TRANSIT NEW ZEALAND

HEAVY VEHICLE LIMITS PROJECT

Report 7

OVERVIEW

Part 1: Main Report

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EXECUTIVE SUMMARY

Transit New Zealand (Transit) commissioned the Heavy Vehicle Limits Project to investigate the economic impacts of potential increases in weight and dimension limits for heavy vehicles. Two scenarios are considered:

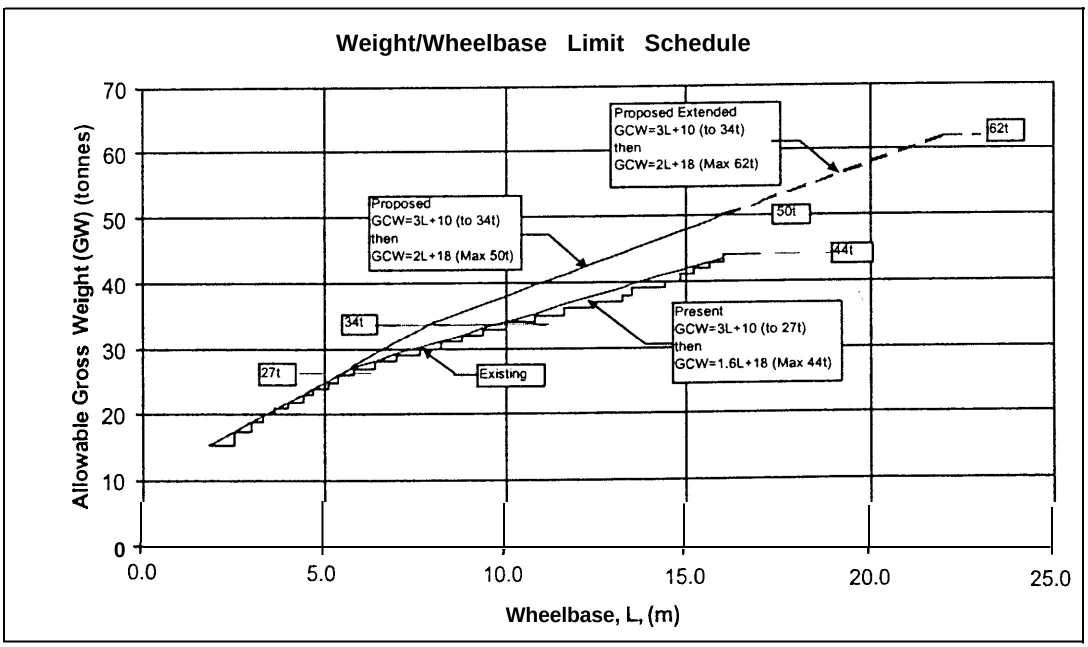
Scenario A – the existing vehicle fleet would be allowed to operate on the whole of the New Zealand public road network at higher weight limits than those currently permitted but with no increase in vehicle dimensions;

Scenario B – increases in both vehicle weight and dimension limits would be allowed on selected routes only.

There are four basic gross weight limit options for Scenario A: 45.5, 47, 48.5 and 50 tonnes. In addition, an articulated vehicle (A123) is specified with three gross weight limits: 40, 4 1 and 42 tonnes. The 42 tonne limit was used for this vehicle in each of the gross weight limit options for Scenario A except where further study showed that a lesser gross weight was required for safety reasons. A truck and trailer vehicle (R12T22) was specified with two alternative configurations for each gross weight limit option. The alternative found to be the most critical was included in each option.

Two vehicle options were used for Scenario B in stage 2 – full-sized B-train vehicles, denoted B(fs), and B(2) vehicles. The B(2) set of vehicles comprises essentially truck-trailer alternatives with overall length up to 24 metres and weight up to 58 tonnes. The B(fs) set of vehicles incorporates heavier alternatives, including a B-train reaching 25 metres in length and 62 tonnes in weight.

The following figure shows a graphical comparison of the current wheelbase weight limits and proposals investigated. The lower line gives the current limits. The upper line shows the proposals, with Scenario A ending at the 50 tonne level, and Scenario B extending further to the 62 tonne level.



The Heavy Vehicle Limits Project involved six interrelated investigations- These were:

- **industry economics** – an evaluation of the likely effects on the transport economics of the road freight industry from increases in heavy vehicle limits;
- **safety-** an evaluation of the likely effects on vehicle safety;
- **bridges-** an evaluation of the likely effects on road bridges from increases in heavy vehicle limits;
- **pavements-** an evaluation of the likely effects on road pavements;
- **road geometry** – an evaluation of the likely costs for geometric changes to the Scenario B routes;
- **environmental evaluation-** an evaluation of the likely environmental effects.

The results of these investigations were used to calculate the overall economics of the proposals.

Summary results from the component investigations are:

Industry Economics

Discounted costs over the twenty-five year project period have been evaluated for both a baseline (existing) case and the changed situation with increased length and weight limits, with the difference between these providing the freight benefits. The streams of costs over time were estimated from:

- vehicle take up by industry over time to larger, more productive vehicle configurations (except for Scenario A which assumed an 'instantaneous take up in the first year – a 'snapshot' view); and
- changes in vehicle kilometres travelled (VKT) for each option;
- changes in vehicle operating costs for the national fleet of heavy freight vehicles affected.

The main assumption of the methodology for estimating VKT changes in Scenario A is that increased heavy vehicle limits will enable fewer fully laden and partly laden trucks to perform a specified road freight task, by carrying increased payloads.

The methodology for the Scenario B evaluation is similar to that for Scenario A, except that Scenario B required the estimation of the benefits as they accrued to industry over time rather than the instantaneous 'snapshot' comparison of take up with the current situation as in Scenario A The other two differences from Scenario A are:

- the potential increase in vehicle dimensions as well as weights; and
- the restriction of these vehicles to selected routes in the national road network.

The annual benefits from Scenario A (first year only – in subsequent years the figures are increased by freight growth), and total discounted benefits from Scenario B are given in the following tables.

Summary of Scenario A annual benefit in snapshot year (base year).

Weight Option (t)	Change in VKT (M km)	Resource cost savings ($M)	Financial cost savings ($M)
45.5	-7.7	8.3	9.7
47	-16.2	16.2	15.9
48.5	-23.8	23.4	21.3
50	-29.6	28.3	29.6

Total discounted Scenario A savings.

WeightOption (t)	Resource cost savings discounted @10% ($M)	Financial cost savings discounted @10% ($M)
45.5	172.7	192.7
47	301.1	297.6
48.5	425.9	394.7
50	499.2	516.9

Summary of total VKT, resource and financial cost savings for Scenario B.

Vehicle Option	Change in total VKT in first year (M km)	Resource costs discounted @10% ($M)	Financial costs discounted @10% ($M)
B (2)	5.405	269.5	240.0
B(fs)	7.728	434.7	372.9

Safety

The first part of the safety evaluation involved a comparative study of a range of vehicles, representing possible configurations if weight limits were changed. The study used computer simulations to examine the relative safety of different configurations. One hundred and twenty one vehicles were simulated, and their stability and performance measures determined, in this part of the study. The process was an iterative one in which early results were used, in conjunction with initial findings from the bridges study, to refine vehicle types for later evaluation and for formulation of the appropriate Scenario A and B vehicles.

The second part of the safety evaluation estimated changes in crash rates. The crash rate per kilometre for each of the trial vehicles was estimated for four categories of crashes:

- Rollover and loss of control crashes;
- Crashes that occur during overtaking;
- Crashes that occur at intersections; and,
- Other types of crashes.

It is anticipated that curves on the network of routes will need to be widened to accommodate the longer vehicles of Scenario B, at a cost to the project that has been included in the economic evaluation. Accordingly the effects of this road widening on reducing the crash rate per kilometre were also estimated. This was carried out by determining modifying factors for the crash rates, related to vehicle types and the extent of widening proposed.

The safety implications of Scenario A and Scenario B are reported in terms of estimated numbers of crashes, requiring estimates of the fatal, injury and non-injury crash rates for each of the trial vehicles.

For Scenario A, estimates have been made of crashes based on current weight regulations and the four new weight options (maximum gross weights of 45.5 tonne, 47 tonne, 48.5 tonne and 50 tonne, respectively). The estimated number of crashes in the base year for these four weight options is provided in the following table.

Estimated numbers of crashes on the network of routes after road widening (base year).

Option	Fatal crashes	Injury crashes	Non-injury cashes
Current regulations	80.9	831.6	2,737.4
45.5 tonne option	79.8	834.5	2,743.0
47 tonne option	79.5	831.3	2,732.5
48.5 tonne option	79.3	828.9	2,724.5
50 tonne option	79.1	826.8	2,717.6

The reduction in crashes with the new vehicles (while small) can be attributed to lower exposure due to the reduction in vehicle kilometres travelled as a result of the increase in weight limits.

For scenario B, six road-widening cases were examined; three related to the off-tracking requirements of the B-Train, B1233-62b, and three related to the off-tracking requirements of the B-train, B1233-62f. Crash rates were adjusted to accommodate road widening in accordance with each case of the road widening assumptions (definitions are given in Section 9.3). The estimated numbers of crashes for each widening scenario for years 1 to 25 on the Scenario B network of routes were calculated. The table below summarises the estimates for the years 1 and 25, and the following table shows the present value total increase in accident costs.

Estimated crashes for widening options for Scenario B routes.

Road Widening Option		Year	No. Fatal Crashes	No. Injury Crashes	No. Non-injury Crashes
Current regulations		1	29.8	306.7	1009.5
		25	96.2	989.1	3255.7
Original assumption	B1233-62b	1	30.4	317.6	1043.9
	B(fs)	25	95.3	995.5	1087.6
	B1233-62f	1	30.7	320.6	1053.8
	B(2)	25	96.2	1004.9	3303.1
Alternative assumption 1	B1233-62b	1	29.7	310.3	1020.2
	B(fs)	25	93.1	972.8	3197.7
	B1233-62f	1	30.5	318.4	1046.7
	B(2)	25	95.5	998.1	3280.9
Alternative assumption 2	B1233-62b	1	29.2	304.8	1002.0
	B(fs)	25	91.5	955.5	3140.8
	B1233-62f	1	30.3	317.0	1042.0
	B(2)	25	95.1	993.6	3266.2

Present value total increase in accident costs ($ million).

Option	Original	Alternative 1	Alternative 2
B(2)	31.4	21.4	13.0
B(fs)	-3.7	-40.0	-69.7

For scenario A, it appears from the results that a small reduction in crash numbers may be realised with increased weight, primarily as a result of a decrease in vehicle kilometres. However, the uncertainties associated with the estimates are large compared to the change in crashes. For scenario B, the estimated change in crash numbers is again small and depends on the widening assumptions. As with scenario A, the uncertainties associated with the estimates are greater than the magnitude of the changes.

Bridges

The economic impact of alternative weight limits on bridges has been evaluated using the assumption that small increases in vehicle loads lead to reductions in the overall service life of bridges. The evaluation has been made by determining the cost of replacing bridges earlier than expected due to this reduction in service life. These calculations have been undertaken for all bridges on the state highway network for Scenario A vehicles, and on selected state highway and local authority routes for Scenario B vehicles.

The use of standard or prescribed values in determining bridge strength leads to overly conservative estimates. The approach adopted by the bridge consultant is based on the application of a proposed bridge testing programme (BTP), which would be expected to indicate reserves of strength above the theoretical values calculated by the conventional bridge manual factors (BMF). This approach indicates significantly lower but more realistic costs for the effects of heavier vehicles on the bridges. The cost of a bridge testing programme has been added to the bridge component costs.

Scenario A involves all public roads and therefore Local Authority bridges as well as the Transit State Highway bridges. The Local Authority bridges have lower load-carrying capacities and would entail considerable expenditure if a uniformly high capacity were to be provided throughout the whole country. In order to manage this cost, it has been assumed that heavy vehicles use only a proportion of bridges on the local network. This portion has been taken as 15%.

The table below summarises the economic impacts for Scenario A and the following table lists the impacts of Scenario B.

Summary of economic impacts for Scenario A (10% discount rate).

Scenario / Bridges	Weight Option (t)	Present Value Cost ($M) BMF	Present Value Cost ($M) BTP
Scenario A / State Highway	45.5	117	15
	47	136	17
	48.5	110	16
	50	111	18
Scenario A / Local Authority 15% of network	45.5	48	28
	47	53	32
	48.5	47	26
	50	51	26

Summary of economic impacts for Scenario B (at 10% discount rate).

Case	Local Authority cost ($ millions)	State Highway cost ($ millions)	All ($ millions)	Local Authority as a % of All
Bridge Manual Factors	0.70	36.4	37.1	1.9 %
Bridge Testing Programme	0.70	15.4	16.1	4.3 %

In Scenario B, route sector 5 (Auckland to Manukau) is the most expensive sector. This is because of the Newton Bridge, which is an expensive bridge with low strength and long spans requiring immediate attention if the proposals proceed.

The study identified a number of issues associated with the implementation of any weight limit increases with respect to bridges. These include:

- Assessment of the economic impact of restricted access for the transport industry on local authority roads is required if the "15 percent" strategy to manage bridge expenditure on local authority bridges is adopted.
- There are possible net savings in implementing both Scenarios A and B. The impacts of these scenarios have been treated separately in the study

The study recommended that:

- Some optimisation of the axle group weight and wheelbase configurations may be required to suit the bridge stock, particularly with the B-train configurations.
- Further investigation into some of the issues associated with local authority bridges is required including the 12 to 13 metre span bridge population and the number of bridges that are on routes that are used by a significant number of heavy vehicles.

Pavements

The estimation of wear to pavements is based on a calculation of the number of Equivalent Standard Axle (ESA) loadings to pavements. The ESA concept involves calculating the wear delivered by the range of axle groups (single axles, tandem axles and tri-axle) and range of loads carried by each axle group, as a multiple of the wear conferred to the pavement by a Standard Axle. The Standard Axle is defined as a single axle with dual tyres carrying a weight of 8.2 tonnes. Knowledge of the current ESA loading and those expected over the next twenty-five years with the existing vehicle types allows a pattern of maintenance costs to be calculated (when calibrated against existing maintenance records). Further knowledge of how the ESA loadings will change with the introduction of heavier vehicles allows changes in maintenance costs to be evaluated.

The life of a pavement is a function of its strength and the traffic loading imposed on it. Using information from a representative nation-wide sample, a relationship was developed between pavement strength and its condition Relative life remaining in a pavement could then be related directly to this condition.

The four load options evaluated under Scenario A (50, 48.5, 47 and 45.5 tonne) have resulted in predicted national ESA changes of between 0.08% and 1.58%.

The two loading options evaluated for the Scenario B routes have resulted in predicted national ESA changes of between 8.1% and 15% over the next 25 years.

The calculated present value costs ($million) are tabulated below at 10% discount rate for Scenario A and Scenario B.

Scenario A – present value pavement costs ($million).

	Region	Weight Option 45.5t	47.0t	48.5t	50.0t
1	Northland	1.34	3.47	4.27	-0.05
2	Auckland	3.01	6.42	7.90	1.52
3	Waikato	0.50	2.30	2.32	-1.38
4	Bay of Plenty	0.73	1.15	1.07	-0.15
5	Gisborne	1.37	2.39	2.41	0.45
6	Hawkes Bay	0.43	1.02	1.22	0.03
7	Taranaki	0.72	2.01	2.33	0.82
8	Wanganui/Manawatu	1.39	3.37	3.84	0.65
9	Wellington	1.01	1.81	2.54	0.39
10	Nelson/Marlborough	0.35	0.76	1.01	-0.18
11	Canterbury	0.70	1.53	1.69	0.34
12	West Coast	0.24	0.72	0.95	0.02
13	Otago	1.35	2.23	2.08	0.09
14	Southland	0.85	1.48	1.26	0.09
	Totals	**14.00**	**30.66**	**34.89**	**2.65***

*The significant reduction in pavement costs in going from the 48.5 tonne option to the 50.0 tonne option is due to the greater number of axles on vehicles operating in the 50 tonne weight limit option.

Scenario B – present value pavement costs ($million).

Route Sector No.	Scenario B(2)	Scenario B(fs)
1	0.81	1.22
2	0.04	0.05
3	0.21	0.33
4	0.44	0.72
5	0.01	0.03
6	0.05	0.07
7	0.63	0.78
8	0.30	0.37
9	0.37	0.45
10	0.28	0.35
11	0.27	0.35
12	0.38	0.47
13	0.12	0. 16
14	0.65	0.79
15	0.50	0.78
16	0.27	0.44
17	0.99	1.24
18	0.11	0.14

Route Sector No.	Scenario B(2)	Scenario B(fs)
19	0.59	0.85
20	0.08	0.15
21	0.66	0.86
22	0.24	0.41
23	0.23	0.45
24	0.03	0.06
25	0.02	0.05
26	0.14	0.27
27	0.06	0.37
28	0.04	0.12
29	0.00	0.01
30	0.15	0.30
31	0.04	0.06
32	0.06	0.10
33	0.73	0.95
34	1.59	1.90
35	0.03	0.05
Total	**11.13**	**15.71**

Road Geometry

The geometric evaluation study involved estimating the cost of modifying a specific network of roads and roundabouts in New Zealand to accommodate Scenario B vehicles, which are longer and heavier than vehicles currently permitted on New Zealand roads. These longer vehicles take up more road space than the current fleet having greater offtracking when cornering.

Analytical models were used to calculate the extent of offtracking for vehicles when cornering. A field test using a 62 tonne, 26.5 metre long B-train was undertaken to verify the validity of these models. The measured offtracking was in good agreement with that predicted by the models.

The extent of modification required over the Scenario B routes depends on assumptions made as to the clearances required between cornering vehicles and road edge constraints. The assumptions chosen also have an effect on vehicle safety, and the road geometry and safety components of this study were undertaken on a common set of assumptions. These included an "Original" alternative and four other alternatives for a sensitivity test The assumptions in each alternative were made relative to the performance of existing vehicles; i.e. it was assumed that the current network of routes is satisfactory for existing vehicles.

The numbers of curves estimated to require modification in the original case and first two alternatives are given in the following table.

Number of curves to be modified

Assumption	Vehicle B(2)	Vehicle B(fs)
Original	376	817
Alternative 1	927	2531
Alternative 2	1247	3784

The costs of modifying the curves and roundabouts for the Scenario B vehicles on the network of routes are shown in the following table.

Costs ($M) of geometric modifications.

Assumption	Vehicle B(2)	Vehicle B(fs)
Curves – Original Assumption	18.8	43.6
- Alternative 1	44.7	132.0
- Alternative 2	62.6	214.0
- Alternative 3	113.5	161.9
- Alternative 4	191.1	292.1
Roundabouts	1.2	1.3

Environment

The Transfund Project Evaluation Manual (PEM) sets out procedures for placing a monetary value on a range of environmental impacts, and for incorporating these into the analysis of roading projects The environmental impacts considered in this study are confined to those that are valued in the PEM. These are carbon dioxide emissions, noise, particulate emissions and vibrations.

The environmental changes associated with Scenario A are given in the following table. Environmental impacts are included in the "benefits" category in the analysis, and hence a negative sign refers to a benefit decrease (a worsening of the existing situation), and a positive value refers to a benefit increase (an improvement). These results are for the first year of the twenty-five year project period only, and need to be modified for growth in freight in subsequent years.

Valuation of environmental impacts – Scenario A options ($/year – base year).

Weight Option	Noise ($/yr)	CO_2 ($/yr)	Particulates ($/yr)	Total ($/yr)
45.5 tonne	-68,400	432,000	192,000	555,600
47.0 tonne	-855,000	837,900	406,000	388,800
48.5 tonne	-1,026,000	1,215,500	594,700	784,200
50.0 tonne	-2,052,000	1,469,500	739,900	157,400

The following table sets out the environmental cost changes for Scenario B at selected years over the twenty-five year project life. As noted above, negative and positive values indicate a worsening and an improvement respectively.

Valuation of environmental impacts – Scenario B options ($/year).

	Option B(2)				Option B(fs)			
Year	**Noise**	**CO_2**	**Particulates**	**Total**	**Noise**	**CO_2**	**Particulates**	**Total**
1	-59,1 00	249,000	127,300	317,100	-76,000	364,200	186,100	474,300
10	-415,100	1,714,700	876,300	2,175,900	-605,400	2,973,200	1,519,500	3,887,300
20	-676,200	2,793,100	1,427,500	3,544,500	-995,900	4,888,500	2,498,400	6,391,000
25	-863,000	3,564,800	1,821,900	4,523,700	-1,271,100	6,239,100	3,188,600	8,156,600

In all options, there is an increase in environmental cost from noise, and a decrease from CO_2 and particulate emissions.

Care is needed in how noise increases are considered in valuations. The average increases found are far too small to be detected by adjacent populations. However populations will probably notice some small noise increases for some of the vehicles. Valuing the small average noise level increases, as carried out in the preceding analysis is then a way of capturing the cost of the environmental noise of the heavier loads.

Both Scenario A and Scenario B offer savings in environmental cost. Noise has a strong influence in Scenario A where significant savings from CO_2 and particulate reduction are almost counterbalanced by increased noise costs. Savings range from $157,000 to $785,000 per year. For Scenario B the noise is much less dominant as the total route length is much less (3300 km cf 14000 km) and benefits range from $4.5 million to $8.1 million per year.

Overall Economics

The results of the component studies have been combined in a cost-benefit framework. For each scenario and weight option the six components have been grouped into costs or benefits in accordance with the definition that costs are impacts that affect the roading authority, whereas benefits are impacts that affect the road user or others external to the roading authority. Totals of costs and benefits (relative to the base or "continuation of existing" case) have been evaluated in each option as has the option benefit/cost ratio. Scenario A results are presented for the four weight options (45.5, 47.0, 48.5, and 50.0 tonnes). The results are given for each of the regions, and as a combined total. Scenario B results have been evaluated for each route sector, each route, and the total of all routes.

The costs or benefits associated with each impact occur over time, and have therefore been discounted to give present value totals. Results are presented for the case of resource costs and a discount rate of 10%. Other results are discussed as a departure from this case as a sensitivity test.

A growth rate in traffic of 5% compounding annually over the twenty-five year period has been assumed in the analysis.

An option is described as "viable" if the benefit/cost ratio is equal to or greater than Transfund funding cut-off ratio of 3.0.

Scenario A Results

Summary benefit/cost ratio results for Scenario A (10% discount rate) are tabulated below. Detailed results are given in Appendix B.

Scenario A benefit/cost ratios[1] (10% discount rate).

	Region	Weight Limit Option 45.5t	47.0t	48.5t	50.0t
1	Northland	1.7	2.0	2.9	7.6
2	Auckland	4.9	4.8	5.5	8.7
3	Waikato	4.6	5.9	10.0	33.3
4	Bay of Plenty	4.5	7.1	12.6	31.0
5	Gisborne	0.6	0.8	1.3	2.8
6	Hawkes Bay	2.7	3.3	5.4	10.9
7	Taranaki	1.4	2.1	3.2	5.3
8	Wanganui/Manawatu	2.5	3.3	4.8	8.7
9	Wellington	6.0	6.5	7.9	19.8
10	Nelson/Marlborough	2.0	2.7	4.0	7.8
11	Canterbury	4.4	5.7	9.3	14.8
12	West Coast	1.9	2.4	3.4	6.5
13	Otago	2.1	3.0	5.0	8.9
14	Southland	1.7	2.3	4.2	7.7
All Regions Combined		**2.7**	**3.4**	**5.0**	**9.0**

There is considerable variation across the regions. However, when considering the country as a whole, only the 45.5 tonne option is non-viable using Transfund's B/C cut-off ratio. The 50.0 tonne option gives the least cost and the highest benefits of the options.

The main reason for the sudden rise in B/C ratio in the 50.0 tonne option is the significant reduction in pavement costs in going from the 48.5 tonne allowable GVW to the 50.0 tonne GVW. This is due to the greater numbers of axles on vehicles operating at the 50 tonne limit.

The 50.0 tonne weight limit option is viable in all except Region 5 (where it is close to viable). The other weight options are viable predominantly in the larger regions.

Scenario B Results

The benefit/cost ratio results for Scenario B for each route, and for all routes combined, are given in the following table for the case of a 10% discount rate. Detailed results are given in Appendix C.

Scenario B benefit/cost ratios.

Route	Description	Vehicle Option B(2)	B(fs)
1	Whangarei – Auckland – Wellington	5.0	6.8
2	Pokeno – Tauranga/Kawerau/Rotorua – Taupo – Napier - Wellington	8.5	10.9
3	SH1 – Kaimai – Tauranga	9.0	12.4
4	Hamilton – New Plymouth – Bulls - Woodville	8.5	10.4
5	Picton – Blenheim – Christchurch – Dunedin - Invercargill	8.0	8.0
6	Blenheim – Nelson – Westport - Greymouth	1.2	0.7
All Combined		**5.2**	**5.8**

These values show that both vehicle options are viable for routes 1 to 5.

[1] The regional ratios do not allow for the bridge testing programme in the costs. This programme is a national cost, and is included only in the national (all regions combined) results.

Optimum Scenario B Vehicle Option

While the B(2) option is clearly viable, the incremental B/C ratio of the B(fs) option above the B(2) option is 6.7. This shows that it is a viable proposition to incur the greater costs of the B(fs) alternative. The B(fs) option is therefore the optimum Scenario B option. The advantage of B(fs) over B(2) is further strengthened if Route 6 is omitted from the Scenario B network. However, no route should be excluded without further consideration of the impact this would have on the remaining routes of the network.

Combined Scenarios A and B

This option has not been explicitly evaluated. However, the results available are sufficient to show that it would be viable to combine Scenario B (fs) with the 48.5 or 50.0 tonne Scenario A option.

Implementation Costs

Detailed implementation costs are set out in Appendix D. Summary costs are set out in the following tables.

Scenario A – average annual costs (total, and additional to baseline).

Option	First 5 Years*		Second 5 Years		Second 10 Years	
	$million/yr	$m/yr above existing	$million/yr	$m/yr above existing	$million/yr	$m/yr above existing
45.5t	210.2	10.2	214.6	3.6	294.9	5.8
47.0t	212.2	12.2	217.7	6.8	296.7	7.7
48.5t	211.4	11.4	216.9	5.9	297.8	8.7
50.0t	209.1	9.1	216.9	6.0	291.4	2.4

* Including Bridge Testing Programme costs.

Scenario B - average annual costs (additional) ($million/year).

Scenario	Case	Year 1*	Year 2*	Year 3*	Years 4 to 10	Second 10 Years
B(2)	Excl. Route 6	8.5	10.2	10.4	3.5	1.0
	Incl. Route 6	11.1	12.9	13.1	3.5	1.0
B(fs)	Excl. Route 6	11.7	10.0	14.1	3.7	1.9
	Incl. Route 6	19.0	17.4	21.5	3.7	2.1

* Including Bridge Testing Programme costs.