NATIONAL TRAFFIC DATABASE

1. RESEARCH REPORT

WORKS CONSULTANCY SERVICES LTD,
Wellington, New Zealand

Transit New Zealand Research Report No. 54A

ISBN 0-478-10511-8
ISSN 1170-9405

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

Works Consultancy Services Ltd. 1996. National Traffic Database.
1. Research Report. *Transit New Zealand Research Report No. 54A.* 97pp.

Keywords: database, national, National Traffic Database, New Zealand, quality plan, planning, roads, road use, traffic, traffic flow, traffic volume, vehicles, vehicle class, vehicle weight, weight

AN IMPORTANT NOTE FOR THE READER

CONTENTS

GLOSSARY & ABBREVIATIONS

AADT	Annual Average Daily Traffic volume on a road section, generally the result of an estimate, and sometimes the result of an actual count using tube counters.
ADT	Average Daily Traffic volume on a road section, a measure that is not based on a year of data.
ARRB	Australian Road Research Board, now operating as ARRB Transport Research Ltd.
AASHTO	American Association of State Highway and Transportation Officials.
ARCHER	A type of portable traffic counter, giving data which enable distinction between vehicle classes.
ASCII	The American Standard Character set: numbers and characters which are able to be read on a computer screen using standard DOS commands, and are not dependent on software for translation.
AUSTROADS	Association of Road Transport and Traffic Authorities in Australasia, the successor to NAASRA.
CBD	Central Business District.
CVIU	Commercial Vehicle Investigation Unit of the New Zealand Police, who are tasked with enforcement of heavy vehicle standards and laden weights.
DKW	A system of vehicle classification, based on the AUSTROADS system, and modified by DK Wanty, Transit New Zealand, to accommodate the New Zealand vehicle fleet.
EDA	Equivalent Design Axle: this is an axle carrying 8.2 tonnes on two sets of dual tyres.
ESAL	Equivalent Standard Axle: this is an axle carrying 8.2 tonnes on two sets of dual tyres, but of slightly different wheel spacings and tyre-road contact area than an Equivalent Design Axle.
Field Name	Name used for a field in the database tables, designated by italics using an initial capital, e.g. *Dkw_c* identifies DKW Class.
GIS	Geographical Information System.
HVADT	Heavy Vehicle Average Daily Traffic.
LTSA	Land Transport Safety Authority: the authority responsible for vehicle and road user safety in New Zealand.
NAASRA	National Association of Australian State Roads Authorities (now operating as AUSTROADS).
NTDB	National Traffic Database: a collection of data about traffic flows and vehicles using New Zealand roads. It contains selected fields from a Working Spreadsheet, plus the statistically averaged estimates of vehicle classification and vehicle weight distribution.

PAT	A system of measuring and classifying vehicles, based on axle spacings. (From its manufacturer's name, Pietzsch Automatisierungstechnik.)
PAT DAW	Weigh-in-motion instruments used on some state highways in New Zealand to weigh and classify vehicles. (PAT - see above, DAW from its trade name, Dynamische Achslastwaage.)
RAMM	Road Assessment and Maintenance Management System: the computer-based databases of road sections and conditions, developed and maintained by each RCA.
RCA	Road Controlling Authority, which is Transit New Zealand in the case of state highways, and a Territorial Authority in the case of local roads.
Roadgroup	The grouping of roads corresponding to those determined and published in "Traffic Count Guideline" (Transit New Zealand 1994).
Road section	A length of public road identified by its location that is described in each line of the RAMM database.
Road use category	A classification system for identifying the main use of a road section. Description is based on the daily pattern of traffic volumes using the road.
RUC	Road User Charge: the system of charges made by the Ministry of Transport on all heavy vehicles using the New Zealand road network. It depends on their axle configuration and the total weight, as well as distance travelled.
TA	Territorial Authority: the body given jurisdiction over local roads in respective territorial districts.
TNZ	Transit New Zealand: the body given jurisdiction over state highways in New Zealand.
VDAS	A type of portable traffic counter, giving data which enable distinction between vehicle classes.
VKT	Vehicle kilometres travelled.
VMT	Vehicle miles travelled.
WCSL	Works Consultancy Services Ltd, New Zealand: consultant undertaking the research for this report.
WIM	A system for Weigh-In-Motion of vehicles - the weight of each vehicle passing at highway speeds over the WIM detector is estimated and recorded. Data from three permanent WIM sites in New Zealand (at Drury, Pukerua Bay and Waipara) have been interrogated for the Database.
Working Spreadsheet	The LOTUS spreadsheet developed for each RCA, consisting of an expansion of the RAMM descriptive inventory and vehicle volume tables. The Working Spreadsheet contains basic classification survey information on a site by site basis, as well as the factors used to improve the ADT values.

EXECUTIVE SUMMARY

1. The National Traffic Database

The National Traffic Database (NTDB) is a system for storing traffic data, including traffic volume, vehicle class and vehicle weight, collected from each of approximately 120,000 sections of public roads (i.e. the state highway and local road network) in New Zealand. It incorporates data collected by each Road Controlling Authority (RCA), i.e. by Transit New Zealand (TNZ) Regional Offices for state highways and by each Territorial Authority (TA) for local roads. The road sections are the divisions of the network used as basic units for the inventories held in the RAMM (Road Assessment and Maintenance Management system) database by each RCA.

As far as can be ascertained from international literature, such a compilation of traffic data has not been made elsewhere in the world.

2. Objective of Project

This project, begun in 1994, has the objective of establishing a database recording where travel is occurring on New Zealand public roads, measured in terms of Annual Average Daily Traffic (AADT), traffic composition and weights of heavy vehicles required to pay Road User Charges (RUC).

3. Structure of Project

The project is reported in three parts:

- National Traffic Database. Content and Operation of Database:
Transit New Zealand Research Report No.53,
- National Traffic Database. 1. Research Report:
Transit New Zealand Research Report No. 54A,
- National traffic Database. 2. Quality Plan:
Transit New Zealand Research Report No. 54B.

This report, *1. Research Report,* describes the execution of the project in full, including the basis for sampling and the precision of the estimates prepared from the NTDB.

The NTDB was developed by bringing traffic count data to a common base of AADT as at June 1994 for every road section. Distributions of heavy vehicle classes associated with each road use category (a description of the main function[1] of the road section) were obtained from field surveys. Vehicle weight distributions for heavy vehicle classes were obtained from field surveys and from weigh-in-motion (WIM) data.

---

1 For example *urban residential, rural arterial*, etc.

A Pilot Study (Stage 1 of this project) was carried out in Regions 5 and 6 (Gisborne and Hawke's Bay) to test the proposed methodology. This task was completed in September 1994, and then the Quality Plan was refined.

The Quality Plan details the actions needed by all parties involved in assembling the NTDB, and is an extension of the methodology produced for the Pilot Study for applying to the remainder of the public road network.

Working Spreadsheets were developed from selected fields of the RAMM database held by each RCA. Assembly of this information and its subsequent enhancement involved the co-operation of 73 TAs and 7 TNZ Regional Offices. The compilation has highlighted a lack of inventory information in some TAs, particularly that about unsealed roads. In order to obtain a nationally complete database, data for some of these sections have been estimated and judgment has been exercised.

4. Structure of the National Traffic Database

The NTDB consists of three data files in DBase format:

- *Road section data (NTDB.DBF),* which are the data on each road section, including length, road use category, and AADT.

- *Vehicle classification distribution data (VEHPROP.DBF),* which describe the proportions of AADT in each of 15 classes of light or heavy vehicles. (Currently a separate distribution is made for each road use category.)

- *Vehicle weight distribution data (WGTDIST.DBF),* which describe the vehicle weight distribution for each vehicle class to assist in generating synthetic vehicle weight data. (Distributions depend not only on the particular vehicle class, but also on the road use category, and RCA.)

The availability of the NTDB will lead to

- Accurate information on vehicle volume demand on all RAMM road sections at a common period in time (currently June 1994),

- An estimate of vehicle kilometres and heavy vehicle kilometres for road use categories within RCAs,

- The basic information needed for making comparison of average ESALs (Equivalent Design Axle) per year between RCAs at a network level or at road use category level.

The following table summarises operations that are possible to obtain from the NTDB, as well as the recommended levels for the operations.

While summary information can be calculated reliably when several road sections are aggregated, the lack of precision of estimate of heavy vehicle distribution at present does not permit meaningful conclusions to be drawn when only a few road sections are involved in the calculation.

Estimates that can be obtained from the NTDB, and recommended levels of operation.

Estimate of daily/yearly total for:	Recommended levels of operation*
Vehicle kilometres travelled	N, R, TA
Tonne-kilometres travelled	N, R, TA
Vehicle kilometres by vehicle class	N, R, TA
Tonne-kilometres by vehicle class	N, R, TA
Vehicle kilometres by road use category	N, R, TA
Tonne-kilometres by road use category	N, R
Vehicle kilometres by vehicle class by road use category	N, R
Tonne-kilometres by vehicle class by road use category	N, R

* N = National level, R = Regional level, TA = Territorial Authority level

5. Vehicle Classification System, Road Use Category, Vehicle Weight Distribution

The *vehicle classification system* used in this project was developed by TNZ (by DK Wanty). It is called the DKW system and is an adaptation of the AUSTROADS system. It divides the vehicle fleet into 15 classes, of which 12 are heavy vehicles.

Road use categories, used for classifying the road sections, have been derived from a separate Transit New Zealand Research Project PR3-0025 (in prep.). The distribution of vehicle classes obtained from field classification surveys differs between the nine road use categories.

An estimate of *distribution of weight* for each class of heavy vehicle was made using data from three WIM sites (Drury, Pukerua Bay, Waipara), as well as from specially designed field surveys executed by the Police Commercial Vehicle Investigation Unit (CVIU).

6. Verification of the National Traffic Database

The integrity of the NTDB was checked by computing values and comparing outputs with independent sources. The following table lists items chosen for comparison between predictions obtained from the NTDB and from independent data.

Comparison of predictions obtained from the NTDB and from independent data.

Item compared	Precision of prediction calculated from NTDB compared with independent data
Petrol consumption	91% of sales for domestic transport and resellers
Diesel consumption	59% to 102% of sales, depending on amounts sold to public transport by domestic transport and resellers
Heavy vehicle kilometres travelled	60% of distance of RUC licences purchased
Heavy vehicle tonne-kilometres	79% of result recorded in independent database
Road User Charges	57% of annual national revenue

7. Improvements and Maintenance of the National Traffic Database

Because of budget and time constraints, surveys were carried out at only five of the randomly selected forty[2] sites in each RCA. Currently, the NTDB can nevertheless be used to generate meaningful comparisons between road use categories on a national basis or between RCAs. To improve the accuracy and usefulness of the NTDB, the additional classification surveys that have already been designed need to be completed. The improved NTDB could then be used to provide meaningful comparisons between smaller aggregations of road sections.

In the longer term, an ongoing programme of importing current RAMM data, including vehicle volume information to replace superseded information, as well as a programme of vehicle classification and vehicle weight surveys, should be implemented to maintain the currency of the NTDB.

8. Summary

The National Traffic Database is able to provide estimates of basic traffic information, including total volume, vehicle class and weight data, for the network of public roads in New Zealand, both state highways and local roads.

The methodology which has been developed and applied has produced a NTDB that includes for each RAMM road section:

- The best available estimate of AADT,
- Categorisation of each road section by use,
- A distribution of heavy vehicle classes (by DKW system) as a proportion of AADT for each road use category,
- Distribution of heavy vehicle gross weight by road use category and by geographic locality.

2 The exact number of selected sites necessary to achieve the target level of precision varied between RCAs, depending on the distribution of AADT between road sections, but was around forty in general.

Arising from this methodology is the basis for systematic upgrade of the NTDB, including:

- A pre-defined sampling plan (by RCA),
- Estimates of reliability of the data.

From the NTDB, estimates can be made for daily, yearly totals and average values for

- Total and heavy vehicle volumes,
- Total and heavy vehicle kilometres,
- Tonne-kilometres,
- ESAL-kilometres,
- RUC revenue,

at national and regional levels. Further subdivision of some of these outputs is possible at an RCA level, as well as by vehicle class and road use category.

The NTDB has internal consistency of measurements on a nationwide basis for traffic volumes. A prepared programme of vehicle classification surveys needs to be completed to improve the precision of the estimate of distribution of heavy vehicles. Regular updating of the NTDB is also required to ensure that it reflects changes in road networks, and changes in the nature of traffic, such as in vehicle classes, weights, and travelled road sections.

ABSTRACT

The National Traffic Database (NTDB) is a system for storing traffic data on each of approximately 120,000 sections of the New Zealand public road network (state highways and local roads). It incorporates data collected by each Road Controlling Authority (RCA), i.e. by Transit New Zealand Regional Offices for state highways and by each Territorial Authority (TA) for local roads. The road sections are as defined in the RAMM (Road Assessment and Maintenance Management system) databases of each RCA.

It describes the relative traffic demand on New Zealand public roads, in terms of traffic volume (i.e. Annual Average Daily Traffic or AADT), traffic composition by vehicle class and by vehicle weight. Such a compilation of these data does not appear to have been made elsewhere in the world.

The availability of a National Traffic Database will provide:

- accurate information on vehicular travel,
- comparative information for traffic demand both in terms of volume and of ESALs (Equivalent Standard Axles) between RCAs or between road use categories on an aggregated national basis.

To improve the accuracy and usefulness of the NTDB, the additional classification surveys that have already been designed need to be completed. In the longer term, an ongoing programme of vehicle classification surveys and vehicle weight surveys needs to be implemented.

At present, estimates by vehicle class at a national level have a precision of approximately ± 10%, whereas at a TA level, estimates by vehicle class have a precision of the order of ± 30% to 40%. Estimates involving weight estimates are relatively less precise.

The project, begun in 1994, is reported in three parts:

- National Traffic Database, Content and Operation of Database:
Transit New Zealand Research Report No.53.

- National Traffic Database. 1. Research Report:
Transit New Zealand Research Report No. 54A (this report).
It describes the execution of the project in full, including the basis for sampling and the precision of the estimates prepared from the NTDB.

- National Traffic Database. 2. Quality Plan:
Transit New Zealand Research Report No. 54B.

1. DESCRIPTION OF NATIONAL TRAFFIC DATABASE

The National Traffic Database (or NTDB) is a compilation of data collected from approximately 120,000 road sections of the New Zealand public road network (state highways and local roads). Road sections are divisions of the network used as basic units for the inventories in the RAMM databases held by each RCA (i.e. by TNZ Regional Offices for state highways and by each Territorial Authority (TA) for local roads). The NTDB contains three files of data.

The first and largest file contains data on road sections exported from the RAMM databases held by the RCAs. The road sections are described in terms of length, traffic volume as at June 1994, type of road use, and whether sealed or unsealed, urban or rural.

A second file contains an estimate of the distribution of traffic volume between 15 classes of vehicle (including 12 classes of heavy vehicle) for 11 different road use categories.

The third file provides an estimate of the distribution of weight in each of the heavy vehicle classes, depending on RCA as well as road use category.

The overall objective of the National Traffic Database project, begun in 1994, is:

> *to establish a database recording where travel is occurring on New Zealand public roads, measured in terms of annual average daily traffic (AADT), traffic composition and weights of Road User Charge (RUC) vehicles.*

The project is reported in three parts.

- National Traffic Database. Content and Operation of Database: Transit New Zealand Research Report No. 53.

- National Traffic Database. 1. Research Report: Transit New Zealand Research Report No. 54A.

- National Traffic Database. 2. Quality Plan: Transit New Zealand Research Report No. 54B.

This part, *1. Research Report*, describes the execution of the project in full, including the basis for sampling and the precision of the estimates prepared from the NTDB. Instructions for execution of individual components of the project are given in a second part, *2. Quality Plan* (Transit New Zealand Research Report No. 54B).

2. TERMS USED IN ASSOCIATION WITH WORKING SPREADSHEETS

The following terms are additional to those included in the Glossary, and are field names used to describe fields used within the Working Spreadsheet. Field names are shown in italic type.

AADT:

The product of axle factor x day factor x week factor x ADT gives the best estimate of an AADT.

Add_adt:

The additional ADT information received, either from the TA or from *VDAS* surveys. (Hence *Add_method*, and *Add_date*. These fields are associated with their own *day factors*, and *week factors*.)

Axle factor:

This factor adjusts the ADT to account for the number of axles on a range of vehicle types, which is slightly greater than the figure of 2 assumed in calculating ADT. It is used with counts obtained from TA tube counting instruments.

Bin:

The "slot" or "group" into which a particular numerical value belongs. Used in this report to describe allocation of vehicles according to their DKW class.

Centreline kilometres:

The length of the road network in an RCA, measured in terms of the road centreline. *Lane kilometres* is an alternative form of measurement which is not used in this report, and is the total length of one lane width in the network. When a road is divided by a physical barrier (usually a motorway), the RAMM database measures road section lengths as though they were separate roads. The result is (normally) *twice* the *centreline kilometre* value.

Day factor:

Factor by which the sampled data are multiplied to account for the particular day of the week during which the survey was taken.

Dkw c_i:

The proportion of ADT in DKW classification "bin" i.

Neymann allocation:

A statistical process that is the optimum method for stratified sampling when the goal is to obtain a minimum variance estimate of a pre-specified goal function.

Stratification of data:

A process whereby data are grouped (or binned) within a set of ranges of values, e.g. according to whether a particular value lies between the ranges 10 and 50, 51 and 100, etc. for a low volume road say, but between 50 and 2000, 2001 and 5000, etc. for a high volume road.

Tla_class:

Additional classification information received from TAs. This information was used to refine, where appropriate, the road use category obtained from the RAMM database.

Vehicle classification:

A system for describing a vehicle[3], usually in terms of length and/or axle number/configuration. The processing of "binning" vehicles into appropriate classes is done using counting instruments consisting of pairs of counter tubes.

Week factor:

Factor by which the sampled data are multiplied to account for the particular week of the year during which the traffic survey was taken.

---

3 "Vehicle" excludes bicycles and the like, being confined to motorised units and unpowered towed units. A motorised and towed unit is classified as an entity, not as separate components.

3. OUTPUTS FROM THE NATIONAL TRAFFIC DATABASE PROJECT

The outputs described below include those from both the product (the NTDB) and the means for maintaining it. The overall aim of this project has been to provide

1. A complete national database of all current RAMM sealed road sections, and sections of all public unsealed roads, that contains:
   - The best available estimate of AADT,
   - Each road section classified by road use category,
   - A distribution of heavy vehicle classes (as a proportion of AADT) associated with each road section,
   - A distribution of the weights of heavy vehicles in each class associated with each road use category.

2. A systematic and efficient method for enhancing the precision of the resulting database. This method includes:
   - A pre-defined sampling plan for ongoing vehicle classification surveys for each TNZ region for state highways, and TA for other public roads,
   - Estimates of reliability of the data,
   - The means of enhancing the precision of the database through incremental improvement.

3. A database that can be used to estimate, for each RCA and aggregation of any greater area:
   - AADT (totals and average values),
   - Heavy vehicle AADT (totals and average by class),
   - Vehicle kilometres travelled (VKT) for each class of heavy vehicle and totals.

4. A database that can be used to assess the distribution of vehicle weights within each vehicle class.

5. Consistency of measurement on a nationwide basis for traffic volumes and vehicle classification distributions.

4. RELEVANT STUDIES

A review of both national and international literature that is available about traffic databases showed that no directly comparable databases have been assembled elsewhere in the world.

4.1 Traffic Supply and Demand

Gur and Hochermann (1989) observe that the most effective means for estimating the demand and supply of vehicles on road links is to estimate the average VMT change on all the counted links. They perceive two main uses for the data:

- On the "demand" side, the data provides information for the description of the amount of vehicular travel, including growth trends and distribution by road use category and location.

- From the "supply" side, estimates of volumes on specific road sections serve as a basis for maintenance planning, for measuring exposure (in accident analysis), and sometimes as input for detailed planning.

4.2 New Zealand Survey

A household survey undertaken in New Zealand between July 1989 and June 1990 (Ministry of Transport 1992) provided data to assist in the development and evaluation of educational programmes relating to road use and safety. It was not designed specifically to provide a measure of the total vehicle kilometres travelled in New Zealand. Although such an estimate was obtained from the survey, the report concludes that the value was too low.

4.3 Sampling Schemes

Design of a robust or well designed sampling scheme is fundamental to successful development of databases of the kind developed by this project. As Lee (1990) describes the issue:

> "The first step in data acquisition is deciding why, what, where, when and how much information is to be collected. For the information to be useful as data, it must contain a statistically valid sample of representative values drawn from an overall population of values, be recorded accurately in a convenient format, and be organised for easy access, transfer and presentation. Thus, sampling plans must be designed, and efficient, effective information-procurement and processing techniques must be utilised."

Levinson et al. (1979) describe the three main sources of statistical variation in the data as follows:

1. The variation in traffic volumes from one link to another: this is defined as the "spatial variation" among the population of traffic counts.

2. The variation in volumes on any given link resulting from day-to-day changes in traffic flow: this is the "temporal variation" in traffic counts.

3. The variation in the lengths of the links.

Ferlis and Bowman (1981) devised a sampling procedure that addressed three major sources of uncertainty in VMT measurements:

1. Spatial variability
2. Temporal variability, and
3. Measurement error.

They point out that the sampling efficiency is improved by "stratifying" the sample, that is by splitting the network into roads classified in terms of volume ranges.

4.4 AASHTO Guidelines for Data Gathering

At a more general level, AASHTO (1992) has established six basic principles for traffic data gathering programs within the context of their Guidelines:

"1. The Guidelines will move towards a common traffic monitoring practice.

2. The Guidelines will establish a phased program to achieve a common practice. This will include near-term minimum practices and future directions.

3. The Guidelines will be practical and capable of implementation.

4. What is practical in the Guidelines will be directed by the need to provide quality traffic data for decision making.

5. "Truth-in-data", which is the disclosure of practical limits and estimate of data variability, is central to their Guidelines to ensure appropriate data quality and use.

6. The Guidelines will present a dynamic approach to traffic data programs. Further development will be encouraged through the clarity and integrity of common practice."

4.5 NAASRA Approach

In Australia, NAASRA (1982) derived a method for estimating the number of VKT counting stations.

4.6 NTDB Approach

Within this NTDB study, the approach used is based on Cochran (1977), and is similar in principle to the NAASRA approach. However, whereas NAASRA consider only spatial variation, the NTDB study in New Zealand considers both spatial and temporal variation.

5. STAGES IN NATIONAL TRAFFIC DATABASE PROJECT

The NTDB project has been executed in three stages. Figure 5.1 summarises the flow of operations that were followed to develop it.

Stage 1: Prepare Quality Plan
Stage 1 consisted of the development of a Quality Plan that would be implemented during Stage 2. Stage 1 was completed in late May 1994.

Stage 2: Develop a Database for Selected Regions
Stage 2 consisted of the execution of a Pilot Study to test the methodology in Regions 5 and 6 (Gisborne and Hawke's Bay). Stage 2 commenced in May 1994 and was completed in early September 1994.

Predictions of the regional traffic database were compared with traffic records obtained from independent sources.

Stage 3: Refine Methodology and Extend Database
The objective of Stage 3 was to refine the methodology trialled in Stage 2, and to complete the database for the rest of New Zealand. Stage 3 was completed in two parts (3a and 3b) carried out consecutively.

Work was completed on Stage 3 in October 1994. Gathering data from RCAs was completed in late December 1994. By this time, field classification sampling at the rate of five road sections per RCA (a total of approximately 400 samples) was completed for all but 46 of the selected sites.

Stage 3(a) Produce Working Spreadsheets
1. Establish contact with RCAs.
2. Obtain digital copy of basic RAMM inventory and traffic volume information.
3. Design format of NTDB.
4. Execute trial survey of vehicle weights using the services of CVIU.

Stage 3(b) Execute Field Surveys and Complete NTDB

1. Expand the database to incorporate effects of traffic growth, axle factors, and day and week factor.
2. Execute vehicle classification survey, and an analysis of survey results.
3. Execute remainder of vehicle weight survey, and an analysis of survey results.
4. Confirm the database, by checking predictions against national traffic data.

Stage 4: Documentation and Reporting

Stage 4 consisted of producing the report, in three parts.

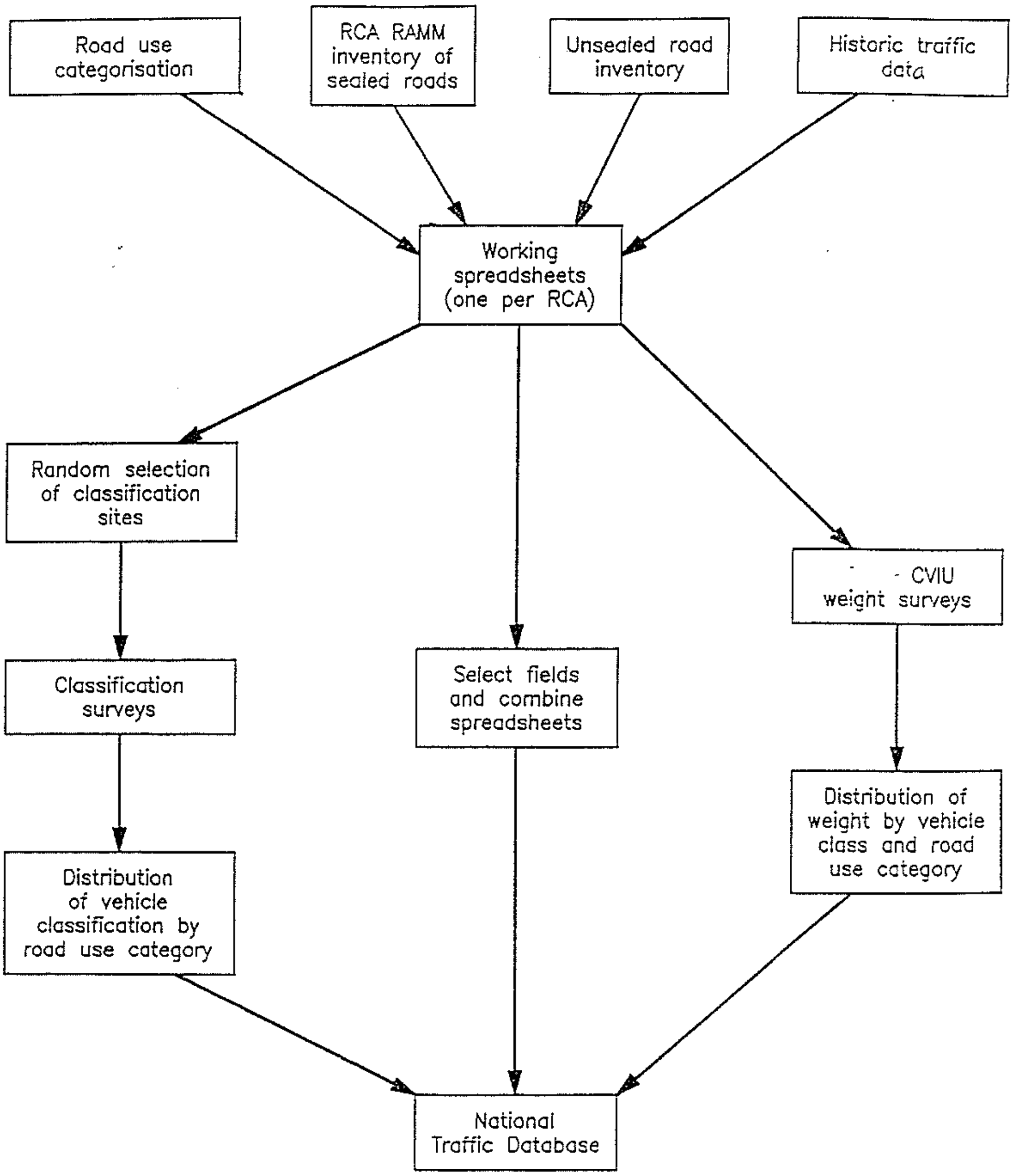


Figure 5.1 Flow of operations followed to develop the NTDB.

6. FORMATS OF WORKING SPREADSHEETS AND NATIONAL TRAFFIC DATABASE

6.1 Format of Working Spreadsheet

The formats of each field used in the Working Spreadsheet for adding data to the NTDB are listed in Table 6.1. Field names are in italic type.

Table 6.1 Fields used in Working Spreadsheet.

Col. no.	Field name	Description of field
a	*Road_ID*	Identifies road section
b	*Roadname*	Name of road
c	*TLA_Dist*	Number of Territorial Authority: 1 to 73[4]
d	*TNZ_Reg*	Number of Region: 1 to 14[4]
e	*Start_m*	Start position of section (metres)
f	*Finish_m*	Finish position of section (metres)
g	*Length*	Length of section - distance from start to finish (metres)
h	*From_desc*	Description of feature at start of section
i	*To_desc*	Description of feature at finish of section
j	*Location*	Name of road, location
k	*S/U*	Sealed (S) or unsealed (U)
l	*Maint_cat*	Maintenance category
m	*Hierarchy*	Description of road use
n	*U/R*	Urban (U) or rural (R)
o	*U/R_adj*	U/R corrected to reflect surrounding environment
p	*Other_usage*	Additional description of use, e.g. logging traffic
q	*Roaduse_cat*	See Section 10 for description of road use categories
r	*HCV%*	Percentage of heavy vehicles
s	*Adt*	Average daily traffic
t	*Dir*	Direction of count (L left, R right, B both directions)

4 See Appendices 3 and 4 for lists of numbers and names.

Col. no.	Field name	Description of field
u	*Count_Status*	Estimate or actual count
v	*Count_date*	Date of count
w	*Dur*	Duration of count
x	*Method*	Method of count
y	*Week_no*	Number of week
z	*Day_no*	Number of day in week
aa	*Week_factor*	Week factor for generating AADT
ab	*Day_factor*	Day factor for generating AADT
ac	*Axle_factor*	Factor to adjust tube counts for average number of vehicles
ad	*Growth_factor*	Factor to update all count data to present date
ae	*AADT_est*	AADT adjusted for day/week of actual count, or date of estimated count, and growth rate
af	*Add_adt*	Additional count information, not currently held within RAMM database
ag	*Add_date*	Date of additional count
ah	*Add_dur*	Duration of additional count
ai	*Add_method*	Method used to execute additional count
aj	*Add_week_no*	Week of year for additional count information
ak	*Add_day_no*	Day of month for additional count information
al	*Add_week_factor*	Factor used with additional count information
am	*Add_day_factor*	Factor used with additional count information
an	*Add_axle_factor*	Factor associated with additional count information
ao	*Add_growth_factor*	Factor associated with additional count information
ap	*Add_AADT_est*	Additional AADT, after adjustment for date of count and growth rate
aq	*AADT_best*	Value of AADT used for subsequent calculation
ar to bg	*Dkw_c1 to Dkw_c16*	Proportion of AADT in each of 16 DKW classes of vehicle type
bh	*Vkt_year*	Vehicle kilometres travelled for road section per year
bi	*Ruc$_year*	RUC revenue per road section

6.2 Format of National Traffic Database

The principal datum in the NTDB is one record for each RAMM road section. A description and the format of each field in a row in the NTDB are given in Table 6.2(a), and there are 123,953 rows. Fields used in the vehicle classification file and heavy vehicle weight distribution files in the NTDB are given in Tables 6.2(b) and (c) respectively. Field names are in italic type.

Table 6.2(a) Road section and vehicle volume file: fields used for the NTDB.

Field name	Description of field
NTDB	Number of the row
Tnz_region	Number of Region: 1 to 14
Tla_number	Number of Territorial Authority: 1 to 73
Road_id	Identifies road section
Start	Start position of section (metres)
Finish	Finish position of section (metres)
Length	Length of section - distance between start and finish (metres)
Roadname	Name of road
From_desc	Description of feature at start of section
To_desc	Description of feature at end of section
H_l	State Highway (H) or local road (l)
S_u	Sealed (S) or unsealed (u)
U_r	Urban (U) or rural (r)
U_r_adj	Urban or rural in terms of surrounding land use or environment
Oth_usage	Additional description of use, e.g. logging traffic
Roaduse	See Section 10 for description of road use categories
Count_meth	Whether Estimate, Tube Count, or Classification Count (*ARCHER* or *VDAS*)
Aadt	Value of AADT used for subsequent calculation

Table 6.2(b) Vehicle classification file: fields used for the NTDB.

Field name	Description of field
VEHPROP	Number of the row
Road_use	Road use category
Dkw_1 to Dkw_15 (15 fields)	Proportion of AADT in each of 15 (DKW) classes of vehicle.

Table 6.2(c) Heavy vehicle weight distribution file: fields used for the NTDB.

Field name	Description of field
WGTDIST	Number of the row
Set	Name attributing a set of weight distributions to particular road use categories and RCAs
Mean	Mean weight (in kg) for the particular weight stratum (DKW class, groups of RCAs and road use categories)
Std	Standard deviation (in kg) for the particular weight stratum (DKW class, groups of RCAs and road use categories)
5%ile to 95%ile (13 fields)	Average weight (in kg) for the percentage of vehicles less than the set 13 percentile points (5%, 10%, 20%, 25%, 30%, 40%, 50%, 60%, 70%, 75%, 80%, 90%, 95%)

7. COMPONENTS OF DATA

7.1 Data From RAMM Database

The Working Spreadsheet was developed from the RAMM databases kept by each RCA. The RAMM fields obtained were[5]:

- Road name,
- Road section start and finish position,
- Road start and finish description (for TA roads),
- Traffic count (ADT); whether estimate or actual count, and if a count the date of count and duration of count.

Central to this part of the project was the establishment of face to face contact with appropriate persons in each RCA.

The specific steps in the development were:

- Initial contact with RCA

The RCAs throughout New Zealand were contacted first by a letter from TNZ Head Office, Wellington. This letter explained the purpose of the survey, assured the RCAs of their access to the NTDB, and enlisted their co-operation.

- Follow up visit, and interview

Each RCA Road Network Manager was visited by an WCSL person from one of the 18 WCSL offices assigned to this project[6]. Two visits were anticipated, the first was to obtain the electronic data and other basic information using a questionnaire. The second was to complete the basic Working Spreadsheet from interviews, mainly to clarify road use category.

- Other measurement data

Other information, including historical traffic data and any vehicle weight information, was also sought from RCAs during the first interview.

7.2 Expansion of RAMM Database

Expanding the RAMM database included adding fields to the Working Spreadsheet to complete those already in the listing. The inventory of road sections was completed as a separate exercise where necessary.

---

5 Note that, although the RAMM database includes the inventory of sealed roads, the unsealed component of the network was sometimes listed in a separate dataset, and in a less controlled format.

6 Details of assignment are given in part 2, Quality Plan, Transit New Zealand Research Report No. 54B.

7.3 Generating AADT

The Working Spreadsheets were developed, one Spreadsheet per RCA, using the road section inventory and traffic volume information from the imported RAMM data as the base. The RAMM information was expanded using the following sequence:

1. The appropriate road use categories were established on the basis of RAMM and other RCA supplied information.

2. As a separate exercise, the vehicle classification data obtained from field surveys[7] were analysed for each road use category, and the proportion of AADT in each of the DKW vehicle classes was estimated.

3. Each road section associated with only an estimate of traffic volume was allocated vehicle proportions appropriate to its road use category.

4. Where a tube site was counted by the RCA, the axle factor was applied to provide a better estimate of number of vehicles. The appropriate week factor and day factor were then applied.

5. Where "exact" traffic count data are available (e.g. from TNZ telemetry), actual AADT was used (i.e. no adjustment factors were applied). Proportions were applied on the basis of the road use category to which the site is best allocated.

6. In the case of TNZ or *VDAS* sites surveyed apart from this project (counted over one week), a conversion matrix[8] was used to convert the data summarised in NAASRA bins to DKW classes. In the case of one week counts, actual observed proportions were used in the database. Only a week factor is applicable in this case for conversion to ADT for the site.

7. At WCSL sampled sites, actual traffic volumes were used in the database, multiplied by the appropriate week factors and day factors. However, individual vehicle distributions were not assigned to the sites from which they were measured. This is because sampling taken from a site for one day is inherently unstable as a means of estimating heavy vehicle AADT or proportions. Consequently, the vehicle proportions obtained from averaging output from sites of the same road use category were attributed to all of that category of measured sites.

8. From historical traffic count information, growth rates were calculated, and the estimates of ADT were thus updated to June 1994.

---

7 Using *VDAS* classifier instruments.

8 See Section 14, Processing Vehicle Classification Data, in this part 1 of the report, for description of the conversion matrix to convert NAASRA to DKW classes.

7.4 Vehicle Classification Surveys

A special set of surveys was commissioned within each RCA area to gather information on distribution of vehicle classes[9] (cars and types of heavy vehicles), as a proportion of ADT[10]. Analysis of these data led to a national distribution of vehicle classes for the nine road use categories.

7.5 Vehicle Weight Data Surveys

Information on the distribution of vehicle weights within DKW classes was obtained from the WIM sites at Drury, Pukerua Bay and Waipara.

The CVIU agreed to gather other weight information for roads of road use categories that were not covered by the WIM sites. The brief for this work is contained in part 2, Quality Plan (Transit New Zealand Research Report No. 54B). Results for a particular class of vehicle were compared between areas and road use categories[11], as well as with the WIM data. The mean values were tested for significant statistical difference. Groups were combined where the difference was not significant.

---

9 DKW classes (see Section 11, Vehicle Classification Systems, in this part 1 of the report).

10 Note that the procedure used for selecting sites during the Pilot Study (Stage 2, in Regions 5 and 6) was modified and extended for Stage 3. Random sites in Regions 5 and 6 and for all remaining RCAs were determined for the remaining surveys. Their locations are described in part 2, Quality Plan, Transit New Zealand Research Report No. 54B.

11 See Section 10, Road Use Categories, in this part 1 of the report.

8. ROAD LENGTH INFORMATION

8.1 Comparison of NTDB with Published Tables[12]

The primary source of road section length information is the RAMM database. This was essentially complete for the sealed part of the New Zealand road network, although not up to date for a few TAs. An interim inventory for one TA (Taupo) was completed as part of this project, using the maps supplied by that TA.

The unsealed component of the network was sometimes entered in RAMM but more often resided in a separate database. In some cases, it existed only as hard copy. Considerable effort was made to complete the inventory of road section lengths (and associated ADT), and to incorporate this information in the Working Spreadsheets.

Table 8.1 shows a comparison of the total road sections for each RCA for both sealed and unsealed components of local roads (Table 8.1a) and state highways (Table 8.1b). The column headings are explained as follows:

NTDB length: the summation of *"length"* field (in km) for sealed and unsealed components for each RCA in the NTDB.

Stats: the network length (km) in the published tables[12] for the year ending June 1994, except where more current information has been verbally advised by the RCA. In such cases, the name of the RCA is in bold font.

Difference: the result (in km) of subtracting the data in the published tables from the NTDB length.

8.2 Differences between NTDB and Published Tables[12]

The data from the published tables shown in Table 8.1 (Stats column) have been adjusted to include the lengths of both sides of divided roads (which are recorded as separate roads in RAMM and the NTDB). Comparison between the columns (NTDB length and Stats) is generally in good agreement.

Separate comment is made in the following paragraphs about those RCAs where the difference between the published tables and the NTDB is significant. Discussion between WCSL personnel and TA officers enabled some comment about differences in length with respect to TA databases and the published tables[13].

---

12 "Roading statistics for the year ending 30 June 1994", published by Transit New Zealand 1994.

13 The normal way to obtain data is from the RAMM databases, and maintenance of these is the responsibility of the individual RCAs. The basic information imported into the Working Spreadsheets in this project is also from the RAMM databases, and therefore should accord with the published tables.

Regions 11 and 13: (Canterbury and Otago)

The NTDB has been adjusted to reflect the change in the regional boundary which took place in 1994, and since the NTDB was first built. The boundary change resulted in 146 km of road changing from Region 11 to Region 13.

Kaipara DC: (TA 2)

The RAMM inventory has been compiled once only for the district, in 1994. There was some difficulty in completing input during this process. In addition, the records are thought to include some unmaintained roads which should not be there. The unmaintained roads have been imported from RAMM during construction of the NTDB.

Waikato DC: (TA 18)

Recent seal extension work has not yet been recorded in the NTDB. This ongoing sealing work could lead to an error of around 40 km. Overall the discrepancy in total length between the published tables and the NTDB is very small.

Waitomo DC: (TA 20)

Many of the unsealed roads recorded in the published tables are no longer maintained, and hence are not present in their RAMM database nor in the NTDB. The June 1995 length values advised verbally are recorded in Table 8.1a (Stats column). These values show a reduction of nearly 300 km of unsealed road compared to those in the June 1994 published tables.

Gisborne DC: (TA 27)

The difference of 326 km between the unsealed length of road and the published tables is the result of erroneous records which were a hangover from the earlier county administration.

Wairoa DC: (TA 31)

This RCA is conscious of a number of roads missing or incorrect in their RAMM database. As a move towards making a firm assessment of inventory, the RCA is currently placing a physical marker at the end of each road that they maintain.

South Taranaki DC: (TA 33)

This RCA believes that its RAMM database is more accurate than the published tables. Both sealed and unsealed roads are included in their RAMM database. The data in Table 8.1a include information given verbally, and which supersede the published tables.

South Wairarapa DC: (TA 47)

The values recorded in the Stats column in Table 8.1a have been advised verbally. Comparison with the values received in 1994 indicates that, while the totals are very close, some of the roads shown as unsealed are in fact sealed.

Table 8.1a Comparison of road lengths in RAMM database with the published tables for local roads.

Local Roads	Sealed			Unsealed		
	NTDB length	Stats	Difference	NTDB length	Stats	Difference
1 Far North	511.420	518.80	-7	1994.106	1991.50	3
2 Kaipara	382.111	381.62	0	1215.357	1216.75	-1
3 Whangarei	748.615	730.22	18	967.518	980.50	-13
4 Auckland	1244.825	1273.11	-28	177.213	176.35	1
5 Franklin	1281.038	1244.50	37	351.405	327.11	24
6 Manukau	1039.692	1032.93	7	43.452	43.60	0
7 North Shore	584.735	580.26	4	18.776	19.99	-1
8 Papakura	251.984	253.51	-2	12.868	12.86	0
9 Rodney	714.524	708.33	6	947.958	952.56	-5
10 Waitakere	681.068	668.26	13	50.974	51.33	0
11 Hamilton	473.431	473.50	0	3.302	3.30	0
12 Hauraki	419.056	416.90	2	175.962	175.60	0
13 Matamata-Piako	912.776	914.71	-2	79.062	79.10	0
14 Otorohanga	385.039	384.50	1	436.229	431.94	4
15 South Waikato	498.504	484.38	14	43.577	13.80	30
16 Taupo	534.189	534.10	0	184.410	183.20	1
17 Thames-Coromandel	358.755	338.46	20	280.280	290.44	-10
18 Waikato	1008.486	1031.00	-23	687.879	666.62	21
19 Waipa	948.753	950.62	-2	128.965	129.23	0
20 Waitomo	318.066	318.75	-1	696.399	700.28	-4
21 Kawerau	38.110	40.30	-2	1.300	1.20	0
22 Opotiki	98.573	95.73	3	236.731	232.76	4
23 Rotorua	660.379	660.52	0	339.392	334.23	5
24 Tauranga	374.071	379.95	-6	4.108	3.94	0
25 West. Bay of Plenty	666.201	667.84	-2	356.235	345.93	10
26 Whakatane	542.358	542.50	0	288.752	288.80	0
27 Gisborne	639.115	624.00	15	1603.296	1603.10	0
28 Central Hawkes Bay	836.742	820.30	16	451.255	456.60	-5
29 Hastings	1079.514	1015.90	64	537.060	575.80	-39
30 Napier	335.808	328.80	7	0.643	1.20	-1
31 Wairoa	242.688	186.30	56	683.762	704.90	-21
32 New Plymouth	1046.957	1047.78	-1	215.506	218.83	-3
33 South Taranaki	1343.410	1342.93	0	274.710	275.07	0
34 Stratford	343.130	343.23	0	256.698	256.27	0
35 Horowhenua	475.694	478.34	-3	77.158	76.94	0
36 Manawatu	1023.925	1043.06	-19	415.525	368.32	47
37 Palmerston North	405.974	408.20	-2	33.376	34.00	-1
38 Rangitikei	739.547	761.61	-22	515.030	509.72	5
39 Ruapehu	436.442	439.88	-3	887.147	886.21	1
40 Tararua	1111.253	1119.30	-8	827.342	825.40	2
41 Wanganui	535.276	525.92	9	331.707	323.02	9
42 Carterton	271.913	266.90	5	167.040	171.90	-5
43 Kapiti Coast	325.141	326.18	-1	21.353	21.31	0
44 Hutt	471.482	468.25	3	0.000	0.00	0
45 Masterton	522.638	505.30	17	294.363	293.20	1
46 Porirua	206.896	211.77	-5	5.227	5.20	0
47 South Wairarapa	332.131	332.04	0	362.040	353.60	8
48 Upper Hutt	222.469	206.66	16	0.000	4.10	-4
49 Wellington	657.819	658.02	0	7.543	11.12	-4
51 Marlborough	735.652	731.91	4	776.063	772.56	4
52 Nelson	195.322	195.28	0	21.137	21.10	0
53 Tasman	731.938	731.94	0	852.702	851.20	2
50 Kaikoura	95.276	96.27	-1	101.761	104.47	-3
54 Ashburton	1474.684	1403.70	71	1223.145	1160.80	62
55 Banks Peninsula	330.183	329.80	0	336.673	325.90	11
56 Christchurch	1519.555	1506.45	13	26.241	27.47	-1
57 Hurunui	569.016	569.01	0	938.601	938.58	0
58 MacKenzie	135.715	125.10	11	551.008	522.70	28
59 Selwyn	1098.182	1015.36	83	1231.326	1228.32	3
60 Timaru	896.079	872.40	24	853.440	902.90	-49
61 Waimakariri	714.133	715.70	-2	704.419	698.83	6
62 Waimate	626.552	625.13	1	720.708	720.68	0
63 Buller	272.904	326.81	-54	343.433	288.49	55
64 Grey	344.316	344.32	0	374.716	375.03	0
65 Westland	343.127	350.90	-8	331.298	339.48	-8
66 Central Otago	388.274	380.82	7	1462.839	1462.21	1
67 Clutha	762.825	753.92	9	2266.454	2272.71	-6
68 Dunedin	956.906	956.60	0	790.139	790.19	0
69 Queenstown-Lakes	249.352	256.75	-7	450.222	452.72	-2
70 Waitaki	694.564	618.55	76	1110.688	1198.64	-88
71 Gore	350.157	350.13	0	568.431	568.51	0
72 Invercargill	448.970	449.12	0	144.824	140.34	4
73 Southland	1882.654	1885.50	-3	3023.210	3032.61	-9
TOTAL	45099.059	44677.423	421.636	36893.469	36825.133	68.336

Table 8.1b Comparison of road lengths in RAMM database with the published tables for state highways.

	State Highways					
	Sealed			Unsealed		
	NTDB length	Stats	Difference	NTDB length	Stats	Difference
1 Northland	683.681	676.34	7	10.462	0.00	10
2 Auckland	408.266	407.20	1	0.000	0.00	0
3 Waikato	1536.195	1527.70	8	24.114	0.00	24
4 Bay of Plenty	704.952	700.50	4	38.117	38.12	0
5 Gisborne	329.417	329.70	0	0.000	0.00	0
6 Hawkes Bay	445.547	441.90	4	20.949	20.95	0
7 Taranaki	411.804	387.00	25	17.855	17.86	0
8 Manawatu-Wanganui	916.453	916.40	0	11.667	0.00	12
9 Wellington	283.721	284.01	0	0.000	0.00	0
10 Nelson-Marlborough	637.112	636.90	0	0.000	0.00	0
11 Canterbury	1373.055	1390.17	-17	0.000	0.00	0
12 West Coast	874.242	873.38	1	0.000	0.00	0
13 Otago	1258.569	1261.64	-3	21.209	0.00	21
14 Southland	736.240	725.50	11	0.000	0.00	0
TOTAL	10599.254	10558.331	40.923	144.373	76.921	67.452

Note: Stats column is the Transit New Zealand Statistics adjusted for divided roads and RAMM length differences.

Tasman DC: (TA 53)

Inclusion of some, but not all, state highways in its RAMM database has resulted in an over-estimate in the published tables. These state highways were included in the published tables because the RCA maintains the adjacent footpaths. The data from the published tables have been adjusted in Table 8.1a to correct for this.

Ashburton DC: (TA 54)

This RCA believes that its data are an accurate record of all legal road sections within the district.

Hurunui DC: (TA 57)

This RCA acknowledges that there are discrepancies, especially about their unsealed roads. Their RAMM database is thought to be 3 years out of date, and is currently being re-measured. A recent GIS survey has indicated the presence of considerably more roads than was thought, but the extent of maintained public roads will be re-measured. The records in the published tables are also thought to be not reliable.

Timaru DC: (TA 60)

The lengths of sealed roads were derived from an updated RAMM database and were considered to be more accurate than the published tables. The unsealed roads were derived from a road grading database which is considered by the RCA to be reasonably accurate. Some of the discrepancy with the published tables may have arisen because a few unsealed roads are no longer maintained by the RCA.

Buller DC: (TA 63)

Some roads recorded as unsealed have been sealed and this causes the discrepancy between RAMM database and the published tables.

Grey DC: (TA 64)

The original RAMM data collection exercise (which took place about 1991) did not record all roads. This RCA is gradually correcting the situation. The total recorded length of unsealed roads is diminishing because some are private roads, and others are not maintained by this RCA.

Waitaki DC: (TA 70)

This RCA believes that its RAMM inventory is more reliable than the published tables. During the course of preparing data for the published tables, which was done manually, wrong assumptions about the location of end of seal had been made, resulting in an erroneous split.

8.3 Similarities between NTDB and Published Tables

Close agreement has been obtained at a national level between the published tables and the NTDB. Approximately 600 km of roads are unaccounted for in a total of over 90,000 km. However, at the level of individual RCA, significant discrepancies are seen in some cases.

These discrepancies will diminish as the RAMM databases are completed by TAs, and the published tables are adjusted accordingly. Some rural-based RCAs are still unsure of the total length of road which can be described as public road and therefore should be maintained by them. There is no absolute basis for comparison of the NTDB in such cases.

8.4 Accounting for Unrecorded Roads

"Surrogate roads", i.e. fictitious road sections, have been included in the NTDB in the following instances:

- Where the total sum of sealed plus unsealed roads in the NTDB, as received from a TA, is less than the published tables,

AND

- The TA has not provided up-to-date information for the data (even if they may question the reliability of the published tables.)

As a result, surrogate roads have been included for the RCAs which are underlined in Tables 8.1a and b.

Where TA numbers are shown in bold in Table 8.1a, then the data have been altered to accord with verbal up-to-date information received during telephone interviews with TA and WCSL officers.

9. VEHICLE VOLUME INFORMATION

9.1 State of Available Traffic Volume Information

The basic traffic volume information resides in the RAMM database, and is also normally in the form of an estimate, i.e. no actual count has been taken at that road section. In some cases, the most recent count or estimate was very old, even more than 10 years old. An effort was made to update this information from interviews with TA officers to obtain a current estimate. Such an estimate would provide a more reliable result than extrapolating an old figure using a calculated growth factor.

Several TAs, notably urban authorities, stored historical traffic data information in successive rows in the RAMM database, i.e. the road section was repeated several times to accommodate count information for respective years. During the process of creating the Working Spreadsheet, all but the row with the most recent count had to be erased. This was necessary to sum the total lengths of sealed and unsealed road from the Spreadsheet and to compare them with published information..

Many TAs had historical traffic information accumulated simply as a sheaf of papers. Because of limited resources available for TAs and from WCSL, as well as limited time, effort was confined to securing historical information that was representative for respective road use categories.

9.2 Determining Traffic Volume Growth

A Working Spreadsheet was prepared to ensure that operations personnel had only to enter data into a prepared LOTUS spreadsheet for a particular road section that had an historical record available. A macro would then calculate the traffic volume growth. The Spreadsheet was to be printed without saving, and then overwritten for subsequent road sections. A minimum of three years of data was required.

From this information, the most recent count or estimate was linearly extrapolated to obtain an estimate of ADT as at June 1994.

10. ROAD USE CATEGORIES

10.1 Definition and Purpose of Road Use Categories

An earlier Transit New Zealand Research Project PR3-0025 (in prep.) had identified ten possible road use groups, where each group displayed an identifiable pattern of use, across hours in a day and across days within a week, distinguishable from all other groups.

In addition to the traffic use patterns, the project also produced weekly factors which could be used to estimate the AADT for a measured site based on one full week of vehicle counts. For each of the groups, a set of fifty weekly factors was produced, one for each of the weeks 2 through to 51 of the year. Estimates of the 95% estimate range for each of the factors were also produced.

The advantage of such information is that sampling any given site, identified as belonging to one of the ten groups, could be limited to, at most, one full week. An estimate of AADT for the site could then be produced using the weekly data and the group factor for the appropriate week. Furthermore, an estimate of the precision of such an estimate is possible. The tables of factors are published in TNZ's "Traffic Count Guideline" (1994).

10.2 Establishing Road Use Categories

The nine appropriate road use categories that have been established for each road section using characteristics of physical environment and traffic volume patterns, are described in Table 10.1.

The designation of *Urban* or *Rural* was assigned to a road section by considering the surrounding environment, rather than simply by assuming the categorisation applied in the RAMM database (which often reflects the speed limit rather than the physical environment).

The traffic flow level was available from the RAMM database as ADT. However, the variation between peak and interpeak flows was estimated mainly from the local knowledge of TA officers, and/or from traffic volume records.

In general, TA officers annotated the description of each road section with the appropriate road use category, although the Working Spreadsheet was designed to take maximum advantage of the "default" categories for categories 4, 6 and 8. These were automatically assigned using macros following insertion of road use categories 1, 2, 3, 5, 7, 9 into each Spreadsheet.

Table 10.1 Definition of road use categories.

Road Use Category		Characteristics
1a	Urban arterial a	Urban road characterised by a 7-8 am and 5-6 pm peak traffic flow of about twice the interpeak low flow
1b	Urban arterial b	Urban road characterised by a 8-9 am and 4-5 pm peak traffic flow of about 1.5 times the interpeak low flow
2	Urban commercial	Urban road primarily in CBD
3	Urban industrial	Urban road that carries local industrial traffic
4	Urban other	Urban roads not otherwise described
5	Rural urban fringe	Road that is either rural or urban and has a high Sunday use and 7-8 am and 5-6 pm weekday peaks of about 1.5 times the interpeak low flow
6	Rural strategic	Rural roads not otherwise described
7a	Rural summer recreational	Rural road characterised by high traffic volumes - e.g. beach in summer
7b	Rural winter recreational	Rural road characterised by high traffic volumes - e.g. skifield in winter
8	Rural feeder	Rural road characterised by low traffic flows
9	Urban residential	Road within a residential area in a city / town

Note: Road use categories 8 and 9 were established for this project: they were not used in earlier stages of Transit New Zealand Research Project PR3-0025 (in prep.).

10.3 Precision of AADT Estimate From Actual Counts

The counts were assumed to be accurate for the site at the time they were made. Consequently, the precision of the adjusted ADT figures is primarily dependent on the precisions of the week factors and day factors (Transit New Zealand in prep.). For example, if the road section is from 1a or 1b (Urban Arterial), the (95%) precision of the week factor ranges between approximately ±3% and ±20%, with an average of ±5%. The day factors for that group have a (Monday-Thursday) likely error of approximately ±10%. Consequently, applying both a day factor and a week factor to a count has an overall likely error of around ±13%. The mathematical basis of this calculation is contained in unpublished material on file PR3-0129, held at TNZ Head Office, Wellington.

11. VEHICLE CLASSIFICATION SYSTEMS

11.1 Introduction

Classification systems are sets of definitions by which vehicle types, especially heavy vehicles, may be distinguished. In principle, the systems incorporate overall dimensions, numbers of axles, numbers and groupings of axles, separable vehicle units, or a combination of some of these measurements.

The optimal scheme for this project would be one that was able to be measured by portable classification equipment, and which gave a sufficiently precise description of each class of vehicle to reduce the range of possibility within each class.

The pros and cons of some existing systems are discussed in Sections 11.2 - 11.6, and the rationales behind these systems are presented.

11.2 NAASRA Classification Scheme

Developed in Australia, the NAASRA system of classification (Table 11.1) is determined for a particular vehicle by considering its

- Overall length
- Number of axles
- Axle configuration

Although the NAASRA system of classification is widely used by the state highway sector (via telemetry sites, as well as from portable classifiers), the system has several deficiencies:

- Many vehicles classified as trucks (e.g. NAASRA class 5) are in fact cars towing a trailer. Even a relatively small mis-classification on this basis could have substantial consequences. In particular, the proportion of heavy vehicles could be (proportionately) substantially over-estimated.

- When cars are travelling close together, the *VDAS* portable classifiers[14] may classify two cars as a four axle truck for assignment to a NAASRA bin. This appears to be more likely when the recorded speed of the vehicles is relatively low. This also leads to an undercount on the number of cars (not necessarily having a large impact on total numbers) but an overcount on the number of trucks. A significant bias in truck volumes can result.

- The "unknown" vehicles (NAASRA class 13) can be relatively high as a proportion of all heavy vehicles. Consequently some re-allocation is appropriate, especially for high volume sites with bi-directional surveys using *VDAS* classifiers.

---

[14] See Section 13, Obtaining Vehicle Classification Data, in this part 1 of the report for description of the *VDAS* portable vehicle classifier instrument.

Table 11.1 NAASRA vehicle classification system.

Class	Length (m)	No. of Axles	Typical Vehicle
1 (short)	0.0 to < 5.25	2	Car, light van, other short vehicle
2 (medium)		2	Two-axle short vehicle towing
3 (medium)		3	Truck, bus
4 (medium)	> 3.0 to ≤ 7.5	4	Tandem drive truck, single drive bus with tandem rear axle
5 (medium)		5	Twin steer truck, other medium vehicle
6 (long)		3	Two axle vehicle towing, articulated bus, articulated truck
7 (long)		4	Two axle vehicle towing, tandem drive truck towing, single drive tandem rear axle bus towing, twin steer truck towing, articulated truck
8 (long)		5	Two-axle vehicle towing, tandem drive truck towing, tandem rear axle bus towing, twin steer truck towing, articulated truck
9		6	Articulated truck, tandem drive truck towing, twin steer truck towing, articulated truck
10		7,8	Heavy truck trailer, other long vehicle
11		5, 6, 7, 8, 9, 10, 11	Heavy truck trailer
12		> 6	Truck and multiple trailers
13			All other

11.3 AUSTROADS Classification System

The AUSTROADS system for classifying vehicle types is described in Table 11.2. This system considers:

- Overall length of vehicle
- Axle number
- Axle configuration

However, additional considerations that are included are:

- Axle groups
- Spacing of the first three axles

Although more precise than the NAASRA system, the AUSTROADS classification does not distinguish well between buses and heavier trucks. In addition, some of the very long vehicles are not used on New Zealand roads.

Table 11.2 AUSTROADS vehicle classification system.

Level 1	Level 2		Level 3	AUSTROADS Classification	
Type **Length** (m) (indicative)	**No. of Axles**	**Axle Groups**	**Vehicle Type Description**	Class	Parameters
	LIGHT VEHICLES				
Short (Up to 5.5m)	2	1 or 2	Short Vehicle Sedan, Wagon, 4WD, Utility, Light Van, Bicycle, Motorcycle, etc.	1	sp(1) ≤ 3.2m and axles = 2
Medium (5.5 to 14.5m)	3,4 or 5	3	Short Vehicle Towing e.g. Trailer, Caravan, Boat, etc.	2	groups = 3, sp(1) ≥ 2.1m, sp(1) ≤ 3.2m sp(2) ≥1 2.1 and axles = 3,4 or 5
	HEAVY VEHICLES				
	2	2	Two Axle Truck or Bus	3	sp(1)>3.2m and axles = 2
	3	2	Three Axle Truck or Bus	4	axles = 3 and groups = 2
	>3	2	Four Axle Truck	5	axles = 3 and groups = 2
Long (11.5 to 19.0m)	3	3	Three Axle Articulated Vehicle Rigid vehicle and trailer, or 4 axle articulated vehicle	6	sp(1) > 3.2m, axles = 3 and groups = 3
	4	>2	Four Axle Articulated Vehicle Rigid vehicle and trailer, or 4 axle articulated vehicle	7	sp(2) < 2.1m or sp(1) < 2 2.1m or sp(1) > 3.2m axles = 4 and groups > 2
	5	>2	Five Axle Articulated Vehicle Rigid vehicle and trailer, or 5 axle articulated vehicle	8	axles = 6 and groups > 2; or axles > 6 and groups = 3
	6 >6	>2 3	Six Axle Articulated Vehicle Rigid vehicle and trailer, or 6 (or more) axle articulated vehicle	9	axles = 6 and groups > 2; or axles > 6 and groups = 3
Medium Combination Vehicle (17.5 to 36.5m)	>6	4	B Double B double, or Heavy truck and trailer	10	groups = 4 and axles > 6
	>6	5 or 6	Double Road Train Double road train, or Heavy truck and trailer	11	groups = 5 or groups = 6. and axles > 6
Long Combination Vehicle (33.0 to 53.5m)	>6	>6 >6	Triple Road Train Triple road train, or Heavy truck and three trailers	12	groups > 6 and axles > 6

Definitions:
axle group : number of axle groups where adjacent axles are less than 2.1m apart
axles : number of axles on the vehicle (maximum axle spacing of 10.0m)
sp(1) : distance between first and second axles of the vehicle
sp(2) : distance between second and third axles of the vehicle

11.4 Road User Charge Vehicle Classification System

The definition[15] of RUC vehicles (Table 11.3) divides the vehicles into powered units and unpowered units. Within these groups, distinction between the axle spacings is neither rigorous, nor consistent. For example, vehicle type 6 is a powered vehicle with three axles, including two twin tyred sets. These may or may not be closely spaced. On the other hand, the closeness or otherwise of spacing of two axles in an unpowered vehicle (a trailer or semi trailer rear section, or similar) has an influence on the RUC type.

In order to calculate the RUC, the weight on each component of the vehicle must be known. Vehicle length is not included in the calculation of the RUC value of a vehicle.

11.5 Weigh-in-Motion PAT Vehicle Classification System

The PAT system of classification is used at the TNZ WIM stations (at Drury, Pukerua Bay, and Waipara). The system classifies the vehicle into one of the PAT classes, according to a system of vehicle classification parameters relating axle spacings and weights, and takes regard of axle configuration (number and spacing between axles). The WIM stations can both count and weigh vehicles, and the output data in its basic form consist of information for individual vehicles.

Table 11.4 describes the vehicle axle configurations associated with each PAT type. It is evident that the PAT system is the most disaggregated system of classification of those considered, and hence a given PAT category can appear in several of the other system's "bins," but not the other way around, i.e. a "one to many" relationship exists.

11.6 DKW Vehicle Classification System

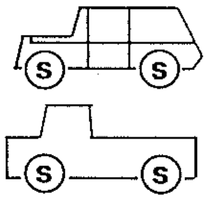
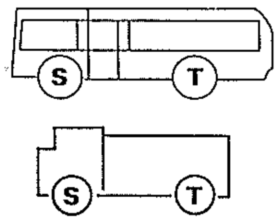
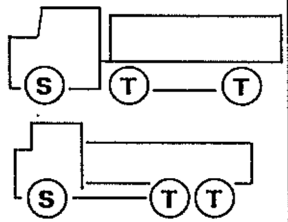
The optimal system is a classification system which minimises the need to re-adjust data later and which is more closely aligned to schemes likely to be used in future.

The DKW vehicle classification system, developed by DK Wanty at Transit New Zealand, was used because this system more closely aligns to the AUSTROADS system. It can also more accurately identify vehicles by axle numbers and configurations for NAASRA classes 2-13 than can the NAASRA system. The system admits 15 classes of vehicles, 3 more than the AUSTROADS system. A "light truck" is added, and long heavy vehicles are redefined to represent the vehicle fleet using New Zealand roads. The parameters for the DKW system are given in Table 11.4.

Table 11.5 compares the RUC classification system with PAT and DKW systems discussed in this Section 11 of the report.

15 As defined by the Road User Charges Act, 1972.

POWERED VEHICLES

No. of Axles	Types of axles	Example Vehicles	Vehicle Type No.
2	2 spaced axles, both single tyred		1
	2 spaced axles, 1 single tyred and 1 twin tyred		2
	Any other configuration		1
3	3 axles, one single tyred and two twin tyred		6
	Any other configuration		5
4	Any configuration		14
5 or more	Any configuration		19

UNPOWERED VEHICLES

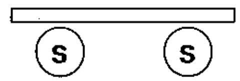
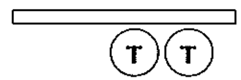
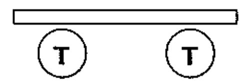
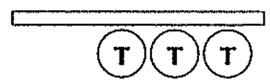
No. of Axles	Types of axles	Example Vehicles	Vehicle Type No.
1	Any configuration		24
2	2 spaced axles, both single tyred		27
	1 group of 2 close axles, both twin tyred		29
	2 spaced axles, both twin tyred		30
	Any other configuration		28
3	1 group of 3 close axles, all twin tyred		33
	Any other configuration		37
4 or more	Any configuration		43

Table 11.3 RUC vehicle classification.

Source: Road User Charges 1992. Government Print Ltd (RUC Act 1977)

Table 11.4 DKW classification system for vehicles.

Level 1	Level 2		Level 3	Classification: TNZ	
Type Vehicle Length (m)	No. of Axles	Axle Groups	Vehicle Type Description	Class	Derived: DKW @ 25/07/94 From: Other class schemes Other Critical Parameters
Short	**LIGHT VEHICLES**				
< 5.5m	2	1 or 2	Short vehicle	1	spl ≤ 3.2 m
Medium	3 4	3 3	Short veh towing Short veh towing	2	2.1 ≤spl≤ 3.2; 2.1 ≤sp2≤ 5.9 2.1 ≤spl≤ 3.2; 2.1 ≤sp2≤ 5.9
5.5 - 11m	2	2	Light truck	3	3.2 < spl < 4.1
	HEAVY VEHICLES				
(coaches	2	2	2 axle truck/bus	4	spl ≥ 4.1 m
> 13 m)	3	2 2	3 axle truck 3 axle coach	5	
	4,5	2	4 (5) axle truck	6	
Long	3	3	3 axle artic Truck + light trailer	7	spl > 3.2 or sp2 > 5.9
11 - 17m	4	3 3 4	4 axle artic Truck + light trailer Truck + heavy trailer	8	spl >3.2 or sp2 <2.1 or >5.9 spl > 3.2
	5	3 ≥ 3	5 axle artic Truck + trailer	9	
	6 7	3 3	6 axle artic 7 axle transporter	10	
Very long	6	4 or 5	Truck + trailer	11	
17 - 35m	7	4	B train	12	2.1 ≤ spl < 4.4
	7,8	4 or 5	Truck + trailer	13	spl < 2.1 or spl ≥ 4.4
	7,8 7,8 9-11	5 6 ≥ 4	A train A train Transporter	14	2.1 ≤ spl < 4.4
	8	4	B train	15	2.1 ≤ spl < 4.4

Definitions:

Groups: number of axle groups, where adjacent axles are less than 2.1 m apart
Axles: number of axles on the vehicle
spl: distance between first and second axles of the vehicle
sp2: distance between second and third axles of the vehicle

Notes:

No. of Axles: Maximum spacing 10.0 m; axle spacing < 0.5 m ignored.

Vehicle Length (m):
Vehicle lengths are indicative only, being the standard lengths used for the dual loop telemetry classification sites.
The law permits trucks to 11 m, articulators to 17 m, and tractor/trailers to 20 m. However loops measure vehicle length to only ± 10%.

Axle Groups: To simplify presentation, it is assumed that "spread" tri-axles (spacing between axles up to 2.5 m) now seldom occur. Some trailers have 3 widespread axles and thus have 3 axle groups.

Short: A few light vehicles towing will not be coded in this case.

Towing: e.g. jeep < 2.1 m or double-cab utility > 3.2 towing.

Artics: 5 axle articulated truck and 5 axle truck + trailer are the same class as they have similar weights and EDA, and occur at 'low' frequency.
6 axle artic is a separate class as it is the primary WIM calibration vehicle and most common vehicle type.
7 axle B train is a separate class as it may be used as a WIM calibration vehicle.
8 axle B train is a separate class as it may be used as a WIM calibration vehicle, and has comparatively low EDA.

Table 11.5 Relationship between DKW, RUC, and PAT vehicle classifications.

DKW	RUC Class	Vehicle Description, Axle Configuration	PAT
3	2	o-o (w/b 3.2-4.1)	20
4	2	o--o (w/b > 4.1)	21
4	2	o--o (bus,coach)	22
5	6	oo--o	31
5	6	o--oo (bus,coach)	32
5	5	oo--o	34
6	14	oo--oo	45
6	14	o--ooo	46
6	19	oo--ooo	58
7	2,24	o-o--o (Artic)	30
8	2,30	o--o-o--o (T&T	40
8	2,29	o-o--oo	41
8	6,24	o-oo--o	42
9	2,24,30	o-o--o-o--o	50
9	2,37	o--o-o--oo	51
9	6,30	o--oo-o--o	52
9	2,37	o--o-oo--o (T&T)	521
9	6,29	o-oo--oo	53
9	5,30	oo--o-o--o	54
9	5,29	oo-o--oo	55
9	2,33	o-o--ooo	57
10	6,33	o-oo--ooo (Artic)	69
10	14,33	oo-oo--ooo (Artic)	791
11	2,24,37	o-o--o-o--oo	61
11	2,29,30	o-o--oo-o--o	62
11	6,24,30	o-oo--o-o--o	621
11	6,37	o--oo--o-o-o (T&T)	622

Table 11.5 continued

DKW	RUC Class	Vehicle Description, Axle Configuration	PAT
11	6,37	o--oo-o--oo (T&T)	63
11	2,43	o--o-oo--oo (T&T)	631
11	6,37	o--oo-oo-o (T&T)	632
11	5,37	oo--o-o--oo (T&T)	65
11	14,30	oo--oo-o--o (T&T)	66
11	14,30	o--ooo-o--o (T&T)	67
12	6,29,29	o-oo--oo--oo (B-train)	751
13	6,43	o--oo-oo--oo (T&T)	752
13	5,29,30	oo-o--oo-o--o (A&T)	76
13	14,37	oo--oo-o--oo (T&T)	77
13	14,37	oo--oo-oo--o (T&T)	771
13	14,24,30	oo-oo--o-o--o (A&T)	772
13	19,24	oo-ooo-o--o (T&T)	773
13	14,37	o--ooo-o--oo (T&T)	78
13	14,43	oo-oo-o--ooo (T&T)	871
13	19,37	oo-ooo-o--oo (T&T)	873
13	14,43	oo--oo-oo--oo (T&T)	891
14	2,29,37	o-o--oo-o--oo (A&T)	73
14	6,24,37	o-oo--o-o--oo (A&T)	731
14	6,29,30	o-oo--oo-o--o (A&T)	74
14	6,29,37	o-oo--oo-o--oo (A&T)	85
14	2,33,37	o-o--ooo-o--oo (A&T)	88
14	6,33,30	o-oo--ooo-o--o (A&T)	89
15	6,33,29	o-oo--ooo--oo (B-train)	851
		oo-o--o	44
		o-oo--ooo-o (A&T)	781
		o-ooo-oo--oo (T&T)	852

12. SAMPLING FOR VEHICLE DISTRIBUTION, AND PRECISION OF ESTIMATE

12.1 Objective of Sampling Scheme

Any plan for random sampling must have a single "objective function", that is a single item which is to be determined. This does not preclude estimation of any other item, but the consequence is that efficiency of sampling to optimise precision of estimation is unlikely to be as good as for the original function. If more than one parameter is to be measured, some judgement is necessary to achieve the best mix of sampling frequencies.

The objective of the sampling scheme used in this project is to estimate *average AADT to a precision of within ±10% within each RCA.*

The result of this approach is that precise statements cannot be made about any road section, but only about the RCA. Hence, the objective relates to the network of roads in the RCA that has been sampled.

If RCA information is grouped, e.g. into regions, or better into a single group describing New Zealand as a whole, then the estimates of precision are greatly improved, because more sampled data are included in the aggregated groups.

12.2 Basis for Sampling

The basic area for sampling is the RCA. The AADT for any particular road section is assumed to be constant for the whole length of the section. Therefore, road section lengths are not used in the design. The road sections are characterised according to which of a set of ranges of AADT their value lies (see Section 12.3). This process of stratification is not in order to make comment on statistical properties of the groups, but is primarily a device for improving sampling efficiency for the RCA[16].

There is a trade-off between numbers of samples and the precision achieved. In the Hawke's Bay region, an estimate of effects was calculated in the case of Hastings District Council (a mix of urban and rural sites), and results are given in Table 12.1.

16 "Efficiency" of sampling is maximised when the number of samples required to achieve the target level of precision is least.

Table 12.1 Example of relationship between number of samples and precision of estimate.

Target Precision for Estimate of ADT or HVADT	Number of Sample Sites Required
±5%	124
±10%	31
±20%	8

These numbers will vary between RCAs, depending as they do on the distribution of traffic volumes between road sections.

Although the sampling area could have been different from that of an RCA (e.g. could have been all TAs and the state highway network in a TNZ Region), the precision of estimate for any RCA would not be known, and it would not be the same between TAs.

12.3 Number of Strata of Traffic Volume Data

The Neyman allocation process (see Section 2 of this report) was used in the sampling scheme for this project. This process is well known as the optimum method for stratified sampling to obtain a minimum variance estimate of a pre-specified goal function. The allocation of sample numbers takes into account the "size" of the AADT strata as well as the variability with the strata. In this case, the goal function is the average AADT.

Strata are selected on an intuitively reasonable basis and, as far as the allocation process is concerned, strata are a "given". Strata were determined on a "per RCA" basis[17] in order to give the optimum efficiency, based on the nature of the AADT distributions within the RCAs.

The time frame for sampling is flexible. That is, sampling may be done progressively, provided that the overall sampling frame and sites are chosen randomly before the sampling begins. This allows for the pre-determination of sites to be sampled. Sampling carried out in this project can therefore be fitted into the whole programme.

In this project, data have been grouped in five strata so that one sample can be taken from each stratum for a year's sampling programme. The traffic volume ranges of each stratum are chosen from the distribution of volumes within the RCA. The ranges within strata will vary greatly between small and large TAs, but will be similar for like-sized TAs.

---

17 This means that a set of AADT strata were <u>not</u> prescribed in advance and then applied to all RCAs.

12.4 Low Volume Sites

Although all other analyses and sampling were conducted at an RCA level, road sections with an AADT of less than or equal to 55 (as identified from RAMM, and adjusted by the day and week factors, as well as by the axle factor determined in Stage 2 of the project) were treated on a nationwide basis.

12.5 Effect on Precision of Estimate of AADT when HVADT is Used

Sampling is designed to give a precision of ±10% of the average goal function to a 95% level of confidence. Estimating a value using a goal function that is not the same as the value being estimated, produces less than optimum efficiency.

If heavy vehicle average daily traffic (HVADT) is used as the basis for sampling, then the precision of estimate of AADT will be more than 10%[18]. In fact, the degree to which the level of precision will reduce will vary between RCAs because of differences in the distribution of road use classifications and traffic volumes.

12.6 Effect on Precision of Estimate of HVADT when AADT is Used

To get some indication for the movement in precision, data from four TAs were examined. The TAs were the Councils of Masterton, Kapiti, Otorohanga Districts and of Wellington City. While by no means at the extremes of types of TA[19], these authorities have road networks which are obviously significantly different. If AADT is used as basis for sampling, it gives a reduced level of precision of estimate of average HVADT (Table 12.2).

Table 12.2 Effect of use of AADT on precision of HVADT estimate.

TA	Precision of Estimate
Masterton DC	±12%
Kapiti Coast DC	±10.2%
Otorohanga DC	±12.3%
Wellington CC	±13.1%

18 Note that HVADT itself is a variable which has a component of unknown precision, because it is the product of AADT and a factor of uncertain precision which is obtained from the TNZ Project Evaluation Manual (1991). Hence the precision of estimate of HVADT cannot be calculated. Note also that the *higher* the level of precision, the *lower* its percentage error.

19 Examples of extremities of types of RCA might be Auckland City and Taupo District, the former containing a large CBD and extensive residential network, and the latter being essentially rural.

12.7 Likely Extreme Reduction in Level of Precision

AADT and HVADT are normally strongly correlated over more than 50% of the volume range. The value of precision will not usually increase beyond ±12% because of the stabilising influence of the correlation, which is expected to apply in other than quite low volume sections.

12.8 Estimating Vehicle Kilometres Travelled

The NTDB derived from the Working Spreadsheets enables VKT to be calculated by three approaches:

1. Using only the *VDAS* and *ARCHER*[20] survey results to obtain an estimate of average AADT for the RCA, multiply the total road length, weighted by the length of the sampled sites, and by stratum.

2. Using both *VDAS* and *ARCHER* survey results and available actual counts to obtain an estimate of average AADT for the RCA, then multiply by the total road length, weighted by length of sampled sites, and by stratum.

3. Using the best estimate of AADT for each road section from the Working Spreadsheet, then sum the product of AADT and section length for each road section.

The advantage of approach 1 is that the estimate of precision of the output can be calculated. Only five samples per TA have been obtained in Stage 3 of the project, and therefore the precision will be very poor[21]. Approach 2 gives better precision, which can be calculated, and the improvement will depend on the proportion of counts which are actual counts. The precision is not known if approach 3 is used.

12.9 Relationship between Sample Number and Precision of Estimates

12.9.1 AADT

The scope of the present project allows for only a small proportion of samples to be taken, namely five per RCA. To achieve the target precision of ±10%, then approximately 40 samples are required. The actual number depends on the distribution of traffic volumes between road sections, and ranges between about 15 and 50.

---

[20] See Section 14, Processing Vehicle Classification Data, in this part 1 of the report for a description of the *ARCHER* portable vehicle classification equipment.

[21] Approximately 30 to 40 samples are needed to give the targeted ±10% precision.

12.9.2 VKT

The precision of estimate of VKT will vary between RCAs because it depends on the proportion of actual count data and the associated lengths of the road sections. Table 12.3 shows the situation applying for four RCAs (Far North (MKM01), North Shore (MKM07), Kapiti Coast (MKM43) and South Wairarapa (MKM47)). These four were chosen because they give a mixture of low, mixed and high volume RCAs.

Table 12.3 Proportion of road sections with actual count data for selected RCAs.

File Name	Number of Sections	Number of Counts	Counts as % of total	VKT_{total}/yr	VKT_{counts}/yr	VKT_{counts}/yr as % of total
MKM01	2179	155	7.1	181,814,891	44,535,890	24.5
MKM07	2623	221	8.4	750,809,681	197,390,046	26.3
MKM43	1318	133	10.1	124,186,697	31,633,046	25.5
MKM47	345	44	12.8	43,986,888	22,491,897	51.1

From Table 12.3, a conservatively low estimate of VKT counts per year is about 25% of total. From this an estimate of precision per RCA of about ±11% can be calculated. However, this calculation assumes that the samples from sites with estimated AADTs are optimally configured, i.e. random in terms of AADT and length.

In reality, this is not likely to be so, and the effect is that the precision of the estimate of average AADT at the "estimate" sites requires adjustment and precision will not be as good as for the average AADT in the total RCA. Preliminary calculations have suggested a precision of about ±14%. Some further work suggests that the estimate of precision is about ±16% on the "estimate" portion and about ±4% to 5% on the "count" portion.

On the basis of a 25% : 75% split of "estimate" to "count," the precision of estimate of the VKT per RCA is assessed at about ±11%. For the national VKT figure, the precision is likely to be ±5% or better. The latter figure results from considering each RCA in turn, and is very dependent on the characteristics of constituent RCAs (mix of AADT values and associated road lengths).

12.10 Summary of Precisions of Estimate

Table 12.4 summarises the estimates of precision for AADT and VKT, on the basis of sample number and (in the case of VKT) the method of calculation. The precision is much better when the RCA information is aggregated for the country as a whole.

Table 12.4 Estimate of precision of AADT and VKT.

Value	Scope of Estimate Calculation	Method of Calculation	Percentage Precision	
			By end of Project (5 samples per RCA)	**By completion of Sampling**
AADT	per RCA	*VDAS* samples	± 25-30%	± 10%
	for whole country	*VDAS* samples	< ± 10%	< ± 3%
VKT	per RCA	*VDAS* samples	± 35-70%	< ± 14%
		Counts plus *VDAS* samples	± 25-55%	< ± 10-11%
	for the whole of New Zealand	*VDAS* samples	< ± 10%	< ± 2%
		Counts plus *VDAS* samples	< ± 7%	< ± 1-2%

13. OBTAINING VEHICLE CLASSIFICATION DATA

13.1 Selection of Random Sites

Within each RCA (i.e. 73 TAs, and 14 regions), the required number of sites is determined using the Neyman allocation process (see Section 2 of this report). This results in subsets within each of the selected five traffic volume strata. The sites within each stratum are then determined on a purely random basis.

When the individual road sections have been chosen, the location of the classifier instrument within the road section is also determined on a random basis. The purpose is to avoid bias in measurement which would result if only the ends of road sections were chosen when placing the counters. It has been assumed that each road section, as defined from RAMM, is, throughout its length, the same. That is, ADT measured is the same at any point along the length of the section. This project cannot address the validity of that assumption, but subsampling at randomly chosen points along the length can at least eliminate any bias caused if the uniformity assumption is inappropriate.

13.2 *VDAS* Classification Equipment

13.2.1 Description of Equipment

The *VDAS* traffic classifiers are manufactured by the ARRB Transport Research Ltd and are currently marketed by Australasian Traffic Surveys.

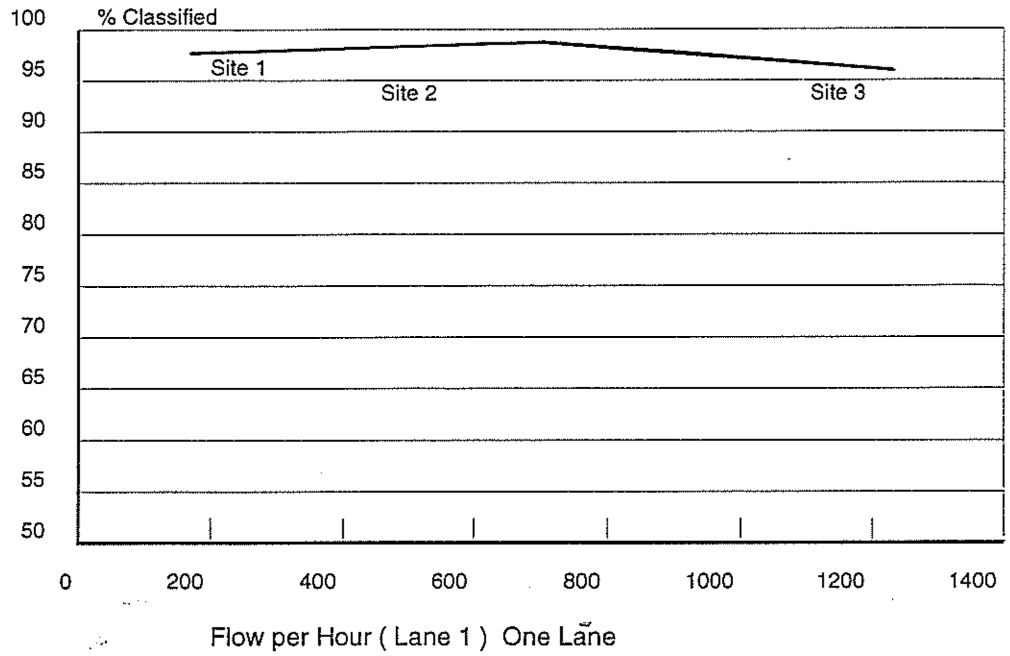
A total of 20 *VDAS* classifiers were used for traffic data gathering over the duration of the project. All *VDAS* classifiers were *VDAS 3000* units, which have the ability to log both summary vehicle data and individual vehicle data concurrently. They also contained within their internal memories the NAASRA vehicle classification scheme for binning vehicle events.

Eight classifiers contained an earlier version of the NAASRA classification scheme while the remaining 12 contained the most recent NAASRA scheme. The major difference between these versions to affect this project was that the wheelbase cutoff point between cars and medium two axle trucks was set at 3.0 metres in the earlier versions, and at 3.2 metres in the most recent (1994) version. However, because the project was concerned with the distribution of vehicle types in terms of the DKW classification scheme, all individual vehicle data were post-processed. During the processing, any individual vehicles from the more recently purchased classifiers with a wheelbase between 3.0 and 3.2 metres were reclassified as cars and added to the car totals in the summary data.

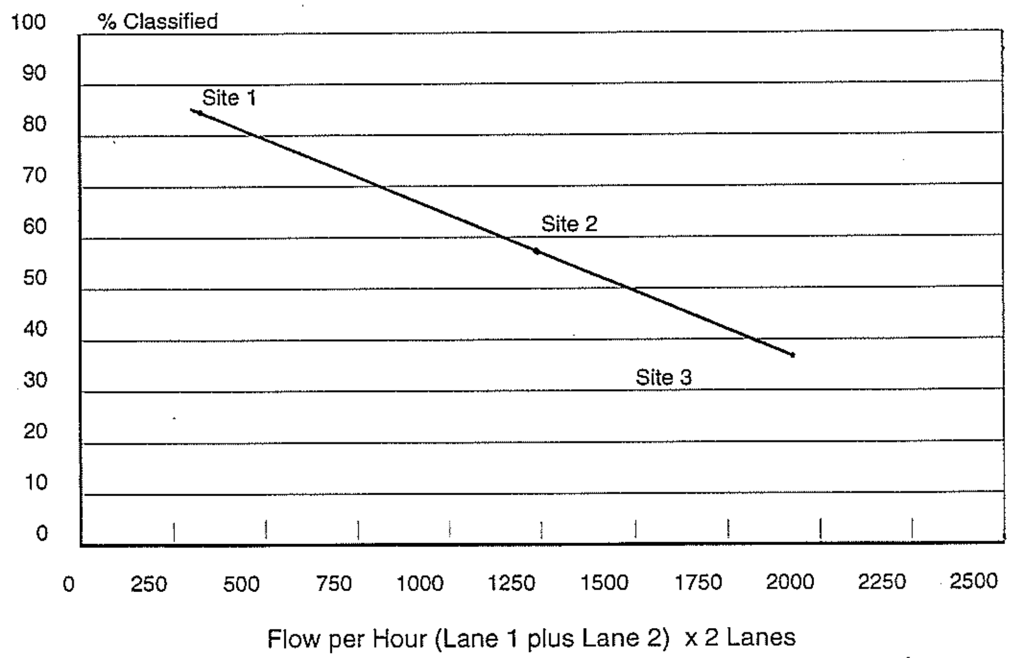
When traffic volumes increase and two lanes are being sampled, the ability of the instrument to classify vehicles diminishes markedly. Figure 13.1 compares output of a single instrument for a two lane count with a one lane count. Appendix 2 (to this report) reports on a field study carried out to confirm the need for multiple *VDAS* instruments at most sites.

To retain control on accuracy of count, and following field trials and discussion with the *VDAS* supplier, the traffic surveyors were instructed to use two counters when ADT (as indicated in the RAMM database) exceeded 2000. This corresponds to a peak flow of not more than about 150 vehicles per hour in most situations. According to Figure 13.1, more than 90% of vehicles would be classified.

Figure 13.1 Effect of traffic volume on *VDAS* accuracy:
(a) using tubes across one lane.



(b) using tubes across two lanes.



13.2.2 *VDAS* Classifier Setup - Logging Regime

Tight time constraints for carrying out the surveys necessitated setting up the classifiers to log a 24 hour period from midnight to midnight. To assist the traffic surveyors to efficiently cover the sites during the period of Monday to Thursday each week, an allowance was made to log for 24 hours from midday to midday as well.

13.2.3 *VDAS* Classifier Setup - Road Tubes

At all chosen sites, two D section rubber tubes were attached to the road 5 metres apart. No venting of the remote ends of the tubes was allowed as according to instructions on the classifier. After about 20 surveys had been undertaken, the results showed that, at all sites where the flow obtained from the RAMM database were likely to be greater than 200 vehicles per day, two classifiers should be used, one in each lane.

Where more than two lanes exist at a particular site a greater number of classifiers was used. For example, on a four lane section of road with an appropriate median to facilitate securing of the classifier boxes, four classifiers were used.

13.3 *ARCHER* Classification Equipment

13.3.1 Description of Equipment

Approximately 20 *ARCHER* classifiers were employed in the survey work, all owned by Harding Electronic Systems Ltd.

ARCHER classifiers do not have the facility to record summary vehicle data and individual vehicle data at the same time, unless interfaced with a laptop computer. As it was not practical to have a laptop computer to accompany each of the 20 *ARCHER* classifiers the classifiers were set to provide summary data only.

Documentation provided by the manufacturer, Golden River Traffic Ltd, Australia, indicated that, for the AUSTROADS classification scheme installed in their equipment, the cutoff point for the transition from a car to a medium two axle truck was 3.0 metres length. However, experimentation with the equipment clearly demonstrated that the change point was 3.2 metres length.

13.3.2 *ARCHER* Classifier Setup - Road Tubes

Round rubber tubes were used with all the *ARCHER* installations. These tubes were vented at the end remote from the classifier. With this system, the tubes were installed one metre apart. As with the *VDAS* classifiers, more than one classifier was required at sites where the expected flows were greater than 2000 vehicles per day.

13.4 Field Operation of *VDAS* and *ARCHER* Classifiers

Once the random sites had been selected, they were plotted on maps and forwarded to the traffic surveyor. Although originally only two teams of surveyors were envisaged, the large project meant that four teams were more practical.

Of the four teams operating, two were external contractors. The teams, the equipment they operated, and area of operation were:

- Summit Holdings (Napier) *(VDAS classifiers)*
  Central and Upper North Island, Napier and part Wairarapa

- Works Consultancy Services Ltd (Central Labs, Lower Hutt) *(VDAS classifiers)*
  Lower and western North Island, and part Wairarapa

- Harding Traffic Systems Ltd *(ARCHER classifiers)*
  Auckland/Waikato and Marlborough/Westland

- Works Consultancy Services Ltd (Dunedin) *(VDAS classifiers)*
  Lower South Island

13.5 Data Transfer for *VDAS* and *ARCHER* Classifiers

All files were downloaded to a laptop computer at the site, at the completion of each survey. Backup copies were made on floppy disk. Two methods of data transfer were used from the surveyors to the traffic survey co-ordinator:

1. Three of the survey teams mailed or hand delivered floppy disks to the co-ordinator, who checked and loaded these onto the WCSL network for subsequent processing.

2. The fourth survey team transferred the files directly from their base in Dunedin to the co-ordinator via the WCSL network.

Samples of typical files from the *VDAS* and *ARCHER* classifiers are shown in Appendix 2 of this report.

14. PROCESSING VEHICLE CLASSIFICATION DATA

14.1 *VDAS* Data

14.1.1 Screening *VDAS* Individual Vehicle Data

Individual vehicle data from the *VDAS* instruments were screened in two stages. The intention of this screening was :

1. To re-interpret spurious "single vehicles" having apparent very short wheelbases and two or three axles as one or two cars. This had the effect of substantially reducing spurious classifications. A series of programs was written in FORTRAN and Turbo PASCAL to carry out this stage.

2. To account for the effect of low speeds that created confusion in allocation. In some cases the speed of the vehicles over the counters was low enough to create confusion as to whether a four axle truck was in fact two cars following closely. A FORTRAN program was compiled (by TNZ) which took account of speeds.

14.1.2 Distribution of Data from Individual Records

The hour by hour 24 hour individual vehicle data were summed in DKW bins. The ADT was factored by the appropriate day and week factors, and estimates of AADT were calculated. The distribution of DKW data was divided by the AADT estimate before inputting into the basic Working Spreadsheet at the sampled road section.

This distribution was also stored in two databases: the **.OU1* series contained the header information from the original instrument outputs, and the **.OU2* series contained the raw numerical information for analysis.

14.2 *ARCHER* Data

These data are normally output in hour by hour distributions into NAASRA bins. The information is summed for each bin over the midnight to midnight period. For periods that were not one hour, the data were separately processed.

14.3 NAASRA to DKW Conversion Matrix

To obtain a reliable expression of the *ARCHER* output in terms of the DKW classification, a conversion matrix relating the two systems of classification from the *VDAS* output was constructed. The individual vehicle records from the *VDAS* instruments record the NAASRA class beside each vehicle. This information was used as input to (NAASRA, DKW) cells which formed the conversion matrix, made stable by inclusion of all *VDAS* data obtained, i.e. it was not confined to a 24 hour period.

14.4 Influence of Traffic Volume of Site on Conversion Matrix

The effect of high volume (> 2500 vpd) and low volume (≤ 2500 vpd) traffic counts on DKW classes 3 to 15 was tested for corresponding NAASRA classes. Significant difference would mean that the conversion matrix used for the *ARCHER* information would vary with ADT.

A Chi-square test was used from which was calculated the probability (P) of the high and low distributions being as different as observed, if they were randomly sampled. A value of P less than 5% is generally accepted as a significant difference.

Significant differences were found, in fact, for NAASRA classes 3, 4, 9, 10 and 11. However, the error in calculated volume, if a separate conversion matrix was not used, would be of the order of 0.1% in the case of NAASRA class 3 for example. This error is considered insignificant.

Accordingly, a single conversion matrix to convert NAASRA data to DKW classes has been used in this project.

14.5 The Single Conversion Matrix

The processed *ARCHER* output of 24 traffic volumes distributed into NAASRA bins was converted into an equivalent set of DKW binned output using the above conversion matrix (Table 14.1).

14.6 Best Estimate of DKW Distribution

A key component of the NTDB is the description of the distribution between the DKW classes of traffic volumes recorded at any road section. The 350 sets of DKW class distributions from the sampled sites provided the raw data used to establish an estimate of this distribution.

The information was analysed with the inclusion of the C16 (unidentified vehicle) bin, and grouped in terms of road use categories. *ARCHER* and *VDAS* results were separately considered, and weekend and weekday samples were also separated.

Within each road use category, the distributions were tested for significant differences between weekend and weekday samples. Although some small differences appeared between weekend-based distributions and weekday-based distributions, these were very minor when applied to even high volume sites. Furthermore, the Chi-square test is technically not valid since the times for sampling were not part of the design. Consequently, unknown bias could easily occur.

Table 14.1 Conversion of NAASRA output to DKW classes.

NAASRA Classes	DKW Class															
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16
1	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0169	0.8750	0.0000	0.0000	0.0702	0.0216	0.0036	0.0103	0.0054	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0137
3	0.4335	0.0000	0.5542	0.4458	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4	0.206	0.0450	0.0000	0.0000	0.9044	0.0000	0.0415	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0092
5	1.2518	0.0538	0.0000	0.0000	0.0000	0.7330	0.0000	0.0147	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1985
6	0.0263	0.4559	0.0000	0.0000	0.0667	0.0000	0.4774	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
7	0.0617	0.2451	0.0000	0.0000	0.0000	0.0583	0.0000	0.6772	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0194
8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0199	0.0000	0.0000	0.9767	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0034
9	0.1388	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2912	0.6869	0.0000	0.0000	0.0000	0.0000	0.0218
10	0.0604	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0258	0.0000	0.2456	0.5221	0.0977	0.0977	0.0112
11	0.0508	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0635	0.0140	0.1218	0.0647	0.1789	0.4239	0.0279	0.1053
12	0.3077	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.5385	0.0000	0.4615
13	0.6309	0.0006	0.0025	0.0820	0.1410	0.0915	0.0089	0.0222	0.0133	0.0019	0.0000	0.0000	0.0000	0.0546	0.0000	0.5813

Although possibly there is a significant difference in distribution of heavy vehicle types between regions of New Zealand, there are insufficient data at this stage to test for this.

The random sampling scheme could not ensure that equal numbers of road use category were sampled. Table 14.2 shows the distribution of eleven road use categories for the national sample. Some road use categories have very few samples, because road sections in these categories are themselves not numerous.

With the data available, a single national distribution of 15 DKW classes (excluding C16) for 10 road use categories (Table 14.3) could be produced.

Table 14.2 Distribution of classification sites between road use categories.

Road Use Category	**Number of Sites Selected**	
	VDAS	*ARCHER*
1a	22	6
1b	55	22
2	23	8
3	4	1
4	56	37
5	1	4
6	46	10
7a	3	1
7b	-	-
8	42	17
9	93	26
TOTAL SITES	**345**	**132**

Table 14.3 Distribution of ADT between DKW vehicle classes for each road use category.

Road Use Category	PROPORTIONS FOR ALL SITES PER ROAD USE CATEGORY according to DKW Class														
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	Precision (±)
1a	0.9386	0.0151	0.0149	0.0107	0.0063	0.0023	0.0012	0.0052	0.0015	0.0008	0.0009	0.0005	0.0009	0.0010	0.0002	0.0009
1b	0.9450	0.0152	0.0107	0.0095	0.0056	0.0026	0.0012	0.0046	0.0016	0.0006	0.0013	0.0005	0.0010	0.0005	0.0002	0.0005
2	0.9525	0.0122	0.0105	0.0080	0.0059	0.0017	0.0015	0.0028	0.0014	0.0009	0.0008	0.0002	0.0009	0.0005	0.0001	0.0005
3	0.8860	0.0247	0.0271	0.0230	0.0141	0.0037	0.0028	0.0048	0.0047	0.0020	0.0033	0.0014	0.0011	0.0006	0.0006	0.0005
4	0.9369	0.0183	0.0115	0.0100	0.0077	0.0028	0.0011	0.0034	0.0023	0.0010	0.0013	0.0009	0.0017	0.0007	0.0004	0.0009
5	0.9249	0.0308	0.0107	0.0139	0.0069	0.0025	0.0053	0.0037	0.0006	0.0000	0.0000	0.0001	0.0002	0.0002	0.0000	0.0005
6	0.8864	0.0238	0.0200	0.0156	0.0101	0.0032	0.0026	0.0069	0.0085	0.0032	0.0079	0.0029	0.0060	0.0017	0.0011	0.0002
7	0.8990	0.0656	0.0083	0.0087	0.0044	0.0011	0.0010	0.0027	0.0037	0.0003	0.0030	0.0002	0.0008	0.0008	0.0003	0.0005
8	0.8764	0.0324	0.0189	0.0158	0.0172	0.0051	0.0028	0.0056	0.0058	0.0020	0.0081	0.0017	0.0059	0.0017	0.0006	0.0004
9	0.9394	0.0195	0.0123	0.0106	0.0066	0.0016	0.0008	0.0023	0.0018	0.0005	0.0029	0.0002	0.0010	0.0005	0.0001	0.0001

14.7 Calculation of AADT

14.7.1 Using Day Factor and Week Factor

To complement the week factors produced by TNZ, a further analysis was conducted examining the consequence of having only a single day (24 hour) count for estimating AADT. The result is a table of factors, one for each day of the week (day factors), which may be used to estimate the weekly average daily traffic volume. This can be converted into an estimate of AADT for the site by using the appropriate weekly factor. These day factors and associated variability estimates are published in TNZ's Traffic Count Guideline (1994), and held unpublished in file PR3-0129 at TNZ Head Office, Wellington.

The updated count and estimate were therefore converted into an estimate of AADT by including the effect of the week factors and day factors from the studies. Where the ADT information available was in the form of an estimate in the RAMM database, then only the week factor was used. Both factors were used when the information was in the form of a 24 hour count.

14.7.2 Using 24-hour Classification Survey

The results of the *VDAS* and *ARCHER* surveys were used to provide improved estimates of AADT for a site from a single day vehicle count, using the day and week factors referred to in Section 14.7.1. This procedure improves considerably the number of sites which are measurable using a fixed budget. Furthermore, an estimate of the precision of such a count process is available, and is ±28 to 30% for the set of five sites surveyed per RCA for this project.

14.7.3 Using Other Tube Counts

The classification surveys provide a third factor, the axle factor, which is useful to improve the ADT estimate obtained from single tube or axle counts.

The axle factor has been calculated from analysis of single vehicle data for the *VDAS* and *ARCHER* classification surveys carried out for this project. Axle factors subsequently used in calculation of ADT for those sites where single tube counts were undertaken, are those given in Table 14.4. No significant difference was determined between the sites measured at weekends and those of the same road use category measured in weekdays. However, there is an unknown bias in these sets of data. The adjustment to the tube count ADT was made as follows:

$$\text{Adjusted ADT} = \text{Tube Count ADT} \, . \, (2/\{\text{axle factor}\})$$

Table 14.4 Axle factors used for calculating ADT.

Road Use Category	Axle Factor
1a	2.1043
1b	2.0620
2	2.1003
3	2.1557
4	2.1007
5	2.0209
6	2.2081
7	2.1224
8	2.1611
9	2.0891

15. ANALYSIS OF TRAFFIC VOLUME AND CLASSIFICATION DATA

15.1 Road Use Category Parameters

The allocation of the sampled sites to the road use categories identified from the Traffic Stream Data (Transit New Zealand Research Project PR3-0025, in prep.) should be considered. This grouping has the effect that, for each group, a set of proportions of vehicle types can be produced. The value of using the group structure is that:

- Single one-day counts may be sampled at the chosen sites, because week and day factors are available for each group with a known value of precision.

- Attribution of vehicle proportions to other sites that are not sampled is more accurate on a group basis than on a general basis.

Two issues concern the use of these groups. First the allocation of sampled sites to the groups, and second the categorisation of all other sites on the basis of RAMM information and the information supplied by the TAs.

15.2 Influence of Region on Classification Distribution

The influence of region on the classification distribution is potentially significant. However, there are insufficient data to confirm it at present. The possibility of regional influence should be addressed once at least 10 further samples per RCA have been collected. At present, it has been assumed that there is no regional influence.

16. VEHICLE WEIGHT INFORMATION

Available data come from two primary sources, i.e. WIM and CVIU. A third potential source is the results of a survey conducted in 1992 by the Ministry of Transport (MOT).

For this MOT survey, heavy vehicles were stopped at random to gather information on driving hours. Two of the questions related to the legal weight limit of the vehicle combination and an estimate of the laden weight of the vehicle combination and its load.

However, given the quite different objectives and design of that study, the data are not appropriate for further consideration in this study.

16.1 Weigh-in-Motion Data

16.1.1 Sites Used for WIM

Three WIM sites have been used in the study to ascertain the relationship between vehicle type and vehicle weight. These sites are situated at Drury on the Auckland southern motorway SH1 (southbound traffic only), Pukerua Bay on SH1 just north of Wellington, and at Waipara on SH1 just north of Christchurch. All are PAT DAW 200 weighplate WIM stations.

WIM stations were the most efficient way of gathering data on truck weights and axle group weights because the data had already been collected. Because data were gathered almost continuously, no bias was expected. The manufacturers claim an accuracy better than 10% for the PAT weighplate systems when properly calibrated, and most sites have been calibrated annually over the sampling period. An analysis of individual vehicle data from all three sites has been undertaken to produce axle group weight histograms for each of the PAT vehicle classes, where the axle groups corresponded to the RUC classes.

Up until 17 June 1994, incomplete logging was a problem at the WIM sites. This problem has been fixed and the analysis used data obtained since this date. A less significant problem of phantom axles[22] was also being addressed in the analysis to assist in binning vehicles with phantom axles into the correct PAT bin.

Potentially, WIM data are available for analysis from three other sites. These are Onewa Road southbound at the Auckland Harbour bridge (PAT DAW 200 piezometer site), Onewa Road northbound at the Auckland Harbour bridge (recently commissioned PAT DAW 200 weighplate site), and northbound on SH1 at Ohakea (Culway system). The accuracy of the PAT piezometer system is known to be not as good as the weighplate systems, and the Culway system appears to be weighing lighter than expected. For these reasons and because all systems are situated on SH1, the study was confined to the best three weighplate systems available.

---

22 The relationship between PAT and DKW classes is shown in Table 11.5 in Section 11, Vehicle Classification Systems, in this part 1 of the report. "Phantom axles" are axles recorded at spacings from adjacent axles which are so small as to be incredible. They have been eliminated during data processing.

16.1.2 Calculation of Vehicle Weight Distribution from WIM Data

The relationship between PAT vehicle classes and DKW classes is not as easy to establish as the PAT–RUC relationship. Only 15 DKW bins are available and it is obvious that more than one PAT type fit into some of the DKW bins. Considering the number of axles in the PAT vehicle classification system, the number of axle groups and to a lesser extent the axle spacings, each PAT type was allocated to a DKW bin. The relationship established between PAT class and DKW bin (and also RUC class) is given in Table 11.5 (in this part 1 of the report).

16.2 Police Commercial Vehicle Investigation Unit Data

16.2.1 Introduction

The CVIU is part of the Traffic Safety Division of the New Zealand Police. Their role of monitoring the transport industry includes all facets of the commercial vehicle industry, such as road and bridge protection, driver and vehicle safety relating to the use of commercial vehicles, and preservation of the integrity of the RUC collection system[23].

The CVIU has some 32 officers patrolling the country. For the first three quarters of 1994,

- 49,275 heavy vehicles were stopped,
- 17,807 vehicles were weighed,
- 3,028 vehicles were issued with overload infringement notices,
- 1,055 vehicles were off-loaded[24].

From these records, an officer would stop 6 to 7 vehicles per day, and would weigh 2 or 3 of these. The officers are skilled at estimating the weight of a vehicle. CVIUs travel all road use categories and this operation provided the necessary reliable means of obtaining weight information from road categories not covered by WIM equipment.

16.2.2 CVIU Vehicle Survey

Following discussions with the Commanding Officer of the CVIU, WCSL prepared a brief requesting a sample of 8,000 vehicles in nominated regions and road use categories. At least 5% of these were to be weighed after the weight had been estimated. These pairs of data were used to adjust individual officers' estimates to reflect the actual weight.

A total of 6,488 vehicle weight estimates was achieved from units operating in Auckland, Taranaki, Hawke's Bay, Wellington, Christchurch and Dunedin. Table 16.1 summarises the numbers of data for respective vehicle types, and compares them with the target number prescribed for this NTDB project. The target was divided between Police Districts.

---

23 "Heavy Motor Vehicle Enforcement in New Zealand", Inspector Ian James, Traffic Safety Division, New Zealand Police.

24 The law requires the vehicle to be off-loaded whenever the weight on any axle or axle group exceeds the legal limit by more than 10%.

Table 16.1 CVIU survey of vehicle weights.

DKW Class	Target Number for Survey	Number Achieved
3	500	1665
4	450	67
5	450	767
6	900	205
7	800	101
8	800	386
9	800	595
10	1000	969
11	600	426
12	600	168
13	450	859
14	450	48
15	350	232

16.2.3 Analysis of CVIU Data

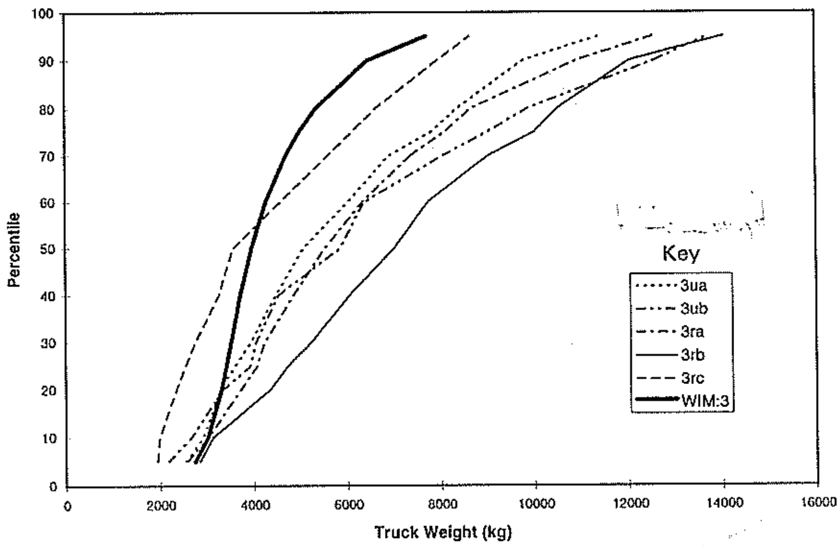
Following adjustment of the data to correct for bias resulting through the estimate process (a separate factor was derived for each officer), the data were summarised in terms of mean, standard deviation and number of samples for each vehicle class, each region and each road use category where the survey took place.

To obtain a large pool of similar data, possibilities of combination of results were examined. In the first instance, tests were carried out to see if the difference for a particular road use category between police districts was significant. The tests concentrated on the difference in mean values: for example were there statistically significantly differences from zero? A z score was calculated and the existence of significant difference at a 5% level was measured. Where the difference between sets was not significant, then these sets were pooled, and the pooled set was tested against other sets.

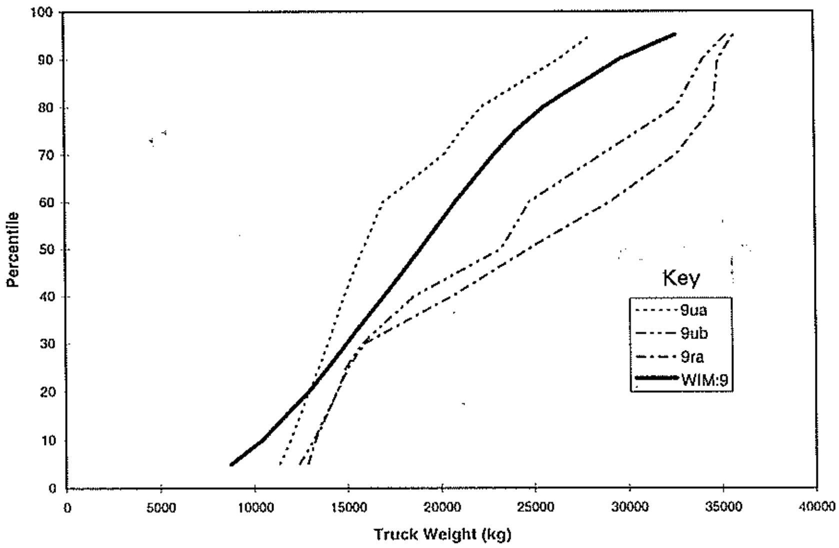
The next step was to see if the difference between road use categories was significant. The previously pooled data were further aggregated where differences were shown to be not significant. Testing for aggregation of road use categories was carried out in two stages, first with rural and urban use categories being kept separate, and then with the resulting rural sets tested against urban sets.

Figure 16.1 Vehicle weight distributions obtained by pooling the data for DKW vehicle classes 3, 9 and 10.

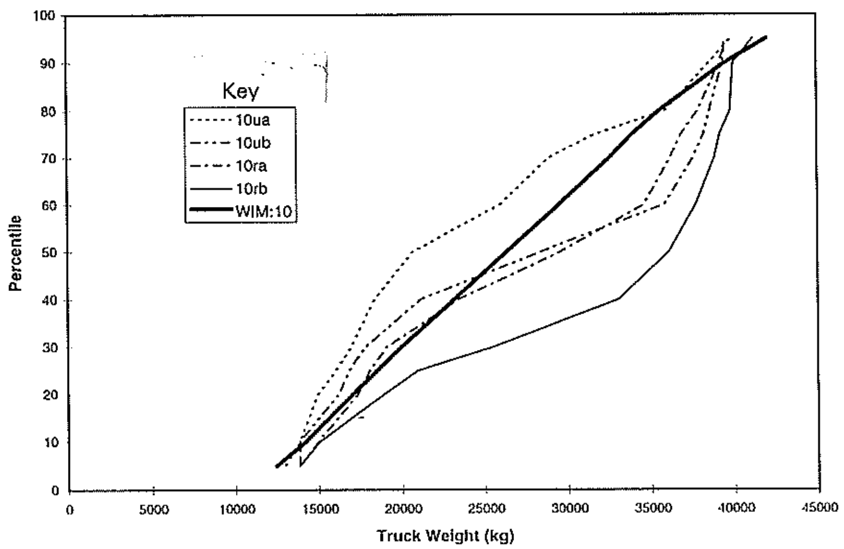
DKW Class 3 (light truck)



DKW class 9 (5 axle artic.; truck & trailer)



DKW Class 10 (6 axle artic.; 7 axle transporter)



Finally, the large body of WIM data (summarised as means, standard deviations and numbers) were tested against the pooled CVIU data to see if CVIU data could be ascribed to additional road use categories. Where the difference between the CVIU data and the WIM data was insignificant, then the CVIU data were discarded, because the WIM information gave about 100 times as much information.

In completing this process, some sets of survey information were statistically significantly different from others. In three cases, the population of the pooled sets are less than 100.

16.3 Summarising Vehicle Weight Information

Table 16.2 summarises the pooled weight data in terms of both mean, standard deviation and number, as well as of the distribution of percentiles (Figure 16.1). The description includes delineation of geographic and road use strata to which alternative distributions apply, where such exist.

16.4 Comparison of CVIU and WIM Data

From the summary in Table 16.2, the expected value of vehicle weight from the WIM data is sometimes greater, and sometimes lower, than the equivalent values calculated from the pooled CVIU information. Where more than one set of CVIU data are available for a particular DKW vehicle class, then the WIM summary information lies generally between the extremes of the CVIU sets. This result gives some assurance that the CVIU information is not abnormal, to the extent that similarly loaded heavy vehicles of a particular class do in fact travel on roads of different road use categories.

Table 16.3 lists the TA areas that apply to each of the vehicle weight distributions in Table 16.2.

16.5 Limitations of Predictions Obtained from Vehicle Weight Information

As a result of pooling using the process described previously, a minimum population of 64 samples resulted within the 25 sets of pooled CVIU data of which 20 sets numbered 100 or more in population.

While the mean of the WIM results generally lie within the scatter from the pools of CVIU information, the separation has been made on the basis that mean values have the potential to differ significantly both between regions[25] and between road use categories.

---

[25] In preparing Table 16.3, the 6 Police regions in New Zealand have been related to TA districts by comparing boundaries on maps.

Table 16.2 Distribution of heavy vehicle weights obtained from CVIU and WIM data.

Set	VKT/day	mean	std	count	5%ile	10%ile	20%ile	25%ile	30%ile	40%ile	50%ile	60%ile	70%ile	75%ile	80%ile	90%ile	95%ile	EXP_VAL	RUC (NZ$/1000km)
3ua	99105	5853	2824	627	2528	2914	3262	3586	3934	4482	5066	6024	6907	7804	8365	9781	11423	5461.475	74.56
3ub	13381	6588	3617	117	2165	2653	3323	3918	4052	4536	5850	6378	8065	9022	9865	12601	13728	6159.975	64.23
3ra	178336	6338	3518	357	2559	3010	3715	4073	4241	4860	5522	6336	7365	8099	8654	10929	12563	5880.05	52.63
3rb	231558	7477	3400	160	2835	3112	4351	4727	5232	6052	7014	7732	9045	10020	10504	12048	14056	6983.6	72.92
3rc	11656	4542	2371	179	1935	1986	2342	2546	2749	3259	3564	4582	5601	6110	6619	7943	8656	4145.85	31.02
WIM:3	787339	4487	1889	40036	2740	3010	3300	3410	3510	3710	3960	4270	4710	4990	5340	6450	7700	4110	31.44
WIM:4	1077573	7530	3439	48998	3600	4190	4990	5350	5710	6440	7200	8010	8880	9370	9940	11360	12480	7085.25	74.04
5ur	310950	13725	4801	519	6771	8855	9606	9804	10032	10870	11933	14059	17134	18775	19249	21095	21647	12983.88	148.18
WIM:5	399686	11750	4172	28774	5670	6690	8080	8660	9200	10300	11380	12470	13660	14300	15030	17310	19450	11066.75	98.57
6ur	83921	17360	6874	172	9849	10352	11734	12371	12876	14433	15438	17526	20101	21912	23196	25100	27301	16063.28	124.2
WIM:6	157993	14696	5602	5480	7240	8410	10160	10800	11370	12410	13520	14730	16470	17650	19370	23580	25770	13841	114.00
7ur	80308	11582	3384	82	7028	7968	8955	9184	9288	10081	11247	12133	12900	13497	13944	15784	17512	10870.08	84.72
WIM:7	82534	8001	4607	6383	2930	3210	3840	4160	4540	5380	6470	8100	10340	11190	12190	14690	16920	7415.75	71.32
8ur	292396	16305	6418	320	6716	9804	10956	11640	12060	13228	14815	17034	19076	20782	21739	24768	27888	15239.23	129.06
WIM:8	152208	12778	6399	14700	3810	4260	5990	7150	8290	10520	12440	14390	16530	17660	19050	21670	23270	12013.75	111.71
9ua	30000	17780	5463	100	11346	11952	12921	13474	13944	14841	15873	16932	20212	21164	22222	26421	28166	16547.5	118.69
9ub	19409	22980	8448	217	12384	13134	14448	14925	15810	18576	23220	24768	28656	30632	32609	34030	35306	21720.28	210.93
9ra	92999	24606	8898	140	12846	13265	14442	15060	15936	20619	24704	29058	32609	33597	34585	34861	35714	23226.3	224.82
WIM:9	221381	19434	7200	14321	8710	10420	12920	13950	14970	16970	18890	20790	22880	24080	25560	29610	32560	18357	163.37
10ua	15361	24566	9549	281	12948	13834	14940	15996	16931	18347	20635	25922	28884	31697	35892	38538	39841	22690.93	165.31
10ub	7440	27764	10393	122	13834	13834	16178	16798	17787	21095	28358	35821	37549	38184	38538	39366	39526	26188.4	219.82
10ra	22295	27881	9438	200	13834	14940	17347	18038	19076	23422	29532	34593	36181	36853	37849	39196	39526	26511.43	213.16
10rb	37049	31255	10031	315	13804	15030	18924	20916	25510	33025	36072	37681	38845	39157	39796	39980	41165	29786.28	271.42
WIM:10	53937	26517	9416	30507	12440	14180	17040	18480	19960	23160	26300	29490	32510	33900	35530	39490	41980	25138.25	247.08
11ra	99134	32504	11227	245	13944	14286	16327	20040	29644	33865	36853	39526	41237	41833	42383	42857	43505	30995.55	381.09
WIM:11	244203	25452	11208	14801	10960	12680	14630	15380	16240	19260	23390	27940	32920	35510	37770	41780	44130	24059.5	264.94
12ra	33576	39822	8324	64	18367	22005	35052	37149	39841	41833	43175	43878	44221	44821	45181	45918	47677	37705.65	408.43
WIM:12	81655	30461	10285	11206	14130	16000	19810	21920	23920	27730	31350	34190	37040	38540	40090	43940	46360	28934.5	279.77
13ur	95462	36818	11199	752	15438	16932	21169	29910	36072	41082	42829	43825	44177	44466	44821	45670	46392	35246.98	336.83
WIM:13	156061	30634	12119	32220	13830	15130	17200	18530	20250	25010	31230	36420	40090	41600	43070	46390	48500	29048.75	269.88
WIM:14	91418	29938	9465	1856	14340	16440	20330	22190	23820	27590	31220	33900	36320	37500	38870	41470	43940	28463.25	245.12
15ra	10322	37363	8408	105	18036	24900	29058	30060	32064	38076	40080	42084	43878	44589	44821	45630	46392	35504.18	269.06
WIM:15	34676	33141	9167	20936	17430	20220	24510	26330	28040	31040	33720	36320	38910	40250	41590	44940	47060	31527.25	280.99

Table 16.3 Allocation of vehicle weight distributions between TAs and road use categories.

DKW Class*	Set	Road Use †	TA No. §
3	3ua	1	28-31, 36-40 50, 54-65
		2	1-10 42-49, 51-53
		4	1-10
		9	66-73
	3ub	4	50, 54-65
	3uc	9	1-10
	3ra	6	28-31, 36-40 50, 54-65
		8	28-31, 36-40 50, 54-65
	3rb	6	11-27 32-35, 41
5	5ur	1	1-10, 28-31, 36-40 42-49, 51-53 50, 54-65
		4	50, 54-65
		6	28-31, 36-40 32-35, 41 50, 54-65
		8	28-31, 36-40 42-49, 51-53 50, 54-65
6	6ur	1	50, 54-65
		2	1-10 42-49, 51-53 50, 54-65
		4	50, 54-65
		6	11-27 28-31, 36-40 32-35, 41 50, 54-65 66-73
7	7ur	1	1-10 42-49, 51-53 50, 54-65
		6	11-27 32-35, 41 50, 54-65 66-73
8	8ur	1	1-10 28-31, 36-40 42-49, 51-53 50, 54-65
		3	1-10 28-31, 36-40
		6	11-27 28-31, 36-40 32-35, 41 50, 54-65 66-73
9	9ua	1	1-10
		3	1-10 66-73
	9ub	1	28-31, 36-40 42-49, 51-53 50, 54-65
		3	42-49, 51-53
		4	50, 54-65
	9ra	5	42-49, 51-53
		6	11-27
		8	28-31, 36-40 50, 54-65
10	10ua	1	1-10
		3	1-10 42-49, 51-53 66-73
		4	50, 54-65
	10ub	1	28-31, 36-40 42-49, 51-53 50, 54-65
	10ra	5	11-27 42-49, 51-53
		6	28-31, 36-40 66-73
		8	28-31, 36-40
	10rb	6	11-27 32-35, 41
11	11ra	5	11-27 42-49, 51-53
		6	11-27 66-73
12	12ra	6	11-27 32-35, 41
13	13ur	1	28-31, 36-40 50, 54-65
		4	50, 54-65
		5	11-27 42-49, 51-53
		6	11-27 32-35, 41 66-73
15	15ra	6	11-27

* See Table 11.4 for DKW classes; † See Table 10.1 for road use categories;
§ See Appendices 3 and 4 for lists of numbers and names of TAs.

Further comment about the reliability of the CVIU data is based on the following attributes of pooled information:

- With the exception of sets 6a3 and 12br which have abnormally low values of standard deviation, the remaining sets of standard deviation within each DKW class are relatively consistent. While these low values might be genuinely reflecting the narrowness of a weight band, this assumption is doubtful in the case of the 12br set which has the relatively low population of 64.

- The correction of CVIU data to account for officer error is quite small, with factors generally near to 1.00 and ranging between 0.82 and 1.05.

- The form of cumulative distribution of weight (shown for the 13 sets of DKW class to be similar within each set). A plateau near the mid range indicates bimodal tendency, reflecting both empty and fully laden vehicles for that class.

17. VERIFICATION OF THE NATIONAL TRAFFIC DATABASE

To verify the overall accuracy and completeness of the NTDB, independent checks can be made against:

- Annual sales of petrol,
- Annual sales of diesel fuel,
- Weights and associated distances of RUC licences purchased for individual heavy vehicles,
- Annual RUC revenue.

17.1 Petrol Consumption

17.1.1 Petrol Sales

Statistics New Zealand produces a quarterly summary, "Deliveries of petroleum fuels by industry". The information is divided into sales of petrol (tonnes) to the "domestic transport" industry and to "resellers." The total sales for the year to these two consumer sectors ending 3 June 1994 is 1,867 megatonnes or 2,524 megalitres.

17.1.2 Petrol Consumption Predicted from NTDB

Cars occupy DKW classes 1 and 2. BCHF (1994) reported that 96.1% of cars were petrol powered and, of the light trucks (DKW class 3), 35% were petrol powered.

In addition, 29% of buses (part of DKW class 4) use petrol. The total number of buses is not readily available, and it is assumed that they constitute 20% of DKW class 4. Of the other 80% of vehicles in DKW class 4, 8% use petrol.

In order to produce an estimate of petrol consumption, the rates of consumption for affected DKW classes is needed. The consumption rate for cars will clearly affect total petrol consumption.

A NZ Automobile Association survey carried out in Auckland found a mean of 8.8 litres per 100 km, and an age range of cars dating from 1985 to 1992. BCHF (1994) report that an increase in average car engine size has occurred since that time and that, with a current average capacity of 2 litres, the prediction is 8 litres per 100 km. Consequently, figures of both 8 and 9 litres per 100 km have been used in the calculation, summarised in Table 17.1.

Table 17.1 Petrol fuel consumption rates (in litres/100 km) (from BCHF 1994).

DKW Class	**Petrol Consumption** (litres/100 km)
1 and 2	8 and 9
3	9.7
4	15.5

17.1.3 Predicted versus Published Consumption

An annual petrol consumption calculated from the NTDB of 2,290 megalitres (cars: 8 litres per 100 km) and 2,406 megalitres (cars: 9 litres per 100 km) is predicted. This may be compared with the annual consumption of 2,524 megalitres by domestic transport and resellers. The NTDB therefore accounts for 91% of the consumption. .

17.2 Diesel Consumption

17.2.1 Diesel Sales

From the Statistics New Zealand quarterly summary, "Deliveries of petroleum fuels by industry", the total tonnage of diesel fuel consumed by the domestic transport industry and by resellers in the year ending 30 June 1994 was 790,957 tonnes, or 947 megalitres.

Statistics New Zealand explained that domestic transport includes depots for large trucking companies. Resellers include service stations and truck stops.

The NZ Road Transport Association advised the researchers in 1994 that most trucks would obtain their diesel supplies from truck stops, not from retail petrol service stations. Other companies have their own "fuel islands", although these are becoming less common.

If, from the above, 70% of resellers to trucks are assumed to be truck stops, and that 30% of domestic sales are to diesel vehicles, then the volume of diesel consumed by road transport is 54% of total sales, or 511 megalitres. Alternative scenarios of a 60% resellers and 20% domestic transport leads to the prediction of 363 megalitres, and with 15% of domestic sales and 50% of resellers sales a prediction of 294 megalitres.

It is, in fact, very difficult to determine how the records relate to the distribution of petrol.

17.2.2 Diesel Consumption Predicted from NTDB

Diesel powered vehicles in 1994 included 1.3% of DKW classes 1 and 2 reported in BCHF (1994), 26% of DKW class 3, 66% of buses (assumed to be 20% of DKW class 4), 92% of other two axle trucks (remainder of DKW class 4), and essentially all remaining DKW classes (classes 5 to 11).

To produce an estimate of diesel consumption, the rates of consumption for the affected classes are needed. BCHF (1994) report fuel consumption for trucks, and from this can be deduced the consumption rates listed in Table 17.2.

Table 17.2 Diesel fuel consumption rates (in litres/100 km) by DKW class.

DKW Class	**Diesel Consumption** (litres/100km)
1, 2	5.5
3	7.9
4	10.4
5, 6	15
7, 8 ,9	20
10, 11	25
12, 13	33
14, 15	43

The information in Table 17.2 when associated with the total vehicle kilometres from affected DKW classes (i.e. classes 1, 2, 3, 4) leads to a predicted diesel consumption. A result of 299.8 megalitres was calculated, 59% of the estimated value (70%:30% assumption), 83% of estimated value (60%:20% assumption) and 102% (50%:15% assumption). The spreadsheet containing the working is in unpublished material held on file PR3-0129 at TNZ Head Office, Wellington.

The NZ Road Transport Association confirms that it is very difficult to determine the distribution of diesel.

17.3 Total Distances Travelled by Heavy Vehicles

17.3.1 Distances Obtained from RUC Data

TNZ has provided a summary of the 1993/94 distances and weights purchased by individual RUC licence units. The file contains a total of 182,708 records. The information has been interrogated, and the total distance purchased for the vehicles, i.e. the prime movers excluding trailers, for the year is summarised in Table 17.3.

Table 17.3 Total distances (km) obtained from RUC licences for powered vehicles in 1993/94.

RUC Category (Powered vehicles)	**Heavy Vehicle Kilometres Travelled** (HVKT/year)
1	1,504,790,668
2	926,626,729
5	36,895,590
6	574,897,435
14	172,641,650
19	4,400,403
TOTAL DISTANCE	**3,220,252,475**

17.3.2 Distances Calculated from the NTDB

Table 17.4 shows the distances travelled for heavy vehicle classes, computed from the NTDB. This totals 1,936 million kilometres per year.

Comparison with the distance of RUC licences purchased for powered units shows that the NTDB accounts for only 60% of the distance.

The LTSA has suggested that up to 10% of total distance purchased are in the form of supplementary licences. These simply "top up" the weight limit for a distance already purchased. However, correction has already been made for this in information supplied by TNZ.

Table 17.4 Total distances (veh-km/year) calculated for DKW class from the NTDB.

DKW Class	Vehicle-km/year
3	482,302,240
4	393,314,145
5	259,382,140
6	88,298,610
7	59,436,600
8	162,280,460
9	132,782,985
10	59,524,930
11	125,318,005
12	42,059,315
13	91,805,895
14	33,367,570
15	16,424,635
TOTAL DISTANCE	**1,946,297,530**

17.4 Total Heavy Vehicle Tonne-kilometres

17.4.1 Heavy Vehicle Tonne-kilometres Obtained from RUC Data

The distance and weight file of individual vehicle records provided by TNZ has been interrogated, and the product of distance and weight for each RUC licence was summed. The result of interrogation, given in Table 17.5, is for all "weights purchased."

Table 17.5 Distribution of total weights (tonne-kilometres) between RUC categories, obtained from RUC licences in 1993/94.

RUC Category	Tonne-km/year
1	3,216,045,819
2	7,050,014,834
5	572,267,947
6	10,616,359,620
14	3,933,924,664
19	117,750,500
24	97,401,190
27	15,070,008
28	21,571,413
30	695,673,444
33	2,411,440,370
37	2,907,861,672
43	2,677,435,124
TOTAL TONNE-KILOMETRES	**34,332,816,605**

The total can be compared with the total obtained by aggregating DKW classes 3 to 15 in the NTDB.

17.4.2 Tonne-kilometres Calculated from the NTDB

In calculating the total weights by tonne-kilometres from the NTDB, the average value of weight has been used, as shown in Table 17.5. The resulting distribution of tonne-kilometres is shown in Table 17.6.

Table 17.6 Distribution of total weights (tonne-kilometres) for DKW classes, calculated from the NTDB.

DKW Class	Tonne-km/year
3	2,602,724,788
4	2,961,656,246
5	3,416,334,464
6	1,379,237,242
7	580,523,793
8	2,450,038,470
9	2,807,683,932
10	1,384,715,116
11	3,444,764,860
12	1,395,887,789
13	3,027,856,199
14	998,961,583
15	560,231,270
TOTAL TONNE-KILOMETRES	**27,010,615,753**

The NTDB accounts for 79% of actual tonne-kilometres per year. The reason for this shortfall of 21% is likely to reside mainly in the prediction of proportions of heavy vehicles. This has been caused by the limited population of field samples.

17.5 Annual RUC Revenue

17.5.1 Revenue Obtained from RUC

The total RUC revenue for the year ending June 1994 has been obtained by extrapolating the published information for 10 months in the 1994 Annual Report (p.32) of the LTSA. The figure is NZ$310,259,110, exclusive of 12.5% GST. When GST is added, and the extrapolation is made, a total revenue for the year of NZ$418.85 million results.

17.5.2 Revenue Calculated from the NTDB

A histogram was generated from the pooled vehicle weight distribution in the NTDB. From each percentile value of each heavy DKW class (3-15), the RUC (unit cost per 1000 kilometres) was calculated from published tables, which are inclusive of GST. Where more than one RUC class of vehicle fitted a DKW class, then two representative possibilities were chosen and the average revenue was calculated.

The average value of RUC was calculated from the area under the frequency distribution described by the percentiles. This calculation was performed for the weight distribution also, and compared with the mean value generated from all weight data in each set. A difference of between 4% and 9% resulted (expected value calculated from distribution was low), and this correction factor was applied to the expected value of road user charge. Table 17.7 shows the results.

Table 17.7 Distribution of RUC revenue by heavy vehicle DKW class.

DKW Class	RUC NZ $/year
3	21,766,899
4	29,120,987
5	31,197,889
6	10,378,476
7	4,631,840
8	19,980,032
9	232,626,357
10	11,798,330
11	37,404,542
12	13,343,672
13	27,109,369
14	8,179,086
15	4,570,172
TOTAL REVENUE	**NZ$ 243,107,651**

A prediction of NZ$243 million per year results. This is 58% of the actual revenue. The prediction is clearly less satisfactory than the tonne-kilometre prediction. A similar process has been used to derive information from the NTDB, differing only in that expected values of RUC were used. Uncertainty in the estimate of this variable results from the following considerations:

- The difference is probably because RUC revenue rises very rapidly even with slight increases in vehicle weight (approximately by the fourth power), and a small error in weight estimate is amplified when it is expressed as an increase in RUC charges. Thus if the average distribution of weight is slightly in error, then the error in the RUC revenue will be grossly magnified, but magnification will not be great in the case of weight alone.

- As the number of the DKW class increases, the number of corresponding RUC combinations also increases. For heavier vehicles (DKW classes 5-12), several combinations of RUC class equate to a single DKW class. The difference between alternatives can be in excess of 30%. There may also be a lack of data for the "heavy" end of the heavy vehicle weight distribution.

- The distribution of weight between RUC components of a single vehicle is not known. In calculating the RUC, the gross weight has been distributed between units in proportion to the total maximum wheel loads for each unit.

17.6 Discussion

A summary of comparisons between the sets of independent data tested, obtained from predictions using the NTDB with predictions from external sources.

Table 17.8 Comparison of predictions obtained from the NTDB and from independent data.

Item compared	Precision of prediction calculated from NTDB compared with independent data
Petrol consumption	91% of sales for domestic transport and resellers
Diesel consumption	59% to 102% of sales depending on the amounts sold to public transport by domestic transport and resellers
Heavy vehicle kilometres travelled	60% of distance of RUC licences purchased
Heavy vehicle tonne-kilometres	79% of result recorded in independent database
Road User Charges	58% of annual revenue

17.6.1 Petrol Consumption

A correlation of 91% with independent data is considered a satisfactory outcome. In defence of this, the following considerations should be borne in mind:

- Many of the ADT values in the NTDB are estimates.
- The distribution of vehicle types is based on a very limited number of samples.

17.6.2 Diesel Consumption

The correlation in this case is much less satisfactory, with a wide range of 59% to 102%. The NZ Road Transport Association advises that it is very difficult to quantify end point outlets for diesel sales, and Statistics New Zealand confirms that it is difficult to break the information down further. Therefore the main reason for the relatively poor correlation appears to be in the quality of the external data when used for this purpose, rather than with the NTDB. (Unlike petrol consumption, a more significant proportion of diesel is used for purposes other than road transport, e.g. agricultural uses, rail transport, shipping.)

17.6.3 Heavy Vehicle Kilometres

The correlation of 60% is disappointing. The main reason for the shortfall is considered to be the large quantity of classification sampling required to improve precision.

17.6.4 Heavy Vehicle Tonne-kilometres

A result of 79% correlation with the independent data is considered reasonably satisfactory. The difference between this and the 60% value probably arises from uncertainly in the weight estimate.

17.6.5 RUC Revenue

The correlation of only 58% is disappointing. RUC revenue rises very rapidly with increase in vehicle weight (approximately by the fourth power). Thus if the average distribution of weight is slightly in error, then the error in the RUC revenue will be grossly magnified. It appears that the distribution of weight between axles on a vehicle may not be well reflected in the assumptions made. There may also be a lack of data at the "heavy" end of the vehicle weight distribution for some of the DKW classes. Improvement in correlation is also likely once the full complement of vehicle classification data is available.

18. PRECISION OF ESTIMATES USING CLASSIFICATION SURVEY RESULTS

18.1 Sources of Error

The two major components of variation are Spatial (sampling) error and Temporal error. A minor component is Measurement error.

- *Spatial error* arises from the fact that only some sites (as determined from the sampling plan and subject to available resource) are measured.

- *Temporal error* arises because the counting and classifying is conducted at each site on only a single day. Variation is reduced by using the most appropriate week and day multipliers.

  Since the sites are chosen at random, the estimates of HVADT, ADT and VKT will be unbiased. The variation refers to the precision of the estimate. Thus, in terms of estimating HVADT, the overall likely error is best illustrated by example (e.g. from Hastings RCA - see Example).

- *Measurement error* will also arise from the instrument used or the operator. From the example, use of tube counts requires the introduction of an axle factor to adjust for vehicle distribution. However, effectively assessing the nature and extent of this type of error is beyond the design of this project.

Example: based on sample of 31 urban arterial sites within Hastings RCA

Spatial Error ± 10%

Temporal Error (week factor ± 5%; day factor ±10%) ±13% per sample. Thus in a sample of 31, the temporal error is approximately ±2.3%.
The mathematical basis of this calculation is contained in unpublished material on file PR3-0129, held at TNZ Head Office, Wellington.

Overall Error ±10.3%

This estimate of overall error applies to HVADT and to AADT over the unknown (i.e. uncounted) sections.

Estimation of the variation of VKT requires knowledge of the actual road section lengths of the sites in the sample. Since section length is itself variable, it must be incorporated in the estimate of variance of $VKT = \Sigma\, l_i\, ADT_i$, where l_i is the length of road section i. The effect of this will be to inflate the uncertainty, to an extent not able to be determined until the sites to be counted are chosen.

18.2 RCA Sites Measured in NAASRA Classification System

These RCA sites, measured by the NAASRA classification system, are assumed to have been counted for one week. The heavy vehicle proportions are obtained from the conversion matrices which convert NAASRA classes to DKW classes.

The estimates of precision apply **only** to the actual sites. No generalisation is feasible without the possibility of bias.

The primary error for these RCA sites is contained in the weekly factor, as it is appropriate to the week during which the site was measured.

For Urban Arterial sites, the error is approximately ±5% (which varies according to the week in the year of measurement). This error also applies to HVADT and to VKT figures for these RCA sites.

18.3 Counted Sites (volumes only)

As for the NAASRA sites, the indicative errors apply **only** to the sites in question. They cannot be generalised to uncounted sites. The errors for these sites are those of measurement. Both day factors and week factors may contribute to the error.

For Urban Arterial sites, the order of the total error is ±13%[26], and again it is dependent on actual day and week that counts are made.

Where the site has a count but an unspecified date of counting, a general (probably conservative) estimate of the week and day factor errors should be used.

No estimate of variability is obtainable for Heavy Vehicle volumes or proportions.

18.4 Uncounted Sites

The error attributable to these sites (with the least known information is that obtained from the sampling programme.

[26] See also Section 10.3 in this part 1 of the report.

18.5 Overall Precision for VKT in an RCA Road Network

The method for determining overall precision in estimating HVADT is only available from the sampling.

To determine the overall precision of estimating total VKT (which is an aggregated figure), estimation takes into account the extent of known count data kept by the RCA as well as the count data that are obtained from the sampling.

The method for evaluating total precision is contained in unpublished material on file PR3-0129, held at TNZ Head Office, Wellington. The total variance figure is a weighted average of the variances of the appropriate components.

The RCA data are divided into three components of data of different precision, namely:

- sections where *classified count* information is available,
- sections where only *volume count* (axle count) information is available,
- sections which are uncounted and for which *estimates* only are available.

The relative proportions of length in the different components will vary between RCAs. The contribution of these components to overall precision is considered in the following example.

- *Classification counts:* 10% of the RCA (as a percentage of VKT) has been measured (classified according to NAASRA systems),
- *Volume counts:* 20% of the RCA road sections have volume counts,
- *Estimates:* 70% of the VKT is uncounted,

And total VKT estimate for the RCA has an associated precision of ±5.2%.

This precision will vary according to RCA and the extent of the "known" information (counts and or classifications).

If the breakdown into the percentage split above is, for example, 0.2, 0.5, 0.3 then the overall estimate of VKT has an associated precision of around ±3.4%.

The calculations are based on the general rule that:

$$\text{Variance}\ (\Sigma a_i X_i) = \Sigma a_i^2 \text{Var}(X_i)$$

and remembering that VKT is a sum of individual VKT values (not an average).
Precisions are expressed as relative (percentage of the estimated VKT) figures.

The effect of knowing individual sample sites is assumed to be negligible in the context of the whole RCA.

18.6 Effect of Road Section Lengths on Precision of VKT Estimate

When estimating VKT, the two major components are length and count. Section 18.5 covered the precision of estimating VKT related to counts. However, the different lengths of the road sections contribute to the determination of the precision of VKT estimates based on samples. The mathematical basis of this calculation is contained in unpublished material on file PR3-0129, held at TNZ Head Office, Wellington.

As with the sampling design itself, the net effect of different road section lengths depends upon the extent of that variation. Basically the more widely dispersed the lengths, the greater is the influence on precision of VKT estimates.

Consequently the exact effect is dependent upon the RCA and upon the sampled sites. Calculation of that effect is possible when the sites for sampling are determined and the lengths of the sections in the sample are known.

19. SUMMARY

The National Traffic Database is able to provide estimates of basic traffic information, including total volume, vehicle class and weight data for the network of public roads in New Zealand, both state highways and local roads. A review of available literature reveals that no directly comparable databases have been assembled elsewhere in the world.

The methodology which has been developed and applied has produced this NTDB, which includes for each RAMM road section:

- The best available estimate of AADT,
- Categorisation of each road section by use,
- A distribution of heavy vehicle classes (by DKW system) as a proportion of AADT for each road use category,
- Distributions of heavy vehicle gross weight by road use category and by geographic locality.

Arising from this methodology is the basis for systematic upgrade of the NTDB, including:

- A pre-defined sampling plan (by RCA),
- Estimates of reliability of the data.

From the NTDB, estimates can be made for daily, yearly totals, and average values for

- Total and heavy vehicle volumes,
- Total and heavy vehicle kilometres,
- Tonne-kilometres,
- ESAL-kilometres,
- RUC revenue,

at a national and regional level. Further subdivision of some of these outputs is possible at an RCA level, as well as by vehicle class and road use categories.

The NTDB has internal consistency of measurements on a nationwide basis for traffic volumes. To improve the precision of estimate of distribution of heavy vehicles, a prepared programme of vehicle classification surveys needs to be completed. Regular updating of the NTDB is also required to ensure that it reflects changes in road networks, and changes in the nature of traffic, such as in vehicle classes, weights, and travelled road sections.

20. REFERENCES

AASHTO. 1992. *Guidelines for traffic data programs.* Joint Task Force on Traffic Monitoring Standards of the AASHTO Highway Subcommittee on Traffic Engineering. American Association of State Highway and Transportation Officials.

BCHF (Beca Carter Hollings and Ferner). 1994. *Changing energy efficiency of petroleum products in the transport sector.* Energy Efficiency and Conservation Authority. May 1994.

Cochran, W.G. 1977. *Sampling techniques.* 3rd edition. John Wiley and Sons, New York.

Ferlis, R.A., Bowman, L.A. 1981. Procedures for measuring regional VMT. *Transportation Research Record 815.* Transportation Research Board, Washington DC.

Gur, H.J., Hochermann, I. 1989. Optimal design of traffic counts. Transportation Data. *Transportation Research Record 1236.* Transportation Research Board, Washington DC.

Lee, C.E. 1990. Overview of traffic data acquisition technologies and applications. Pp.1-6 in National Traffic Data Acquisition Technologies Conference and Expo, Austin, Texas.

Levinson, H.S., Roark, A.L., Guhin, J.S. 1979. Sampling vehicle kilometres of travel. *Transportation Research Record 629.* Transportation Research Board, Washington DC.

LTSA (Land Transport Safety Authority). 1994. Annual report to 30 June 1994. Land Transport Safety Authority, Wellington, New Zealand.

Ministry of Transport (MOT). 1992. New Zealand household travel survey, July 1989 - June 1990. Traffic Research and Statistics Sections, Safety Standards Branch, Land Transport Division, Ministry of Transport, Wellington, New Zealand.

NAASRA. 1982. *Guide to traffic counting in state road authorities.* National Association of Australian State Road Authorities.

Transit New Zealand. 1991. *Project evaluation manual.* Transit New Zealand, Wellington, New Zealand.

Transit New Zealand (in prep.) Traffic stream data. Transit New Zealand Research Project PR3-0025.

Transit New Zealand. 1994. *A guide on estimating AADT and traffic growth, and a traffic count monitoring programme basis. Traffic count guideline.* Transit New Zealand, Wellington, New Zealand.

APPENDICES

APPENDIX 1. ESTIMATION OF RUC ASSOCIATED WITH EACH PAT CLASS

The vehicles in each PAT class of vehicle were divided into the RUC vehicle types based on the axle groupings. For example, an 851 PAT B-train consists of RUC vehicle type 6 for the tractor, RUC vehicle type 33 for the first triple axle semitrailer, and RUC vehicle type 29 for the second two axle semitrailer. The breakdown of all PAT types is tabulated as follows:

PAT Type	RUC Types	PAT Type	RUC Types	PAT Type	RUC Types
20	2	55	5,29	76	5,29,30
21	2	57	2,33	77	14,37
22	2	58	19	771	14,37
30	2,24	61	2,24,37	772	14,24,30
31	6	62	2,29,30	773	19,24
32	6	621	6,24,30	78	14,37
34	5	622	6,37	781	6,43
40	2,30	63	6,37	791	14,33
41	2,29	631	2,43	85	6,29,37
42	6,24	632	6,37	851	6,33,29
44	5,24	65	5,37	852	14,43
45	14	66	14,30	871	14,43
47	14	67	14,30	873	19,37
50	2,24,30	69	6,33	88	2,33,37
51	2,37	73	2,29,37	89	6,33,30
52	6,30	731	6,24,37	891	14,43
521	2,37	74	6,29,30		
53	6,29	751	6,29,29		
54	5,30	752	6,43		

Certain assumptions were made in producing the relationships. Because the PAT WIM system cannot differentiate between single tyres and twin tyres, all axles other than steer axles on trucks are assumed to be twin tyred. Hence, there are no RUC type 27 vehicles in the table.

To determine the maximum expected RUC for each PAT type, assumptions were made based on the maximum legal weights for axle groups and for the rig as a whole. These assumptions were as follows:

1. For a PAT type for each axle group, the maximum legal weight was determined. With tandem and triple axle sets the spacing of the axles determines the maximum legal weight (3 spacing ranges per set). For tandem sets the shortest spacing assumed to be the most common (from personal observation), and for the triple sets the middle (17.5 tonnes) range was the commonest.

2. For bigger rigs, the sum of the maximum legal weights for the axle groups is often greater than the maximum legal weight for the whole rig. In these cases was attempted to be distribute the maximum legal weight for the whole rig over the axle groups, based on advice received from the NZ Road Transport Association.

APPENDIX 2. SAMPLE OUTPUTS FROM VEHICLE CLASSIFIERS

A2.1 Sample Output from *VDAS* Classifier

TITLE: v35_28 cambridge st north 12/11/94
RUN 1
TIME 11:00:00
DATE 1994-11-12
C 94/11/12 COMPOSITION BY NAASRA TYPE

C TIME	LN	TOTL	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	MSPD	%FOL	85%
C12:00	1	171	149	8	9	0	2	0	2	0	0	0	0	0	1	50.4	23.3	57
C12:00	2	138	117	10	6	2	3	0	0	0	0	0	0	0	0	54.4	18.1	64
C13:00	1	139	127	4	6	1	0	0	0	1	0	0	0	0	0	52.4	10.7	61
C13:00	2	81	71	3	5	1	1	0	0	0	0	0	0	0	0	53.8	7.4	64
C14:00	1	103	98	2	2	0	0	0	1	0	0	0	0	0	0	52.2	4.8	59
C14:00	2	73	64	7	2	0	0	0	0	0	0	0	0	0	0	54.2	12.3	63
C15:00	1	97	84	5	7	0	0	0	0	0	1	0	0	0	0	53.8	7.2	64
C15:00	2	99	91	5	2	0	0	1	0	0	0	0	0	0	0	55.8	10.0	65
C16:00	1	99	93	5	1	0	0	0	0	0	0	0	0	0	0	53.6	17.1	60
C16:00	2	89	83	6	0	0	0	0	0	0	0	0	0	0	0	54.3	8.9	63
C17:00	1	124	118	3	1	0	0	0	2	0	0	0	0	0	0	52.5	10.4	60
C17:00	2	93	89	1	1	0	1	0	0	0	0	1	0	0	0	56.0	13.9	64
C18:00	1	101	94	1	3	0	0	0	2	0	1	0	0	0	0	53.2	9.8	60
C18:00	2	72	67	2	2	0	0	0	1	0	0	0	0	0	0	54.0	6.9	61
C19:00	1	89	81	2	4	0	2	0	0	0	0	0	0	0	0	53.1	10.1	64
C19:00	2	41	40	0	1	0	0	0	0	0	0	0	0	0	0	57.8	7.3	65
C20:00	1	63	61	0	1	0	0	0	1	0	0	0	0	0	0	52.8	9.5	62
C20:00	2	41	39	0	1	1	0	0	0	0	0	0	0	0	0	53.0	7.3	63
C21:00	1	40	36	2	2	0	0	0	0	0	0	0	0	0	0	52.4	2.4	60
C21:00	2	31	31	0	0	0	0	0	0	0	0	0	0	0	0	57.3	6.4	66
C22:00	1	29	26	0	2	0	1	0	0	0	0	0	0	0	0	52.2	0.0	60
C22:00	2	24	23	0	1	0	0	0	0	0	0	0	0	0	0	54.4	4.1	63
C23:00	1	30	28	2	0	0	0	0	0	0	0	0	0	0	0	52.1	9.9	60
C23:00	2	18	18	0	0	0	0	0	0	0	0	0	0	0	0	57.5	5.5	64
C00:00	1	30	30	0	0	0	0	0	0	0	0	0	0	0	0	51.1	6.6	59
C00:00	2	9	9	0	0	0	0	0	0	0	0	0	0	0	0	54.7	0.0	57
C01:00	1	20	20	0	0	0	0	0	0	0	0	0	0	0	0	49.2	9.9	56
C01:00	2	16	16	0	0	0	0	0	0	0	0	0	0	0	0	58.5	0.0	73
C02:00	1	3	3	0	0	0	0	0	0	0	0	0	0	0	0	50.1	0.0	56
C02:00	2	5	5	0	0	0	0	0	0	0	0	0	0	0	0	49.7	0.0	52
C03:00	1	5	5	0	0	0	0	0	0	0	0	0	0	0	0	59.2	0.0	58
C03:00	2	4	4	0	0	0	0	0	0	0	0	0	0	0	0	54.5	0.0	52
C04:00	1	4	4	0	0	0	0	0	0	0	0	0	0	0	0	58.4	0.0	65
C04:00	2	4	4	0	0	0	0	0	0	0	0	0	0	0	0	61.4	0.0	61
C05:00	1	6	4	0	1	1	0	0	0	0	0	0	0	0	0	55.8	0.0	64
C05:00	2	3	2	0	1	0	0	0	0	0	0	0	0	0	0	44.2	0.0	47
C06:00	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	55.2	0.0	55
C06:00	2	5	5	0	0	0	0	0	0	0	0	0	0	0	0	57.3	0.0	61
C07:00	1	12	12	0	0	0	0	0	0	0	0	0	0	0	0	53.8	0.0	58
C07:00	2	25	21	3	1	0	0	0	0	0	0	0	0	0	0	57.9	3.9	67
C08:00	1	19	18	0	1	0	0	0	0	0	0	0	0	0	0	50.8	0.0	58
C08:00	2	19	17	0	2	0	0	0	0	0	0	0	0	0	0	54.8	10.5	61
C09:00	1	47	46	0	1	0	0	0	0	0	0	0	0	0	0	52.0	6.3	58
C09:00	2	41	38	1	2	0	0	0	0	0	0	0	0	0	0	57.4	0.0	68
C10:00	1	99	90	4	1	2	0	0	1	0	0	0	0	0	1	50.6	14.1	58
C10:00	2	70	64	3	2	1	0	0	0	0	0	0	0	0	0	52.9	7.1	60
C11:00	1	81	79	0	1	0	1	0	0	0	0	0	0	0	0	49.8	11.1	58
C11:00	2	83	73	4	4	0	1	0	0	1	0	0	0	0	0	52.6	9.6	61
C12:00	1	95	83	7	3	0	1	0	1	0	0	0	0	0	0	48.6	12.6	56
C12:00	2	108	101	3	3	0	0	1	0	0	0	0	0	0	0	51.7	9.2	59
C13:00	1	91	81	5	4	0	0	0	0	0	1	0	0	0	0	50.7	14.2	59

C13:00	2	150	140	2	1	0	1	2	2	1	0	0	0	0	1	51.5	13.9	60
C14:00	1	100	94	4	0	1	0	0	0	1	0	0	0	0	0	49.7	15.9	56
C14:00	2	133	124	6	2	0	0	0	1	0	0	0	0	0	0	52.2	18.7	61
C15:00	1	124	112	6	3	1	1	0	0	0	0	0	0	0	1	51.1	12.0	58
C15:00	2	97	84	7	4	1	1	0	0	0	0	0	0	0	0	51.5	16.4	59
C16:00	1	150	133	9	4	0	2	0	2	0	0	0	0	0	0	49.2	19.3	58
C16:00	2	85	73	4	5	1	0	0	0	0	0	0	0	0	2	55.2	17.6	63
C17:00	1	134	123	5	4	0	0	0	1	1	0	0	0	0	0	50.7	14.1	58
C17:00	2	64	61	1	1	1	0	0	0	0	0	0	0	0	0	52.8	10.9	59
C18:00	1	87	83	1	2	0	0	0	1	0	0	0	0	0	0	51.2	11.4	58
C18:00	2	75	72	0	2	0	0	0	1	0	0	0	0	0	0	56.4	14.6	66
C19:00	1	106	99	1	2	2	1	0	1	0	0	0	0	0	0	52.0	14.1	59
C19:00	2	38	34	1	2	0	0	0	1	0	0	0	0	0	0	53.6	7.8	61
C20:00	1	52	49	1	1	0	0	0	0	0	1	0	0	0	0	52.9	5.7	63
C20:00	2	41	41	0	0	0	0	0	0	0	0	0	0	0	0	55.0	0.0	64
C21:00	1	32	31	0	1	0	0	0	0	0	0	0	0	0	0	51.2	9.3	61
C21:00	2	33	31	0	2	0	0	0	0	0	0	0	0	0	0	52.5	6.0	61
C22:00	1	18	18	0	0	0	0	0	0	0	0	0	0	0	0	47.5	0.0	57
C22:00	2	15	15	0	0	0	0	0	0	0	0	0	0	0	0	56.7	0.0	68
C23:00	1	19	19	0	0	0	0	0	0	0	0	0	0	0	0	52.5	0.0	61
C23:00	2	10	10	0	0	0	0	0	0	0	0	0	0	0	0	54.7	0.0	66
C00:00	1	17	16	0	1	0	0	0	0	0	0	0	0	0	0	55.7	5.8	58
C00:00	2	4	4	0	0	0	0	0	0	0	0	0	0	0	0	51.7	0.0	54
C01:00	1	2	1	0	1	0	0	0	0	0	0	0	0	0	0	43.2	0.0	52
C01:00	2	4	3	0	1	0	0	0	0	0	0	0	0	0	0	60.8	0.0	68
C02:00	1	2	1	0	1	0	0	0	0	0	0	0	0	0	0	54.7	0.0	77
C02:00	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	73.0	0.0	79
C03:00	1	3	3	0	0	0	0	0	0	0	0	0	0	0	0	40.0	0.0	46
C03:00	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	59.2	0.0	59
C04:00	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	57.3	0.0	57
C04:00	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	72.2	0.0	72
C05:00	1	2	1	0	1	0	0	0	0	0	0	0	0	0	0	52.5	0.0	54
C05:00	2	8	7	0	1	0	0	0	0	0	0	0	0	0	0	53.1	12.5	61
C06:00	1	8	4	1	3	0	0	0	0	0	0	0	0	0	0	55.5	0.0	63
C06:00	2	19	18	0	1	0	0	0	0	0	0	0	0	0	0	61.8	5.2	68
C07:00	1	25	21	2	1	0	0	0	0	0	0	1	0	0	0	58.4	0.0	67
C07:00	2	43	40	1	2	0	0	0	0	0	0	0	0	0	0	58.9	2.3	70
C08:00	1	70	61	1	4	0	1	0	1	0	0	1	0	0	1	49.8	12.8	58
C08:00	2	121	111	4	4	2	0	0	0	0	0	0	0	0	0	54.3	9.9	63
C09:00	1	165	123	11	11	2	5	0	1	0	2	3	0	0	7	52.3	24.2	59
C09:00	2	136	117	3	6	0	1	2	2	0	2	0	1	0	2	52.3	21.3	61
C10:00	1	152	129	6	7	0	1	0	2	2	0	2	0	0	3	49.1	17.7	58
C10:00	2	120	112	1	5	0	0	0	1	0	0	0	0	0	1	52.8	10.8	61

V:	TIME	DATE	LANE	CLASS	AXLES	KM/H	HEADWAY	LENGTH		
V	11:00:32	94/11/12	1	7	4	46.87	29.892	8736	WB 1	2773
									WB 2	3919
									WB 3	2044
V	11:03:14	94/11/12	1	3	2	43.37	8.446	3180	WB 1	3180
V	11:04:08	94/11/12	1	2	3	50.13	20.385	6448	WB 1	2646
									WB 2	3802
V	11:04:30	94/11/12	2	2	3	60.40	6.710	6106	WB 1	2952
									WB 2	3154
V	11:06:02	94/11/12	2	2	3	67.16	54.790	5521	WB 1	2499
									WB 2	3022
V	11:07:46	94/11/12	1	3	2	64.51	3.362	3082	WB 1	3082
V	11:08:19	94/11/12	2	3	2	22.81	4.996	3073	WB 1	3073
V	11:09:13	94/11/12	2	5	4	25.97	0.919	3814	WB 1	1305
									WB 2	1233
									WB 3	1276
V	11:10:45	94/11/12	2	3	2	37.34	5.555	3257	WB 1	3257
V	11:11:05	94/11/12	2	3	2	39.47	12.442	3015	WB 1	3015
^									WB 2	1773

Remainder of individual data

v 9 END FILE

A2.2 Sample Output from *ARCHER* Classifier

```
DP ARCHER 400 VERSION 4.0 13 Jan 1993
   94/12/06 19:05:49  BATTERY   OK
   CONFIGURATION = 66
   CLASSIFICATION SCHEME = GRCS-05
   SITE PARAMETERS :        SITE NUMBER = 51429001
   1. TUBE SEP   = 100 CM   2. MIN SPEED = 005 KPH   3. MAX SPEED= 200 KPH
   4. MIN AX SEP= 050 CM    5. MAX AX SEP= 0500 CM   6. % SPEED VAR = 03%
   7. INTERVAL   = 60 MIN
*BEGIN 66 01 51429001 0060 8 9.9 1 2
*CLASS          01   02   03   04   05   06   07   08   09   10   11   12   13
941204 1700 1 0001 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941204 1700 2 0087 0001 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941204 1800 1 0001 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941204 1800 2 0076 0001 0001 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941204 1900 1 0001 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941204 1900 2 0091 0000 0000 0000 0000 0000 0001 0000 0000 0000 0000 0000 0000
941204 2000 1 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941204 2000 2 0047 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941204 2100 1 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941204 2100 2 0033 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941204 2200 1 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941204 2200 2 0016 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941204 2300 1 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941204 2300 2 0018 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941204 2400 1 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941204 2400 2 0005 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941205 0100 1 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941205 0100 2 0003 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941205 0200 1 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941205 0200 2 0001 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941205 0300 1 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941205 0300 2 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941205 0400 1 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941205 0400 2 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941205 0500 1 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941205 0500 2 0001 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941205 0600 1 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941205 0600 2 0010 0000 0002 0000 0000 0000 0000 0000 0000 0000 0000 0000 0001
941205 0700 1 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941205 0700 2 0025 0001 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941205 0800 1 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941205 0800 2 0070 0001 0000 0000 0000 0000 0002 0000 0000 0000 0000 0000 0000
941205 0900 1 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941205 0900 2 0159 0003 0000 0001 0001 0000 0000 0000 0000 0000 0000 0000 0003
941205 1000 1 0001 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941205 1000 2 0119 0001 0001 0001 0000 0000 0000 0000 0000 0000 0000 0000 0000
941205 1100 1 0002 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941205 1100 2 0126 0002 0002 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941205 1200 1 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941205 1200 2 0131 0002 0001 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941205 1300 1 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941205 1300 2 0099 0001 0001 0001 0000 0000 0001 0000 0000 0000 0000 0000 0000
941205 1400 1 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941205 1400 2 0152 0002 0002 0000 0001 0000 0000 0000 0000 0000 0000 0000 0000
941205 1500 1 0001 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941205 1500 2 0115 0003 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941205 1600 1 0003 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
```

```
941205 1600 2 0166 0001 0003 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941205 1700 1 0002 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941205 1700 2 0143 0001 0001 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941205 1800 1 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941205 1800 2 0125 0001 0002 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941205 1900 1 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941205 1900 2 0094 0001 0001 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941205 2000 1 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941205 2000 2 0077 0004 0000 0000 0000 0000 0001 0000 0000 0000 0000 0000 0000
941205 2100 1 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941205 2100 2 0060 0003 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941205 2200 1 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941205 2200 2 0043 0000 0000 0000 0000 0000 0001 0000 0000 0000 0000 0000 0000
941205 2300 1 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941205 2300 2 0017 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941205 2400 1 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941205 2400 2 0003 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941206 0100 1 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941206 0100 2 0005 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941206 0200 1 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941206 0200 2 0002 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941206 0300 1 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941206 0300 2 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941206 0400 1 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941206 0400 2 0001 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941206 0500 1 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941206 0500 2 0003 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941206 0600 1 0001 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941206 0600 2 0013 0000 0002 0000 0000 0000 0000 0000 0000 0000 0000 0000 0001
941206 0700 1 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941206 0700 2 0029 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941206 0800 1 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
941206 0800 2 0074 0001 0001 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
*CLASS         01   02   03   04   05   06   07   08   09   10   11   12   13
*END   66 01 51429001 0060 8 9.9 1 2
***EOF
```

APPENDIX 3. LIST OF TERRITORIAL AUTHORITIES

1 FAR NORTH	26 WHAKATANE	51 MARLBOROUGH
2 KAIPARA	27 GISBORNE	52 NELSON CITY
3 WHANGAREI	28 CENTRAL HAWKE'S BAY	53 TASMAN
4 AUCKLAND	29 HASTINGS	54 ASHBURTON
5 FRANKLIN	30 NAPIER	55 BANKS PENINSULA
6 MANUKAU	31 WAIROA	56 CHRISTCHURCH
7 NORTH SHORE	32 NEW PLYMOUTH	57 HURUNUI
8 PAPAKURA	33 SOUTH TARANAKI	58 MACKENZIE
9 RODNEY	34 STRATFORD	59 SELWYN
10 WAITAKERE	35 HOROWHENUA	60 TIMARU
11 HAMILTON	36 MANAWATU	61 WAIMAKARIRI
12 HAURAKI	37 PALMERSTON NORTH	62 WAIMATE
13 MATAMATA-PIAKO	38 RANGITIKEI	63 BULLER
14 OTOROHANGA	39 RUAPEHU	64 GREY
15 SOUTH WAIKATO	40 TARARUA	65 WESTLAND
16 TAUPO	41 WANGANUI	66 CENTRAL OTAGO
17 THAMES-COROMANDEL	42 CARTERTON	67 CLUTHA
18 WAIKATO	43 KAPITI COAST	68 DUNEDIN
19 WAIPA	44 LOWER HUTT	69 QUEENSTOWN LAKES
20 WAITOMO	45 MASTERTON	70 WAITAKI
21 KAWERAU	46 PORIRUA	71 GORE
22 OPOTIKI	47 SOUTH WAIRARAPA	72 INVERCARGILL
23 ROTORUA	48 UPPER HUTT	73 SOUTHLAND
24 TAURANGA	49 WELLINGTON	
25 WESTERN BAY OF PLENTY	50 KAIKOURA	

APPENDIX 4. LIST OF REGIONS

1	FAR NORTH
2	AUCKLAND
3	HAMILTON
4	ROTORUA
5	GISBORNE
6	HAWKE'S BAY
7	NEW PLYMOUTH
8	WANGANUI-MANAWATU
9	WELLINGTON
10	NELSON-MARLBOROUGH*
11	CHRISTCHURCH
12	WEST COAST
13	OTAGO
14	SOUTHLAND

* Unitary authorities that have been grouped for the purpose of compiling the NTDB.