METHODOLOGIES FOR ESTIMATING AND CHARACTERIZING TRUCK VOLUMES ON RURAL HIGHWAYS

BY

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A Thesis
Submitted to the Faculty of Graduate Studies
In Partial Fulfillment of the Requirements
For the Degree

MASTER OF SCIENCE

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University of Manitoba
Winnipeg, Manitoba

THE UNIVERSITY OF MANITOBA

FACULTY OF GRADUATE STUDIES

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ABSTRACT

The research develops and applies methodologies and new information systems for estimating and characterizing truck volumes on Manitoba highways. Monitoring and understanding truck volumes is critical for highway planning, design, and management functions.

The thesis provides a systematic analysis of truck volumes using truck data developed through the period 1993 to 2003 inclusive for Manitoba provincial highways. It develops methods and related criteria for screening and editing truck data, and creates a detailed understanding of annual average daily truck traffic (AADTT), temporal variations, and classification mix of truck volumes.

A subsystem of the University of Manitoba Transport Information Group (UMTIG)-Manitoba Truck Planning Network (Tang, Minty and Han, 2003) is developed and uniquely segmented for purposes of truck volume estimation and characterization for the year 2002.

Three methods are developed and applied for the estimation of truck volumes: (1) direct measurement method; (2) transferring method; and (3) base Manitoba truck volume method. Truck volumes on different highway segments are characterized by temporal variations and classification mix through the assignment of control stations and truck traffic pattern groups developed in this research.

The 2002 AADTT estimates are assigned to different quality measurements based on the estimating methods and data sources used for the estimation. The quality measurements, coupled with truck volume classes, are used to develop a rating system for evaluating AADTT estimates on Manitoba highways. The information produced by this rating system is critical for decision-making process and allocation of resources for the highway system.

The results produced by the application of these methodologies present significant findings of truck volumes in the subsystem network. The truck-kilometers of travel (TKT) for the network grew from 455 million in 1999 to 524 million in 2002. The highway segments in the subsystem network are also prioritized (with five different levels of priority) for improvement in truck volumes estimation based on the rating of AADTT estimates.

The creation of this new system for truck volume estimation and characterization will facilitate decision-making about highway planning, design, and management functions.

ACKNOWLEDGEMENTS

I want to express my sincere gratitude to my advisor, Professor Alan Clayton, P.Eng., for his help, patience, guidance, and encouragement during the process of making this thesis a reality. I am also grateful to my fellow graduate students at the University of Manitoba Transport Information Group for all their support: Kai Han, Scott Minty, Mitchell Jacobson, Ana Malbasa, Jennifer Malzer, and Jonathan Regehr.

I am extremely grateful to officials and engineers from Manitoba Transportation and Government Services, and the Manitoba Transportation Traffic Engineering Branch for providing me with valuable opportunities and tremendous insights during the course of this research. I would like to express my gratitude to Mr. Ben Rogers, Mr. Glenn Cuthbertson, Mr. Willmar Skrumeda, Mr. Jim Irving, and special thanks to Mr. Craig Lobban for providing valuable data throughout the analysis process.

My sincere thanks to the individuals who provided me with the help and continuous support that I needed to complete this thesis – Mr. Ian Clayton, Mr. Edward Lemke, and Dr. Jeannette Montufar, P.Eng.

Finally, but most importantly, I want to thank God, my family, brothers and sisters at the Winnipeg Chinese Mennonite Church, for their endless love, moral support, and encouragement.

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GLOSSARY OF TERMS

AADT	Annual Average Daily Traffic
AADTT	Annual Average Daily Truck Traffic
AADWTT	Annual Average Days of the Week Truck Traffic
AASHTO	American Association of State Highway and Transportation Officials
ADTT	Average Daily Truck Traffic
AVC	Automatic Vehicle Classifier
FHWA	United States Federal Highway Administration
GIS	Geographic Information System
GVW	Gross Vehicle Weight
MADTT	Monthly Average Daily Truck Traffic
MTPN	UMTIG-Manitoba Truck Planning Network
MHTIS	Manitoba Highway Traffic Information System
MHTTIS	Manitoba Highway Truck Traffic Information System
PR	Provincial Road
PTH	Provincial Trunk Highway
RTAC	Roads and Transportation Association of Canada
TKT	Truck-Kilometers of Travel
TS&W	Truck Size and Weight
TTPG	Truck Traffic Pattern Group
UMTIG	University of Manitoba Transport Information Group
VKT	Vehicle-Kilometers of Travel
WIM	Weigh-in-Motion

CHAPTER 1

INTRODUCTION

1.1 THE RESEARCH

The research develops and applies methodologies and new information systems for estimating and characterizing the volume aspects of truck traffic on rural highways. Volume considerations of specific interest are: annual average daily truck traffic (AADTT); truck-kilometers of travel (TKT); temporal characteristics of the AADTT; and truck classification mix.

The research is a fundamental part of a comprehensive program to design, develop and implement the Manitoba Highway Truck Traffic Information System (MHTTIS). This program is a partnership between Manitoba Transportation and Government Services (MTGS) and the University of Manitoba Transport Information Group (UMTIG, 2001).

The research utilizes traffic databases developed through the period 1993 to 2003 inclusive for Manitoba provincial highways, and for major connecting routes. The geographical scope of the research focuses on dominant truck routes in the UMTIG-Manitoba Truck Planning Network (Tang, Minty and Han, 2003), which is itself a subset of the provincial highway system accounting for nearly 90 percent of TKT in the province (based on 1999 data). The dominant truck routes are uniquely segmented in the research for purposes of truck volume estimation and characterization for the year 2002. Methodological guidelines recommended in the United States Federal Highway

Administration (FHWA) Traffic Monitoring Guide (U.S. DOT, 2001) are utilized throughout the research where practical and appropriate.

1.2 NEED AND BACKGROUND

Accurate knowledge and understanding of truck traffic is needed for a variety of highway planning, design, and management functions. Specific areas of need include pavement engineering (Van Cauwenberghe, 1997), planning and programming, traffic engineering, road use management, design and evaluation of compliance programs, performance analysis, and bridge design and management (Tang et al., 2003). Measurement, estimation and characterization of truck volumes are basic requirements to service these needs.

Truck volume estimates have often been criticized by researchers. Weinblatt (1996) argues that procedures used to estimate truck volumes without any seasonal or day-of-week adjustment may contribute to substantial overestimates of AADTT and truck Vehicle Miles of Travel (VMT) -- by 25 to 40 percent for combination trucks. Hallenbeck et al. (1997) have argued that because truck volumes vary in time and space in much different ways than non-truck traffic, truck volume estimates should be addressed using separate and unique procedures than those for general traffic. Sharma et al. (1998) observe that truck traffic is consistently and substantially overestimated when truck counts are estimated using adjustment factors obtained from total traffic volumes.

In this research, a truck is defined as a vehicle contained within the group defined by classes 5 to 13 inclusive of the U.S. Federal Highway Administration's (FHWA) 13-Category Classification system (U.S. DOT, 2001). For most practical purposes in Manitoba, these are heavy and/or large single unit trucks (with 2 or 3, and sometimes 4, axles), tractor-single semitrailer combinations (nearly always having 5 or 6 axles), and double trailer combinations (having 7 or more axles).

Over the past decade, new technologies have increasingly allowed for easier, less costly and more objective acquisition of raw truck volume data over large geographical areas. In Manitoba, an extensive network of Automated Vehicle Classifier (AVC) and Weigh-In-Motion (WIM) sites has been implemented over the past five years (Tang et al., 2002). During the course of this research, the raw data produced by this network has been coupled with traditional visual classification counts at intersections, data from automated sites in adjacent jurisdictions, and the Bureau of Transportation Statistics (BTS) U.S.-Canada Border Crossing database to produce a core truck volume database for highways in Manitoba (UMTIG, 1998). While this core database will be expanded and strengthened in the coming years, its content as of 2002 has made this research possible.

1.3 OBJECTIVES

Specific objectives of this research are:

1. To understand current methods and information sources used for estimating and characterizing truck volumes, and their strengths and limitations. This requires a comprehensive environmental scan of the literature and jurisdictional practices relevant to the research, as well as critical consideration of current and past approaches used in Manitoba.

2. To conduct a systematic analysis of the volume aspects of the new truck traffic core database created for Manitoba's provincial highway system, and to establish standard procedures for such analysis. This analysis requires: (1) interpreting, screening and cleaning field-based raw data; (2) reality-checking and quality control; (3) design and/or definition of standardized analytical procedures, templates, and outcome expectations; (4) conduct of the analysis; (5) statistical assessments; (6) comparative analyses; and (7) practical verifications. Results of this analysis provide the new information sources required for the research.

3. To identify those components of the Manitoba provincial highway system which together account for more than two-thirds of truck-kilometers of travel in the province using the 1999 AADTT estimates. These components are selected from the UMTIG-Manitoba Truck Planning Network (Tang, Minty and Han, 2003), and define the geographical scope of the research.

4. To segment this subset of the UMTIG-Manitoba Truck Planning Network for purposes of truck volume estimation and characterization. These truck volume segments are unique, but can be logically related to both the provincial highway control section system and the total traffic volume segment system used for general traffic estimates (MHTIS, 2003).

5. To research, select, and prescribe methodologies for estimating and characterizing truck volumes on rural highways.

6. To apply the methodologies (from Objective 5) and information systems (from Objective 2) to estimate and characterize truck volumes on the truck volume segments defined in Objective 4.

7. To recommend further research and development requirements.

1.4 RESEARCH CONSIDERATIONS

The following requirements were essential to the conduct of this research:

1. Assistance in the creation of the core database required for the research. This was made feasible by my work as Project Engineer in Training (EIT) and Manager of the Manitoba Highway Traffic Information System through the period 2000-2003.

2. Field inspections of truck traffic on most major provincial highways in Manitoba through the period 2001 to 2003 inclusive. The inspections were normally done in the company of trucking experts. The inspections provided a practical understanding of trucking, trucks, truck traffic, the effects of relevant regulations, and freight movement considerations. At the same time, they provided

opportunities to consider the importance of individual highway segments and the structure of the highway network in servicing truck traffic in the province.

3. Regular professional interaction and communication with technical field staff and engineers in Manitoba Transportation and Government Services, including field inspections involving placement and calibration of AVC and WIM equipment.

4. Experience with database creation, field inspections, and regular interaction with knowledgeable professionals, coupled with active participation in relevant symposia and conferences in Canada and the United States, and continuous involvement in the traffic component of Strategic Highway Research Program (SHRP/C-SHRP) and Long-Term Pavement Performance (LTPP) activities in Manitoba and elsewhere. This provided practical insights and inputs into the research which made it possible to transfer and translate vast databases into useful information.

5. Utilization of the Manitoba Highway Single Centerline spatial database platform (Han, 2003), and the specialized geographic information systems for transportation (GIS-T) and database software used for traffic information system analysis and synthesis in Manitoba (TransCAD, Maptitude, Intergraph Geomedia, Paradox). This GIS platform is fully integrated with other spatial database files from adjacent jurisdictions. Understanding the structure of this spatial file is critical to the design and implementation of a truck traffic information system which can operate easily and efficiently on a GIS-T platform.

6. Analysis and design of the UMTIG-Manitoba Truck Planning Network (Tang, Minty, and Han, 2003). The network accounts for about 55 percent of route kilometers in the province, and nearly 90 percent of truck kilometers of travel. It is from this network that a sub-system is selected for the detailed truck volume estimation and characterization undertaken in the research.

1.5 THESIS ORGANIZATION

The thesis is comprised of seven chapters. Chapter 2 discusses the findings from a comprehensive environmental scan of the literature and jurisdictional practices on estimating and characterizing truck volumes.

Chapter 3 describes the development of the UMTIG-Manitoba Truck Planning Network, and the sub-system of the UMTIG-MTPN selected for the geographical scope of this research.

Chapter 4 describes the development of a truck volume core database for the Manitoba Highway Truck Traffic Information System (MHTTIS), and the methodology and standard procedures for the systematic analysis of truck volume data.

Chapter 5 presents the methodologies used to estimate and characterize truck volumes on Manitoba Highways. This involves developing truck traffic pattern groups (TTPGs) and the assignment of truck volume segments to appropriate control stations and TTPGs.

Chapter 6 discusses the application of methodologies and information systems developed in the research, which produce the truck volume estimates and characteristics on highway segments created inside the sub-system of the UMTIG-MTPN. These estimates are evaluated using a rating system developed as part of the thesis.

Chapter 7 presents the conclusions and recommendations of this research.

CHAPTER 2
TRUCK VOLUME ESTIMATION AND CHARACTERIZATION

This Chapter presents findings from a comprehensive environmental scan concerning the research. The environmental scan consists of two parts, a review of relevant literature and a survey of practices in key jurisdictions for estimating and characterizing truck volumes. The Chapter describes the environmental scan, discusses the findings from the literature review for vehicle classification system, and the methodologies recommended for estimating and characterizing truck volumes. It also summarizes the results of survey with six highway agencies for their truck traffic monitoring practices, vehicle classification systems, and the algorithms for truck volume estimation, considering jurisdictional differences in Canada and the United States.

2.1 ENVIRONMENTAL SCAN

The environmental scan consists of a literature review and jurisdictional survey on current methods used for estimating and characterizing truck volumes, and their strengths and limitations. This was facilitated by active participation in professional conferences and symposia related to truck traffic monitoring and information systems, and regular interaction with traffic-related SHRP/C-SHRP, LTPP officials and engineers from different highway agencies regarding truck traffic monitoring and truck data issues.

Thirteen documents were selected for the literature review. The selected documents are listed in the bibliography. The literature search involved: (1) engineering periodicals and journals; (2) readily-available research papers and texts; (3) conference proceedings; (4)

manuals; and (5) guidelines. The search and survey involved the agencies shown in the following.

Professional Associations/Affiliations

- U.S. Transportation Research Board, including Conference Proceedings
- Institute of Transportation Engineers Conference Proceedings
- North American Travel Monitoring Exhibition and Conference Proceedings
- Transportation Association of Canada
- Geographic Information System for Transportation Symposium Proceedings

Government Agencies

- U.S. Federal Highway Administration
- American Association of State Highway and Transportation Officials
- Manitoba Transportation and Government Services
- Saskatchewan Highways and Transportation
- British Columbia Ministry of Transportation
- Washington Department of Transportation
- Minnesota Department of Transportation
- Texas Department of Transportation

Scientific/Engineering Journals

- Institute of Transportation Engineers Journal
- Transportation Research Record Journal
- Computing in Civil Engineering Journal
- Canadian Society of Civil Engineering Journal
- American Society of Civil Engineering Journal

2.2 VEHICLE CLASSIFICATION SYSTEM

At the heart of truck traffic monitoring is the objective to gather enough information on travel patterns of important vehicle types to accurately portray the traffic stream in a way that meets the needs of users (U.S. DOT, 2001). In this case, what is a "truck"?

Many systems are used to classify vehicles by configuration. Details of classification systems used in Canada are presented in Clayton et al. (2000). The classification systems used in the United States are the Federal Highway Administration's (FHWA) 13-Category Classification system (common in parts of Canada) and the system that is used in the U.S. Comprehensive Truck Size and Weight Study (U.S. DOT, 2000). These classification systems vary according to different data collection algorithms and reporting needs. The key is that users must understand how the different classification systems relate to one another.

In this research, a truck is defined as a vehicle contained within the group defined by classes 5 to 13 inclusive of the U.S. FHWA 13-Category Classification system (U.S. DOT, 2001) – see Table A.1 of Appendix A.

Recent research (Hallenbeck et al., 1997 and Clayton et al., 2000) recommends truck traffic monitoring programs concentrate on attempting to classify vehicles into four categories: (1) non-trucks (cars and light pick-ups, classes 1 to 4); (2) single-unit trucks (classes 5 to 7); (3) single-trailer trucks (classes 8 to 10); and (4) multi-trailer trucks (classes 11 to 13). Each of these categories is a simple aggregation of existing FHWA 13 classes. These higher aggregations are recommended for the following reasons:

- They are readily understood by the public and users.
- In many cases, the traffic patterns for some vehicle classes are very similar, and aggregating the FHWA classes facilitates a simplified explanation of the results (Hallenbeck et al., 1997).

- Modern Automated Vehicle Classifier equipment often has difficulty differentiating among specific vehicle types (e.g., class 2, 3, and 5). The data are more accurately treated at a more aggregated level (Hallenbeck et al., 1997).

- These four groupings of vehicles provide more statistically reliable truck volume counts for many analyses, because some FHWA categories of vehicles contain so few vehicles that it is not possible to count and accurately report them. When volumes within a vehicle class are low, the adjustment factors computed for those vehicle categories become unstable and inaccurate (U.S. DOT, 2001).

2.3 TRUCK VOLUMES ESTIMATION

Truck traffic is typically characterized in terms of volume (per unit time), seasonal, day-of-week, and time-of-day variations, and vehicle classification mix (by configuration) (Montufar, 2002). Traditionally, little of the truck traffic information has been systematically collected and/or analyzed. Thus, truck travel patterns are often not well understood at the state/province and individual roadway level.

Truck traffic monitoring programs are designed to estimate the volume of truck traffic on the road network. Each road in the network is divided into a number of sections such that truck volumes in any one section remain relatively constant. The following presents a summary of procedures for estimating AADTT recommended by recent research (Weinblatt, 1996 and Hallenbeck et al., 1997) and the U.S. Department of Transportation (2001). The general procedures distinguish two major categories of highway sections and use different procedures to estimate AADTT on highway sections in these two categories:

- sections that contain permanent classification counters
- sections on which short-term classification counts are collected periodically

2.3.1 Sections Containing Permanent Classification Counters

For highway sections containing permanent classification counters, there are two basic procedures used to estimate the annual average daily truck traffic: (1) a simple average of all days; and (2) an average of averages (the AASHTO method).

In the first technique, AADTT is computed as the simple average of all 365 days in a given year. When days of data are missing, the denominator is reduced by the number of missing days. This approach has the advantage of being simple and easy to program. Its drawbacks come from the fact that missing data can cause biases (and thus inaccuracy) in the AADTT estimates produced. For example, on a heavy summer truck route, missing data from June 15th through July 15th would likely result in an underestimation of the true AADTT for that road.

AASHTO adopted a different approach for calculating AADTT (AASHTO, 1992). This is shown mathematically in the following equation:

$$AADTT_c = \frac{1}{7}\sum_{i=1}^{7}\left[\frac{1}{12}\sum_{j=1}^{12}\left(\frac{1}{n}\sum_{k=1}^{n}ADTT_{ijkc}\right)\right] \qquad \text{(Eq. 2.1)}$$

Where c = the vehicle class for which the statistic is being computed

k = 1 when the day is the first occurrence of that day of the week in a month, 4 when it is the fourth day of the week

j = month of the year (January to December)

i = day of the week (Monday to Sunday)

n = the number of days of that day of the week during that month (usually between 1 and 5, depending on the calendar and the number of missing days).

$ADTT_{ijkc}$ = average daily truck traffic for vehicle class c, day k, of day-of-week i, and month j

$AADTT_c$ = annual average daily truck traffic for vehicle class c

The AASHTO approach first computes seven averages, corresponding to the 7 days of the week, for each month of the year for each vehicle class. These monthly average days of the week truck traffic (MADWTT) are averaged across all 12 months to yield a single set of seven annual average days of the week truck traffic (AADWTT). These seven values are then averaged to yield the AADTT. This method explicitly accounts for missing data by weighting each day of the week the same, and each month the same, regardless of how many counts are actually present within that category.

Wright et al. (1997) discovered that the differences between these two versions of AADTT estimates are so small as to be unimportant when the data set is complete or when little bias is present in the missing data. However, the AASHTO method is recommended by the U.S. DOT (2001) and is used in this research because it allows factors to be computed consistently even when a considerable number of data are missing from a year at a site.

2.3.2 Sections Containing Short-Term Classification Counts

This category of highways consists of sections on which short-term classification counts are collected on a regular basis. These sections should be distributed across functional systems and traffic volume groups to provide a minimum level of traffic information on all roads under control of the highway agency.

The duration of short-term classification counts is recommended to be 48 consecutive hours (U.S. DOT, 2001). The raw 48-hour classification count by itself does not provide accurate annual estimates of truck traffic and, if the counts are taken on weekdays, the estimates for trucks are likely to be quite high (Weinblatt, 1996). Therefore the AADTT should be derived by applying seasonal and day-of-week factors to the raw counts.

2.3.3 Adjustment Factors for Short-Term Classification Counts

Highway agencies need a set of continuously operating classification counters to measure truck travel patterns within each type of roadway they operate and maintain. From this, the counters can be used to create adjustment factors and factor groups for converting short-term classification counts into better estimates of AADTT.

These factors are recommended to be computed only for three or four "generalized" vehicle classes (Hallenbeck et al., 1997 and U.S. DOT, 2001): (1) non-trucks (passenger vehicles and light pick-ups); (2) single-unit trucks; (3) single-trailer trucks; and (4) multi-trailer trucks.

The reasons for grouping vehicles into these aggregated classes are discussed in section 2.2. The following two procedures are recommended for developing the expansion factors: (1) the use of "roadway specific" factors; and (2) an extension of the traditional traffic volume factoring process (determination of "like roadway" groups and the development of "average factors" for each of those groups) (U.S. DOT, 2001).

Roadway Specific Factors

The roadway specific approach requires the highway agency to operate continuous counters on all major roads in the state/province. These counters are used to develop roadway specific adjustment factors. A short-term classification count taken on a specific road is adjusted using factors taken from the nearest continuous classification counter on that road.

This approach has the advantage of removing the majority of the "location" errors associated with applying an average factor in the computation of AADTT. The operation of road specific continuous counters also reduces the number of short-term counts that are needed, since the continuous counters provide excellent classification data for road sections near the count locations. Finally, this approach can simplify both the calculation of adjustment factors and the application of those factors because it does not require the labour-intensive task of identifying roads with similar truck travel patterns.

The major problem with this approach is that it is expensive for highway agencies to install, operate, and maintain large numbers of continuous classification counters. Secondly, some roads are quite long and change character over their length. One good example is PTH 10, which runs from the Manitoba-North Dakota border to the City of Flin Flon in northern Manitoba. The truck travel patterns change significantly on this highway because of the change in land use, and interceps with major highways (Trans Canada 1 and 16). Therefore more than one continuous counter is needed for this roadway, which not only further increases the number of continuous counters required, but also creates difficulty in selecting between permanent counters when the short-term counts in question lie between them.

In addition, because of the large number of counters required, some counters will fail at any given time. If the highway agency is not able to repair failed continuous counters quickly, they will lose the ability to develop factors for those roads. Therefore not only the maintenance cost for this approach is high, but the consequences of losing a continuous counter are much worse than with the traditional factor approach.

As a result of these problems, the U.S. DOT (2001) recommends that highway agencies use the "traditional" method described below as a "back-up" for places where a specific road factor is not available.

The Traditional Factoring Approach

The traditional factoring process involves grouping roads that "act alike" in terms of the traffic pattern that they experience. A sample of data collection locations is then selected from within each "group" of roads, and factors are computed and averaged for each of the data collection sites within a group.

Traditionally, roads are grouped by their functional class (e.g., urban, rural, collector, and recreational, etc.) and geographical location within the state/province. However, these functional classes of roadways have been shown to have a very inconsistent relationship to truck travel patterns (Hallenbeck et al., 1997). It is suggested that truck travel patterns are governed by the following factors, which should be considered when establishing the truck traffic pattern groups (U.S. DOT, 2001):

- The amount of long-distance "through" truck traffic versus the amount of short locally oriented truck traffic.
- The existence of large "point" or "area" truck traffic generators along a road, such as a factory or agricultural area.
- The presence or absence of large populations that require the delivery of freight and goods.

In addition, the highway agency should obtain information from either truck volume data collection efforts or interviews with professionals familiar with the trucking activities of specific roads, to identify road usage characteristics.

The highway agency of each state/province will need to account for its own truck travel patterns to develop the truck traffic pattern groups. For example, in Saskatchewan, five truck factor groups are identified in the highway system on the basis of the temporal truck volume patterns, vehicle type distribution, geographical location and land use information, and other knowledge of Saskatchewan roads (Thomas et al., 1997). These five truck factor groups are: (1) Inter-Provincial Routes; (2) U.S. Access Routes; (3) Provincial Routes; (4) Farm Truck Routes; and (5) Special Truck Routes.

2.3.4 Application of the AADTT Estimates

The AADTT estimates are the fundamental information for many highway planning, design and management functions. One example is the use of AADDT estimates in developing the Axle Load Spectra (ALS) for characterizing the weight of trucks. This is illustrated using the following ALS equation developed by Hajek et al. (2002).

$$ALS_{year} = \Sigma\ (AADTT_i \bullet RALS_i \bullet 365) \text{ for } i = 1..n \qquad \text{(Eq. 2.2)}$$

Where ALS_{year} = annual combined axle load spectra (for single, tandem, triple, quadruple axle groups) for a base year
$AADTT_i$ = annual average daily truck traffic of vehicle class i for a given year
$RALS_i$ = representative axle load spectrum for vehicle class i for a given year
n = number of vehicle classes i.

Note that the first term at the right side of the equation is the AADTT estimates developed using equation 2.1. Tan (2002) has calculated the ALS for the three dominant truck types (3-S2, 3-S3, and 3-S3-S2) inside Manitoba using the AADTT estimates from the permanent classification stations. By using this information, a road load rating is also developed and applied for grain transport in Manitoba (Regehr, 2002).

2.4 TRUCK TRAFFIC MONITORING IN CANADA AND THE UNITED STATES

This section summarizes the truck traffic monitoring programs currently practiced in Canada and the United States for estimating and characterizing truck volumes. The discussion is based on interviews with engineers from six highway agencies in Canada and the United States, as well as from manuals and reports produced by each Department of Transportation (DOT). The following six highway agencies were considered:

- Manitoba Transportation and Government Services
- Saskatchewan Highways and Transportation
- British Columbia Ministry of Transportation
- Minnesota Department of Transportation
- Washington Department of Transportation
- Texas Department of Transportation.

The discussion is towards understanding the following: (1) truck traffic monitoring programs and truck data sources; (2) vehicle classification systems; and (3) truck volume estimation and characterization. The following subsections discuss the details of truck traffic monitoring programs for each highway agency.

2.4.1 Manitoba Transportation and Government Services

Truck traffic monitoring:

- The primary sources of truck data are: (1) automated vehicle classifiers; (2) weigh-in-motion devices; and (3) manual short-term classification counts at intersections (14-hour period).

Vehicle classification system:

- Traffic data are collected using the FHWA 13-Category Classification System (See Appendix A).
- "Truck" is defined as a vehicle contained within classes 5 to 13 inclusive of the FHWA 13-Category Classification System.
- Truck data are categorized into three sub-classes: (1) single-unit trucks (classes 5-7); (2) single-trailer trucks (classes 8-10); and (3) multiple-trailer trucks (classes 11-13).

Truck volume estimation and characterization:

- The AADTT, temporal distributions of AADTT, and classification mix of trucks are estimated at the permanent classification counters.
- The current procedures used to estimate the link-AADTT on the highway network involve: (1) multiplying the link-AADT with the "percent truck" estimates (established from the permanent classification counters, visual observations of truck traffic in turning movement counts, and other special surveys); (2) transferring or averaging the AADTT estimates from adjacent links; (3) transferring the percent truck value from an adjacent link; and (4) assigning a base Manitoba percent truck of 7.5 percent (Escobar et al., 1997).

- As deemed appropriate, the existing procedures may be replaced by the methodologies developed from this research, which enhance truck volume estimation using the following three methods: (1) direct measurement of AADTT; (2) transferring of AADTT; and (3) base Manitoba truck volume. The detail of the methodologies is discussed in Chapter 5.

2.4.2 Saskatchewan Highways and Transportation

Truck traffic monitoring:

- The primary sources of truck data are: (1) automated vehicle classifiers; (2) weigh-in-motion devices; and (3) short-term classification count sites (48-hour period)

Vehicle classification system:

- Traffic data are collected using the FHWA 13-Category Classification System.
- "Truck" is defined as a vehicle contained within classes 5 to 13 inclusive of the FHWA 13-Category Classification System.
- Truck data are categorized into three sub-classes: (1) non-articulated trucks (classes 5-7); (2) semi-trailer trucks (classes 8-10); and (3) multiple-trailer trucks (classes 11-13).

Truck volume estimation and characterization:

- The Saskatchewan Highways and Transportation Department estimates the AADTT, temporal distributions of AADTT, and classification mix of trucks at the permanent classification counters.
- The truck volume information on the highway network is kept in the form of commercial percentages (corresponding to the three sub-classes). The department uses its collection of coverage classifications and insights from continuous classification data combined with personal knowledge of the economic activity in the province to assign a commercial percentage to each control section. The percentages are applied to the control section average AADT to obtain the truck volume estimates (Anderson, 2003).

2.4.3 British Columbia Ministry of Transportation

Truck traffic monitoring:

- Classification data are only available from the permanent traffic counter sites that are able to capture the overall length of vehicle.

Vehicle classification system:

- Traffic data are collected using the British Columbia Ministry of Transportation 5 Bin Classification Scheme. Table A.2 in Appendix A shows the typical vehicle types in each of these 5 bins and their equivalent classes to the FHWA 13-Category Classification System.

- Traffic flows are categorized into five classifications based on the overall length of the vehicles: (1) 0-6 meters: motorcycles, cars, and light single unit trucks (FHWA classes 1-3); (2) 6-12.5 meters: buses and single unit trucks (FHWA classes 4-7); (3) 12.5-22.5 meters: single trailer trucks (FHWA classes 8-10); (4) 22.5-35.0 meters: B-trains and multiple trailer trucks (FHWA classes 11-13); and (5) over 35 meters: other multiple trailer trucks (FHWA class 13).

Truck volume estimation and characterization:

- The British Columbia Ministry of Transportation presents the volume information in the form of vehicle class percentages at the permanent traffic counter sites.

- Currently, the province does not use any of its traffic data to estimate link truck volume on the highway network. However, the ministry has a project underway -- TIG2 (Traffic Information GIS2) -- which is intended to make traffic volumes by segment available online. While the initial effort is on traffic volumes, subsequent enhancement would be in the area of truck volume estimation (Dixon, 2003).

2.4.4 Washington Department of Transportation

Truck traffic monitoring:

- The primary sources of truck data are: (1) automated data collection sites; and (2) short-term classification count sites (48 or 72-hour period).

Vehicle classification system:

- Traffic data are collected using the FHWA 13-Category Classification System.

- "Truck" is defined as a vehicle contained within classes 5 to 13 inclusive of the FHWA 13-Category Classification System.

- Truck data are categorized into three classifications: (1) single unit (2 and 3-axle trucks and busses); (2) double unit (trucks with a trailer); and (3) triple unit (trucks with trailer combinations).

Truck volume estimation and characterization:

- The Washington DOT estimates the AADTT, temporal distributions of AADTT, and classification mix of trucks at the automated data collection sites.

- The truck volume information on the highway network is kept in the form of truck percentages (corresponding to the three classifications), which are obtained from the short-term classification count sites. These would only reflect the truck percentages from the period the count was taken and often do not accurately represent truck percentages over the course of an entire year (St. Charles, 2003).

2.4.5 Minnesota Department of Transportation

Truck traffic monitoring:

- The primary sources of truck data are: (1) automated vehicle classifiers; (2) weigh-in-motion devices; (3) short-term classification count sites (48-hour period); and (4) manual classification counts (16-hour period).

Vehicle classification system:

- Traffic data are collected using the FHWA 13-Category Classification System.

- "Truck" is defined as a vehicle contained within classes 4 to 13 inclusive of the FHWA 13-Category Classification System.

- For traffic forecasting purposes, Minnesota DOT uses a classification scheme based on eight vehicle types (Levenson, 2003).

Truck volume estimation and characterization:

- The Minnesota DOT estimates the AADTT, temporal distributions of AADTT, and classification mix of trucks at the continuous classification sites (automated vehicle classifiers and weigh-in-motion devices).

- The AADTTs on the highway system are estimated using truck data collected from the short-term classification count sites. The short-term counts are expanded into the AADTT using one general set of adjustment factors developed from the continuous classifiers for the whole state (Nelson, 2003).

- The Minnesota DOT also runs a MnESAL Traffic Forecasting Program (in Excel format) to estimate traffic and load projections on Minnesota's roadways (Minnesota DOT, 2003).

2.4.6 Texas Department of Transportation

Truck traffic monitoring:

- The primary sources of truck data are: (1) automated vehicle classifiers; (2) weigh-in-motion devices; (3) short-term classification count sites (48-hour period); and (4) manual counts (24-hour period).

Vehicle classification system:

- Traffic data are collected using the FHWA 13-Category Classification System.

- "Truck" is defined as a vehicle contained within classes 3 to 13 inclusive of the FHWA 13-Category Classification System.

Truck volume estimation and characterization:

- The Texas DOT estimates the AADTT, temporal distributions of AADTT, and classification mix of trucks at the continuous classification sites (automated vehicle classifiers and weigh-in-motion devices).

- The AADTTs on the highway system are estimated using truck data collected from the short-term classification count sites. The short-term counts are expanded into the AADTT using adjustment factors established from the continuous classifiers (Hodges, 2003).

CHAPTER 3

UMTIG-MANITOBA TRUCK PLANNING NETWORK AND TRUCK VOLUME SEGMENTATION

This Chapter discusses the background for the development of the UMTIG-Manitoba Truck Planning Network (UMTIG-MTPN), and the subsystem of the network that is created for truck volume estimation and characterization in this research. The Chapter explains the rationale for the UMTIG-MTPN, and the segmentation of the system for estimation and characterization purposes. The information is transferred into the Manitoba Highway Single Centerline spatial database platform developed by Han (2003) for analysis purposes.

3.1 FACTORS GOVERNING TRUCK TRAVEL PATTERNS

There are two principal factors governing truck travel patterns: (1) truck size and weight (TS&W) regulations; and (2) economic activities. The following subsections discuss these two factors in detail.

3.1.1 Truck Size and Weight Regulations

In Manitoba, highways under the control of the Minister of Transportation and Government Services are classified as RTAC routes, Class A1, Class B1 and Seasonal RTAC/Class A1. The designation of seasonal RTAC routes indicates the route is upgraded to RTAC loading from its original class (Class A1 or B1) commencing December 1st in any year ending on the last day of February in the ensuing year (MTGS, 2003).

The basic weight limit (maximum gross vehicle weight) allowed on RTAC highways is 62,500 kg. A1 highways allow a maximum GVW of 56,500 kg, and B1 highways allow a maximum GVW of 47,630 kg.

Using the 1999 truck data, Table 3.1 shows the percentage of truck-kilometers of travel (TKT) and length of the highways by different load classes.

Table 3.1: 1999 TKT and Highway Kilometers by Load Class in Manitoba

Weight Class	1999 TKT (in millions)	Percentage of 1999 TKT	Route Kilometers (km)	Percentage of Route km
RTAC	493.5	74.0	5,127	29.1
Seasonal RTAC	20.5	3.1	1,510	8.6
Class A1	74.2	11.1	3,011	17.1
Class B1	78.4	11.8	7,991	45.3
Total	666.5	100.0	17,639	100.0

In 1999, the total TKT generated in the province is 666.5 millions. The table shows that RTAC highways are the primary truck operating routes, accounting for about three-quarters of the total 1999 TKT and about one-third of provincial highway kilometers. Class A1 highways account for one-tenth of the TKT and 17 percent of the highway kilometers. Class B1 highways also account for one-tenth of the TKT and almost half of the highway kilometers.

TS&W regulations have significant implications for truck operations in Manitoba as discussed in the following.

- The RTAC Memorandum of Understanding (MoU) development has resulted in significant relative decline in 3-S2s and A-trains, compared with significant relative increase in the usage of 3-S3s and 8-axles B-trains.

- U.S. TS&W regulations govern the weight and dimension characteristics for trucks operating between the U.S. and Canada. The principal example is PTH 75, which connects to the I-29 in North Dakota. The U.S.-related truck operations on this route are constrained by U.S. Federal Bridge Formula B, and for trucks operating to/from Minnesota and beyond, the maximum GVW limit is 80,000 lbs. This results in significant proportions of 3-S2 semi-trailer trucks crossing the border as compared to other highways in the province.

- The Winter Weight Premium (WWP) policy in Manitoba attracts truck traffic to the winter months by allowing 3-S2s to operate at higher GVWs, and B-train operations at basic RTAC MoU weights on several low grade highways.

For details and explanations of these regulations and effects, see Montufar (2002), Tan (2002), and Montufar et al. (2000).

3.1.2 Economic Activities

The economic activities that impact truck operations can be classified in terms of node and area. For example, truck traffic can be generated by a single facility such as a factory, or by an area-wide activity such as agriculture or commercial and industrial operations. These "node" or "area" truck trip sinks and sources create specific seasonal and day-of-week patterns.

Truck trips generated by these sinks and sources can be highly seasonal (such as from many agricultural areas) or fairly constant (such as flow patterns produced by industrial plants).

These truck trip sinks and sources can also affect the types of trucks operating on the road. Specific commodities tend to be carried by specific types of trucks. For example, truck traffic in northwestern Manitoba is significantly influenced by raw forest products hauled to The Pas -- particularly in 8-axle B-trains.

3.2 BACKGROUND OF THE UMTIG-MTPN

The UMTIG-Manitoba Truck Planning Network (UMTIG-MTPN) is a subset of the provincial highway system accounting for nearly 90 percent of TKT in the province (based on 1999 data). The purpose of creating this truck planning network is to identify the primary truck routes in the province that are related to highway engineering planning, design and management functions.

Factors governing truck operations on Manitoba highways are the key inputs in developing the network. As discussed in the previous section, truck traffic is significantly influenced by TS&W regulations. RTAC routes account for about three-quarters of the total 1999 TKT generated in the province. Therefore the weight classification of highways is used as the primary criterion for selecting the highways for the network.

Other criteria needed in defining the network are: (1) network connectivity and integrity (integrating highways connecting two major truck routes and major truck sinks/sources); (2) the Manitoba LCV network; (3) connecting routes to adjacent provinces and the U.S.; (4) industrial intelligence about trucking at specific locations; and (5) engineering judgement. Figure 3.1 provides the summary of procedures that are used to create the UMTIG-MTPN.

Development of the UMTIG-MTPN was completed in August 2003, and the rationale and procedure for creating the network are recorded in a report produced by Tang, Minty, and Han (2003).

Figure 3.2 shows the UMTIG-MTPN and its major external connectors (e.g., highways connecting to adjacent provinces and the United States, major truck routes inside the City of Winnipeg and Brandon, etc.) .

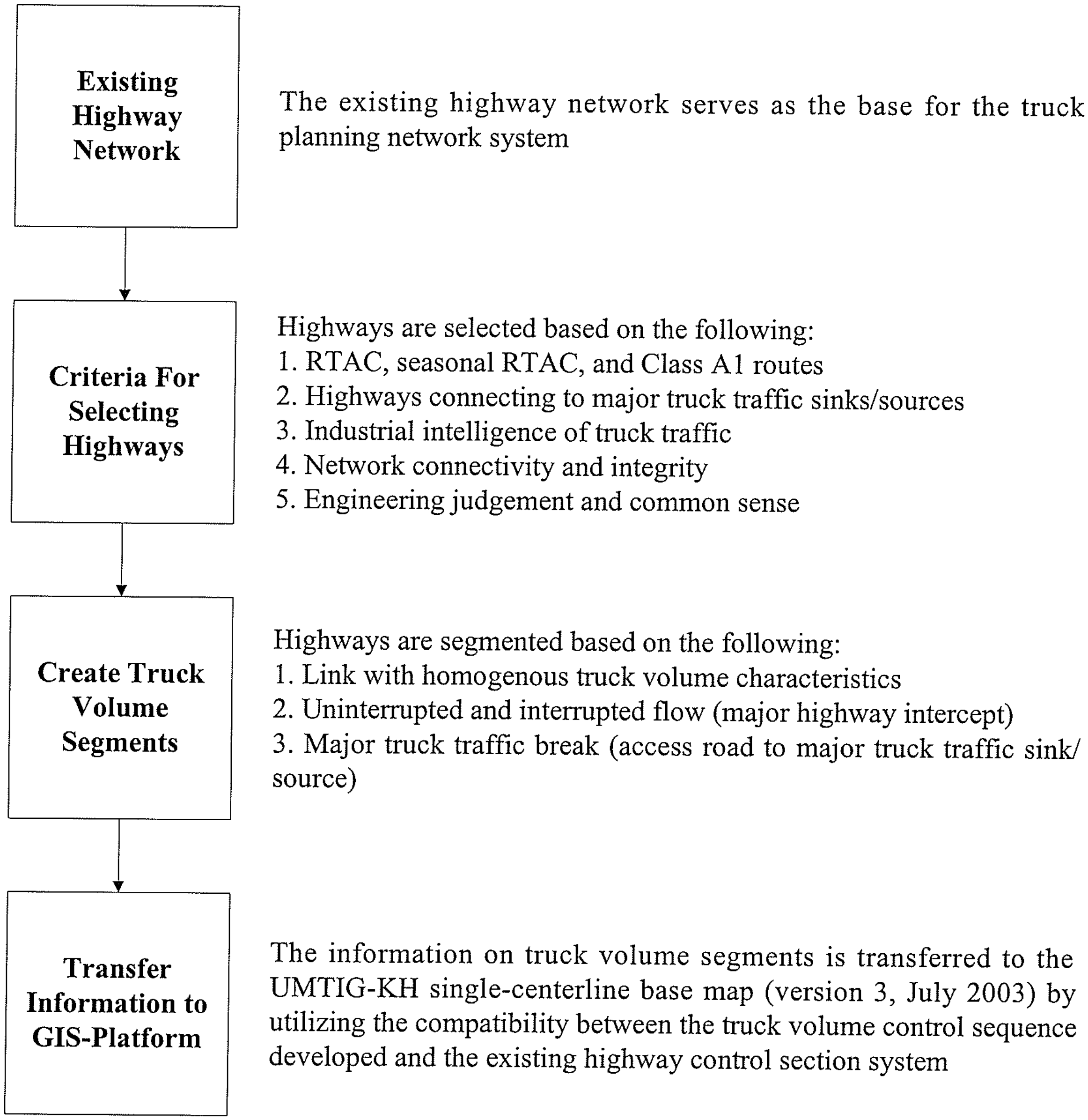


Figure 3.1: Development of the UMTIG-Manitoba Truck Planning Network

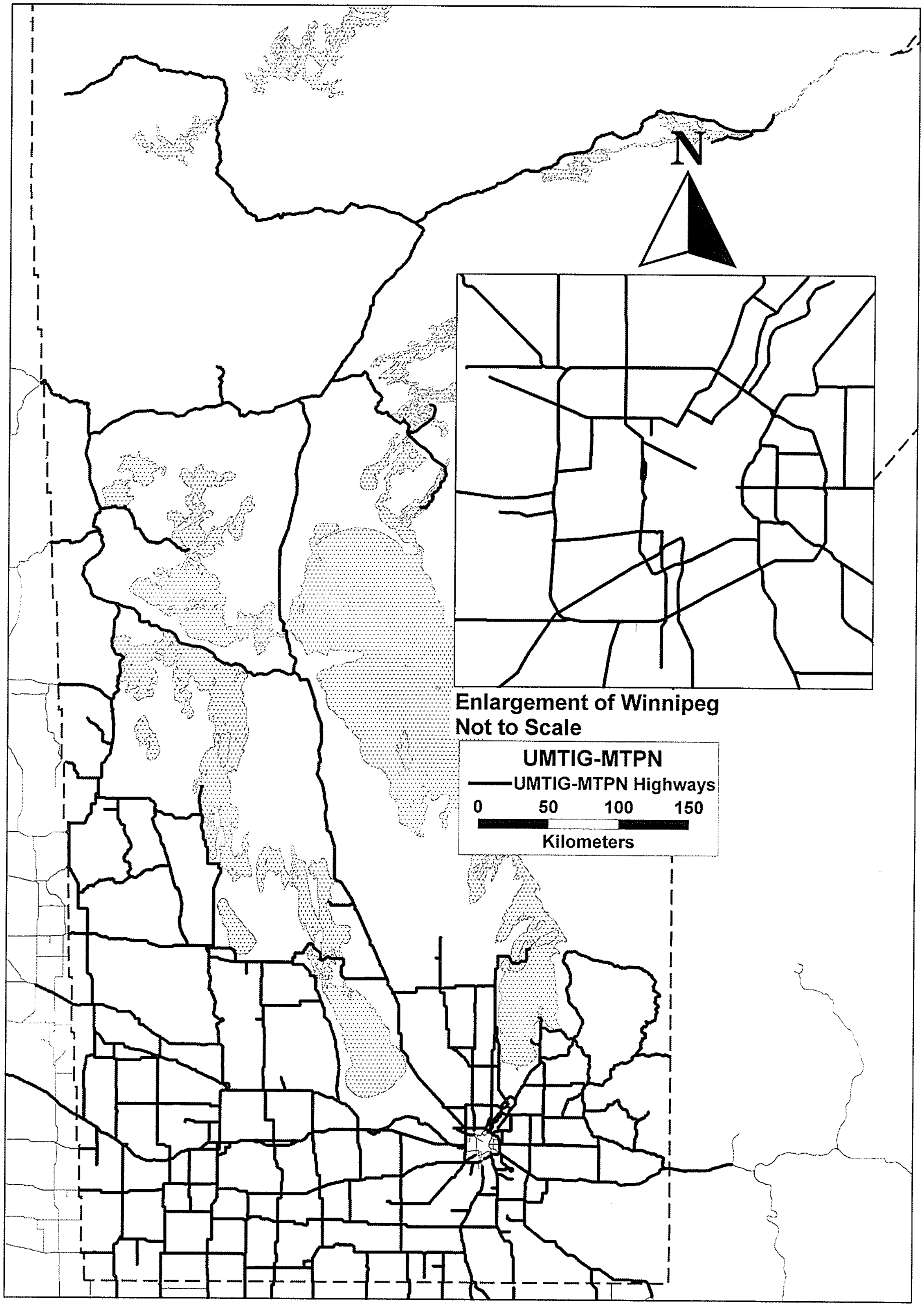


Figure 3.2: UMTIG-MTPN with Major External Connectors

3.3 THE SUBSYSTEM OF THE UMTIG-MTPN IN THE RESEARCH

This section discusses the development of a subsystem of the UMTIG-Manitoba Truck Planning Network, which is referred to as "DT-Network" in the rest of the thesis. The DT-Network defines the geographical scope of this research for purposes of truck volume estimation and characterization for the year 2002.

The DT-Network is developed by selecting the dominant truck routes in the province. The network consists of major highways serving east-west truck traffic traveling across Manitoba, as well as north-south truck traffic traveling to and from the U.S., and other highways with major intra-provincial truck traffic. Table 3.2 shows the list of the 14 highways that are included in the DT-Network, and their proportions of 1999 TKT and total highway kilometers.

Table 3.2: 1999 TKT and Highway Kilometers of the Highways in the DT-Network

Highway	1999 TKT (in millions)	Percentage of 1999 TKT	Route Kilometers (km)	Percentage of Route km
1	173.4	26.0	482	2.7
2	22.6	3.4	315	1.8
3	20.9	3.1	396	2.2
5	16.7	2.5	407	2.3
6	35.8	5.4	742	4.2
10	29.0	4.3	732	4.1
12	13.9	2.1	257	1.5
13	4.9	0.7	50	0.3
14	11.6	1.7	50	0.3
16	36.3	5.4	268	1.5
59	0.1	0.0	1	0.0
75	45.1	6.8	286	1.6
Perimeter Hwy (100 & 101)	44.0	6.6	90	0.5
110	0.7	0.1	17	0.1
Sub-Total	455.0	68.3	4,093	23.2
Hwys Not in the DT-Network	211.5	31.7	13,546	76.8
Total	666.5	100.0	17,639	100.0

Together these fourteen highways define the DT-Network, which accounts for more than two-thirds of the province's TKT (based on 1999 data) and about one-quarter of the highway kilometers (based on the UMTIG-KH single centerline highway system). This research focuses on estimating and characterizing truck volumes for the DT-Network by applying the methodologies developed in Chapter 5.

3.4 DEVELOPMENT OF THE TRUCK VOLUME SEGMENTS

A truck volume segment is defined as a section of road with homogenous truck volume characteristics (AADTT, temporal distribution, and classification mix). It is assumed that truck volume characteristics do not materially change throughout the segment. The truck volume segments are created inside the DT-Network and used for enhancing the truck traffic monitoring program through the following:

- Determine the count locations needed to cover the truck planning network system.
- Determine how counts can be combined to make best use of available counting resources.
- Schedule the counts so as to efficiently use the available data collection crews and equipment.
- Reduce count duplication and increase the efficiency of the data collection staff.

3.4.1 Truck Volume Segmentation

Truck volume segmentation is part of the UMTIG-MTPN development process as shown in Figure 3.1 of section 3.2. A truck volume segment is defined by linking any two adjacent nodes. The truck volume segment nodes are created using a rule-based procedure. The details of the procedure are presented in the report of the UMTIG-MTPN (Tang, Minty, and Han, 2003).

A total of 202 truck volume segments are created in the DT-Network for purposes of truck volume estimation and characterization for the year 2002. Figure 3.3 shows the truck volume segments in the DT-Network.

3.4.2 Truck Volume Control Sequences

For every truck volume segment created, it must start or end at the same milepost as used for the highway control section because of the desired compatibility with the existing highway control section system. This operation can later be utilized for the integration of data into an existing Geographic Information System (GIS) platform developed by Han (2003). A truck volume control sequence number is created to identify a specific truck volume segment. This is done by designating a highway segment link with "9##" after the highway control section number of that link. The following is an example of a truck volume control sequence:

e.g., 1001260***925***

Where:

- The first 7 digits are the highway control section for this particular highway link with the following information:
  - 1^{st} digit is the MTGS zone that highway link belongs to
  - 2^{nd} to 4^{th} digits represents the highway number
  - 5^{th} to 7^{th} digits represents the control section number
- "9" denotes this link is a truck volume segment
- "25" is the truck volume control sequence number for a highway (increases from west to east and south to north accordingly)

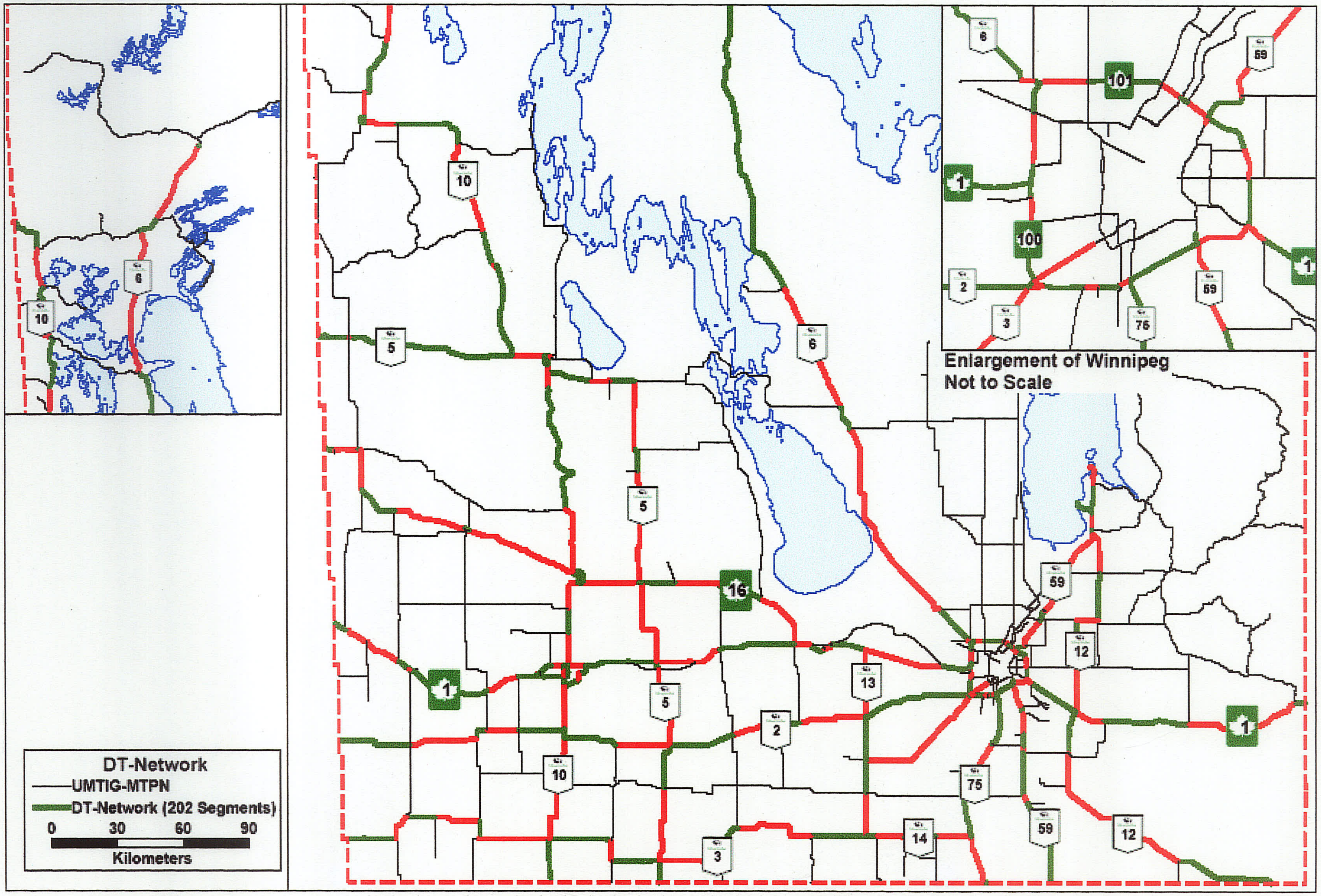


Figure 3.3: Truck Volume Segments in the DT-Network

CHAPTER 4

TRUCK VOLUME CORE DATABASE

This Chapter discusses the development of a truck volume core database for the Manitoba Truck Traffic Information System (MHTTIS). It describes the use of the MHTTIS and WIM/AVC network to monitor truck traffic on provincial highways. The Chapter also develops the methodologies and standard procedures for the systematic analysis of truck volume data. The MHTTIS truck volume core database, which consists of the permanent classification sites in Manitoba and adjacent provinces, short-term classification sites, and the Bureau Transportation Statistics U.S.-Canada Border Crossing database (BTS, 2003), is created and the outputs are presented in Appendix B.

4.1 TRUCK TRAFFIC MONITORING

Truck traffic on Manitoba's provincial highways is monitored through the MHTTIS. The monitoring is conducted in four phases: (1) collecting truck traffic data; (2) editing truck traffic data; (3) creating summaries of truck traffic statistics; and (4) reporting the summary of truck traffic statistics. The details of creating the MHTTIS are reported in Clayton and Escobar (1998).

Manitoba currently maintains a fully operational network of 30 AVC sites, 6 WIM/AVC sites and 1 WIM site. These sites operate year-round to monitor traffic, classify vehicles, and for WIM sites, record dynamic weights of vehicles. This WIM/AVC network is the principal source of on-road traffic data being used in the development of the truck volume core database for the MHTTIS. The base count data collected from these sites have been included in MHTIS (2003).

The following factors were considered in designing the WIM/AVC network concept (Tang et al., 2003):

- Areas and major truck routes lacking historical truck traffic monitoring (e.g., northern Manitoba).
- Significant changes in road network structure known to have altered truck routing (e.g., around Brandon).
- Significant changes in the demand for trucking (e.g., branchline abandonment accompanied by rail-to-road shifts in farm commodity movements).
- Significant changes in trade arrangements impacting freight flows by truck (e.g., large increases in cross-border truck traffic due to free trade and the NAFTA).
- Significant changes in truck size and weight regulations impacting truck volumes, routing, classes, and weight characteristics (e.g., expansion of Manitoba's RTAC and long combination vehicle (LCV) highway network).

In addition to these transportation system issues, the physical feasibility of placing and successfully operating WIM/AVC devices in potentially useful locations has to be considered, such as the availability of communication systems (a particular problem in the North), inadequate pavement structures (often experienced in the large, relatively low volume highway network of Manitoba and other Prairie region jurisdictions), and the accessibility of sites to adequate maintenance services (Lobban, 2003). Figure 4.1 shows the WIM/AVC network that is currently maintained by the MTGS, and the external classification counters in adjacent provinces.

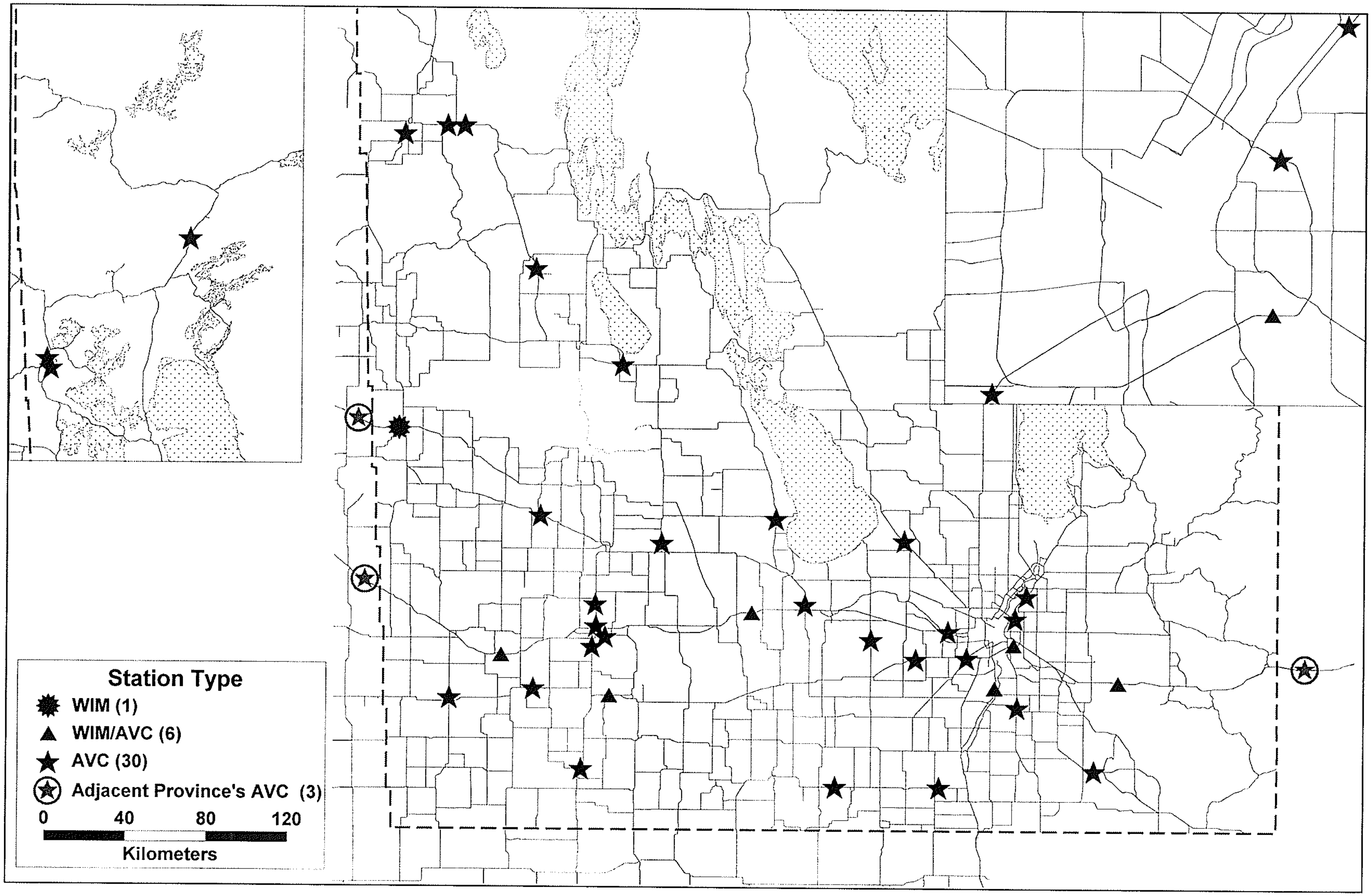


Figure 4.1: Manitoba WIM/AVC Network

Traffic monitoring practices are based on the principle of truth-in-data (Albright, 1991), which means disclosing the methods used throughout the data collection and analysis process. This enables users to judge the quality of the data and its appropriateness for their application, and to relate the sensitivity of decisions to the quality of the data (Lucas, 1996). The details of the principle are discussed in various UMTIG published papers and reports (Clayton et al., 1994 and Lucas, 1996).

The following sections discuss the development of methodologies and procedures for the systematic analysis of truck volume data in the core database, which involves screening and editing the field-based raw data, and analyzing truck volume data. The methods used to conduct such analysis conform to those specified in the following documents:

1. FHWA Highway Administration (FHWA) Traffic Monitoring Guide (U.S. DOT, 2001)

2. American Association of State Highway and Transportation Officials (AASHTO) Guidelines for Traffic Data Programs (AASHTO, 1992)

4.2 SCREENING AND EDITING FIELD-BASED RAW DATA

After truck volume data have been collected, they are edited to ensure the field measurements are valid prior to being summarized and reported. After the data are edited and accepted as valid traffic measurements, the "edit-accepted" truck data are summarized and reported using the methods described in section 4.3 for various truck volume estimates (AADTT, TKT, temporal distributions, and classification mix of trucks).

Editing truck volume data involves screening the raw data to identify: (1) errors and anomalies caused by machine malfunctions; (2) counts that do not represent the normal truck traffic -- normally conducted during atypical periods such as festivals and unusual weather conditions; and (3) the current measurements in relation to historical measurements at the same sites, and their consistency on the same roadway.

4.2.1 Screening and Editing

The following are the screening criteria and editing procedures for the permanent and short-term classification count data (Escobar et al., 1997 and Tang et al., 2001):

<u>Permanent Classification Count Data – WIM and AVC</u>

Screening criteria for WIM data:

- overall length of the vehicle must be greater than zero
- wheelbase must be greater than zero and less than overall length
- GVW must be greater than zero
- at least one axle spacing is recorded
- at least two axle weights are recorded
- classification field is not “0” or empty

Screening criteria for AVC data:

- data with sudden increases or decreases in truck volumes
- data with repeated zeroes or blanks

Editing procedures for the permanent classification count data

The base data that are identified as errors or anomalies using the above criteria are:
- removed from the database
- excluded from the calculation of summary truck volume statistics
- retained for future analysis

Short-Term Classification Count Data

Screening criteria for 48-hour classification count:

- minimum count duration is 48 hours
- data with sudden increases or decreases in traffic volumes
- data with repeated zeroes or blanks

Screening criteria for 14-hour classification count at intersections:

- minimum count duration is 14 hours
- data with sudden increases or decreases in traffic volumes
- data with repeated zeroes or blanks

Editing procedures for the short-term classification count data

The base data that are identified as errors or anomalies using the above criteria are:
- removed from the database
- excluded from the calculation of summary truck volume statistics
- retained for future analysis

4.2.2 Problems with Weigh-In-Motion Data

Through the data editing process and field observations from the traffic monitoring staff, the WIM devices were observed to have problems classifying correct vehicle types. These problems occur at WIM/AVC station 61-Brokenhead, 62-Oak Lake, 63-Glenlea, and 65-Macgregor. At these stations, WIM devices are installed in the drive lane of the westbound or northbound flow directions to collect traffic data, whereas AVC devices collect traffic data in the passing lane (in the same flow direction as WIM devices are installed) and in the opposite direction. For the WIM/AVC station 64 at Symington and station 66 at Nesbitt, AVC counters are installed in both directions to collect traffic data.

The WIM devices were found to overestimate the number of single-unit trucks, and underestimate the number of multiple-trailer trucks. This is shown in Table 4.1 using the comparison analysis of the classification mix of trucks at the 4 WIM/AVC stations in 2002. The WIM classification data are also compared to the truck classification mix analysis conducted at the AVC stations in adjacent provinces based on their geographical proximity, and the results are shown in Table 4.2.

Table 4.1: Comparison of 2002 Classification Mix of Trucks (Class 5-13) at Manitoba WIM/AVC Stations (Truck Data on Drive Lane only)

Station No.	Data Type	Truck %	Percentage of Total Truck Traffic								
			5	6	7	8	9	10	11	12	13
61	WIM (WB)	27.6	19.4	2.3	0.0	4.5	52.3	13.5	0.1	1.0	6.8
	AVC (EB)	21.3	3.5	0.9	2.8	5.6	51.9	19.8	0.3	1.0	14.3
62	WIM (WB)	34.9	9.5	2.2	0.0	2.0	58.2	14.8	0.1	3.9	9.1
	AVC (EB)	31.8	2.5	2.1	0.1	4.9	51.1	21.0	0.5	1.3	16.4
63	WIM (NB)	19.9	15.4	4.8	0.1	2.5	66.3	5.8	0.5	2.3	2.3
	AVC (SB)	19.0	4.5	4.6	0.3	5.8	68.5	8.5	2.4	0.6	4.8
65	WIM (WB)	29.7	12.7	3.7	0.1	2.2	53.6	13.8	0.2	4.5	9.2
	AVC (EB)	25.7	4.2	3.9	0.2	2.3	53.3	20.6	0.0	1.0	14.6

Developed from raw data from MHTTIS by D.T. July 2003
Note: See Appendix A for the descriptions of vehicle class

Table 4.2: Comparison of 2002 Classification Mix of Trucks (Class 5-13) (Manitoba WIM Data vs. AVC Data in Adjacent Provinces)

Station No.	Data Type	Truck %	Percentage of Total Truck Traffic								
			5	6	7	8	9	10	11	12	13
61	WIM	27.6	19.4	2.3	0.0	4.5	52.3	13.5	0.1	1.0	6.8
S17*	AVC	23.0	5.8	11.5	0.3	10.3	38.6	17.0	1.5	1.2	13.9
62	WIM	34.9	9.5	2.2	0.0	2.0	58.2	14.8	0.1	3.9	9.1
S1	AVC	41.3	1.9	2.1	0.2	2.9	52.3	21.4	1.4	1.5	16.3
80	WIM	30.8	13.1	3.5	0.0	3.0	47.0	12.7	0.1	3.9	16.6
S16**	AVC	35.3	2.4	3.3	0.9	12.4	34.6	17.5	3.6	2.0	23.3

based on 2-week classification data in 2001* * based on 3-month classification data in 2002*

S17 - PTH 1, 15 km east of MB-ONT border
S1 - PTH 1, 8.3 km west of MB-SASK border
S16 – PTH 16, 7.7 km west of MB-SASK border
80 – PTH 16, 2.0 km west of west junction with PTH 83

Table 4.1 indicates that the WIM devices, in contrast to AVC stations, overestimate the number of single-unit trucks (particularly for class 5) and underestimate the number of multiple-trailer trucks (particularly for class 13).

This problem is caused by the default weight criteria in the WIM device, which classifies vehicles not only by length but also by the weight they carry. For example, if a passing pickup or van (class 3) is carrying weight that is above the criteria set by the device, it will be classified as a single-unit truck (class 5). Similarly, if a passing class 13 vehicle (multiple-trailer truck) is below the weight criteria (this is especially a problem when it is an empty B-train), it will not be classified and will be assigned to class "0" (Lobban, 2003). The same problems are also found by comparing the WIM classification mix to the AVC stations in adjacent provinces (Table 4.2)[1].

This problem are also confirmed by using the truck data from the automated truck weight data collection program at the Westhawk and Headingley weigh scales (Tan, 2002), which shows that the WIM data from the two stations nearby (61-Brokenhead and 65-Macgregor) have the problem of underestimating class 13 trucks.

For many years, traffic monitoring crews have recognized that WIM devices produce questionable classification data (Lobban, 2003). This problem is experienced with WIM devices in Saskatchewan (Gienow, 2003). Because of the problem, the WIM data are excluded in this research. The analysis of truck volumes at the WIM/AVC stations is

[1] After the discussion with the MTGS traffic monitoring technician about WIM devices classifying problems, the WIM devices have been recalibrated with a new weight criteria since October 2003, and the results show a significant improvement for the vehicle classification of WIM data.

done based on the AVC data collected at the same locations, because the AVC stations produce accurate and dependable data.

4.3 ANALYSIS OF TRUCK VOLUME DATA

After the data screening and editing process, the accepted data are used for the estimation of AADTT, TKT, temporal distributions of truck volumes, and classification mix of trucks. A valid annual average estimate of truck volumes at each permanent classification station requires a one-day minimum of data for each day of the week and each month of the year (AASHTO, 1992). Based on this requirement, 33 AVC stations are selected for the analysis. The truck data from these stations are subsequently used for developing the truck traffic pattern groups. The following subsections discuss the methodologies and procedures used to analyze truck volume data.

4.3.1 Annual Average Daily Truck Traffic (AADTT)

The primary measure of truck volumes is AADTT, which can be developed from direct observation of truck traffic (e.g., across a permanent classification counter), or by expanding short-term classification counts using the adjustment factors developed from the permanent classification stations.

<u>Permanent Classification Stations</u>

At permanent classification stations, the AADTT is calculated using the following procedures recommended by AASHTO.

Step 1: Averages are calculated for each day of the week (Monday, Tuesday, etc.) for each month, yielding seven values for each month (Monthly Average Days of the Week Truck Traffic – MADWTT)

Step 2: The MADWTT for each month is averaged across the twelve months, yielding seven annual values (Annual Average Days of the Week Truck Traffic – AADWTT)

Step 3: AADTT is calculated as the arithmetic mean of the seven AADWTTs.

This procedure is shown mathematically by Equation 2.1 in Chapter 2. Table 4.3 shows an example for the calculation of AADTT at AVC station 24, which is located on PTH 10, 2.7 kilometers north of PTH 1. To calculate the 2002 AADTT for this station, the first step is to calculate the seven MADWTTs from January to December. Next, the seven MADWTTs are averaged across twelve months to compute the seven AADWTTs, as shown in Table 4.3. Finally the AADTT is estimated by averaging the seven AADWTTs.

This method effectively divides the calendar year into twelve months of seven daily means, and weights the calendar days equally. The advantage of this method is that it compensates for unequal distribution of data during the year (especially when missing data occurs). Tables B.1 in Appendix B show the location descriptions and AADTT estimates at the 33 AVC stations.

Table 4.3: Calculation of AADTT for Trucks (Classes 5-13) at AVC Station 24 (PTH 10, 2.7 km North of PTH 1)

Month	MADWTT							AADTT
	Sun	Mon	Tue	Wed	Thu	Fri	Sat	
Jan	70	288	209	234	266	269	84	
Feb	62	213	295	298	290	213	63	
Mar	66	357	380	337	356	260	81	
Apr	87	385	418	411	437	382	105	
May	213	523	575	519	552	554	339	
Jun	122	380	430	417	424	410	158	
Jul	142	347	368	394	392	352	152	
Aug	142	389	437	411	437	413	153	
Sep	123	394	419	461	454	437	159	
Oct	146	440	504	554	539	527	206	
Nov	85	345	426	441	439	392	117	
Dec	93	317	266	249	252	289	120	
AADWTT	112	365	394	394	403	375	145	**313**

Short-Term Classification Counting Stations

Short-term classification counts are expanded to AADTT estimates by using the adjustment factors (time-of-day, day-of-week, and seasonal) from the control station or truck traffic pattern group (TTPG). A control station is a permanent classification counter which exhibits similar truck flow patterns to those of the short-term count site. A TTPG is a group of permanent classification counters which exhibit similar characteristics of truck volumes. The details of the method are discussed in Chapter 5.

Categorization of AADTT

The AADTT estimates on Manitoba highways are subdivided into the Very Low, Low, Medium, High, and Very High truck volume categories. Table 4.4 shows the AADTT categories developed for Manitoba.

Table 4.4: Manitoba AADTT Categories

Category	AADTT Range
Very Low	0-240
Low	241-480
Medium	481-960
High	961-1920
Very High	> 1920

Table 4.5 shows the basic density and spacing characteristics for each of the Manitoba AADTT categories used in this analysis. These categories are chosen to give a practical physical sense of different levels of truck traffic when functioning in an idealized BASIC FLOW manner. When calculating BASIC FLOW characteristics, the following is assumed: (1) the AADTT is evenly split in each direction and travels in one lane in each direction; (2) it experiences no seasonality, day-of-week, or time-of-day variation; (3) all trucks travel at 100 km/h (27.78 m/sec); and (4) all trucks travel at constant time and space headways, varying only by AADTT level.

This idea is also used in the Texas truck accommodation design project for the analysis of truck travel distribution on Texas' highway system by AADTT category (Middleton et al., 2002).

Table 4.5: BASIC FLOW Density and Spacing Characteristics by AADTT Category

Manitoba AADTT Category	AADTT Range	Average Time Headway Between Trucks (minutes) In Each Direction	Average Space Headway Between Trucks In Each Direction @ 100 km/h	Average Space Headway In Typical 3-S2 Trucks (assume 20 m length)	Average Truck Density per km In Each Direction @ 100 km/h
Very Low	0 – 240	infinite to 12 min	infinite to 20 km	Infinite to 1000	<<<<< 1
Low	241 – 480	12 to 6 min	20 to 10 km	1000 to 500	<<<< 1
Medium	481 – 960	6 to 3 min	10 to 5 km	500 to 250	<<< 1
High	961 - 1920	3 to 1.5 min	5 to 2.5 km	250 to 125	<< 1
Very High	1921 - 3840	1.5 to 0.75 min	2.5 to 1.25 km	125 to 62.5	< 1

4.3.2 Truck-Kilometers of Travel (TKT)

The second primary measure of truck volumes is truck-kilometers of travel. TKT per year is calculated by multiplying the AADTT of a given road segment by the segment length. TKT for a particular road network is determined by adding the TKTs from all road segments in the network.

Using 1999 truck data, the annual TKT and route kilometers are calculated for the DT-Network as defined in section 3.3 of Chapter 3. Figure 4.2 and Table 4.6 show the comparison between the percentage of TKT and route kilometers in this network by AADTT classes. There are 455 million TKT on highways inside the DT-Network, accounting for about two-thirds of the province's TKT in 1999.

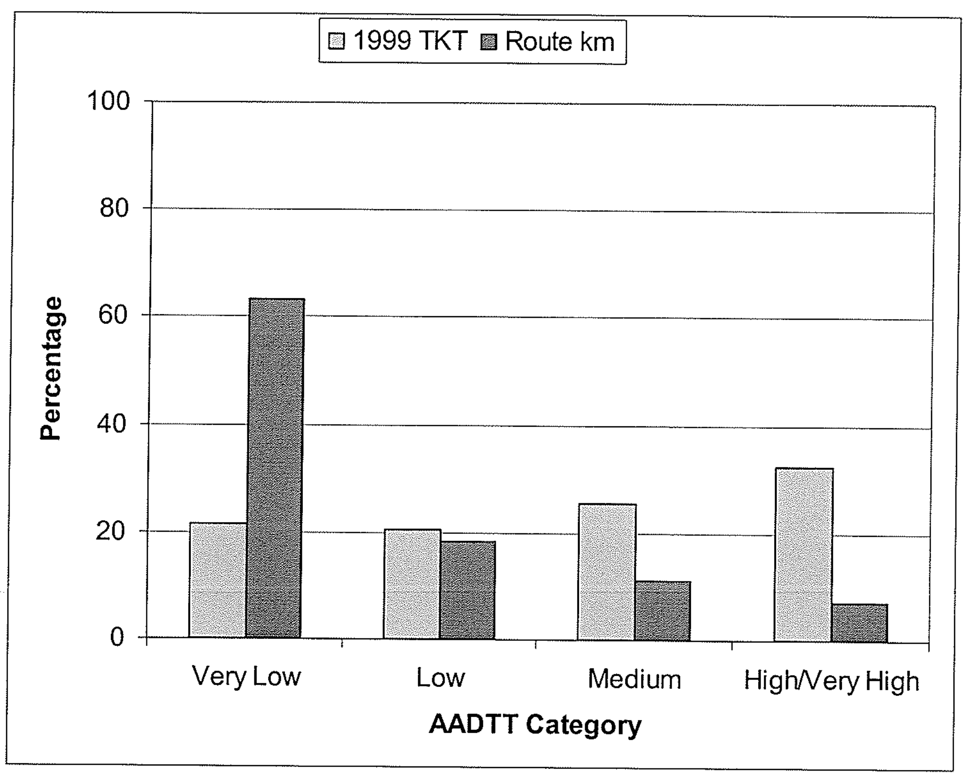


Figure 4.2: 1999 TKT and Route Kilometers for the DT-Network

Table 4.6: 1999 TKT and Route Kilometers for the DT-Network by AADTT Class

MB AADTT Class	AADTT Range	1999 TKT (in millions)	% of TKT	Route km	% of Route km
Very Low	0 - 240	97.3	21.4	2,591	63.3
Low	240 - 480	94.0	20.7	757	18.5
Medium	481 - 960	116.0	25.5	454	11.1
High	961 - 1920	106.3	23.4	236	5.8
Very High	> 1920	41.4	9.1	55	1.3
	Total	455.0	100.0	4,093	100.0

Table 4.6 facilitates the following findings by AADTT category for the DT-Network:

- Highways with very low truck volumes (AADTT less than 240) account for one-fifth of the TKT and about two-thirds of the route kilometers.
- Highways with low truck volumes (240-480 AADTT) account for one-fifth of the TKT and one-fifth of the route kilometers.
- Highways with medium truck volumes (480-960 AADTT) account for one-quarter of the TKT and one-tenth of the route kilometers.
- Highways with high and very high truck volumes (AADTT > 960) together account for about one-third of the TKT and 6 percent of the route kilometers.

These findings provide some useful information on the DT-Network, as more than 80 percent of the highways in the network experience low to very low truck volumes and account for 40 percent of the network's TKT. About one-fifth of the highways inside the DT-Network contain AADTT greater than 480, and they account for more than half of the network's TKT.

4.3.3 Temporal Distributions of Truck Volumes

The temporal distributions of truck volumes are the fundamental information required to understand how truck traffic varies over time, and the results are subsequently used for grouping stations to create the TTPGs. This section discusses the methodology used to conduct the variation analysis of truck volumes over a number of different time scales: (1) season (month) of the year; (2) day of week; and (3) time of day. The analysis of temporal variations for different truck groups (single-unit, single-trailer, and multiple-trailer trucks) is presented in Tang (2003).

Seasonal Distributions of Truck Volumes

Monthly distribution factors are calculated as the ratio of monthly average daily truck traffic (MADTT) to the annual average daily truck traffic (AADTT).

Table 4.7 illustrates the calculation of the monthly distribution factors at AVC station 24, located on PTH 10, 2.7 km north of PTH 1. The first step is to calculate the 12 MADTTs from January to December 2002. Then the MADTTs are divided by the AADTT to obtain the Monthly Distribution Factors. Figure 4.3 shows the seasonal distribution of trucks at this station.

Table 4.7: Calculation of 2002 Monthly Distribution Factors for Trucks (Class 5-13) at Station 24 (PTH 10, 2.7 km North of PTH 1)

Month	MADWTT							MADTT	Monthly Distribution Factor
	Sun	Mon	Tue	Wed	Thu	Fri	Sat		
Jan	70	288	209	234	266	269	84	203	0.65
Feb	62	213	295	298	290	213	63	205	0.66
Mar	66	357	380	337	356	260	81	262	0.84
Apr	87	385	418	411	437	382	105	318	1.02
May	213	523	575	519	552	554	339	468	1.50
Jun	122	380	430	417	424	410	158	334	1.07
Jul	142	347	368	394	392	352	152	307	0.98
Aug	142	389	437	411	437	413	153	340	1.09
Sep	123	394	419	461	454	437	159	350	1.12
Oct	146	440	504	554	539	527	206	417	1.33
Nov	85	345	426	441	439	392	117	321	1.03
Dec	93	317	266	249	252	289	120	227	0.72
							AADTT =	313	

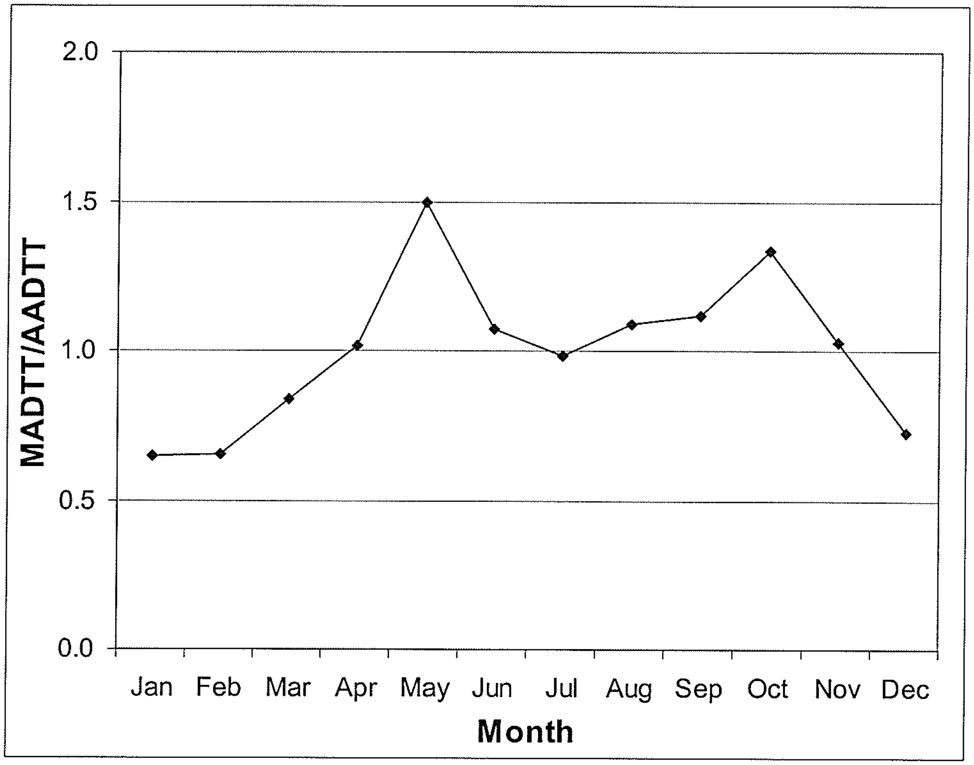


Figure 4.3: 2002 Seasonal Variations of Trucks (Class 5-13) at Station 24

At AVC station 24, the following is observed for the seasonality of truck volumes:

- The months of December to March inclusive experience monthly distribution factors below 1, ranging from 0.65 (in January) to 0.84 (in March).

- April to November inclusive experience monthly distribution factors greater than 1, except the month of July (0.98), ranging from 1.02 (in April) to 1.50 (in May).

- In almost 60 percent of the months, monthly average daily truck traffic varies more than 10 percent from the annual average daily truck traffic (i.e., 7 out of 12 months have monthly distribution factors greater than 1.1 or less than 0.9). This means that in a large percentage of cases, estimating short-term truck counts without adjustments will lead to an inaccurate measure of annual conditions (with a possible maximum error of 50 percent – corresponding to monthly distribution factor of 1.50 in May).

- The May and October peaking could reasonably be expected to reflect increased agricultural-related trucking at this location (fertilizer and seed in the spring, and grain in the fall).

Table B.2 in Appendix B shows the monthly distribution factors at the 33 AVC stations.

Day-of-Week Distributions of Truck Volumes

The day-of-week factors are developed by first calculating the 7 annual average days of the week truck traffic (AADWTT) estimates. The 7 AADWTTs are then divided by the AADTT to get the day-of-week factors. This is shown in Table 4.8 using the data from station 24 again. Figure 4.4 shows the day-of-week distributions of truck volumes.

The following are the findings regarding the day-of-week variations at AVC station 24:

- The average weekday truck volumes are 50 percent more than the weekend volumes.
- Throughout the year, Sunday truck volumes are the lowest of the week. Monday has slightly lower truck volumes than other weekdays but the difference is not significant.
- The huge variations between the weekday and weekend truck volumes might be caused by the dominant local freight movement at this location (in the vicinity of Brandon), where Saturday and Sunday are relatively "low" freight days.

Table B.3 in Appendix B show the day-of-week factors at the 33 AVC stations.

Table 4.8: Calculation of 2002 Day-of-Week Factors for Trucks (Class 5-13) at Station 24 (PTH 10, 2.7 km North of PTH 1)

Month	MADWTT							AADTT
	Sun	Mon	Tue	Wed	Thu	Fri	Sat	
Jan	70	288	209	234	266	269	84	
Feb	62	213	295	298	290	213	63	
Mar	66	357	380	337	356	260	81	
Apr	87	385	418	411	437	382	105	
May	213	523	575	519	552	554	339	
Jun	122	380	430	417	424	410	158	
Jul	142	347	368	394	392	352	152	
Aug	142	389	437	411	437	413	153	
Sep	123	394	419	461	454	437	159	
Oct	146	440	504	554	539	527	206	
Nov	85	345	426	441	439	392	117	
Dec	93	317	266	249	252	289	120	
AADWTT	112	365	394	394	403	375	145	313
Day of Week Factor	0.36	1.17	1.26	1.26	1.29	1.20	0.46	

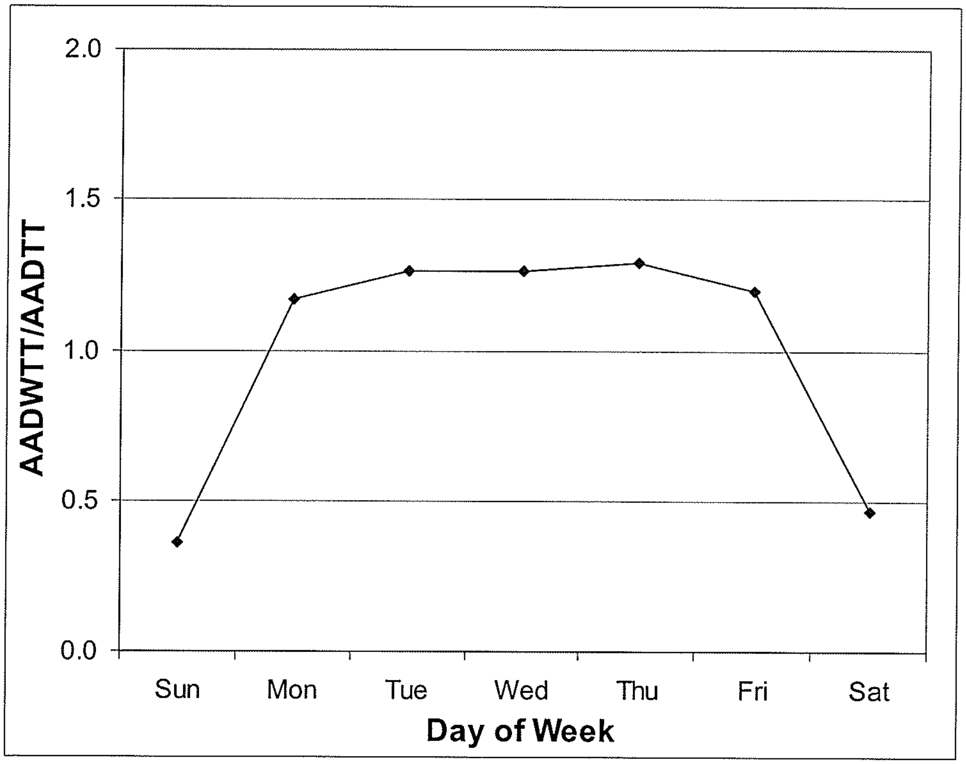


Figure 4.4: 2002 Day-of-Week Variations of Trucks (Class 5-13) at Station 24

Time-of-Day Distributions of Truck Volumes

The time-of-day factors are calculated by computing the percentage of daily truck volumes that occurs during any one hour of the day. Using truck data collected at AVC station 24, Table 4.9 shows the hourly percentage of daily truck volumes experienced at this site.

Table 4.9 shows that during the peak hours for truck volumes (08:00 to 17:00), there are an average of 12 trucks per hour in each direction. This means that in any one hour during the peaks, each truck is separated by 5 minutes headway on average. The time headway is increased to 20 minutes during the off-peak hours (21:00 to 07:00), with an average of 3 trucks per hour in each direction. The distribution of hourly truck volumes is presented in Figure 4.5.

Table 4.9: Calculation of 2002 Time-of-Day Factors for Trucks (Class 5-13) at Station 24 (PTH 10, 2.7 km North of PTH 1)

Time of Day	Truck Count	Number of Days	Average Truck Volumes By Hour	% of Truck Volume
1	1,186	364	3	1.0
2	1,145	364	3	1.0
3	782	364	2	0.7
4	848	364	2	0.7
5	1,261	364	3	1.1
6	1,659	364	5	1.5
7	3,122	363	9	2.7
8	5,755	358	16	5.1
9	6,936	347	20	6.4
10	7,782	356	22	7.0
11	7,840	354	22	7.1
12	7,861	355	22	7.0
13	8,098	362	22	7.1
14	8,336	361	23	7.4
15	8,720	363	24	7.6
16	8,802	363	24	7.7
17	7,626	363	21	6.7
18	5,930	363	16	5.2
19	5,035	364	14	4.4
20	4,104	364	11	3.6
21	3,308	364	9	2.9
22	2,757	364	8	2.4
23	2,488	364	7	2.2
24	1,724	364	5	1.5
		Total	314	100.0

The time-of-day distributions of daily truck volumes for different vehicle groups at the 33 AVC station are presented in Table B.4 of Appendix B.

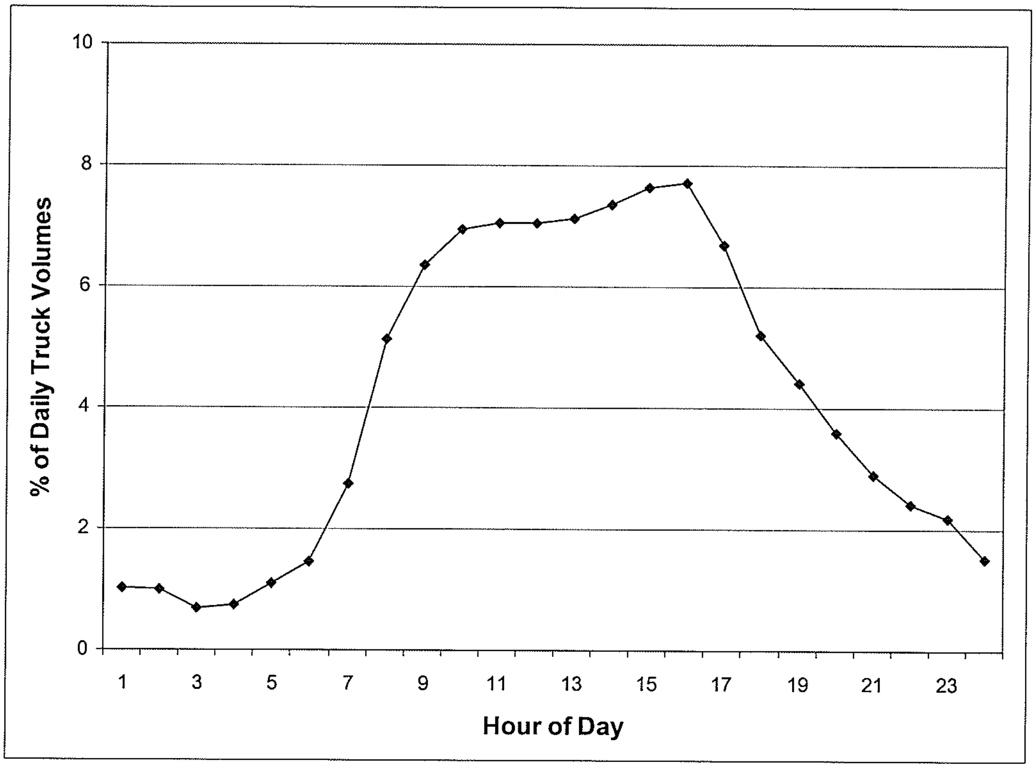


Figure 4.5: 2002 Time-of-Day Variations of Trucks (Class 5-13) at Station 24

4.3.4 Classification Mix of Trucks

The classification mix analysis on different highways is critical for understanding what types of trucks will use the road, the dimensional characteristics of these trucks, and their impact on the highway geometric design. The classification mix analysis is calculated in two ways: (1) computing the percentage of each vehicle class in the total traffic; and (2) computing the percentage of each vehicle class within the truck traffic (class 5-13).

Using AVC station 55 at Headingley (PTH 1, 3.9 km West of PR 334) as an example, Table 4.10 and Figure 4.6 show the classification mix of vehicle types.

Table 4.10: Calculation of 2002 Classification Mix for Trucks (Class 5-13) at Station 55 (PTH 1, 3.9 km West of PR 334)

Vehicle Class	Vehicle Count	Percentage of Total Traffic	Percentage of Total Truck
Class1	6,969	0.2	
Class2	2,953,958	64.2	
Class3	883,144	19.2	
Class4	12,658	0.3	
Class5	40,256	0.9	5.4
Class6	35,646	0.8	4.8
Class7	1,071	0.0	0.1
Class8	41,843	0.9	5.6
Class9	370,769	8.1	49.6
Class10	138,369	3.0	18.5
Class11	9,874	0.2	1.3
Class12	7,639	0.2	1.0
Class13	101,892	2.2	13.6
Total Traffic	4,604,088	100.0	100.0
Total Truck Traffic	747,359		
Truck %	16.2		

Developed from raw data from MHTTIS by D.T. July 2003
Note: See Appendix A for the descriptions of vehicle class

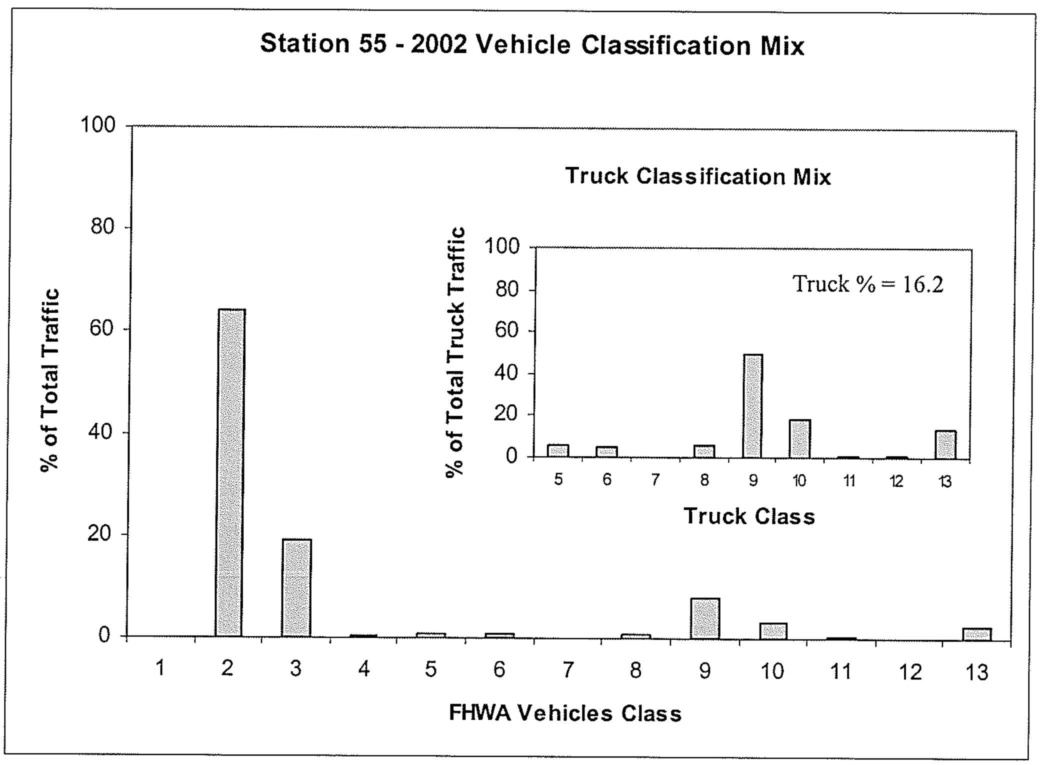


Figure 4.6: 2002 Vehicle Classification Mix at Station 55

The following are the findings provided from the classification analysis at this site:

- Trucks (FHWA classes 5 to 13) account for 16 percent of a total of 4,604,088 vehicles classified.
- Of the 747,359 classified trucks, single-unit trucks (classes 5 to 7) account for 10 percent; single-trailer trucks (classes 8 to 10) account for three-quarters of the total truck volume; and multiple-trailer trucks (classes 11 to 13) account for 16 percent of the total truck volumes.

The classification mix of the 33 AVC stations are presented in Tables B.5 (a) and B.5 (b) of Appendix B.

4.4 MANITOBA EXTERNAL INFORMATION DATABASES

There are two other primary sources of truck volume data outside Manitoba: (1) truck data from AVC stations in adjacent provinces; and (2) the BTS U.S.-Canada Border Crossing database. The truck databases are used to enhance truck volume estimation and characterization at the borders with adjacent jurisdictions.

Classification Count Stations in Adjacent Provinces

Table 4.11 presents the descriptions of locations and truck data for the 3 AVC stations in adjacent provinces. The AADTT and classification mix for these sites are calculated, and the results are presented in Appendix B.

Table 4.11: Descriptions of the Classification Count Sites in Adjacent Provinces

Province	Station No.	Location Description	Data Period	Duration of Available Data
SASK	S1	Highway 1, 8.3 km West of MB/SASK Border	01/01 - 12/31 2002	356 days
	S16	Highway 16, 7.7 km West of MB/SASK Border	10/01 -12/31 2002	92 days
ONT	S17	Highway 17, 15 km East of MB/ON Border	05/30 - 06/12 2001	14 days

The BTS U.S.-Canada Border Crossing Database

The truck volume estimates at the U.S. border crossing were developed using the BTS U.S.-Canada Border Crossing database, which records the total number of trucks travelling into the United States (southbound truck traffic) every month at the border crossing. The truck volume estimates at major ports of entry between Manitoba and the United States are presented in Table B.6 of Appendix B.

CHAPTER 5

METHODOLOGIES FOR ESTIMATING AND CHARACTERIZING TRUCK VOLUMES

This Chapter discusses the development of methodologies to estimate and characterize truck volumes on Manitoba highways. The methods developed to estimate the truck volumes are: (1) direct measurement; (2) transferring AADTT from adjacent segments; and (3) base Manitoba truck volumes for highway segments with no available truck information. Each of the methods produces estimates of varying quality, which will be discussed in Chapter 6. This Chapter also discusses the development of truck traffic pattern groups (TTPGs) for characterizing truck volumes on the highways.

5.1 DIRECT MEASUREMENT METHOD

The direct measurement method distinguishes two categories of truck volume segments, and uses different procedures for estimating AADTT on these segments in each category. These two categories are:

1. segments containing AVC stations
2. segments containing short-term classification counts

5.1.1 Segments Containing AVC Stations

For each truck volume segment containing an AVC station, AADTT at the stations is estimated by applying the AASHTO three-step averaging process to the daily truck counts. See details in section 4.3.1.

5.1.2 Segments Containing Short-Term Classification Counts

Truck volume segments containing short-term classification counts are assigned to AVC stations (control stations) or truck traffic pattern groups for the expansion to AADTT using the seasonal and day-of-week factors developed in Chapter 4. The control stations and the TTPGs are assumed to have similar truck travel patterns as that experienced at these short-term classification counters.

The short-term count collected on the truck volume segment is expanded to an AADTT estimate using the following formula:

$$AADTT_{(h/c)i} = [\{(VOL_{(h/c)i} \div T_{(h/c)}) \div D_{(h/c)} \} \div M_{(h/c)}] \qquad \text{(Eq. 5.1)}$$

Where $AADTT_{(h/c)i}$ = the annual average daily truck traffic at location i of control station c or truck traffic pattern group h

$VOL_{(h/c)i}$ = the truck volume count at location i of control station c or TTPG h

$T_{(h/c)}$ = the applicable time-of-day factor for control station c or TTPG h

$D_{(h/c)}$ = the applicable day-of-week factor for control station c or TTPG h

$M_{(h/c)}$ = the applicable monthly factor for control station c or TTPG h

If a AVC station is assigned as the control station for a short-term count site, then the short-term count is expanded using adjustment factors of that control station. If no control station has been identified, or if adjustment factors are not available at the control station, then the short-term count is expanded using adjustment factors of its truck traffic pattern group. This method is a combination of the roadway specific and traditional factoring approaches discussed in Chapter 2.

Time-of-Day Adjustments

The FHWA Traffic Monitoring Guide and AASHTO Guidelines recommend that classification counts should be collected for a minimum of 24 hours, and preferably 48 consecutive hours. However, current practice in the province shows the majority of short-term classification counts collected by the Manitoba Transportation and Government Services are conducted manually at intersections for a duration of 14 hours, for two consecutive days. These 14-hour counts are expanded to 24-hour estimates using time-of-day adjustment factors created from permanent classification counters.

Time-of-day adjustment factors should be created for specific roadways (using data collected from the control stations) or specific types of roadways (using data collected from control stations within the same truck traffic pattern group), and for specific hours of the day. The time-of-day adjustment factors are developed using the procedure discussed in section 4.3.3.

Table 5.1 shows the hourly percentage of the daily truck volume at AVC station 24 (PTH 10, 2.7 km North of PTH 1). The percentages can be added together as needed to create an adjustment percentage for any series of hours of data collection. The formula below is used to compute the daily total truck volume estimated by the short count:

$$\text{Daily Truck Volume} = \frac{\text{short count volume}}{\text{percent of travel during time period counted}} \times 100 \qquad \text{(Eq. 5.2)}$$

Thus, if a 14-hour count was taken from 07:00 to 20:00, and 255 trucks were counted, then using the hourly percentages from Table 5.1 and the above equation, the total daily truck volume would be estimated as 300 trucks (Daily Truck Volume = 255/85 x 100 = 300). The adjusted daily truck volume count is then expanded into an AADTT estimate using the adjustment factors.

Table 5.1: Calculation of Average Travel by Time of Day for Trucks (Classes 5-13) at AVC station 24 (PTH 10, 2.7 km North of PTH 1)

Time of Day	Truck Counts	Number of Hours	Average Weekday Truck Volumes By Hour	Percentage of Truck Volume
1	1186	312	4	1.0
2	1145	312	4	1.0
3	782	312	3	0.7
4	848	312	3	0.7
5	1261	312	4	1.1
6	1659	312	5	1.4
7	3122	311	10	2.7
8	5755	306	19	5.1
9	6936	295	24	6.4
10	7782	304	26	7.0
11	7840	302	26	7.1
12	7861	303	26	7.1
13	8098	310	26	7.1
14	8336	309	27	7.3
15	8720	311	28	7.6
16	8802	311	28	7.7
17	7626	311	25	6.7
18	5930	311	19	5.2
19	5035	312	16	4.4
20	4104	312	13	3.6
21	3308	312	11	2.9
22	2757	312	9	2.4
23	2488	312	8	2.2
24	1724	312	6	1.5
		Total	367	100.0

5.2 TRANSFERRING METHOD

The transferring method distinguishes two categories of truck volume segments, and uses different procedures for estimating AADTT on these segments in each category. The two categories are:

1. segments adjacent to segments with AADTT estimates
2. segments connecting to segments in adjacent jurisdictions with truck volume information

5.2.1 Segments Adjacent to Segments with AADTT Estimates

For each segment that is located adjacent to segments containing permanent classification stations or short-term classification counts, the AADTT is estimated by transferring the AADTT from adjacent segments through flow balancing analysis at the segmentation node. This is illustrated in the schematic diagram shown in Figure 5.1.

The truck traffic at the intersection node of segments A, B, and C only involves a turning movement between segments B and C. Therefore the AADTT on segment C is estimated by adding the AADTT on segments A and B (AADTT = 200).

This method requires expert knowledge about the truck activities at the specific location. Truck turning movement information at the intersection can be obtained using the 14-hour visual turning movement counts conducted by the traffic monitoring staff.

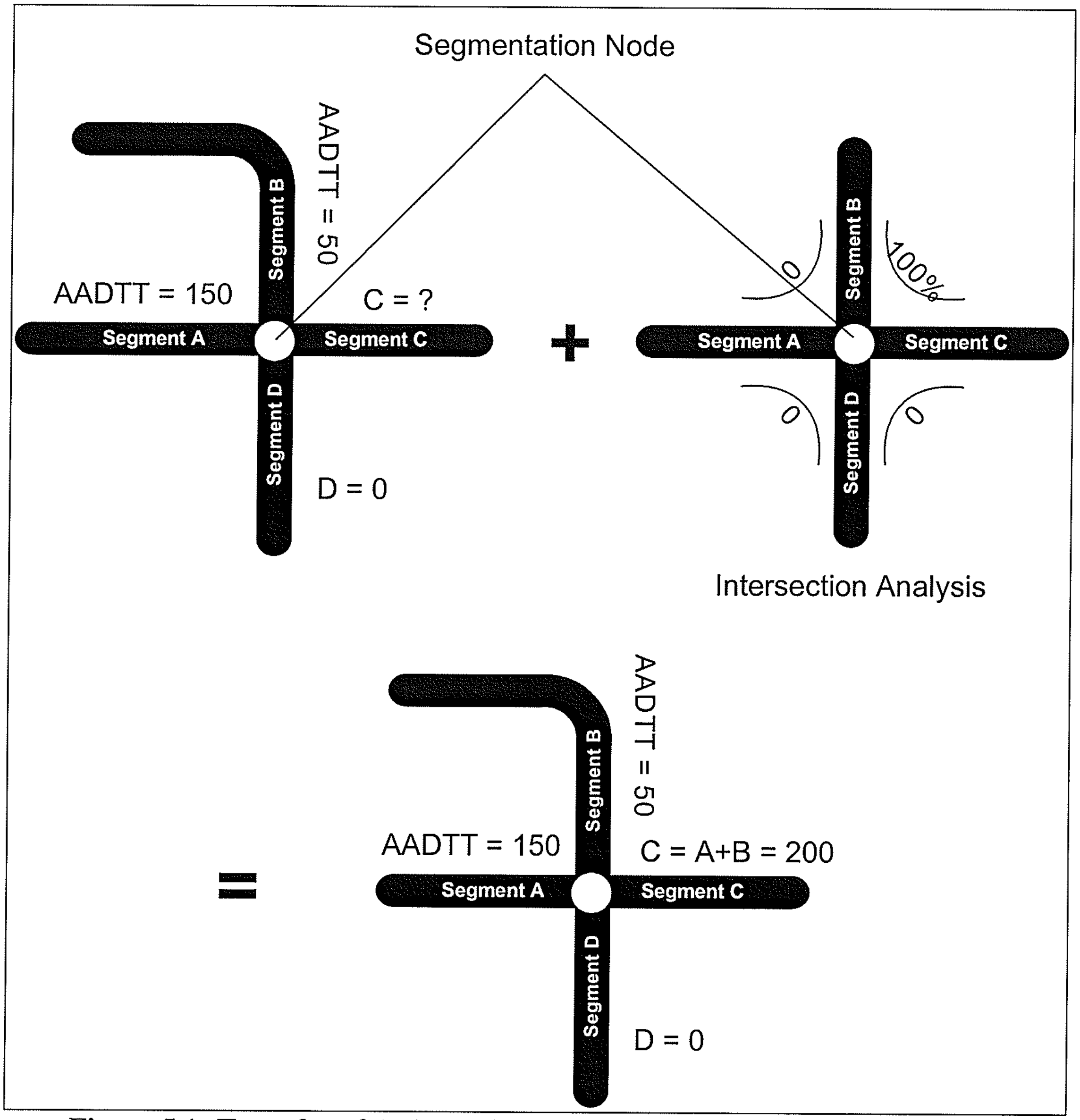


Figure 5.1: Transfer of AADTT from Adjacent Truck Volume Segments

5.2.2 Segments Connecting to Segments in Adjacent Jurisdictions

Truck volume segments at the borders are separated by an "imaginary" node to differentiate segments in different jurisdictions. After applying engineering judgement, the AADTT estimates are directly transferred from segments in adjacent jurisdictions that contain AVC stations (Saskatchewan and Ontario), and from truck volume information from the BTS U.S.-Canada Border Crossing database.

5.3 BASE MANITOBA TRUCK VOLUME METHOD

Highway segments in the DT-Network with no existing truck information are assigned to the base Manitoba truck volume by using 1999 AADTT as the default estimates. The method used for the estimation of 1999 AADTT is covered in Section 2.4.1. Eighty five percent of these segments are located on very low volume highways with AADTT less than 240 (based on 1999 data), which have minimal impact on the overall TKT generated in the DT-Network.

5.4 DEVELOPMENT OF TRUCK TRAFFIC PATTERN GROUPS

Truck volumes on Manitoba highways are characterized through the development of truck traffic pattern groups (TTPGs). The following subsections describe the details for the development of Manitoba truck traffic pattern groups.

The development of truck traffic pattern groups (TTPGs) begins with existing AVC stations defined in the truck volume core database for the MHTTIS (section 4.3). The following is the procedure used to develop the TTPGs in this research:

1. Select permanent classification stations for the analysis.
2. Develop first grouping based on the seasonal variations at each permanent classification station.
3. Further define the seasonal groups by sub-dividing each group based on the day-of-week variations at each permanent classification station.
4. Apply engineering judgement to finalize the grouping of stations, based on the geographic distribution of stations and industrial intelligence about the truck activities for each station within the same group.

5.4.1 Cluster Analysis

The cluster analysis is a hierarchical grouping algorithm used to identify similar objects from the characteristics they possess (Anderberg, 1973). The first step in the cluster analysis is to determine which objects (or variables) will determine the process. In the field of transportation engineering, the most common and important adjustment factors are the seasonal (monthly) and day-of-week factors computed for expanding the short-term counts (U.S. DOT, 2001). Therefore these two factors are used as the variables for grouping the AVC stations into their similar seasonal and day-of-week travel patterns.

However, this does not provide definable characteristics or criteria upon which to form groups. Therefore the cluster groups should be further analyzed by geographical location, land use information, and other knowledge of truck traffic to provide adequate criteria for final group formation.

Table 5.2 shows the 33 AVC stations that are used for the grouping process, based on the data set for 2002. The stations are selected based on the requirement that it must contain data for at least two consecutive weeks for each month in the year 2002. This provides continuous data from at least half of each month for analysis.

Table 5.2: List of the 33 AVC Stations for the Cluster Analysis

Station No.	Hwy No.	Location Description
55	1	Headingley (PTH 1, 3.9 km W. of PR 334)
61	1	Brokenhead (PTH 1, 4.4 km W. of Brokenhead River)
62	1	Oak Lake (PTH 1, 7.3 km W. of PTH 21)
65	1	Macgregor (PTH 1, 7.0 km W. of PR 350)
11	2	Starbuck (PTH 2, 5.2 km W. of PR 332)
66	2	Nesbitt (PTH 2, 4.1 km W. of PR 344)
92	2	Souris (PTH 2, 3.3 km E. of PR 347)
15	3	Morden (PTH 3, 9.9 km W. of PR 432)
51	3	Oakbluff (PTH 3, 0.3 km S.W. of PTH 2)
49	5	Ochre Ricer (PTH 5, 1.6 km E. of PTH 20)
54	5	Neepawa (PTH 5, 4.8 km N. of PTH 16)
82	6	Paint Lake (PTH 6, 0.8 km S. of Paint Lake Access)
88	6	Woodlands (PTH 6, 4.2 km N. of PR 248)
21	10	Boissevain (PTH 10, 1.6 km N. of PR 448)
24	10	Brandon West (PTH 10, 2.7 km N. of PTH 1)
50	10	Swan River L.P. East (PTH 10, 4.8 E. of PR 268)
52	10	Swan River L.P. W. (PTH 10, 3.3 km W. of L.P. Plant)
84	10	Mink Creek (PTH 10, 3.8 km S. of S. Jct. with PTH 10A)
90	10	The Pas (PTH 10, 5.3 km N. of Tolko Access Rd)
98	10	The Pas S. (PTH 10, 0.5 km S. of Young's Point Rd)
10	12	Zhoda (PTH 12, 6.4 km S. of PR 302)
81	13	Oakville (PTH 13, 3.2 km S. of Oakville)
87	14	Altona (PTH 14, 1.0 km E. of PTH 30)
43	16	Strathclair (PTH 16, E. of E. Jct. with PR 354)
46	16	Portage La Prairie (PTH 16, 2.4 km N. of PTH 1)
83	50	Langruth (PTH 50, 1.3 km S. of PR 265)
89	59	Niverville (PTH 59, 1.9 km N. of PTH 52)
63	75	Glenlea (PTH 75, 5.1 km S. of PR 210)
53	83	Swan River South (PTH 83, 1.1 km S.W. of PR 486)
91	83	Pipestone (PTH 83, 1.6 km N. of PTH 2)
64	100	Symington (PTH 100, 0.2 km W. of Murdock Rd)
86	101	Wenzel (PTH 101, 1.0 km E. of Wenzel Rd)
85	110	Brandon East (PTH 110, 0.5 km S. of PR 457)

In the cluster analysis, AVCs with similar seasonal and day-of-week variation patterns are grouped using the CLUSTER procedure of the Statistical Analysis Software (SAS). For a description of SAS procedures, refer to the SAS User's Guides (SAS Institute, 2000). This procedure uses Ward's minimum variance method of hierarchical grouping, which involves calculating the distance between two clusters through an analysis of variance (ANOVA) (SAS Institute, 2000). The ANOVA sum-of-squares is summed over all the variables (e.g., there are 12 variables in the seasonal grouping analysis, one for each month of the year), and the two objects with the least within-cluster sum-of-squares are joined to form a new cluster. This process is repeated until only one cluster remains.

5.4.2 Analysis of Seasonal Truck Travel Patterns

At each of the 33 AVC stations, the 12 monthly distribution factors (calculated as the ratio of MADTT to AADTT) are used as input values into the CLUSTER procedure in SAS. The SAS software produces numbers of groups ranging from 32 groups (each site was considered as a separate group) to one group (all sites were grouped together into a single group). The outputs of the analysis of seasonal grouping from the SAS program are provided in Appendix C.

The resulting groups are analyzed in terms of the semi-partial R^2 at each level of the grouping process. The semi-partial R^2 is an indication of the change in the R^2 statistic at each level of the grouping process. Each time two stations are grouped together, the R^2 value becomes less than it was compared to the previous step, due to the greater difference associated with joining two sites which are not the same. The semi-partial R^2 measures the decrease in the proportion of variance as a result of joining two clusters.

Figure 5.2 shows a graph of the semi-partial R^2 in the grouping process, from 32 groups to one group. The figure shows that a substantial increase in semi-partial R^2 value is observed before five groups, and there is little change in the semi-partial R^2 after eight groups. Therefore the ideal number of groups is selected between five and eight.

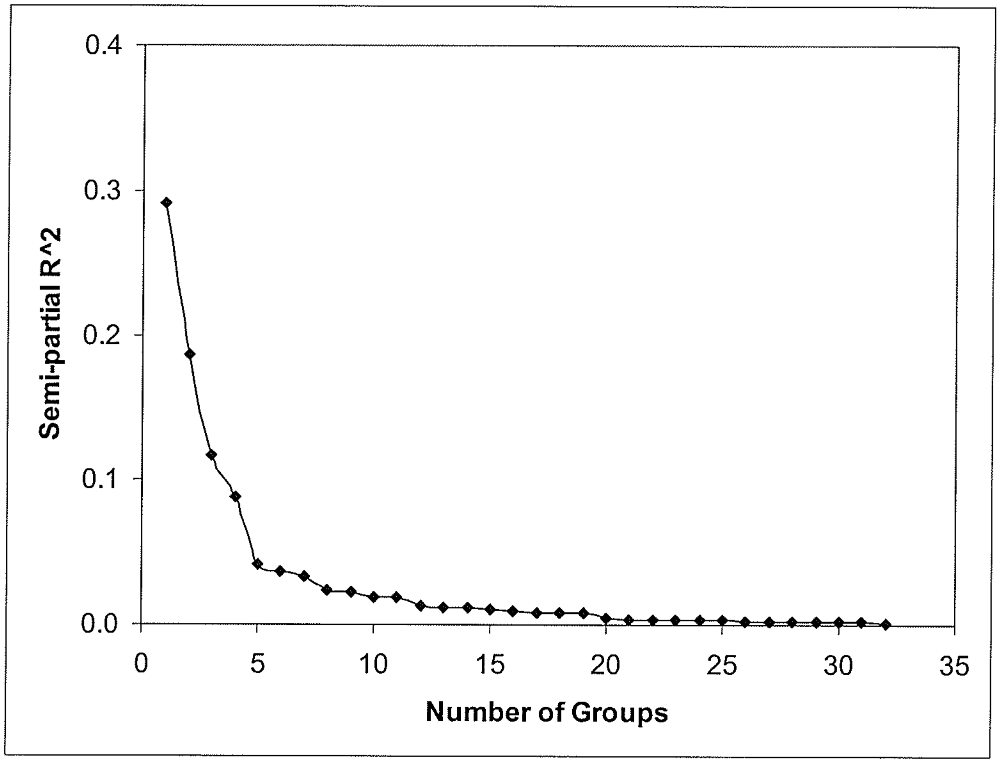


Figure 5.2: Semi-Partial R^2 in the Seasonal Grouping Process

<u>Results of the Seasonal Grouping Analysis</u>

After examining the seasonal variations of truck volumes for different cluster groups, the following three counters, Station 61 (PTH 1, 4.4 km west of Brokenhead River), Station 83 (PTH 50, 1.3 km south of PR 265), and Station 90 (PTH 10, 5.3 km north of Tolko Access Road) are observed to have distinctly different patterns from the other stations. These three counters are left ungrouped. The seasonal patterns of truck volumes at these stations are shown in Table B.2 of Appendix B.

There are four seasonal groups identified in this research. Each group is further analyzed based on its geographic characteristics and industrial intelligence about the truck activities for each station within the same group. The following describe the characteristics of the resulting four seasonal groups:

- *Seasonal Group 1 Counters* exhibit low seasonal variations (+/- 18 %) compared to the other seasonal groups. These counters are located on major highways that carry intra/inter-provincial and international long-distance truck traffic, and a broad mix of commodities. Examples of such highways are the TransCanada Highway, Yellowhead Highway, Perimeter Highway, PTHs 2, 3, and 12 close to the Winnipeg, and PTH 75 connecting to the U.S. All stations in this group experience lower truck volumes in winter months compared to other seasons.

- *Seasonal Group 2 Counters* exhibit moderate seasonal variations (+/- 28%), and are located on highways transporting broad mix of commodities to population centers over longer distances, such as Thompson on PTH 6, and The Pas on PTH 10. These counters have high summer truck traffic with seasonal peaks in June and September.

- *Seasonal Group 3 Counters* have high seasonal variations (+/- 34 %) and are located on highways related to agricultural activities (e.g., PTHs 2 and 3 west of PTH 34). The seasonal peaks of these counters are in May and October, which correspond to increased agricultural-related trucking at these times – fertilizer and seed in the spring, and grain in the fall.

- *Seasonal Group 4 Counters* have high seasonal variation (+/- 36%), and are all located on highways close to forestry activities (e.g., PTH 10 in northwestern Manitoba). These counters exhibit high truck volumes in winter months, corresponding to the logging season for forestry products.

Figure 5.3 summarizes the seasonal variation patterns of these four groups. The y-axis shows the ratio of MADTT to AADTT. All groups have more truck traffic in the summer and fall than in winter and spring months, except Seasonal Group 4 which experiences high winter truck traffic due to forestry activities. Seasonal Group 1 has the least seasonal variation, and Seasonal Group 2 has moderate seasonal changes with peaks in the months of June and September. Seasonal Group 3 experiences high seasonal variations with patterns that reflect agricultural-related trucking activities (high seasonal peaks in May and October).

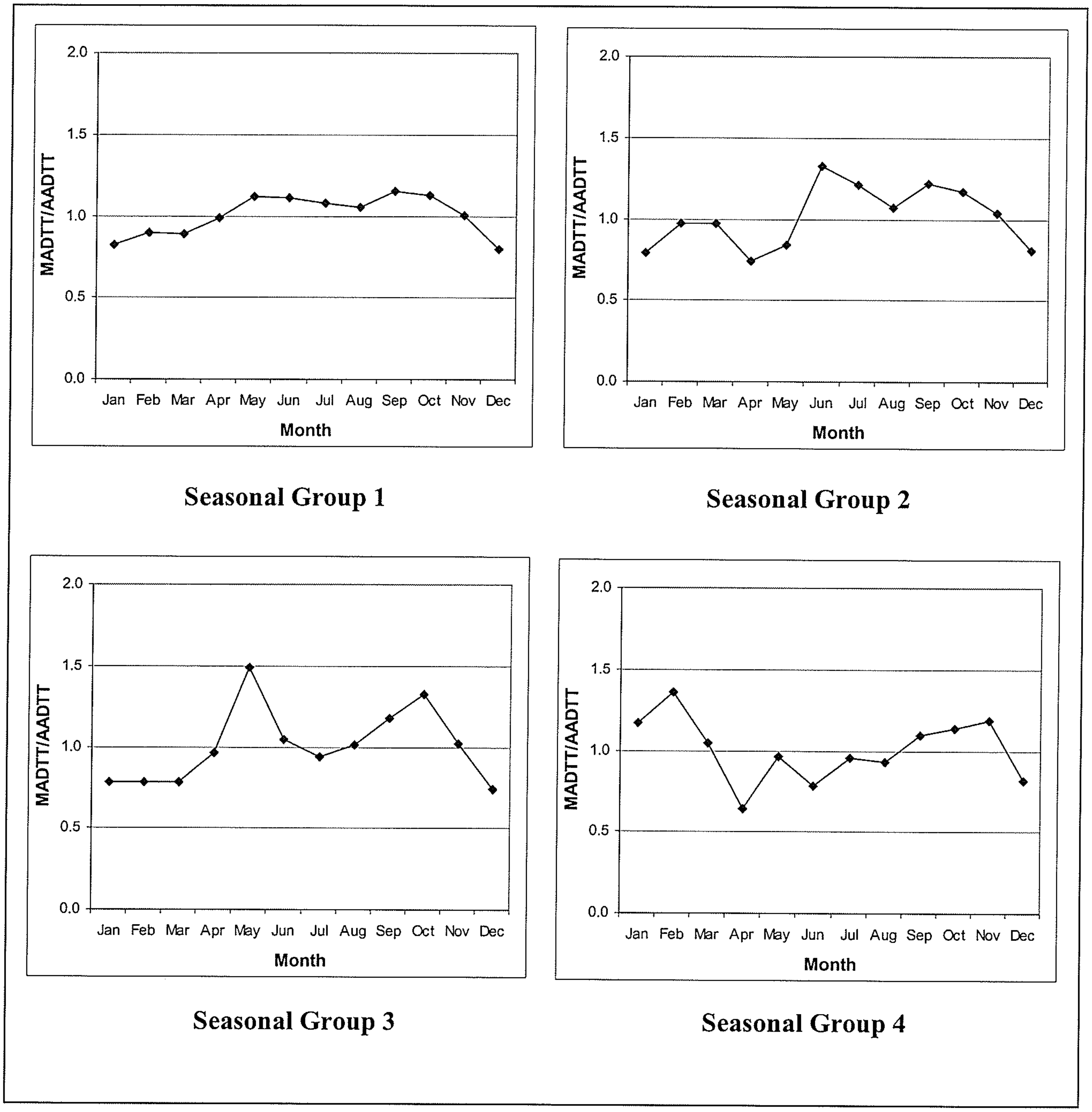


Figure 5.3: Seasonal Variations of the Four Seasonal Groups

5.4.3 Analysis of Day-of-Week Truck Travel Patterns

Each of the four seasonal groups is further subdivided in terms of the day-of-week travel patterns within each seasonal group. This is done to further define the truck traffic patterns in terms of day-of-week truck travel variations.

Results of the Day-of-Week Grouping Analysis

Figure 5.4 shows the results of the day-of-week truck travel patterns for each seasonal group. AVC counters of Seasonal Group 1 are subdivided into two groups of day-of-week patterns: (1) counters exhibiting moderate day-of-week variation (located on highways carrying long-distance truck traffic, such as TransCanada Highway, Perimeter Highway, PTHs 16 and 75); and (2) counters exhibiting very high variations between weekday and weekend truck volumes (located on highways close to population centers, such as Winnipeg, Morden, and Winkler, where Saturday and Sunday are "low" freight days).

Seasonal groups 2, 3, and 4 all experience similar day-of-week patterns with very high variations between weekday and weekend truck volumes. The very high variations are caused by the local-oriented trip type carried by the majority of truck traffic on these highways, and their proximity to rural population centers.

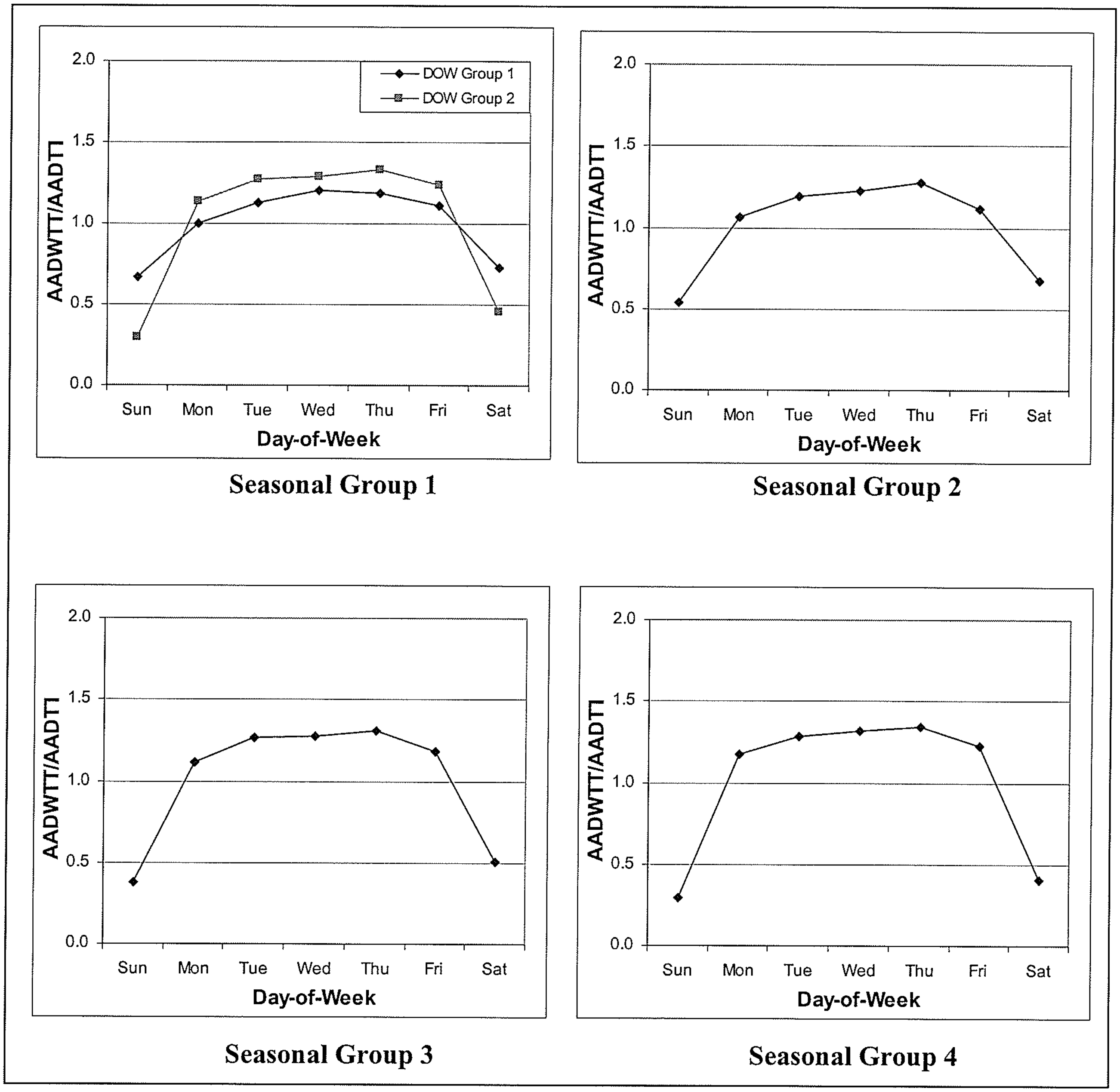


Figure 5.4: Day-of-Week Variations of the Four Seasonal Groups

5.4.4 Summary of the Truck Traffic Pattern Groups

Based on the analysis of seasonal and day-of-week variations at AVC stations, and the further analysis of geographical location and industrial intelligence about truck activities for the counters within each seasonal and day-of-week pattern group, five TTPGs are developed. Table 5.3 describes the TTPGs by their seasonal and day-of-week variation patterns, and provides general comments on the geographical locations and truck activities of the sites. Table 5.4 lists the permanent classification counters belonging to each of these groups.

Table 5.3: Summary of the TTPGs Developed from the Study Region

TTPG	Seasonal Pattern	Day-of-Week Pattern	Geographical Characteristics
Group 1	Small seasonal variations, with summer truck volumes higher than winter.	Moderate day-of-week variations, with weekend truck volumes lower than weekday.	These routes are major highways that serve mainly inter-provincial long-distance trip purposes and transport a broad mix of commodities. They are located further away from population centers.
Group 2	Small seasonal variations, similar to Group 1	Very high day-of-week variations, with very low weekend truck volumes compared to weekday.	These routes are major highways that serve long-distance purposes and transport a broad mix of commodities. They lie adjacent to urban and rural population centers, such as Winnipeg and Dauphin.
Group 3	Moderate seasonal variations, with seasonal peaks in June and September.	Very high variations between weekday and weekend truck volumes.	These routes are highways that serve intra-provincial long-distance trip purposes and transport a broad mix of commodities, and are located further away from population centers.
Group 4	High seasonal variations, with May and October peaks.	Similar to Group 3, with very low weekend truck volumes compared to weekday.	These routes are similar to Group 2, but normally contain truck traffic with specific commodities related to agricultural activities.
Group 5	High seasonal variations, with very high truck volumes in winter months.	Similar to Groups 2, 3, and 4.	These routes are located close to population centers in Northwestern Manitoba, such as Swan River, with truck traffic that reflects logging activities (high truck volumes in winter months).

Table 5.4: List of Permanent Classification Counters in the TTPGs

Station No.	Highway	Location
Truck Traffic Pattern Group 1		
55	1	Headingley (PTH 1, 3.9 km W. of PR 334)
62	1	Oak Lake (PTH 1, 7.3 km W. of PTH 21)
65	1	Macgregor (PTH 1, 7.0 km W. of PR 350)
10	12	Zhoda (PTH 12, 6.4 km S. of PR 302)
43	16	Strathclair (PTH 16, E. of E. Jct. with PR 354)
46	16	Portage La Prairie (PTH 16, 2.4 km N. of PTH 1)
63	75	Glenlea (PTH 75, 5.1 km S. of PR 210)
64	100	Symington (PTH 100, 0.2 km W. of Murdock Rd)
86	101	Wenzel (PTH 101, 1.0 km E. of Wenzel Rd)
Truck Traffic Pattern Group 2		
Station No.	Highway	Location
11	2	Starbuck (PTH 2, 5.2 km W. of PR 332)
15	3	Morden (PTH 3, 9.9 km W. of PR 432)
51	3	Oakbluff (PTH 3, 0.3 km S.W. of PTH 2)
49	5	Ochre Ricer (PTH 5, 1.6 km E. of PTH 20)
84	10	Mink Creek (PTH 10, 3.8 km S. of S. Jct. with PTH 10A)
87	14	Altona (PTH 14, 1.0 km E. of PTH 30)
89	59	Niverville (PTH 59, 1.9 km N. of PTH 52)
91	83	Pipestone (PTH 83, 1.6 km N. of PTH 2)
Truck Traffic Pattern Group 3		
Station No.	Highway	Location
82	6	Paint Lake (PTH 6, 0.8 km S. of Paint Lake Access)
88	6	Woodlands (PTH 6, 4.2 km N. of PR 248)
98	10	The Pas S. (PTH 10, 0.5 km S. of Young's Point Rd)
Truck Traffic Pattern Group 4		
Station No.	Highway	Location
66	2	Nesbitt (PTH 2, 4.1 km W. of PR 344)
92	2	Souris (PTH 2, 3.3 km E. of PR 347)
54	5	Neepawa (PTH 5, 4.8 km N. of PTH 16)
21	10	Boissevain (PTH 10, 1.6 km N. of PR 448)
24	10	Brandon West (PTH 10, 2.7 km N. of PTH 1)
81	13	Oakville (PTH 13, 3.2 km S. of Oakville)
85	110	Brandon East (PTH 110, 0.5 km S. of PR 457)
Truck Traffic Pattern Group 5		
Station No.	Highway	Location
50	10	Swan River L.P. East (PTH 10, 4.8 E. of PR 268)
52	10	Swan River L.P. W. (PTH 10, 3.3 km W. of L.P. Plant)
53	83	Swan River South (PTH 83, 1.1 km S.W. of PR 486)

5.5 ASSIGNMENT OF TRUCK VOLUME SEGMENTS TO TTPGs AND CONTROL STATIONS

This section discusses the assignment of truck volume segments to appropriate TTPGs and control stations. The analysis in the previous section indicates that permanent counters within the same TTPG normally exhibit similar geographic characteristics and carries similar type of truck traffic.

For example, PTH 1 (TransCanada highway) west of Winnipeg to the Saskatchewan border exhibits small seasonal variation (+/- 20 percent) with higher summer truck traffic compared to winter truck traffic, and a moderate decline (+/- 30 percent) in weekend truck traffic compared to weekdays. This temporal pattern can be found on other major highways that carry long-distance truck traffic and a broad mix of commodities (e.g., PTHs 16 and 75). Hence, knowledge of a highway's geographic characteristics and industrial intelligence about truck activities at specific locations is critical in determining the most appropriate TTPG and control station for a truck volume segment.

The assignment of TTPGs involves identifying the truck volume segment on a map and determining its geographical location, such as proximity to population centers or agricultural areas, and whether it is a route that serves long-distance purposes and transports a broad mix of commodities. Once the geographic characteristics of a truck volume segment are determined, it is assigned to the appropriate TTPG and nearest AVC station that belongs to the same TTPG. The results of the assignment of TTPGs and control stations are discussed in Chapter 6.

CHAPTER 6

APPLICATION AND EVALUATION OF THE METHODOLOGIES

This Chapter discusses the application of the methodologies for estimating and characterizing truck volumes on the highways in the DT-Network, which account for more than two-thirds of the province's TKT based on 1999 data. The Chapter also discusses the quality measurements of AADTT estimates produced by different methods, which are subsequently used to develop a rating system for evaluating AADTT estimates on Manitoba highways.

6.1 ASSIGNMENT OF TTPGs AND CONTROL STATIONS

Truck volumes for the DT-Network are characterized through the assignment of TTPGs and control stations. The process of assigning the TTPGs and control stations is discussed in Chapter 5. Each of the 202 truck volume segments in the DT-Network are assigned to the appropriate control station and TTPG, and the results are shown in Figures D.1 to D.3 of Appendix D. Table 6.1 shows the percentages of highway kilometers in the DT-Network that are assigned to different TTPGs.

Table 6.1: Percentage of Highway Kilometers in the DT-Network by TTPG

TTPG	Route Kilometers (km)	Percentage of Route km
TTPG1	915	22.3
TTPG2	952	23.3
TTPG3	1,086	26.5
TTPG4	883	21.6
TTPG5	94	2.3
Not Assigned	165	4.0
Total	4,093	100.0

There are 4,093 kilometers of highways in the DT-Network. The route kilometers are almost evenly distributed among TTPGs 1 to 4, with each group accounting for about 22 percent of the total highways. TTPG 5 has the least amount of highway kilometers, accounting for only 2 percent of total highways. There are 4 percent of highways not assigned to any TTPG because they exhibit unique truck travel patterns that are not defined by any one of the five TTPGs. These highways are PTH 1 from the Perimeter Highway to the border of Manitoba and Ontario (control station 61) and PTH 10 between PR 283 and PR 287 (control station 90).

6.2 ESTIMATION OF TRUCK VOLUMES

Truck volumes on the highways in the DT-Network are estimated using the three methods developed in Chapter 5: (1) direct measurement method; (2) transferring method; and (3) base Manitoba truck volume method. The application of each method is discussed in the following subsections.

6.2.1 Direct Measurement Method

The application of direct measurement method for segments containing permanent classification stations and short-term classification counts is shown in the following example. In this example, AVC station 88 is selected as the control station for the manual 14-hour classification count collected at the intersection of PTH 6 and PR 332. Figure 6.1 shows the location of the AVC station and 14-hour counts, together with their corresponding truck volume control sequences.

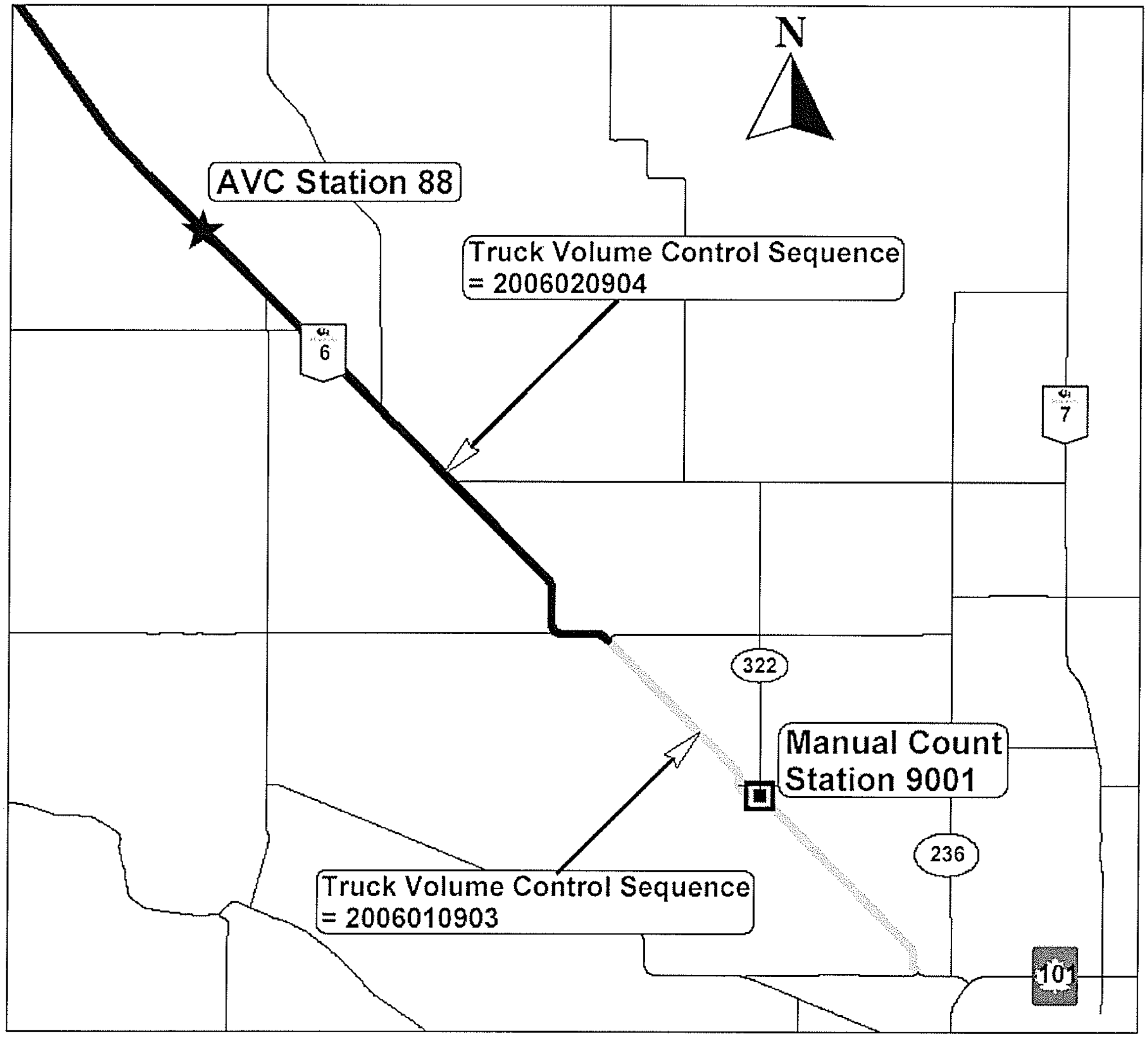


Figure 6.1: Example for the Application of Direct Measurement Method

For truck volume control sequence "2006020904", the AADTT on this segment is calculated using the AASHTO three-step averaging process with 2002 continuous truck data collected from station 88. The resulting AADTT is used as the denominator in the calculation of the monthly factors (ratio of MADTT to AADTT) and day-of-week factors (ratio of AADWTT to AADTT). The continuous truck traffic data are also used to calculate the average hourly percentage of the daily truck volume at station 88 for the expansion of 14-hour counts to 24-hour counts.

Table 6.2 shows the example for the calculation of AADTT on a truck volume segment which contains short-term classification counts.

Table 6.2: Example of AADTT Estimation for Short-Term Classification Counts

Truck Volume Control Sequence	Hwy No.	Short-Term Count Station	Control Station	TTPG	Date	Month	Day	Start Time	End Time
2006010903	6	9001	88	3	11/1/2002	11	Fri	7:00	21:00
2006010903	6	9001	88	3	11/7/2002	11	Thu	7:00	21:00

Continue' Table 6.2

14-Hour Count	14-Hour Factor	24-Hour Count	Monthly Factor	DOW Factor	2002 AADTT
325	0.76	428	1.07	1.09	367
309	0.76	407	1.07	1.28	297
				Average 2002 AADTT =	332
				2002 AADTT (nearest 10) =	330

In 2002, there were two short-term counts collected on truck volume control sequence "2006010903". The counts were collected on November 1 and 7, for the time period 7:00 to 21:00. The two 14-hour counts are expanded to daily counts using time-of-day factors developed from control station 88. These 24-hour counts are then expanded using the monthly and day-of-week factors corresponding to the date of the short-term counts. The two AADTTs are averaged to obtain the 2002 AADTT estimate for this particular truck volume segment.

In the above example, if the adjustment factors are not available at control station 88, the short-term counts are expanded using adjustment factors developed from TTPG 3.

6.2.2 Transferring Method

There are two types of transferring methods: (1) transferring of AADTT from adjacent segments using flow balancing analysis; and (2) direct transferring of AADTT from segments in adjacent jurisdictions at the borders.

Figure 6.2 shows an example for the transferring of AADTT using flow balancing analysis at a "T" intersection of PTHs 12 and 59, which contains 3 truck volume segments.

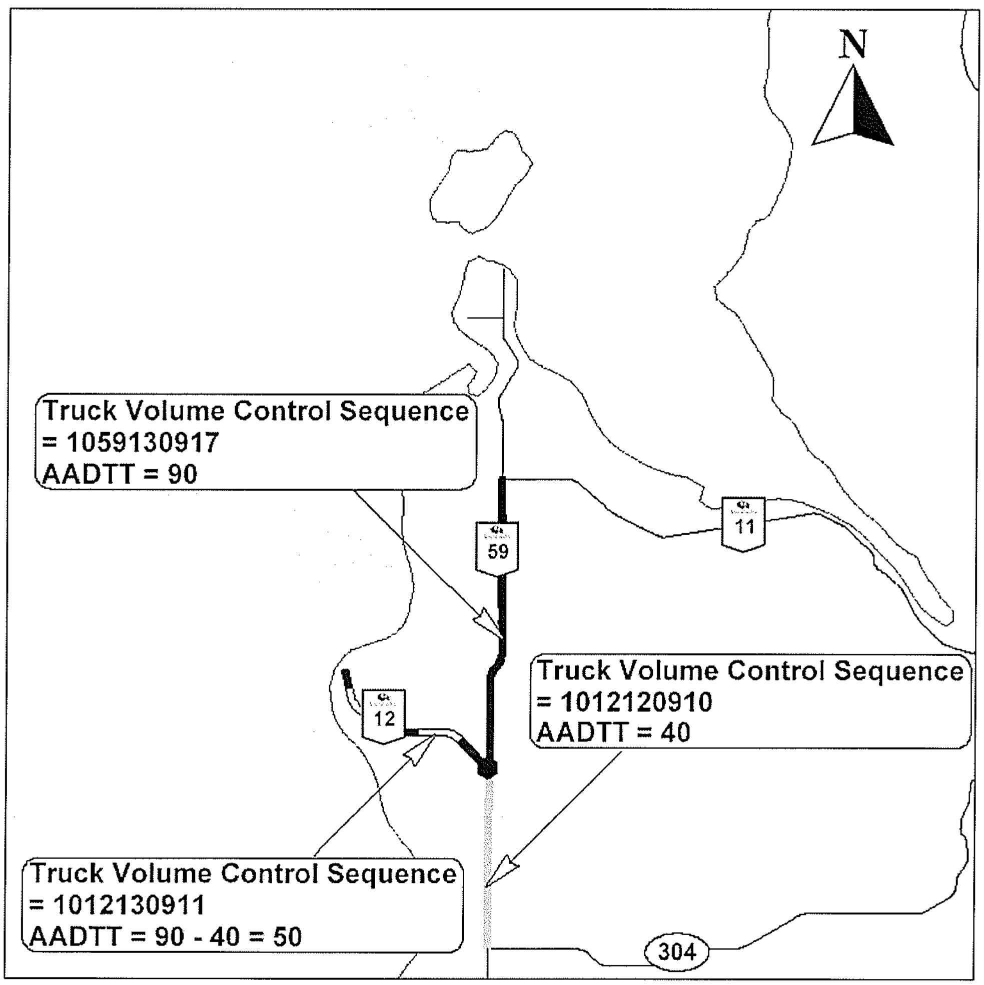


Figure 6.2: Example for the Application of Transferring Method with Flow Balancing Analysis

The figure shows that the AADTT on the north and south segments is 90 and 40 respectively. By using flow balancing analysis at the intersection, the AADTT on the west segment (truck volume control sequence "1012130911") is estimated by calculating the difference of AADTT between the north and south segment (i.e., AADTT = 90 – 40 = 50).

For truck volume segments that connect to adjacent jurisdictions, the AADTT is directly transferred from segments in adjacent jurisdictions that contain truck volume information. This is illustrated using an example shown in Figure 6.3.

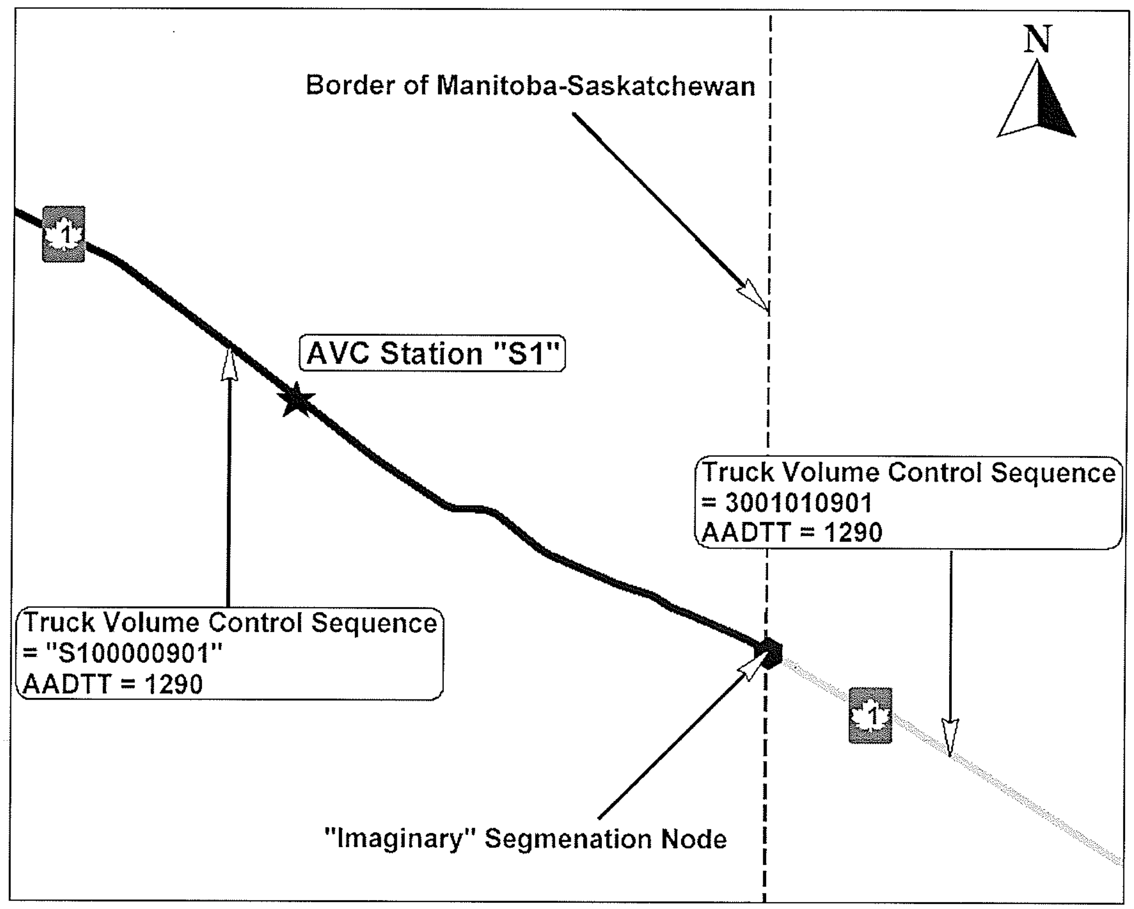


Figure 6.3: Example for the Direct Transfer of AADTT at the Border of Manitoba and Saskatchewan

In the above example, an "imaginary" segmentation node is created at the border of Manitoba and Saskatchewan to differentiate the truck volume segments in two different jurisdictions. The AADTT on truck volume control sequence "3001010901" is estimated by directly transferring the AADTT on the adjacent truck volume segment in Saskatchewan, which contains an AVC station with AADTT of 1290.

6.2.3 Base Manitoba Truck Volume Method

Truck volume segments that do not contain any truck information from after the year 1999 are assigned to the base Manitoba truck volume by using 1999 AADTT as the default estimates. These segments account for 15 percent (615 km) of the total highway kilometers in the DT-Network.

6.2.4 Quality Measurements of AADTT Estimates

This section describes the different quality measurements for the AADTT estimates produced by different methods and sources of truck data. The purpose of this analysis is to measure the quality of AADTT estimates based on selected objective parameters. The two parameters used for this analysis are: (1) methods of estimation (direct measurement, transferring, and base Manitoba truck volume); and (2) source year of truck data used for the estimation (2002, 2001, 2000, and 1999).

Table 6.3 shows the percentages of 2002 TKT in the DT-Network using truck data sources from different years. Two-thirds of the TKT generated in the network is estimated based on 2002 truck data, 19 percent from 2001 data, and 6 percent from 2000 data. The 1999 default values account for about 10 percent of the 2002 TKT in the DT-

Network. Users should apply their own judgement when applying AADTT estimates other than current year.

Table 6.3: 2002 TKT for the DT-Network by Source Year

Source Year of Truck Data	2002 TKT (in millions)	Percentage of 2002 TKT
2002	345.3	65.9
2001	100.4	19.2
2000	29.7	5.7
1999 Default	48.6	9.3
Total	524.0	100.0

Using this information, different quality measurements are assigned to each AADTT estimate based on the methods and data sources. Table 6.4 shows the quality measurements of AADTT estimates using different parameters.

Table 6.4: Quality Measurements of AADTT Estimates

Quality Measurement	Direct Measurement	Transferring	Default 1999 AADTT	Engineering Judgement
Exceptional (2002 Data)				
Excellent (2002 Data)				
Very Good (2000-2001 Data)				
Good (2000-2001 Data)				
Adequate (1999 or before data)				

Each cell of the above table represents a parameter that is applicable to the AADTT estimates. There are five quality measurements for AADTT estimates: (1) exceptional; (2) excellent; (3) very good; (4) good; and (5) adequate. The table shows that AADTTs produced by the direct measurement method with 2002 truck data are the highest quality of AADTT estimates. They are deemed to be "Exceptional" because they are calculated based on the latest available data, and account for the seasonal and day-of-week variations in truck volumes.

AADTT estimates calculated using the 1999 default AADTT values are assigned to the lowest quality measurement because it is using values produced by 1999 estimation, which involves multiplying the total traffic with percent truck and are not subjected to any temporal adjustments. The quality measurement method also suggests that each of the AADTT estimates need to be justified using engineering judgement, which involves quality control of field-based raw data, consistency of truck volumes on the same route, and flow balancing analysis at intersections.

6.3 RATING SYSTEM FOR AADTT ESTIMATES ON MANITOBA HIGHWAYS

Using Table 6.4 in the previous section, AADTT on every truck volume segment in the DT-Network is assigned to the appropriate quality measurement based on its estimation method and source year of data. The quality measurements are coupled with volume classes of AADTT to develop a rating system for evaluating AADTT estimates on Manitoba highways.

The 2002 AADTT estimates in the DT-Network are subcategorized into five volume classes using the Manitoba AADTT classification (section 4.3.1): (1) very low (AADTT: 0-240); (2) low (AADTT: 241-480); (3) medium (AADTT: 481-960); (4) high (AADTT:

961-1920); and (5) very high (AADTT > 1920). The basic assumption in the development of this rating system is that truck volume segments with higher AADTT contribute more to truck-kilometer of travel. Therefore it is more critical to have better estimation on these segments because of their overall impact on TKT generated in the DT-network.

The system rates the truck volume segments based on the quality measurements and the AADTT classes. For illustrative purposes, a diagram of the rating system is shown in Figure 6.4. The x-axis shows the five different AADTT classes, each corresponding to the numbers of 1 to 5. The numbers represent the relative importance of the AADTT estimates to the overall TKT, where "1" represents the least important and "5" represents the most critical. The y-axis shows the five different quality measurements for the AADTT estimates, each corresponding to the qualities of A to E, where "A" represents the best quality of AADTT estimates and "E" represents the lowest quality of AADTT estimates.

This rating system allows engineers to analyze and determine the quality of truck volume estimates that they are using for different highway planning, design, and management functions. The rating system can also be used for evaluating the existing truck traffic monitoring program through the identification of truck volume segments which have poor estimation of truck volumes.

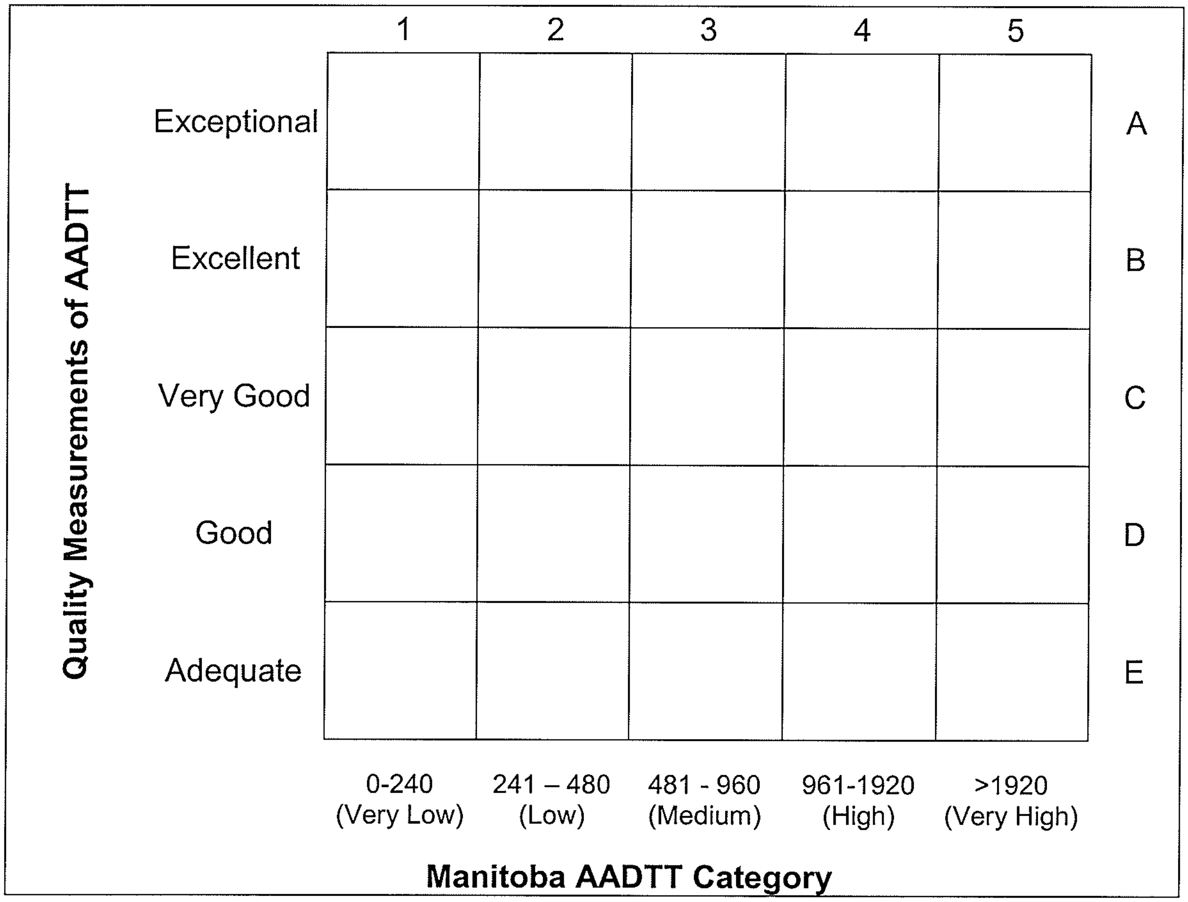


Figure 6.4: Rating System for AADTT Estimates

Using the above figure as an example, if the AADTT on a truck volume segment is estimated using base Manitoba truck volume and falls into the very high AADTT category, it is rated as "E5", which results in the worst rating because the truck volume segment contains a very high volume of truck traffic but is estimated using the lowest quality method. The users should be careful when applying such truck volume information, and more efforts should be spent on collecting truck data on this truck volume segment in the future. On the other hand, if a truck volume segment is rated as "A5", this means that monitoring resources are well spent because the segment which contains a very high AADTT is estimated using the best quality method.

This facilitates planning for future truck counting programs by allocating resources to highway segments that require better truck data, and thus improves the results of truck volume estimation using better truck data.

6.4 RESULTS FOR THE ESTIMATION OF 2002 AADTT

This section presents the results from the estimation of 2002 AADTT on truck volume segments in the DT-Network. Table 6.5 shows the 2002 TKT and route kilometers for different quality measurements (based on estimation methods and data sources).

Table 6.5: 2002 TKT and Highway Kilometers in the DT-Network by Quality Measurements

Quality Measurement	2002 TKT (in millions)	Percentage of 2002 TKT	Route Kilometers (km)	Percentage of Route km
Exceptional	271.2	51.8	1,584	38.7
Excellent	74.1	14.1	369	9.0
Very Good	101.8	19.4	1,437	35.1
Good	28.3	5.4	343	8.4
Adequate	48.6	9.3	360	8.8
Total	524.0	100.0	4,093	100.0

In 2002, two-thirds of the TKT in the DT-Network are produced by AADTT estimates with "Exceptional" and "Excellent" qualities, which accounts for 40 percent of the total highway kilometers. AADTT estimates with "Very Good" and "Good" qualities account for one-quarter of the TKT and 44 percent of the total highway kilometers. The 1999 default AADTT estimates account for 10 percent of the 2002 TKT and 9 percent of the total highway kilometers. The table also shows that TKT for the DT-Network grew from 455 million in 1999 to 524 million in 2002.

Figure 6.5 shows the 2002 AADTT flow on highways in the DT-Network. Truck volume segments in the DT-Network are assigned to their appropriate rating using the method developed in previous section. The details of AADTT estimates and rating for each truck volume segment are presented in Appendix E.

Highway Segments for Future Improvement in Truck Volume Estimation

The ratings of the AADTT estimates can be used to identify highway segments in the DT-Network that need improvement in truck volume estimation, and facilitate the prioritization of the truck traffic monitoring program.

Highway segments in the DT-Network are prioritized for improvement in truck volume estimation by subcategorizing the ratings into five different levels of priority, each corresponding to a set of ratings. Figure 6.6 shows the five different levels of priority and their corresponding ratings, represented by different colors. The designations of priority numbers represent the relative importance of the segments for improvement, where "P1" represents the highest priority and "P5" represents the lowest priority.

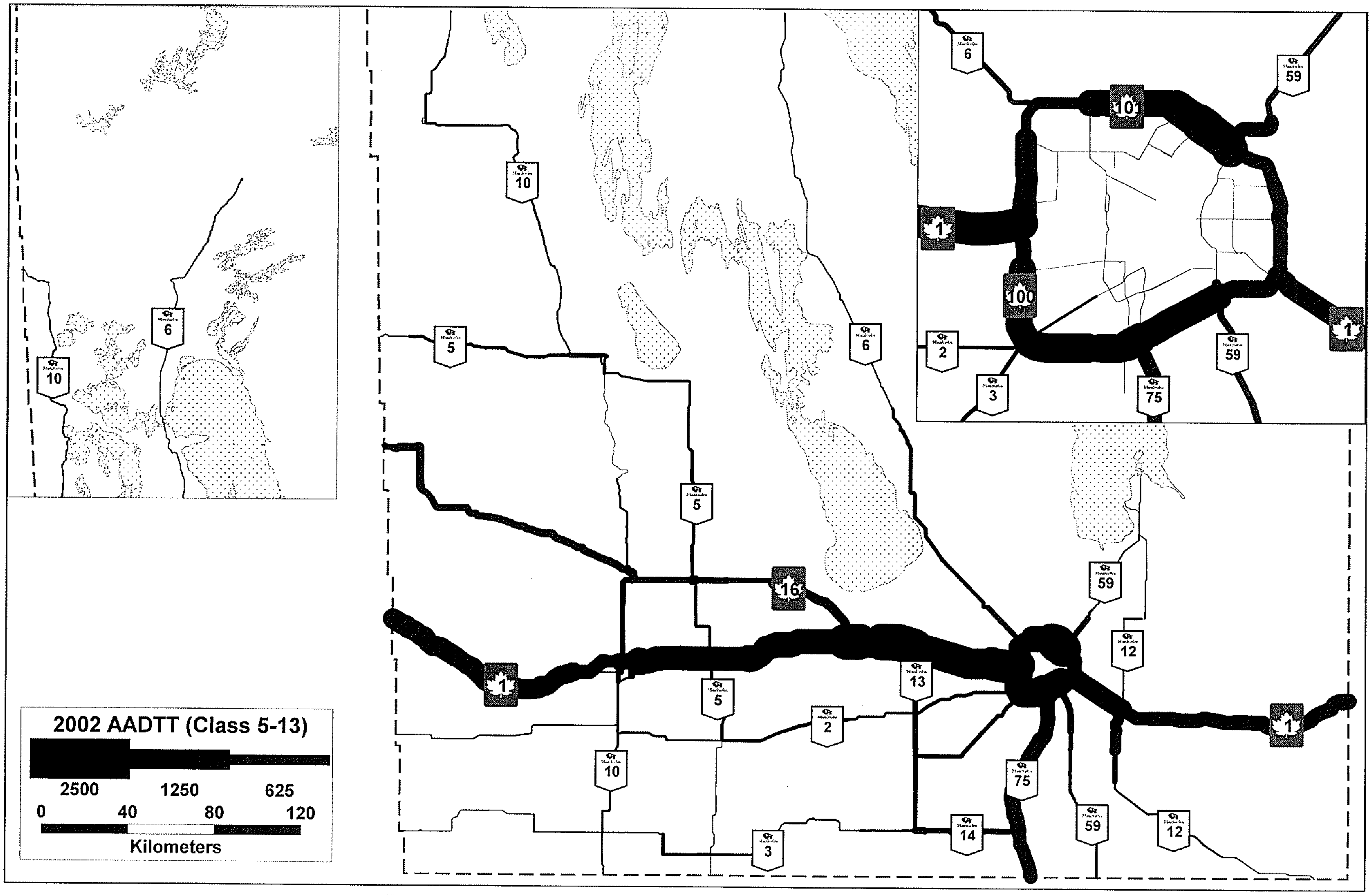


Figure 6.5: 2002 AADTT (Class 5-13) Flow for the DT-Network

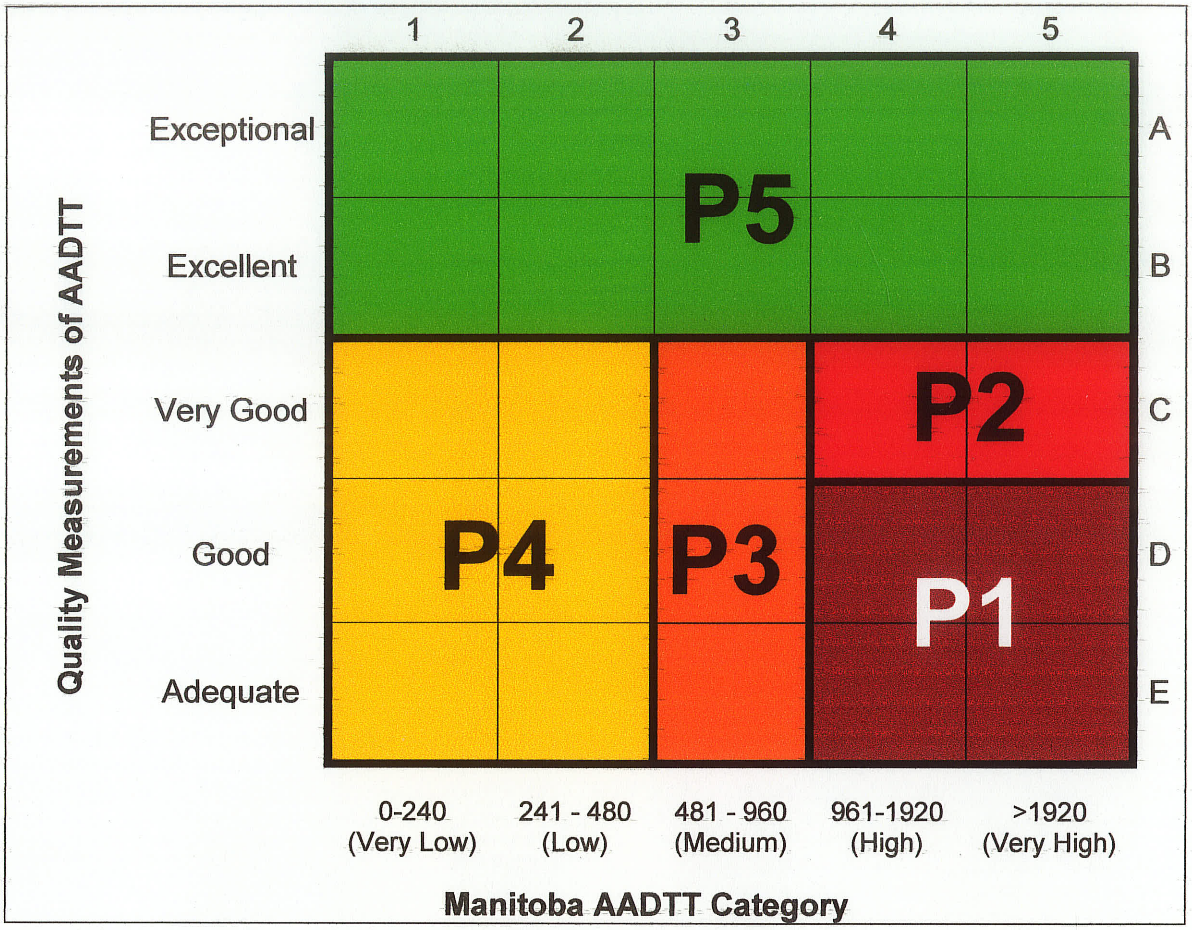


Figure 6.6: Priority Classification in the Rating System

Using the classifications in the above table, highway segments in the DT-Network are prioritized for improving truck volume estimation. The results are presented in Figure 6.7. The percentages of highway kilometers in the DT-Network by different levels of priority for improvement are shown in Table 6.6.

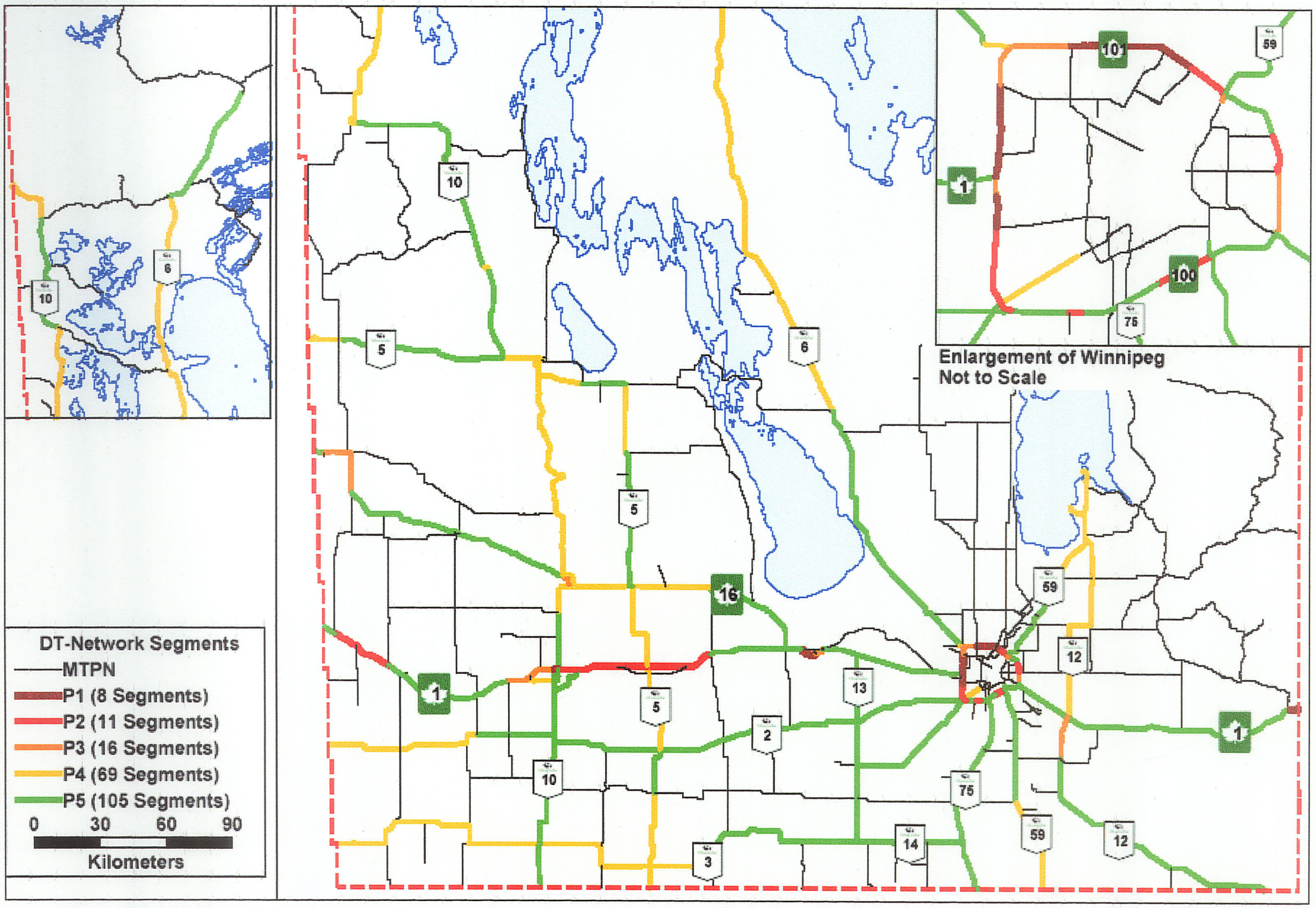


Figure 6.7: Priority for Improvement in Truck Volume Estimation for Highway Segments in the DT-Network

Table 6.6: Percentage of Route Kilometers in the DT-Network by Improvement Priority

Improvement Priority	Route Kilometers (km)	Percentage of Route km
P1	38	0.9
P2	127	3.1
P3	105	2.6
P4	1,578	38.6
P5	2,246	54.9
Total	4,093	100.0

The results show that there are eight highway segments listed as the highest priority for truck volume estimation improvement, and they account for 1 percent of the total highway kilometers in the DT-Network. These highway segments are distributed along highway segments that carry very high truck volumes and are close to urban centers (e.g., PTH 1 at Brandon and Portage La Prairie, and the Perimeter Highway at Winnipeg, etc.). The locations of these highway segments are shown in Figure 6.7, and descriptions of the segments are presented in Table 6.7.

Table 6.7: Descriptions of Highway Segments with the Highest Improvement Priority in the DT-Network

Highway	Segment No.	From	To	Length of Segment (km)
1	911	PTH 10 West	PTH 10 East	1.6
1	917	PTH 1A West at Portage La Prairie	PR 240	8.9
1	927	PTH 44	MB/Sask Border	4.0
100	902	PR 241	Wilkes Ave at Winnipeg	2.8
101	901	PTH 1 West at Winnipeg	Sask. Ave at Winnipeg	2.1
101	902	Saskatchewan Ave at Winnipeg	PR 221	6.5
101	905	PTH 7	PTH 8	8.9
101	906	PTH 8	PTH 9	2.9

CHAPTER 7

CONCLUSIONS AND RECOMMENDATIONS

The purpose of this research is to develop and apply methodologies and new information systems for truck volume estimation and characterization on Manitoba highways. The research creates a fundamental truck volume information database for the Manitoba Highways Truck Traffic Information System (MHTTIS). This core database produces essential information used by decision-makers for highway planning, design and management functions.

This Chapter presents findings for each of the following: (1) the UMTIG-Manitoba Truck Planning Network and DT-Network used for this research; (2) the systematic analysis of truck volume data; (3) the development of methodologies for estimating and characterizing truck volumes on Manitoba highways; and (4) the application of methodologies and the rating system for AADTT estimates on Manitoba highways. The chapter also addresses the need for future research.

7.1 UMTIG-MANITOBA TRUCK PLANNING NETWORK

The UMTIG-Manitoba Truck Planning Network (UMTIG-MTPN) is a subset of the provincial highway system accounting for nearly 90 percent of TKT in the province (based on 1999 data). The network is developed through the use of weight classification of highways to identify major truck routes, the analysis of network connectivity and integrity, and industrial intelligence for trucking activities in the province.

From this UMTIG-Manitoba Truck Planning Network, fourteen highways are selected to create the DT-Network, which defines the geographical scope of this research for purposes of truck volume estimation and characterization for the year 2002. The DT-Network consists of the dominant truck routes in the province, and accounts for more than two-thirds of the 1999 truck-kilometers of travel. This research develops a systematic procedure for segmenting the DT-Network into 202 truck volume segments with homogenous truck volume characteristics (AADTT, temporal distribution, and classification mix).

7.2 SYSTEMATIC ANALYSIS OF TRUCK VOLUME DATA

During the course of the research, over 35 million records of truck data are collected and analyzed from the AVC stations in Manitoba and adjacent provinces, and through the BTS U.S.-Canada Border Crossing database. Methods and procedures are designed, developed, and implemented to screen and edit the field-based raw data, and conduct the systematic analysis of truck volume data. This has led to the creation of a rich and reliable truck volume database for the MHTTIS.

Through the creation of this database, planners and engineers have access to reliable truck volume data collected from provincial truck routes continuously throughout the year. This makes possible the analysis of truck volumes by direction, time-of-day, day-of-week, season, and truck type. This truck volume database also enables the development of truck traffic pattern groups (TTPGs), which are used for characterizing truck volumes on Manitoba highways.

From the analysis of classification mix, the WIM stations are found to have problems classifying vehicles into their proper classes. The results show that WIM stations overestimate single-unit trucks (particularly for Class 5) and underestimate multiple-trailer truck types (particularly for Class 13). The problems are caused by the weight criteria set in the WIM devices. Therefore, the WIM data are excluded from the estimation of truck volumes in this research. The analysis of truck volumes is done based on the AVC data collected at the same location in opposite flow directions.

7.3 DEVELOPMENT OF THE METHODOLOGIES

Because of the important role of trucking in today's economic and highway engineering planning, design, and management functions, there is an ever-increasing need to understand truck traffic. The most fundamental truck traffic information is truck volume estimates and characteristics. Three methods are developed to estimate truck volumes on the DT-Network for the year 2002:

1. Direct measurement method:
   - Estimation of AADTT at permanent classification stations using the AASHTO three-step averaging process.
   - Estimation of AADTT at short-term classification count stations using adjustment factors developed from control stations or TTPGs.

2. Transferring method:
   - Transferring of AADTT from adjacent segments containing AADTT estimates using flow balancing analysis.
   - Direct transferring of AADTT from segments in adjacent jurisdictions containing truck volume information at the borders.

3. Base Manitoba truck volume method:
   - Assigning 1999 default AADTT estimates to truck volume segments with no existing truck volume information.

Truck data collected from the 33 AVC stations in Manitoba are used to develop the TTPGs. The seasonal and day-of-week variations of trucks (classes 5 to 13) are used as the input variables for the cluster analysis of pattern groups. Five TTPGs are created based on their similarity in temporal variations, geographic characteristics, and land use information. These TTPGs are used for characterizing truck volumes on Manitoba highways.

7.4 APPLICATION OF METHODOLOGIES AND THE RATING SYSTEM

AADTT (classes 5 to 13) on truck volume segments inside the DT-Network is estimated using different methods based on the availability of truck data on the truck volume segments. Truck volumes on these segments are characterized through the assignment of the appropriate TTPGs, and the nearest control station is assigned to each truck volume segment if they belong to the same TTPG. Appendix E presents the results of AADTT estimation and the assignment of TTPGs and control stations for each truck volume segment in the DT-Network.

The results show that TKT for the DT-Network grew from 455 million in 1999 to 524 million in 2002. They also indicate that two-thirds of the 2002 TKT in the DT-Network are estimated based on 2002 data.

The AADTT estimates on Manitoba highways are evaluated by a rating system developed in the research. Each truck volume segment in the DT-Network is rated based on the quality measurement and volume class of the AADTT estimate, and the results are presented in Appendix E. This rating system allows engineers to analyze and determine the quality of truck volume estimates that they are using for different highway planning, design, and management functions.

The highway segments in the DT-Network are also prioritized (with five different levels of priority) for improvement in truck volume estimation based on their ratings. The analysis shows that highway segments with the highest priority for improvement are distributed along highway segments that carry very high truck volumes and are close to urban centers (e.g., PTH 1 at Brandon and Portage La Prairie, and the Perimeter Highway at Winnipeg, etc.). The following eight highway segments are designated the highest priority for improvement in truck volume estimation for the DT-Network:

- PTH 1 from PTH 10 west to PTH 10 east at Brandon
- PTH 1 from PTH 1A west to PR 2004 at Portage La Prairie
- PTH 1 from PTH 44 to the border of Manitoba-Saskatchewan
- PTH 100 from PR 241 to Wilkes Avenue at Winnipeg
- PTH 101 from PTH 1 west to Saskatchewan Avenue at Winnipeg
- PTH 101 from Saskatchewan Avenue to PR 221 at Winnipeg
- PTH 101 from PTH 7 to PTH 8 at Winnipeg
- PTH 101 from PTH 8 to PTH 9 at Winnipeg

7.5 FUTURE RESEARCH

The thesis has identified the following needs for future research:

- The collection of better truck data (48-hour classification counts) at important locations that are identified in the research for improvements in truck volume estimation. Traffic monitoring staff observe that the cost difference between collecting 48-hour classification counts and the traditional total volume counts is small.

- The investigation of the need for developing Truck Traffic Pattern Groups for different truck groups (single-unit, single-trailer, and multiple-trailer trucks). This would enhance the analysis of travel patterns, and the expansion of short-term classification counts into AADTT estimates for different truck groups. The preliminary analysis of truck volumes for different truck groups is reported by Tang (2003).

- The development of an integrated traffic monitoring system for Manitoba Transportation and Government Services and adjacent jurisdictions (e.g., City of Winnipeg, City of Brandon, Saskatchewan, North Dakota, Minnesota and Ontario, etc.). This would improve the quality of truck traffic data by combining efforts for data collection, and employing a standardized method for data analysis and reporting. These truck traffic data can also be used to enhance the TTPGs.

- Constant review and verification of truck volume segments in the UMTIG-Manitoba Truck Planning Network. Truck volume segments should be constantly reviewed and checked using new truck volume data collected within the segments, because truck traffic is constantly changing, and a perfect segment definition is not possible. The FHWA traffic monitoring guide recommends that a new segment should be created if volumes within a segment change more than 10 percent.

- The expansion of the analysis to distinguish truck types of specific interest (e.g., B-trains and Long Combination Vehicles). These vehicle types can be identified by utilizing the capability of AVC stations that store axle-spacing information for each vehicle passing through the equipment.

BIBLIOGRAPHY

1. Albright David (1991), "Development of National Highway Traffic Monitoring Standards," Transportation Research Board 70th Annual Meeting, Washington, D.C., 1991.

2. American Association of State Highway and Transportation Officials (AASHTO) (1992), "AASHTO Guidelines for Traffic Data Programs," AASHTO, 1992.

3. Anderberg, M.R. (1973), "Cluster Analysis for Applications," Academic Press, Inc., 1973

4. Anderson Tom (2003), Senior Traffic Operations Engineer, Saskatchewan Highways and Transportation, personal communication, August 2003.

5. Bureau of Transportation Statistics (2003), Border Crossing/Entry Data, Website: http://www.bts.gov/programs/international/border_crossing_entry_data/

6. Clayton Alan, Montufar Jeannette, Middleton Dan, and McCauley Bill (2000), "Feasibility of a New Vehicle Classification System for Canada," University of Manitoba Transport Information Group, April 2000.

7. Clayton Alan and Escobar Luis (1998), "Truck Traffic Information System for Manitoba Highways and Transportation," University of Manitoba Transport Information Group, December 1998.

8. Clayton Alan, Lucas Brian, and Alam Mohammed (1994), "Manitoba Highway Traffic Information System – System Specification," University of Manitoba Transport Information Group, August 1994.

9. Dixon H. Richard (2003), British Columbia Ministry of Transportation, Highway Planning Branch, personal communication, August 2003.

10. Escobar Luis, Chiasson J.P. and Alam Mohammed (1997), "Truck Traffic on Manitoba Highways 1995," University of Manitoba Transport Information Group, February 1997.

11. Faghri A. and Hua J. (1995), "Roadway Seasonal Classification Using Neural Networks," Journal of Computing in Civil Engineering, July 1995.

12. Fekpe Edward (1993), "Characteristics of Heavy Vehicle Weight Distributions and Pavement Loading," Doctor of Philosophy Thesis, University of Manitoba, Civil Engineering Department, 1993.

13. Gienow Wayne (2003), Traffic Engineer, EIT, Saskatchewan Highways and Transportation, personal communication, September 2003.

14. Hajek J. J., Selezneva O., Jiang J. Y., and Mladenovic G. (2002), "Improving the Reliability of Pavement Loading Estimates Using the Pavement Loading," Transportation Research Board, Washington, D.C., 2002.

15. Hallenbeck, Rice, Cornell-Martinez, and Smith (1997), "Vehicle Volume Distributions by Classification," FHWA-PL-97-025, June 1997.

16. Han Kai (2003), "UMTIG-KH Single Centerline Base Map (Version 2, June 2003) in UTM Projection (Zone 14, North) and NAD 83 Datum," University of Manitoba Transport Information Group, June 2003

17. Hodges Mark (2003), Transportation Program Administrator, Texas Department of Transportation, personal communication, August 2003.

18. Levenson Mark (2003), Minnesota Department of Transportation, Office of Transportation Data and Analysis, personal communication, August 2003.

19. Lobban Craig (2003), Manitoba Transportation and Government Service, Traffic Monitoring Department, personal interview, August 2003.

20. Lucas Brian (1996), "Design, Development, and Implementation of the Manitoba Highway Traffic Information System," Master of Science Thesis, University of Manitoba, Civil Engineering Department, October 1996.

21. Manitoba Highway Traffic Information System (MHTIS) (2003), "Traffic on Manitoba Highways 2002," University of Manitoba Transport Information Group, June 2003.

22. Manitoba Transportation and Government Services (MTGS) (2003), Website: http://www.gov.mb.ca/tgs/transreg/compreg/rtacroutes.html

23. Middleton Dan, Clayton Alan, and Jasek Debbie (2002), "Truck Accommodation Design Guidance Year 1 Report," Texas Transportation Institute, October 2002.

24. Minnesota Department of Transportation (2003), Website: http://www.dot.state.mn.us/tda/html/traffic.html

25. Montufar Jeannette (2002), "Heavy Truck Safety in the Prairie Region: Applying Exposure-Based Analysis and the System Safety Review Concept," Doctor of Philosophy Thesis, University of Manitoba, Civil Engineering Department, March 2002.

26. Montufar J., Han K., Lew K., Clayton A., McGregor R., Sims R., and Palsat D. (2000), "Harmonization of Spring Weight Restrictions and Winter Weight Premiums for Roads in the Prairie Region: Laws, Regulations, and Policies Relating to Winter Premiums and Spring Restrictions," University of Manitoba Transport Information Group, 2000

27. Nelson Tom (2003), Minnesota Department of Transportation, Office of Transportation Data and Analysis, personal communication, August 2003

28. Nikiforos, Stamatiadis, David Allen (1997), "Seasonal Factors Using Vehicle Classification Data," Transportation Research Record 1593 pg 23-28, September 1997

29. Schmoyer R., Hu P., Swank P. (1998), "Analysis of Vehicle Classification and Truck Weight Data of the New England States," Oak Ridge National Laboratory, September 1998.

30. Regehr Jonathan (2002), "Estimating Live Truck Loads on Roads and Bridges: A Sectoral Approach Applied to Grain Transport," Bachelor of Science Thesis, University of Manitoba, Civil Engineering Department, December 2002.

31. Statistical Analysis Software Institute (2000), "SAS User's Guide, Version 8 Edition," SAS Institute, 2000.

32. Sharma Satish, Liu Guo Xin, and Thomas Scott (1998), "Sources of Error in Estimating Truck Traffic from Automatic Vehicle Classification Data," Journal of Transportation and Statistics, 1998.

33. Sharma Satish, Luo Zong Fan, and Liu Guo Xin (2002), "Short-Period Counts with a Focus on Truck Traffic Estimation," Institue of Transportation Engineering Journal, November 2002.

34. St. Charles Joe (2003), Washington Department of Transportation, Transportation Data Office, personal communication, August 2003.

35. Tan Errol (2002), "Weight Characteristics of Predominant Truck Configuration in Manitoba," Master of Science Thesis, University of Manitoba, Civil Engineering Department, November 2002.

36. Tang David (2003), "The Analysis of Seasonal, Day-of-Week, and Time-of-Day Variations for Single-Unit, Single-Trailer, and Multiple-Trailer Trucks at the 33 AVC Stations in Manitoba," University of Manitoba Transport Information Group, September 2003.

37. Tang David, Minty Scott, and Han Kai (2003), "Development of the UMTIG-Manitoba Truck Planning Network (Network Definition and Segmentation)," University of Manitoba Transport Information Group, August 2003.

38. Tang D., Clayton A., Montufar J., Rogers B., Minty S., Malbasa A., Regehr J., and Tan E. (2003), "Development and implementation of Manitoba's New Truck Traffic Information System," Canada Institute of Transportation Engineering Conference, June 2003.

39. Tang D., Clayton A., Montufar J., Middleton D., Minty S., Tan E., Malbasa A., and Han K. (2002), "Using Weigh-In-Motion Data in a Modern Truck Traffic Information System," 3rd International Conference on Weigh-in-Motion, May 2002.

40. Tang D., Tan E., Han K., and Montufar J. (2001), "Manitoba Highway Traffic Information System Procedures Manual (Reference Document)," University of Manitoba Transport Information Group, September 2001.

41. Thomas Scott, Sharma Satish, and Liu Guo Xin (1997), "Statewide Monitoring of Truck Traffic Using Automatic Vehicle Classifiers," Institute of Transportation Engineers Journal, April 1997.

42. U.S. DOT (2001), "Traffic Monitoring Guide," Federal Highway Administration, 2001.

43. U.S. DOT (2000), "Comprehensive Truck Size and Weight Study," Volume I, Summary Report, Publication Number FHWA-PL-00-029, August 2000.

44. Van Cauwenberghe R. (1997), "Truck Traffic Needs for Effective Pavement Management," Unpublished Report, Materials and Research Branch of Manitoba Transportation and Government Services, 1997.

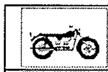
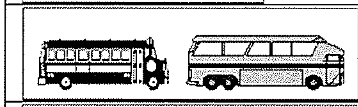
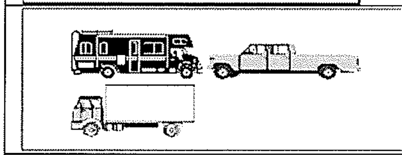
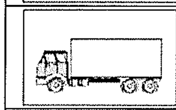
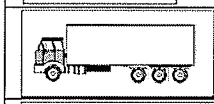
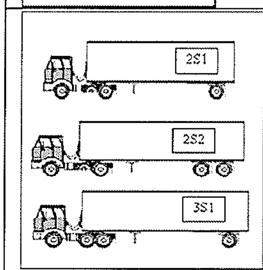
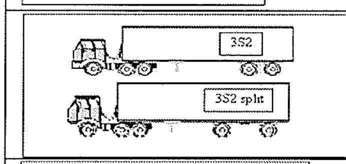
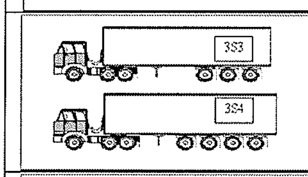
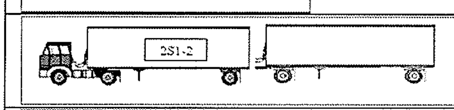
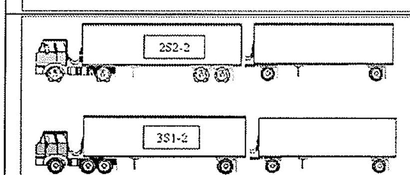
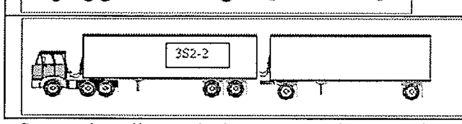
45. Weinblatt Herbert (1996), "Using Seasonal and Day-of-Week Factoring to Improve Estimates of Truck Vehicle Miles Traveled," Transportation Research Record 1522 pg 1-8, 1996.

46. Wright T., Hu P., Young J., and Lu A (1997), "Variability in Traffic Monitoring Data, Final summary report," Oak Ridge National Laboratory for the US Department of Energy, August 1997.

APPENDIX A

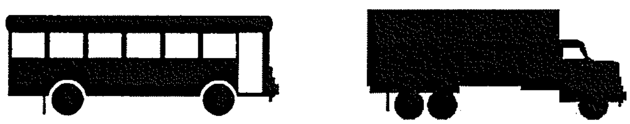
Vehicle Classification Systems

Table A.1: FHWA Vehicle Classifications

	**FHWA Class 1 – Motorcycles**
	**FHWA Class 2 – Passenger Cars (With 1- or 2-Axle Trailers)**
	**FHWA Class 3 – 2 Axles, 4-Tire Single Units, Pickup or Van (With 1- or 2-Axle Trailers)**
	**FHWA Class 4 – Buses**
	**FHWA Class 5 – 2 Axles, 6-Tire Single Units (Includes Handicappe-Equipped Bus and Mini School Bus)**
	**FHWA Class 6 – 3 Axles, Single Unit**
	**FHWA Class 7 – 4 or More Axles, Single Unit**
	**FHWA Class 8 – 3 to 4 Axles, Single Trailer**
	**FHWA Class 9 – 5 Axles, Single Trailer**
	**FHWA Class 10 – 6 or More Axles, Single Trailer**
	**FHWA Class 11 – 5 or Less Axles, Multi-Trailers**
	**FHWA Class 12 – 6 Axles, Multi-Trailers**
	**FHWA Class 13 – 7 or More Axles, Multi-Trailers**

Source: http://manuals.dot.state.tx.us/dynaweb/coltrsys/tda/@Generic__BookTextView/20168

Table A.2: British Columbia 5 Bin Classification Scheme

B.C. MoT 5 Bin Classification Scheme *(Overall Vehicle Length)*	**FHWA13 Equivalents**
BIN 1: 0 to 6 metres 	Motorcycles (class 1), passenger cars (class 2), and light single unit trucks (class 3)
BIN 2: 6 to 12.5 metres 	Buses (class 4), two axle, 6 tire single unit trucks (class 5), three axle single unit trucks (class 6), four axle single unit trucks (class 7)
BIN 3: 12.5 to 22.5 metres 	4 or less axles, single trailer truck (class 8); five axle single trailer truck (class 9); six or more axle single trailer truck (class 10)
BIN 4: 22.5 to 35 metres 	B-trains, multi trailer truck (class 11); six axle, multi trailer truck (class 12); seven axle, multi trailer truck (class 13)
BIN 5: > 35 metres 	Multi-Trailer (class 13)

Source: British Columbia Ministry of Transportation Information Management Department, August 2003

APPENDIX B

Analysis of Truck Volume Data

Table B.1: 2002 AADTT for Trucks (Class 5-13) at AVC Stations

Hwy No.	Location Description	Counter Type	Flow Direction	AADT	Directional Split
1	55 - Headingley (PTH 1, 3.9 km W. of PR 334)	AVC	EB WB	990 1070	48/52
	61 - Brokenhead (PTH 1, 4.4 km W. of Brokenhead River)	AVC WIM/AVC*	EB WB	460	
	62 - Oaklake (PTH 1, 7.3 km W. of PTH 21)	AVC WIM/AVC*	EB WB	640	
	65 - Macgregor (PTH 1, 7.0 km W. of PR 350)	AVC WIM/AVC*	EB WB	790	
	S1 - Sask (PTH 1, 8.3 km W. of MB-Sask Border)	AVC	EB WB	620 670	48/52
	S17 - Ont (PTH 17, 15 km E. of MB-Ont Border)	AVC^	EB WB	470 560	46/54
2	11 - Starbuck (PTH 2, 5.2 km W. of PR 332)	AVC	EB WB	120 100	55/45
	66 - Nesbitt (PTH 2, 4.1 km W. of PR 344)	AVC	EB WB	80 80	50/50
	92 - Souris (PTH 2, 3.3 km E. of PR 347)	AVC	EB WB	70 70	50/50
3	15 - Morden (PTH 3, 9.9 km W. of PR 432)	AVC	EB WB	80 80	50/50
	51 - Oakbluff (PTH 3, 0.3 km S.W. of PTH 2)	AVC	NB SB	140 140	50/50
5	49 - Ochre Ricer (PTH 5, 1.6 km E. of PTH 20)	AVC	EB WB	100 100	50/50
	54 - Neepawa (PTH 5, 4.8 km N. of PTH 16)	AVC	NB SB	100 100	50/50
6	82 - Paint Lake (PTH 6, 0.8 km S. of Paint Lake Access)	AVC	NB SB	50 50	50/50
	88 - Woodlands (PTH 6, 4.2 km N. of PR 248)	AVC	NB SB	130 130	50/50
10	21 - Boissevain (PTH 10, 1.6 km N. of PR 448)	AVC	NB SB	80 80	50/50
	24 - Brandon West (PTH 10, 2.7 km N. of PTH 1)	AVC	NB SB	160 150	52/48
	50 - Swan River L.P. East (PTH 10, 4.8 E. of PR 268)	AVC	EB WB	70 70	50/50
	52 - Swan River L.P. W. (PTH 10, 3.3 km W. of L.P. Plant)	AVC	EB WB	90 90	50/50
	84 - Mink Creek (PTH 10, 3.8 km S. of S. Jct. with PTH 10A)	AVC	NB SB	50 50	50/50
	90 - The Pas (PTH 10, 5.3 km N. of Tolko Access Rd)	AVC	NB SB	70 70	50/50
	95 - Brandon South (PTH 10, 0.6 km S. of PTH 110)	AVC**	NB SB	150 160	48/52
	98 - The Pas S. (PTH 10, 0.5 km S. of Young's Point Rd)	AVC	NB SB	60 50	55/45
12	10 - Zhoda (PTH 12, 6.4 km S. of PR 302)	AVC	NB SB	70 70	50/50

Continue' Table B.1: 2002 AADTT for Trucks (Class 5-13) at AVC Stations

Hwy No.	Location Description	Counter Type	Flow Direction	AADT	Directional Split
13	81 - Oakville (PTH 13, 3.2 km S. of Oakville)	AVC	NB SB	170 190	47/53
14	87 - Altona (PTH 14, 1.0 km E. of PTH 30)	AVC	EB WB	180 180	50/50
16	43 - Strathclair (PTH 16, E. of E. Jct. with PR 354)	AVC	EB WB	240 250	49/51
	46 - Portage La Prairie (PTH 16, 2.4 km N. of PTH 1)	AVC	NB SB	300 300	50/50
	S16 - Sask (PTH 16, 7.7 km W. of MB-Sask Border)	AVC**	EB WB***	200	
50	83 - Langruth (PTH 50, 1.3 km S. of PR 265)	AVC	NB SB	30 30	50/50
59	78 - Birds Hill (PTH 59, 5.4 km S. of PTH 44)	AVC	NB SB	190 190	50/50
	89 - Niverville (PTH 59, 1.9 km N. of PTH 52)	AVC	NB SB	170 150	53/47
75	63 - Glenlea (PTH 75, 5.1 km S. of PR 210)	WIM/AVC* AVC	NB SB	 470	
83	53 - Swan River South (PTH 83, 1.1 km S.W. of PR 486)	AVC	NB SB	70 70	50/50
	91 - Pipestone (PTH 83, 1.6 km N. of PTH 2)	AVC	NB SB	50 60	45/55
100	64 - Symington (PTH 100, 0.2 km W. of Murdock Rd)	AVC	EB WB	510 560	48/52
101	86 - Wenzel (PTH 101, 1.0 km E. of Wenzel Rd)	AVC	EB WB	420 450	48/52
110	85 - Brandon East (PTH 110, 0.5 km S. of PR 457)	AVC	NB SB	220 230	49/51

Source: Developed from 2002 Data from MHTTIS by D.T., August 2003

*Note: * Exclude WIM data in the estimation, the combined AADTT is calculated as 2 times the AVC station's AADTT*

*** AADTT estimates are calculated as simple average daily truck traffic (ADTT)*

**** WB classification data is rejected due to errors, the combined AADTT is calculated as 2 times the EB's AADTT*

^ AADTT estimates are calculated as simple average daily truck traffic (ADTT) using 2-week data in 2001

Table B.2: 2002 Monthly Distribution Factors (MADTT/AADTT) for Trucks (Classes 5-13) at the 33 AVC Stations

Hwy No.	Station No.	AADTT	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	55	2,060	0.80	0.92	0.94	1.03	1.11	1.11	1.10	1.08	1.12	1.07	0.90	0.83
	61*	920	0.84	0.90	0.97	0.94	1.04	1.21	1.18	1.07	1.06	1.03	0.99	0.79
	62*	1,280	0.89	0.93	0.93	1.04	1.10	1.05	1.08	1.07	1.02	1.04	1.02	0.84
	65*	1,580	0.86	0.90	0.91	1.01	1.11	1.03	1.04	1.03	1.08	1.11	1.04	0.87
2	11	220	0.83	0.92	0.88	0.96	1.04	1.12	1.01	1.06	1.31	1.15	0.99	0.75
	66	160	0.80	0.82	0.76	0.95	1.34	1.01	0.98	1.11	1.10	1.48	1.00	0.69
	92	140	0.80	0.88	0.78	0.85	1.71	1.01	0.94	1.01	1.11	1.14	1.09	0.70
3	15	160	0.74	0.89	0.85	1.16	1.15	1.29	1.05	0.91	1.06	1.10	1.06	0.79
	51	280	0.78	0.80	0.84	1.02	1.03	1.15	1.13	1.07	1.22	1.22	1.03	0.82
5	49	200	0.83	0.88	0.87	0.86	1.21	1.13	1.10	1.01	1.04	1.20	1.07	0.83
	54	200	0.70	0.77	0.80	1.04	1.48	1.10	0.81	0.87	1.39	1.59	0.90	0.67
6	82	100	0.84	1.02	1.16	0.78	0.85	1.25	1.23	1.12	1.13	0.98	0.98	0.87
	88	260	0.85	0.91	0.94	0.69	0.84	1.28	1.14	1.11	1.17	1.20	1.07	0.83
10	21	160	0.96	0.76	0.77	0.97	1.49	1.12	0.89	0.99	1.11	1.12	1.05	0.87
	24	310	0.65	0.66	0.84	1.02	1.50	1.08	0.99	1.09	1.12	1.34	1.03	0.73
	50	140	1.19	1.40	1.07	0.64	0.91	0.81	0.88	0.89	0.97	1.07	1.35	0.92
	52	180	1.21	1.41	1.16	0.58	0.81	0.67	1.07	0.95	1.20	1.14	1.14	0.75
	84	100	0.77	0.94	0.89	0.97	1.28	1.07	1.10	1.04	1.04	1.08	1.06	0.81
	90	140	1.26	1.41	1.12	0.38	0.44	1.39	1.26	1.11	1.03	1.11	0.89	0.76
	98	110	0.68	0.97	0.80	0.74	0.82	1.45	1.26	0.98	1.34	1.33	1.05	0.72
12	10	140	0.87	0.97	0.93	0.85	1.05	1.16	1.07	1.07	1.22	1.04	1.00	0.83
13	81	360	0.84	0.82	0.79	1.04	1.45	1.03	0.98	0.95	1.18	1.17	1.00	0.79
14	87	360	0.80	0.90	0.94	1.12	1.16	1.12	1.07	1.09	1.13	1.15	0.87	0.67
16	43	490	0.91	0.94	0.94	1.00	1.16	1.10	1.06	1.04	1.04	1.02	1.01	0.81
	46	600	0.79	0.94	0.95	1.05	1.20	1.15	1.09	1.09	1.14	0.94	0.95	0.73
50	83	60	0.78	0.79	0.74	0.76	1.20	1.45	1.47	1.03	1.27	1.17	0.87	0.53
59	89	320	0.81	0.87	0.79	0.92	1.14	1.09	1.08	1.00	1.15	1.19	1.10	0.87
75	63*	940	0.91	0.93	0.95	1.09	1.08	1.10	1.01	1.05	1.11	1.00	1.00	0.78
83	53	140	1.10	1.26	0.91	0.70	1.16	0.88	0.92	0.95	1.12	1.19	1.05	0.78
	91	110	0.86	0.89	0.82	0.95	1.18	1.02	0.93	0.98	1.27	1.25	1.02	0.91
100	64	1,070	0.74	0.77	0.78	0.90	1.06	1.13	1.19	1.12	1.36	1.35	0.92	0.72
101	86	870	0.79	0.85	0.88	0.91	0.99	1.04	1.16	1.13	1.31	1.23	0.96	0.77
110	85	450	0.75	0.76	0.72	0.85	1.46	0.96	0.99	1.09	1.20	1.46	1.04	0.75

** AADTT and factors are calculated based on AVC data only*

Table B.3: 2002 Day-of-Week Factors (AADWTT/AADTT) for Trucks (Classes 5-13) at the 33 AVC Stations

Hwy No.	Station No.	AADTT	Sun	Mon	Tue	Wed	Thu	Fri	Sat
1	55	2,060	0.77	0.97	1.04	1.16	1.18	1.11	0.78
	61*	920	0.89	0.92	0.99	1.06	1.04	1.07	1.03
	62*	1,280	0.78	0.77	1.04	1.20	1.16	1.10	0.97
	65*	1,580	0.72	0.85	1.05	1.19	1.17	1.13	0.90
2	11	220	0.27	1.12	1.29	1.28	1.38	1.30	0.39
	66	160	0.36	1.13	1.25	1.27	1.33	1.20	0.47
	92	140	0.39	1.10	1.27	1.24	1.28	1.16	0.57
3	15	160	0.23	1.19	1.31	1.28	1.33	1.22	0.46
	51	280	0.19	1.11	1.32	1.35	1.36	1.32	0.42
5	49	200	0.38	1.14	1.23	1.29	1.28	1.21	0.48
	54	200	0.33	1.12	1.22	1.30	1.38	1.23	0.49
6	82	100	0.59	0.98	1.19	1.20	1.34	1.07	0.76
	88	260	0.50	1.14	1.18	1.25	1.28	1.09	0.58
10	21	160	0.42	1.06	1.34	1.27	1.32	1.14	0.50
	24	310	0.36	1.17	1.27	1.27	1.30	1.20	0.47
	50	140	0.35	1.14	1.25	1.32	1.34	1.23	0.43
	52	180	0.27	1.18	1.28	1.38	1.36	1.22	0.37
	84	100	0.40	1.11	1.22	1.27	1.30	1.16	0.58
	90	140	0.49	1.00	1.21	1.23	1.28	1.19	0.69
	98	110	0.53	1.06	1.21	1.22	1.21	1.17	0.68
12	10	140	0.66	1.13	1.14	1.30	1.14	1.00	0.67
13	81	360	0.49	1.10	1.20	1.26	1.24	1.12	0.63
14	87	360	0.35	1.18	1.27	1.28	1.30	1.16	0.46
16	43	490	0.71	1.02	1.14	1.20	1.21	1.03	0.70
	46	600	0.61	1.03	1.17	1.23	1.25	1.09	0.63
50	83	60	0.19	1.16	1.36	1.27	1.43	1.28	0.35
59	89	320	0.28	1.09	1.27	1.30	1.39	1.29	0.40
75	63*	940	0.71	1.13	1.22	1.16	1.07	1.00	0.70
83	53	140	0.27	1.21	1.32	1.25	1.34	1.21	0.42
	91	110	0.51	1.05	1.23	1.20	1.27	1.21	0.58
100	64	1,070	0.71	0.97	1.08	1.20	1.18	1.13	0.73
101	86	870	0.51	1.04	1.11	1.21	1.26	1.26	0.62
110	85	450	0.30	1.14	1.30	1.28	1.31	1.24	0.44

** AADTT and factors are calculated based on AVC data only*

Table B.4: 2002 Time-of-Day Factors (Percentage of Daily Volume) for Trucks (Classes 5-13) at the 33 AVC Stations

Hwy No.	Station No.	AADTT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	55	2,060	2.7	2.2	2.1	2.1	2.1	2.4	2.9	3.4	4.4	5.2	5.6	5.7	5.9	5.9	6.1	5.9	5.5	5.2	4.9	4.6	4.4	4.1	3.5	3.1
	61*	920	2.3	1.9	1.8	1.8	1.9	2.3	3.2	4.1	4.5	5.1	5.4	5.5	5.4	5.5	5.6	5.4	5.6	5.3	5.4	5.3	4.9	4.8	3.8	3.4
	62*	1,280	3.8	3.2	2.9	2.2	2.0	2.2	2.5	3.4	4.0	4.8	4.9	5.1	5.3	5.6	5.4	5.2	4.9	5.1	4.7	4.6	4.6	4.7	4.5	4.2
	65*	1,580	2.9	2.6	2.6	2.3	2.2	2.1	2.6	3.5	4.4	5.4	5.9	5.9	5.9	5.8	5.8	5.5	5.2	4.9	4.5	4.4	4.4	4.0	3.8	3.4
2	11	220	1.3	1.0	0.8	0.8	1.0	1.8	3.0	5.1	6.0	7.0	7.5	7.8	7.0	7.4	7.6	7.1	6.6	5.4	4.1	3.2	2.7	2.4	2.0	1.6
	66	160	1.1	0.8	0.6	0.6	0.8	1.3	3.0	4.7	6.1	6.8	7.3	7.1	7.1	7.6	7.3	7.7	6.9	5.5	4.6	3.6	3.3	2.7	1.9	1.5
	92	140	1.1	0.8	0.6	0.5	0.7	1.1	2.7	4.7	5.3	6.5	6.7	7.2	7.1	7.7	8.1	8.3	6.7	5.9	4.7	3.7	3.3	2.7	2.2	1.7
3	15	160	0.6	0.3	0.2	0.2	0.4	0.8	2.6	5.4	7.1	8.2	8.6	8.9	7.9	8.2	8.0	7.3	6.6	5.4	3.8	2.9	2.3	1.9	1.4	0.9
	51	280	0.8	0.7	0.8	0.9	1.5	2.3	3.1	5.6	7.3	8.5	8.1	7.7	7.5	7.5	7.4	7.4	6.4	4.8	3.8	2.5	1.8	1.3	1.3	1.0
5	49	200	2.1	1.6	1.4	1.1	1.6	1.7	2.6	4.3	6.2	6.2	6.3	6.7	6.6	6.4	6.7	6.3	5.8	5.9	4.9	3.9	3.4	3.1	2.7	2.6
	54	200	1.4	1.2	0.8	0.6	0.7	1.6	2.3	3.6	6.3	7.5	7.6	7.2	7.3	7.4	7.4	7.8	6.2	5.4	4.6	3.6	2.8	2.6	2.5	1.7
6	82	100	1.8	1.2	1.1	1.9	3.0	3.0	4.6	3.8	4.6	5.9	6.2	5.4	5.5	5.2	5.0	5.3	4.7	5.4	6.6	4.6	4.5	4.3	3.7	2.7
	88	260	1.8	1.3	1.0	1.3	1.4	2.1	3.2	4.0	4.7	4.9	5.4	5.7	5.3	5.7	6.1	6.3	6.8	5.6	5.0	4.7	5.6	5.2	3.9	2.9
10	21	160	1.5	0.9	0.8	0.9	0.6	0.9	2.1	4.2	5.9	7.3	7.7	7.7	7.1	7.1	7.3	7.2	6.6	5.6	4.7	3.8	3.2	2.7	2.3	1.9
	24	310	1.0	1.0	0.7	0.7	1.1	1.5	2.7	5.1	6.4	7.0	7.1	7.0	7.1	7.4	7.6	7.7	6.7	5.2	4.4	3.6	2.9	2.4	2.2	1.5
	50	140	1.2	0.9	0.7	0.8	1.3	1.9	4.1	4.5	6.3	6.6	6.5	6.5	6.7	7.0	7.0	7.2	6.7	5.5	5.1	4.0	3.2	2.7	2.0	1.7
	52	180	1.0	0.7	0.6	0.6	1.0	1.5	3.7	5.2	7.1	7.0	6.8	6.3	6.9	7.3	7.2	7.0	7.1	5.8	5.2	3.8	2.9	2.2	1.6	1.4
	84	100	1.8	1.4	1.3	1.2	1.6	2.4	2.5	4.8	5.0	6.1	6.4	6.4	6.2	6.5	6.2	5.9	5.9	6.8	5.1	4.5	3.7	3.1	2.8	2.4
	90	140	1.5	1.2	1.1	1.4	1.9	3.2	4.1	4.7	5.8	5.5	6.2	6.8	6.4	6.6	6.3	6.0	6.9	5.9	4.8	3.4	2.8	2.9	2.3	2.1
	98	110	2.1	1.9	2.3	2.2	2.5	3.5	3.2	4.0	4.8	4.8	5.4	5.9	6.0	6.5	6.7	6.6	6.3	5.2	4.2	3.9	3.4	3.5	2.9	2.2
12	10	140	1.6	1.2	1.0	1.0	1.0	1.6	2.4	4.2	4.9	5.5	6.6	6.8	6.5	6.4	6.3	6.6	6.7	5.9	5.6	5.0	4.0	3.9	3.0	2.2
13	81	360	1.7	1.1	0.8	0.6	0.9	1.3	2.6	3.7	5.0	6.8	7.5	7.2	7.0	6.8	6.7	6.4	6.0	5.5	5.1	4.7	3.9	3.4	3.0	2.4
14	87	360	0.9	0.7	0.4	0.6	0.6	1.3	2.4	4.7	6.6	7.7	8.2	8.2	7.9	7.5	7.6	7.6	6.2	4.8	4.1	3.3	2.8	2.3	1.8	1.4
16	43	490	2.9	2.1	1.8	1.5	1.6	1.8	2.3	3.2	4.3	4.9	5.3	5.5	5.6	5.6	5.8	6.0	5.6	5.5	5.4	5.0	5.0	4.9	4.5	4.1
	46	600	2.3	1.9	1.6	1.6	1.8	2.0	2.5	3.8	4.6	5.2	6.2	6.4	5.9	6.0	6.0	5.9	5.8	5.5	4.7	4.7	4.5	4.3	3.8	3.1
50	83	60	0.2	0.2	0.2	0.4	1.5	4.3	0.9	7.5	6.6	6.8	8.0	10.6	10.1	9.2	8.1	6.5	5.1	4.2	3.3	2.4	1.7	1.1	0.6	0.5
59	89	320	1.0	0.6	0.5	0.5	0.8	1.4	3.5	5.6	7.9	7.6	7.3	7.5	7.4	7.5	7.6	6.7	6.8	4.9	4.0	3.1	2.6	2.3	1.7	1.2
75	63*	940	1.2	0.9	0.9	0.7	0.9	1.6	3.1	4.4	4.9	5.8	6.6	7.0	7.0	7.2	7.4	6.7	6.2	5.5	5.2	4.5	4.1	3.7	2.6	1.8
83	53	140	0.8	0.5	0.4	0.4	1.0	1.3	2.1	4.7	8.3	7.6	7.0	6.6	6.8	7.6	7.9	8.1	7.9	5.5	4.3	3.4	2.7	2.2	1.7	1.1
	91	110	1.1	0.8	0.7	0.8	1.1	1.9	2.2	3.5	5.3	6.5	6.5	7.2	7.2	7.0	7.4	7.4	7.1	6.3	5.4	4.3	3.5	2.8	2.2	1.8
100	64	1,070	2.0	1.7	1.5	1.3	1.3	1.6	2.7	4.8	6.0	6.6	6.7	6.8	6.6	6.8	7.0	6.7	6.2	5.2	4.1	3.4	3.2	2.9	2.6	2.3
101	86	870	1.6	1.3	1.2	1.2	1.3	2.0	3.6	5.0	6.0	6.4	6.4	6.4	6.3	6.5	6.6	6.5	6.5	5.6	4.4	3.9	3.5	3.0	2.7	2.0
110	85	450	1.6	1.2	0.8	0.7	0.7	1.0	2.3	4.6	6.3	7.0	7.5	7.7	7.1	7.3	7.3	6.8	6.9	5.2	4.2	3.6	3.1	2.8	2.4	2.0

** AADTT and factors are calculated based on AVC data only*

Table B.5 (a): 2002 Classification Mix at AVC Stations

Hwy No.	Station	Mix of Total Traffic (Percentage)												
		Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8	Class 9	Class 10	Class 11	Class 12	Class 13
1	55	0.2	64.2	19.2	0.3	0.9	0.8	0.0	0.9	8.1	3.0	0.2	0.2	2.2
	61	0.2	60.8	19.0	0.3	0.7	0.2	0.6	1.1	10.2	3.9	0.1	0.2	2.8
	62	0.2	51.9	16.9	0.3	0.8	0.7	0.0	1.6	15.6	6.4	0.2	0.4	5.0
	65	0.0	59.7	15.9	0.3	1.0	0.9	0.0	0.6	12.8	5.0	0.0	0.2	3.5
	S1	0.2	43.6	14.6	0.3	0.8	0.9	0.1	1.2	21.6	8.9	0.6	0.6	6.7
	S17^	2.9	55.3	18.6	0.3	1.3	2.6	0.1	2.4	8.9	3.9	0.3	0.3	3.2
2	11	0.1	66.5	20.9	0.1	1.0	1.4	0.0	1.0	4.1	2.1	0.0	0.1	2.7
	66	0.1	63.7	25.7	0.1	0.8	0.8	0.0	0.9	3.9	1.4	0.0	0.0	2.4
	92	0.3	59.9	27.4	0.1	1.0	1.2	0.0	1.2	4.0	1.4	0.0	0.0	3.4
3	15	0.2	63.8	27.0	0.1	0.8	1.6	0.0	0.7	3.4	1.3	0.0	0.0	1.0
	51	0.1	72.4	20.6	0.1	1.1	1.1	0.0	0.3	2.4	1.1	0.0	0.0	0.7
5	49	0.1	60.1	29.3	0.2	0.8	1.0	0.0	0.5	3.2	1.4	0.1	0.0	3.3
	54	0.1	60.8	30.2	0.1	0.8	1.2	0.0	0.5	2.8	1.5	0.1	0.0	1.9
6	82	0.1	43.5	41.8	1.0	1.2	1.1	0.1	0.9	4.8	1.5	0.1	0.0	4.1
	88	0.1	64.0	25.3	0.3	0.8	0.6	0.0	1.4	3.4	1.4	0.1	0.1	2.5
10	21	0.3	61.5	24.6	0.1	0.8	1.5	0.1	0.9	5.3	2.1	0.1	0.0	2.6
	24	0.2	67.5	24.8	0.6	0.8	0.9	0.0	0.7	1.9	1.0	0.0	0.0	1.5
	50	0.1	48.9	34.2	0.4	1.2	1.3	0.0	1.1	2.8	2.7	0.0	0.0	7.2
	52	0.1	46.9	37.3	0.2	1.2	1.2	0.0	0.5	2.3	1.9	0.1	0.0	8.3
	84	0.1	54.2	31.4	0.3	1.0	1.4	0.0	1.1	3.2	1.3	0.1	0.0	5.7
	90	0.1	58.0	34.6	0.2	1.0	0.6	0.0	1.1	1.1	0.5	0.0	0.0	2.7
	95	0.1	66.1	27.0	0.1	0.7	0.6	0.0	0.6	2.5	0.9	0.0	0.0	1.4
	98	0.1	49.5	38.2	0.4	1.1	0.6	0.0	1.5	2.9	1.2	0.0	0.0	4.4
12	10	0.1	58.1	25.7	0.6	0.8	1.2	0.0	1.4	10.7	1.1	0.1	0.0	0.2
13	81	0.2	45.3	22.0	0.0	1.2	1.5	0.1	1.6	16.6	5.6	0.1	0.0	5.8
14	87	0.3	60.3	18.8	0.4	1.3	1.7	0.1	1.9	10.0	2.3	0.1	0.1	2.8
16	43	0.2	54.1	19.0	0.2	1.1	1.1	0.1	1.2	12.4	4.6	0.2	0.3	5.4
	46	0.2	58.6	23.1	0.2	0.9	0.9	0.0	1.1	8.5	2.7	0.1	0.2	3.5
	S16	0.1	44.8	19.5	0.2	0.8	1.2	0.3	4.4	12.2	6.2	1.3	0.7	8.2
50	83	0.1	62.2	32.1	0.0	0.9	1.1	0.0	0.3	1.0	0.5	0.0	0.0	1.8
59	78	0.1	76.4	19.7	0.0	0.5	0.7	0.0	0.5	1.3	0.4	0.0	0.0	0.5
	89	0.1	71.4	20.8	0.1	1.0	1.4	0.0	0.5	3.2	1.1	0.0	0.0	0.4
75	63	0.2	62.7	18.5	0.3	0.8	0.8	0.1	1.0	12.2	1.6	0.4	0.1	1.2
83	53	0.1	54.5	36.2	0.0	0.9	1.1	0.0	0.5	1.2	1.1	0.1	0.0	4.3
	91	0.1	49.6	32.5	0.0	0.9	1.6	0.0	2.0	6.4	3.5	0.1	0.1	3.2
100	64	0.1	64.2	18.9	0.0	0.7	1.7	0.1	0.7	8.3	3.2	0.1	0.1	1.9
101	86	0.2	60.5	19.7	0.0	0.9	2.4	0.0	0.7	10.6	2.9	0.3	0.1	1.8
110	85	0.2	62.0	22.3	0.0	1.1	2.4	0.0	0.4	4.6	3.0	0.0	0.0	3.9

^ classification mix is calculated based on 2-week data in 2001

Table B.5 (b): 2002 Truck Fleet Mix at AVC Stations

Hwy No.	Station	Truck %	Mix of Total Truck (Percentage)								
			Class 5	Class 6	Class 7	Class 8	Class 9	Class 10	Class 11	Class 12	Class 13
1	55	16.2	5.4	4.8	0.1	5.6	49.6	18.5	1.3	1.0	13.6
	61	19.8	3.5	0.9	2.9	5.7	51.9	19.8	0.3	0.9	14.2
	62	30.7	2.6	2.1	0.1	5.2	50.9	20.9	0.6	1.3	16.2
	65	24.1	4.2	3.9	0.2	2.4	53.2	20.7	0.0	1.0	14.4
	S1	41.3	1.9	2.1	0.2	2.9	52.3	21.4	1.4	1.5	16.3
	S17^	23.0	5.8	11.5	0.3	10.3	38.6	17.0	1.5	1.2	13.9
2	11	12.5	8.1	11.6	0.3	7.7	33.2	16.7	0.4	0.5	21.5
	66	10.3	7.9	8.1	0.1	9.1	37.5	13.9	0.2	0.0	23.1
	92	12.3	8.4	9.6	0.1	9.9	32.8	11.3	0.4	0.2	27.4
3	15	8.8	8.8	17.9	0.1	7.8	38.0	15.3	0.1	0.1	11.8
	51	6.8	15.7	15.6	0.3	4.2	36.0	16.8	0.4	0.1	10.9
5	49	10.3	8.0	9.4	0.3	5.2	30.9	13.9	0.5	0.2	31.5
	54	8.8	8.6	13.2	0.3	5.5	31.7	17.6	0.8	0.1	22.2
6	82	13.6	8.5	7.9	0.4	6.5	35.1	10.9	0.4	0.3	30.1
	88	10.3	7.9	6.2	0.2	13.6	32.9	13.4	1.2	0.7	23.9
10	21	13.4	5.8	10.9	0.6	6.6	39.3	15.7	1.0	0.2	19.8
	24	6.8	11.9	13.0	0.3	10.5	27.3	14.4	0.6	0.2	21.6
	50	16.4	7.6	8.1	0.2	6.5	16.9	16.5	0.3	0.1	44.0
	52	15.4	7.5	7.5	0.3	3.4	14.7	12.4	0.3	0.1	53.8
	84	13.9	7.5	9.9	0.2	8.3	22.7	9.5	0.4	0.2	41.3
	90	7.1	14.4	7.8	0.2	15.7	15.7	6.5	0.7	0.2	38.8
	95	6.8	10.7	9.5	0.3	8.1	37.0	13.2	0.5	0.2	20.4
	98	11.7	9.7	4.7	0.1	12.6	25.0	9.8	0.4	0.2	37.4
12	10	15.5	5.2	7.6	0.1	9.1	69.2	7.1	0.3	0.0	1.3
13	81	32.5	3.8	4.6	0.2	5.0	51.2	17.2	0.2	0.1	17.8
14	87	20.3	6.6	8.2	0.3	9.3	49.4	11.5	0.5	0.5	13.7
16	43	26.4	4.1	4.0	0.4	4.5	46.9	17.5	0.9	1.2	20.6
	46	17.9	5.0	5.1	0.1	6.3	47.3	15.3	0.5	0.9	19.4
	S16	35.3	2.4	3.3	0.9	12.4	34.6	17.5	3.6	2.0	23.3
50	83	5.7	15.7	19.4	0.2	5.9	18.0	9.4	0.3	0.2	31.0
59	78	3.7	13.2	18.5	0.2	12.8	33.6	9.4	0.2	0.0	12.1
	89	7.5	12.9	19.2	0.1	6.5	42.1	14.0	0.2	0.0	4.8
75	63	18.2	4.4	4.6	0.3	5.4	67.0	8.8	2.4	0.6	6.5
83	53	9.2	9.7	12.0	0.5	5.6	13.2	11.7	0.6	0.1	46.5
	91	17.8	5.3	9.1	0.2	11.3	35.8	19.4	0.4	0.3	18.1
100	64	16.7	4.2	10.0	0.3	4.4	49.5	19.2	0.3	0.6	11.4
101	86	19.7	4.4	12.0	0.1	3.4	54.0	15.0	1.3	0.4	9.3
110	85	15.5	7.2	15.2	0.2	2.6	29.9	19.5	0.3	0.2	24.9

^ classification mix is calculated based on 2-week data in 2001

Table B.6: 2002 AADTT at major Border Crossings in Manitoba

Month	Total Truck Traffic (Southbound)		
	Pembina, ND (PTH 75)	Dunseith, ND (PTH 10)	Warroad, MN (PTH 12)
Jan	16,376	2,604	1,700
Feb	16,466	1,594	1,486
Mar	16,844	1,353	1,433
Apr	19,612	1,102	935
May	19,815	1,949	1,280
Jun	16,830	1,826	1,000
Jul	16,119	1,657	1,025
Aug	16,131	1,752	1,201
Sep	16,680	1,762	1,719
Oct	17,894	2,043	1,523
Nov	16,116	2,040	1,097
Dec	14,533	1,840	1,149
Total	203,416	21,522	15,548
SB-AADTT*	557	59	43
AADTT**	1,120	120	90

Developed from BTS U.S.-Canada Border Crossing Database by S.M., EIT 2003

** SB AADTT is calculated as the total truck traffic divided by 365 days (ADTT)*

*** AADTT is calculated as 2 times the SB AADTT*

APPENDIX C

Cluster Analysis Results

Results of Cluster Analysis

The following program shows the SAS program code used for performing cluster analysis on the permanent classification data based on their monthly truck travel patterns. This program requires the input variables to be the 12 monthly distribution factors (ratio of MADTT to AADTT) for each permanent classification counters for grouping.

```
Data MGROUP;
INFILE 'C:\MHTTIS\Truck Traffic Data Analysis\2002 Truck
Data\TTPGs\2002MADTT.PRN' LRECL=256;
INPUT STNNO $ M1 M2 M3 M4 M5 M6 M7 M8 M9 M10 M11 M12;
CARDS;
PROC PRINT DATA=MGROUP;
PROC CLUSTER METHOD=WARD;
VAR M1 M2 M3 M4 M5 M6 M7 M8 M9 M10 M11 M12;
ID STNNO;
PROC TREE lineprinter;
ID STNNO;
RUN;
```

(The output from this program is shown in the following pages).

Obs	STNNO	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12
1	10	0.85	0.96	0.93	0.85	1.04	1.23	1.14	1.07	1.21	1.03	1.00	0.82
2	11	0.83	0.92	0.88	0.96	1.04	1.12	1.01	1.06	1.31	1.15	0.99	0.75
3	15	0.74	0.89	0.85	1.16	1.15	1.29	1.05	0.91	1.06	1.10	1.06	0.79
4	21	0.95	0.76	0.77	0.96	1.48	1.15	0.88	0.98	1.13	1.11	1.04	0.87
5	24	0.65	0.66	0.84	1.02	1.50	1.08	0.99	1.09	1.12	1.34	1.03	0.73
6	43	0.91	0.94	0.94	1.00	1.16	1.10	1.06	1.04	1.04	1.02	1.01	0.81
7	46	0.79	0.94	0.95	1.05	1.21	1.15	1.09	1.09	1.14	0.94	0.94	0.73
8	49	0.82	0.92	0.86	0.90	1.21	1.12	1.10	1.01	1.04	1.20	1.07	0.82
9	50	1.18	1.39	1.06	0.64	0.90	0.80	0.87	0.93	0.97	1.07	1.34	0.91
10	51	0.78	0.80	0.84	0.96	1.03	1.15	1.15	1.09	1.22	1.22	0.99	0.82
11	52	1.21	1.41	1.16	0.58	0.81	0.67	1.07	0.95	1.20	1.14	1.14	0.75
12	53	1.10	1.26	0.91	0.70	1.16	0.88	0.92	0.95	1.12	1.19	1.05	0.78
13	54	0.69	0.77	0.79	1.03	1.46	1.09	0.80	0.86	1.37	1.69	0.87	0.66
14	55	0.80	0.92	0.94	1.03	1.11	1.11	1.10	1.08	1.12	1.08	0.87	0.84
15	61	0.85	0.91	0.99	0.96	1.06	1.14	1.10	1.07	1.08	1.05	1.01	0.80
16	62	0.91	0.96	0.95	1.07	1.14	1.08	1.12	1.10	1.05	1.07	1.05	0.87
17	63	0.91	0.93	0.95	1.09	1.08	1.10	1.01	1.05	1.11	1.00	1.00	0.78
18	64	0.71	0.77	0.78	0.90	1.04	1.14	1.20	1.14	1.36	1.31	0.94	0.74
19	65	0.86	0.90	0.91	1.01	1.11	1.03	1.04	1.03	1.08	1.11	1.04	0.87
20	66	0.80	0.82	0.76	0.95	1.34	1.01	0.98	1.11	1.10	1.48	1.00	0.69
21	81	0.84	0.81	0.79	1.03	1.45	1.03	0.98	1.00	1.17	1.16	0.99	0.79
22	82	0.83	1.00	1.13	0.76	0.83	1.22	1.20	1.29	1.11	0.96	0.96	0.85
23	83	0.78	0.79	0.74	0.76	1.20	1.45	1.50	1.03	1.27	1.17	0.87	0.53
24	84	0.77	0.94	0.89	0.97	1.28	1.07	1.09	1.04	1.04	1.08	1.06	0.84
25	85	0.75	0.77	0.72	0.85	1.46	0.96	0.99	1.09	1.20	1.46	1.04	0.75
26	86	0.79	0.85	0.88	0.91	0.98	1.04	1.17	1.13	1.31	1.23	0.96	0.77
27	87	0.80	0.90	0.94	1.12	1.16	1.12	1.07	1.09	1.13	1.15	0.87	0.67
28	88	0.85	0.91	0.94	0.69	0.84	1.28	1.14	1.11	1.17	1.20	1.07	0.83
29	89	0.80	0.86	0.81	0.97	1.12	1.08	1.07	1.05	1.13	1.18	1.08	0.86
30	90	0.90	1.34	1.14	0.38	0.45	1.41	1.55	1.13	1.04	1.13	0.90	0.77
31	91	0.81	0.88	0.79	0.97	1.17	1.01	0.92	1.06	1.25	1.24	1.01	0.90
32	92	0.81	0.89	0.79	0.74	1.68	1.02	0.95	1.02	1.13	1.16	1.12	0.71
33	98	0.67	0.96	0.79	0.73	0.81	1.42	1.24	0.96	1.32	1.31	1.03	0.92

The CLUSTER Procedure
Ward's Minimum Variance Cluster Analysis

Eigenvalues of the Covariance Matrix

	Eigenvalue	Difference	Proportion	Cumulative
1	0.11592176	0.05550698	0.4565	0.4565
2	0.06041478	0.02998831	0.2379	0.6944
3	0.03042647	0.01476995	0.1198	0.8142
4	0.01565652	0.00607872	0.0617	0.8759
5	0.00957780	0.00237157	0.0377	0.9136
6	0.00720623	0.00145670	0.0284	0.9420
7	0.00574953	0.00205766	0.0226	0.9646
8	0.00369187	0.00154758	0.0145	0.9792
9	0.00214429	0.00032468	0.0084	0.9876
10	0.00181960	0.00082994	0.0072	0.9948
11	0.00098966	0.00065427	0.0039	0.9987
12	0.00033539		0.0013	1.0000

Root-Mean-Square Total-Sample Standard Deviation = 0.145469
Root-Mean-Square Distance Between Observations = 0.712648

Cluster History

NCL	--Clusters Joined---		FREQ	SPRSQ	RSQ	Tie
32	43	62	2	0.0013	.999	
31	65	89	2	0.0018	.997	
30	49	84	2	0.0020	.995	
29	CL32	63	3	0.0021	.993	
28	51	86	2	0.0021	.991	
27	CL29	61	4	0.0023	.988	
26	55	87	2	0.0028	.986	
25	66	85	2	0.0031	.982	
24	CL28	64	3	0.0035	.979	
23	21	81	2	0.0036	.975	
22	46	CL26	3	0.0037	.972	
21	CL30	CL31	4	0.0040	.968	
20	10	11	2	0.0046	.963	
19	24	CL25	3	0.0078	.955	
18	CL21	91	5	0.0081	.947	
17	CL27	CL22	7	0.0083	.939	
16	88	98	2	0.0096	.929	
15	CL20	CL24	5	0.0113	.918	
14	15	CL17	8	0.0119	.906	
13	50	52	2	0.0125	.894	
12	CL23	92	3	0.0133	.880	
11	CL14	CL18	13	0.0190	.861	
10	CL13	53	3	0.0197	.842	
9	82	CL16	3	0.0228	.819	
8	CL19	54	4	0.0238	.795	
7	CL15	CL9	8	0.0331	.762	
6	CL12	CL8	7	0.0370	.725	
5	CL7	83	9	0.0423	.683	
4	CL5	CL11	22	0.0882	.594	
3	CL10	90	4	0.1171	.477	
2	CL4	CL6	29	0.1862	.291	
1	CL2	CL3	33	0.2910	.000	

The TREE Procedure
Ward's Minimum Variance Cluster Analysis

```
                                      STNNO

         1 1 5 8 6 8 8 9 8 1 4 6 6 6 4 5 8 4 8 6 8 9 2 8 9 2 6 8 5 5 5 5 9
         0 1 1 6 4 2 8 8 3 5 3 2 3 1 6 5 7 9 4 5 9 1 1 1 2 4 6 5 4 0 2 3 0
    0.3 +
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S       |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXX
e       |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXX
m       |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXX
i       |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXX
-   0.2 +XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXX
P       |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXX
a       |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXX
r       |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXX XXXXXXX
t       |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXX XXXXXXX
i       |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXX XXXXXXX
a       |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXX XXXXXXX
l  0.15 +XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXX XXXXXXX
        |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXX XXXXXXX
R       |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXX XXXXXXX
-       |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXX XXXXXXX
S       |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXX XXXXXXX
q       |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXX XXXXXXX
u       |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXX XXXXX .
a   0.1 +XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXX XXXXX .
r       |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXX XXXXX .
e       |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXX XXXXX .
d       |XXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXX XXXXX .
        |XXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXX XXXXX .
        |XXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXX XXXXX .
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   0.05 +XXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXX XXXXX .
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        |XXX XXXXX . XXX . . XXXXXXXXXXXXX XXXXXXXXX XXX . XXXXX . . . . .
      0 +. . XXXXX . . . . . XXXXXXX . XXX XXX XXX . . . . . XXX . . . . .
```

APPENDIX D

TTPGs and Control Stations in the DT-Network

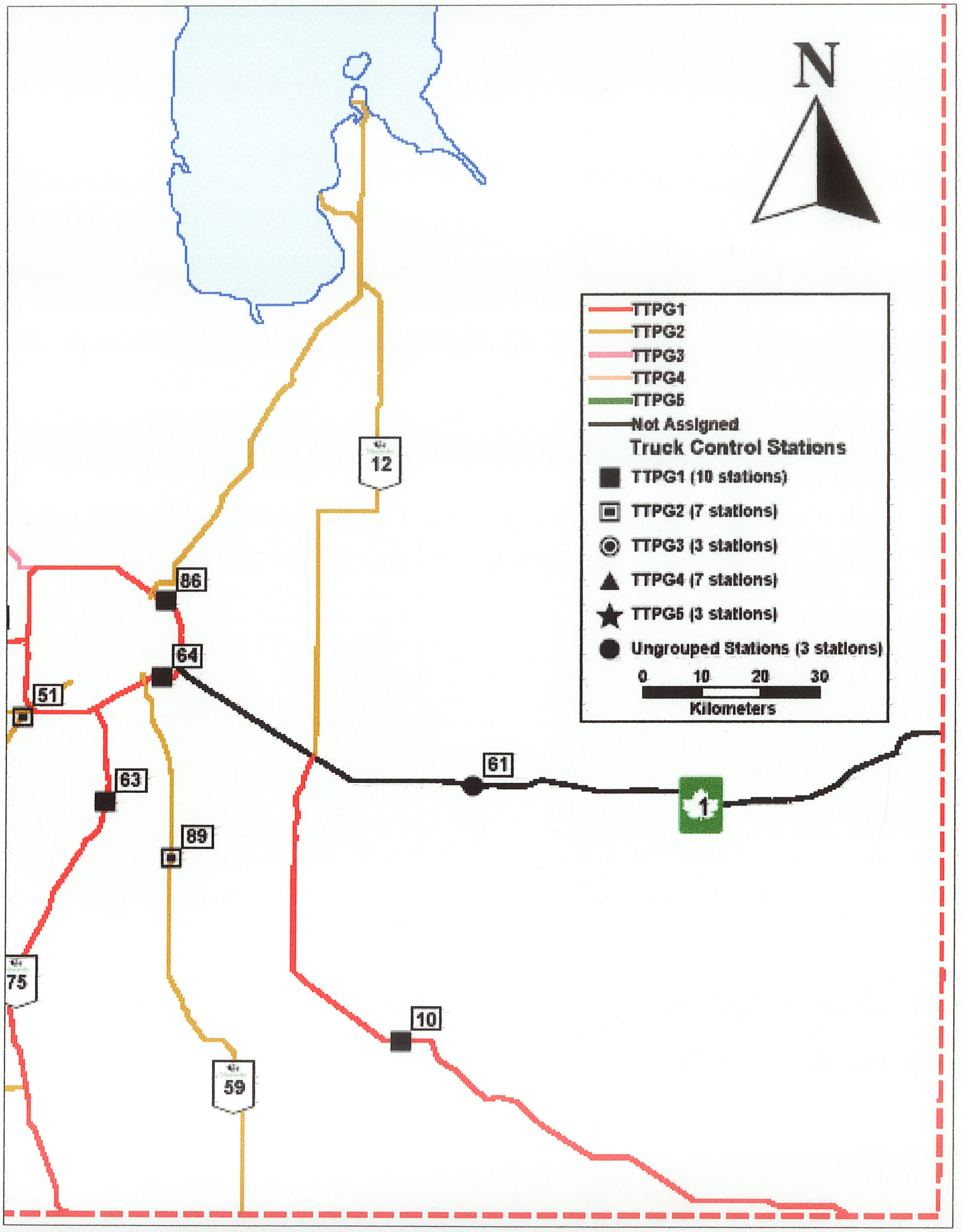

Figure D.1: TTPGs and Control Stations in the DT-Network (East of Winnipeg)

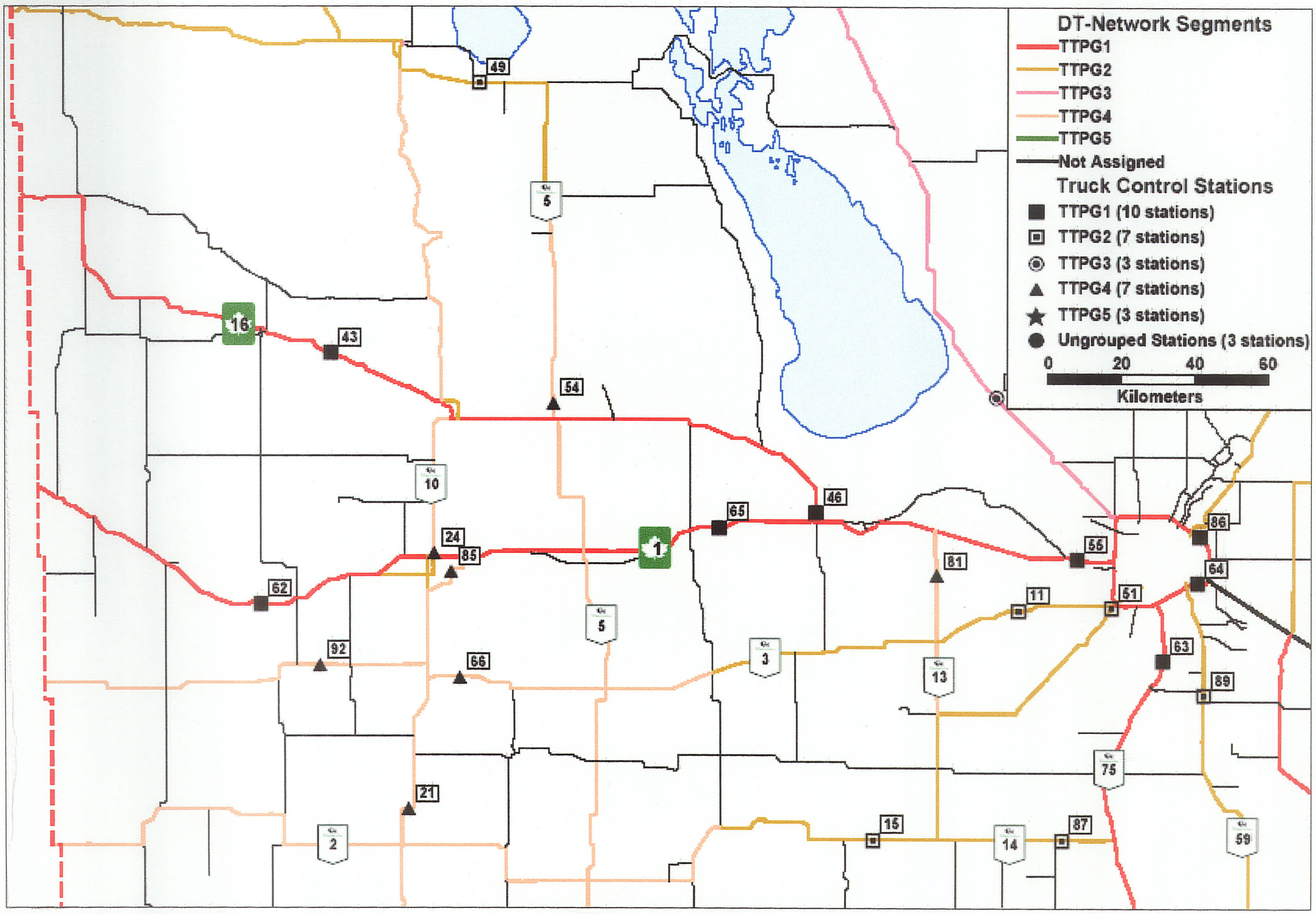

Figure D.2: TTPGs and Control Stations in the DT-Network (Southwestern Manitoba)

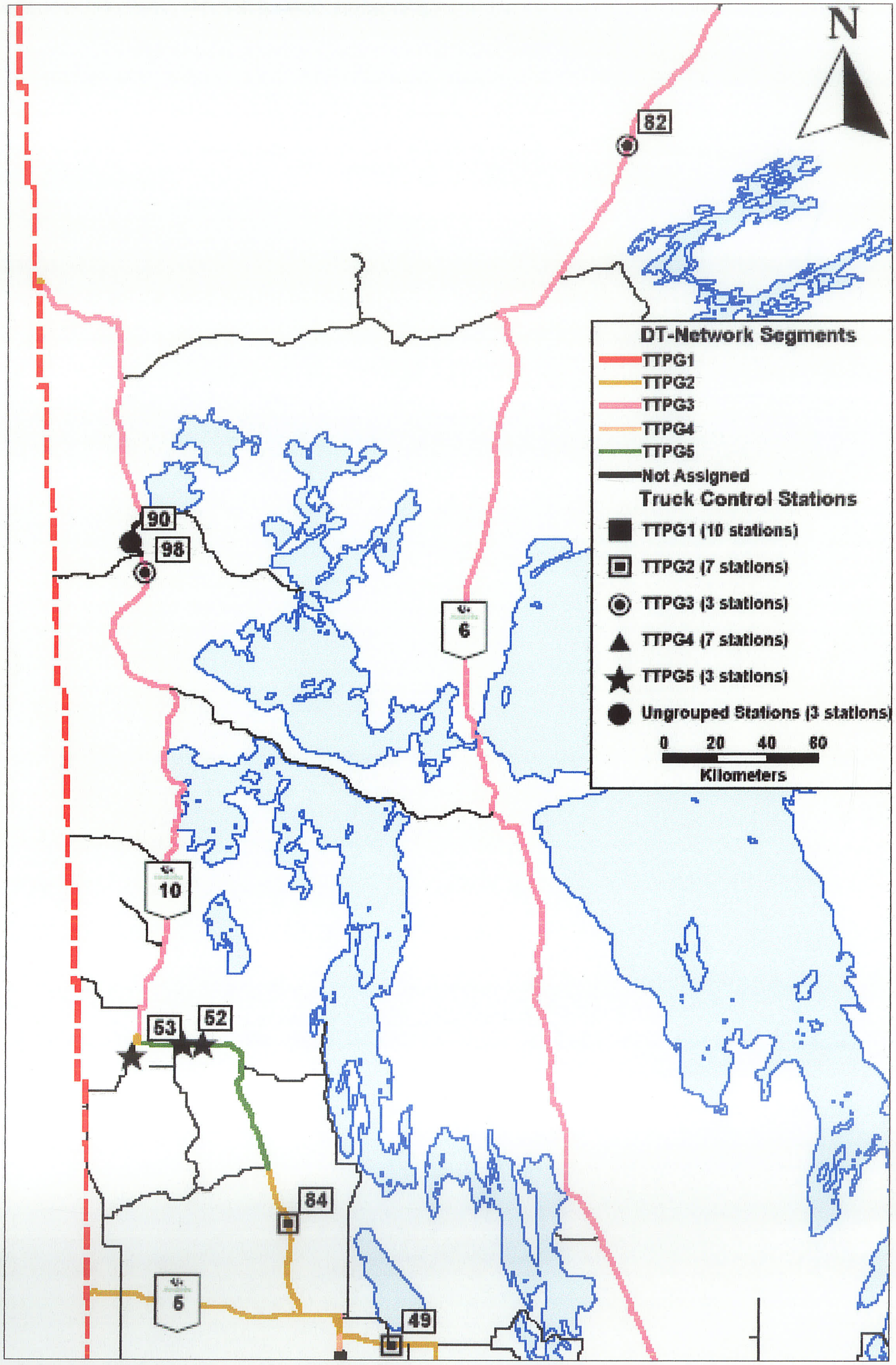

Figure D.3: TTPGs and Control Stations in the DT-Network (Northern Manitoba)

APPENDIX E

Results of Truck Volume Estimation and Characterization In the DT-Network

Hwy No.	Truck Volume Sequence No.	Hwy Control Section No.	Traffic Control Sequence No.	Control Station	TTPG	2002 AADTT	Length (km)	2002 TKT (in millions)	Data Year	Rating
1	901	3001010	300101010	62	TTPG1	1,290	5.7	2.68	2002	B4
1	902	3001020	300102010	62	TTPG1	1,270	11.6	5.36	2001	C4
1	902	3001020	300102020	62	TTPG1	1,270	17.9	8.31	2001	C4
1	903	3001030	300103010	62	TTPG1	1,210	5.9	2.59	2002	B4
1	904	3001030	300104010	62	TTPG1	1,210	0.3	0.14	2002	A4
1	905	3001040	300104020	62	TTPG1	1,250	3.3	1.52	2002	A4
1	905	3001045	300104020	62	TTPG1	1,250	3.3	1.52	2002	A4
1	905	3001045	300104030	62	TTPG1	1,250	2.1	0.95	2002	A4
1	905	3001045	300104040	62	TTPG1	1,250	16.3	7.43	2002	A4
1	905	3001050	300105010	62	TTPG1	1,250	5.2	2.37	2002	A4
1	905	3001050	300105020	62	TTPG1	1,250	9.0	4.11	2002	A4
1	905	3001050	300105030	62	TTPG1	1,250	4.7	2.14	2002	A4
1	906	3001060	300106010	62	TTPG1	1,200	7.3	3.20	2002	B4
1	906	3001060	300106020	62	TTPG1	1,200	5.9	2.58	2002	B4
1	906	3001070	300107010	62	TTPG1	1,200	3.4	1.48	2002	B4
1	907	3001070	300107020	62	TTPG1	910	8.0	2.67	1999	E3
1	908	3001080	300108010	62	TTPG1	890	2.0	0.65	1999	E3
1	909	3001080	300108010	62	TTPG1	890	2.7	0.88	1999	E3
1	909	3001080	300108020	62	TTPG1	890	3.6	1.18	1999	E3
1	910	3001080	300108030	62	TTPG1	790	6.3	1.82	1999	E3
1	911	3001090	300109010	62	TTPG2	1,030	0.9	0.34	2000	D4
1	911	3001090	300109011	62	TTPG2	1,030	0.7	0.26	2000	D4
1	912	3001100	300110010	65	TTPG1	1,070	4.3	1.68	2000	C4
1	912	3001100	300110020	65	TTPG1	1,070	3.9	1.51	2000	C4
1	913	3001100	300110030	65	TTPG1	1,520	0.4	0.24	2001	C4
1	913	3001100	300110040	65	TTPG1	1,520	8.5	4.72	2001	C4
1	913	3001110	300111010	65	TTPG1	1,520	8.3	4.61	2001	C4
1	913	3001110	300111020	65	TTPG1	1,520	1.3	0.73	2001	C4
1	913	3001110	300111030	65	TTPG1	1,520	15.2	8.42	2001	C4
1	914	3001120	300112010	65	TTPG1	1,510	9.1	5.02	2001	C4
1	914	3001120	300112020	65	TTPG1	1,510	9.1	5.02	2001	C4
1	914	3001130	300113010	65	TTPG1	1,700	1.7	1.05	2001	C4
1	914	3001130	300113020	65	TTPG1	1,510	12.0	6.62	2001	C4
1	915	2001140	200114010	65	TTPG1	1,580	6.3	3.63	2002	A4
1	915	2001140	200114020	65	TTPG1	1,580	7.4	4.25	2002	A4
1	915	2001140	200114030	65	TTPG1	1,580	9.9	5.71	2002	A4
1	915	2001140	200114040	65	TTPG1	1,580	11.5	6.63	2002	A4
1	916	2001150	200115010	65	TTPG1	2,240	6.6	5.40	2002	A5
1	917	2001160	200116010	65	TTPG1	1,130	8.9	3.67	1999	E4
1	918	2001170	200117010	65	TTPG1	960	5.3	1.86	1999	E3
1	919	2001180	200118010	55	TTPG1	2,290	8.4	7.02	2002	A5
1	919	2001180	200118020	55	TTPG1	2,290	6.4	5.35	2002	A5
1	920	2001190	200119010	55	TTPG1	1,950	8.6	6.10	2002	A5
1	920	2001190	200119020	55	TTPG1	1,950	10.2	7.28	2002	A5
1	920	2001200	200120010	55	TTPG1	1,950	8.7	6.19	2002	A5
1	920	2001200	200120020	55	TTPG1	1,950	7.8	5.57	2002	A5
1	920	2001200	200120030	55	TTPG1	1,950	2.0	1.42	2002	A5
1	921	2001210	200121010	55	TTPG1	2,060	3.9	2.93	2002	A5
1	921	1001220	100122010	55	TTPG1	2,060	3.0	2.27	2002	A5
1	921	1001220	100122020	55	TTPG1	2,060	0.2	0.17	2002	A5
1	921	1001220	100122030	55	TTPG1	2,060	5.9	4.44	2002	A5

Hwy No.	Truck Volume Sequence No.	Hwy Control Section No.	Traffic Control Sequence No.	Control Station	TTPG	2002 AADTT	Length (km)	2002 TKT (in millions)	Data Year	Rating
1	922	1001240	100124010	61		1,260	2.6	1.20	2002	B4
1	923	1001250	100125010	61		1,260	8.0	3.69	2002	A4
1	923	1001250	100125020	61		1,260	2.1	0.97	2002	A4
1	923	1001250	100125030	61		1,260	3.9	1.81	2002	A4
1	923	1001250	100125040	61		1,260	4.1	1.90	2002	A4
1	923	1001250	100125050	61		1,260	7.1	3.26	2002	A4
1	924	1001260	100126010	61		830	14.6	4.44	2002	A3
1	925	1001260	100126020	61		910	13.1	4.34	2002	A3
1	925	1001270	100127010	61		910	13.4	4.45	2002	A3
1	925	1001280	100128010	61		910	13.5	4.48	2002	A3
1	926	1001290	100129010	61		940	2.2	0.75	2002	B3
1	926	1001290	100129020	61		940	6.1	2.08	2002	B3
1	926	1001290	100129030	61		940	13.3	4.58	2002	B3
1	926	1001300	100130010	61		940	22.2	7.62	2002	B3
1	926	1001310	100131010	61		940	8.5	2.91	2002	B3
1	926	1001310	100131020	61		940	2.6	0.90	2002	B3
1	927	1001320	100132010	61		1,030	4.0	1.50	2001	D4
1A	901	3001910	300191010		TTPG2	90	6.9	0.23	1999	E1
1A	901	3001910	300191020		TTPG2	90	6.1	0.20	1999	E1
1A	902	3001920	300192010		TTPG2	100	1.7	0.06	2000	D1
1A	903	3001920	300192011		TTPG2	350	0.7	0.09	2002	B2
1A	903	3001920	300192012		TTPG2	350	1.3	0.17	2002	B2
1A	903	3001920	300192013		TTPG2	350	0.6	0.07	2002	B2
1A	903	3001920	300192020		TTPG2	350	1.5	0.20	2002	B2
1A	903	3001920	300192021		TTPG2	350	1.0	0.13	2002	B2
2	901	3002010	300201010	92	TTPG4	80	9.1	0.26	1999	E1
2	901	3002010	300201020	92	TTPG4	80	4.1	0.12	1999	E1
2	901	3002010	300201030	92	TTPG4	80	20.9	0.61	1999	E1
2	902	3002020	300202010	92	TTPG4	90	25.3	0.83	1999	E1
2	902	3002020	300202020	92	TTPG4	90	6.7	0.22	1999	E1
2	903	3002030	300203010	92	TTPG4	80	8.2	0.24	1999	E1
2	904	3002040	300204010	92	TTPG4	140	3.3	0.17	2002	A1
2	904	3002040	300204020	92	TTPG4	140	8.7	0.45	2002	A1
2	904	3002040	300204021	92	TTPG4	140	2.8	0.14	2002	A1
2	905	3002050	300205010	92	TTPG4	100	4.8	0.18	2002	A1
2	905	3002050	300205020	92	TTPG4	100	10.1	0.37	2002	A1
2	905	3002050	300205030	92	TTPG4	100	6.7	0.24	2002	A1
2	905	3002060	300206010	21	TTPG4	170	4.2	0.26	2002	A1
2	907	3002070	300207010	66	TTPG4	160	6.7	0.39	2002	A1
2	907	3002070	300207020	66	TTPG4	160	6.8	0.40	2002	A1
2	907	3002070	300207021	66	TTPG4	160	1.5	0.09	2002	A1
2	907	3002070	300207030	66	TTPG4	160	6.3	0.37	2002	A1
2	907	3002070	300207040	66	TTPG4	160	4.3	0.25	2002	A1
2	908	3002080	300208010	66	TTPG4	100	2.5	0.09	2002	B1
2	908	3002080	300208020	66	TTPG4	100	12.0	0.44	2002	B1
2	908	3002080	300208030	66	TTPG4	100	7.1	0.26	2002	B1
2	908	3002080	300208040	66	TTPG4	100	4.0	0.15	2002	B1
2	909	3002090	300209010	66	TTPG4	200	13.2	0.96	2002	A1
2	909	3002100	300210010	66	TTPG4	200	15.6	1.14	2002	A1
2	909	3002100	300210020	66	TTPG4	200	1.8	0.13	2002	A1
2	910	2002110	200211010	11	TTPG2	230	13.9	1.17	2002	A1

Hwy No.	Truck Volume Sequence No.	Hwy Control Section No.	Traffic Control Sequence No.	Control Station	TTPG	2002 AADTT	Length (km)	2002 TKT (in millions)	Data Year	Rating
2	910	2002110	200211020	11	TTPG2	230	10.4	0.87	2002	A1
2	911	2002120	200212020	11	TTPG2	230	8.4	0.71	2002	A1
2	912	2002120	200212030	11	TTPG2	170	7.2	0.45	2002	A1
2	912	2002130	200213010	11	TTPG2	170	25.3	1.57	2002	A1
2	913	2002140	200214010	11	TTPG2	220	1.6	0.13	2002	A1
2	913	2002140	200214020	11	TTPG2	220	7.7	0.61	2002	A1
2	913	2002140	200214030	11	TTPG2	220	9.1	0.73	2002	A1
2	913	2002140	200214040	11	TTPG2	220	12.2	0.98	2002	A1
2	913	2002150	200215010	11	TTPG2	220	8.2	0.66	2002	A1
2	913	2002150	200215020	11	TTPG2	220	3.3	0.26	2002	A1
2	913	2002150	200215030	11	TTPG2	220	3.3	0.26	2002	A1
2	913	2002150	200215040	11	TTPG2	220	6.1	0.49	2002	A1
2	914	2002160	200216010	11	TTPG2	140	1.6	0.08	2002	A1
3	901	3003010	300301010	92	TTPG4	70	9.9	0.25	1999	E1
3	901	3003010	300301020	92	TTPG4	70	0.6	0.01	1999	E1
3	901	3003010	300301030	92	TTPG4	70	9.2	0.23	1999	E1
3	901	3003010	300301040	92	TTPG4	70	4.9	0.12	1999	E1
3	902	3003020	300302010	92	TTPG4	70	12.7	0.32	1999	E1
3	903	3003030	300303010	92	TTPG4	90	10.0	0.33	1999	E1
3	903	3003040	300304010	92	TTPG4	90	3.3	0.11	1999	E1
3	904	3003040	300304020	92	TTPG4	50	8.3	0.15	1999	E1
3	904	3003040	300304030	92	TTPG4	50	0.4	0.01	1999	E1
3	904	3003040	300304040	92	TTPG4	50	13.1	0.24	1999	E1
3	905	3003050	300305010	92	TTPG4	80	8.2	0.24	1999	E1
3	906	3003060	300306010	92	TTPG4	80	3.0	0.09	1999	E1
3	906	3003060	300306020	92	TTPG4	60	10.5	0.23	1999	E1
3	906	3003070	300307010	92	TTPG4	70	20.1	0.51	1999	E1
3	907	3003080	300308010	66	TTPG4	100	13.2	0.48	1999	E1
3	907	3003090	300309010	66	TTPG4	100	16.1	0.59	1999	E1
3	908	3003100	300310010	66	TTPG4	220	9.2	0.74	2001	C1
3	909	3003110	300311010	66	TTPG4	190	13.3	0.92	2001	C1
3	909	3003110	300311020	66	TTPG4	190	9.9	0.69	2001	C1
3	910	3003120	300312010	66	TTPG4	160	11.2	0.66	2001	D1
3	910	3003120	300312020	66	TTPG4	140	11.3	0.58	2001	D1
3	911	3003130	300313010	66	TTPG4	40	6.6	0.10	1999	E1
3	912	3003140	300314010	66	TTPG4	60	5.1	0.11	1999	E1
3	913	3003150	300315010	66	TTPG4	80	9.2	0.27	2002	A1
3	913	3003150	300315020	66	TTPG4	80	4.0	0.12	2002	A1
3	914	2003160	200316010	15	TTPG2	120	12.3	0.54	2002	B1
3	914	2003170	200317010	15	TTPG2	120	0.6	0.03	2002	B1
3	914	2003170	200317020	15	TTPG2	120	10.5	0.46	2002	B1
3	914	2003170	200317030	15	TTPG2	120	9.3	0.41	2002	B1
3	914	2003170	200317040	15	TTPG2	120	7.8	0.34	2002	B1
3	915	2003180	200318010	15	TTPG2	160	16.3	0.95	2002	A1
3	915	2003180	200318020	15	TTPG2	160	1.9	0.11	2002	A1
3	915	2003180	200318030	15	TTPG2	160	8.2	0.48	2002	A1
3	916	2003190	200319010	15	TTPG2	270	10.0	0.99	2002	B2
3	916	2003190	200319020	15	TTPG2	270	9.6	0.95	2002	B2
3	917	2003200	200320010	15	TTPG2	320	10.7	1.25	2002	B2
3	917	2003200	200320020	15	TTPG2	320	4.1	0.48	2002	B2
3	918	2003210	200321010	51	TTPG2	270	3.5	0.34	2002	A2

Hwy No.	Truck Volume Sequence No.	Hwy Control Section No.	Traffic Control Sequence No.	Control Station	TTPG	2002 AADTT	Length (km)	2002 TKT (in millions)	Data Year	Rating
3	918	2003210	200321020	51	TTPG2	270	17.7	1.74	2002	A2
3	918	2003220	200322010	51	TTPG2	270	0.2	0.02	2002	A2
3	918	2003220	200322020	51	TTPG2	270	13.7	1.35	2002	A2
3	918	2003230	200323010	51	TTPG2	270	14.1	1.39	2002	A2
3	918	2003230	200323020	51	TTPG2	270	1.0	0.10	2002	A2
3	918	2003230	200323030	51	TTPG2	270	1.9	0.18	2002	A2
3	918	2003230	200323040	51	TTPG2	270	10.5	1.03	2002	A2
3	919	2003240	200324010	51	TTPG2	420	1.1	0.17	2002	A2
3	920	1003250	200324020	51	TTPG2	180	8.2	0.54	2001	C1
5	901	3005010	300501010	21	TTPG4	10	10.0	0.04	1999	E1
5	902	3005020	300502010	21	TTPG4	40	10.3	0.15	1999	E1
5	902	3005020	300502020	21	TTPG4	40	10.5	0.15	1999	E1
5	902	3005030	300503010	21	TTPG4	40	1.5	0.02	1999	E1
5	902	3005030	300503020	21	TTPG4	40	13.3	0.19	1999	E1
5	903	3005040	300504010	21	TTPG4	30	10.5	0.11	2002	B1
5	903	3005040	300504020	21	TTPG4	30	11.2	0.12	2002	B1
5	904	3005050	300505010	21	TTPG4	190	11.1	0.77	1999	E1
5	904	3005060	300506010	21	TTPG4	190	20.7	1.44	1999	E1
5	904	3005060	300506020	21	TTPG4	190	5.9	0.41	1999	E1
5	905	3005070	300507010	21	TTPG4	310	3.4	0.38	2001	C2
5	906	3005080	300508010	54	TTPG4	200	3.0	0.22	2001	C1
5	906	3005080	300508020	54	TTPG4	200	8.5	0.62	2001	C1
5	906	3005080	300508030	54	TTPG4	200	11.2	0.82	2001	C1
5	906	3005090	300509010	54	TTPG4	200	15.0	1.10	2001	C1
5	906	3005090	300509020	54	TTPG4	200	4.8	0.35	2001	C1
5	907	3005100	300510010	43	TTPG1	600	1.4	0.31	2002	B3
5	908	3005110	300511010	54	TTPG4	200	11.4	0.84	2002	A1
5	908	3005110	300511020	54	TTPG4	200	5.0	0.37	2002	A1
5	908	3005110	300511030	54	TTPG4	200	1.8	0.13	2002	A1
5	908	3005110	300511040	54	TTPG4	200	4.9	0.36	2002	A1
5	908	3005120	300512010	54	TTPG4	200	1.7	0.12	2002	A1
5	908	3005120	300512020	54	TTPG4	200	13.1	0.96	2002	A1
5	908	4005130	400513010	54	TTPG4	200	13.5	0.99	2002	A1
5	909	4005140	400514010	54	TTPG4	190	4.9	0.34	2002	B1
5	909	4005140	400514020	54	TTPG4	190	5.3	0.37	2002	B1
5	910	4005150	400515010	49	TTPG2	160	13.4	0.78	1999	E1
5	910	4005150	400515020	54	TTPG2	160	11.6	0.68	1999	E1
5	910	4005150	400515030	54	TTPG2	160	6.5	0.38	1999	E1
5	911	4005160	400516010	49	TTPG2	180	1.5	0.10	2002	B1
5	911	4005160	400516020	49	TTPG2	180	9.8	0.65	2002	B1
5	912	4005160	400516030	49	TTPG2	190	8.2	0.57	2002	A1
5	913	4005170	400517010	49	TTPG2	140	10.2	0.52	2001	C1
5	913	4005170	400517020	49	TTPG2	140	10.1	0.52	2001	C1
5	914	4005180	400518010	49	TTPG2	230	4.2	0.35	2001	C1
5	915	4005190	400519010	49	TTPG2	140	5.1	0.26	2000	C1
5	916	4005200	400520010	49	TTPG2	310	8.2	0.93	2000	C2
5	916	4005200	400520020	49	TTPG2	310	6.6	0.74	2000	C2
5	917	4005210	400521010	49	TTPG2	210	7.1	0.54	2002	B1
5	917	4005210	400521020	49	TTPG2	210	6.1	0.47	2002	B1
5	917	4005220	400522010	49	TTPG2	210	7.4	0.57	2002	B1
5	917	4005220	400522020	49	TTPG2	210	8.0	0.61	2002	B1

Hwy No.	Truck Volume Sequence No.	Hwy Control Section No.	Traffic Control Sequence No.	Control Station	TTPG	2002 AADTT	Length (km)	2002 TKT (in millions)	Data Year	Rating
5	917	4005230	400523010	49	TTPG2	210	24.5	1.88	2002	B1
5	917	4005230	400523020	49	TTPG2	210	14.0	1.08	2002	B1
5	917	4005240	400524010	49	TTPG2	210	10.3	0.79	2002	B1
5	918	4005250	400525010	49	TTPG2	80	0.1	0.00	1999	E1
5	919	4005260	400526010	49	TTPG2	80	6.5	0.19	1999	E1
5	919	4005260	400526020	49	TTPG2	80	7.1	0.21	1999	E1
5A	901	4005910	400591010	49	TTPG2	150	3.7	0.20	2001	C1
5A	902	4005920	400592010	49	TTPG3	150	0.2	0.01	2001	C1
5A	903	4005930	400593010	49	TTPG2	260	1.1	0.11	2000	C2
5A	903	4005930	400593020	49	TTPG2	260	1.6	0.15	2000	C2
6	901	2006010	200601010	88	TTPG3	400	0.9	0.13	2000	C2
6	902	2006010	200601020	88	TTPG3	310	1.5	0.17	2000	C2
6	903	2006010	200601030	88	TTPG3	330	10.3	1.24	2002	A2
6	903	2006010	200601040	88	TTPG3	330	1.1	0.13	2002	A2
6	903	2006010	200601050	88	TTPG3	330	8.6	1.03	2002	A2
6	904	2006020	200602010	88	TTPG3	250	1.7	0.16	2002	A2
6	904	2006020	200602020	88	TTPG3	250	9.0	0.82	2002	A2
6	904	2006020	200602030	88	TTPG3	250	4.4	0.40	2002	A2
6	904	2006020	200602040	88	TTPG3	250	4.9	0.45	2002	A2
6	904	2006020	200602050	88	TTPG3	250	2.1	0.19	2002	A2
6	904	2006030	200603010	88	TTPG3	250	9.8	0.89	2002	A2
6	904	2006030	200603020	88	TTPG3	250	13.8	1.26	2002	A2
6	904	4006040	200604010	88	TTPG3	250	22.0	2.01	2002	A2
6	904	4006050	200605010	88	TTPG3	250	12.9	1.18	2002	A2
6	904	4006060	400606010	88	TTPG3	250	19.6	1.79	2002	A2
6	905	4006070	400607010	88	TTPG3	190	10.6	0.74	2002	B1
6	906	4006080	400608010	82	TTPG3	100	28.8	1.05	2000	C1
6	906	4006090	400609010	82	TTPG3	100	2.0	0.07	2000	C1
6	906	4006090	400609020	82	TTPG3	100	3.3	0.12	2000	C1
6	906	4006090	400609021	82	TTPG3	100	9.2	0.34	2000	C1
6	906	4006090	400609030	82	TTPG3	100	1.8	0.07	2000	C1
6	906	4006090	400609040	82	TTPG3	100	16.0	0.58	2000	C1
6	907	4006100	400610010	82	TTPG3	80	9.0	0.26	2000	C1
6	907	4006100	400610020	82	TTPG3	80	14.2	0.41	2000	C1
6	907	4006110	400611010	82	TTPG3	80	14.0	0.41	2000	C1
6	907	4006120	400612010	82	TTPG3	80	3.0	0.09	2000	C1
6	907	4006120	400612020	82	TTPG3	80	39.4	1.15	2000	C1
6	907	4006130	400613010	82	TTPG3	80	39.2	1.14	2000	C1
6	907	5006140	500614010	82	TTPG3	80	50.4	1.47	2000	C1
6	907	5006150	500615010	82	TTPG3	80	16.9	0.49	2000	C1
6	908	5006160	500616010	82	TTPG3	70	10.0	0.26	2000	D1
6	908	5006160	500616020	82	TTPG3	70	23.3	0.60	2000	D1
6	908	5006170	500617010	82	TTPG3	70	45.9	1.17	2000	D1
6	908	5006180	500618010	82	TTPG3	70	39.2	1.00	2000	D1
6	908	5006190	500619010	82	TTPG3	70	32.5	0.83	2000	D1
6	908	5006200	500620010	82	TTPG3	70	24.1	0.62	2000	D1
6	908	5006210	500621010	82	TTPG3	70	33.0	0.84	2000	D1
6	909	5006220	500622010	82	TTPG3	80	29.8	0.87	2002	B1
6	910	5006230	500623010	82	TTPG3	90	35.9	1.18	2002	A1
6	910	5006240	500624010	82	TTPG3	90	16.9	0.56	2002	A1
6	910	5006250	500625010	82	TTPG3	90	28.5	0.94	2002	A1

Hwy No.	Truck Volume Sequence No.	Hwy Control Section No.	Traffic Control Sequence No.	Control Station	TTPG	2002 AADTT	Length (km)	2002 TKT (in millions)	Data Year	Rating
6	910	5006250	500625020	82	TTPG3	90	14.3	0.47	2002	A1
6	910	5006260	500626010	82	TTPG3	90	14.0	0.46	2002	A1
6	910	5006260	500626020	82	TTPG3	90	14.8	0.49	2002	A1
10	901	3010010	301001010	21	TTPG4	120	13.5	0.59	2002	B1
10	901	3010010	301001020	21	TTPG4	120	6.8	0.30	2002	B1
10	902	3010020	301002010	21	TTPG4	160	2.6	0.15	2002	A1
10	902	3010020	301002020	21	TTPG4	160	3.3	0.19	2002	A1
10	902	3010020	301002030	21	TTPG4	160	4.0	0.23	2002	A1
10	902	3010020	301002040	21	TTPG4	160	11.2	0.65	2002	A1
10	902	3010020	301002050	21	TTPG4	160	6.6	0.39	2002	A1
10	903	3010030	301003010	21	TTPG4	200	5.0	0.37	2002	B1
10	904	3010040	301004010	21	TTPG4	160	11.0	0.64	2002	A1
10	904	3010040	301004020	21	TTPG4	160	6.3	0.37	2002	A1
10	906	3010050	301005010	21	TTPG4	170	7.8	0.49	2002	A1
10	906	3010050	301005020	21	TTPG4	170	5.0	0.31	2002	A1
10	906	3010060	301006010	21	TTPG4	170	7.1	0.44	2002	A1
10	907	3010060	301006020		TTPG2	320	4.4	0.52	2002	A2
10	908	3010070	301007010		TTPG2	220	2.4	0.19	2002	B1
10	909	3010070	301007020		TTPG2	540	2.6	0.51	1999	E3
10	910	3010080	301008010	24	TTPG4	310	7.3	0.83	2002	A2
10	910	3010080	301008020	24	TTPG4	310	7.7	0.87	2002	A2
10	911	3010090	301009010	24	TTPG4	300	3.3	0.36	2002	B2
10	911	3010090	301009020	24	TTPG4	300	8.3	0.91	2002	B2
10	912	3010100	301010010	24	TTPG4	370	15.3	2.07	2001	D2
10	913	3010110	301011010	43	TTPG1	560	3.4	0.70	2001	C3
10	913	3010110	301011020	43	TTPG1	560	2.7	0.54	2001	C3
10	914	3010120	301012010	24	TTPG4	140	14.4	0.74	2001	C1
10	914	3010120	301012020	24	TTPG4	140	9.1	0.46	2001	C1
10	914	3010120	301012030	24	TTPG4	140	7.1	0.36	2001	C1
10	915	3010130	301013010	24	TTPG4	130	11.1	0.53	2001	C1
10	915	3010130	301013020	24	TTPG4	130	2.6	0.12	2001	C1
10	916	4010140	401014010	24	TTPG4	60	6.6	0.14	2001	C1
10	917	4010150	401015010	84	TTPG2	100	24.6	0.90	2002	A1
10	917	4010160	401016010	84	TTPG2	100	9.7	0.35	2002	A1
10	917	4010160	401016020	84	TTPG2	100	6.7	0.24	2002	A1
10	918	4010170	401017010	84	TTPG2	70	2.4	0.06	1999	E1
10	918	4010170	401017020	84	TTPG2	70	0.5	0.01	1999	E1
10	919	4010180	401018010	84	TTPG2	120	7.8	0.34	2002	B1
10	919	4010180	401018020	84	TTPG2	120	8.9	0.39	2002	B1
10	920	4010190	401019010	50	TTPG5	140	13.5	0.69	2002	B1
10	920	4010200	401020010	50	TTPG5	140	14.3	0.73	2002	B1
10	920	4010200	401020020	50	TTPG5	140	16.5	0.84	2002	B1
10	921	4010210	401021010	50	TTPG5	140	12.0	0.61	2002	A1
10	921	4010210	401021020	50	TTPG5	140	14.4	0.74	2002	A1
10	921	4010220	401022010	52	TTPG5	180	6.5	0.43	2002	A1
10	922	4010220	401022020	52	TTPG5	150	9.9	0.54	2002	B1
10	922	4010220	401022030	52	TTPG5	150	5.2	0.28	2002	B1
10	923	4010230	401023010	98	TTPG2	150	2.4	0.13	1999	E1
10	924	4010240	401024010	98	TTPG3	140	5.1	0.26	1999	E1
10	924	4010240	401024020	98	TTPG3	140	6.2	0.32	1999	E1
10	925	4010240	401024030	98	TTPG3	120	2.6	0.11	1999	E1

Hwy No.	Truck Volume Sequence No.	Hwy Control Section No.	Traffic Control Sequence No.	Control Station	TTPG	2002 AADTT	Length (km)	2002 TKT (in millions)	Data Year	Rating
10	925	4010250	401025010	98	TTPG3	120	11.3	0.49	1999	E1
10	925	4010250	401025020	98	TTPG3	120	9.8	0.43	1999	E1
10	925	4010260	401026010	98	TTPG3	120	4.4	0.19	1999	E1
10	926	4010260	401026020	98	TTPG3	80	15.4	0.45	2001	D1
10	926	4010260	401026030	98	TTPG3	80	18.3	0.53	2001	D1
10	927	4010270	401027010	98	TTPG3	100	19.2	0.70	2001	C1
10	927	4010280	401028010	98	TTPG3	100	35.8	1.31	2001	C1
10	927	4010290	501029010	98	TTPG3	100	24.7	0.90	2001	C1
10	928	5010300	501030010	98	TTPG3	110	15.0	0.60	2002	A1
10	928	5010300	501030020	98	TTPG3	110	25.7	1.03	2002	A1
10	928	5010310	501031010	98	TTPG3	110	15.0	0.60	2002	A1
10	928	5010310	501031020	98	TTPG3	110	17.9	0.72	2002	A1
10	929	5010320	501032010	90		130	6.5	0.31	2002	A1
10	929	5010320	501032020	90		130	6.5	0.31	2002	A1
10	929	5010320	501032030	90		130	6.9	0.33	2002	A1
10	930	5010330	501033010	98	TTPG3	60	25.8	0.57	2002	B1
10	930	5010340	501034010	98	TTPG3	60	29.6	0.65	2002	B1
10	931	5010350	501035010	98	TTPG3	50	16.6	0.30	1999	E1
10	931	5010360	501036010	98	TTPG3	50	15.0	0.27	1999	E1
10	931	5010360	501036020	98	TTPG3	50	9.3	0.17	1999	E1
10	931	5010370	501037010	98	TTPG3	50	20.3	0.37	1999	E1
10	932	5010380	501038010		TTPG2	50	6.0	0.11	1999	E1
10A	901	4010910	401091010	84	TTPG2	20	2.3	0.02	1999	E1
10A	902	4010910	401091020	84	TTPG2	60	1.1	0.02	1999	E1
10A	901	4010920	401092010	52	TTPG5	50	1.3	0.02	1999	E1
10A	901	4010930	401093010	98	TTPG2	50	0.8	0.02	1999	E1
10A	901	4010930	401093020	98	TTPG2	50	3.4	0.06	1999	E1
12	901	1012010	101201010	10	TTPG1	85	20.6	0.64	2002	B1
12	901	1012020	101202010	10	TTPG1	85	9.4	0.29	2002	B1
12	901	1012020	101202020	10	TTPG1	85	17.2	0.53	2002	B1
12	902	1012030	101203010	10	TTPG1	140	13.9	0.71	2002	A1
12	902	1012030	101203020	10	TTPG1	140	22.1	1.13	2002	A1
12	902	1012040	101204010	10	TTPG1	140	10.9	0.56	2002	A1
12	902	1012040	101204020	10	TTPG1	140	8.2	0.42	2002	A1
12	902	1012050	101205010	10	TTPG1	140	10.1	0.52	2002	A1
12	902	1012050	101205020	10	TTPG1	320	7.5	0.88	2002	A2
12	902	1012050	101205030	10	TTPG1	320	5.8	0.68	2002	A2
12	903	1012060	101206010	10	TTPG1	730	5.0	1.34	2001	C3
12	903	1012060	101206020	10	TTPG1	730	3.3	0.89	2001	C3
12	903	1012060	101206030	10	TTPG1	730	7.2	1.92	2001	C3
12	903	1012060	101206040	10	TTPG1	730	1.4	0.36	2001	C3
12	903	1012060	101206050	10	TTPG1	730	2.9	0.76	2001	C3
12	904	1012070	101207010		TTPG2	110	15.0	0.60	2000	C1
12	904	1012070	101207020		TTPG2	110	5.8	0.23	2000	C1
12	905	1012080	101208010		TTPG2	70	9.8	0.25	2000	C1
12	905	1012080	101208020		TTPG2	70	9.9	0.25	2000	C1
12	905	1012080	101208030		TTPG2	70	1.7	0.04	2000	C1
12	906	1012090	101209010		TTPG2	180	8.2	0.54	1999	E1
12	906	1012090	101209020		TTPG2	20	1.6	0.01	1999	E1
12	907	1012100	101210010		TTPG2	70	8.2	0.21	2001	C1
12	907	1012100	101210020		TTPG2	70	13.2	0.34	2001	C1
12	908	1012110	101211010		TTPG2	40	15.1	0.22	2001	C1

Hwy No.	Truck Volume Sequence No.	Hwy Control Section No.	Traffic Control Sequence No.	Control Station	TTPG	2002 AADTT	Length (km)	2002 TKT (in millions)	Data Year	Rating
12	908	1012110	101211020		TTPG2	40	4.7	0.07	2001	C1
12	909	1012120	101212010		TTPG2	70	2.1	0.05	2000	C1
12	910	1012120	101212020		TTPG2	40	8.2	0.12	2000	C1
12	911	1012130	101213010		TTPG2	30	3.5	0.04	2000	D1
12	911	1012130	101213020		TTPG2	30	4.2	0.05	2000	D1
13	901	2013010	201301010	81	TTPG4	330	4.1	0.49	2002	A2
13	901	2013010	201301020	81	TTPG4	330	5.9	0.71	2002	A2
13	901	2013020	201302010	81	TTPG4	330	10.0	1.20	2002	A2
13	902	2013030	201303010	81	TTPG4	360	13.0	1.71	2002	A2
13	902	2013030	201303020	81	TTPG4	360	14.9	1.95	2002	A2
13	902	2013030	201303030	81	TTPG4	360	2.5	0.33	2002	A2
14	901	2014010	201401010	87	TTPG2	430	5.0	0.78	2002	B2
14	902	2014020	201402010	87	TTPG2	360	13.5	1.77	2002	A2
14	903	2014020	201402020	87	TTPG2	430	15.1	2.37	2002	A2
14	904	2014030	201403010	87	TTPG2	360	11.5	1.52	2002	A2
14	904	2014030	201403020	87	TTPG2	360	5.2	0.68	2002	A2
16	901	3016010	301601010	43	TTPG1	400	4.5	0.66	2002	B2
16	902	3016010	301601010	43	TTPG1	520	4.0	0.76	2001	C3
16	902	3016010	301601020	43	TTPG1	520	7.3	1.39	2001	C3
16	903	3016020	301602010	43	TTPG1	610	0.9	0.20	2001	C3
16	904	3016030	301603010	43	TTPG1	530	3.3	0.63	2001	D3
16	904	3016030	301603020	43	TTPG1	530	5.6	1.09	2001	D3
16	904	3016030	301603030	43	TTPG1	530	7.6	1.47	2001	D3
16	904	3016030	301603040	43	TTPG1	530	2.0	0.39	2001	D3
16	905	3016040	301604010	43	TTPG1	420	1.6	0.24	2002	B2
16	905	3016040	301604020	43	TTPG1	420	11.5	1.76	2002	B2
16	905	3016040	301604030	43	TTPG1	420	6.6	1.01	2002	B2
16	906	3016050	301605010	43	TTPG1	450	3.3	0.54	2002	A2
16	906	3016050	301605020	43	TTPG1	450	7.9	1.30	2002	A2
16	906	3016050	301605030	43	TTPG1	450	8.7	1.43	2002	A2
16	906	3016060	301606010	43	TTPG1	450	3.3	0.54	2002	A2
16	906	3016060	301606020	43	TTPG1	450	12.1	1.99	2002	A2
16	907	3016070	301607010	43	TTPG1	450	1.8	0.30	2002	B2
16	908	3016080	301608010	43	TTPG1	490	14.1	2.52	2002	A3
16	908	3016080	301608020	43	TTPG1	490	4.1	0.74	2002	A3
16	908	3016080	301608030	43	TTPG1	490	10.7	1.91	2002	A3
16	908	3016090	301609010	43	TTPG1	490	2.5	0.44	2002	A3
16	908	3016090	301609020	43	TTPG1	490	12.5	2.24	2002	A3
16	908	3016100	301610010	43	TTPG1	490	9.4	1.68	2002	A3
16	909	3016110	301611010	43	TTPG1	380	1.9	0.26	2001	D2
16	910	3016120	301612010	43	TTPG1	400	11.5	1.68	2000	C2
16	910	3016120	301612020	43	TTPG1	400	8.2	1.20	2000	C2
16	910	3016120	301612030	43	TTPG1	400	6.5	0.95	2000	C2
16	911	3016130	301613010	46	TTPG1	400	15.1	2.20	2001	D2
16	912	2016140	301614010	46	TTPG1	330	12.0	1.45	1999	E2
16	912	2016140	301614020	46	TTPG1	330	9.6	1.15	1999	E2
16	913	2016150	201615010	46	TTPG1	550	12.4	2.50	2002	B3
16	913	2016150	201615020	46	TTPG1	550	8.8	1.76	2002	B3
16	914	2016160	201616010	46	TTPG1	600	7.4	1.63	2002	A3
16	914	2016160	201616020	46	TTPG1	600	2.3	0.51	2002	A3
16	914	2016160	201616030	46	TTPG1	600	1.7	0.38	2002	A3
16	914	2016160	201616040	46	TTPG1	600	8.2	1.79	2002	A3

Hwy No.	Truck Volume Sequence No.	Hwy Control Section No.	Traffic Control Sequence No.	Control Station	TTPG	2002 AADTT	Length (km)	2002 TKT (in millions)	Data Year	Rating
16	914	2016160	201616041	46	TTPG1	600	8.5	1.86	2002	A3
16A	901	3016910	301691010		TTPG2	20	2.6	0.02	2001	C1
16A	901	3016910	301691020		TTPG2	22	0.9	0.01	2001	C1
16A	901	3016910	301691030		TTPG2	22	5.5	0.04	2001	C1
59	901	1059010	105901010	89	TTPG2	150	8.4	0.46	2001	C1
59	901	1059010	105901020	89	TTPG2	150	6.6	0.36	2001	C1
59	901	1059020	105902010	89	TTPG2	150	15.4	0.84	2001	C1
59	901	1059020	105902020	89	TTPG2	150	10.7	0.58	2001	C1
59	901	1059020	105902030	89	TTPG2	150	0.7	0.04	2001	C1
59	902	1059020	105902040	10	TTPG2	190	3.7	0.25	2001	C1
59	903	1059030	105903010	89	TTPG2	240	8.4	0.73	2002	A1
59	903	1059030	105903020	89	TTPG2	240	1.2	0.11	2002	A1
59	903	1059030	105903030	89	TTPG2	240	10.4	0.91	2002	A1
59	904	1059040	105904010	89	TTPG2	320	3.0	0.35	2002	A2
59	905	1059040	105904020	89	TTPG2	280	4.8	0.49	2002	B2
59	906	1059040	105904030	89	TTPG2	420	8.0	1.23	2002	B2
59	906	1059040	105904040	89	TTPG2	420	1.3	0.20	2002	B2
59	907	1059040	105904050	89	TTPG2	440	3.7	0.60	2002	A2
59	908	1059050	105905010	89	TTPG2	430	4.3	0.67	2002	A2
59	908	1059050	105905020	89	TTPG2	430	4.2	0.66	2002	A2
59	908	1059050	105905030	89	TTPG2	430	3.1	0.49	2002	A2
59	909	1059060	105906010	89	TTPG2	620	1.3	0.29	2002	B3
59	910	1059070	105907010		TTPG2	860	0.6	0.19	2000	C3
59	911	1059080	105908010		TTPG2	900	2.2	0.74	2002	A3
59	911	1059080	105908020		TTPG2	900	3.4	1.10	2002	A3
59	912	1059090	105909010		TTPG2	380	9.2	1.28	2002	A2
59	912	1059090	105909020		TTPG2	380	4.8	0.66	2002	A2
59	913	1059100	105910010		TTPG2	160	4.8	0.28	2002	A1
59	914	1059100	105910020		TTPG2	110	2.4	0.10	2002	A1
59	914	1059100	105910040		TTPG2	110	3.0	0.12	2002	A1
59	914	1059100	105910050		TTPG2	110	2.8	0.11	2002	A1
59	915	1059110	105911010		TTPG2	110	3.9	0.16	2000	C1
59	915	1059110	105911020		TTPG2	110	8.4	0.34	2000	C1
59	916	1059120	105912010		TTPG2	90	7.9	0.26	2000	C1
59	916	1059120	105912020		TTPG2	90	9.4	0.31	2000	C1
59	916	1059120	105912030		TTPG2	90	1.8	0.06	2000	C1
59	916	1059120	105912040		TTPG2	90	3.2	0.11	2000	C1
59	917	1059130	105913010		TTPG2	70	7.6	0.19	1999	E1
59	917	1059130	105913020		TTPG2	70	5.6	0.14	1999	E1
59	918	1059140	105914010		TTPG2	20	7.8	0.06	1999	E1
59	918	1059140	105914020		TTPG2	20	1.7	0.01	1999	E1
75	901	1075010	107501010	63	TTPG1	10	0.6	0.00	2002	B1
75	901	1075010	107501020	63	TTPG1	10	1.7	0.01	2002	B1
75	902	1075020	107502010	63	TTPG1	850	1.3	0.42	2002	A3
75	902	1075020	107502020	63	TTPG1	850	6.9	2.13	2002	A3
75	902	1075020	107502030	63	TTPG1	850	7.2	2.23	2002	A3
75	902	1075020	107502040	63	TTPG1	850	6.8	2.11	2002	A3
75	903	1075030	107503010	63	TTPG1	990	4.5	1.63	2002	A4
75	903	1075030	107503011	63	TTPG1	990	5.4	1.95	2002	A4
75	903	1075030	107503020	63	TTPG1	990	3.6	1.30	2002	A4
75	903	1075030	107503030	63	TTPG1	990	4.8	1.73	2002	A4
75	904	1075040	107504010	63	TTPG1	960	0.4	0.14	2002	A3

Hwy No.	Truck Volume Sequence No.	Hwy Control Section No.	Traffic Control Sequence No.	Control Station	TTPG	2002 AADTT	Length (km)	2002 TKT (in millions)	Data Year	Rating
75	905	1075050	107505010	63	TTPG1	960	1.7	0.59	2002	A3
75	905	1075050	107505020	63	TTPG1	960	6.4	2.25	2002	A3
75	905	1075050	107505021	63	TTPG1	960	5.3	1.86	2002	A3
75	906	1075060	107506010	63	TTPG1	990	14.3	5.17	2002	A4
75	907	1075060	107506020	63	TTPG1	950	0.5	0.17	2002	A3
75	907	1075060	107506030	63	TTPG1	950	5.4	1.87	2002	A3
75	907	1075060	107506040	63	TTPG1	950	7.6	2.64	2002	A3
75	907	1075070	107507010	63	TTPG1	950	4.8	1.65	2002	A3
75	907	1075070	107507020	63	TTPG1	950	2.6	0.91	2002	A3
75	907	1075070	107507020	63	TTPG1	950	4.1	1.41	2002	A3
100	901	1100010	110001010	64	TTPG1	930	1.8	0.61	1999	E3
100	902	1100020	110002010	64	TTPG1	990	2.8	1.02	1999	E4
100	903	1100020	110002020	64	TTPG1	1,700	4.1	2.53	2001	C4
100	903	1100020	110002030	64	TTPG1	1,700	3.2	1.99	2001	C4
100	904	1100030	110003010	64	TTPG1	1,700	1.6	0.99	2001	C4
100	905	1100040	110004010	64	TTPG1	1,840	5.2	3.47	2002	B4
100	906	1100040	110004020	64	TTPG1	1,640	1.3	0.76	2001	C4
100	907	1100040	110004020	64	TTPG1	1,780	2.9	1.86	2002	A4
100	908	1100040	110004030	64	TTPG1	1,960	1.3	0.93	2002	A5
100	909	1100050	110005010	64	TTPG1	1,960	3.5	2.50	2002	A5
100	909	1100060	110006010	64	TTPG1	1,700	3.6	2.23	2001	C4
100	909	1100060	110006020	64	TTPG1	1,700	1.9	1.18	2001	C4
100	910	1100070	110007010	64	TTPG1	1,080	2.3	0.91	2002	A4
100	910	1100070	110007020	64	TTPG1	1,080	4.5	1.77	2002	A4
101	901	1101010	110101010	86	TTPG1	1,540	2.1	1.16	1999	E4
101	902	1101010	110101020	86	TTPG1	1,390	6.5	3.31	1999	E4
101	903	1101010	110101030	86	TTPG1	660	3.6	0.87	1999	E3
101	904	1101020	110102010	86	TTPG1	750	5.8	1.59	1999	E3
101	905	1101030	110103010	86	TTPG1	1,650	4.9	2.95	1999	E4
101	905	1101030	110103020	86	TTPG1	1,650	4.0	2.41	1999	E4
101	906	1101040	110104010	86	TTPG1	2,110	2.9	2.23	1999	E5
101	907	1101050	110105010	86	TTPG1	2,360	0.8	0.69	2000	C5
101	908	1101060	110106010	86	TTPG1	2,240	3.4	2.78	2000	C5
101	909	1101070	110107010	86	TTPG1	870	2.3	0.73	2002	A3
101	909	1101070	110107020	86	TTPG1	870	4.1	1.30	2002	A3
101	910	1101070	110107030	86	TTPG1	970	3.5	1.24	2001	C4
101	911	1101080	110108010	86	TTPG1	920	5.8	1.95	2001	C3
110	901	3110010	311001010	85	TTPG4	150	7.4	0.41	2002	B1
110	902	3110020	311002010	85	TTPG4	450	3.1	0.51	2002	A2
110	903	3457010	345701012	85	TTPG4	460	3.4	0.57	2002	A2
110	904	3468010	346801010	85	TTPG4	460	3.2	0.54	2002	B2