West Virginia Department of Transportation Research Project #164

USE OF PERMANENT TRAFFIC RECORDER DATA TO DEVELOP FACTORS FOR TRAFFIC AND TRUCK VARIATIONS

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EXECUTIVE SUMMARY

This project entailed the development of the following four traffic volume adjustment factors from 1995 and 1996 permanent traffic recorder data:

(1) A truck (axle) adjustment factor for single pneumatic tube counters

(2) A factor for estimating Design Hourly Volume (DHV) from Peak Hour Volume (PHV)

(3) A factor for estimating the % trucks in the Average Daily Traffic (ADT) from the % trucks in the PHV

(4) A factor for estimating the % trucks in the ADT from the % trucks in the typical hours in a manual classification study, which are 7 am - 10 am, 11 am - 1 pm, and 2 pm - 6 pm.

The results are as follows:

(1) Axle Correction Factor

Functional Class	Quarter 1	Quarters 2 - 4	Entire Year
1	0.74	0.80	---
2	---	---	0.92
6 & 7	---	---	0.94
11	---	---	0.83
12 & 14	---	---	0.96
16 & 17	---	---	0.99

(2) Factor for estimating DHV from PHV (shown next page)

PHV to DHV Summary by Day of the Month

Functional Class	AADT Split	January 2 Monday	3 Tuesday	4 Wednesday	5 Thursday	February 2 Monday	3 Tuesday	4 Wednesday	5 Thursday	March 2 Monday	3 Tuesday	4 Wednesday	5 Thursday
1	≥30,000	1.35	1.28	1.23	1.21	1.37	1.31	1.38	1.25	1.28	1.27	1.28	1.21
1	<30,000	2.18	2.20	2.21	2.08	2.18	2.25	2.27	2.09	1.91	1.94	1.99	1.78
2		1.47	1.35	1.38	1.31	1.42	1.35	1.46	1.31	1.25	1.25	1.31	1.20
6 and 7	≥5,000	1.43	1.24	1.27	1.19	1.26	1.24	1.31	1.23	1.25	1.22	1.19	1.13
6 and 7	<5,000	1.64	1.60	1.53	1.39	1.73	1.73	1.75	1.49	1.81	1.81	1.77	1.64
11		1.54	1.43	1.42	1.41	1.62	1.49	1.55	1.46	1.54	1.48	1.54	1.51
12 and 14		1.44	1.25	1.34	1.28	1.37	1.24	1.31	1.21	1.26	1.24	1.19	1.12
16 and 17		1.35	1.13	1.15	1.10	1.21	1.14	1.32	1.18	1.07	1.08	1.22	1.13

Functional Class	AADT Split	April 2 Monday	3 Tuesday	4 Wednesday	5 Thursday	May 2 Monday	3 Tuesday	4 Wednesday	5 Thursday	June 2 Monday	3 Tuesday	4 Wednesday	5 Thursday
1	≥30,000	1.24	1.22	1.21	1.14	1.19	1.20	1.17	1.12	1.17	1.22	1.17	1.11
1	<30,000	1.68	1.82	1.77	1.51	1.62	1.84	1.86	1.62	1.73	1.82	1.73	1.56
2		1.23	1.20	1.22	1.18	1.22	1.21	1.20	1.10	1.28	1.19	1.20	1.17
6 and 7	≥5,000	1.15	1.15	1.15	1.10	1.17	1.15	1.17	1.13	1.15	1.17	1.18	1.15
6 and 7	<5,000	1.55	1.54	1.47	1.40	1.49	1.48	1.47	1.46	1.48	1.38	1.44	1.37
11		1.39	1.37	1.37	1.25	1.40	1.39	1.50	1.40	1.29	1.30	1.26	1.22
12 and 14		1.23	1.18	1.16	1.11	1.22	1.16	1.17	1.11	1.19	1.17	1.16	1.12
16 and 17		1.12	1.10	1.11	1.12	1.19	1.09	1.08	1.08	1.16	1.14	1.15	1.11

Functional Class	AADT Split	July 2 Monday	3 Tuesday	4 Wednesday	5 Thursday	August 2 Monday	3 Tuesday	4 Wednesday	5 Thursday	September 2 Monday	3 Tuesday	4 Wednesday	5 Thursday
1	≥30,000	1.16	1.22	1.16	1.12	1.14	1.15	1.14	1.09	1.15	1.17	1.16	1.12
1	<30,000	1.62	1.72	1.65	1.52	1.59	1.71	1.70	1.54	1.63	1.63	1.83	1.76
2		1.31	1.27	1.19	1.19	1.29	1.22	1.16	1.18	1.29	1.20	1.23	1.19
6 and 7	≥5,000	1.17	1.31	1.20	1.17	1.18	1.20	1.23	1.16	1.17	1.16	1.18	1.16
6 and 7	<5,000	1.38	1.51	1.33	1.29	1.39	1.38	1.36	1.27	1.45	1.42	1.39	1.37
11		1.28	1.36	1.22	1.17	1.26	1.23	1.23	1.17	1.28	1.31	1.30	1.25
12 and 14		1.26	1.35	1.22	1.20	1.28	1.16	1.17	1.13	1.35	1.17	1.15	1.08
16 and 17		1.16	1.37	1.11	1.14	1.17	1.15	1.16	1.14	1.24	1.12	1.17	1.08

Functional Class	AADT Split	October 2 Monday	3 Tuesday	4 Wednesday	5 Thursday	November 2 Monday	3 Tuesday	4 Wednesday	5 Thursday	December 2 Monday	3 Tuesday	4 Wednesday	5 Thursday
1	≥30,000	1.16	1.13	1.13	1.08	1.16	1.28	1.23	1.38	1.34	1.39	1.34	1.58
1	<30,000	1.69	1.89	1.81	1.72	1.82	1.94	1.80	1.91	2.22	2.08	2.17	1.78
2		1.30	1.18	1.19	1.17	1.31	1.28	1.28	1.22	1.29	1.22	1.24	1.23
6 and 7	≥5,000	1.15	1.14	1.19	1.13	1.19	1.26	1.22	1.22	1.29	1.17	1.16	1.22
6 and 7	<5,000	1.36	1.33	1.29	1.29	1.53	1.55	1.47	1.49	1.73	1.50	1.60	1.38
11		1.29	1.28	1.30	1.23	1.39	1.39	1.38	1.31	1.50	1.44	1.52	1.50
12 and 14		1.23	1.14	1.08	1.10	1.33	1.29	1.25	1.47	1.28	1.36	1.54	1.22
16 and 17		1.15	1.09	1.09	1.13	1.12	1.14	1.14	1.34	1.18	1.13	1.11	1.17

(3) Factor for Estimating the % Trucks in the ADT from the % Trucks in the PHV

Group	Factor
Rural Heavy Truck Routes	1.2
Urban Heavy Truck Routes	1.2
Others	1.1

(4) Factor for Estimating the % Trucks in the ADT from the % Trucks in the Typical Hours in a Manual Classification Study

Group	Factor
Rural Heavy Truck Routes	1.1
Urban Heavy Truck Routes	1.1
Others	1.0

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CHAPTER 1 - INTRODUCTION

1.0 Background

A traffic-monitoring program consists of several facets, including the collection of traffic volumes, vehicle classifications, and truck weights. Traffic volumes are collected both manually and through the use of counting equipment. Counting equipment includes portable, short duration counters and permanent, continuous counters. Data collected through a traffic-monitoring program are used widely throughout state highway agencies in applications such as project planning, pavement design, safety analysis, capacity analysis, and air quality assessment (AASHTO, 1992). Because of the role that traffic data play in decision making and the allocation of funds for highway improvements, it is important that quality traffic information be used.

The process of traffic monitoring begins with the collection of data from continuous counters throughout the state. In addition to providing traffic data specifically at their locations, these data are also used to develop factors to correct or expand short-term counts. In West Virginia, there are 52 permanent count stations. These stations are identified in Table 1.1. Vehicle class, weight, speed, and volume of traffic are among the data that can be collected at these permanent count stations, although most do not collect weight data. The type of permanent counter used in West Virginia, and typically in the United States, is an arrangement of inductive loops and piezo electric sensors that are installed in the pavement. If weight data are needed, weigh-in-motion devices are added to the in-place sensors.

Table 1.1 - List of West Virginia Permanent Traffic Count Stations

Number	Route	Location	Functional Class	No. of Lanes
1	1-64	1.2 miles west of WV 20	Rural Interstate	4
2	I-64	1.5 miles west of CO 60/89	Urban Interstate	4
3	I-77	2.2 miles north of CO 15	Rural Interstate	4
401/402	I-77	1.2 miles south of WV 14	Rural Interstate	6
5	I-79	0.8 miles north of US 19	Rural Interstate	4
6	I-79	0.2 miles south of WV 131	Rural Interstate	4
7	WV 2	2.9 miles north of CO 2/2	Rural Prin. Art.	2
8	US 19	0.2 miles north of CO 19/45	Rural Prin. Art.	4
9	US 50	1.0 miles east of I-77	Rural Prin. Art.	4
10	US 60	0.5 miles west of CO 60/4	Rural Prin. Art.	2
11	US 119	0.8 miles south of WV 3	Rural Prin. Art.	4
12	WV 131	1.2 miles north of US 50	Rural Min. Art.	2
13	WV 152	0.3 miles north of CO 52/1	Rural Min. Art.	2
14	US 33	1.1 miles east of CO 13	Rural Min. Art.	2
15	US 35	1.0 miles north of CO 27	Rural Min. Art.	2
16	US 52	0.5 miles east of CO 52/17	Rural Min. Art.	2
17	US 119	1.1 miles south of CO 119/90	Rural Min. Art.	2
18	US 219	1.4 miles north of CO 56	Rural Min. Art.	2
19	CO 21	0.4 miles north of CO 33/12	Rural Maj. Coll.	2
20	US 220	1.5 miles south of CO 220/4	Rural Maj. Coll.	2
21	WV 28	0.2 miles west of CO 41	Rural Maj. Coll.	2
22	US 19	1.5 miles north of CO 19/36	Rural Maj. Coll.	2
23	US 19	0.4 miles south of CO 40/2	Rural Maj. Coll.	2
24	US 40	0.2 miles west of CO 41	Rural Maj. Coll.	2
25	US 60	0.1 miles west of CO 25/1	Rural Maj. Coll.	2

Table 1.1 - List of West Virginia Permanent Traffic Count Stations (continued)

Number	Route	Location	Functional Class	No. of Lanes
26	I-64	1.5 miles east of US 52	Urban Interstate	4
27	I-64	2.2 miles west of WV 622	Urban Interstate	4
29	I-70	4.0 miles west of CO 41	Urban Interstate	4
30	I-77	2.2 miles south of WV 3	Urban Interstate	4
31	WV 2	0.2 miles north of WV 2 ALT	Urban Prin. Art. (Freeway)	4
32	US 50	0.4 miles west of CO 50/40	Urban Prin. Art.	4
33	WV 10	0.4 miles south of I-64	Urban Prin. Art.	2
34	WV 25	1.0 miles west of WV 622	Urban Prin. Art.	2
351/352	US 52	0.7 miles west of CO 29	Urban Prin. Art.	4
36	US 60	0.1 miles west of CO 85	Urban Prin. Art.	4
37	US 11	1.0 miles south of WV 45	Urban Min. Art.	2
38	WV 61	1.4 miles south of I-77 KC	Urban Collector	2
39	I-64	2.5 miles west of WV 34	Rural Interstate	4
40	WV 114	0.2 miles north of CO 114/1	Urban Min. Art.	2
41	US 119	0.1 miles north of CO 119/16	Urban Min. Art.	2
42	I-64	1.7 miles south of WV 114	Urban Interstate	4
43	WV 44	0.5 miles south of US 119	Rural Maj. Coll.	2
44	WV 94	0.5 miles north of WV 3	Rural Min. Art.	2
45	WV 7	0.2 miles east of WV 2	Rural Maj. Coll.	2
46	US 250	0.7 miles south of CO 56/1	Rural Maj. Coll.	2
47	I-77	1.0 miles south of WV 112	Rural Interstate	4
48	WV 20	0.1 miles west of CO 20/12	Rural Min. Art.	2
49	WV 92	2.5 miles south of WV 39	Rural Min. Art.	2

Table 1.1 - List of West Virginia Permanent Traffic Count Stations (continued)

Number	Route	Location	Functional Class	No. of Lanes
50	I-81	1.6 miles south of WV 44	Rural Interstate	4
51	WV 20	0.6 miles south of WV 55	Rural Maj. Coll.	2
53	I-68	1.0 miles west of WV 26	Rural Interstate	4

Short duration counts collected for the federal Highway Performance Monitoring System (HPMS) program are recorded at over 2,500 locations statewide annually. There are a total of 7,500 short-term count stations throughout the state, and they are generally taken every three years. In addition to these HPMS counts, there are numerous other short-term counts taken to support the planning and design of individual projects.

Data for short-term counts are collected either manually or by temporary traffic counters such as single pneumatic tube counters. Single pneumatic tube counters are devices that are placed transversely across the roadway, and that estimate traffic volume by counting axles. In general, two axle detections is counted as a vehicle. Vehicles with more than two axles, such as large trucks, are usually counted as several vehicles by these counters. Consequently, correction factors are applied to the raw machine count to provide a better estimate of traffic volume. Short term counts of less than 24-hours are also limited in that the results must be "expanded" to provide data concerning time periods not counted. For example, manual counts are typically taken for less than 24-hour durations. However, an estimate of overall truck percentage in the 24-hour volume may be desired. In this case, a factor is needed to estimate the truck percentage in the 24-hour volume from the one or more hours that were observed.

1.1 Problem Statement

To add value to short-term count programs, factors can be developed from the permanent count stations that either (1) correct anomalies in the counts, or (2) expand the count to provide an estimate of a traffic parameter during a time period when data were not collected.

In 1975, the Traffic Analysis Section of the WVDOH-Advanced Planning Division (1975) conducted three studies to develop adjustment factors that could be applied to the short

duration counts. The study results were reported in three separate reports and have received extensive use since their development. One of the studies, “Determination of a Truck Adjustment Factor for ATRs” (Traffic Analysis Section, May 1975), was performed to establish a factor that could be applied to the raw counts from short-term traffic recorders (single pneumatic tube counter) to account for the effect of vehicles with 3 or more axles.

Another study was “The Development of a Method of Estimating Design Hour Volume” (Traffic Analysis Section, December 1975). The study's purpose was "to establish a factor by which peak hour volume from short-term counts could be converted to an estimate of design hour volume." This study provided a factor by which the largest volume occurring during one hour of the short-term count (peak hour) could be multiplied to estimate the design hour volume on that roadway. The factor took into account the roadway's AADT and the season during which the short-term count was performed.

The last study, “The Relationship of the Percentage of Trucks in the Average Daily Traffic (ADT) to the Percentage of Trucks in the Peak Hour Volume (PHV)” (Traffic Analysis Section, February 1975), was performed because through observation, they expected that the percentage of trucks in the AADT was normally greater than the percentage of trucks in the peak hour volume. It was generally understood that the temporal distribution of the percentage of trucks was not necessarily uniform over a 24-hour period, and that truck flow did not necessarily peak during the general vehicle peak. These elements combine to make the percentage of trucks in the peak hour less than the overall percentage of trucks in daily traffic. However, traffic-counting techniques that utilize manual classification are typically performed for durations shorter than 24-hours. As a result, the WVDOT used vehicle count and classification data that

were collected manually to develop factors that relate the percentage of trucks in the peak hour to the percentage of trucks in the AADT.

These studies are now over 25 years old. It is likely that changing travel patterns caused by increased personal mobility and changing demographics in West Virginia have reduced the validity of these factors for use in the traffic analyses of the present day and the planning horizon. In particular, the travel patterns of large trucks have changed greatly over the past 25 years. In the past, goods were stored in warehouses throughout the country and trucks were used to deliver goods to and from these warehouses. Today, goods are delivered from the factory to the customer in a just-in-time fashion. This has changed the operational pattern of trucks. They can no longer travel predominately at night to avoid heavy traffic during the day. Another factor related to truck operations has been the completion of the Interstate Highway System in West Virginia. In 1975, the system was incomplete in West Virginia with many missing links that were not attractive as through routes for commercial vehicles.

These studies had a common thread in that they were performed primarily using traffic count data from permanent count stations in West Virginia. Since these data are still collected, these studies can essentially be repeated with a present day database. It would be desirable to determine the above-mentioned parameters using current traffic count data from West Virginia permanent counter stations.

In addition, there was one other factor that could be obtained from the permanent traffic recorder data that was of interest to WVDOT planners. It was a factor that relates the percentage of trucks in the average daily traffic to the percentage of trucks in the hours currently used by the WVDOT in conducting manual classification counts. It is another factor that will allow the user

to estimate the truck percentage in the ADT from a shorter term count. This factor is needed for pavement design, intersection analysis, capacity analysis, and may be used to compare potential roadway projects.

1.2 Project Objectives

The objectives of this study were to:

(1) Establish correction factors that can be applied to the raw data from axle-counting single pneumatic tube traffic count stations to adjust for the effect of trucks with three or more axles on the volume counts.

(2) Establish factors that use the peak hour volume to estimate the design hour volume.

(3) Establish factors that relate the percentage of trucks in the ADT to a) the percentage of trucks in the peak hour and b) the percentage of trucks in the hours used by the WVDOT in conducting manual classification counts.

1.3 Organization of Report

Chapter 1 has presented background to the problem and identified the problem and study objectives. Chapter 2 contains a summary of the literature reviewed to identify relevant information concerning the factors to be developed and the methods used. The literature review is followed by the methodology which is presented in Chapter 3. Project results are presented in Chapter 4. Conclusions, recommendations, and suggestions for implementation are discussed in Chapter 5.

CHAPTER 2 - LITERATURE REVIEW

2.0 Introduction

This chapter documents the literature reviewed relative to the factors developed by this research. This review is provided in three main sections:

(1) The three prior studies conducted by the WVDOT (1975)

(2) Literature containing information needed to develop the factors

(3) Literature documenting the procedures or results of other states factor development program

2.1 Prior Studies by the WVDOT

As mentioned in Chapter 1, in 1975, three studies were performed by the West Virginia Department of Highways (now WVDOT) to determine the following factors:

(1) A truck (axle) adjustment factor for single pneumatic tube counters

(2) A factor for estimating DHV from PHV

(3) A factor for estimating the % trucks in the ADT from the % trucks in the PHV

In performing the truck adjustment factor study (Traffic Analysis Section, May 1975), 62 temporary stations were established for the purpose of the study, at which a short-term (8 to 24 hour) manual count and a longer count lasting from 24 hours to 7 days was performed. The roadway was classified as either an expressway/trunkline or feeder/local roadway. The results from the truck adjustment factor study were as follows:

Actual count = 0.92974 * (short-term count) for feeders and locals

Actual count = 0.88589 * (short-term count) for expressways and trunklines

In this case, as would be expected, the higher roadway classifications experience a greater volume of truck traffic. This 1975 study documented that the magnitude of the factor depends upon the type of highway on which the count was performed.

The data for the PHV to DHV study (Traffic Analysis Section, December 1975) were derived from the permanent traffic recorder record for the year 1972. Analysis of variance (ANOVA) was performed to determine if there was a significant difference in the factors developed using the PHV to estimate the 10th highest hourly volume and the 30th highest hourly volume. This test determined that factors should be derived separately for the 10th highest and 30th highest hourly volumes. The study also determined that the Annual Average Daily Traffic (AADT) had a statistically significant influence on the factor. Separate factors were determined for roads with an AADT less than or equal to 500 vehicles, and roads with AADT greater than 500 vehicles. The equation used to derive the factor relating PHV to DHV can be found below and the resulting factors are reported in Table 2.1.

$DHV = B_{ij} * (PHV)$

where: Bij is the factor relating the PHV to the DHV from Table 2.1

i = 1 if AADT $\leq$ 500

= 2 if AADT > 500

j = 1, 2, 3, 4; depending on the quarter the count was taken

Table 2.1 - Factors (Bij) from 1975 WVDOT Study Relating PHV to DHV

j	Quarter	i = 1	i = 2
j = 1	Dec - Feb	1.42257	1.3316
j = 2	Mar - May	1.32577	1.23895
j = 3	Jun - Aug	1.28892	1.20249
j = 4	Sept - Nov	1.23583	1.15346

In the study estimating truck percentages (Traffic Analysis Section, February 1975), data were collected from manual classification counts performed 4 times a year (one each season) at seventeen truck weight stations. ANOVA analysis was used to determine that there was a significant difference in the factors developed for each season, thus they were reported by season. The equation used is found below and the results found from the estimation of the % Trucks in the ADT by using the % Trucks in the PHV are reported in Table 2.2.

Percentage of trucks in ADT $= B_i$ * Percentage of trucks in peak hour volume

where: B_i is the seasonal factor from Table 2.2

Table 2.2 - 1975 Factors (B_i) Relating Percent Trucks in the ADT to Percent Trucks in the Peak Hour Volume

Quarter		Factor
1	Dec - Feb	1.57329
2	Mar - May	1.53734
3	Jun - Aug	1.23805
4	Sept - Nov	1.32063

The factors derived in this study (Traffic Analysis Section, February 1975) show that the ratio of the percentage of trucks in the ADT to percentage of trucks in the PHV was greater in the first and second quarters, meaning that large trucks were traveling less during the day in these

quarters. The third and fourth quarters consisted of factors lower than those reported for the first and second quarters. This indicated that either more trucks were traveling during the peak hour of travel or that less passenger cars were traveling in these months causing the percentage of trucks in the ADT to increase. However, June through November are months of high travel for passenger cars, thus negating the latter possibility.

2.2 Literature Pertinent to Factor Development

Three items were central to this part of the literature review. First, for each of the vehicle classifications, the number of axles per vehicle was needed. Second, information related to errors in the data was needed. This included the types of errors that can occur, and guidelines for minimum sample size in factor development. Finally, guidelines on the grouping of sites for factor development were needed.

2.2.1 FHWA Vehicle Classifications

The conversion chart, found in the Traffic Monitoring Guide or TMG (FWHA, 2001) and included as Table 2.3, lists the suggested values to be used for each vehicle class when calculating an axle adjustment factor.

Table 2.3 - Average Number of Axles per Vehicle Class (Source: FHWA, 2001)

Vehicle Class	Description	Average Number of Axles per Vehicle
1	Motorcycles	2
2	Passenger Cars	2
3	4-Tire Single Unit Vehicle	2
4	Buses	2
5	2-Axle, 6-Tire Single Unit Truck	2
6	3-Axle Single Unit Truck	3
7	4+ Axle Single Unit Truck	4
8	4 or Less Axle Single Trailer Truck	4
9	5-Axle Single Trailer Truck	5
10	6+ Axle Single-Trailer Truck	6
11	5 or Less Axle Multi-Trailer Truck	5
12	6-Axle Multi-Trailer Truck	6
13	7+ Axle Multi-Trailer Truck	7

2.2.2 Errors in Traffic Data

According to the Traffic Monitoring Guide (FHWA, 2001), two types of error are possible in collecting and analyzing traffic data. The two types of error are 1) errors in collection, and 2) errors in editing. A wide range of factors including power failure, recorder malfunction, and detector malfunction are sources of invalid data and missing data from the permanent counters. The errors resulting from these malfunctions include missing days and/or missing hours of data, negative numbers included in the figures, and vehicle classification errors. How these errors are handled can have a major impact in the validity of the factors generated. Depending on the handling of these errors, errors in the editing process can also result.

When permanent counts are visually found to contain errors, there is not a correction process. The only manual step in editing permanent counter data is to review the data set for completeness and to exclude data that has been rendered invalid through a power failure or machine malfunction. The following statements from AASHTO (1992) address the issue of attempting to manually correct erroneous data:

> "Some current traffic editing programs estimate missing or edit-rejected data. This practice, termed "imputation", is not recommended."
>
> and
>
> "Subjective editing procedures for identifying and imputing missing or invalid data are discouraged, since the efforts of such data adjustments are unknown and frequently bias the resulting estimates."

The AASHTO Guidelines (AASHTO, 2001) state that there should be a sufficient number of days of valid traffic measurements during a year to compute average traffic characteristics at the site. The number of days needed is determined by whether or not an automated editing process is used to evaluate the recorded data. If automated edits are performed, it is recommended that agencies adopt a one-day minimum of edit-accepted data for each day of the week and each month of the year. Until agencies have implemented automated edits, it is recommended by AASHTO that a two-day minimum for each day of the week, each month of the year, be adopted. These statements from AASHTO, which are further supported by the TMG, should be followed to ensure the quality and validity of the developed factors.

2.2.3 Grouping the Permanent Count Stations

Grouping roadways once the factors are calculated from the permanent traffic counters is essential; for the short term counts will not all be taken from the same roadways from which the permanent counters were used. Sites are grouped so that they are statistically similar based on several factors. These factors include geography, roadway classification, recreational usage, and any other relevant variable that would allow the sites to by grouped in a statistically significant manner. The TMG (FHWA, 2001) recommends a basic grouping pattern for various uses, including growth factor estimation. It is shown in Table 2.4.

Table 2.4 -Roadway Groups Recommended by Traffic Monitoring Guide (FHWA, 2001)

Recommended Group	Functional Class Codes and Descriptions
Interstate Rural	1 (Rural Interstate)
Other Rural	2 (Rural Principal Arterial), 6 (Rural Minor Arterial.), 7 (Rural Major Collector), and 8 (Rural Minor Collector)
Interstate Urban	11 (Urban Interstate)
Other Urban	12 (Urban Principal Arterial - Other Freeways), 14 (Other Urban Principal Arterials), 16 (Urban Minor Arterial), and 17 (Urban Collector)
Recreational	Any

Testing the quality of the selected groups is a key aspect to any grouping procedure. The following statement from the TMG (FWHA, 2001) includes their recommended methods of testing the quality of the groups.

> "The quality of a given factor group can be examined in two ways. The first is to graphically examine the traffic pattern present at each site in the group. Graphs give an excellent visual description of whether different data collection sites have similar travel

patterns. The second method is to compute the mean and standard deviation for various factors that the factor group is designed to provide. If these factors have small amounts of deviation, the roads can be considered to have similar characteristics. If the standard deviations are large, the road groupings may need to be revised."

The AASHTO Guidelines (1992) parallel much of what was noted in the TMG. In addition, they recommend that when forming the permanent counter locations into groups, the recommended rule-of-thumb is that there should be a minimum of five counters in each of the defined groups. They also recommend that if the data fail to group according to functional classification, to combine the functional classification of the roadway with the geographic location of the count site within the state to obtain a more effective grouping.

2.3 Other States' Programs

The PENNDOT factors from 1998 (Bureau of Planning and Research, 1999) and the Michigan DOT (Bureau of Transportation Planning, 2000) factor development manual were examined. Both documents contained information on axle correction factors, but not the other factors to be developed in this research. It was apparent that PENNDOT and Michigan DOT both used the TMG and AASHTO recommended process of developing axle correction factors. Both began with raw count data collected at permanent count stations located throughout the state. These count stations were then grouped into statistically similar groups based on functional class or geography. The factors developed from the permanent count stations were then applied to short-term counts performed with axle counters such as pneumatic tubes.

The traffic pattern groupings (TPG) used by PENNDOT and the axle correction factors are shown in Table 2.5. Functional classification, geography, and urban/rural characteristics were used to group the locations.

Table 2.5 - PENNDOT'S Traffic Pattern Groupings (TPG)

TPG Number	Description
1	Urban Interstate
2	Rural Interstate
3	Urban Other Principal Arterials
4	Rural Other Principal Arterials
5	Urban Minor Arterials, Collectors, Local Roads
6	North Rural Minor Arterials
7	Central Rural Minor Arterials
8	North Rural Collectors and Local Roads
9	Central Rural Collectors and Local Roads
10	Special Recreational

The axle correction factors developed from 1998 data by PENNDOT will be used to draw a comparison with the current WVDOT study. The factors reported by PENNDOT for the ten traffic pattern groups are shown in Table 2.6.

Table 2.6 - Axle Correction Factors Reported by PENNDOT

TPG Number	Axle Correction Factor
1	0.840
2	0.702
3	0.941
4	0.897
5	0.980
6	0.935
7	0.950
8	0.966
9	0.97
10	0.968

Since the Michigan DOT document was a procedures manual, it did not report any specific factors. However, it did provide a list of the traffic pattern groups used when developing factors. Surprisingly, the traffic pattern groups were not based on functional classification; rather they were grouped based on urban/rural characteristics, geography, and recreational uses. The groupings used by Michigan DOT are shown in Table 2.7.

Table 2.7 - Michigan DOT's Traffic Pattern Groupings

Group Number	Description
1	Urban/Rural
2	Rural
3	Urban
4	Recreational
5	Straits Area Recreational
6	Rural / Recreational
7	Urban Area Limit

2.4 Concluding Remarks

In summary, the previous WVDOT studies were reviewed because, generally speaking, they are essentially being repeated. While the same groupings will not necessarily be carried over from the 1975 study, the results from 1975 will need to be generally compared to the current results since this research is essentially an update of the 1975 studies.

Both the Traffic Monitoring Guide (FHWA, 2001) and the AASHTO Guidelines for Traffic Data Programs (1992) provide key information related to the development of factors from a permanent count database. They recommend that errant data be identified and eliminated from the database, not estimated. Furthermore, they recommend that a factor developed from the data for a specific site have at least two good days in the sample, and that a factor developed for a group have at least five sites in the sample.

Finally, information related to axle correction factors was extracted from PENNDOT and the Michigan DOT. Their groupings and factors will provide a benchmarking reference point for this research.

CHAPTER 3 - METHODOLOGY

3.0 Introduction

In this chapter, the procedures followed in the execution of this research are detailed. Each factor developed is described in a separate section, with a special section devoted at the beginning to the establishment of the permanent count database.

3.1 Permanent Count Database

The data from the 52 permanent count stations were used in this research. These data were provided in raw format for the years 1995 and 1996 by the Traffic Analysis Section of the Planning and Research Division of the WVDOT for stations located throughout the state. The years 1995 and 1996 were used because extensive equipment malfunctions render the data from 1997 to the present not useful for the purposes of factor development.

At the permanent count stations, traffic volumes and classification data were recorded for every hour of the year for every lane at every station. Vehicles were classified into one of the thirteen FHWA vehicle classification categories. Each site was tagged with a functional class code that was consistent with the classification scheme presented in the Traffic Monitoring Guide (FHWA, 2001). The number of sites in each functional class as well as the descriptions of each functional class are shown in Table 3.1.

Table 3.1 - Number of Sites in Each Functional Class

Functional Class Code	Description	Number of Sites	
		1995	1996
1	Rural interstate	7	7
2	Rural principal arterial - other	4	4
6	Rural minor arterial	10	8
7	Rural major collector	11	11
11	Urban interstate	5	5
12	Urban principal arterial - other freeways	2	2
14	Urban other principal arterial	5	5
16	Urban minor arterial	3	3
17	Urban collector	1	1
	TOTAL	48	46

Note that the numbers vary from 1995 to 1996 and add up to less than 52 count stations. This is because some sites were not included in the raw data and others had many data errors and, therefore, had to be discarded. Of the 104 possible count stations (52*2=104) used between both 1995 and 1996, 9 sites were missing all of their data. These sites included four from functional class 1, one from functional class 2, two came from functional class 6, and two were missing from functional class 11.

The raw data files for an individual site consisted of one file for every day of the year. The files from each site for a given year needed to be converted to ASCII and aggregated into one large file. The software program *Reporter* was used to perform the conversion of the data files from their raw format into an ASCII text format. The ASCII text was then imported into *Microsoft Excel* for organization, storage, and analysis. For each site, the following workbooks

were created within *Microsoft Excel* to organize the data: "by lane", "by direction", "by hour", "by day", and "by month."

The next step was to identify and eliminate the errant data in the database. The errors were detected primarily manually at the database organization stage, but also when the factors were computed (because they had a significant impact of the factors). Types of errors identified included the following: 1) missing data, 2) unreasonably large numbers, 3) functional classes switched (e.g., functional classes 1 and 2), and 4) zeros. Errors at an individual site ranged from 81% of the days containing errors to 4% of the days in error. Overall, the data for 1996, averaging 28% of the days containing errors per site, contained more erroneous data than 1995 which averaged 25% of the days in error per site. These figures are skewed slightly because several sites were completely removed from 1996 because they contained so many errors, or no data at all, thus they were not included in the raw data sent by the WVDOT. By recommendation of the AASHTO Guidelines for Traffic Data Programs (1992) and the Traffic Monitoring Guide (FHWA, 2001), data in error were omitted from further analysis. No data containing errors were corrected and used in the formulation of any factors. The data were then analyzed in accordance with the Traffic Monitoring Guide (FHWA, 2001) and the AASHTO Guidelines (1992).

As stated previously, the factors of interest were:

(1) An axle correction factor that could be applied to short-term single pneumatic tube axle counts to counteract the effect of 3 or more axle trucks on vehicle counts

(2) A factor to estimate the design hour volume from the peak hour volume

(3) A factor to estimate the % trucks in the ADT from the % trucks in the peak hour

(4) A factor to estimate the % trucks in the ADT from the % trucks in the manual count hours

The factors were developed using the 1995 data and 1996 data independently. In discussions with the WVDOT, it was generally agreed that the factors developed using the 1996 database were to be used as a benchmark to check for errors in the 1995 factors. Previously overlooked errors were discovered when the 1995 and 1996 factors were plotted and compared. These errors were located and removed.

3.2 Axle Correction Factor Development

The process of developing the axle correction factors began by assigning the 13 FHWA vehicle classes a number of axles as recommended by the TMG (FHWA, 2001) and previously shown in Table 2.3. The actual number of vehicles was known by tabulating the vehicles in the thirteen vehicle classifications counted by the permanent count station. The number of vehicles that would have been reported by the single pneumatic tube counter was estimated as the total number of axles divided by two. The following equation demonstrates how the factor was developed. This factors allows the volume at a single pneumatic tube count station to be estimated by multiplying the raw count from the single pneumatic tube counter by the axle correction factor.

Axle Correction Factor =

actual vehicle count / # of vehicles predicted by pneumatic tube counter

where:

# of vehicles predicted by pneumatic tube counter = total # of axles / 2

It should be noted that the raw data files contained 15 vehicle classifications.

Classifications 1 through 13 were the FWHA classifications, and 14 and 15 were "classifications" to which vehicles were assigned when the vehicle could not be classified by the counter. These "classifications" were disregarded and not included in the factor development.

The average numbers of axles per vehicle class were then applied to the "by day" summaries. Data calculated included number of axles, predicted pneumatic tube count, the actual count, and the axle correction factor. The axle correction factors were then aggregated within each site for the following time periods: (1) day of the week regardless of month, (2) month, and (3) quarter.

The next step was to establish a method of grouping the factors for the sites in a statistically significant manner. Based on what was contained in the TMG, Rural Interstates (Functional Class 1) and Urban Interstates (Functional Class 11), were established as individual groups before any statistical analysis. Further grouping was then considered based functional classification, geography, and AADT. Grouping by functional class, which included the aggregation of different functional classes into groups, was found to be the most logical and statistically sound.

As in the 1975 study, single-factor analysis of variance (ANOVA), was used to perform the statistical analysis throughout the project. Single-factor ANOVA involves the analysis of either data sampled from more than two populations or data from an experiment in which more than two treatments have been used. Single-factor ANOVA provides a comparison of the two data sets to determine if there is a statistically significant difference. A 95% confidence level was used in this research, thus, a statistically significant difference in factors implies a 95% certainty that the factors are different. In this research, the factors were compared by day of the

week, by month, and by quarter. ANOVA analysis of the functional class groupings based on the aforementioned time increments would then indicate whether there was a statistically significant difference in the groupings. Table 3.2 was constructed to aid in analysis of the groupings. Functional classification 12 was not originally included in the groupings because it consisted of only two sites, one of which contained many (81%) erroneous days. This would not permit functional class 12 to be sufficiently analyzed by ANOVA analysis. Functional class 12 was eventually grouped with class 14.

Table 3.2 shows that the most significant difference occurs when the axle correction factors are grouped by day regardless of the month of the year. With the other groupings, there were generally no significant differences.

Table 3.3 provides a summary of the ANOVA analysis on the functional classification groupings with all Fridays, Saturdays, and Sundays removed. The WVDOT suggested that the factors be developed without Friday, Saturday, and Sunday due to the fact that manual and short-term counts are not usually performed on these days and also because these days have the greatest variability. When these weekend days are not considered, there is virtually no significant difference in the axle correction factors when grouped by functional class, no matter which time increment grouping is used. Similar results were found for the other factors developed. Therefore, data for Friday, Saturday, and Sunday were not used in the development of any of the factors presented in the body of this study. Factors for this weekend period (Friday, Saturday, and Sunday) were developed and are included in Appendix E for informational purposes.

Table 3.2 - Summary of Results - ANOVA Analysis for the Axle Correction Factor

Temporal Grouping	Functional Class Groupings	1995	1996
by month	1	different	not different
	2	not different	not different
	6,7	not different	not different
	11	not different	not different
	14,16,17	not different	not different
by quarter	1	different	not different
	2	not different	not different
	6,7	not different	not different
	11	not different	not different
	14,16,17	not different	not different
by day of the week (regardless of month)	1	different	different
	2	different	different
	6,7	not different	not different
	11	different	not different
	14,16,17	not different	not different

Table 3.3 - Summary of Results - ANOVA Analysis for the Axle Correction Factor with Friday, Saturday, and Sunday Data Omitted

Temporal Grouping	Functional Class Groupings	1995	1996
by month	1	different	not different
	2	not different	not different
	6,7	not different	not different
	11	not different	not different
	14,16,17	not different	not different
by quarter	1	not different	not different
	2	not different	not different
	6,7	not different	not different
	11	not different	not different
	14,16,17	not different	not different
by day of the week (regardless of month)	1	not different	not different
	2	not different	not different
	6,7	not different	not different
	11	not different	not different
	14,16,17	not different	not different

The decision was then made to re-evaluate some of the functional class groupings to ensure that they were grouped in the best possible manner. The non-interstate functional class groupings analyzed were as follows:

2, 6, and 7

12 and 14

16 and 17

12, 14, 16, and 17

After analyzing the factors developed by such groupings, it was decided that the functional class groupings should be as follows:

Group 1)	1	Rural interstate
Group 2)	2	Rural principal arterial - other
Group 3)	6 and 7	Rural minor arterial, Rural major collector
Group 4)	11	Urban interstate
Group 5)	12 and 14	Urban principal arterial - other freeways, Urban other principal arterial
Group 6)	16 and 17	Urban minor arterial, Urban collector

Factors were developed for these new groupings (still excluding Friday, Saturday, and Sunday) for the day of the week, by month, and by quarter. The proposed axle correction factors are contained in Chapter 4.

3.3 Peak Hour Volume (PHV) to Design Hour Volume (DHV) Factor Development

The following equation was used in determining the peak hour to design hour factor:

PHV to DHV Factor = Design Hour Volume / Peak Hour Volume

Since a complete set of data was not available for any of the sites, the researchers could not rely on arbitrary estimates of design hour volume, such as the 10th, 30th, or 50th highest hour. The design hourly volumes were determined by inspection from graphs of the 100 or 300 highest hourly volumes for each site. In keeping with the theory of the design hour volume, the DHV was selected at the point at which the marginal increase in hourly volume began to increase dramatically. For different types of facilities, this point is usually located in the vicinity of either the 10th or 30th highest hourly volume.

The factor was then computed by dividing the design hourly volume for each site by the peak hour volume for each day. The factors were then combined by day of the week (regardless of month), by month, and by quarter. The same functional class groupings identified with the axle correction factors were used. ANOVA analysis was then performed on the functional classification groupings to ensure that the same groupings would be sufficient. Table 3.4 was constructed to aid in the evaluation of the groupings. Table 3.4 shows that all grouping procedures yielded statistically significantly different values. This led to the conclusion that the day of the week by month, which is the finest level of aggregation, should be used to report the factors.

Table 3.4 - Summary of Results - ANOVA Analysis for the PHV to DHV Factor

Temporal Grouping	Functional Class Groupings	1995	1996
by month	1	different	not different
	2	not different	different
	6,7	different	different
	11	not different	not different
	14,16,17	different	not different
by quarter	1	different	not different
	2	not different	different
	6,7	different	not different
	11	not different	not different
	14,16,17	not different	not different
by day of the week (regardless of month)	1	different	not different
	2	not different	different
	6,7	different	not different
	11	not different	not different
	14,16,17	different	not different

For the reasons cited in the discussion of the axle correction factors, the groupings were re-evaluated with Friday, Saturday, and Sunday removed from the database. Similar to the axle correction factors, there was no statistically significant difference detected among any of the groupings once these data were omitted.

The decision was then made to re-evaluate the functional class groupings to ensure that they were grouped in the best possible way. The same conclusion was reached as before in the axle correction factor. The functional class groupings were as follows:

Group 1)	1	Rural interstate
Group 2)	2	Rural principal arterial - other
Group 3)	6 and 7	Rural minor arterial, Rural major collector
Group 4)	11	Urban interstate
Group 5)	12 and 14	Urban principal arterial - other freeways, Urban other principal arterial
Group 6)	16 and 17	Urban minor arterial, Urban collector

Because high AADT facilities may have more uniform peaking characteristics due to capacity constraints, AADT was used to further stratify the sites. The AADT was determined by averaging the daily volumes for an entire year. A yearly factor was calculated for each site by taking the average of the day of the month factors. This led to 48 factors being averaged together (4 days in the week multiplied by 12 months of the year). The functional classification groupings were then sorted based on their AADT and the factors were analyzed. Table 3.5 shows the relationship between the AADT and the PHV to DHV factor. The results of this analysis were that 1) a breakpoint in functional class 1 occurred at 30,000 vehicles in the AADT, thus two different factors would be developed for this group, and 2) a breakpoint occurred in the grouping of functional classifications 6 and 7 around 5,000 vehicles in the AADT. Separate factors would be developed for this grouping based on this AADT relationship. The resulting factors are provided in Chapter 4.

Table 3.5 - PHV to DHV Factors by Sorted by AADT

Func Class	Site #	AADT	Factor	Func Class	Site #	AADT	Factor
1	50	45,500	1.20	6 & 7 continued	12	2,900	1.19
	39	34,500	1.38		22	2,600	1.28
	3	29,000	1.87		21	2,300	2.11
	47	23,500	1.86		19	2,000	1.18
	5	18,000	1.67		18	1,800	1.25
	53	16,000	1.99		20	1,500	1.30
	1	11,500	2.00		46	1,400	1.67
2	11	12,300	1.30		49	800	1.90
	9	11,400	1.27	11	27	63,000	1.14
	10	5,000	1.25		42	43,000	1.27
	7	3,700	1.20		30	42,500	1.94
6 & 7	13	14,000	1.11		2	36,500	1.19
	14	12,600	1.26		26	28,500	1.30
	43	12,400	1.08	12 & 14	351/352	20,800	1.22
	25	7,800	1.27		401/402	20,000	1.64
	17	7,100	1.09		34	14,200	1.19
	16	6,900	1.26		31	11,700	1.24
	23	6,700	1.12		32	11,200	1.24
	15	6,100	1.44		33	8,500	1.07
	44	5,900	1.13		36	8,400	1.11
	48	5,900	1.16	16 & 17	37	12,700	1.15
	51	5,300	1.16		40	11,100	1.18
	45	5,100	1.34		38	8,100	1.19
	24	4,100	1.20		41	5,100	1.12

3.4 % Trucks in the ADT from % Trucks in the Peak Hour Factor Development

At each station for each day, the peak hour was selected and its percentage of trucks was determined. The percentage of trucks for the entire day was also determined. The factor was calculated as follows:

% T in ADT from % T in PHV Factor = % trucks in ADT / % trucks in PHV

In reviewing the original cut of factors, the factors for all but the known heavy truck routes were near 1.1. This was brought to the attention of the WVDOT and it was decided to develop a factor for heavy truck routes, and for other routes to assume a factor of 1.1. Factors were rounded to the nearest 0.1 because this is the minimum increment needed to change 10% trucks by 1% (10% * 1.1 = 11%). The permanent count sites were grouped together by 1) Urban Heavy Truck Routes, 2) Rural Heavy Truck Routes, and 3) Others. The sites falling into each group were developed by the staff of the Planning and Research Division of the WVDOT. The groupings became as follows:

Urban Heavy Truck Routes: Functional class 1

Rural Heavy Truck Routes: Functional class 11 and site 15 in functional class 6

Others: All other sites

Factors were then developed and analyzed for the groupings by day of the week (e.g., Tuesday), by day of week by the month (e.g.,Tuesday in January) , by month, and by quarter. There was no statistically significant difference between any times of the year, thus, a single factor was developed for each truck route type based on all the data in the year. The results are provided in Chapter 4.

3.5 % Trucks in the ADT from % Trucks in the Manual Count Hours Factor Development

The percentage of trucks in the manual classification study hours was compared to the percentage of trucks for the entire day. The hours typically used in manual classification studies conducted by the WVDOT are:

7 am - 10 am

11 am - 1 pm

2 pm - 6 pm

The factor was computed as follows:

% T in ADT from % T in Manual Count Hours Factor =

% trucks in ADT / % trucks in manual count hours

As with the previous % truck factors, a first cut revealed that all but the heavy truck routes had factors near 1.0. Therefore, the factors were developed for the heavy truck routes listed in Section 3.4, with non-heavy truck routes having a factor of 1.0. As with the previous % truck factors, these factors were also rounded to the nearest 0.1. Again, a single factor was developed using all of the data for the year for each truck route type. The resulting factors are provided in Chapter 4.

CHAPTER 4 - RESULTS

4.0 Introduction

In this chapter, the proposed factors are presented. Each factor is presented in a separate section. Section 4.1 contains the axle correction factors, 4.2 contains the PHV to DHV factors, 4.3 contains the % trucks in the peak hour to % trucks in the ADT factor, and Section 4.4 contains the % trucks in the manual classification hours to % trucks in the ADT factor.

4.1 Axle Correction Factor

After grouping the functional classes and determining the most significant temporal grouping, the axle correction factors were developed. The resulting axle correction factors are reported in Table 4.1. Functional class 1 (rural interstates) was the only grouping in which the factor changed significantly at some point in the year. For this reason, a factor was reported for the first quarter, and another factor for the rest of the year. The other functional classification groupings could be adequately reported with one factor for the entire year. Axle correction factors developed by day of the week in each month, by month, and by quarter are presented in Appendix A for informational purposes.

Table 4.1 - Axle Correction Factors

Functional Class	Quarter 1	Quarters 2 - 4	Entire Year
1	0.74	0.80	---
2	---	---	0.92
6 & 7	---	---	0.94
11	---	---	0.83
12 & 14	---	---	0.96
16 & 17	---	---	0.99

The following is an example of how these factors would be applied to a short-term pneumatic tube axle count to compute the actual traffic volume. A pneumatic tube counter located on an urban interstate (functional class 11) recorded a traffic volume of 10,000 vehicles. The factor for urban interstates would be applied, yielding the following result:

10,000 vehicles * 0.83 = 8,300 actual number of vehicles

The factors derived by the 1975 WVDOH study were:

0.93 for feeders and local roads

0.89 for expressways and trunklines

The factors for the current study were not grouped in the same manner, i.e., were developed for six different roadway classification groups. Aggregating the numbers derived for the different functional class groupings in the current study for the purpose of drawing a comparison with the 1975 results yields the following values:

0.97 for collectors and locals

0.87 for interstates and other arterials

The values determined by both studies are similar in that the factor for interstates are lower than that of other roadway classifications because these roadways experience a larger amount of truck travel. A difference lies in the range between values for the different roadway classifications. In 1975 (Traffic Analysis Section, May 1975), the range was 0.04, while for 1995-1996 data, the same values differed by a value of 0.10.

The comparison of these factors seem to indicate a shift of truck traffic from collectors and local roads to higher type facilities. It could be speculated that the completion of the interstate system and a decline in the coal industry could have caused this shift.

Data from current research (Bureau of Planning and Research, 2001) by the Pennsylvania Department of Transportation concerning axle correction factors were available for comparison. Table 4.2 presents a comparison of the values derived in this project to axle correction factors derived by PENNDOT for the year 2000. The values for the axle correction factors are very similar, with the largest disparity being the 0.08 difference in the factor used for rural interstates.

Table 4.2 - West Virginia and Pennsylvania Axle Correction Factors

Functional Class	West Virginia (1995)	Pennsylvania (2000)	Difference
1	0.74 - 0.80 (0.78 average)	0.70	+.08
2	0.92	0.90	+.02
6	0.94	0.97	-.03
7	0.94	0.97	-.03
11	0.83	0.84	-.01
12	0.96	0.94	+.02
14	0.96	0.94	+.02
16	0.99	0.98	+.01
17	0.99	0.98	+.01

4.2 Peak Hour Volume to Design Hour Volume Factor

The peak hour to design hour volume factors developed are reported by day of the week by month in Table 4.3. The factors developed by day of the year, by month, and by quarter are reported in Appendix B for informational purposes. The values for functional class 1 (rural interstates) and the functional class 6-7 group (rural minor arterials & major collectors) were split based on AADT, with functional class 1 being split at 30,000 vehicles and functional class grouping 6-7 being divided at a value of 5,000 vehicles.

Table 4.3 - DHV Summary by Day of the Month

Functional Class	AADT Split	January 2 Monday	3 Tuesday	4 Wednesday	5 Thursday	February 2 Monday	3 Tuesday	4 Wednesday	5 Thursday	March 2 Monday	3 Tuesday	4 Wednesday	5 Thursday
1	greater than 30,000	1.35	1.28	1.23	1.21	1.37	1.31	1.38	1.25	1.28	1.27	1.28	1.21
1	less than 30,000	2.18	2.20	2.21	2.08	2.18	2.25	2.27	2.09	1.91	1.94	1.99	1.78
2		1.47	1.35	1.38	1.31	1.42	1.35	1.46	1.31	1.25	1.25	1.31	1.20
6 and 7	greater than 5,000	1.43	1.24	1.27	1.19	1.26	1.24	1.31	1.23	1.25	1.22	1.19	1.13
6 and 7	less than 5,000	1.64	1.60	1.53	1.39	1.73	1.73	1.75	1.49	1.81	1.81	1.77	1.64
11		1.54	1.43	1.42	1.41	1.62	1.49	1.55	1.46	1.54	1.48	1.54	1.51
12 and 14		1.44	1.25	1.34	1.28	1.37	1.24	1.31	1.21	1.26	1.24	1.19	1.12
16 and 17		1.35	1.13	1.15	1.10	1.21	1.14	1.32	1.18	1.07	1.08	1.22	1.13

Functional Class	AADT Split	April 2 Monday	3 Tuesday	4 Wednesday	5 Thursday	May 2 Monday	3 Tuesday	4 Wednesday	5 Thursday	June 2 Monday	3 Tuesday	4 Wednesday	5 Thursday
1	greater than 30,000	1.24	1.22	1.21	1.14	1.19	1.20	1.17	1.12	1.17	1.22	1.17	1.11
1	less than 30,000	1.68	1.82	1.77	1.51	1.62	1.84	1.86	1.62	1.73	1.82	1.73	1.56
2		1.23	1.20	1.22	1.18	1.22	1.21	1.20	1.10	1.28	1.19	1.20	1.17
6 and 7	greater than 5,000	1.15	1.15	1.15	1.10	1.17	1.15	1.17	1.13	1.15	1.17	1.18	1.15
6 and 7	less than 5,000	1.55	1.54	1.47	1.40	1.49	1.48	1.47	1.46	1.48	1.38	1.44	1.37
11		1.39	1.37	1.37	1.25	1.40	1.39	1.50	1.40	1.29	1.30	1.26	1.22
12 and 14		1.23	1.18	1.16	1.11	1.22	1.16	1.17	1.11	1.19	1.17	1.16	1.12
16 and 17		1.12	1.10	1.11	1.12	1.19	1.09	1.08	1.08	1.16	1.14	1.15	1.11

Functional Class	AADT Split	July 2 Monday	3 Tuesday	4 Wednesday	5 Thursday	August 2 Monday	3 Tuesday	4 Wednesday	5 Thursday	September 2 Monday	3 Tuesday	4 Wednesday	5 Thursday
1	greater than 30,000	1.16	1.22	1.16	1.12	1.14	1.15	1.14	1.09	1.15	1.17	1.16	1.12
1	less than 30,000	1.62	1.72	1.65	1.52	1.59	1.71	1.70	1.54	1.63	1.63	1.83	1.76
2		1.31	1.27	1.19	1.19	1.29	1.22	1.16	1.18	1.29	1.20	1.23	1.19
6 and 7	greater than 5,000	1.17	1.31	1.20	1.17	1.18	1.20	1.23	1.16	1.17	1.16	1.18	1.16
6 and 7	less than 5,000	1.38	1.51	1.33	1.29	1.39	1.38	1.36	1.27	1.45	1.42	1.39	1.37
11		1.28	1.36	1.22	1.17	1.26	1.23	1.23	1.17	1.28	1.31	1.30	1.25
12 and 14		1.26	1.35	1.22	1.20	1.28	1.16	1.17	1.13	1.35	1.17	1.15	1.08
16 and 17		1.16	1.37	1.11	1.14	1.17	1.15	1.16	1.14	1.24	1.12	1.17	1.08

Functional Class	AADT Split	October 2 Monday	3 Tuesday	4 Wednesday	5 Thursday	November 2 Monday	3 Tuesday	4 Wednesday	5 Thursday	December 2 Monday	3 Tuesday	4 Wednesday	5 Thursday
1	greater than 30,000	1.16	1.13	1.13	1.08	1.16	1.28	1.23	1.38	1.34	1.39	1.34	1.58
1	less than 30,000	1.69	1.89	1.81	1.72	1.82	1.94	1.80	1.91	2.22	2.08	2.17	1.78
2		1.30	1.18	1.19	1.17	1.31	1.28	1.28	1.22	1.29	1.22	1.24	1.23
6 and 7	greater than 5,000	1.15	1.14	1.19	1.13	1.19	1.26	1.22	1.22	1.29	1.17	1.16	1.22
6 and 7	less than 5,000	1.36	1.33	1.29	1.29	1.53	1.55	1.47	1.49	1.73	1.50	1.60	1.38
11		1.29	1.28	1.30	1.23	1.39	1.39	1.38	1.31	1.50	1.44	1.52	1.50
12 and 14		1.23	1.14	1.08	1.10	1.33	1.29	1.25	1.47	1.28	1.36	1.54	1.22
16 and 17		1.15	1.09	1.09	1.13	1.12	1.14	1.14	1.34	1.18	1.13	1.11	1.17

These divisions were made due to a significant variability in the PHV to DHV factors developed on the roadways with these values of AADT.

As an example of the usage of these factors, assume that a peak hour count of 1000 was obtained on rural minor arterial having an AADT of 10,000. This count was performed on a Thursday in April. The appropriate factor is that for functional class group 6 and 7, AADT>5,000, for a Thursday in April, which is 1.10. Therefore, the DHV can be estimated as 1000 vph * 1.10, which is 1100 vph.

The procedure for the development of the 1975 factors was presented in Chapter 2. In the 1975 study, the design hourly volume was either the 10th or 30th highest hourly volume. If the AADT was less than or equal to 500 vehicles, the tenth highest hourly volume was used to define the design hourly volume. If the AADT was greater than 500 vehicles, the thirtieth highest hourly volume was used to define the design hourly volume. The resulting values for the PHV to DHV correction factor (B) were presented in Table 2.3.

The similarities between the 1975 and 2001 studies are that they both realized the variability involved in the factors, and reported the factors using a finer level of aggregation based on this variability. Where the 1975 study reported factors by AADT and by quarter, the current study reported factors for every functional class by day of the month. Although the methods of reporting were different, the magnitude of the factors developed in 1975 and those derived in the 2001 study are similar. The range of the factors developed in 1975 was 0.27 compared to a range of 1.20 for the 2001 factors. This difference can be attributed to the quantity of factors produced. In 1975, eight factors were reported, and in 2001, 384 factors were reported. Interestingly, taking an average of the factors reported yields values of 1.28 and 1.34 for 1975

and 2001, respectively. These values show that overall, the PHV to DHV factors have changed very little in the past 25 years.

The PHV to DHV factors are reported differently from the axle correction factor because of the differences between the two factors. The axle correction factors are mainly reported as one factor for the entire year, while the PHV to DHV factors are reported by day of the week by month. This is due to the fact that the axle correction factor is a function of the percent trucks on the roadway, which varies little throughout the year, while the PHV to DHV factor will vary as overall traffic volume varies over the course of the year, which can be highly variable. For example, more people travel in the summer months than during the winter, and traffic towards the end of a week tends to be higher than traffic towards the beginning..

4.3 Percent Trucks in the ADT from Percent Trucks in the Peak Hour Factor

The Percent Trucks in the ADT from Percent Trucks in the Peak Hour factors results are reported in Table 4.4. For example, if the % trucks on a rural interstate, which generally tend to be heavy truck routes, is 20% during the peak hour, then the % trucks in the ADT can be estimated as 20% * 1.2 = 24%.

Table 4.4 - Factors Relating the % Trucks in Peak Hour to the % Trucks in ADT

Group	Factor
Rural Heavy Truck Routes	1.2
Urban Heavy Truck Routes	1.2
Others	1.1

Although the factors did not vary between the rural and urban heavy truck routes, they did vary slightly between the heavy truck routes and the other roadways. A lower value for the other

roadways shows that a greater percentage of trucks are traveling during the peak hour in these non-heavy truck routes than the roadways identified as heavy truck routes. The relationships of % trucks in the ADT to % trucks in the peak hour factors developed by day of the year, by month, and by quarter are included as Appendix C for informational purposes.

The factors developed in 1975 relating the % Trucks ADT to the % Trucks in the peak hour volume were reported in Table 2.2. These factors are different from those determined in the current study. While the current study predicts factors in the range of 1.1 and 1.2, the 1975 study predicted factors from 1.24 in the summer to 1.57 in the winter. No mathematical issues could be identified to account for this difference, other than the fact that in 1975, linear regression analysis was used to develop the factors, and, in the current study, a complete database was used to develop every factor. It could be speculated that more trucks were traveling in the peak hours in 1995-1996 than in 1975 due to just-in-time inventory techniques. This trend in commerce might cause more trucks to be traveling throughout the day, rather than avoiding the peak hours and traveling throughout the night. It is also interesting to note that the seasonal variation in truck traffic relative to personal travel has also disappeared, as evidenced by all three of truck related factors developed as part of this study.

4.4 Percent Trucks in the ADT from Percent Trucks in the Manual Count Hours Factor

The % Trucks in the ADT to % Trucks in the Manual Count Hour factors are shown in Table 4.5. For example, if the % trucks observed during a manual count at a typical suburban intersection was 2%, then this is likely a good estimate of % trucks in the 24-hour period at this location, based on the “Others” group factor of 1.0.

Table 4.5 - Factors Relating the % Trucks in Manual Count Hours to the % Trucks in the ADT

Group	Factor
Rural Heavy Truck Routes	1.1
Urban Heavy Truck Routes	1.1
Others	1.0

The factors indicate that the percent trucks in the ADT on rural and urban heavy truck routes is slightly higher than the percent trucks obtained by performing counts during the manual classification count hours. The factor did not vary between urban and rural heavy truck routes, but did vary slightly for other roadways. On roadways not classified as either a rural heavy truck route or urban heavy truck route, the percent trucks in the traffic stream counted during the manual classification count hours is an accurate estimate of the overall percent trucks in the ADT. The relationships of % trucks in the ADT to % trucks in the manual count hours factors developed by day of the year, by month, and by quarter are presented in Appendix D for informational purposes.

This factor was not developed in 1975. PENNDOT, however, reported some information that could be used to derive these factors in a rough way. Using traffic distribution information for both overall traffic and specifically truck traffic over a 24-hour period, the % trucks in the manual classification hours to % trucks in the ADT factor could be computed. Table 4.6 compares the values of the factors developed in this study using West Virginia data and those determined from Pennsylvania data (Bureau of Planning and Research, 2001). Note that the factor developed using PENNDOT data combined rural and urban heavy truck routes.

Table 4.6 - Comparison of WVDOT 1995-1996 Data and PENNDOT 2001 Data

Group	WV (95-96)	PA (2001)
Rural Heavy Truck Routes	1.1	1.26
Urban Heavy Truck Routes	1.1	
Other	1.0	0.91

The factors developed for heavy truck routes in Pennsylvania were higher than those developed in West Virginia with a difference of 13%, but they are on the same order of magnitude. It should be noted that the values reported for Pennsylvania were not actual factors computed by PENNDOT. The author determined the factors used for the comparison by using tabular data values of percentage of vehicles and percentage of trucks traveling during each hour of the day for the different Pennsylvania roadway classifications. These factors were then related to corresponding values reported for % trucks for the same roadway classifications. For this reason, the Pennsylvania values are highly subject to variability due to rounding. Also, the factors are not compiled by site then aggregated; they are generalities that are combined together.

CHAPTER 5 - CONCLUSIONS AND RECOMMENDATIONS

5.0 Conclusions

The factors developed as part of this study were derived using data collected in 1995 and 1996 from West Virginia's system of 52 permanent count stations. The data provided from these counters were reviewed and erroneous data were removed in order to ensure validity of the raw data from the count stations.

A key limitation of the study was that about 25% of the total data from the permanent traffic recorders was either missing or in error with some sites up to 81% missing and/or in error. A notable finding relating to the missing data occurred during the aggregation of the factors. In some instances, it was not possible to test for a significant difference in the factors developed by day of the week by month because there were too many factors missing to perform an ANOVA analysis.

The results of this study are valid for use in West Virginia and can be utilized throughout the state. The limitation of the factors derived by this study is that they should only be used to adjust short-term counts performed in West Virginia. This limitation is noted for the reason that the raw data collected at West Virginia permanent count stations was used in the development of the factors.

It is intended that the factors presented in this report replace those developed in 1975, as they are a more accurate estimate current traffic characteristics. Overall, the factors developed in this research are consistent with those factors developed in 1975 by the WVDOT. The changes encountered were consistent with the changing trends of truck travel.

An axle correction factor was developed as part of this study to be applied to single pneumatic tube axle counting equipment. Applying an axle correction factor transforms the vehicle estimate based on the axle count into more accurate estimate of traffic volume. Due to variability determined by ANOVA analysis, factors were reported for each of six different functional classification groupings. The factor developed for functional class 1 contained variability in the first quarter significant enough to necessitate that a separate factor be reported for this quarter, with another factor representing the last three quarters of the year. Factors for the other functional class groupings were reported as one factor for the entire year.

Factors relating PHV to DHV were developed so that the peak hour volume measured on any typical weekday could be used to estimate the design hour volume. Due to the high variability experienced within the different time groupings, the factors were reported by day of the month for the 6 roadway functional classification groupings. Due to significant differences within the factors with respect to AADT, divisions were made in the groups where AADT was a source of variation.

Factors relating percent trucks in ADT to percent trucks in peak hour were developed based on three groupings: 1) urban heavy truck routes, 2) rural heavy truck routes, and 3) other roadways. These factors are to be used to adjust the percent trucks during the peak hour volume of the short-term counts to more accurately estimate the percentage of trucks in the average daily traffic. Similarly, factors relating percent trucks in the ADT to percent trucks in the manual count hours were developed based on the same three groupings. These factors are to be used to adjust the percent trucks experienced during the manual classification count hours to more accurately estimate the percentage of trucks in the average daily traffic.

5.1 Other Recommendations

The recommendation of the research not specific to the factors that were developed include the following:

(1) Update these factors periodically to validate the current factors used and to identify new trends that may be developing on West Virginia's roadways. PENNDOT for example, develops similar factors every year.

(2) The hardware at the permanent counter stations is in need of significant repair. This could affect the ability of the WVDOT to comply with federal traffic volume reporting requirements.

5.2 Implementation

The factors developed herein will be immediately useful to persons analyzing traffic count data in West Virginia. The axle correction factors are critical when machine counts are collected with pneumatic tube counters. Furthermore, since continuous 365 day counts are available only at the permanent stations, the PHV to DHV factors will be heavily used by highway designers, traffic engineers, and other practitioners in the planning and design of projects statewide. Lastly, the truck percentage factors have numerous applications, and will be used by a wide variety of practitioners. They can be used to maximize the value of short-term truck counts in projecting total daily truck traffic, which will be useful in both planning and design. In addition to being distributed within the WVDOT, these factors should be made available to consultants, MPOs, and other local entities concerned with transportation planning

data collection and analysis. Using the factors developed in this study, the aforementioned agencies will be able to:

- Apply an axle correction factor to a single pneumatic tube axle count to determine a more accurate traffic volume.
- Determine the design hourly volume (DHV) by measuring the peak hour volume and applying the appropriate PHV to DHV factor.
- Determine the percent trucks in the average daily traffic (ADT) on a roadway by determining the percentage of trucks in the peak hour and applying the appropriate % trucks in the ADT to % trucks in the peak hour factor.
- Determine the percent trucks in the ADT on a roadway by measuring the percentage of trucks in the manual count hours and applying the appropriate % trucks in the ADT to % trucks in the manual count hours factor.

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APPENDIX A

AXLE CORRECTION FACTOR SUMMARIES BY DAY OF THE WEEK, BY MONTH, AND BY QUARTER

Axle By Day Correction Factor Summary - By Day Regardless of Month

Functional Class	Monday	Tuesday	Wednesday	Thursday	Minimum	Maximum	Range
1	0.81	0.76	0.76	0.78	0.76	0.81	0.04
2	0.92	0.92	0.92	0.92	0.92	0.92	0.01
6, 7	0.95	0.94	0.94	0.94	0.94	0.95	0.01
11	0.85	0.82	0.81	0.82	0.81	0.85	0.04
12, 14	0.96	0.95	0.95	0.95			
16, 17	0.99	0.99	0.99	0.99	0.99	0.99	0.00

Axle by Month Factors

Funct Class	January	February	March	April	May	June	July	August	September	October	November	December	Minimum	Maximum	Range
1	0.75	0.74	0.74	0.77	0.78	0.79	0.82	0.80	0.78	0.77	0.81	0.81	0.74	0.82	0.09
2	0.93	0.91	0.90	0.90	0.92	0.92	0.93	0.92	0.91	0.91	0.93	0.91	0.90	0.93	0.03
6, 7	0.94	0.94	0.91	0.94	0.95	0.96	0.95	0.94	0.94	0.94	0.94	0.94	0.91	0.96	0.04
11	0.81	0.80	0.82	0.82	0.82	0.82	0.85	0.84	0.83	0.82	0.83	0.83	0.80	0.85	0.04
12, 14	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.96	0.96	0.96	0.95	0.96	0.01
16, 17	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.00

Axle by Quarter

Funct Class	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Minimum	Maximum	Range
1	0.74	0.78	0.81	0.80	0.74	0.81	0.06
2	0.92	0.92	0.92	0.92	0.92	0.92	0.00
6, 7	0.94	0.94	0.94	0.94	0.94	0.94	0.00
11	0.81	0.83	0.84	0.83	0.81	0.84	0.02
12, 14	0.95	0.96	0.95	0.96	0.95	0.96	0.01
16, 17	0.99	0.99	0.99	0.99	0.99	0.99	0.00

APPENDIX B

PHV TO DHV FACTOR SUMMARIES BY DAY OF THE WEEK, BY MONTH, AND BY QUARTER

DHV By Day Correction Factor Summary - By Day Regardless of Month

Functional Class		Monday	Tuesday	Wednesday	Thursday	Minimum	Maximum	Range
1	greater than 30,000	1.28	1.38	1.27	1.26	1.26	1.38	0.12
	less than 30,000	1.83	1.90	1.92	1.74	1.74	1.92	0.17
2		1.32	1.24	1.25	1.21	1.21	1.32	0.11
6 and 7	greater than 5,000	1.22	1.20	1.20	1.19	1.19	1.22	0.03
6 and 7	less than 5,000	1.50	1.47	1.49	1.40	1.40	1.50	0.10
11		1.40	1.37	1.38	1.32	1.32	1.40	0.07
12,14		1.28	1.16	1.15	1.12	1.12	1.28	0.16
16,17		1.19	1.14	1.15	1.15	1.14	1.19	0.05

DHV by Month Factors

Funct Class		January	February	March	April	May	June	July	August	September	October	November	December	Minimum	Maximum	Range
1	greater than 30,000	1.27	1.33	1.26	1.20	1.17	1.17	2.07	1.13	1.15	1.12	1.26	1.41	1.12	2.07	0.95
	less than 30,000	2.17	2.23	1.91	1.69	1.73	1.71	1.63	1.63	1.71	1.78	1.87	2.06	1.63	2.23	0.60
2		1.38	1.39	1.25	1.21	1.18	1.21	1.24	1.24	1.23	1.21	1.27	1.25	1.18	1.39	0.20
6 and 7	greater than 5,000	1.30	1.26	1.20	1.21	1.16	1.16	1.21	1.19	1.17	1.15	1.22	1.21	1.15	1.30	0.15
6 and 7	less than 5,000	1.54	1.67	1.48	1.49	1.48	1.42	1.38	1.35	1.41	1.32	1.51	1.55	1.32	1.67	0.36
11		1.45	1.53	1.52	1.34	1.42	1.27	1.26	1.22	1.28	1.28	1.37	1.49	1.22	1.53	0.31
12,14		1.22	1.19	1.07	1.08	1.12	1.10	1.36	1.18	1.18	1.13	1.23	1.18	1.07	1.36	0.29
16,17		1.21	1.21	1.13	1.11	1.11	1.14	1.19	1.16	1.15	1.12	1.20	1.15	1.11	1.21	0.10

DHV by Quarter

Funct Class		1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Minimum	Maximum	Range
1	greater than 30,000	1.29	1.18	1.45	1.27	1.18	1.45	0.27
	less than 30,000	2.10	1.71	1.66	1.90	1.66	2.10	0.45
2		1.34	1.20	1.24	1.24	1.20	1.34	0.14
6 and 7	greater than 5,000	1.25	1.18	1.19	1.19	1.18	1.25	0.08
6 and 7	less than 5,000	1.57	1.46	1.38	1.46	1.38	1.57	0.19
11		1.50	1.35	1.26	1.38	1.26	1.50	0.24
12,14		1.16	1.10	1.24	1.18	1.10	1.24	0.14
16,17		1.18	1.12	1.17	1.16	1.12	1.18	0.06

APPENDIX C

PERCENT TRUCKS IN ADT FROM PERCENT TRUCKS IN THE PEAK HOUR FACTOR SUMMARIES BY DAY OF THE WEEK, BY MONTH, AND BY QUARTER

Truck PH Correction Factor Summary - By Day Regardless of Month

Grouping	Monday	Tuesday	Wednesday	Thursday	Minimum	Maximum	Range
Rural Heavy Truck Routes	1.15	1.16	1.20	1.18	1.15	1.20	0.05
Urban Heavy Truck Routes	1.19	1.21	1.18	1.21	1.18	1.21	0.03
Other	1.08	1.13	1.08	1.09	1.08	1.13	0.05

Truck PH by Month Factors

Grouping	January	February	March	April	May	June	July	August	September	October	November	December	Minimum	Maximum	Range
Rural Heavy Truck Routes	1.17	1.17	1.18	1.19	1.18	1.16	1.18	1.17	1.15	1.17	1.17	1.17	1.15	1.19	0.04
Urban Heavy Truck Routes	1.18	1.20	1.23	1.24	1.21	1.19	1.14	1.19	1.26	1.22	1.15	1.18	1.14	1.26	0.12
Other	1.09	1.10	1.08	1.07	1.19	1.10	1.09	1.14	1.09	1.10	1.10	1.20	1.07	1.20	0.13

Truck PH by Quarter

Grouping	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Minimum	Maximum	Range
Rural Heavy Truck Routes	1.17	1.18	1.16	1.20	1.16	1.20	0.04
Urban Heavy Truck Routes	1.20	1.21	1.20	1.18	1.18	1.21	0.03
Other	1.09	1.11	1.11	1.13	1.09	1.13	0.04

APPENDIX D

PERCENT TRUCKS IN ADT FROM PERCENT TRUCKS IN THE MANUAL COUNT HOUR FACTOR SUMMARIES BY DAY OF THE WEEK, BY MONTH, AND BY QUARTER

Truck MC Correction Factor Summary - By Day Regardless of Month

Grouping	Monday	Tuesday	Wednesday	Thursday	Minimum	Maximum	Range
Rural Heavy Truck Route	1.10	1.11	1.13	1.10	1.10	1.13	0.02
Urban Heavy Truck Route	1.07	1.08	1.06	1.07	1.06	1.08	0.02
Other	0.97	0.98	0.96	0.97	0.96	0.98	0.01

Truck MC by Month Factors

Grouping	January	February	March	April	May	June	July	August	September	October	November	December	Minimum	Maximum	Range
Rural Heavy Truck Route	1.12	1.12	1.12	1.12	1.09	1.12	1.05	1.11	1.11	1.18	1.10	1.08	1.05	1.18	0.13
Urban Heavy Truck Route	1.06	1.09	1.08	1.08	1.05	1.08	1.06	1.08	1.09	1.09	1.03	1.07	1.03	1.09	0.06
Other	0.98	0.98	0.98	0.98	0.95	0.97	0.97	0.96	0.98	0.98	0.96	0.94	0.94	0.98	0.04

Truck MC by Quarter

Grouping	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Minimum	Maximum	Range
Rural Heavy Truck Route	1.12	1.11	1.09	1.11	1.09	1.12	0.03
Urban Heavy Truck Route	1.08	1.04	1.07	1.06	1.04	1.08	0.03
Other	0.98	0.97	0.97	0.96	0.96	0.98	0.02

APPENDIX E

FACTORS DEVELOPED USING ONLY FRIDAY, SATURDAY, AND SUNDAY DATA

Axle By Day Correction Factor Summary - By Day Regardless of Month

Functional Class	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Minimum	Maximum	Range
1	0.88					0.84	0.88	0.84	0.88	0.04
2	0.97					0.93	0.97	0.93	0.97	0.04
6, 7	0.98					0.95	0.98	0.95	0.98	0.03
11	0.89					0.87	0.90	0.87	0.90	0.03
12, 14	0.98					0.96	0.98	0.96	0.98	0.03
16, 17	1.00					0.99	1.00	0.99	1.00	0.00

Axle by Month Factors

Funct Class	January	February	March	April	May	June	July	August	September	October	November	December	Minimum	Maximum	Range
1	0.81	0.82	0.85	0.86	0.87	0.88	0.89	0.89	0.87	0.87	0.89	0.89	0.81	0.89	0.08
2	0.95	0.94	0.94	0.95	0.96	0.96	0.96	0.96	0.95	0.96	0.96	0.96	0.94	0.96	0.02
6, 7	0.96	0.97	0.95	0.97	0.97	0.98	0.97	0.97	0.97	0.97	0.97	0.97	0.95	0.98	0.03
11	0.86	0.86	0.89	0.89	0.89	0.89	0.90	0.90	0.89	0.88	0.89	0.89	0.86	0.90	0.05
12, 14	0.98	0.97	0.96	0.97	0.98	0.97	0.97	0.97	0.98	0.98	0.98	0.98	0.96	0.98	0.02
16, 17	1.00	1.00	1.00	1.00	1.00	0.99	0.99	0.99	0.99	1.00	1.00	1.00	0.99	1.00	0.00

Axle by Quarter

Funct Class	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Minimum	Maximum	Range
1	0.83	0.87	0.89	0.88	0.83	0.89	0.06
2	0.95	0.96	0.96	0.96	0.95	0.96	0.00
6, 7	0.96	0.97	0.97	0.97	0.96	0.97	0.01
11	0.87	0.89	0.90	0.89	0.87	0.90	0.03
12, 14	0.97	0.98	0.97	0.98	0.97	0.98	0.01
16, 17	1.00	1.00	0.99	1.00	0.99	1.00	0.00

Friday

Functional Class	1st Quarter	Rest of Year	Entire Year
1	0.80	0.85	
2			0.93
6, 7			0.95
11			0.87
12, 14			0.96
16, 17			0.99

Saturday-Sunday

Functional Class	1st Quarter	Rest of Year	Entire Year
1	0.84	0.89	
2			0.97
6, 7			0.98
11			0.90
12, 14			0.98
16, 17			1.00

PHV-DHV Factor Summary - By Day Regardless of Month

Functional Class	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Minimum	Maximum	Range
1	1.48					1.35	1.67	1.35	1.67	0.32
2	1.99					1.53	2.02	1.53	2.02	0.48
6, 7	1.43					1.17	1.41	1.17	1.43	0.26
11	1.49					1.21	1.52	1.21	1.52	0.31
12, 14	1.67					1.09	1.63	1.09	1.67	0.58
16, 17	1.53					1.12	1.42	1.12	1.53	0.41

PHV-DHV by Month Factors

Funct Class	January	February	March	April	May	June	July	August	September	October	November	December	Minimum	Maximum	Range
1	2.14	1.97	1.42	1.32	1.37	1.29	1.35	1.16	1.30	1.41	1.44	1.79	1.16	2.14	0.98
2	2.61	3.27	2.01	1.96	1.69	1.67	1.66	1.71	1.66	1.62	1.78	1.88	1.62	3.27	1.65
6, 7	1.69	1.51	1.31	1.30	1.26	1.27	1.26	1.27	1.27	1.23	1.34	1.39	1.23	1.69	0.46
11	1.82	1.90	1.45	1.32	1.36	1.23	1.16	1.18	1.31	1.27	1.30	1.53	1.16	1.90	0.74
12, 14	1.90	1.61	1.25	1.32	1.37	1.35	1.43	1.35	1.33	1.33	1.39	1.37	1.25	1.90	0.66
16, 17	1.57	1.21	1.10	1.29	1.26	1.31	1.39	1.40	1.36	1.33	1.46	1.43	1.10	1.57	0.47

PHV-DHV by Quarter

Funct Class	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Minimum	Maximum	Range
1	1.88	1.33	1.25	1.55	1.25	1.88	0.63
2	2.34	1.71	1.68	1.76	1.68	2.34	0.67
6, 7	1.53	1.27	1.26	1.32	1.26	1.53	0.26
11	1.76	1.30	1.22	1.37	1.22	1.76	0.55
12, 14	1.68	1.38	1.37	1.36	1.36	1.68	0.32
16, 17	1.32	1.29	1.38	1.41	1.29	1.41	0.12

Truck PH Correction Factor Summary - By Day Regardless of Month

Grouping	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Minimum	Maximum	Range
Rural Heavy Truck Routes	1.13					1.16	1.11	1.11	1.16	0.05
Urban Heavy Truck Route	1.11					1.18	1.11	1.11	1.18	0.07
Other	1.10					1.07	1.01	1.01	1.10	0.09

Truck PH by Month Factors

Grouping	January	February	March	April	May	June	July	August	September	October	November	December	Minimum	Maximum	Range
Rural Heavy Truck Routes	1.15	1.19	1.17	1.17	1.16	1.10	1.06	1.13	1.09	1.18	1.13	1.12	1.06	1.19	0.13
Urban Heavy Truck Route	1.07	1.15	1.17	1.18	1.14	1.17	1.10	1.14	1.11	1.18	1.08	1.11	1.07	1.18	0.11
Other	0.99	1.05	1.08	1.04	1.13	1.05	1.06	1.02	1.08	1.05	0.99	1.03	0.99	1.13	0.14

Truck PH by Quarter Factors

Grouping	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Minimum	Maximum	Range
Rural Heavy Truck Routes	1.17	1.14	1.09	1.14	1.09	1.17	0.07
Urban Heavy Truck Route	1.12	1.19	1.12	1.13	1.12	1.19	0.07
Other	1.03	1.11	1.05	1.02	1.02	1.11	0.10

	Friday	Saturday, Sunday
Rural Truck Route	1.2	1.1
Urban Truck Route	1.2	1.1
Other	1.1	1.1

Truck MC Correction Factor Summary - By Day Regardless of Month

Grouping	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Minimum	Maximum	Range
Rural Heavy Truck Routes	1.09					1.07	1.06	1.06	1.09	0.03
Urban Heavy Truck Route						1.03	1.04	1.03	1.04	0.00
Other	0.99					0.95	0.97	0.95	0.99	0.04

Truck MC by Month Factors

Grouping	January	February	March	April	May	June	July	August	September	October	November	December	Minimum	Maximum	Range
Rural Heavy Truck Routes	1.08	1.08	1.10	1.09	1.08	1.07	1.03	1.07	1.07	1.10	1.06	1.04	1.03	1.10	0.07
Urban Heavy Truck Route	1.00	1.06	1.06	1.07	1.06	1.05	1.04	1.05	1.06	1.07	1.01	1.04	1.00	1.07	0.07
Other	0.97	0.98	0.98	0.99	0.97	0.97	0.97	0.98	0.98	0.98	0.96	0.93	0.93	0.99	0.05

Truck MC by Quarter

Grouping	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Minimum	Maximum	Range
Rural Heavy Truck Routes	1.09	1.08	1.06	1.06	1.06	1.09	0.03
Urban Heavy Truck Route	1.03	1.06	1.05	1.04	1.03	1.06	0.02
Other	0.98	0.98	0.98	0.96	0.96	0.98	0.02

	Friday, Saturday, and Sunday
Rural Truck Route	1.1
Urban	1.0
Other	1.0