	*1TO2*	*NEW2*	*NEW1*	*GRAV*	*NEWG*	*FORM*	*CONV*	*Total*
S2 standards[b]															
4	..	..	..	..	..	71.0	57.3	–	..	..	5.0	..	..	..	64.4
7	..	..	..	..	..	63.2	44.1	–	..	..	5.0	..	..	..	56.9
10	..	..	..	..	..	44.8	39.5	–	..	..	5.0	..	..	..	41.0

a. As there are no alignment data in the Tasmanian inventory, these work types are not generated.
b. There are no other standards for Tasmania.

– nil or rounded to zero

.. not applicable

TABLE X.4—EXPENDITURES IN THE FIRST AND SECOND BUDGET PERIOD BY WORK TYPE, TASMANIA

($'000 1980-81 prices)

	S2 Standards	
Work type	*First Budget Period*	*Second Budget Period*
DUPW	–	–
DUP	–	–
OTAK	–	–
2ALW[a]	..	..
REAL[b]	..	..
2W	45 494	40 153
RHAB	3 859	8 684
1TO2	789	251
NEW2	–	–
NEW1	–	–
GRAV	3 743	3 310
NEWG	–	–
FORM	–	–
CONV	–	–
Total	53 885	52 399

a. As there is no alignment data in the Tasmanian inventory, these work types are not generated.
b. There are not other standards for Tasmania.

– Nil or rounded to zero

.. Not applicable

Note: The first and second budget periods are 1985-86 and 1989-90 and 1990-91 to 1994-95 respectively.

TABLE X.5—EXPENDITURES WITH BCR > 1 BY ROAD STUDY REGIONS, 7 PER CENT DISCOUNT RATE, TASMANIA: 1985-86 TO 1989-90

	Road study region[a]			
	701	*702*	*703*	*Total*
Length of network (km)	813	820	752	2 385
Per cent by region	34.1	34.4	31.5	100.0
S2 standards[b]				
Expenditure in first budget period[c]	24 668	14 502	14 715	53 885
Per cent by region	45.8	26.9	27.3	100.0
Per cent in region with BCR > 1	69.2	45.7	47.3	56.9

a. 701—South, 702—North, 703—West.
b. There are no other standards for Tasmania.
c. $'000, 1980-81 prices.

APPENDIX XI—NORTHERN TERRITORY ECONOMIC RETURNS

This appendix contains detailed information concerning the economic returns from NIMPAC-generated expenditure on the Northern Territory's rural arterial road system. There is a set of four tables.

Table XI.1 provides the average BCRs and the percentage of expenditure with BCRs greater than one by work type. Table XI.2 gives the level of discounted costs and benefits and the sources of benefits by type of work performed. Table XI.3 lists the percentage of expenditure with BCRs greater than one for the three discount rates at each set of standards. Table XI.4 allows comparisons to be made between the first (1985-86 to 1989-90) and second (1990-91 to 1994-95) budget period expenditure by work type for the four alternative standards.

TABLE XI.1—BENEFIT COST RATIOS BY WORK TYPE, 7 PER CENT DISCOUNT RATE, NORTHERN TERRITORY

	DUPW	*DUP*	*OTAK*	*2ALW*	*REAL*	*2W*	*RHAB*	*1TO2*	*NEW2*	*NEW1*	*GRAV*	*NEWG*	*FORM*	*CONV*	*Total*
S1 standards															
Per cent of expenditure with BCR > 1	..	..	..	..	..	100.0	–	..	..	..	–	..	..	..	85.7
Overall BCR	..	..	..	..	..	1.2	0.1	..	..	..	0.3	..	..	..	1.1
S2 standards															
Per cent of expenditure with BCR > 1	..	..	..	..	..	100.0	–	..	..	31.6	10.5	..	..	..	24.0
Overall BCR	..	..	..	..	..	1.2	0.3	..	..	0.9	0.5	..	..	..	0.7
S3 standards															
Per cent of expenditure with BCR > 1	..	..	..	..	..	100.0	–	..	..	31.6	3.4	..	..	..	12.2
Overall BCR	..	..	..	..	..	1.2	0.4	..	..	0.8	0.4	..	..	..	0.5
S4 standards															
Per cent of expenditure with BCR > 1	..	..	..	..	..	100.0	–	..	..	22.1	–	..	..	..	12.0
Overall BCR	..	..	..	..	..	1.2	0.4	..	..	0.7	0.3	..	..	..	0.5

– nil or rounded to zero

.. not applicable

TABLE XI.2—COMPONENTS OF BENEFITS, S2 STANDARDS, 7 PER CENT DISCOUNT RATE, NORTHERN TERRITORY

	DUPW	*DUP*	*OTAK*	*2ALW*	*REAL*	*2W*	*RHAB*	*1TO2*	*NEW2*	*NEW1*	*GRAV*	*NEWG*	*FORM*	*CONV*	*Total*
Total discounted benefits[a]	..	..	..	..	..	1.5	1.1	..	..	4.2	2.9	..	..	..	9.7
Total discounted costs[a]	–	–	–	–	–	1.2	3.4	–	–	4.8	5.4	–	–	–	14.8
Discounted benefits as a percentage of total discounted benefits															
Road user															
Travel time	..	..	..	..	..	21.6	24.5	..	..	27.6	39.6	..	..	..	29.9
Vehicle operating costs	..	..	..	..	..	68.2	60.1	..	..	78.3	69.8	..	..	..	72.2
Accident costs	..	..	..	..	..	1.0	–	..	..	-1.9	-1.3	..	..	..	-1.1
Total	..	..	..	..	..	90.7	84.5	..	..	104.0	108.1	..	..	..	101.0

TABLE XI.2(Cont)—COMPONENTS OF BENEFITS, S2 STANDARDS, 7 PER CENT DISCOUNT RATE, NORTHERN TERRITORY

	DUPW	*DUP*	*OTAK*	*2ALW*	*REAL*	*2W*	*RHAB*	*1TO2*	*NEW2*	*NEW1*	*GRAV*	*NEWG*	*FORM*	*CONV*	*Total*
Road authority															
Maintenance	..	..	..	..	..	-0.1	-0.1	..	..	2.1	-1.6	..	..	..	0.4
Resealing	..	..	..	..	..	9.3	15.6	..	..	-6.1	-6.5	..	..	..	-1.4
Total	..	..	..	..	..	9.3	15.5	..	..	-4.0	-8.1	..	..	..	-1.0

a. $ million, 1980-81 prices.

\- nil or rounded to zero

.. *not applicable*

Note: These figures are for road sections with projects generated in the budget period (1985-86 to 1989-90).

TABLE XI.3—EXPENDITURES WITH BCR > 1 BY WORK TYPE, VARYING DISCOUNT RATES, NORTHERN TERRITORY

(per cent)

Discount rate (per cent)	*DUPW*	*DUP*	*OTAK*	*2ALW*	*REAL*	*2W*	*RHAB*	*1TO2*	*NEW2*	*NEW1*	*GRAV*	*NEWG*	*FORM*	*CONV*	*Total*
S1 standards															
4	..	..	..	..	..	100.0	–	..	..	..	–	..	..	..	85.7
7	..	..	..	..	..	100.0	–	..	..	..	–	..	..	..	85.7
10	..	..	..	..	..	100.0	–	..	..	..	–	..	..	..	85.7
S2 standards															
4	..	..	..	..	..	100.0	–	..	..	31.6	10.5	..	..	..	24.0
7	..	..	..	..	..	100.0	–	..	..	31.6	10.5	..	..	..	24.0
10	..	..	..	..	..	–	–	..	..	31.6	10.5	..	..	..	14.5
S3 standards															
4	..	..	..	..	..	100.0	–	..	..	31.6	3.4	..	..	..	12.2
7	..	..	..	..	..	100.0	–	..	..	31.6	3.4	..	..	..	12.2
10	..	..	..	..	..	–	–	..	..	22.7	–	..	..	..	4.6
S4 standards															
4	..	..	..	..	..	100.0	–	..	..	26.6	–	..	..	..	13.5
7	..	..	..	..	..	100.0	–	..	..	22.1	–	..	..	..	12.0
10	..	..	..	..	..	–	–	..	..	17.5	–	..	..	..	6.1

– nil or rounded to zero

.. not applicable

TABLE XI.4—EXPENDITURES IN THE FIRST AND SECOND BUDGET PERIOD BY WORK TYPE, NORTHERN TERRITORY

($'000 1980-81 prices)

Work type	*S1 Standards*		*S2 Standards*		*S3 Standards*		*S4 Standards*	
	First Budget Period	*Second Budget Period*	*First Budget Period*	*Second Budget Period*	*First Budget Period*	*Second Budget Period*	*First Budget Period*	*Second Budget Period*
DUPW	-	-	-	-	-	-	-	-
DUP	-	-	-	-	-	-	-	-
OTAK	-	-	-	-	-	-	-	-
2ALW	-	-	-	-	-	-	-	-
REAL	-	-	-	-	-	-	-	-
2W	1 501	317	1 501	317	1 501	317	1 501	317
RHAB	208	20 390	5 039	15 559	14 208	18 267	14 208	18 267
1TO2	-	-	-	-	-	-	-	-
NEW2	-	-	-	-	-	-	-	-
NEW1	-	-	6 239	-	6 239	-	12 171	-
GRAV	43	4 845	2 971	10 587	9 138	9 253	7 134	11 042
NEWG	-	-	-	-	-	-	-	-
FORM	-	-	-	-	-	-	-	-
CONV	-	-	-	-	-	-	-	-
Total	1 752	25 511	15 749	26 463	31 085	27 837	35 013	29 626

\- Nil or rounded to zero

Note: The first and second budget periods are 1985-86 and 1989-90 to 1994-95 respectively.

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ABBREVIATIONS

1TO2	Widen to 2 lanes
2ALW	Realign and widen
2W	Rehabilitate and widen (2 lanes)
AADT	Annual average daily traffic
BCR	Benefit cost ratio
BTE	Bureau of Transport Economics
CBR	Commonwealth Bureau of Roads
CONV	Miscellaneous road projects
DUP	Duplicate
DUPW	Widening to 6 or 8 lanes
ERVL	Economics of road vehicle limits
FORM	New formation
GRAV	Gravel resheet
HDM	Highway Design Model
km	kilometre
km/h	kilometre per hour
m	metre
m^2	square metre
MERIN	Model for the Evaluation of Road Improvement Needs
MERRI	Model for the Evaluation of Rural Road Improvements
MODMERRI	Modified Model for the Evaluation of Rural Road Improvements
NAASRA	National Association of Australian State Road Authorities
NEW1	New one lane seal
NEW2	New two lane seal
NEWG	New gravel
NIMPAC	NAASRA Improved Model for Project Assessment and Costing
NRM	NAASRA roughness meter
NSW	New South Wales
NT	Northern Territory
OTAK	Overtaking lanes
PIAP	Performance Investment Analysis Process
Qld	Queensland
REAL	Realign (existing width)
RHAB	Rehabilitate (existing width)

SA	South Australia
SRA	State road authority
Tas	Tasmania
VC	Vertical curve
Vic	Victoria
VKT	Vehicle kilometres travelled
VOC	Vehicle Operating Cost
WA	Western Australia