Investigation Into The Feasibility Of Heavy Transport Routes In New Zealand

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1. ABSTRACT

This paper reports the progress on a two-staged project to investigate the safety and feasibility of changing weight and dimension limits, either on selected routes or on all roads in New Zealand. The methodology has included information gathering from transport operators to select routes for detailed study; determining physical restraints (eg bridge, pavement, geometric); consideration of environmental and vehicle safety issues; and economic analysis of benefits and costs to New Zealand.

The research is exploratory only and in no way can be considered to be Transit New Zealand or Government policy.

2. INTRODUCTION

New Zealand's national economy relies on its road network to deliver primary products (eg timber, dairy, meat and wool) from rural areas to markets and export ports. During the last 15 years there has been a noticeable increase in the number and use of heavy vehicles on the road network.

A thorough review of the structural capacity of the network in 1988 resulted in the adoption of the 44 tonne gross weight limit. However, single axle, tandem, and triaxle weight limits still lie somewhat below those of many countries. This has the effect of limiting the competitiveness and productivity of the road transport industry. The current legal weight limits are summarised in Appendix 1.

3. THE EXISTING ROAD NETWORK

New Zealand has 92,600 km of roads of which 10,677 km form the national state highway system. This roading network has to be supported by a population of only 3.45 million people whose resources are already stretched to provide other essential services such as health and education to a population dispersed over a land area roughly the size of the United Kingdom. However, the economy still has a large rural component which is almost entirely dependent on road transport, so the roading infrastructure has to be preserved.

Much of New Zealand's roading terrain is hilly or mountainous which requires considerable bridging, costly maintenance and construction, and can severely constrain geometric standards.

To meet its roading challenge within the funding limitations, New Zealand has relied on thin flexible pavements and light bridge structures, and acceptance of geometric standards which can sometimes be less than those commonly seen in other countries.

4. OBJECTIVES FOR STAGE 1

Transit New Zealand (TNZ) first initiated the research project in 1992, in response to requests from the road transport industry. The work has been conducted in two separate stages, each with their own objectives.

The overall objectives for Stage 1 were:

(1) To identify the currently used heavy transport road routes,

(2) To develop a methodology to evaluate the present load and dimensional capacities of a few of these identified routes, irrespective of legal load limits, under normal vehicle operating conditions (i.e. within legal weight and dimension limits), and

(3) For the routes in (2) above, determine the vehicle types that are:
   (a) currently used; and
   (b) which would be used if the legal load and dimensional restrictions were increased.

5. STAGE 1 METHODOLOGY

This comprised four tasks as follows:

(1) Industry Survey and Analysis of the Results
(2) Selection of a Pilot Route
(3) Development of an Evaluation Methodology
(4) Evaluation of the Pilot Route

5.1 INDUSTRY SURVEY

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

A questionnaire was designed in consultation with the Road Transport Association, the Heavy Haulage Association, and TNZ.

Industry groups provided lists of their members for the questionnaire mailout and advice about the transportation needs of their industry. They also endorsed the objectives of the study and provided covering letters to accompany the questionnaires encouraging their members to complete and return them. The groups with relatively small membership such as the forest owners and oil companies were all individually contacted and invited to participate in the study.

The total response was 44 percent of those mailed, although only 35 percent were completed returns. The rather low rate is in part due to companies on the mailing list who are not truck operators, or have gone out of business. There is thus reason to believe the effective rate was higher than it appears. Table 1 shows the response rate by industry groups.

Table 1. Survey response by industry group

Group	Mailout Nos	Returns		Response %
		Completed	N/A	
RTA (Road Transport)	1178	430	112	46
HHA (Heavy Haulage)	97	23	2	26
PCA (Power Crane)	68	7	3	15
Dairy Companies	16	13	1	88
Petroleum Companies	6	1	1	33
Forestry Companies	15	15	0	100
Total	1380	489	119	44

5.2 ANALYSIS OF THE SURVEY RESULTS

Surveyed trips were aggregated by origin and destination and plotted on maps along with TNZ's vehicle flow data for state highways (known as telemetry sites) categorised for long and very long vehicles. It was concluded from the analysis that the surveyed trips were not a reasonably consistent proportion of the telemetry trips (long plus very long vehicles) at each telemetry point. The ratios of surveyed trips to telemetry trips varied from 5% to 171%. The survey appears to represent only a small proportion of total telemetry trips in the vicinity of the main urban areas, but a much larger proportion in the more rural areas.

This indicated that, if it were desired to select routes for evaluation on the basis of heavy vehicle volumes or tonnages, there were dangers in using the surveyed data alone as it represented a much smaller proportion of total heavy vehicle movements at some sites than at others.

However use of the telemetry data on its own was also considered to be not very helpful, as it included many shorter-distance trips in the vicinity of the major urban centres. The best compromise was to use both sets of data together, with application of suitable judgement.

Appendices 2 and 3 show the surveyed daily net tonnages for New Zealand's two main islands.

The questionnaire also asked respondents to indicate whether they saw an advantage to their operation if the legal axle limit were to be raised. This question was analysed for each route by each respondent, and by whether the route was on state highways or local authority roads. The result is shown in Table 2.

Table 2. Interest in increased axle limit

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

The overall response showed a perceived advantage from increasing axle limits in 57% of the cases. However for local roads, less than half the routes identified were seen as benefiting from heavier axle limits

5.3 SELECTION OF A PILOT ROUTE

Selection of a pilot route took into account both vehicle volumes, as determined from the survey and analysis of telemetry data, and the nature of the expected traffic flows. Table 3 overleaf ranks the candidate routes by their heavy vehicle/freight tonnage flows over their whole length.

Heavy transport routes were expected to be of two main types (or combinations thereof):

(1) One-Way Export Route

This would be a one-way route out of New Zealand, probably using the left lane only and would probably be commodity related.

An example of such a route could be from Tokoroa (located in a major inland forestry area) to Port Tauranga.

(2) Depot to Depot Route

This would be 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 could be Auckland to Hamilton. The first route selected to be evaluated as a pilot route for developing the evaluation procedure was Tokoroa to Port Tauranga. Midway along the route there is an alternative to the main state highway route, involving local authority roads. The route is shown in Appendix 4.

This route was chosen because it has one of the highest heavy vehicle/freight tonnage flows, and the clear purpose

Table 3. Heavy traffic flows by route

Rank	Route	Telemetry Trips/Day (1)	Survey Tons/Trip (2)	Factored Survey Tons/Day (3)
1.	Auckland to Hamilton	686	22	15000-22300
2.	Tokoroa to Port Tauranga	311/458	24	7600-11900
3.	Murupara to Paengaroa	269/311	27	6800-8400
	then to Port Tauranga	-	30	12100-12600
4.	Kawerau to Paengaroa	253	26	6000-7200
	then to Port Tauranga	-	30	12100-12600
5.	Stratford to Hawera	339	23	6900-7800
6.	Hastings to Napier	-	21	5800-6700
7.	Christchurch to Timaru	349	22	4300-6100
8.	Taupo to Napier	163	26	4100-4500

Notes: (1) Individual telemetry traffic counting data (long and very long vehicles)
(2) Indicates the average payload weight
(3) Range of values: These tonnages have been obtained by factoring the survey results up to equal the same number of trips per day as the telemetry results

of presently being the major route from South Waikato to Port Tauranga for exports of timber (in particular), dairy and other agricultural produce.

5.4 EVALUATION METHODOLOGY

Evaluation of the pilot route was made using eight vehicle types, distinguished by axle configuration. Seven of these vehicles were selected as representing typical examples of potential configurations and are all built within current vehicle dimension limits. In addition a 27 metre A-train logging vehicle was tested to show the effect of varying the vehicle length. These vehicles are shown diagrammatically in Appendix 5.

The study evaluated the ability of the route to cope with these vehicles in terms of geometric constraints (curvature, width, grade, height) and vehicle weight constraints (bridges, pavement, traction on grades).

The pilot route was examined using TNZ's Highway Information Sheets and Pavement Management Strategy Studies. The Highway Information Sheets summarise geometric aspects, and the Pavement Management Strategy describes the future demand on the road and proposes actions to be taken to lessen route constraints.

The minimum turning circle for a series of lane widths was determined from analysis, for the B-train vehicle, and locations on the route determined at which the vehicle would cross into an adjacent lane while negotiating a curve.

To determine the effect of increasing the legal weight, bridges on the state highway sections of the pilot route were examined using the TNZ software HPERMIT. This software simulates the action of a nominated type of vehicle (axle configuration and axle weights) over all of the bridges on a route under overload conditions.

A new methodology was developed for using the HPERMIT output to examine the impacts of the truck types under normal conditions.

Information was obtained from a TNZ pavement structure and subgrade database. The database is far from complete, but estimates of pavement structure were able to be made for most of the road. Where data was available, this was translated into numbers of Equivalent Design Axles (EDAs), using the 1989 National Roads Board "State Highway Pavement Design and Rehabilitation Manual."

HPERMIT also gives an indication of the load demand on the pavement relative to its capacity, but HPERMIT pavement classification is considered of lesser accuracy than the methods used.

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

6. STAGE 1 OUTCOMES

There are some geometric constraints on the state highway route which were considered to require remedial work. However it should be noted that these constraints apply to currently legal vehicles.

The alternative local authority link was not evaluated for geometric constraints in detail but has sections which have poor sightlines and poor curvature both horizontally and vertically.

The pilot route contains pavements assessed as Grade A in the HPERMIT program,which are already being trafficked by heavy vehicles without any sign of distress. The maximum gross vehicle weights determined in Stage 1 do not imply significant increases in axle weights. Pavement strength is therefore not regarded as a constraint on the vehicle weights which are being considered.

The bridges on the state highway route can accept

Table 4. Comparison of capacities for different vehicle types on the pilot route

Vehicle	Vehicle Type	Current maximum legal gross vehicle weight (tonnes)	Potential maximum weights (tonnes)			Weight increase %
			Gross vehicle weight with current maximum legal axle weights	Potential axle weight maximum (1)	Gross at potential axle weight	
1	B-train 7 axle	44	51	8.3	55.7	25
2	B-train 8 Axsle	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 (2)	59	7.9	61.3	57

Notes: (1) Calculated on the assumption that all non-driving axles carry equal weight.
(2) This is not currently a legal length vehicle.

significant increases in the current legal gross vehicle weights for the vehicle types considered. This is because all the bridges are short span (except the Tauranga Harbour Bridge which is built to modern standards) and the vehicles chosen relatively long. These results are shown in Table 4 above.

The table compares the route capacity (most restraining bridge) for each vehicle, with the current legal weight limits. The capacity increases for the constraining bridge range from 12% to 25% for the seven legal length vehicle types considered.

Many of these capacities can be achieved without increasing the legal axle weight limits, however, for some vehicles these increases would require increases in legal axle weights of up to 20%.

The overlength A-Train vehicle records the highest route capacity because it is spread over a greater length.

The constraining bridge (Hamlins Overbridge) can be bypassed using the alternative local roads. There are four bridges on this link, but the bridge constraints have not been evaluated in the same detail because they are not in HPERMIT.

7. CONCLUSIONS FROM STAGE 1

This first stage of the project has successfully evaluated the capacity of the pilot route, showing that the route has the capacity to accept vehicles which are significantly heavier than current legal weight limits.

At the conclusion of this evaluation TNZ decided that the methodology had been sufficiently tested, and that there was no need to examine in detail the outcomes for any of the other potential routes.

It was therefore decided to proceed to Stage 2 of the project. It is envisaged that the pilot route will be included in the Stage 2 study.

8. OBJECTIVE FOR STAGE 2

The objective is to investigate the possibilities of an increase in the statutory weight and dimension limits of heavy vehicles operating on public roads in New Zealand.

Economic costs and benefits are to be identified and quantified for various limits so that optimum limits can be determined.

Two cases are to be considered:

(1) all roads (ie existing legal limits would be increased)

(2) selected routes (ie a new legal limit would be created which would only apply to certain roads).

9. STAGE 2 GENERAL APPROACH

The original purpose of the second stage of the project was to evaluate the economic benefits of developing some heavy transport routes, based upon the results of the first stage. When embarking on Stage 2 TNZ recognised that there would be practical difficulties in reintroducing a roading hierarchy based on different weight limits. Hence the approach with Stage 2 will be to examine both the concept of designated heavy transport routes and an overall increase in legal weight limits applying to all roads.

In considering the applicability of raising limits on selected routes the evaluation will review a wider range of route types (eg heavily trafficked and lightly trafficked, farm pickup/delivery, intercity, logging), taking into account particular infrastructure characteristics on these routes.

Stage 2 is to broken down further into three phases occupying a period of 18 months.

9.1 PHASE 1

This is expected to take 6 months to complete. It will comprise preliminary economic feasibility studies of the costs and benefits of upgrading the whole road network to higher load limits, and for a range of typical heavy transport routes. It would include some preliminary consideration of safety and environmental impacts of higher weight limits. The objective is to identify potentially feasible scenarios for more detailed analysis in subsequent phases.

9.2 PHASE 2

This is envisaged to involve confirmation of the results of Stage 1 and extension of them to the whole existing state highway network, together with the assessment of the cost of upgrading the network and/or selected routes. A more detailed evaluation of safety and environmental issues would be included.

9.3 PHASE 3

This would involve further detailed economic analysis, and recommendations on appropriate weight and dimension limits for all roads and/or selected heavy transport routes.

10. METHODOLOGY FOR PHASE 1 OF STAGE 2

TNZ is currently finalising the brief for this first phase with the researcher. The tasks have been proposed as follows:

10.1 DEVELOPMENT OF PROPOSED LOAD LIMITS

A study will be carried out on a range of vehicle weight/dimensional relationships depending on commodity. These will be guided by the bridge analysis and by the consultation with operators so that practical and efficient vehicle configurations are chosen.

10.2 VEHICLE AND OPERATOR BENEFITS

An assessment will be made of the total costs and savings to the road transport industry of higher limits. A database will be produced of total tonnes-kilometres carried. The vehicle industry will be consulted about the likely new vehicle fleet which would be required in response to any new load limits. Utilisation of the new vehicles would be considered.

10.3 PAVEMENTS

Life cycle costs for pavement rehabilitation and reseals will be obtained for state highways and local roads. A relationship between repair cycle time and pavement wear from axle loading will be developed.

10.4 GEOMETRY

It is expected that for a number of commodities there will be no gains to be made without an increase in the length limit. The industry has in fact already signalled a desire for such an increase. Longer vehicles normally occupy a greater width of swept path on curves. As a result of this, lane widening will be required on certain curves. This will also depend on the terrain.

10.5 BRIDGES

All bridges on state highways and local roads will be assessed for the influence of the proposed new load vehicles on them. Sufficient evaluation will be carried out to give category ranges and assess the need or otherwise for strengthening work.

It is expected that the majority of strengthening work will relate either to decks (influenced by axle load) or to main beams (influenced by overall vehicle weight). It is possible some bridges may require strengthening of transverse members.

10.6 ECONOMIC ANALYSIS - ALL ROADS

Vehicle, road and bridge cost models will be combined to give an overall indicator of the economic feasibility of altering limits on all roads. This will be evaluated as a Benefit/Cost ratio and as a Net Present Value, using standard Transit New Zealand procedures.

10.7 ECONOMIC ANALYSIS - SELECTED ROUTES

An evaluation will be made of the cost components of the general case to determine influences and trends. Consideration will also be given to the requirements of particular commodity groups in defining transport routes. The evaluation will lead to the classification of particular route types into those which are most likely to be economic or likely to be uneconomic.

10.8 SENSITIVITY ANALYSIS

All parameters used in the analysis will be evaluated for overall effect on results, to determine which aspects require more detailed consideration in subsequent phases of the study and which aspects do not significantly affect the outcome.

10.9 SAFETY ISSUES

Safety issues will be identified and their significance commented on, including overtaking, stopping distances, and intersection design parameters.

ACKNOWLEDGEMENTS

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The use of extracts from the draft research report for Stage 1 and the draft brief for Stage 2 has been made with the kind permission of Travers Morgan (NZ) Limited and Works Consultancy Services Limited.

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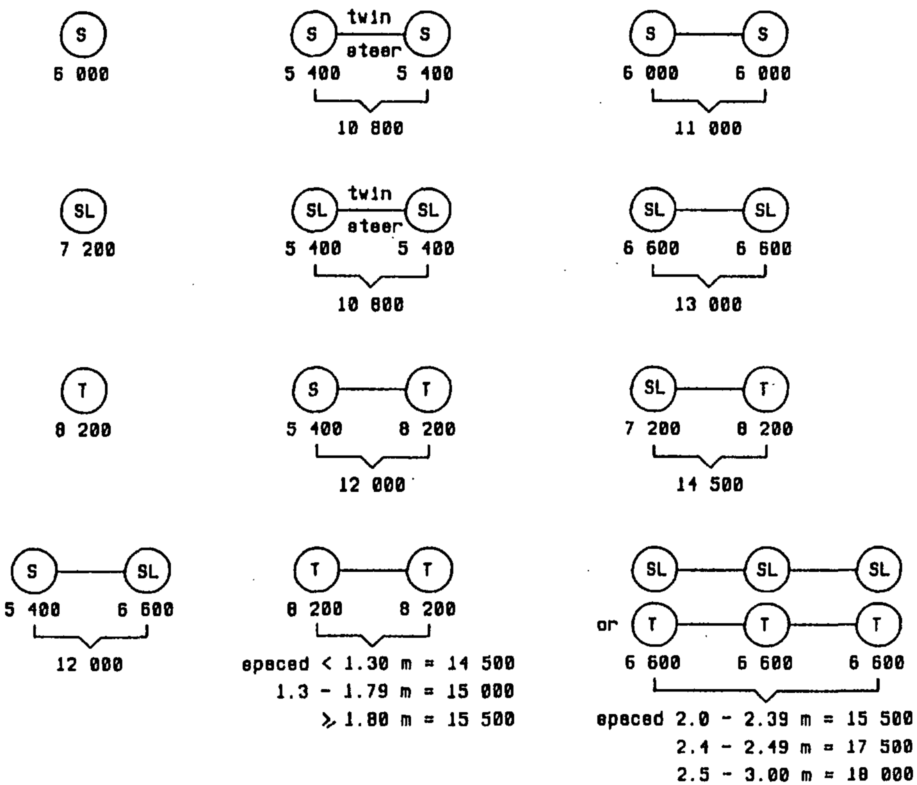
1. Sleath L and Edgar J. Weight regulations, overweight vehicle permit policy, and enforcement procedures in New Zealand. Third International Symposium on Heavy Vehicle Weights and Dimensions, Cambridge, 1992.
2. McMillan J. Heavy Transport Routes. Institute of Road Transport Engineers of New Zealand Fifth International Heavy Vehicle Seminar, Auckland 1992.
3. Travers Morgan (NZ) Limited. Heavy Transport Routes Stage I. Unpublished Transit New Zealand Report, 1994.

MAXIMUM VEHICLE AND AXLE WEIGHTS (Kilograms) — FEBRUARY 1989

AXLE SETS



WHEELS 1/2 axle limit plus 500 kg.

S .... Single standard tyred axle.

SL .... Single large tyred axle (tyres at least 330 mm (13 inch) width by 24 inch diameter or 355 mm (14 inch) width by 19.5 inch diameter)

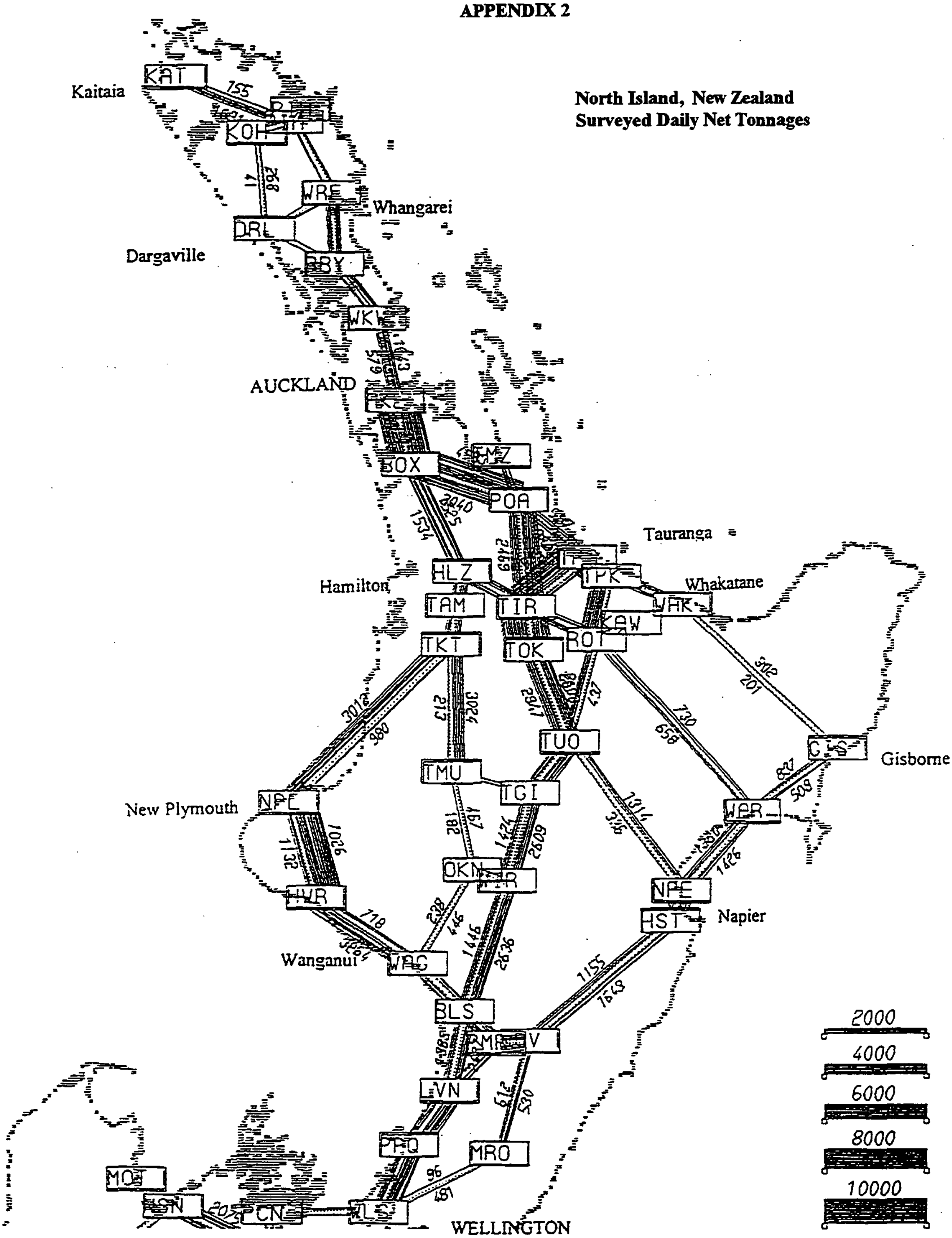
T .... Twin tyred axle.

Note: For weights on oscillating axles and other axle combinations not shown above, refer to the Heavy Motor Vehicle Regulations 1974, Amendment No.5.

Distance from 1st to last axle of any vehicle or combination.

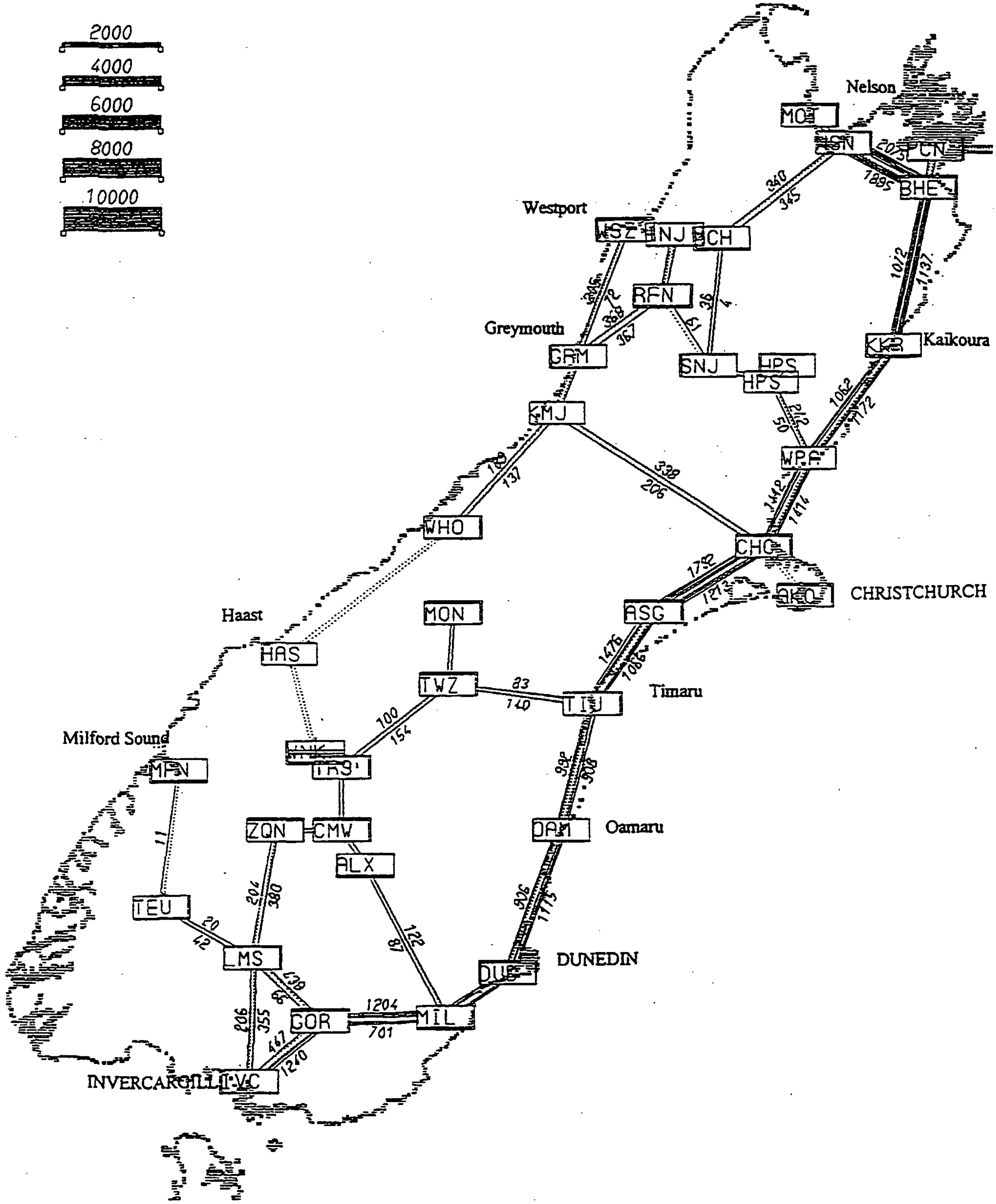
2.5 m or more	17 500 kg	
3.0 m or more	19 000 kg	
3.3 m or more	20 000 kg	
3.6 m or more	21 000 kg	
4.0 m or more	22 000 kg	
4.4 m or more	23 000 kg	
4.7 m or more	24 000 kg	
5.1 m or more	25 000 kg	
5.4 m or more	26 000 kg	
5.8 m or more	27 000 kg	
6.4 m or more	28 000 kg	
7.0 m or more	29 000 kg	
7.6 m or more	30 000 kg	
8.2 m or more	31 000 kg	
8.8 m or more	32 000 kg	
9.4 m or more	33 000 kg	
10.0 m or more	34 000 kg	
10.8 m or more	35 000 kg	
11.6 m or more	36 000 kg	
12.4 m or more	37 000 kg	
13.2 m or more	38 000 kg	
13.5 m or more	39 000 kg	
14.4 m or more	40 000 kg	Vehicles exceeding
14.8 m or more	41 000 kg	39 000 kg are subject
15.2 m or more	42 000 kg	to preconditions
15.6 m or more	43 000 kg	determined by the
16.0 m or more	44 000 kg	Secretary for Transport.

APPENDIX 2

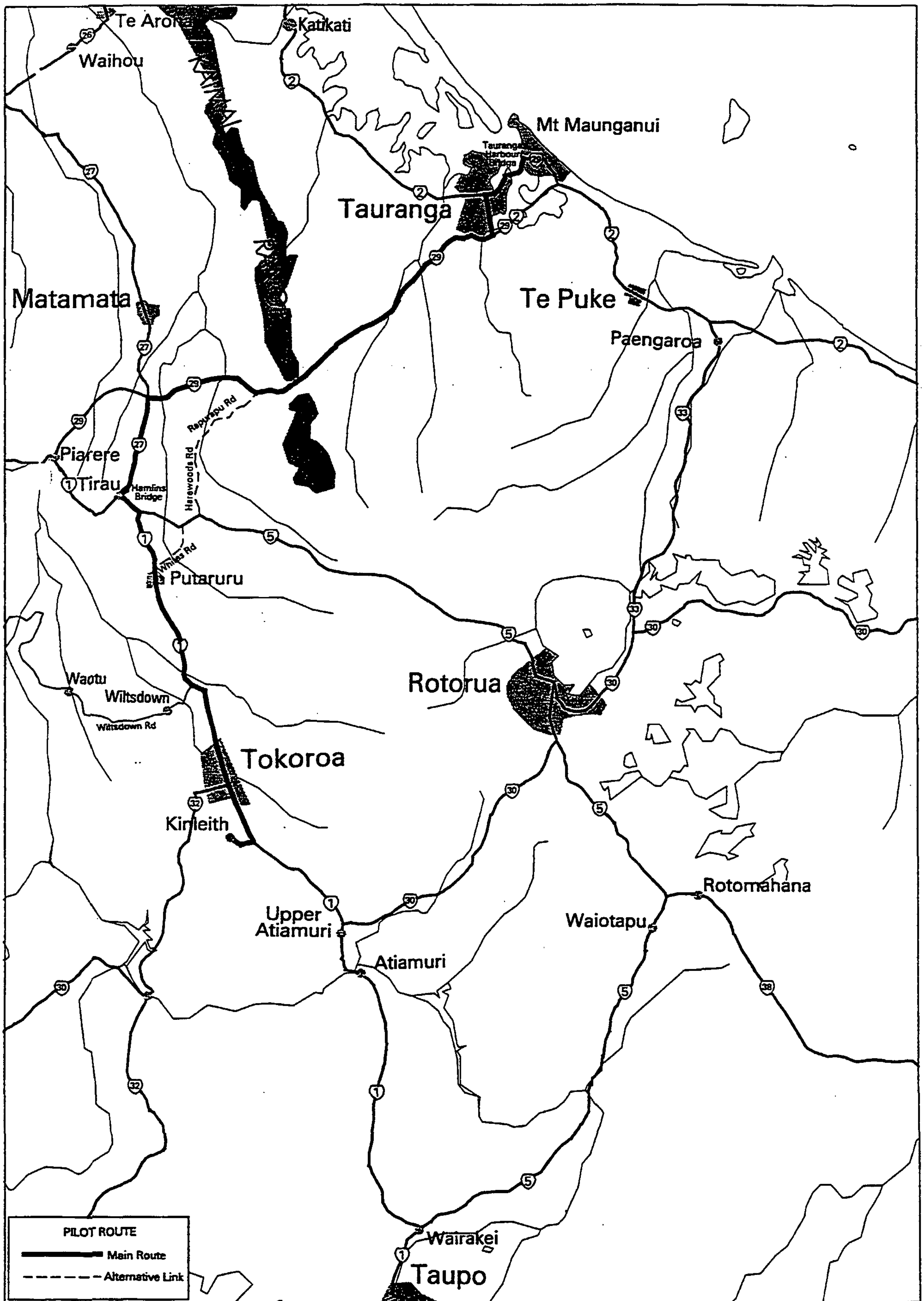

North Island, New Zealand
Surveyed Daily Net Tonnages
Kaitaia
Whangarei
Dargaville
AUCKLAND
Tauranga
Hamilton
Whakatane
Gisborne
New Plymouth
Napier
Wanganui
WELLINGTON
2000
4000
6000
8000
10000

APPENDIX 3

South Island, New Zealand
Surveyed Daily Net Tonnages



APPENDIX 4



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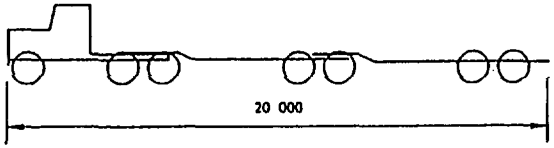
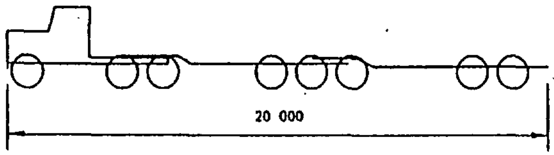
1. B-TRAIN (7 AXLE)



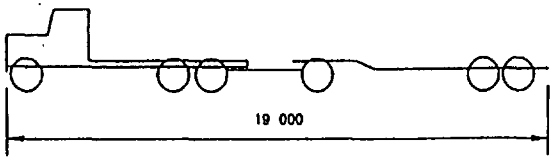
AXLE SPACING	0	3.5	5.0	10.0	11.5	16.5	18.0
AXLE TYPE	S	T	T	T	T	T	T

2. B-TRAIN (8 AXLE)



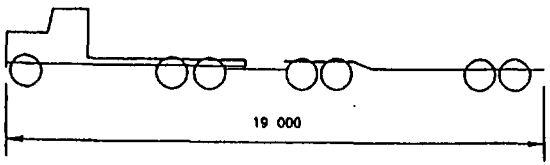
AXLE SPACING	0	3.5	5.0	9.0	10.5	12.0	16.5	18.0
AXLE TYPE	S	T	T	T	T	T	T	T

3. TRUCK (3 AXLE) & TRAILER (3 AXLE)



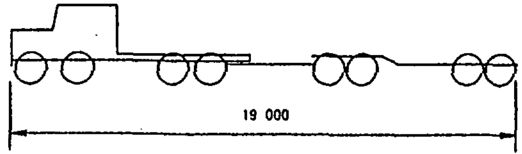
AXLE SPACING	0	5.4	6.8	10.7	16.9	18.2
AXLE TYPE	S	T	T	T	T	T

4. TRUCK (3 AXLE) & TRAILER (4 AXLE)



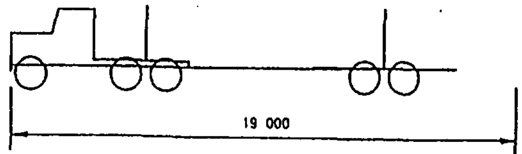
AXLE SPACING	0	5.4	6.8	10.2	11.5	16.9	18.2
AXLE TYPE	S	T	T	T	T	T	T

5. TRUCK (4 AXLE TWIN STEER) & TRAILER (4 AXLE)



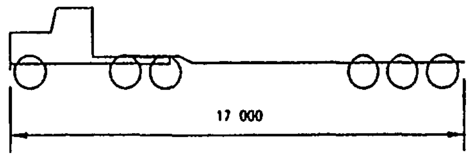
AXLE SPACING	0	1.7	5.25	6.65	11.15	12.4	16.4	17.65
AXLE TYPE	S	S	T	T	T	T	T	T

6. LOGGING JINKER



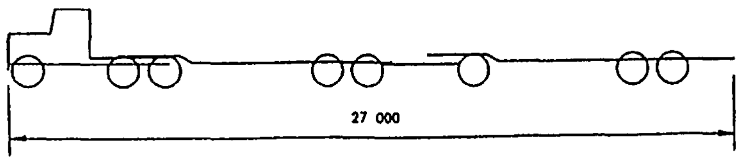
AXLE SPACING	0	3.5	5.0	12.5	14.0
AXLE TYPE	S	T	T	T	T

7. SINGLE ARTICULATED (6 AXLE)



AXLE SPACING	0	3.5	5.0	12.5	14.0	15.5
AXLE TYPE	S	T	T	T	T	T

8. A-TRAIN (8 AXLE)



AXLE SPACING	0	3.5	5.0	11.0	12.5	16.5	22.5	24.0
AXLE TYPE	S	T	T	T	T	T	T	T