HEAVY TRANSPORT ROUTES: THEIR IDENTIFICATION, & EVALUATION OF A PILOT ROUTE

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TRAVERS MORGAN (NZ) LTD
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PO Box 5084, Lambton Quay, Wellington, New Zealand
Telephone (04) 499-6600; Facsimile (04) 496-6666

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AN IMPORTANT NOTE FOR THE READER

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EXECUTIVE SUMMARY

1. The Project

This report covers Stage 1 of an investigation, begun in 1993, into the feasibility of increasing the legal loads for heavy vehicles on New Zealand roads.

The overall objectives of Stage 1 were to identify the road routes, in use at the time of the study, that carry significant flows of heavy vehicles and have a clear purpose (e.g. mill to port), and to develop a methodology to evaluate the load and dimensional capacities of these identified routes under normal operating conditions.

2. Survey of the Heavy Transport Industry

A transport industry survey was undertaken first, to identify heavy traffic flows in terms of both vehicle numbers and tonnage, and to obtain other information such as the level of interest by the heavy transport industry in an increase in the legal axle limit.

A questionnaire was designed in consultation with the New Zealand Road Transport Association, the Heavy Haulage Association, and Transit New Zealand. It was mailed out to members of freight industry groups and the total response was 44% of those mailed.

Information obtained about freight trips from the survey were aggregated by origin and destination and plotted on maps, together with Transit New Zealand telemetry AADT (Average Annual Daily Traffic) vehicle counts for long and very long vehicles. Analysis of the information from the two sources showed that the surveyed trips at each telemetry point were not a reasonably consistent proportion of the telemetry trips (long plus very long vehicles). The questionnaire-survey trips expressed as a percentage of telemetry trips ranged from 5% to 170%.

Using the surveyed data alone presented problems when selecting routes for evaluation on the basis of heavy vehicle trips or freight tonnages, as they may represent a much smaller proportion of total heavy vehicle movements at some sites than at others.

However telemetry data used on their own were also considered to be not very helpful, as they included many short distance trips near major urban centres. Short distance trips are unlikely to benefit from designation of heavy transport routes. The best compromise was to use both sets of data and apply appropriate judgement.

3. Selection of a Pilot Heavy Transport Route

A pilot heavy transport route was selected in order to establish a methodology for evaluating the capability of a route to cater for vehicles with higher axle and/or weight limits. Selection of a pilot route took into account both heavy vehicle flows, as determined from the survey and analysis of telemetry data, and the composition of the main heavy vehicle flows using the route.

Heavy transport routes are expected to be of two main types:

(1) **One-Way Export Route**
A one-way route to a port, probably with an imbalance of tonnage and most likely to be commodity related.
An example of such a route is Tokoroa to Port Tauranga.

(2) **Depot to Depot Route**
A two-way route between reloading depots. At such depots freight would be reloaded to/from port or rail to lighter vehicles operating under general road network legal weight limits.
An example of such a route is Auckland to Hamilton.

The first pilot route selected for developing the evaluation procedure was that from the Kinleith wood-pulp mill at Tokoroa to Port Tauranga on Bay of Plenty. It includes two route options between Putaruru and State Highway 29:

- State Highway 1 and 27 (the SH 27 option); and
- Whites Road to Rapurapu Road (the local authority road option).

This route was chosen because it has one of the highest heavy vehicle/freight tonnage flows and is the major route from South Waikato to Port Tauranga for exports of wood products in particular, as well as of dairy and other agricultural produce.

4. Methodology for Evaluating Pilot Heavy Transport Route

Vehicle Types: Evaluation of the pilot route was made using eight vehicle types, each distinguished by axle configuration. Seven of these vehicles were selected as representing vehicle configurations most likely to be used on the route and are within current vehicle dimensions. In addition a 27 m-long vehicle for log cartage was tested to show the effect of varying the vehicle length.

Road Geometry Constraints: The study evaluated the ability of the route to cope with these vehicles in terms of road geometry constraints (such as sight distances, intersections, lane widths, curvatures, road gradients, overhead clearances, railway level crossings).

The principal sources for road geometry data were the Highway Information Sheets and the Pavement Management Strategy Studies (these are held at Transit New Zealand regional offices). The Highway Information Sheets summarise geometric aspects, and the Pavement Management Strategy Studies describe the future demands on a road and propose actions to be taken to lessen route constraints.

The adequacy of the curve radii on the route was analysed by computer simulation of the passage of a B-train vehicle.

Vehicle Weight Constraints: The study also evaluated the ability of the route to cope with heavy vehicles in terms of vehicle weight constraints (such as pavement strengths and bridge strengths).

For pavements, information including values of subgrade CBR (Californian Bearing Ratio) was obtained from the RAMM (Road Assessment and Maintenance Management) database (held at Transit New Zealand). Although the RAMM database is far from complete, estimates of structure could be made for most of the route. Where data were available, they were translated into numbers of EDA (Equivalent Design Axles), using the 1989 National Roads Board *State Highway Pavement Design and Rehabilitation Manual.*

For bridges, the effect of increasing the legal weight was examined for those on the state highway sections of the pilot route using the *HPERMIT*[1] database. This program simulates the action of a nominated type of vehicle (axle configuration and axle weights) under overload conditions on a bridge on a route. A methodology was developed for using the *HPERMIT* output to examine the effects of the vehicle types under normal operating conditions on the bridges.

5. Results of Evaluating the Pilot Heavy Transport Route

Some of the geometric constraints on the pilot route require remedial work to accommodate a heavy transport vehicle of maximum dimensions within the left hand lane width, even though all but one of the test vehicles were within current (1994) legal vehicle dimension limits.

The local authority road option was not evaluated for geometric constraints in detail but has sections which have poor sight distances and poor curvature both horizontally and vertically.

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1 *HPERMIT* system (Vogel Corporation Ltd/ Transit New Zealand) is used to check applications for overweight permits. It checks pavements, bridges and railway level crossings on a specified route for their ability to carry specified overweight vehicles, and prints any restrictions or supervision requirements for the route.

The bridges on the pilot route can accept significant increases in the current legal gross vehicle weights for the vehicle types considered, because all the bridges are mainly short span (except for Tauranga Harbour Bridge) and all the vehicles considered are relatively long. The weight increases that can be accommodated by the constraining bridge (Hamlins Overbridge) range from 12% to 25% for the legal vehicle types considered. This constraining bridge can be bypassed by the local authority road option.

As the four bridges on the local authority road option have no data entered in *HPERMIT*, they could not be evaluated to the same degree of accuracy for the constraints they impose, as could state highway bridges.

6. Conclusions and Recommendations

This project (Stage 1)

1. Identified the routes predominantly used by heavy vehicles;
2. Developed a methodology to evaluate the capacity of such routes to accommodate heavier vehicles within the legal limits;
3. Evaluated a pilot route and found the methodology satisfactory.

For the eight heavy vehicle types tested, a significant increase in gross vehicle weights can be used on the pilot route. For the current legal vehicle types these gross weight increases range from 12% to 25% of the current legal weight limits. An extra long "A Train" combination for carrying logs can be loaded to the greatest gross weight because the weight is spread over a greater length.

From the information available about the two options for part of the pilot route, the SH 27 option was likely to be preferable to the local authority road option.

The project should proceed to Stage 2 to consider the feasibility of increasing legal weight and dimension limits of heavy vehicles, and address the issues of:

- economics,
- environmental impacts,
- vehicle safety,
- public perception, and
- alternative solutions other than roading.

The heavy transport route Tokoroa to Port Tauranga is a suitable pilot route for developing appropriate methodology for these issues.

ABSTRACT

An investigation into the feasibility of increasing the legal loads for heavy vehicles on New Zealand roads was begun in 1993. Roads carrying major flows of heavy vehicles in both the North and South Islands were identified, and those that have potential to be used as heavy transport routes were selected. These are routes that carry significant flows of heavy vehicles, and that have a clear purpose (e.g. mill to port).

To evaluate the potential for increasing the legal gross weight of heavy vehicles that could be carried on these heavy transport routes, the route between the wood-pulp mill at Kinleith, near Tokoroa in the centre of the North Island, and the Port of Tauranga on the Bay of Plenty, was taken as a pilot.

The main concern was to evaluate the road geometry and vehicle weight constraints of the pavements and bridges along the pilot route. To determine the maximum axle weights and gross vehicle weights that the bridges on the route could safely accommodate, a methodology based on the use of the Transit New Zealand overweight permit system was developed.

For the eight heavy vehicle types tested, a significant increase in gross vehicle weights can be used on the pilot route. For the current legal vehicle types these gross weight increases range from 12% to 25% of the current legal weight limits.

1. INTRODUCTION

1.1 Background

Deregulation of the road and rail transport industry in the 1980s has meant that heavy vehicle operators are able to compete between themselves and with NZ Rail on a national basis. This deregulation has led to a significant increase in the number of heavy vehicles on New Zealand's road network.

Growth in heavy vehicle traffic and the potential for greater transport productivity through an increase in whole gross weight, group axle weights and configurations, and vehicle dimensions has necessitated a study, carried out in 1993-94, of the ability of the existing road network in New Zealand to carry heavier vehicles. All data relate to that period unless otherwise stated.

This report is of the first stage of a multi-stage project into this issue. Based on this study, the feasibility of increasing the legal loads for heavy vehicles that use these state highways will be investigated in Stage 2.

The issue examined is the effect of an increase in the limits which currently apply to the gross weight and dimensions of heavy vehicles, and to group axle weights and axle configurations.

The study was primarily concerned with flows of heavy freight vehicles on New Zealand roads. Where flows relate to all types of freight vehicles, this is stated in the text.

For the purpose of this report the term "Heavy transport route" means a road or series of roads between two distinct points encompassing the origin and destination of a significant freight flow.

1.2 Project Objectives and Scope

Stage 1 of this study was designed to:

(a) Identify those routes which are carrying high volumes of heavy traffic and may be potential heavy transport routes,

(b) Develop the methodology to evaluate the present (1994) load and dimensional capacities of the routes identified in (a) above, irrespective of legal load limits, under normal vehicle operating conditions (i.e. **not** limited to overweight or over-dimensional permit conditions);

(c) Evaluate the developed methodology on one of the identified heavy transport routes, as a pilot.

The project objective was also to evaluate the capacity of routes in use at the time of the study to carry vehicles of loads and dimensions greater than the existing operating conditions. It was thus not concerned with the possible designation of new routes, such as heavy traffic bypasses or the separation of freight traffic from passenger vehicle traffic.

In Stage 2 the proposal will consider the feasibility of increasing statutory weight and dimension limits of heavy vehicles on:

(a) all roads
(b) selected routes
(c) a core network of strategic roads,

and will address the issues of:

- economics,
- environmental impacts,
- vehicle safety,
- public perception,
- alternative solutions other than roading.

2. IDENTIFICATION OF EXISTING HEAVY TRANSPORT VEHICLE FLOWS

2.1 Survey of Heavy Transport Sector

2.1.1 Introduction

A survey of the heavy transport industry was undertaken to identify heavy traffic flows based on both vehicle movements and freight tonnage, and to obtain other information such as the level of interest in an increase in maximum vehicle weights. The survey was undertaken using questionnaires sent to industry members.

To obtain co-operation and mailing lists for the survey, known transport industry groups were contacted. These groups were:

- New Zealand Road Transport Association (RTA),
- Heavy Haulage Association (HHA),
- Forest Owners/Operators (through the Forest Owners Association and the Logging Industry Research Organisation (LIRO)),
- Power Crane Association (PCA),
- Oil Companies, and
- Dairy Companies through the New Zealand Dairy Group.

The Local Government Association and the Contractors' Federation were also consulted.

Submissions were received from a number of district councils after a request for information had been sent by Transit New Zealand to all regional, district and city councils.

These industry groups responded with mailing lists of their members, together with their perceptions of their transportation needs. They also endorsed the objectives of the study and provided covering letters to accompany the questionnaires encouraging their members to complete and return them. Members of those groups with relatively small membership, such as the forest owners and oil companies, were individually contacted and invited to participate in the study.

2.1.2 Survey Design

The questionnaire was designed in consultation with the New Zealand Road Transport Association, the Heavy Haulage Association, and Transit New Zealand.

The questionnaire was trialled on nine companies before carrying out the main survey. Using the responses from these companies together with discussion with Transit New Zealand, changes were made to the questionnaire. The final questionnaire is included as Appendix 1.

Approximately 1380 questionnaires were mailed out accompanied by a covering letter. Both *NZ Trucking Magazine* and the Road Transport Association magazine *Transport News* assisted by publicising the need for responses to the questionnaire. A follow-up mailout covering all who had not responded to the initial survey was mailed a month after the initial deadline.

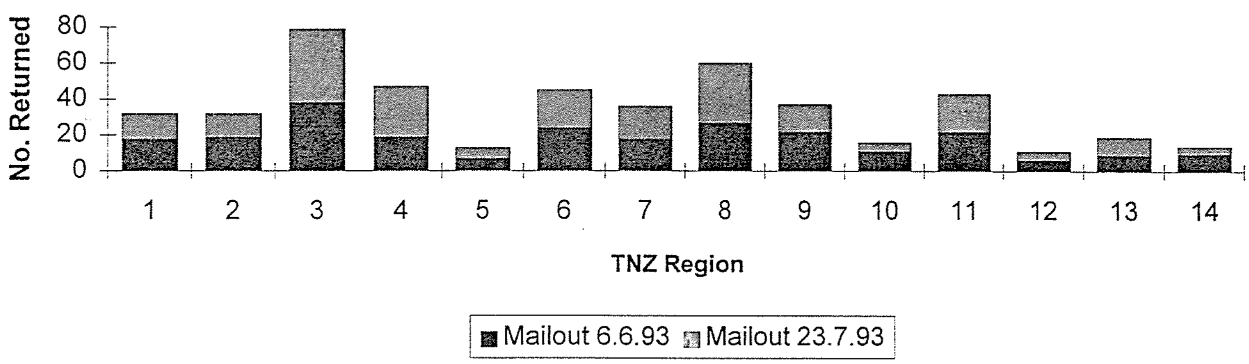
2.1.3 Responses to Questionnaire

From the first mailing, a total of 283 responses (including 33 nil returns) was received. After the subsequent mailings and telephone calls to the main companies who had not responded, a further 325 responses (including 86 nil returns) were received.

A comparison of the distribution of returns by Transit New Zealand region between successive mailouts is shown in Figure 2.1.

The total response was 44% of those mailed, as shown in Table 2.1. This included a number of nil returns: excluding these brings the percentage of completed returns down to 35%. While this response appears disappointing, not all members of the Road Transport Association (from which organisation most of the addresses had been obtained) are operating trucks. Some are suppliers to the heavy transport industry, and some are no longer in business. Moreover, some bigger companies centralised their replies on a single form, and some smaller companies combined their replies with associated companies. It was thus not possible to estimate the effective response rate as a proportion of all the operators of trucks that received questionnaires.

Figure 2.1 Distribution, according to Transit New Zealand regions (1 - 14), of returns to questionnaire, and responses to the two mailouts (on 6.6.93 and 23.7.93).



TNZ Regions: 1 - Northland; 2 - Auckland; 3- Waikato; 4 - Bay of Plenty; 5 - Gisborne; 6 - Hawke's Bay; 7 - Taranaki; 8 - Wanganui/Manawatu; 9 - Wellington; 10 - Nelson/Marlborough; 11 - Canterbury; 12 - West Coast; 13 - Otago; 14 - Southland

Table 2.1 Response rates to questionnaires from heavy transport industry groups.

Heavy Transport Industry Group	No. of Mailouts	No. of Returns		Total Response %
		Completed	NA/Nil	
Road Transport Assn	1178	430	112	46
Heavy Haulage Assn	97	23	2	26
Power Crane Assn	68	7	3	15
Dairy Companies	16	13	1	88
Oil Companies	6	1	1	33
Forestry Companies	15	15	0	100
Total Number	1380	489	119	44
%	100	35	9	-

2.2 Analysis of Results

2.2.1 Comparison with Traffic Counts

Another way of measuring the effectiveness of the questionnaire survey in "capturing" all heavy vehicle trips is to compare the number of trips surveyed in the questionnaire (the "surveyed" trips) with observed heavy vehicle flows based on Transit New Zealand telemetry count traffic data (the "telemetry figures") taken on state highways.

The survey responses were analysed, and the vehicle flow and tonnage data were summarised by origin and destination, and assigned to a simplified representation of the highway system using the *EMME/2* (INRO 1992) modelling package. This enabled the main flows to be identified easily, although in the process some detail of the roads used was lost. (The original data are held by Transit New Zealand.)

From vehicle flow data for state highways obtained from the traffic monitoring group of Transit New Zealand, comparisons between surveyed data and Transit New Zealand telemetry data were made (Table 2.2). All figures have been expressed in terms of Average Annual Daily Traffic (AADT) volumes. AADT telemetry figures are generally available directly from the telemetry counts. The survey derived weekly figures, and these were divided by seven to provide average daily estimates. The AADT figures are the totals for both directions of travel combined.

The telemetry counts categorise vehicles by their length, i.e. short, medium, long and very long. For comparison, the long and very long categories only have been taken.

Table 2.2 Vehicle counts derived from telemetry data and vehicle survey.

1992 Vehicle Counts by Length Class from Telemetry Sites (AADTs)

TNZ Region	Site No.	Description	Vehicle Length Classes (volumes) Short	Medium	Long	V. Long	Total	Medium+Long+VL Trips	% Total	Long+VL Trips	% Total	Surveyed trips Trips	Sample(1)
1	18	SH1N Kawakawa	3,552	328	91	89	4,060	508	12.5%	180	4.4%	74	41%
2	17	SH1N Wellsford	4,783	409	103	117	5,412	629	11.6%	220	4.1%	106	48%
	7	SH1N Drury	28,336	1,749	724	703	31,512	3,176	10.1%	1,427	4.5%	469	33%
3	33	SH27 Kaihere	2,470	204	95	179	2,948	478	16.2%	274	9.3%	287	105%
	19	SH1 Taupiri	11,225	807	370	316	12,718	1,493	11.7%	686	5.4%	158	23%
	34	SH2 Waihi	4,514	366	96	129	5,105	591	11.6%	225	4.4%	70	31%
	20	SH1N Karapiro	8,032	608	229	282	9,151	1,119	12.2%	511	5.6%	151	30%
	21	SH1N Lichfield	5,378	541	176	282	6,377	999	15.7%	458	7.2%	468	102%
	16	SH3 Te Kuiti	2,537	260	86	144	3,027	490	16.2%	230	7.6%	124	54%
	43	SH32 West Lake Taupo	385	42	4	11	442	57	12.9%	15	3.4%		
	42	SH1N Halletts Bay	3,380	284	101	205	3,970	590	14.9%	306	7.7%	193	63%
4	12	SH29 Kaimai	4,192	416	139	172	4,919	727	14.8%	311	6.3%	330	106%
	14	SH33 Paengaroa	2,573	358	99	170	3,200	627	19.6%	269	8.4%	61	23%
	13	SH2 Ohinepanea	2,171	272	69	184	2,696	525	19.5%	253	9.4%	76	30%
	22	SH30 Lake Rotoma	2,080	174	32	36	2,322	242	10.4%	68	2.9%	71	104%
	61	SH30A Rotorua City	16,189	641	104	36	16,970	781	4.6%	140	0.8%		
	41	SH5 Waipa	4,279	482	125	186	5,072	793	15.6%	311	6.1%	95	31%
5	26	SH2 Ormond	1,563	172	37	55	1,827	264	14.4%	92	5.0%	25	27%
6	23	SH5 Te Pohue	1,477	181	65	98	1,821	344	18.9%	163	9.0%	71	44%
	24	SH2 Tangoio	1,119	151	38	37	1,345	226	16.8%	75	5.6%	128	171%
	58	SH50 Napier South	8,855	494	115	147	9,611	756	7.9%	262	2.7%		
7	6	SH3 Tariki	4,955	360	204	135	5,654	699	12.4%	339	6.0%	443	131%
	5	SH3 Waitotara	2,275	205	67	53	2,600	325	12.5%	120	4.6%	194	162%
8	37	SH4 Horopito	1,266	106	28	61	1,461	195	13.3%	89	6.1%	33	37%
	29	SH1N Hihitahi	2,870	236	110	197	3,413	543	15.9%	307	9.0%	183	60%
	28	SH4 Upokongaro	1,491	137	20	27	1,675	184	11.0%	47	2.8%	29	62%
	25	SH2 Norsewood	2,335	214	101	117	2,767	432	15.6%	218	7.9%	141	65%
	38	SH1N Sanson	7,919	607	225	304	9,055	1,136	12.5%	529	5.8%	216	41%
	30	SH3 Manawatu Gorge	4,154	349	120	179	4,802	648	13.5%	299	6.2%	159	53%
	56	SH1N Ohau	9,756	1,036	251	286	11,329	1,573	13.9%	537	4.7%	305	57%
9	1	SH2 Rimutaka	3,255	224	39	29	3,547	292	8.2%	68	1.9%	36	53%
	52	SH1N Pukerua Bay (Est)	15,017	1,171	355	404	16,947	1,930	11.4%	759	4.5%	305	40%
	3	SH1N Ngauranga *	33,423	663	155	63	34,304	881	2.6%	218	0.6%		
	4	SH2 Ngauranga *	36,561	977	231	60	37,829	1,268	3.4%	291	0.8%		
10	36	SH6 Hira	1,536	177	66	70	1,849	313	16.9%	136	7.4%	200	147%
	60	SH6 Nelson South	20,007	1,012	181	160	21,360	1,353	6.3%	341	1.6%	49	14%
	9	SH1S Kaikoura	1,156	134	45	51	1,386	230	16.6%	96	6.9%	100	104%
11	32	SH7 Lewis Pass	589	76	23	52	740	151	20.4%	75	10.1%	4	5%
	11	SH73 Springfield	839	73	13	11	936	97	10.4%	24	2.6%	18	75%
	59	SH59 Christchurch South	18,425	538	88	13	19,064	639	3.4%	101	0.5%		
	10	SH1S Rakaia	4,894	459	192	157	5,702	808	14.2%	349	6.1%	156	45%
	31	SH1S St Andrews	3,161	303	98	172	3,734	573	15.3%	270	7.2%	101	37%
12	39	SH6 Punakaiki	475	48	19	14	556	81	14.6%	33	5.9%	14	42%
	40	SH7 Ahaura	673	85	15	30	803	130	16.2%	45	5.6%	25	56%
13	44	SH1S Alexandra South	1,255	126	26	24	1,431	176	12.3%	50	3.5%	11	22%
	27	SH1S Milton	3,556	319	97	123	4,095	539	13.2%	220	5.4%	103	47%
14	45	SH1S Gore	2,566	257	69	100	2,992	426	14.2%	169	5.6%	93	55%
	46	SH1S Winton	2,711	249	48	63	3,071	360	11.7%	111	3.6%	92	83%

AADT Source TRANSIT NEW ZEALAND
TRAFFIC MONITORING GROUP

Note (1) ie ratio Sample Survey: Long + VL

The vehicle length definitions are:

- Short — less than 5.5m
- Medium — between 5.5m and 11m
- Long — between 11m and 17m
- Very long — over 17m.

2.2.2 Discrepancies in Data

Discrepancies between the surveyed and telemetry figures can occur for a number of reasons:

- Under-counting in the survey would be expected as a result of a failure to contact all companies and non-response of some companies. The companies that did respond may not have included their lesser flows.

- Over-counting can occur where high flows were reported but these are in fact seasonal or where the origin of the flow changes with time (as in forestry operations). This is likely to be a particular problem when the total flow is small.

- Over-simplification of the network used to represent the New Zealand road system.

Most survey figures are between 25% and 50% of the AADT count, with an average of 35%. The correlation coefficient is 0.7 which can be considered reasonable given the nature of the survey.

The variability of the ratio of telemetry:survey data at different sites (shown in Table 2.2 and Figure 2.2) indicates that the surveyed traffic volumes cannot be taken as an complete guide to the total traffic volumes of long and very long heavy traffic vehicles at each location. It is unclear how representative the surveyed traffic is of the total heavy traffic at each location. Figure 2.3 compares the movements of long and very long vehicles, obtained from the telemetry data, with the total traffic volume at each of 48 telemetry sites. Large vehicles appear to represent approximately 5% of the total volume at typical sites. However, near large population centres (e.g. Auckland and Wellington) the proportion of large vehicles drops to 1% or lower because of the high amount of commuter traffic.

Figures 2.4 - 2.6 (for North and South Islands) show the telemetry data (for long and very long vehicles), surveyed trips, and surveyed tonnage. The telemetry data are from only 48 sites (which are listed in Table 2.2). Heavy vehicle flows for roads which have no telemetry data have been estimated from other Transit New Zealand traffic count data to provide a comparison with the survey data.

Figure 2.2 Telemetry count of long and very long vehicles compared to numbers of trips recorded in the survey.

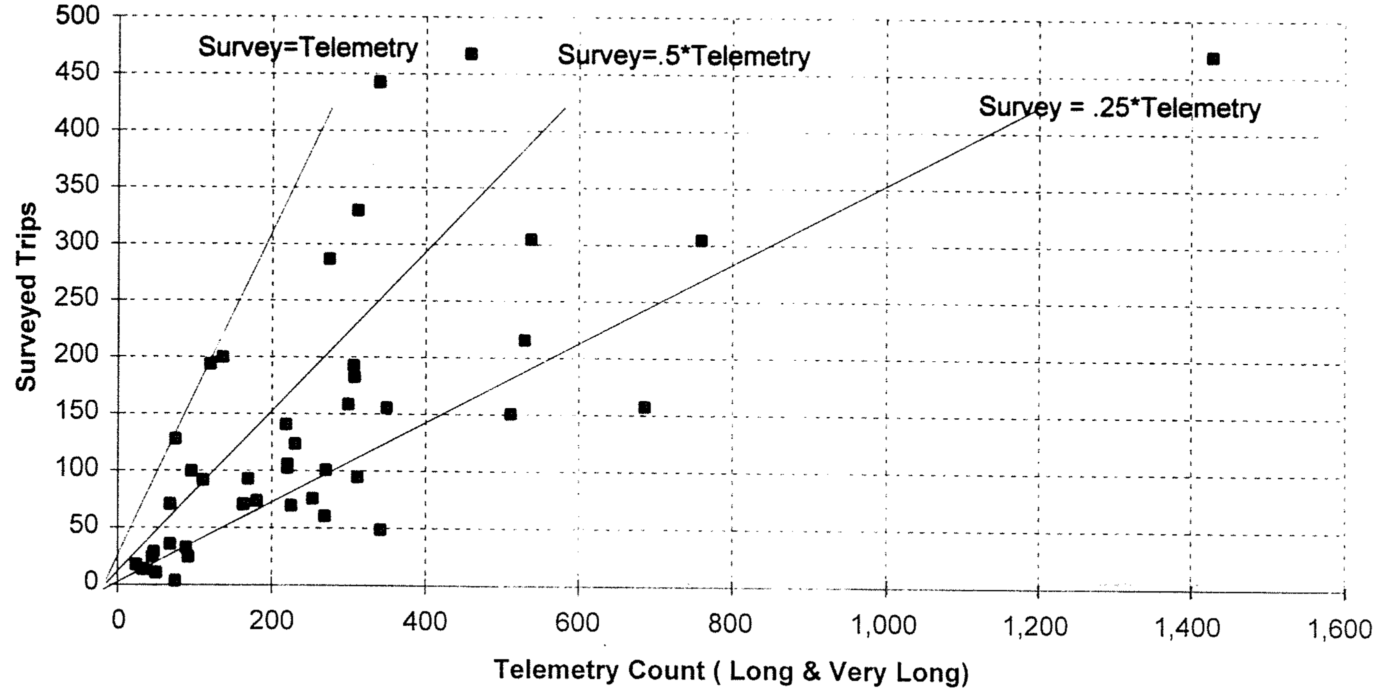
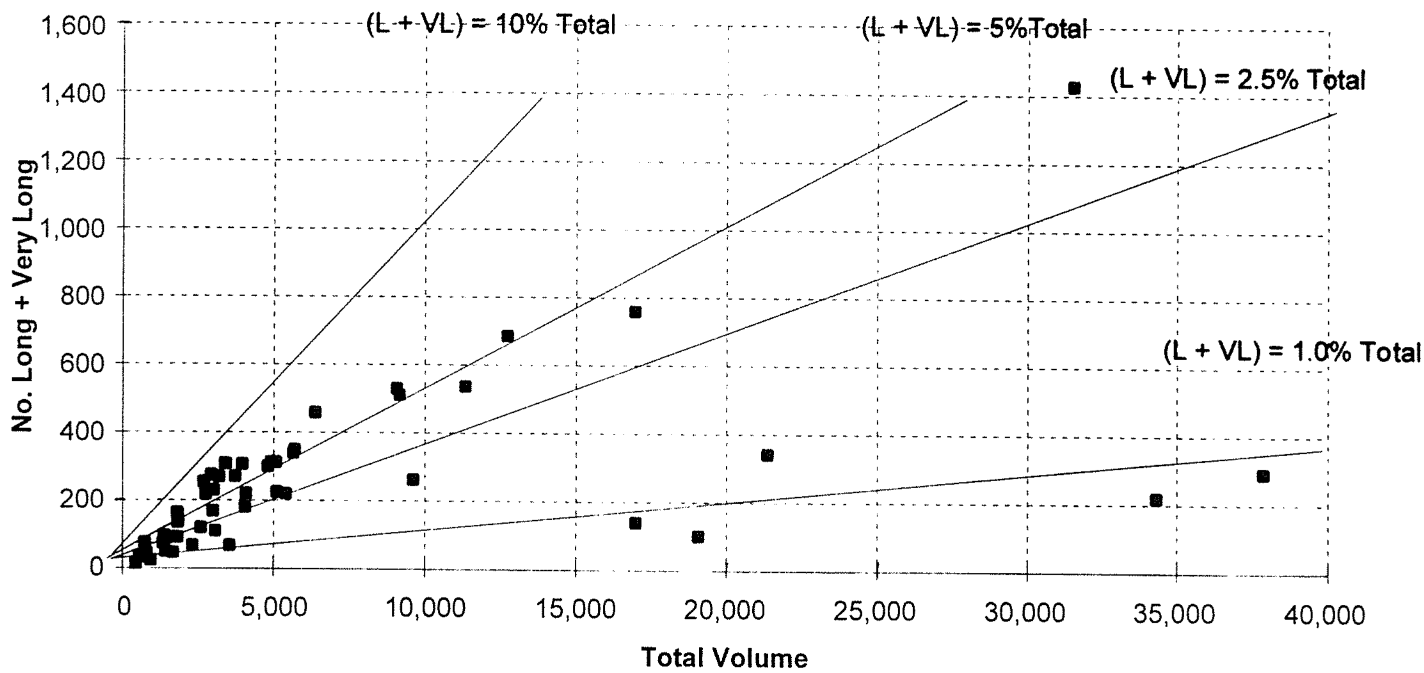


Figure 2.3 Total volume of traffic compared to numbers of long and very long vehicles, counts obtained from telemetry data.



The patterns of vehicle flows shown by the two data sources are similar in very broad terms. The survey data are particularly low near the major urban centres and in the Auckland – Hamilton corridor. In the Rotorua – Bay of Plenty region, the survey data have picked up significant local flows which do not pass through the telemetry points. Flows in this region are even more pronounced in the tonnage graphs, suggesting that higher than average tonnages per vehicle are involved.

2.2.3 Heavy Transport Industry Interest in Increased Axle Limits

Respondents were asked in the questionnaire to indicate if their operation would gain from an increased legal axle limit. The answers to this question were analysed for each route by respondent and by the kind of route: either state highway or local authority road. The results are shown in Table 2.3.

Table 2.3 Advantage perceived by heavy transport operators of increased axle loads for vehicles.

Type of Road	Routes with Perceived Advantage	%	Routes with No Perceived Advantage	%	Total Number of Routes
State Highway	1293	61	823	39	2116
Local Authority	356	46	420	54	776
Total	1649	57	1243	43	2892

The "total number of routes" shown in Table 2.3 counts each line of the returned questionnaire as a separate response. Thus if a respondent identified three routes which are frequently used, this counts as three routes in the table.

If one of those routes is used by other respondents, it will be counted once for each respondent. Thus the "total number of routes" equals the sum of the number of respondents times the number of routes reported per respondent.

The overall response to the questionnaire showed that a perceived advantage would be gained from increasing axle limits in 57% of the cases. However for local roads, less than half the routes identified (46%) were seen as benefiting from heavier axle limits.

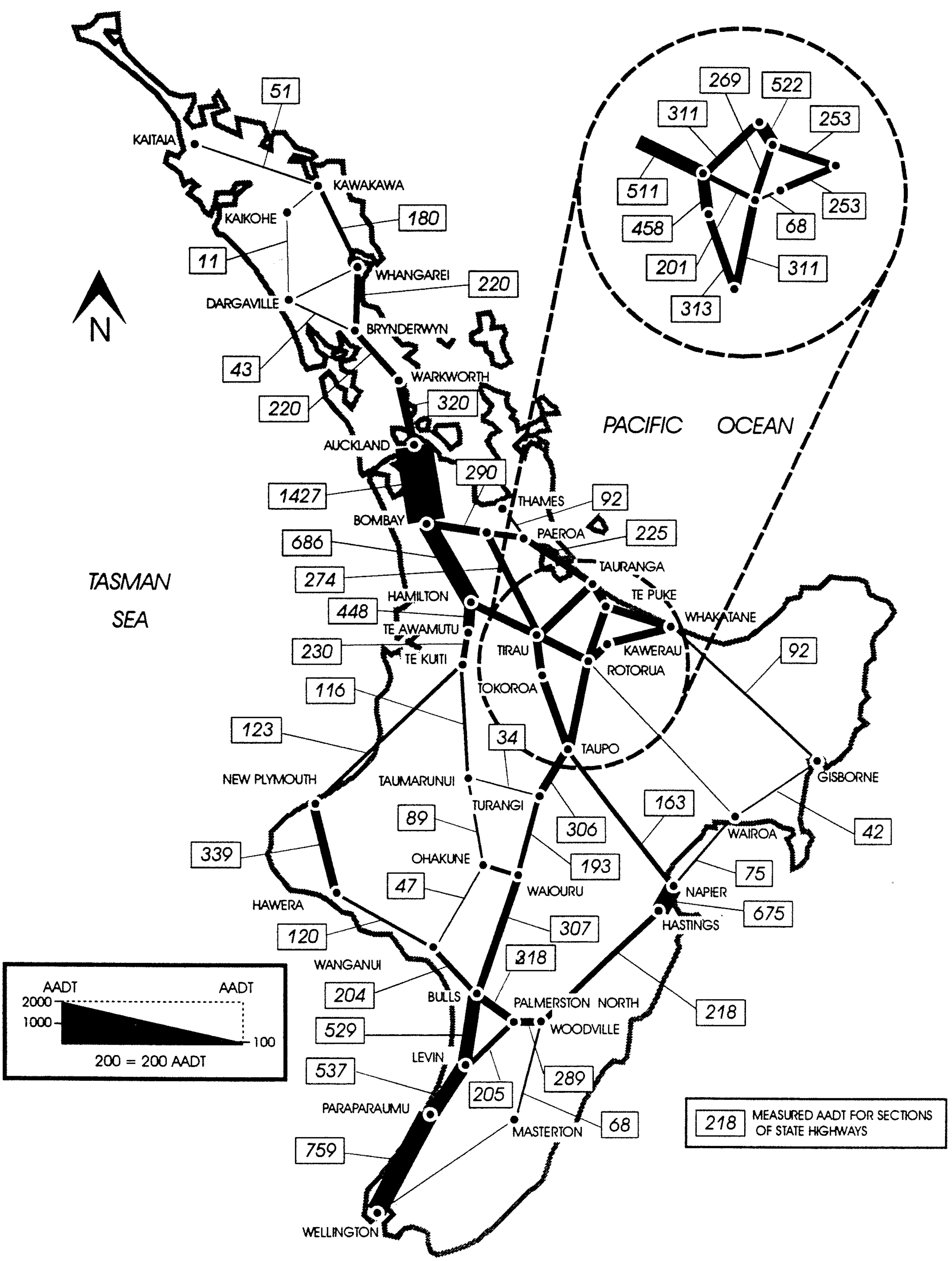


Figure 2.4 Annual average daily traffic (AADT) (from 1992 telemetry counts for "long" and "very long" vehicles only) on state highways of North Island, New Zealand.

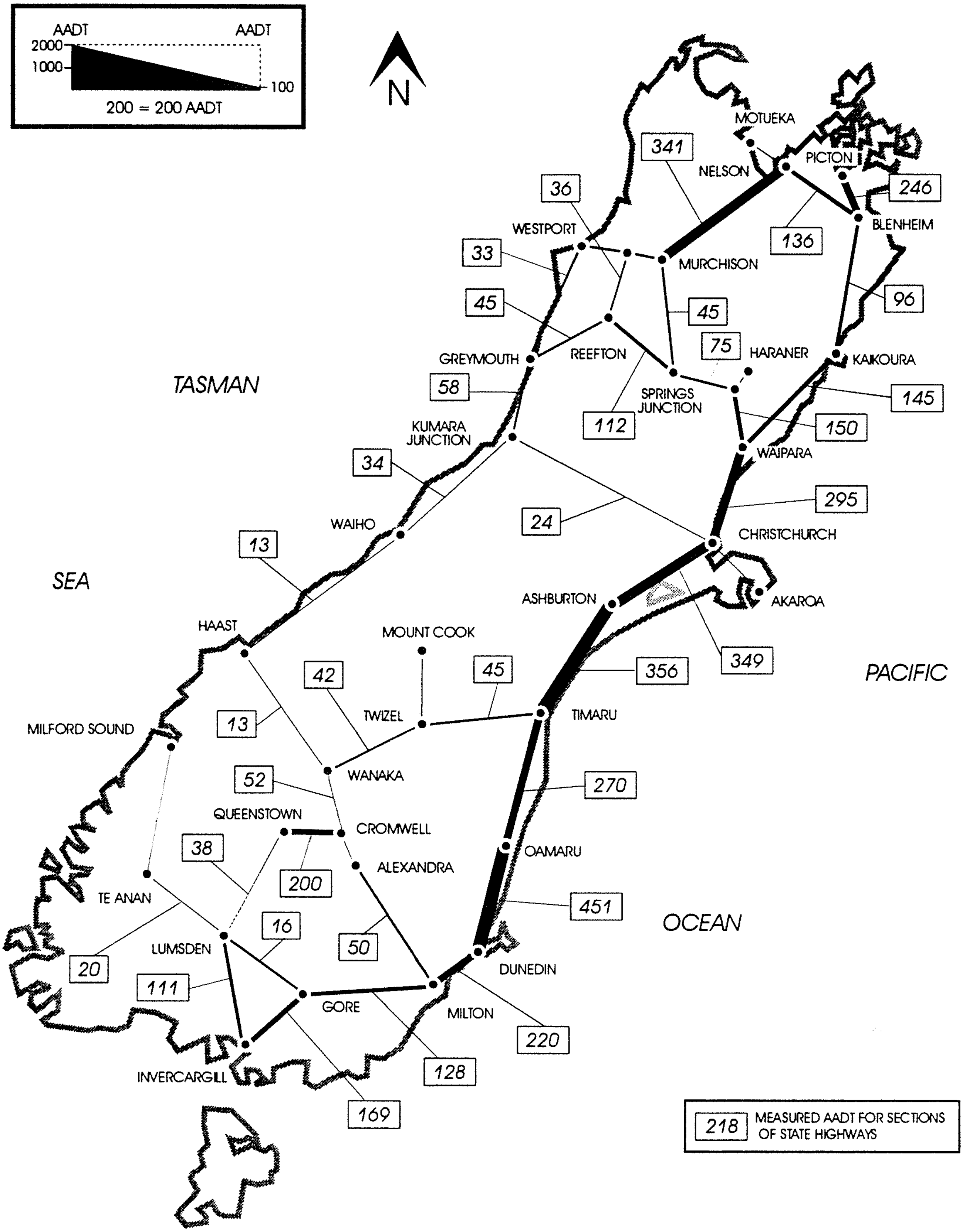


Figure 2.4 Annual average daily traffic (AADT) (from 1992 telemetry counts for "long" and "very long" vehicles only) on state highways of South Island, New Zealand.

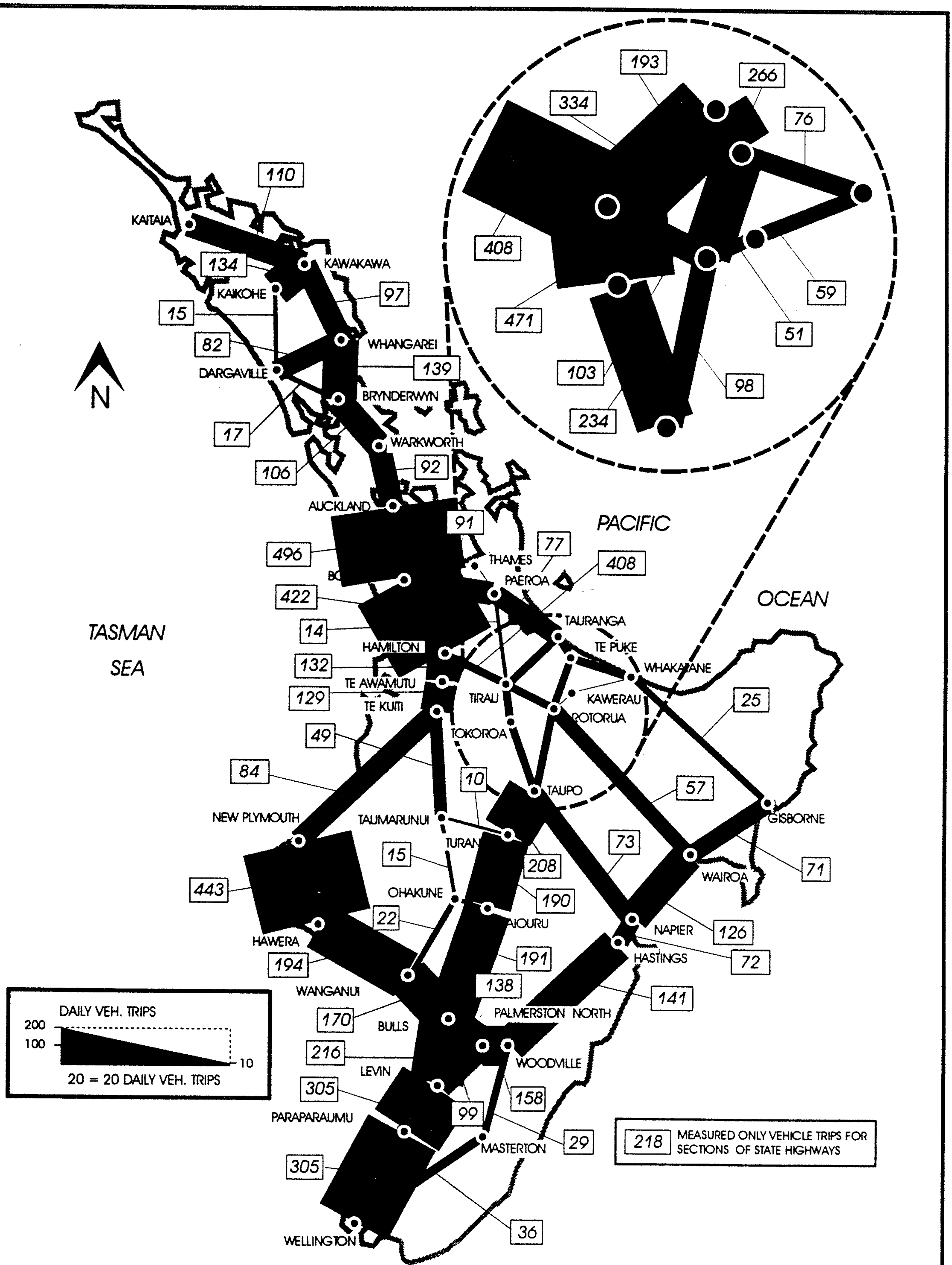


Figure 2.5 Number of daily trips made on state highways of North Island, New Zealand, obtained from survey.

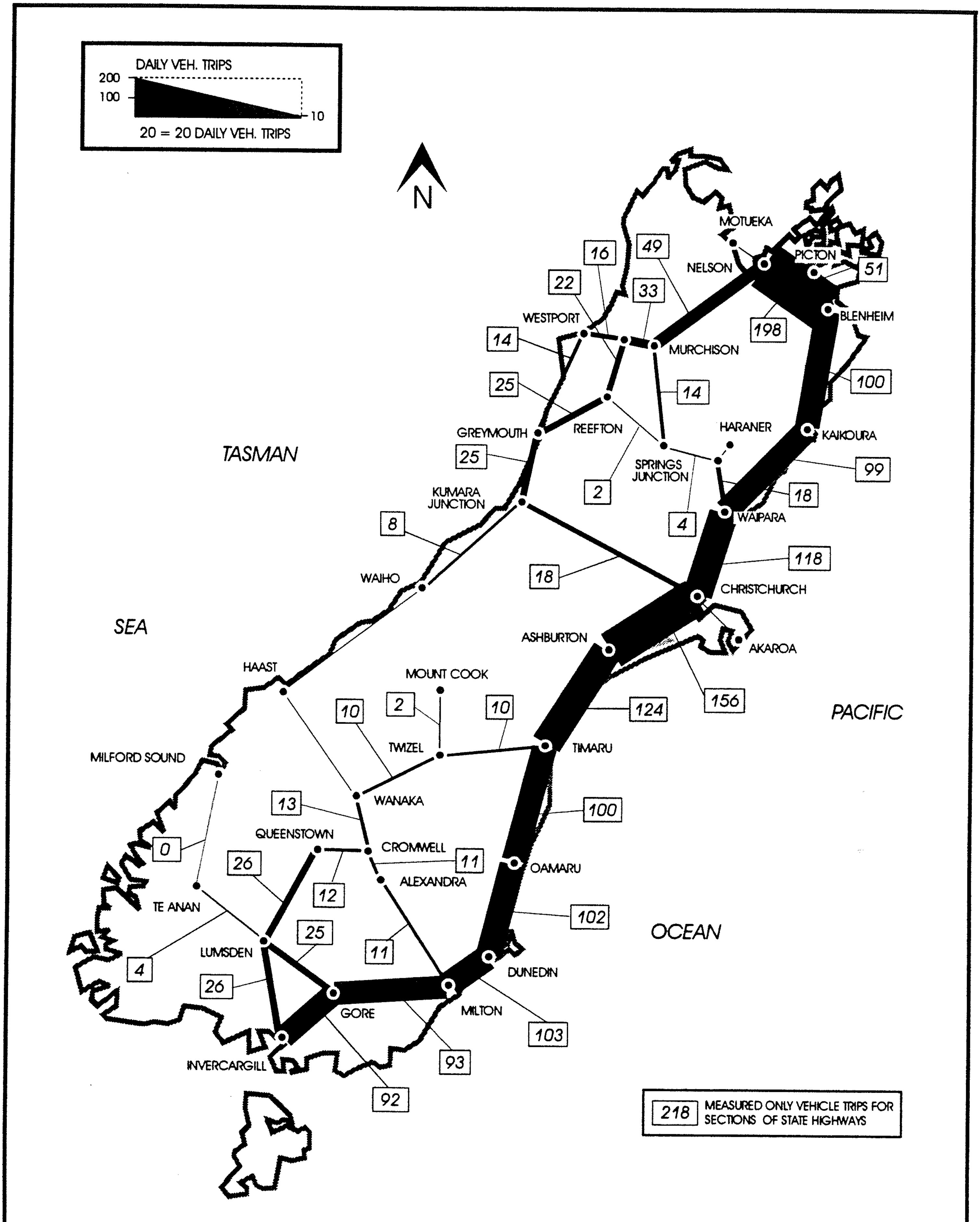


Figure 2.5 Number of daily trips made on state highways of South Island, New Zealand, obtained from survey.

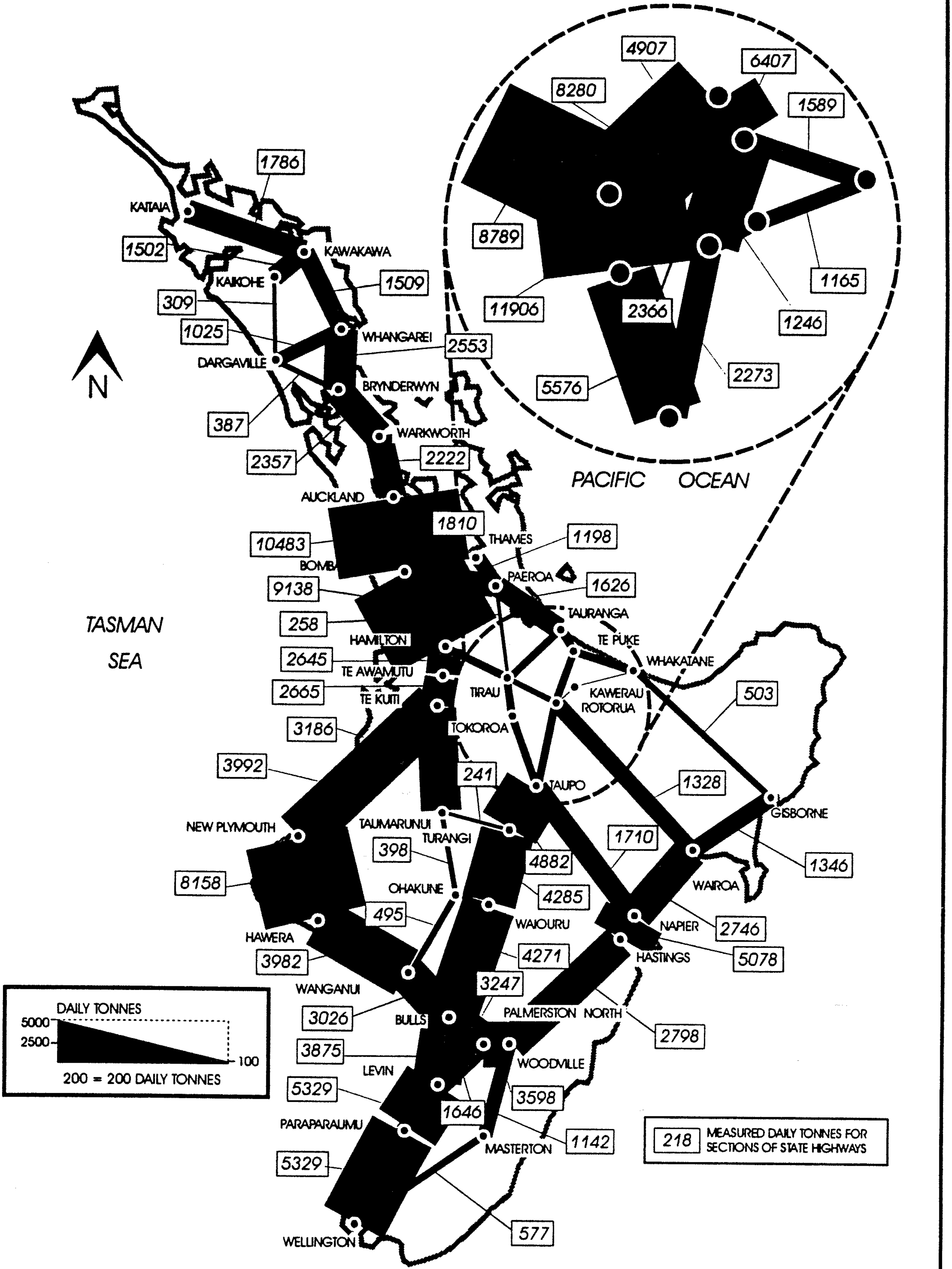


Figure 2.6 Daily net tonnage carried on state highways of North Island, New Zealand, obtained from survey.

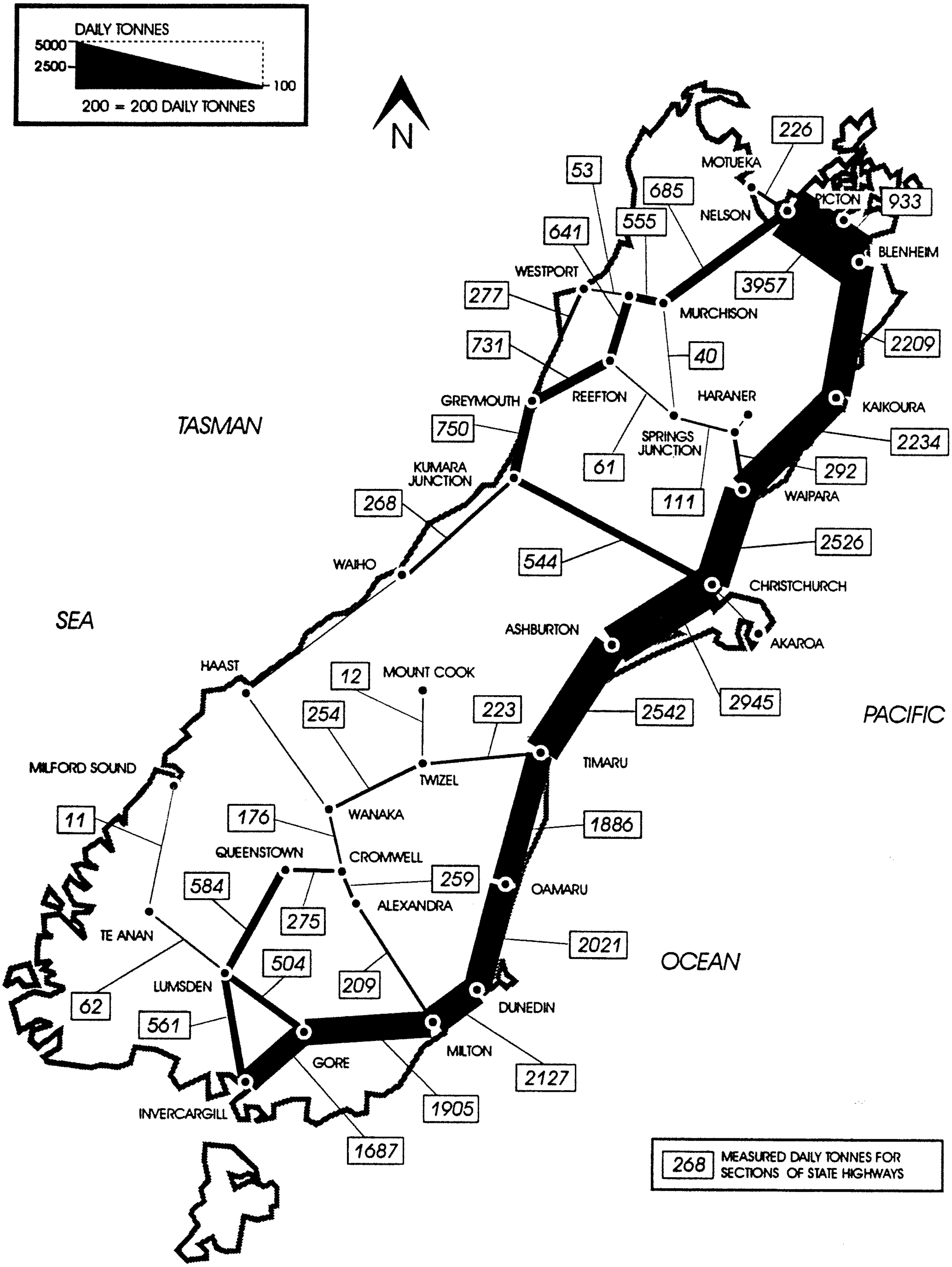


Figure 2.6 Daily net tonnage carried on state highways of South Island, New Zealand, obtained from survey.

2.3 Conclusions and Implications from the Survey

The main conclusions obtained from analysis of questionnaire and telemetry data are:

1. While there is a reasonably high correlation (0.7) between the questionnaire and the telemetry data, the vehicle trips reported in the questionnaire are not a consistent proportion of the telemetry trips (long plus very long vehicles) at each telemetry point. The questionnaire-survey trips expressed as a percentage of telemetry trips ranged from 5% to 170%. The trips indicated in the questionnaire responses appear to represent only a small proportion of total long and very long vehicle trips near the main urban areas, but a much larger proportion in the more rural areas. This difference is because the traffic volumes near the main urban areas are likely to comprise diverse local traffic flows, which would not have been reported in the survey. In any case these trips would be difficult to accommodate by a heavy transport route.

2. The telemetry data show a reasonably consistent ratio of "heavy" vehicle trips (long plus very long vehicles) to total vehicle trips at the 48 sites. Typically the percentage of heavy vehicles is around 5%. Of the telemetry sites 40% ranged between 2.5% and 10%. Near the major urban centres, the percentages were lower, at around 1% or even less.

3. Trips and tonnages as reported in the questionnaire show a reasonably consistent relationship to each other, as would be expected.

It would be inappropriate to select routes for evaluation on the basis of heavy vehicle trips or freight tonnages determined from the questionnaire data only, as these data and the telemetry figures show significant discrepancies. Similarly telemetry figures used on their own may not be very helpful, as they include many short distance trips near major urban centres. Therefore the best compromise may be to use both sets of data and apply appropriate judgement.

The pattern of movements obtained from the questionnaire responses seems unlikely to be representative of all movements (either at individual sites or overall). The questionnaire responses are likely to be biased towards longer distance flows of specific industries (e.g. forestry). However, such flows may account for a high proportion of the flows that are likely to benefit from any heavy transport routes. Therefore the trips and freight tonnages identified in the questionnaire may provide a reasonable starting basis for evaluating the benefits of any heavy transport route.

3. SELECTION OF A PILOT HEAVY TRANSPORT ROUTE

3.1 Purpose of the Pilot Route

Using the results recorded in Section 2, potential heavy transport routes (i.e. routes with significant flows that have a clear purpose, such as mill to port) were selected for evaluation, primarily on the basis of tonnage/usage. A specific route was also selected to be evaluated first, to enable the methodology to be developed, tested and refined. This pilot route was to identify whether or not:

- the method would enable the capacity of a route to be calculated; and
- the capacity of the pilot route was significantly greater than the legal load limits imply.

3.2 Selection of Potential Pilot Routes

In Section 2, heavy traffic flows were identified from an analysis of both telemetry data and the heavy transport industry survey data. These data were plotted on maps to identify and select routes that qualify as heavy transport routes because they have:

- significant movements of heavy vehicles; and
- a clear purpose (such as from mill to port).

From inspection of the data collated in Section 2, a set of seven potential routes was identified. Table 3.1 ranks these routes by their heavy vehicle and freight tonnage flows over their whole length.

3.3 Types of Heavy Transport Routes

Heavy transport routes are of two main types:

1. **One-Way Export Route**
   This would probably be commodity-related with (say) mills, dairy factories, freezing works, canneries and packing depots located along the heavy transport route.
   An example of such a route is Tokoroa, central North Island, to Port Tauranga, Bay of Plenty.

2. **Depot to Depot Route**
   A two-way route between reloading depots. At such depots freight would be reloaded to/from port or rail or lighter vehicles operating under general road network legal weight limits. An example of such a route is Auckland to Hamilton.

Table 3.1 Heavy traffic flows recorded on seven heavy traffic routes.

Rank: Route	Telemetry Trips/Day[(1)]	Survey Tonnes/Trip[(2)]	Factored Survey Tonnes/ Day[(3)]
1: Auckland to Hamilton	686	22	15,000-22,300
2: Tokoroa to Port Tauranga	311	24	7,600-11,900
3: Kawerau to Paengaroa: Paengaroa to Port Tauranga	253 311	26 30	6,000-7,200 12,100-12,600
4: Stratford to Hawera	339	23	6,900-7,800
5: Hastings to Napier	na	21	5,800-6,700
6: Christchurch to Timaru	349	22	4,300-6,100
7: Taupo to Napier	163	26	4,100-4,500

(1) Individual telemetry sites (long + very long vehicles) (from telemetry data, see Section 2).
(2) Indicates the average payload weight (obtained from transport industry survey).
(3) Range of values: these tonnages have been obtained by factoring the transport industry survey results up to equal the same number of trips per day as the telemetry results.
na not available.

3.4 Selection of Pilot Route for Evaluation

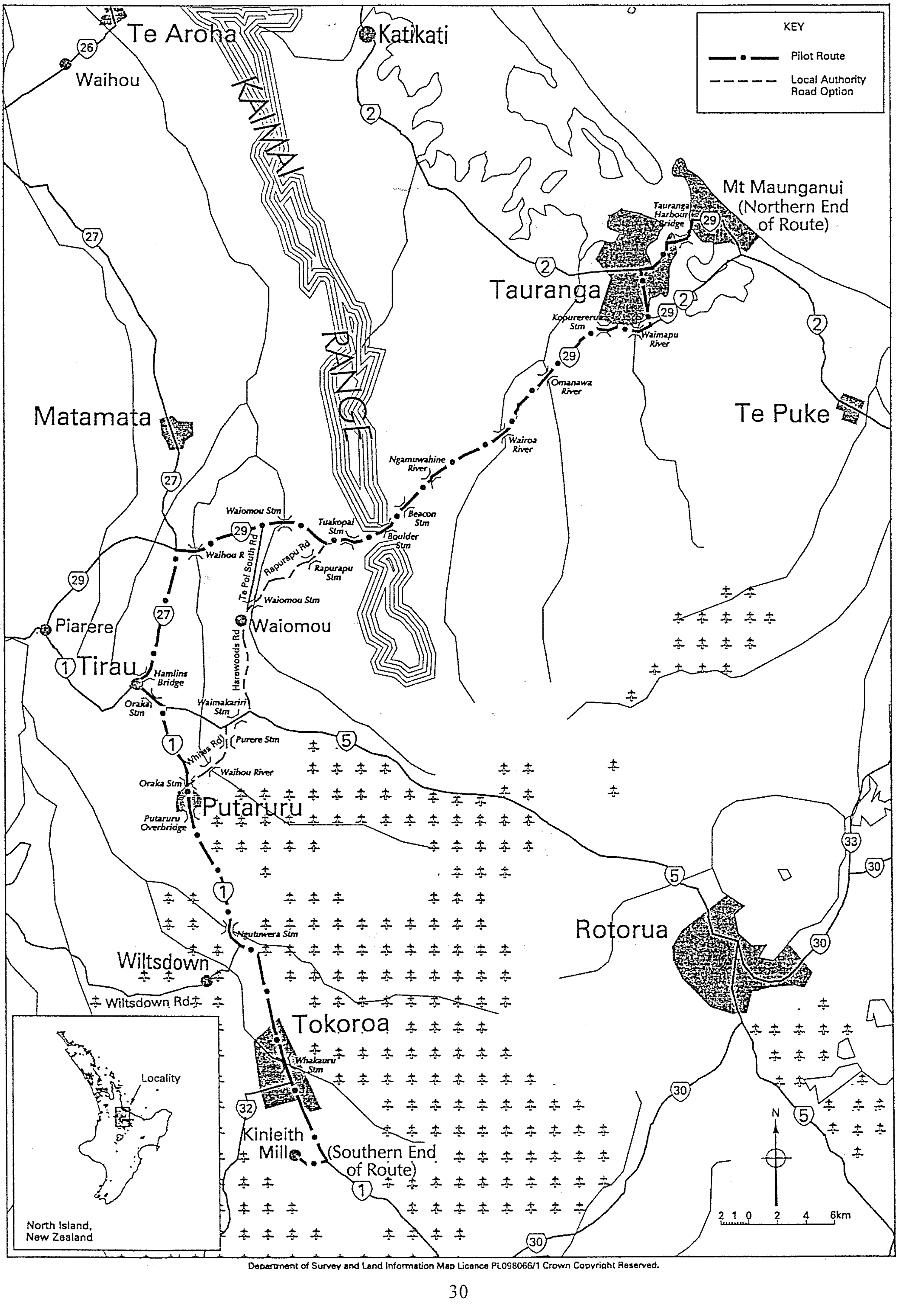
The pilot route selected to develop and test the evaluation methodology was the route from **Tokoroa to Port Tauranga**. This route was chosen because it has one of the highest heavy vehicle/freight tonnage flows and is the major route from South Waikato to Port Tauranga for exports of wood products in particular, and of dairy and other agricultural produce.

Between Putaruru and State Highway 29 on the pilot route two options are available to users. They may travel either:

- by State Highways 1 and 27 (the SH 27 option); or
- by Whites Road, State Highway 5, Harewoods Road, Te Poi South Road, Rapurapu Road (the local authority road option, for which the local road controlling authorities are South Waikato District Council and Matamata–Piako District Council). This route option is 28 km long, and reduces the total pilot route length by 7 km, from 100 km to 93 km.

The remainder of the pilot route is on state highways except at Mount Maunganui where use of the Tauranga Harbour (toll) bridge is assumed. The pilot route and the two options are shown in Figure 3.1.

Figure 3.1 Location of pilot heavy transport route, and the SH 27 and local authority road options, between Tokoroa and Port of Tauranga, central North Island, New Zealand.



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4. METHODOLOGY FOR EVALUATING THE PILOT HEAVY TRANSPORT ROUTE

4.1 Overview

The evaluation of the pilot route was based on the following requirements:

(a) Identify the main vehicle types currently used and, if legal load limits were raised, the potential vehicle types for use on the route;

(b) Identify and list along the route all the physical constraints, including bridge strengths and dimensions, railway crossings, road geometry and pavement strength;

(c) Evaluate the significance of route constraints (in (b)) to the potential vehicle types (in (a)) that could use the route.

The evaluation encompassed:

- Consultations with actual users of the proposed pilot route to determine their needs.
- Consultations with the affected local authorities.
- Evaluation of road geometry constraints of the proposed pilot route.
- Evaluation of vehicle weight constraints of selected vehicle types.

4.2 Consultations

Consultations with the users and local authorities were used to identify the current and future vehicle types using the pilot route as well as to identify issues relating to the pilot route, including the perceived constraints. Additional information on the local authority road option was sought from the two local authorities.

4.3 Definition of Vehicle Types

The heavy vehicle types representing typical vehicle configurations likely to use the pilot route were based on the consultations with users and on observations of the traffic using the route.

4.4 Road Geometry Constraints

The pilot route was examined using the Highway Information Sheets and the Pavement Management Strategy Studies held at Transit New Zealand regional offices. The Highway Information Sheets summarise geometric aspects of roads, and the Pavement Management

Strategy Studies describe future demands on a road and propose actions to be taken to lessen route constraints.

Information about the following list of geometric constraints pertaining to the roads comprising the pilot route and the two options was collected for the evaluation (and listed in Appendix 3, Table A3.2). A B-train combination was used as the representative vehicle to determine geometric constraints because it requires the most road space when manoeuvring.

4.4.1 Sight Distances

Information on sight distances was obtained from Transit New Zealand, from Works Consultancy Services' Hamilton office, from the two District Councils, from consultations with operators and from previous reports and surveys.

4.4.2 Intersections

Information about the impacts of intersections on laden heavy vehicles while turning, climbing etc. was obtained from Transit New Zealand, from Works Consultancy Services' Hamilton office, from the two District Councils, from consultations with operators and from previous reports and surveys.

4.4.3 Lane Widths

The widths of the lanes on the state highways of the pilot route were obtained from the Highway Information Sheets. Sections less than 3.5 m wide were considered to be a constraint because of the likelihood of heavy vehicles (maximum legal width of 2.5 m) encroaching on adjacent lanes.

4.4.4 Curvatures

Sections of the state highways which are substandard, using the criteria defined in AUSTROADS' (1989) *Guide to the geometric design of rural roads*, were obtained from the State Highway Strategy Studies.

The computer program *VPATH*[1] was used to determine the limiting radii for the representative B-train vehicle, i.e. the minimum radius which could be negotiated without crossing into the adjacent lane, assuming a 3.5 m-lane width. The minimum acceptable radius was determined as 50 m, while radii between 50 and 75 m were considered marginal. The assumption was that the vehicle path taken would not be influenced by vehicle speed.

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1 *VEHICLE/PATH* software system for calculating and plotting swept path details for turning vehicles (Main Roads Department, Queensland, 1987-88).

4.4.5 Road Grades

Vertical grades for the state highway parts of the pilot route were obtained from the Highway Information Sheets. The route position of any grade of 3% or more and of vertical rise 15 m or over was noted.

The maximum gradient that allows traction (without damaging the surfacing) was determined for the eight test vehicles under current legal load limits, and for the maximum weights calculated in this study.

4.4.6 Overhead Clearances

The heights of overhead clearances on the pilot route, to compare with the maximum legal height (in 1994) for heavy vehicles of 4.25 m, were obtained from Works Consultancy Services' Hamilton office.

4.4.7 Railway Level Crossings

The level crossings on the pilot route were obtained from Works Consultancy Services' Hamilton office.

4.5 Vehicle Weight Constraints

4.5.1 Pavements

Pavement structure data, including values of subgrade CBR (Californian Bearing Ratio), were obtained from the RAMM (Road Assessment and Maintenance Management) database (held at Transit New Zealand). Although the RAMM database is far from complete, estimates of structure could be made for most pavements on the pilot route. Where data were available, they were translated into numbers of EDA (Equivalent Design Axles), using the National Roads Board *State Highway Pavement Design and Rehabilitation Manual* (1989).

In addition, local road controlling authority personnel and consultants familiar with the route were questioned about pavement condition.

4.5.2 Bridges

Information that is available for bridges on state highways includes bridge class and deck grade.

Bridge class is a measure of the ability of the main structural members of a bridge to carry overweight vehicles complying with overweight conditions. It is expressed as a percentage of the rating load which is a function of the standard design loading.

Deck grade is a measure of the ability of a bridge deck to carry vehicles complying with overweight conditions. Decks are graded A, B, C, D and E in descending order of strength.

Thus a new bridge designed in 1994 to the bridge design loading HN-HO-72 would have a bridge class of 120% and a deck grade of A (Appendix 2).

Details of all state highway bridges are included in the *HPERMIT* database. *HPERMIT*[2] is normally used to manage the movement of overloaded vehicles that are then permitted to travel on prescribed routes under controlled conditions. Details of bridges on local authority roads are not entered in *HPERMIT*.

A methodology for calculating the maximum load of a heavy vehicle under normal operating conditions on a bridge was specifically developed for this study using the *HPERMIT* software. The methodology takes account of the bridge span lengths, the vehicle length, the gross vehicle weight, and the weight of the most critical axle group. This methodology is described in Appendix 2.

2 *HPERMIT* system (Vogel Corporation Ltd/ Transit New Zealand) is used to check applications for overweight permits. It checks pavements, bridges and railway level crossings on a specified route for their ability to carry specified overweight vehicles, and prints any restrictions or supervision requirements for the route.

5. RESULTS OF EVALUATING THE PILOT HEAVY TRANSPORT ROUTE

5.1 Overview

The evaluation of the pilot heavy transport route comprised four activities:

- Consultations with users and local authorities;
- Evaluation of the selected vehicle types;
- Evaluation of road geometry constraints;
- Evaluation of vehicle weight constraints.

5.2 Consultations

5.2.1 User Views

The main users identified and consulted were major truck operators carrying forestry products to Tauranga and a major forestry company.

Three of the major truck operators involved in carrying forestry products to Tauranga were consulted. They pointed out that they were not the ultimate beneficiaries of any efficiency improvements arising from increasing the legal gross vehicle weights, as cost reductions would be passed on to the forest owners.

One operator, who carries wood chips in four-axle trucks with twin-steer axles pulling four-axle trailers, was quite positive towards transporting higher loads. He claimed that these rigs could carry 63 tonnes now without modification, instead of their current legal maximum gross weight of 44 tonnes.

Another of the operators is carrying wood chips using a three-axle truck and four-axle trailer. This operator and the operator referred to above both considered that such vehicles would be unstable at gross weights significantly greater than the current legal maximum.

The third operator has a major export log contract over the pilot route and carries loads in excess of the legal public road limit loads while on forest roads. This operator did not consider that his rigs would be suitable for carrying such loads on public roads at highway speeds without modification. The higher axle loads are however suitable on the forest roads where speeds are low.

The prospect of specialist trucks for use on a designated heavy transport route did not please any of the operators, as all stressed the need for flexibility in the use of heavy vehicles. For example, not all trucks return empty to Kinleith as some carry imports from Tauranga to the Waikato before returning to Tokoroa.

None of the operators interviewed encouraged their drivers to use the Whites Road "short cut" (the local authority road option). They agreed that some companies do use the route, but they considered it too dangerous and that it required too many stop-starts at the intersections.

Carter Holt Harvey, a major forestry company, is a major "end user" for the pilot route. They maintain their own roads in their forests on which bridges and pavements can carry 10 tonne axle weights (i.e. 20 tonnes on a twin-tyred tandem axle set, compared with the limit of 14.5 tonnes on public roads). They would gain considerable benefits if they could load to a higher maximum legal weight in the forest for direct transport to the port.

They also noted that if Wiltsdown Road (which joins SH 1 about 10 km north of Tokoroa) was opened to higher axle/vehicle loads, they could transport all their export logs direct from forest to port using their own roads plus the heavy vehicle route.

5.2.2 Road Controlling Authority Views

The South Waikato District Council is the road controlling authority for the southern part of the local authority road option, and discussions were held with its mayor and council officers.

South Waikato District Council considered that the main issue is the use of local authority roads by heavy vehicles. It also considered that Transit New Zealand should designate certain local authority roads as heavy traffic routes which would then attract higher Transit New Zealand contributions[3] to compensate for the use of these roads by the heavy traffic.

The Council expressed particular concern about the use of the Whites Road–Rapurapu Road "short cut" (the local authority road option). It has been progressively upgrading its (southern) part of the route, although the northern part of this local authority route option comes under the control of Matamata–Piako District Council, which does not regard Rapurapa Road as an arterial route and tries to discourage its use as such.

South Waikato District Council believed that much of the pavement damage on minor roads is made by milk tankers. These vehicles generally have only a single drive axle and thus poor torque distribution at the wheel–road interface. The Council suggested that higher vehicle weights should be restricted to specific vehicle types.

Concern by local authorities over the impact of logging vehicles led to the preparation of the *Report from Forestry Road Funding Task Force* (Ministry of Forestry 1993). This report states that any increase in the present maximum vehicle width (which is 2.5 m) or in maximum height (of 4.25 m) is unrealistic as these dimensions will impact on road width requirements and vehicle stability, respectively. The view expressed in the report is that the only practical options are:

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3 State highways are fully funded by Transit New Zealand; local authority roads are jointly funded by Transit New Zealand and the local authority.

- Change the maximum axle loading; or
- Change maximum vehicle lengths; or
- Some combination of the two.

The report states that to increase the maximum axle loading to 10 tonnes per axle or beyond would require legislative amendments. For example, to take advantage of a 10-tonne axle loading, the vehicle length would need to be 27 m compared with the current maximum vehicle length of 20 m.

The report also states that any change in vehicle length could impinge on road safety and it considered that those roads specifically designated for longer vehicles would have to be upgraded by providing more passing lanes and improved intersection design.

5.3 Evaluation of Selected Vehicle Types

Seven vehicle types, each with different axle configurations, were defined after the consultation with users. Their dimensions are shown in Figure 5.1 (and listed in Appendix 3, Table A3.1) and all are within 1994 legal vehicle dimensions.

The eighth vehicle has greater than legal dimensions, being 27.0 m long (used for log cartage, and referred to in the Ministry of Forestry Report (1993) as suitable for this work), to show the effects of increasing vehicle length, as discussed in Section 5.5.

5.4 Evaluation of Road Geometry Constraints

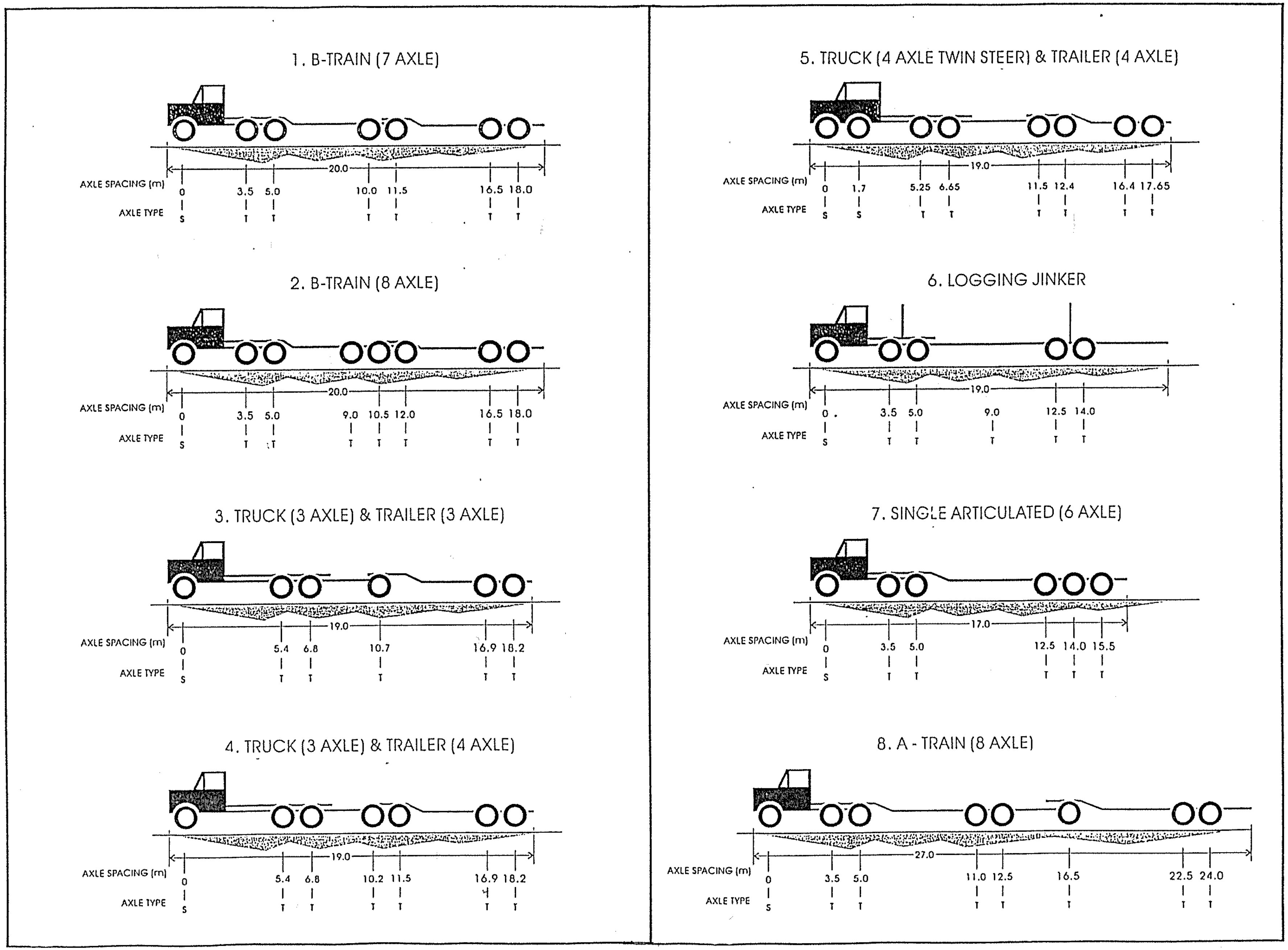
Details of the road geometric constraints encountered on the pilot route, and used for the evaluation, are summarised in Table A3.2 (Appendix 3). The following sections summarise these constraints.

5.4.1 Sight Distances

On the state highway portion of the pilot route sight distances were not considered to be a problem.

On the local authority road option the lack of adequate sight distance at the intersection of Rapurapu Road with SH 29 has been recognised by the local road controlling authorities. Before the Matamata–Piako District Council assumed responsibility for the intersection, the then Matamata District Council had plans to relocate the intersection 100 m downhill, on a straight section of SH 29.

Figure 5.1 Dimensions and configurations of the eight heavy vehicle types defined for the evaluation of the pilot route (summarised in Appendix 3, Table A3.1).



5.4.2 Intersections

The only intersection of concern on the state highway option of the pilot route is the intersection between SH 27 and SH 29 which is considered difficult to negotiate.

On the local authority road option, the T-intersection at Waiomou is a problem for northbound traffic turning right through from the "stem" of Harewoods Road onto Te Poi South Road. The turn is in excess of 120 degrees. For southbound traffic the problem intersection is that between Harewoods Road and SH 5, where the turning movement is in excess of 120 degrees.

At the intersection of Rapurapu Road with SH 29, vehicles must turn right uphill across two lanes into a climbing lane.

5.4.3 Lane Widths

As discussed in Section 4.4.3, any lane less than 3.5 m wide was identified as a constraint to the safe passage of heavy vehicles, because encroachment across adjacent lanes is likely. Three locations in both directions on part SH 29 of pilot route were identified to have this constraint (Table A3.2, Appendix 3):

- Route position 39/0.00 to 39/2.23 (east of Tuakopai Stream)
- Route position 24/10.70 to 24/11.60 (in vicinity of Boulder Bridge)
- Route position 24/3.30 to 24/4.20 (Wairoa River)

The total width of each of eight two-way bridges on the state highway sections of the pilot route, and of two on the local authority road option, is only 7.3 m, and this width is considered to be marginal.

5.4.4 Curvatures

Sections of roads with potential curvature problems included corners at intersections and tight curves on SH 29, primarily on the western side of the Kaimai Range.

Table A3.2 (Appendix 3) summarises the geometric constraints identified along the state highway sections of the pilot route. From Table A3.2, a total of 22 bends have curve radii less than 50 m, and a further 13 are marginal with curve radii between 50m and 75 m. These curves are marginal for negotiation by B-train vehicles and for vehicles of similar dimensions and axle configurations. A further 18 curves are identified as being "sub-standard" when applying criteria from the State Highway Strategy Studies. Also two locations have curves of lane width of only 3.3 m (at route positions 13/0.00 and 13/6.00). Although the lesser lane width was not analysed, these lanes need widening to more than 3.5 m to be satisfactory.

Highway information sheets are not available for the local authority road option. However, part of Rapurapu Road was noted to have poor curvature both horizontally and vertically.

5.4.5 Road Grades

Vertical grades affect vehicle speed, and hence travel time. In addition, provision for passing for other vehicles are required as a result of the slow speed of laden heavy vehicles, which will travel slowly both uphill and downhill. Table A3.2 (Appendix 3) shows 29 stretches where grades of 3% or more and of vertical rise 15 m or over ("+" for ascent, "-" for descent) are located.

The maximum allowable gradient for traction is 18%-23%[4] for heavy vehicles complying with current legal load limits, and 15%-24% using maximum weights[5] calculated in this study. The maximum gradient encountered on the state highway part of the pilot route is 9%, and this is well within the limits required.

5.4.6 Overhead Clearances

The two locations on the pilot route with the least overhead clearance are:

- Maungatapu Overbridge on SH 29 on the outskirts of Tauranga (clearance 5.5 m),
- Tirau South Overbridge (clearance 4.7 m), near Tirau township.

As the maximum legal height for heavy vehicles is currently 4.25 m, these clearances are not constraints.

5.4.7 Railway Level Crossings

On the pilot route the only level crossings are in the Tauranga area. The SH 2 route around Tauranga estuary has five rail crossings, but other more popular routes do not have any rail crossings. Heavy traffic coming from the west tends to turn off SH 29, thence to the Tauranga Harbour Bridge, rather than going around the estuary on SH 2.

A new route to serve the Tauranga port development, "route J" which is still in the design stage, will avoid all these rail crossings.

5.5 Evaluation of Vehicle Weight Constraints

5.5.1 Pavements

Available pavement structural information is very limited. However vehicle weight constraints do not appear to be an immediate problem for pavements on the pilot route because the route has been used by heavy vehicles for many years and no gross structural deficiencies are apparent. Such deficiencies would be apparent in the form of shear failures in the basecourse, or severe rutting caused by failure at deeper levels in the pavement.

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4 See Transit New Zealand (1984) *Overweight Permit Manual.*

5 Maximum gross vehicle limits and the calculated potential vehicle weights are listed in Table 5.3.

In general, the main effect of increasing axle weights on this route will be to reduce the time of cycles of rehabilitation operations, and thus to increase maintenance costs.

5.5.2 Bridges

The number of bridges if the SH 27 option is used is 17, and that if the local authority road option is used is 18. Table 5.1 lists the bridges on the SH 27 option, showing the construction date, overall length, the number and length of individual spans, the bridge class, deck grade and width. The bridge class and deck grade are used to classify the bridges for use complying with overweight permit conditions (see Section 4.5.2). The bridge classification information for the local authority road option is shown in Table 5.2.

Tables A3.3, A3.4, A3.5 (Appendix 3) summarise the results of the analysis undertaken using the methodology established for this study (Appendix 2). The analysis determined the deck, beam and total capacities of the bridges on the pilot route when used by any of the eight vehicle types chosen for this study. For multi-span bridges, the span with the least capacity was taken as the constraining object. These tables relate to normal vehicle operating conditions (i.e. not to overweight permit conditions).

- Some bridges have a Class of less than 100 but, because they have short spans and the vehicles being considered are relatively long, they can generally accept greater than legal gross vehicle weights. A different result would be obtained for a route that includes bridges with long spans or if the vehicles were of short wheelbase.

  For example Whakauru Stream bridge is class 90, which implies that its maximum capacity is less than the current legal maximum vehicle weight. But the span is only 12.2 m long so it will never take the full weight of any of the test vehicles. It is therefore able to carry test vehicles with greater than the legal maximum weight.

- The Tauranga Harbour Bridge has not been evaluated using *HPERMIT* because its details are not entered in *HPERMIT*. Capacities estimated for this bridge (listed in Tables A3.3, A3.4 and A3.5, Appendix 3) indicate that this bridge may be a constraint for the B-train and 8-axle truck and trailer vehicle types. These vehicles have the most axles, which indicates that it is the total vehicle weight which is the constraint.

  This result should be confirmed by more detailed analysis. Alternative local routes can be chosen so that the Tauranga Harbour Bridge could be excluded should this route be designated as a heavy transport route.

- The limiting axle load corresponding to the capacity of each bridge deck is shown in Table A3.3, Appendix 3, assuming that each non-steering axle carries an equal weight. This is the maximum axle load which could safely be permitted on the bridge deck under normal operating conditions.

All the bridge decks are able to take axle loads greater than 10 tonnes (i.e. 20 tonnes for a tandem axle set), and some are capable of taking considerably greater loads. The current legal load limit for a tandem axle set is 14.5 tonnes.

- The limiting axle loads corresponding to the capacity of the bridge beams are listed in Table A3.4, Appendix 3. These are lower in most cases than the bridge deck loads, and as low as 7.1 tonnes for the 8-axle B-train (Vehicle 2, Figure 5.1) on the Tauranga Harbour bridge. Therefore the beam capacity is the constraint on the maximum weight which can be used on the route.

- The maximum gross vehicle weights for each vehicle so that the vehicle does not exceed the total bridge capacity are listed in Table A3.5, Appendix 3. This is calculated assuming that each non-steering axle carries an equal weight.

5.6 Conclusions from the Evaluation

5.6.1 Constraining Bridges

The Tauranga Harbour bridge is shown as the most restrictive bridge for vehicle types 1, 2, 5 and 8 (Figure 5.1), but it can be bypassed.

Hamlins Overbridge is the second most restrictive bridge for these vehicles and is also the most restrictive bridge for the other vehicle types. Hamlins Overbridge therefore is effectively the constraining bridge on the SH 27 option. However it can be bypassed by the local authority road option. This raises the possibility of gaining greater weight increases for vehicles if the local authority road option is used.

The bridges on the local authority road option are not in the *HPERMIT* database, and further work would be required to confirm their capacities. However by comparing the bridges on the pilot route for bridge class, grade and length, the local authority road option bridges do not appear to be constraining.

Boulder Bridge is the next most constraining bridge if Hamlins Overbridge were to be bypassed by the local authority road option. This bridge is on the SH 29 section crossing the Kaimai Range and is common to both options. The limits imposed by this bridge are not significantly higher than those imposed by Hamlins, so the benefit from bypassing Hamlins Overbridge would be small.

5.6.2 Possible Maximum Gross Weights

The maximum gross weights which could be carried on the pilot route using the SH 27 option for each vehicle type (Figure 5.1) are given in Table 5.3. These maximum vehicle weights are currently constrained by the sum of the maximum axle weights or a set gross maximum weight, whichever is the lesser.

Table 5.1 Description of bridges on pilot heavy transport route using the SH 27 option.

State Highway Number	Route Position	Bridge	Construction Date	Length (m)	Span (No./Length(m))	Class +	Deck Grade	Road Width (m)
1N	548/0.0	Whakauru Stream	1967	13.1	1/12.2	90	A	8.48
1N	537/0.0	Ngutuwera Stream	1939	26.2	1/8.8,1/8.6,1/8.8	107	A	7.34
1N	518/9.37	Putaruru Rail Overbridge	1938	68.5	1/7.6,4/15.2	89	B	8.40
1N	518/6.71	Oraka Stream	1936	13.7	1/13.1	86	B	8.00
1N	516/1.26	Oraka Stream, No. 1 *	1938	24.4	1/6.1,1/12.2,1/6.1	86	B	7.32
27	83/9.16	Hamlins Overbridge *	1938	35.7	1/11.2,1/13.1,1/10.9	79	A	7.32
29	52/7.05	Waihou River *	1961	28.2	3/9.4	97	A	7.32
29	52/0.0	Waiomou Stream *	1957	37.8	1/10.5,1/15.2,1/10.5	120	A	7.32
29	39/0.0	Tuakopai Stream	1938	36.6	3/12.2	87	A	7.32
29	24/10.36	Boulder Bridge	1939	36.6	3/12.2	82	A	8.38
29	24/9.10	Beacon (Te Ahura)	1939	60.9	4/15.2	94	A	8.23
29	24/8.41	Ngamuwahine Stream	1975	65.9	3/21.7	118	A	8.53
29	24/3.96	Ruahihi (Wairoa R.)	1975	101.7	1/24.6,2/25.3,1/24.6	120	A	8.53
29	24/0.0	Omanawa River	1936	38.1	1/3.0,3/10.7,1/3.0	120	B	7.32
29	13/6.22	Kopurererua Stream	1941	13.7	1/13.7	92	D	7.32
29	13/3.19	Waimapu Stream	1960	48.8	1/9.9,3/9.6,1/9.9	116	A	10.06
29	6/4.82	Tauranga Harbour	1988	478.0	2/34, 10/41	120	A	9.40

* Bypassed by alternative route.
\+ Defined as the percentage of the routing load which the bridge can carry under overload criteria.

Table 5.2 Description of bridges on local authority road option of the pilot route.

Road Name	Bridge Number	Bridge	Const-ruction Date	Length (m)	Span (No./Length(m))	Class %	Deck Grade	Road Width (m)
Whites	34	Waihou River	1950	12.8	1/9.5,1/12.2,1/9.1	100	A	7.32
Whites	33	Purere Stream	1935	12.8	1/11.5	100	A	7.32
Rapurapu	219	Waiomou Stream	1966	22.02	1/10.6,1/10.6	120	A	8.70
Rapurapu	218	Rapurapu Stream	1971	36.55	1/10.4,1/15.25,1/10/2	117	A	8.75

Table 5.3 Bridge deck capacities: comparison of potential maximum weights with 1994 legal limits for pilot route using the SH 27 option. (1) - (7) column identification numbers (see Figure 5.1, text).

Test Vehicle No. (1)	**Vehicle Type** (2)	**Maximum legal gross vehicle weight**[a] **(t)** (3)	**Potential maximum weights (tonnes)**			**Weight increase** % (7)
			Gross vehicle weight with maximum legal axle weights[a] (4)	**Potential axle weight maximum**[b] (5)	**Gross at potential axle weight** (6)	
1	B-train 7 Axle	44	51	8.3	55.7	25
2	B-train 8 Axle	44	54	7.1	55.7	25
3	Truck & Trailer (6 axle)	44	44	8.7	49.4	12
4	Truck & Trailer (7 axle)	44	51	8.0	53.8	22
5	Truck & Trailer (8 axle)	44	55	7.2	55.0	25
6	Logging Jinker	36	36	9.0	42.4	18
7	Articulated Truck (6 axle)	39	39	8.0	45.7	17
8	Logging Truck (A-train)	39[c]	59	7.9	61.3	57

[a] As at 1994.
[b] Calculated on the assumption that all non-steering axles carry equal weight.
[c] This is not currently a legal vehicle.

- Column 4 shows, for each vehicle type, the maximum gross vehicle weight which would be permitted without any increase in the current legal individual axle weights. Compared with the current maximum gross vehicle weights (column 3), this would have the the following impacts on gross vehicle weight:
  - Vehicle Types 3, 6 and 7: no increase - these are the vehicles with the least number of axles.
  - Vehicle types 1 and 4: 7 tonne increase.
  - Vehicle types 2 and 5: 10-11 tonne increase.
  - Vehicle type 8: 20 tonne increase (but this vehicle type is not currently legal).

- Column 6 shows, for each vehicle type, the maximum gross vehicle weight if each vehicle was entitled to operate with individual axle weights increased to the maximum safe weights (column 5). This permits a further incremental increase in maximum gross weight over column 4 ranging from zero (vehicle type 5) to 6.7 tonnes (vehicle type 7).

  The increase in maximum axle weights would most benefit vehicle types 3, 6 and 7 which have 5 or 6 axles.

- Column 7 shows the percentage increase above legal gross vehicle weights that the pilot route can accept (ratio of column 6 to column 3). For the current legal vehicle types these gross weight increases range from 12% to 25%. The extra long "A Train" combination for carrying logs can be loaded to the greatest gross weight because the weight is spread over a greater length.

These results are for the specific vehicle configurations selected for this route. Therefore the potential for any increase in gross vehicle weight (or axle weight) is dependent on the specific details of each vehicle. However as a generalisation, high weight limits would appear to require more axles and/or wider axle spacings.

5.6.3 Route Options

The local authority road option has merit because it avoids the following four bridges (see Table 5.2 for their locations):

- Oraka Stream No. 1
- Hamlins Overbridge
- Waihou River Bridge
- Waiomou Stream Bridge.

However the information indicates that the local authority road option has other geometric constraints that would limit its use.

Therefore the SH 27 option is likely to be the more suitable option for designation as a heavy transport route.

6. CONCLUSIONS AND RECOMMENDATION

6.1 Conclusions

Stage 1 of this project identified those roads with large flows of heavy traffic in the North and South Islands of New Zealand. From these a pilot route, Tokoroa to Port Tauranga, was selected and its capacity was evaluated.

For the eight heavy vehicle types tested, a significant increase in gross vehicle weights can be used on the pilot route. The evaluation has shown that this route can accept current legal vehicles which are significantly heavier, i.e. of gross weight increases ranging from 12% to 25%, than current legal weight limits.

An extra long "A Train" combination that is of greater than legal dimensions, and could be used for carrying logs, could be loaded to the greatest gross weight within the constraints imposed by the existing pavements and bridges, because the weight is spread over a greater length.

Some road geometry constraints to the pilot route relating to curves, lane widths and intersections would require attention before it could be used as a heavy transport route.

From the information available about the two options for part of the pilot route, the SH 27 option was likely to be preferable to the local authority road option.

6.2 Recommendation for Stage 2

The project should proceed to Stage 2, using the route Tokoroa to Port Tauranga as the pilot route to develop the appropriate methodology, to consider the feasibility of increasing legal weight and dimension limits of heavy vehicles, and to address the issues of:

- economics,
- environmental impacts,
- vehicle safety,
- public perception, and
- alternative solutions other than roading.

7. REFERENCES

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APPENDIX 1. HEAVY TRANSPORT ROUTES: QUESTIONNAIRE TO THE HEAVY TRANSPORT INDUSTRY

HEAVY TRANSPORT ROUTES: ROUTE DESCRIPTION

CONFIDENTIAL

Please return to Tony Fong, Works Consultancy Services Ltd, PO Box 12-003, Wellington, *by 30 July 1993*
Telephone (04) 471 7233, Fax (04) 471 1397

Your Company/Organisation: ______________________________
Your Name: ______________________ *Your position:* ______________
Your Telephone No.: ______________________ *Date:* ______________

Route Description (Separate line for each direction: Copy this sheet before completing, if space is insufficient)	Route length (km)	Increase legal axle weight?	Freight tonnage per week	No. of trips per week	Route ranking: (1,2, etc)	Light & bulky freight?

SEE NOTES ON REVERSE SIDE

Write any comment in this space if you wish.

NOTES

Route description: Describe the route, naming all roads - e.g. *SH1 from Manurewa to Papakura, then Great South Road to Pukekohe.* Complete one line for each direction.

Legal axle weight: Indicate "YES" if you see advantage to your operation if the legal axle weight was increased, otherwise indicate "NO."

Freight tonnage: Estimate the average tonnage per week which has been carried over the last twelve months. Enter "0" if the direction is an "empty trip."

No. of trips: Estimate the average number of trips travelled on a route per week over the last twelve months. Each direction is a single trip, whether "empty" or not.

Route ranking: Write **1** in this column for the route you consider most important, **2** for the next most important, etc.

Light and bulky freight: Indicate with "YES" if the freight is bulky so that volume is the constraint, rather than weight.

APPENDIX 2. METHOD FOR CALCULATING THE MAXIMUM LOAD ON BRIDGES

METHOD FOR CALCULATING THE MAXIMUM LOAD ON BRIDGES

A2.1 Initial Vehicle Study

Bridges on the State Highway sections of the pilot route were examined using the Transit New Zealand software *HPERMIT* for three vehicle configurations. This software simulates the action of a nominated type of vehicle (axle configuration and load) over all of the bridges on a route.

The non-steering axle loads for each truck were set at a nominal 12 tonnes, and the steering axle at 6 tonnes. The *HPERMIT* output was the *FOC* (Fraction of Capacity) used by the truck plus a legal vehicle in the adjacent lane, applying overload criteria for each bridge, for both gross load and deck load.

HPERMIT considers the ability of a bridge to take individual overweight vehicles by comparing the vehicle effects with the bridge capacity under overload. For this study, it was necessary to derive the equivalent bridge capacity under normal load, and then use that capacity and the *HPERMIT* output to derive the allowable axle loads.

(a) For steel and reinforced concrete structures, the bridge moment capacity for normal load, *LCAP*, was derived from:

$$\mathrm{LCAP} = \frac{(\mathrm{CLASS}/100\mathrm{x}\ \mathrm{ESTD}\ \mathrm{x}\ \mathrm{I}\ \mathrm{x}\ (\mathrm{HN} + \mathrm{HO})\ \mathrm{x}\ 0.85 + \mathrm{DL})}{n/1.2} - \mathrm{DL}$$

where: *CLASS* is the percentage of the rating load which the bridge can carry using overload criteria.

Rating load is the nominal overload used to quantify overload capacity, which for a 2 lane bridge is (HN + HO) x 0.85.

ESTD is the eccentricity factor for the bridge when loaded with the rating load.

n is the factor by which the allowable over stress exceeds nominal allowable stress - usually 1.33 or 1.4.

I is the design impact factor for the bridge.

1.2 is the factor by which the allowable stress under normal load exceeds the nominal allowable stress. (This was used historically to determine whether bridges should be posted with a load restriction.)

DL is the dead load moment.
HN and *HO* are the design live load and overload moments respectively.

(b) For prestressed concrete bridges, the capacity for normal load was taken to be equal to the design load effect multiplied by an assumed eccentricity factor and the design impact factor.

The *limiting axle load* was then derived from:

$$\text{Limiting axle load} = 12 \times \frac{\text{LCAP / MCAP}}{\text{FOC (12t axles)}}$$

where *LCAP* is as described in (a) above
MCAP is the equivalent moment capacity for overload, stored in *HPERMIT*.
FOC is obtained from *HPERMIT* as described above.

For deck loading, a similar procedure was followed, although because the effect of dead load could be ignored, the process was simpler.

A2.2 Additional Vehicles

The project was then extended to eight additional test vehicles, at the request of Transit New Zealand. These are the vehicles described in the report.

The method was modified so that further use of *HPERMIT* was not required.

A2.2.1 Gross Loading

The limiting axle load for each of the eight trucks examined was derived for each bridge from the limiting axle load and associated data for one of the three trucks, Truck (a) considered previously, as follows:

(a) For each bridge, the maximum moment produced by each truck (t), with 12 tonnes on all non-steering axles, and 6 tonnes on steering axles was determined. This was recorded as the *basic truck moment* (M_t).

(b) From the *HPERMIT* output, the basic truck moment (M_a) from Truck (a) was obtained.

(c) The *legal truck moment* M_l was obtained from previous *HPERMIT* output. This is the moment produced by a legal truck in the adjacent lane.

(d) The *limiting axle load* for Truck (t) was calculated from:

Limiting axle for Truck (t) = (Limiting axle for truck (a)) x $(M_a + M_l)/(M_t + M_l)$.

A2.2.2 Deck Loading

Axle load limits for decks are governed by the limiting axle set of each vehicle. In the cases under investigation, the following govern:

Truck	*Governing Axle Set*
1	Tandem axles at 1.5m spacing
2	Tri-axle at 1.5m spacing
3	Tandem axles at 1.3m spacing
4	Tandem axles at 1.3m spacing
5	Tandem axles at 1.25m spacing
6	Tandem axles at 1.5m spacing
7	Tri-axle at 1.5m spacing
8	Tandem axle at 1.5m spacing.

HPERMIT was used to obtain the axle weight limit for each deck for each distinct governing axle set. Separate runs were undertaken with trucks 2, 3, 5 and 6. In all other cases the governing axle set is the same as one of these four.

A2.3 Tauranga Harbour Bridge

This bridge is not on the *HPERMIT* system. No design calculations were available. Because all the vehicles considered are very much shorter than its 41 m spans, its response to vehicle gross load is significantly different from the short span bridges which predominate on the rest of the route.

It was assumed that each truck could be represented by a uniformly distributed load over the length of its wheelbase. The load on the wheelbase which would produce a moment equal to that of the design load, HN, on a 41 m simple span was then calculated. From this, the equivalent axle loads were derived.

The deck slab span is also much larger than the usual beam and slab bridges, and there was no easy way of assessing its capacity for wheelloads without a proper analysis. It was assumed to be less critical than the gross effects.

A2.4 Error Estimate

HPERMIT assumes that the vehicle in question is the only one in its lane. It assumes a vehicle at the maximum allowed by Heavy Motor Vehicle Regulations is in the other lane. This is taken to be 85% HN loading. One of the parameters used by *HPERMIT* in determining bridge capacity is the *eccentricity factor*.

The larger the difference in load effects of the test vehicle and the "legal" truck the larger the eccentricity will be. This is quantified by:

$$\text{Eccentricity factor} = \frac{\text{load effect in the most heavily loaded beam}}{\text{mean load effect in all beams}}$$

The analyses carried out using *HPERMIT* assumed that the eccentricity factor generated by *HPERMIT* for the truck with 12 tonne axles would not be significantly different from the value which would apply to the truck with limiting axle weights.

A study was done to check the effect of this assumption in the case of one critical bridge/load condition (Hamlins Overbridge). The difference amounted to 4%, and is therefore not significant.

For the pilot route, vehicles are expected to be loaded above current limits in one direction only.

A2.5 Comments

The procedures above are applicable to this particular route. Specifically, the procedure in A2.2.1 above is applicable to bridges for which:

(a) *HPERMIT* data has been derived using the criteria of *Bridge Classification and Deck Grading for Overweight Permits,* CDP 703:1973, Ministry of Works and Development;

(b) the moment in a simple span, or one which can be considered equivalent to a simple span, is critical;

(c) the design calculations are generally not available.

For cases where these conditions do not apply, other procedures may be more appropriate.

APPENDIX 3. DATA FOR BRIDGES ON THE PILOT HEAVY TRANSPORT ROUTE AND ITS OPTIONS

Table A3.1 Dimensions for the eight heavy vehicle types defined for the evaluation. (Figure 5.1 shows them diagrammatically.)

Type (Description)	**Axle Length (m) (measured from front axle)**	**Total Length (m)**	**Maximum 1994 legal weight (tonnes)**
1. B Train (7 axle)	3.5, 5.0, 10.0, 11.5, 16.5, 18.0	20	44
2. B Train (8 axle)	3.5, 5.0, 9.0, 10.5, 12.0, 16.5, 18.0	20	44
3. Truck (3 axle) and trailer (3 axle)	5.4, 6.8, 10.7, 16.9, 18.2	19	43.9
4. Truck (3 axle) and trailer (4 axle)	5.4, 6.8, 10.2, 11.5, 16.9, 18.2	19	44
5. Truck (4 axle twin steer) & trailer (4 axle)	1.7, 5.25, 6.65, 11.15, 12.4, 16.4, 17.65	19	44
6. Logging Jinker	3.5, 5.0, 12.5, 14.0	19	36
7. Single Articulated (6 axle)	3.5, 5.0, 12.5, 14.0, 15.5	17	39
8. Logging truck (A Train) (8 axles)	3.5, 5.0, 11.0, 12.5, 16.5, 22.5, 24.0	27	39

Table A3.2 Evaluation of road geometric constraints for pilot heavy transport route from Tokoroa to Port Tauranga.

SH	RS	RP from	RP to	PAVEMENT Width LHS	Width RHS	Height	Pavement Structure & Strength B/C	S/B	S/G	CBR(S/G)	EDA	Date	Grade	Curvature R < 50m	50<R<75	Sub-std (radius(m))	RAIL CROSSING	Ref. Document
1	548	8.00	10.50				300	-	>100		93000	> 25 yrs						Tokoroa Golf Course SCT
1	548	7.30	7.30				300	-	>100	35								Kinleith (WCS Lab Test Pits)
1	548	7.00	7.00				210	-	>100	100+								Kinleith (WCS Lab Test Pits)
1	548	6.80	6.80				120	-	>100	60								Kinleith (WCS Lab Test Pits)
1	548	6.53	6.53				160	-	>100	?								Kinleith (WCS Lab Test Pits)
1	548	6.10	6.10				150	180	>100	20								Kinleith (WCS Lab Test Pits)
1	548	5.80	5.80				160	-	>100	100+								Kinleith (WCS Lab Test Pits)
1	548	5.65	5.65				100	-	>100	100+								Kinleith (WCS Lab Test Pits)
1	548	0.80	3.60				250	250	>600	30		?						Tokoroa Borough SCT (Ashworth - Campbell)
1	548	0.00	0.80				240	-	>100			> 20 yrs						Tokoroa Borough SCT & Multi Lane
1	537	7.40	8.20										3.0%					
1	537	6.80	7.40										-6.0%					
1	537	6.67	7.70				190	-	>1000	8	56800	Dec-74						West Rd to Pokaiwhenua Stream Bridge SCT
1	537	5.90	6.70										5.0%					
1	518	18.50	18.90										-5.0%					
1	518	17.60	18.20										-5.0%					
1	518	16.95	18.56				150	100	>100	8		Dec-63						Lichfield to Ngutuwera SCT
1	518	15.02	15.32				500	-	>100	?	86000	Dec-63						Scrivenor's Rd SCT
1	518	14.20	14.60				150	-	>100	15		Dec-62						Lichfield SCT
1	518	12.55	12.80				100	-	>100	25		Dec-63						Pinedale Rd Sth SCT
1	518	10.20	10.65				100	-	>100	v. hard		Dec-63						MOT - Pinedale Rd Nth SCT
1	518	9.3	9.5															
1	518	8.30	8.30												*			
1	518	7.65	8.25				250	-	>200	30		Dec-57						Putaruru SCT
1	518	7.20	7.50										5.0%					
1	518	6.60	7.20										7.0%					
1	518	6.51	6.51											*				
1	518	0.80	1.20										-5.0%					
1	518	0.00	0.00												*			
27	94	0.00	0.00											*				SH1/27 Inters
27	83	10.14	10.14				130	-	>300	100+								SH1/27 Intersection (Tirau) Test Pits
27	66	8.60	9.80				150	-	>200	4		> 25 yrs						Matamata Borough (Farmers to Hinuera) SCT
27	66	7.90	8.60				250	-	>100	16		> 25 yrs						Matamata Borough St II SCT
27	66	2.71	2.71													*(30)	*	Link Rd Rail Crossing
27	66 ?		?													*(600)		Waharoa Overbridge
27	66	1.90	2.46				200	-	>200	3		Dec-74						Waharoa Township SCT
27	46	13.30	13.30													*(300)		Tatuanui - Tirau Strategy Study (Given Rd)
27	46	12.20	12.20													*(240)		Tatuanui - Tirau Strategy Study
27	46	9.00	9.00													*(200)		Tatuanui - Tirau Strategy Study
27	46 ?		?													*(300)		Tatuanui - Tirau Strategy Study (Ngarua Rd)
27	46	6.00	6.00													*(280)		Tatuanui - Tirau Strategy Study
27	46	2.30	2.30													*(240)		Tatuanui - Tirau Strategy Study
27	46	1.30	1.30													*(240)		Tatuanui - Tirau Strategy Study (Cussin Rd)
29	61	9.50	11.00													200		Andersons No.2 Bridge
29	61	2.20	2.20													300		Hinuera Rd West
29	61	0.00	0.00											*				
29	52	8.30	8.80				200	100	>100	40		?						Waihou SCT
29	52	7.00	7.60										7.0%					
29	52	6.50	7.00										-5.0%					
29	52	6.00	8.00													280		McNab/Moore Rd
29	52	5.00	5.70										4.0%					
29	52	4.70	5.00										-3.0%					
29	52	4.40	4.70										5.0%					

Table A3.2 Evaluation of road geometric constraints for pilot heavy transport route from Tokoroa to Port Tauranga (continued).

SH	RS	RP from	RP to	PAVEMENT Width LHS	RHS	Height	Pavement Structure & Strength B/C	S/B	S/G	CBR(S/G)	EDA	Date	Grade	Curvature R < 50m	50<R<75	Sub-std (radius(m))	RAIL CROSSING	Ref. Document
29	52	4.00	6.00													280		Watson Rd
29	52	2.00	2.44				200	-	>100	40		?						Stopford Rd SCT
29	52	0.00	0.30										5.0%					
29	39	11.40	52/1.00													280		Waiomou River Bridge Appr
29	39	10.00	11.40													260		Matamata Rd/SH29 Intersection
29	39	8.19	8.93				150	200	400	15	4500000	Jul-78						Western Kaimai Reconstr
29	39	7.00	7.50													130		Lower Kaimai's
29	39	6.10	8.30				200	180	>200	v. hard		Apr-87						Western Kaimai St II & III
29	39	5.55	6.17													90		Kaimai Reconstr St 2
29	39	4.32	5.23				150	150+100	500	15	-	Jul-77						Western Kaimai Realignment St I
29	39	4.32	8.22				150	150+100	400	15	1150000	Dec-84						Western Kaimai Reconstr
29	39	4.20	4.30													105		Upper Kaimai's
29	39	4.00	6.80											17	8			
29	39	2.50	3.11										7.0%					
29	39	0.10	1.90										8.0%					
29	39	0.00	2.30	6.6	3.3													
29	39	0.00	4.90										-6.0%					
29	24	13.00	13.30				150+1.5	-	200	-	-	Jul-89						Mill Rd SCT
29	24	11.60	12.50				150	165	250			Dec-87						Rest Area to Mill Rd SCT
29	24	10.70	11.60	6.8	3.4													
29	24	10.60	13.70										9.0%					
29	24	7.30	8.40										-4.0%					
29	24	6.80	7.30										8.0%					
29	24	6.40	7.10				150	150	200	-	-							
29	24	3.40	5.20										8.0%					
29	24	3.30	4.20	6.2	2.9													
29	24	2.90	3.40										7.0%					
29	24	2.37	2.70				200	200	400	-	-	May-81						Ruahihi (Power station) SCT
29	24	1.20	2.50				150	140	210	5	260000	Apr-89						Omanawa Rd to Ruahihi rd Reconstr
29	24	0.75	1.02				200	100	}	5	3000000	Dec-89						} Omanawa Culvert SCT
29	24	0.75	1.02				200	200	}	5	3000000	Dec-89						} Omanawa Culvert SCT
29	24	0.00	0.50										8.0%					
29	13	9.30	10.10										-7.0%					
29	13	8.58	9.94				150	280	450	-	-	Nov-75						Tauriko - Omanawa St II Reconstr
29	13	7.70	8.58				150	280	450	-	-	Feb-75						Tauriko - Omanawa St I Reconstr
29	13	6.85	7.70				150	200	450	-	-	May-74						Kopurereroa Br -Tauriko Reconstr St II
29	13	6.70	7.30										9.0%					
29	13	6.24	6.85				200	150	450	-	-	Apr-72						Kopurereroa Br -Tauriko Reconstr
29	13	5.35	5.75				150	200	500	15	-	Oct-76						Barkes - Kopurereroa Strm Br Reconstr
29	13	4.99	4.99				150	190+190	-	-	3700000	Oct-82						Barkes Cnr Int. Reconstr
29	13	4.99	4.99												*			
29	13	4.90	5.50										-9.0%					
29	13	4.30	4.90										7.5%					
29	13	3.39	3.39				150	150	440	-	-	Sep-88						Oropi Rd Int.
29	13	2.32	2.32				150	150	440	15	59400	Mar-83						Paike Rd Int.
29	13	0.20	0.60										-3.0%					
29	13	0.00	0.00												*(3.3m)			
29	6	3.70	4.30										-4.0%					
29	6	0.00	0.00												*(3.3m)			
29	0	3.35	3.35											*				
29	0	1.21	1.21											*				

Table A3.3 Bridge deck capacity (limiting axle weights in tonnes) of bridges on pilot heavy transport route..

Bridge Name	TEST VEHICLE No. (see Table A3.1)							
	1	2	3	4	5	6	7	8
Whakauru Stream +	-	-	-	-	-	-	-	-
Ngutuwera Stream	17.2	13.9	17.0	17.0	16.9	17.2	13.9	17.2
Putaruru Rail Overbridge	12.7	10.8	12.5	12.5	12.4	12.7	10.8	12.7
Oraka Stream	12.4	10.0	12.3	12.3	12.3	12.4	10.0	12.4
Oraka Stream, No. 1 *	12.5	10.0	12.2	12.2	12.1	12.5	10.0	12.5
Hamlins Overbridge *	14.6	10.5	14.4	14.4	14.3	14.6	10.5	14.6
Waihou River * +	-	-	-	-	-	-	-	-
Waiomou Stream *	18.4	-	18.3	18.3	18.2	18.4	-	18.4
Tuakopai Stream	12.6	10.9	12.5	12.5	12.4	12.6	10.9	12.6
Boulder Bridge	12.6	10.9	12.5	12.5	12.4	12.6	10.9	12.6
Beacon (Te Ahura)	12.8	11.2	12.7	12.7	12.7	12.8	11.2	12.8
Ngamuwahine Stream	15.2	14.4	14.9	14.9	14.8	15.2	14.4	15.2
Ruahihi (Wairoa River)	18.4	15.5	17.6	17.6	17.4	18.4	15.5	18.4
Omanawa River	18.1	14.9	17.8	17.8	17.7	18.1	14.9	18.1
Kopurererua Stream	13.1	11.3	13.0	13.0	12.9	13.1	11.3	13.1
Waimapu Stream +	-	-	-	-	-	-	-	-
Tauranga Harbour Bridge	**	**	**	**	**	**	**	**

+ Slab bridge
* Bypassed by local authority road option

Table A3.4 Bridge beam capacity (limiting axle weights in tonnes) of bridges on pilot heavy transport route..

Bridge Name	**TEST VEHICLE No. (see Table A3.1)**							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Whakauru Stream	11.42	9.74	11.04	10.21	10.52	11.65	10.24	11.22
Ngutuwera Stream	11.00	9.41	11.04	10.31	10.78	10.99	9.41	10.96
Putaruru Rail Overbridge	11.52	10.08	11.89	10.72	10.61	12.64	11.25	11.98
Oraka Stream	10.07	8.66	10.0	9.13	9.38	10.61	9.24	10.07
Oraka Stream, No. 1 *	11.27	9.77	11.04	11.04	10.99	11.27	9.77	11.27
Hamlins Overbridge *	8.98	7.65	8.67	7.97	8.23	9.05	7.94	8.75
Waihou River *	9.75	8.38	9.53	9.02	9.46	9.75	8.38	9.66
Waiomou Stream *	14.86	12.88	14.36	13.35	13.87	14.86	12.94	14.51
Tuakopai Stream	9.82	8.36	9.48	8.72	9.00	9.89	8.69	9.56
Boulder Bridge	9.39	8.01	9.09	8.35	8.63	9.48	8.32	9.16
Beacon (Te Ahura)	10.40	9.07	10.75	9.67	9.54	11.47	10.20	10.80
Ngamuwahine Stream	9.96	8.76	10.98	9.50	9.33	11.45	10.58	10.53
Ruahihi (Wairoa River)	10.06	8.91	11.10	9.68	9.47	11.74	10.82	10.68
Omanawa River	14.02	12.16	13.58	12.60	13.08	14.07	12.26	13.71
Kopurererua Stream	11.00	9.49	11.03	10.05	10.24	11.57	10.23	11.11
Waimapu Stream	10.45	9.56	10.23	9.67	10.15	10.45	8.89	10.35
Tauranga Harbour Bridge	8.3	7.1	10.0	8.3	7.2	11.6	9.5	7.9

* Bypassed by local authority road option

Table A3.5 Total bridge capacity (limiting gross vehicle weight in tonnes) of bridges on pilot heavy transport route.

Bridge Name	**TEST VEHICLE No. (see Table A3.1)**							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Whakauru Stream	74.5	74.2	61.2	67.3	75.1	52.6	57.2	84.5
Ngutuwera Stream	72.0	71.9	60.1	67.9	76.7	50.0	53.1	82.7
Putaruru Rail Overbridge	75.1	76.6	65.5	70.3	75.7	56.6	62.3	89.9
Oraka Stream	66.4	66.6	56.0	60.8	68.3	48.4	52.2	76.5
Oraka Stream, No. 1 *	61.4	64.0	53.1	58.3	65.6	45.3	49.2	72.4
Hamlins Overbridge *	**59.9**(2)	**59.6**(2)	**49.4**(1)	**53.8**(1)	**61.4**(2)	**42.2**(1)	**45.7**(1)	**67.3**(2)
Waihou River *	64.5	64.7	53.7	60.1	68.8	45.0	47.9	73.6
Waiomou Stream *	95.2	96.2	77.8	86.1	95.2	65.4	70.7	107.6
Tuakopai Stream	64.9	64.5	53.4	58.3	66.0	45.6	49.5	72.9
Boulder Bridge	62.3	62.1	**51.2**(2)	56.1	63.8	**43.9**(2)	**47.6**(2)	70.1
Beacon (Te Ahura)	68.4	69.5	59.8	64.0	69.2	51.9	57.0	81.6
Ngamuwahine Stream	65.8	67.3	60.9	63.0	68.0	51.8	58.9	79.7
Ruahihi (Wairoa River)	66.4	68.4	61.5	64.1	68.8	53.0	60.1	80.8
Omanawa River	90.1	91.1	73.9	81.6	90.5	62.3	67.3	102.0
Kopurererua Stream	72.0	72.4	61.2	66.3	73.4	52.3	57.2	83.8
Waimapu Stream	68.7	72.9	57.2	64.0	72.9	47.8	50.9	78.5
Tauranga Harbour Bridge	**55.7**(1)	**55.7**(1)	55.9	**55.9**(2)	**55.4**(1)	52.4	53.6	**61.5**(1)

* Bypassed by local authority road option.
(1) Most restrictive bridge
(2) Second most restrictive bridge