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Development of a Traffic Data Input System in Arizona for the MEPDG

Arizona Department of Transportation Research Center

ADOT

Development of a Traffic Data Input System in Arizona for the MEPDG

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Prepared by:
Michael I. Darter
Leslie Titus-Glover
Dean J. Wolf
Applied Research Associates, Inc.
100 Trade Centre Dr., Suite 200
Champaign, IL 61820

Prepared for:
Arizona Department of Transportation
206 S. 17th Ave.
Phoenix, AZ 85007

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16. Abstract

Accurate traffic data is one of the key data elements required for the cost-effective design of all rehabilitation and reconstruction of pavement structures. This research study addresses the collection, preparation, and use of traffic data required for pavement design by the Arizona Department of Transportation (ADOT), focusing on data required as inputs for the American Association of State Highway and Transportation Officials (AASHTO) Mechanistic-Empirical Pavement Design Guide (MEPDG) design procedures. ADOT's current traffic data collection and preparation processes are not adequate to meet the needs of the MEPDG procedure, and improvements are needed. These improvements include enhanced volume, classification, and weight data collection for vehicles, processing data and performing quality assurance checks, and the preparation/analysis of the data for use in the MEPDG. Use of the MEPDG in Arizona will require (1) an annual flow of updated key traffic data and (2) the ability to collect on-site (MEPDG Level 1) data in a timely manner for key projects.

An action plan (Chapter 8) calls for the establishment of an Arizona Traffic Segment Database that includes all state highways (or the expansion of an existing traffic database). This database would include all traffic inputs required for the AASHTO MEPDG and AASHTO 1993 design procedures, as well as ADOT pavement management activities. Traffic segments would be identified by beginning and ending milepost numbers and global positioning system (GPS) coordinates along each highway.

The researchers propose, and have partly developed, a system for traffic data collection for the MEPDG in Arizona. Level 1 data collection procedures are provided for selected traffic inputs. ADOT's traffic data collection group will need to develop a process for collecting Level 1 data in a timely manner for important projects requested from the pavement design group. This report also discusses recommended Level 2 and Level 3 inputs, which were prepared based on the best historical data available. These data represent a good initial set of inputs that can be used over the next few years. However, the inputs should be updated annually using improved data collection methods beginning as soon as possible.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
^oF	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^oC
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
^oC	Celsius	1.8C+32	Fahrenheit	^oF
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003)

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ACRONYMS AND ABBREVIATIONS

AADT	Annual average daily traffic
AADTT	Annual average daily truck traffic
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ADOT	Arizona Department of Transportation
ADR	Automatic data recorder
ALD	Axle load distribution
ATLAS	Advanced Traffic Loading and Analysis System
ATR	Automated traffic recorder
ATRC	Arizona Transportation Research Center
AVC	Automatic vehicle classification
CCC	Cubic clustering criterion
ESAL	Equivalent single-axle load
FHWA	Federal Highway Administration
GPS	Global positioning system
GPS	General Pavement Studies
GVW	Gross vehicle weight
HMA	Hot mix asphalt
IRI	International Roughness Index
JPCP	Jointed plain concrete pavement
LDF	Load distribution factor
LEF	Load equivalency factor
LTPP	Long-Term Pavement Performance
MEPDG	Mechanistic-Empirical Pavement Design Guide
MAF	Monthly adjustment factors
MP	Milepost
MPD	Multimodal Planning Division
MVD	Motor Vehicle Division
NCHRP	National Cooperative Highway Research Program
PCC	Portland cement concrete
POE	Port-of-entry
PSF	Pseudo F-value
PST2	Pseudo t^2 value
R^2	Cumulative and partial squared multiple correlation
SHRP	Strategic Highway Research Program
SPS	Specific Pavement Studies
TPD	Transportation Planning Division
TTC	Truck traffic classification
VAR	Eigenvalue and associated variance
VCD	Vehicle class distribution
WIM	Weigh-in-motion

CHAPTER 1. INTRODUCTION

The Arizona Department of Transportation (ADOT) maintains over 7,000 miles of highways that require new construction, reconstruction of existing alignments, maintenance, resurfacing, and rehabilitation, including lane widening, to carry future heavy truck traffic. Approximately one-half of the ADOT highway construction budget is dedicated to pavement. Accurate estimates of traffic are important for the cost-effective design of new and rehabilitated pavement.

This research study, SPR-672, addresses the collection, preparation, and use of traffic data for the design of new and rehabilitated pavement. The study focuses primarily on traffic data that ADOT will require for implementing the American Association of State Highway and Transportation Officials (AASHTO) Mechanistic-Empirical Pavement Design Guide (MEPDG) (AASHTO, 2008).

BRIEF BACKGROUND

Currently, the only traffic data available to ADOT's Pavement Design Section for designing pavements in Arizona are the annual average daily traffic (AADT) data obtained from the ADOT Multimodal Planning Division (MPD) and the equivalent single-axle load (ESAL) data predicted by the pavement management software. These predictions are based on the statewide traffic weight data and vehicle class data collected in the 1990s. Truck volume data have been updated to the present time to compute growth rate. The future growth rates are based on AADT and does not account for the types of vehicles in the traffic stream (Federal Highway Administration [FHWA] Classes 4 through 13). Essentially, the predictions are based on very old classification and weight information, as well as growth rate based on total traffic growth. Using old data could lead to significant errors in predictions of traffic loadings, which could affect design and construction costs. Therefore, it is extremely important that ADOT use current traffic volume, classification, and weight data based on periodic traffic surveys and measurements.

The MEPDG uses much of the same information as that required for the AASHTO 1993 *Guide for Design of Pavement Structures* procedure (AASHTO, 1993), but it requires major changes in the way ADOT has been acquiring and compiling traffic data. For example, the MEPDG uses truck axle load spectra data directly instead of calculating ESALs. There are also other inputs needed that are not currently being collected. Therefore, it is imperative that ADOT has a comprehensive traffic data input system that is kept current. This type of traffic data input system will ultimately save the State of Arizona substantial costs by providing more accurate and cost-effective designs. After Indiana implemented the MEPDG, they found that they saved a total of $36 million on 136 projects designed using the MEPDG instead of the 1993 AASHTO procedure (Nantung, 2011).

OBJECTIVES

ADOT initiated efforts to implement the MEPDG (1) as a design tool for new, reconstructed, and rehabilitated pavements and (2) for conducting forensic evaluation of existing pavements. A key aspect of the MEPDG implementation effort in Arizona is to develop an MEPDG traffic data input system. Developing an MEPDG traffic data input system requires:

- Identification of MEPDG traffic data input needs.
- Evaluation of current ADOT traffic data collection, storage, and analysis practices to determine whether the system can adequately meet MEPDG traffic data needs.
- Performance of quality checks of existing traffic data to determine that they are reasonable and to identify anomalies.
- Development of a detailed action plan to satisfy future MEPDG traffic data needs.
- Documentation of findings and recommendations.

BRIEF SUMMARY OF FINDINGS

ADOT's current traffic data collection and preparation practices require several improvements to be compatible with MEPDG data needs. For example, ADOT needs to improve data collection on truck volume and weight, perform quality assurance checks of those data, and prepare/analyze the data for use in the MEPDG. Using the MEPDG in Arizona will require (1) an annual flow of updated key traffic data for use as MEPDG Level 2/3 defaults and (2) the ability to collect Level 1 data for key projects being designed.

An action plan in Chapter 8 for developing a traffic data collection system for the MEPDG in Arizona has been prepared. This plan calls for the establishment of a homogeneous traffic segment database that includes all highways in Arizona (Interstate, U.S., and state). This database would include all traffic inputs required for the MEPDG and AASHTO 1993 design procedures. Traffic segments would include milepost (MP) to MP limits, as well as global positioning system (GPS) coordinates of the beginning and ending MP. The traffic segment database would include segment beginning and ending MP and GPS coordinates, traffic volume inputs, traffic weight inputs, traffic geometry inputs, and other inputs.

This report discusses types of equipment recommended for collecting traffic data based on the accuracies needed in support of the MEPDG. Cost estimates are provided for the equipment, installation, site maintenance, equipment calibration, monitoring (data retrieval), and data analyses.

This report documents procedures to collect Level 1 traffic inputs. Level 2/3 recommended inputs and defaults are provided based on the best historical data available to date. These data can be used for MEPDG design for now, but they will need annual updates from improved traffic volume, classification, and weight stations. ADOT also will need to develop the ability to collect on-site data for requested key projects where current data are deficient or the size of the project requires more accurate Level 1 data, as requested by pavement designers.

ORGANIZATION OF REPORT

This report provides the results of work accomplished to satisfy the project objectives. Following is brief description of the report contents:

- Chapter 2 summarizes ADOT's current and future MEPDG traffic data requirements.
- Chapter 3 provides a framework for developing an ADOT traffic data input system.
- Chapter 4 provides a statistical analysis of traffic input clusters.
- Chapter 5 provides the results of a sensitivity analysis.
- Chapter 6 provides detailed default recommendations for Level 2/3 statewide traffic inputs for Arizona.
- Chapter 7 provides a detailed input system for ADOT traffic inputs for the MEPDG.
- Chapter 8 summarizes an action plan for future work.
- Appendix A presents a review of historical ADOT traffic data collection practices.
- Appendixes B through F summarize various data used in the analyses for this study, including vehicle class distribution (VCD), hourly truck distribution, monthly adjustment factors (MAFs), axle load distribution (ALD), and axles per truck.
- Appendix G presents a recommended business process overview for obtaining MEPDG and pavement management system traffic data.

CHAPTER 2. CURRENT AND FUTURE TRAFFIC DATA REQUIREMENTS FOR PAVEMENT DESIGN

CURRENT ADOT TRAFFIC DATA REQUIREMENTS

ESAL Truck Factors

ADOT performs highway pavement design using the 1993 AASHTO Design Guide. The traffic data required for this procedure are ESALs. The ESAL concept was developed using data assembled from the American Association of State Highway Officials (AASHO) Road Test (1958 to 1960), and it establishes a damage relationship between the reference 18,000-lb single axle with dual tires and different axle types carrying different loads. Design ESALs used for pavement design are, in effect, a cumulative traffic load summary statistic (over the design period) representing a mixed stream of axle types and loads converted into an equivalent number of 18,000-lb single-axle loads totaled over that design period.

The ADOT Pavement Management Section estimates design ESALs using the equation below: (Alavi and Senn, 1999)

Rigid ESALs:

$$\text{Yearly } ESAL_{seg} = 0.5*(AADT_{seg})*365*(\%Trucks)*[(\%VC4)*(ESAL4) + (\%VC5)*(ESAL5) + \dots\dots\dots + (\%VC13)*(ESAL13)] \qquad \text{(Eq. 1)}$$

Where

$ESAL_{seg}$ = total yearly one-way ESALs for all lanes for a network segment
$AADT_{seg}$ = average annual daily traffic collected by ADOT for the total two-way traffic for all lanes for a single network segment
%Trucks = percentage of trucks in the traffic system
%VC# = percentage of vehicle Classes 4 through 13 in the truck lane determined from weigh-in-motion (WIM) data
ESAL# = average ESAL of Classes 4 through 13 in the truck lane determined from WIM data

Flexible ESALs:

$$\text{Yearly } ESAL_{seg} = 0.5*(AADT_{seg})*365*(\%Trucks)*[(\%VC4)*(ESAL4) + (\%VC5)*(ESAL5) + \dots\dots\dots + 1.1*(\%VC9)*(ESAL9) + \dots\dots\dots\dots\dots\dots\dots + 1.1*\%(VC13)*(ESAL13) \qquad \text{(Eq. 2)}$$

Where

$ESAL_{seg}$ = total yearly one-way ESALs for all lanes for a network segment
$AADT_{seg}$ = average annual daily traffic collected by ADOT for the total two-way traffic for all lanes for a single network segment
%Trucks = percentage of trucks in the traffic system
%VC# = percentage of vehicle Classes 4 through 13 in the truck lane determined

from WIM data

ESAL# = average ESALs of Class 4 through 13 vehicles in the truck lane determined from WIM data

Vehicle Classes 9 through 13 were multiplied by a safety factor of 1.1 for flexible pavements.

In general, AADT and percent of trucks information is provided for each highway segment by the ADOT Multimodal Planning Division. VCD and ESALs-per-truck information is computed using data from the nearest appropriate WIM station. For highway segments with only volume counts data available, Alavi and Senn (1999) developed an overall ESAL per truck factor of 1.08 for flexible pavements, as shown in Table 1.

Table 1. Estimate of Overall ESALs-per-Truck Factor for ADOT (Alavi & Senn, 1999).

Vehicle Class	Average ESALs per Class	Average % Class	ESALs x Average % Class
4	0.87	4.8	0.04
5	0.21	21.8	0.04
6	0.82	10.4	0.09
7	1.64	2.4	0.04
8	0.61	16.1	0.10
9	1.71	36.1	0.62
10	1.31	2.0	0.03
11	1.86	5.1	0.09
12	0.97	0.6	0.01
13	3.73	0.5	0.02
		100	1.08

As part of this study, analyses were performed to update the ESAL truck factors developed in the early 1990s. This was accomplished using WIM data available from the FHWA Long-Term Pavement Performance (LTPP) program database (up to 2009 data).

Updated ESAL Truck Factors

Using the most recent WIM data from several Arizona LTPP project sites, a comprehensive analysis updated the ESAL truck factors published by Alavi and Senn (1999). Those LTPP sites are shown in Table 2. For each project selected, the following data were assembled:

- VCD over all years with data available.
- ALD for single, tandem, tridem, and quad axles over all years with data available.
- Mean number of single, tandem, tridem, and quad axles per truck over all years with data available.
- For computing ESALs, load equivalency factors (LEF) for 6-inch hot mix asphalt (HMA) and 9-inch portland cement concrete (PCC) pavement were assumed.
- Initial (base year) truck traffic = 1,500 trucks.
- Truck traffic annual linear growth rate = 3 percent.
- Analysis period = 20 years.

Table 2. LTPP Sites from Which WIM Data Were Assembled and Used for Analysis.

LTPP Site	Route No.	Rural or Urban	County	Direction	Milepost
0100	U.S.-93	Rural	Mohave	NB	53.6
0500	I-8	Rural	Pinal	EB	159
0600	I-40	Rural	Coconino	EB	202.2
1002	I-40	Rural	Yavapai	WB	135.4
1024	I-40	Rural	Yavapai	EB	107
6060	I-19	Rural	Santa Cruz	NB	14.9
6055	SR-85	Rural and Urban	Maricopa	SB	141.8
7079	SR-101	Urban	Maricopa	NB	11.9

Figure 1 presents VCD of the selected LTPP projects.

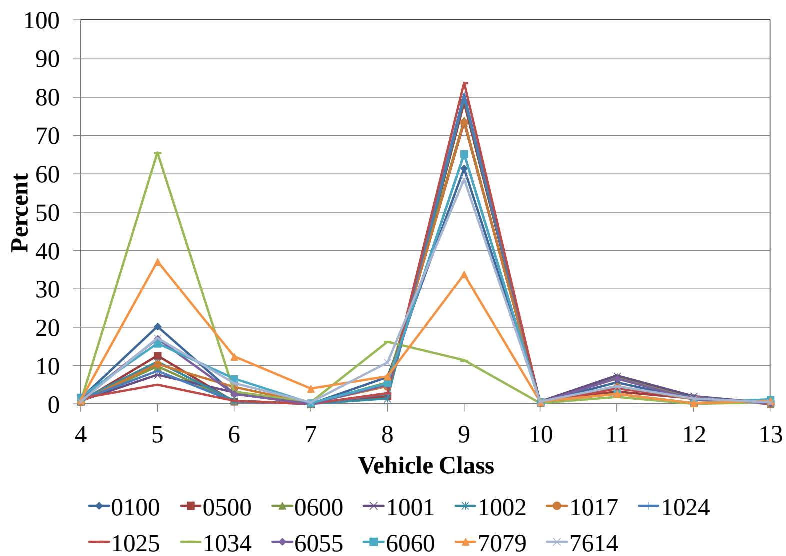

Figure 1. Illustration of Vehicle Class Distribution (FHWA Vehicle Classes 4 through 13) for the Selected LTPP Sites.

Using the assembled data, the following tasks were performed to obtain estimates of ESALs-per-truck factors:

- Estimate cumulative number of trucks (for each individual vehicle class) for the 20-year analysis period for all of the LTPP sites analyzed.
- Estimate cumulative number of flexible and rigid ESALs (for each individual vehicle class) for the 20-year analysis period for all of the LTPP sites analyzed.
- Mean ESALs-per-truck factors for each site, vehicle class, and pavement type.

The results are summarized in Table 3. Several comparisons for the estimated ESALs-per-truck factors are presented in Figure 2 through Figure 5.

Table 3. Computed ESALs for Several Sites in Arizona (ARA, 2004).

		Rural	Rural	Rural	Rural	Rural	Rural	Urban	Urban
LTTP Site		0100	0500	0600	1002	1024	6060	6055	7079
Route No.		U.S.-93	I-8	I-40	I-40	I-40	I-19	SR-85	SR-101
County			Pinal	Coconino	Yavapai	Yavapai	Santa Cruz	Maricopa	Maricopa
Direction		NB	EB	EB	WB	EB	NB	SB	NB
Milepost		53.6	159.0	202.2	135.4	107.0	14.9	141.8	11.9
PCC	4	1.36	1.09	0.83	1.99	1.79	0.82	0.59	0.74
	5	0.13	0.28	0.11	0.65	0.24	0.33	0.16	0.26
	6	1.07	0.67	0.78	1.23	0.00	0.79	0.99	0.99
	7								2.09
	8	0.37	0.40	0.36	1.33	0.69	1.19	0.98	1.02
	9	2.00	1.40	2.64	3.85	2.60	1.89	1.39	1.72
	10	1.85	2.25	1.98	4.10	2.36	4.31	1.24	
	11	1.73	1.50	2.31	2.95	1.78	1.09		2.36
	12	0.90	1.30	1.49	3.94	1.45	0.75	0.71	0.91
	13	1.34	9.18				2.83		3.90
AC	4	0.95	0.93	0.67	1.43	1.21	0.67	0.48	0.63
	5	0.12	0.27	0.11	0.60	0.23	0.32	0.16	0.25
	6	0.71	0.51	0.55	0.85		0.58	0.65	0.72
	7								1.38
	8	0.32	0.37	0.33	1.08	0.61	0.93	0.79	0.80
	9	1.28	0.92	1.62	2.32	1.56	1.18	0.88	1.11
	10	1.04	1.26	1.10	2.17	1.22	2.51	0.67	
	11	1.73	1.48	2.31	2.82	1.77	1.03		2.32
	12	0.81	1.19	1.40	3.32	1.32	0.65	0.65	0.86
	13	0.85	5.17				2.14		2.38

Note: No current data available for Class 7 trucks; previous values used.

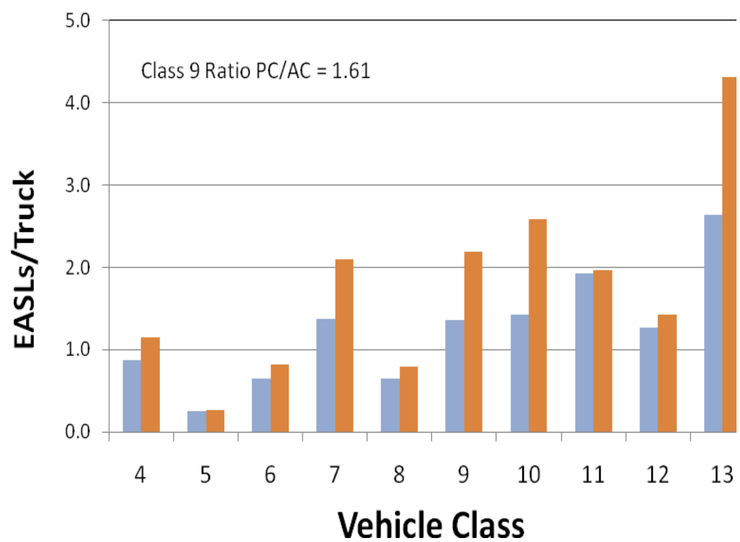

Figure 2. Comparison between Concrete and Asphalt Pavement ESALs.

The ratio of Class 9 trucks for concrete and asphalt is 1.61, which is a typical value.

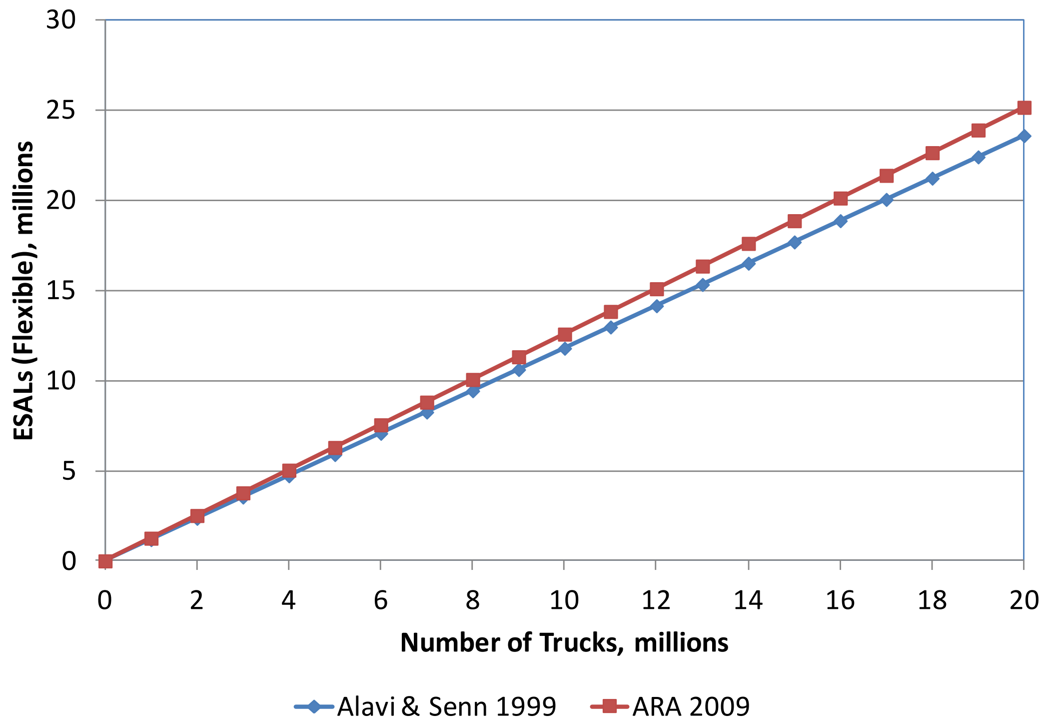

Figure 3. Comparison between Flexible Pavement ESALs Estimated Using Current 2009 Data (Labeled ARA 2009) and Older Data (Labeled Alavi and Senn 1999).

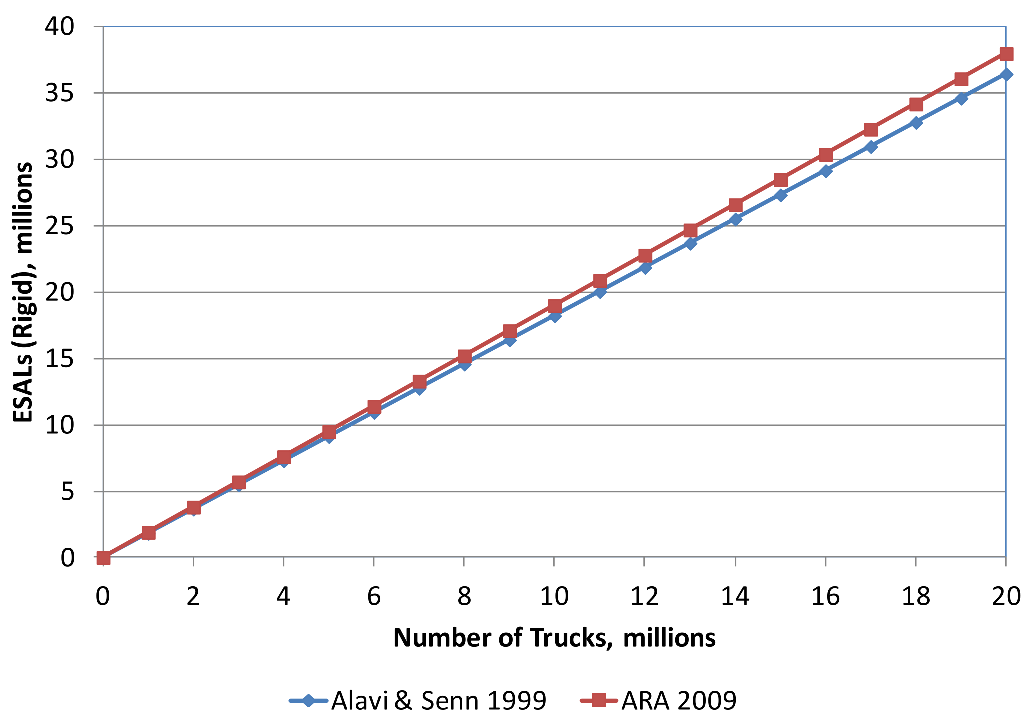

Figure 4. Comparison between Rigid Pavement ESALs Estimated Using Current 2009 Data (Labeled ARA 2009) and Older Data (Labeled Alavi and Senn 1999).

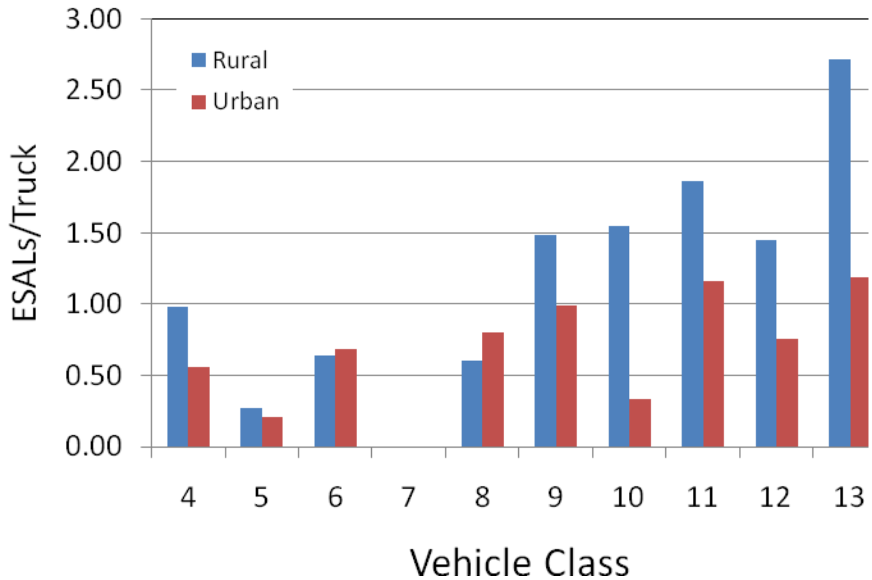

Figure 5. Comparison between Computed Rural and Urban Flexible Pavement ESALs-per-Truck Ratios.

The comparisons illustrated in Figure 2 through Figure 5 show the following:

- Truck factors have not changed significantly between 1999 and 2009.
- There were considerable differences in ESALs-per-truck factors for urban and rural sites, with rural factors being higher for most truck classes.

Appendix A presents a summary of current ADOT traffic data collection practices.

MEPDG TRAFFIC DATA REQUIREMENTS

The MEPDG software requires (1) base year traffic inputs and traffic volume adjustment factors and (2) general traffic inputs for pavement design. Descriptions of these traffic input requirements are presented in this section.

Which MEPDG Level of Input (1 through 3) is Recommended for Each Traffic Variable?

Levels of input to the MEPDG are described briefly as follows:

Level 1. Direct measure of the traffic input at the project site. Examples include portable WIM equipment on the project or visual counting of trucks across multiple lanes at a point on the project.

Level 2. Correlation of measured traffic inputs with field-measured traffic inputs. VCD based on specific highways or districts is an example.

Level 3. Mean statewide or regional traffic inputs. Examples would include ALD for a certain class of highway.

The recommended level of input depends on the significance that the input has on the pavement design (i.e., the impact of future pavement damage and distress predictions) and the ability to measure it.

Initial Year Traffic Inputs and Traffic Volume Adjustment Factors

Detailed descriptions of the required traffic inputs are presented in Table 4 through Table 9. An illustration of the distance from the outer edge of tire to the paint stripe input is shown in Figure 6, of the truck tractor wheelbase input in Figure 7, and various truck input variables in Figure 8. The column labeled "General Factors that Influence Input" in Tables 4 and 5 provides information on how the many traffic inputs vary across the highways of Arizona. Although a factor may influence an input, it does not necessarily indicate that the factor significantly impacts pavement design.

Summary of MEPDG Traffic Inputs Required

Table 10 presents recommended levels of input for all MEPDG traffic input variables based on national sensitivity analysis results and engineering experience.

Table 4. Initial Year Traffic Data.

MEPDG Traffic Input Variable	Description	Typical Source	General Factors that Influence Input
Analysis period or pavement design life	Time in years for which the new or rehabilitated pavement is being designed. Information used to project future traffic volumes.	Obtained from pavement design manual	Highway surface type, functional class
Date newly constructed or rehabilitated and date pavement is opened to traffic (each are first of month specified)	Date on which the new or rehabilitated pavement is opened for use to public traffic. Note that the pavement will be subjected to some form of construction traffic prior to this date, but this is not considered.	Project specific	Local climate, contracting policy, traffic management, construction type
Base year two-way AADTT	(a) Total volume of truck traffic (the total number of heavy vehicles [Classes 4 to 13] in the traffic stream) passing a point or segment of a road facility to be designed in both directions during a 24-hour period. (b) Determined for the opening to traffic year.	Obtained from on-site vehicle counts data (AVC, WIM)	Site specific. To obtain AADTT, the total AADT and percent of trucks must be known
Number of lanes in design direction	The number of lanes in the design direction. Represents the total number of lanes in one direction	Obtained from geometric design	Traffic volumes, highway capacity, congestion
Truck traffic direction distribution factor, also referred to as directional distribution factor	Percentage of all two-way AADTT in the design lane direction. It is used to quantify a difference in the overall volume of trucks in two directions. It is usually assumed to be 50 percent; however, this is not always the case as using a different route for transporting goods to and from some facilities is quite common.	Obtained from on-site vehicle counts data (AVC, WIM) in both directions	Site specific
LDF	It is the percentage of trucks in the design lane as a proportion of all truck traffic in the design lane direction. For two-lane, two-way highways (one lane in one direction), this factor is 1.0 because all truck traffic in any one direction must use the same lane.	Obtained from on-site vehicle counts data (AVC, WIM)	Number of lanes in design direction, entrance/exit ramps in area, AADT
Operational speed	Truck operational speed or average travel speed. A description of a detailed methodology used for determining operational speeds can be found in the Transportation Research Board *Highway Capacity Manual* or AASHTO's *Policy on Geometric Design of Highways and Streets* (often referred to as the "Green Book").	Arizona Department of Public Safety and Police databases	Close to speed limit, has little effect at higher speeds, but special steep grades will greatly have an effect, as well as signalized intersections

AADTT = annual average daily truck traffic; AVC = automatic vehicle classification; LDF = load distribution factor; other abbreviations and acronyms are as previously defined.

Table 5. Truck Traffic Volume Adjustment Factors.

Traffic Input Variable	Description	Source	Factors That Influence Input
MAF	MAF are used to distribute estimates of annual truck traffic volumes across the 12 months that make up a year. Note that although the MEPDG assumes an even distribution of annual traffic across 12 months (this implies that the same number of trucks was applied each month within a year, default MAF =1.0), in reality, truck volumes vary across the months. Distribution is performed separately for each vehicle class or truck type. The MEPDG assumes that MAF remains stable for the typical pavement design period.	Obtained from vehicle counts data (AVC, WIM)	Agricultural and industrial activities, seasonal climatic effects, functional class
Vehicle class distribution factors	VCD factors are used to distribute annual truck traffic volumes across the 10 truck types (FHWA vehicle Classes 4 through 13) considered by the MEPDG. The MEPDG assumes that VCD factors remain stable over the pavement design period. The MEPDG provides 17default VCD factors called TTC groups. These default TTC groups represented different mixes of truck traffic in a given traffic stream. A detailed definition and descriptions of the MEPDG TTC groups is presented in Table 6. VCD factors for each of the MEPDG default TTC groups is presented in Table 7, while recommendations for assigning TTC groups based on highway functional class is presented in Table 8.	Obtained from vehicle counts data (AVC & WIM)	Agricultural and industrial activities, functional class, land-use (urban or rural)
Truck hourly distribution factors	Used to distribute estimates of daily truck traffic volumes across the 24 hours that make up a day. The MEPDG assumes that truck hourly distribution factors remains stable over the typical pavement design period. The MEPDG provides default hourly truck traffic distribution values.	Obtained from hourly vehicle counts data (AVC, WIM)	Agricultural and industrial activities, functional class, land-use (urban or rural), desert conditions
Truck traffic growth factors (growth rate and type)	Used to forecast future truck traffic volumes (over the design period). For new highways/alignments, both are estimated using historical truck traffic volumes adjusted using trip generation models/factors. For existing highways/alignments, historical traffic volume counts for the given site is mostly adequate. Growth type can be none (zero percent growth), linear, or compound. The rate of truck traffic growth is the average annual percent change in truck traffic over the analysis period. Note that both truck growth rate and type can be assigned individually for each of the 10 truck types/vehicle classes considered by the MEPDG.	Obtained from historical vehicle counts data (AVC, WIM)	Economic, (agricultural, industrial, recreational activities), climate, land-use (urban or rural), terrain

TTC = truck traffic classification; other abbreviations and acronyms are as previously defined.

Table 5. Truck Traffic Volume Adjustment Factors, continued.

Traffic Input Variable	Description	Source	Factors That Influence Input
Axles per truck	Described as the mean number of single, tandem, tridem, and quad axles per vehicle class/truck type. It is estimated for each of the 10 truck types/vehicle classes considered by the MEPDG. It is used to estimate the total number of single, tandem, tridem, and quad axles applied at a given site over the design period.	Obtained from WIM site data	Vehicle classification, truck size, and weight regulations
Axle load distribution (ALD) factors	Used to distribute estimates of single, tandem, tridem, and quad axles over up to 40 load intervals for each axle type as follows: • Single axles – 3,000 lb to 40,000 lb at 1,000-lb intervals. • Tandem axles – 6,000 lb to 80,000 lb at 2,000-lb intervals. • Tridem and quad axles – 12,000 lb to 102,000 lb at 3,000-lb intervals. The MEPDG allows for separate estimates of ALD factors for the combination of truck type/vehicle class and month of the year. The MEPDG software provides default normalized percentage of axle weights for each vehicle class that falls within each weight range for each month of the year. Default values were developed using LTPP traffic data.	Obtained from WIM site data	Axle type, vehicle classification, truck size, and weight regulations; economic, (agricultural, industrial, and recreational activities) and land-use (urban or rural)

Table 6. Descriptions of MEPDG Default TTC Groups (ARA, 2004).

Buses in Traffic Stream	Commodities Being Transported by Type of Truck		TTC Group No.
	Multi-Trailer	Single-Trailers and Single-Segments	
Low to none (<2%)	Relatively high amount of multi-trailer trucks (>10%)	Predominantly single-trailer trucks	5
		High percentage of single-trailer trucks, but some single-segment trucks	8
		Mixed truck traffic with a higher percentage of single-trailer trucks	11
		Mixed truck traffic with approximately equal percentages of single-segment and single-trailer trucks	13
		Predominantly single-segment trucks	16
	Moderate amount of multi-trailer trucks (2-10%)	Predominantly single-trailer trucks	3
		Mixed truck traffic with a higher percentage of single-trailer trucks	7
		Mixed truck traffic with approximately equal percentages of single-segment and single-trailer trucks	10
		Predominantly single-segment trucks	15
Low to moderate (>2%)	Low to none (<2%)	Predominantly single-trailer trucks	1
		Predominantly single-trailer trucks, but with a low percentage of single-segment trucks	2
		Predominantly single-trailer trucks with a low to moderate amount of single-segment trucks	4
		Mixed truck traffic with a higher percentage of single-trailer trucks	6
		Mixed truck traffic with approximately equal percentages of single-segment and single-trailer trucks	9
		Mixed truck traffic with a higher percentage of single-segment trucks	12
		Predominantly single-segment trucks	14
Major bus route (>25%)	Low to none (<2%)	Mixed truck traffic with approximately equal single-segment and single-trailer trucks	17

Table 7. Default Vehicle Class Distribution for Each MEPDG TTC Group (ARA, 2004).

TTC Group	TTC Description	Vehicle/Truck Class Distribution (percent)									
		4	5	6	7	8	9	10	11	12	13
1	Major single-trailer truck route (Type I)	1.3	8.5	2.8	0.3	7.6	74.0	1.2	3.4	0.6	0.3
2	Major single-trailer truck route (Type II)	2.4	14.1	4.5	0.7	7.9	66.3	1.4	2.2	0.3	0.2
3	Major single- and multi-trailer truck route (Type I)	0.9	11.6	3.6	0.2	6.7	62.0	4.8	2.6	1.4	6.2
4	Major single-trailer truck route (Type III)	2.4	22.7	5.7	1.4	8.1	55.5	1.7	2.2	0.2	0.4
5	Major single- and multi-trailer truck route (Type II).	0.9	14.2	3.5	0.6	6.9	54.0	5.0	2.7	1.2	11.0
6	Intermediate light and single-trailer truck route (Type I)	2.8	31.0	7.3	0.8	9.3	44.8	2.3	1.0	0.4	0.3
7	Major mixed truck route (Type I)	1.0	23.8	4.2	0.5	10.2	42.2	5.8	2.6	1.3	8.4
8	Major multi-trailer truck route (Type I)	1.7	19.3	4.6	0.9	6.7	44.8	6.0	2.6	1.6	11.8
9	Intermediate light and single-trailer truck route (Type II)	3.3	34.0	11.7	1.6	9.9	36.2	1.0	1.8	0.2	0.3
10	Major mixed truck route (Type II)	0.8	30.8	6.9	0.1	7.8	37.5	3.7	1.2	4.5	6.7
11	Major multi-trailer truck route (Type II)	1.8	24.6	7.6	0.5	5.0	31.3	9.8	0.8	3.3	15.3
12	Intermediate light and single-trailer truck route (Type III)	3.9	40.8	11.7	1.5	12.2	25.0	2.7	0.6	0.3	1.3
13	Major mixed truck route (Type III)	0.8	33.6	6.2	0.1	7.9	26.0	10.5	1.4	3.2	10.3
14	Major light truck route (Type I)	2.9	56.9	10.4	3.7	9.2	15.3	0.6	0.3	0.4	0.3
15	Major light truck route (Type II)	1.8	56.5	8.5	1.8	6.2	14.1	5.4	0.0	0.0	5.7
16	Major light and multi-trailer truck route	1.3	48.4	10.8	1.9	6.7	13.4	4.3	0.5	0.1	12.6
17	Major bus route	36.2	14.6	13.4	0.5	14.6	17.8	0.5	0.8	0.1	1.5

Table 8. Recommendations for Selecting MEPDG TTC Groups Based on Highway Functional Class (ARA, 2004).

Highway Functional Class Descriptions	Applicable Truck Traffic Classification Group Number
Principal arterials – Interstate and defense routes	1,2,3,4,5,8,11,13
Principal arterials – Intrastate routes, including freeways and expressways	1,2,3,4,6,7,8,9,10,11,12,14,16
Minor arterials	4,6,8,9,10,11,12,15,16,17
Major collectors	6,9,.12,14,15,17
Minor collectors	9,12,14,17
Local routes and streets	9,12,14,17

Table 9. Truck Traffic Volume Other Adjustment Factors.

Traffic Input Variable	Description	Source	Factors That Influence Input
Mean Wheel Location (from Lane Marking) and Truck Traffic Wander	Mean wheel location is the mean distance from the outer edge of the wheel to the lane longitudinal pavement marking. Truck traffic wander is the standard deviation of the distribution of actual wheel locations (see Figure 6) as a truck travels along the traffic lane. MEPDG uses a default mean wheel location of 18 inches and a mean truck traffic wander standard deviation of 10 inches. These values were used in the national calibration. They should not be changed without measured data indicating other values. Information on mean wheel location and traffic wander is obtained from actual field measurements. A review of past literature indicates very little information available on both mean wheel location and associated variability. Default mean wheel location values of 18 inches and truck traffic wander of 10 inches is provided by the MEPDG based on information presented in national literature.	Past research national/local studies. Can be measured through use of video camera, spots on pavements, etc.	Lane width, shoulder type, deep valleys/drop offs, mountain sides, etc.
Truck Wheelbase Distribution	Distance from the steering axle to the first next axle for trucks Class 8 and above is called the wheelbase. Three levels are specified as short, medium, and long. This input affects top-down cracking of JPCP. Figure 7 illustrates the truck wheelbase.	WIM data	This factor has not been measured generally before, but is affected by the length of haul of trucks on the highway
Axle Configuration	Axle configuration inputs required by the MEPDG are as described in Figure 8.	Manufacturers' specifications, measurements of individual trucks at WIM sites, etc.	Legal requirements

JPCP = jointed plain concrete pavement. All other abbreviations and acronyms are as previously defined.

Table 9. Truck Traffic Volume Other Adjustment Factors, continued.

Traffic Input Variable	Description	Source	Factors That Influence Input
Tire Pressure	This input is the typical hot rolling tire pressure of FHWA vehicle Class 4 through 13 trucks. The MEPDG assumes a default hot tire pressure of 120 psi. The hot inflation pressure is typically approximately 10 to 15 percent greater than the cold inflation pressure. A mean tire inflation pressure of 120 psi was used in the national calibration and should not be changed without measured data indicating another value. Description	Manufacturers' specifications, measurements of individual trucks at rest areas, etc.	Manufacturers' specifications and recommendations

Figure 6. Example of Distance from the Outer Edge of the Wheel to the Pavement Marking.

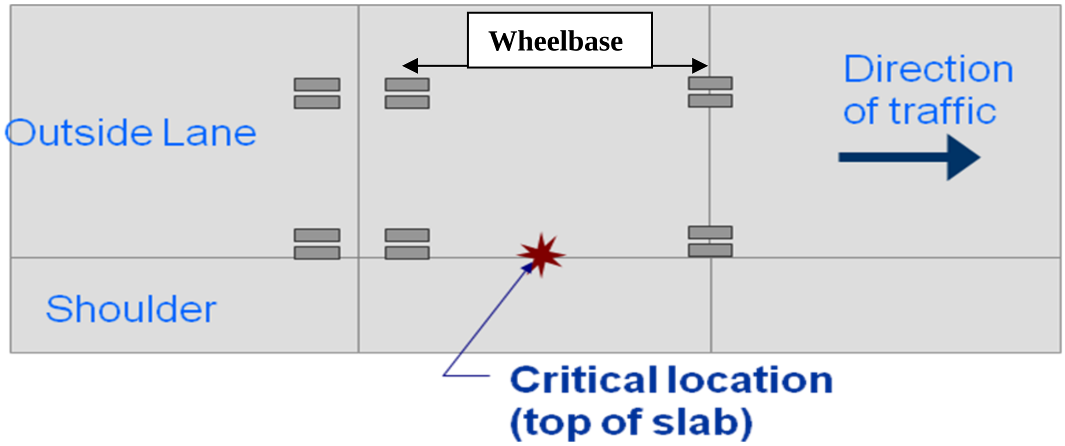

Figure 7. Illustration of Truck Wheelbase Definition.

The percentage of short, medium, and long wheelbase truck tractors is a critical factor in MEPDG input.

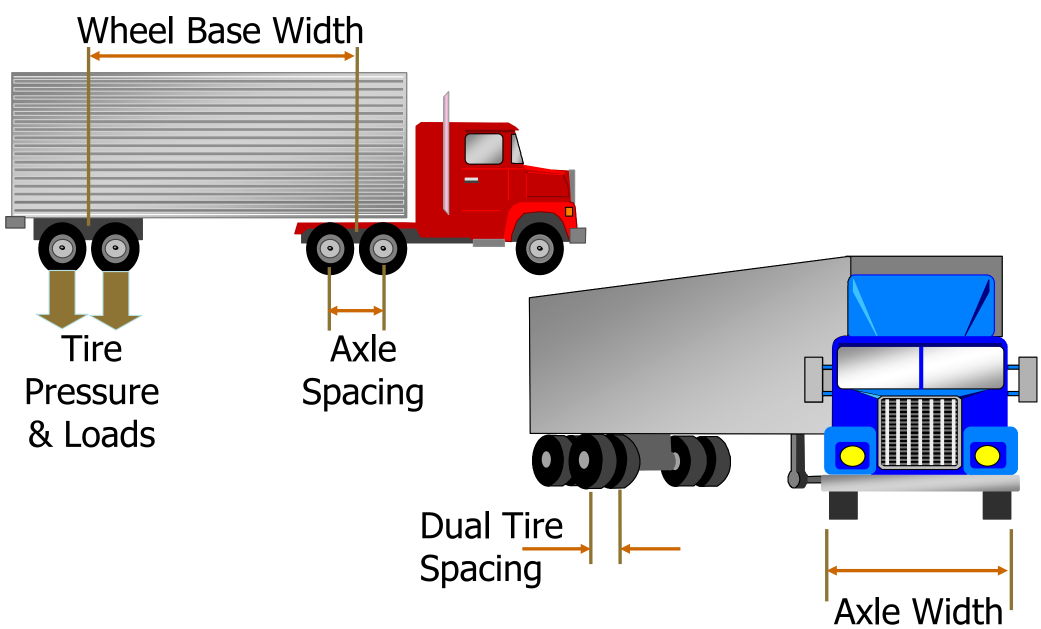

Figure 8. Axle Wheel Configuration Inputs (Average Axle Width Edge to Edge), Dual Tire Spacing, Axle Wheel Spacing (Tandem, Tridem, and Quad Axles).

Table 10. Recommended Level of Input for MEPDG Traffic Input Variables.

MEPDG Traffic Input Variable	Overall Impact on Pavement Design	Level of Effort	Ability to Measure?	Recommended Level of Input
Analysis period or pavement design life	High	Low	Yes	Level 1 (site specific)
Date newly constructed or rehabilitated and date pavement is opened to traffic (each are first of month specified)	Moderate	N/A (best estimate based on construction expectations)	No	Level 2/3 (estimate only)
Base year two-way average initial AADTT	High	Moderate	Yes	Level 1 (site specific)
Number of lanes in design direction	High	Low	Yes	Level 1 (site specific)
Truck traffic direction distribution factor, also referred to as directional distribution factor	Low	Moderate	Yes	Level 2/3 (site specific)
LDF	Moderate	High (requires an on-site AVC across all lanes with an appropriate sample)	Yes	Level 2/3 (site specific)
Operational speed	Low, however if speed < 30 mph, can be moderate to high for HMA	Moderate (requires an AVC on-site with an appropriate sample)	Yes	Level 2/3 (based on speed limit and topography)
MAF	Low, however could be moderate if significant seasonal variations exist	High (requires on-site AVC over an entire year)	Yes	Level 2/3 (based on statewide defaults)
Vehicle class distribution factors	Moderate, however could be high if special recreational or industrial conditions exist	Moderate (requires an on-site AVC with an appropriate sample)	Yes	Level 1 or 2/3 based on functional class (e.g., urban versus rural, principal arterials versus collectors and minor arterials)
Truck hourly distribution factors	HMA: None JPCP: Low	Moderate (requires an on-site AVC with an appropriate sample)	Yes	Level 2/3 based on functional class (e.g., urban versus rural, principal arterials versus collectors and minor arterials)

Table 10. Recommended Level of Input for MEPDG Traffic Input Variables, continued.

MEPDG Traffic Input Variable	Overall Impact on Pavement Design	Level of Effort	Ability to Measure?	Recommended Level of Input
Truck traffic growth factors (growth rate and type)	High	Moderate (requires historical truck volume data and expectations of future land use, population growth, etc.)	No, past growth only	Level 1 (site-specific historical traffic and other data)
Axles per truck	Low	Moderate (requires AVC or WIM data with an appropriate sample)	Yes	Level 2/3 (statewide or national defaults)
ALD factors	Moderate	High (requires WIM data with an appropriate sample)	Yes	Level 2/3 based on urban versus rural versus long desert haul
Mean wheel location (from lane marking to outer edge of wheel)	HMA: None JPCP: Moderate to high	High (requires an on-site video measurement system or manual observations)	Yes, pavement markings and observations from top of bridge	Level 2/3 (statewide or national defaults)
Truck traffic lateral wander within lane	High	High (requires an on-site video measurement system or manual observations)	Yes, same as wheel location	Level 2/3 (statewide or national defaults)
Axle spacings	Low	Moderate, WIM equipment	Yes	Level 2/3 (statewide or national defaults)
Tire pressure	HMA: Moderate JPCP: Low	High	Yes	Level 2/3 (statewide or national defaults)
Truck wheelbase	HMA: None JPCP: Moderate	Moderate (requires WIM)	Yes	Level 2/3 (statewide or national defaults)

CHAPTER 3. FRAMEWORK FOR DEVELOPING THE ADOT MEPDG TRAFFIC DATA INPUT SYSTEM

The framework for developing the ADOT MEPDG traffic data input system is presented below:

1. Traffic data identification and assembly.
2. Traffic data processing, review, identification of anomalies and errors, and data cleansing.
3. Statistical analysis to assign measured traffic data into subsets or natural groupings (called clusters) with similar characteristics and distribution patterns.
4. Determination of optimum number of clusters within Arizona for each of the following MEPDG traffic data types:
    a. MAF.
    b. Hourly truck distribution.
    c. VCD (for a given highway section, VCD affects the computation of the number of single, tandem, tridem, and quad axles that pass over the design period and is thus an important MEPDG input).
    d. ALD factors.
    e. Number of axles per truck.
5. Performance of sensitivity analysis and interpretation of sensitivity analysis results.
6. Development of default statewide Level 2/3 traffic inputs for the MEPDG implementation in Arizona.

The following sections describe these steps in greater detail.

STEP 1: TRAFFIC DATA IDENTIFICATION AND ASSEMBLY

Several government entities monitor and collect traffic data in Arizona, leading to significant variations in traffic data collection practices, data accuracy, and data storage practices and availability. For the SPR-672 study, a comprehensive effort was required to identify the historic traffic data available in Arizona.

A thorough review of ADOT and other state entities’ business practices identified at least three entities that could potentially supply the traffic data required for this study:

- ADOT Motor Vehicle Division (MVD).
- ADOT Multimodal Planning Division (MPD).
- ADOT Arizona Transportation Research Center (ATRC).

The researchers made an initial effort to obtain Arizona traffic data and review the data for usefulness. AVC data collected at various sites across the state were obtained from the MVD. Data from 10 WIM sites and eight AVC sites across the state were available from the ADOT Research Center through the FHWA LTPP program. Although the MPD collects WIM data at port-of-entry (POE) sites across the state, efforts to obtain these data were not successful.

All of the data obtained were assembled in a project database. The following sections provide detailed descriptions of the data assembled.

Summary of Data Assembled from the MVD

From the MVD, the researchers obtained VCD data from 21 sites across the state. Data obtained from all of the sites applied the FHWA 13-bin classification scheme. Table 11 presents general information and characteristics of the sites from which VCD data were available. Figure 9 presents a map showing the locations of the 21 automated traffic recorder (ATR) sites, illustrating the statewide coverage of the representative ATR sites.

Table 11. Arizona ATR Sites Used in the Analysis of VCD.

Site	Lanes	County	Route	Functional Class	Latitude	Longitude
100010	4	Yuma	I-08	Rural Principal Arterial - Interstate	32.6780	-114.0380
100070	4	La Paz	I-10	Rural Principal Arterial - Interstate	33.6610	-114.0060
100139	6	Pima	I-10	Urban Principal Arterial - Interstate	32.4540	-111.2050
100188	4	Cochise	I-10	Rural Principal Arterial - Interstate	32.3410	-109.5680
100327	4	Mohave	I-15	Rural Principal Arterial - Interstate	36.9800	-113.6540
100473	4	Pima	I-19	Urban Principal Arterial - Interstate	32.1710	-110.9850
100537	4	Coconino	I-40	Rural Principal Arterial - Interstate	35.2300	-111.8100
100541	4	Coconino	I-40	Urban Principal Arterial - Interstate	35.1730	-111.6470
100767	2	La Paz	SR 72	Rural Major Collector	33.8530	-113.9070
100800	6	Pima	SR 77	Urban Principal Arterial - Other	32.3430	-110.9770
100854	2	Pinal	SR 79	Rural Minor Arterial	33.1550	-111.3560
100922	4	Maricopa	SR 85	Rural Principal Arterial - Other	33.2630	-112.6340
101113	2	Yuma	SR 95	Rural Principal Arterial - Other	33.7580	-114.2170
101248	10	Maricopa	SR 101	Urban Principal Arterial - Other Freeways or Expressways	33.4570	-111.8900
101602	2	Maricopa	SR 303	Urban Principal Arterial - Other Freeways or Expressways	33.6360	-112.4180
101622	4	Pinal	SR 347	Rural Minor Collector	33.0920	-112.0340
101849	4	Maricopa	U.S. 60	Rural Principal Arterial - Other	33.6890	-112.4150
101928	2	Navajo	U.S. 60	Rural Minor Arterial	34.2090	-110.0780
102068	4	Coconino	U.S. 89	Urban Principal Arterial - Other	35.2590	-111.5510
102094	2	Yavapai	U.S. 93	Rural Principal Arterial - Other	34.0120	-112.7890
102230	2	Graham	U.S. 191	Rural Major Collector	32.7960	-109.5400

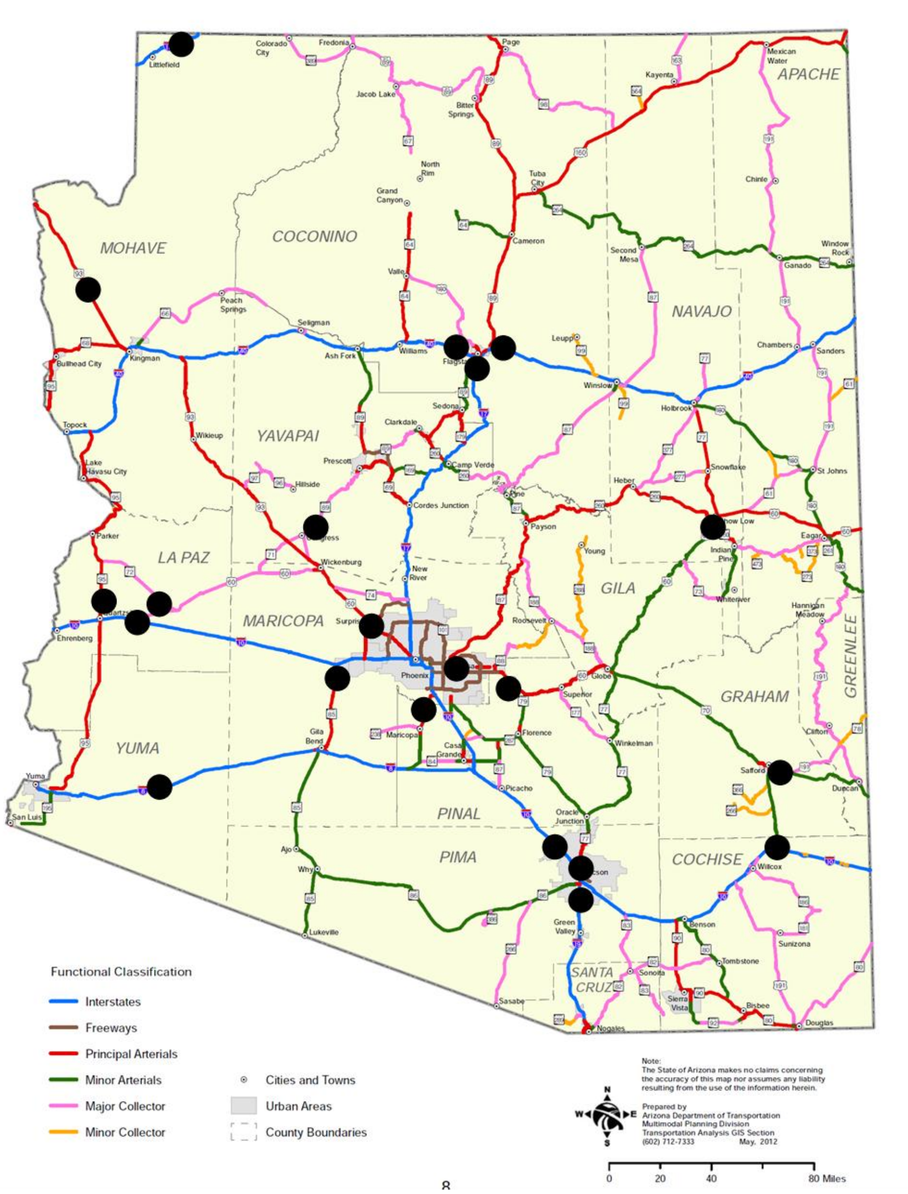

Figure 9. Locations of the Arizona ATR Data Collection Sites.

Summary of Data Assembled from the LTPP Regional Center

The LTPP Western Regional Center collects WIM and AVC data in two Canadian provinces and 12 states in the United States, including Arizona. The LTPP program uses the raw AVC and WIM data to compute several of the parameters that are required MEPDG traffic inputs.

For this study, various MEPDG computed traffic inputs were estimated using raw data from 10 Regional Center WIM sites and eight Regional Center AVC sites. The data were obtained from the LTPP traffic and inventory databases (Standard Data Release 23.0, January 2009). Table 12 lists the LTPP data tables from which traffic and related data were obtained.

Table 12. LTPP Data Tables from Which Data Were Obtained for Analysis.

LTPP Data Table	Description
TRF_MEPDG_MONTH_ADJ_FACTR	This table contains adjustment factors for ADTT for each truck class by month based on either classification or weight monitoring data as indicated by the code contained in the TRF_DATA_TYPE field. A value of four in the TRF_DATA_TYPE field indicates the estimate was based on only classification data, and a value of seven indicates the estimate was based on only weight data.
TRF_MEPDG_HOURLY_DIST	This table contains annual average hourly distribution of trucks by hour in the LTPP lane based on classification data. The computations were performed following the algorithm contained in the MEPDG developed under NCHRP project 1-37A. The table contains data from only SPS_1, -2, -5 and -6 sites, which have passed a validation study under the SPS WIM Pooled Fund study. Only years with at least 210 days of classification data are included.
TRF_MEPDG_AX_DIST_ANL	This table contains normalized axle distributions by month, truck class, and axle group. Records in this table are generated from the MM_AX table in the LTPP traffic database that contain at least 210 days of WIM data in that calendar year. The monthly distribution bin counts are based on day of the week averages. The 4,000-lb weight bins for quad axles in the LTPP traffic database are reduced to the MEPDG 3,000-lb weight bins using an assumption that the 4,000-lb bins have a uniform distribution between adjacent bins.
TRF_MEPDG_AX_PER_TRUCK	This table contains the annual average number of number of axles by vehicle class and axle type by year. This is computed from the axles actually weighed as summed in the TRF_MONITOR_LTPP_LN table. In this beta release of data, records with average numbers of axles per truck less than 0.1 or greater than five have a RECORD_STATUS=C.
TRF_MEPDG_VEH_CLASS_DIST	This table contains the percentage of trucks by vehicle class within the truck population (FHWA Classes 4 through 13) in the LTPP lane-based classification, weight, or a combination of classification and weight data as indicated by the code contained in the TRF_DATA_TYPE field. For some sections, up to three different estimates are provided. Estimates are provided by year. On SPS sites, the estimates are provided using a project-level Strategic Highway Research Program (SHRP) ID. In most cases, it is a good assumption that the project level traffic applies to all test sections on the project. The SPS_PROJECT_STATIONS table can be used to identify sites where test sections are located in both directions of travel on one SPS project.
INV_ID	This table contains section location coordinates by route number and milepost, longitude and latitude, direction of travel, identification if the location is part of the FHWA Highway Performance Monitoring System, and county/parish name. Location information is provided in this table for sections classified in a GPS experiment or an SPS maintenance and rehabilitation experiment where CONSTRUCTION_NO = 1 in the EXPERIMENT_SECTION table. Location information for SPS projects that is based on construction of a new pavement structure is stored in the SPS_ID table.

NCHRP = National Cooperative Highway Research Program; SPS = Specific Pavement Studies; GPS = General Pavement Studies; all other abbreviations and acronyms are as previously defined.

General information and characteristics of the LTPP sites with MEPDG traffic data available are presented in Table 13. A map showing the locations of the 32 LTPP projects is presented in Figure 10, which illustrates the statewide coverage of the representative LTPP sites. Two sets of LTPP pavement sites—0100, 0900, and A900 located on U.S. 93; and 1007 and B900 located on I-10—were so geographically close to each other that traffic data from these project sites were deemed the same.

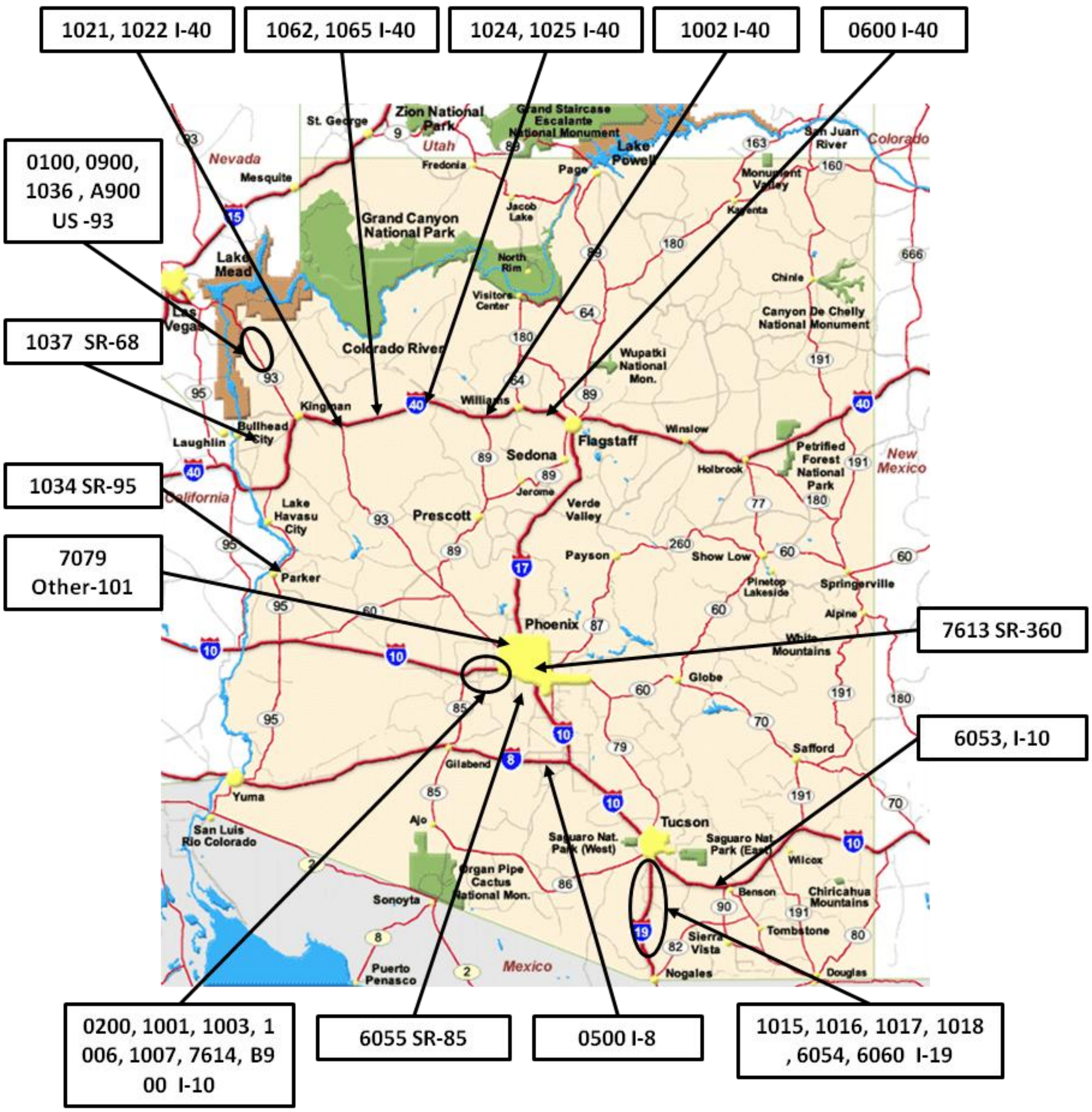

Figure 10. LTPP Sites across Arizona.

Table 13. Detailed Description of LTPP Sites in Arizona.

No.	SHRP ID	Total Lanes (Two-Way)	Pavement Type	County	FHWA Functional Class*	Travel Direction	Milepost	Route No.
1	0100	4	HMA	Mohave	RPA - US	Northbound	52.62	U.S. 93
2	0200	4	PCC	Maricopa	RPA - I	Eastbound	109	I-10
3	0500	4	HMA	Pinal	RPA - I	Eastbound	159.01	I-8
4	0600	4	HMA	Coconino	RPA - I	Eastbound	202.16	I-40
5	0900		HMA	Mohave	RPA - US	Northbound	60.14	U.S. 93
6	1001	4	HMA	Maricopa	RPA - I	Westbound	123.34	I-10
7	1002	4	HMA	Yavapai	RPA - I	Westbound	145.37	I-40
8	1003	4	HMA	Maricopa	RPA - I	Westbound	98.53	I-10
9	1006	4	HMA	Maricopa	RPA - I	Westbound	110.65	I-10
10	1007	4	HMA	Maricopa	RPA - I	Westbound	115.43	I-10
11	1015	4	HMA	Santa Cruz	RPA - I	Southbound	18.33	I-19
12	1016	4	HMA	Santa Cruz	RPA - I	Southbound	24.17	I-19
13	1017	4	HMA	Pima	RPA - I	Northbound	32.98	I-19
14	1018	4	HMA	Pima	RPA - I	Southbound	36.2	I-19
15	1021	4	HMA	Mohave	RPA - I	Westbound	72.87	I-40
16	1022	4	HMA	Mohave	RPA - I	Westbound	77.69	I-40
17	1024	4	HMA	Yavapai	RPA - I	Eastbound	106.95	I-40
18	1025	4	HMA	Yavapai	RPA - I	Westbound	113.03	I-40
19	1034	2	HMA	La Paz	RMA	Southbound	145.25	SR 95
20	1036	4	HMA	Mohave	RPA - US	Northbound	27.64	U.S. 93
21	1037	2	HMA	Mohave	RPA - SR	Eastbound	1.4	SR 68
22	1062	4	HMA	Mohave	RPA - I	Westbound	92.75	I-40
23	1065	4	HMA	Yavapai	RPA - I	Eastbound	97.72	I-40
24	6053	4	HMA over HMA	Pima	RPA - I	Eastbound	292.89	I-10
25	6054	4	HMA over HMA	Santa Cruz	RPA - I	Southbound	52.25	I-19
26	6055	2	HMA over HMA	Maricopa	PRA - SR	Southbound	141.84	SR 85
27	6060	4	HMA over HMA	Santa Cruz	RPA - I	Northbound	14.88	I-19
28	7079	6	CRCP	Maricopa	UPA – O	Northbound	11.9	101
29	7613	6	JPCP	Maricopa	UPA – SR	Westbound	180	SR 360
30	7614	6	JPCP	Maricopa	RPA – I	Westbound	130.5	I-10
31	A900	4	HMA	Mohave	RPA - US	Northbound	60.14	U.S. 93
32	B900	4	HMA	Maricopa	RPA - I	Westbound	122.29	I-10

RPA-I: Rural Principal Arterial-Interstate; RLC: Rural Local Collector; RPA-US: Rural Principal Arterial-US Route; RMA: Rural Minor Arterial; RMC: Rural Major Collector; UPA-State: Urban Principal Arterial-State Route; UPA-US: Urban Principal Arterial-US Route; CRCP = continuously reinforced concrete pavement; HMA = hot mixed asphalt.

STEP 2: TRAFFIC DATA PROCESSING, REVIEW, IDENTIFICATION OF ANOMALIES AND ERROR, AND DATA CLEANSING

The reviewers performed step 2 based on published recommendations for reviewing traffic data (AASHTO, 2009; FHWA, 2009) as well as engineering judgment.

Data Processing

Data processing consisted of the following:

- MVD raw AVC and WIM data:
    - Raw data in electronic format were collected by the MVD. The raw data were processed using ADOT-licensed TRADAS software to create Traffic Monitoring Guide classification (C-card) and weight (W-card) files (FHWA, 2001).
    - The MVD provided the Traffic Monitoring Guide C-card and W-card files to the researchers.
    - The C-card and W-card files were processed using ARA's Advanced Traffic Loading and Analysis System (ATLAS) software. The essential features of ATLAS that were used for data processing were:
        - Traffic import module that was used to process and read the Traffic Monitoring Guide C-card and W-card data.
        - Traffic export module that was used to create site-specific MEPDG traffic input files (vehicle classification, ALD, MAF, 24-hour truck counts, and growth rates based on historical data), a reference library database, and ESAL estimates.
        - Data analysis module to perform quality checks on the historical traffic data and perform data filtering on a site-by-site basis and by truck class.
    - Outputs from the ATLAS software was assembled in a project database for further review and consisted of the following data types for each site analyzed:
        - AADTT (by site, direction, lane number, year, and vehicle class).
        - Hourly truck distribution (by site, direction, and lane number).
        - Hourly truck volume (by site, direction, lane number, year, month, day, and week).
        - VCD (by site, direction, lane number, year, and month).
        - Wheelbase of truck Classes 8 through 13 was determined from two Arizona LTPP WIM sites. The results obtained for short, medium, and long truck wheelbases were very similar from site to site; however, additional data are desirable to provide a more accurate estimate. The results are summarized in Table 14.

Table 14. Arizona Truck Wheelbase Distribution at Two Sites (Classes 8 through 13 Only).

Wheelbase Type	Wheelbase Length (feet)	Percent of Trucks (Classes 8 through 13)
Short	10.0 to 13.4	11
Medium	13.5 to 16.5	17
Long	16.6 to 20.0	72

- Field measurements:
    - ARA staff collected data on lateral wander (within a traffic lane) of trucks. This was done by making small marks at 6-inch spacings across the outer wheel path near an overhead bridge. Observations of the lateral offset of the outer edge of the truck/tire from the paint strip were made from the bridge. Data were obtained from four sites for a significant number of trucks. The mean and standard deviation of truck wander was computed and combined from all four sites.
- Regional Center LTPP data:
    - LTPP traffic data were received post-processing. The LTPP data received did not contain "raw" traffic data measurements (counts, weights, classification, etc.), but rather estimates of various MEPDG traffic input variables computed from the LTPP AVC and WIM sites in Arizona. (If required, the raw data can be obtained directly from LTPP.) Also, as part of the data processing, the LTPP data received various levels of quality assurance checks to ensure accuracy and reasonableness.

The processed MVD and LTPP traffic data were used to compute required MEPDG traffic inputs and put in a database for further review, identification of anomalies and error, and cleansing.

Data Review

The MVD and LTPP traffic data were subjected to rigorous quality control checks. Review and identification of anomalies consisted of:

- Developing plots for use in accessing reasonableness of data and trends in data over the years:
    - Plot of percent truck versus hour of the day (midnight through 11:00 pm) for all years with data available for a given site.
    - Plot of MAF versus month of the year (January through December) for all years with data available for a given site.
    - Plot of percent of trucks versus vehicle class (Classes 4 through 13) for all years with data available for a given site.
    - Plot of number of single, tandem, tridem, and quad axles per truck versus vehicle class (Classes 4 through 13) for all years with data available for a given site.
    - Plot of percent single, tandem, tridem, and quad trucks versus axle load (e.g., for single axles 3,000 lb to 41,000 lb in 1,000-lb increments) for all years with data available for a given site.

- Review of the plots for consistency, accuracy, and completeness (note that this did not involve basic quality assurance/quality control checks of the raw traffic data, but rather a check of MEPDG computed traffic inputs). Examples of the checks that were performed are as follows:
  - Whether hourly truck distribution factors add up to 100 percent or if the MAFs add up to 12.
  - Occurrences of long zero or “flat” periods in the monthly adjustment or hourly distribution data (several months or hours with no data).
  - Whether plots of axle loads versus the percentage of all axles display distinct peaks as expected, and whether the percentage of all axles of a given axle type add up to 100.
  - Was there consistency in trends over the years with data?

Identification of Anomalies and Error

The plots developed for each site with data were reviewed and checked for reasonableness and consistency. Also, basic statistics such as mean, standard deviation, variance, etc., were computed to identify outliers and potential errors.

Data points and overall trends found to be inconsistent with expected trends were flagged. A tremendous effort was made during review to distinguish between unusual data, correct data, and incorrect data. For example, both breakdown in equipment and a special event could cause significant changes in expected traffic patterns. Generally, such data were identified and removed from the database, as the specific cause of the unusual data pattern was not important. Other causes of unusual traffic patterns were construction of new freeways in the Phoenix area that may have resulted in significant change in VCD and the stoppage of heavy trucks from using U.S. 93 since September 2001, resulting in significant change in VCD after 2001 on that highway (see Figures 11 and 12). Plots of all of the key MEPDG inputs for all sites with traffic data assembled are presented in Appendixes B through F. Examples of the plots used in data review and identification of anomalies are presented in Figures 11 through 17.

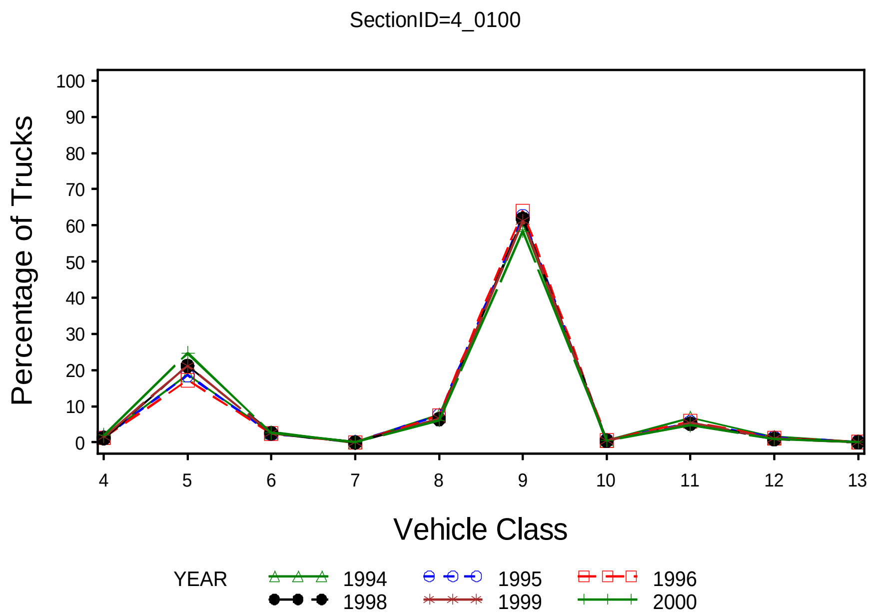

Figure 11. Plot of Vehicle Class Distribution for Site 4_0100 (Prior to September 2001).

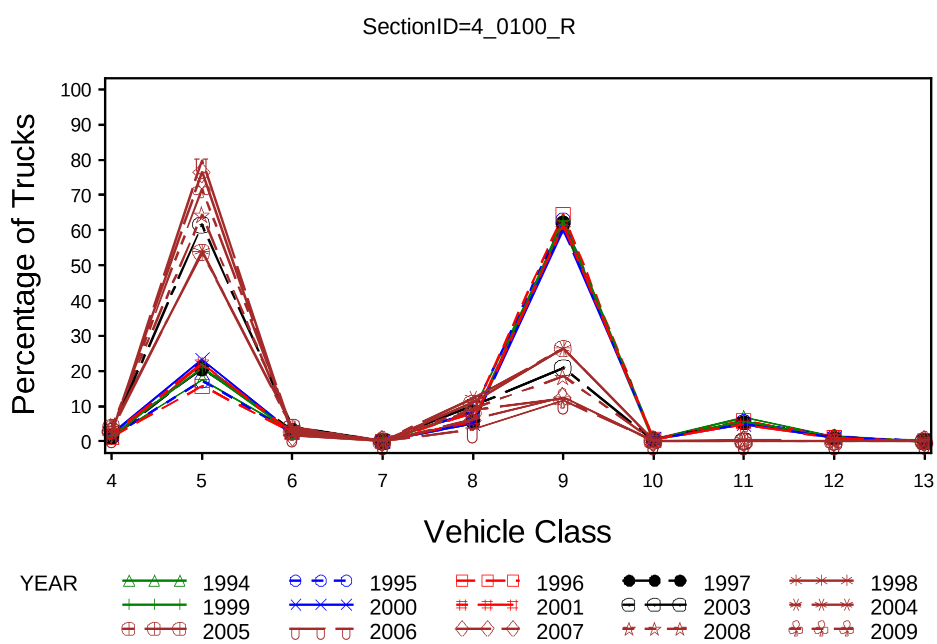

Figure 12. Plot of Vehicle Class Distribution for Site 4_0100 (Prior to and After September 2001) Showing Significant Reduction in Class 9 Trucks.

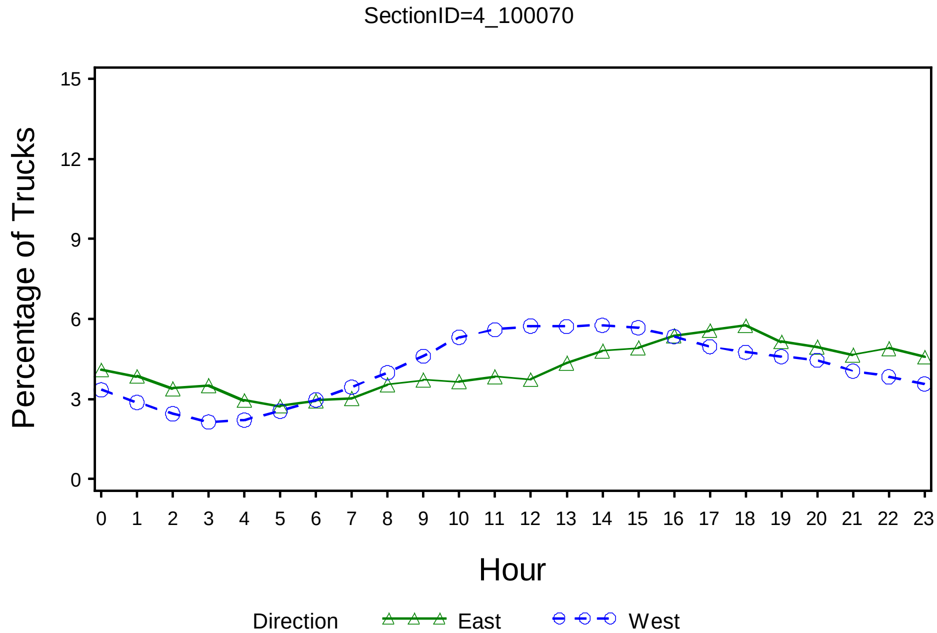

Figure 13. Plot of Hourly Truck Distribution for Site 4 100070.

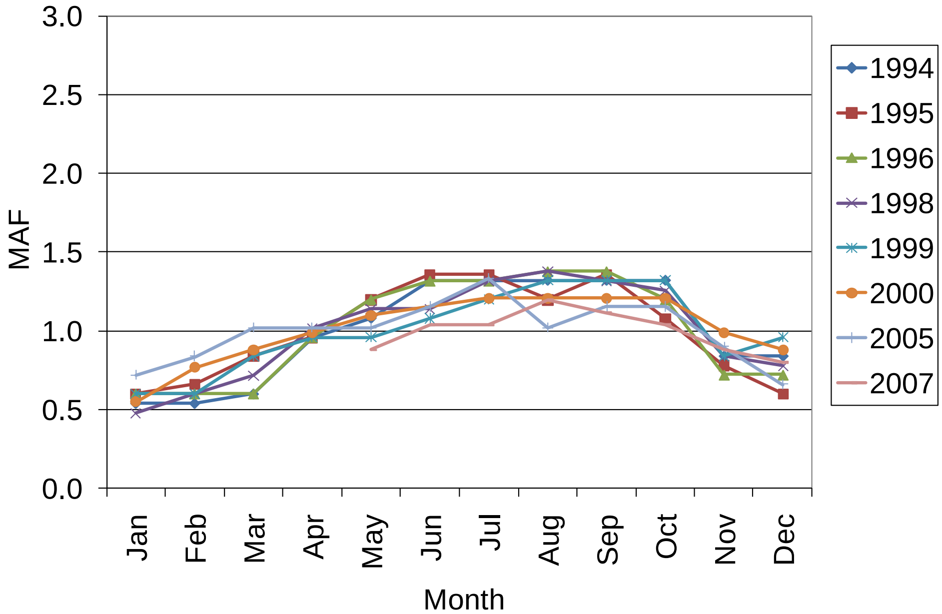

Figure 14. Plot of Monthly Adjustment Factors for LTPP 0100 (Class 4 Vehicles Only).

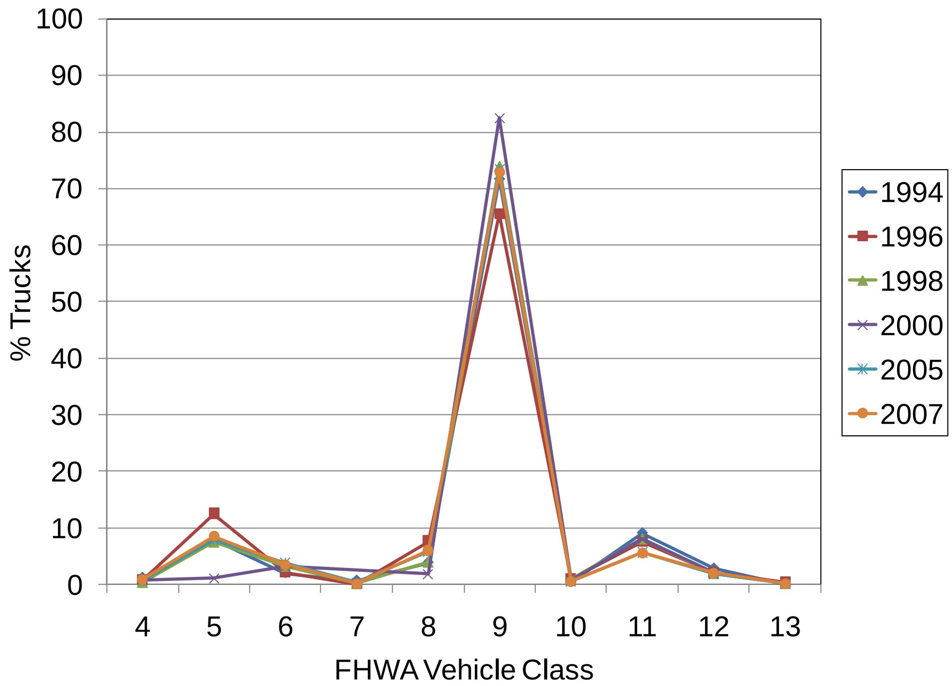

Figure 15. Plot of Vehicle Class Distribution for LTPP 1001.

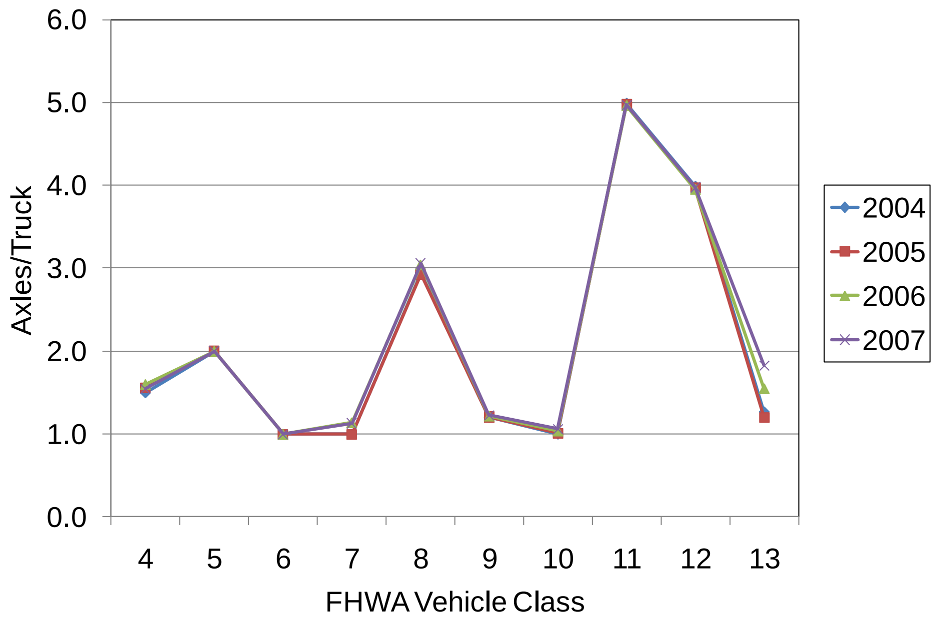

Figure 16. Plot Showing Number of Single Axles Per Truck for LTPP 0500.

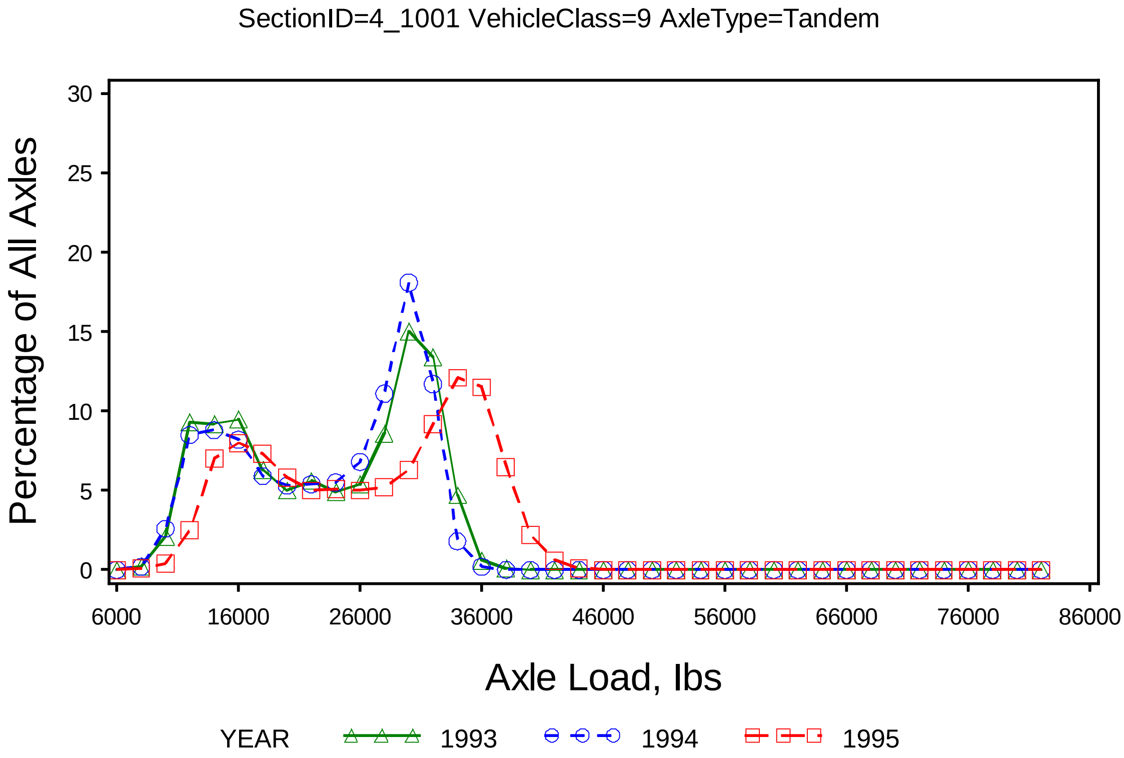

Figure 17. Plot Showing Tandem-Axle Load Distribution for LTPP 1001.

Data Cleansing

The outcome of the data review process was the identification of all potentially anomalous or erroneous data. All suspected anomalous or erroneous data were removed from the project database and not used in the analysis. Table 15 lists the sites from which all reasonably good and accurate hourly distribution, MAFs, VCD, axles per truck, and ALD data were obtained. Note that only traffic data from the design lane (for highways with multiple lanes) were assembled for use in this analysis.

Table 15. Summary of Traffic Data Availability for Analysis in Arizona.

SHRP ID	Lane Number	Direction			
		North	East	South	West
100010	1		X		X
100070	2		X		X
100139	2		X		X
100188	1		X		X
100327	1	X		X	
100473	2	X		X	
100537	2		X		X
100541	2		X		X
100767	1		X		X
100800	3	X		X	
100854	1	X		X	
100922	1	X		X	
101113	1	X		X	
101248	4	X		X	
101602	1	X		X	
101622	2	X		X	
101849	1		X		X
101928	1		X		X
102068	1	X		X	
102084	1	X		X	
102094	1	X		X	
102230	1	X		X	
0100	1	X			
0200	1		X		
0500	1		X		
0600	1		X		
0900	1	X			
1001	1				X
1002	1				X
1003	1				X
1006	1				X
1007	1				X

Table 15. Summary of Traffic Data Availability for Analysis in Arizona, continued.

SHRP ID	Lane Number	Direction			
		North	East	South	West
1015	1			X	
1016	1			X	
1017	1	X			
1018	1			X	
1021	1				X
1022	1				X
1024	1		X		
1025	1				X
1034	1			X	
1036	1	X			
1037	1		X		
1062	1				X
1065	1		X		
6053	1		X		
6054	1			X	
6055	1			X	
6060	1	X			
7079	1	X			
7613	1				X
7614	1				X
A900	1	X			
B900	1				X

STEP 3: STATISTICAL ANALYSIS TO ASSIGN MEASURED TRAFFIC DATA INTO CLUSTERS WITH SIMILAR CHARACTERISTICS AND DISTRIBUTION PATTERNS

The main objective of this traffic data analysis was to:

- Determine how representative the available traffic data are for pavement design in Arizona using the MEPDG.
- Detect natural groupings or clusters within the available traffic data.
- Develop defaults for Level 2/3 MEPDG traffic inputs for pavement design.
- Develop recommendations regarding traffic data collection practices and uses for pavement design in Arizona.

Satisfying the project objectives required performing statistical analysis to determine natural clusters within the traffic data, as well as the optimum number of clusters.

The researchers determined the natural clusters within the assembled data using statistical multivariate hierarchical cluster analysis. Multivariate hierarchical cluster analysis is a statistical procedure used to group “like” observations together when the underlying structure of the data is unknown. Hierarchical cluster analysis consists of a series of successive divisions of the assembled traffic dataset, which for analysis, considered a single cluster or a merger of data from individual sites to form a single cluster. The divisions or mergers are performed according to their similarities in the individual datasets. The similarities are based on distances between individual datasets of clusters within the larger database. Thus, cluster analysis begins with grouping individual sites with the smallest distances between them to form the first set of clusters. Next, the individual sites with the next smallest distances between them and the clusters are added to the original set of clusters. This continues until all individual observations and clusters end up together in one large group. Although clusters can be developed using a variety of different methods, all of the methods available apply some measure of distance between observations as a basis for creating clusters.

Since the cluster analysis methodology does not require prior knowledge of the number of clusters within a given set of data, it is critical that a procedure be applied to determine, in an efficient manner, the optimum number of clusters within the database being analyzed. There is no clean-cut method for determining the optimum number of clusters within a dataset. Analysts must depend on a combination of diagnostic statistics to determine the optimum number of clusters. Although several of these statistics are available, for this study, the following five diagnostic statistics were selected for use in determining an optimum number of clusters:

- Cubic clustering criterion (CCC).
- Cumulative and partial squared multiple correlations (R^2).
- Eigenvalue and associated variance (VAR).
- Pseudo F (PSF).
- Pseudo t^2 (PST2).

Criteria for selecting the optimum number of clusters based on these five statistics are summarized in Table 16.

Table 16. Criteria for Selecting the Optimum Number of Clusters.

Statistic	Criteria	Source
CCC	Evaluate plot of CCC versus number of clusters. Local peaks indicate potential optimum number of clusters. If the local peak occurs when the value of the CCC is greater than 2 or 3, it is a good indication that the corresponding number of clusters is most likely the optimum. Local peaks occurring at CCC values between zero and two indicate potential clusters, however, they should be considered with caution while large negative values can indicate outliers.	Adapted after SAS, 1999; Fernandez, 2003; Khattree and Naik, 2000
R^2	Evaluate plot of R^2 versus number of clusters. As R^2 is an indicator of the proportion of variance accounted for by the clusters, typically, the optimum number of clusters must account for a significant proportion of variance in that raw data. Optimum number of clusters when the addition of the next additional cluster does not significantly change R^2 (e.g., increase in R^2 is less than five percent).	Adapted after SAS, 1999
VAR	The number of clusters is determined based on the following: • VAR is greater than 1.0 • Proportion of variance for each cluster is greater than 5 percent • Cumulative proportion of variance is greater than 70 percent	
PSF	Relatively large local peak values of this statistic generally indicate a potential optimum number of clusters. For most analysis, there are several local/global maximums (peaks) of the PSF statistic. In such situations, the appropriate value is the number of clusters value that corresponds to results from other statistics such as CCC.	Adapted after SAS, 1999; Fernandez, 2003; Khattree and Naik, 2000
PST2	A general rule for interpreting the values of PST2 is to evaluate the plot of t^2 versus the number of clusters (moving from right to left, decreasing the number of clusters). Identify all PST2 values markedly lager than the previous value. Move back one cluster (increasing) and this is a potential optimum number of clusters for the data being analyzed. For most analysis, there are several local/global maximums (peaks) of the PST2 statistic. In such situations, the appropriate value is the number of clusters value that corresponds to results from other statistics such as CCC.	Adapted after SAS, 1999; Fernandez, 2003; Khattree and Naik, 2000

STEP 4: DETERMINATION OF OPTIMUM NUMBER OF CLUSTERS WITHIN ARIZONA

CCC, R^2, VAR, PSF, and PST2 were used as needed in determining the optimum number of clusters for each traffic data type. As noted, since no one method was more accurate than the others, a consensus determination of the optimum number of clusters was developed based on the results from all of the statistics. A visual dendogram (a graphical representation of the clustering procedure as a hierarchical tree, where each step in the clustering process is illustrated by the joining of the tree) was produced and reviewed to confirm the results of the diagnostic statistics. Where no useful results were produced by the diagnostic statistics, an optimum number of clusters was determined by reviewing the dendogram plot alone. The optimum number of clusters for Arizona traffic data was determined for each key MEPDG traffic input individually, including:

- MAF.
- Hourly distribution.
- VCD (for a given highway section, VCD affects the computation of the number of single, tandem, tridem, and quad axles that pass over the design period and is thus an important MEPDG input).
- ALD factors.
- Number of axles per truck.

For this study, the Cluster and Aceclus procedures in the SAS statistical package were used for all analyses (SAS, 1999).

STEP 5: PERFORMANCE OF SENSITIVITY ANALYSIS AND INTERPRETATION OF SENSITIVITY ANALYSIS RESULTS

As noted, statistical cluster analysis groups data in natural clusters with similar characteristics. However, although the VCD from the various sites in Arizona representing different highway functional classes (e.g., urban Interstate versus rural minor arterial), geographic locations (south versus north), and population centers (rural versus urban) may be grouped into various combinations of clusters, the effect of the typical VCD on actual pavement design may not be significant (e.g., < 0.5 in difference in design pavement thickness). Therefore, it is necessary to conduct a comprehensive sensitivity analysis using typical ADOT new HMA pavement and new JPCP to determine:

- If there are significant differences in pavement design due to the various clusters identified in step 4.
- Whether and how clusters that do not produce significantly different designs can be combined as needed.

STEP 6: DEVELOPMENT OF DEFAULT STATEWIDE LEVEL 2/3 TRAFFIC INPUTS

The MEPDG requires several traffic data inputs, as described in Chapter 2. The required inputs are mostly obtained from a mix of traffic data monitoring and collection equipment (WIM, AVC, and Arizona research sites). In practice, for a given design project, traffic data are synthesized by combining data from many sources. The sources can be site-specific or statewide/regional or national in nature.

The following levels of traffic data input are defined for Arizona and have been simplified from the initial MEPDG definitions. The level of input depends on the source of the data, as follows:

- **Level 1: Traffic data inputs are measured on or near the highway segment location.** Traffic data measured at the site include vehicle counts, vehicle classification, truck lane percentage, monthly truck distribution, hourly truck distribution, and other inputs. These should be measured by lane and direction over a sufficiently long period of time to reliably establish patterns in these traffic inputs. It is possible only with an on-site WIM installation, and it is recommended for use in designing most high-volume highways.
- **Level 2/3: Traffic data inputs are obtained from correlation or association with other traffic or other factors, or from averages of volume, growth, vehicle classification, axle weight data, hourly truck percentages, and other inputs.** For example, some traffic inputs are directly related to functional classification of the highway, including VCD. Lane truck distribution is estimated using number of lanes and truck volume. These traffic data should be obtained from AVC and/or WIM installations from sites that exhibit similar traffic distributions and load patterns as the site in question.

Level 2 and Level 3 require some sort of regional or national default inputs for vehicle classification and/or ALD.

The primary objective of this study was to develop default Level 2/3 MEPDG traffic inputs for pavement design in Arizona. This was accomplished by synthesizing information and analysis outcomes resulting from steps 1 through 5 as follows:

1. Determine optimum number of natural clusters from the various project sites (AVC and WIM data) within Arizona for the following traffic inputs:
    a. MAF.
    b. Hourly distribution.
    c. VCD.
    d. ALD factors.
    e. Number of axles per truck.

   Note that, for monthly distribution, axles per truck, and ALD, the optimum number of clusters was determined using data from only the predominant vehicle classes (Classes 5 and 9, which accounted for more than 70 percent of all trucks).
2. For each of the five traffic inputs listed above, develop a detailed description of the site/traffic characteristics (functional class, location, predominant truck types, etc.) of each of the clusters identified.

3. For each of the five traffic inputs, compare each cluster identified to the MEPDG defaults (e.g., for VCD, MEPDG defaults are TTC groupings 1 through 17) and determine if they are very different from the national defaults.
4. Use the results of the sensitivity analysis to revise the optimum number of clusters.
5. For each of the five traffic inputs, develop default MEPDG inputs and recommendations for assigning default inputs based on the sensitivity analysis and revised optimum number of clusters. Note that the MEPDG default inputs are basically mean values for all sites that fall into a given cluster category.

CHAPTER 4. STATISTICAL CLUSTER ANALYSIS

The results of the statistical cluster analysis for the key MEPDG traffic inputs are presented in this chapter.

VEHICLE CLASS DISTRIBUTION

Analysis of VCD Using ADOT Sites Only

Data were evaluated from the 21 AVC sites to help derive Level 2/3 defaults for MEPDG traffic inputs. The MEPDG includes TTCs that include national recommendations or defaults (based on averages from over 100 sites located across the United States) for 13-bin vehicle classes. How well do these TTC VCDs match Arizona traffic? Based on this information, Arizona-specific TTCs can be derived as needed. The TTCs are based on functional class and a description of the truck mix. The initial step was to determine what MEPDG TTCs reasonably represent Arizona highways.

A significant challenge was presented by the presence of one of the most prevalent vehicles on Arizona roads—recreational vehicles. Although these vehicles do not have a significant impact on MEPDG pavement design when classified correctly, the cross-classifications of recreational vehicles between vehicle Classes 4, 5, 6 and 8 creates a disproportionate distribution of the types of vehicles. Recreational vehicles pulling two-axle trailers, or other Type 5 or Type 3 vehicles pulling campers, often are classified as Class 8 vehicles, which play a much more significant role in MEPDG design. For the Arizona AVC data that were analyzed, 60 percent of the vehicles were classified as Class 4, 5, 6, or 8. For current and future AVC installations, it is recommended that a manual classification study be performed to verify the accuracy of the classification algorithm being used by the data collection equipment.

In developing Arizona highway TTCs, significant emphasis was placed on the percentage of Class 9 trucks, which are typically classified correctly, barring any equipment problems. However, Class 5 percentages were also considered. In addition, the presence of one (usually Class 9) or two humps (Classes 5 and 9) in the distribution curves was considered.

For comparative purposes, the national MEPDG TTC classification distributions are shown in Table 17. The numbers of representative Arizona sections that follow these distributions relatively closely are shown in Table 18.

Table 17. National Highway TTC VCD Defaults in the MEPDG.

TTC	Arizona Representative Highways Included	Percentage of All Trucks									
		VC4	VC5	VC6	VC7	VC8	VC9	VC10	VC11	VC12	VC13
1	11	1.3	8.5	2.8	0.3	7.6	74.0	1.2	3.4	0.6	0.3
2	18	2.4	14.1	4.5	0.7	7.9	66.3	1.4	2.2	0.3	0.2
3		0.9	11.6	3.6	0.2	6.7	62.0	4.8	2.6	1.4	6.2
6	7	2.8	31.0	7.3	0.8	9.3	44.8	2.3	1.0	0.4	0.3
9	12	3.3	34.0	11.7	1.6	9.9	36.2	1.0	1.8	0.2	0.3
12	6	3.9	40.8	11.7	1.5	12.2	25.0	2.7	0.6	0.3	1.3
14	24	2.9	56.9	10.4	3.7	9.2	15.3	0.6	0.3	0.4	0.3

Table 18. VCD TTCs Based on Arizona Data That Are Closely Related to the National TTCs.

Arizona Derived TTC	Percentage of All Trucks									
	VC4	VC5	VC6	VC7	VC8	VC9	VC10	VC11	VC12	VC13
1	1.8	6.5	1.9	0.2	10.3	73.2	1.0	3.1	1.9	0.1
2	3.1	14.7	2.9	0.1	9.3	64.4	1.3	1.9	1.5	0.8
6	3.7	21.3	5.7	0.4	19.0	45.6	1.7	1.5	0.7	0.4
9	5.3	38.5	6.2	0.2	9.0	36.9	1.8	1.3	0.3	0.4
12	5.3	46.3	5.7	0.7	16.1	24.1	1.1	0.3	0.1	0.3
14	7.8	65.8	4.4	0.2	11.7	9.1	0.7	0.2	0.0	0.1

Classification data from 21 Arizona AVC segments were analyzed to develop clusters for Level 2/3 Arizona TTC development. These data provided 84 lanes of statistics for analysis. There were seven national TTCs represented by Arizona highways. The vehicle classification distributions for the representative lanes evaluated are presented in Appendix B.

Once representative Arizona vehicle classification distributions were developed from Arizona AVC data, they were compared with the national MEPDG defaults in the MEPDG software. The comparisons are presented in Table 19. For example, a Class 9 vehicle for TTC 1 in the MEPDG is 74 percent. A Class 9 vehicle for the TTCs derived for Arizona is 73.2 percent. The difference is 74 – 73.2 = 0.8 percent, as shown in Table 19.

From the table, it can be seen that the greatest discrepancy in distributions is among Class 5, 6, and 8 vehicles. This is mainly due to the cross-classification problems described earlier in this report. As stated, the percentage of Class 9 vehicles was the primary consideration in determining TTCs for Arizona. There are no major differences between the Level 3 MEPDG defaults and the Arizona truck distribution.

Table 19. Differences between MEPDG and Arizona TTC Recommendations for VCD.

TTC	Percentage of All Trucks									
	VC4	VC5	VC6	VC7	VC8	VC9	VC10	VC11	VC12	VC13
1	0.5	-2.0	-0.9	-0.1	2.7	-0.8	-0.2	-0.3	1.3	-0.2
2	0.7	0.6	-1.6	-0.6	1.4	-1.9	-0.1	-0.3	1.2	0.6
6	0.9	-9.7	-1.6	-0.4	9.7	0.8	-0.6	0.5	0.3	0.1
9	2.0	4.5	-5.5	-1.4	-0.9	0.7	0.8	-0.5	0.1	0.1
12	0.5	7.9	-8.1	-1.4	2.5	2.2	-2.0	-0.3	-0.1	-1.2
14	4.9	6.6	-5.4	-3.3	3.2	-5.7	0.3	-0.1	-0.4	-0.2

Considerable time was spent examining the actual VCDs. The distributions divide into two major groups:

- Single peak Class 9 vehicles, as shown in Figure 18. This distribution is typical of Arizona Interstate highways in rural and urban areas. However, a few of these urban sites show double peaks.
- Double peak Class 5 and 9 vehicles as shown in Figure 19. This distribution is typical of all other functional classes, in particular urban sites.

Table 20 shows a possible Level 3 selection criterion for inputting MEPDG TTCs based on highway functional class. Arizona Interstates are represented primarily by TTCs 1, 2, and 3. This indicates that the classification distribution on these roads consists primarily of Class 5 and 9 vehicles. There are also a significant number of Class 8 vehicles, which may be a combination of semi-tractor trailers and recreational vehicles. Other arterial roadways, such as urban and rural roadways, also show Class 5 and 9 vehicle peaks; however, the number of Class 5 vehicles is greater on these roads than on Interstates. All other roadways are primarily represented by a mixture of Class 5 and 9 vehicles.

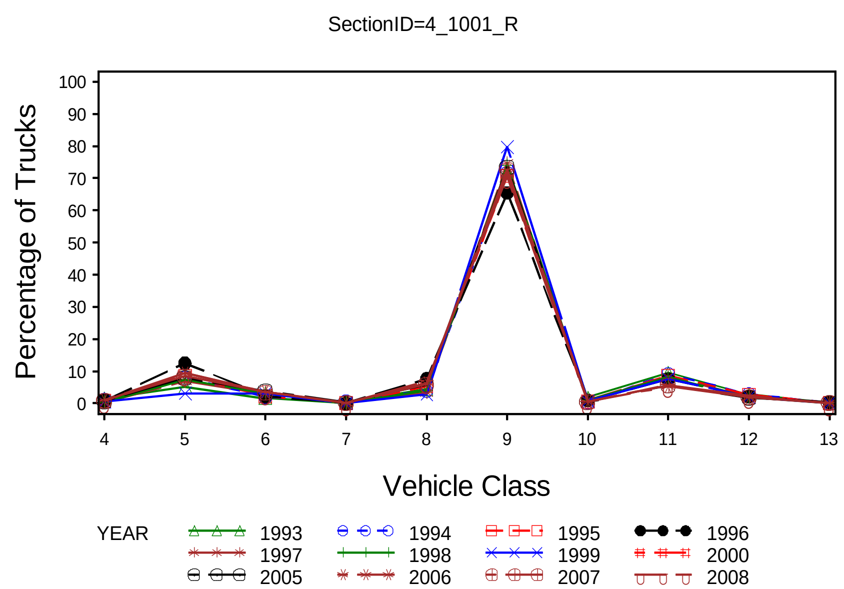

Figure 18. Typical Arizona Interstate Highway Single Peak VCD.

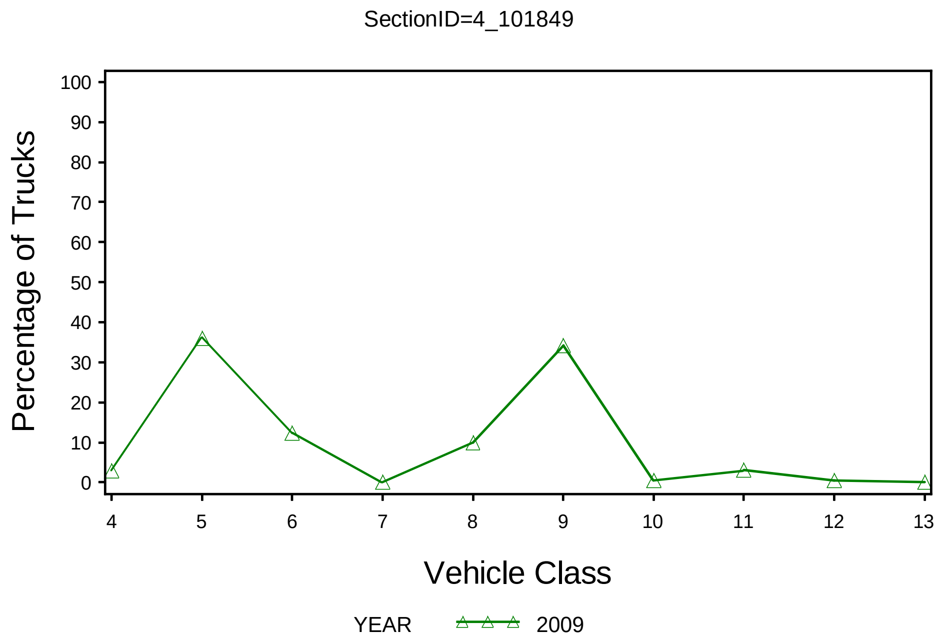

Figure 19. Typical Arizona Non-Interstate Highway Double Peak VCD Found in Urban Areas or Other Rural Highways.

Table 20. Selection Criteria for Level 3 MEPDG Arizona TTCs Based on Functional Class.

Functional Class	Arizona MEPDG TTCs	Arizona Representative Highways
Rural Principal Arterial – Interstate	1, 2	I-8, I-10, I-15, I-19, I-40 (single peak for Class 9)
Rural Principal Arterial – Other	6, 9, 12	SR 85, U.S. 60, SR 77, U.S. 93, SR 360, SR 101, SR 303 (double peak for Classes 5 and 9)
Rural Major Collector	6, 9, 12	U.S. 91 (double peak for Classes 5 and 9)
Rural Minor Arterial or Collector	6, 9, 12, 14	SR 79, U.S. 60, SR 347 (double peak for Classes 5 and 9)
Urban Principal Arterial – Interstate	1, 2	I-10, I-19, I-40 (some in urban area had double peak Classes 5 and 9)
Urban Principal Arterial – Other	9, 12, 14	SR 360, SR 101, SR 101, SR 303, SR 77 (double peak for Classes 5 and 9)

Analysis of VCD Using Combined ADOT and LTPP Vehicle Classification Data

A cluster analysis similar to that conducted for other inputs was conducted of the combined data sets of ADOT and LTPP. A summary of all of the sites used in the analysis is shown in Table 21. The table also shows the final results from the cluster analysis. There were two major groupings for VCD. A third cluster includes two sections that had a very high percentage of Class 4 vehicles (buses) as the only peak.

Table 21. Summary of Cluster Analysis for VCD Using ADOT and LTPP Datasets.

ID	Cluster/Peak	Latitude	Longitude	County	Route	Functional Class	Route Type	AADTT
4_0200_R	1P	33.453	-112.74	Maricopa	I-10	RPA-I	I	4820
4_0500_R	1P	32.829	-112.006	Pinal	I-8	RPA-I	I	930
4_0600_R	1P	35.218	-111.564	Coconino	I-40	RPA-I	I	6225
4_100010	1 (2P)	32.7	-114	Yuma	I-08	RPA-I	I	1256
4_100070	1P	33.661	-114.006	La Paz	I-10	RPA-I	I	2978
4_100139	1P	32.454	-111.205	Pima	I-10	UPA-I	I	1980
4_100188	1P	32.341	-109.568	Cochise	I-10	RPA-I	I	2740
4_1001_R	1P	33.461	-112.45	Maricopa	I-10	RPA-I	I	4660
4_1002_R	1P	35.219	-112.49	Yavapai	I-40	RPA-I	I	2310
4_100327	1P	36.98	-113.654	Mohave	I-15	UPA-I	I	1961
4_1003_R	1P	33.481	-112.864	Maricopa	I-10	RPA-I	I	5681
4_100473	1(2P)	32.2	-111	Pima	I-19	UPA-I	I	1311
4_100537	1(2P)	35.23	-111.81	Coconino	I-40	RPA-I	I	2671
4_100541	1(2P)	35.173	-111.647	Coconino	I-40	UPA-I	I	3865
4_1006_R	1P	33.435	-112.661	Maricopa	I-10	RPA-I	I	5740
4_1007_R	1P	33.436	-112.582	Maricopa	I-10	RPA-I	I	5439
4_100922	1P	33.263	-112.634	Maricopa	SR 85	RPA-O	SR	1202
4_1015_R	1P	31.559	-111.052	Santa Cruz	I-19	RPA-I	I	1187
4_1016_R	1P	31.643	-111.058	Santa Cruz	I-19	RPA-I	I	1175
4_1017_R	1P	31.765	-111.036	Pima	I-19	RPA-I	I	1164
4_1018_R	1P	31.807	-111.013	Pima	I-19	RPA-I	I	1139
4_102094	1(2P)	34.012	-112.789	Yavapai	U.S. 93	RPA-O	US	764
4_1022_R	1P	35.161	-113.598	Mohave	I-40	RPA-I	I	2729
4_1024_R	1P	35.278	-113.13	Yavapai	I-40	RPA-I	I	2830
4_1025_R	1P	35.295	-113.029	Yavapai	I-40	RPA-I	I	2858
4_1036_R	1P	35.712	-114.481	Mohave	U.S. 93	RPA-O	US	473
4_1062_R	1P	35.191	-113.347	Mohave	I-40	RPA-I	I	2808
4_1065_R	1P	35.208	-113.268	Yavapai	I-40	RPA-I	I	2802
4_6053_R	1P	31.974	-110.506	Pima	I-10	RPA-I	I	2140
4_6054_R	1P	32.039	-110.993	Santa Cruz	I-19	RPA-I	I	1104
4_6055_R	1P	33.246	-112.638	Maricopa	SR 85	RPA-O	SR	3649
4_6060_R	1P	31.519	-111.017	Santa Cruz	I-19	RPA-I	I	2121
4_7614_R	1P	33.457	-112.325	Maricopa	I-10	RPA-I	I	2667
4_B900_R	1P	33.462	-112.469	Maricopa	I-10	RPA-I	I	5439
4_100767	1P	33.853	-113.907	La Paz	SR 72	RMC	SR	434
4_1021_R	1P	35.161	-113.681	Mohave	I-40	RPA-I	I	2746

Note: Cluster 1 typically has one large peak (1P) for Class 9; Cluster 2 has two peaks, indicated by 2P, for Classes 5 and 9; and Cluster 3 has one peak for Class 4.

Table 21. Summary of Cluster Analysis for VCD Using ADOT and LTPP Datasets, continued.

ID	Cluster/Peak	Latitude	Longitude	County	Route	Functional Class	Route Type	AADTT
4_100854	2(2P)	33.155	-111.356	Pinal	SR 79	RMA	SR	269
4_101248	2(2P)	33.457	-111.89	Maricopa	SR 101	UPA-FE	SR	210
4_101602	2(2P)	33.636	-112.418	Maricopa	SR 303	UPA-FE	SR	826
4_101622	2(2P)	33.092	-112.034	Pinal	SR 347	RMA	SR	986
4_101849	2(2P)	33.689	-112.415	Maricopa	U.S. 60	RPA-O	US	925
4_101928	2(2P)	34.209	-110.078	Navajo	U.S. 60	RMA	US	88
4_102084	2(2P)	35.834	-114.565	Mohave	U.S. 93	RPA-O	US	299
4_102230	2(2P)	32.796	-109.54	Graham	U.S. 191	RMC	US	159
4_7613_R	2(2P)	33.386	-111.839	Maricopa	SR 360	UPA-O	SR	916
4_100800	2(2P)	32.343	-110.977	Pima	SR 77	UPA-O	SR	404
4_7079_R	2(2P)	33.602	-112.253	Maricopa	SR 101	UPA-FE	SR	4498
4_101113	3(Bus)	33.758	-114.217	Yuma	SR 95	RPA-O	SR	201
4_102068	3(Bus)	35.259	-111.551	Coconino	U.S. 89	UPA-O	US	279

1P: Denotes one peak for Class 9 vehicles; 2P denotes two peaks for Classes 5 and 9.

Cluster 1 had one large peak for Class 9 vehicles. The percentage ranged from 60 to 80 for this group. The Class 5 vehicles ranged from 5 to 20 percent. The main functional class highway was Rural Principal Arterial – Interstate. There were a few sections with two peaks, and these were usually Urban Principal Arterial – Interstate or Urban Principal Arterial – Other.

Cluster 2 had two large peaks for Class 5 and 9 vehicles. The percentage of Class 5 ranged from 20 to 70 for this group. The percentage of Class 9 ranged from 20 to 40 for this group. The main functional class highway was Urban Principal Arterial. There were also some Rural Major/Minor Arterials or Collectors.

Cluster 3 had one large peak for Class 4 vehicles. The percentage of Class 4 vehicles was approximately 90 percent. These were Rural Principal Arterial and Urban Principal Arterial.

Clusters 1 and 2 can be matched to TTC 2 and TTC 12 very closely, as shown in Table 22.

Note that the results from the two analyses (ADOT sites only, and ADOT and LTPP sites) were similar, and both were used to develop recommendations for Level 3 MEPDG inputs for VCD for Arizona’s highway, as discussed in Chapter 6.

Table 22. Matching Cluster 1 to TTC 2 and Cluster 2 to TTC 12.

TTC/Cluster	Description	VC4	VC5	VC6	VC7	VC8	VC9	VC10	VC11	VC12	VC13
TTC 2 (1 Peak)	Major single-trailer truck route (Type II)	2.4	14.1	4.5	0.7	7.9	66.3	1.4	2.2	0.3	0.2
Arizona Cluster 1 (1 Peak)	Primarily RPA-I	1.8	14.1	2.7	0.1	7.6	66.8	0.7	4.3	1.4	0.5
TTC 12 (2 Peaks)	Intermediate light and single-trailer truck route (Type III)	3.9	40.8	11.7	1.5	12.2	25.0	2.7	0.6	0.3	1.3
Arizona Cluster 2 (2 Peaks)	UPA_FE, RMA, and RMC (US and state routes)	4.7	47.2	7.4	0.4	12.4	25.1	1.7	0.6	0.1	0.4

Several examples of Arizona VCDs that fit into the typical functional classes are provided in Figures 20 through 29. Appendix B provides plots for VCD for all sites used in this analysis.

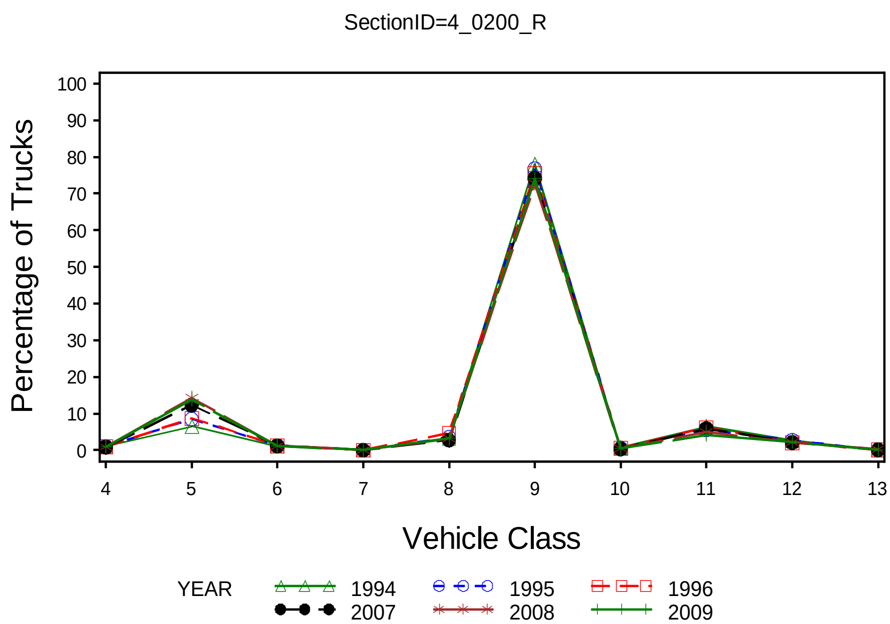

Figure 20. Plot of VCD for Rural Principal Arterial – Interstate (Project 4_0200R, I-10, Maricopa County).

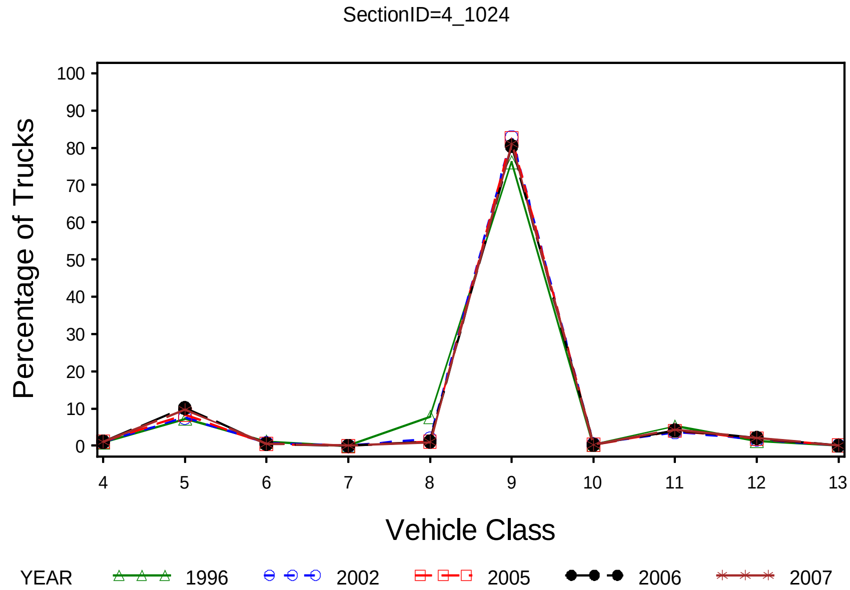

Figure 21. Plot of VCD for Rural Principal Arterial – Interstate (Project 4_1024, I-40, Yavapai County).

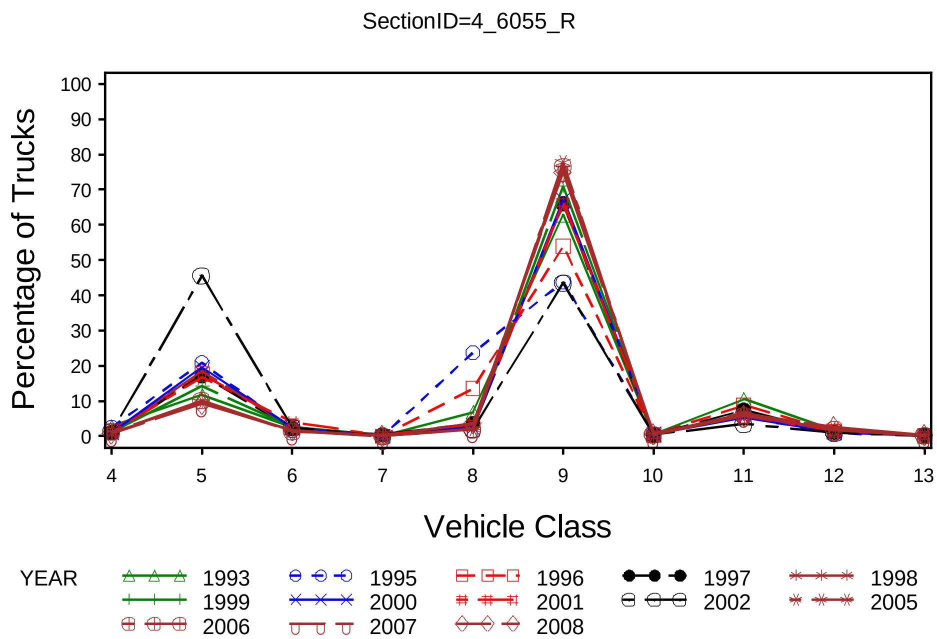

Figure 22. Plot of VCD for Rural Principal Arterial – Other (Project 4_6055_R, SR 85, Maricopa County).

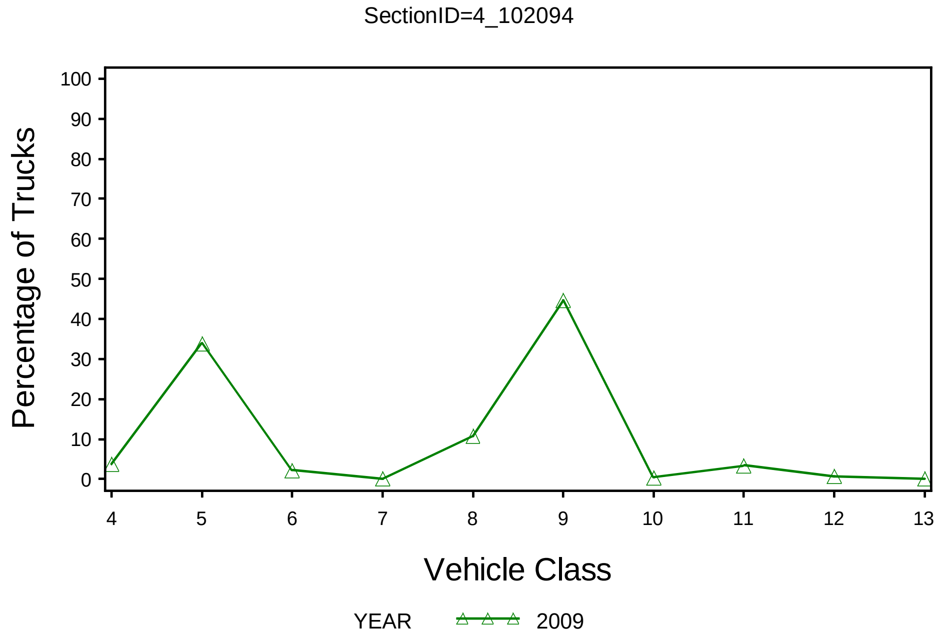

Figure 23. Plot of VCD for Rural Principal Arterial – Other (Project 4_102094, U.S. 93, Yavapai County).

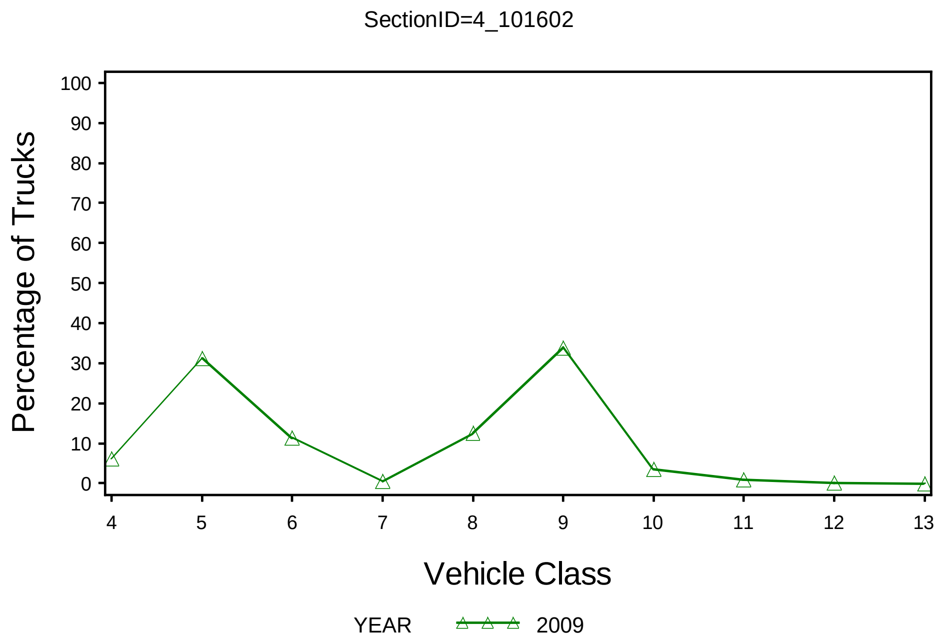

Figure 24. Plot of VCD for Urban Principal Arterial (Project 4_101602, SR 303, Maricopa County).

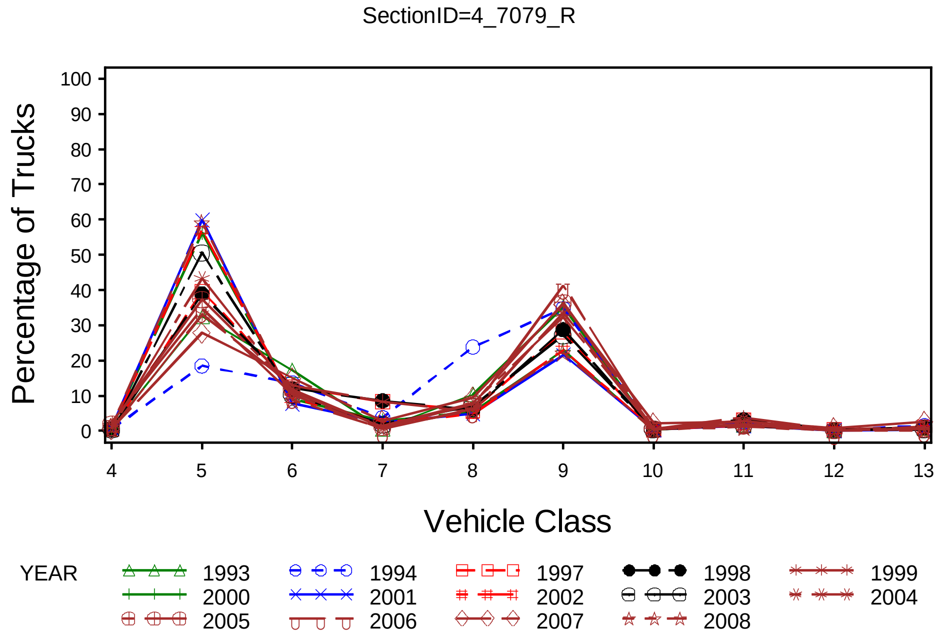

Figure 25. Plot of VCD for Urban Principal Arterial (Project 4_7079_R, SR 101, Maricopa County).

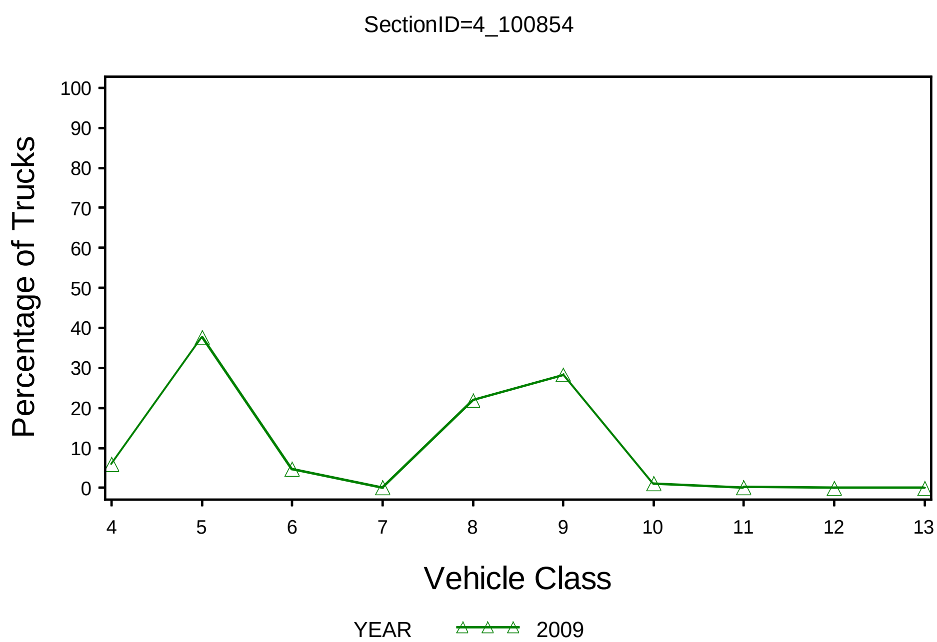

Figure 26. Plot of VCD for Site Rural Major Arterial (Project 4_100854, SR 79, Pinal County).

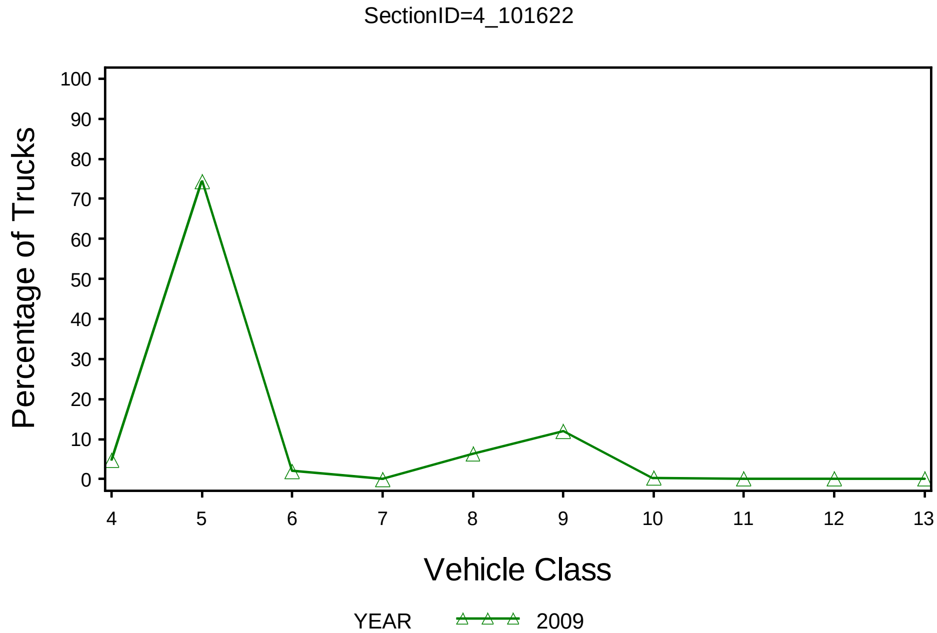

Figure 27. Plot of VCD for Rural Major Arterial (Project 4_101622, SR 347, Pinal County).

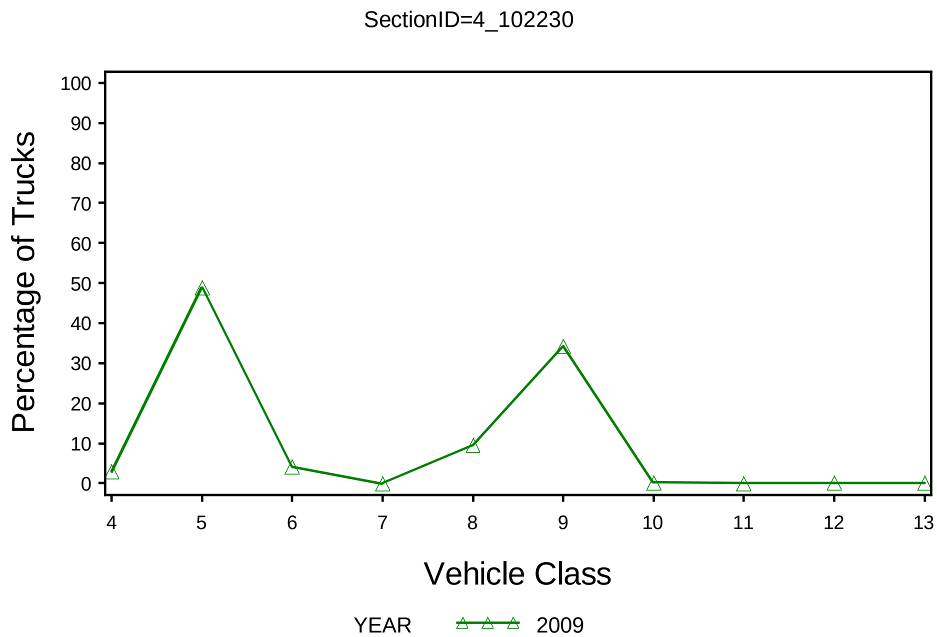

Figure 28. Plot of VCD for Rural Major Collector (Project 4_102230, U.S. 191, Graham County).

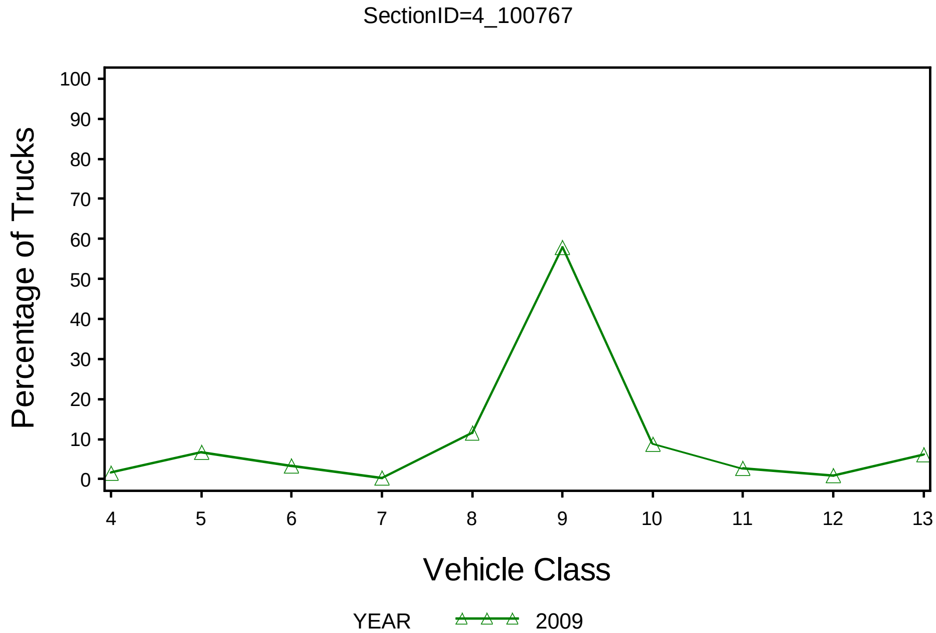

Figure 29. Plot of VCD for Rural Major Collector (Project 4_100767, SR 72, La Paz County).

HOURLY TRUCK TRAFFIC DISTRIBUTION

Hourly truck distribution data over 24 hours is available for 21 AVC sites and for two LTPP sections (0100 and 0200). Figure 30 shows the geographical distribution of the AVC sites. A cluster analysis was performed for the AVC sections. A result of the correlation coefficient approach to cluster analysis that distinguishes significantly different hourly distributions is shown in Figure 31, which indicates that there are three distinct clusters. Table 23 summarizes the actual sections divided into the three clusters. (Note a single section cluster on the far right, a central cluster, and a cluster located on the right.) The three clusters are described as follows:

1. A cluster that generally represents typical “rural” highway truck distributions. These sections are labeled Cluster 1 in Table 23 and can be observed in Figure 31 in the center right (100139, 100327,100767, etc.). The difference between the nighttime and daytime truck traffic is significant (typically ranges from three to seven), but not as peaked as typical urban distribution. An example of this “rural” hourly truck distribution is shown in Figure 32, which is for a site in Coconino County on I-40 (range in hourly percent of trucks ranges from two at night to seven in the daytime).
2. A cluster that generally represents typical “urban” highway truck distributions. These sections are labeled Cluster 2 in Table 23 and can be observed in Figure 31 (far left 00473, 00922, 01602, etc.). There is a greater difference between the daytime and nighttime truck traffic than on rural sites. An example of an “urban” hourly truck distribution is shown in Figure 33, which is for site 4_100800 located in urban Pima County on SR 77.

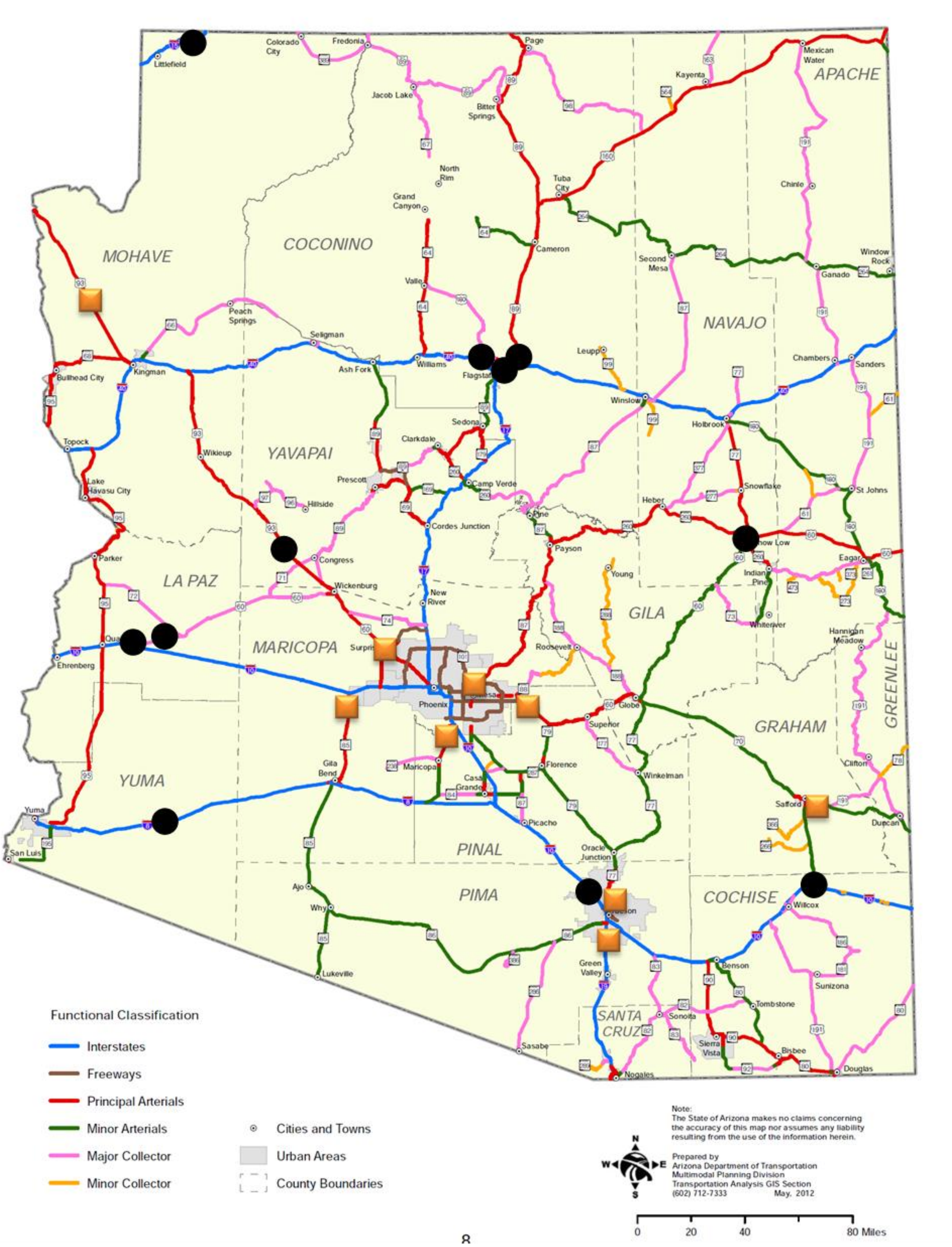

Figure 30. Location of AVC Sites in Arizona Used in the Hourly Traffic Analysis.

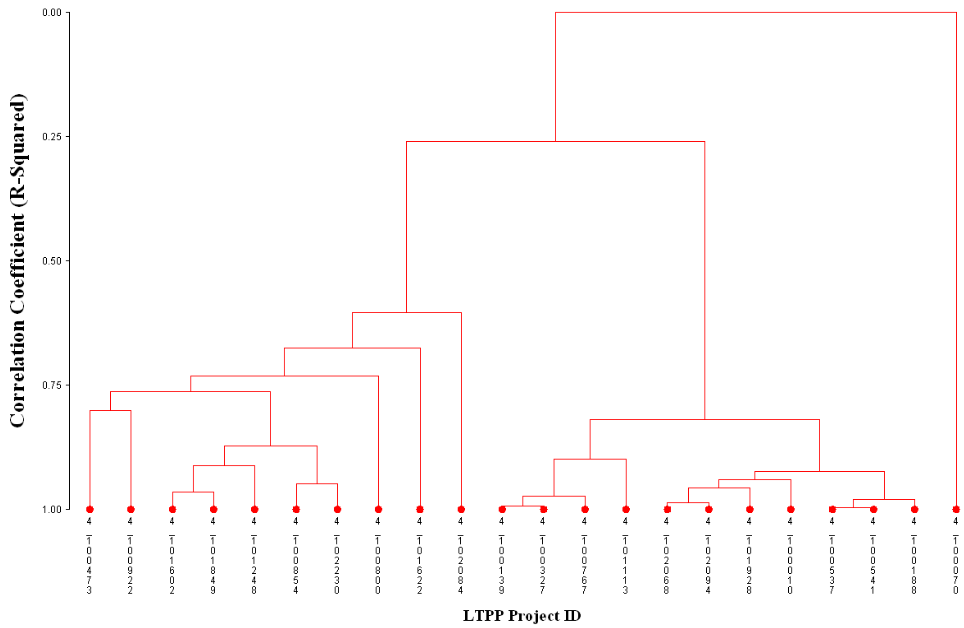

Figure 31. Illustration of a Cluster Analysis for "Correlation Coefficient" to Distinguish Between Hourly Truck Distributions.

Table 23. Summary of Sites and Clusters Determined for Hourly Truck Traffic Distribution.

SHRP ID	Cluster No.	County	Route ID	Functional Class	Route Type	AADTT
4_100010	1	Yuma	I-08	RPA-I	I	1256
4_100139	1	Pima	I-10	UPA-I	I	1980
4_100188	1	Cochise	I-10	RPA-I	I	2740
4_100327	1	Mohave	I-15	UPA-I	I	1961
4_100537	1	Coconino	I-40	RPA-I	I	2671
4_100541	1	Coconino	I-40	UPA-I	I	3865
4_100767	1	La Paz	SR 72	RMC	SR	434
4_101113	1	Yuma	SR 95	RPA-O	SR	201
4_101928	1	Navajo	U.S. 60	RMA	US	88
4_102068	1	Coconino	U.S. 89	UPA-O	US	279
4_102094	1	Yavapai	U.S. 93	RPA-O	US	764
4_100473	2	Pima	I-19	UPA-I	I	1311
4_100800	2	Pima	SR 77	UPA-O	SR	404
4_100854	2	Pinal	SR 79	RMA	SR	269
4_100922	2	Maricopa	SR 85	RPA-O	SR	1202
4_101248	2	Maricopa	SR 101	UPA-FE	SR	210
4_101602	2	Maricopa	SR 303	UPA-FE	SR	826
4_101622	2	Pinal	SR 347	RMA	SR	986
4_101849	2	Maricopa	U.S. 60	RPA-O	US	925
4_102084	2	Mohave	U.S. 93	RPA-O	US	299
4_102230	2	Graham	U.S. 191	RMC	US	159
4_100070	3	La Paz	I-10	RPA-I	I	2978

3. A cluster that represents a long haul section of rural highway across the desert (section 100070 on the western end of I-10 in La Paz County). This section is located in Figure 31 at the far right side. The distribution is shown in Figure 34 and is a very flat truck hourly distribution with 3 to 4 percent of all trucks being applied at nighttime and increasing to only 5 percent in the daytime. A similar flat hourly distribution on the same I-10 located near Phoenix is shown in Figure 35. The U.S. 93 distribution shown in Figure 35 is in a rural area in the northeastern region of Arizona, which is representative of Cluster 1. The MEPDG default hourly distribution fits generally between these two distributions.

Plots of all of the hourly data identified for use in this analysis are presented in Appendix C. This analysis has shown that hourly truck distributions vary across the state and that three Level 2/3 defaults can be provided for three cluster types. Recommendations for the MEPDG Level 2/3 will include three hourly truck distributions representing “rural,” “urban,” and “long-haul desert” types of highways. The 2/3 level indicates that the hourly truck distributions are correlated to type of land use for the highway under consideration.

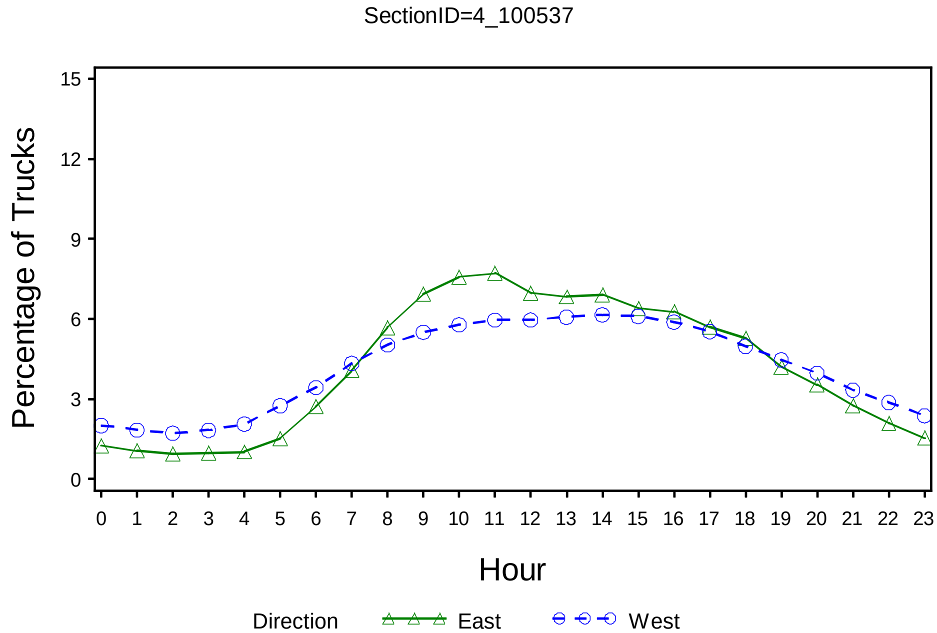

Figure 32. Plot of Typical Rural Truck Hourly Distribution for Site 4_100537 Located in Coconino County on I-40.

The range in hourly distribution of trucks is from 2 percent at nighttime to 7 percent in daytime.

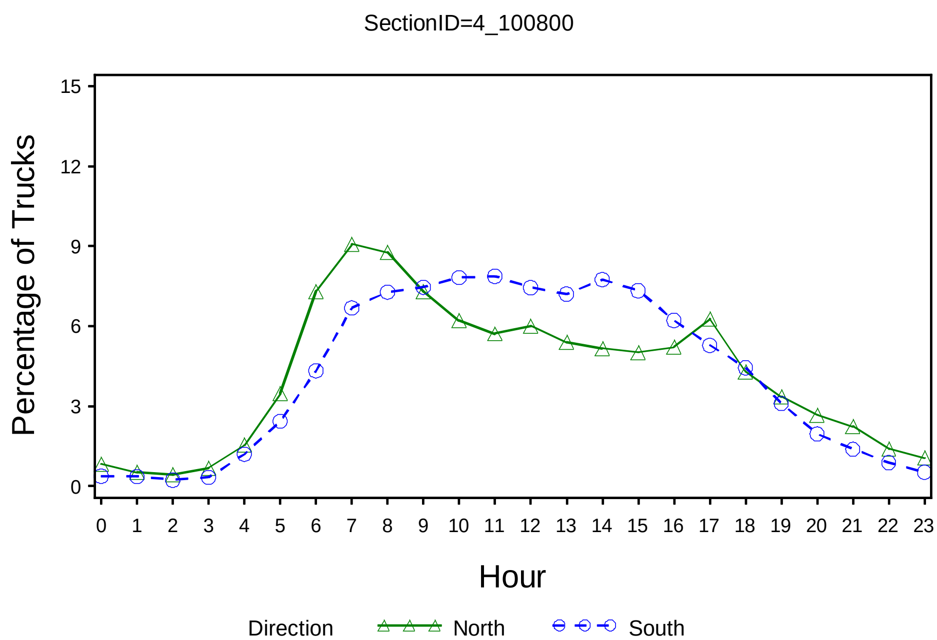

Figure 33. Plot of Typical Urban Truck Hourly Distribution for Site 4_100800 Located in Urban Pima County (Tucson) on SR 77.

The range in hourly distribution of trucks is from less than 1 percent at nighttime to more than 9 percent in daytime.

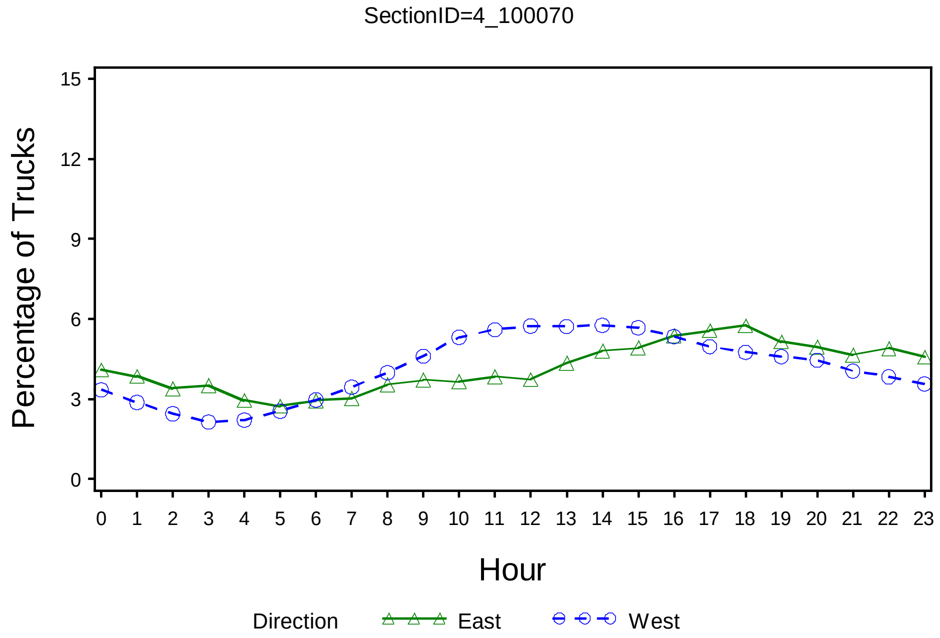

Figure 34. Plot of Relatively Flat Hourly Distribution for Site 4_100070 from a Far–Western, Long-Haul Section on I-10 in the Desert.

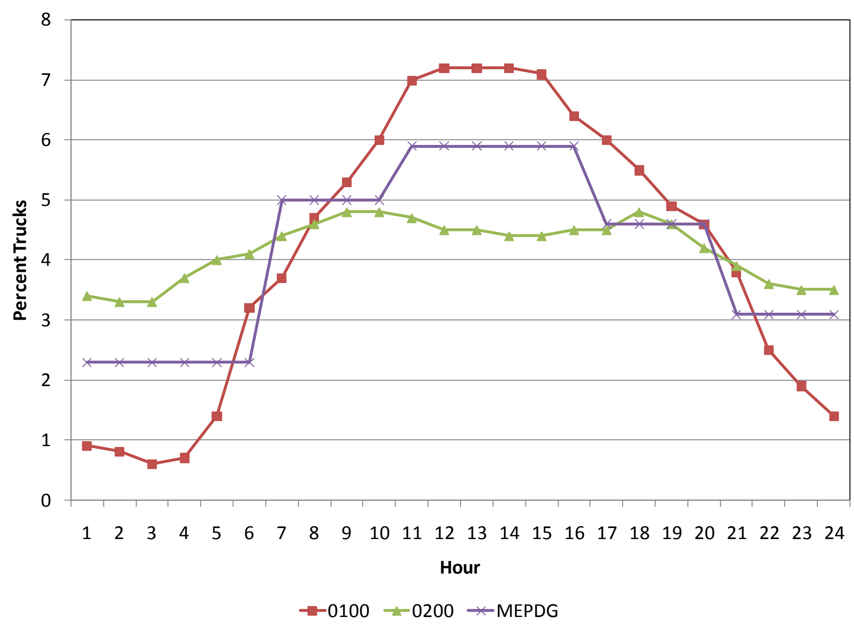

Figure 35. Plot of Three Hourly Truck Distributions.

The hourly truck distributions are (1) site LTPP 0200 west of Phoenix on I-10 showing a relatively flat long-haul desert distribution, (2) site LTPP 0100 in northwestern Arizona showing a rural peaked distribution, and (3) the default MEPDG distribution.

Monthly Truck Adjustment

The MAF input in the MEPDG provides the opportunity to fine-tune the design considering month-to-month truck volumes. The national defaults were 1.00 for each month, which provides for the same truck volume each month of a given year.

The MAF was computed for a number of sites in Arizona to determine variations around the state. A cluster analysis was conducted using the data from 22 AVC sites in Arizona, as shown on the map in Figure 36. Details of the 22 sites are provided in Table 24.

A cluster analysis similar to that conducted for other MEPDG traffic inputs was conducted. Results from the correlation coefficient approach are shown in Figure 37. These analyses were conducted using Class 5 and Class 9 vehicles.

The overall results from this and the other methods show that the MAF factors break down into a single cluster with two outliers. It is certainly possible to have "outliers" that represent a significantly different MAF; however, by far the most Arizona sections had MAF that do not vary significantly from each other in terms of Class 5 and Class 9 trucks. The analysis included only sections with all 12 months of MAF.

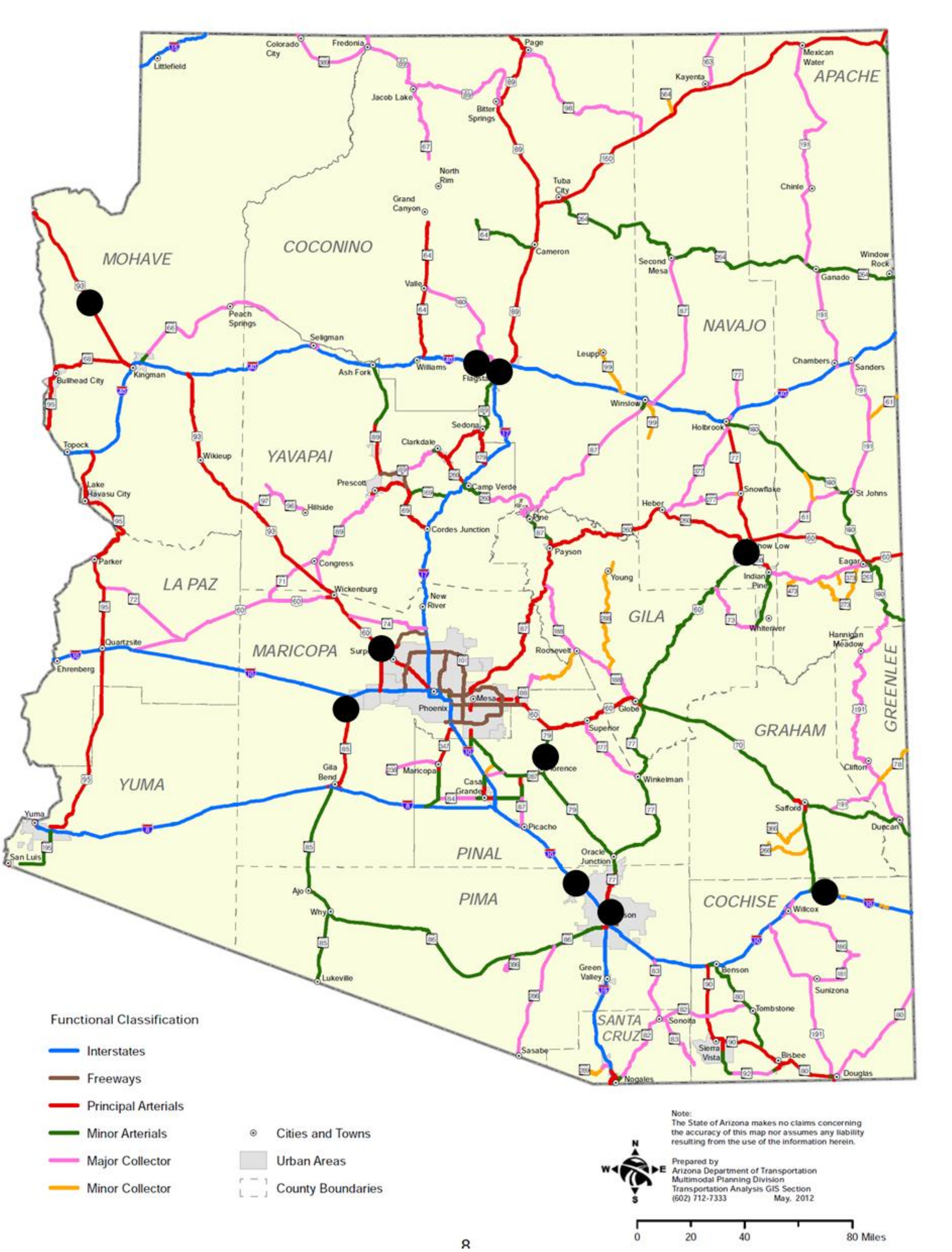

Figure 36. Locations of AVC Sites Used in the Analysis of Monthly Truck Adjustment Factors.

Table 24. AVC Sites Used in the Monthly Truck Adjustment Factors.

SHRP ID	Cluster No.	Vehicle Class	Latitude, deg.	Longitude, deg.	County	Route ID	Functional Class	Route Type	AADTT
4_100010	1	MAF5	32.7	-114	Yuma	I-08	RPA-I	I	1256
4_100010	1	MAF9	32.7	-114	Yuma	I-08	RPA-I	I	1256
4_100139	1	MAF9	32.454	-111.205	Pima	I-10	UPA-I	I	1980
4_100188	1	MAF5	32.341	-109.568	Cochise	I-10	RPA-I	I	2740
4_100188	1	MAF9	32.341	-109.568	Cochise	I-10	RPA-I	I	2740
4_100473	1	MAF5	32.2	-111	Pima	I-19	UPA-I	I	1311
4_100473	1	MAF9	32.2	-111	Pima	I-19	UPA-I	I	1311
4_100537	1	MAF9	35.23	-111.81	Coconino	I-40	RPA-I	I	2671
4_100541	1	MAF5	35.173	-111.647	Coconino	I-40	UPA-I	I	3865
4_100541	1	MAF9	35.173	-111.647	Coconino	I-40	UPA-I	I	3865
4_100767	1	MAF5	33.853	-113.907	La Paz	SR 72	RMC	SR	434
4_100767	1	MAF9	33.853	-113.907	La Paz	SR 72	RMC	SR	434
4_100854	1	MAF5	33.155	-111.356	Pinal	SR 79	RMA	SR	269
4_100854	1	MAF9	33.155	-111.356	Pinal	SR 79	RMA	SR	269
4_100922	1	MAF5	33.263	-112.634	Maricopa	SR 85	RPA-O	SR	1202
4_100922	1	MAF9	33.263	-112.634	Maricopa	SR 85	RPA-O	SR	1202
4_101622	1	MAF5	33.092	-112.034	Pinal	SR 347	RMA	SR	986
4_101622	1	MAF9	33.092	-112.034	Pinal	SR 347	RMA	SR	986
4_101849	1	MAF5	33.689	-112.415	Maricopa	U.S. 60	RPA-O	US	925
4_101849	1	MAF9	33.689	-112.415	Maricopa	U.S. 60	RPA-O	US	925
4_101928	1	MAF5	34.209	-110.078	Navajo	U.S. 60	RMA	US	88
4_101928	1	MAF9	34.209	-110.078	Navajo	U.S. 60	RMA	US	88
4_102084	1	MAF5	35.834	-114.565	Mohave	U.S. 93	RPA-O	US	299
4_102084	1	MAF9	35.834	-114.565	Mohave	U.S. 93	RPA-O	US	299
4_100139	2	MAF5	32.454	-111.205	Pima	I-10	UPA-I	I	1980
4_100537	3	MAF5	35.23	-111.81	Coconino	I-40	RPA-I	I	2671

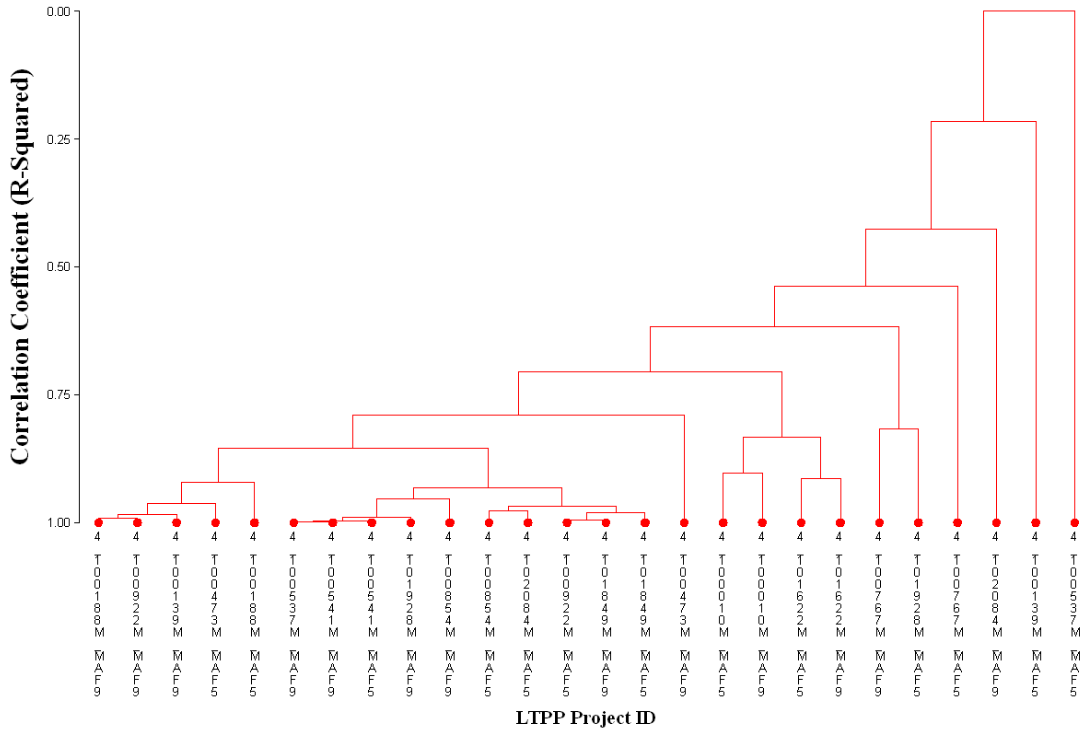

Figure 37. Results from the Correlation Coefficient Method for Monthly Truck Adjustment Factors.

Plots of MAF for several of the AVC sites are shown in Figure 38 through Figure 41. MAF plots for all of the projects used in this analysis are presented in Appendix D.

Statistically, all of these MAF factors are the same. The main question is whether these monthly variations will cause a significant change in the pavement design. While some of these plots show differences from month to month that may appear to be significant, some designs prepared with the MEPDG with these monthly distribution factors showed no significant thickness differences for HMA (fatigue damage) or PCC thickness (fatigue damage) to control structural damage.

Thus, it is concluded that while Level 1 MAFs can be obtained with on-site AVCs, using straight 1.00 for every month for Level 3 would not normally produce a different required thickness.

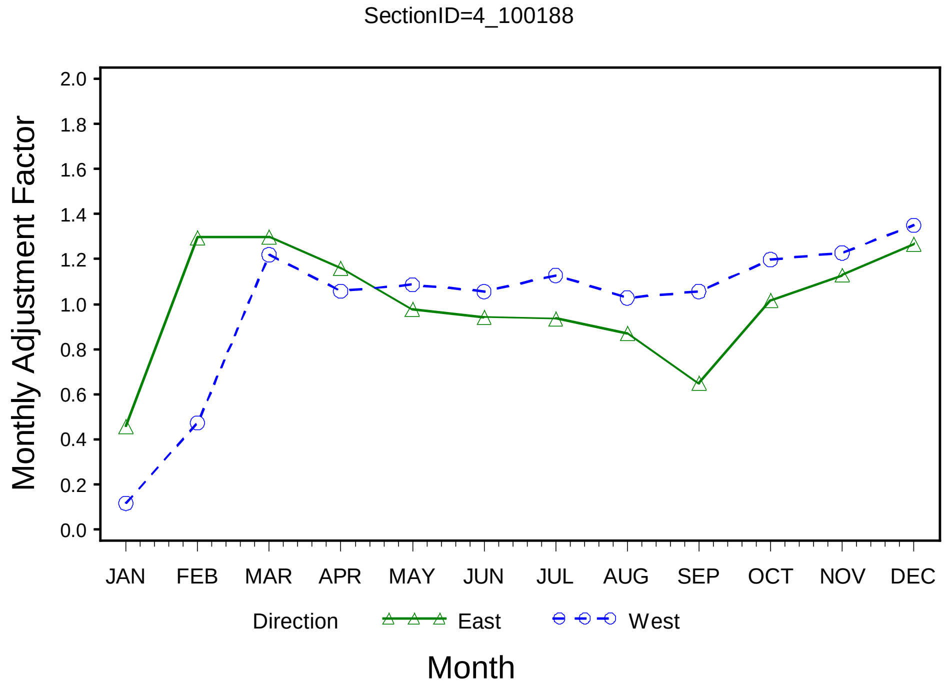

Figure 38. Plot of MAF for Site 4_100188 (Vehicle Class 5), I-10 in Cochise County.

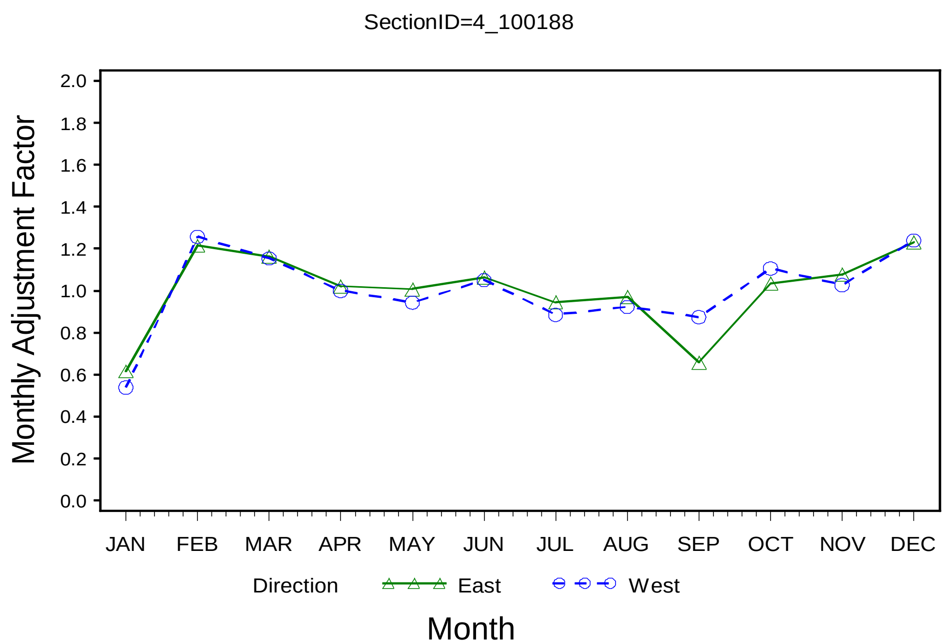

Figure 39. Plot of MAF for Site 4_100188 (Vehicle Class 9), I-10 in Cochise County.

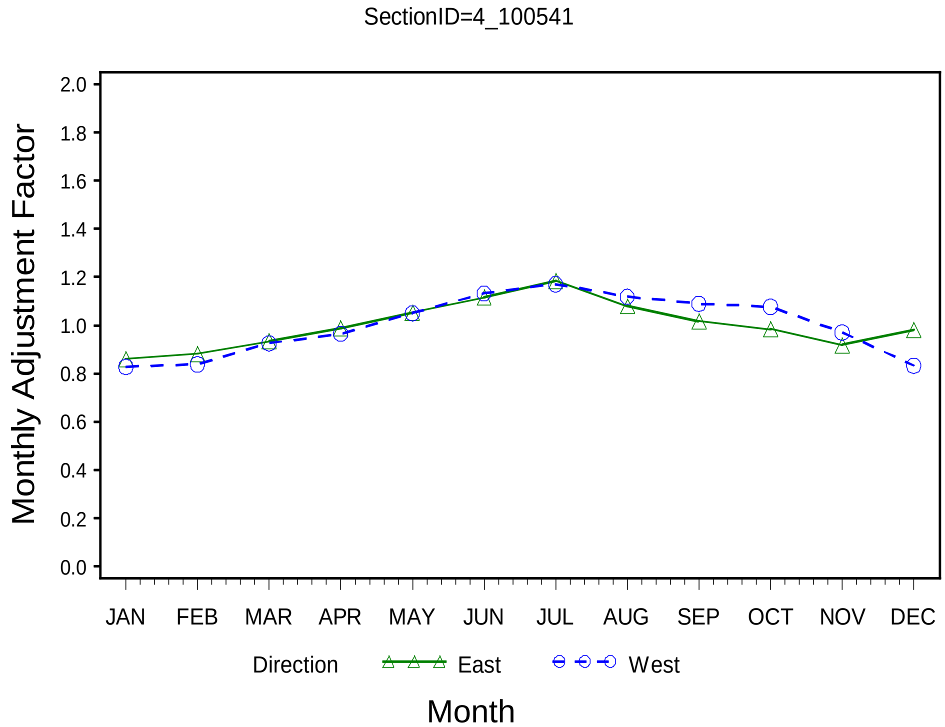

Figure 40. Plot of MAF for Site 4_100541 (Vehicle Class 5), I-40 in Coconino County.

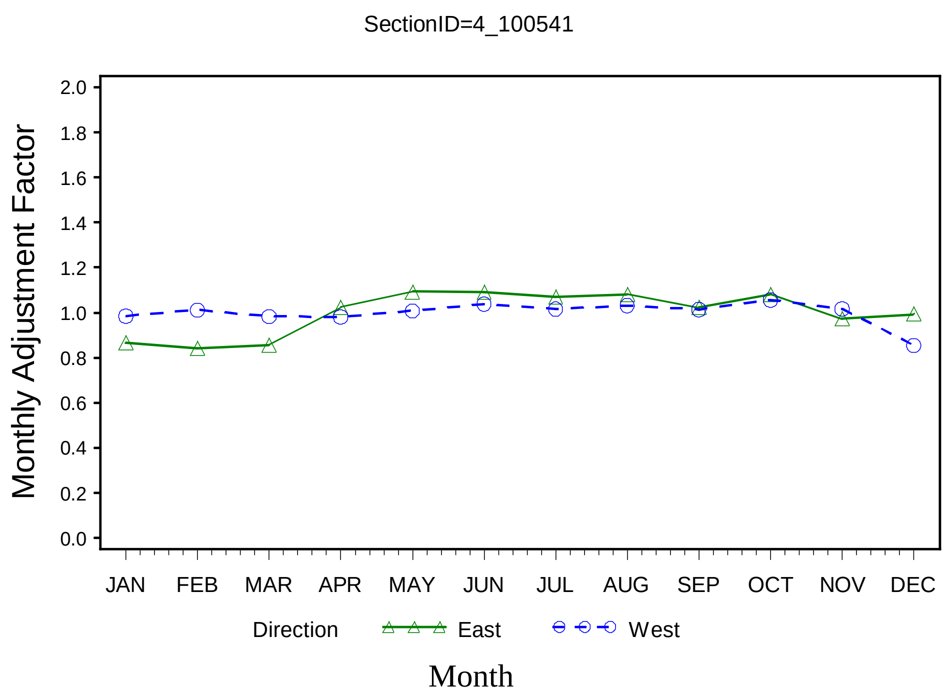

Figure 41. Plot of MAF for Site 4_100541 (Vehicle Class 9), I-40 in Coconino County.

AXLE LOAD DISTRIBUTION

The ALD for a given highway section affects the load applied to the pavement by each single, tandem, tridem, and quad axles that pass over the given section during the design period, and it is an important MEPDG input. ALD data were analyzed using data representing 29 ADOT LTPP project sites. A map showing the locations of the project sites is shown in Figure 42.

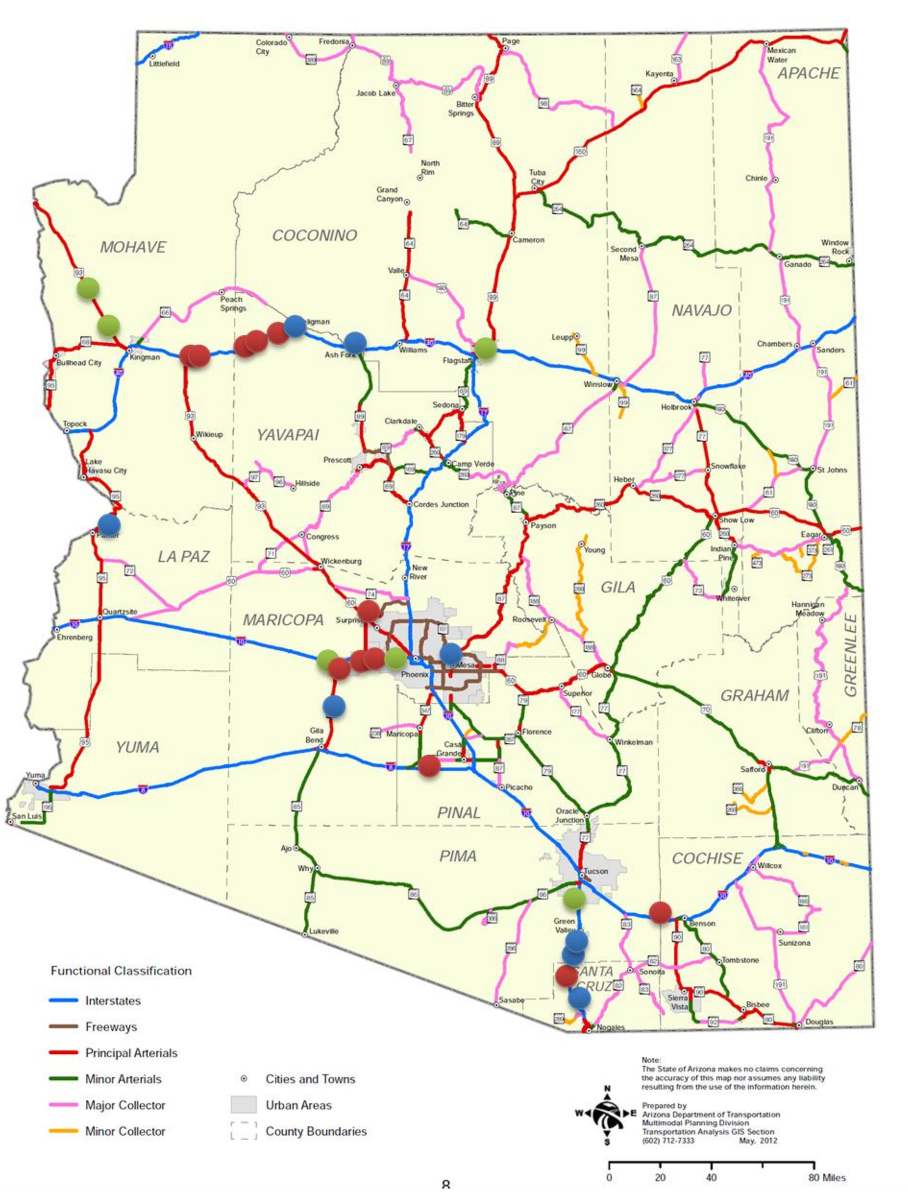

Figure 42. Locations of the LTPP Sites with WIM Data.

Data were evaluated from the 29 sites to help derive Level 3 defaults for MEPDG traffic inputs. The MEPDG includes national recommendations or default ALD (based on averages from over 100 sites located across the United States) for all four axle types. Of primary interest is how well the national defaults match local Arizona ALD, and if there is the need for Arizona-specific ALD defaults. Based on this information, Arizona-specific ALDs can be derived as needed.

The predominant truck types on Arizona highways are Classes 5 and 9. Emphasis was placed on how ALD for Classes 5 and 9 match with national defaults. Note that the predominant axle type for Class 5 trucks is single, and Class 9 trucks include both single and tandem.

For comparative purposes, the default MEPDG ALD and ALD from selected ADOT LTPP sites are shown in Figure 43 through Figure 45. Also included in these plots are the MEPDG default ALD.

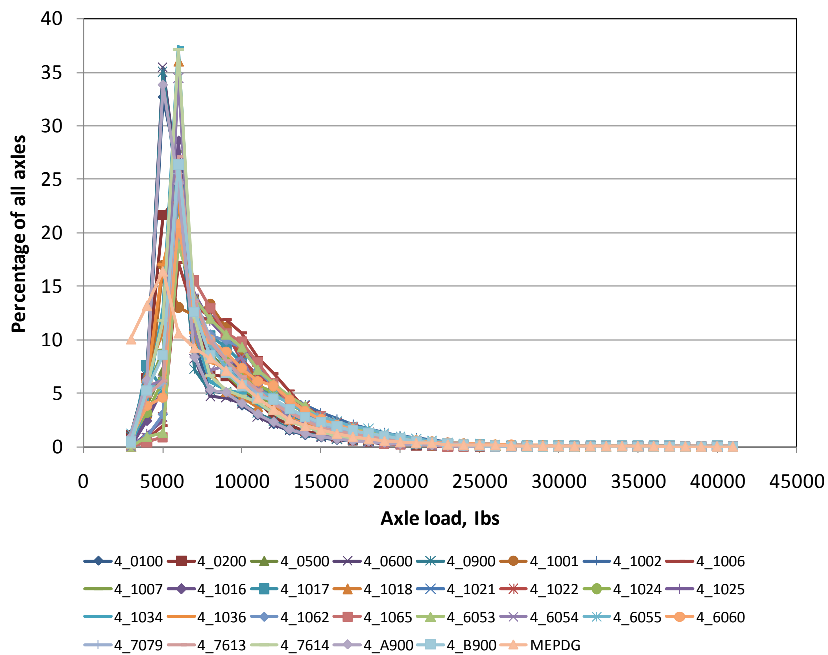

Figure 43. Typical Arizona Highway Class 5 Truck Single-Axle Load Distribution.

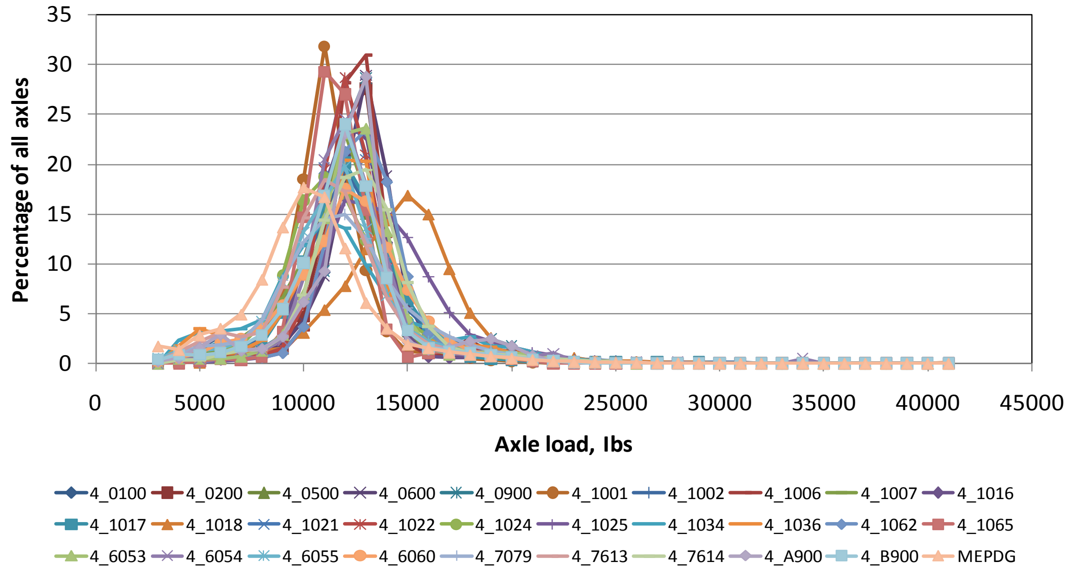

Figure 44. Typical Arizona Highway Class 9 Truck Single-Axle Load Distribution.

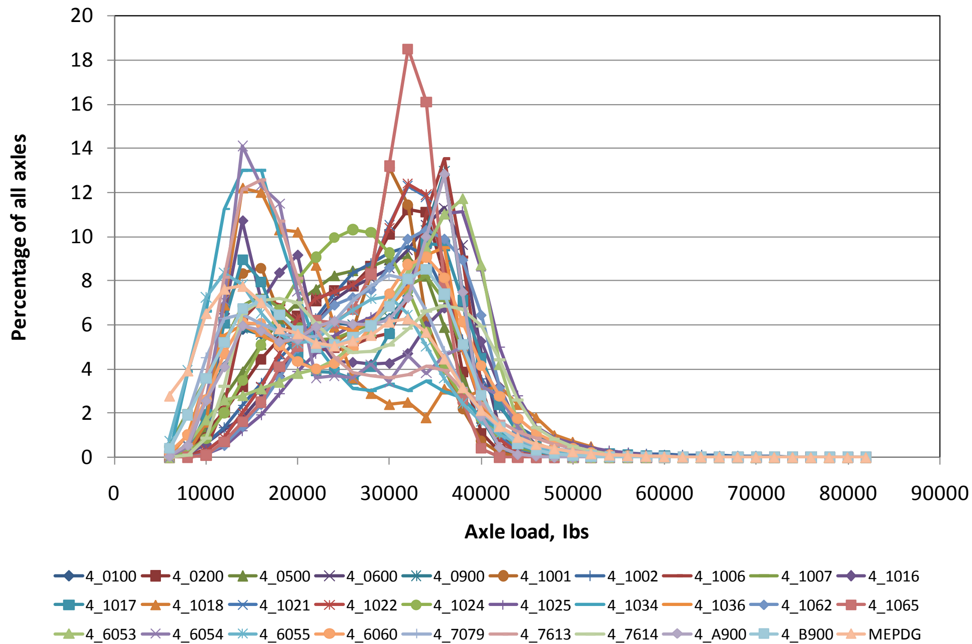

Figure 45. Typical Arizona Highway Class 9 Truck Tandem-Axle Load Distribution.

A review of the ALD plots showed the following:

- Class 5 and Class 9 single ALD exhibited a single peak load. The peak load ranged from 5,000 to 7,000 lb for Class 5 single axles and 11,000 to 15,000 lb for Class 9 single axles. This distribution is typical of Arizona highways in rural and urban areas; however, a few of these Class 9 trucks showed single axles with significantly higher axle loads when compared to other sites within the state.
- For both Class 5 and Class 9 single ALD, the Arizona sites exhibited higher peak loads when compared to the MEPDG national defaults.
- Class 9 tandem ALD exhibited two peak loads. The peak loads ranged from 12,000 to 18,000 lb and 32,000 to 38,000 lb.

ALD data from the 29 LTPP sites were analyzed to develop clusters for Level 3 Arizona ALD defaults. The results are presented in the following sections.

Cluster Analysis of ADOT LTPP ALD Data

A cluster analysis similar to that conducted for other inputs was conducted using all LTPP sites with WIM and ALD data. The data were reviewed and cleaned as previously described prior to performing this cluster analysis. ALD data from specific years that were deemed outliers or obvious data errors were excluded from this analysis. The reasons for deviations from the typical distributions included local construction resulting in roadway closures, construction of new routes leading to the permanent diversion of traffic, and problems with WIM equipment. Specific data not included in this analysis are shown in Table 25.

Table 25. Summary of Outlier Data Excluded from the Cluster Analysis.

Section ID	Year	Vehicle Class and Axle Type
4_0100	2004	Class 5, Single Axles
4_0600	2002	
4_0600	2003	
4_0900	2004	
4_6060	1998	
4_A900	2004	
4_B900	1997	
4_B900	1998	
4_0100	2006	Class 9, Single Axles
4_0500	2008	
4_0600	2002	
4_0600	2003	
4_1002	1999	
4_1002	2005	
4_1007	2000	
4_1007	2001	
4_1007	2002	
4_1007	2003	
4_6055	2001	
4_6055	2002	
4_7079	1993	
4_7079	1994	
4_B900	2000	
4_B900	2001	
4_B900	2002	
4_B900	2003	
4_0100	2006	Class 9, Tandem Axles
4_0600	2002	
4_0600	2003	
4_1002	1999	
4_1007	2000	
4_6055	2001	
4_6055	2002	
4_7079	1993	
4_7079	1994	
4_7614	1993	

Figure 46 through Figure 48 show ALD for Class 5 and Class 9 trucks, and Table 26 shows the final results from the ALD cluster analysis. The cluster analysis showed that there were three major groupings for ALD and a possible sub-grouping within Cluster 1. All of the three main Arizona groupings were different from the MEPDG default ALD for Class 5 and Class 9 single axles and Class 9 tandem axles.

Cluster 1: This distribution had one large peak for Class 5 single axles. The peak corresponded with approximately 6,000 lbs of weight. The percentage of single axles at this weight was approximately 25. The Class 9 single axles that also had a large peak corresponded with approximately 11,000 lbs of weight. The percentage of single axles at this weight was approximately 20. For Class 9 tandems, the ALD had two large peaks. The difference in percentage of axles at the peaks was quite small (i.e., 2 percent). The heavier peak exhibited a higher percentage of axles. The main functional class highway was Rural Principal Arterial – Interstate.

Cluster 2: This distribution had one large peak for Class 5 single axles. The peak corresponded with approximately 6,000 lbs of weight. The percentage of single axles at this weight was approximately 25. The Class 9 single axles that also had a large peak corresponded with approximately 11,000 lbs of weight. The percentage of single axles at this weight was approximately 16. For Class 9 tandems, ALD had two large peaks. The difference in percentage of axles at the peaks was quite small (i.e., 2.5 percent). The heavier peak exhibited a lower percentage of axles. The main functional class highway was urban freeways and rural minor arterials/collectors.

Cluster 3: This distribution had one large peak for Class 5 single axles. The peak corresponded with approximately 6,000 lbs of weight. The percentage of single axles at this weight was approximately 32.5. This was significantly higher than those reported for Clusters 1 and 2. The Class 9 single axles that also had a large peak corresponded with approximately 11,000 lbs of weight. The percentage of single axles at this weight was approximately 25 (higher than that reported for Clusters 1 and 2). For Class 9 tandems, ALD had two large peaks. The difference in percentage of axles at the peaks was significant (i.e., 10 percent). The heavier peak exhibited a significantly higher percentage of axles. The main functional class highway was rural principal arterial (non-Interstates).

None of the Arizona-derived clusters matched with the MEPDG defaults. Plots of ALD for all of the projects analyzed are presented in Appendix E.

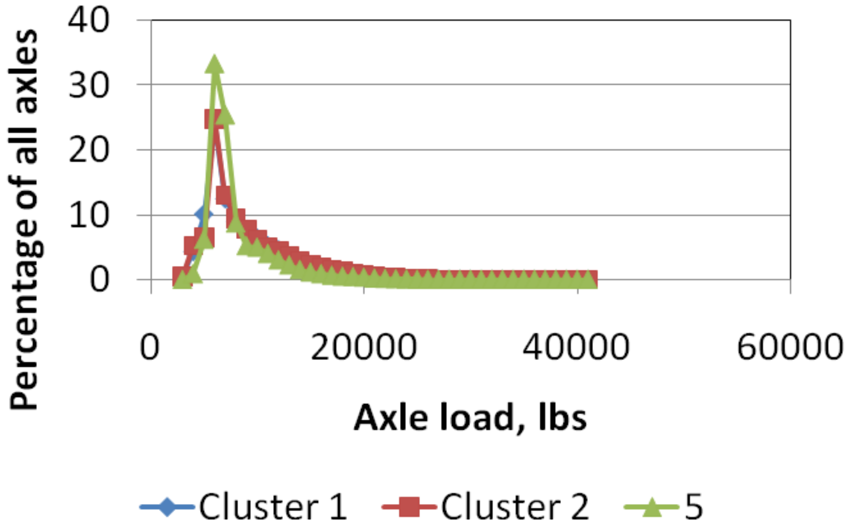

Figure 46. Single-Axle Load Distribution for Truck Class 5.

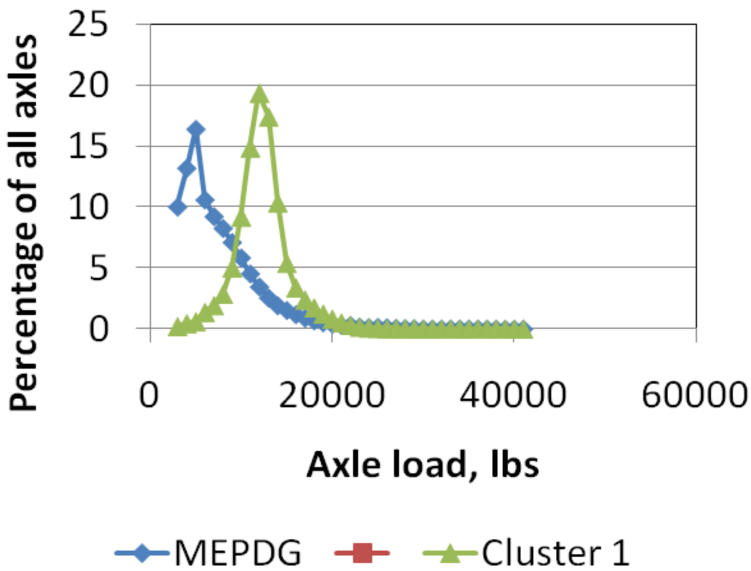

Figure 47. Single-Axle Load Distribution for Truck Class 9.

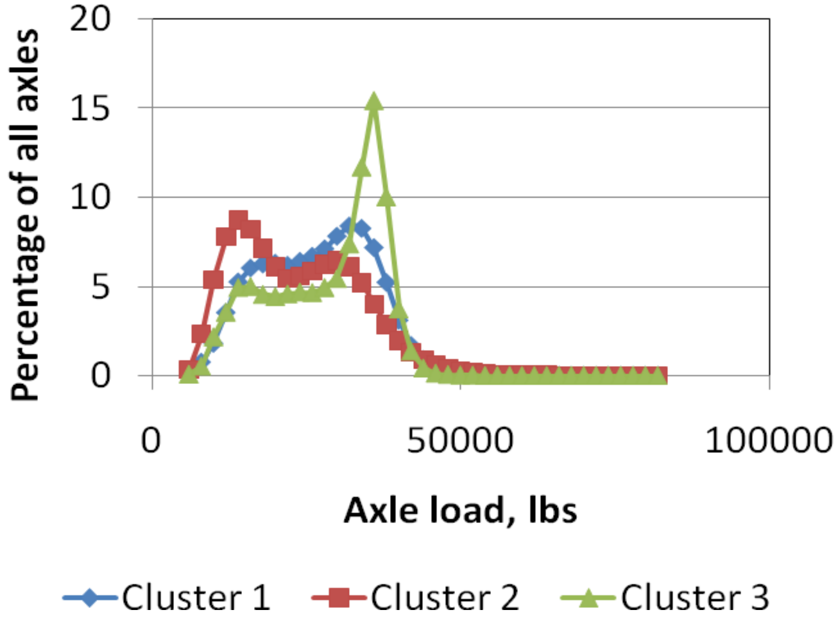

Figure 48. Tandem-Axle Load Distribution for Truck Class 9.

Table 26. Summary of Cluster Analysis for ALD Using ADOT and LTPP Datasets.

ID	S5, Cluster	ID	S9, Cluster	ID	T9, Cluster	County	Route	FClass	Route Type	AADTT	Cluster Combined
4_0500	1	4_0500	1	4_0500	1	Pinal	I-08	RPA-I	I	930	Rural principal arterial (Interstates)
4_1001	1	4_1001	1	4_1001	1	Maricopa	I-10	RPA-I	I	4660	
4_1006	1	4_1006	1	4_1006	1	Maricopa	I-10	RPA-I	I	5740	
4_1007	1	4_1007	1	4_1007	1	Maricopa	I-10	RPA-I	I	5439	
4_6053	1	4_6053	1	4_6053	1	Pima	I-10	RPA-I	I	2140	
4_B900	1	4_B900	1	4_B900	1	Maricopa	I-10	RPA-I	I	5439	
4_0200**	2	4_0200	1	4_0200	1	Maricopa	I-10	RPA-I	I	4820	
4_7614**	2	4_7614	1	4_7614	1	Maricopa	I-10	RPA-I	I	2667	
4_1016	1	4_1016	1	4_1016	1	Santa Cruz	I-19	RPA-I	I	1175	
4_6054**	2	4_6054	1	4_6054	1	Santa Cruz	I-19	RPA-I	I	1104	
4_1018**	2	4_1018*	2	4_1018*	2	Pima	I-19	RPA-I	I	1139	
4_6060**	3	4_6060	1	4_6060	1	Santa Cruz	I-19	RPA-I	I	2121	
4_1017**	5	4_1017*	4	4_1017	1	Pima	I-19	RPA-I	I	1164	
4_1021	1	4_1021	1	4_1021	1	Mohave	I-40	RPA-I	I	2746	
4_1022	1	4_1022	1	4_1022	1	Mohave	I-40	RPA-I	I	2729	
4_1024	1	4_1024	1	4_1024	1	Yavapai	I-40	RPA-I	I	2830	
4_1062	1	4_1062	1	4_1062	1	Mohave	I-40	RPA-I	I	2808	
4_1065	1	4_1065	1	4_1065	1	Yavapai	I-40	RPA-I	I	2802	
4_1025	1	4_1025*	2	4_1025*	3	Yavapai	I-40	RPA-I	I	2858	
4_0600**	2	4_0600	1	4_0600	1	Coconino	I-40	RPA-I	I	6225	
4_1002**	3	4_1002*	5	4_1002*	6	Yavapai	I-40	RPA-I	I	2310	
4_7079	1	4_7079	1	4_7079	1	Maricopa	SR 101	UPA-FE	SR	4498	Urban freeways and rural minor arterials/collectors
4_7613	1	4_7613	1	4_7613	2	Maricopa	SR 360	UPA-O	SR	916	
4_6055	3	4_6055	1	4_6055	5	Maricopa	SR 85	RPA-O	SR	3649	
4_1034	2	4_1034	1	4_1034	2	LaPaz	SR 95	RMA	SR	1111	
4_0100	2	4_0100	1	4_0100	1	Mohave	U.S. 93	RPA-O	US	410	Rural principal arterial (non-Interstates)
4_0900	2	4_0900	1	4_0900	1	Mohave	U.S. 93	RPA-O	US	420	
4_1036	2	4_1036	1	4_1036	1	Mohave	U.S. 93	RPA-O	US	473	
4_A900	2	4_A900	1	4_A900	1	Mohave	U.S. 93	RPA-O	US	420	
MEPDG	4	MEPDG	3	MEPDG	4						National default

Cluster 1 typically has one large peak (1P) for Class 9; Cluster 2 has two peaks, indicated by 2P, for Classes 5 and 9; and Cluster 3 has one peak for Class 4.

AXLES PER TRUCK

The numbers of single, tandem, tridem, and quad axles per truck are used to determine the total number of axles of each type to pass over the design traffic lane over the analysis period. For some trucks, such as Class 5, the number of single axles is set by the classification criteria at 2.00. For others, this value varies somewhat depending on the definition of the classification.

A cluster analysis was conducted using 33 LTPP sites in Arizona for Class 9 trucks to determine if there were any significant differences in axles per truck across the state. As a result, none are expected since a Class 9 truck is specified to have one single and two tandem axles. The sites are shown in Figure 49.

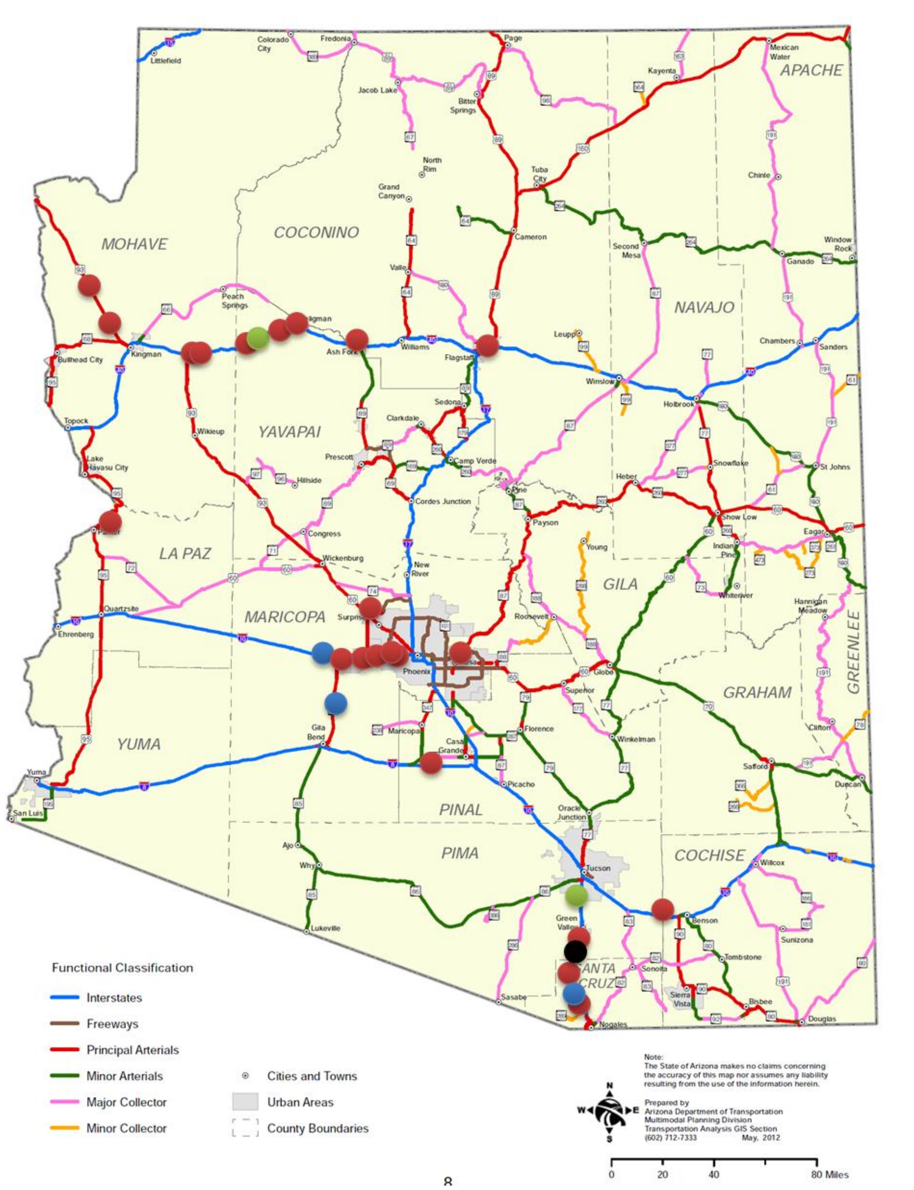

Figure 49. Map of Sites Used for the Axles-Per-Truck Analysis.

A summary of the cluster analysis is provided in Table 27. The cluster analysis indicates that a single cluster for Class 9 trucks and some outliers explain the data. This result indicates that the various sites shown in Figure 49 do not show significantly different axles per truck values. Several plots of the Class 9 tandem cluster of axles are provided as Figures 50 through 53. Plots of axles per truck for all of the projects analyzed are presented in Appendix F.

Table 27. Summary of All Sites Used in the Axles-per-Truck Cluster Analysis.

ID	Tandem Axle Cluster	Latitude, deg.	Longitude, deg.	County	Route	Functional Class	Route Type	AADTT
4_1003	1	33.48	-112.86	Maricopa	I-10	RPA-I	I	5681
4_1015	1	31.56	-111.05	Santa Cruz	I-19	RPA-I	I	1187
4_1037	1	35.19	-114.55	Mohave	SR 68	RPA-O	SR	2057
4_1065	2	35.21	-113.27	Yavapai	I-40	RPA-I	I	2802
4_6054	2	32.04	-110.99	Santa Cruz	I-19	RPA-I	I	1104
4_0100	2	35.40	-114.26		U.S. 93	RPA-O	US	410
4_0200	2	33.45	-112.74	Maricopa	I-10	RPA-I	I	4820
4_0500	2	32.83	-112.01	Pinal	I-08	RPA-I	I	930
4_0600	2	35.22	-111.56	Coconino	I-40	RPA-I	I	6225
4_0900	2	35.39	-114.26		U.S. 93	RPA-O	US	420
4_1001	2	33.46	-112.45	Maricopa	I-10	RPA-I	I	4660
4_1002	2	35.22	-112.49	Yavapai	I-40	RPA-I	I	2310
4_1006	2	33.44	-112.66	Maricopa	I-10	RPA-I	I	5740
4_1007	2	33.44	-112.58	Maricopa	I-10	RPA-I	I	5439
4_1016	2	31.64	-111.06	Santa Cruz	I-19	RPA-I	I	1175
4_1018	2	31.81	-111.01	Pima	I-19	RPA-I	I	1139
4_1021	2	35.16	-113.68	Mohave	I-40	RPA-I	I	2746
4_1022	2	35.16	-113.60	Mohave	I-40	RPA-I	I	2729
4_1024	2	35.28	-113.13	Yavapai	I-40	RPA-I	I	2830
4_1025	2	35.30	-113.03	Yavapai	I-40	RPA-I	I	2858
4_1034	2	34.16	-114.27	La Paz	SR 95	RMA	SR	1111
4_1036	2	35.71	-114.48	Mohave	U.S. 93	RPA-O	US	473
4_1062	2	35.19	-113.35	Mohave	I-40	RPA-I	I	2808
4_6053	2	31.97	-110.51	Pima	I-10	RPA-I	I	2140
4_6055	2	33.25	-112.64	Maricopa	SR 85	RPA-O	SR	3649
4_6060	2	31.52	-111.02	Santa Cruz	I-19	RPA-I	I	2121
4_7079	2	33.60	-112.25	Maricopa	SR 101	UPA-FE	SR	4498
4_7613	2	33.39	-111.84	Maricopa	SR 360	UPA-O	SR	916
4_7614	2	33.46	-112.33	Maricopa	I-10	RPA-I	I	2667
4_A900	2	35.39	-114.26		U.S. 93	RPA-O	US	420
4_B900	2	33.46	-112.47	Maricopa	I-10	RPA-I	I	5439
4_1017	3	31.77	-111.04	Pima	I-19	RPA-I	I	1164

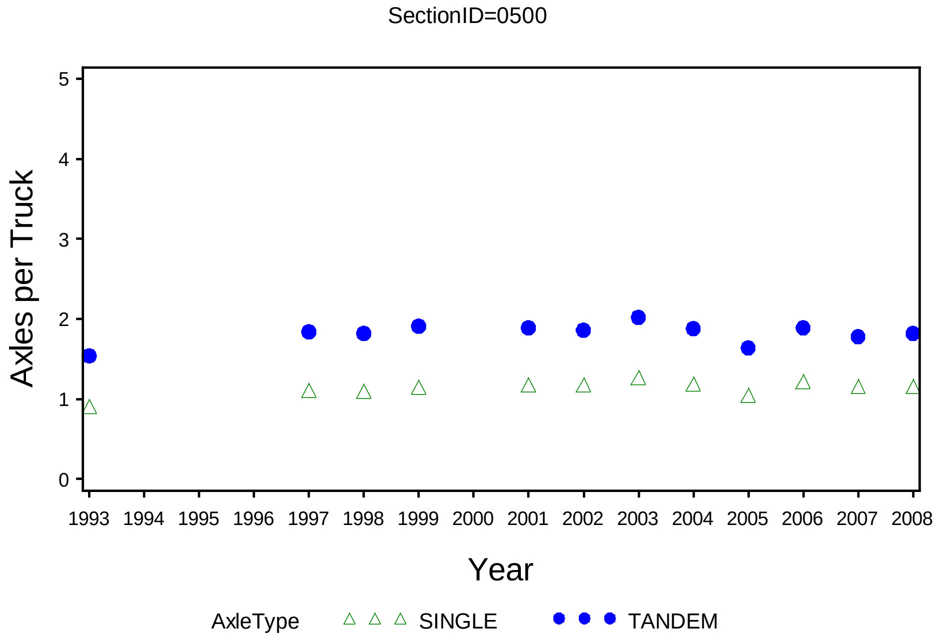

Figure 50. Plot of Axles per Truck for Site 4_0500 (Vehicle Class 9).

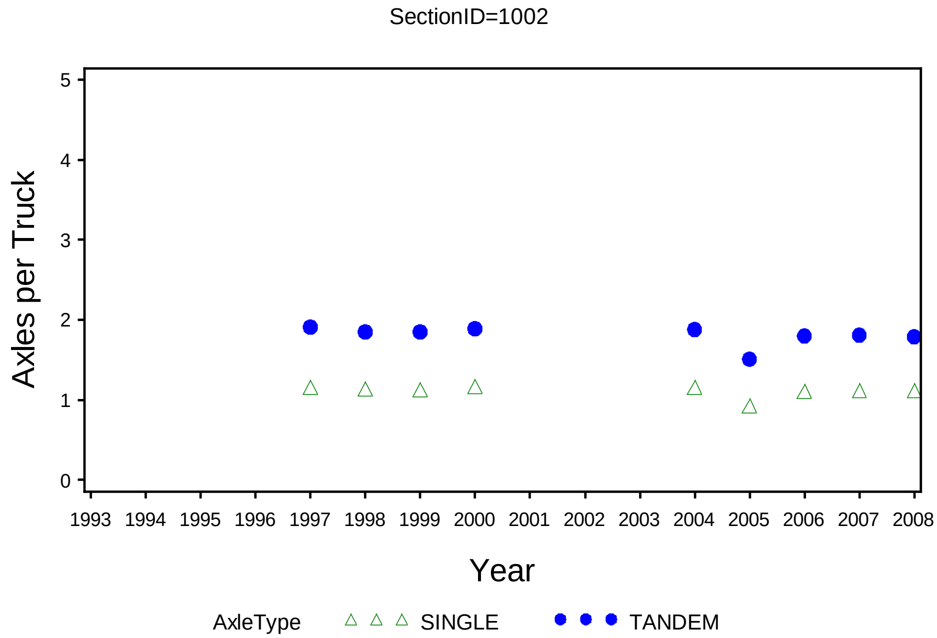

Figure 51. Plot of Axles per Truck for Site 4_1002 (Vehicle Class 9).

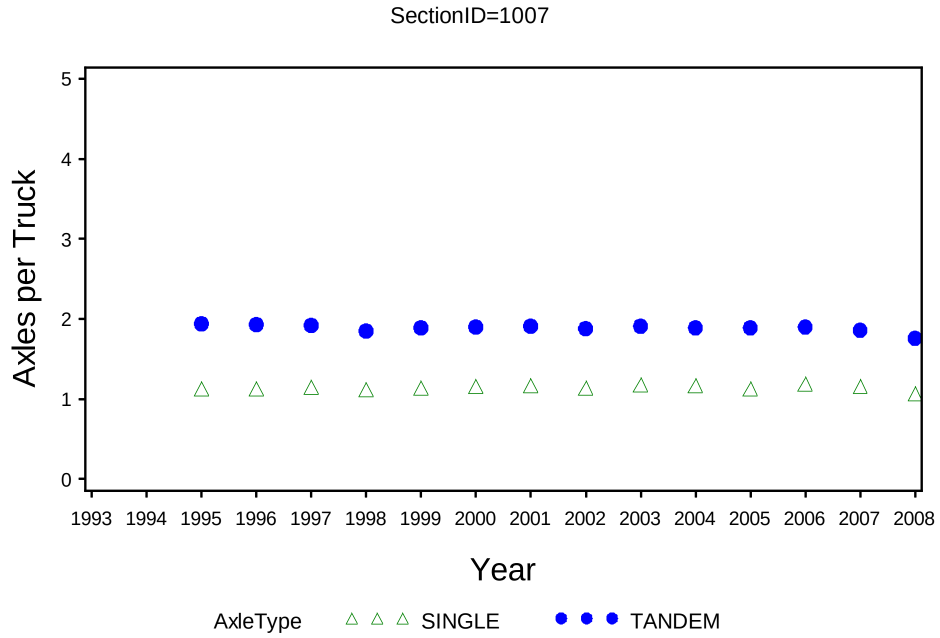

Figure 52. Plot of Axles per Truck for Site 4_1007 (Vehicle Class 9).

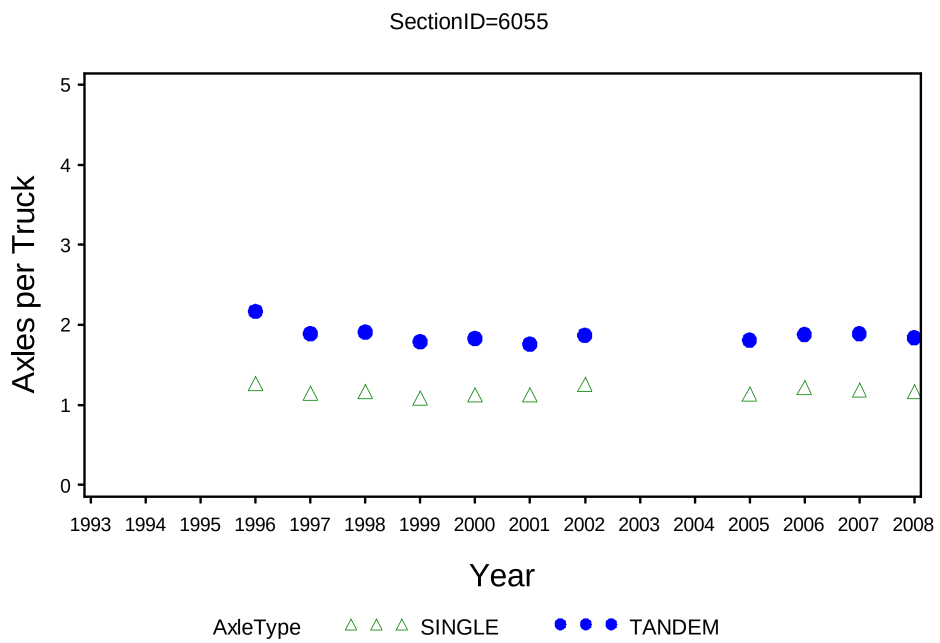

Figure 53. Plot of Axles per Truck for Site 4_6055 (Vehicle Class 9).

CHAPTER 5. SENSITIVITY ANALYSIS

A sensitivity analysis was conducted to determine the impact of the identified clusters on pavement design and to revise the clusters as needed. Typical ADOT designs for new HMA pavement and new JPCP were used as baseline pavement designs for the sensitivity analysis. This chapter presents a description of the baseline pavement designs along with traffic inputs (MEPDG inputs representing the various clusters identified) and sensitivity analysis results.

DESCRIPTION OF BASELINE PAVEMENT DESIGNS

Baseline New HMA Pavement Design

The baseline HMA pavement was modeled after LTPP project 1003 in Arizona (located on I-10, Rural Principal Arterial, in Maricopa County). The project consisted of 6-inch HMA over a 6-inch AASHTO soil class A-1, and a granular base constructed over a granular subgrade (AASHTO soil class A-2-6). MEPDG default inputs for all of the materials were assumed (see Table 28). Traffic volume is shown in Figure 54. National defaults were assumed for all other MEPDG traffic inputs. Climate data were obtained from the four closest weather stations to the project in the Phoenix/Scottsdale area (see Figure 55). An analysis period of 20 years was assumed. Only the HMA pavement distress type influenced by traffic (namely alligator cracking, rutting, and International Roughness Index [IRI]) were considered in the sensitivity analysis.

Table 28. HMA Pavement Materials Properties.

Layer Type	Properties	
HMA	**Thickness:** 6 inches	
	Gradation:	
	Sieve Size	Percent Retained or Passing
	¾-inch	7
	⅜-inch	32.5
	No. 4	48
	No. 200 (passing)	4.1
	Volumetric Properties:	
	Effective binder content	11.6 percent by volume
	Air voids	7 percent
	Bulk unit weight	150 pcf
Granular Base	AASHTO soil class	A-1-a
	Resilient modulus (at optimum)	29,500 psi
	Maximum dry density	127.7 pcf
	Optimum moisture content	7.4 percent
Subgrade	AASHTO soil class	A-2-6
	Resilient modulus (at optimum)	20,500 psi
	Max. dry density	121.9 pcf
	Optimum moisture content	10.0 percent

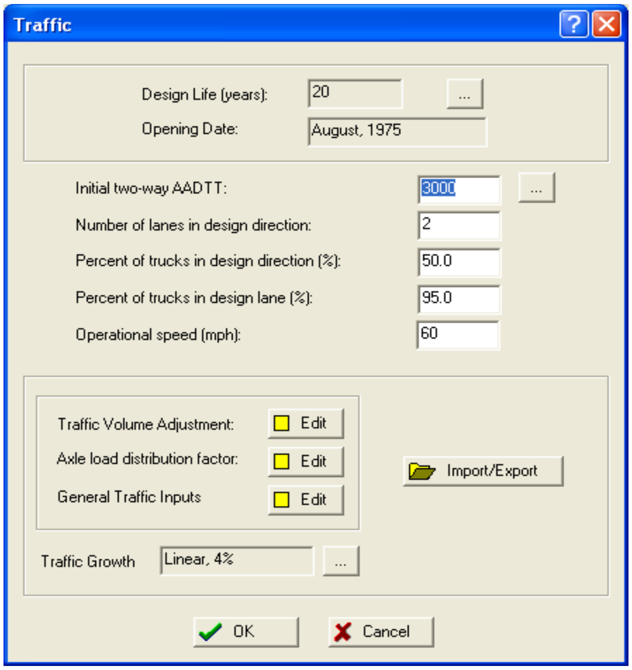

Figure 54. Baseline Traffic Volume Inputs Used for Sensitivity Analysis.

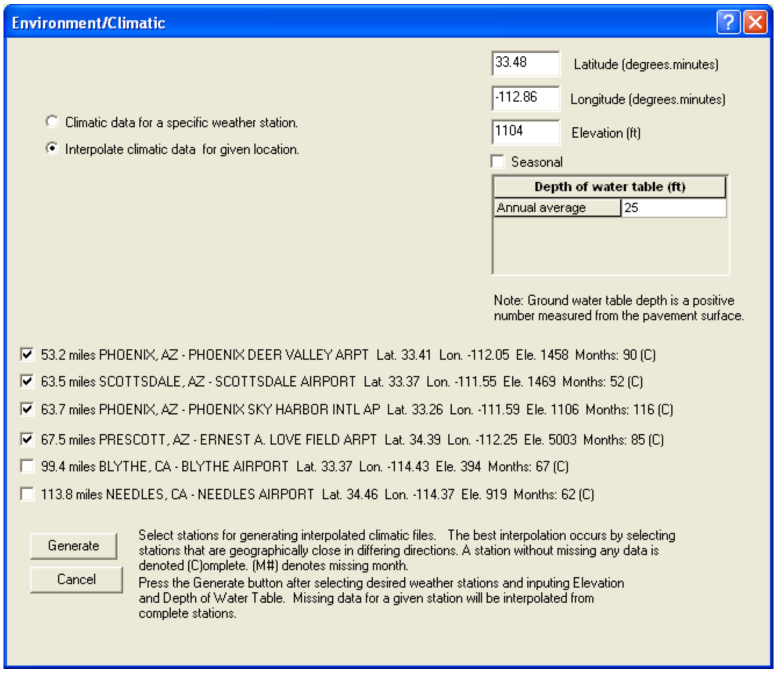

Figure 55. Location of Climate Stations for Baseline HMA Pavement Project.

Baseline New JPCP Design

The baseline JPCP was modeled after LTPP project 7613 in Arizona (located on SR 360/60, Urban Principal Arterial, in Maricopa County). The project consisted of 9-inch PCC over a 12-inch AASHTO soil class 2-2-7 granular base constructed over a granular subgrade (AASHTO soil class A-2-7). MEPDG default inputs for all of the materials were assumed (see Table 29). The traffic volume was as shown in Figure 54 (for new HMA pavement). National defaults were assumed for all other MEPDG traffic inputs for the baseline project. Climate data were obtained from the three closest weather stations to the project in the Phoenix/Scottsdale area (see Figure 56). An analysis period of 30 years was assumed. Only the JPCP distress types influenced by traffic (transverse cracking, faulting, and IRI) were considered in the sensitivity analysis.

Table 29. JPCP Materials Properties.

Layer Type	Properties	
PCC	**Thickness:** 9 inches	
	Strength	
	28-day flexural strength	684 psi
	28-day elastic modulus	3,770,000
	Coef. of thermal expansion	5.5/deg. C
Granular Base	AASHTO soil class	A-2-7
	Resilient modulus (at optimum)	16,000 psi
	Maximum dry density	121.0 pcf
	Optimum moisture content	10.8 percent
Subgrade	AASHTO soil class	A-2-6
	Resilient modulus (at optimum)	16,000 psi
	Maximum dry density	120.4 pcf
	Optimum moisture content	10.8 percent

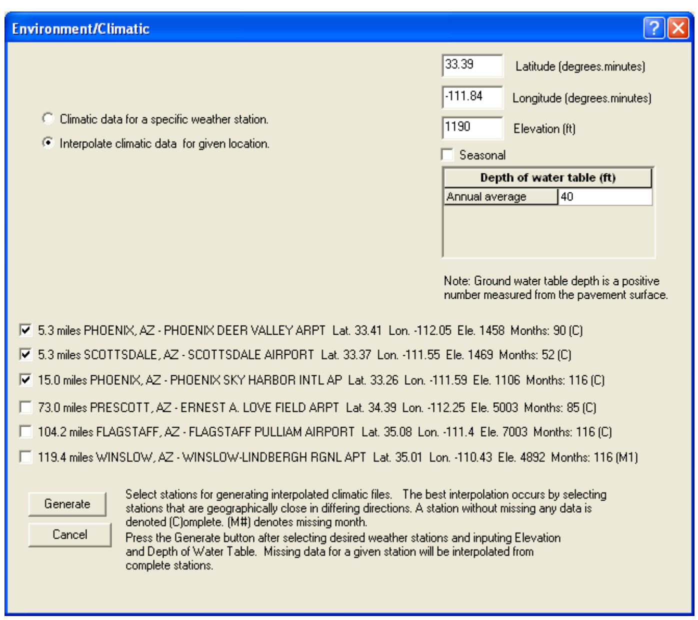

Figure 56. Location of Climate Stations for Baseline HMA Pavement Project.

MEPDG TRAFFIC INPUTS USED FOR SENSITIVITY ANALYSIS

All of the natural clusters identified in Chapter 4 were considered for use in this sensitivity analysis. The representative MEPDG input for a given cluster (e.g., ALD) was the average of all ALD for projects that fall within the given cluster. Based on the outcome of this cluster analysis, the clusters presented in Table 30 were used for this sensitivity analysis. Figures 57 through 61 show plots of the clusters used for sensitivity analysis for VCD, ALD, and hourly distribution.

Table 30. MEPDG Traffic Input Data Clusters Used for Sensitivity Analysis.

MEPDG Data Type	Number of Clusters
Vehicle class distribution	2
Axle load distribution	3
Hourly distribution	3*
Monthly adjustment factors	1
Axles per truck	1**

*The third cluster consisted of a single project. This cluster was not considered.
**Identified outliers were not considered.

Figure 57. Plot of VCD for Clusters 1 and 2 and the MEPDG Default.

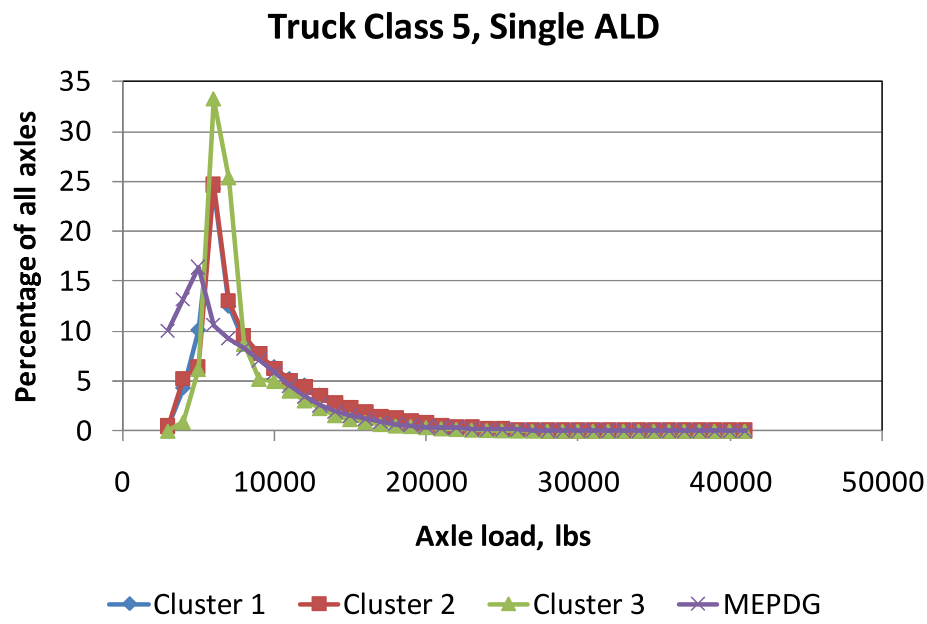

Figure 58. Plot of Single ALD for Clusters 1, 2, and 3 (Class 5 Trucks Only).

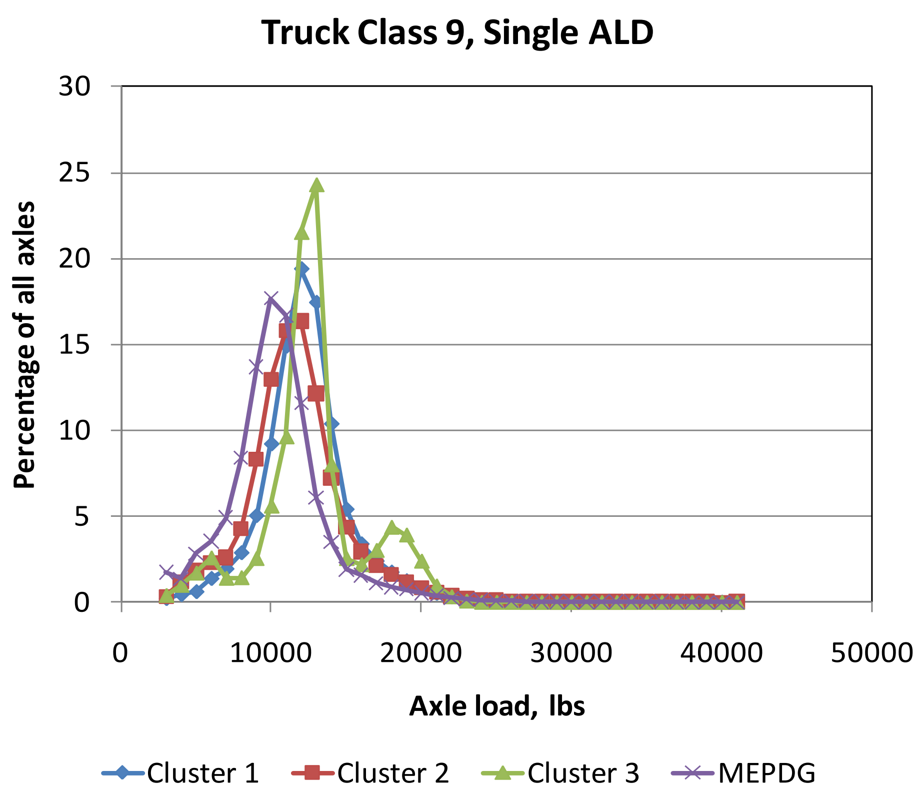

Figure 59. Plot of Single ALD for Clusters 1 and 2 (Class 9 Trucks Only).

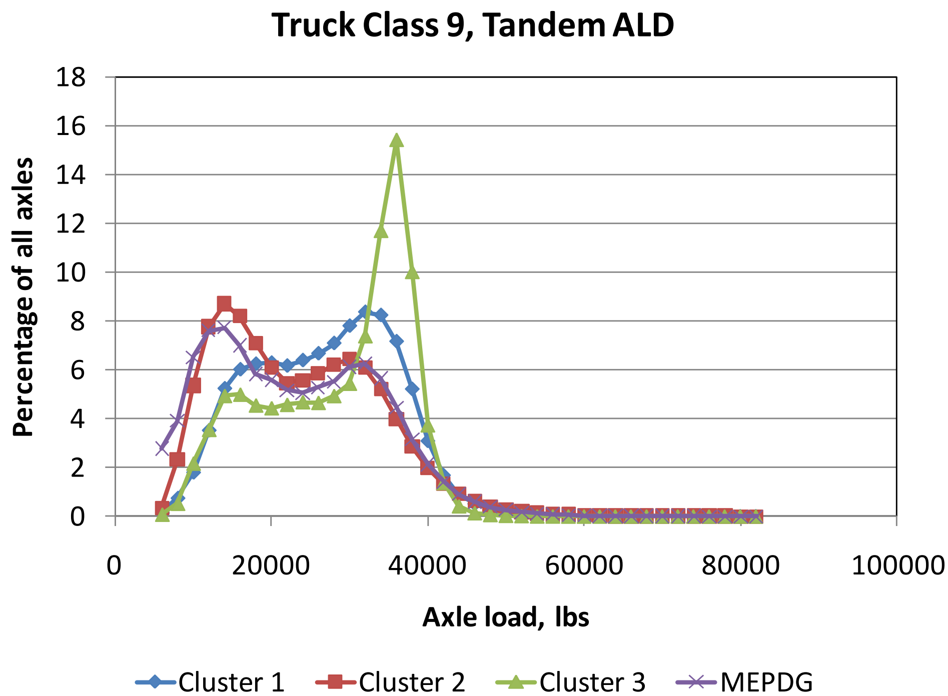

Figure 60. Plot of Tandem ALD for Clusters 1 and 2 (Class 9 Trucks Only).

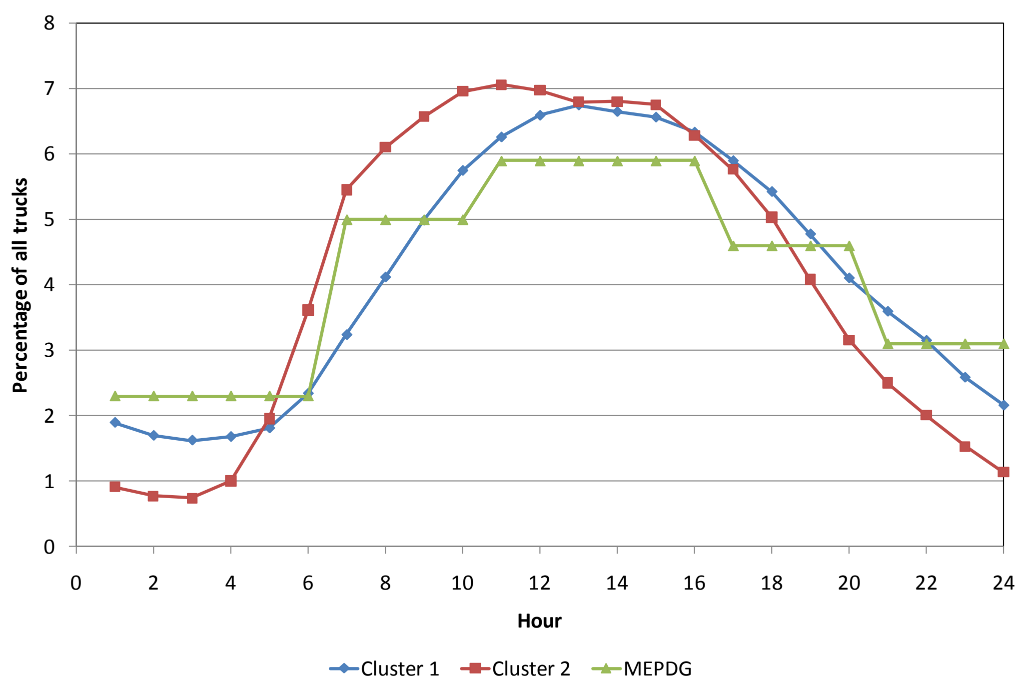

Figure 61. Plot of Hourly Distribution for Clusters 1 and 2 and the MEPDG Default.

SENSITIVITY ANALYSIS RESULTS

Vehicle Class Distribution

Sensitivity analysis results showing the impact of VCD from the two Arizona clusters are presented in Figures 62 through 67. A sensitivity analysis was performed using typical Arizona HMA and JPCP projects (LTPP projects 1003 and 7613 for HMA and JPCP, respectively, with some modifications to JPCP design features and base year AADTT).

HMA thickness was varied from 4 to 14 inches until an adequate design was achieved. All distresses were below terminal values: alligator cracking = 20 percent lane area, total rutting = 0.75 inches. It is worth noting that it is obvious from these analyses that rutting is over-predicting and will need local calibration, and IRI = 172 inches/mile at 90 percent reliability .

PCC thickness was varied from 8 to 12 inches until an adequate design was achieved. All distresses were below terminal values: faulting = 0.12 inches, cracking = 15 percent, and IRI = 172 inches/mile at 90 percent reliability. The sensitivity analysis results are summarized in Table 31.

The sensitivity analysis results show a significant impact of VCD (Arizona Clusters 1 and 2) on both HMA and JPCP design. For HMA pavements, the difference in HMA thickness (depending on the selected failure criterion) ranged from 4.3 to 28.6 percent. For JPCP, the difference in PCC thickness (depending on the selected failure criterion) ranged from 2.9 to 9.4 percent. The difference in overall design thickness was 4.3 percent for new HMA pavements and 5.7 percent for new JPCP. The impact of this on pavement construction costs will be significant.

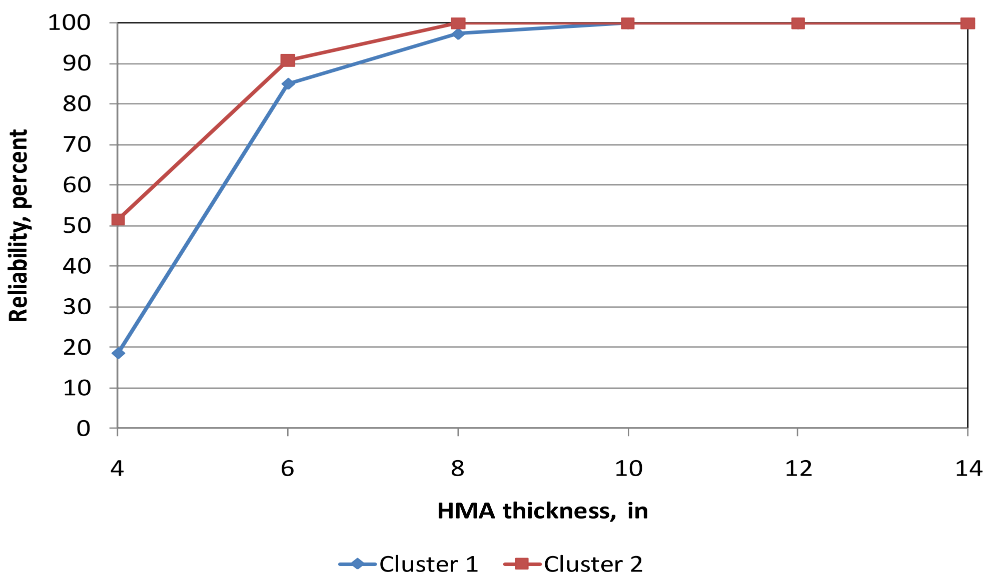

Figure 62. Plot Showing the Effect of VCD Clusters 1 and 2 on New HMA Pavement Alligator Cracking.

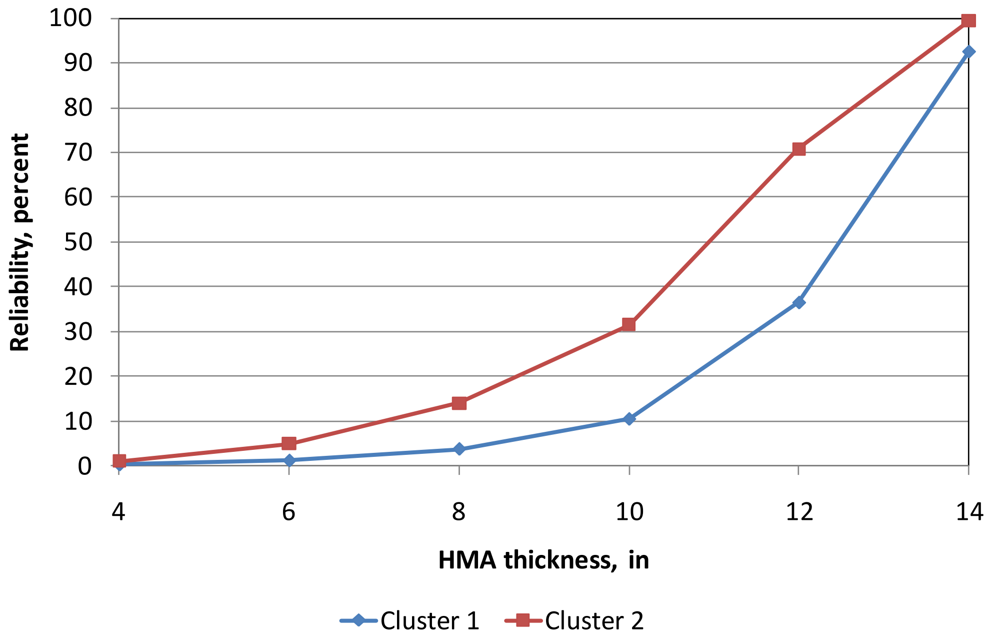

Figure 63. Plot Showing the Effect of VCD Clusters 1 and 2 on New HMA Pavement Rutting.

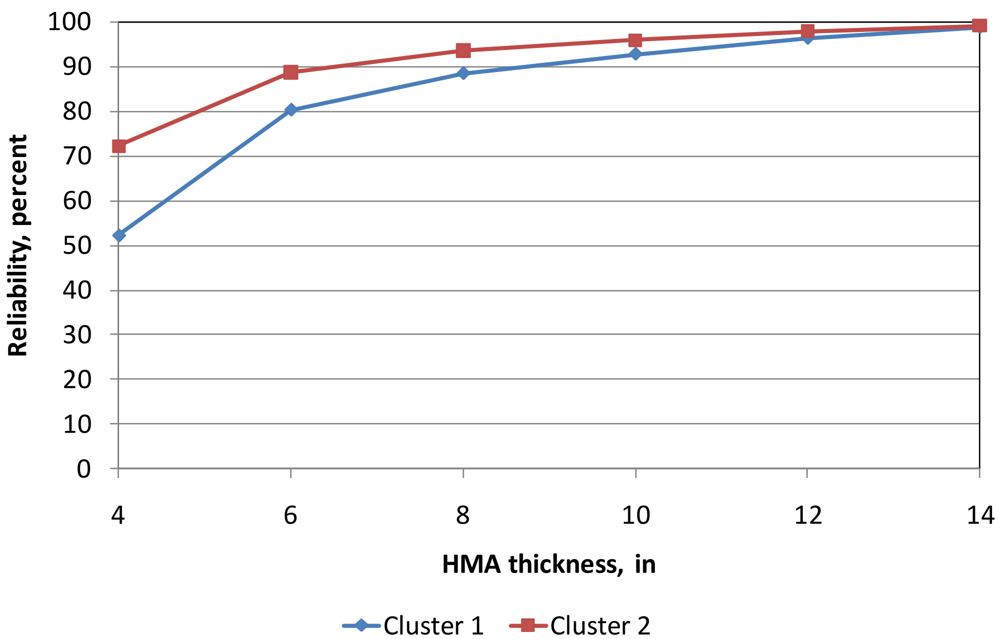

Figure 64. Plot Showing the Effect of VCD Clusters 1 and 2 on New HMA Pavement IRI.

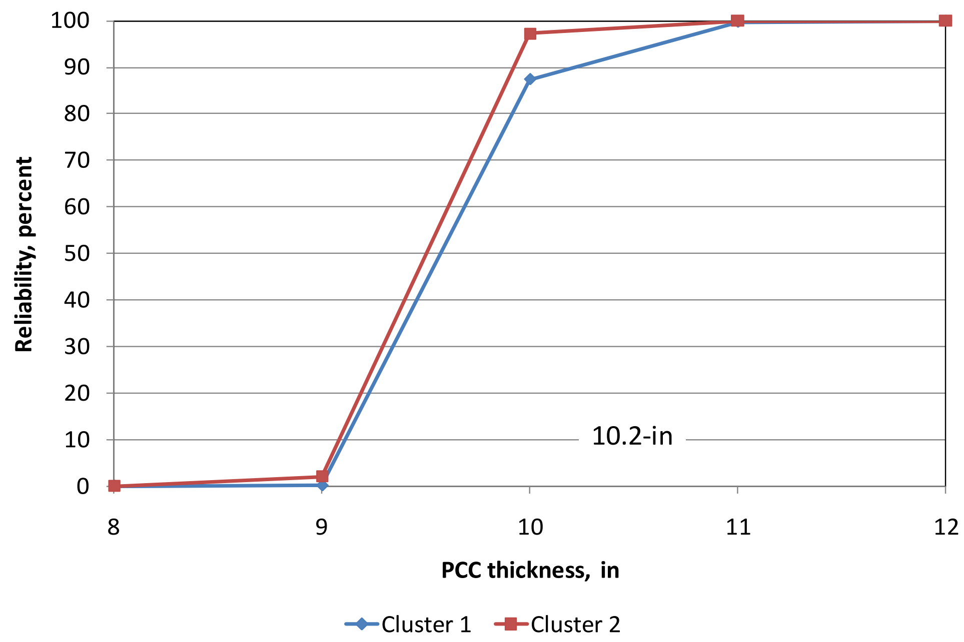

Figure 65. Plot Showing the Effect of VCD Clusters 1 and 2 on New JPCP Transverse Cracking.

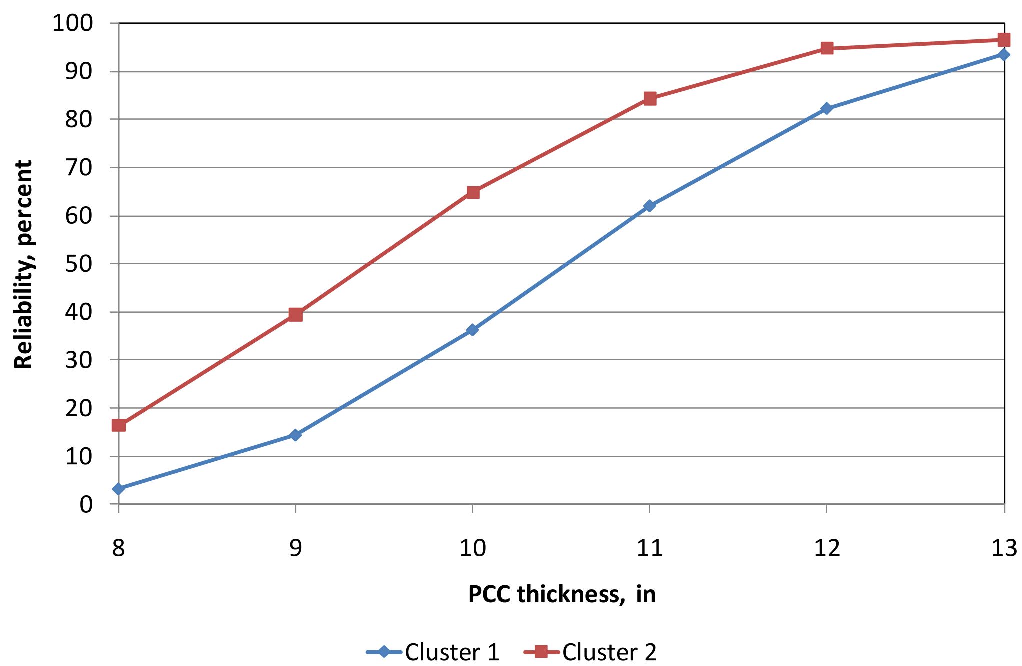

Figure 66. Plot Showing the Effect of VCD Clusters 1 and 2 on New JPCP Faulting.

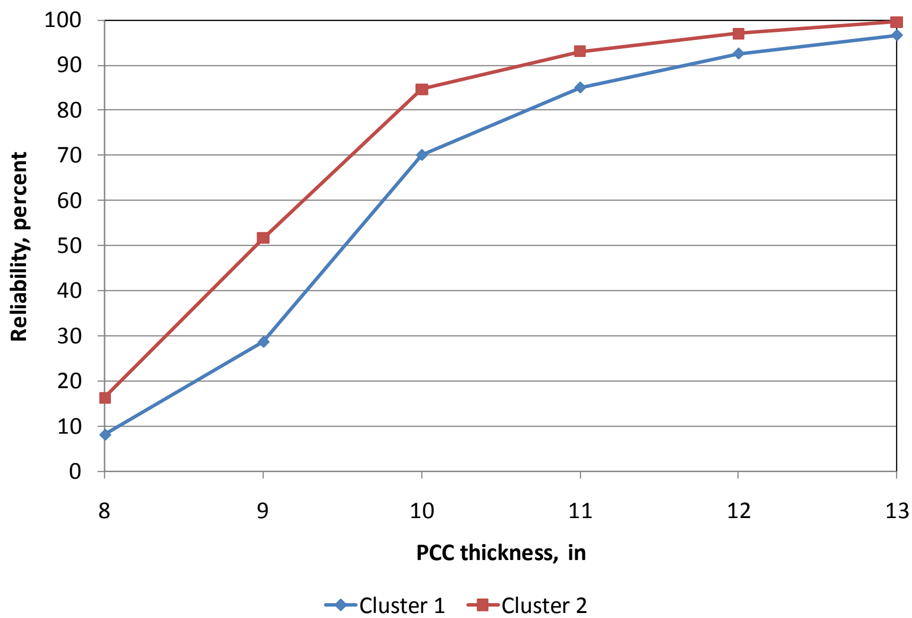

Figure 67. Plot Showing the Effect of VCD Clusters 1 and 2 on New JPCP IRI.

Table 31. Summary of Sensitivity Results for VCD.

Pavement Type	Distress/IRI	Design HMA/PCC Thickness at 90 Percent Reliability, in.		Percent Difference
		Cluster 1	Cluster 2	
HMA	Alligator cracking	6.9	6.1	11.6
	Rutting	13.9	13.3	4.3
	IRI	9.1	6.5	28.6
HMA overall design		13.9	13.3	4.3
JPCP	Transverse cracking	10.2	9.9	2.9
	Faulting	12.2	11.5	5.7
	IRI	11.7	10.6	9.4
JPCP overall design		12.2	11.5	5.7

Axle Load Distribution

Sensitivity analysis results showing the impact of ALD from the three Arizona clusters and MEPDG national defaults are presented in Figures 68 through 73. Sensitivity analysis was performed using the typical Arizona LTPP projects as described for VCD. The sensitivity analysis results are summarized in Table 32.

The sensitivity analysis showed mixed results. Depending on the distress type of interest in setting the design criteria, the ALD could have a significant impact on thickness (6.7 percent difference in HMA thickness for alligator cracking, 7.1 percent difference in HMA thickness for HMA IRI, and a 3.9 percent difference in PCC thickness for transverse cracking).

However, the analysis results showed no significant impact of ALD (Arizona clusters and MEPDG national default) on overall HMA and JPCP design. This was because, for new HMA pavement, overall HMA thickness was based on rutting, which showed no significant difference for ALD. For both HMA rutting and JPCP faulting and IRI, it may be that the very high axle loads that cause most of the permanent strains in HMA, fatigue damage, and faulting erosion in PCC are not very different for the three clusters.

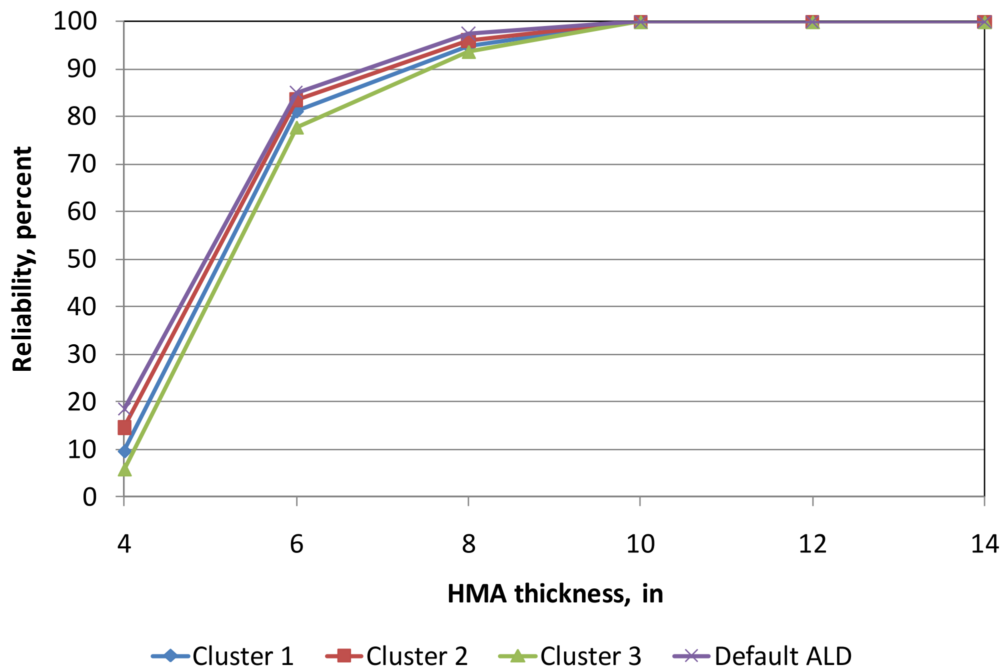

Figure 68. Plot Showing the Effect of ALD Clusters 1 through 3 on New HMA Pavement Alligator Cracking.

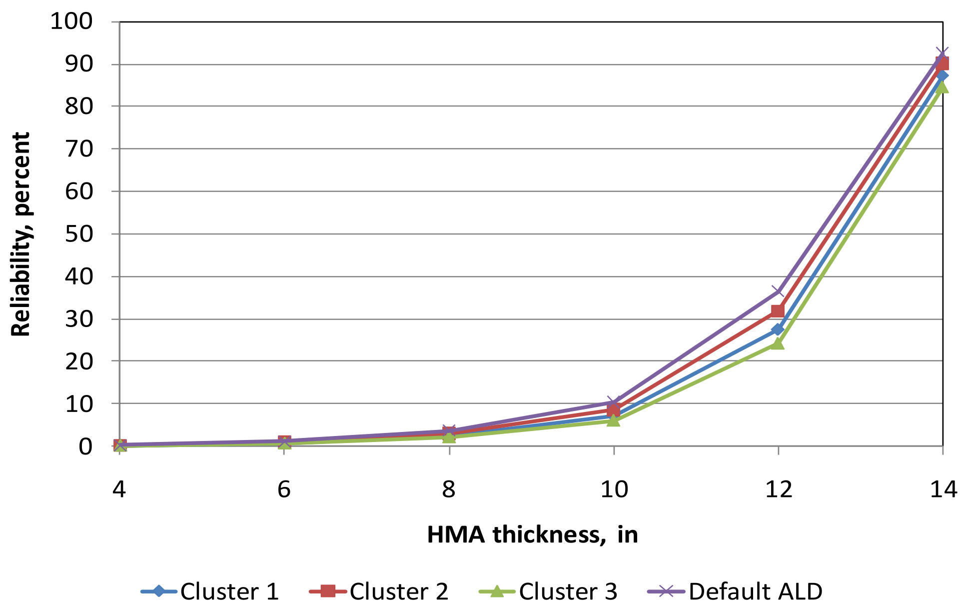

Figure 69. Plot Showing the Effect of ALD Clusters 1 through 3 on New HMA Pavement Rutting.

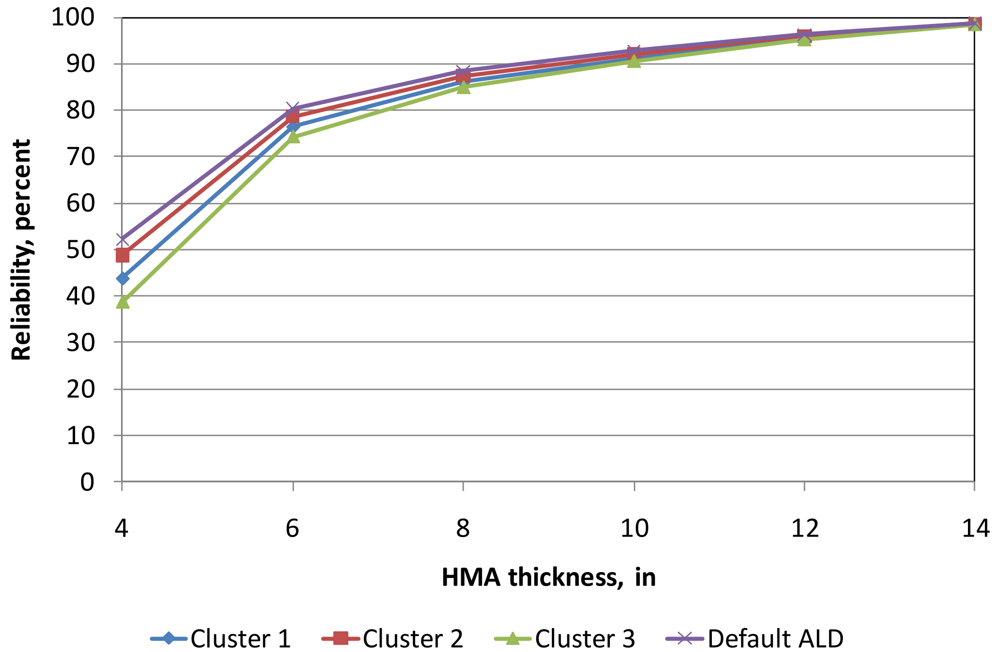

Figure 70. Plot Showing the Effect of ALD Clusters 1 through 3 on New HMA Pavement IRI.

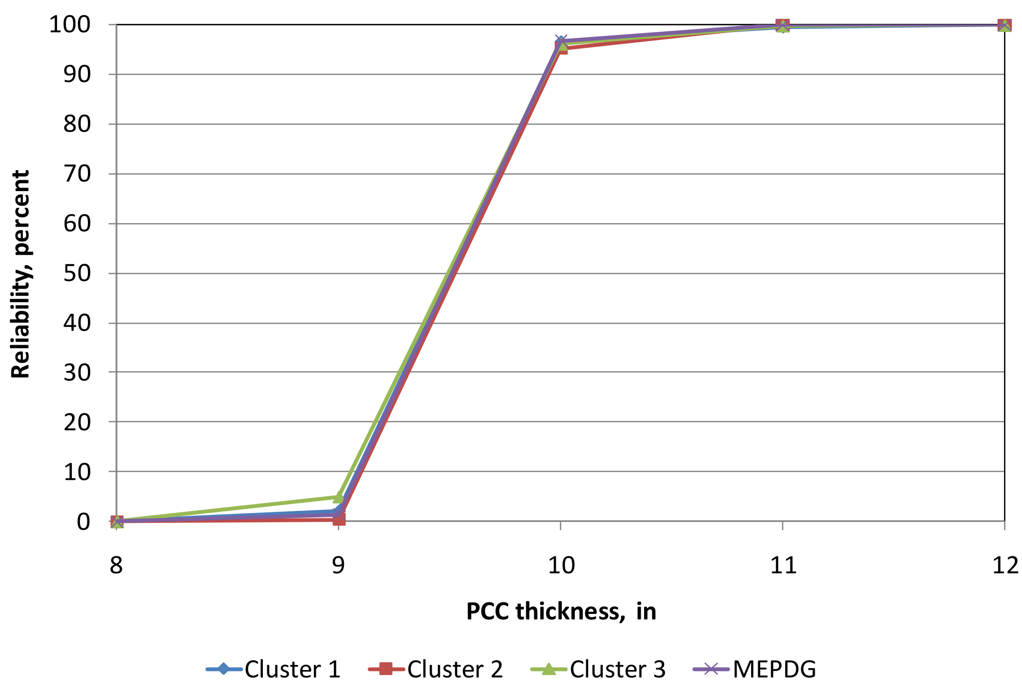

Figure 71. Plot Showing the Effect of ALD Clusters 1 through 3 on New JPCP Transverse Cracking.

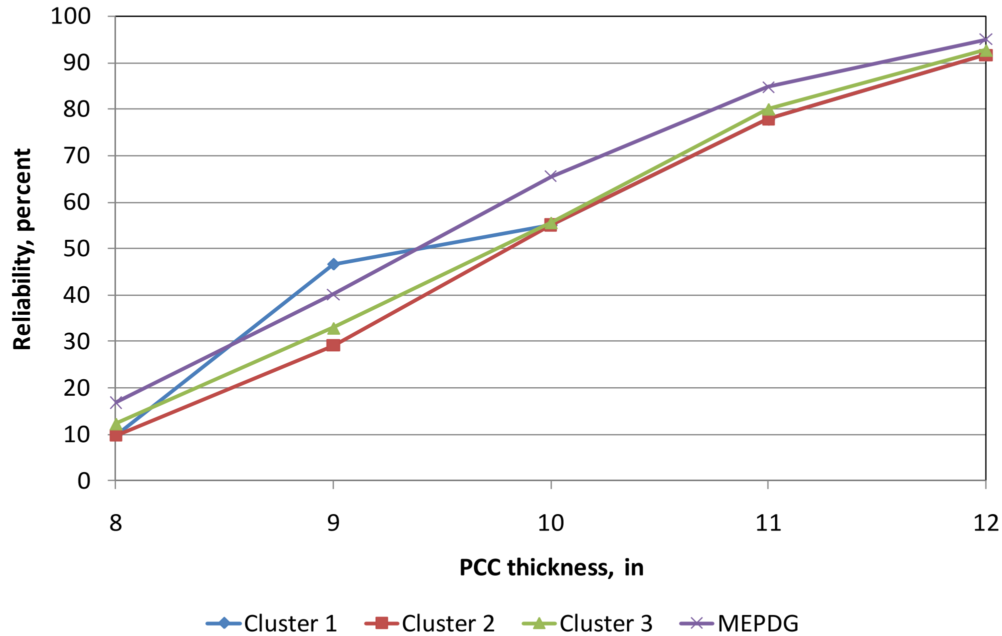

Figure 72. Plot Showing the Effect of ALD Clusters 1 through 3 on New JPCP Faulting.

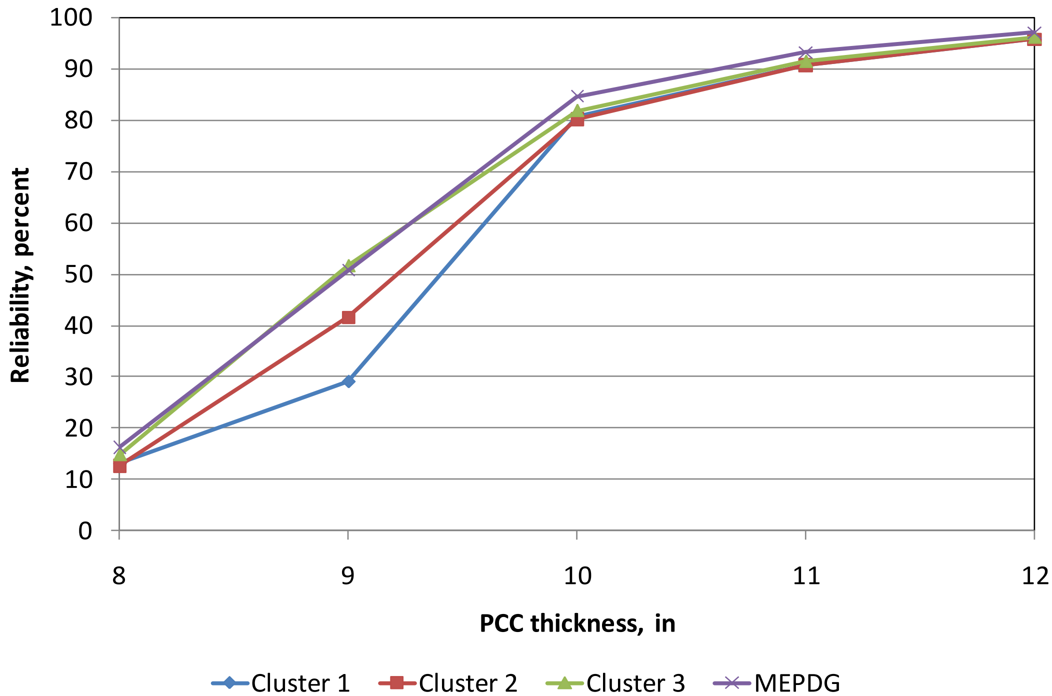

Figure 73. Plot Showing the Effect of ALD Clusters 1 through 3 on New JPCP IRI.

Table 32. Summary of Sensitivity Results for ALD.

Pavement Type	Distress/IRI	Design HMA/PCC Thickness at 90 Percent Reliability, in.				Percent Difference*
		Cluster 1	Cluster 2	Cluster 3	MEPDG	
HMA	Alligator cracking	7.3	7.0	7.5	6.8	6.7
	Rutting	14.1	14	14.1	13.9	0.7
	IRI	9.5	9.1	9.8	8.7	7.1
HMA overall design		14.1	14	14.1	13.9	0.7
JPCP	Transverse cracking	9.9	9.9	10.3	9.9	3.9
	Faulting	11.9	11.9	11.8	11.5	0.8
	IRI	10.9	10.9	10.8	10.6	0.9
JPCP overall Design		11.9	11.9	11.8	11.5	0.8

*Computed using the maximum and minimum thickness required for the three Arizona clusters.

Hourly Distribution

Sensitivity analysis results showing the impact of hourly truck distribution are presented in Figures 74 through 76. Sensitivity analysis results are presented only for JPCP, as the hourly truck distribution has no impact on HMA pavements. The sensitivity analysis results show that the Arizona hourly truck distribution clusters had no significant impact on PCC thickness and the overall design.

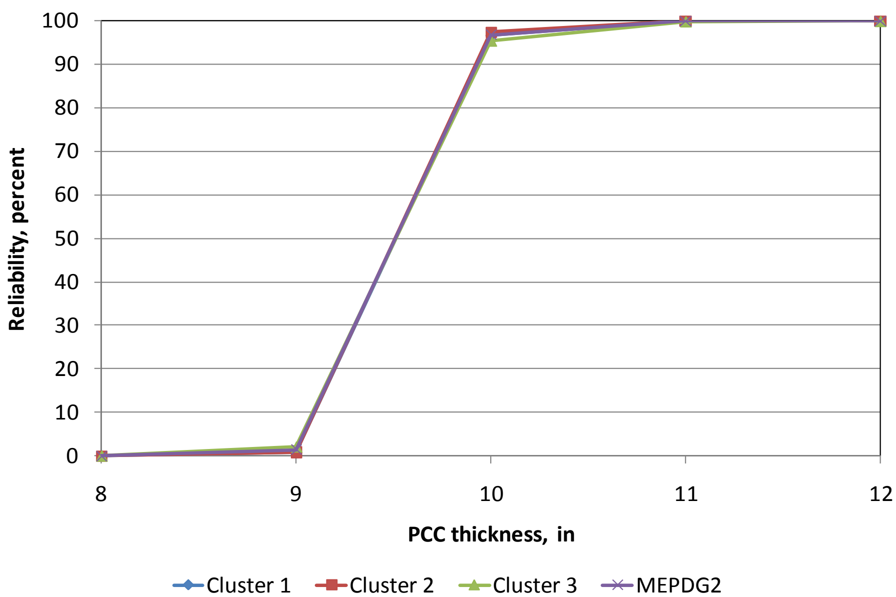

Figure 74. Plot Showing the Effect of Hourly Distribution Clusters 1 and 2 on New JPCP Transverse Cracking.

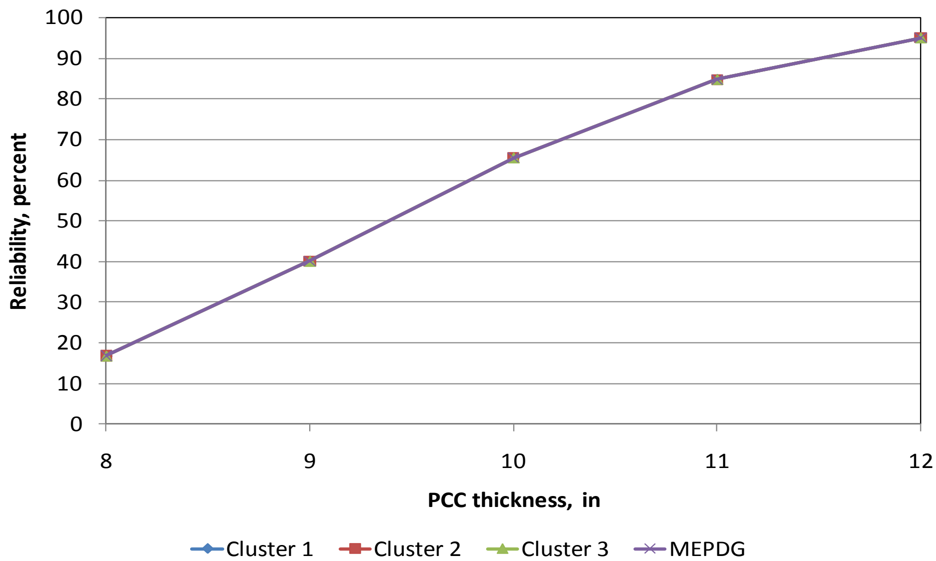

Figure 75. Plot Showing the Effect of Hourly Distribution Clusters 1 and 2on New JPCP Faulting.

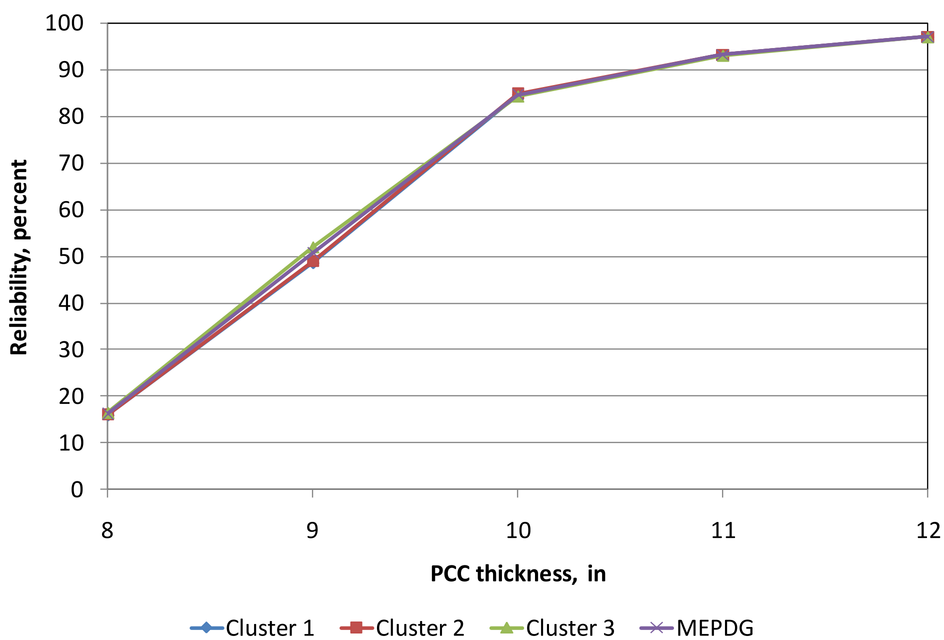

Figure 76. Plot Showing the Effect of Hourly Distribution Clusters 1 and 2 on New JPCP IRI.

CHAPTER 6. DEVELOPMENT OF STATEWIDE LEVEL 2/3 MEPDG TRAFFIC INPUTS

The results of the statistical cluster analysis and sensitivity analysis were used to develop typical MEPDG Level 2/3 traffic inputs. This chapter presents the defaults developed for the following:

- VCD.
- Hourly distribution.
- MAF.
- ALD.
- Number of axles per truck.
- Lateral wander.
- Truck wheelbase.

VEHICLE CLASS DISTRIBUTION

The statistical analysis identified two VCD clusters in Arizona. The sensitivity analysis confirms that the three identified clusters produced significantly different new HMA and new JPCP designs. Thus, the application of two VCD clusters for MEPDG pavement design is recommended. A description of the two VCD clusters is presented in Table 33.

Table 33. Recommended MEPDG VCD Inputs for Level 2/3 Design in Arizona.

Vehicle Class	Cluster 1—Major Single Truck Trailer Route, Primarily Rural Principal Arterial	Cluster 2—Intermediate Light and Single Trailer Route, Primarily Urban Principal Arterial, Rural Minor Arterials
4	1.8	4.7
5	14.1	47.2
6	2.7	7.4
7	0.1	0.4
8	7.6	12.4
9	66.8	25.1
10	0.7	1.7
11	4.3	0.6
12	1.4	0.1
13	0.5	0.4

HOURLY TRUCK DISTRIBUTION

Statistical analysis identified three hourly truck distribution clusters in Arizona. Sensitivity analysis, however, indicated that there was no significant change in pavement design (PCC thickness, HMA not affected) due to application of the identified hourly distribution clusters. However, the sensitivity analysis was limited, and it is still recommended that these three distributions be used as appropriate, as it is the true representation of actual truck loading throughout the 24-hour period. The recommended hourly distributions are shown in Table 34.

Table 34. Recommended MEPDG Hourly Truck Distribution Input for Design in Arizona.

Time of Day, Hours	Cluster 1—Rural Highways	Cluster 2—Urban Highways	Cluster 3—Long Haul Sections of Rural Highways
0	1.9	0.9	3.7
1	1.7	0.8	3.4
2	1.6	0.7	2.9
3	1.7	1.0	2.8
4	1.8	2.0	2.6
5	2.3	3.6	2.6
6	3.2	5.5	3.0
7	4.1	6.1	3.2
8	5.0	6.6	3.8
9	5.8	7.0	4.2
10	6.3	7.1	4.5
11	6.6	7.0	4.7
12	6.8	6.8	4.7
13	6.7	6.8	5.0
14	6.6	6.8	5.3
15	6.3	6.3	5.3
16	5.9	5.8	5.4
17	5.4	5.0	5.3
18	4.8	4.1	5.3
19	4.1	3.2	4.9
20	3.6	2.5	4.7
21	3.2	2.0	4.4
22	2.6	1.5	4.4
23	2.2	1.1	4.1

MONTHLY ADJUSTMENT FACTOR

Statistical analysis identified a single cluster for MAF for Arizona. Thus, a sensitivity analysis was not necessary. The statewide default Arizona MEPDG MAF input recommended for design is presented in Table 35. Heavier truck traffic in the winter is reflected in these values.

Table 35. Recommended MEPDG MAF Input for Design in Arizona.

Month	Statewide Default Monthly Adjustment Factors									
	VC4	VC5	VC6	VC7	VC8	VC9	VC10	VC11	VC12	VC13
January	0.99	0.87	0.85	1.11	0.90	0.86	1.03	0.69	0.62	1.23
February	1.03	0.97	0.90	0.87	0.94	0.92	0.95	0.78	0.85	0.96
March	1.02	0.99	0.92	0.94	1.02	0.94	0.88	0.85	0.98	0.84
April	0.97	0.91	0.94	1.13	0.92	0.93	0.91	0.81	1.00	0.91
May	0.96	0.95	0.91	0.78	0.92	0.93	0.83	0.97	0.91	0.79
June	0.89	0.96	0.93	0.96	0.93	0.98	1.00	1.13	1.13	0.79
July	0.91	0.98	0.92	0.64	0.91	0.92	0.84	1.13	0.95	1.00
August	0.95	0.99	1.01	0.86	0.93	1.08	0.95	1.25	1.20	0.74
September	1.05	0.95	0.90	0.84	0.90	0.90	0.82	0.96	0.91	0.67
October	1.06	1.01	1.05	1.00	1.08	1.00	0.96	1.00	0.99	1.05
November	1.10	1.24	1.35	1.25	1.40	1.25	1.42	1.14	1.22	1.41
December	1.05	1.19	1.33	1.63	1.14	1.27	1.42	1.30	1.24	1.60

*Winter months (October, November, December, and January) experienced higher levels of truck traffic.

AXLE LOAD DISTRIBUTION

Statistical analysis identified three ALD clusters in Arizona. Sensitivity analysis results were mixed, showing that ALD could significantly impact both HMA and JPCP design under different design scenarios. Thus, the application of three ALD clusters for MEPDG pavement design is recommended. A description of the three ALD clusters is presented in Tables 36 through 47 for single, tandem, tridem, and quad axles.

AXLES PER TRUCK

Statistical analysis identified a single cluster for axles-per-truck statistics for Arizona. Thus, sensitivity analysis was not necessary. The single statewide default for axles per truck recommended for design is presented in Table 48.

Table 36. Recommended Cluster 1 Single Axle MEPDG ALD Input for Design in Arizona.

Axle Load, lb	Vehicle Class									
	4	5	6	7	8	9	10	11	12	13
3,000	0.038	0.486	0.000	0.973	4.537	0.210	0.310	0.460	0.271	1.896
4,000	0.050	4.309	0.002	0.325	7.207	0.443	0.102	1.552	1.152	1.431
5,000	0.050	10.099	0.374	0.604	4.568	0.610	0.107	2.697	2.160	1.439
6,000	0.561	24.219	2.839	1.130	12.103	1.374	0.952	4.161	4.024	2.560
7,000	1.186	12.469	3.379	1.569	8.580	1.938	1.709	5.079	6.453	3.890
8,000	2.753	8.969	3.971	2.240	7.778	2.871	3.149	6.035	7.945	4.738
9,000	5.038	7.621	6.495	4.258	8.637	5.029	6.124	7.079	8.436	6.337
10,000	7.637	6.402	10.604	1.845	9.136	9.190	11.881	8.643	9.645	7.880
11,000	9.989	5.215	14.328	9.324	8.390	14.862	17.107	9.816	10.853	10.451
12,000	13.469	4.577	16.163	9.040	7.190	19.357	19.704	9.964	11.722	12.204
13,000	14.165	3.573	13.318	5.189	5.256	17.404	15.820	8.913	10.620	11.182
14,000	12.605	2.770	8.826	10.954	3.797	10.360	9.559	7.502	8.067	8.574
15,000	9.455	2.186	6.182	9.957	2.941	5.397	5.321	6.415	6.276	5.654
16,000	6.763	1.714	4.304	6.482	2.287	3.385	3.034	5.554	4.598	4.316
17,000	4.416	1.347	3.049	7.679	1.877	2.393	1.907	4.641	3.063	3.721
18,000	3.101	1.067	1.991	6.646	1.467	1.745	1.319	3.730	1.884	2.777
19,000	2.432	0.804	1.323	4.462	1.119	1.240	0.695	2.730	1.201	2.466
20,000	1.873	0.601	0.878	3.590	0.816	0.824	0.407	1.917	0.667	2.301
21,000	1.367	0.446	0.650	2.700	0.551	0.514	0.233	1.250	0.362	1.282
22,000	0.944	0.311	0.396	1.885	0.374	0.307	0.122	0.744	0.244	1.167
23,000	0.661	0.207	0.281	2.898	0.259	0.171	0.097	0.462	0.140	0.747
24,000	0.513	0.146	0.205	1.663	0.164	0.099	0.048	0.248	0.095	0.626
25,000	0.296	0.094	0.114	1.586	0.105	0.064	0.038	0.139	0.039	0.521
26,000	0.219	0.064	0.089	1.231	0.059	0.039	0.031	0.079	0.017	0.367
27,000	0.131	0.037	0.056	0.732	0.043	0.026	0.044	0.055	0.016	0.299
28,000	0.118	0.029	0.044	0.280	0.028	0.018	0.026	0.035	0.011	0.166
29,000	0.055	0.026	0.033	0.050	0.020	0.007	0.007	0.020	0.006	0.177
30,000	0.045	0.013	0.014	0.112	0.012	0.003	0.031	0.009	0.000	0.145
31,000	0.015	0.006	0.018	0.125	0.005	0.004	0.005	0.004	0.001	0.063
32,000	0.016	0.007	0.011	0.000	0.003	0.003	0.005	0.005	0.000	0.032
33,000	0.006	0.006	0.005	0.000	0.002	0.002	0.002	0.003	0.000	0.038
34,000	0.004	0.003	0.003	0.308	0.002	0.006	0.007	0.002	0.001	0.032
35,000	0.002	0.004	0.005	0.000	0.001	0.001	0.006	0.002	0.000	0.032
36,000	0.001	0.003	0.001	0.029	0.002	0.001	0.018	0.003	0.000	0.018
37,000	0.009	0.004	0.004	0.000	0.003	0.000	0.004	0.002	0.000	0.023
38,000	0.001	0.002	0.003	0.057	0.001	0.001	0.005	0.000	0.001	0.028
39,000	0.004	0.002	0.004	0.048	0.000	0.001	0.003	0.002	0.000	0.004
40,000	0.004	0.002	0.004	0.019	0.001	0.001	0.000	0.000	0.000	0.007
41,000	0.010	0.002	0.011	0.000	0.002	0.014	0.030	0.000	0.000	0.065

Table 37. Recommended Cluster 1 Tandem Axle MEPDG ALD Input for Design in Arizona.

Axle Load, lb	Vehicle Class									
	4	5	6	7	8	9	10	11	12	13
6,000	0.011	0.000	0.290	0.000	5.050	0.141	0.188	0.000	0.111	0.714
8,000	0.011	0.000	4.419	0.000	7.927	0.747	0.636	50.000	0.563	1.083
10,000	0.018	0.000	10.371	0.000	5.991	1.799	1.565	25.000	2.054	2.590
12,000	0.090	0.000	14.419	0.000	8.533	3.519	2.762	0.000	4.427	5.103
14,000	0.301	0.000	13.063	0.000	11.528	5.235	5.318	0.000	8.715	6.632
16,000	0.807	0.000	8.055	0.000	12.541	6.013	6.893	0.000	12.451	6.310
18,000	2.583	0.000	5.543	100.00	11.386	6.240	8.209	0.000	13.291	6.604
20,000	5.417	0.000	4.607	0.000	9.107	6.284	7.922	0.000	14.918	5.181
22,000	9.568	0.000	4.618	0.000	6.941	6.165	8.416	0.000	14.368	5.148
24,000	13.467	0.000	5.081	0.000	5.326	6.388	8.015	0.000	12.356	4.560
26,000	15.595	0.000	5.359	0.000	3.988	6.667	7.735	0.000	8.337	4.293
28,000	15.288	0.000	5.137	0.000	2.989	7.087	7.740	0.000	4.441	4.377
30,000	12.411	0.000	4.544	0.000	2.190	7.796	7.462	0.000	1.967	4.153
32,000	9.015	0.000	3.866	0.000	1.772	8.362	6.391	0.000	1.000	4.583
34,000	6.407	0.000	2.885	0.000	1.256	8.232	5.366	0.000	0.377	5.106
36,000	3.582	0.000	2.296	0.000	0.956	7.160	4.827	25.000	0.182	5.626
38,000	1.935	0.000	1.705	0.000	0.777	5.210	3.127	0.000	0.137	5.551
40,000	1.306	0.000	1.188	0.000	0.501	3.086	2.436	0.000	0.068	4.950
42,000	0.738	0.000	0.866	0.000	0.303	1.683	1.647	0.000	0.036	4.187
44,000	0.503	0.000	0.552	0.000	0.218	0.895	1.096	0.000	0.019	3.269
46,000	0.377	0.000	0.435	0.000	0.098	0.514	0.774	0.000	0.006	2.382
48,000	0.212	0.000	0.244	0.000	0.170	0.302	0.432	0.000	0.011	1.809
50,000	0.138	0.000	0.140	0.000	0.037	0.174	0.326	0.000	0.030	1.453
52,000	0.065	0.000	0.102	0.000	0.020	0.101	0.164	0.000	0.000	1.050
54,000	0.045	0.000	0.053	0.000	0.009	0.059	0.172	0.000	0.000	0.820
56,000	0.027	0.000	0.035	0.000	0.006	0.034	0.116	0.000	0.000	0.627
58,000	0.022	0.000	0.024	0.000	0.011	0.016	0.060	0.000	0.010	0.514
60,000	0.010	0.000	0.019	0.000	0.004	0.006	0.036	0.000	0.005	0.305
62,000	0.007	0.000	0.014	0.000	0.003	0.004	0.026	0.000	0.000	0.269
64,000	0.011	0.000	0.009	0.000	0.001	0.002	0.065	0.000	0.095	0.194
66,000	0.001	0.000	0.004	0.000	0.001	0.001	0.018	0.000	0.000	0.122
68,000	0.003	0.000	0.005	0.000	0.001	0.001	0.015	0.000	0.000	0.106
70,000	0.003	0.000	0.003	0.000	0.001	0.000	0.011	0.000	0.000	0.111
72,000	0.001	0.000	0.002	0.000	0.000	0.000	0.001	0.000	0.000	0.062
74,000	0.000	0.000	0.007	0.000	0.000	0.000	0.002	0.000	0.000	0.076
76,000	0.000	0.000	0.002	0.000	0.000	0.000	0.001	0.000	0.000	0.039
78,000	0.000	0.000	0.001	0.000	0.000	0.000	0.001	0.000	0.000	0.024
80,000	0.000	0.000	0.002	0.000	0.000	0.000	0.004	0.000	0.000	0.010
82,000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.000	0.000	0.003

Table 38. Recommended Cluster 1 Tridem Axle MEPDG ALD Input for Design in Arizona.

Axle Load, lb	Vehicle Class									
	4	5	6	7	8	9	10	11	12	13
12,000	0.000	0.000	0.000	0.407	0.000	0.105	0.735	0.000	3.111	0.594
15,000	0.000	0.000	0.000	0.394	0.000	1.295	2.336	0.000	3.842	1.000
18,000	0.000	0.000	0.000	5.444	0.000	33.438	6.388	0.000	7.616	1.431
21,000	0.000	0.000	0.000	5.957	0.000	12.495	9.254	0.000	9.580	2.955
24,000	0.000	0.000	0.000	5.374	0.000	9.010	9.670	0.000	20.038	3.998
27,000	0.000	0.000	0.000	3.184	0.000	5.533	8.246	0.000	13.931	4.515
30,000	0.000	0.000	0.000	3.707	0.000	1.862	6.863	0.000	16.044	5.753
33,000	0.000	0.000	0.000	3.412	0.000	1.067	7.361	0.000	1.338	3.861
36,000	0.000	0.000	0.000	6.737	0.000	1.571	7.440	0.000	1.418	4.878
39,000	0.000	0.000	0.000	6.619	0.000	1.510	7.897	0.000	8.847	6.155
42,000	0.000	0.000	0.000	11.794	0.000	1.286	8.187	0.000	0.236	6.803
45,000	0.000	0.000	0.000	9.811	0.000	0.410	7.334	0.000	0.342	6.066
48,000	0.000	0.000	0.000	11.127	0.000	0.614	5.520	0.000	1.453	6.879
51,000	0.000	0.000	0.000	7.935	0.000	4.971	3.890	0.000	3.549	7.441
54,000	0.000	0.000	0.000	5.380	0.000	2.495	2.809	0.000	1.596	11.680
57,000	0.000	0.000	0.000	3.377	0.000	5.429	2.036	0.000	2.471	5.717
60,000	0.000	0.000	0.000	3.084	0.000	4.762	1.670	0.000	1.111	6.126
63,000	0.000	0.000	0.000	3.335	0.000	2.381	0.817	0.000	2.458	4.731
66,000	0.000	0.000	0.000	2.002	0.000	0.000	0.552	0.000	0.000	3.632
69,000	0.000	0.000	0.000	0.483	0.000	9.524	0.395	0.000	0.513	2.345
72,000	0.000	0.000	0.000	0.121	0.000	0.000	0.250	0.000	0.000	0.801
75,000	0.000	0.000	0.000	0.300	0.000	0.000	0.126	0.000	0.000	0.972
78,000	0.000	0.000	0.000	0.000	0.000	0.000	0.074	0.000	0.000	1.026
81,000	0.000	0.000	0.000	0.000	0.000	0.000	0.055	0.000	0.000	0.211
84,000	0.000	0.000	0.000	0.000	0.000	0.000	0.026	0.000	0.000	0.218
87,000	0.000	0.000	0.000	0.000	0.000	0.000	0.021	0.000	0.000	0.016
90,000	0.000	0.000	0.000	0.000	0.000	0.000	0.009	0.000	0.000	0.037
93,000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.000	0.513	0.017
96,000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.011
99,000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.005
102,000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000

Table 39. Recommended Cluster 1 Quad Axle MEPDG ALD Input for Design in Arizona.

Axle Load, lb	Vehicle Class									
	4	5	6	7	8	9	10	11	12	13
12,000	0.000	0.000	0.000	0.000	0.000	0.000	0.541	0.000	0.000	0.335
15,000	0.000	0.000	0.000	0.000	0.000	7.000	0.312	0.000	1.753	0.329
18,000	0.000	0.000	0.000	0.280	0.000	2.000	2.297	0.000	0.000	1.589
21,000	0.000	0.000	0.000	0.280	0.000	15.375	3.921	0.000	10.526	4.071
24,000	0.000	0.000	0.000	0.820	0.000	3.440	5.838	0.000	10.526	6.419
27,000	0.000	0.000	0.000	10.000	0.000	8.215	1.241	0.000	1.753	6.580
30,000	0.000	0.000	0.000	0.000	0.000	10.000	0.376	0.000	1.753	3.973
33,000	0.000	0.000	0.000	1.060	0.000	5.625	1.515	0.000	5.263	6.529
36,000	0.000	0.000	0.000	0.280	0.000	0.000	4.541	0.000	0.000	5.374
39,000	0.000	0.000	0.000	0.540	0.000	0.000	6.162	0.000	12.016	9.536
42,000	0.000	0.000	0.000	11.260	0.000	0.000	5.503	0.000	2.295	8.463
45,000	0.000	0.000	0.000	14.200	0.000	0.000	12.556	0.000	4.874	7.089
48,000	0.000	0.000	0.000	4.140	0.000	0.000	10.197	0.000	5.668	6.515
51,000	0.000	0.000	0.000	14.600	0.000	10.000	9.732	0.000	13.868	4.971
54,000	0.000	0.000	0.000	11.700	0.000	0.000	8.729	0.000	15.579	4.699
57,000	0.000	0.000	0.000	21.360	0.000	0.000	8.024	0.000	7.979	5.794
60,000	0.000	0.000	0.000	3.640	0.000	0.625	3.126	0.000	3.958	2.460
63,000	0.000	0.000	0.000	3.520	0.000	10.000	3.159	0.000	1.363	2.749
66,000	0.000	0.000	0.000	1.840	0.000	0.000	2.935	0.000	0.532	1.945
69,000	0.000	0.000	0.000	0.540	0.000	0.000	3.038	0.000	0.000	1.293
72,000	0.000	0.000	0.000	0.000	0.000	0.000	0.544	0.000	0.274	1.304
75,000	0.000	0.000	0.000	0.000	0.000	0.000	0.450	0.000	0.000	1.224
78,000	0.000	0.000	0.000	0.000	0.000	0.000	2.382	0.000	0.000	1.979
81,000	0.000	0.000	0.000	0.000	0.000	15.000	0.000	0.000	0.000	1.696
84,000	0.000	0.000	0.000	0.000	0.000	0.000	0.121	0.000	0.000	1.705
87,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.234
90,000	0.000	0.000	0.000	0.000	0.000	7.500	0.782	0.000	0.000	0.406
93,000	0.000	0.000	0.000	0.000	0.000	0.000	1.471	0.000	0.000	0.061
96,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.036
99,000	0.000	0.000	0.000	0.000	0.000	2.500	0.000	0.000	0.000	0.001
102,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 40. Recommended Cluster 2 Single Axle MEPDG ALD Input for Design in Arizona.

Axle Load, lb	Vehicle Class									
	4	5	6	7	8	9	10	11	12	13
3,000	0.000	0.483	0.003	0.000	1.870	0.327	0.110	1.197	0.547	2.010
4,000	0.003	5.240	0.007	0.130	4.660	1.167	0.203	4.313	2.613	1.910
5,000	0.000	6.467	0.013	0.377	3.513	1.820	0.347	6.103	4.260	1.053
6,000	0.813	24.707	1.520	0.343	9.947	2.287	1.103	6.173	5.973	1.743
7,000	2.597	12.997	2.213	1.303	8.213	2.587	2.640	6.763	8.160	2.820
8,000	5.853	9.477	3.910	1.437	9.240	4.280	5.057	7.827	9.503	4.083
9,000	9.740	7.770	7.057	2.677	10.167	8.300	9.987	8.813	11.223	7.913
10,000	10.473	6.267	10.717	4.523	9.520	12.957	13.567	8.070	10.720	11.610
11,000	10.533	5.100	12.917	10.240	8.227	15.793	16.677	6.693	9.950	12.047
12,000	10.333	4.387	13.483	5.933	7.130	16.363	17.030	5.870	9.523	11.620
13,000	8.970	3.577	11.367	7.757	5.573	12.140	11.493	5.030	7.123	9.320
14,000	7.987	2.790	8.947	9.630	4.357	7.240	8.203	4.840	5.310	7.103
15,000	6.293	2.270	7.070	8.387	3.700	4.337	4.417	4.787	4.083	4.960
16,000	5.657	1.857	5.527	6.800	3.067	2.937	3.197	4.830	2.797	4.430
17,000	4.760	1.473	4.087	8.147	2.543	2.107	1.650	4.370	2.287	3.303
18,000	3.880	1.240	3.173	6.060	2.010	1.587	0.997	3.840	1.537	2.713
19,000	3.613	0.940	2.177	5.787	1.557	1.143	0.993	2.983	1.280	2.183
20,000	2.513	0.757	1.810	4.810	1.213	0.860	0.850	2.310	1.030	1.830
21,000	1.903	0.557	1.357	3.797	0.913	0.603	0.447	1.560	0.607	2.127
22,000	1.477	0.423	0.830	7.473	0.657	0.367	0.390	1.087	0.503	0.940
23,000	0.833	0.303	0.583	1.657	0.473	0.243	0.217	0.747	0.297	1.150
24,000	0.763	0.230	0.333	0.977	0.343	0.150	0.133	0.527	0.137	0.530
25,000	0.373	0.187	0.210	0.467	0.217	0.097	0.060	0.333	0.097	0.417
26,000	0.277	0.113	0.163	0.213	0.157	0.073	0.090	0.263	0.097	0.410
27,000	0.150	0.060	0.083	0.203	0.120	0.047	0.083	0.183	0.060	0.263
28,000	0.070	0.040	0.087	0.517	0.077	0.033	0.010	0.103	0.050	0.140
29,000	0.027	0.027	0.090	0.160	0.067	0.017	0.013	0.080	0.040	0.093
30,000	0.030	0.023	0.020	0.017	0.030	0.013	0.003	0.067	0.020	0.137
31,000	0.013	0.017	0.033	0.153	0.020	0.003	0.007	0.043	0.020	0.123
32,000	0.010	0.010	0.040	0.007	0.020	0.003	0.000	0.033	0.017	0.033
33,000	0.003	0.010	0.027	0.053	0.007	0.003	0.000	0.023	0.013	0.100
34,000	0.003	0.003	0.013	0.000	0.007	0.003	0.000	0.020	0.010	0.017
35,000	0.023	0.003	0.003	0.000	0.013	0.003	0.017	0.010	0.017	0.013
36,000	0.000	0.003	0.010	0.003	0.003	0.003	0.003	0.013	0.007	0.037
37,000	0.003	0.007	0.023	0.000	0.003	0.003	0.027	0.010	0.007	0.017
38,000	0.000	0.003	0.020	0.000	0.003	0.003	0.000	0.007	0.010	0.010
39,000	0.000	0.003	0.007	0.000	0.003	0.003	0.003	0.007	0.010	0.007
40,000	0.000	0.003	0.023	0.000	0.003	0.000	0.000	0.007	0.003	0.003
41,000	0.003	0.003	0.007	0.000	0.003	0.003	0.000	0.003	0.003	0.000

Table 41. Recommended Cluster 2 Tandem Axle MEPDG ALD Input for Design in Arizona.

Axle Load, lb	Vehicle Class									
	4	5	6	7	8	9	10	11	12	13
6,000	0.000	0.000	0.487	0.000	1.720	0.340	0.230	0.000	0.070	0.253
8,000	0.017	0.000	4.410	0.000	7.433	2.333	1.273	0.000	1.070	1.060
10,000	0.090	0.000	6.453	0.000	6.467	5.373	2.423	0.000	3.877	3.793
12,000	0.373	0.000	7.197	0.000	9.687	7.783	6.507	0.000	9.180	7.917
14,000	0.807	0.000	7.500	0.000	10.947	8.717	8.117	0.000	16.933	10.177
16,000	1.670	0.000	7.300	0.000	10.387	8.217	9.567	0.000	17.207	8.763
18,000	3.877	0.000	6.697	0.000	8.320	7.120	9.403	0.000	15.760	6.820
20,000	10.083	0.000	6.373	0.000	7.063	6.110	8.683	0.000	11.910	4.950
22,000	11.833	0.000	6.150	0.000	5.307	5.460	7.567	0.000	6.963	3.857
24,000	14.067	0.000	6.410	0.000	4.727	5.593	6.893	0.000	6.037	4.053
26,000	14.563	0.000	6.407	0.000	4.270	5.863	5.847	0.000	4.307	4.277
28,000	11.913	0.000	6.173	0.000	3.900	6.240	5.907	0.000	2.640	4.203
30,000	9.687	0.000	5.530	0.000	3.847	6.450	4.920	0.000	1.177	4.330
32,000	6.043	0.000	4.713	0.000	3.463	6.103	4.453	0.000	0.970	4.870
34,000	4.753	0.000	3.990	0.000	2.957	5.213	4.053	0.000	0.517	4.533
36,000	3.437	0.000	3.450	0.000	2.517	4.003	2.590	0.000	0.343	3.907
38,000	2.640	0.000	2.653	0.000	1.957	2.857	2.283	0.000	0.337	3.527
40,000	1.833	0.000	2.250	0.000	1.353	1.967	2.227	0.000	0.130	3.023
42,000	0.940	0.000	1.793	0.000	0.980	1.323	1.940	0.000	0.120	2.593
44,000	0.527	0.000	1.103	0.000	0.787	0.907	1.417	0.000	0.067	2.447
46,000	0.273	0.000	0.810	0.000	0.587	0.610	1.073	0.000	0.063	1.883
48,000	0.247	0.000	0.707	0.000	0.347	0.410	0.717	0.000	0.050	1.550
50,000	0.133	0.000	0.413	0.000	0.253	0.290	0.447	0.000	0.043	1.553
52,000	0.080	0.000	0.287	0.000	0.143	0.183	0.473	0.000	0.077	1.013
54,000	0.080	0.000	0.223	0.000	0.097	0.123	0.327	0.000	0.023	1.100
56,000	0.037	0.000	0.133	0.000	0.057	0.077	0.227	0.000	0.023	0.713
58,000	0.013	0.000	0.093	0.000	0.033	0.060	0.110	0.000	0.027	0.713
60,000	0.003	0.000	0.073	0.000	0.013	0.040	0.143	0.000	0.030	0.437
62,000	0.003	0.000	0.040	0.000	0.017	0.023	0.077	0.000	0.017	0.493
64,000	0.003	0.000	0.030	0.000	0.017	0.020	0.063	0.000	0.020	0.320
66,000	0.000	0.000	0.027	0.000	0.013	0.017	0.020	0.000	0.017	0.257
68,000	0.000	0.000	0.003	0.000	0.003	0.013	0.010	0.000	0.013	0.163
70,000	0.000	0.000	0.013	0.000	0.007	0.010	0.007	0.000	0.003	0.107
72,000	0.000	0.000	0.013	0.000	0.000	0.007	0.003	0.000	0.000	0.107
74,000	0.000	0.000	0.017	0.000	0.000	0.007	0.000	0.000	0.000	0.083
76,000	0.000	0.000	0.000	0.000	0.000	0.007	0.000	0.000	0.000	0.043
78,000	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.020
80,000	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.023
82,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.010

Table 42. Recommended Cluster 2 Tridem Axle MEPDG ALD Input for Design in Arizona.

Axle Load, lb	Vehicle Class									
	4	5	6	7	8	9	10	11	12	13
12,000	0.000	0.000	0.000	0.000	0.000	0.000	1.187	0.000	0.000	0.177
15,000	0.000	0.000	0.000	0.017	0.000	0.000	4.453	0.000	7.288	2.030
18,000	0.000	0.000	0.000	4.223	0.000	66.667	13.067	0.000	14.169	3.180
21,000	0.000	0.000	0.000	0.313	0.000	0.000	9.680	0.000	14.750	4.303
24,000	0.000	0.000	0.000	2.490	0.000	0.044	7.483	0.000	19.200	3.123
27,000	0.000	0.000	0.000	3.347	0.000	0.133	7.557	0.000	10.631	3.933
30,000	0.000	0.000	0.000	1.907	0.000	1.167	5.907	0.000	0.000	1.653
33,000	0.000	0.000	0.000	3.587	0.000	2.456	7.013	0.000	8.506	3.487
36,000	0.000	0.000	0.000	7.653	0.000	1.533	6.147	0.000	0.675	2.563
39,000	0.000	0.000	0.000	7.900	0.000	1.589	5.463	0.000	3.300	3.720
42,000	0.000	0.000	0.000	10.507	0.000	3.222	6.010	0.000	1.550	5.807
45,000	0.000	0.000	0.000	11.580	0.000	2.678	5.750	0.000	0.694	6.150
48,000	0.000	0.000	0.000	18.143	0.000	1.856	4.740	0.000	2.938	9.500
51,000	0.000	0.000	0.000	7.083	0.000	4.867	4.057	0.000	4.469	7.980
54,000	0.000	0.000	0.000	6.513	0.000	12.056	2.977	0.000	0.694	6.273
57,000	0.000	0.000	0.000	4.247	0.000	1.511	2.370	0.000	10.775	4.353
60,000	0.000	0.000	0.000	6.077	0.000	0.089	1.907	0.000	0.175	7.800
63,000	0.000	0.000	0.000	2.560	0.000	0.044	1.407	0.000	0.175	2.747
66,000	0.000	0.000	0.000	0.727	0.000	0.011	0.860	0.000	0.000	6.403
69,000	0.000	0.000	0.000	0.347	0.000	0.022	0.690	0.000	0.000	3.793
72,000	0.000	0.000	0.000	0.487	0.000	0.022	0.360	0.000	0.000	2.597
75,000	0.000	0.000	0.000	0.050	0.000	0.011	0.260	0.000	0.000	1.513
78,000	0.000	0.000	0.000	0.090	0.000	0.000	0.337	0.000	0.000	0.807
81,000	0.000	0.000	0.000	0.007	0.000	0.000	0.113	0.000	0.000	1.097
84,000	0.000	0.000	0.000	0.120	0.000	0.000	0.077	0.000	0.000	0.230
87,000	0.000	0.000	0.000	0.007	0.000	0.000	0.057	0.000	0.000	0.257
90,000	0.000	0.000	0.000	0.013	0.000	0.000	0.013	0.000	0.000	0.140
93,000	0.000	0.000	0.000	0.000	0.000	0.000	0.040	0.000	0.000	0.440
96,000	0.000	0.000	0.000	0.000	0.000	0.000	0.020	0.000	0.000	0.000
99,000	0.000	0.000	0.000	0.003	0.000	0.000	0.007	0.000	0.000	3.793
102,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.050

Table 43. Recommended Cluster 2 Quad Axle MEPDG ALD Input for Design in Arizona.

Axle Load, lb	Vehicle Class									
	4	5	6	7	8	9	10	11	12	13
12,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.015
15,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.815
18,000	0.000	0.000	0.000	0.200	0.000	0.000	0.219	0.000	0.000	7.326
21,000	0.000	0.000	0.000	0.200	0.000	6.660	0.971	0.000	0.000	4.178
24,000	0.000	0.000	0.000	0.200	0.000	20.000	0.300	0.000	0.000	4.859
27,000	0.000	0.000	0.000	0.200	0.000	0.000	1.181	0.000	2.100	7.944
30,000	0.000	0.000	0.000	0.900	0.000	0.000	0.900	0.000	0.150	7.719
33,000	0.000	0.000	0.000	1.800	0.000	0.000	1.290	0.000	0.975	5.319
36,000	0.000	0.000	0.000	6.400	0.000	0.000	4.143	0.000	0.850	5.889
39,000	0.000	0.000	0.000	14.800	0.000	0.000	5.643	0.000	9.200	9.563
42,000	0.000	0.000	0.000	10.100	0.000	20.000	4.186	0.000	8.450	6.207
45,000	0.000	0.000	0.000	10.700	0.000	0.000	4.833	0.000	21.325	6.700
48,000	0.000	0.000	0.000	7.500	0.000	0.000	6.957	0.000	7.575	6.852
51,000	0.000	0.000	0.000	8.500	0.000	0.000	8.538	0.000	12.950	3.856
54,000	0.000	0.000	0.000	8.900	0.000	0.000	10.014	0.000	5.850	2.256
57,000	0.000	0.000	0.000	8.200	0.000	0.000	5.162	0.000	10.600	2.533
60,000	0.000	0.000	0.000	6.900	0.000	10.000	5.519	0.000	14.250	1.496
63,000	0.000	0.000	0.000	4.800	0.000	0.000	7.162	0.000	4.025	1.278
66,000	0.000	0.000	0.000	2.400	0.000	0.000	4.652	0.000	0.775	1.756
69,000	0.000	0.000	0.000	2.800	0.000	0.000	8.062	0.000	0.125	5.426
72,000	0.000	0.000	0.000	0.800	0.000	6.660	1.567	0.000	0.525	0.381
75,000	0.000	0.000	0.000	1.700	0.000	0.000	0.943	0.000	0.050	0.763
78,000	0.000	0.000	0.000	0.500	0.000	0.000	5.576	0.000	0.025	0.859
81,000	0.000	0.000	0.000	0.700	0.000	30.000	1.257	0.000	0.025	1.219
84,000	0.000	0.000	0.000	0.000	0.000	0.000	9.800	0.000	0.025	0.493
87,000	0.000	0.000	0.000	0.100	0.000	0.000	0.343	0.000	0.050	1.815
90,000	0.000	0.000	0.000	0.200	0.000	6.660	0.057	0.000	0.025	0.078
93,000	0.000	0.000	0.000	0.200	0.000	0.000	0.067	0.000	0.000	1.107
96,000	0.000	0.000	0.000	0.200	0.000	0.000	0.133	0.000	0.000	0.496
99,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.330
102,000	0.000	0.000	0.000	0.000	0.000	0.000	0.529	0.000	0.000	0.470

Table 44. Recommended Cluster 3 Single Axle MEPDG ALD Input for Design in Arizona.

Axle Load, lb	Vehicle Class									
	4	5	6	7	8	9	10	11	12	13
3,000	0.003	0.883	0.000	0.268	7.963	0.403	0.215	0.458	0.173	0.348
4,000	0.000	6.158	0.000	3.246	12.843	0.993	0.053	0.993	0.468	0.765
5,000	0.005	33.240	0.420	0.251	9.020	1.703	0.118	2.935	1.208	1.635
6,000	0.078	25.343	3.210	1.284	11.650	2.588	0.370	2.500	3.103	3.095
7,000	0.235	8.685	5.378	3.576	8.488	1.403	0.540	5.060	9.008	12.428
8,000	1.083	5.198	2.755	5.981	6.773	1.435	0.825	4.350	7.508	14.968
9,000	1.465	4.983	2.673	2.530	6.020	2.550	1.690	5.795	7.558	5.345
10,000	2.310	4.010	4.870	5.332	5.710	5.595	5.570	8.723	7.918	5.715
11,000	4.288	3.025	11.203	4.830	5.978	9.620	16.163	11.168	11.265	14.053
12,000	7.043	2.248	16.895	8.141	5.313	21.498	27.958	8.678	15.065	14.655
13,000	12.550	1.538	16.353	14.792	4.295	24.273	25.995	5.653	11.558	8.393
14,000	21.823	1.143	14.953	16.403	3.025	7.993	10.668	5.115	6.730	4.933
15,000	25.410	0.890	9.360	3.327	2.118	2.548	3.368	5.235	6.960	2.445
16,000	14.423	0.660	4.123	2.741	1.685	2.190	2.438	6.020	4.200	3.035
17,000	5.383	0.513	2.115	12.332	1.370	3.025	1.868	6.408	3.088	1.503
18,000	1.698	0.453	2.020	3.022	1.228	4.368	0.598	6.413	1.653	1.535
19,000	0.710	0.340	1.573	1.519	1.065	3.920	0.308	5.008	1.188	1.785
20,000	0.495	0.225	0.935	2.976	0.925	2.398	0.008	5.458	0.665	0.873
21,000	0.338	0.170	0.430	1.751	0.658	0.960	0.000	2.548	0.528	0.638
22,000	0.195	0.105	0.333	3.341	0.403	0.328	0.000	0.830	0.045	0.218
23,000	0.155	0.063	0.153	0.043	0.208	0.078	1.278	0.288	0.020	0.188
24,000	0.145	0.028	0.023	0.132	0.128	0.005	0.000	0.183	0.000	0.153
25,000	0.083	0.013	0.020	0.000	0.018	0.005	0.000	0.028	0.000	0.068
26,000	0.033	0.005	0.050	0.314	0.013	0.003	0.000	0.010	0.005	0.038
27,000	0.020	0.000	0.033	0.014	0.003	0.000	0.000	0.030	0.005	0.088
28,000	0.005	0.000	0.000	0.000	0.003	0.000	0.000	0.010	0.000	0.033
29,000	0.003	0.000	0.025	0.000	0.003	0.000	0.000	0.003	0.000	0.000
30,000	0.000	0.000	0.020	0.000	0.003	0.000	0.000	0.010	0.000	0.000
31,000	0.000	0.000	0.008	0.000	0.000	0.000	0.000	0.003	0.000	0.000
32,000	0.003	0.000	0.000	0.000	0.003	0.000	0.000	0.003	0.000	0.000
33,000	0.008	0.000	0.008	0.000	0.000	0.000	0.000	0.003	0.000	0.005
34,000	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
35,000	0.000	0.000	0.003	0.924	0.000	0.000	0.000	0.003	0.000	0.000
36,000	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
37,000	0.000	0.000	0.015	0.000	0.000	0.000	0.000	0.000	0.000	0.000
38,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
39,000	0.000	0.000	0.000	0.700	0.000	0.000	0.000	0.000	0.000	0.000
40,000	0.000	0.000	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.020
41,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 45. Recommended Cluster 3 Tandem Axle MEPDG ALD Input for Design in Arizona.

Axle Load, lb	Vehicle Class									
	4	5	6	7	8	9	10	11	12	13
6,000	0.000	0.000	0.013	0.000	14.135	0.078	0.168	0.000	0.000	0.165
8,000	0.000	0.000	0.275	0.000	7.453	0.525	0.220	0.000	0.015	0.795
10,000	0.023	0.000	3.400	0.000	2.855	2.173	0.415	0.000	0.108	2.188
12,000	0.035	0.000	12.353	0.000	4.743	3.555	0.808	0.000	0.368	15.225
14,000	0.073	0.000	7.678	0.000	9.233	4.945	2.640	0.000	9.020	19.918
16,000	0.173	0.000	7.775	0.000	12.365	5.000	5.895	0.000	8.268	12.485
18,000	0.468	0.000	6.498	0.000	10.983	4.555	8.575	0.000	12.258	5.343
20,000	0.450	0.000	4.740	0.000	8.248	4.443	10.300	0.000	15.963	4.453
22,000	2.275	0.000	3.103	0.000	6.398	4.583	8.048	0.000	17.083	3.888
24,000	4.103	0.000	2.650	0.000	4.850	4.690	5.968	0.000	14.728	2.725
26,000	7.488	0.000	3.558	0.000	2.983	4.663	6.428	0.000	10.870	2.795
28,000	12.265	0.000	7.030	0.000	1.800	4.943	7.815	0.000	8.008	2.058
30,000	16.505	0.000	9.960	0.000	1.468	5.450	7.990	0.000	1.900	3.215
32,000	20.985	0.000	9.523	0.000	1.505	7.398	6.708	0.000	0.930	2.915
34,000	21.285	0.000	7.458	0.000	2.043	11.720	6.898	0.000	0.058	4.153
36,000	11.315	0.000	5.953	0.000	2.935	15.453	6.535	0.000	0.015	3.065
38,000	2.223	0.000	3.580	0.000	2.335	10.035	3.970	0.000	0.015	4.400
40,000	0.203	0.000	1.850	0.000	0.945	3.743	2.598	0.000	0.000	2.315
42,000	0.083	0.000	0.940	0.000	0.355	1.373	1.305	0.000	0.000	1.933
44,000	0.005	0.000	0.623	0.000	0.150	0.420	1.058	0.000	0.000	1.420
46,000	0.003	0.000	0.438	0.000	0.148	0.138	0.820	0.000	0.000	1.088
48,000	0.000	0.000	0.193	0.000	0.095	0.063	1.008	0.000	0.000	1.358
50,000	0.000	0.000	0.120	0.000	0.050	0.030	2.068	0.000	0.000	0.510
52,000	0.000	0.000	0.068	0.000	0.015	0.020	0.688	0.000	0.000	0.345
54,000	0.000	0.000	0.038	0.000	0.010	0.003	0.305	0.000	0.000	0.240
56,000	0.000	0.000	0.060	0.000	0.010	0.003	0.245	0.000	0.000	0.240
58,000	0.000	0.000	0.030	0.000	0.000	0.000	0.068	0.000	0.000	0.058
60,000	0.000	0.000	0.013	0.000	0.000	0.000	0.038	0.000	0.000	0.053
62,000	0.000	0.000	0.013	0.000	0.000	0.000	0.158	0.000	0.000	0.128
64,000	0.000	0.000	0.003	0.000	0.000	0.000	0.058	0.000	0.000	0.150
66,000	0.000	0.000	0.000	0.000	0.000	0.000	0.120	0.000	0.000	0.008
68,000	0.000	0.000	0.005	0.000	0.000	0.000	0.053	0.000	0.000	0.120
70,000	0.000	0.000	0.008	0.000	0.000	0.000	0.013	0.000	0.000	0.010
72,000	0.000	0.000	0.020	0.000	0.000	0.000	0.053	0.000	0.000	0.045
74,000	0.000	0.000	0.000	0.000	0.000	0.000	0.013	0.000	0.000	0.015
76,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.015
78,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
80,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
82,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 46. Recommended Cluster 3 Tridem Axle MEPDG ALD Input for Design in Arizona.

Axle Load, lb	Vehicle Class									
	4	5	6	7	8	9	10	11	12	13
12,000	0.000	0.000	0.000	0.000	0.000	0.000	0.255	0.000	0.000	0.000
15,000	0.000	0.000	0.000	1.150	0.000	12.500	1.263	0.000	0.000	1.538
18,000	0.000	0.000	0.000	1.469	0.000	37.500	5.300	0.000	0.000	7.590
21,000	0.000	0.000	0.000	9.369	0.000	25.000	10.040	0.000	100.00	3.959
24,000	0.000	0.000	0.000	2.053	0.000	0.000	9.265	0.000	0.000	5.608
27,000	0.000	0.000	0.000	0.900	0.000	0.000	5.265	0.000	0.000	4.515
30,000	0.000	0.000	0.000	4.103	0.000	0.000	4.885	0.000	0.000	3.510
33,000	0.000	0.000	0.000	3.050	0.000	0.000	5.705	0.000	0.000	2.749
36,000	0.000	0.000	0.000	2.456	0.000	0.000	5.735	0.000	0.000	1.744
39,000	0.000	0.000	0.000	3.416	0.000	0.000	8.415	0.000	0.000	5.064
42,000	0.000	0.000	0.000	3.919	0.000	0.000	11.255	0.000	0.000	3.208
45,000	0.000	0.000	0.000	7.731	0.000	0.000	10.195	0.000	0.000	9.064
48,000	0.000	0.000	0.000	17.606	0.000	25.000	6.675	0.000	0.000	1.354
51,000	0.000	0.000	0.000	29.588	0.000	0.000	5.960	0.000	0.000	4.972
54,000	0.000	0.000	0.000	3.447	0.000	0.000	3.125	0.000	0.000	8.874
57,000	0.000	0.000	0.000	2.147	0.000	0.000	2.398	0.000	0.000	4.369
60,000	0.000	0.000	0.000	0.963	0.000	0.000	1.388	0.000	0.000	3.610
63,000	0.000	0.000	0.000	4.616	0.000	0.000	2.158	0.000	0.000	3.728
66,000	0.000	0.000	0.000	0.000	0.000	0.000	0.153	0.000	0.000	8.741
69,000	0.000	0.000	0.000	0.863	0.000	0.000	0.118	0.000	0.000	4.113
72,000	0.000	0.000	0.000	0.000	0.000	0.000	0.020	0.000	0.000	8.659
75,000	0.000	0.000	0.000	0.000	0.000	0.000	0.030	0.000	0.000	1.236
78,000	0.000	0.000	0.000	0.000	0.000	0.000	0.265	0.000	0.000	0.000
81,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
84,000	0.000	0.000	0.000	0.000	0.000	0.000	0.078	0.000	0.000	0.000
87,000	0.000	0.000	0.000	0.000	0.000	0.000	0.043	0.000	0.000	0.269
90,000	0.000	0.000	0.000	0.000	0.000	0.000	0.033	0.000	0.000	0.000
93,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.256
96,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.454
99,000	0.000	0.000	0.000	1.150	0.000	0.000	0.000	0.000	0.000	0.000
102,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 47. Recommended Cluster 3 Quad Axle MEPDG ALD Input for Design in Arizona.

Axle Load, lb	Vehicle Class									
	4	5	6	7	8	9	10	11	12	13
12,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
18,000	0.000	0.000	0.000	0.000	0.000	100.00	0.000	0.000	0.000	1.777
21,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	7.517
24,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	15.687
27,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	9.017
30,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	100.00	4.937
33,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.967
36,000	0.000	0.000	0.000	0.000	0.000	0.000	83.333	0.000	0.000	0.930
39,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	9.200
42,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	5.830
45,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	13.100
48,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.867
51,000	0.000	0.000	0.000	7.700	0.000	0.000	0.000	0.000	0.000	5.993
54,000	0.000	0.000	0.000	11.550	0.000	0.000	0.000	0.000	0.000	2.927
57,000	0.000	0.000	0.000	36.650	0.000	0.000	0.000	0.000	0.000	6.670
60,000	0.000	0.000	0.000	32.400	0.000	0.000	0.000	0.000	0.000	0.830
63,000	0.000	0.000	0.000	11.750	0.000	0.000	0.000	0.000	0.000	0.647
66,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.450
69,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
72,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.450
75,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
78,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.327
81,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.197
84,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
87,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
90,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
93,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
96,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.457
99,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.130
102,000	0.000	0.000	0.000	0.000	0.000	0.000	16.667	0.000	0.000	8.104

Table 48. Recommended MEPDG Axles-per-Truck Statistics Default Input for Design in Arizona.

Vehicle Class	Axle Type			
	Single	Tandem	Tridem	Quad
4	1.34	0.75	0.00	0.00
5	2.14	0.00	0.00	0.00
6	0.95	0.95	0.00	0.00
7	0.33	0.02	0.26	0.07
8	2.61	0.49	0.00	0.00
9	1.20	1.84	0.00	0.00
10	0.98	1.01	0.86	0.06
11	4.78	0.00	0.00	0.00
12	3.88	0.98	0.03	0.14
13	1.29	1.90	0.19	0.14

LATERAL WANDER OF TRUCKS WITHIN LANE

As vehicles drive down the traffic lane, they wander from side to side in normal driving. This lateral wander creates fewer full load repetitions for some locations and more repetitions for other locations. This distribution of lateral wander has been established to be normal and is defined as follows:

- Lateral Offset: Mean distance from the outer paint stripe to the outer edge of the wheel, in inches.
- Standard Deviation: Lateral variation of trucks within the lane, in inches. A normal distribution was assumed based on previous measurements.

Both the mean lateral offset and the standard deviation have been shown to be significant MEPDG inputs. They both affect the cracking and joint faulting of JPCP and the lateral standard deviation affects wheel path rutting for HMA pavements. Lateral truck wander was measured at four sites in Arizona, as shown in Figure 77. A summary of the data assembled and the computed MEPDG inputs are presented in Figure 78.

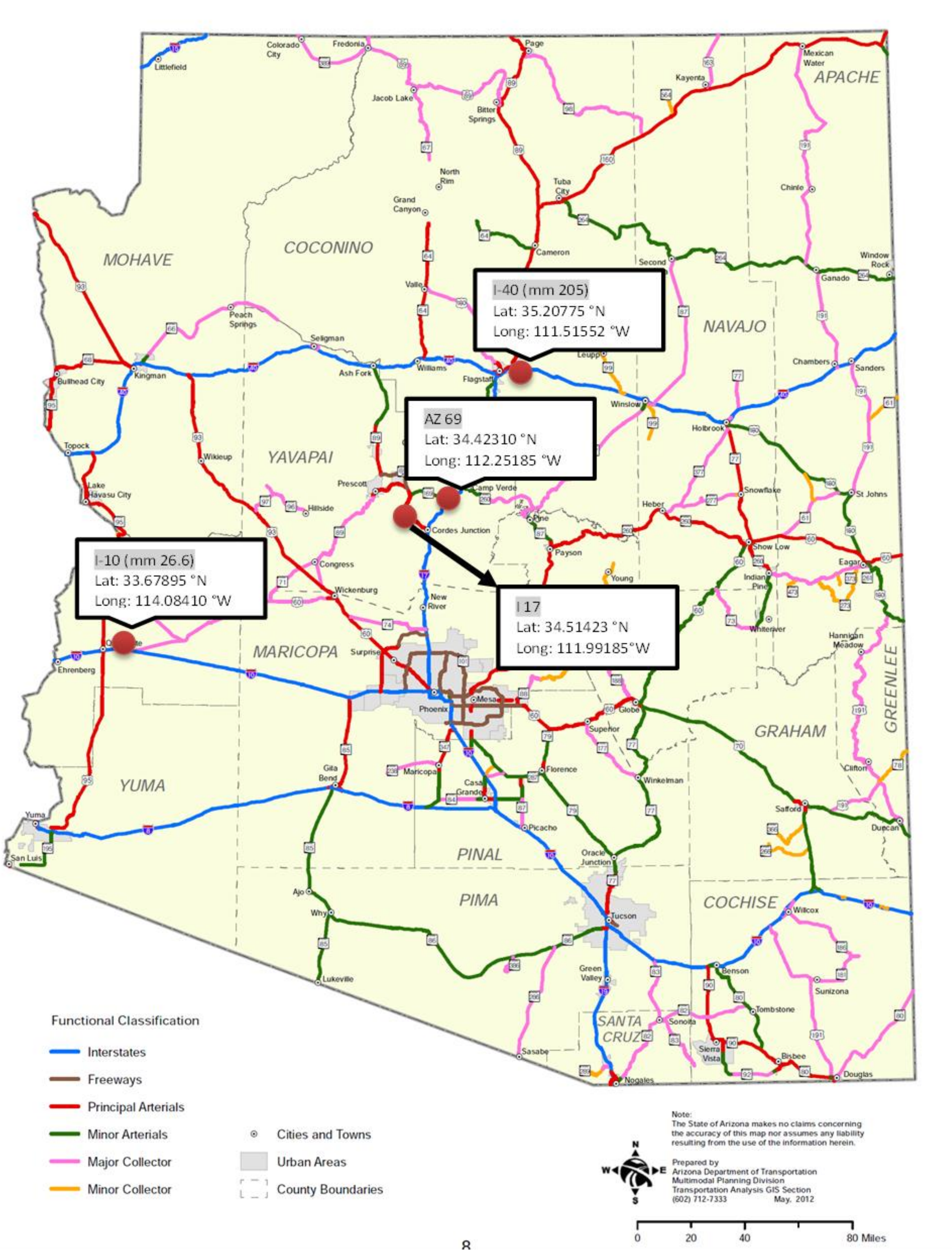

Figure 77. Map of Sites Where Lateral Wander of Trucks Was Measured in Arizona.

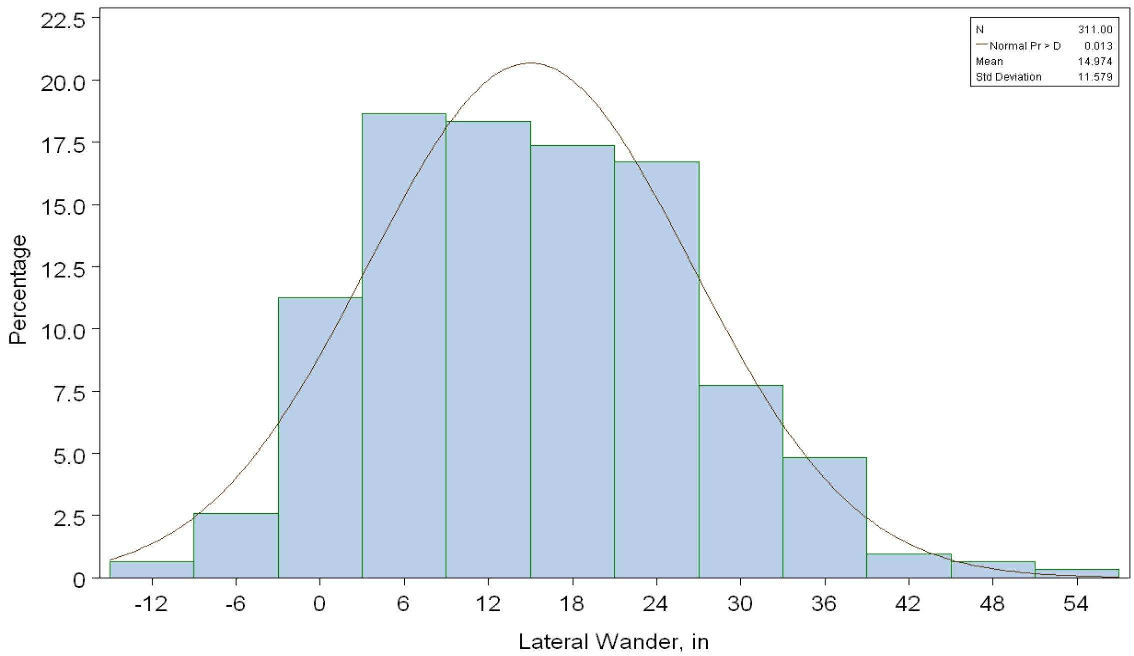

Figure 78. Histogram and Fitted Normal Distribution Curve Showing the Distribution of Wheel Lateral Wander.

The results of the analysis showed that the mean and standard deviation were as follows:

- Analysis: Mean lateral distribution and standard deviation were computed for Arizona sites:
    - Mean lateral offset: 15 inches.
    - Standard deviation: 12 inches.
- Recommendations: Use these values for pavement design. If the lane is narrower, reduce these values for design.
- Impact: Lateral wander has a significant effect on transverse cracking in concrete pavement and rutting in asphalt pavement.

These mean and standard deviation values are recommended for Arizona use, as they represent a refinement of the national calibration values and may show a significant difference in design.

TRUCK WHEELBASE

The truck wheelbase was previously defined as the distance from the steering axle to the first next axle for Classes 8 through 13 only. This distance varies from "short" to "medium" to "long" truck cabs.

WIM data were downloaded from two Arizona LTPP sites. The data were divided into three sections so that the average wheelbase for these three sections was 12, 15, and 18 feet. All trucks in Classes 8 through 13 were evaluated. The percentage of trucks for each average wheelbase section was determined (see Table 49).

Table 49. Wheelbase Distribution.

Wheelbase Type	Wheelbase Length (feet)	Percent of Trucks (Class 8 through 13)
Short	10.0 to 13.4	11
Medium	13.5 to 16.5	17
Long	16.6 to 20.0	72

Results of the analysis showed that the mean and standard deviation were as follows:

- Analysis: Data were analyzed and the following results obtained:
    - Short wheelbase: 11 percent.
    - Medium wheelbase: 17 percent.
    - Long wheelbase: 72 percent.
- Recommendations:
    - Level 1: Use WIM data to compute the percentage of trucks in Classes 8 through 13 that have short, medium, and long wheelbases.
    - Level 2/3: Use the results above.

CHAPTER 7. DETAILED SYSTEM FOR ADOT TRAFFIC DATA INPUTS FOR THE MEPDG DESIGN PROCESS

This chapter provides detailed inputs for the ADOT comprehensive traffic data input system for the MEPDG. This system recommends the following components:

- A homogeneous traffic segment database that includes all highways in Arizona (Interstate, U.S., and state). This database would include all traffic inputs required for the MEPDG and AASHTO 1993 design procedures. Traffic segments would include MP to MP limits, as well as GPS coordinates of the beginning and ending MP.
- Coordinates, traffic volume inputs, traffic weight inputs, traffic geometry inputs, and other inputs.

This chapter also discusses types of equipment recommended for collecting the traffic data, based on the accuracies needed in support of the MEPDG. A cost estimate is provided for the equipment, installation, site maintenance, equipment calibration, monitoring (data retrieval), and data analyses.

OVERALL SUMMARY OF ARIZONA TRAFFIC DATA INPUT SYSTEM

The traffic data input system includes field data collection equipment, procedures to process the raw data, a traffic segment database, and detailed procedures for obtaining the data required. The traffic segment database would include the section breakdown currently included in the pavement management system database used by pavement management and design groups. For each segment of highway, all inputs for the MEPDG would be provided. Recommendations for inputs for the initial version of the traffic segment database are provided in this chapter. The general traffic segment database is presented using the format shown in Table 50.

DETAILED DESCRIPTION OF TRAFFIC SEGMENT DATABASE

The development of a traffic segment database was recommended in SPR-402 Project No. 11, "Development of Design Guide Traffic Files for ADOT." (Witczak, 2008) That study recommended four major components of traffic information to be included in each section of the database:

- AADT.
- Traffic growth rate.
- Percent of trucks.
- Vehicle classification percentage.

Table 50. ADOT Comprehensive Traffic Data Input System for the MEPDG.

MEPDG Traffic Input	Input Level	Who Collects and Processes Input	How Is Input Obtained?	How Often Is Input Provided?	User of Input
Volume Inputs	1	MPD	AVC for specific project	As requested for specific project	PD, PM
	2	MPD	AVC	Annually	PD, PM
	3	MPD	AVC	Annually	PD, PM
Weight Inputs	1	MPD	WIM for specific project	As requested for specific project	PD
	2/3	MPD	WIM: urban, rural, desert	Annually	PD
Geometry Inputs	1	PD	Measured for specific project	As requested for specific project	PD
	2/3	PD	AZ Default	Constant or annually	PD
Other Inputs	1	MPD	Measured for specific project	As requested for specific project	PD
	2/3	MPD	AZ Default	Constant or Annually	PD

MPD = ADOT Multimodal Planning Division; PD = Pavement Design; PM = Pavement Manager.

The traffic segment database would also include location inputs such as beginning and ending MP and GPS coordinates of these locations. The MEPDG requires additional inputs that should be stored in the database, including axle weight distribution data, truck lane percentage, directional distribution of trucks, hourly distribution of trucks, and monthly truck volume adjustments.

This database would provide a significant amount of information to pavement designers, pavement management staff, and several others in ADOT, as well as consultants who design projects for ADOT.

This database would be updated annually, with the results from the previous year of the traffic data collection. Over time, it would become an excellent source of current and historical traffic data. The database would be managed and updated by the MPD for use by the pavement design and pavement management sections.

ADOT MEPDG Traffic Volume Inputs

The traffic segment database would provide all traffic volume inputs required for the MEPDG along every state highway in Arizona. The traffic volume inputs are shown in Table 51, with all recommendations provided for Levels 1, 2, and 3. Some further explanations are provided to more fully describe the recommendations. Table 51 also shows the specific traffic inputs required under this topic.

Table 51. Traffic Volume Inputs Required for the MEPDG.

MEPDG Traffic Input	Input Level	Who Collects and Processes Input?	How Is Input Obtained?	How Often Is Input Provided?	User of Input
Initial AADT	1	MPD	AVC for project	As requested for project	PD
	2/3	MPD	AVC	Annual tables, maps, pavement management system software	PD, PM
Growth AADT	1	MPD	AVC for project	As requested for project	PD, PM
	2/3	MPD	AVC	Annual tables and pavement management system software	PD, PM
Vehicle Class Distribution	1	MPD	AVC for project	As requested for project	PD
	2	MPD	AVC	Annual tables and pavement management system software	PD, PM
	3	SPR-672	Historical AVC	Tables and guidelines	PD
Percent Trucks	1	MPD	AVC for project	As requested for project	PD
	2	MPD	AVC	Annual tables and pavement management system software	PD, PM
	3	SPR-672	Historical AVC	Tables and guidelines	PD
Truck Lane Distribution	1	MPD	AVC for project	As requested for project	PD
	2/3	SPR-672	Historical AVC	Guideline based on number of lanes	PD
Directional Distribution	1	MPD	AVC for project	As requested for project	PD
	2/3	SPR-672	Historical AVC	Set to 0.50	PD, PM
Hourly AADTT	1	MPD	AVC for project	As requested for project	PD
	2/3	SPR-672	Historical AVC by highway class or urban/rural?	Annual update	PD
Monthly Distribution	1	MPD	AVC for project	As requested for project	PD
	2/3	SPR-672	Historical AVC by highway class or urban/rural?	Set to 1.00, except for exceptions (recreational, industrial)	

Initial Two-Way AADT

The initial two-way AADT is a significant input because any error in this value will project itself throughout the future design life of the pavement. When the initial AADT is multiplied by the percentage of buses and trucks (Classes 4 through 13), the expected number of buses and trucks (AADTT) in the base year is obtained. This is calculated from the AVC/WIM data or trip generation studies by averaging the number of trucks measured over multiple 24-hour periods of time in each season/month, and weighted between weekends and weekdays. The MPD collects this input through remote download of raw data files from each traffic data collection device. The data are then automatically processed and reduced using TRADAS software. AADTs for each equipment site are calculated and presented in the software. The software then validates the data through historical and multiple count AADT checks. The AADT is then assigned along each highway to the various homogenous segments.

The AADT values collected and developed annually are made available to ADOT's pavement design and pavement management system sections through the ADOT Web site. Spreadsheets are populated annually with these data, which are entered into the Basic pavement management system software used by pavement design and management groups.

For MEPDG design at Level 1 and Level 2/3, data collection and processing consists of the following:

- **Level 1:** Temporary AVC equipment is installed on the project site and data are measured as described above over an appropriate sampling time. The data are then processed and used as described above.
- **Level 2/3:** AADT data are obtained from the annually updated and developed spreadsheets for the project segment under design and projected to the initial year AADT.

Growth of AADTT (Truck Traffic)

Traditionally, ADOT has determined future truck traffic growth through a projection of historical AADT (all vehicles). This implies that future growth will be as significant as past growth, which may or may not be correct for various highway segments. It also assumes that truck volume growth will be the same as all vehicle growth. The proper input is truck traffic growth (Classes 4 through 13).

The MEPDG allows the user to specify the nature and rate of traffic growth relative to the base year. The MEPDG software (now called Pavement ME Design) can consider the growth for each truck class separately. The user can choose one of three growth functions:

- **No growth:** Truck volume remains the same throughout the design life.
- **Linear growth:** The truck volume increases by a constant percentage of the base year traffic across each truck class.
- **Compound growth:** The truck volume increases by the constant percentage of the preceding year's traffic across each truck class.

The user can select a different growth rate and growth function for each truck class by selecting the option for "vehicle-class specific traffic growth."

For MEPDG design at Level 1 and Level 2/3, data collection and processing consists of the following:

- **Level 1:** Determine the historic growth in AADTT by plotting AADTT over time for as many years as available. Five or more years' worth of data is desirable to reduce unrealistically high or low values. These data will likely reflect a downturn in AADTT due to the recession from 2007 to 2010. Then adjust this value up or down based on the relative expected growth in the area of the highway. The recommended range is from 0 to 10 percent per year. If the resulting value is negative growth, use +2 percent.
- **Level 2/3:** If no historical data are available for a highway segment, obtain data from another segment as close or as representative as possible to the highway segment under design. If no such data are available, use a value of +3 percent compound growth, which is typical of major highways in Arizona.

Percent Trucks (T Factor)

Percent trucks is the percentage of the AADT volume generated by buses and trucks (percentage of all vehicles identified as Classes 4 to 13 from the entire two-way truck count). The T factor is the percentage of trucks to be used in the MEPDG design input and is multiplied by AADT to obtain the direct MEPDG input AADTT. The truck percentage should be selected from the existing ADOT spreadsheet, which is updated annually from data provided by the MPD. Since it was determined that the values that currently populate this spreadsheet are valid, this practice should continue.

For MEPDG design at Level 1 and Level 2/3, data collection and processing consists of the following:

- **Level 1:** The percent of trucks is determined from AVC equipment located on or near the project under design.
- **Level 2/3:** The percent of trucks is are determined from the ADOT spreadsheet, which is updated annually from data provided by the MPD.

Vehicle Class Distribution

The VCD for a given highway represents the percent of each type of vehicle (Classes 4 through 13). This input is important because it is used to compute the number of single, tandem, tridem, and quad axles that pass on a highway over a design period. This input can be obtained on site and from results of Arizona vehicle counts.

For MEPDG design at Level 1 and Level 2/3, data collection and processing consists of the following:

- **Level 1:** Measure the VCD on the highway section under design through placement of 13-bin AVC equipment in the design lane or in all lanes. This measurement must be in place for a minimum of 7 days, 24 hours per day.
- **Level 2/3:** The approximate percentage of VCDs is developed from Arizona AVC measured data. Table 52 shows the recommended selection criteria for TTCs based on highway functional class in Arizona. The Arizona TTC VCD percentages calculated for these TTCs are shown in Table 53.

Table 52. Recommended Selection Criteria for Level 3 Arizona TTCs Based on Highway Functional Class.

Functional Class	AZ MEPDG TTCs	AZ Representative Highways
Rural Principal Arterial – Interstate	1, 2	I-8, I-10, I-15, I-19, I-40 (single peak for Class 9)
Rural Principal Arterial – Other	6, 9, 12	SR 85, U.S. 60, SR 77, U.S. 93, SR 360, SR 101, SR 303 (double peak for Classes 5 and 9)
Rural Major Collector	6, 9, 12	U.S. 91 (double peak for Classes 5 and 9)
Rural Minor Arterial or Collector	6, 9, 12, 14	SR 79, U.S. 60, SR 347 (double peak for Classes 5 and 9)
Urban Principal Arterial – Interstate	1, 2	I-10, I-19, I-40 (some in urban areas had double peak Classes 5 and 9)
Urban Principal Arterial – Other	9, 12, 14	SR 360, SR 101, SR 101, SR 303, SR 77 (double peak for Classes 5 and 9)

Table 53. Recommended Level 3 VCDs for Specific Arizona TTCs.

AZ TTC	Vehicle Class									
	4	5	6	7	8	9	10	11	12	13
1	1.8	6.5	1.9	0.2	10.3	73.2	1.0	3.1	1.9	0.1
2	3.1	14.7	2.9	0.1	9.3	64.4	1.3	1.9	1.5	0.8
6	3.7	21.3	5.7	0.4	19.0	45.6	1.7	1.5	0.7	0.4
9	5.3	38.5	6.2	0.2	9.0	36.9	1.8	1.3	0.3	0.4
12	5.3	46.3	5.7	0.7	16.1	24.1	1.1	0.3	0.1	0.3
14	7.8	65.8	4.4	0.2	11.7	9.1	0.7	0.2	0.0	0.1

Percent Trucks in the Design Lane

The percentage of trucks in the design lane is the percentage of total trucks in one direction expected to use the design lane. If 100 trucks were using a highway with two lanes in one direction and 85 were in the outer driving lane and 15 were in the inner passing lane, the percent of trucks in the design lane would be 85 percent (outer lane). The percentage of trucks in the design lane is used to calculate the total number of trucks and then axles expected to travel in the design lane over the analysis period. A summary of data obtained for Arizona sections is shown in Table 50.

For MEPDG design at Level 1 and Level 2/3, data collection and processing consists of the following:

- **Level 1:** Install AVC equipment across all lanes in one direction and measure the number of trucks each hour over at least a 7-day, 24-hour per day count. If the highway is to be widened, the percentage of trucks in the design lane will likely be lower. Follow recommendations provided for Level 2/3 to make an adjustment. Level 1 is recommended specifically for unusual urban conditions where various ramp on/off situations exist along the project. The critical area along the project (highest percentage of trucks in one lane) should be used for the design.

- **Level 2/3:** Use the following statewide averages for truck lane distribution design (see Table 54):
  - One lane in design direction: 100 percent.
  - Two lanes in design direction: 81 percent (60 to 97 measured).
  - Three lanes in design direction: 51 percent (40 to 62 measured).
  - Four or more lanes in design direction: 44 percent (44 percent measured).

Table 54. Percent of Trucks in Design Lane for Arizona Sections.

Site	Route	Total No. of Lanes in Design Direction	Arizona County	Route No.	Functional Class	Percent Truck in Design Lane	Lane Description
100767	SR 72	1	La Paz	SR 72	Rural Major Collector	100	East
100767	SR 72	1	La Paz	SR 72	Rural Major Collector	100	West
100854	SR 79	1	Pinal	SR 79	Rural Minor Arterial	100	North
100854	SR 79	1	Pinal	SR 79	Rural Minor Arterial	100	South
101113	SR 95	1	Yuma	SR 95	Rural Principal Arterial - Other	100	North
101113	SR 95	1	Yuma	SR 95	Rural Principal Arterial - Other	100	South
101602	SR 303	1	Maricopa	SR 303	Urban Principal Arterial - Other Freeways or Expressways	100	North
101602	SR 303	1	Maricopa	SR 303	Urban Principal Arterial - Other Freeways or Expressways	100	South
101928	U.S. 60	1	Navajo	U.S. 60	Rural Minor Arterial	100	East
101928	U.S. 60	1	Navajo	U.S. 60	Rural Minor Arterial	100	West
102094	U.S. 93	1	Yavapai	U.S. 93	Rural Principal Arterial - Other	100	North
102094	U.S. 93	1	Yavapai	U.S. 93	Rural Principal Arterial - Other	100	South
102230	U.S. 191	1	Graham	U.S. 191	Rural Major Collector	100	North
102230	U.S. 191	1	Graham	U.S. 191	Rural Major Collector	100	South
100010	I-08	2	Yuma	I-08	Rural Principal Arterial - Interstate	90	East
100010	I-08	2	Yuma	I-08	Rural Principal Arterial - Interstate	92	West
100070	U.S. 60	2	La Paz	U.S. 60	Rural Principal Arterial - Interstate	71	East
100070	U.S. 60	2	La Paz	U.S. 60	Rural Principal Arterial - Interstate	85	West
100188	I-10	2	Cochise	I-10	Rural Principal Arterial - Interstate	91	East
100188	I-10	2	Cochise	I-10	Rural Principal Arterial - Interstate	90	West

Table 54. Percent of Trucks in Design Lane for Arizona Sections, continued.

Site	Route	Lanes in Design Direction	Arizona County	Rout e No.	Functional Class	Percent Truck in Design Lane	Lane Description
100327	I-15	2	Mohave	I-15	Rural Principal Arterial - Interstate	88	North
100327	I-15	2	Mohave	I-15	Rural Principal Arterial - Interstate	89	South
100473	I-19	2	Pima	I-19	Urban Principal Arterial - Interstate	63	North
100473	I-19	2	Pima	I-19	Urban Principal Arterial - Interstate	65	South
100537	I-40	2	Coconino	I-40	Rural Principal Arterial - Interstate	85	East
100537	I-40	2	Coconino	I-40	Rural Principal Arterial - Interstate	88	West
100541	I-40	2	Coconino	I-40	Urban Principal Arterial - Interstate	80	East
100541	I-40	2	Coconino	I-40	Urban Principal Arterial - Interstate	83	West
100922	SR 85	2	Maricopa	SR 85	Rural Principal Arterial - Other	93	North
100922	SR 85	2	Maricopa	SR 85	Rural Principal Arterial - Other	93	South
101622	SR 347	2	Pinal	SR 347	Rural Minor Collector	73	North
101622	SR 347	2	Pinal	SR 347	Rural Minor Collector	75	South
101849	U.S. 60	2	Maricopa	U.S. 60	Rural Principal Arterial - Other	79	East
101849	U.S. 60	2	Maricopa	U.S. 60	Rural Principal Arterial - Other	60	West
102068	U.S. 89	2	Coconino	U.S. 89	Urban Principal Arterial - Other	75	North
102068	U.S. 89	2	Coconino	U.S. 89	Urban Principal Arterial - Other	67	South
102084	U.S. 93	2	Mohave	U.S. 93	Rural Principal Arterial - Other	97	North
102084	U.S. 93	2	Mohave	U.S. 93	Rural Principal Arterial - Other	78	South
100139	I-10	3	Pima	I-10	Urban Principal Arterial - Interstate	56	East
100139	I-10	3	Pima	I-10	Urban Principal Arterial - Interstate	62	West
100800	SR 77	3	Pima	SR 77	Urban Principal Arterial - Other	47	North
100800	SR 77	3	Pima	SR 77	Urban Principal Arterial - Other	40	South
101248	SR 101	5	Maricopa	SR 101	Urban Principal Arterial - Other Freeways or Expressways	44	North
101248	SR 101	5	Maricopa	SR 101	Urban Principal Arterial - Other Freeways or Expressways	44	South

Percent Trucks in Design Direction

The percentage of trucks in the design direction is the percentage of trucks (from the entire two-way truck count) that is expected to travel in the design direction. Although this value should be very close to 50 percent, it is not necessarily so, especially in cases where truck traffic does not use the same route for both out and return trips.

For MEPDG design at Level 1 and Level 2/3, data collection and processing consists of the following:

- **Level 1:** Install AVC equipment across all lanes in both directions and compute the percentage of trucks in the design direction over a sufficient sample period on or near the project under design.
- **Level 2:** The Arizona statewide average is 50 percent (ranged from 36 to 64 percent). This is approximately the MEPDG Level 3 default and should be used for Arizona pavement designs.

Truck Hourly Distribution

Truck volume varies hour-to-hour over a 24-hour day. The following recommendations are provided for 24-hour truck distribution:

- **Level 1:** Measure the number of trucks (Classes 4 through 13) in the design lane each hour over a representative number of 24-hour periods. It is recommended that a 7-day, 24-hour per day minimum count be conducted. The number of trucks in each hour is divided by the total number of trucks counted over 24 hours to obtain a percentage for every hour of the day and night.
- **Level 2/3:** Three distinct hourly truck distributions are recommended for Arizona—rural, urban, and long-haul desert. These distributions are described as follows:
    - **Moderate Peak for Rural Highways:** A distribution that represents “rural” highway trucks over 24 hours. The difference between the nighttime and daytime truck traffic is significant (typically ranges from 3 to 7 percent), but not as peaked as typical urban distribution. An example of this “rural” hourly truck distribution is shown in Figure 79, which is for a site in Coconino County on I-40.
    - **High Peak Distribution for Urban Highways:** A distribution that represents “urban” highway trucks over 24 hours. The difference between the daytime and nighttime truck traffic is typically higher than for rural sites. The difference between nighttime and daytime truck traffic typically ranges from less than 1 percent at nighttime to greater than 9 percent at daytime. An example of an “urban” hourly truck distribution is shown in Figure 80, which is for site 4_100800 located in urban Pima County on SR 77.
    - **Desert Long-Haul Highways (Flat Distribution):** A distribution that represents a long-haul section of rural highway across the desert. This distribution is far flatter than either the rural or urban distributions. An example is section 100070 on the western end of I-10 in La Paz County, shown in Figure 81.

These three, 24-hour truck distributions, recommended for use in design for Level 2/3 input to the MEPDG, are provided in Table 55.

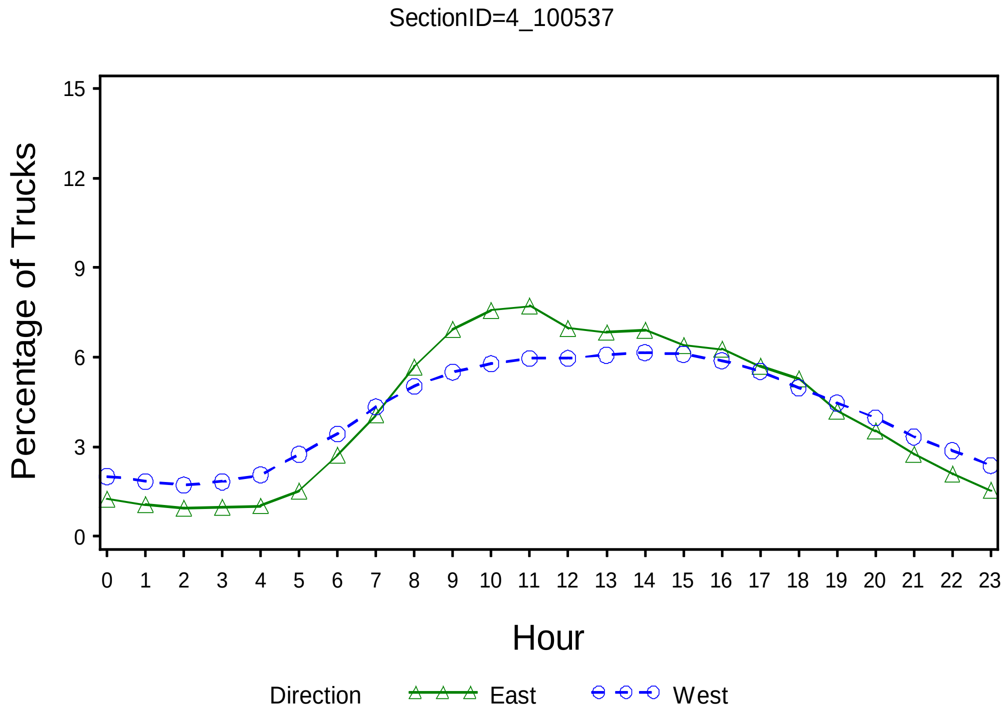

Figure 79. Typical Arizona Rural 24-Hour Distribution of Trucks.

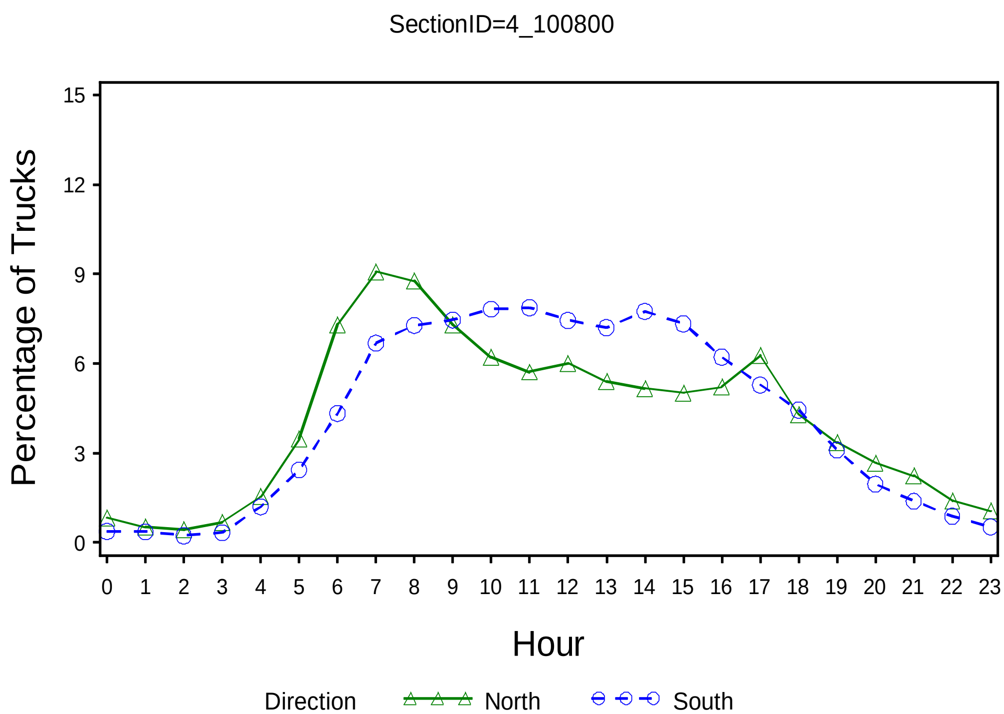

Figure 80. Typical Arizona 24-hour Urban Distribution of Trucks.

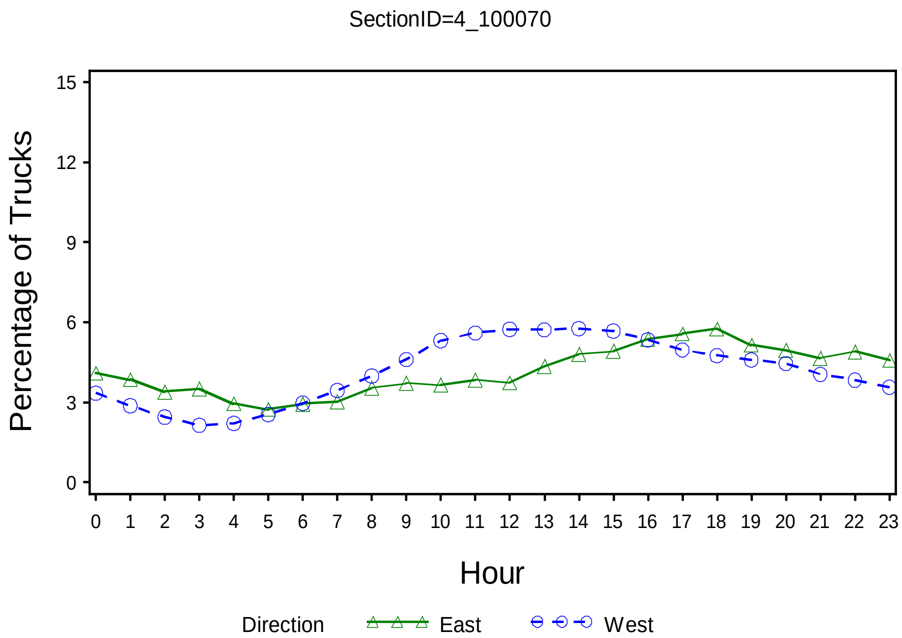

Figure 81. Typical 24-Hour Long-Haul Distance Desert Distribution of Trucks.

Table 55. Summary of 24-Hour Truck Distributions Recommended for Arizona MEPDG for Input Level 2/3 by Rural and Urban Functional Class.

Time of Day (24-hour clock)	"Rural" Distribution	"Urban" Distribution	"Long-Haul Desert" Distribution
1 Early morning	1.9	0.9	3.7
2	1.7	0.8	3.4
3	1.6	0.7	2.9
4	1.7	1.0	2.8
5	1.8	2.0	2.6
6	2.3	3.6	2.6
7	3.2	5.5	3.0
8	4.1	6.1	3.2
9	5.0	6.6	3.8
10	5.8	7.0	4.2
11	6.3	7.1	4.5
12 Noon	6.6	7.0	4.7
13	6.8	6.8	4.7
14	6.7	6.8	5.0
15	6.6	6.8	5.3
16	6.3	6.3	5.3
17	5.9	5.8	5.4
18	5.4	5.0	5.3
19	4.8	4.1	5.3
20	4.1	3.2	4.9
21	3.6	2.5	4.7
22	3.2	2.0	4.4
23	2.6	1.5	4.4
24 Midnight	2.2	1.1	4.1

Monthly Truck Adjustment

The MAF input in the MEPDG provides the opportunity to fine-tune the design considering month-to-month truck volumes. The national defaults were 1.00 for each month, which provides for the same truck volume each month of a given year. The MAF was computed for a number of sites in Arizona to determine its variation around the state. Results from the analysis showed that the MAF factors for various highways over a 12-month period were very similar, with a few exceptions.

For MEPDG design at Level 1 and Level 2/3, data collection and processing consists of the following:

- **Level 1:** Measure the MAF using AVC equipment on or near the highway section under design. A minimum of 7 days and 24 hours per day is required.
- **Level 2/3:** Use the values determined for Arizona for all months unless there is some known reason why truck traffic would vary significantly. For example, this could occur on a highway in mountainous area used only by recreational vehicles in the summer months. The MAF could then be varied to reflect this knowledge.

ADOT MEPDG Traffic Weight Inputs

Recommended sources for truck traffic axle weight inputs are shown in Table 56. Some further explanations are provided to more fully describe the recommendations. Table 56 also shows the specific traffic inputs required under this topic. A summary of recommended truck weight inputs for Arizona MEPDG for input Level 2/3 is presented in Tables 57 through 68.

Table 56. Traffic Weight Inputs Required.

MEPDG Traffic Input	Input Level	Who Collects and Processes Input	How Is Input Obtained	How Often Is Input Provided	User of Input
Axle Load Distributions: Single, Tandem, Tridem, Quad	1	MPD	Representative WIM	As requested for project, normalized	PD
	2	MPD	AZ WIM mean	Annually updated, normalized tables	
	3	SPR-672	AZ WIM mean by highway class or urban/rural	SPR-672 final report	

Table 57. Summary of Level 2/3 Single Axle ALD Recommended for Arizona Rural Principal Arterials, Interstate.

Axle Load, lb	Vehicle Class									
	4	5	6	7	8	9	10	11	12	13
3,000	0.038	0.486	0.000	0.973	4.537	0.210	0.310	0.460	0.271	1.896
4,000	0.050	4.309	0.002	0.325	7.207	0.443	0.102	1.552	1.152	1.431
5,000	0.050	10.099	0.374	0.604	4.568	0.610	0.107	2.697	2.160	1.439
6,000	0.561	24.219	2.839	1.130	12.103	1.374	0.952	4.161	4.024	2.560
7,000	1.186	12.469	3.379	1.569	8.580	1.938	1.709	5.079	6.453	3.890
8,000	2.753	8.969	3.971	2.240	7.778	2.871	3.149	6.035	7.945	4.738
9,000	5.038	7.621	6.495	4.258	8.637	5.029	6.124	7.079	8.436	6.337
10,000	7.637	6.402	10.604	1.845	9.136	9.190	11.881	8.643	9.645	7.880
11,000	9.989	5.215	14.328	9.324	8.390	14.862	17.107	9.816	10.853	10.451
12,000	13.469	4.577	16.163	9.040	7.190	19.357	19.704	9.964	11.722	12.204
13,000	14.165	3.573	13.318	5.189	5.256	17.404	15.820	8.913	10.620	11.182
14,000	12.605	2.770	8.826	10.954	3.797	10.360	9.559	7.502	8.067	8.574
15,000	9.455	2.186	6.182	9.957	2.941	5.397	5.321	6.415	6.276	5.654
16,000	6.763	1.714	4.304	6.482	2.287	3.385	3.034	5.554	4.598	4.316
17,000	4.416	1.347	3.049	7.679	1.877	2.393	1.907	4.641	3.063	3.721
18,000	3.101	1.067	1.991	6.646	1.467	1.745	1.319	3.730	1.884	2.777
19,000	2.432	0.804	1.323	4.462	1.119	1.240	0.695	2.730	1.201	2.466
20,000	1.873	0.601	0.878	3.590	0.816	0.824	0.407	1.917	0.667	2.301
21,000	1.367	0.446	0.650	2.700	0.551	0.514	0.233	1.250	0.362	1.282
22,000	0.944	0.311	0.396	1.885	0.374	0.307	0.122	0.744	0.244	1.167
23,000	0.661	0.207	0.281	2.898	0.259	0.171	0.097	0.462	0.140	0.747
24,000	0.513	0.146	0.205	1.663	0.164	0.099	0.048	0.248	0.095	0.626
25,000	0.296	0.094	0.114	1.586	0.105	0.064	0.038	0.139	0.039	0.521
26,000	0.219	0.064	0.089	1.231	0.059	0.039	0.031	0.079	0.017	0.367
27,000	0.131	0.037	0.056	0.732	0.043	0.026	0.044	0.055	0.016	0.299
28,000	0.118	0.029	0.044	0.280	0.028	0.018	0.026	0.035	0.011	0.166
29,000	0.055	0.026	0.033	0.050	0.020	0.007	0.007	0.020	0.006	0.177
30,000	0.045	0.013	0.014	0.112	0.012	0.003	0.031	0.009	0.000	0.145
31,000	0.015	0.006	0.018	0.125	0.005	0.004	0.005	0.004	0.001	0.063
32,000	0.016	0.007	0.011	0.000	0.003	0.003	0.005	0.005	0.000	0.032
33,000	0.006	0.006	0.005	0.000	0.002	0.002	0.002	0.003	0.000	0.038
34,000	0.004	0.003	0.003	0.308	0.002	0.006	0.007	0.002	0.001	0.032
35,000	0.002	0.004	0.005	0.000	0.001	0.001	0.006	0.002	0.000	0.032
36,000	0.001	0.003	0.001	0.029	0.002	0.001	0.018	0.003	0.000	0.018
37,000	0.009	0.004	0.004	0.000	0.003	0.000	0.004	0.002	0.000	0.023
38,000	0.001	0.002	0.003	0.057	0.001	0.001	0.005	0.000	0.001	0.028
39,000	0.004	0.002	0.004	0.048	0.000	0.001	0.003	0.002	0.000	0.004
40,000	0.004	0.002	0.004	0.019	0.001	0.001	0.000	0.000	0.000	0.007
41,000	0.010	0.002	0.011	0.000	0.002	0.014	0.030	0.000	0.000	0.065

Table 58. Summary of Level 2/3 Tandem Axle ALD Recommended for Arizona Rural Principal Arterials, Interstate.

Axle Load, lb	Vehicle Class									
	4	5	6	7	8	9	10	11	12	13
6,000	0.011	0.000	0.290	0.000	5.050	0.141	0.188	0.000	0.111	0.714
8,000	0.011	0.000	4.419	0.000	7.927	0.747	0.636	50.000	0.563	1.083
10,000	0.018	0.000	10.371	0.000	5.991	1.799	1.565	25.000	2.054	2.590
12,000	0.090	0.000	14.419	0.000	8.533	3.519	2.762	0.000	4.427	5.103
14,000	0.301	0.000	13.063	0.000	11.528	5.235	5.318	0.000	8.715	6.632
16,000	0.807	0.000	8.055	0.000	12.541	6.013	6.893	0.000	12.451	6.310
18,000	2.583	0.000	5.543	100.00	11.386	6.240	8.209	0.000	13.291	6.604
20,000	5.417	0.000	4.607	0.000	9.107	6.284	7.922	0.000	14.918	5.181
22,000	9.568	0.000	4.618	0.000	6.941	6.165	8.416	0.000	14.368	5.148
24,000	13.467	0.000	5.081	0.000	5.326	6.388	8.015	0.000	12.356	4.560
26,000	15.595	0.000	5.359	0.000	3.988	6.667	7.735	0.000	8.337	4.293
28,000	15.288	0.000	5.137	0.000	2.989	7.087	7.740	0.000	4.441	4.377
30,000	12.411	0.000	4.544	0.000	2.190	7.796	7.462	0.000	1.967	4.153
32,000	9.015	0.000	3.866	0.000	1.772	8.362	6.391	0.000	1.000	4.583
34,000	6.407	0.000	2.885	0.000	1.256	8.232	5.366	0.000	0.377	5.106
36,000	3.582	0.000	2.296	0.000	0.956	7.160	4.827	25.000	0.182	5.626
38,000	1.935	0.000	1.705	0.000	0.777	5.210	3.127	0.000	0.137	5.551
40,000	1.306	0.000	1.188	0.000	0.501	3.086	2.436	0.000	0.068	4.950
42,000	0.738	0.000	0.866	0.000	0.303	1.683	1.647	0.000	0.036	4.187
44,000	0.503	0.000	0.552	0.000	0.218	0.895	1.096	0.000	0.019	3.269
46,000	0.377	0.000	0.435	0.000	0.098	0.514	0.774	0.000	0.006	2.382
48,000	0.212	0.000	0.244	0.000	0.170	0.302	0.432	0.000	0.011	1.809
50,000	0.138	0.000	0.140	0.000	0.037	0.174	0.326	0.000	0.030	1.453
52,000	0.065	0.000	0.102	0.000	0.020	0.101	0.164	0.000	0.000	1.050
54,000	0.045	0.000	0.053	0.000	0.009	0.059	0.172	0.000	0.000	0.820
56,000	0.027	0.000	0.035	0.000	0.006	0.034	0.116	0.000	0.000	0.627
58,000	0.022	0.000	0.024	0.000	0.011	0.016	0.060	0.000	0.010	0.514
60,000	0.010	0.000	0.019	0.000	0.004	0.006	0.036	0.000	0.005	0.305
62,000	0.007	0.000	0.014	0.000	0.003	0.004	0.026	0.000	0.000	0.269
64,000	0.011	0.000	0.009	0.000	0.001	0.002	0.065	0.000	0.095	0.194
66,000	0.001	0.000	0.004	0.000	0.001	0.001	0.018	0.000	0.000	0.122
68,000	0.003	0.000	0.005	0.000	0.001	0.001	0.015	0.000	0.000	0.106
70,000	0.003	0.000	0.003	0.000	0.001	0.000	0.011	0.000	0.000	0.111
72,000	0.001	0.000	0.002	0.000	0.000	0.000	0.001	0.000	0.000	0.062
74,000	0.000	0.000	0.007	0.000	0.000	0.000	0.002	0.000	0.000	0.076
76,000	0.000	0.000	0.002	0.000	0.000	0.000	0.001	0.000	0.000	0.039
78,000	0.000	0.000	0.001	0.000	0.000	0.000	0.001	0.000	0.000	0.024
80,000	0.000	0.000	0.002	0.000	0.000	0.000	0.004	0.000	0.000	0.010
82,000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.000	0.000	0.003

Table 59. Summary of Level 2/3 Tridem Axle ALD Recommended for Arizona Rural Principal Arterials, Interstate.

Axle Load, lb	Vehicle Class									
	4	5	6	7	8	9	10	11	12	13
12,000	0.000	0.000	0.000	0.407	0.000	0.105	0.735	0.000	3.111	0.594
15,000	0.000	0.000	0.000	0.394	0.000	1.295	2.336	0.000	3.842	1.000
18,000	0.000	0.000	0.000	5.444	0.000	33.438	6.388	0.000	7.616	1.431
21,000	0.000	0.000	0.000	5.957	0.000	12.495	9.254	0.000	9.580	2.955
24,000	0.000	0.000	0.000	5.374	0.000	9.010	9.670	0.000	20.038	3.998
27,000	0.000	0.000	0.000	3.184	0.000	5.533	8.246	0.000	13.931	4.515
30,000	0.000	0.000	0.000	3.707	0.000	1.862	6.863	0.000	16.044	5.753
33,000	0.000	0.000	0.000	3.412	0.000	1.067	7.361	0.000	1.338	3.861
36,000	0.000	0.000	0.000	6.737	0.000	1.571	7.440	0.000	1.418	4.878
39,000	0.000	0.000	0.000	6.619	0.000	1.510	7.897	0.000	8.847	6.155
42,000	0.000	0.000	0.000	11.794	0.000	1.286	8.187	0.000	0.236	6.803
45,000	0.000	0.000	0.000	9.811	0.000	0.410	7.334	0.000	0.342	6.066
48,000	0.000	0.000	0.000	11.127	0.000	0.614	5.520	0.000	1.453	6.879
51,000	0.000	0.000	0.000	7.935	0.000	4.971	3.890	0.000	3.549	7.441
54,000	0.000	0.000	0.000	5.380	0.000	2.495	2.809	0.000	1.596	11.680
57,000	0.000	0.000	0.000	3.377	0.000	5.429	2.036	0.000	2.471	5.717
60,000	0.000	0.000	0.000	3.084	0.000	4.762	1.670	0.000	1.111	6.126
63,000	0.000	0.000	0.000	3.335	0.000	2.381	0.817	0.000	2.458	4.731
66,000	0.000	0.000	0.000	2.002	0.000	0.000	0.552	0.000	0.000	3.632
69,000	0.000	0.000	0.000	0.483	0.000	9.524	0.395	0.000	0.513	2.345
72,000	0.000	0.000	0.000	0.121	0.000	0.000	0.250	0.000	0.000	0.801
75,000	0.000	0.000	0.000	0.300	0.000	0.000	0.126	0.000	0.000	0.972
78,000	0.000	0.000	0.000	0.000	0.000	0.000	0.074	0.000	0.000	1.026
81,000	0.000	0.000	0.000	0.000	0.000	0.000	0.055	0.000	0.000	0.211
84,000	0.000	0.000	0.000	0.000	0.000	0.000	0.026	0.000	0.000	0.218
87,000	0.000	0.000	0.000	0.000	0.000	0.000	0.021	0.000	0.000	0.016
90,000	0.000	0.000	0.000	0.000	0.000	0.000	0.009	0.000	0.000	0.037
93,000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.000	0.513	0.017
96,000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.011
99,000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.005
102,000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000

Table 60. Summary of Level 2/3 Quad Axle ALD Recommended for Arizona Rural Principal Arterials, Interstate.

Axle Load, lb	Vehicle Class									
	4	5	6	7	8	9	10	11	12	13
12,000	0.000	0.000	0.000	0.000	0.000	0.000	0.541	0.000	0.000	0.335
15,000	0.000	0.000	0.000	0.000	0.000	7.000	0.312	0.000	1.753	0.329
18,000	0.000	0.000	0.000	0.280	0.000	2.000	2.297	0.000	0.000	1.589
21,000	0.000	0.000	0.000	0.280	0.000	15.375	3.921	0.000	10.526	4.071
24,000	0.000	0.000	0.000	0.820	0.000	3.440	5.838	0.000	10.526	6.419
27,000	0.000	0.000	0.000	10.000	0.000	8.215	1.241	0.000	1.753	6.580
30,000	0.000	0.000	0.000	0.000	0.000	10.000	0.376	0.000	1.753	3.973
33,000	0.000	0.000	0.000	1.060	0.000	5.625	1.515	0.000	5.263	6.529
36,000	0.000	0.000	0.000	0.280	0.000	0.000	4.541	0.000	0.000	5.374
39,000	0.000	0.000	0.000	0.540	0.000	0.000	6.162	0.000	12.016	9.536
42,000	0.000	0.000	0.000	11.260	0.000	0.000	5.503	0.000	2.295	8.463
45,000	0.000	0.000	0.000	14.200	0.000	0.000	12.556	0.000	4.874	7.089
48,000	0.000	0.000	0.000	4.140	0.000	0.000	10.197	0.000	5.668	6.515
51,000	0.000	0.000	0.000	14.600	0.000	10.000	9.732	0.000	13.868	4.971
54,000	0.000	0.000	0.000	11.700	0.000	0.000	8.729	0.000	15.579	4.699
57,000	0.000	0.000	0.000	21.360	0.000	0.000	8.024	0.000	7.979	5.794
60,000	0.000	0.000	0.000	3.640	0.000	0.625	3.126	0.000	3.958	2.460
63,000	0.000	0.000	0.000	3.520	0.000	10.000	3.159	0.000	1.363	2.749
66,000	0.000	0.000	0.000	1.840	0.000	0.000	2.935	0.000	0.532	1.945
69,000	0.000	0.000	0.000	0.540	0.000	0.000	3.038	0.000	0.000	1.293
72,000	0.000	0.000	0.000	0.000	0.000	0.000	0.544	0.000	0.274	1.304
75,000	0.000	0.000	0.000	0.000	0.000	0.000	0.450	0.000	0.000	1.224
78,000	0.000	0.000	0.000	0.000	0.000	0.000	2.382	0.000	0.000	1.979
81,000	0.000	0.000	0.000	0.000	0.000	15.000	0.000	0.000	0.000	1.696
84,000	0.000	0.000	0.000	0.000	0.000	0.000	0.121	0.000	0.000	1.705
87,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.234
90,000	0.000	0.000	0.000	0.000	0.000	7.500	0.782	0.000	0.000	0.406
93,000	0.000	0.000	0.000	0.000	0.000	0.000	1.471	0.000	0.000	0.061
96,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.036
99,000	0.000	0.000	0.000	0.000	0.000	2.500	0.000	0.000	0.000	0.001
102,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 61. Summary of Level 2/3 Single Axle ALD Recommended for Arizona Urban Freeways and Rural Minor Arterials/Collectors.

Axle Load, lb	Vehicle Class									
	4	5	6	7	8	9	10	11	12	13
3,000	0.000	0.483	0.003	0.000	1.870	0.327	0.110	1.197	0.547	2.010
4,000	0.003	5.240	0.007	0.130	4.660	1.167	0.203	4.313	2.613	1.910
5,000	0.000	6.467	0.013	0.377	3.513	1.820	0.347	6.103	4.260	1.053
6,000	0.813	24.707	1.520	0.343	9.947	2.287	1.103	6.173	5.973	1.743
7,000	2.597	12.997	2.213	1.303	8.213	2.587	2.640	6.763	8.160	2.820
8,000	5.853	9.477	3.910	1.437	9.240	4.280	5.057	7.827	9.503	4.083
9,000	9.740	7.770	7.057	2.677	10.167	8.300	9.987	8.813	11.223	7.913
10,000	10.473	6.267	10.717	4.523	9.520	12.957	13.567	8.070	10.720	11.610
11,000	10.533	5.100	12.917	10.240	8.227	15.793	16.677	6.693	9.950	12.047
12,000	10.333	4.387	13.483	5.933	7.130	16.363	17.030	5.870	9.523	11.620
13,000	8.970	3.577	11.367	7.757	5.573	12.140	11.493	5.030	7.123	9.320
14,000	7.987	2.790	8.947	9.630	4.357	7.240	8.203	4.840	5.310	7.103
15,000	6.293	2.270	7.070	8.387	3.700	4.337	4.417	4.787	4.083	4.960
16,000	5.657	1.857	5.527	6.800	3.067	2.937	3.197	4.830	2.797	4.430
17,000	4.760	1.473	4.087	8.147	2.543	2.107	1.650	4.370	2.287	3.303
18,000	3.880	1.240	3.173	6.060	2.010	1.587	0.997	3.840	1.537	2.713
19,000	3.613	0.940	2.177	5.787	1.557	1.143	0.993	2.983	1.280	2.183
20,000	2.513	0.757	1.810	4.810	1.213	0.860	0.850	2.310	1.030	1.830
21,000	1.903	0.557	1.357	3.797	0.913	0.603	0.447	1.560	0.607	2.127
22,000	1.477	0.423	0.830	7.473	0.657	0.367	0.390	1.087	0.503	0.940
23,000	0.833	0.303	0.583	1.657	0.473	0.243	0.217	0.747	0.297	1.150
24,000	0.763	0.230	0.333	0.977	0.343	0.150	0.133	0.527	0.137	0.530
25,000	0.373	0.187	0.210	0.467	0.217	0.097	0.060	0.333	0.097	0.417
26,000	0.277	0.113	0.163	0.213	0.157	0.073	0.090	0.263	0.097	0.410
27,000	0.150	0.060	0.083	0.203	0.120	0.047	0.083	0.183	0.060	0.263
28,000	0.070	0.040	0.087	0.517	0.077	0.033	0.010	0.103	0.050	0.140
29,000	0.027	0.027	0.090	0.160	0.067	0.017	0.013	0.080	0.040	0.093
30,000	0.030	0.023	0.020	0.017	0.030	0.013	0.003	0.067	0.020	0.137
31,000	0.013	0.017	0.033	0.153	0.020	0.003	0.007	0.043	0.020	0.123
32,000	0.010	0.010	0.040	0.007	0.020	0.003	0.000	0.033	0.017	0.033
33,000	0.003	0.010	0.027	0.053	0.007	0.003	0.000	0.023	0.013	0.100
34,000	0.003	0.003	0.013	0.000	0.007	0.003	0.000	0.020	0.010	0.017
35,000	0.023	0.003	0.003	0.000	0.013	0.003	0.017	0.010	0.017	0.013
36,000	0.000	0.003	0.010	0.003	0.003	0.003	0.003	0.013	0.007	0.037
37,000	0.003	0.007	0.023	0.000	0.003	0.003	0.027	0.010	0.007	0.017
38,000	0.000	0.003	0.020	0.000	0.003	0.003	0.000	0.007	0.010	0.010
39,000	0.000	0.003	0.007	0.000	0.003	0.003	0.003	0.007	0.010	0.007
40,000	0.000	0.003	0.023	0.000	0.003	0.000	0.000	0.007	0.003	0.003
41,000	0.003	0.003	0.007	0.000	0.003	0.003	0.000	0.003	0.003	0.000

Table 62. Summary of Level 2/3 Tandem Axle ALD Recommended for Arizona Urban Freeways and Rural Minor Arterials/Collectors.

Axle Load, lb	Vehicle Class									
	4	5	6	7	8	9	10	11	12	13
6,000	0.000	0.000	0.487	0.000	1.720	0.340	0.230	0.000	0.070	0.253
8,000	0.017	0.000	4.410	0.000	7.433	2.333	1.273	0.000	1.070	1.060
10,000	0.090	0.000	6.453	0.000	6.467	5.373	2.423	0.000	3.877	3.793
12,000	0.373	0.000	7.197	0.000	9.687	7.783	6.507	0.000	9.180	7.917
14,000	0.807	0.000	7.500	0.000	10.947	8.717	8.117	0.000	16.933	10.177
16,000	1.670	0.000	7.300	0.000	10.387	8.217	9.567	0.000	17.207	8.763
18,000	3.877	0.000	6.697	0.000	8.320	7.120	9.403	0.000	15.760	6.820
20,000	10.083	0.000	6.373	0.000	7.063	6.110	8.683	0.000	11.910	4.950
22,000	11.833	0.000	6.150	0.000	5.307	5.460	7.567	0.000	6.963	3.857
24,000	14.067	0.000	6.410	0.000	4.727	5.593	6.893	0.000	6.037	4.053
26,000	14.563	0.000	6.407	0.000	4.270	5.863	5.847	0.000	4.307	4.277
28,000	11.913	0.000	6.173	0.000	3.900	6.240	5.907	0.000	2.640	4.203
30,000	9.687	0.000	5.530	0.000	3.847	6.450	4.920	0.000	1.177	4.330
32,000	6.043	0.000	4.713	0.000	3.463	6.103	4.453	0.000	0.970	4.870
34,000	4.753	0.000	3.990	0.000	2.957	5.213	4.053	0.000	0.517	4.533
36,000	3.437	0.000	3.450	0.000	2.517	4.003	2.590	0.000	0.343	3.907
38,000	2.640	0.000	2.653	0.000	1.957	2.857	2.283	0.000	0.337	3.527
40,000	1.833	0.000	2.250	0.000	1.353	1.967	2.227	0.000	0.130	3.023
42,000	0.940	0.000	1.793	0.000	0.980	1.323	1.940	0.000	0.120	2.593
44,000	0.527	0.000	1.103	0.000	0.787	0.907	1.417	0.000	0.067	2.447
46,000	0.273	0.000	0.810	0.000	0.587	0.610	1.073	0.000	0.063	1.883
48,000	0.247	0.000	0.707	0.000	0.347	0.410	0.717	0.000	0.050	1.550
50,000	0.133	0.000	0.413	0.000	0.253	0.290	0.447	0.000	0.043	1.553
52,000	0.080	0.000	0.287	0.000	0.143	0.183	0.473	0.000	0.077	1.013
54,000	0.080	0.000	0.223	0.000	0.097	0.123	0.327	0.000	0.023	1.100
56,000	0.037	0.000	0.133	0.000	0.057	0.077	0.227	0.000	0.023	0.713
58,000	0.013	0.000	0.093	0.000	0.033	0.060	0.110	0.000	0.027	0.713
60,000	0.003	0.000	0.073	0.000	0.013	0.040	0.143	0.000	0.030	0.437
62,000	0.003	0.000	0.040	0.000	0.017	0.023	0.077	0.000	0.017	0.493
64,000	0.003	0.000	0.030	0.000	0.017	0.020	0.063	0.000	0.020	0.320
66,000	0.000	0.000	0.027	0.000	0.013	0.017	0.020	0.000	0.017	0.257
68,000	0.000	0.000	0.003	0.000	0.003	0.013	0.010	0.000	0.013	0.163
70,000	0.000	0.000	0.013	0.000	0.007	0.010	0.007	0.000	0.003	0.107
72,000	0.000	0.000	0.013	0.000	0.000	0.007	0.003	0.000	0.000	0.107
74,000	0.000	0.000	0.017	0.000	0.000	0.007	0.000	0.000	0.000	0.083
76,000	0.000	0.000	0.000	0.000	0.000	0.007	0.000	0.000	0.000	0.043
78,000	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.020
80,000	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.023
82,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.010

Table 63. Summary of Level 2/3 Tridem Axle ALD Recommended for Arizona Urban Freeways and Rural Minor Arterials/Collectors.

Axle Load, lb	Vehicle Class									
	4	5	6	7	8	9	10	11	12	13
12,000	0.000	0.000	0.000	0.000	0.000	0.000	1.187	0.000	0.000	0.177
15,000	0.000	0.000	0.000	0.017	0.000	0.000	4.453	0.000	7.288	2.030
18,000	0.000	0.000	0.000	4.223	0.000	66.667	13.067	0.000	14.169	3.180
21,000	0.000	0.000	0.000	0.313	0.000	0.000	9.680	0.000	14.750	4.303
24,000	0.000	0.000	0.000	2.490	0.000	0.044	7.483	0.000	19.200	3.123
27,000	0.000	0.000	0.000	3.347	0.000	0.133	7.557	0.000	10.631	3.933
30,000	0.000	0.000	0.000	1.907	0.000	1.167	5.907	0.000	0.000	1.653
33,000	0.000	0.000	0.000	3.587	0.000	2.456	7.013	0.000	8.506	3.487
36,000	0.000	0.000	0.000	7.653	0.000	1.533	6.147	0.000	0.675	2.563
39,000	0.000	0.000	0.000	7.900	0.000	1.589	5.463	0.000	3.300	3.720
42,000	0.000	0.000	0.000	10.507	0.000	3.222	6.010	0.000	1.550	5.807
45,000	0.000	0.000	0.000	11.580	0.000	2.678	5.750	0.000	0.694	6.150
48,000	0.000	0.000	0.000	18.143	0.000	1.856	4.740	0.000	2.938	9.500
51,000	0.000	0.000	0.000	7.083	0.000	4.867	4.057	0.000	4.469	7.980
54,000	0.000	0.000	0.000	6.513	0.000	12.056	2.977	0.000	0.694	6.273
57,000	0.000	0.000	0.000	4.247	0.000	1.511	2.370	0.000	10.775	4.353
60,000	0.000	0.000	0.000	6.077	0.000	0.089	1.907	0.000	0.175	7.800
63,000	0.000	0.000	0.000	2.560	0.000	0.044	1.407	0.000	0.175	2.747
66,000	0.000	0.000	0.000	0.727	0.000	0.011	0.860	0.000	0.000	6.403
69,000	0.000	0.000	0.000	0.347	0.000	0.022	0.690	0.000	0.000	3.793
72,000	0.000	0.000	0.000	0.487	0.000	0.022	0.360	0.000	0.000	2.597
75,000	0.000	0.000	0.000	0.050	0.000	0.011	0.260	0.000	0.000	1.513
78,000	0.000	0.000	0.000	0.090	0.000	0.000	0.337	0.000	0.000	0.807
81,000	0.000	0.000	0.000	0.007	0.000	0.000	0.113	0.000	0.000	1.097
84,000	0.000	0.000	0.000	0.120	0.000	0.000	0.077	0.000	0.000	0.230
87,000	0.000	0.000	0.000	0.007	0.000	0.000	0.057	0.000	0.000	0.257
90,000	0.000	0.000	0.000	0.013	0.000	0.000	0.013	0.000	0.000	0.140
93,000	0.000	0.000	0.000	0.000	0.000	0.000	0.040	0.000	0.000	0.440
96,000	0.000	0.000	0.000	0.000	0.000	0.000	0.020	0.000	0.000	0.000
99,000	0.000	0.000	0.000	0.003	0.000	0.000	0.007	0.000	0.000	3.793
102,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.050

Table 64. Summary of Level 2/3 Quad Axle ALD Recommended for Arizona Urban Freeways and Rural Minor Arterials/Collectors.

Axle Load, lb	Vehicle Class									
	4	5	6	7	8	9	10	11	12	13
12,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.015
15,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.815
18,000	0.000	0.000	0.000	0.200	0.000	0.000	0.219	0.000	0.000	7.326
21,000	0.000	0.000	0.000	0.200	0.000	6.660	0.971	0.000	0.000	4.178
24,000	0.000	0.000	0.000	0.200	0.000	20.000	0.300	0.000	0.000	4.859
27,000	0.000	0.000	0.000	0.200	0.000	0.000	1.181	0.000	2.100	7.944
30,000	0.000	0.000	0.000	0.900	0.000	0.000	0.900	0.000	0.150	7.719
33,000	0.000	0.000	0.000	1.800	0.000	0.000	1.290	0.000	0.975	5.319
36,000	0.000	0.000	0.000	6.400	0.000	0.000	4.143	0.000	0.850	5.889
39,000	0.000	0.000	0.000	14.800	0.000	0.000	5.643	0.000	9.200	9.563
42,000	0.000	0.000	0.000	10.100	0.000	20.000	4.186	0.000	8.450	6.207
45,000	0.000	0.000	0.000	10.700	0.000	0.000	4.833	0.000	21.325	6.700
48,000	0.000	0.000	0.000	7.500	0.000	0.000	6.957	0.000	7.575	6.852
51,000	0.000	0.000	0.000	8.500	0.000	0.000	8.538	0.000	12.950	3.856
54,000	0.000	0.000	0.000	8.900	0.000	0.000	10.014	0.000	5.850	2.256
57,000	0.000	0.000	0.000	8.200	0.000	0.000	5.162	0.000	10.600	2.533
60,000	0.000	0.000	0.000	6.900	0.000	10.000	5.519	0.000	14.250	1.496
63,000	0.000	0.000	0.000	4.800	0.000	0.000	7.162	0.000	4.025	1.278
66,000	0.000	0.000	0.000	2.400	0.000	0.000	4.652	0.000	0.775	1.756
69,000	0.000	0.000	0.000	2.800	0.000	0.000	8.062	0.000	0.125	5.426
72,000	0.000	0.000	0.000	0.800	0.000	6.660	1.567	0.000	0.525	0.381
75,000	0.000	0.000	0.000	1.700	0.000	0.000	0.943	0.000	0.050	0.763
78,000	0.000	0.000	0.000	0.500	0.000	0.000	5.576	0.000	0.025	0.859
81,000	0.000	0.000	0.000	0.700	0.000	30.000	1.257	0.000	0.025	1.219
84,000	0.000	0.000	0.000	0.000	0.000	0.000	9.800	0.000	0.025	0.493
87,000	0.000	0.000	0.000	0.100	0.000	0.000	0.343	0.000	0.050	1.815
90,000	0.000	0.000	0.000	0.200	0.000	6.660	0.057	0.000	0.025	0.078
93,000	0.000	0.000	0.000	0.200	0.000	0.000	0.067	0.000	0.000	1.107
96,000	0.000	0.000	0.000	0.200	0.000	0.000	0.133	0.000	0.000	0.496
99,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.330
102,000	0.000	0.000	0.000	0.000	0.000	0.000	0.529	0.000	0.000	0.470

Table 65. Summary of Level 2/3 Single Axle ALD Recommended for Arizona Rural Principal Arterials, Non-Interstate.

Axle Load, lb	Vehicle Class									
	4	5	6	7	8	9	10	11	12	13
3,000	0.003	0.883	0.000	0.268	7.963	0.403	0.215	0.458	0.173	0.348
4,000	0.000	6.158	0.000	3.246	12.843	0.993	0.053	0.993	0.468	0.765
5,000	0.005	33.240	0.420	0.251	9.020	1.703	0.118	2.935	1.208	1.635
6,000	0.078	25.343	3.210	1.284	11.650	2.588	0.370	2.500	3.103	3.095
7,000	0.235	8.685	5.378	3.576	8.488	1.403	0.540	5.060	9.008	12.428
8,000	1.083	5.198	2.755	5.981	6.773	1.435	0.825	4.350	7.508	14.968
9,000	1.465	4.983	2.673	2.530	6.020	2.550	1.690	5.795	7.558	5.345
10,000	2.310	4.010	4.870	5.332	5.710	5.595	5.570	8.723	7.918	5.715
11,000	4.288	3.025	11.203	4.830	5.978	9.620	16.163	11.168	11.265	14.053
12,000	7.043	2.248	16.895	8.141	5.313	21.498	27.958	8.678	15.065	14.655
13,000	12.550	1.538	16.353	14.792	4.295	24.273	25.995	5.653	11.558	8.393
14,000	21.823	1.143	14.953	16.403	3.025	7.993	10.668	5.115	6.730	4.933
15,000	25.410	0.890	9.360	3.327	2.118	2.548	3.368	5.235	6.960	2.445
16,000	14.423	0.660	4.123	2.741	1.685	2.190	2.438	6.020	4.200	3.035
17,000	5.383	0.513	2.115	12.332	1.370	3.025	1.868	6.408	3.088	1.503
18,000	1.698	0.453	2.020	3.022	1.228	4.368	0.598	6.413	1.653	1.535
19,000	0.710	0.340	1.573	1.519	1.065	3.920	0.308	5.008	1.188	1.785
20,000	0.495	0.225	0.935	2.976	0.925	2.398	0.008	5.458	0.665	0.873
21,000	0.338	0.170	0.430	1.751	0.658	0.960	0.000	2.548	0.528	0.638
22,000	0.195	0.105	0.333	3.341	0.403	0.328	0.000	0.830	0.045	0.218
23,000	0.155	0.063	0.153	0.043	0.208	0.078	1.278	0.288	0.020	0.188
24,000	0.145	0.028	0.023	0.132	0.128	0.005	0.000	0.183	0.000	0.153
25,000	0.083	0.013	0.020	0.000	0.018	0.005	0.000	0.028	0.000	0.068
26,000	0.033	0.005	0.050	0.314	0.013	0.003	0.000	0.010	0.005	0.038
27,000	0.020	0.000	0.033	0.014	0.003	0.000	0.000	0.030	0.005	0.088
28,000	0.005	0.000	0.000	0.000	0.003	0.000	0.000	0.010	0.000	0.033
29,000	0.003	0.000	0.025	0.000	0.003	0.000	0.000	0.003	0.000	0.000
30,000	0.000	0.000	0.020	0.000	0.003	0.000	0.000	0.010	0.000	0.000
31,000	0.000	0.000	0.008	0.000	0.000	0.000	0.000	0.003	0.000	0.000
32,000	0.003	0.000	0.000	0.000	0.003	0.000	0.000	0.003	0.000	0.000
33,000	0.008	0.000	0.008	0.000	0.000	0.000	0.000	0.003	0.000	0.005
34,000	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
35,000	0.000	0.000	0.003	0.924	0.000	0.000	0.000	0.003	0.000	0.000
36,000	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
37,000	0.000	0.000	0.015	0.000	0.000	0.000	0.000	0.000	0.000	0.000
38,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
39,000	0.000	0.000	0.000	0.700	0.000	0.000	0.000	0.000	0.000	0.000
40,000	0.000	0.000	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.020
41,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 66. Summary of Level 2/3 Tandem Axle ALD Recommended for Arizona Rural Principal Arterials, Non-Interstate.

Axle Load, lb	Vehicle Class									
	4	5	6	7	8	9	10	11	12	13
6,000	0.000	0.000	0.013	0.000	14.135	0.078	0.168	0.000	0.000	0.165
8,000	0.000	0.000	0.275	0.000	7.453	0.525	0.220	0.000	0.015	0.795
10,000	0.023	0.000	3.400	0.000	2.855	2.173	0.415	0.000	0.108	2.188
12,000	0.035	0.000	12.353	0.000	4.743	3.555	0.808	0.000	0.368	15.225
14,000	0.073	0.000	7.678	0.000	9.233	4.945	2.640	0.000	9.020	19.918
16,000	0.173	0.000	7.775	0.000	12.365	5.000	5.895	0.000	8.268	12.485
18,000	0.468	0.000	6.498	0.000	10.983	4.555	8.575	0.000	12.258	5.343
20,000	0.450	0.000	4.740	0.000	8.248	4.443	10.300	0.000	15.963	4.453
22,000	2.275	0.000	3.103	0.000	6.398	4.583	8.048	0.000	17.083	3.888
24,000	4.103	0.000	2.650	0.000	4.850	4.690	5.968	0.000	14.728	2.725
26,000	7.488	0.000	3.558	0.000	2.983	4.663	6.428	0.000	10.870	2.795
28,000	12.265	0.000	7.030	0.000	1.800	4.943	7.815	0.000	8.008	2.058
30,000	16.505	0.000	9.960	0.000	1.468	5.450	7.990	0.000	1.900	3.215
32,000	20.985	0.000	9.523	0.000	1.505	7.398	6.708	0.000	0.930	2.915
34,000	21.285	0.000	7.458	0.000	2.043	11.720	6.898	0.000	0.058	4.153
36,000	11.315	0.000	5.953	0.000	2.935	15.453	6.535	0.000	0.015	3.065
38,000	2.223	0.000	3.580	0.000	2.335	10.035	3.970	0.000	0.015	4.400
40,000	0.203	0.000	1.850	0.000	0.945	3.743	2.598	0.000	0.000	2.315
42,000	0.083	0.000	0.940	0.000	0.355	1.373	1.305	0.000	0.000	1.933
44,000	0.005	0.000	0.623	0.000	0.150	0.420	1.058	0.000	0.000	1.420
46,000	0.003	0.000	0.438	0.000	0.148	0.138	0.820	0.000	0.000	1.088
48,000	0.000	0.000	0.193	0.000	0.095	0.063	1.008	0.000	0.000	1.358
50,000	0.000	0.000	0.120	0.000	0.050	0.030	2.068	0.000	0.000	0.510
52,000	0.000	0.000	0.068	0.000	0.015	0.020	0.688	0.000	0.000	0.345
54,000	0.000	0.000	0.038	0.000	0.010	0.003	0.305	0.000	0.000	0.240
56,000	0.000	0.000	0.060	0.000	0.010	0.003	0.245	0.000	0.000	0.240
58,000	0.000	0.000	0.030	0.000	0.000	0.000	0.068	0.000	0.000	0.058
60,000	0.000	0.000	0.013	0.000	0.000	0.000	0.038	0.000	0.000	0.053
62,000	0.000	0.000	0.013	0.000	0.000	0.000	0.158	0.000	0.000	0.128
64,000	0.000	0.000	0.003	0.000	0.000	0.000	0.058	0.000	0.000	0.150
66,000	0.000	0.000	0.000	0.000	0.000	0.000	0.120	0.000	0.000	0.008
68,000	0.000	0.000	0.005	0.000	0.000	0.000	0.053	0.000	0.000	0.120
70,000	0.000	0.000	0.008	0.000	0.000	0.000	0.013	0.000	0.000	0.010
72,000	0.000	0.000	0.020	0.000	0.000	0.000	0.053	0.000	0.000	0.045
74,000	0.000	0.000	0.000	0.000	0.000	0.000	0.013	0.000	0.000	0.015
76,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.015
78,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
80,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
82,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 67. Summary of Level 2/3 Tridem Axle ALD Recommended for Arizona Rural Principal Arterials, Non-Interstate.

Axle Load, lb	Vehicle Class									
	4	5	6	7	8	9	10	11	12	13
12,000	0.000	0.000	0.000	0.000	0.000	0.000	0.255	0.000	0.000	0.000
15,000	0.000	0.000	0.000	1.150	0.000	12.500	1.263	0.000	0.000	1.538
18,000	0.000	0.000	0.000	1.469	0.000	37.500	5.300	0.000	0.000	7.590
21,000	0.000	0.000	0.000	9.369	0.000	25.000	10.040	0.000	100.00	3.959
24,000	0.000	0.000	0.000	2.053	0.000	0.000	9.265	0.000	0.000	5.608
27,000	0.000	0.000	0.000	0.900	0.000	0.000	5.265	0.000	0.000	4.515
30,000	0.000	0.000	0.000	4.103	0.000	0.000	4.885	0.000	0.000	3.510
33,000	0.000	0.000	0.000	3.050	0.000	0.000	5.705	0.000	0.000	2.749
36,000	0.000	0.000	0.000	2.456	0.000	0.000	5.735	0.000	0.000	1.744
39,000	0.000	0.000	0.000	3.416	0.000	0.000	8.415	0.000	0.000	5.064
42,000	0.000	0.000	0.000	3.919	0.000	0.000	11.255	0.000	0.000	3.208
45,000	0.000	0.000	0.000	7.731	0.000	0.000	10.195	0.000	0.000	9.064
48,000	0.000	0.000	0.000	17.606	0.000	25.000	6.675	0.000	0.000	1.354
51,000	0.000	0.000	0.000	29.588	0.000	0.000	5.960	0.000	0.000	4.972
54,000	0.000	0.000	0.000	3.447	0.000	0.000	3.125	0.000	0.000	8.874
57,000	0.000	0.000	0.000	2.147	0.000	0.000	2.398	0.000	0.000	4.369
60,000	0.000	0.000	0.000	0.963	0.000	0.000	1.388	0.000	0.000	3.610
63,000	0.000	0.000	0.000	4.616	0.000	0.000	2.158	0.000	0.000	3.728
66,000	0.000	0.000	0.000	0.000	0.000	0.000	0.153	0.000	0.000	8.741
69,000	0.000	0.000	0.000	0.863	0.000	0.000	0.118	0.000	0.000	4.113
72,000	0.000	0.000	0.000	0.000	0.000	0.000	0.020	0.000	0.000	8.659
75,000	0.000	0.000	0.000	0.000	0.000	0.000	0.030	0.000	0.000	1.236
78,000	0.000	0.000	0.000	0.000	0.000	0.000	0.265	0.000	0.000	0.000
81,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
84,000	0.000	0.000	0.000	0.000	0.000	0.000	0.078	0.000	0.000	0.000
87,000	0.000	0.000	0.000	0.000	0.000	0.000	0.043	0.000	0.000	0.269
90,000	0.000	0.000	0.000	0.000	0.000	0.000	0.033	0.000	0.000	0.000
93,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.256
96,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.454
99,000	0.000	0.000	0.000	1.150	0.000	0.000	0.000	0.000	0.000	0.000
102,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 68. Summary of Level 2/3 Quad Axle ALD Recommended for Arizona Rural Principal Arterials, Non-Interstate.

Axle Load, lb	Vehicle Class									
	4	5	6	7	8	9	10	11	12	13
12,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
18,000	0.000	0.000	0.000	0.000	0.000	100.00	0.000	0.000	0.000	1.777
21,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	7.517
24,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	15.687
27,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	9.017
30,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	100.00	4.937
33,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.967
36,000	0.000	0.000	0.000	0.000	0.000	0.000	83.333	0.000	0.000	0.930
39,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	9.200
42,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	5.830
45,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	13.100
48,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.867
51,000	0.000	0.000	0.000	7.700	0.000	0.000	0.000	0.000	0.000	5.993
54,000	0.000	0.000	0.000	11.550	0.000	0.000	0.000	0.000	0.000	2.927
57,000	0.000	0.000	0.000	36.650	0.000	0.000	0.000	0.000	0.000	6.670
60,000	0.000	0.000	0.000	32.400	0.000	0.000	0.000	0.000	0.000	0.830
63,000	0.000	0.000	0.000	11.750	0.000	0.000	0.000	0.000	0.000	0.647
66,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.450
69,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
72,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.450
75,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
78,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.327
81,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.197
84,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
87,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
90,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
93,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
96,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.457
99,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.130
102,000	0.000	0.000	0.000	0.000	0.000	0.000	16.667	0.000	0.000	8.104

Traffic Geometry Inputs

Geometry inputs include a variety of measurements related to truck and traffic lanes. Table 69 shows the specific traffic inputs required under this topic.

Table 69. Traffic Geometric Inputs Required.

MEPDG Traffic Input	Input Level	Who Collects and Processes Input	How Is Input Obtained?	How Often Is Input Provided?	User of Input
Axles Per Truck	1	MPD	WIM/AVC	As Requested for Project	PD
	2/3	National Defaults	National Defaults	National Defaults	PD
Axle Spacing	1	MPD	WIM/AVC	As Requested for Project	PD
	2/3	National Defaults	National Defaults	National Defaults	PD
Truck Wheelbase	1	MPD	WIM/AVC	As Requested for Project	PD
	2/3	SPR-672	AZ WIM	Use 11%, 17%, and 72% for Short (12-ft.), Medium (15-ft.), and Long (18-ft.)	PD
Lateral Wander and Offset	1	PD	WIM/AVC	As Requested for Project	PD
	2/3	SPR-672	Measured for AZ SPR-672	Use 15 in. and 12 in. for Mean Wheel Location and Standard Deviation	PD
Dual Tire Spacing	3	National Defaults	National Defaults, Use 12 in.	Once	PD
Average Axle Width	3	National Defaults	National Defaults, Use 8.5 ft.	Once	PD
Design Lane Width	1	PD	Design Plans and Standards	For Specific Project	PD

Axles per Truck

This input is defined as the mean number of axles per truck for each class of vehicle and axle type. This input is used to compute the total number of each type of axle to pass over the design traffic lane over the analysis period. For some trucks, such as Class 5, the number of axles is set by the classification criteria at 2.00 single axles. For others, this value varies somewhat depending on the definition of the classification. An analysis of Arizona data showed similar results to the national defaults. Recommended values for axles per truck are provided below, with quads provided from Arizona data:

- **Level 1:** This input can be computed from WIM data for a representative number of trucks in the design lane for a specific site. A minimum of 7 days, 24 hours per day is recommended.
- **Level 2/3:** Recommended values based on the national defaults and Arizona measurements for each axle type and vehicle class are shown in Table 70.

Table 70. Recommended Values of Axles per Truck for Arizona Design.

Vehicle Class	Axle Type			
	Single	Tandem	Tridem	Quad
Class 4	1.34	0.75	0.00	0.00
Class 5	2.14	0.00	0.00	0.00
Class 6	0.95	0.95	0.00	0.00
Class 7	0.33	0.02	0.26	0.07
Class 8	2.61	0.49	0.00	0.00
Class 9	1.20	1.84	0.00	0.00
Class 10	0.98	1.01	0.86	0.06
Class 11	4.78	0.00	0.00	0.00
Class 12	3.88	0.98	0.03	0.14
Class 13	1.29	1.90	0.19	0.14

Axle Spacing

The axle spacings for tandems, tridems, and quads vary somewhat around the country. The following national values are recommended for use in Arizona:

- Tandem axles: 51.6 inches.
- Tridem axles: 49.2 inches.
- Quad axles: 49.2 inches.

Truck Wheelbase

This input is defined as the distance from the steering axle to the nearest axle on the truck tractor for Classes 8 through 13. This distance varies between trucks depending on the presence of a cab and the size of the driver's compartment. This input has been characterized as short, medium, and long axle spacing. The user also has to specify the percentage of trucks that have short, medium, and long axle spacing. The MEPDG software uses this information to compute JPCP structural responses.

For MEPDG design at Level 1 and Level 2/3, data collection and processing consists of the following:

- **Level 1:** This input can be computed from WIM data for a representative number of trucks in the design lane for a specific site.
- **Level 2/3:** WIM data from LTPP were analyzed to derive percentages for trucks whose wheelbase axle spacing, when grouped, equals the MEPDG axle spacing of 12, 15, and 18 feet. The results of the evaluation were very consistent. The percentage of trucks, Classes 8 through 13, whose axle spacing fell within the limits are as follows:
    - Short 12 ft. (10.5 to 13.5 ft): 11 percent.
    - Medium 15 ft. (13.5 to 16.5 ft): 17 percent.
    - Long 18 ft. (16.5 to 20 ft): 72 percent.

Spacing between Dual Tires

This is the center-to-center of tires on a dual axle and is set at 12 inches, based on truck manufacturers' information. This value was used for the national calibration of the MEPDG. It should not be changed without a study that measures existing trucks on the highway system.

Axle Width Spacing

This is the distance from the outer wheel edge to the outer wheel edge for typical trucks. It is determined from truck manufacturers' information. A value of 8.5 feet was used in all of the national calibrations. This value should be used in Arizona.

Lateral Traffic Wander

Trucks experience lateral wander as they travel down a traffic lane. This wander reduces the number of load applications at a single point on the pavement cross section, and it affects rutting of HMA pavements and transverse cracking of JPCP. It is characterized by a normal distribution, a mean lateral offset on one side of the truck (that is closest to the paint stripe), and the standard deviation:

- **Mean Wheel Location.** This is the distance from the outer edge of the wheel to the pavement marking, measured in inches. This value varies down a pavement project and the mean should be used for design.
- **Traffic Wander Standard Deviation.** The standard deviation of the lateral traffic wander is used to estimate the number of axle load repetitions over a single point in a probabilistic manner for predicting distress and performance. For MEPDG design at Level 1 and Level 2/3, data collection and processing consists of the following:
  - **Level 1:** Measurement on the highway under design is performed from an overhead structure. Either manual or video records are made after spot-painting dots across the traffic lane at 6-inch intervals.
  - **Level 2/3:** The measured mean value from Arizona highways is a 15-inch mean wheel location and 12 inches for the standard deviation.

Average Axle Width (Outside to Outside), Edge of Truck Dimensions

The actual width of the truck axles is determined from truck manufacturers or measured on representative trucks. The value recommended for use in Arizona is 8.5 feet.

Design Lane Width (Not Slab Width for Concrete Pavement)

This is the actual width of the lane paint stripes as defined by the distance between the lane markings on either side of the design lane. For some concrete pavements, the lane is widened 1 or 2 feet, but the paint stripes are nearly always spaced at 12 feet (a few agencies may use 13 feet for lane width). Thus, if the slab width is 14 feet, the design lane width is 12 feet, or 144 inches.

For MEPDG design at Level 1 and Level 2/3, data collection and processing consists of the following:

- **Level 1:** This width is obtained from the plans documents for the project under design.
- **Level 2/3:** A value of 12 feet is recommended.

Other Traffic Inputs

Other traffic inputs include tire pressure and operational speed. Table 71 shows the specific traffic inputs required under this topic.

Table 71. Other Traffic Inputs Required.

MEPDG Traffic Input	Input Level	Who Collects and Processes Input	How Is Input Obtained?	How Often Is Input Provided?	User of Input
Tire Pressure	3	National Default	National Default, Use 120 psi	Once	PD
Operational Speed	1	PD	Use Speed Limit Unless Steep Grade or Other Cause to Slow Trucks Exists	Once	PD

Tire Pressure

This is the hot inflation pressure of the tire. It is assumed that the hot inflation pressure equals the contact pressure and is 10 percent or more above the cold inflation pressure. The tire pressure needs to be input for both single and dual tires. The national default of 120 should be used for this input.

Operational Speed

The truck operational speed is the mean truck speed over the highway pavement under design. While this speed could vary somewhat from the speed limit, it is usually recommended to use the speed limit. Variations in speed at highway speeds will not make any significant difference in the MEPDG designs. However, there are a few critical situations where truck speed is greatly reduced to less than 15 mph, such as long and steep grades going up a large mountain, and intersections.

For MEPDG design at Level 1 and Level 2/3, data collection and processing consists of the following:

- **Level 1:** Measure the mean speed of trucks traveling along the highway at the slowest speed location. Use this value in the design.
- **Level 2/3:** Use the speed limit as the default value, unless the pavement is located at an unusual speed reduction area such as a long mountain grade (15 mph recommended), or an intersection (5 mph recommended).

CHAPTER 8. ACTION PLAN

The action plan described in this chapter calls for the establishment of a new traffic segment database that includes all highways in Arizona. Alternatively, this objective could be accomplished by expanding the current Arizona traffic database. In either case, this database would include all traffic inputs required for the MEPDG and AASHTO 1993 design procedures. Traffic segments would be identified by beginning and ending MP (along with GPS coordinates) along each highway.

During the conduct of this project the MPD indicated that it was upgrading its own traffic database and that it may be possible to incorporate the MEPDG data requirements into the planned software implementation that is currently underway.

Table 72 summarizes the general action plan for developing a comprehensive traffic data input system for the MEPDG. For each data input level, the table specifies who collects and processes the input, how the input is obtained, how often the input is updated, and the user of the input.

Table 73 provides another set of recommendations for each action plan implementation step—who, what, and when:

- Responsibilities: who will do it?
- Resources: funding, time, people?
- Timeline: by when?

These recommendations require additional resources in terms of staffing, mainly for the analysis of WIM data and other traffic data to prepare them for use in the MEPDG.

Table 72. Action Plan for Development of an ADOT Comprehensive Traffic Data Input System for the MEPDG.

MEPDG Traffic Input	Input Level	Who Collects and Processes Input	How Is Input Obtained?	How Often Is Input Updated?	User of Input
Volume Inputs	1 On-site	MPD	AVC (perm./port.) for Specific Project	As Requested for Specific Project	PD, PM
	2/3	MPD	AVC (Database)	Annually	PD, PM
Weight Inputs	1 On-site	MPD	WIM (perm./port.) for Specific Project	As Requested for Specific Project	PD
	2/3	MPD	WIM: Urban, Rural, Desert (Database)	Annually	PD
Geometry Inputs	1 On-site	PD	If Used, Measured for Specific Project	As Requested for Specific Project	PD
	2/3	PD	AZ Default (Database)	Constant or Annually	PD
Other Inputs	1 On-site	MPD	If Used, Measured for Specific Project	As Requested for Specific Project	PD
	2/3	MPD	AZ Default (Database)	Constant or Annually	PD

Table 73. Action Plan Summary of What, Who, and When.

Implementation Steps (What will be done?)	Responsibilities (Who will do it?)	Resources (Funding/Time/People?)	Timeline (By when?)
Develop Traffic Unit Database (Contains all MEPDG traffic Inputs)	MPD and PD/PM (this may be performed under current upgrades of MPD software)	Funding: $100K Time: 12 months Staff: 1.5 FTE	December 2011
Volume Inputs: *AVC Equipment *Quality Assurance Procedures *Analysis Procedures	MPD	Funding: MPD Ongoing Time: MPD Ongoing Staff: One Additional FTE	December 2011
Weight Inputs: *WIM Equipment *Calibration *Quality Assurance Procedures *Analysis Procedures	MPD	Funding: $2,500K Annual: $90K Time: Two years Staff: Two additional FTE (One WIM, One Data Analyst)	December 2013
Geometry Inputs: *Equipment	PD	Funding: None Extra Time: None Staff: Included in 1.5 FTE Above	December 2011
Other Inputs:	PD	Funding: None Time: None Staff: Included in 1.5 FTE above	December 2011

A system for traffic data collection for the MEPDG in Arizona has been proposed and partly developed conceptually. Inputs for Level 2/3 have been derived based on available Arizona data. These inputs should be sufficient for most design situations.

- Level 1 traffic measurement procedures have been recommended for traffic inputs, when deemed necessary by ADOT pavement design staff. These inputs likely will not be used often. They probably will be used with high-profile and costly projects where traffic inputs are difficult to estimate without additional accurate information. ADOT's traffic data collection section will need to develop the ability to collect Level 1 on-site data in a timely manner for requested important projects from the pavement design section.
- Level 2/3 recommended inputs and defaults were prepared based on the best historical data available. These data will need annual updates from improved traffic volume and classification equipment, as well as from WIM sites over the next few years.

LOCATIONS OF WIM EQUIPMENT

Currently, there are two WIM sites that have been determined as capable of providing data accurate enough for input for the MEPDG: the LTPP SPS-1 site on U.S. 93 north of Kingman, and the LTPP SPS-2 on I-10 west of Phoenix.

There are four other WIM sites operated by the MPD that may be capable of providing good quality data, but recent calibration results are not available, and a full series of quality assurance checks have not been conducted, so the level of accuracy of the data has not yet been determined. Figure 82 has been prepared along with Tables 74 through 76 to show the recommended WIM sites to better cover the state of Arizona.

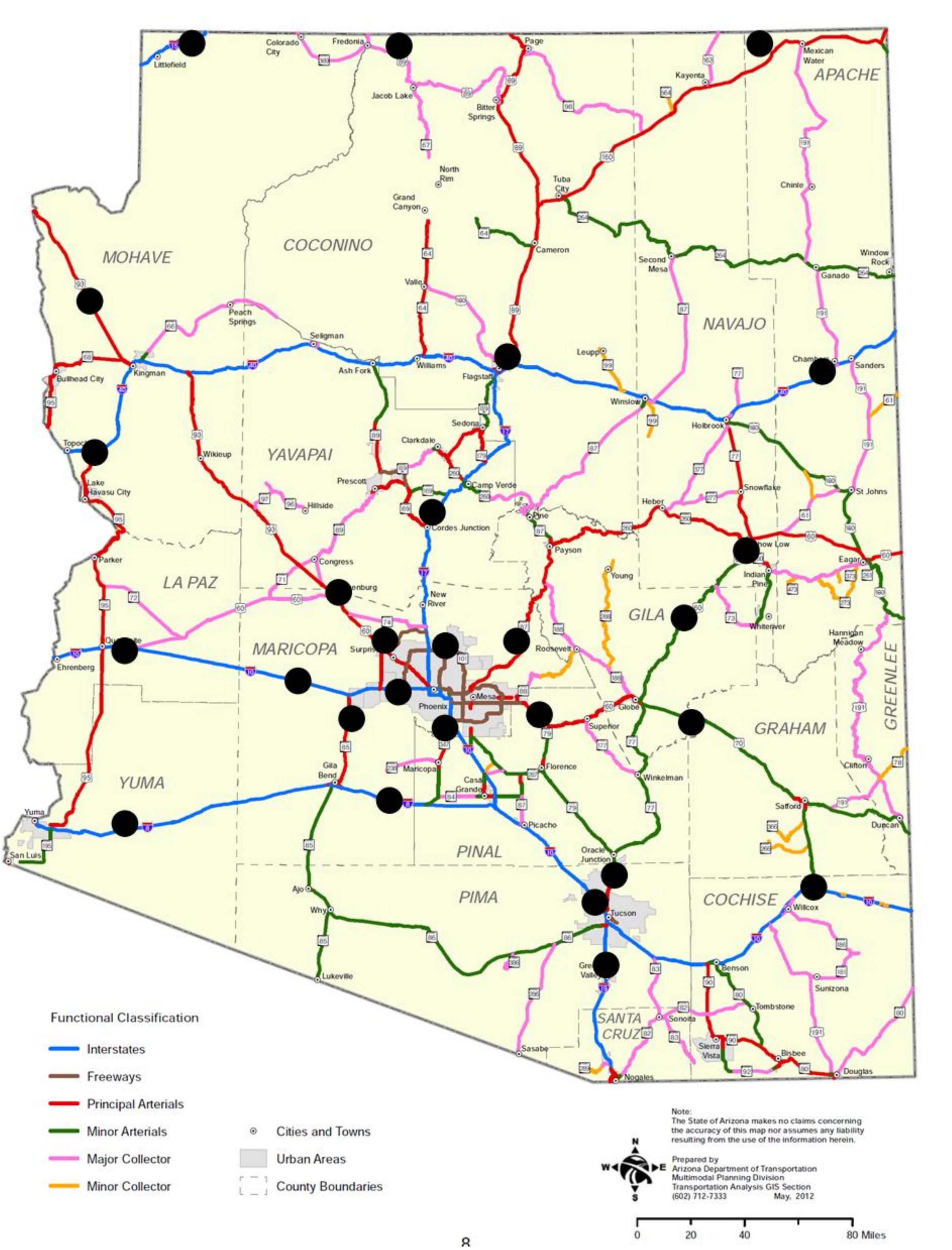

Figure 82. Map of Recommended WIM Sites.

Table 74. Recommended WIM Sites: New, Upgrades, and POEs.

Site	Route	Functional Class	TTCs	WIM Coverage Options	
1	AZ-347	RMA/C	6, 9, 12, 14	Upgrade 101622	New
2	AZ-79	RMA/C	6, 9, 12, 14	Upgrade 100854	New
3	US-60	RMA/C	6, 9, 12, 14	Current - Peek/Piezo	
4	I-10	RPA-I	1, 2, 3	Ehrenburg POE	
5	I-10	RPA-I	1, 2, 3	Current - LTPP SPSWIM - ISINC/BP	
6	I-10	RPA-I	1, 2, 3	San Simon POE	
7	I-17	RPA-I	1, 2, 3	New	
8	I-19	RPA-I	1, 2, 3	Nogales POE	
9	I-40	RPA-I	1, 2, 3	Sanders POE	New
10	I-40	RPA-I	1, 2, 3	Topock POE	
11	I-8	RPA-I	1, 2, 3	Yuma POE	Upgrade 100010
12	I-8	RPA-I	1, 2, 3	New	
13	US-15	RPA-I	1, 2, 3	St. George POE	Upgrade 100327
14	AZ-77	RPA-O	6, 9, 12	Upgrade 100800	New
15	AZ-77	RPA-O	6, 9, 12	New	
16	AZ-85	RPA-O	6, 9, 12	Upgrade 100922	
17	AZ-87	RPA-O	6, 9, 12	Current - Cardinal/Quartz	ECM w/Piezo sensors
18	US-160	RPA-O	6, 9, 12	New	
19	US-89	RPA-O	6, 9, 12	Fredonia POE	
20	US-89	RPA-O	6, 9, 12	Upgrade 102068	New
21	US-93	RPA-O	6, 9, 12	Kingman POE	LTPP SPSWIM - ISINC/BP
22	I-10	UPA-I	1, 2, 3	Current - TDC/Piezo	
23	I-10	UPA-I	1, 2, 3	Upgrade 100139	
24	SL-101	UPA-O	9, 12, 14	Upgrade 101253	New
25	SL-303	UPA-O	9, 12, 14	New	
26	US-70	UPA-O	9, 12, 14	New	Upgrade 102024 or 102044

Table 75. Functional Class for Recommended WIM sites.

Highway Functional Class	Number of Project Sites
RMA/C	3
RPA-I	10
RPA-O	8
UPA-I	2
UPA-O	3

Table 76. Options for Meeting the Recommended WIM Site Requirements.

Options	Number of Project Sites
New	6
Upgrade	7
POE	9
Current	4

TYPE OF WIM EQUIPMENT

ADOT is performing an internal study to determine standard equipment for collecting WIM data. There are several combinations of WIM controllers and in-road sensors being investigated:

- TDC Systems Limited controller with piezo WIM sensors.
- Cardinal Q-WIM controller with Kistler quartz sensors.
- Peek ADR controller with piezo WIM sensors.
- ECM Hestia controller and Kistler quartz sensors.

The MPD is also monitoring the performance of the LTPP SPSWIM site equipment, which includes International Road Dynamics iSINC controller and bending plate technology.

To date, strong consideration has been given to the TDC and piezo WIM sensor configuration. Since its installation, the equipment has been reliable and consistent in the weight values it has been reporting.

To assist in the evaluation of this equipment, ARA conducted a comparison of the TDC/piezo system with the nearby LTPP SPS-2 site for all Class 9 trucks. Since the LTPP site has been regularly calibrated under the pooled-fund study and data analyses are performed regularly, the data are considered to be of research quality and provided a valuable source for comparison. The gross vehicle weight (GVW) distribution for the TDC site is shown in Figure 83. The GVW distribution for the same data, collected by the LTPP equipment, is shown in Figure 84.

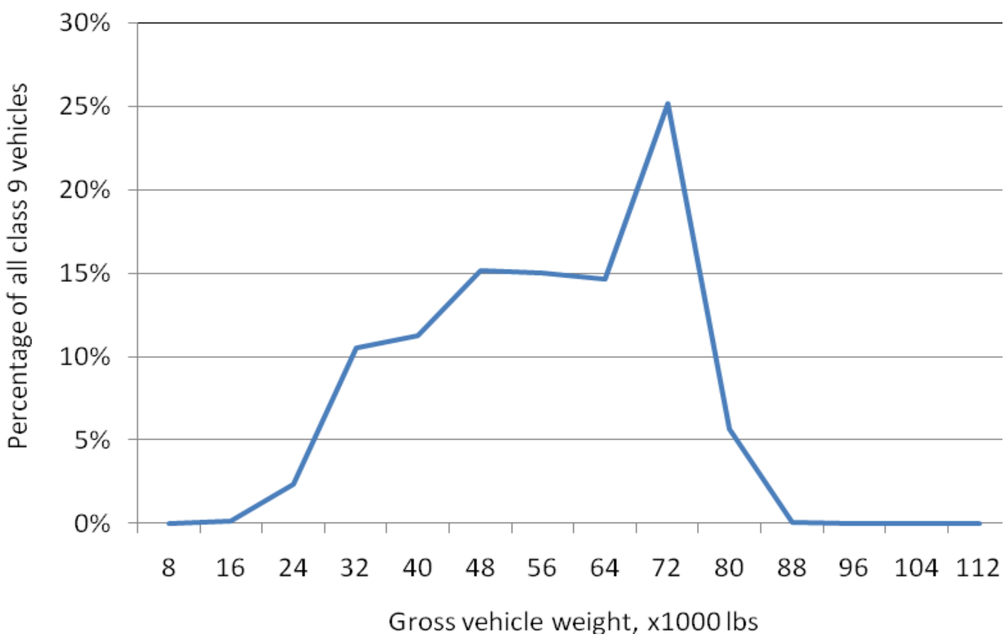

Figure 83. TDC/Piezo GVW Distribution.

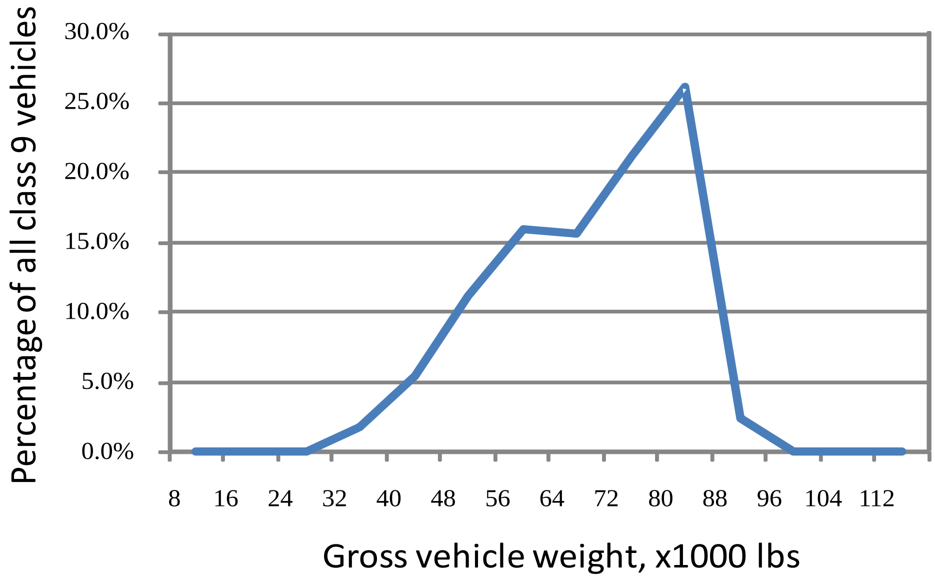

Figure 84. LTPP SPS-2 GVW Distribution.

As illustrated in Figures 83 and 84, the TDC equipment is reporting lower weight values for the same data. A further breakdown of the reported weights by each equipment type is shown in Table 77. Additionally, the axle measurement for the TDC was determined, on average, to be 6.9 percent greater than the iSINC system. Axle spacing measurements are shown in Table 78.

Table 77. TDC/LTPP Weight Measurement Comparison.

Equipment	GVW (kips)	Front Axle	Tandem 1	Tandem 2	Unloaded Peek	Loaded Peek
LTPP (iSINC/BP)	61.5	11.2	25.6	24.6	56.0	81.0
MPD (TDC/piezo)	52.2	10.0	21.2	21.2	48.0	73.0
Difference	-15.1%	-10.7%	-17.2%	-13.8%	-14.3%	-9.9%

Table 78. Axle Spacing Measurement Comparison.

Equipment	A-B	B-C	C-D	D-E
LTPP (iSINC/BP)	17.6	4.4	32.6	4.6
MPD (TDC/piezo)	18.3	4.7	34.5	5.1
Difference	4.0%	6.8%	5.8%	10.9%

Industry standards have determined an estimate for the B-C axle spacings of 4.3 feet. As shown in Table 78, the LTPP data are within 0.1 feet of this standard, while the TDC data are 0.4 feet off this standard. This error is easily calibrated, however, and should not be a determining factor in the evaluation for the Arizona standard.

Although it was expected that the TDC system would display weight measurements that were directly related to temperature, these indications were not visible. This could mean that the TDC is superior to other piezo WIM controllers in its ability to correlate the effects of temperature on a temperature-dependent sensor, or it could mean that the ambient temperatures that were experienced during the time the data were collected did not change significantly. Further analysis would be required to determine if this equipment can compensate for the high effects of temperature on the precision of piezo sensor measurements.

COST OF EQUIPMENT

When deciding to install a permanent WIM site, cost is a primary consideration. The decision to purchase one type of WIM technology over another is a balance between system performance accuracies and the cost of the system over its expected life cycle. The performance of the WIM system is more a function of the in-road sensors than any other factor.

To supplement the MPD’s WIM selection study, ARA performed a cost analysis of the different types of WIM technologies, including installation, maintenance, calibration, monitoring, and data analyses. The information provided in Table 79 is based on one lane of sensors and does not include costs that are associated with installation or maintenance.

Table 79. Performance and Cost of WIM Equipment.

Technology	Performance	In-Road Equipment
Piezo	+/- 10%	$3,500
Quartz	+/- 5%	$14,500
Bending Plate	+/- 3-5%	$21,000
Load Cell	+/- 3%	$60,000

Typically, the cost of the controller is related to its capabilities, so the selection of the WIM controller should be based on the ability of the equipment to consistently deliver the collected data to the user. Evaluations of WIM controllers and their capabilities and reliabilities are outside the scope of this project. The range of costs for WIM controllers is approximately $12,000 to $22,000, and there is a minimal cost difference for the controller based on the in-road sensor that is used.

For installation, the differences in costs for one type of sensor versus another are also negligible. However, for traffic control, the number of lane closure days required are 0.5 days per lane for piezos and quartz, one day per lane for bending plate, and two to three days for each lane of load cell sensors.

Regular maintenance costs (semi-annual and annual visits) among the different systems are comparable. All require approximately the same degree of effort to assess, electronically test, and calibrate. Unscheduled maintenance (repair) depends on the reliability of the system, including the sensor and road condition. Based on past performance, piezo sensors have a much shorter lifespan than load cells, but load cells are much more expensive to replace. Overall, it has been shown that the bending plate sensor has the highest reliability and is second to the piezo in expected life cycle repair costs. Kistler sensors are comparable with bending plates for initial cost, but they are not as reliable. With regular maintenance, and without significant pavement deterioration, the bending plate is a much better value.

Based on the experience of ARA WIM experts, the Kistler quartz sensor is recommended for flexible roadway applications because the bending plate will often last longer than the pavement in which it is installed. For rigid pavements, the bending plate provides the best value when reliability, life cycle cost, and performance are prime considerations.

RECOMMENDED BUSINESS PROCESS OVERVIEW

Figure 85 illustrates the recommended business process overview for operating the MEPDG and pavement management system needs for traffic data. Additional details of this process are provided in Appendix G.

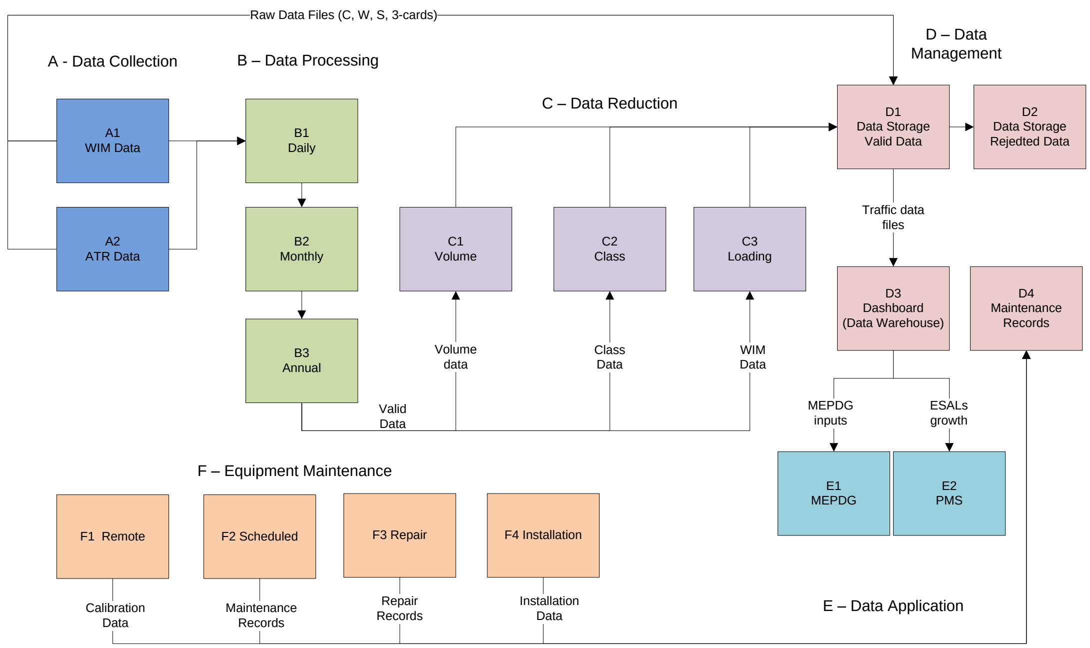

Figure 85. Recommended Business Process Overview.

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APPENDIX A. REVIEW OF HISTORICAL ADOT TRAFFIC DATA COLLECTION PRACTICES

The purpose of this study of ADOT traffic data collection practices is to understand how traffic data were collected and managed and determine how coordination and sharing of traffic data can be enhanced to maximize the usefulness of the data collection effort as related to MEPDG data needs. The review of traffic data collection practices was performed through (1) a series of interviews with individuals in various divisions of ADOT, and (2) assembling and reviewing pertinent documents.

Soon after the commencement of this study, a project meeting was held with ADOT/local agency/department staff and ARA engineers. The meeting goals included seeking information on current statewide traffic data collection practices and identifying traffic data currently available to ADOT. An important outcome of this meeting was to identify key personnel to be interviewed and sources of literature containing information pertinent to this study. A list of personnel interviewed or identified for interview is presented in Table A-1, while pertinent literature identified and reviewed to date is presented in Table A-2. A summary of findings is presented in the following sections.

AGENCIES WITH TRAFFIC DATA COLLECTION RESPONSIBILITY IN ARIZONA

Skszek, 2003

Several entities are responsible for gathering traffic data statewide, as presented below (Table A-3 presents a listing of traffic data types collected by each entity):

- ADOT Motor Vehicle Division (MVD).
- ADOT Multimodal Planning Division (MPD).
- ADOT Intermodal Transportation Division (ITD).
- ADOT Freeway Management System (FMA).
- Arizona Transportation Research Center (ATRC).
- Local metropolitan planning organizations (MPOs).

Data are collected for multiple purposes, including:

- Research.
- Pavement design and management.
- Air quality monitoring.
- Vehicle size and weight enforcement.
- Meeting information requests from public and private stakeholders and state governments (e.g., meeting FHWA reporting requirements).

Table A-1. Literature Assembled for Review.

Title	Authors	Literature Review Situation		
		Identified	Obtained	Reviewed
Preliminary Engineering and Design Manual, 3rd Edition, 1989	ADOT	X	X	X
Five-page example print-out of pavement management system-generated traffic data used for AC overlay design using SODA		X	X	X
Two-page ADOT Organization Chart	ADOT	X	X	X
Three-page abstract of the report Coordination of Commercial Vehicle Data Collected by Automatic Traffic Counter (ATC) and Weigh-In-Motion (WIM) , Final Report, 2003	Skszek, S.L.	X	X	X
Implementation of the Simplified Arizona Highway Cost Allocation Study Model, Final Report, 2001	Carey, J.	X	X	X
Update of the Arizona Highway Cost Allocation Study, Final Report, 1999	Carey, J.	X	X	X
ADOT Traffic Manual	ADOT	X	X	X
Coordination of Commercial Vehicle Data Collected by Automatic Traffic Counter (ATC) and Weigh-In-Motion (WIM), Report No. FHWA-AZ-03-526 , 2003	Skszek, S.L.	X	X	X
Development of new pavement design ESAL, Report No. FHWA-AZ99-455, 1999	Alavi, S.H., and K.A. Senn	X	X	X
Enhancing Arizona Department of Transportation's Traffic Data Resource, Report No. FHWA-AZ01-492, 2001	Sterling, J., S. Hossak, and T. Bills	X	X	X
Cluster Analysis of Arizona Automatic Traffic Recorder Data, Transportation Research Record No. 1410, 1993	Flaherty, J.	X	X	X
Estimating the Cost of Overweight Vehicle Travel on Arizona Highways, Report No. FHWA-AZ-06-528, 2006	Straus, S.H., and J. Semmens	X	X	X
Development of Design Guide Traffic Files for ADOT (Project 11), Arizona State University, July, 2003	Witczak, M.W., and Y. Ho	X	X	X
Normalized Axle Load Spectra and Pavement Design—Are the MEPDG Default Normalized Axle Load Spectra Inadequate? Position Paper, 15 December 2009, Applied Research Associates, Inc.	Von Quintus, H.L.	X	X	X

Table A-2. Traffic Data Types Collected by Various Agencies in Arizona (Skszek, 2003).

Data Collection Group	Commercial Vehicle Data Type		
	Count	Class	Weight
ADOT Transportation Planning Division – Data Section	Permanent ATC	Manual, ATC (length only)	Equipment not functional
ATRC – LTPP Program	ATC, WIM	ATC, WIM	WIM
ADOT Freeway Management System	ATC	WIM	None
ADOT MVD	WIM		WIM, portable and static scales
Traffic Research & Analysis, Inc. – Consultant	Permanent ADOT sites and portable equipment	Permanent ADOT sites and portable equipment	None

Table A-3. ADOT Engineers and Other Personnel Interviewed.

ADOT/Local Agency or Department Staff	Agency/Department
Dimitroplos, Christ	Administrator of Arizona Transportation Research Center research and development projects
Bari, Javed	Team Leader, ADOT Pavement Design Section
Burch, Paul	Head, ADOT Pavement Design Section
Delton, Jim	Head, ADOT Materials Section. Note that pavement design and pavement management system groups are part of the Materials Group.
Hodges, Mark	Director, Data Management and Analysis Group, Multimodal Planning Division.
Eberline, Douglas	Technical Representative of Data Management and Analysis Section. Schedule includes downloading WIM data and WIM scale installations.
Fregin, Ron	Technical Representative, ADOT Pavement Management System Section.

STATEWIDE TRAFFIC MONITORING AND DATA COLLECTION INFRASTRUCTURE

Traffic monitoring and data collection are performed using a variety of methods depending on the entity performing the monitoring and the purpose for which data are being collected. Methods applied statewide in Arizona include:

- Coverage counts (typically 48 hours in duration).
- ATRs (length classification).
- Permanent vehicle classification sites (axle classification).
- WIM (portable and permanent).

The following sections detail the information gathered regarding the statewide traffic monitoring and data collection infrastructure.

Interview with Mark Hodges

- Metropolitan Planning Organizations and other local agencies carry out approximately 4,500 short duration, mostly manual vehicle counts, annually. These counts are performed mostly on city streets and may, in some limited instances, include vehicle classification. ADOT verifies permanent classification sites monthly with a 60-minute manual vehicle classification study, along with quality control checks in processing software. Currently, field technicians verify coverage counts by watching the traffic in the lanes and verifying the counts on the machines.
- The MPD operates the following:
    - One hundred seventeen-ATRs operating 24 hours a day, 7 days a week.
    - One thousand two hundred short-duration counters. The duration ranges from 48 hours to 7 days.
    - The MPD plans to have approximately 50 ATRs by 2011. Traffic counts and other outputs from the AVCs are monitored monthly and verified by quality assurance checks. Vehicle classification is performed using a vehicle classification algorithm supplied by an AVC equipment manufacturer.
    - Two WIM sites on I-10 and SR 87. The MPD plans to operate five WIM sites by the end of 2011.
- The MVD operates four WIM sites at POEs. The actual data collection and equipment used need to be further verified.
- The ATRC/MPD operates the following:
    - Several WIM and AVC sites co-located with LTPP projects. It is believed that after so many years of service, the LTPP WIM and AVC equipment are in poor shape. In recent years, some data obtained from a few remaining LTPP sites do not pass LTPP quality assurance checks. ADOT is considering reinstalling new, improved WIM scales on approximately eight LTPP sites. The installation will be on all lanes in all directions. The preferred WIM technology is the Kessler loops (they are inductive loops of recent development).

Sterling et al., 2001

- ADOT divides the state highway system into 1,400 segments for traffic monitoring purposes. Each segment is identified by route and milepost and contains an identified location for a traffic counting station.
- At approximately 140 sites, ADOT collects data to classify vehicles by type. Vehicle weight, determined by WIM equipment, is collected at seven sites, when the WIM equipment is operational.
- The majority of traffic volume counts performed by ADOT consist of either 24-hour or 48-hour counts using pneumatic road tubes or inductive loops.
- On a statewide level, ADOT traffic counts begin in January in the southern part of the state and move north throughout the year. Low-volume sections are counted every three years.
- The ADOT Traffic Studies Section uses several different mechanisms to collect the traffic data as follows:
    - ATR: in 2001, there were approximately 24 active ATRs in the state that continuously monitor traffic 24 hours a day, each day of the year (see Table A-4 for a listing of ATR locations). ATR data are summarized to estimate daily, monthly, and annual traffic counts.
    - LTPP requires ADOT to collect WIM and AVC data. Currently, ADOT has nine AVC sites and 16 WIM sites as part of the LTPP program (some of these have dropped out). Table A-5 lists these sites. The data collected on these sites include yearly truck traffic volumes reported by truck class and trucks as a percentage of the total traffic.
- The MPD used private contractors to collect traffic data for use in Small Area Transportation Studies.
- ADOT receives traffic data annually from:
    - Yuma Metropolitan Planning Organization, (Yuma and Yuma County).
    - Maricopa Association of Governments (Maricopa County and cities including Phoenix, Mesa, and Glendale).
    - Pima Association of Governments (Pima County and cities including Tucson).
- ADOT receives traffic data infrequently from the following agencies:
    - Bureau of Indian Affairs.
    - Bureau of Land Management.
    - National Forest Service, National Park Service.
    - Tribal Governments.
- Note that only traffic count data are supplied to ADOT from outside agencies. Currently there is no procedure in place for storing the collected data other than in report form, and no linkage exists between the outside agencies and the MPD collection efforts.
- Since 1994, the MPD has undertaken a program of annual traffic counts on the entire National Highway System in Arizona and one-third of the state highways.
- In 1999, ADOT initiated the Special Counts for Air Quality and Rural HPMS project to obtain 48-hour traffic counts at approximately 1,200 locations throughout the state, with the assistance of contractors. The extent of traffic counts under this scheme is presented in Table A-6.

Table A-4. Automatic Traffic Recorder Locations.

#	Route	Location	#	Route	Location
1	I-8	Yuma Spd/Len	38	SR 83	Sonoita Spd/Len
2	I-8	Wellton Spd/Len	39	SR 85	Why
3	I-8	Gila Bend Spd/Len	40	SR 86	Robles Jct. Spd/Len
4	I-10	Ehrenburg Spd/Lcn	41	SR 87	Payson Spd/Len
5	I-10	Tonopah Spd/Len	42	SR 87	Winslow Spd/Len
6	I-10	Tempe Alameda BE	43	SR 89	Prescott Spd/Len
7	I-10	Tempe Alameda WE	44	SR 89	Ash Fork Spd/Len
8	I-10	Bapchule Spd/Len	45	SR 90	Benson WIM 002
9	I-10	Marana WIM Cox	46	SR 95	Quartzite WIM 003
10	I-10	Marana	47	SR 95	Parker Spd/Len
11	I-10	Tucson Grant BE Sp	48	SR 99	Leupp Spd/Len
12	I-10	Tucson Grant WE Sp	49	SR 260	Overgaard Spd/Len
13	I-10	Benson WIM 001	50	SR 260	Eager Spd/Len
14	I-10	Cochise Spd/Len	51	SR 264	Moenkopi
15	I-17	Pioneer WIM	52	SR 264	Ganado Spd/Len
16	I-17	New River	53	SR 277	Snowflake Spd/Len
17	I-17	SR-169/Cherry Rd.	54	SR 286	Robles Jct. Spd/Len
18	I-19	Amado Spd/Len	55	SR 377	Holbrook Spd/Len
19	I-19	Tucson Ajo Way Spd	56	US 60	Aquila Spd/Len
20	I-40	Topock Spd/Len	57	ÚS 60	Glendale EB Spd/Len
21	I-40	Seligman Spd/Len	58	US 60	Glendale WB Spd/Len
22	I-40	Winona Spd/Len/CLs	59	US 60	Tempe Hardy EB
23	I-40	Winslow Spd/Len	60	US 60	Tempe Hardy WB
24	SA 89	Sedona Spd/len	61	US 60	Globe Spd/Len
25	SB 8	Yuma	62	US 60	Show Low Spd/Len
26	SR 51	Phoenix Crittendon	63	US 70	Cutter WIM 005
27	SR 64	Valle Spd/Len	64	US 70	Safford Spd/Len
28	SR 68	Bullhead City/Spd	65	US 89	Flagstaff
29	SR 69	Cordes Jct	66	US 93	Kingman Spd/Len
30	SR 69	Mayer Spd/Len	67	US 93	Wikieup
31	SR 72	Utting Spd/Len	68	US 93	Wickenburg Spd/Len
32	SR 77	Snowflake Spd/Len	69	US 95	Yuma WIM 004
33	SR 79	Oracle Spd/Len	70	US 160	Tuba City Spd/Len
34	SR 80	St David Spd/Len	71	US 180	Flagstaff Spd/Len
35	SR 80	Douglas Spd/Len	72	US 180	St Johns Spd/Len
36	SR 82	Nogales Spd/Len	73	US 180	Springerville Spd/Len
37	SR 82	Sonoita Spd/Len	74	US 191	St Johns Spd/Len

Table A-5. ADOT/ATRC LTPP AVC/WIM Sites (Many Have Terminated Collection).

Arizona/ATRC Site # and Pavement Type	Site Location Route & MP (KIM)	SHRP ID	WIM/AVC		
			Status	Make	Sensor
025 RIGID	US-93 NB 052	0100	PERM WIM	PAT	BENDING PLATE
026 RIGID	1-10 EB 108	0200	PERM WIM	IRD	BENDING PLATE
009 FLEX	1-8 EB 159	0500	PERM WIM	PAT	PIEZO
202 RIGID	1-40 EB 202	0600	PERM WIM	PAT	BENDING PLATE
204 RIGID	1-40 WB 202	0600	PERM WIM	PAT	BENDING PLATE
020 FLEX	1-40 WB 145	1002	PERM WIM	PAT	PIEZO
012 FLEX	I-I0 WB 110	1006	PERMWIM	PAT	PIEZO
011LFLEX	I-I0 WB 115	1007	PERMWIM	PAT	PIEZO
005 FLEX	1-19 SB (029)	1015	PERM WIM	IRD	PIEZO
018 FLEX	I-40 EB 106	1024	PERM WIM	PAT	PIEZO
010 FLEX	SR-85 SB 141	6055	PERM WIM	PAT	PIEZO
006 FLEX	1-19 NB (023)	6060	PERM WIM	PAT	PIEZO
021 RIGID	SR-I0 INB 011	7079	PERMWIM	PAT	PIEZO
024 RIGID	US-60 WB 179	7613	PERM WIM	PAT	PIEZO
019 FLEX	I-40 WB 113	1025	PERM AVC PORT WIM	PAT	PIEZO
015 FLEX	SR-68 EB 001	1037	PERM AVC PORT WIM	PAT	PIEZO
023 FLEX	I-I0 WB 123	1001	PERM AVC NO WIM	PAT	PIEZO
007 FLEX	1-19 NB (054)	1017	PERM AVC NO WIM	PAT	PIEZO
013 FLEX	R-95 SB 145	1034	PERM AVC NO WIM	PAT	PIEZO
008 FLEX	1-19 SB (084)	6054	PERM AVC NO WIM	PAT	PIEZO
022 RIGID	1-10 WB 130	7614	PERM AVC NO WIM	PAT	PIEZO

Table A-6. Traffic Counts by County.

County	Number of Counts
Apache	44
Cochise	170
Coconino	150
Gila	64
Graham	68
Greenlee	10
LaPaz	40
Maricopa	-
Mohave	160
Navajo	95
Pima	-
Pinal	110
Santa Cruz	30
Yavapai	70
Yuma	25 (rural only)
Unassigned	164
Total	1,200

- In 1999, ADOT initiated the Urban Traffic Counting Project to expand its traffic data collection efforts in the Phoenix and Tucson metropolitan areas through the collection of 24-hour counts on urban highways, ramps, and frontage roads. Traffic counts were taken on established locations in 15-minute increments. A database was established listing count locations, identifiers, beginning and ending times of counts, and comments. Field data were collected using tube and loop machines, excluding those of the ADOT Freeway Management System. Ramp and crossover counts were taken at approximately 548 sites in the Phoenix metropolitan area and at approximately 23 sites in the Tucson urban area. In addition, approximately 88 mainline counts were taken on state highways in the Phoenix urban area. The counts were taken for continuous periods of 24 hours or more, between midnight Tuesday and midnight Thursday.
- In 2000, ADOT initiated a Long-Term Vehicle Classification Project to improve vehicle classification data at approximately 65 statewide locations through 168-hour (1-week) classification counts on the major sites (see Table A-7). The intent of the study was to determine the magnitude of variation between 6-hour manual classifications and those of week-long durations, especially to identify the implications for axle factors and percent truck estimates. Preliminary results revealed essentially no differences between the 6- and 168-hour counts.
- The Traffic Engineering Group has very specialized data needs on a project-by-project basis such as turning movement counts, peak period volumes, or percentage of trucks required for intersection design or signal phasing. As a result, this group collects additional specific data such as turning movement counts, peak hour factors, stopped delay, or vehicle classification. Currently, these special counts are published in the traffic studies themselves, and there is no systematic mechanism to electronically store the information for later use.
- ADOT's Freeway Management System collects real time data at 237 locations throughout the greater Phoenix metropolitan freeway system. The Transportation Technology Group manages the Freeway Management System. Collected data include speed, volume, and occupancy. The recording devices are either inductive loops or acoustic sensors. According to the Transportation Technology Group's staff, up to 90 percent of the traffic recording devices do not properly report data on a continuous basis. This situation precludes the acquisition and utilization of this data for any useful planning, design, operation, or maintenance purposes.
- In the early 2000s, the MPD maintained approximately 27 WIM stations (now there are many fewer). The data from these WIM stations are formatted to LTPP standards and are tabulated for hourly vehicle weights, counts, and classifications. The main goal of the LTPP is the monitoring and evaluating of traffic data, particularly along test sections for the evaluation of pavement conditions.

Table A-7. ADOT Long-Term Vehicle Classification, 2000.

Group	ADOT C#	Highway Description	LEG	No. of Lanes	No of machines	Nearby Town
I	15	I-8 & SB8	E	4	4	GILA BEND
I	16	I-8 & SB8	W	4	4	GILA BEND
I	17	I-8& SB8	N	4	4	GILA BEND
I	127	SR85 & MC85	N	2	2	BUCKEYE
I	128	SR85 & MC85	S	2	2	BUCKEYE
I	129	SR85 & MC85	B	2	2	BUCKEYE
II	12	US7O&SR77	W	2	2	GLOBE
II	13	US70 & SR77	E	2	2	GLOBE
II	14	US7O & SR77	S	2	2	GLOBE
III	84	SR260 & SS260	W	2	2	EAGAR
III	85	SR260 & SR260	N	2	2	EAGAR
III	86	US180 & 5R260	E	2	2	EAGAR
III	87	SR260 & 5R277	SW	4	4	HEBER
III	88	SR260 & SR277	E	2	2	HEBER
III	89	SR260 & SR277	NE	4	4	HEBER
III	92	I-40 & SR77	NE	4	4	HOLBROOK
III	93	I-40 & 5R77	SW	4	4	HOLBROOK
III	94	I-40 & SR77	N	2	2	HOLBROOK
III	107	I-40 & USI80	B	4	4	HOLBROOK
III	108	SB40 & US180	W	4	4	HOLBROOK
III	109	S840 & US180	N	2	2	HOLBROOK
III	90	SR87 & SR99	N	2	2	WINSLOW
III	91	SR87 & 5R99	SE	2	2	WINSLOW
IV	19	I-10 & SR95	W	4	4	OUARTSITE
IV	20	I-10 & SR96	E	4	4	QUARTSITE
IV	21	I-10 & SR95	N	2	2	OUARTSITE
IV	22	I-10 & SR95	S	2	2	OUARTSITE
V	23	US89 & US93	NW	2	2	WICKENBURG
V	24	US89 & US93	SE	2	2	WICKENBURG
V	25	US9 & US93	N	2	2	WICKENBURO
VI	26	I-10 & US95	W	4	4	HAVASU
VI	27	1-40 & US95	E	4	4	HAVASU
VI	28	1-40 & US95	S	2	2	HAVASU
VI	29	SB40 & 1-40	SW	4	2	KING MAN
VI	30	US66 & 1-40	NE	4	2	KINGMAN
VI	31	US66 & 1-40	B	4	2	KINGMAN
VI	52	US93 & 5R68	SE			KINGMAN
VI	53	US93 & SR88	NW	4	4	KINGMAN
VI	54	US93 & SR68	W	2	2	KINGMAN
VII	38	SR89 & SR69	N	4	4	PRESCOTT
VII	39	SR89 & SR69	SW	4	4	PRESCOTT
VII	40	SR89 & SR69	E	4	4	PRESCOTT
VIII	42	I-8&5B8	NW	4	4	YUMA
VIII	43	l-8&5B8	W	4	4	YUMA
VIII	58	US95&C014	S	2	2	YUMA
IX	44	SR82 & B19	NE	2	2	NOGALES

Table A-7. ADOT Long-Term Vehicle Classification, 2000, continued.

Group	ADOT C#	Highway Description	LEG	No. of Lanes	No of machines	Nearby Town
X	62	I-8 & I-10	W	4	4	CASA GRANDE
X	63	I-8 & I-10	N	4	4	CASA GRANDE
X	64	I-8 & -10	SE	4	4	CASA GRANDE
X	65	SR84 & SR387	W	2	2	CASA GRANDE
X	66	SR84 & SR387	E	2	2	CASA GRANDE
X	67	SR84 & SR387	N	2	2	CASA GRANDE
XI	95	SR264 & SR87	E	2	2	SECOND MESA
XI	96	SR264 & SR87	W	2	2	SECOND MESA
XI	97	SR264 & SR87	S	2	2	SECOND MESA
XI	98	US16O & US163	NE	2	2	KAYENTA
XI	99	US160 & US163	SW	2	2	KAYENTA
XI	100	US160&US163	N	2	2	KAYENTA
XI	101	US160 & SR264	W	2	2	TUBA CITY
XI	102	US160 & SR264	NE	2	2	TUBA CITY
XI	103	US160 & SR264	SE	2	2	TUBA CITY
XI	104	US89 & SR64	S	2	2	CAMERON
XI	105	US89 & SR64	N	2	2	CAMERON
XI	106	US89 & SR64	W	2	2	CAMERON
XI	122	SR264 & US191	E	2	2	GANADA
XI	123	SR264 & US191	W	2	2	GANADA
XI	124	SR264&US191	N	2	2	GANADA
XII	113	SR64 & US160	S	2	2	GRAND CANYON
XII	114	SR64 & US180	N	2	2	GRAND CANYON
XII	115	SR64&US180	SE	2	2	GRAND CANYON
XII	116	SR67 & US89A	SE	2	2	JACOBS LAKE
XII	117	SR67 & US89A	NW	2	2	JACOBS LAKE
XII	118	SR67 & US89A	S	2	2	JACOBS LAKE

Strauss and Semmens, 2006

- ADOT POE sites collect traffic data as follows:
    - Large POE facilities tend to be located on Interstates and mostly operate seven days a week, 24 hours a day.
    - Smaller/secondary POEs operate eight to 16 hours a day, five to seven days a week. Hours of operation are determined according to traffic and/or staffing availability.
    - International POE hours of operation are determined by U.S. Customs.
    - For a location of Arizona POEs, see Figure A-1.

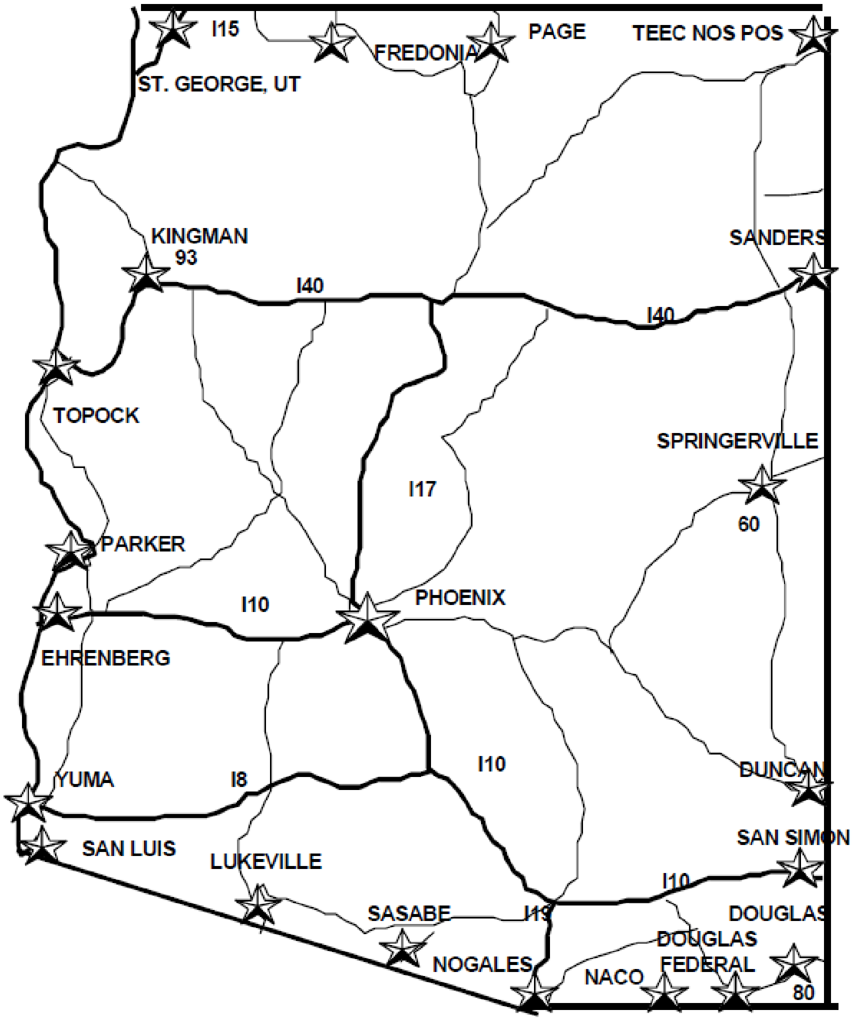


Figure A-1. Arizona Port of Entry Facility Locations.

These POE facility locations are measurement tools for assessing MVD POE performance (Jason Carey, Arizona Department of Transportation, September 2003). Several of these sites are no longer operable.

Skszek, 2003

- As of 2003, the MPD Traffic Studies Section maintained 65 ATRs and 6 WIM sites.
  - Of the 65 ATR sites, only 26 were functional.
  - The traffic data collected from these sites included count, speed, and length. The length data were not classifiable into the FHWA 13-vehicle format due to the sensor type and configuration issues.

    - Five of the 26 sites that provided counts had one or more of the loops damaged and needing to be replaced.
    - None of the six WIM sites were functional.
- The ATRC maintains 18 traffic data collection sites for LTPP (see Figure A-2). Ten of the 18 sites are WIM sites and the remaining eight are AVCs.
    - Fifteen of the 18 sites have piezo-electric sensors embedded in the pavement surface (asphalt or concrete).
    - Three sites had bending plate sensors embedded in concrete.
    - Mostly, for all the sites, traffic data were retrieved monthly. For two of the high truck volume lanes/sites, traffic data were retrieved twice monthly, or if remote access to the site was possible and functional, then the traffic data were retrieved weekly.
- ADOT's Freeway Management System routinely collects count, speed, and some limited classification data from the inductive loop sensors placed roughly 0.33 miles apart along the freeway corridor.
    - Using this system, trucks could only be classified using two categories, namely:
        - Trucks with lengths between 35 and 55 ft.
        - Trucks greater than 55 ft long.
        - The loops do not categorize trucks accurately for various reasons and should not be used for MEPDG inputs.
- The MVD has responsibility for commercial vehicle size and weight enforcement throughout the state.
    - There are 13 POE facilities that collect commercial vehicle data in support of the MVD.
    - Six of the 13 POE sites are equipped with WIM and gather count, speed, gross and axle weight, and classification data on a continuous basis.
    - The remaining seven POEs gather truck data manually through the use of static and/or portable scales. Information is recorded on a daily basis and then reported to the MVD on a monthly and yearly basis for statistical reviews.
    - The MVD has no permanent data collection sites on highways within the interior of the state.
- MPOs collect traffic counts for certain delegated highways in Maricopa and Pima counties using contractors. Traffic counts are performed to meet federal reporting requirements with no differentiation made between vehicle types. Any additional traffic data collection such as vehicle classification is performed for special studies only.

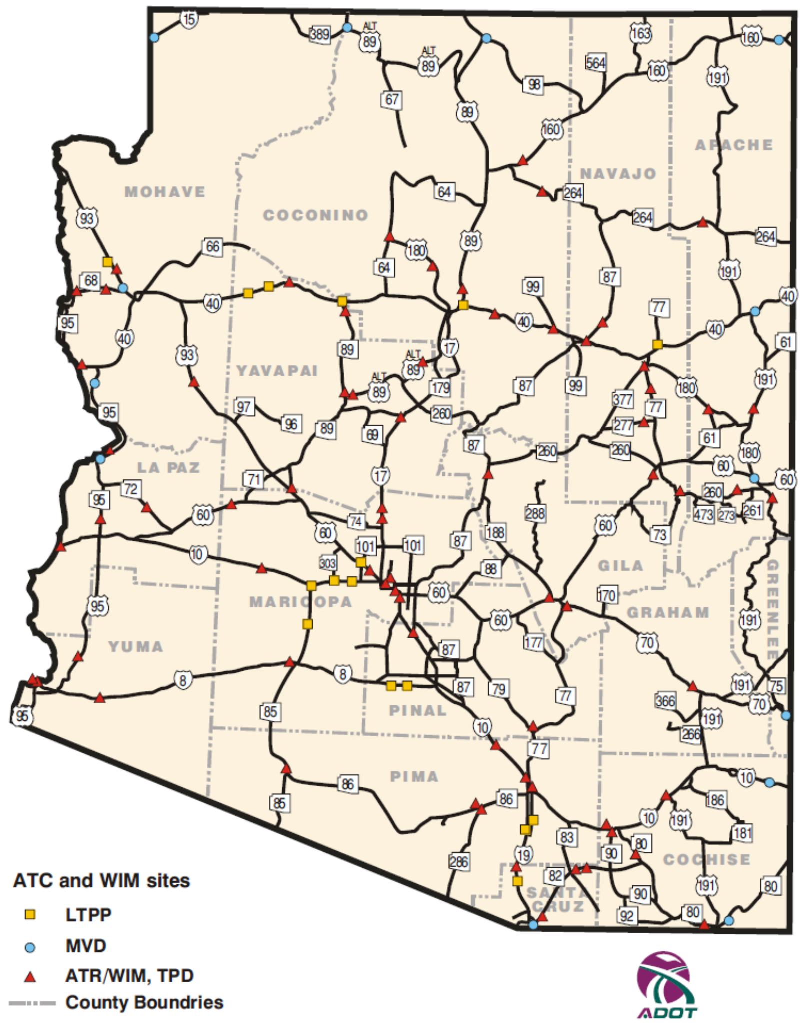


Figure A-2. Location of ATC and WIM Sites in Arizona in 2002.

TRAFFIC DATA FOR PAVEMENT DESIGN

Interview with Javed Bari

- The current pavement design methodology (AASHTO 1993) is based on ESALs.
- For ADOT pavement design, the Pavement Management System Section computes ESALs using the pavement management system software.
- ESALs are estimated using:
    - The most recent estimates of AADT.
        - AADT and truck percentage are usually provided by the Traffic Engineering Group. The group typically hires a consultant to generate volume estimates, which may include truck percentage.
        - Growth factor is part of the ADOT traffic database. It is calculated as a 5-year moving average of AADT. Sometimes, a growth rate as high as 6

percent may be reported. The highest estimate of ESALs for a 20-year cumulative rigid ESAL historically used by ADOT is 338 million.

  - 1999 vehicle classification and weight data.
    - The 1999 vehicle classification and weight data are based on the results of a study sponsored by ADOT from 1995 to 1997 (Alavi and Senn, 1999).
  - Truck factors used for estimating ESALs are obtained from the *Preliminary Engineering and Design Manual* (ADOT, 1989). Note that the manual was published in 1989, while truck classification and weight data are obtained from Alavi and Senn, published in 1999. ESALs computed using the ADOT *Preliminary Engineering and Design Manual* may be significantly different than would be calculated with current weight data.
  - Truck weights used for estimating ESALs are obtained from four designated POEs. LTPP WIM data are not used for deriving truck factors used for estimating ESALs for ADOT.

ADOT Preliminary Engineering and Design Manual, 1989

- Raw traffic data for estimating ESALs for pavement design are provided by ADOT's Transportation Planning Division (TPD) or the Local Government Coordination Group. The latter provides traffic data for all urban areas with the exception of Pima (Tucson) and Maricopa (Phoenix and suburbs) counties. Traffic data for these counties are provided by the Pima Association of Governments and the Maricopa Association of Governments, respectively. Traffic data for all other regions of the state are provided by the TPD. An actual estimation of 18-kip ESALs is performed by the ADOT Materials Group for all state highways.
- The ADOT Materials Group maintains the last 10 years of traffic volume data from which traffic volume and growth factors are calculated using regression analysis.
- In 1989, the TPD had 983 ATRs located throughout the state. Traffic counts from these ATR sites are published annually.
- The TPD categorizes traffic into seven classes as follows (see Figure A-3):
  - Commercial vehicles:
    - Light trucks.
    - Medium trucks.
    - Tractor semi-trailer.
    - Tractor trailer.
    - Tractor semi-trailer trailer.
  - Non-commercial vehicles:
    - Buses.
    - Automobiles.

  A 5-year moving average of classification data is used to estimate the percentage distribution among the vehicle categories.
- Truck factors:
  - The TPD conducts a truck weight study biennially during which a sample of the axle weights for the 13 FHWA vehicle classes is obtained and used to generate truck factor information needed to compute 18-kip ESALs. Actual values of truck

factors are determined using regression models developed using data from the last six truck weight studies.
  - Multiplying the truck factors for each vehicle type by the number of vehicles of each type over the design period and summing it will provide the cumulative number of 18-kip ESALs used in the design.
  - These values have not been updated since the 1990s.
- WIM:
  - The TPD has two WIM devices that automatically sense the dynamic weight of moving axles, estimate vehicle velocity, and classify vehicles by type.
  - There are 14 POE locations where commercial vehicles are regularly weighed. The weight data are collected and recorded manually by the MVD. The present procedures do not offer a convenient means of using the POE truck weight data for traffic loading estimates.

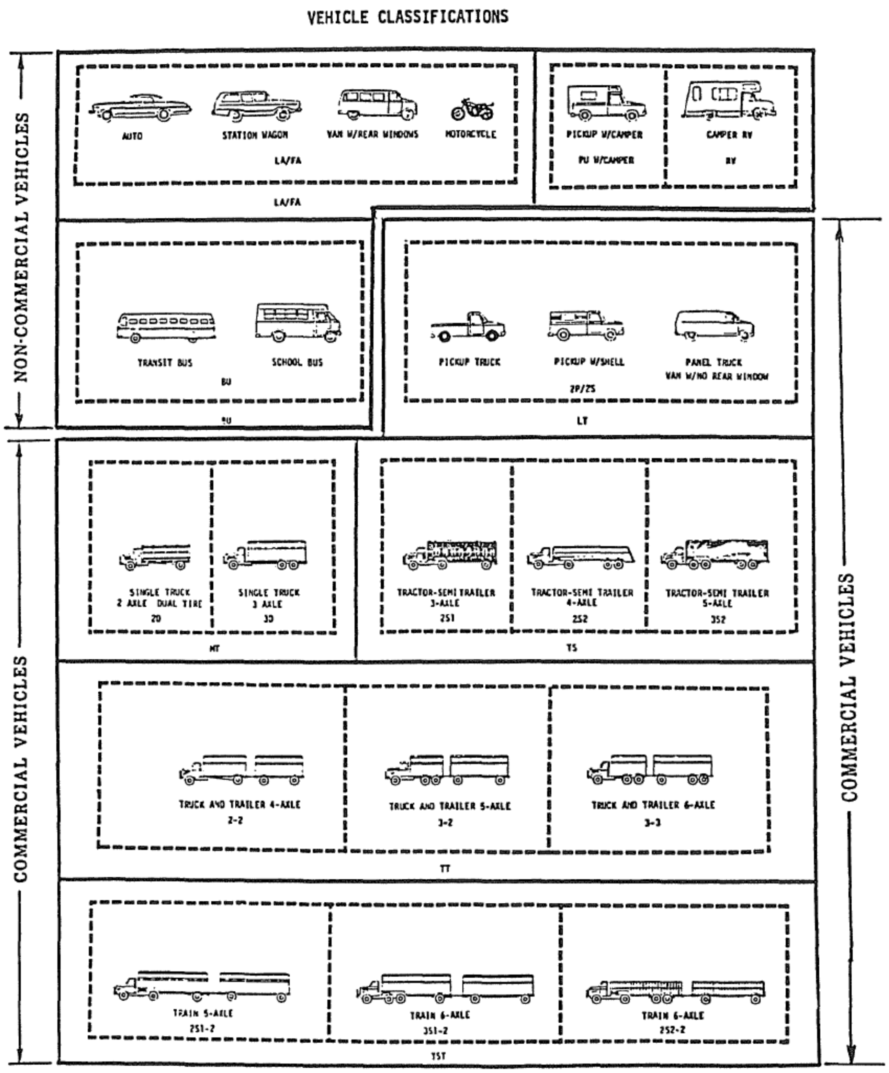


Figure A-3. ADOT Vehicle Classification Scheme.

APPENDIX B. SUMMARY OF VCD DATA USED FOR ANALYSIS

This appendix presents plots of the VCD data for projects in Arizona identified with the required VCD data. Note that not all of the data presented in this appendix were included in the analysis, as some data wereas deemed atypical, anomalous, or erroneous.

Figure B-1. Plot of Vehicle Class Distribution for Site 4_0100.

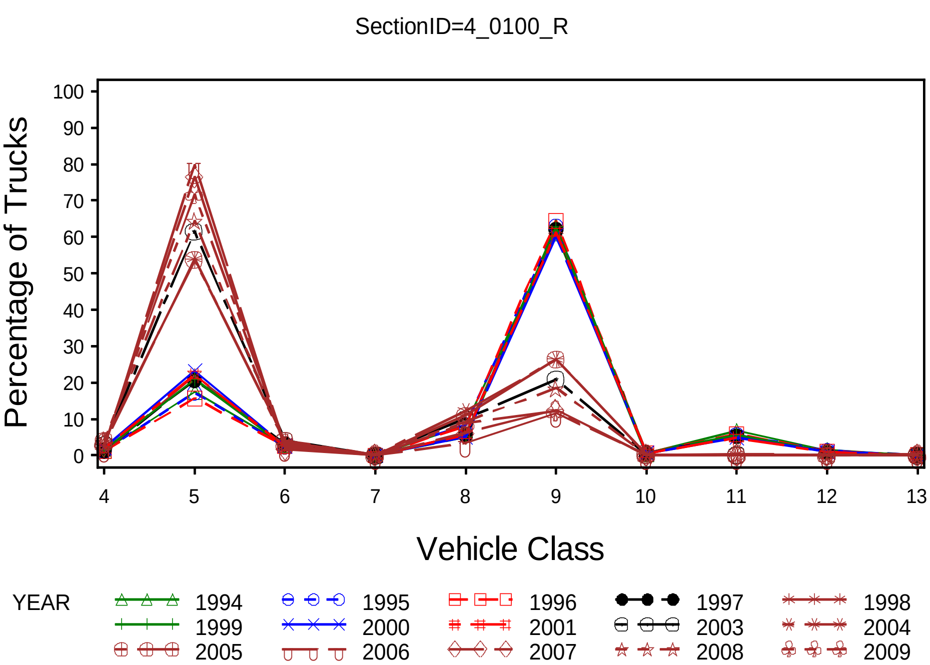


Figure B-2. Plot of Vehicle Class Distribution for Site 4_0100_R.

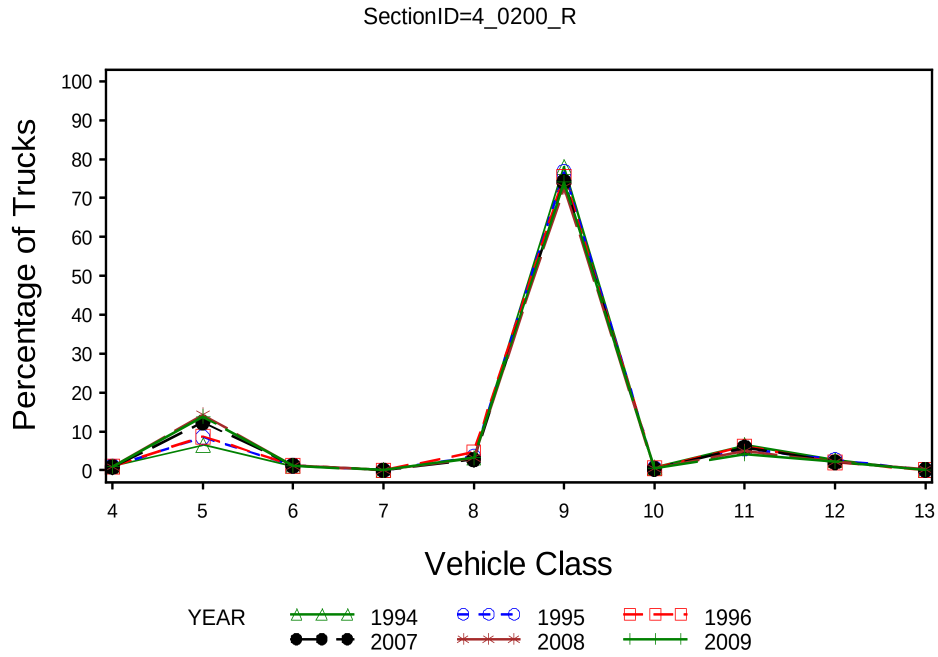


Figure B-3. Plot of Vehicle Class Distribution for Site 4_0200_R.

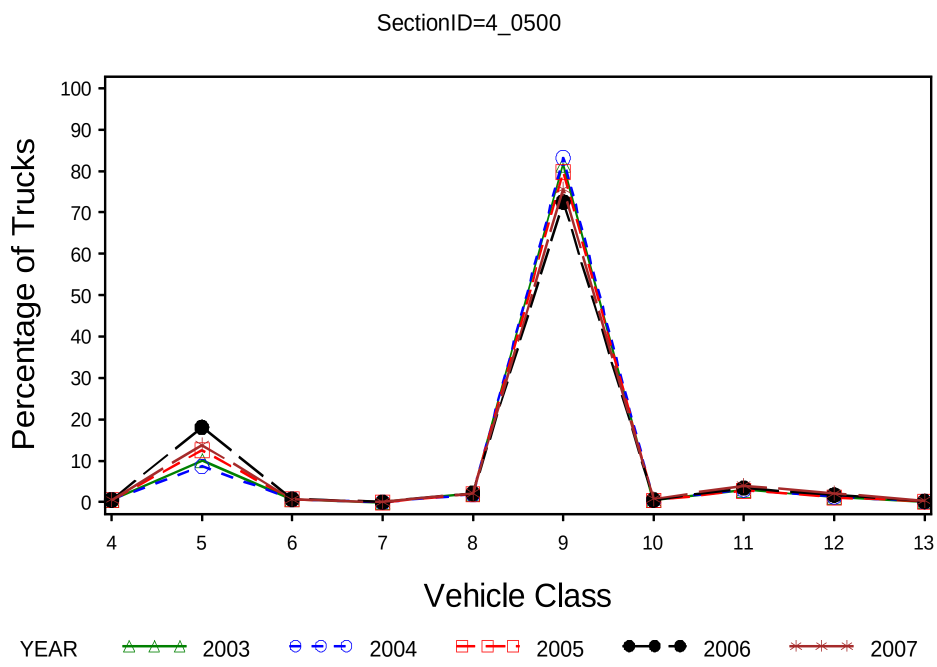


Figure B-4. Plot of Vehicle Class Distribution for Site 4_0500.

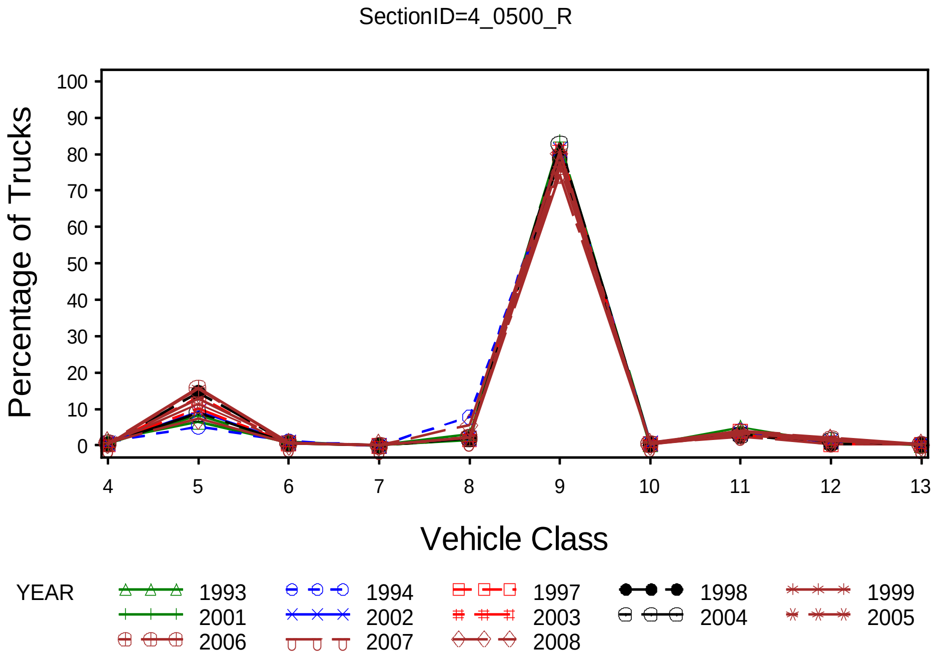


Figure B-5. Plot of Vehicle Class Distribution for Site 4_0500_R.

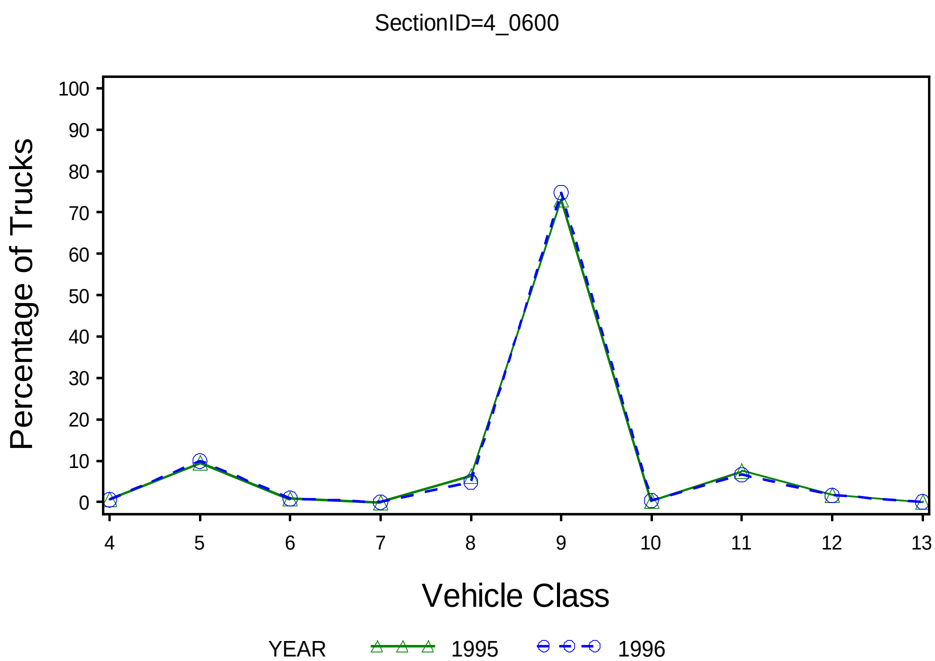


Figure B-6. Plot of Vehicle Class Distribution for Site 4_0600.

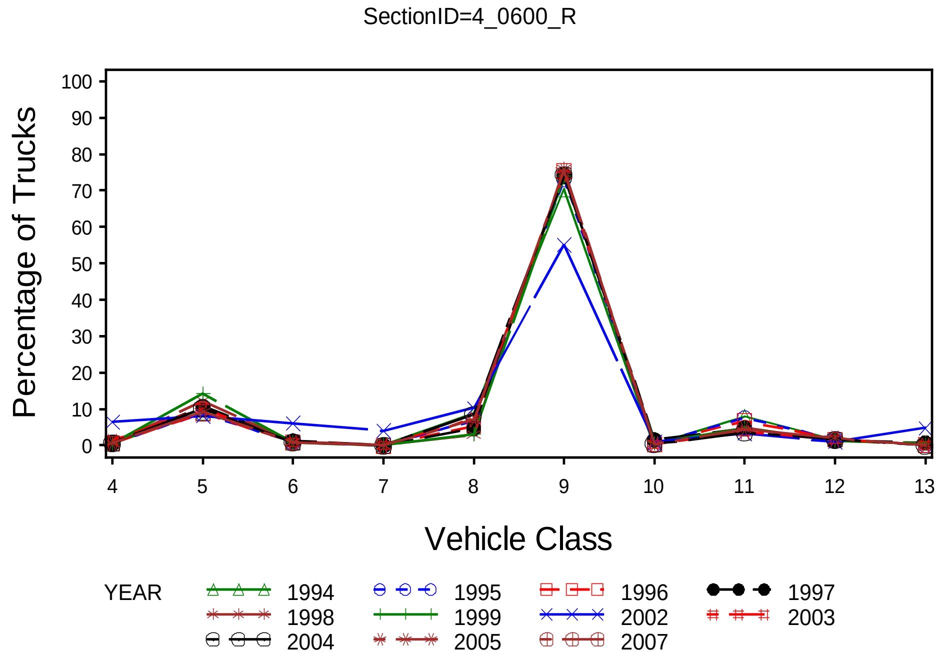


Figure B-7. Plot of Vehicle Class Distribution for Site 4_0600_R.

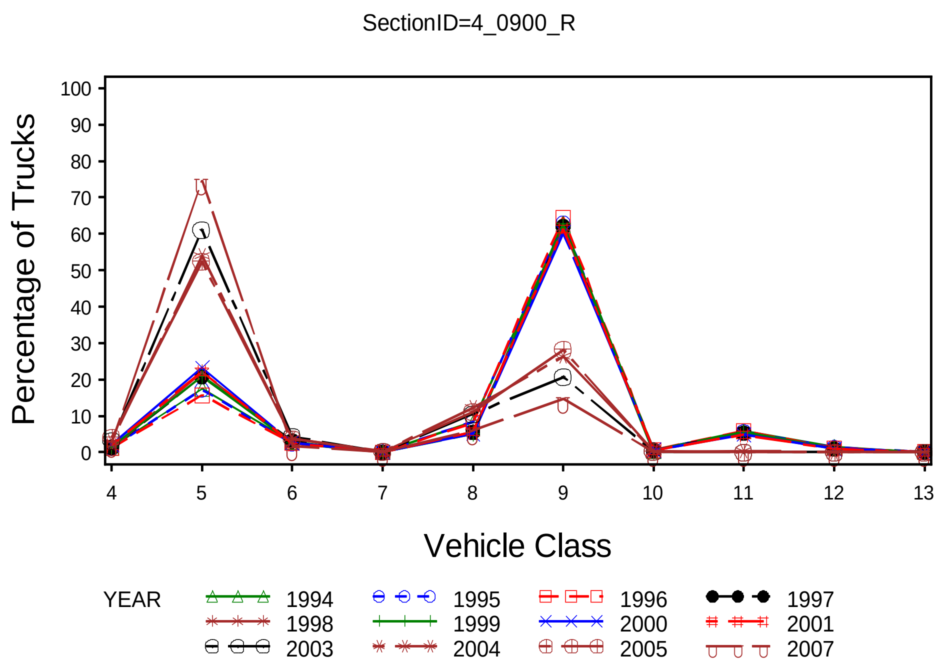


Figure B-8. Plot of Vehicle Class Distribution for Site 4_0900_R.

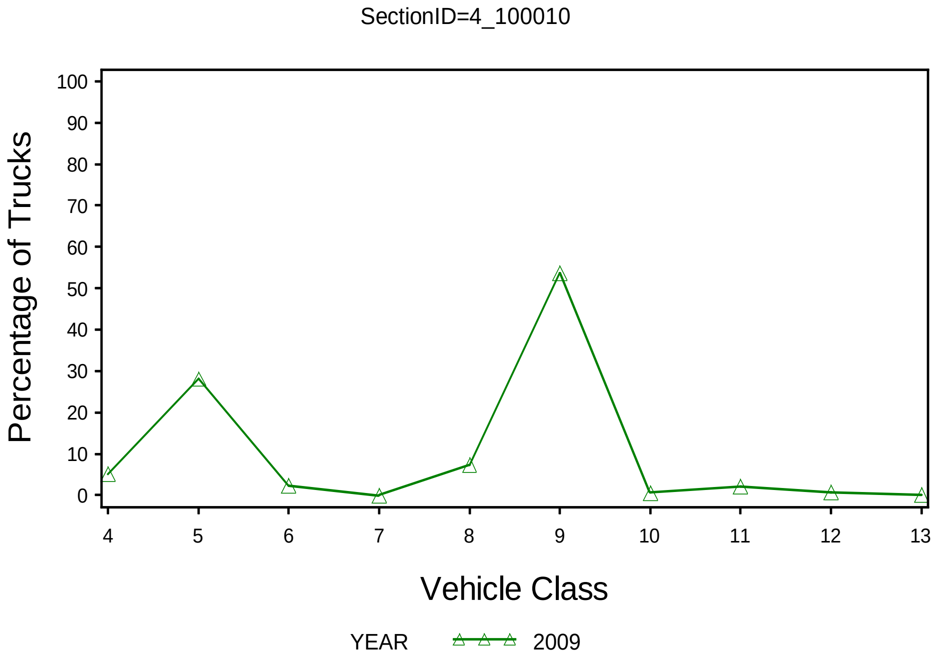


Figure B-9. Plot of Vehicle Class Distribution for Site 4_100010.

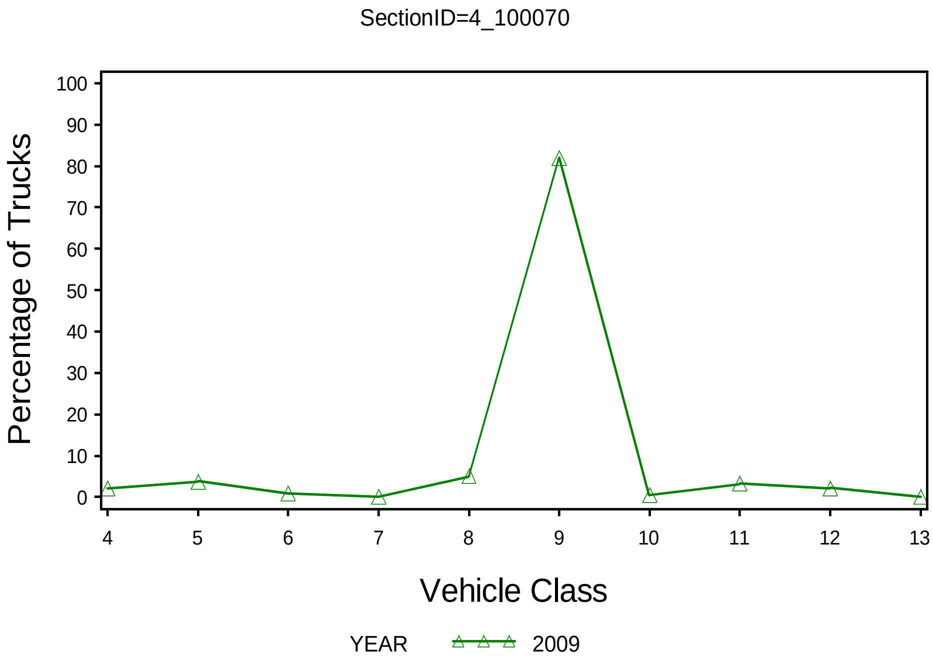


Figure B-10. Plot of Vehicle Class Distribution for Site 4_100070.

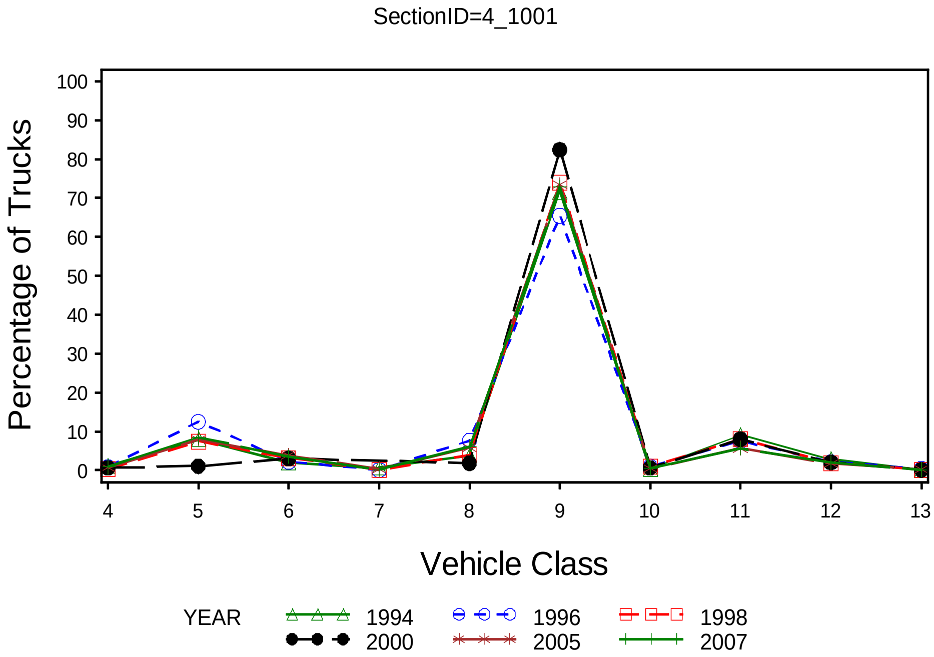


Figure B-11. Plot of Vehicle Class Distribution for Site 4_1001.

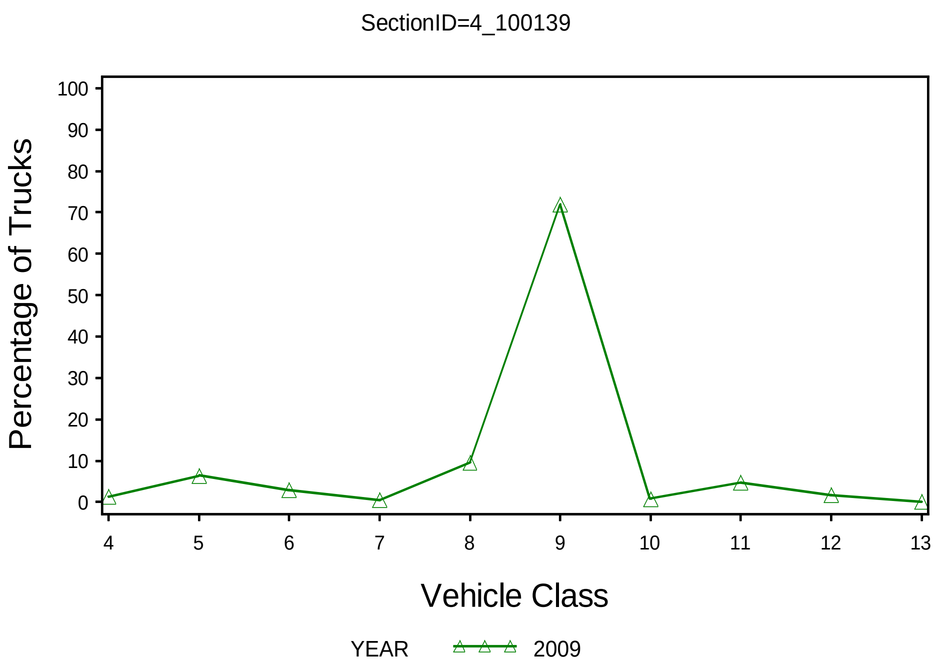


Figure B-12. Plot of Vehicle Class Distribution for Site 4_100139.

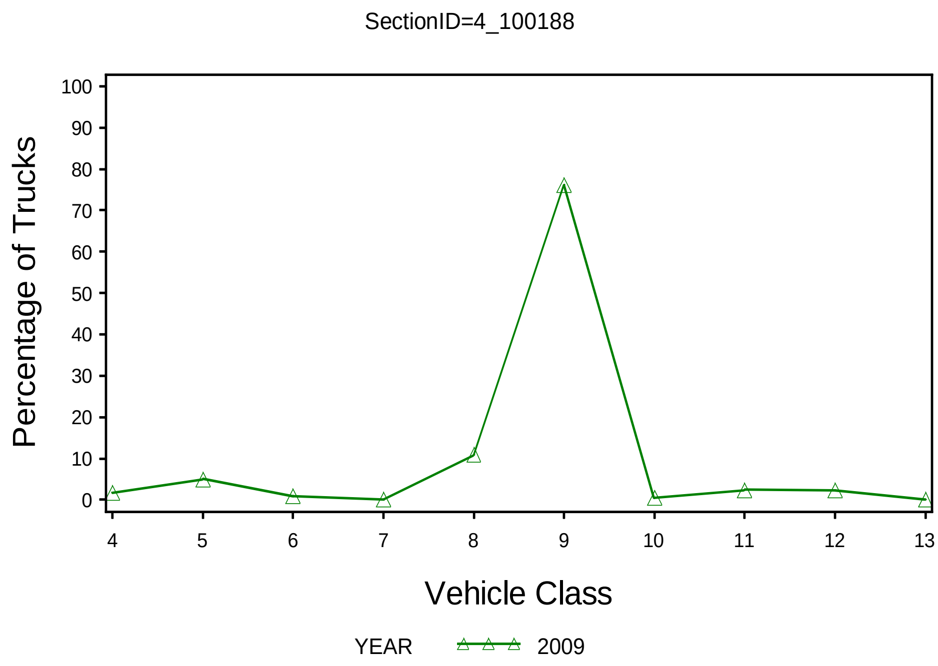


Figure B-13. Plot of Vehicle Class Distribution for Site 4_100188.

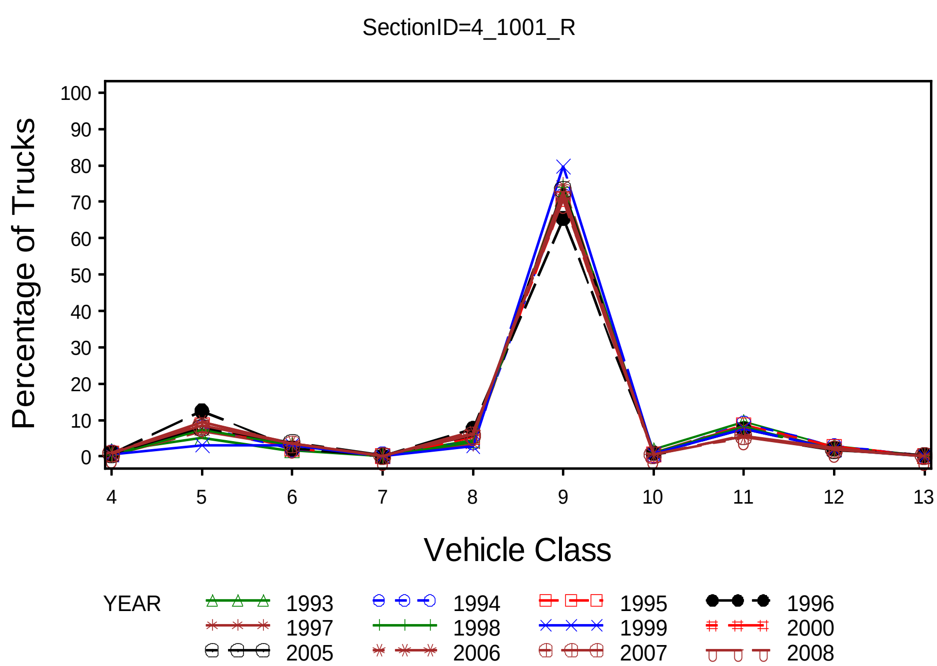


Figure B-14. Plot of Vehicle Class Distribution for Site 4_1001_R.

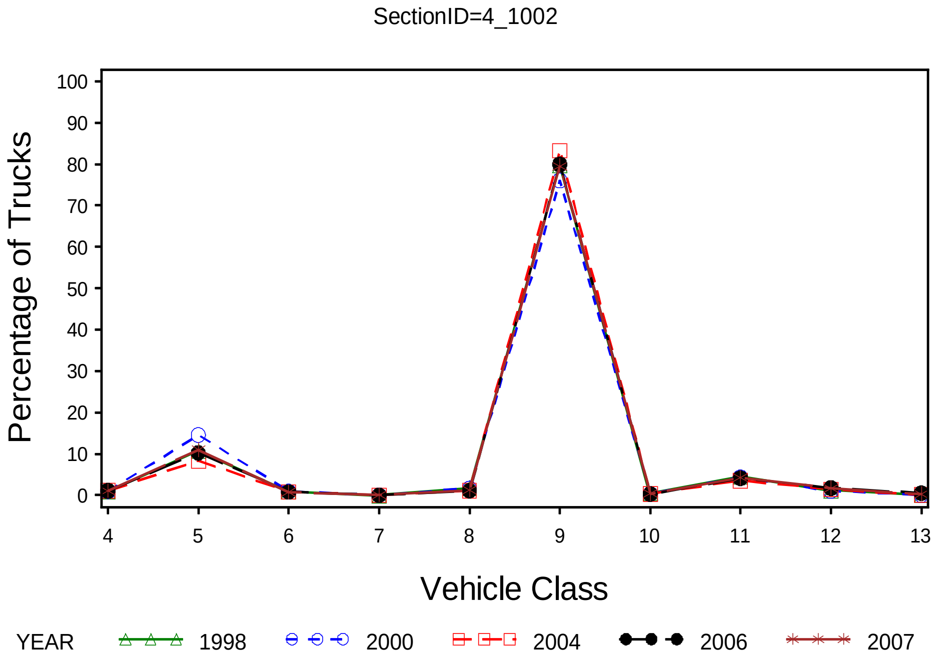


Figure B-15. Plot of Vehicle Class Distribution for Site 4_1002.

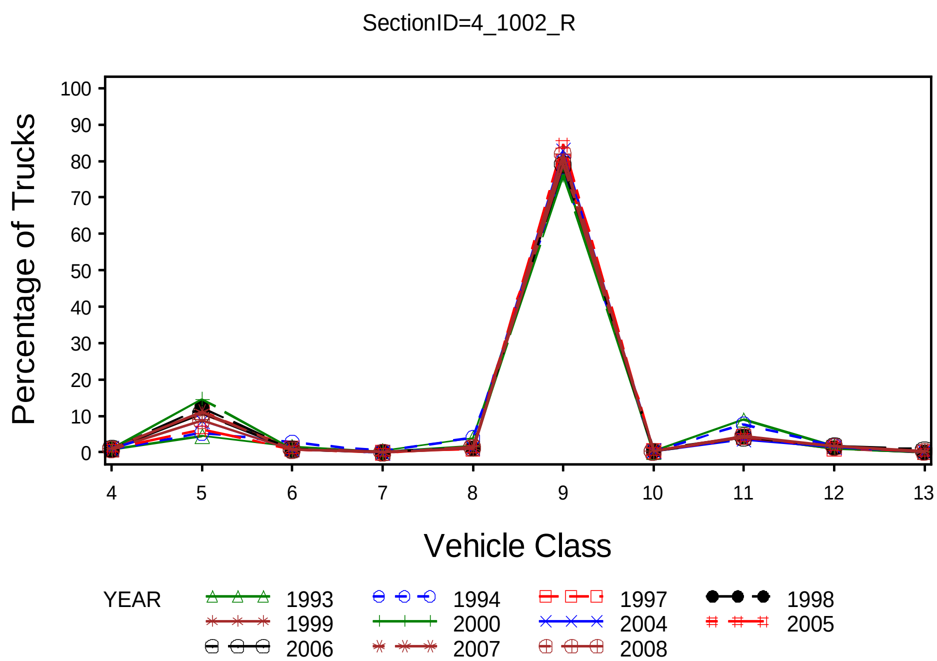


Figure B-16. Plot of Vehicle Class Distribution for Site 4_1002_R.

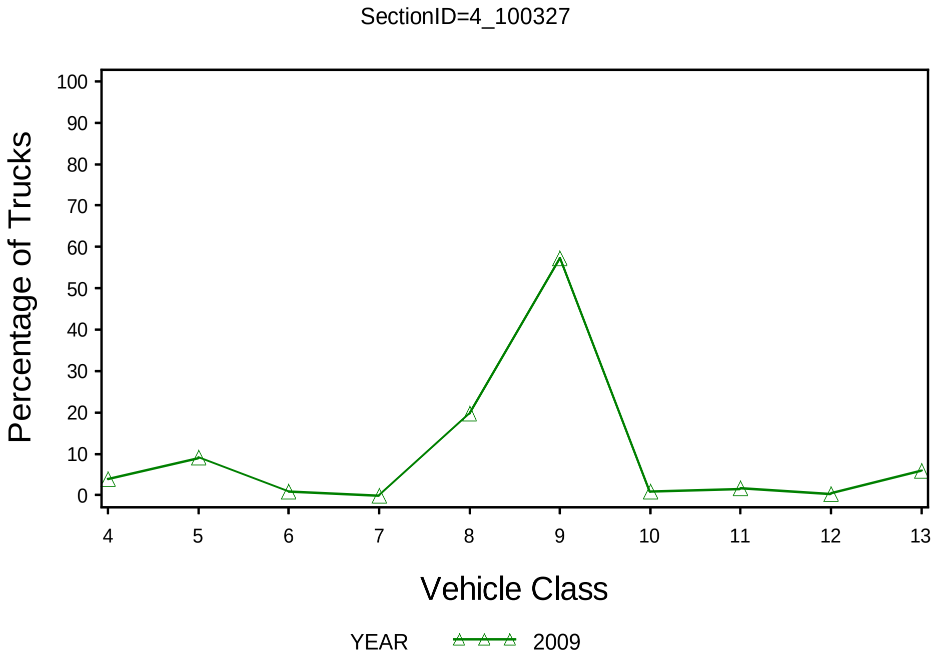


Figure B-17. Plot of Vehicle Class Distribution for Site 4_100327.

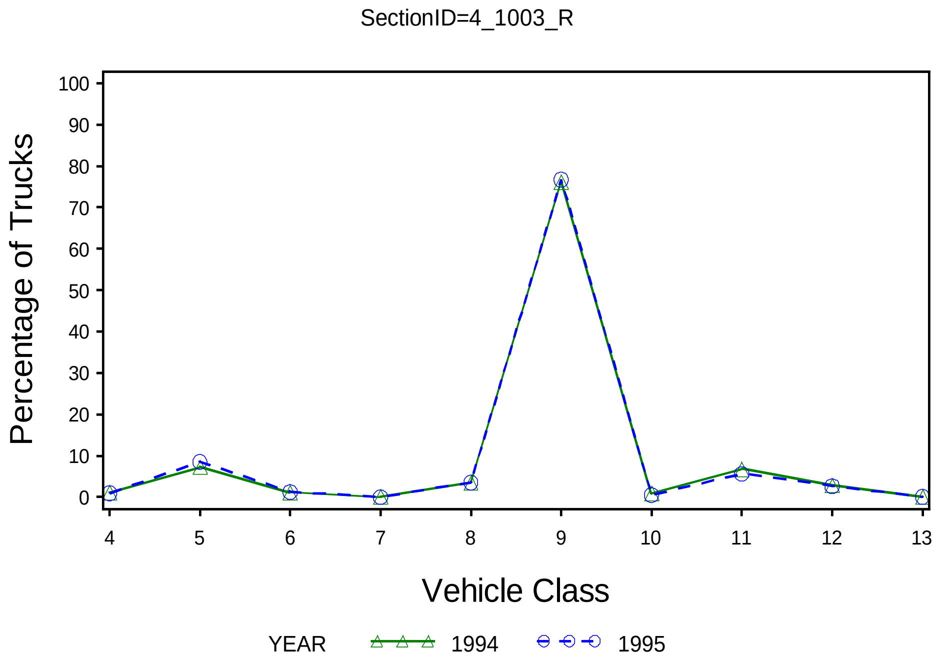


Figure B-18. Plot of Vehicle Class Distribution for Site 4_1003_R.

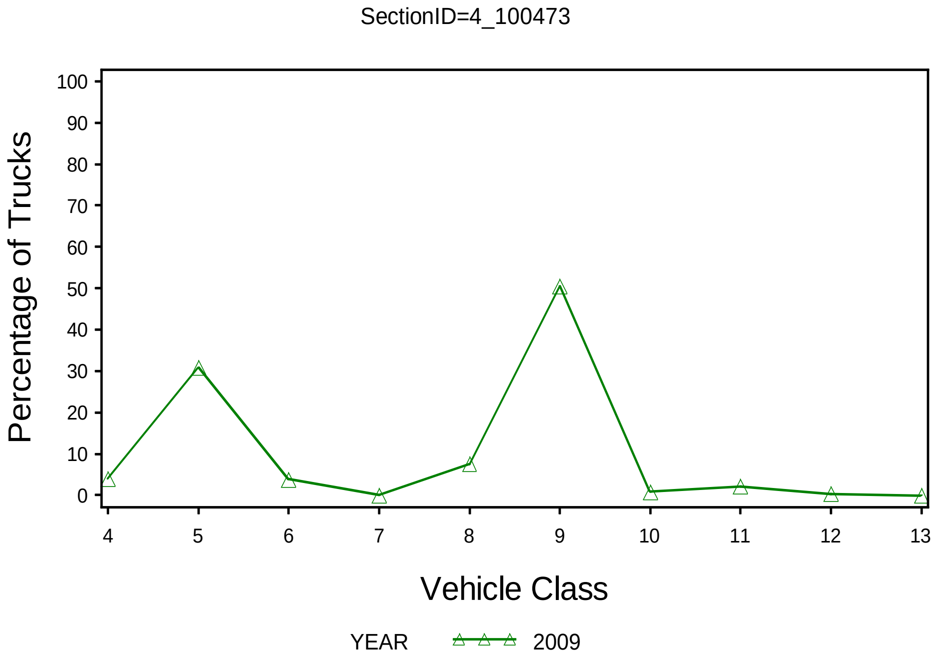


Figure B-19. Plot of Vehicle Class Distribution for Site 4_100473.

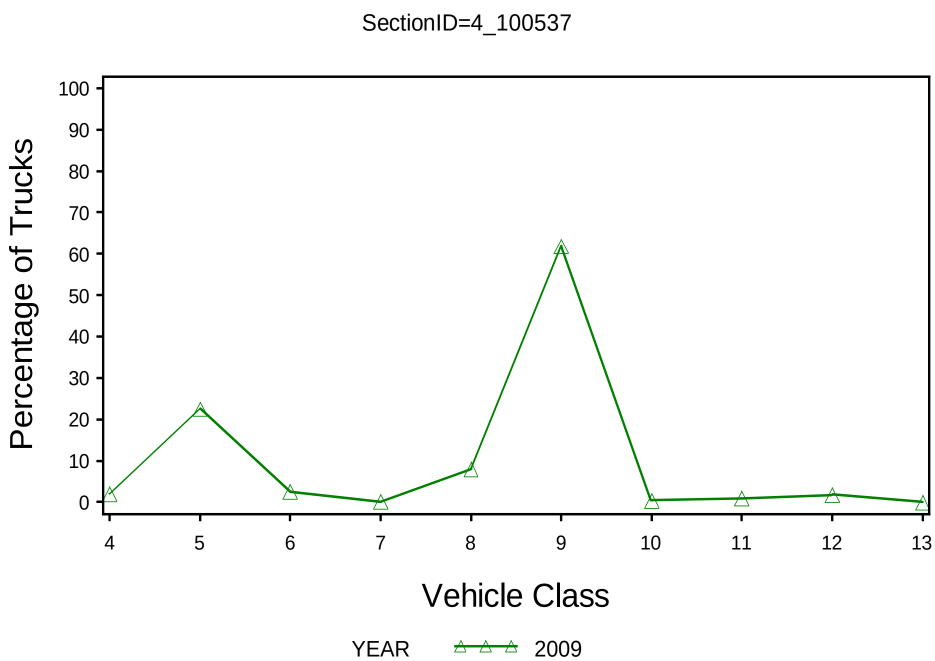


Figure B-20. Plot of Vehicle Class Distribution for Site 4_100537.

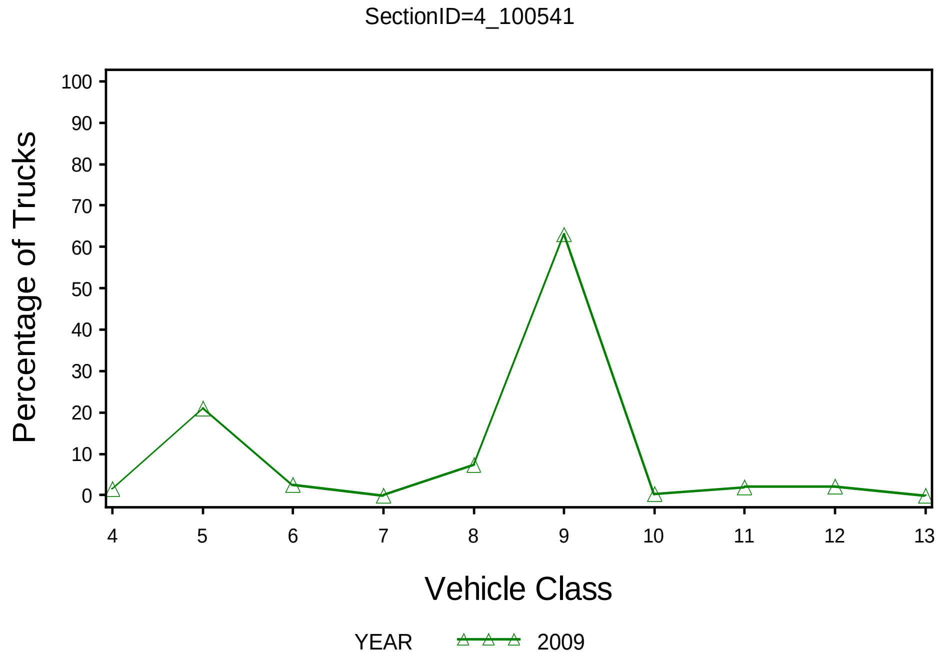


Figure B-21. Plot of Vehicle Class Distribution for Site 4_100541.

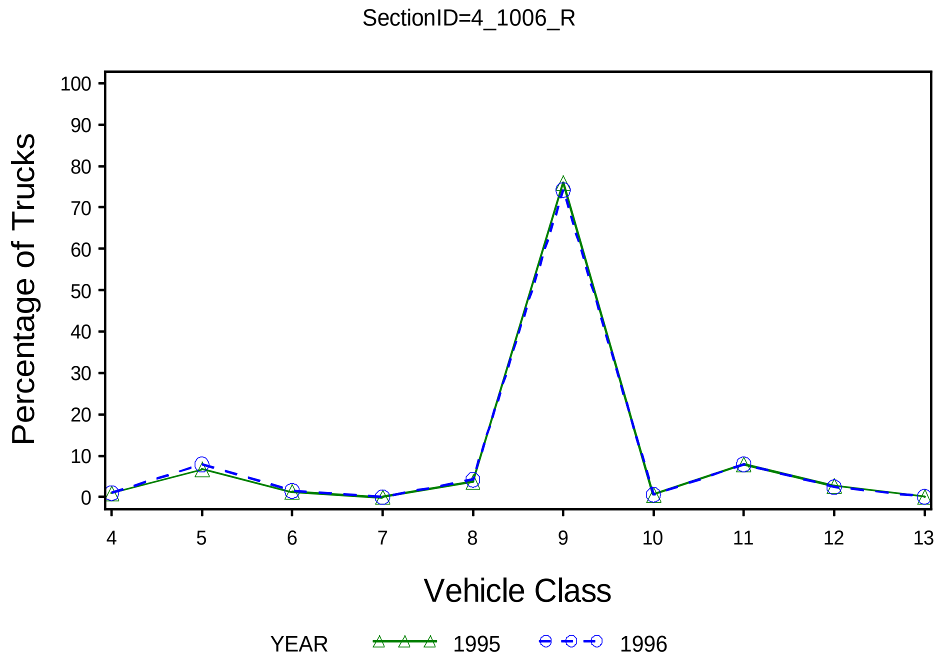


Figure B-22. Plot of Vehicle Class Distribution for Site 4_1006_R.

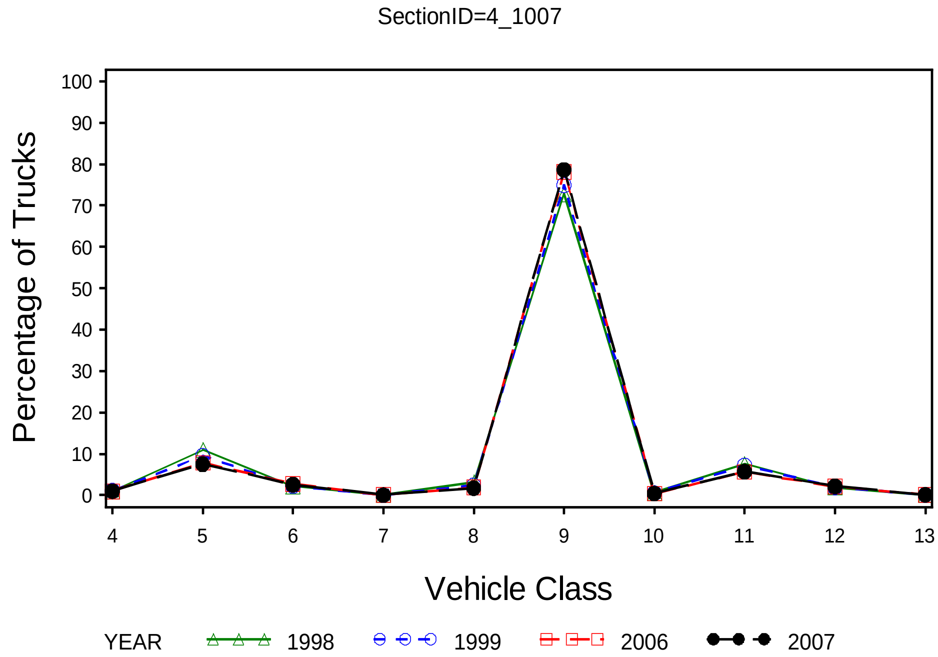


Figure B-23. Plot of Vehicle Class Distribution for Site 4_1007.

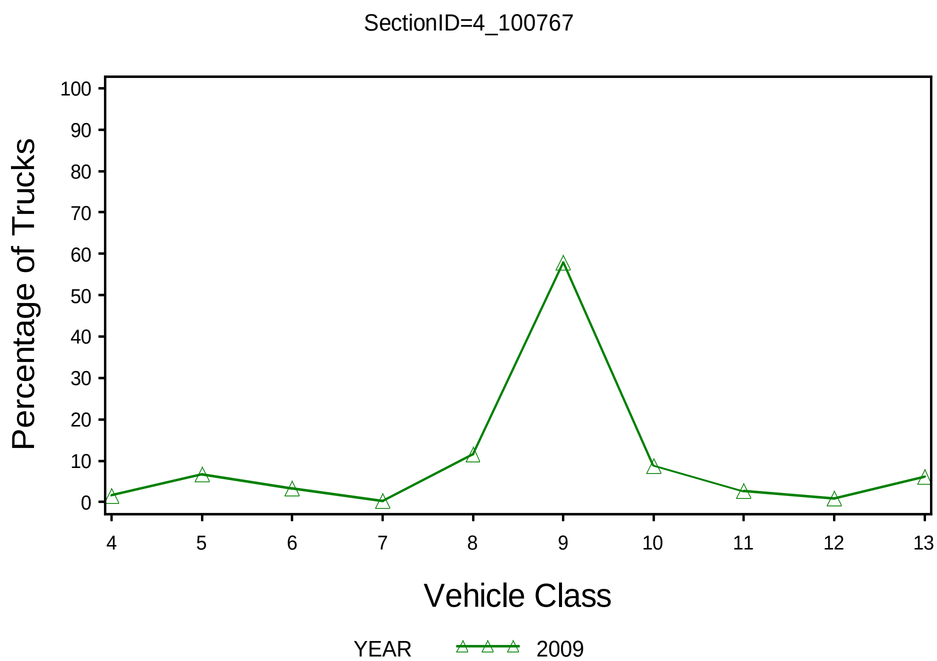


Figure B-24. Plot of Vehicle Class Distribution for Site 4_100767.

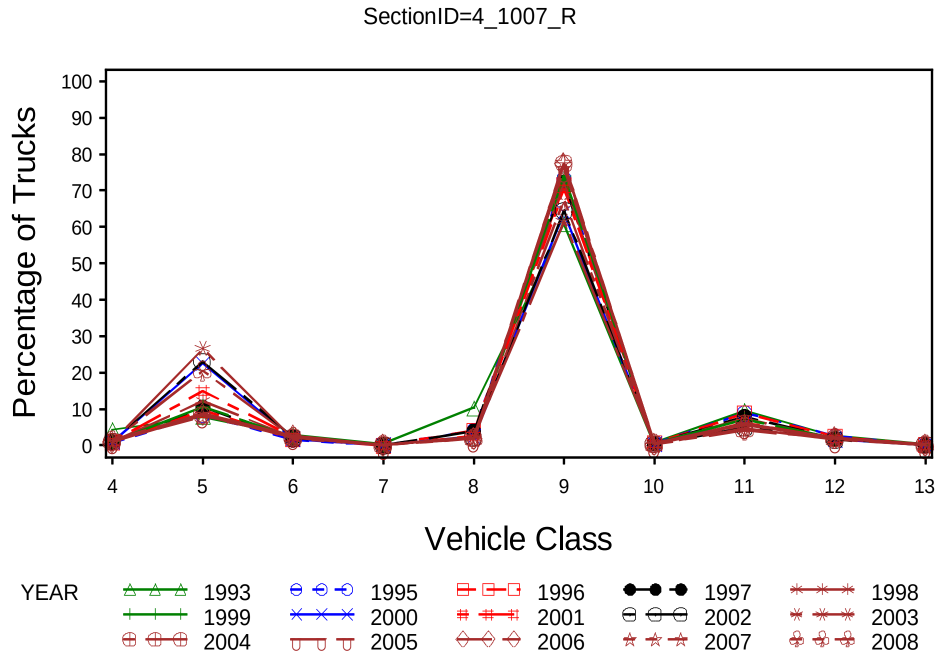


Figure B-25. Plot of Vehicle Class Distribution for Site 4_1007_R.

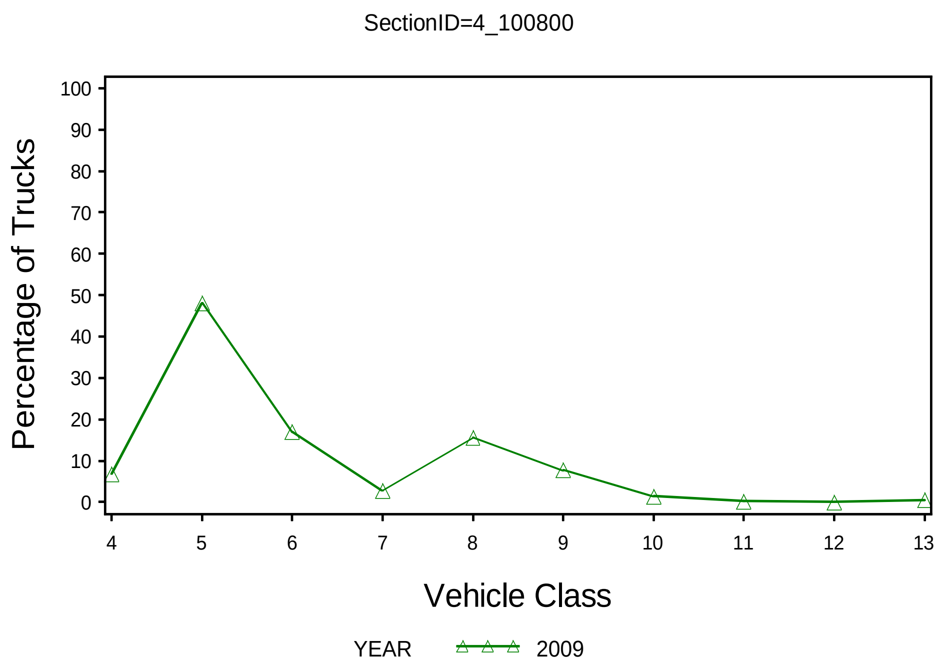


Figure B-26. Plot of Vehicle Class Distribution for Site 4_100800.

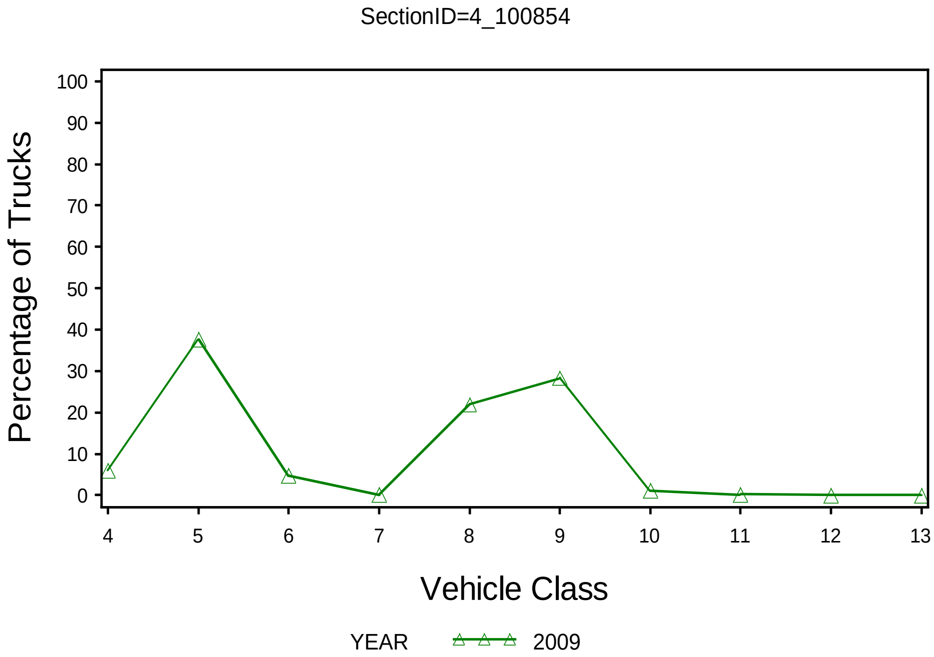


Figure B-27. Plot of Vehicle Class Distribution for Site 4_100854.

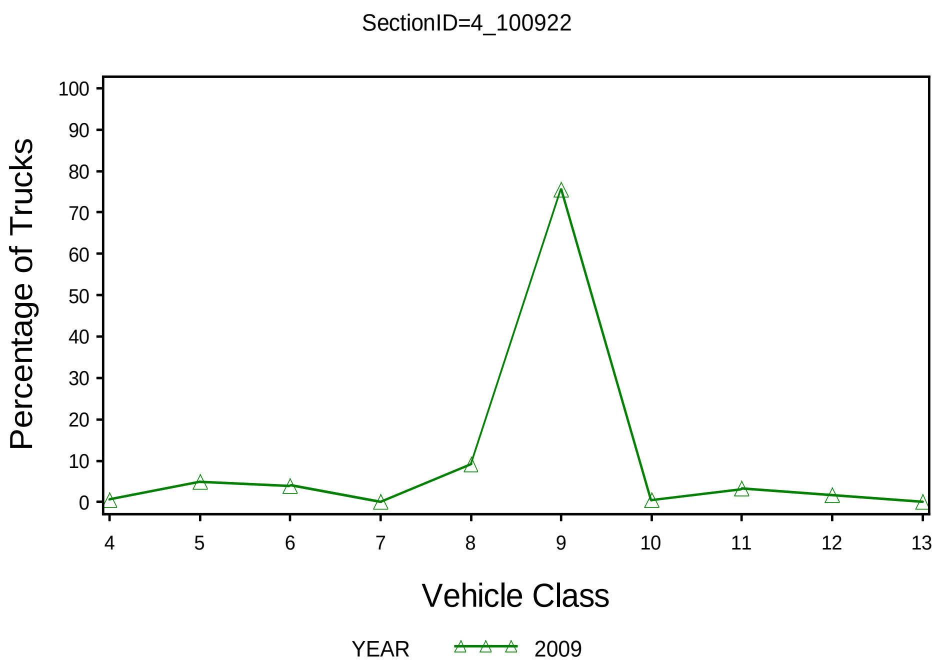


Figure B-28. Plot of Vehicle Class Distribution for Site 4_100922.

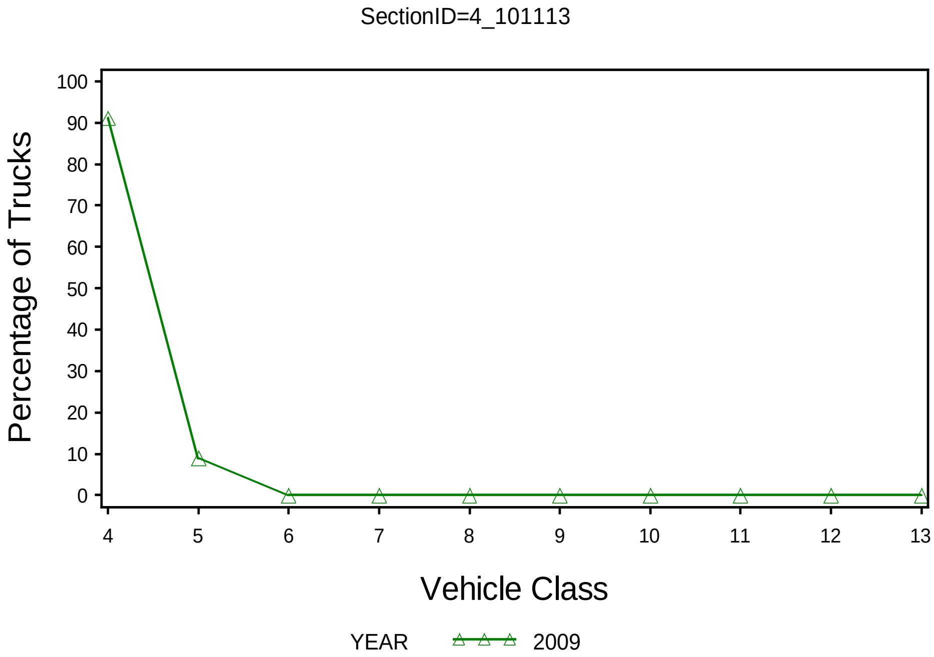


Figure B-29. Plot of Vehicle Class Distribution for Site 4_101113.

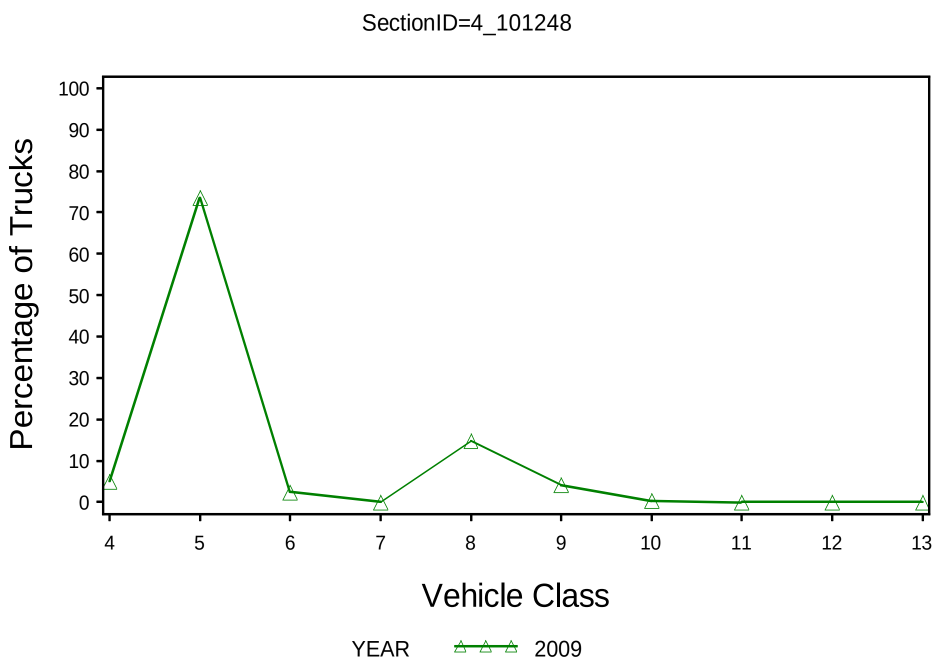


Figure B-30. Plot of Vehicle Class Distribution for Site 4_101248.

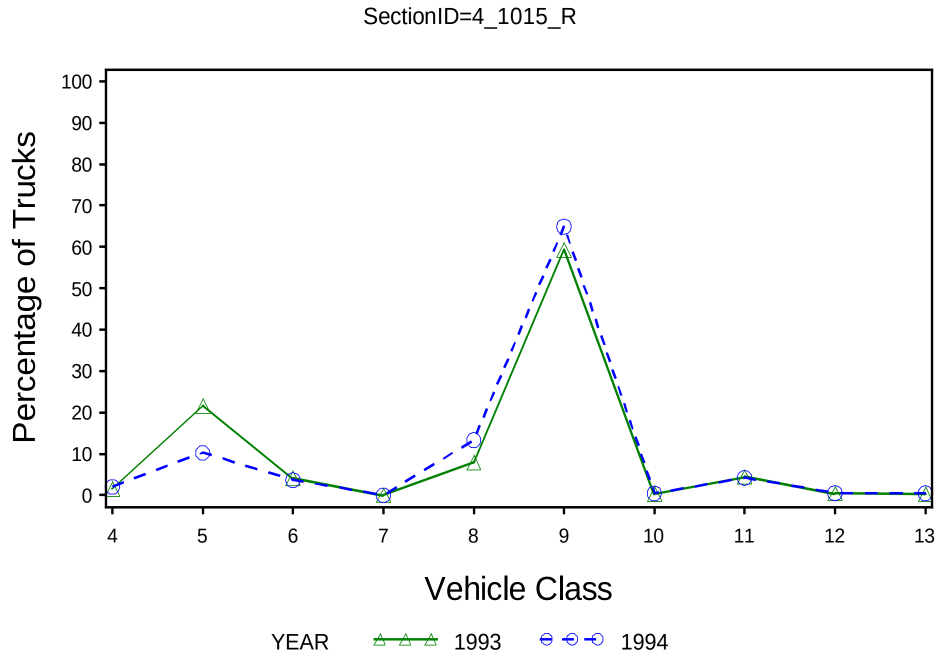


Figure B-31. Plot of Vehicle Class Distribution for Site 4_1015_R.

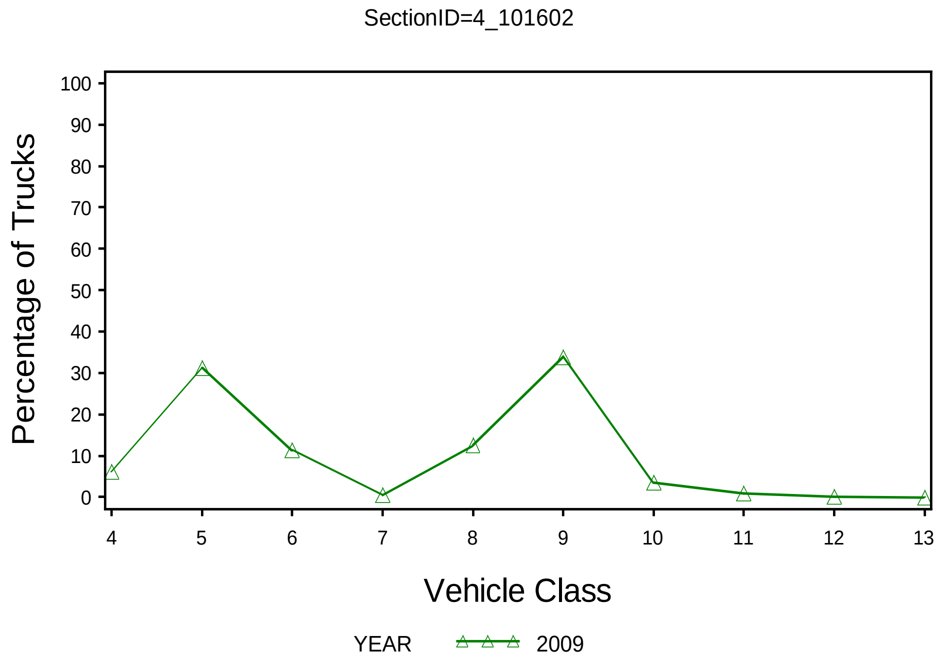


Figure B-32. Plot of Vehicle Class Distribution for Site 4_101602.

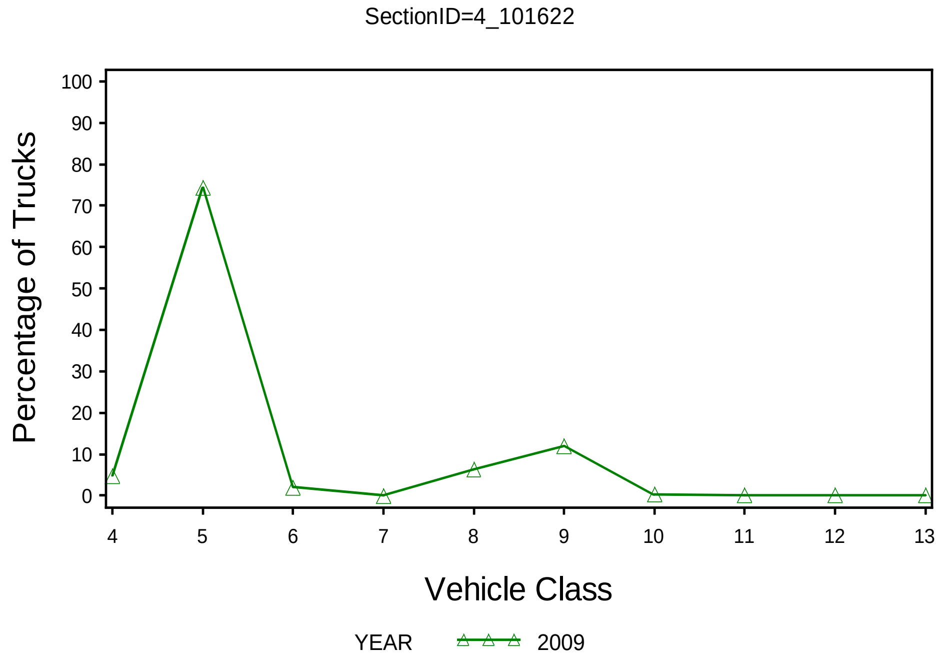


Figure B-33. Plot of Vehicle Class Distribution for Site 4_101622.

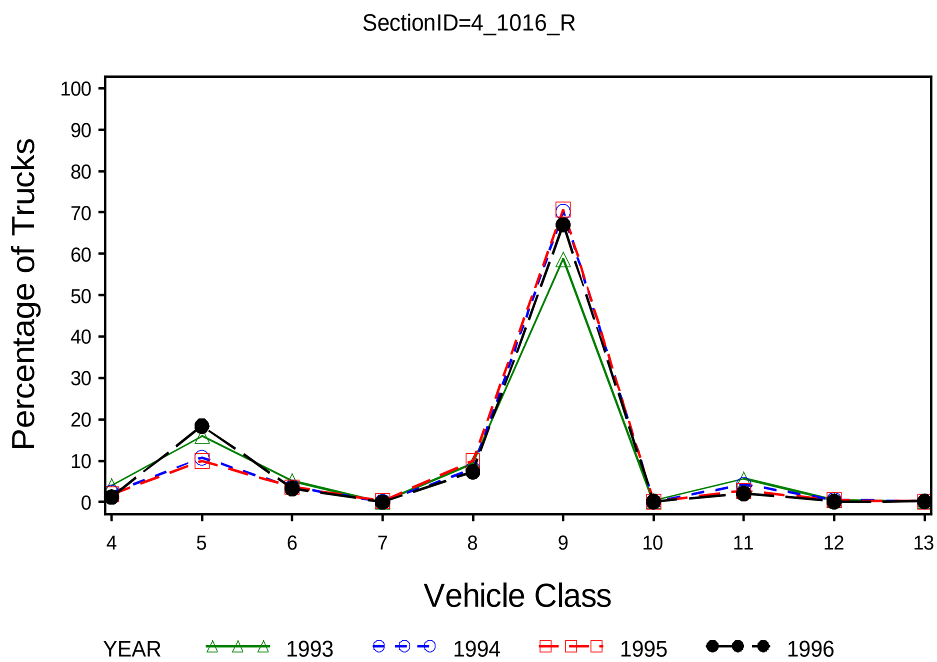


Figure B-34. Plot of Vehicle Class Distribution for Site 4_1016_R.

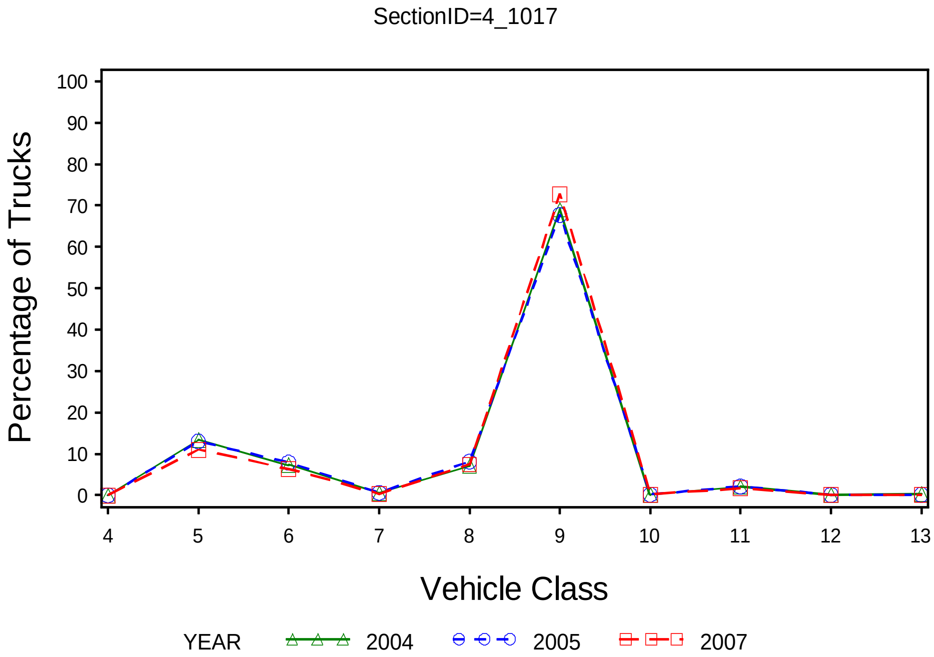


Figure B-35. Plot of Vehicle Class Distribution for Site 4_1017.

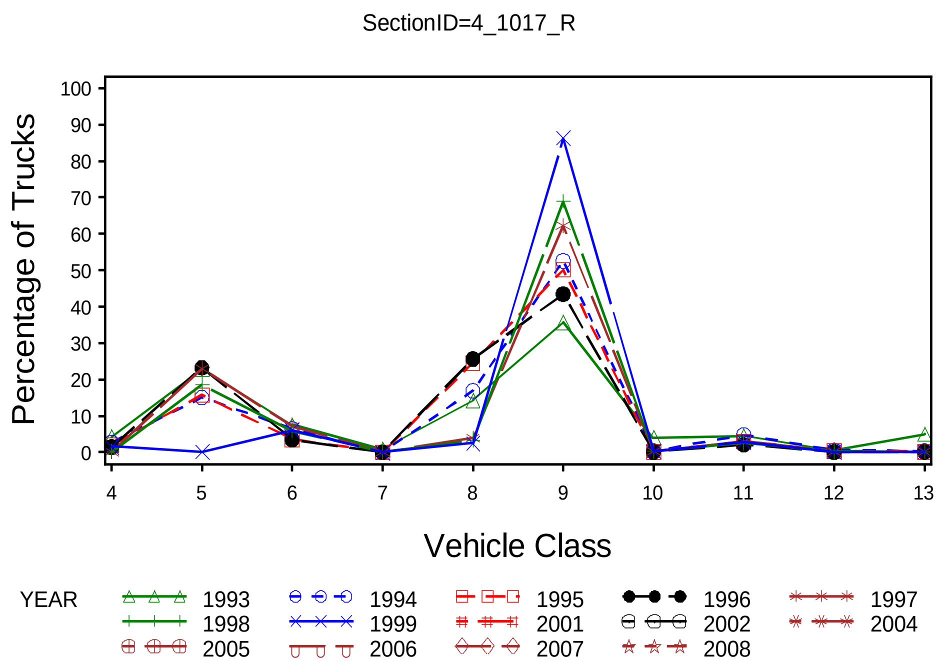


Figure B-36. Plot of Vehicle Class Distribution for Site 4_1017_R.

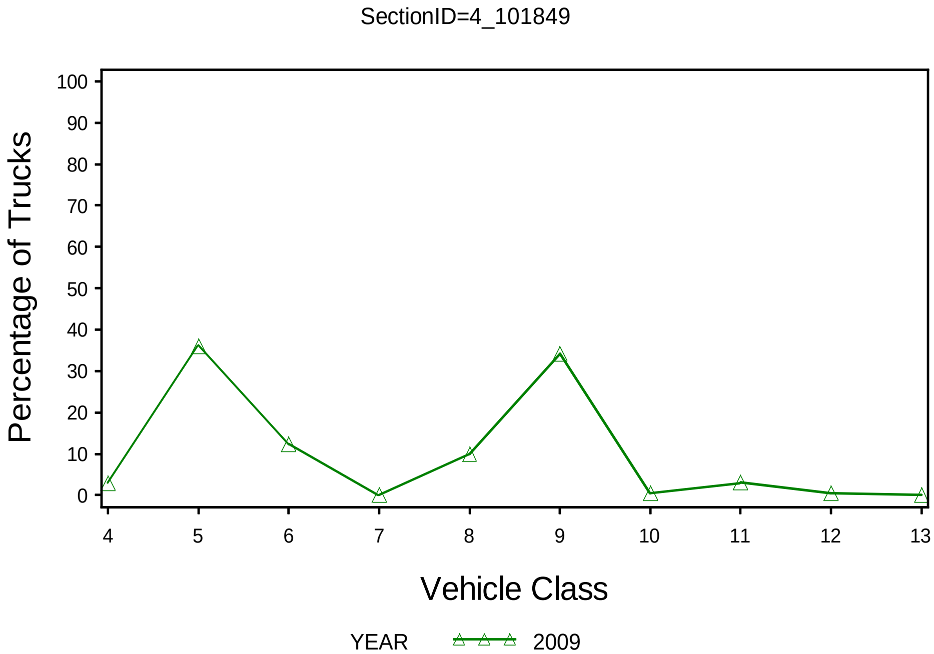


Figure B-37. Plot of Vehicle Class Distribution for Site 4_101849.

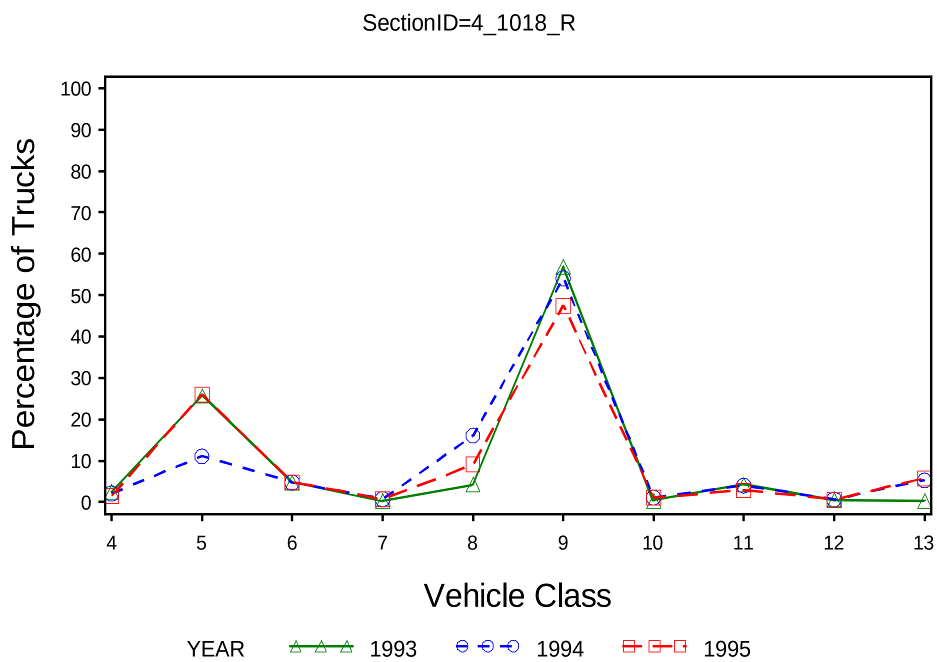


Figure B-38. Plot of Vehicle Class Distribution for Site 4_1018_R.

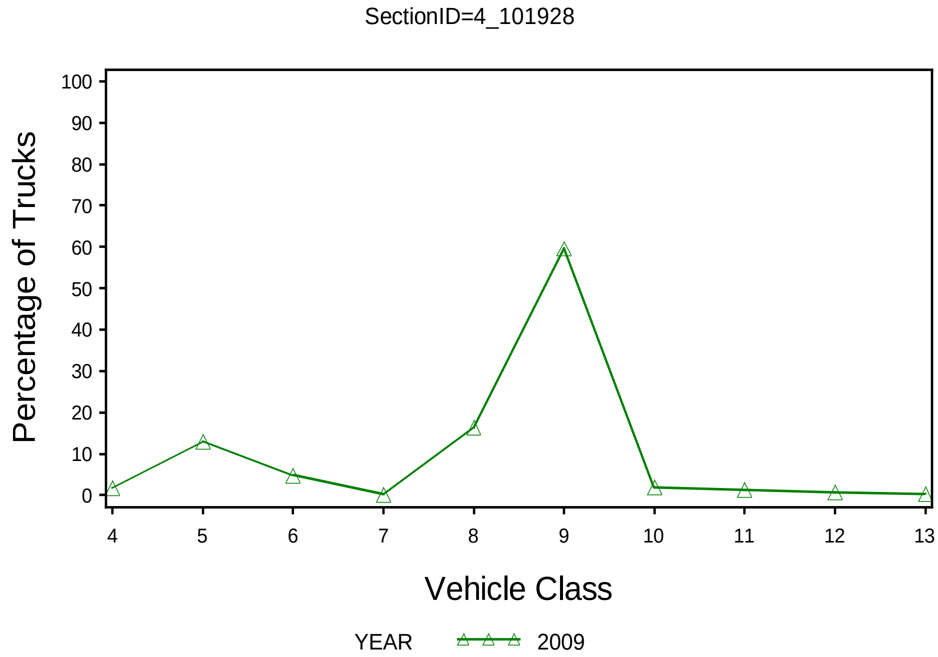


Figure B-39. Plot of Vehicle Class Distribution for Site 4_101928.

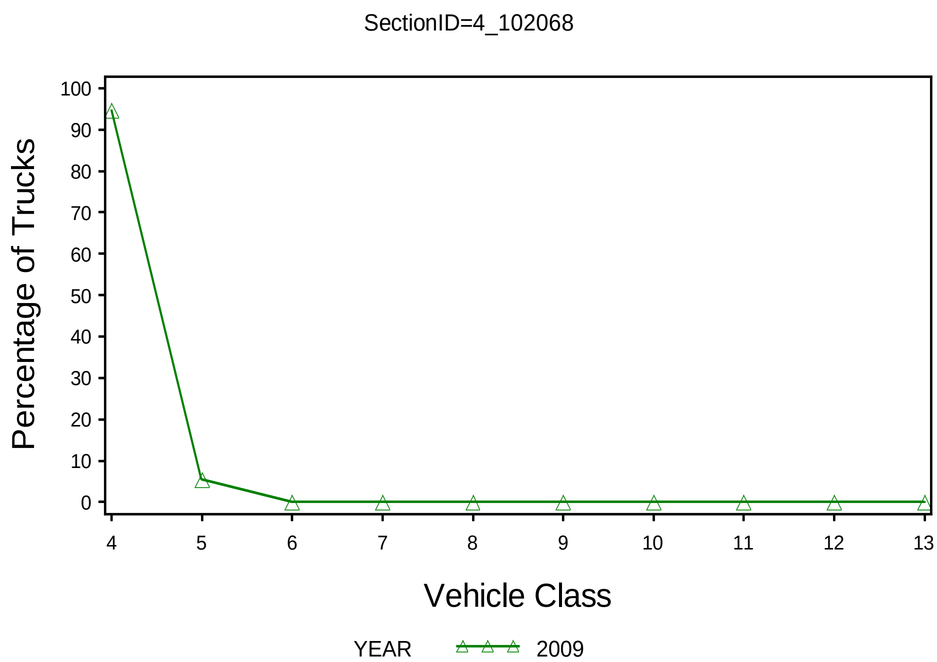


Figure B-40. Plot of Vehicle Class Distribution for Site 4_102068.

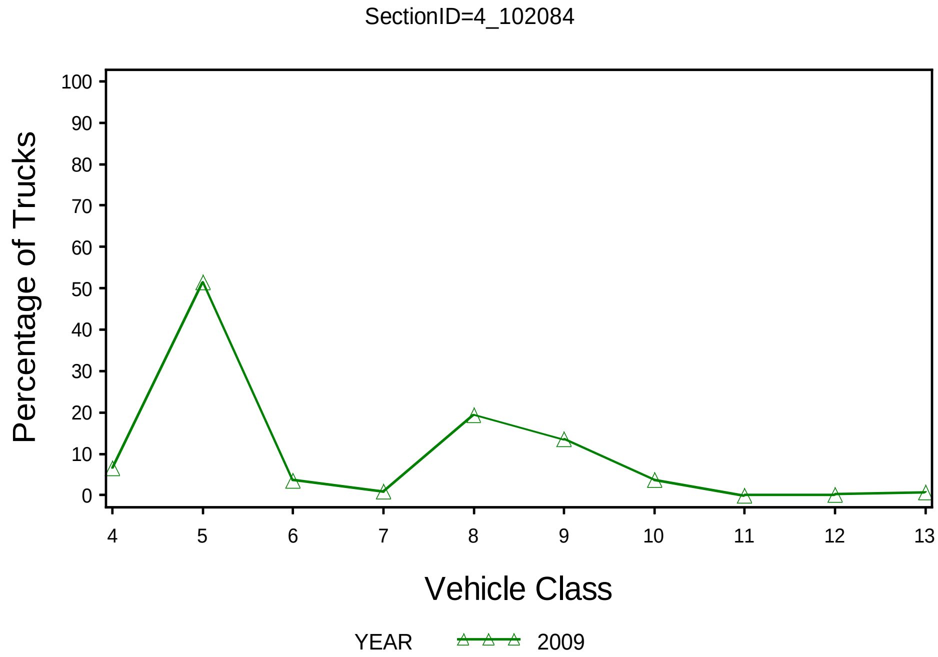


Figure B-41. Plot of Vehicle Class Distribution for Site 4_102084.

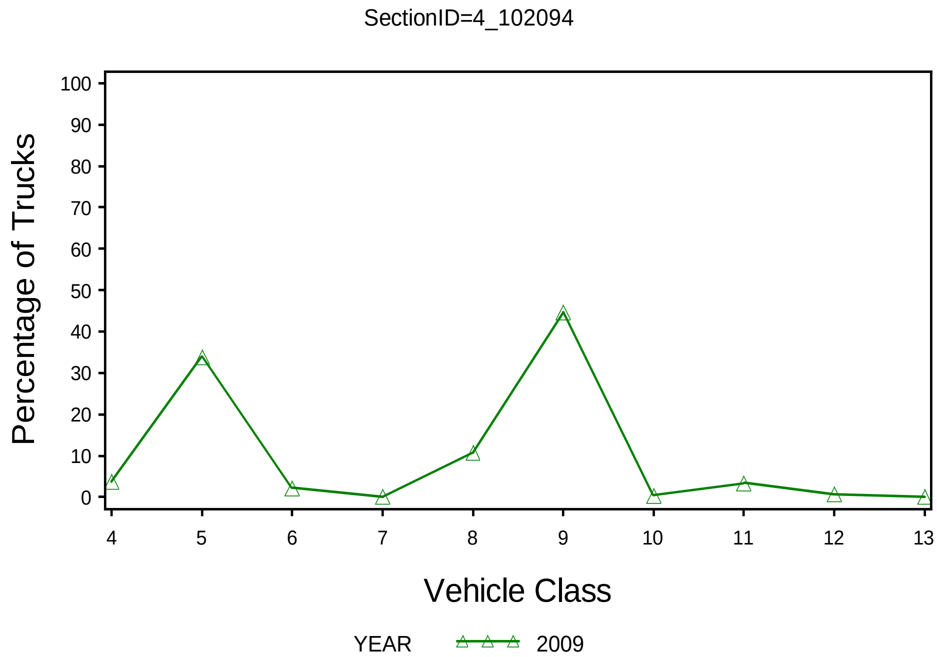


Figure B-42. Plot of Vehicle Class Distribution for Site 4_102094.

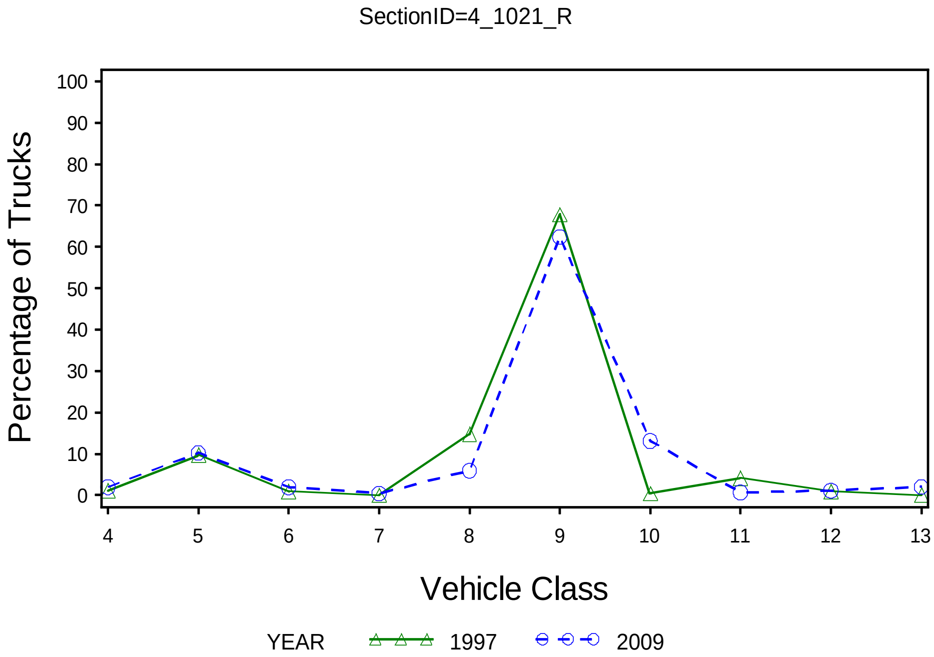


Figure B-43. Plot of Vehicle Class Distribution for Site 4_1021_R.

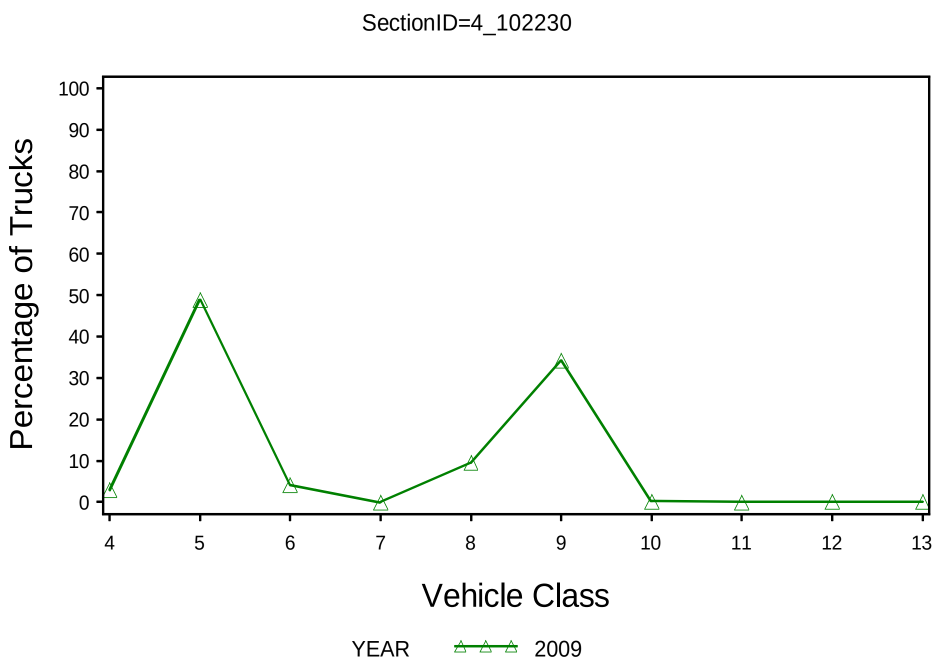


Figure B-44. Plot of Vehicle Class Distribution for Site 4_102230.

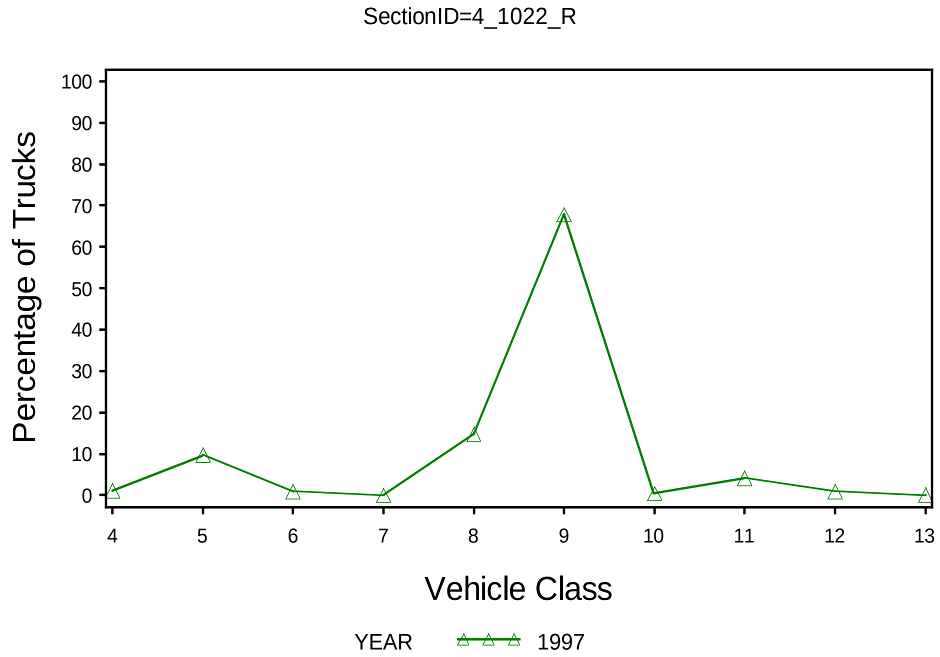


Figure B-45. Plot of Vehicle Class Distribution for Site 4_1022_R.

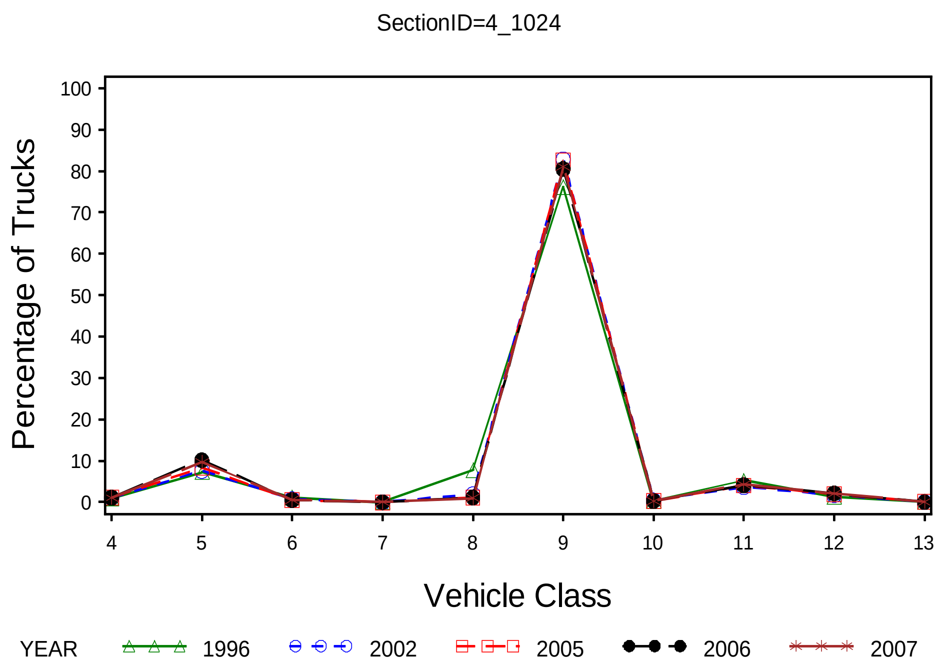


Figure B-46. Plot of Vehicle Class Distribution for Site 4_1024.

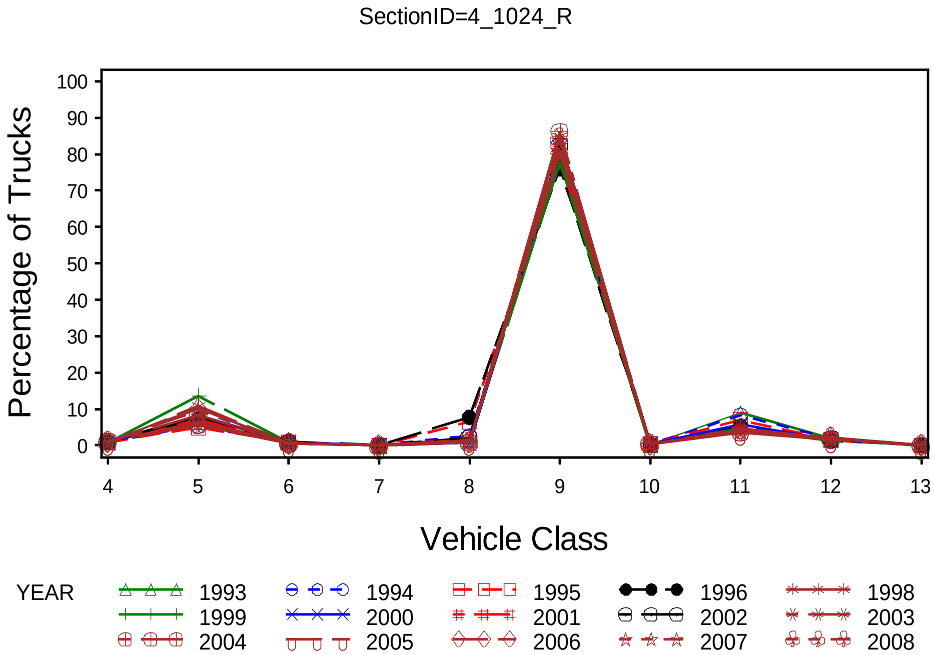


Figure B-47. Plot of Vehicle Class Distribution for Site 4_1024_R.

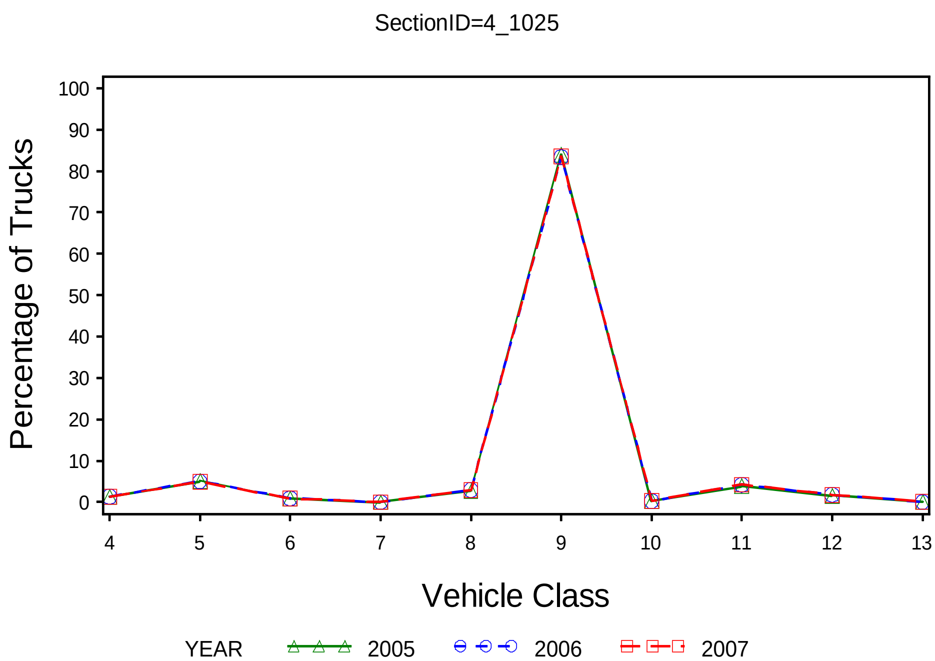


Figure B-48. Plot of Vehicle Class Distribution for Site 4_1025.

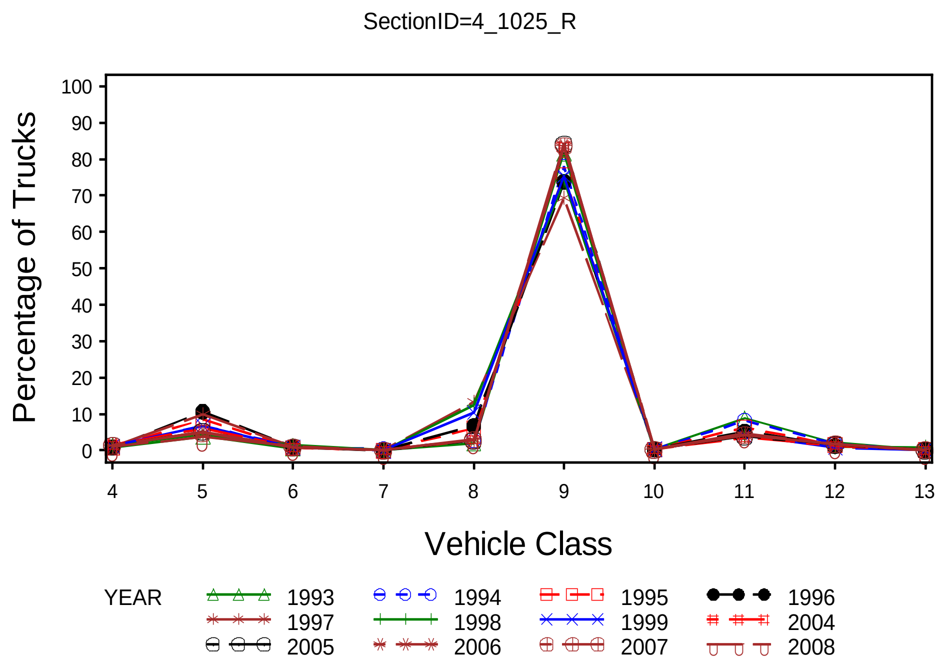


Figure B-49. Plot of Vehicle Class Distribution for Site 4_1025_R.

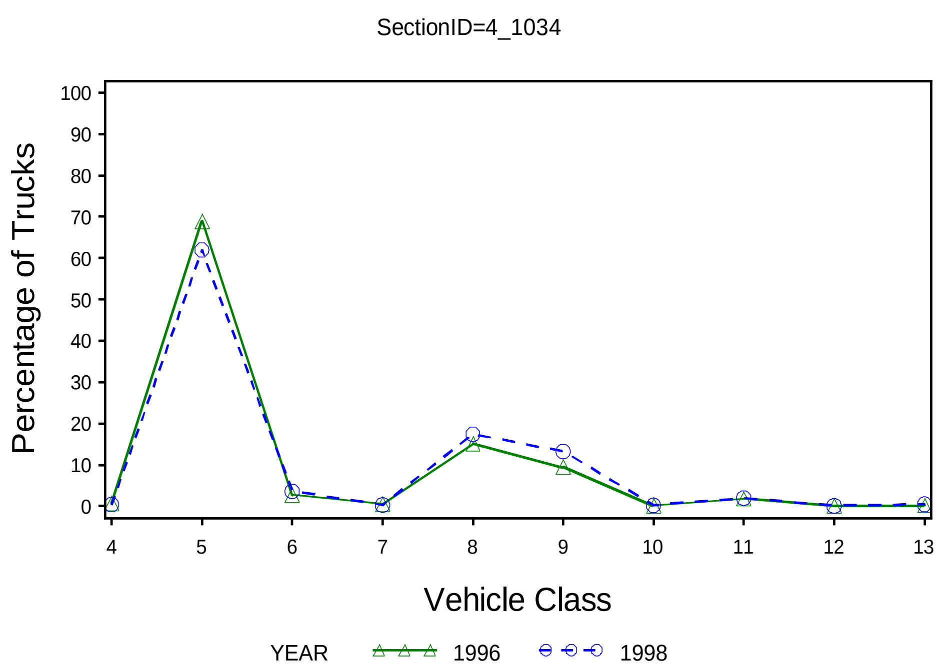


Figure B-50. Plot of Vehicle Class Distribution for Site 4_1034.

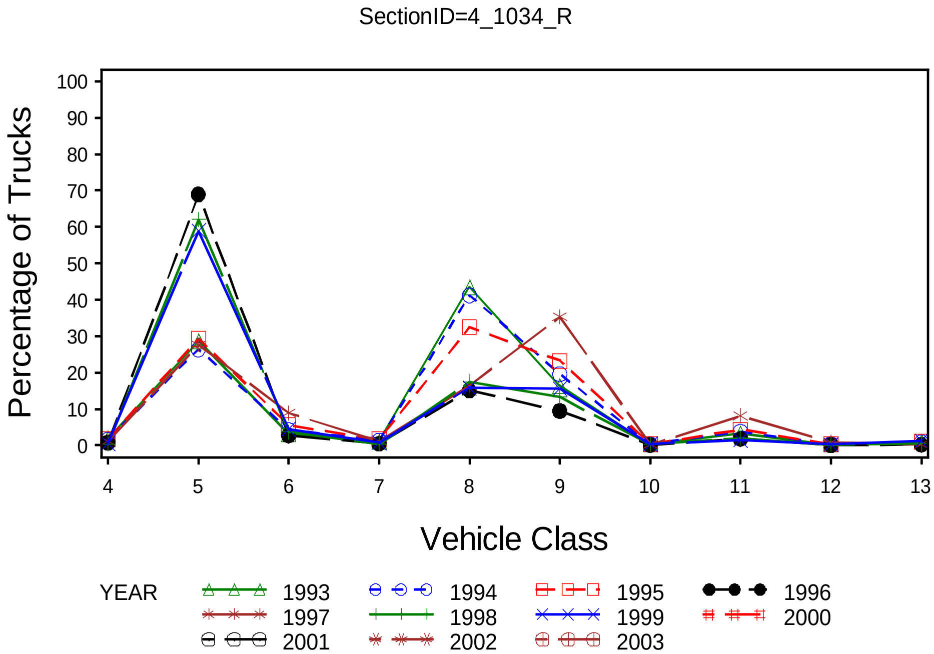


Figure B-51. Plot of Vehicle Class Distribution for Site 4_1034_R.

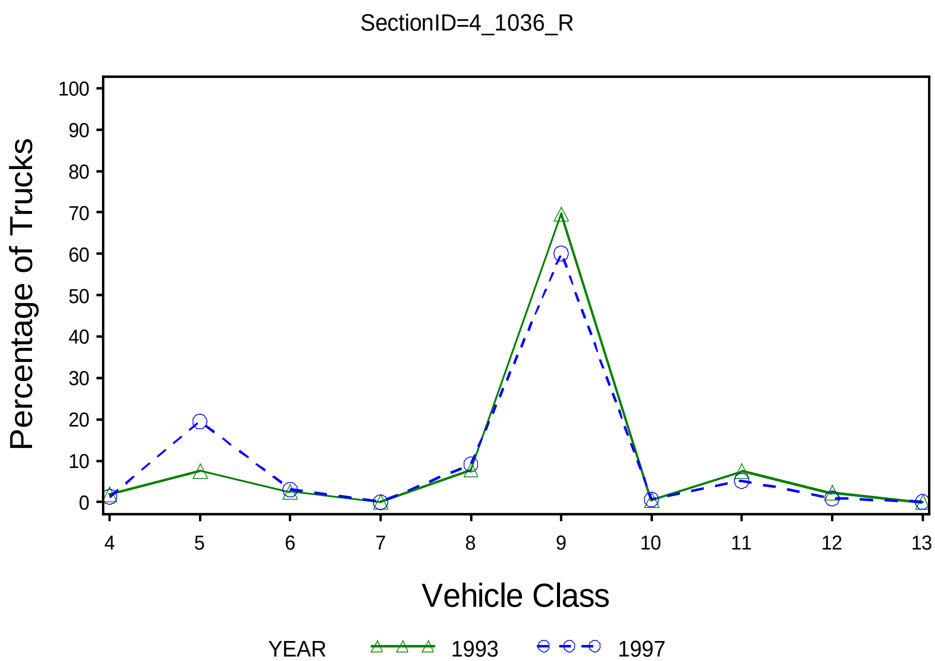


Figure B-52. Plot of Vehicle Class Distribution for Site 4_1036_R.

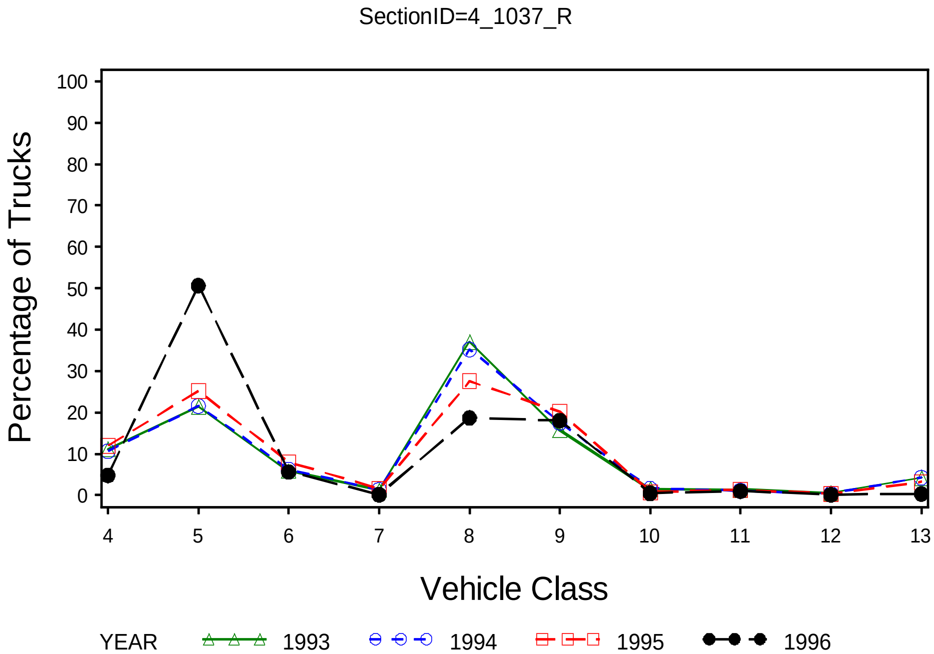


Figure B-53. Plot of Vehicle Class Distribution for Site 4_1037_R.

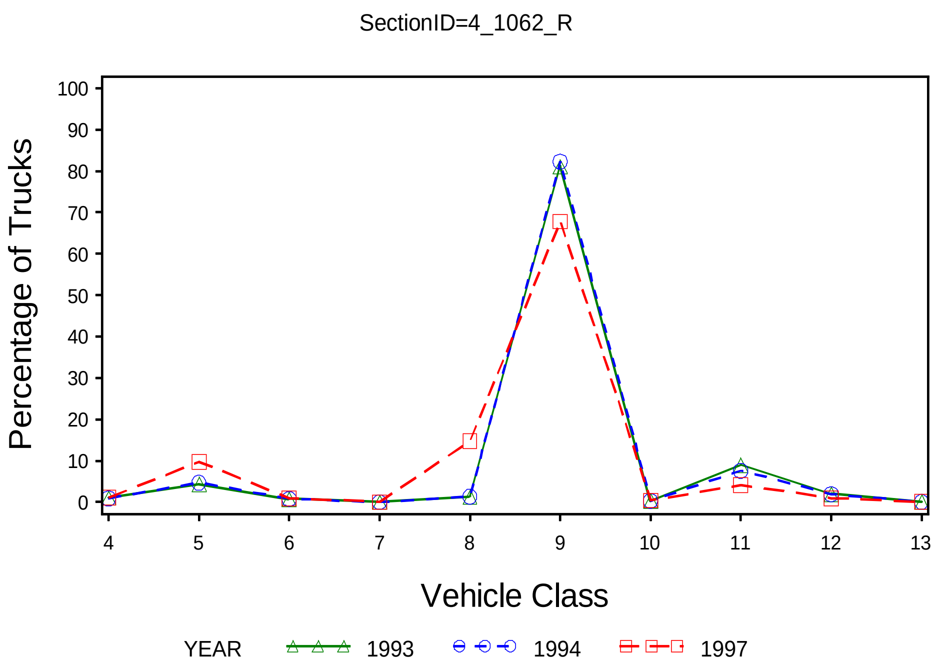


Figure B-54. Plot of Vehicle Class Distribution for Site 4_1062_R.

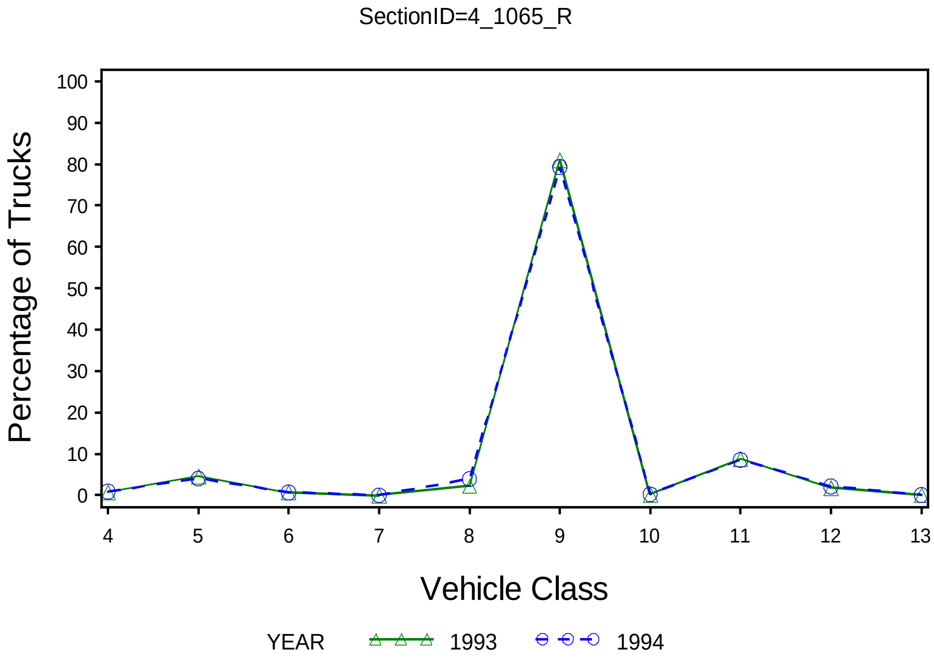


Figure B-55. Plot of Vehicle Class Distribution for Site 4_1065_R.

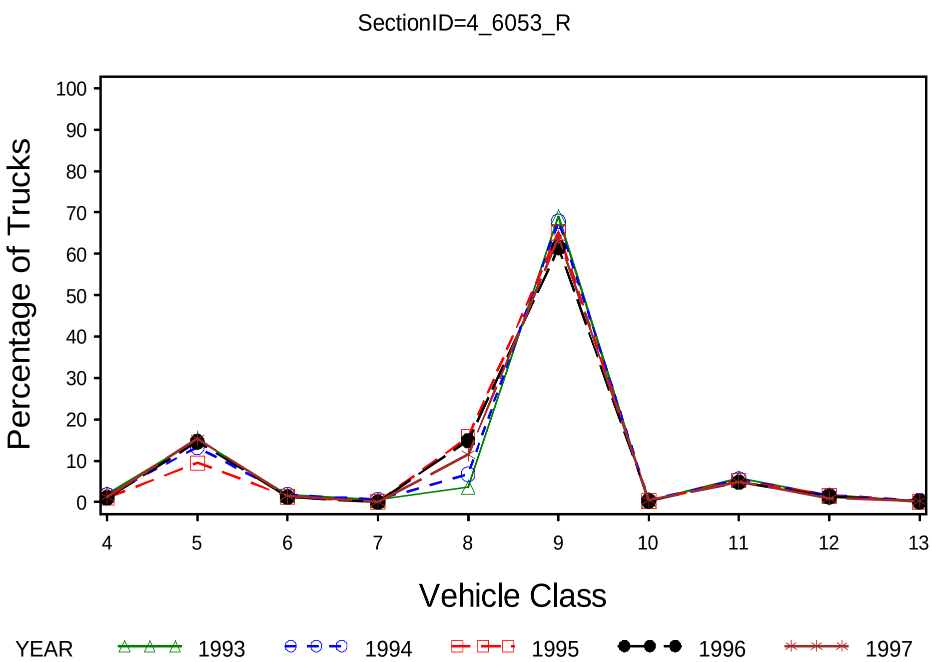


Figure B-56. Plot of Vehicle Class Distribution for Site 4_6053_R.

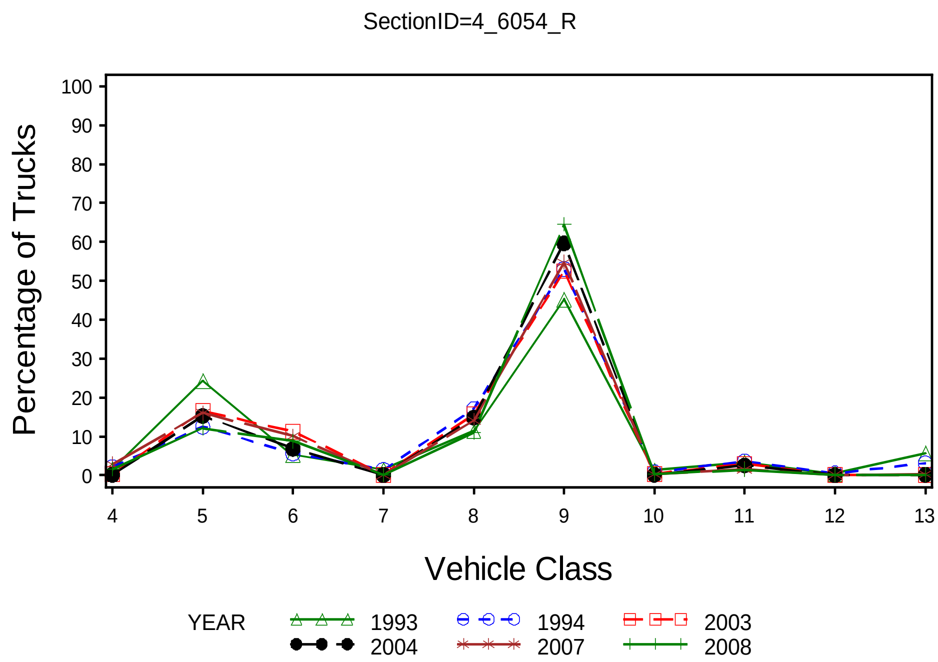


Figure B-57. Plot of Vehicle Class Distribution for Site 4_6054_R.

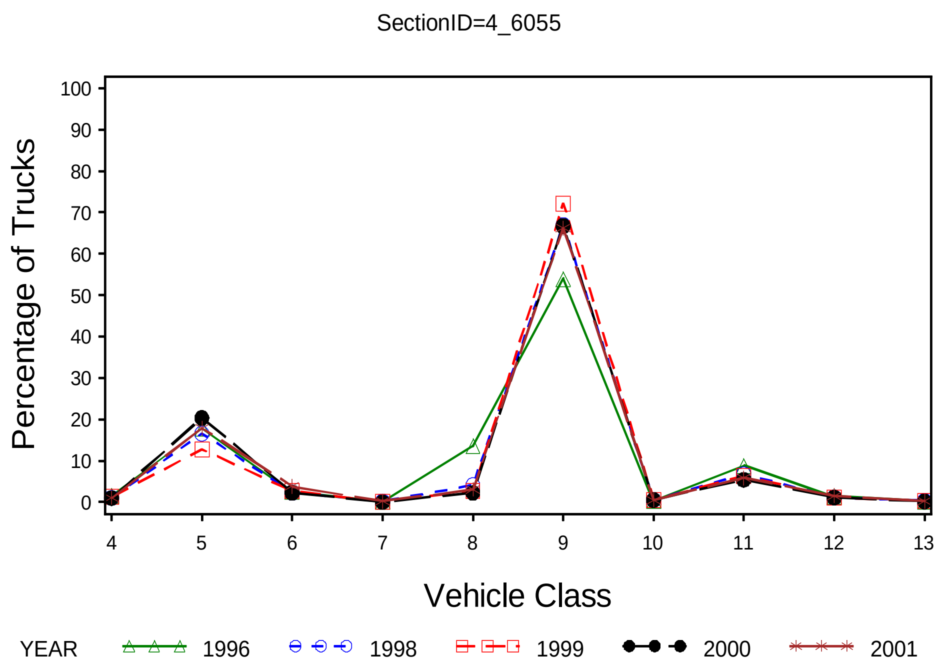


Figure B-58. Plot of Vehicle Class Distribution for Site 4_6055.

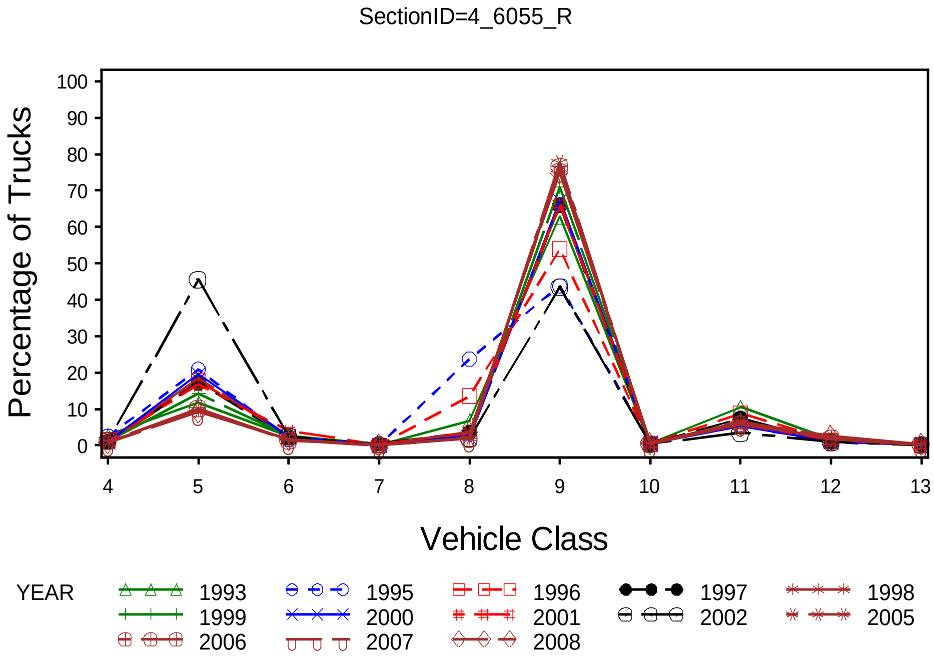


Figure B-59. Plot of Vehicle Class Distribution for Site 4_6055_R.

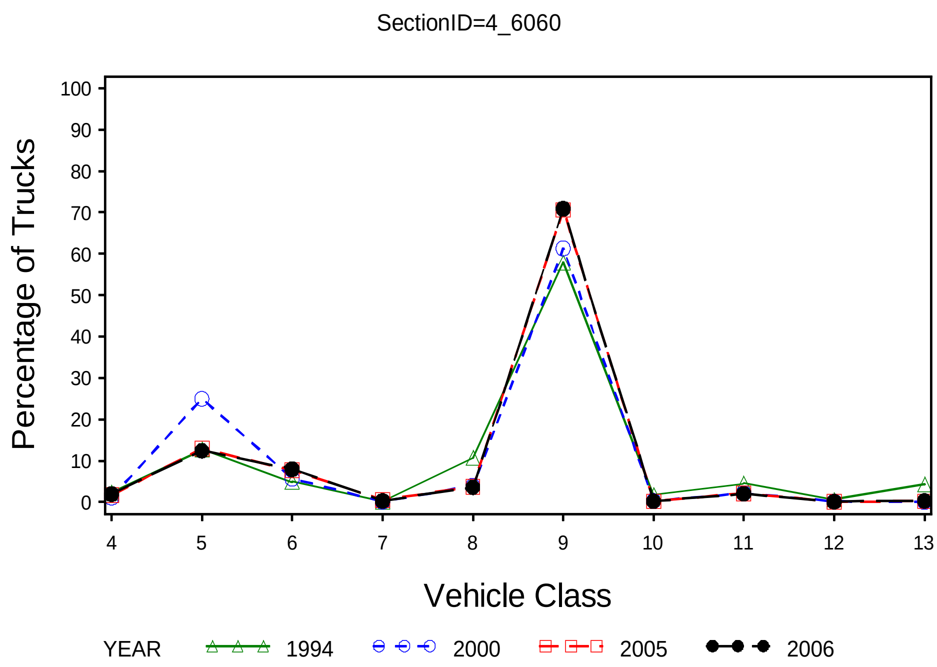


Figure B-60. Plot of Vehicle Class Distribution for Site 4_6060.

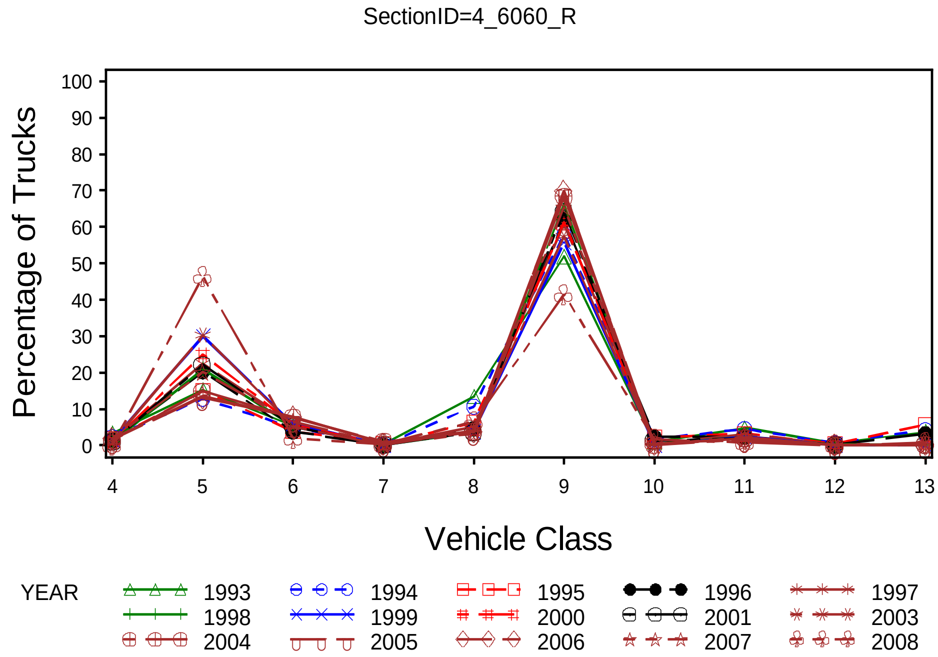


Figure B-61. Plot of Vehicle Class Distribution for Site 4_6060_R.

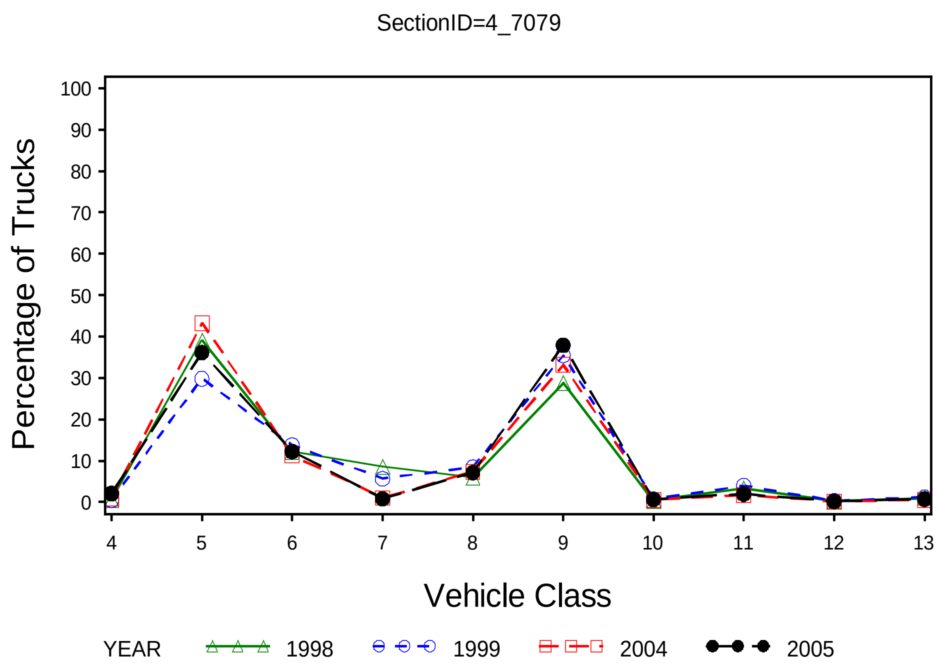


Figure B-62. Plot of Vehicle Class Distribution for Site 4_7079.

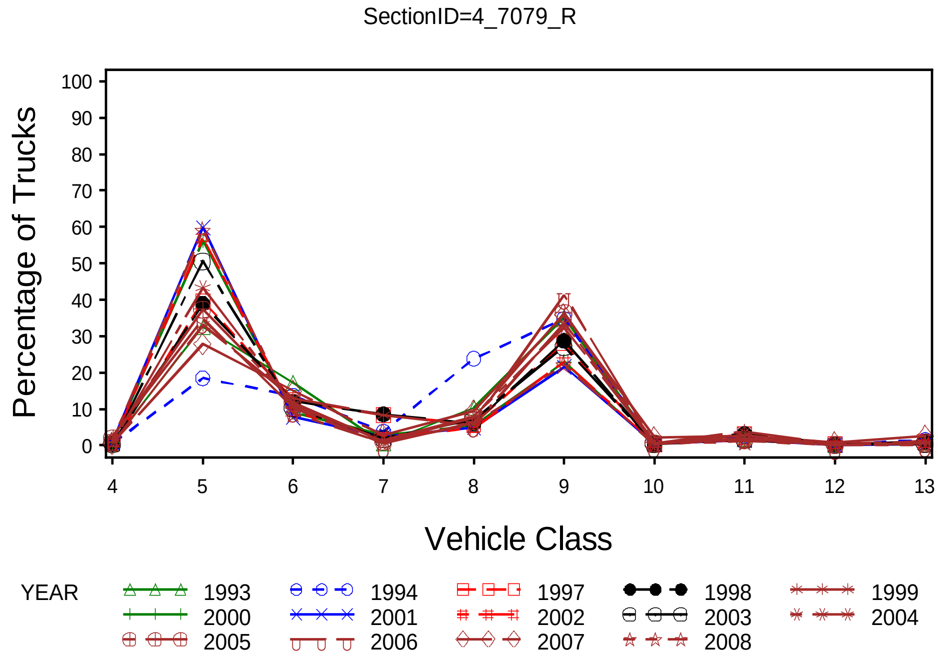


Figure B-63. Plot of Vehicle Class Distribution for Site 4_7079_R.

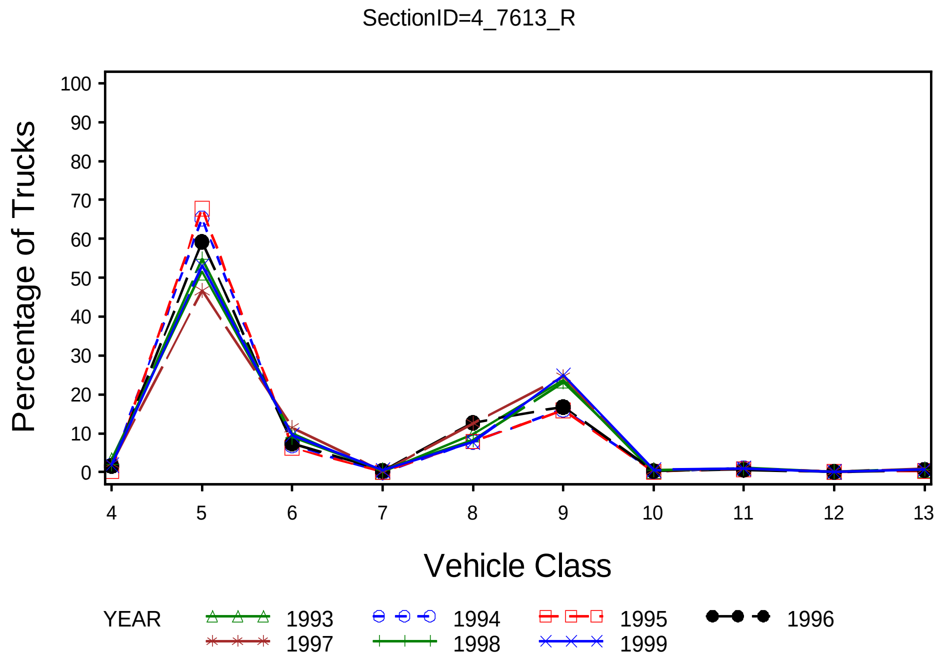


Figure B-64. Plot of Vehicle Class Distribution for Site 4_7613_R.

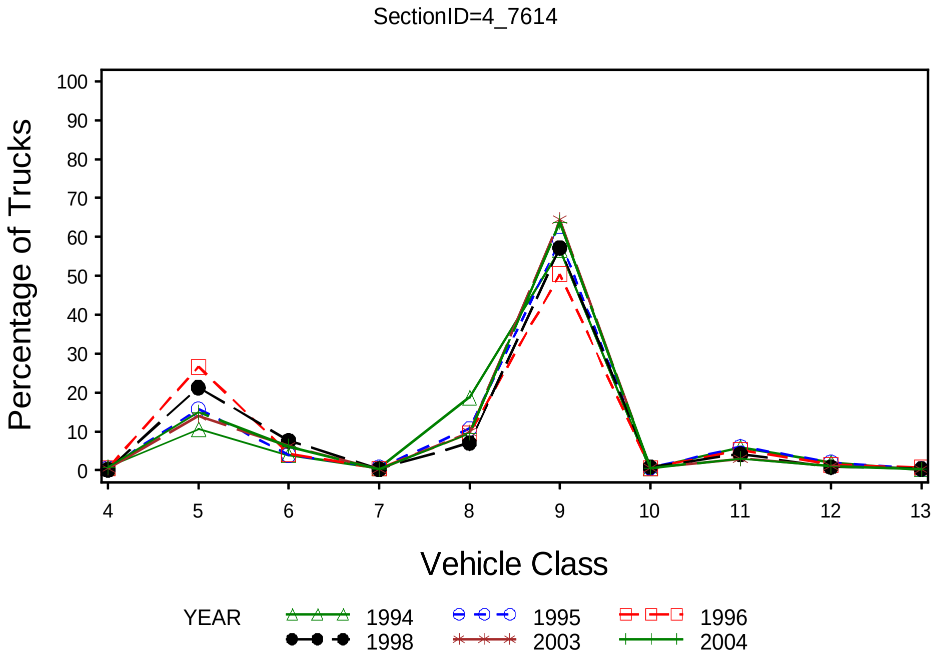


Figure B-65. Plot of Vehicle Class Distribution for Site 4_7614.

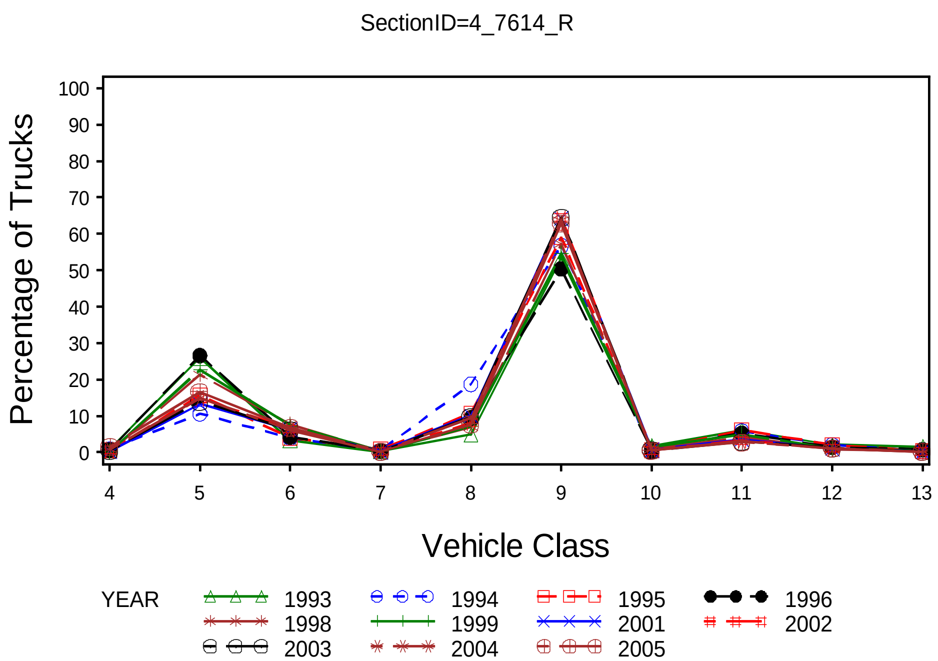


Figure B-66. Plot of Vehicle Class Distribution for Site 4_7614_R.

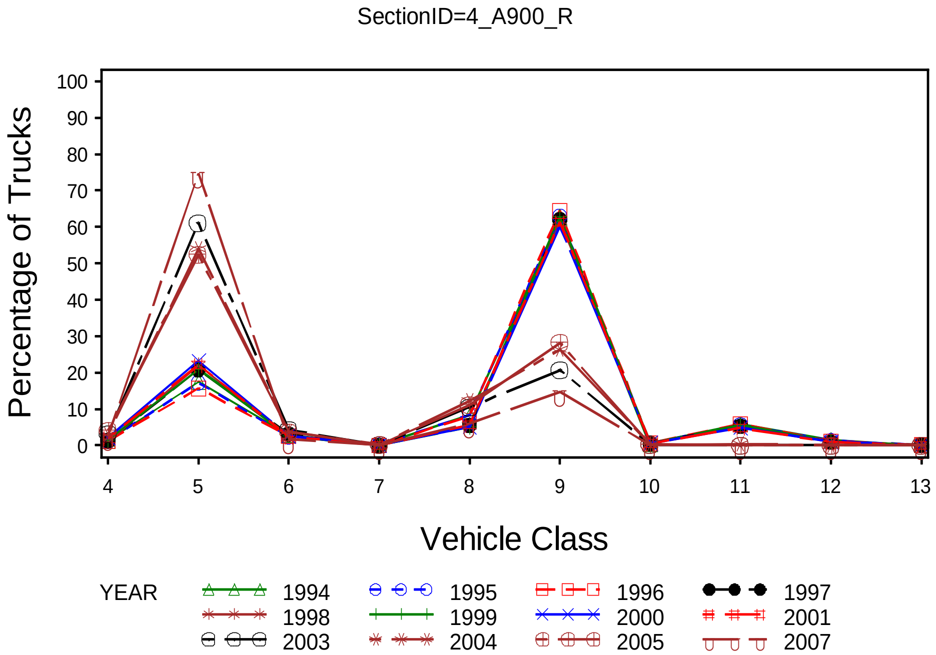


Figure B-67. Plot of Vehicle Class Distribution for Site 4_A900_R.

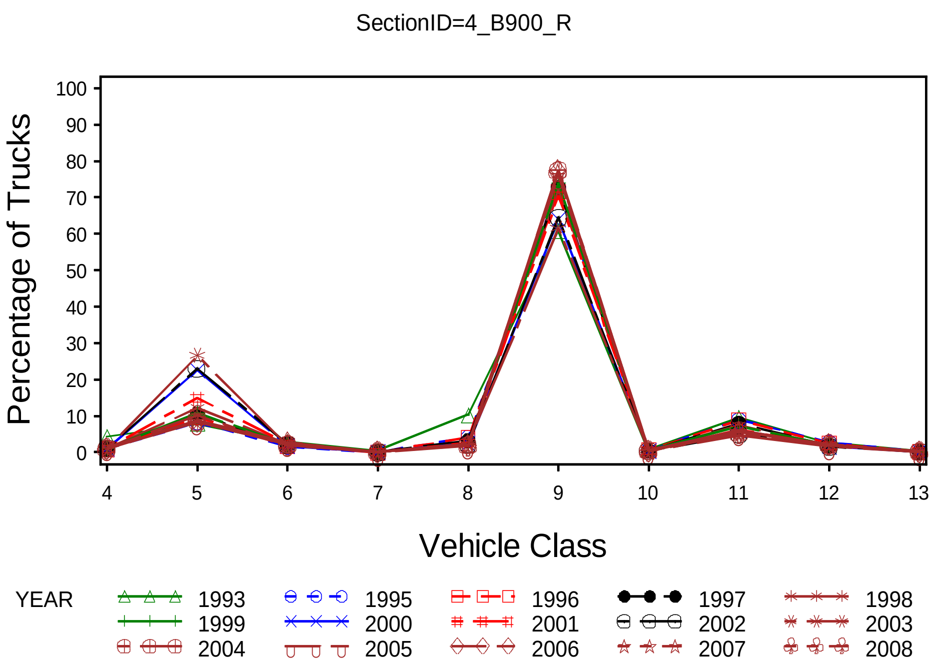


Figure B-68. Plot of Vehicle Class Distribution for Site 4_B900_R.

APPENDIX C. SUMMARY OF HOURLY TRUCK DISTRIBUTION DATA USED FOR ANALYSIS

This appendix presents plots of hourly truck distribution for Arizona projects for which these data were available. Note that not all of the data presented in this appendix were included in the analysis, as some data were deemed atypical, anomalous, or erroneous.

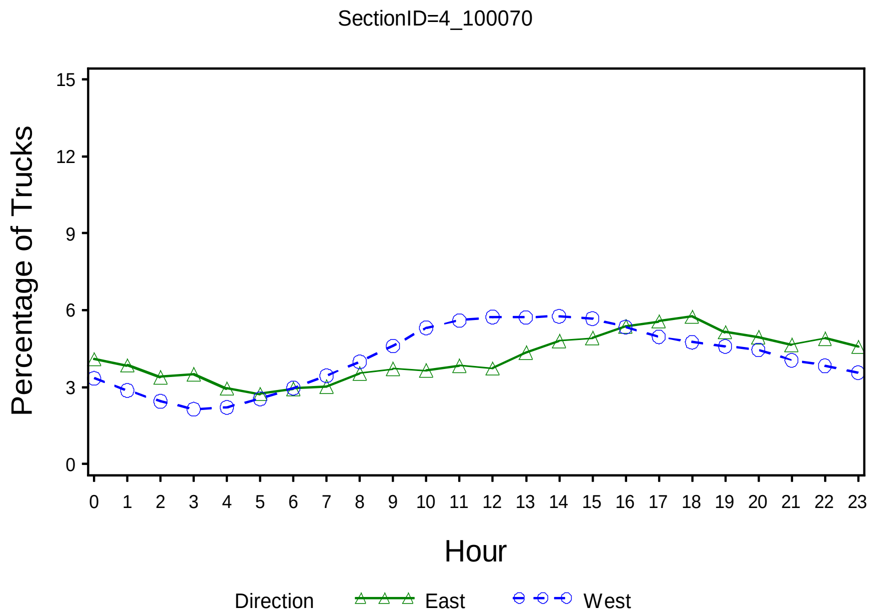


Figure C-1. Plot of Hourly Distribution for Site 4_100070.

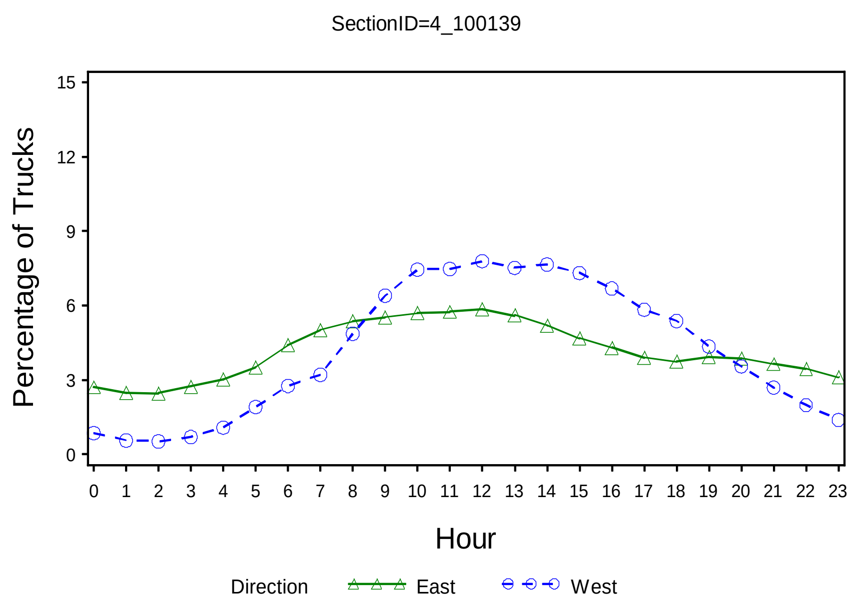


Figure C-2. Plot of Hourly Distribution for Site 4_100139.

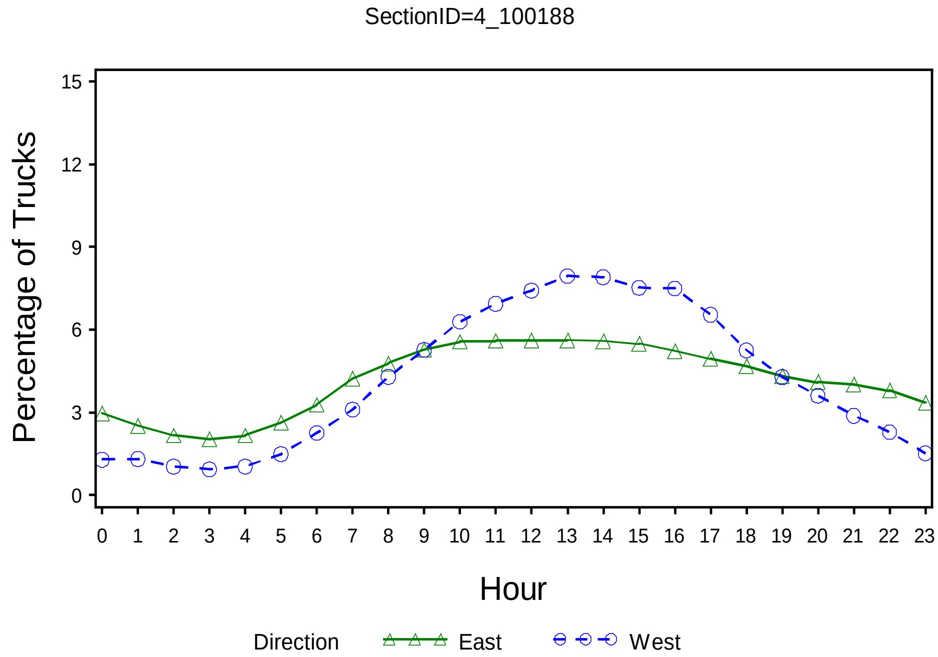


Figure C-3. Plot of Hourly Distribution for Site 4_100188.

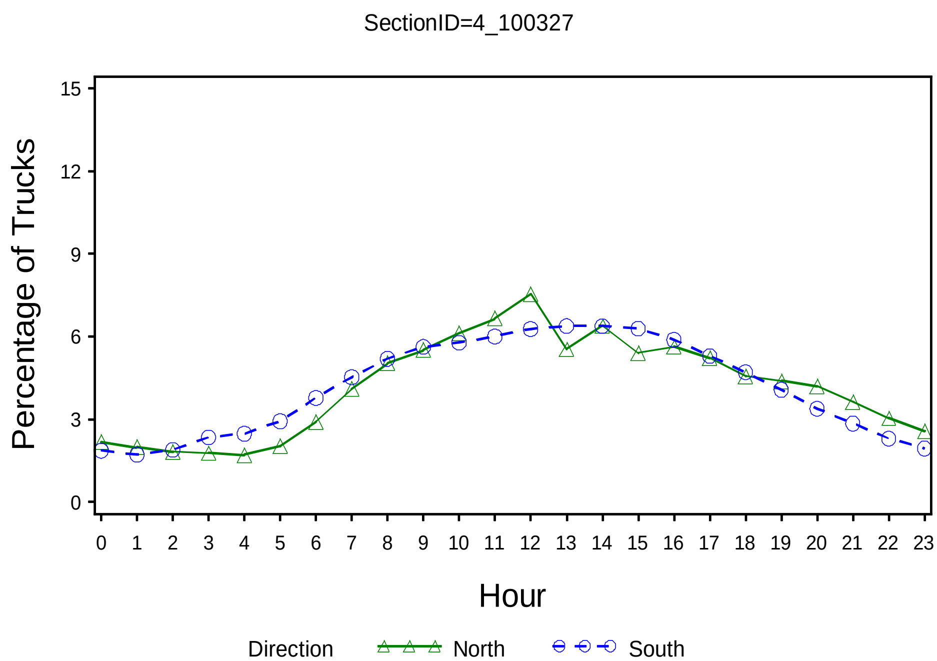


Figure C-4. Plot of Hourly Distribution for Site 4_100327.

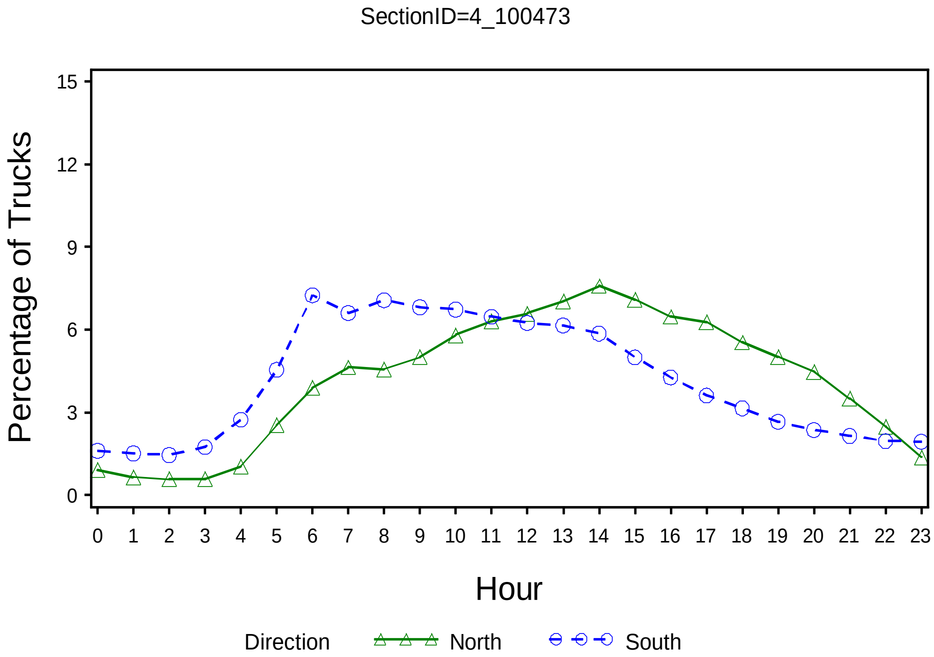


Figure C-5. Plot of Hourly Distribution for Site 4_100473.

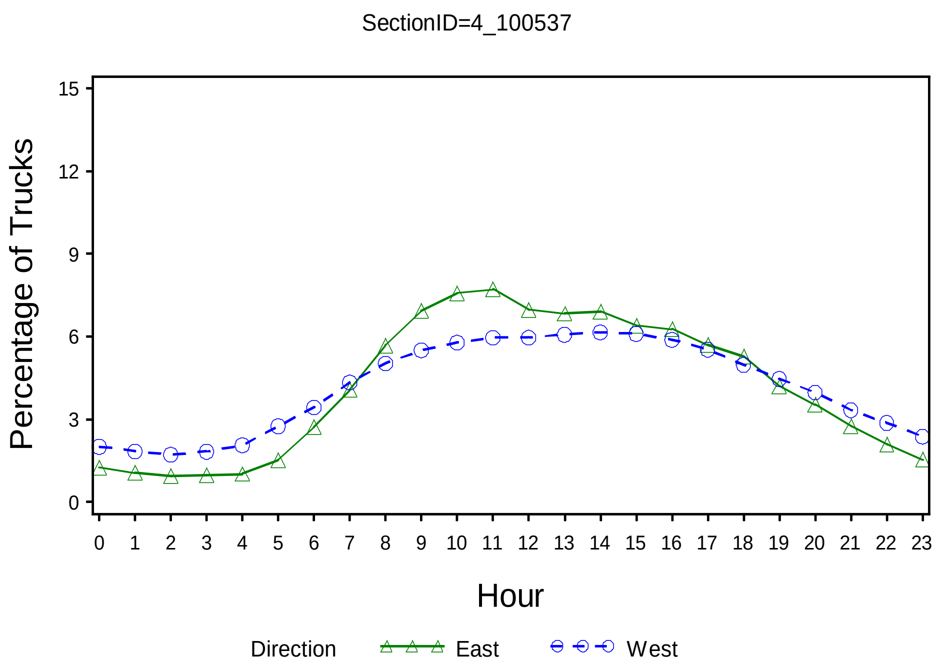


Figure C-6. Plot of Hourly Distribution for Site 4_100537.

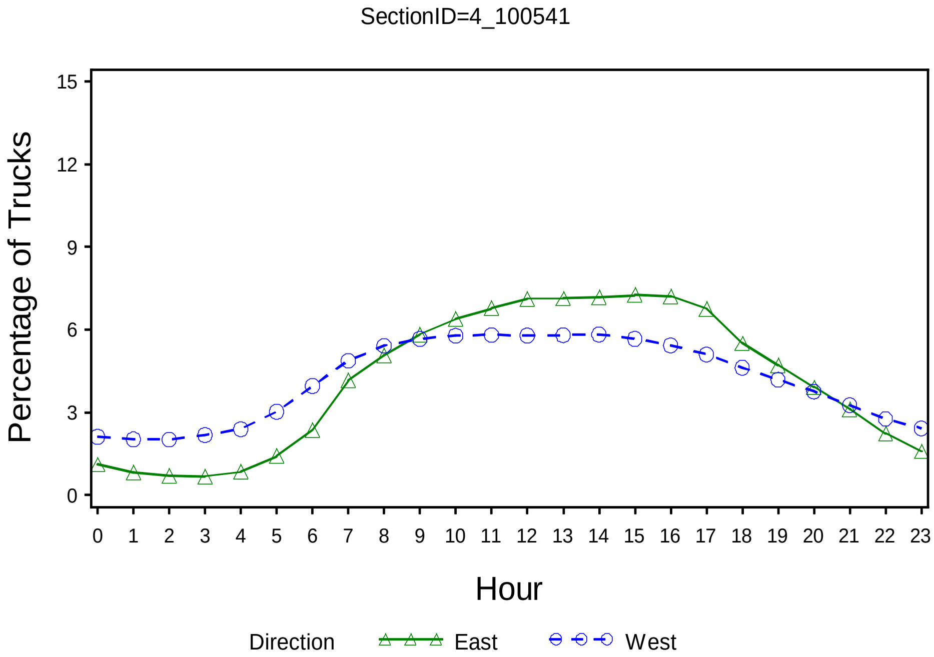


Figure C-7. Plot of Hourly Distribution for Site 4_100541.

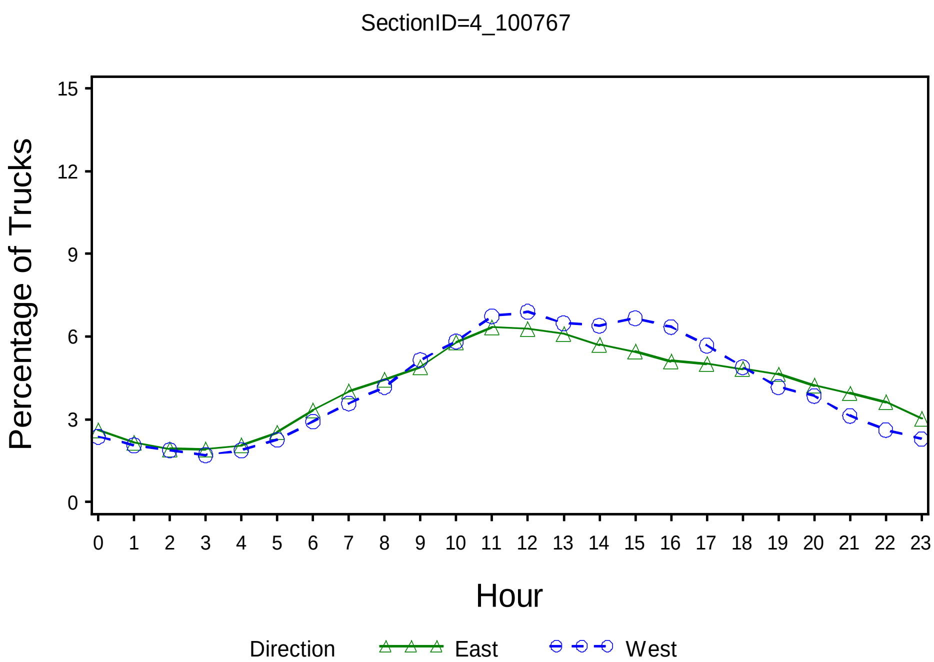


Figure C-8. Plot of Hourly Distribution for Site 4_100767.

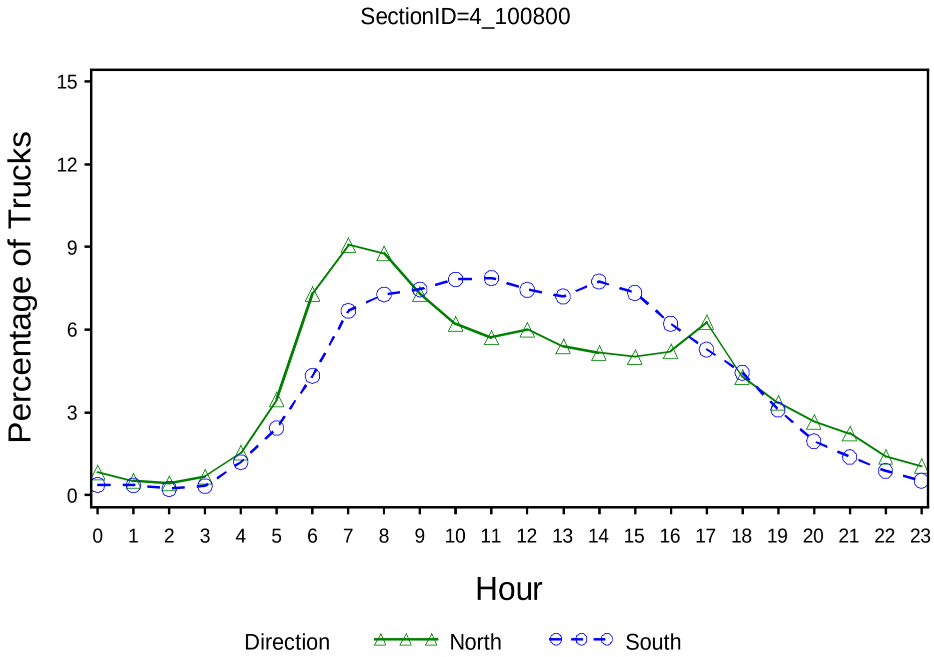


Figure C-9. Plot of Hourly Distribution for Site 4_100800.

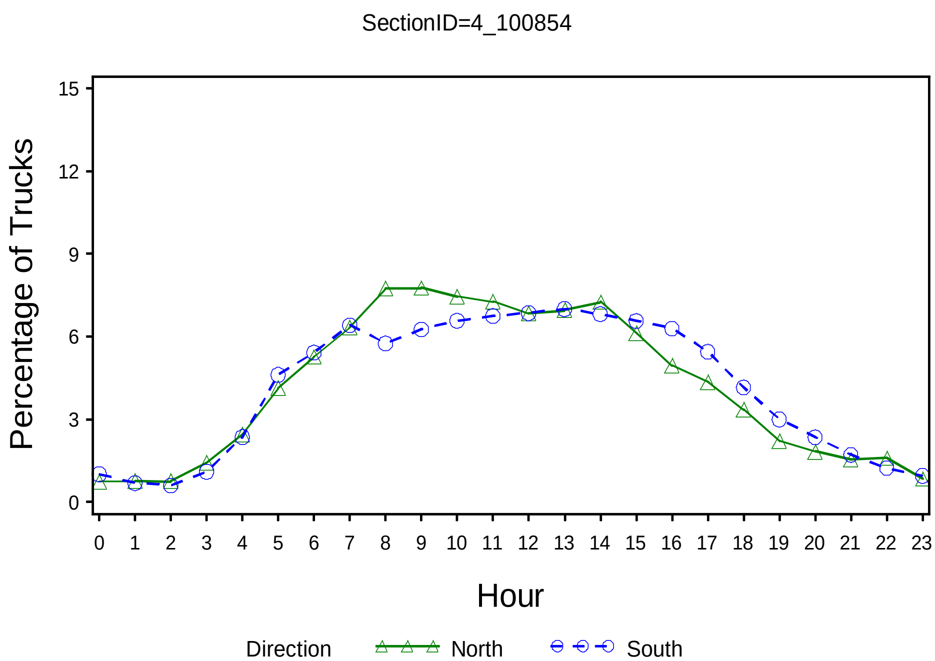


Figure C-10. Plot of Hourly Distribution for Site 4_100854.

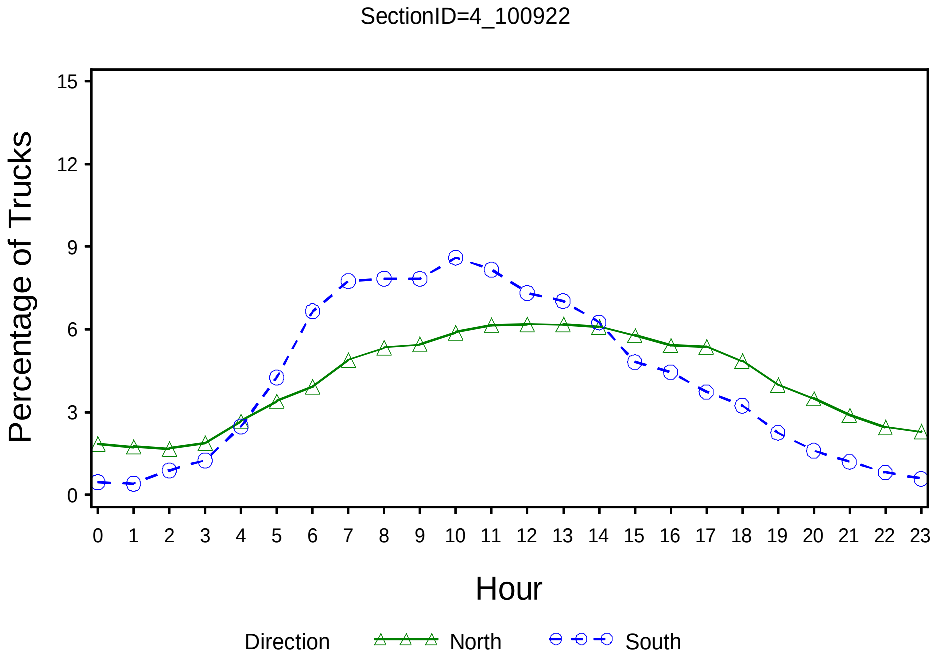


Figure C-11. Plot of Hourly Distribution for Site 4_100922.

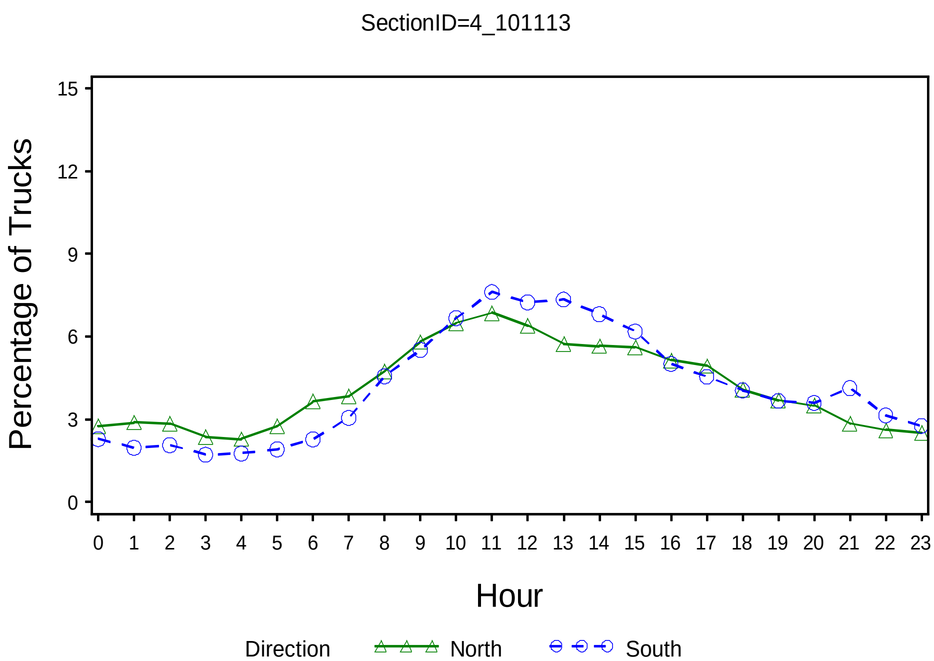


Figure C-12. Plot of Hourly Distribution for Site 4_101113.

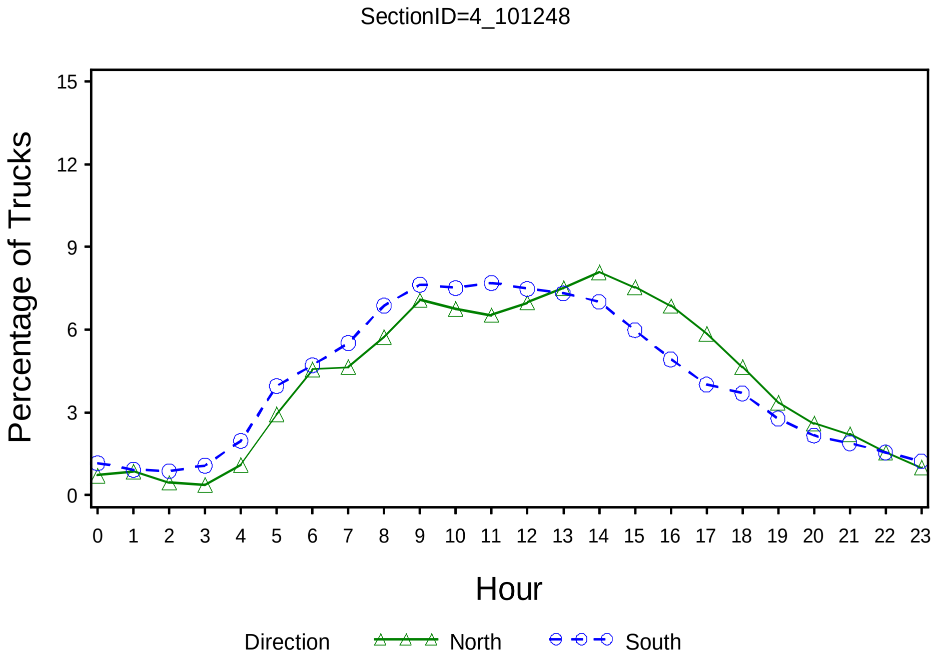


Figure C-13. Plot of Hourly Distribution for Site 4_101248.

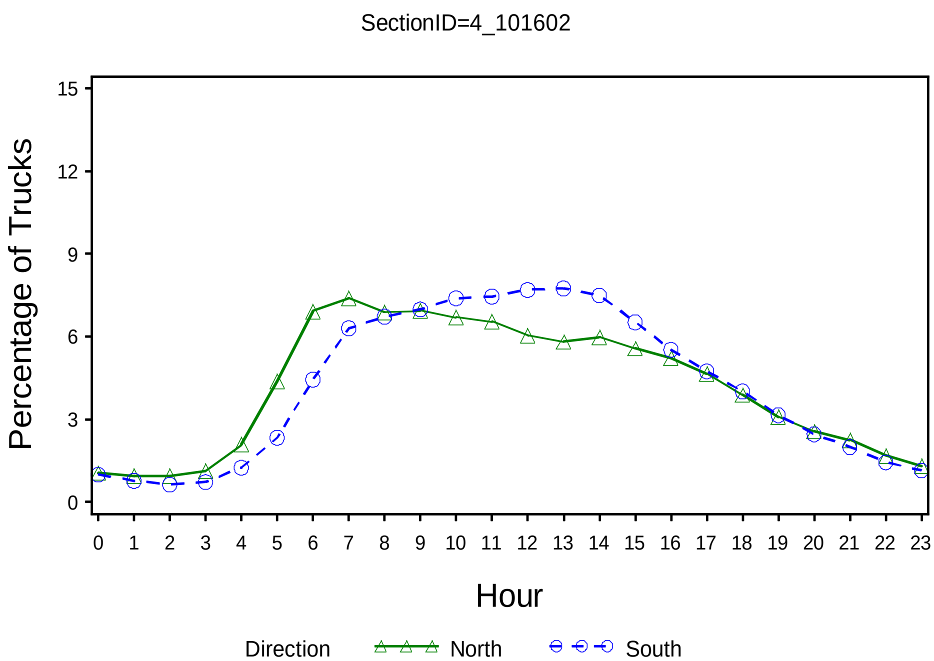


Figure C-14. Plot of Hourly Distribution for Site 4_101602.

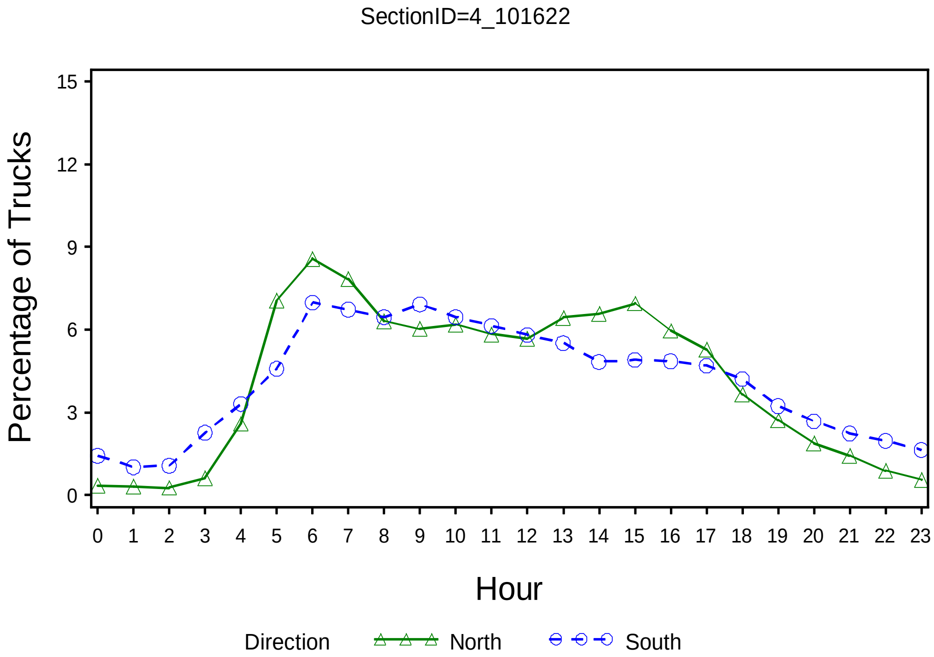


Figure C-15. Plot of Hourly Distribution for Site 4_101622.

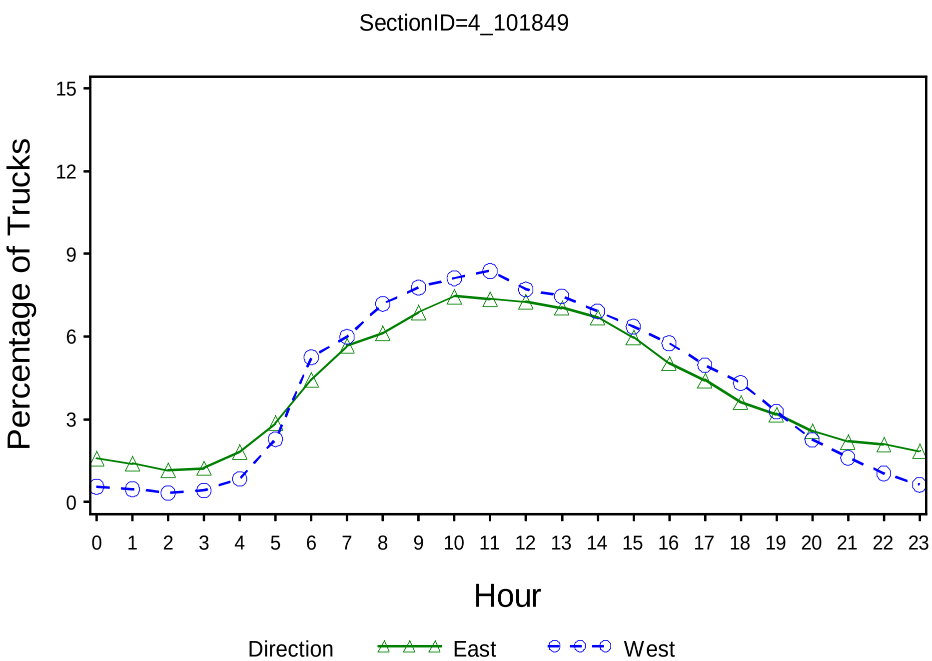


Figure C-16. Plot of Hourly Distribution for Site 4_101849.

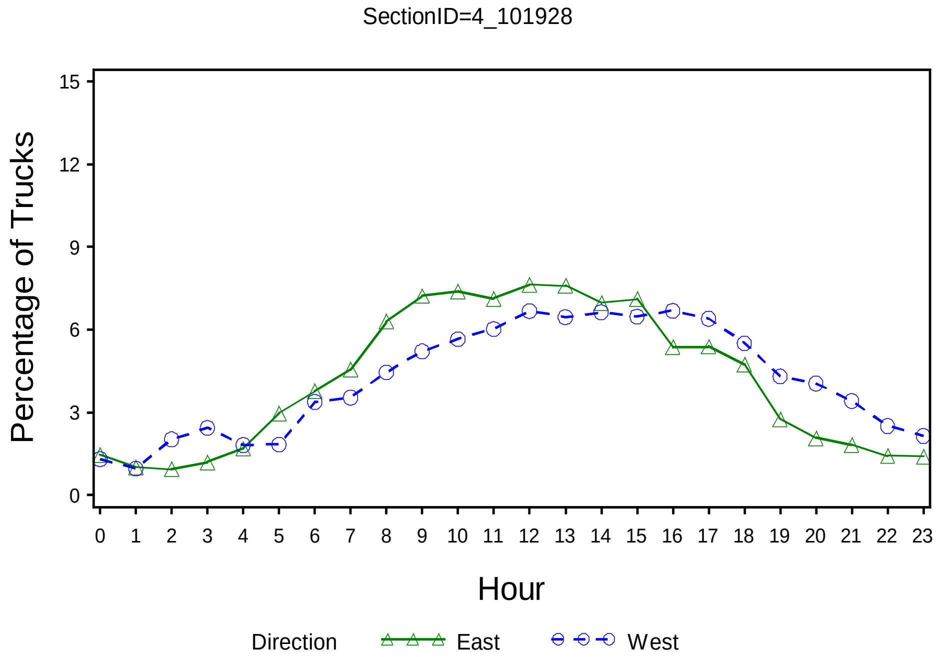


Figure C-17. Plot of Hourly Distribution for Site 4_101928.

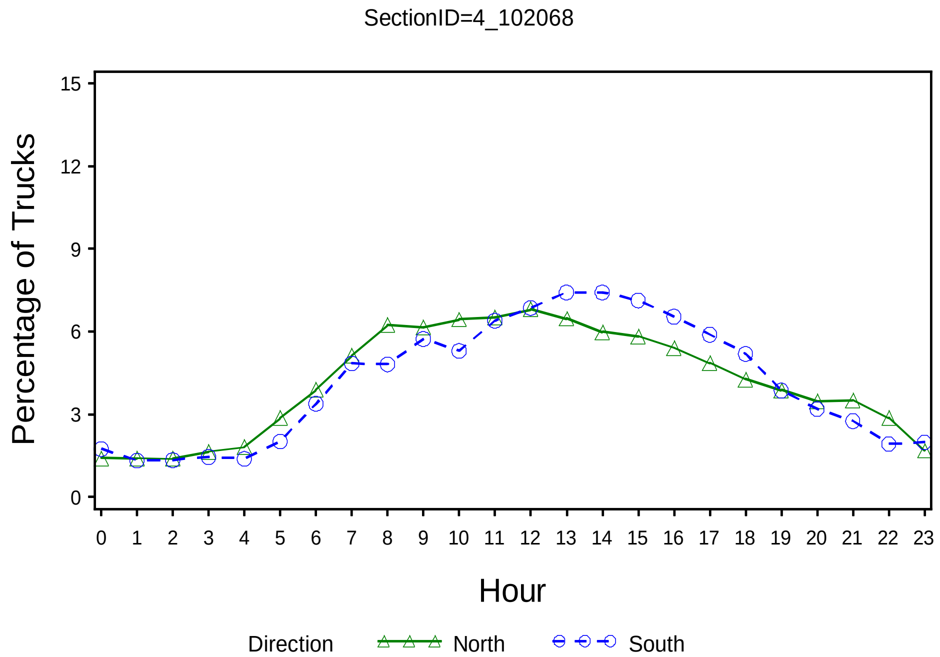


Figure C-18. Plot of Hourly Distribution for Site 4_102068.

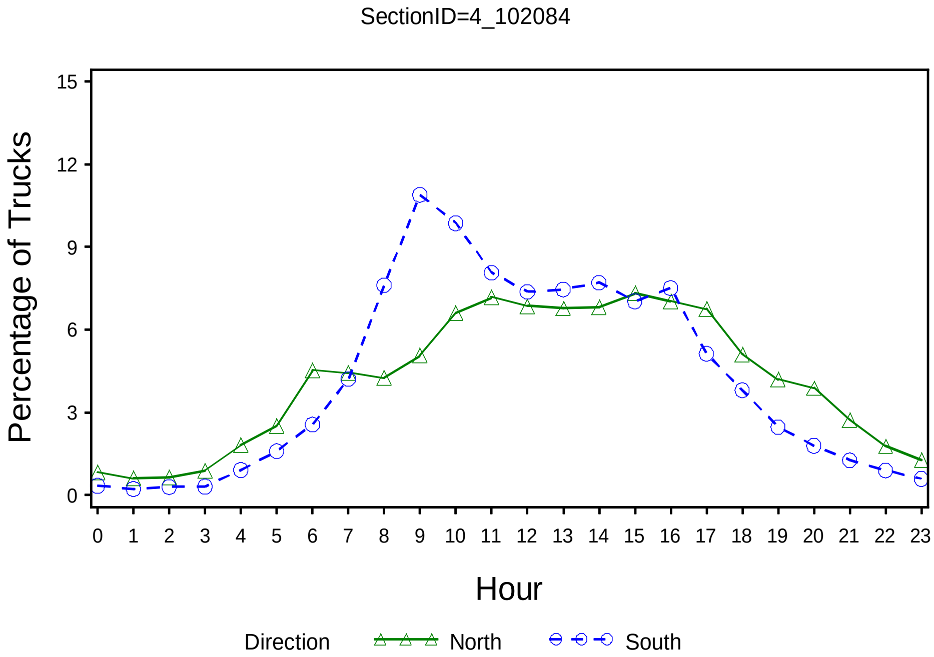


Figure C-19. Plot of Hourly Distribution for Site 4_102084.

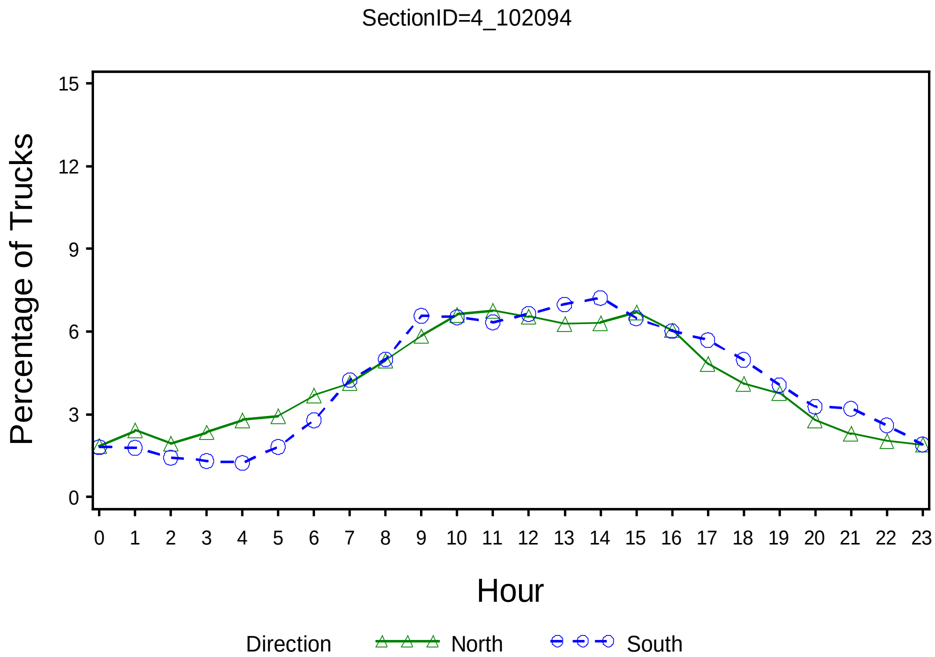


Figure C-20. Plot of Hourly Distribution for Site 4_102094.

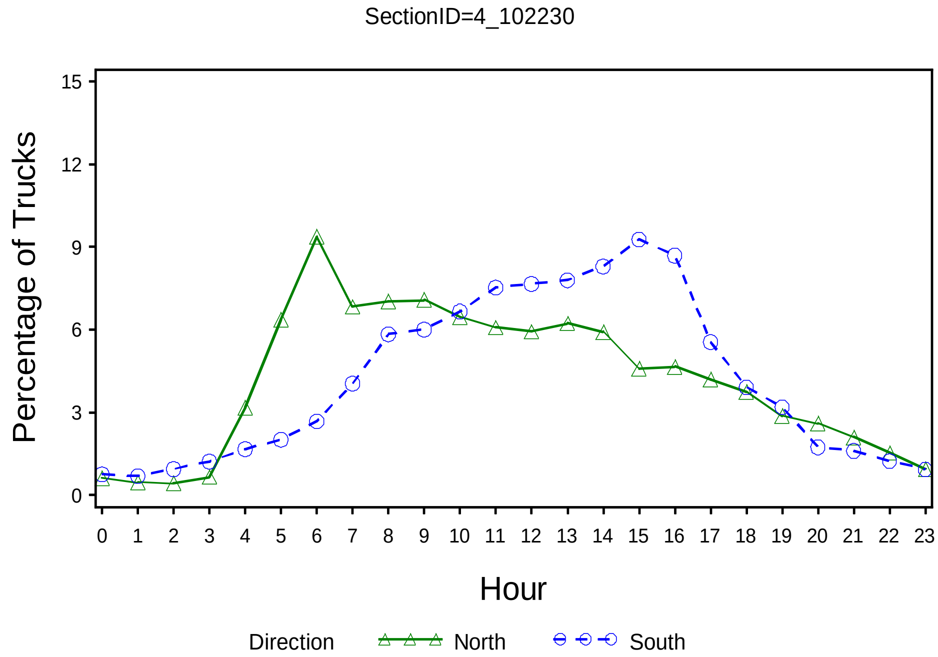


Figure C-21. Plot of Hourly Distribution for Site 4_102230.

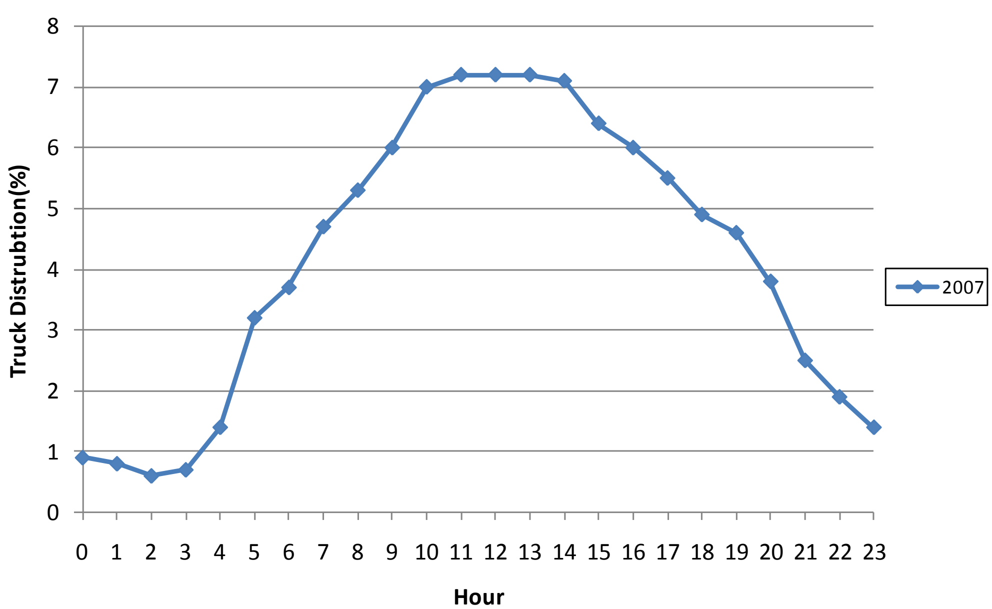


Figure C-22. Hourly Truck Distribution for Site 4_0100.

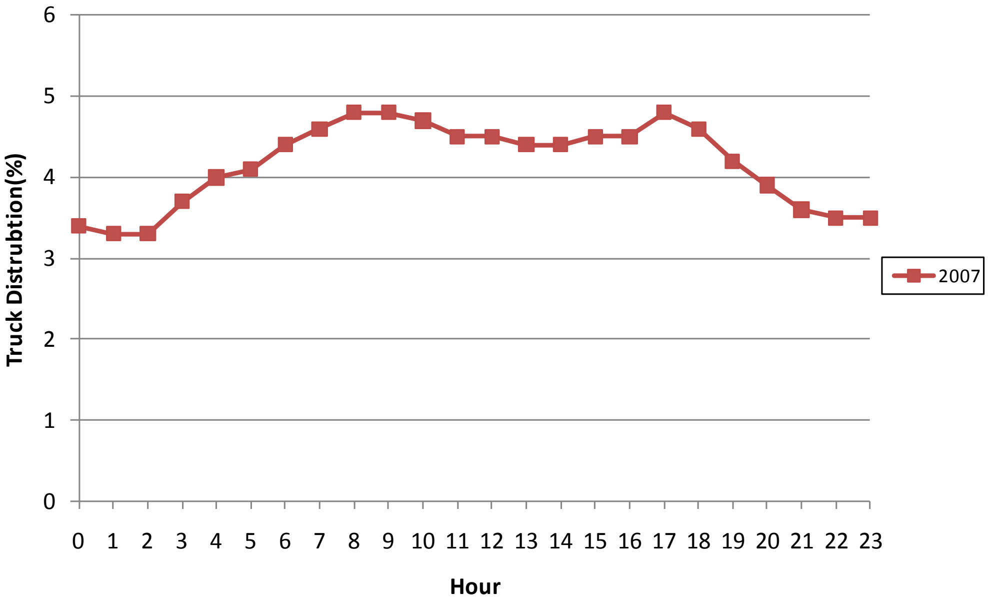


Figure C-23. Hourly Truck Distribution for Site 4_0200.

APPENDIX D. SUMMARY OF MAF DATA USED FOR ANALYSIS

This appendix presents plots of MAF for Arizona projects that had the required data. Note that not all of the data presented in this appendix were included in the analysis, as some data were deemed atypical, anomalous, or erroneous.

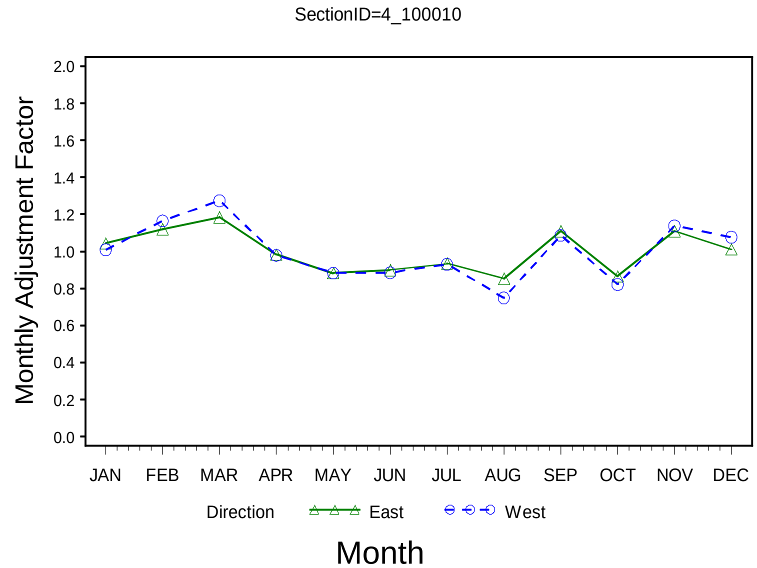


Figure D-1. Plot of Monthly Adjustment Factor for Site 4_100010 (Vehicle Class 5).

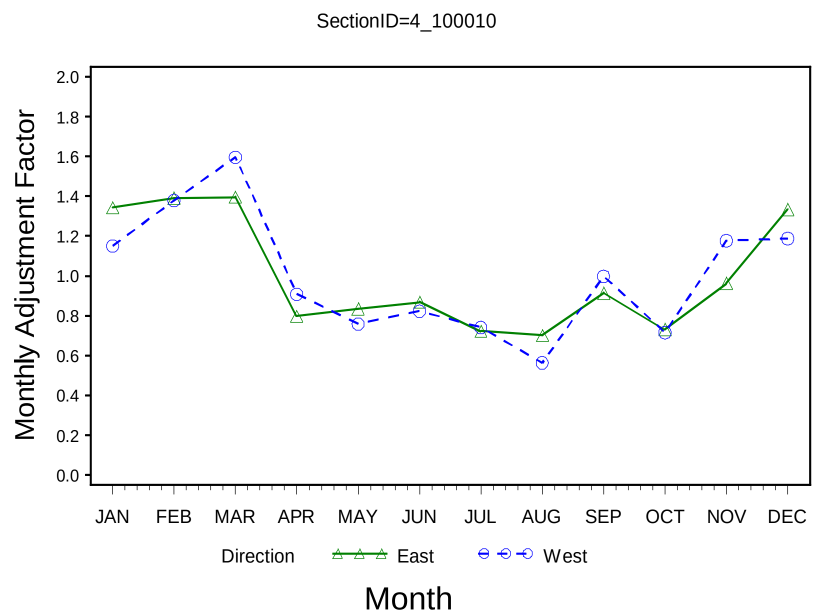


Figure D-2. Plot of Monthly Adjustment Factor for Site 4_100010 (Vehicle Class 9).

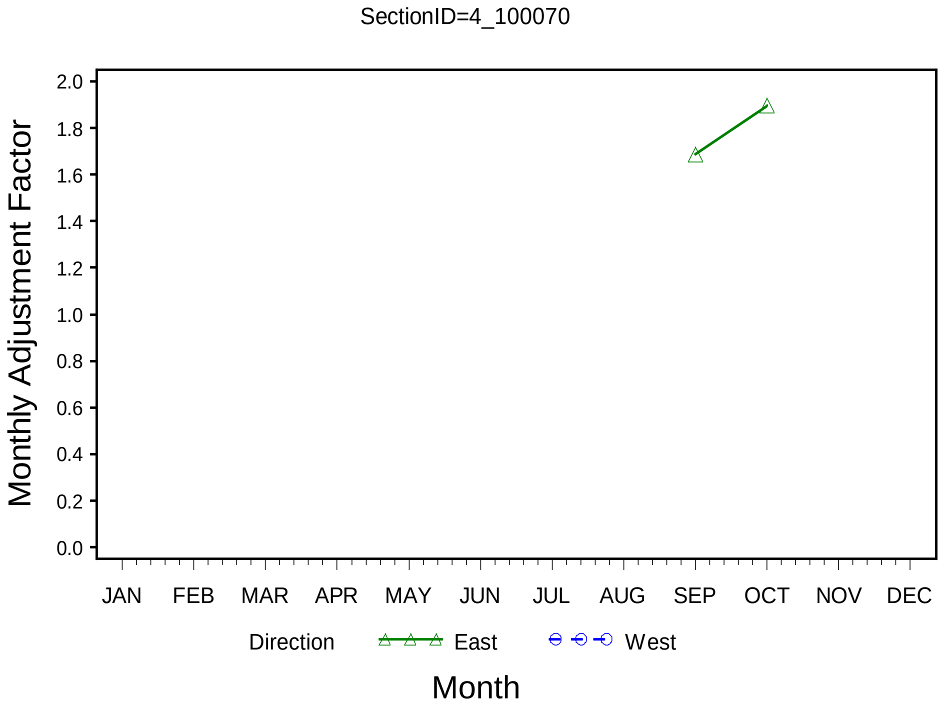


Figure D-3. Plot of Monthly Adjustment Factor for Site 4_100070 (Vehicle Class 5).

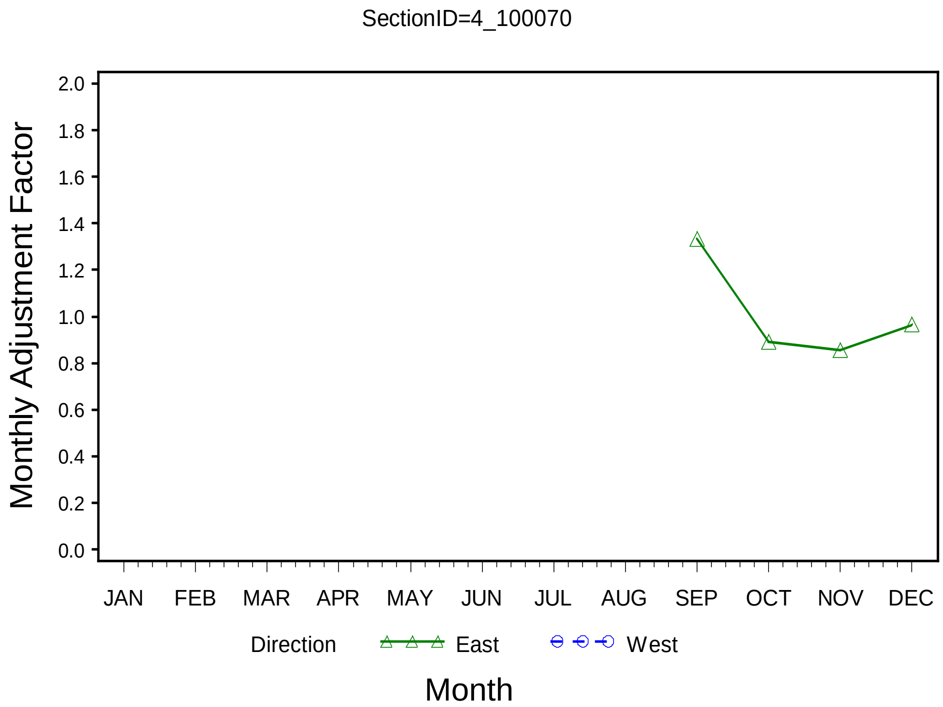


Figure D-4. Plot of Monthly Adjustment Factor for Site 4_100070 (Vehicle Class 9).

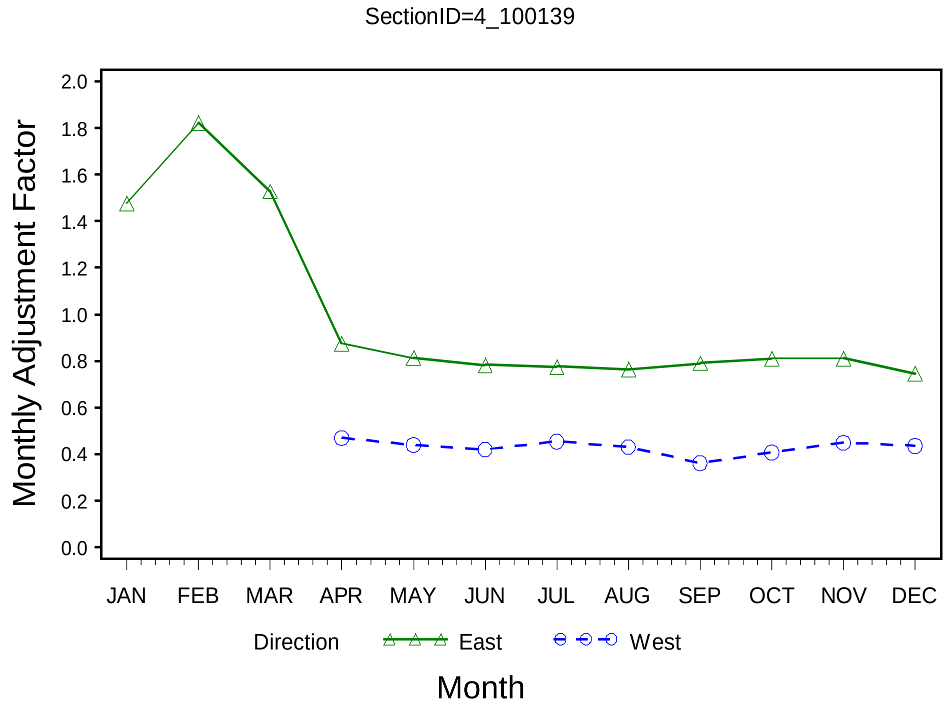


Figure D-5. Plot of Monthly Adjustment Factor for Site 4_100139 (Vehicle Class 5).

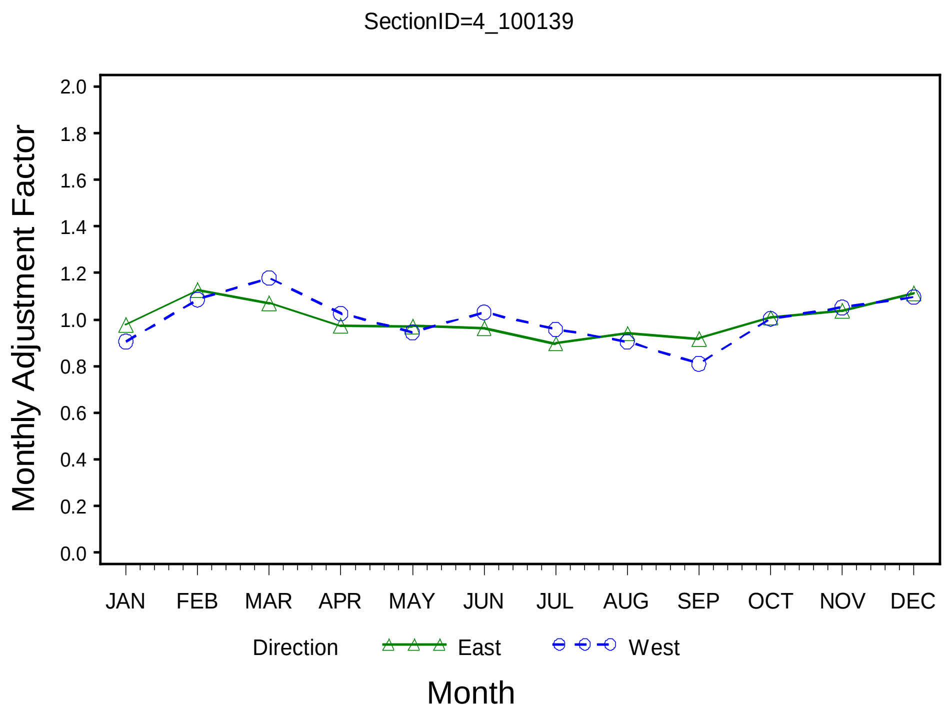


Figure D-6. Plot of Monthly Adjustment Factor for Site 4_100139 (Vehicle Class 9).

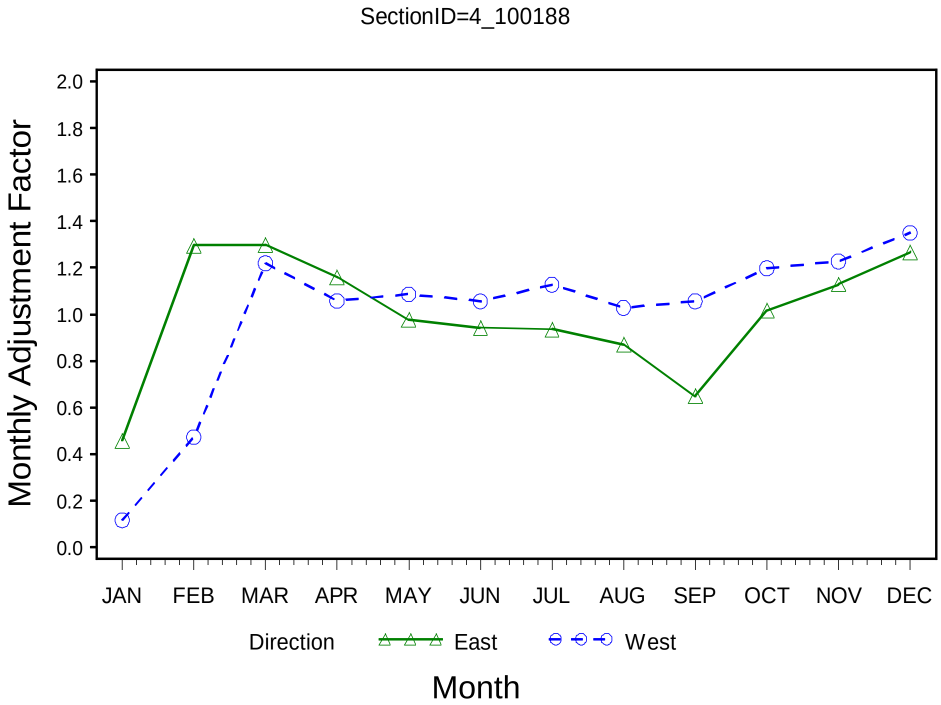


Figure D-7. Plot of Monthly Adjustment Factor for Site 4_100188 (Vehicle Class 5).

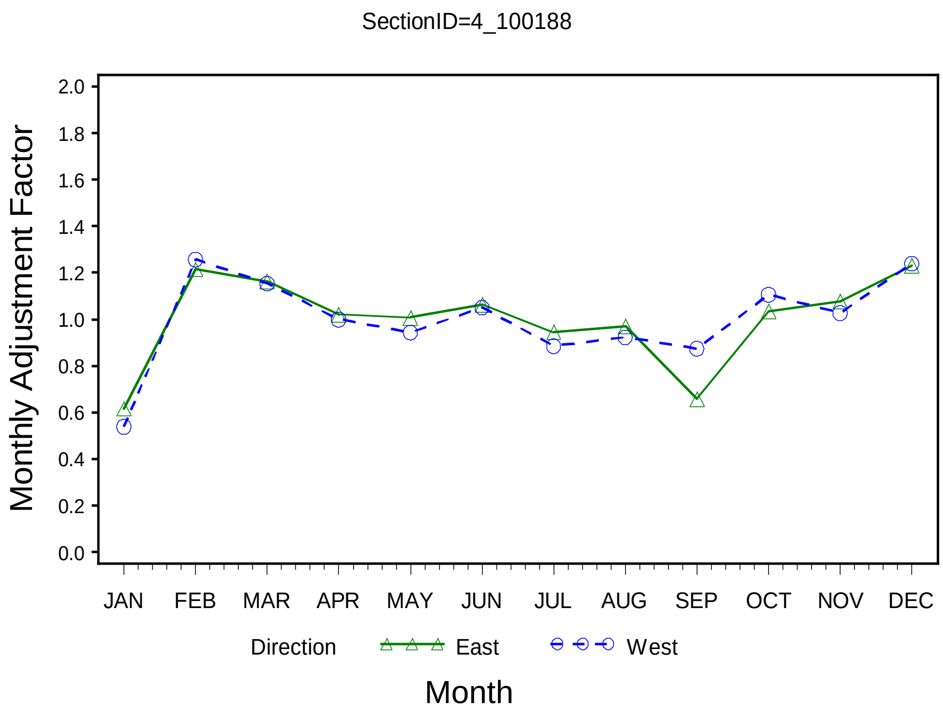


Figure D-8. Plot of Monthly Adjustment Factor for Site 4_100188 (Vehicle Class 9).

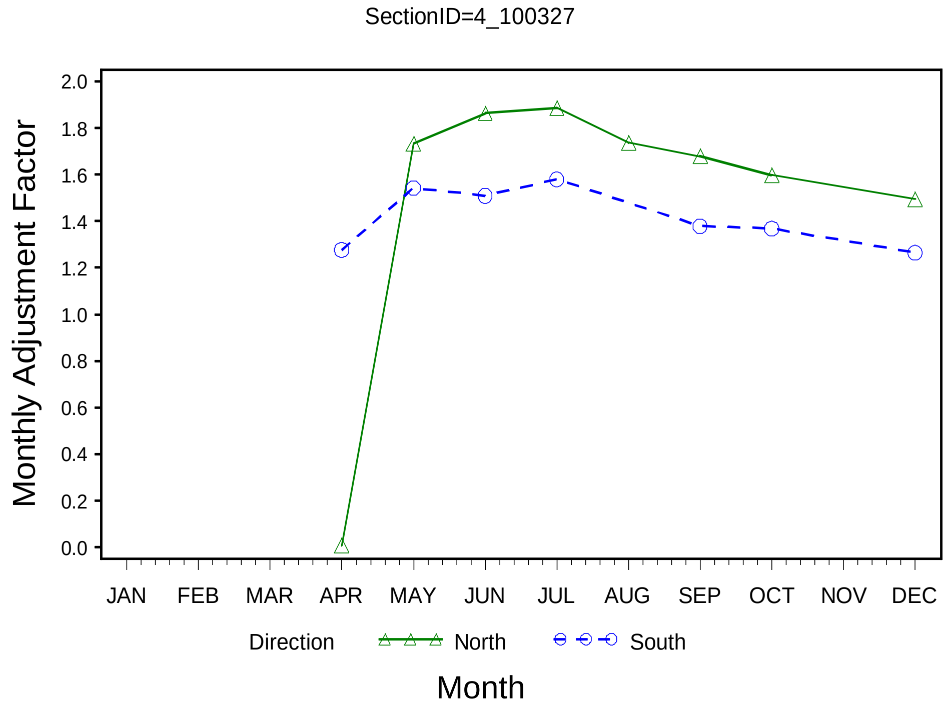


Figure D-9. Plot of Monthly Adjustment Factor for Site 4_100327 (Vehicle Class 5).

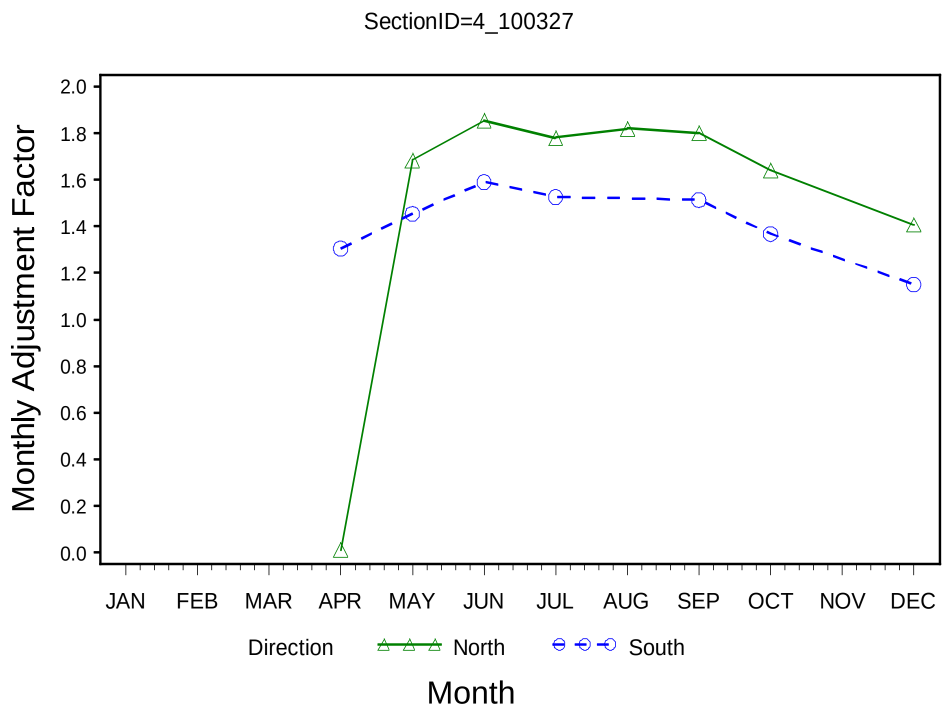


Figure D-10. Plot of Monthly Adjustment Factor for Site 4_100327 (Vehicle Class 9).

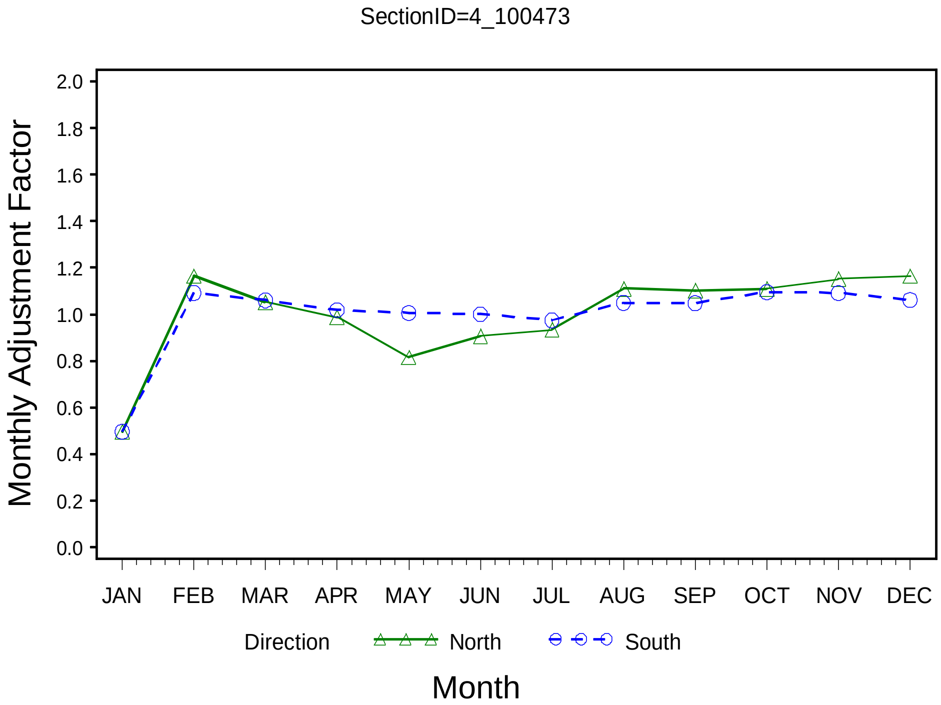


Figure D-11. Plot of Monthly Adjustment Factor for Site 4_100473 (Vehicle Class 5).

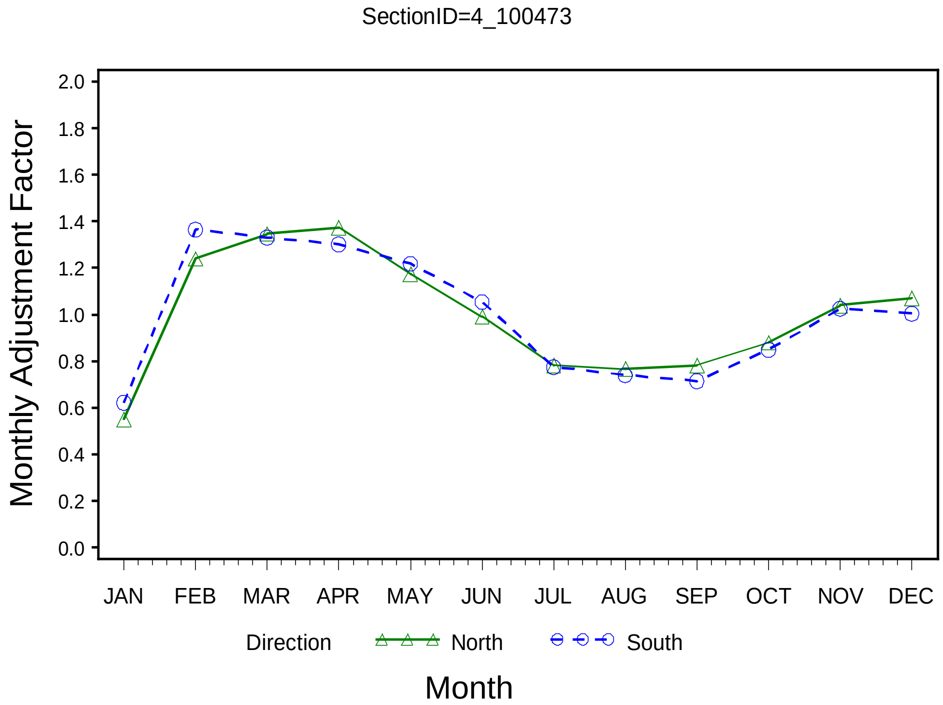


Figure D-12. Plot of Monthly Adjustment Factor for Site 4_100473 (Vehicle Class 9).

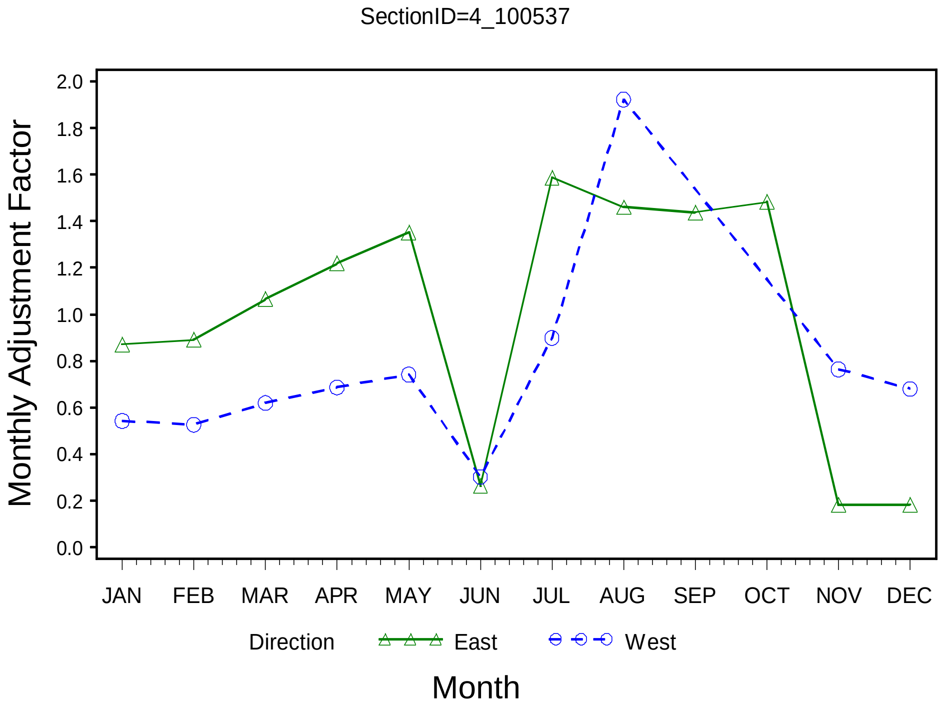


Figure D-13. Plot of Monthly Adjustment Factor for Site 4_100537 (Vehicle Class 5).

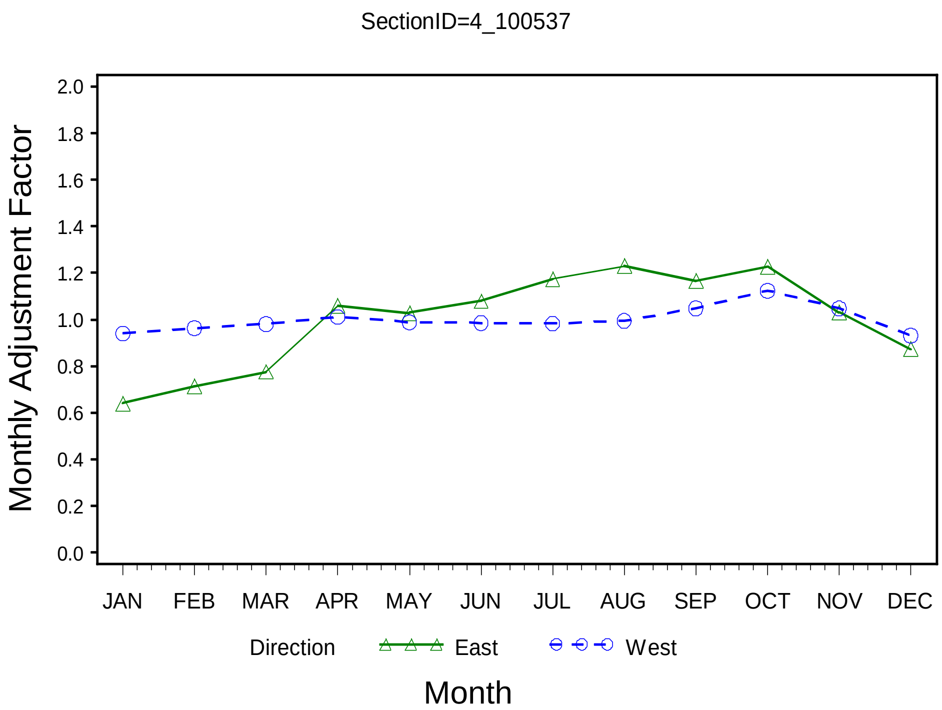


Figure D-14. Plot of Monthly Adjustment Factor for Site 4_100537 (Vehicle Class 9).

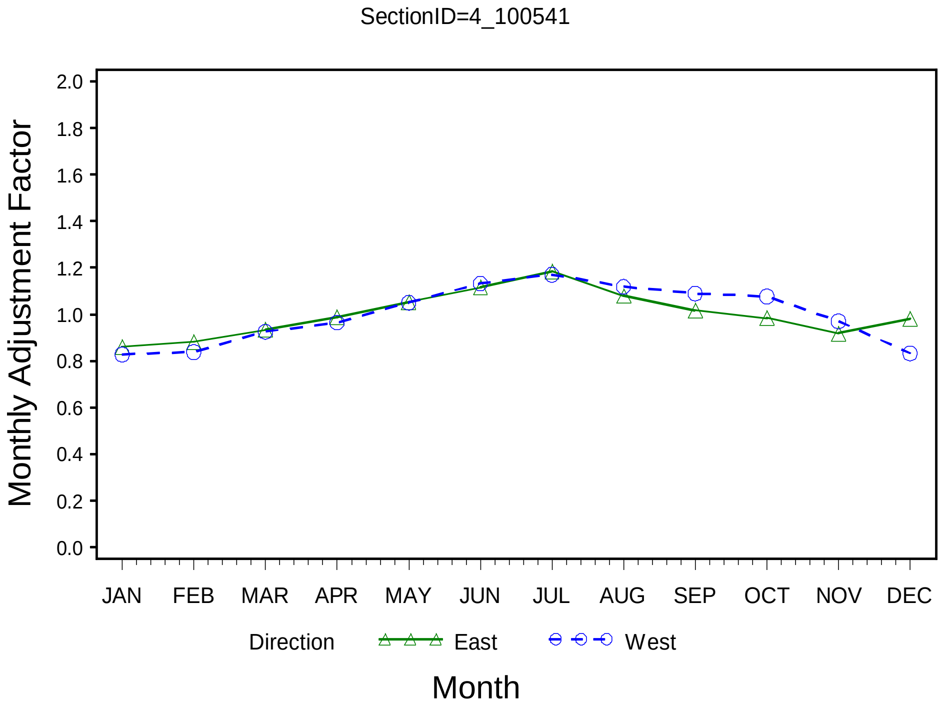


Figure D-15. Plot of Monthly Adjustment Factor for Site 4_100541 (Vehicle Class 5).

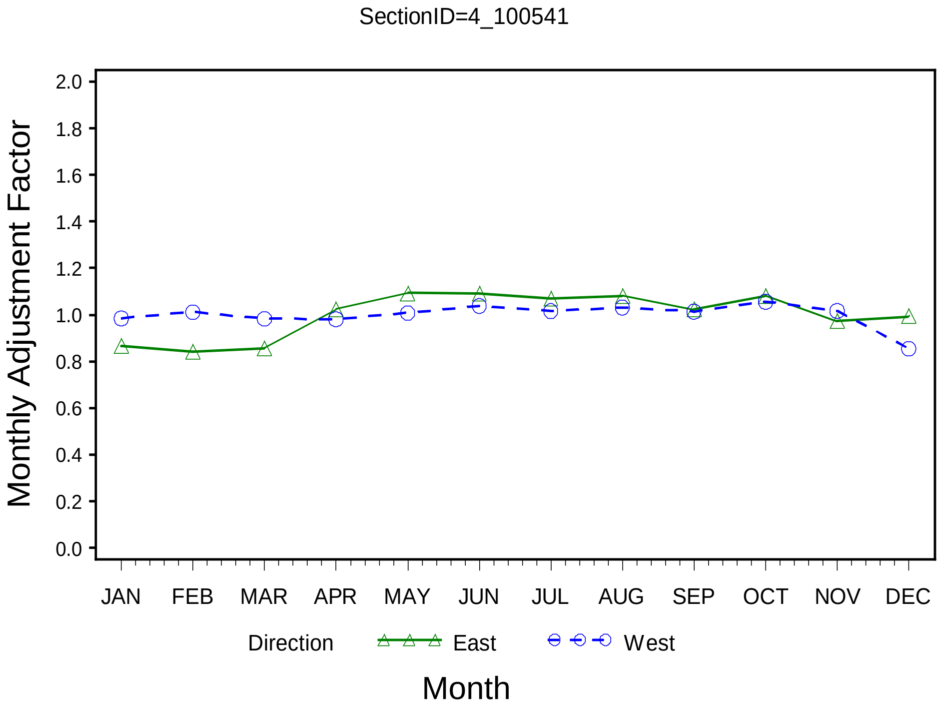


Figure D-16. Plot of Monthly Adjustment Factor for Site 4_100541 (Vehicle Class 9).

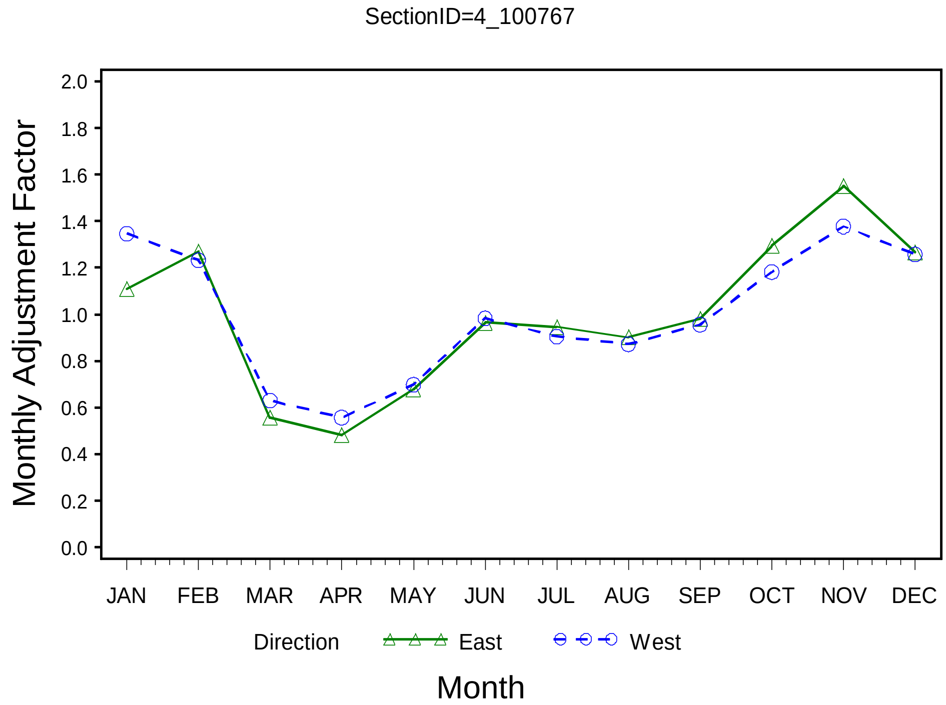


Figure D-17. Plot of Monthly Adjustment Factor for Site 4_100767 (Vehicle Class 5).

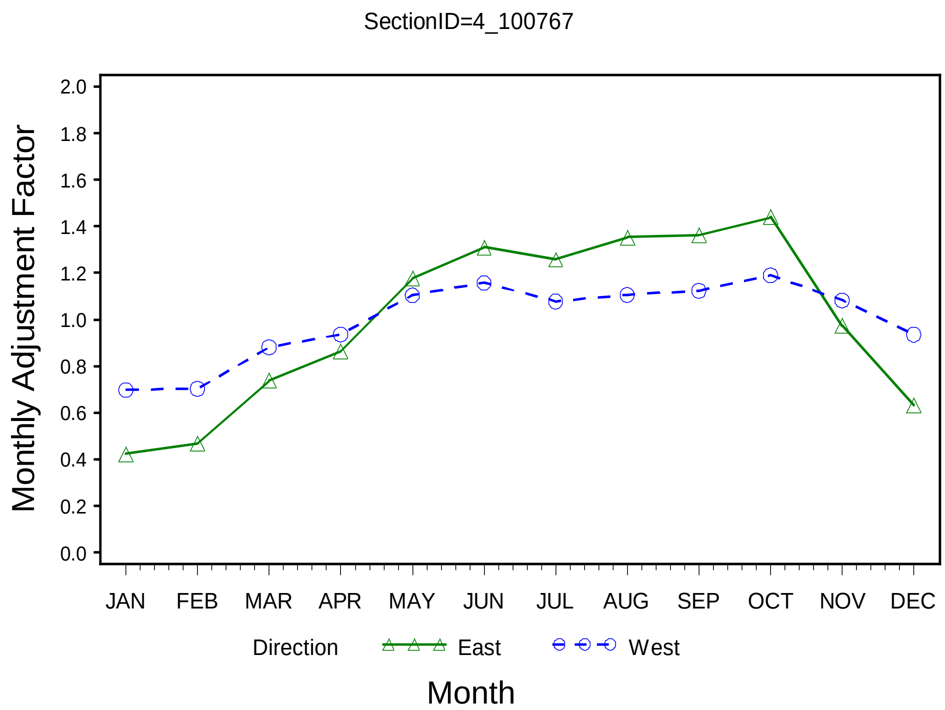


Figure D-18. Plot of Monthly Adjustment Factor for Site 4_100767 (Vehicle Class 9).

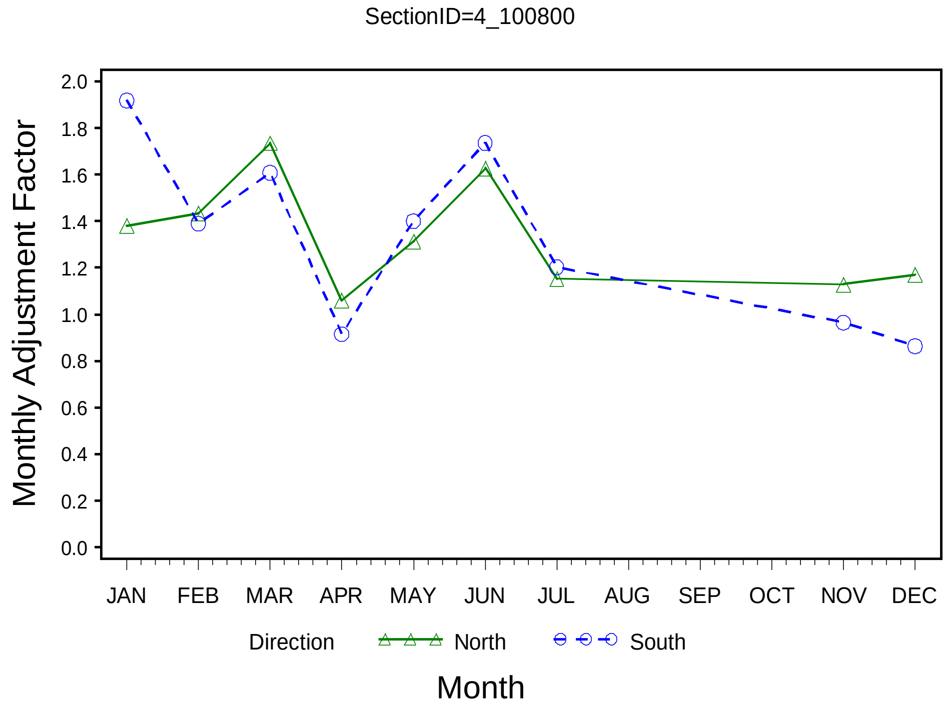


Figure D-19. Plot of Monthly Adjustment Factor for Site 4_100800 (Vehicle Class 5).

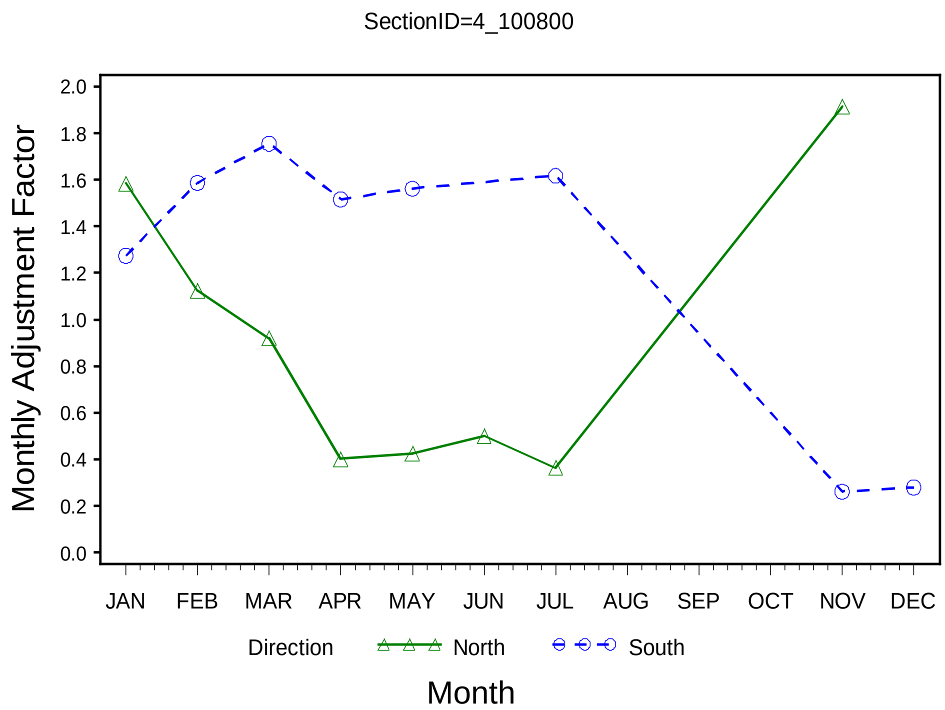


Figure D-20. Plot of Monthly Adjustment Factor for Site 4_100800 (Vehicle Class 9).

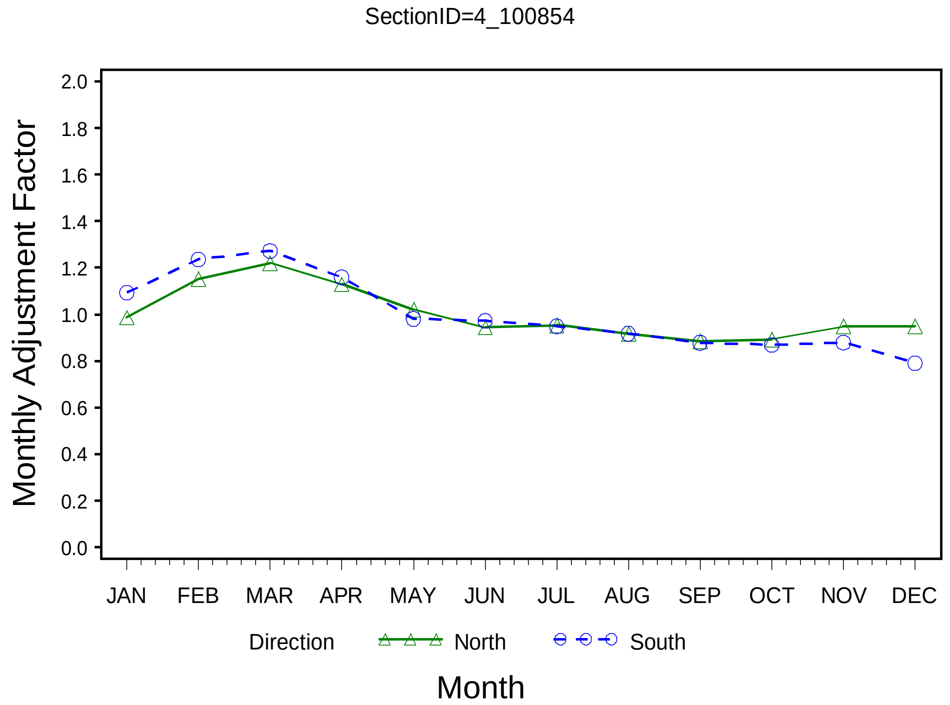


Figure D-21. Plot of Monthly Adjustment Factor for Site 4_100854 (Vehicle Class 5).

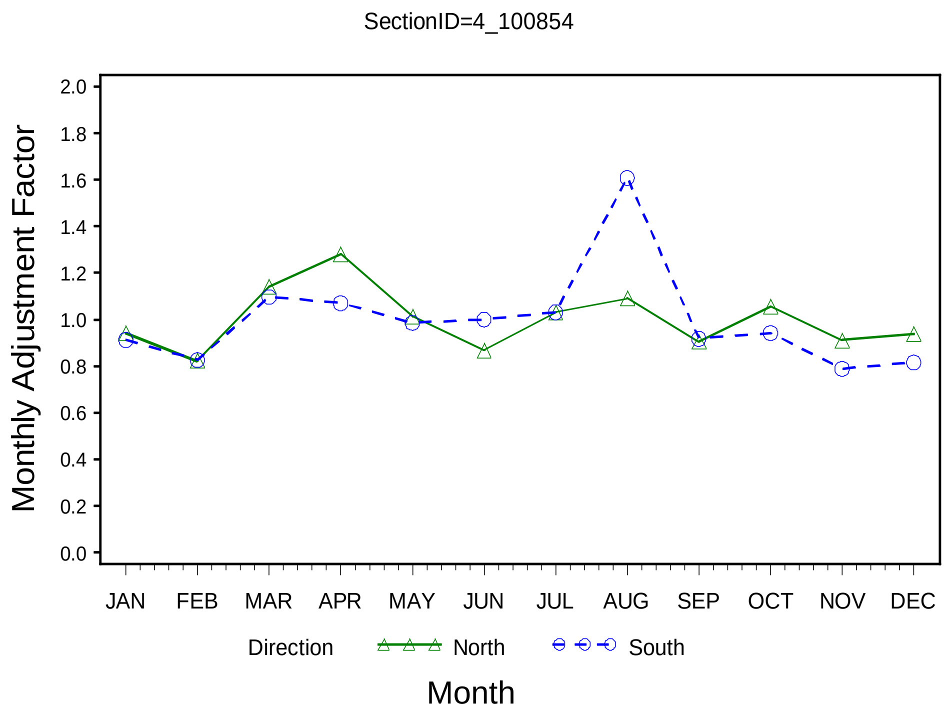


Figure D-22. Plot of Monthly Adjustment Factor for Site 4_100854 (Vehicle Class 9).

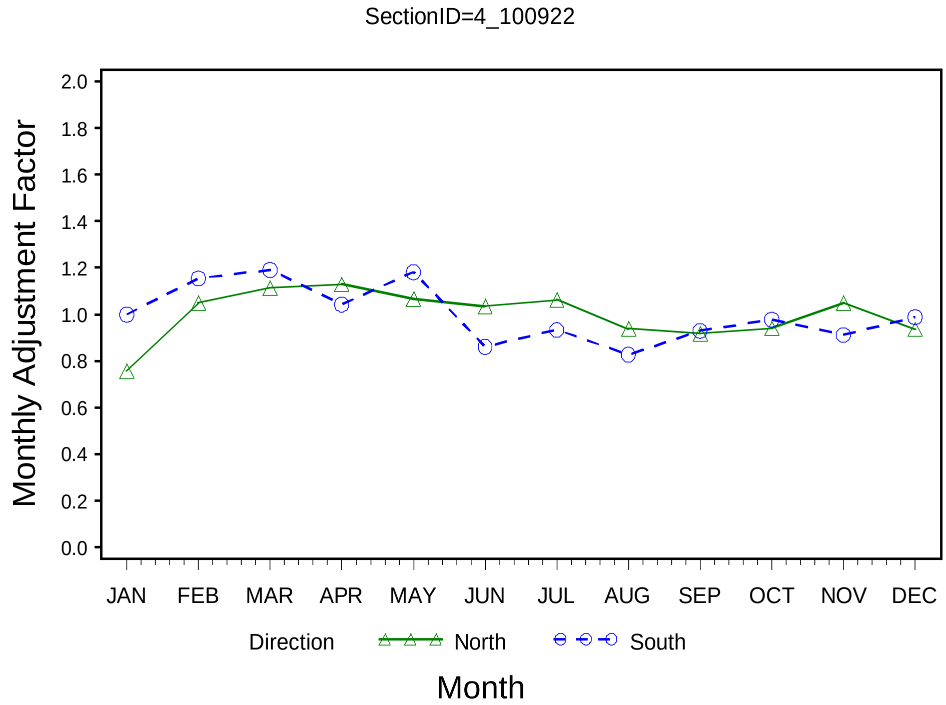


Figure D-23. Plot of Monthly Adjustment Factor for Site 4_100922 (Vehicle Class 5).

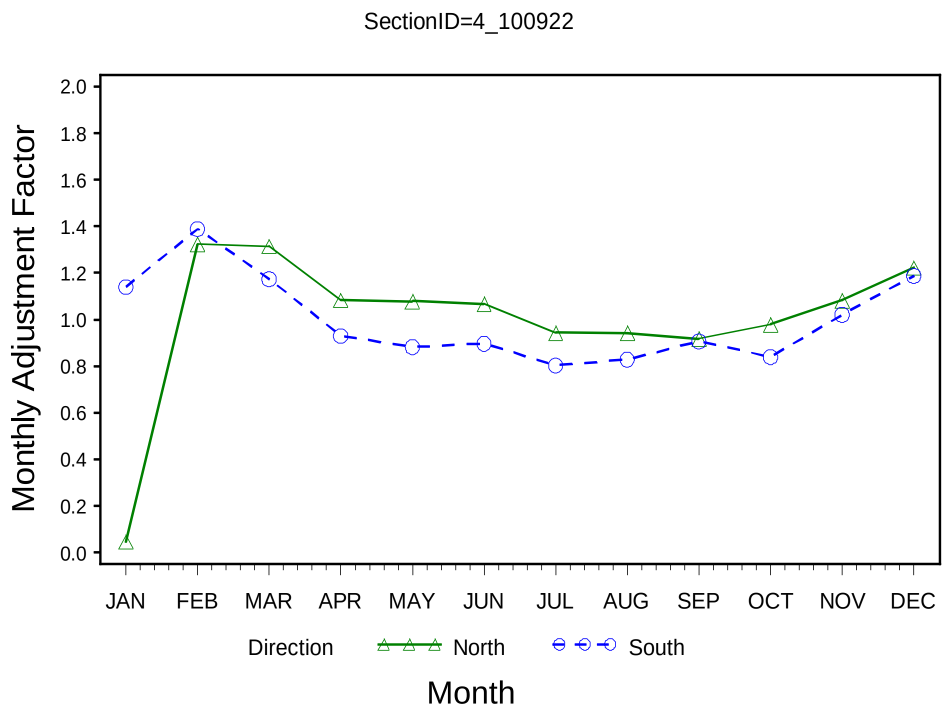


Figure D-24. Plot of Monthly Adjustment Factor for Site 4_100922 (Vehicle Class 9).

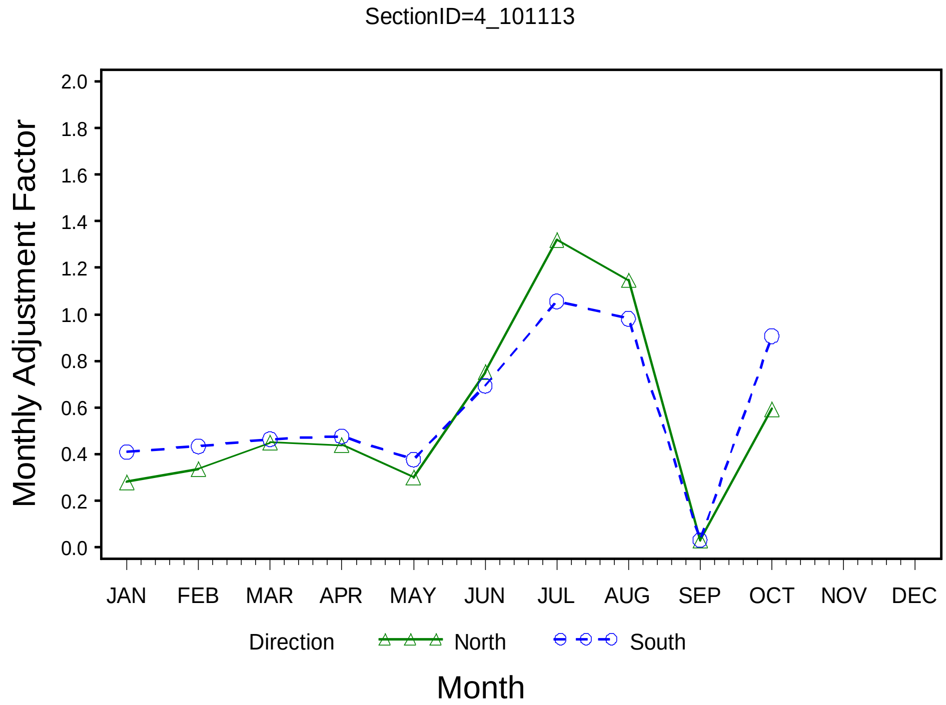


Figure D-25. Plot of Monthly Adjustment Factor for Site 4_101113 (Vehicle Class 5).

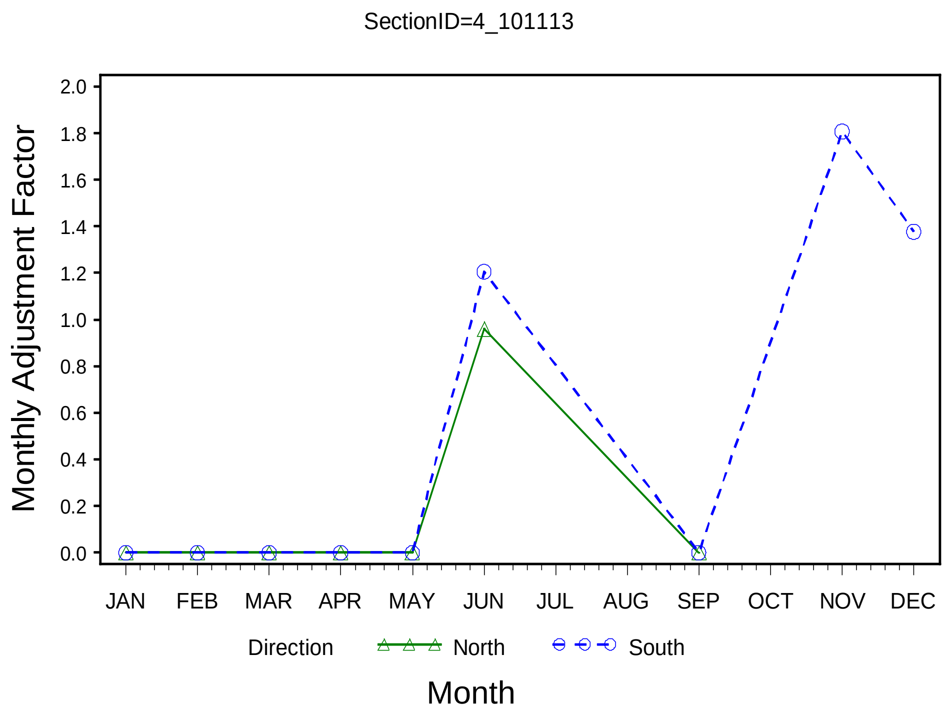


Figure D-26. Plot of Monthly Adjustment Factor for Site 4_101113 (Vehicle Class 9).

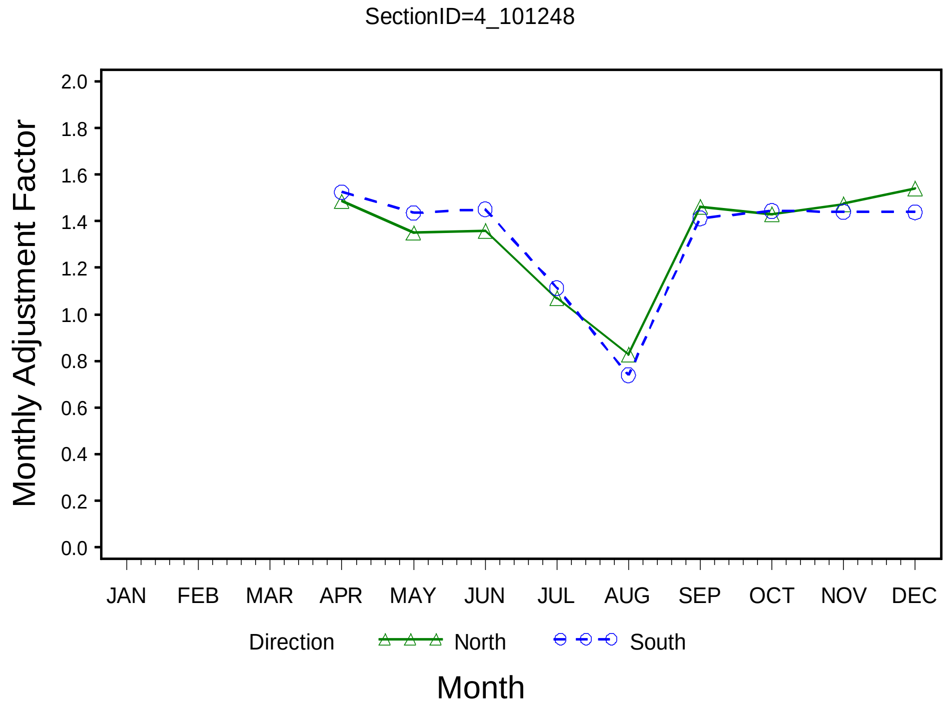


Figure D-27. Plot of Monthly Adjustment Factor for Site 4_101248 (Vehicle Class 5).

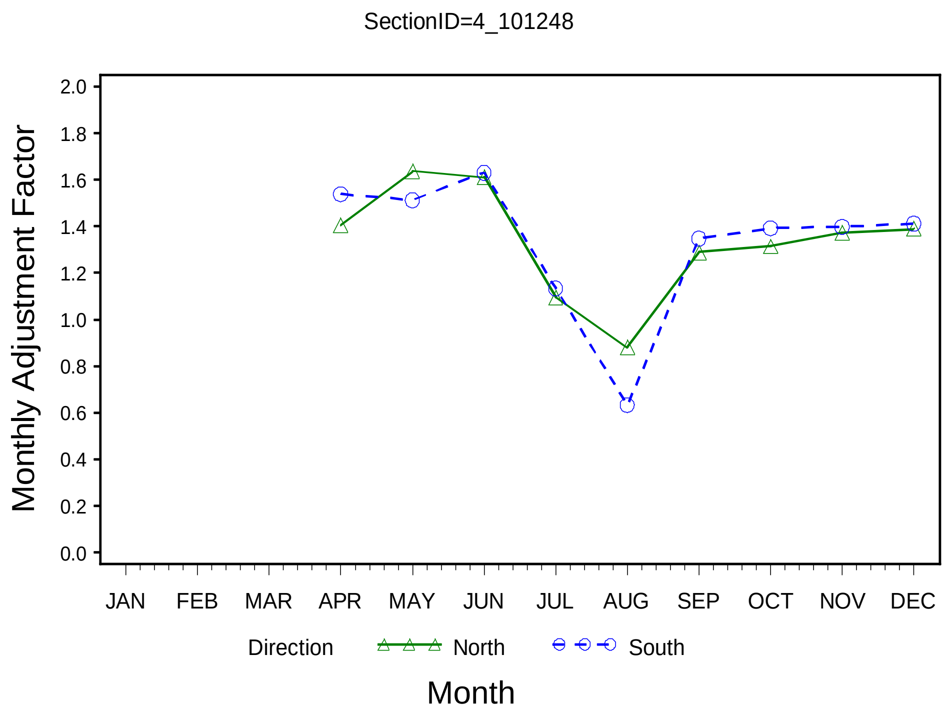


Figure D-28. Plot of Monthly Adjustment Factor for Site 4_101248 (Vehicle Class 9).

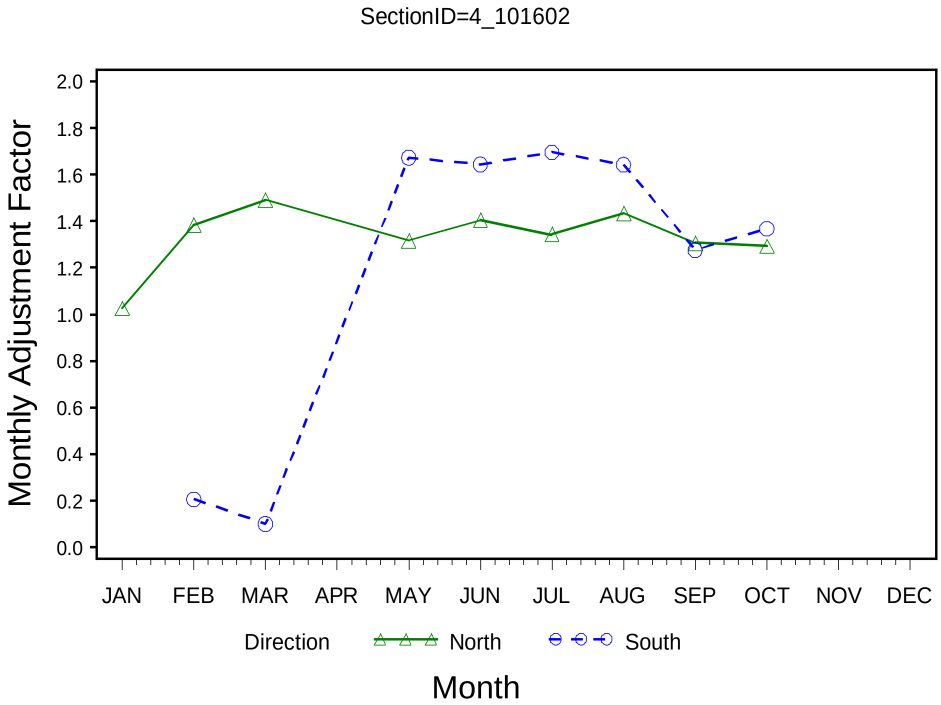


Figure D-29. Plot of Monthly Adjustment Factor for Site 4_101602 (Vehicle Class 5).

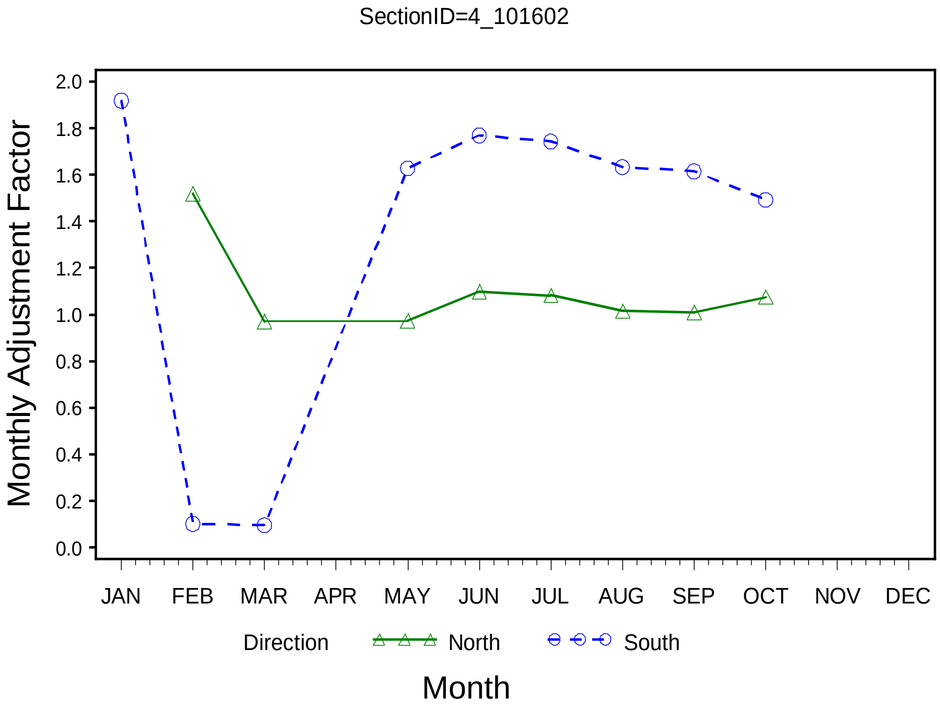


Figure D-30. Plot of Monthly Adjustment Factor for Site 4_101602 (Vehicle Class 9).

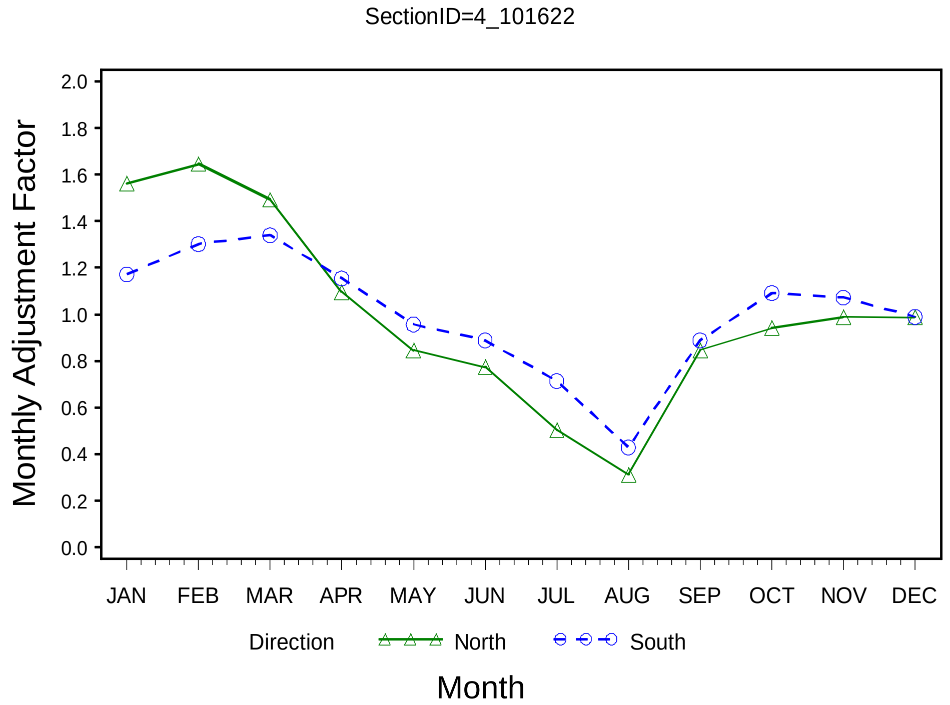


Figure D-31. Plot of Monthly Adjustment Factor for Site 4_101622 (Vehicle Class 5).

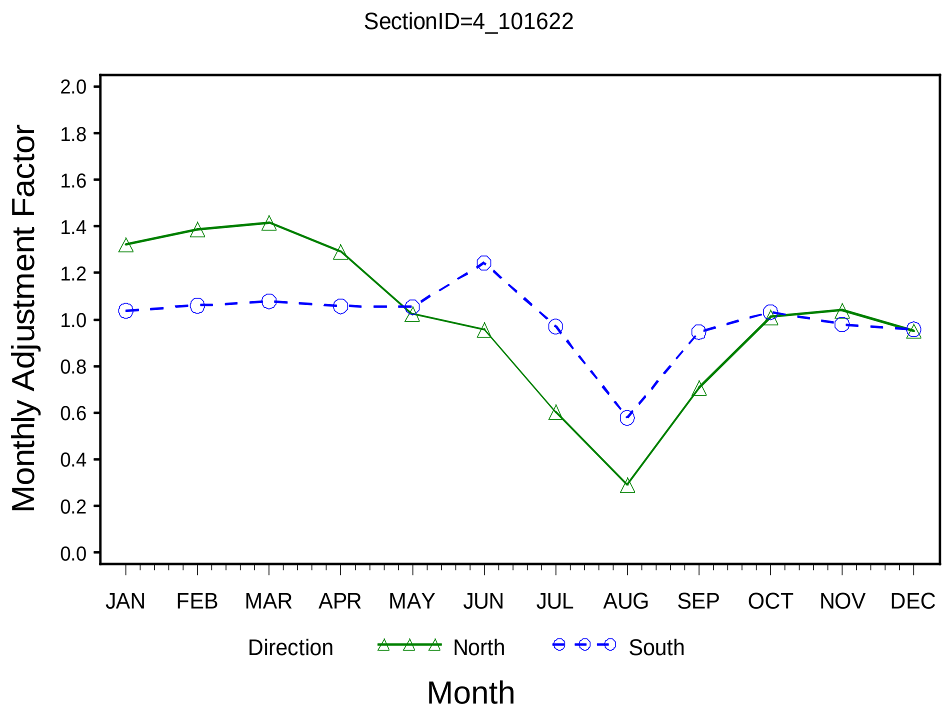


Figure D-32. Plot of Monthly Adjustment Factor for Site 4_101622 (Vehicle Class 9).

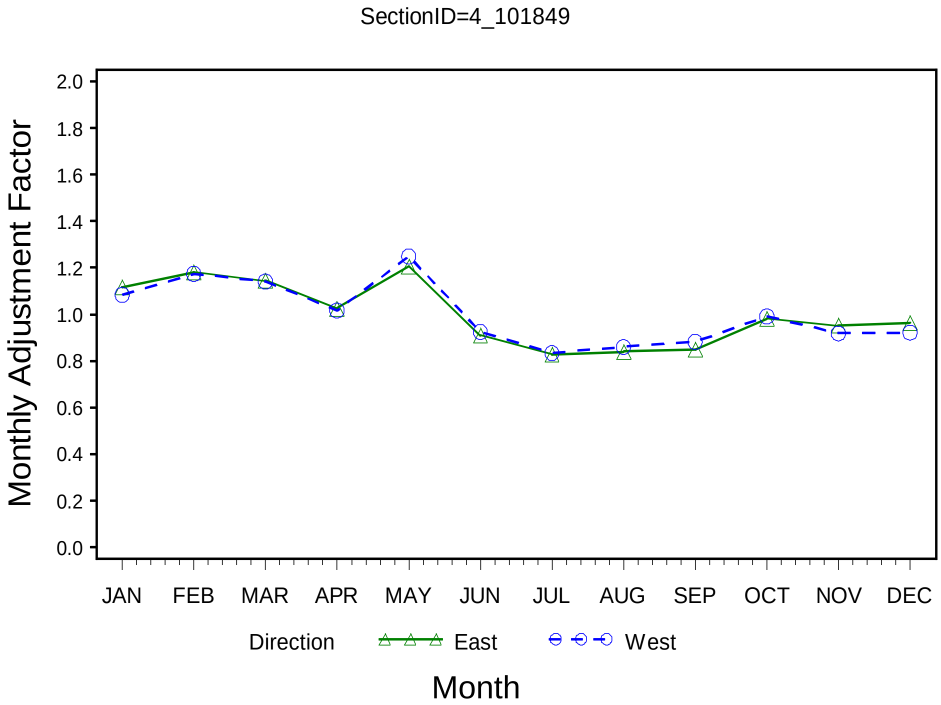


Figure D-33. Plot of Monthly Adjustment Factor for Site 4_101849 (Vehicle Class 5).

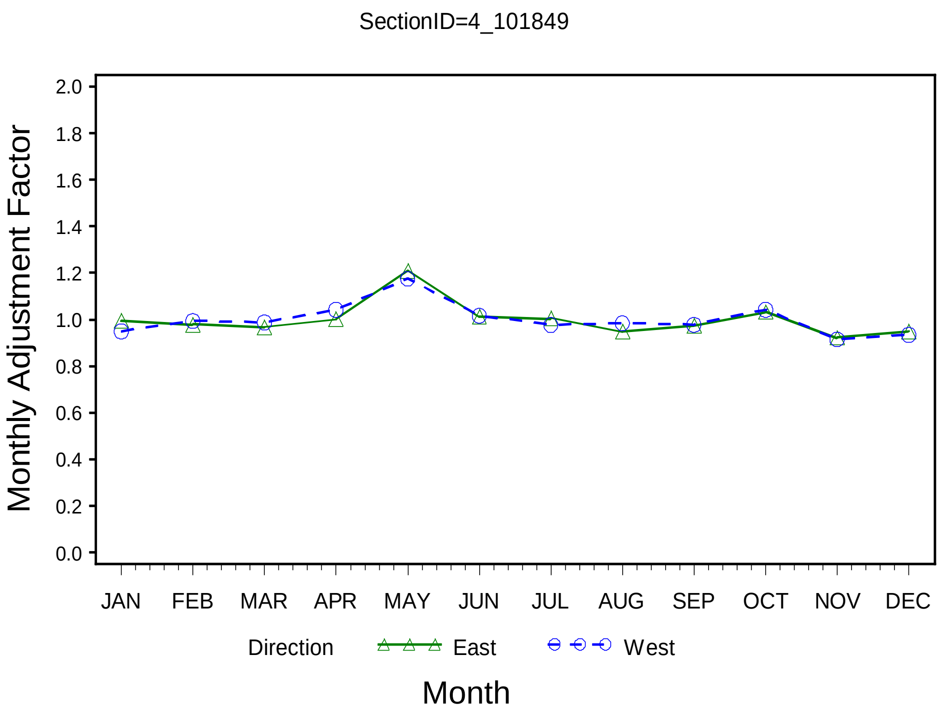


Figure D-34. Plot of Monthly Adjustment Factor for Site 4_101849 (Vehicle Class 9).

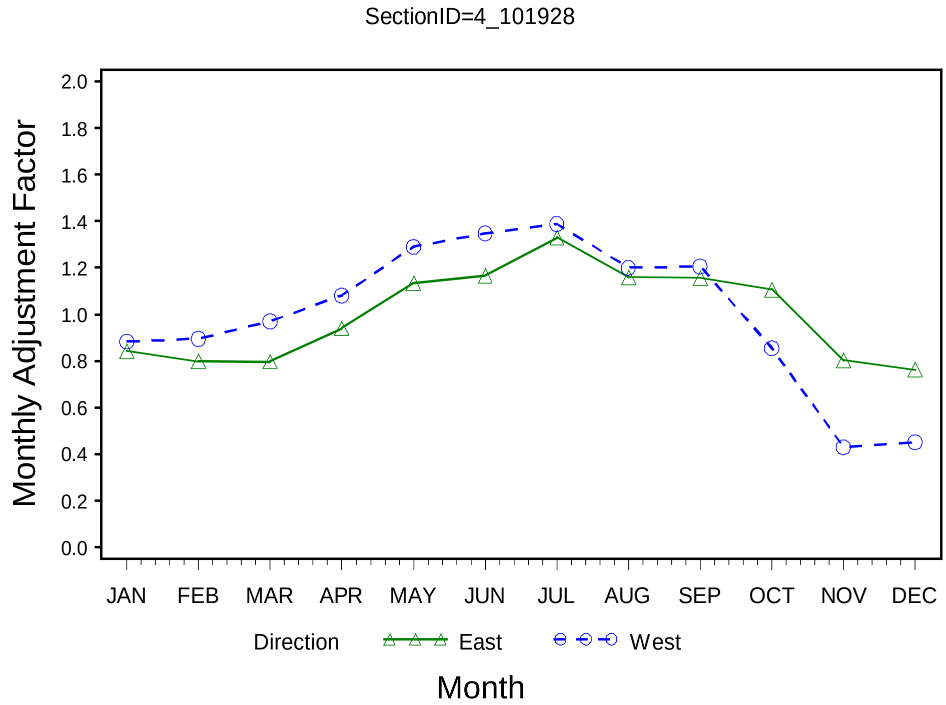


Figure D-35. Plot of Monthly Adjustment Factor for Site 4_101928 (Vehicle Class 5).

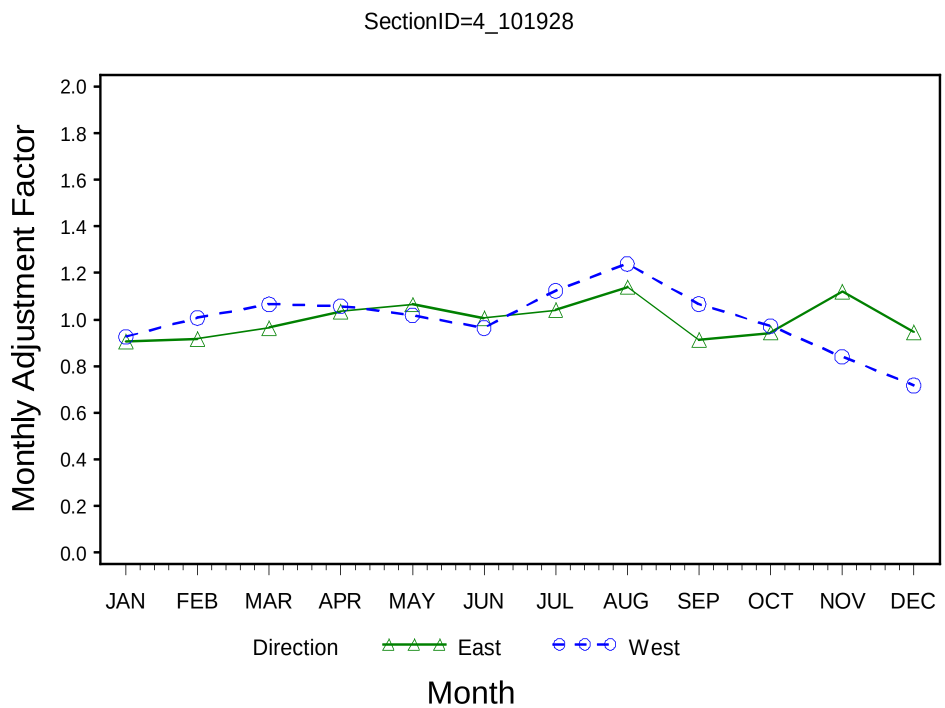


Figure D-36. Plot of Monthly Adjustment Factor for Site 4_101928 (Vehicle Class 9).

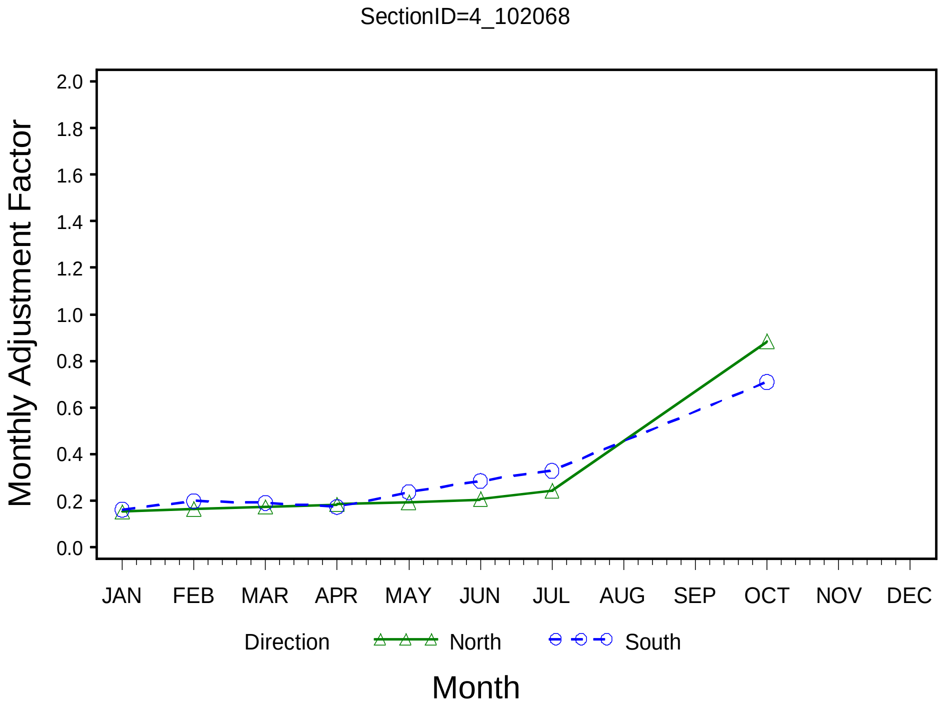


Figure D-37. Plot of Monthly Adjustment Factor for Site 4_102068 (Vehicle Class 5).

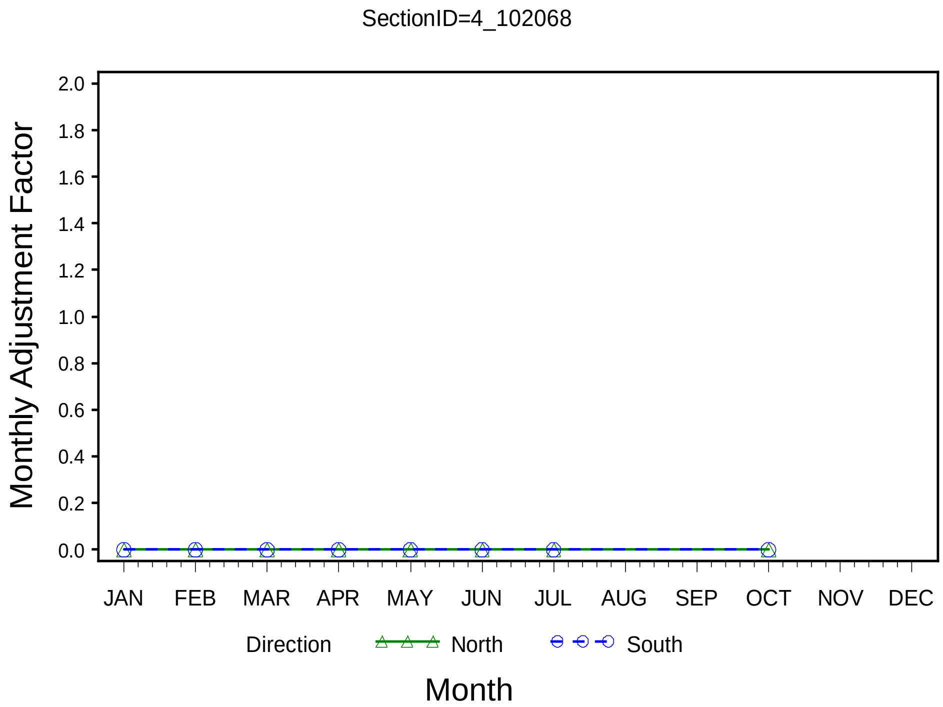


Figure D-38. Plot of Monthly Adjustment Factor for Site 4_102068 (Vehicle Class 9).

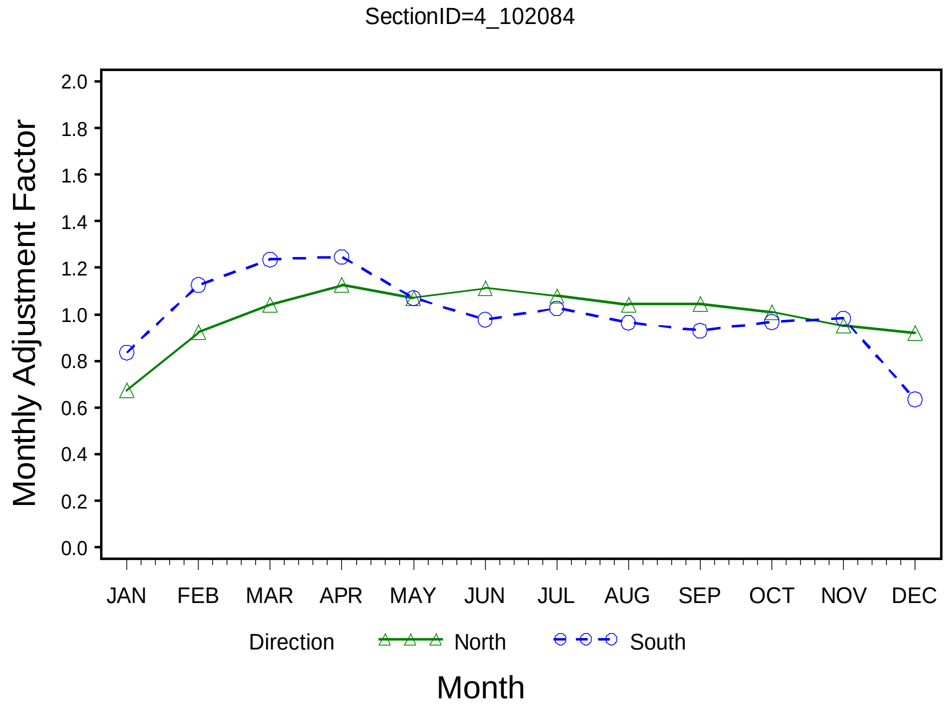


Figure D-39. Plot of Monthly Adjustment Factor for Site 4_102084 (Vehicle Class 5).

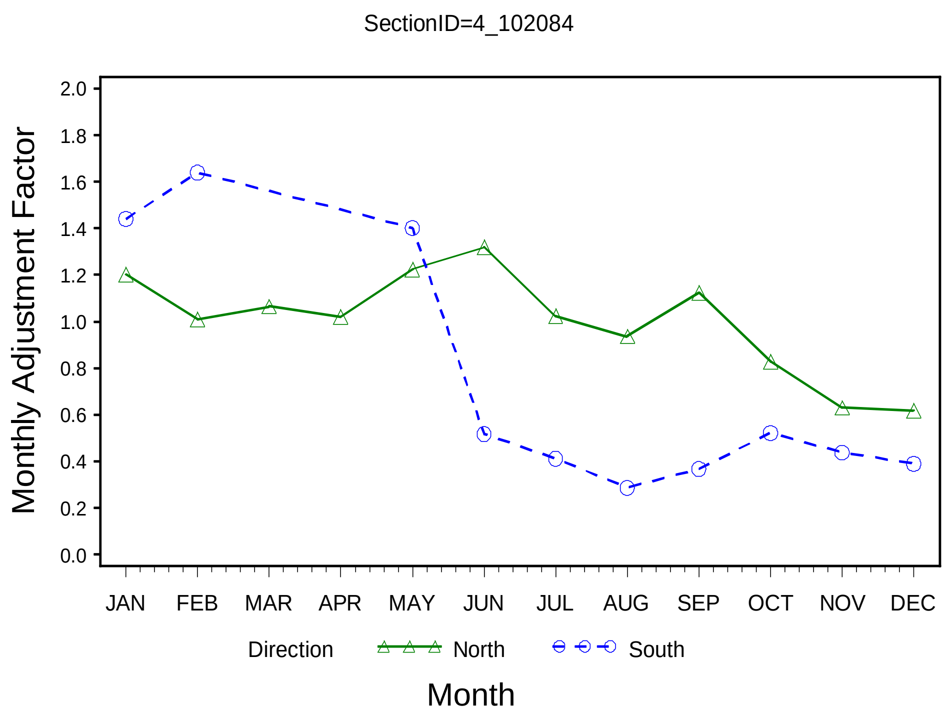


Figure D-40. Plot of Monthly Adjustment Factor for Site 4_102084 (Vehicle Class 9).

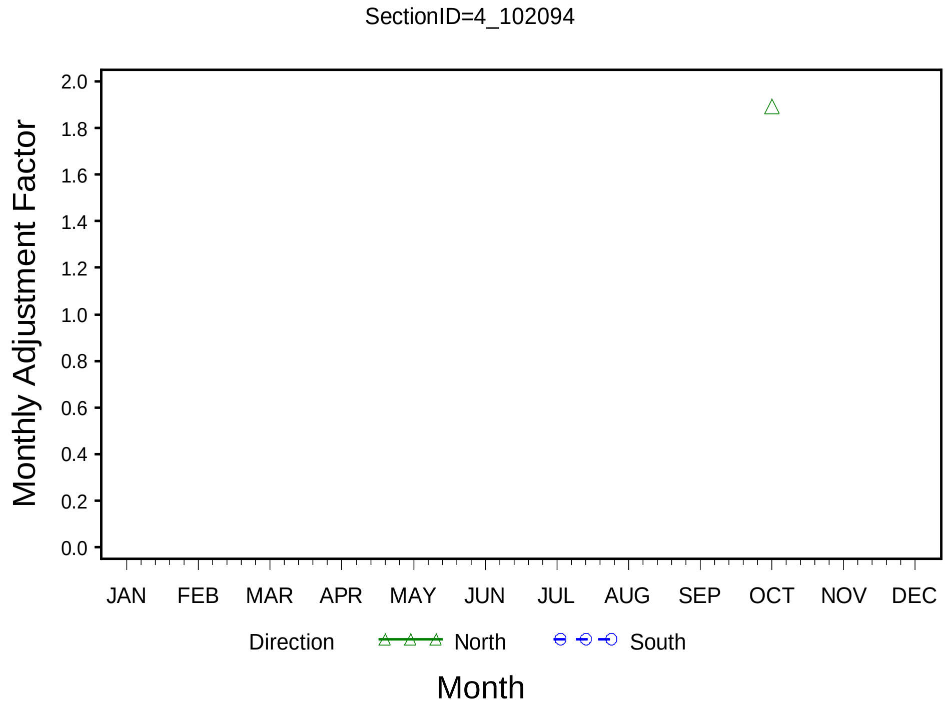


Figure D-41. Plot of Monthly Adjustment Factor for Site 4_102094 (Vehicle Class 5).

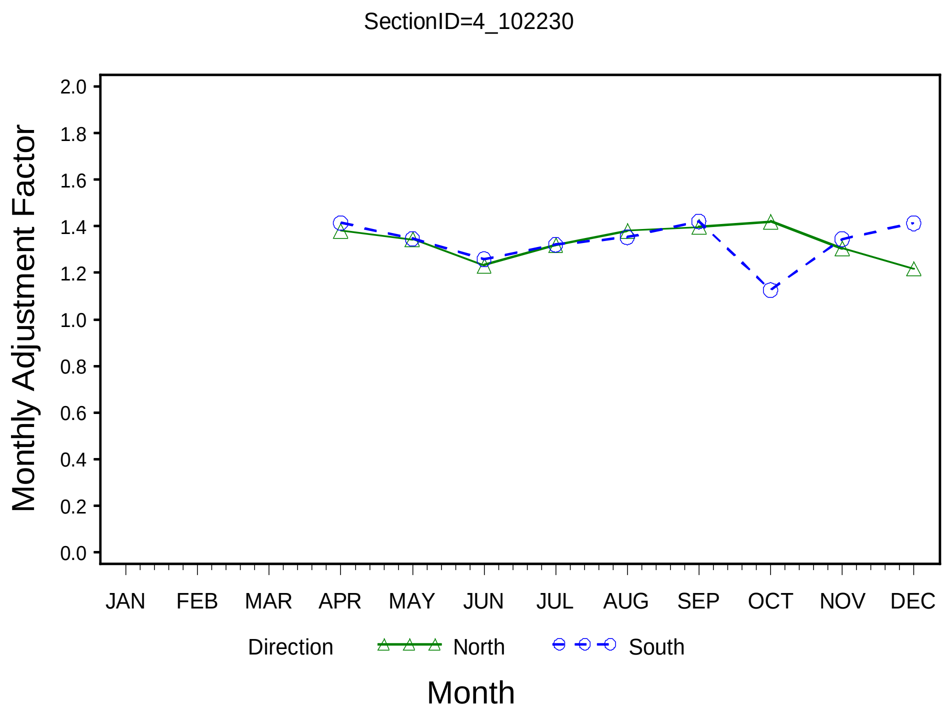


Figure D-42. Plot of Monthly Adjustment Factor for Site 4_102230 (Vehicle Class 5).

SectionID=4_102230

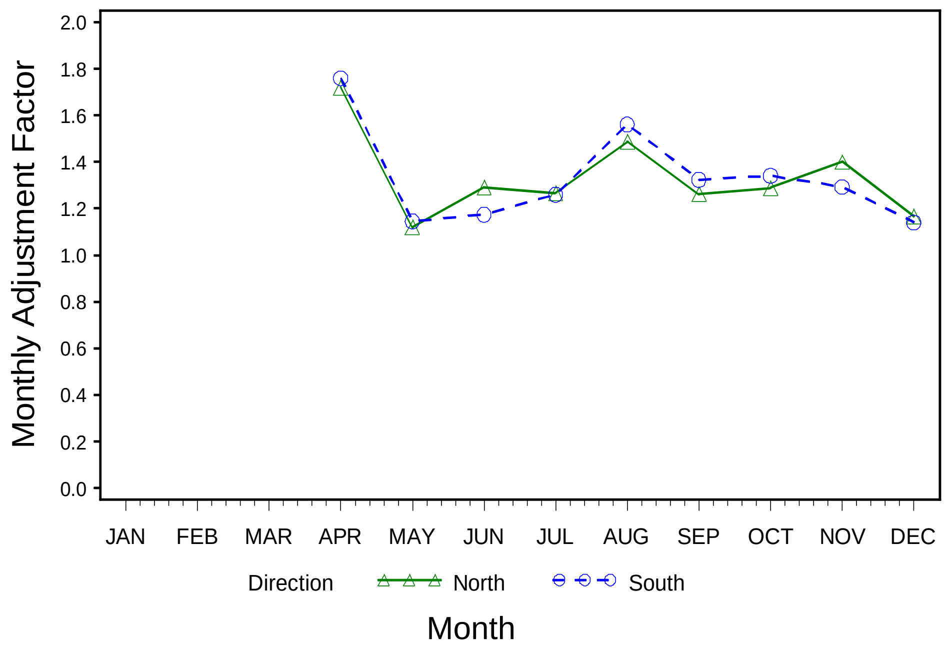


Figure D-43. Plot of Monthly Adjustment Factor for Site 4_102230 (Vehicle Class 9).

SectionID=4_100010

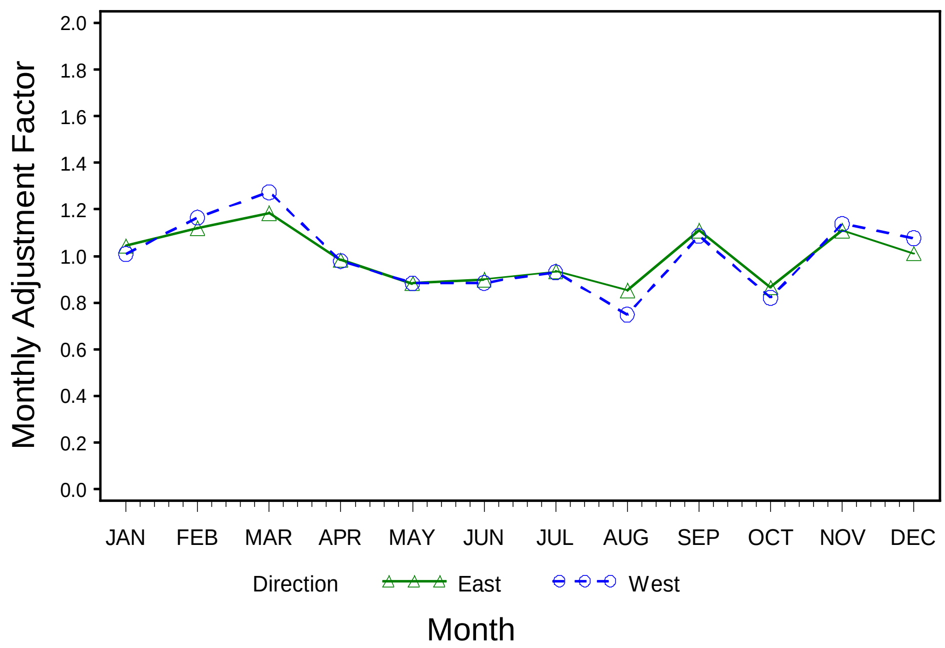


Figure D-44. Plot of Monthly Adjustment Factor for Site 4_100010 (Vehicle Class 5).

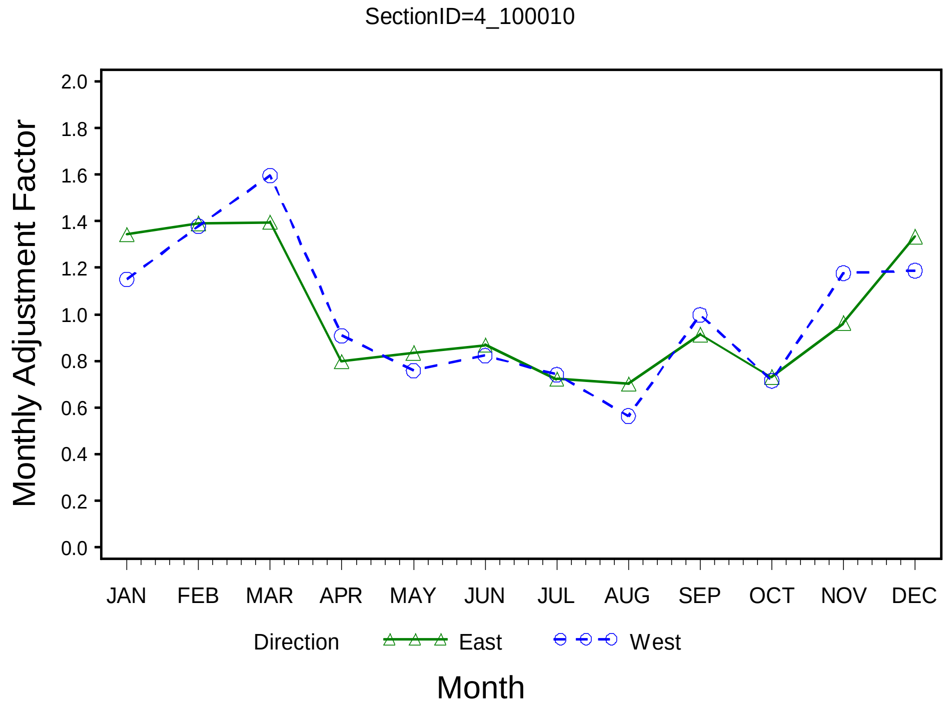


Figure D-45. Plot of Monthly Adjustment Factor for Site 4_100010 (Vehicle Class 9).

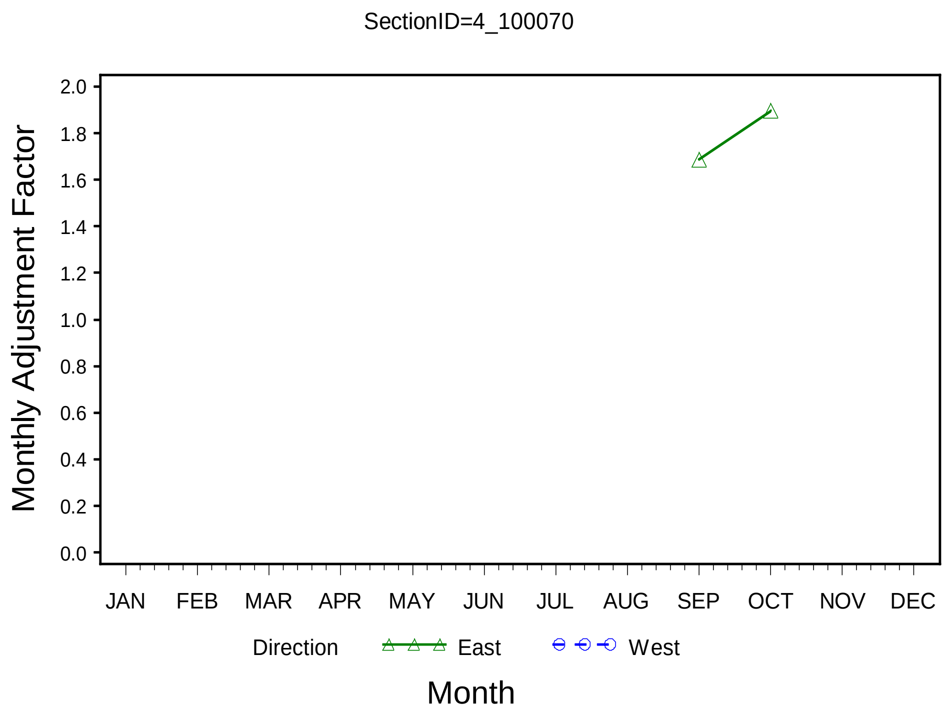


Figure D-46. Plot of Monthly Adjustment Factor for Site 4_100070 (Vehicle Class 5).

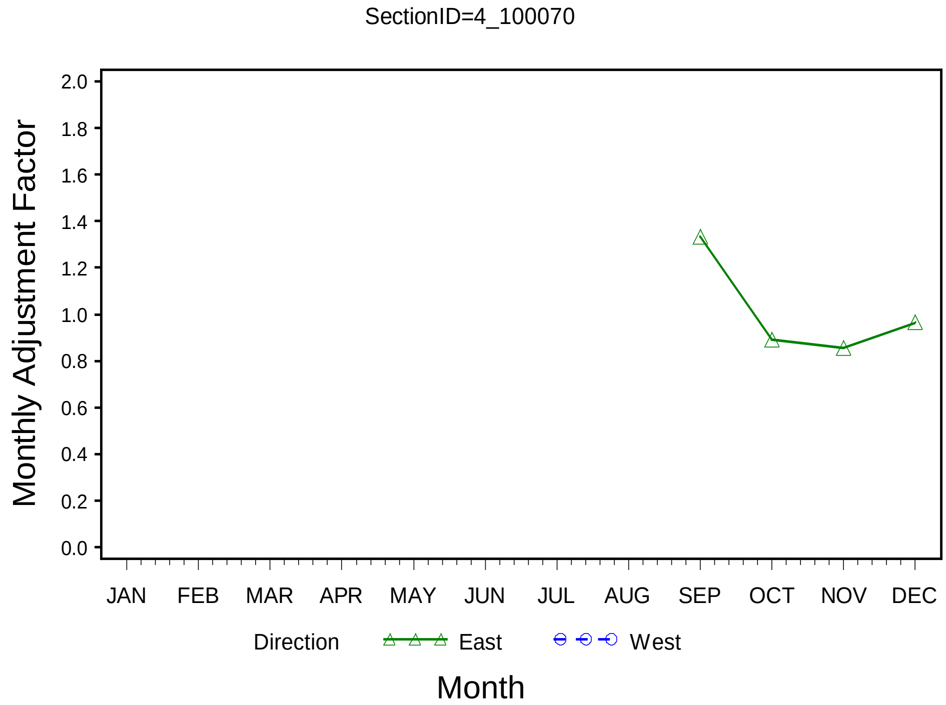


Figure D-47. Plot of Monthly Adjustment Factor for Site 4_100070 (Vehicle Class 9).

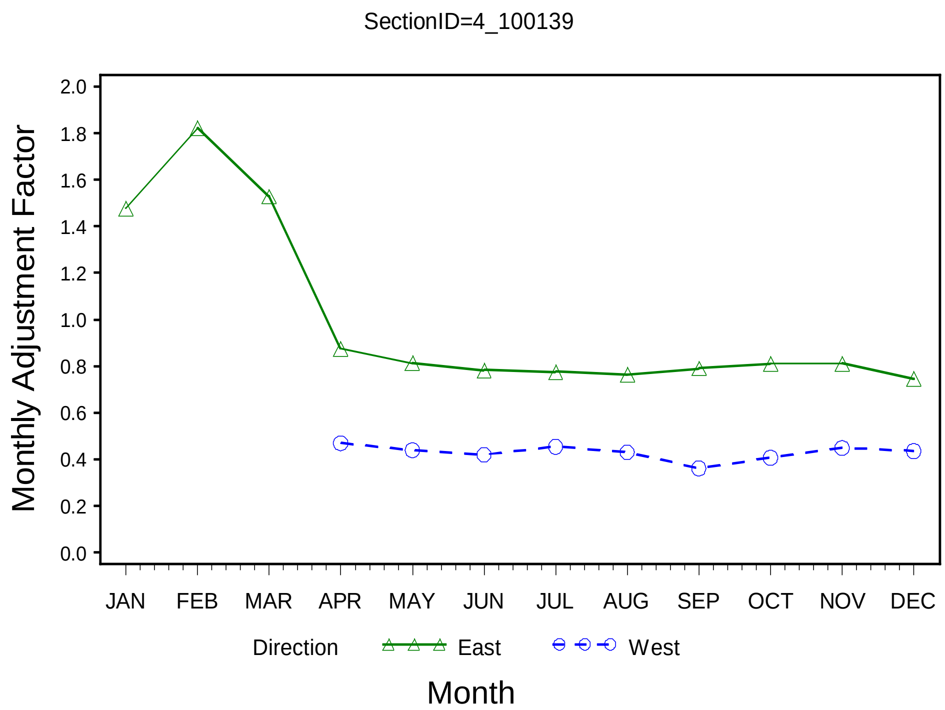


Figure D-48. Plot of Monthly Adjustment Factor for Site 4_100139 (Vehicle Class 5).

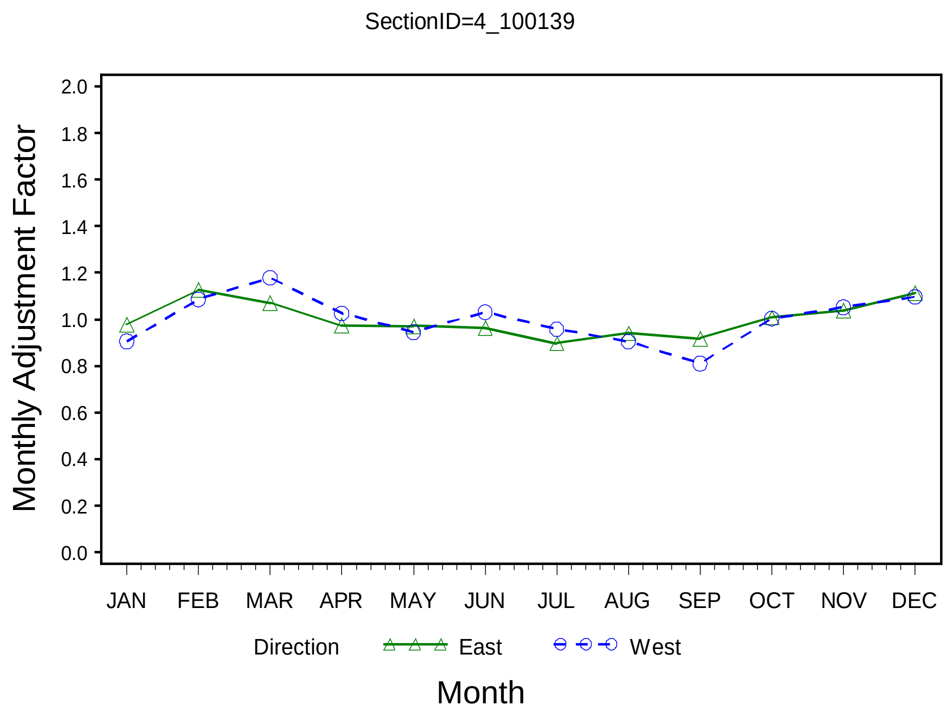


Figure D-49. Plot of Monthly Adjustment Factor for Site 4_100139 (Vehicle Class 9).

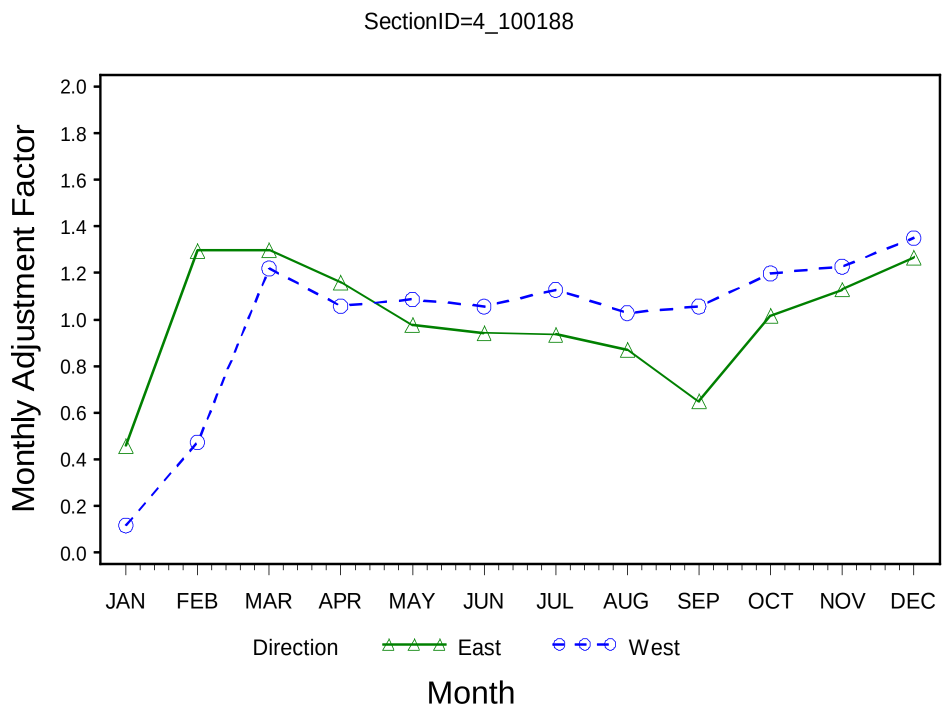


Figure D-50. Plot of Monthly Adjustment Factor for Site 4_100188 (Vehicle Class 5).

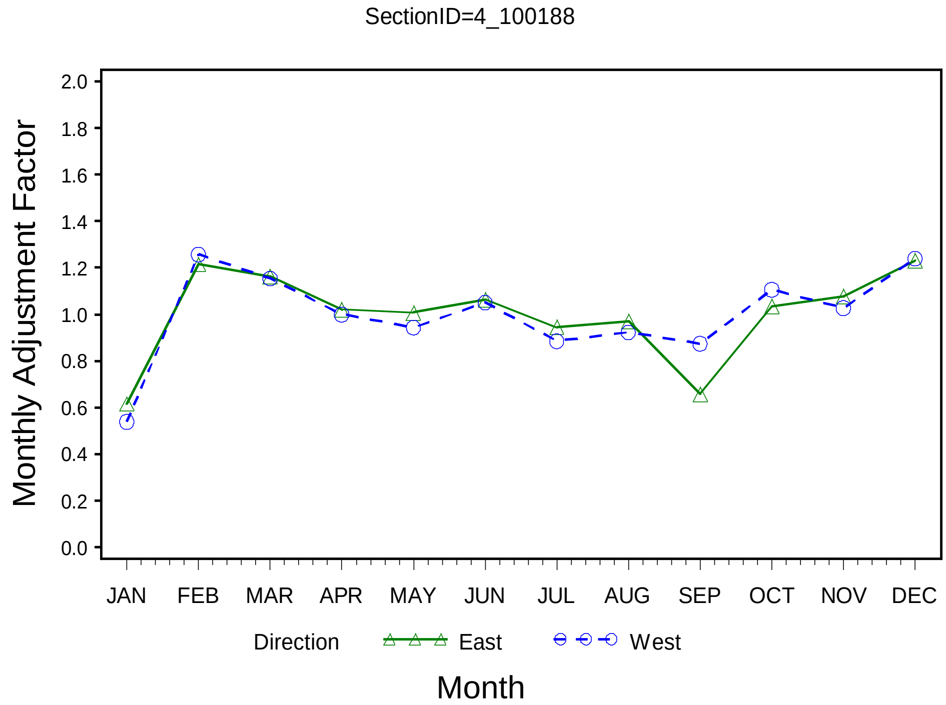


Figure D-51. Plot of Monthly Adjustment Factor for Site 4_100188 (Vehicle Class 9).

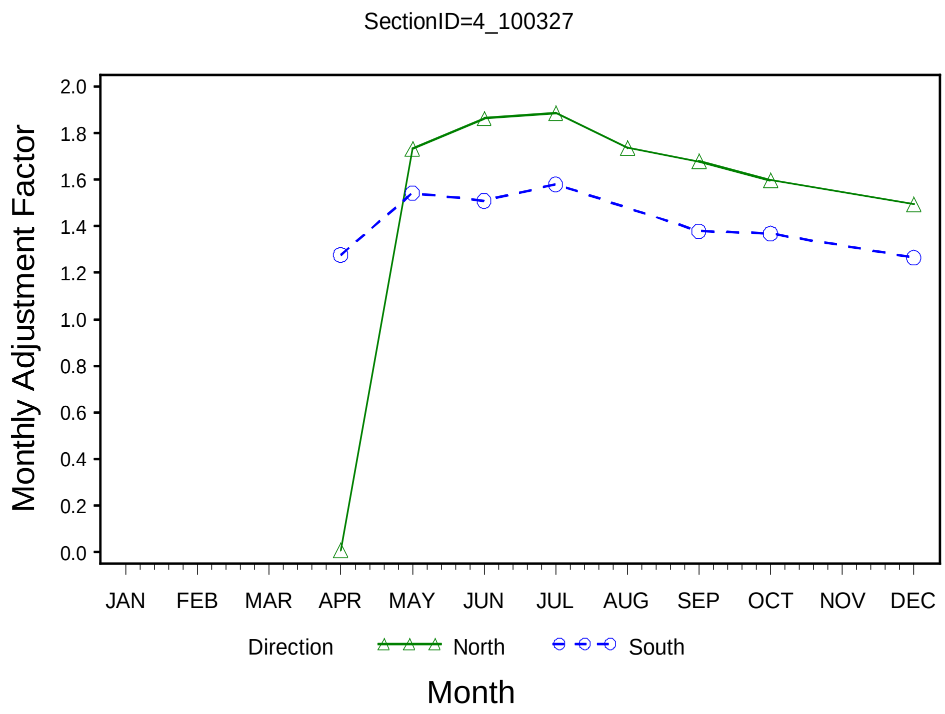


Figure D-52. Plot of Monthly Adjustment Factor for Site 4_100327 (Vehicle Class 5).

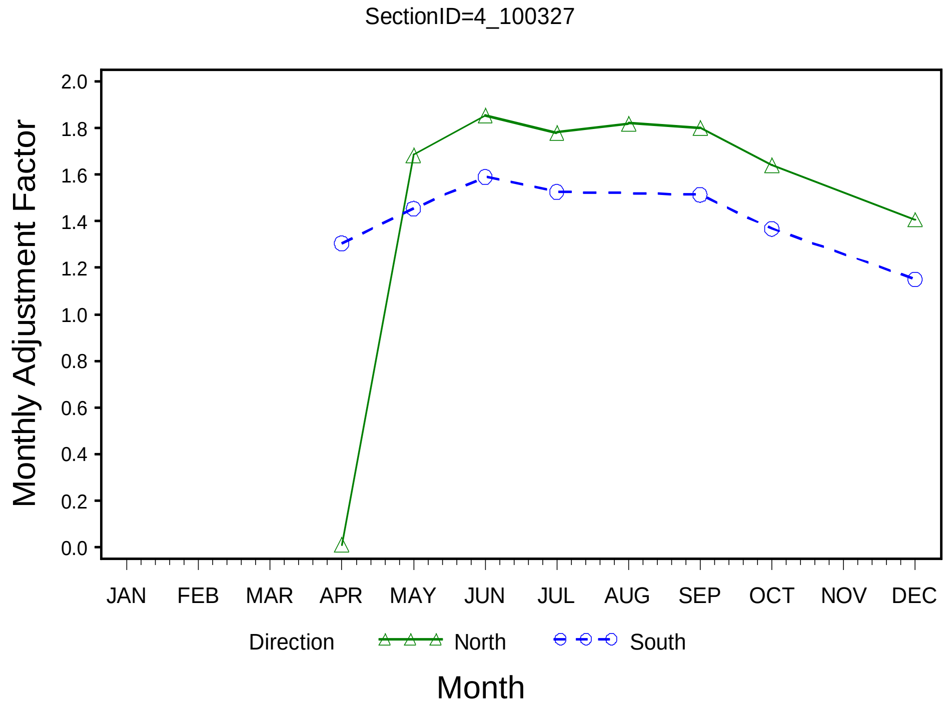


Figure D-53. Plot of Monthly Adjustment Factor for Site 4_100327 (Vehicle Class 9).

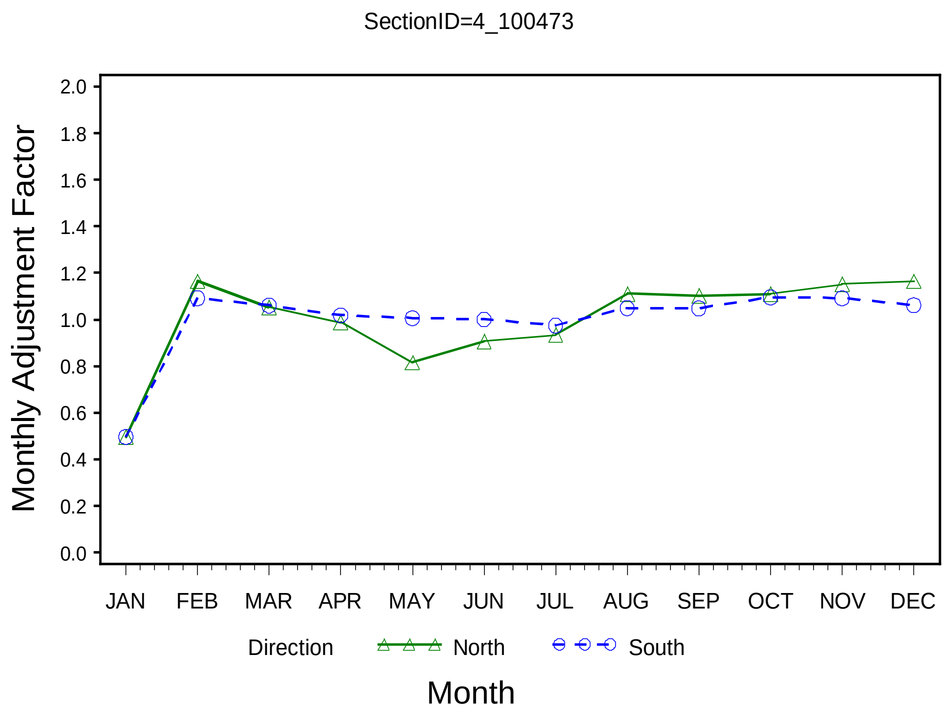


Figure D-54. Plot of Monthly Adjustment Factor for Site 4_100473 (Vehicle Class 5).

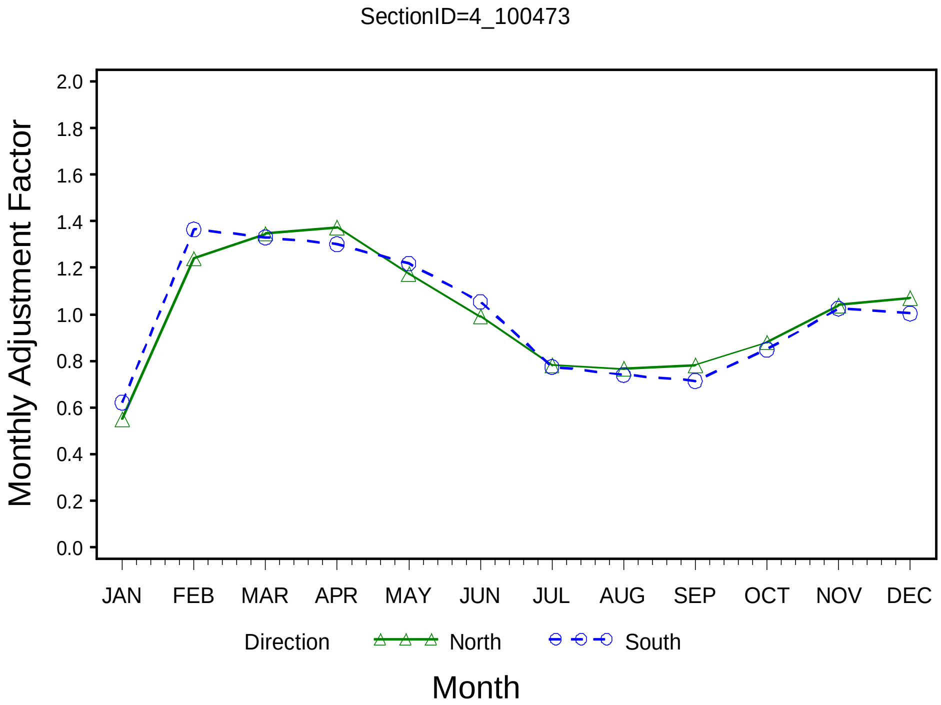


Figure D-55. Plot of Monthly Adjustment Factor for Site 4_100473 (Vehicle Class 9).

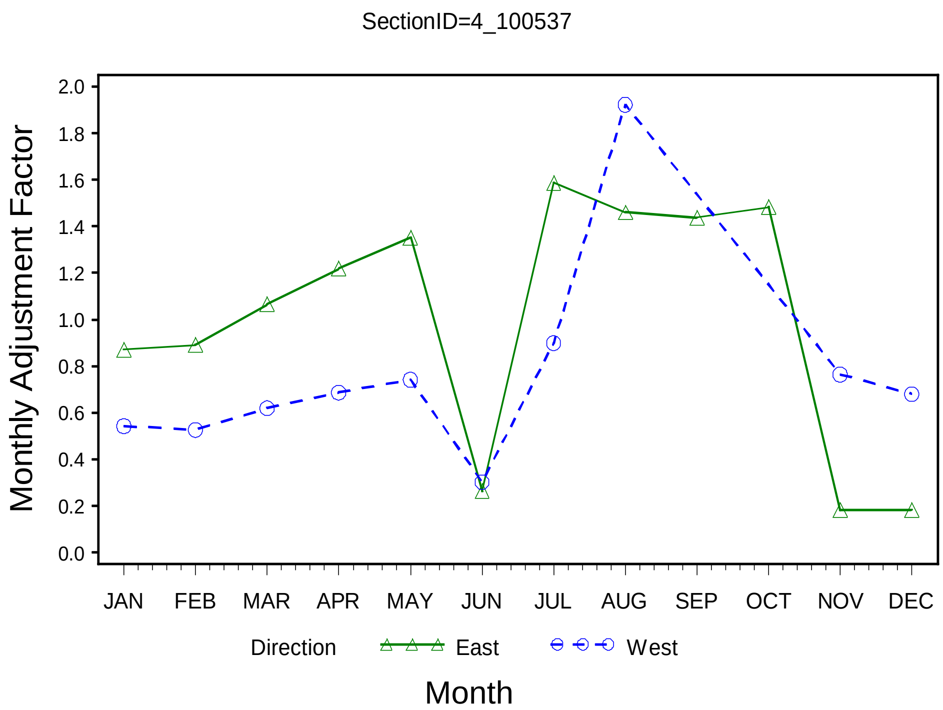


Figure D-56. Plot of Monthly Adjustment Factor for Site 4_100537 (Vehicle Class 5).

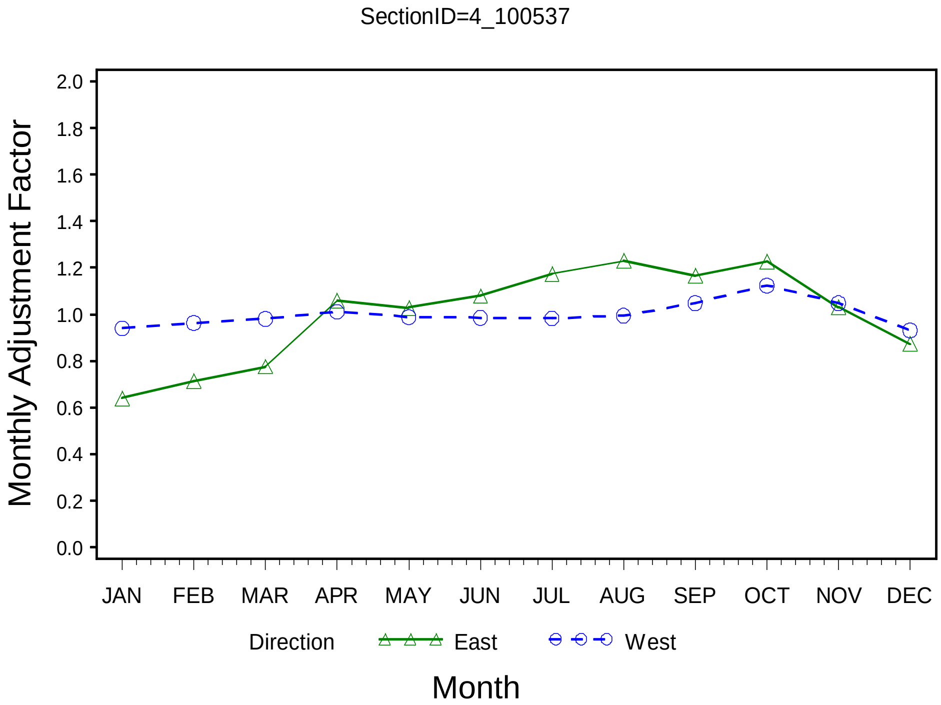


Figure D-57. Plot of Monthly Adjustment Factor for Site 4_100537 (Vehicle Class 9).

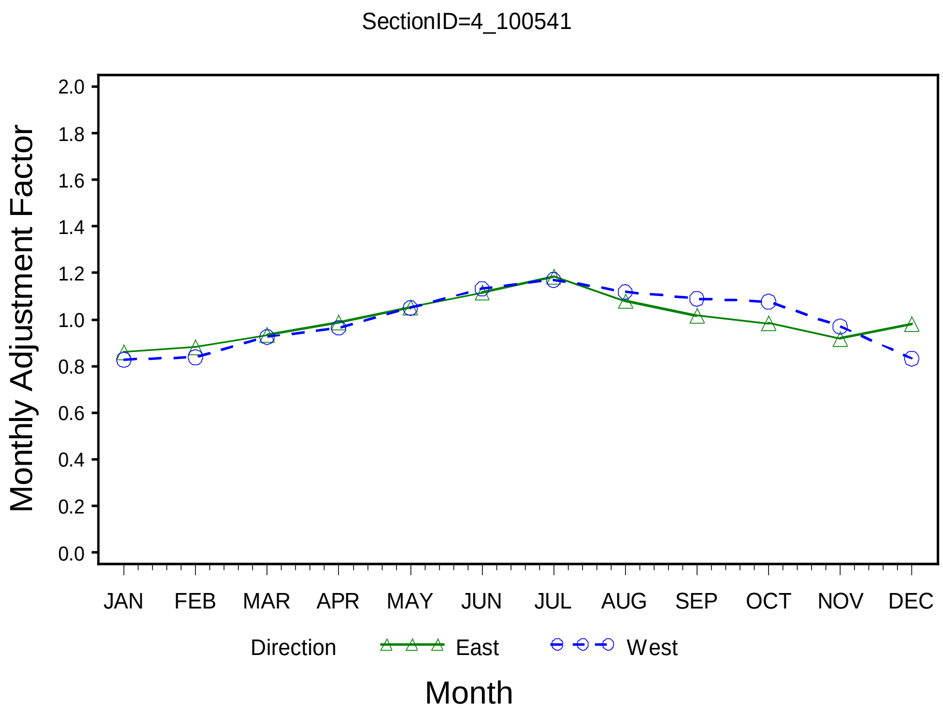


Figure D-58. Plot of Monthly Adjustment Factor for Site 4_100541 (Vehicle Class 5).

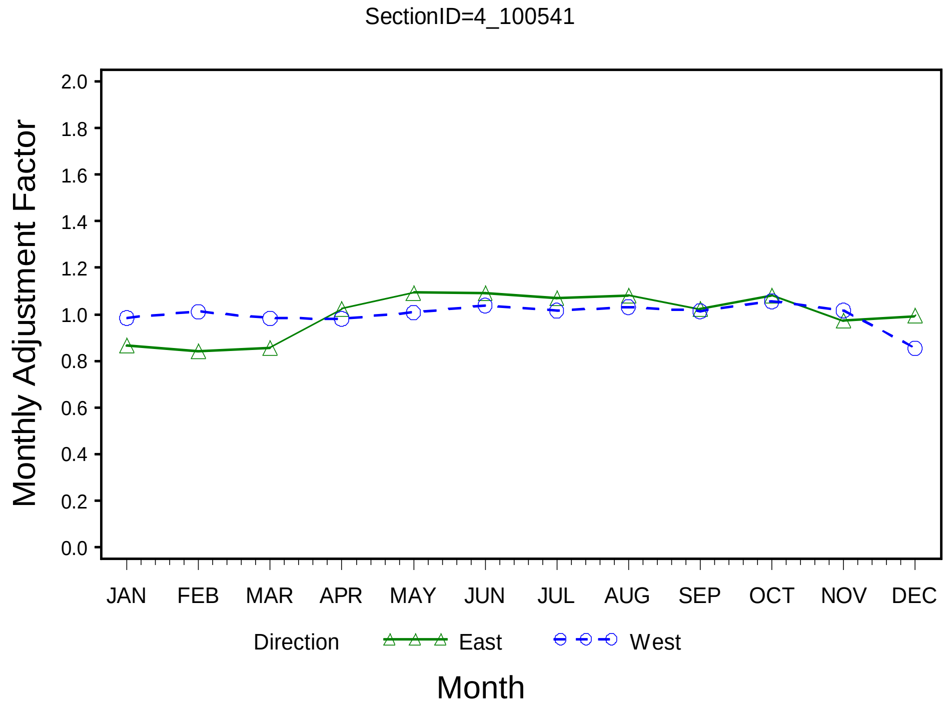


Figure D-59. Plot of Monthly Adjustment Factor for Site 4_100541 (Vehicle Class 9).

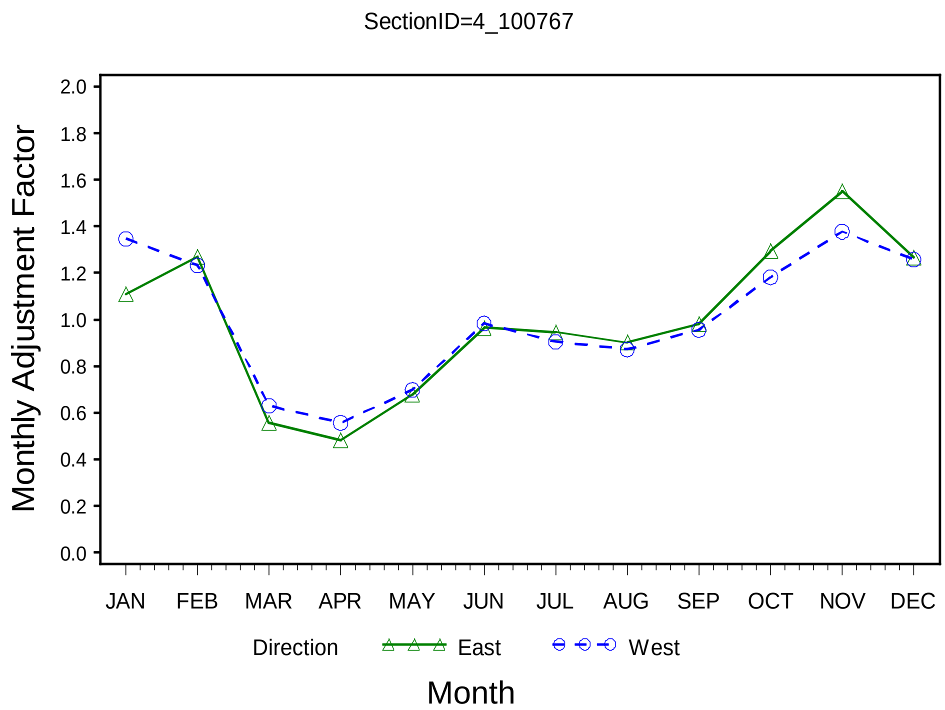


Figure D-60. Plot of Monthly Adjustment Factor for Site 4_100767 (Vehicle Class 5).

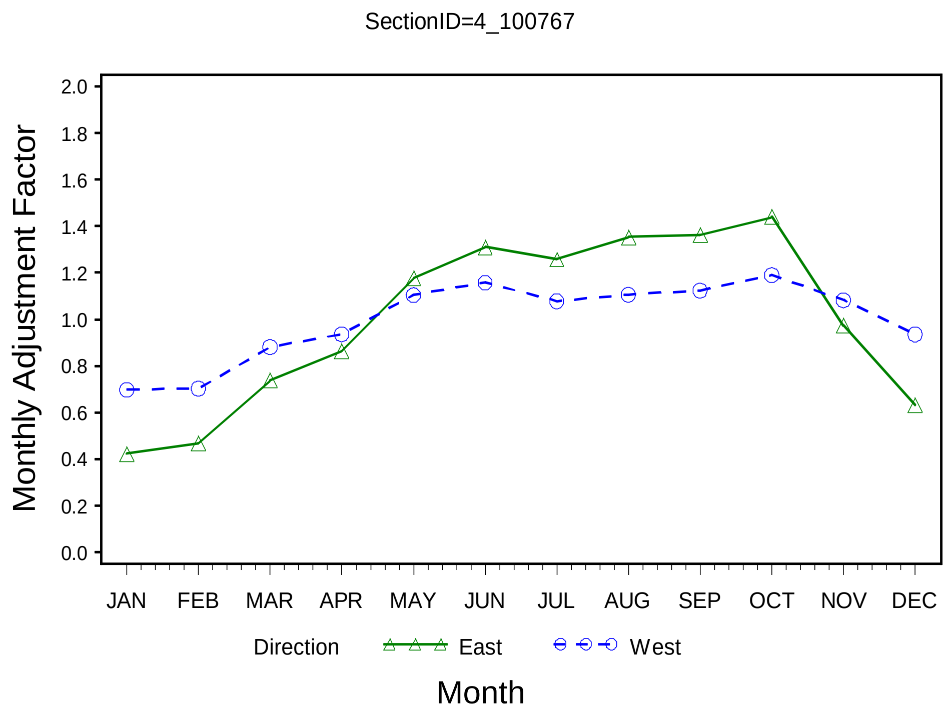


Figure D-61. Plot of Monthly Adjustment Factor for Site 4_100767 (Vehicle Class 9).

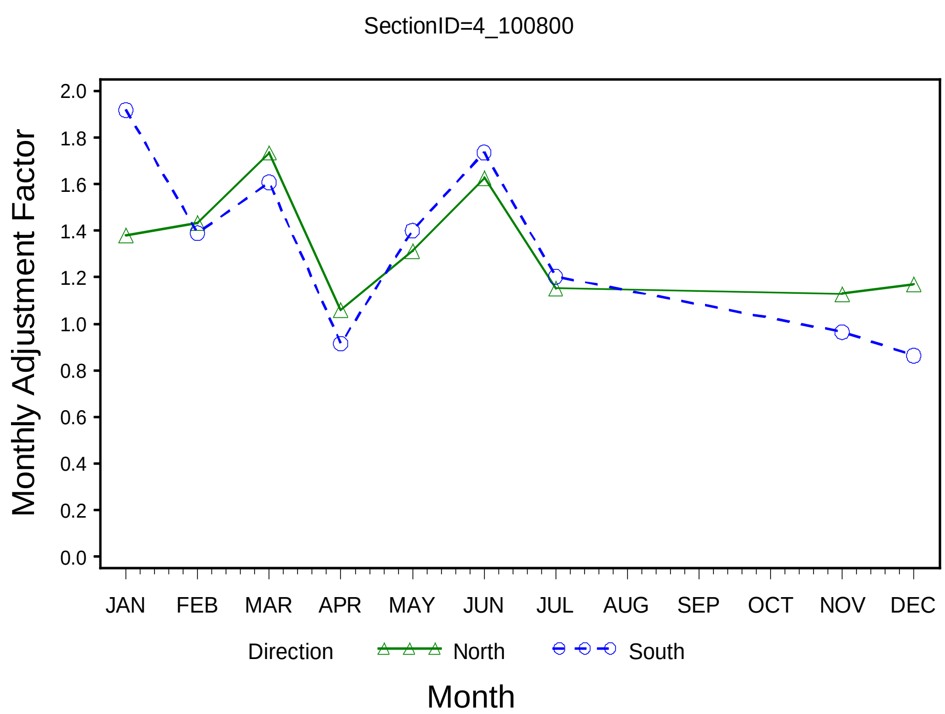


Figure D-62. Plot of Monthly Adjustment Factor for Site 4_100800 (Vehicle Class 5).

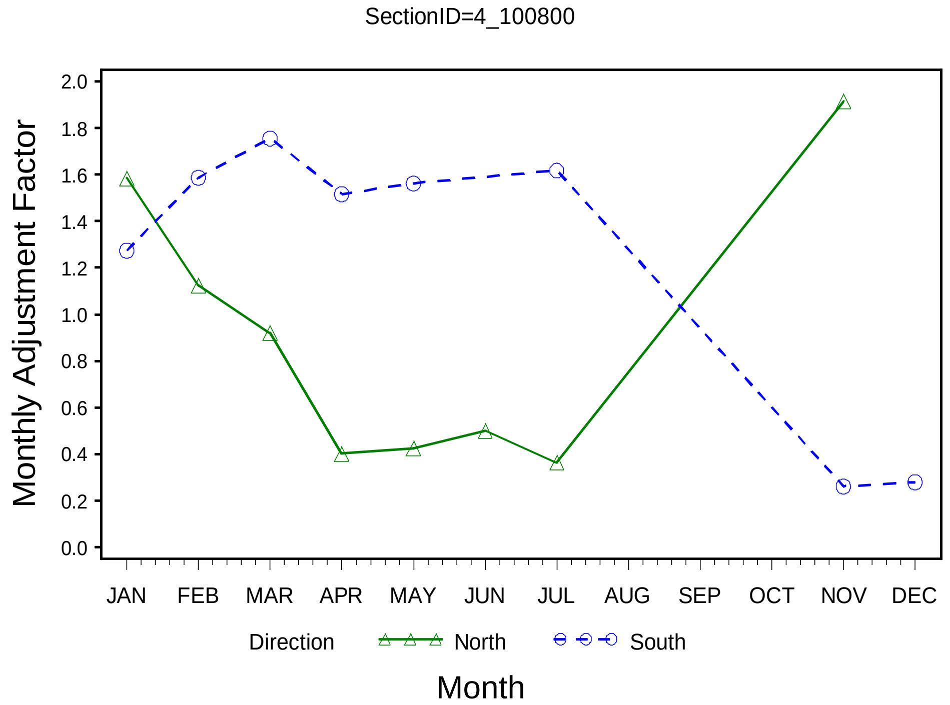


Figure D-63. Plot of Monthly Adjustment Factor for Site 4_100800 (Vehicle Class 9).

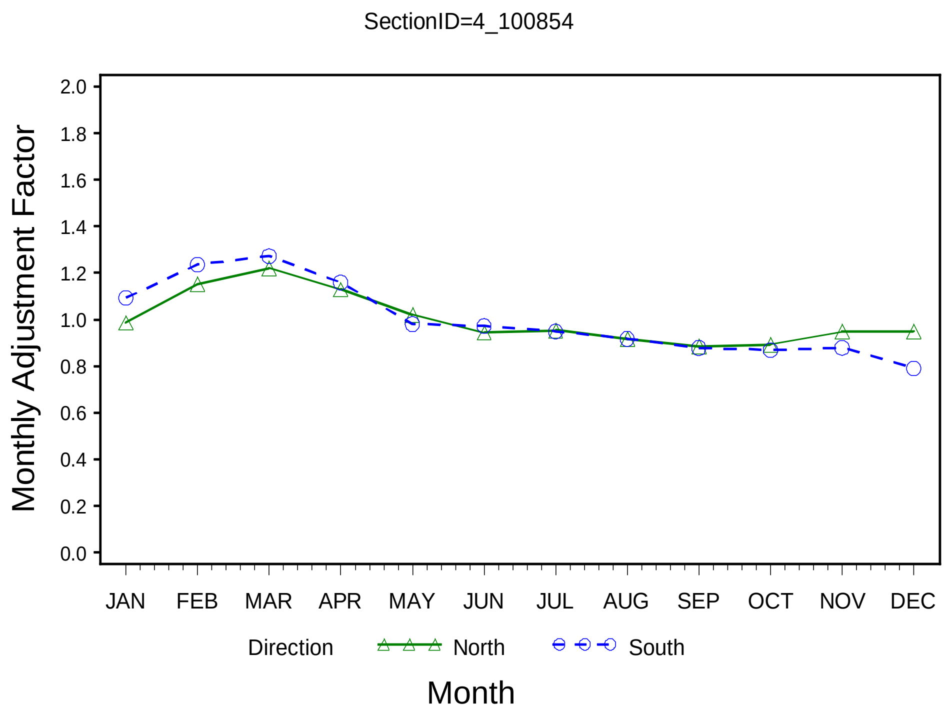


Figure D-64. Plot of Monthly Adjustment Factor for Site 4_100854 (Vehicle Class 5).

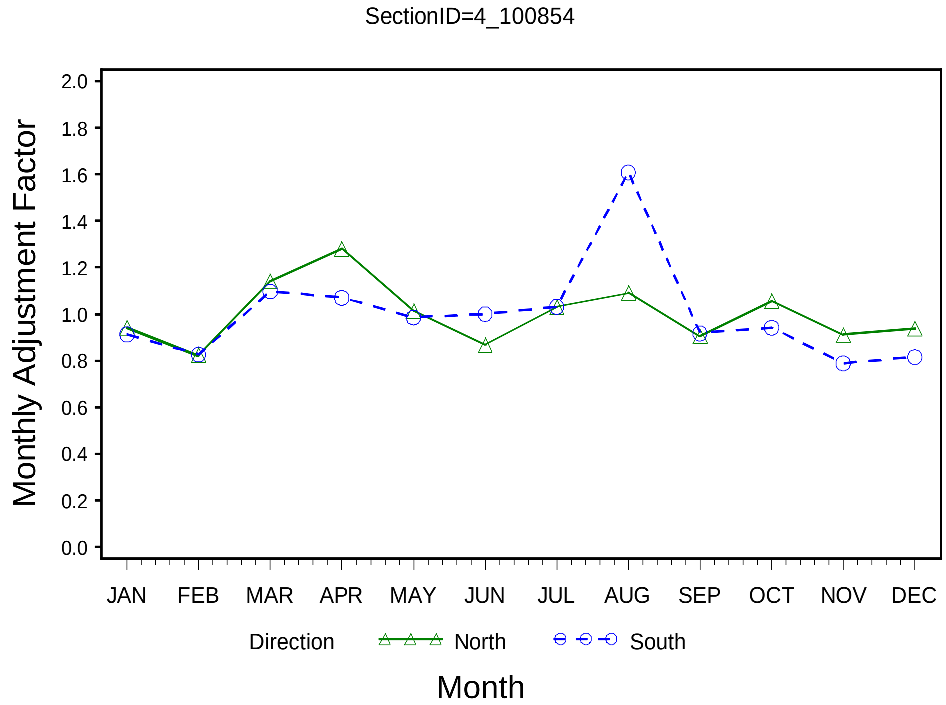


Figure D-65. Plot of Monthly Adjustment Factor for Site 4_100854 (Vehicle Class 9).

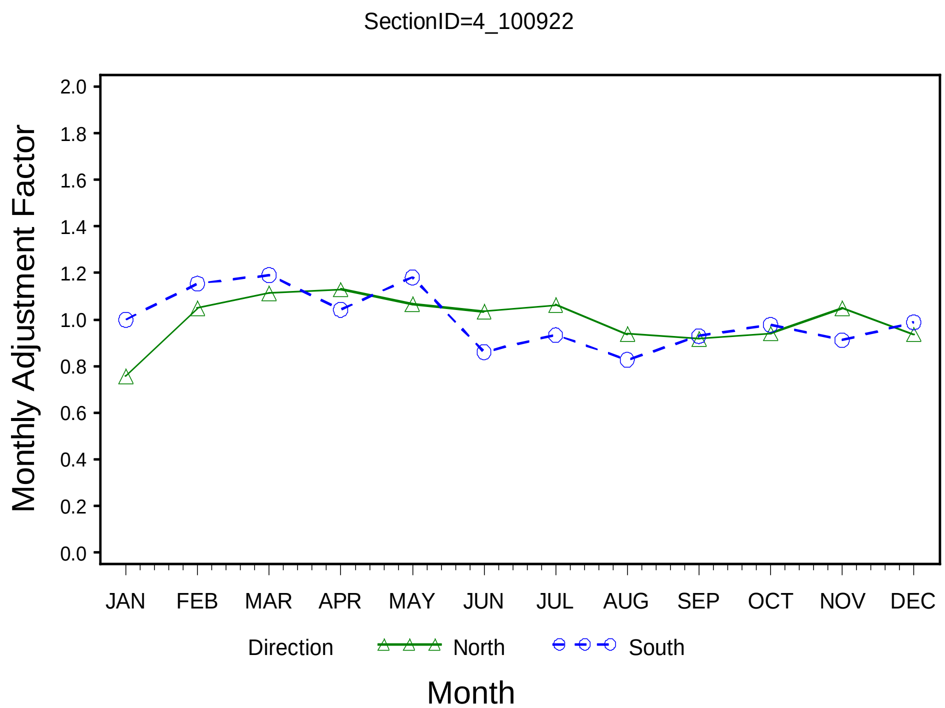


Figure D-66. Plot of Monthly Adjustment Factor for Site 4_100922 (Vehicle Class 5).

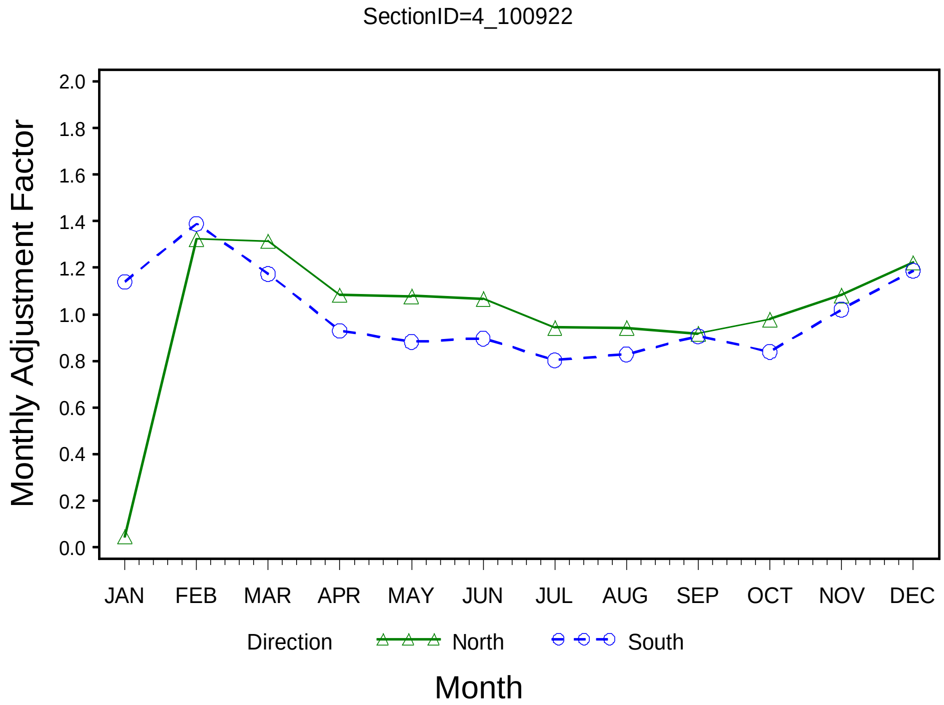


Figure D-67. Plot of Monthly Adjustment Factor for Site 4_100922 (Vehicle Class 9).

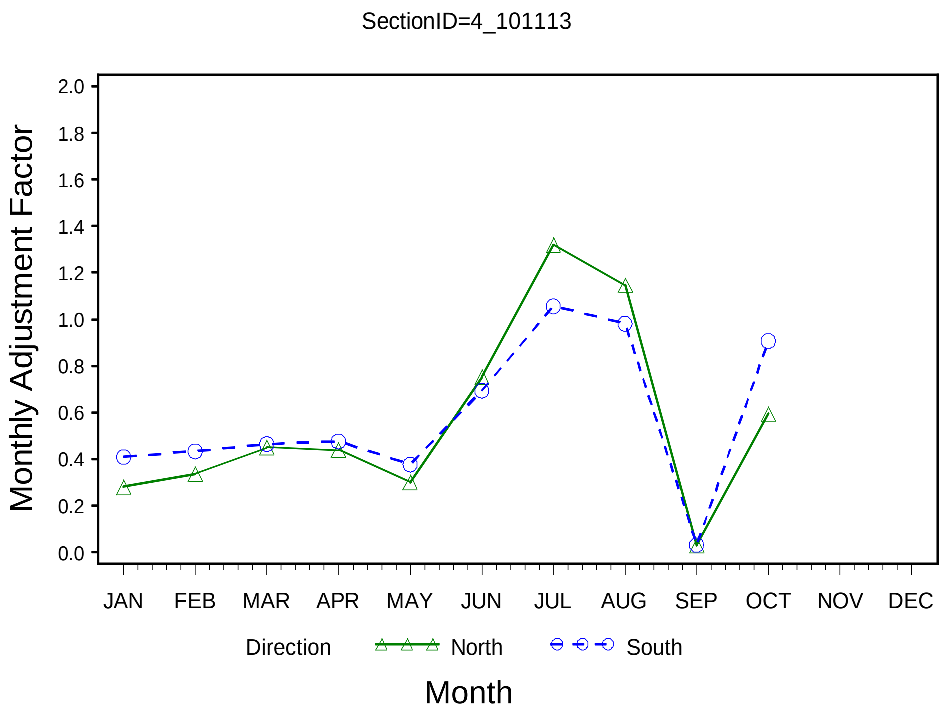


Figure D-68. Plot of Monthly Adjustment Factor for Site 4_101113 (Vehicle Class 5).

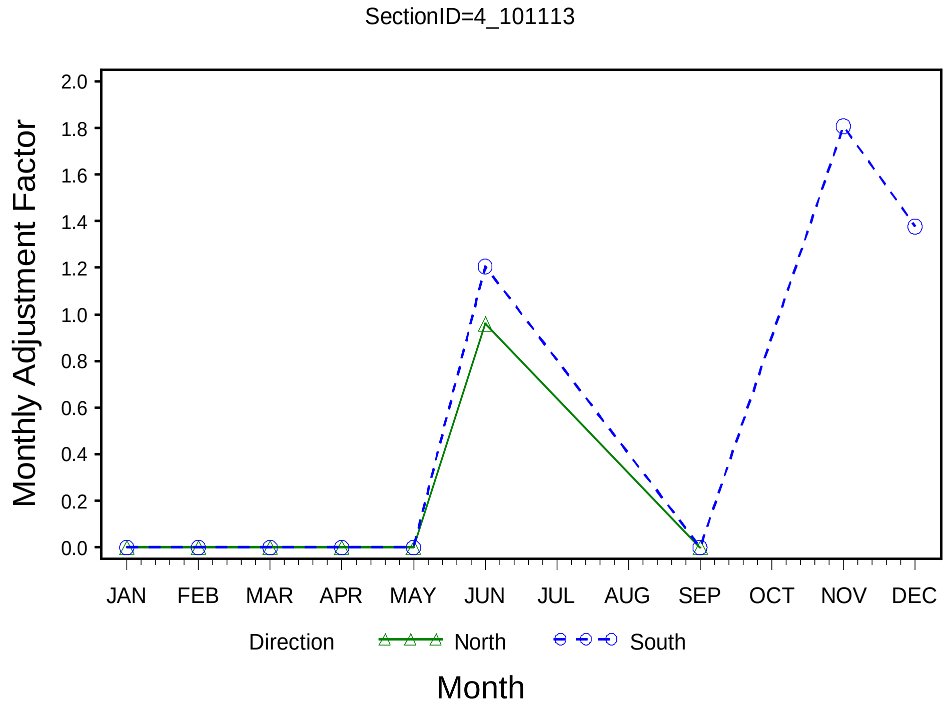


Figure D-69. Plot of Monthly Adjustment Factor for Site 4_101113 (Vehicle Class 9).

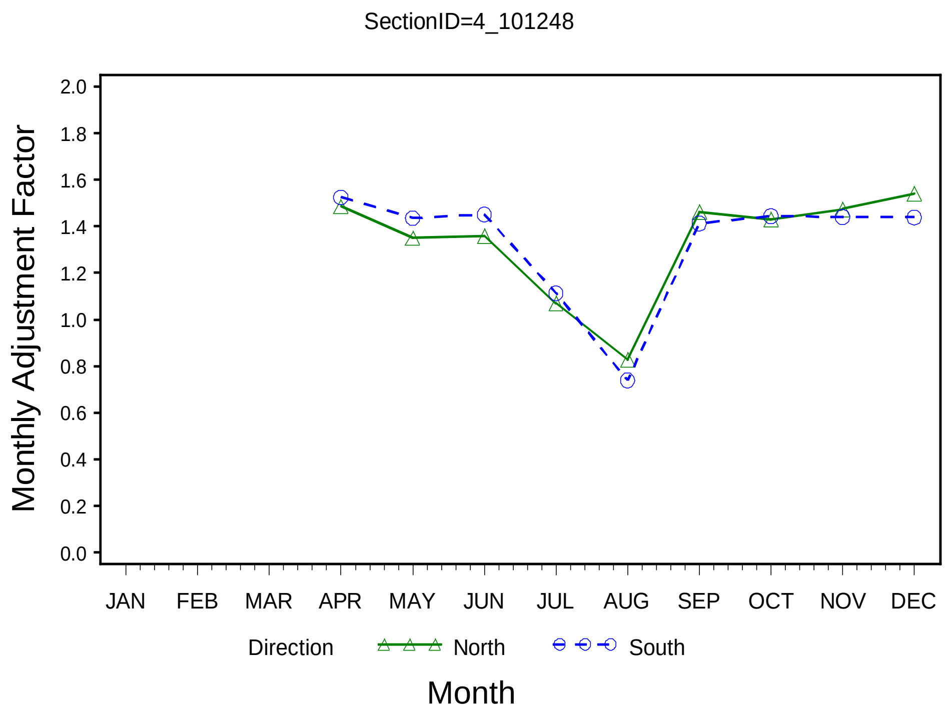


Figure D-70. Plot of Monthly Adjustment Factor for Site 4_101248 (Vehicle Class 5).

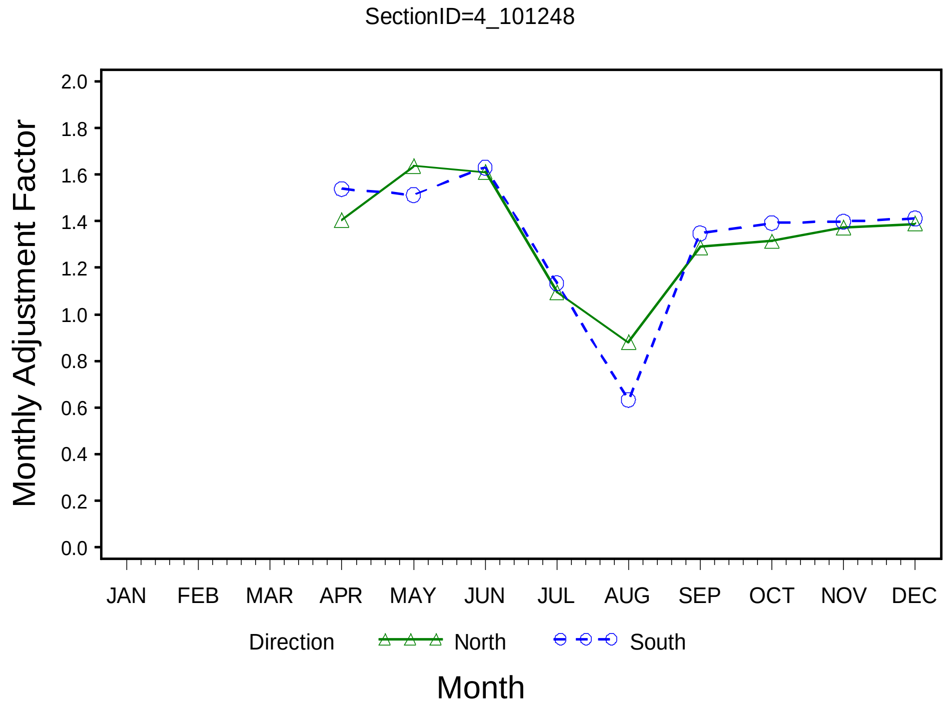


Figure D-71. Plot of Monthly Adjustment Factor for Site 4_101248 (Vehicle Class 9).

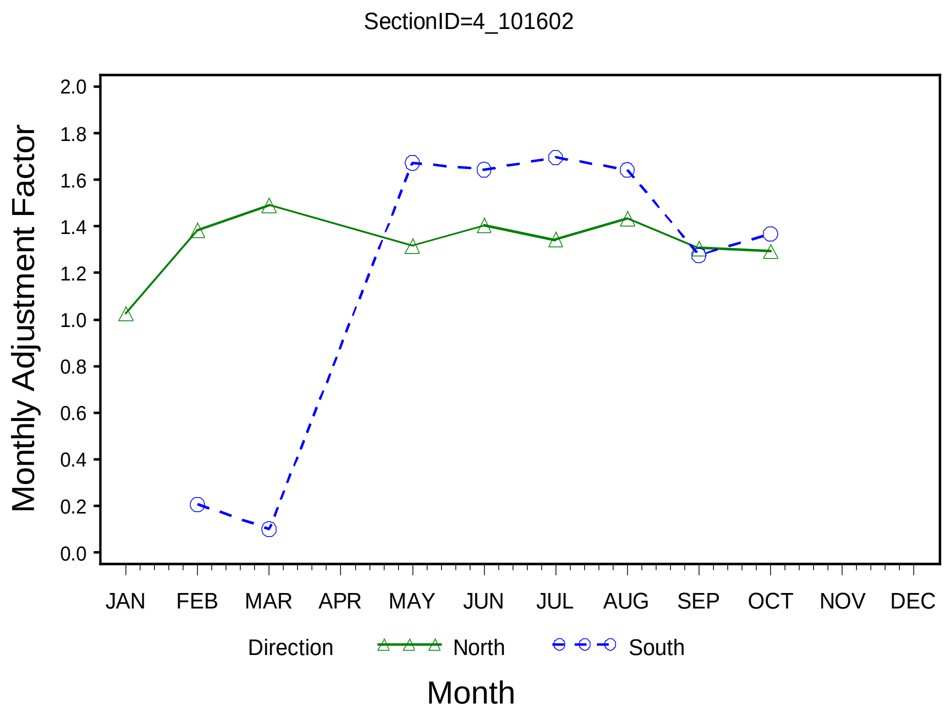


Figure D-72. Plot of Monthly Adjustment Factor for Site 4_101602 (Vehicle Class 5).

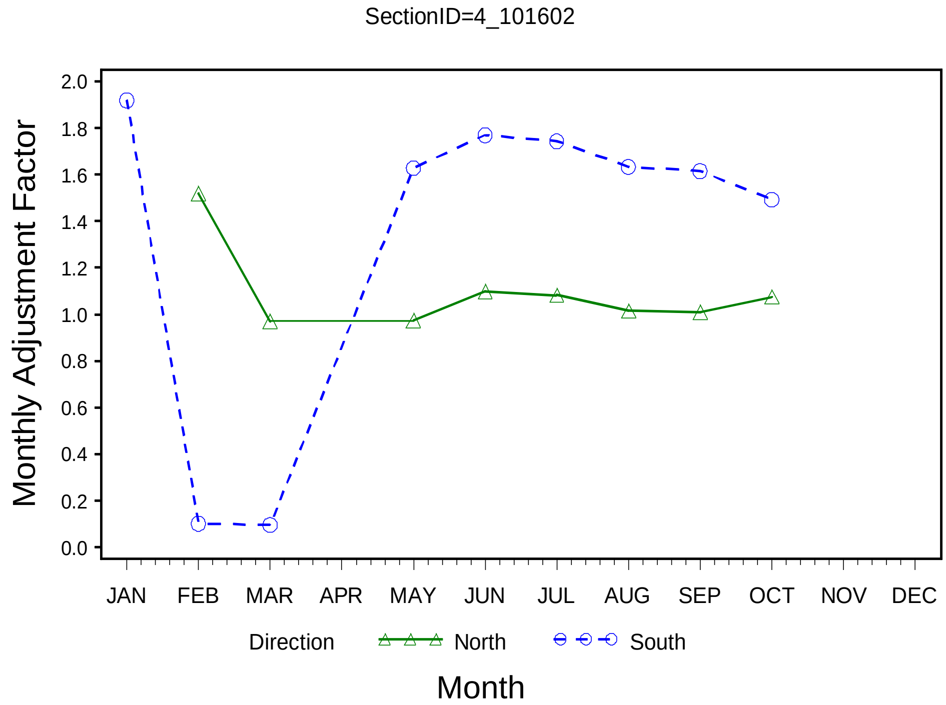


Figure D-73. Plot of Monthly Adjustment Factor for Site 4_101602 (Vehicle Class 9).

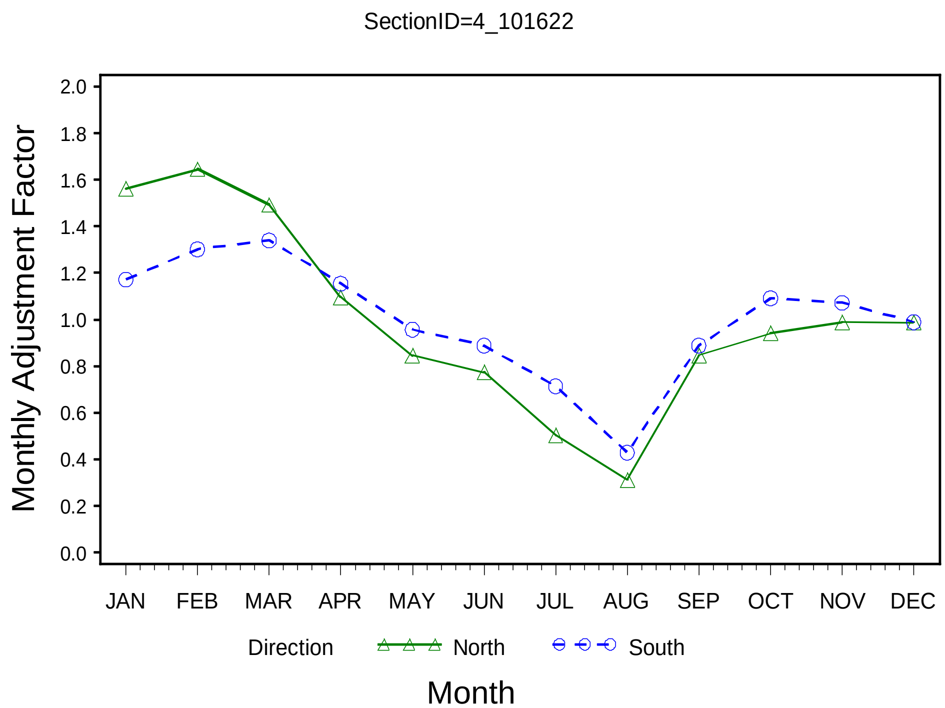


Figure D-74. Plot of Monthly Adjustment Factor for Site 4_101622 (Vehicle Class 5).

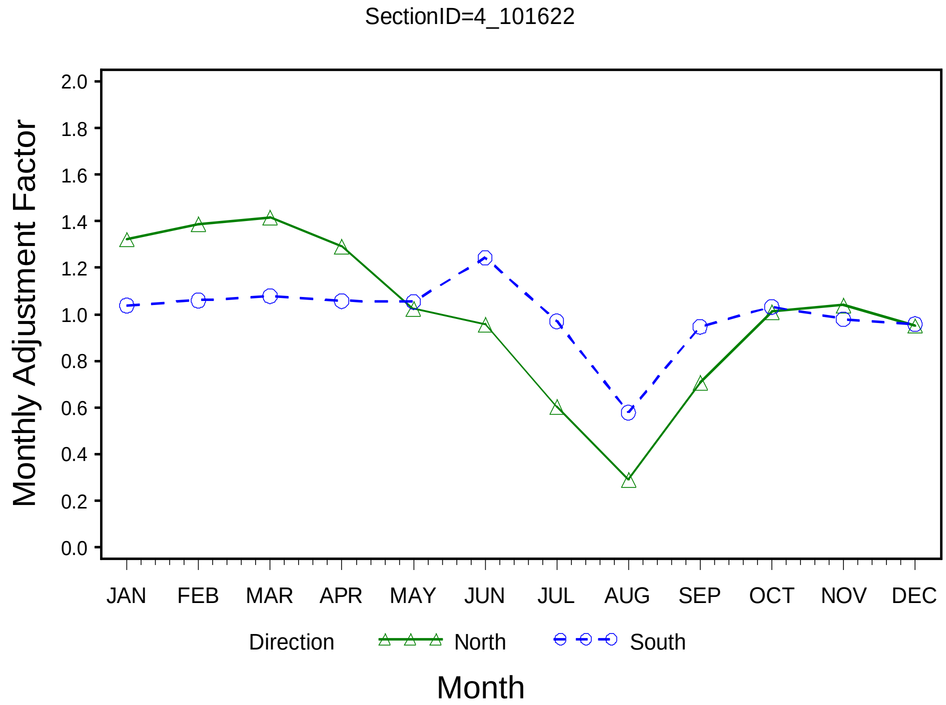


Figure D-75. Plot of Monthly Adjustment Factor for Site 4_101622 (Vehicle Class 9).

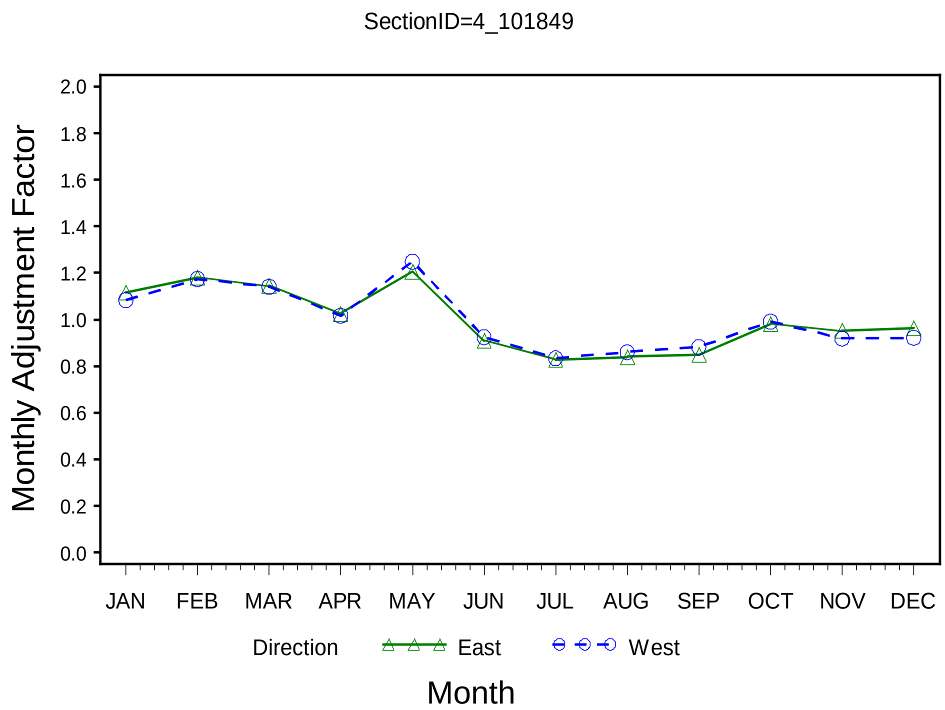


Figure D-76. Plot of Monthly Adjustment Factor for Site 4_101849 (Vehicle Class 5).

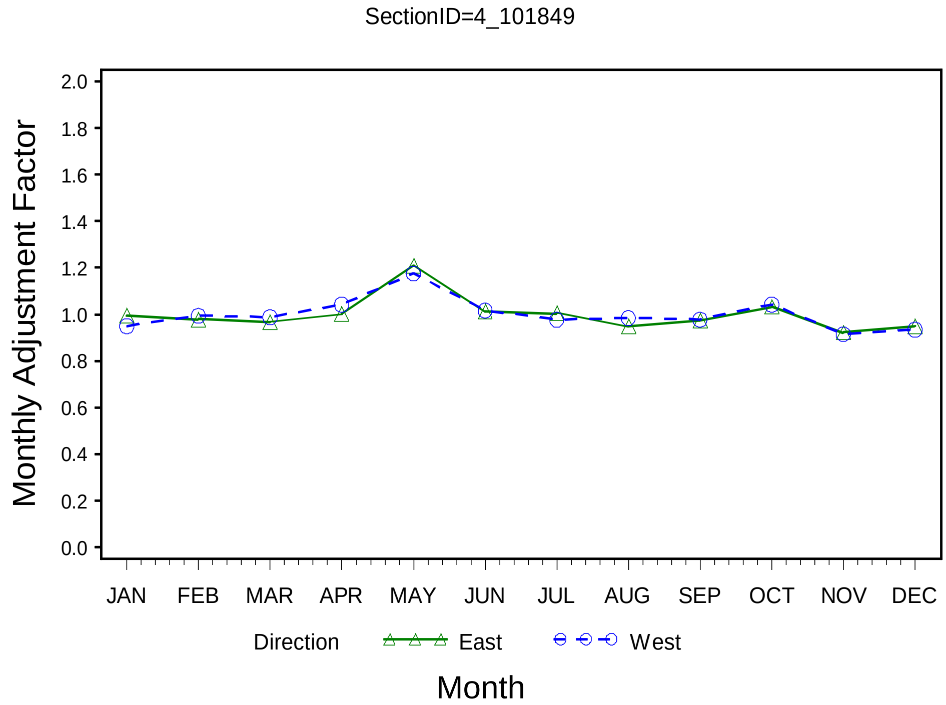


Figure D-77. Plot of Monthly Adjustment Factor for Site 4_101849 (Vehicle Class 9).

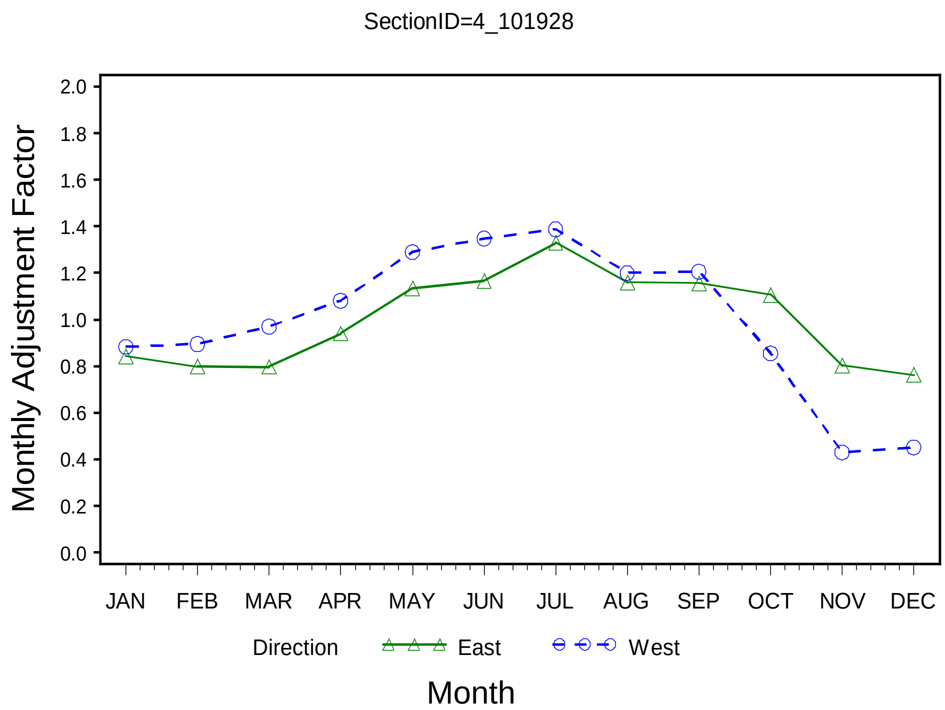


Figure D-78. Plot of Monthly Adjustment Factor for Site 4_101928 (Vehicle Class 5).

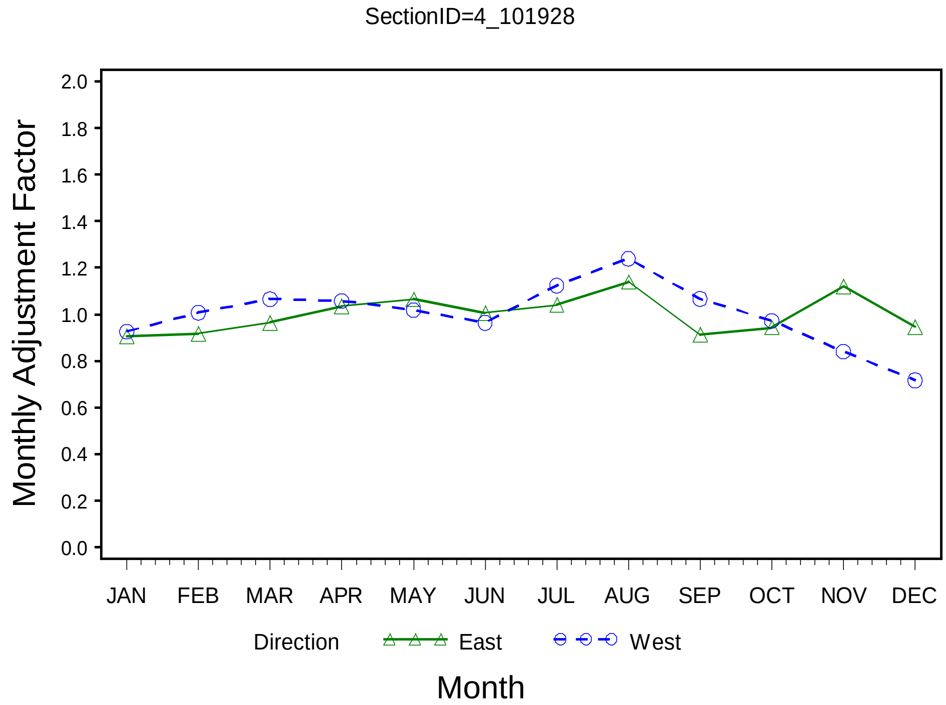


Figure D-79. Plot of Monthly Adjustment Factor for Site 4_101928 (Vehicle Class 9).

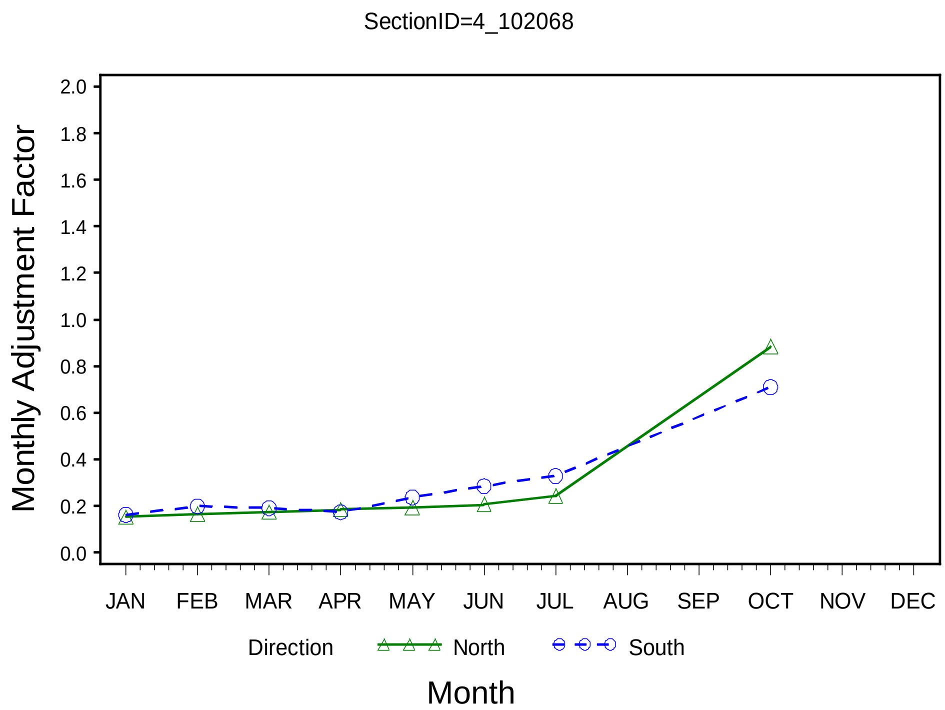


Figure D-80. Plot of Monthly Adjustment Factor for Site 4_102068 (Vehicle Class 5).

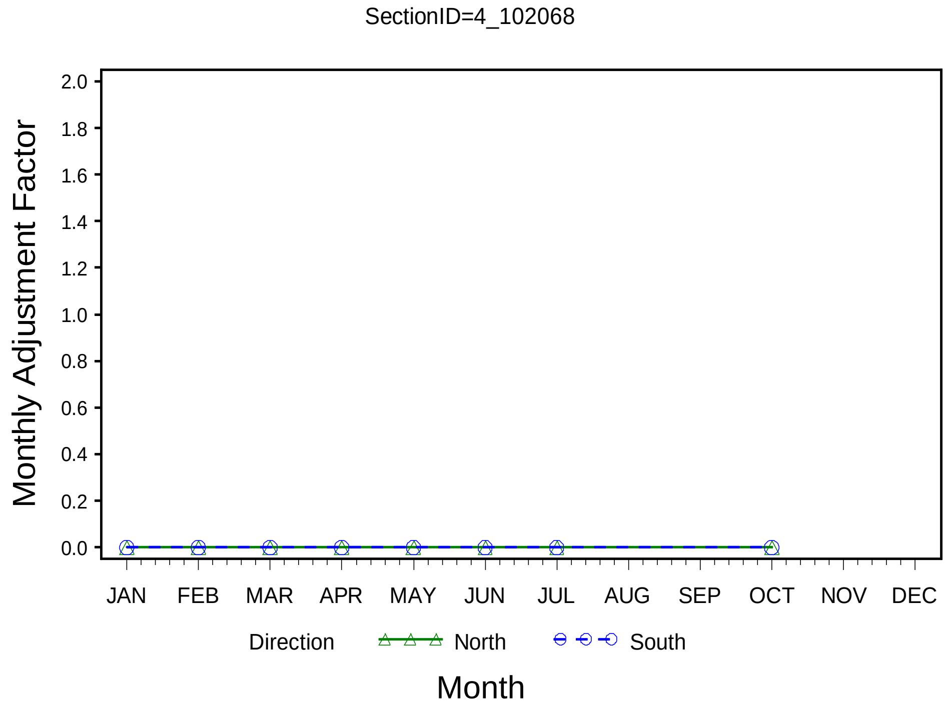


Figure D-81. Plot of Monthly Adjustment Factor for Site 4_102068 (Vehicle Class 9).

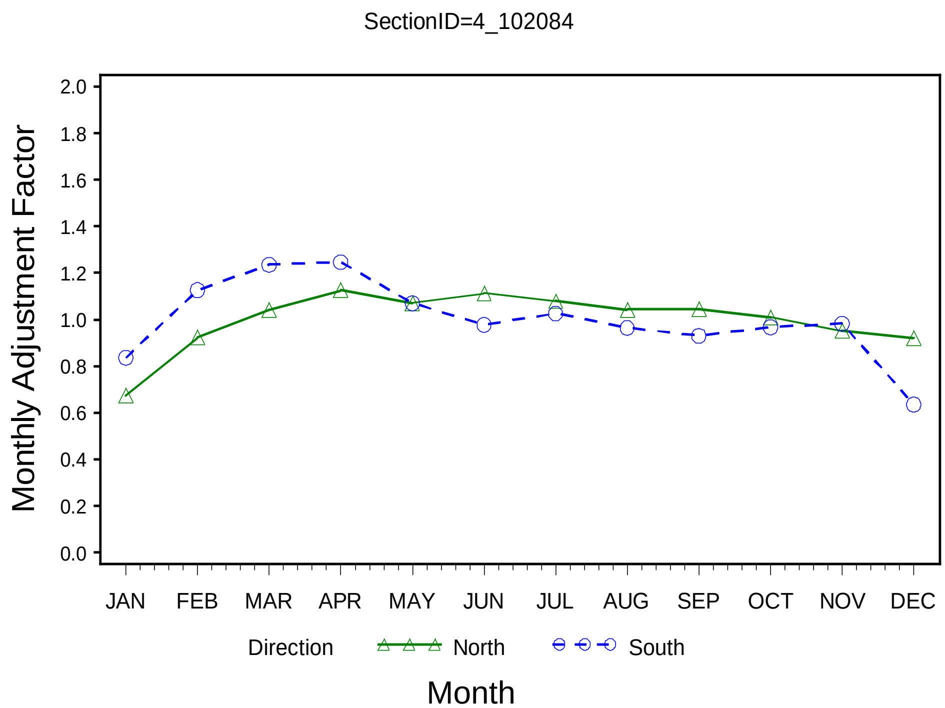


Figure D-82. Plot of Monthly Adjustment Factor for Site 4_102084 (Vehicle Class 5).

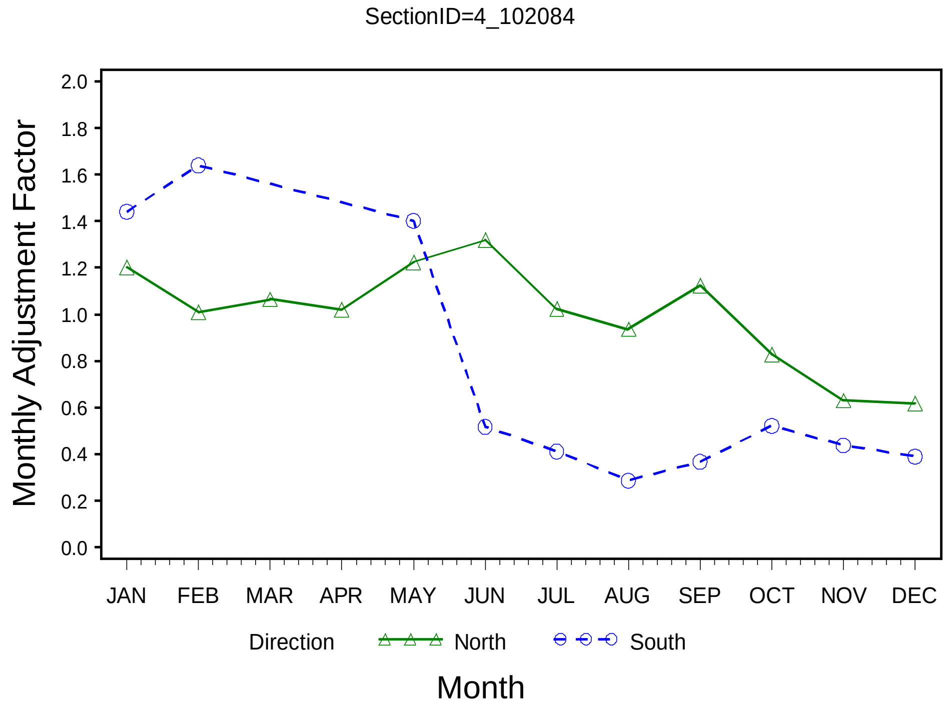


Figure D-83. Plot of Monthly Adjustment Factor for Site 4_102084 (Vehicle Class 9).

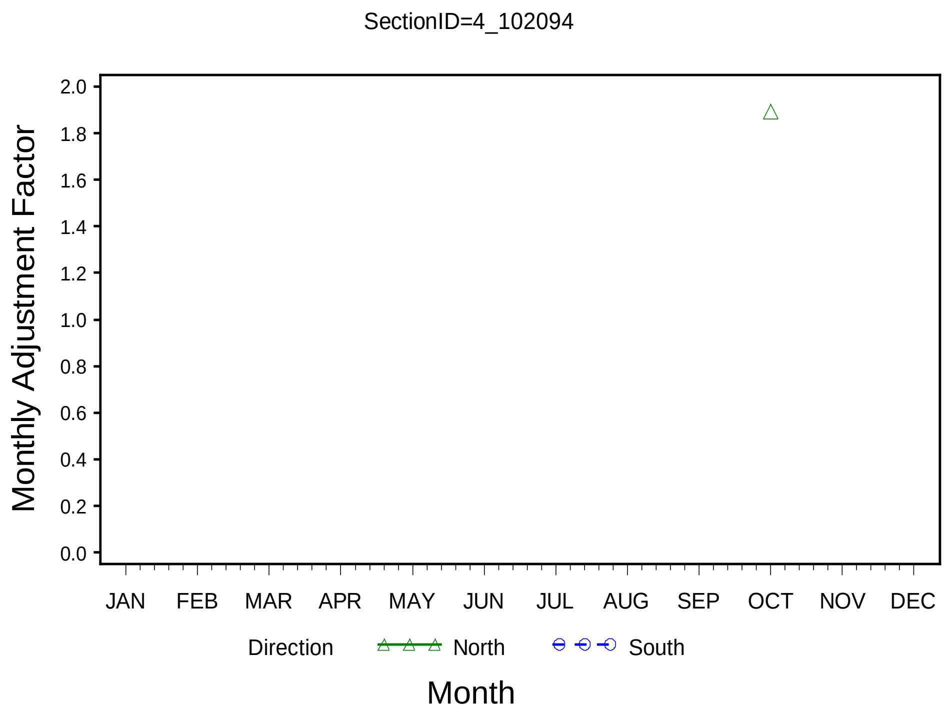


Figure D-84. Plot of Monthly Adjustment Factor for Site 4_102094 (Vehicle Class 5).

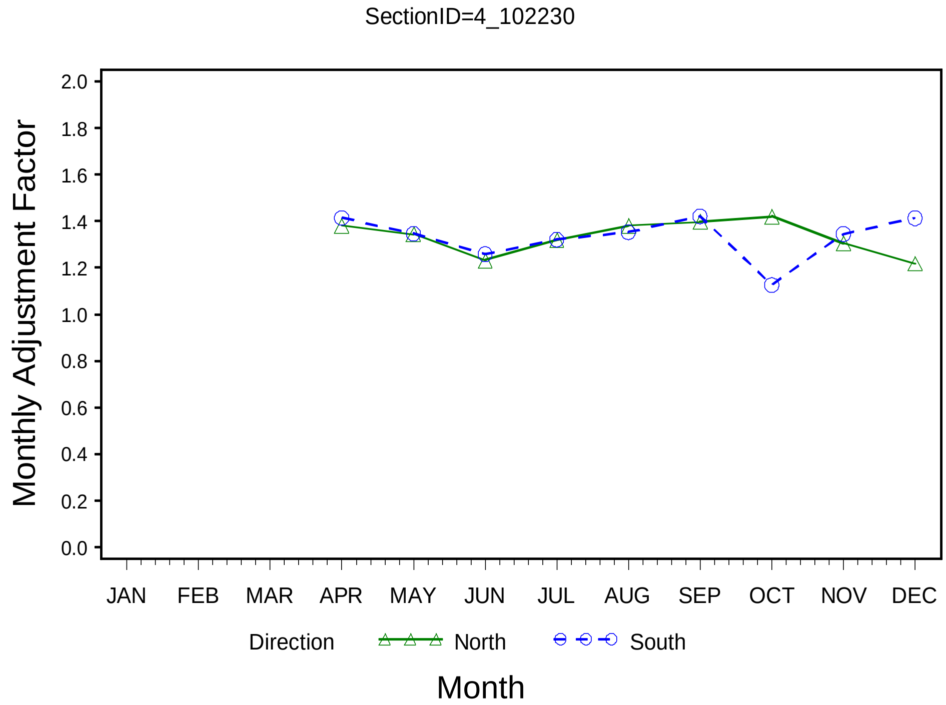


Figure D-85. Plot of Monthly Adjustment Factor for Site 4_102230 (Vehicle Class 5).

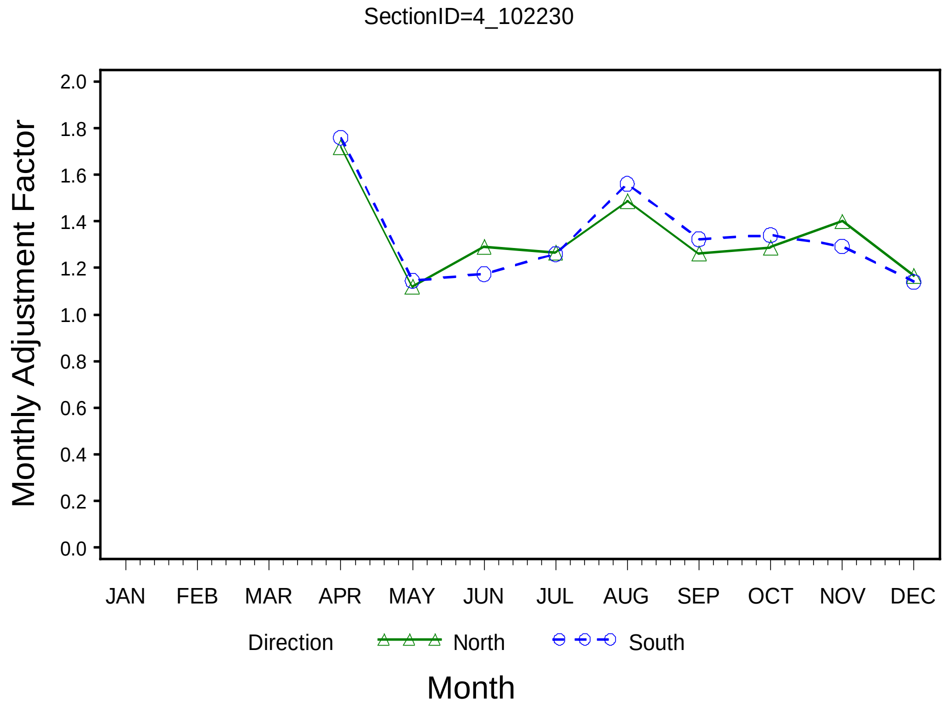


Figure D-86. Plot of Monthly Adjustment Factor for Site 4_102230 (Vehicle Class 9).

APPENDIX E. SUMMARY OF ALD DATA USED FOR ANALYSIS

This appendix presents ALD plots for Arizona projects for which the required data were available. Note that not all of the data presented in this appendix were included in the analysis, as some data were deemed atypical, anomalous, or erroneous.

AXLE LOAD DISTRIBUTION PLOTS FOR CLASS 5 TRUCKS

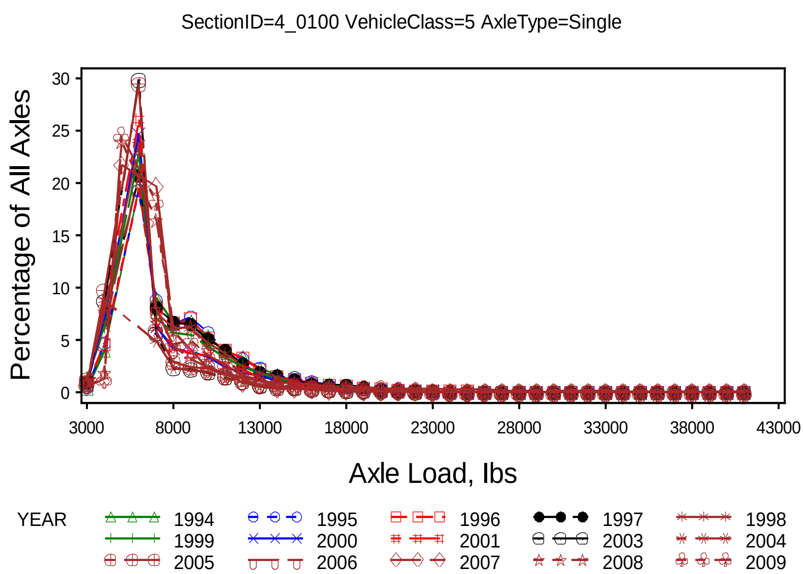


Figure E-1. Plot of Single-Axle Load for Site 4_0100 (Vehicle Class 5).

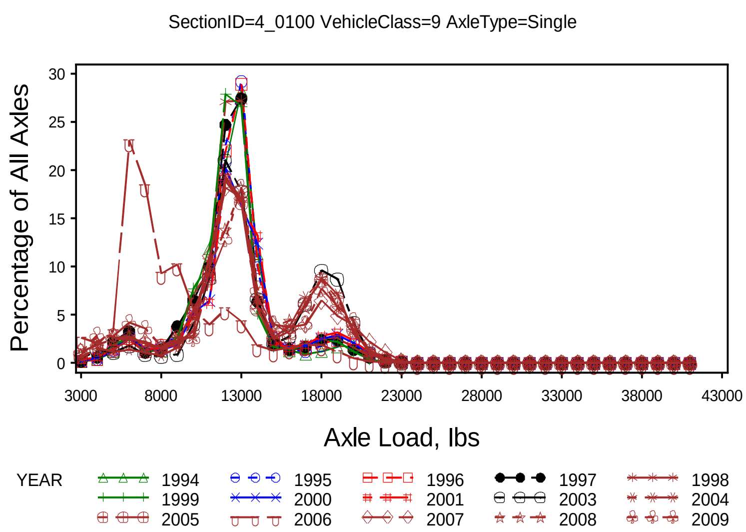


Figure E-2. Plot of Single-Axle Load for Site 4_0100 (Vehicle Class 9).

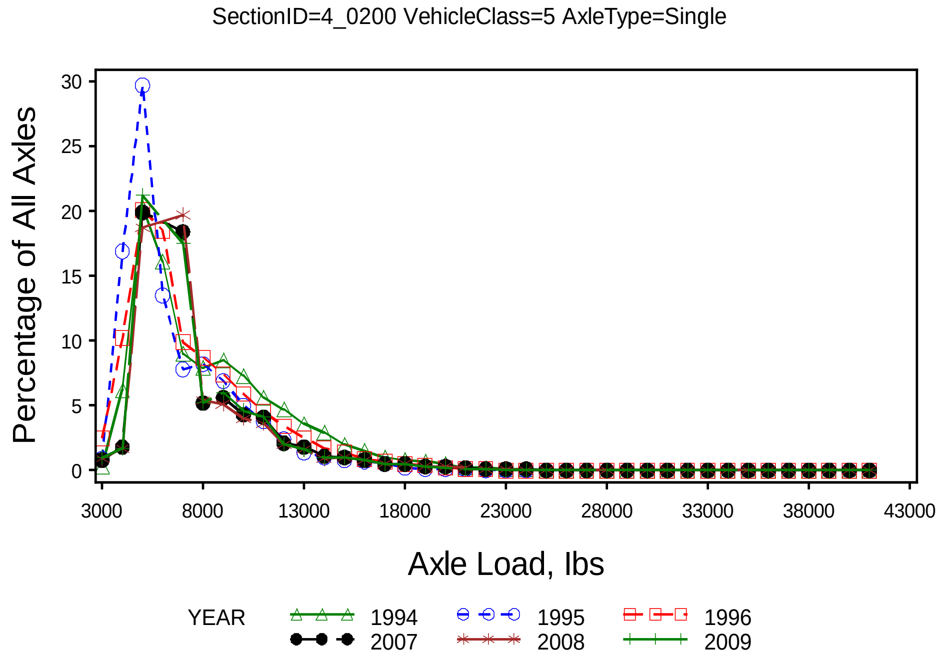


Figure E-3. Plot of Single-Axle Load for Site 4_0200 (Vehicle Class 5).

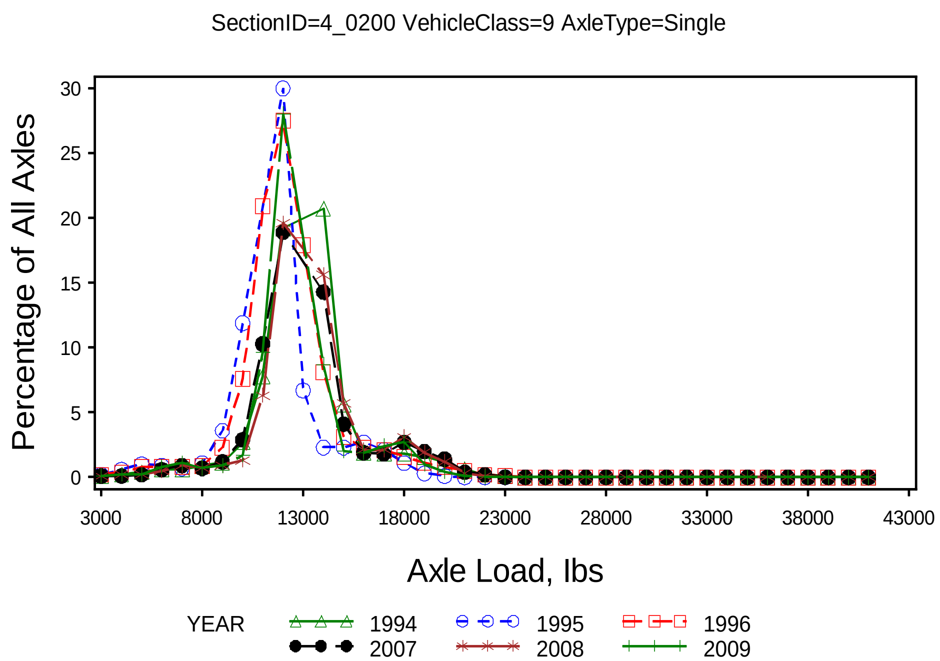


Figure E-4. Plot of Single-Axle Load for Site 4_0200 (Vehicle Class 9).

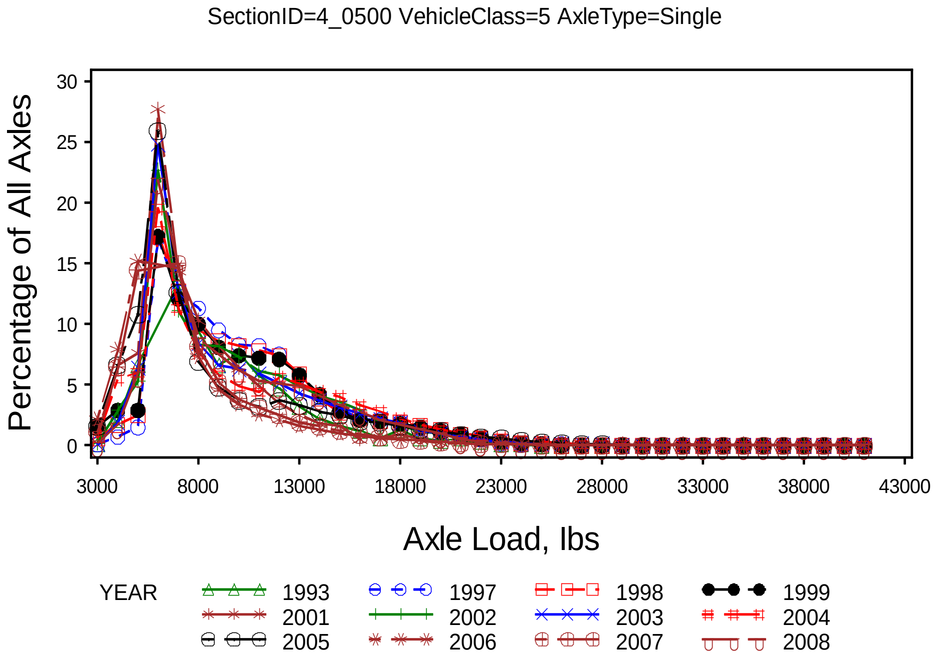


Figure E-5. Plot of Single-Axle Load for Site 4_0500 (Vehicle Class 5).

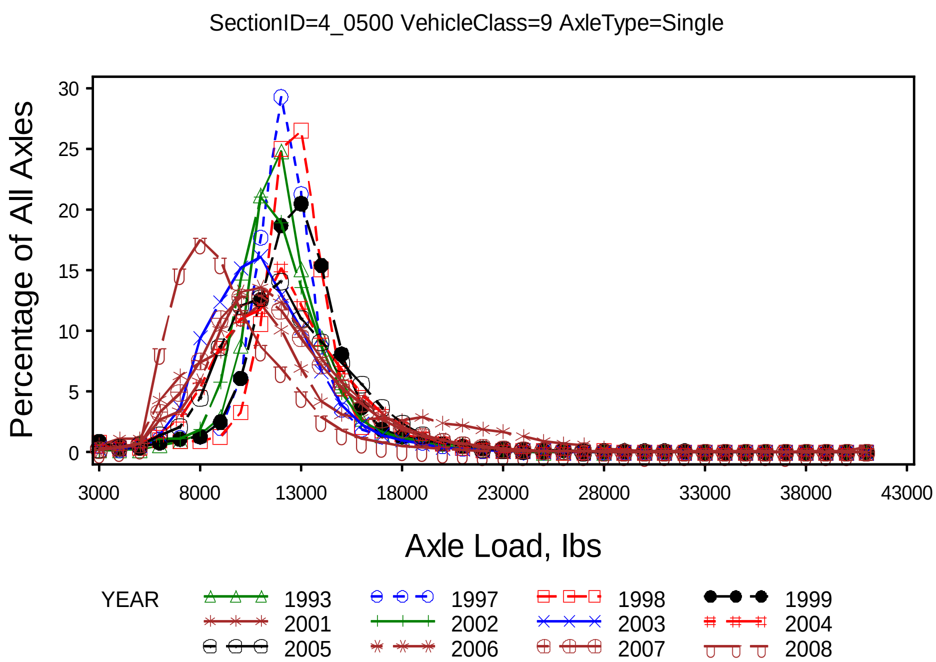


Figure E-6. Plot of Single-Axle Load for Site 4_0500 (Vehicle Class 9).

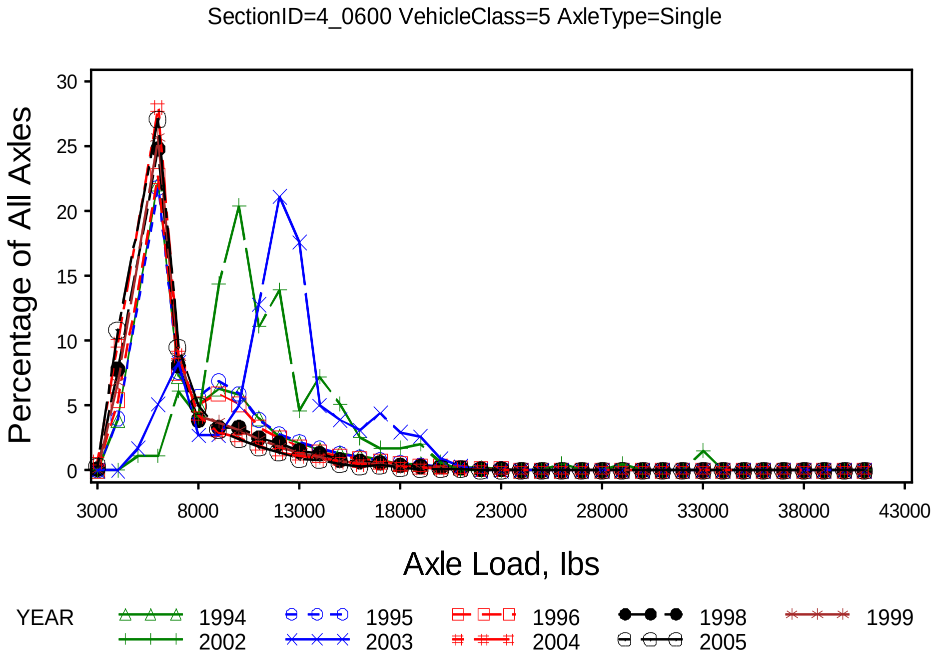


Figure E-7. Plot of Single-Axle Load for Site 4_0600 (Vehicle Class 5).

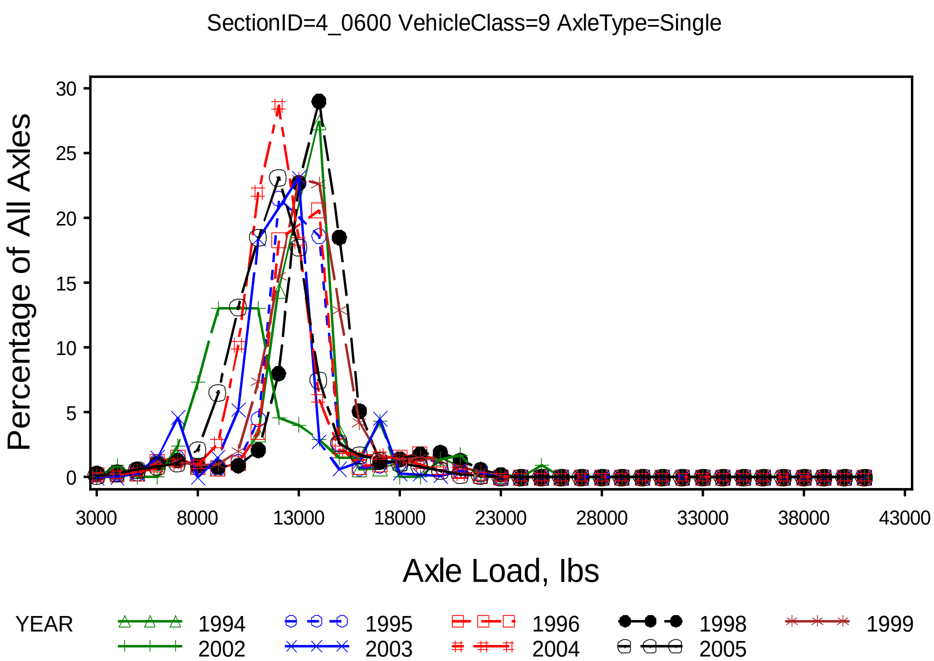


Figure E-8. Plot of Single-Axle Load for Site 4_0600 (Vehicle Class 9).

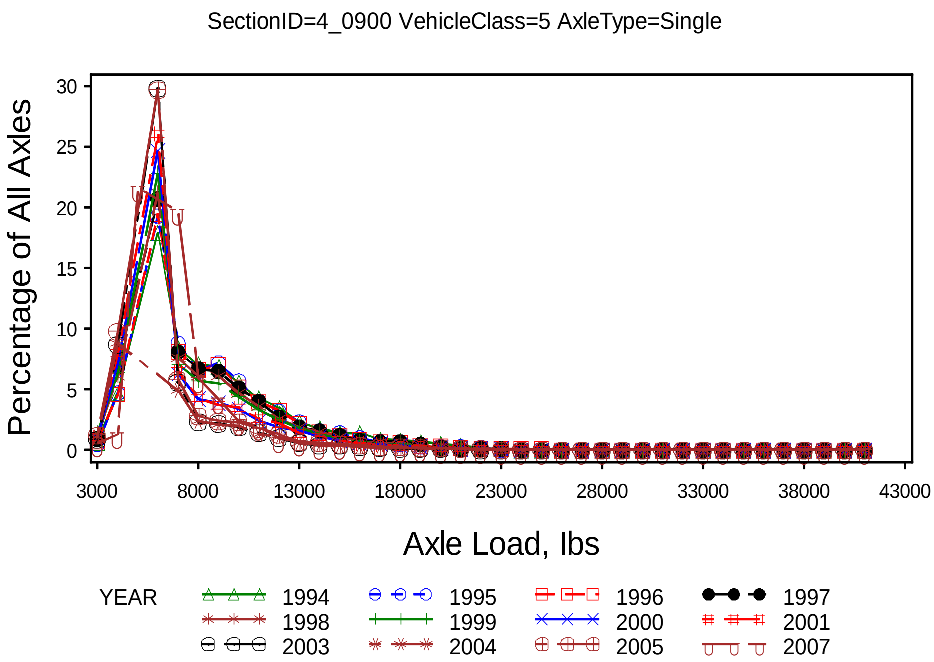


Figure E-9. Plot of Single-Axle Load for Site 4_0900 (Vehicle Class 5).

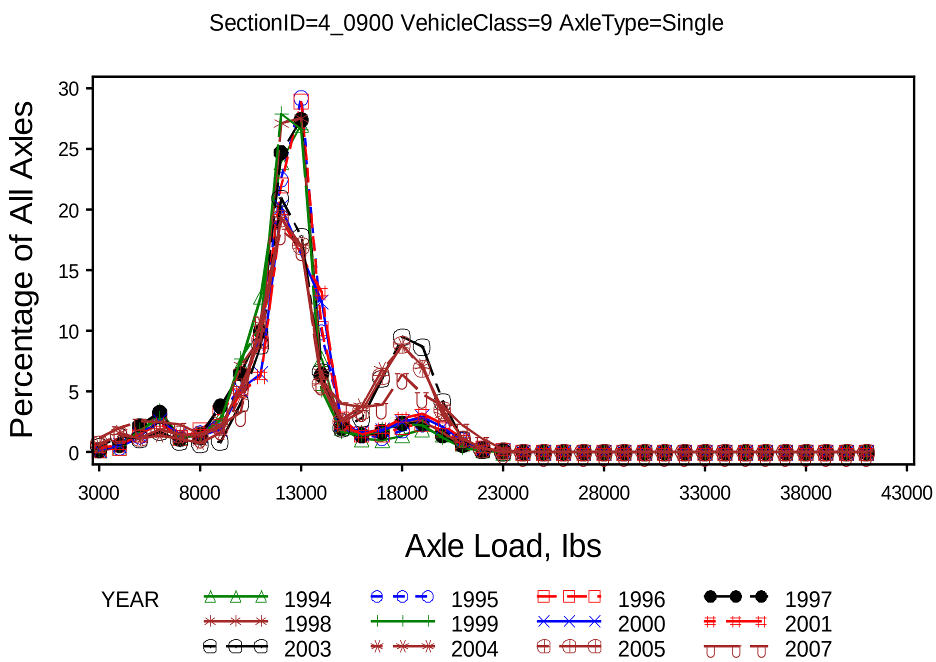


Figure E-10. Plot of Single-Axle Load for Site 4_0900 (Vehicle Class 9).

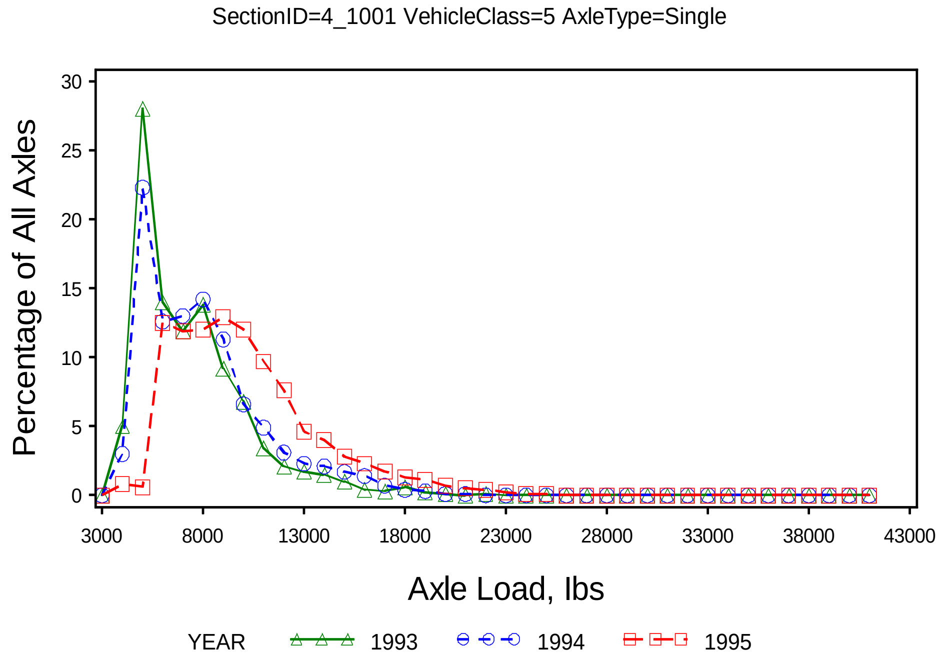


Figure E-11. Plot of Single-Axle Load for Site 4_1001 (Vehicle Class 5).

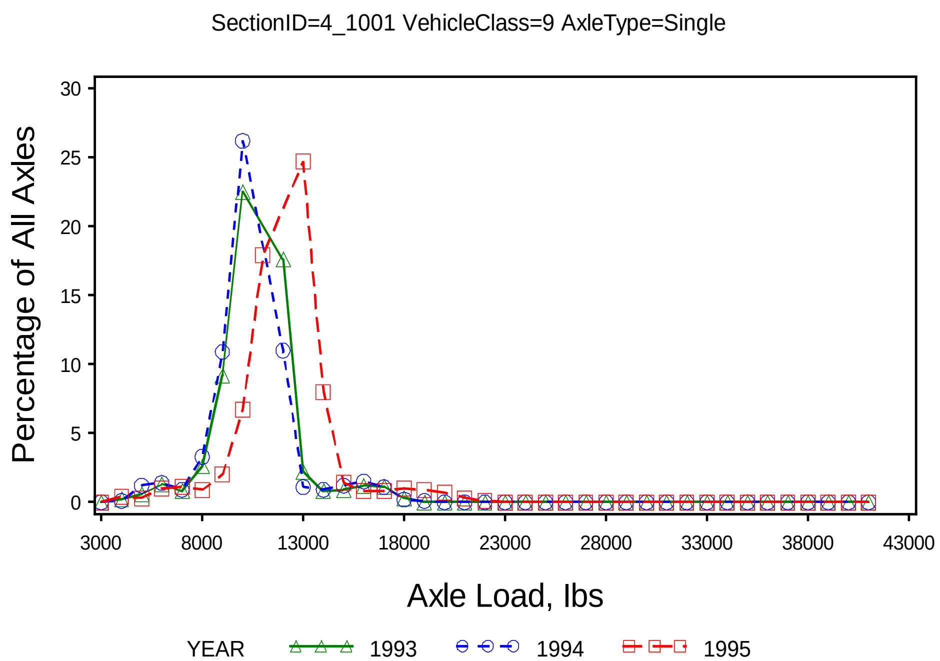


Figure E-12. Plot of Single-Axle Load for Site 4_1001 (Vehicle Class 9).

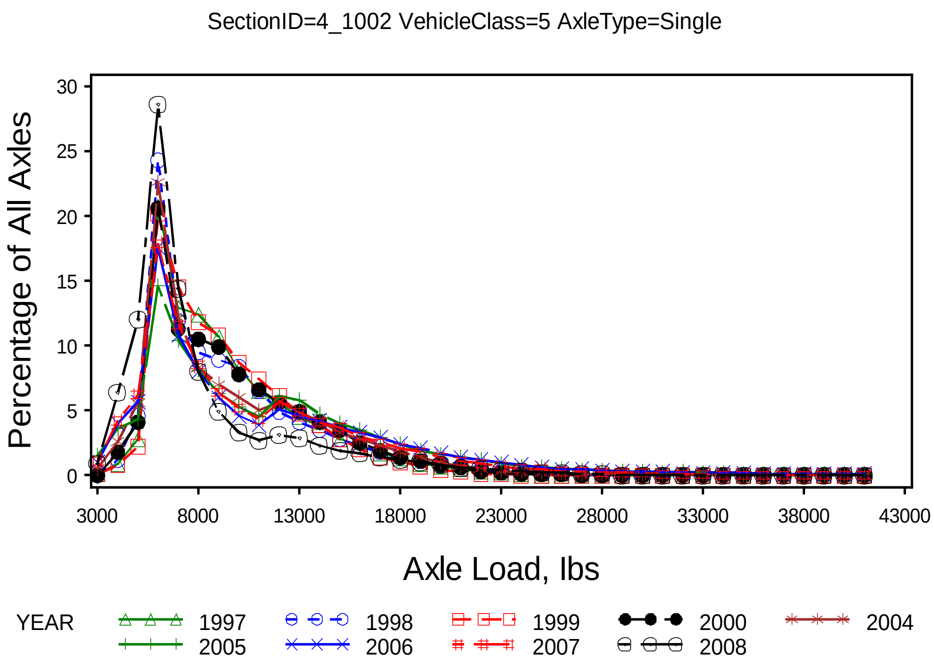


Figure E-13. Plot of Single-Axle Load for Site 4_1002 (Vehicle Class 5).

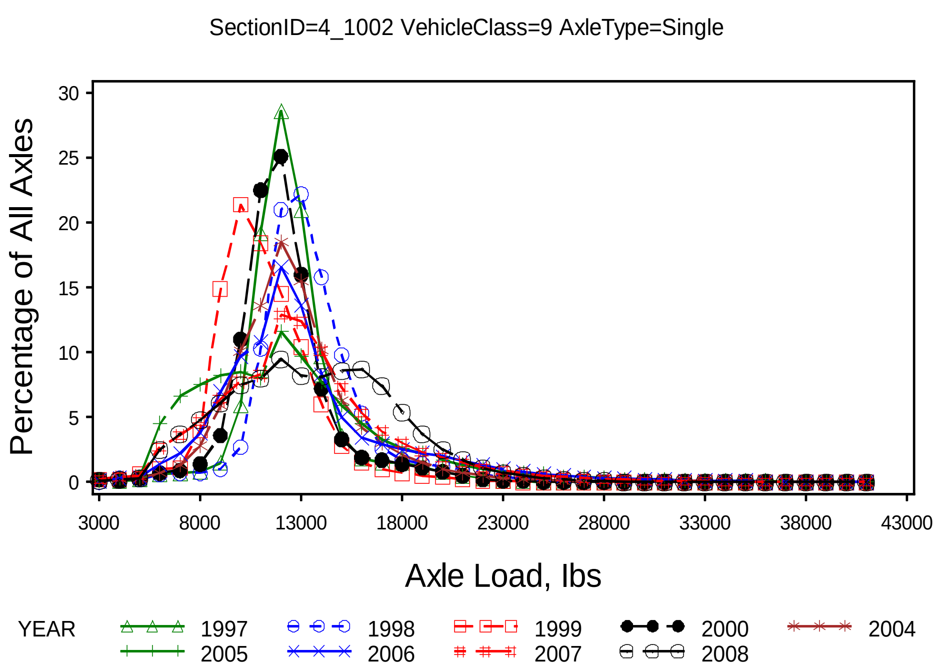


Figure E-14. Plot of Single-Axle Load for Site 4_1002 (Vehicle Class 9).

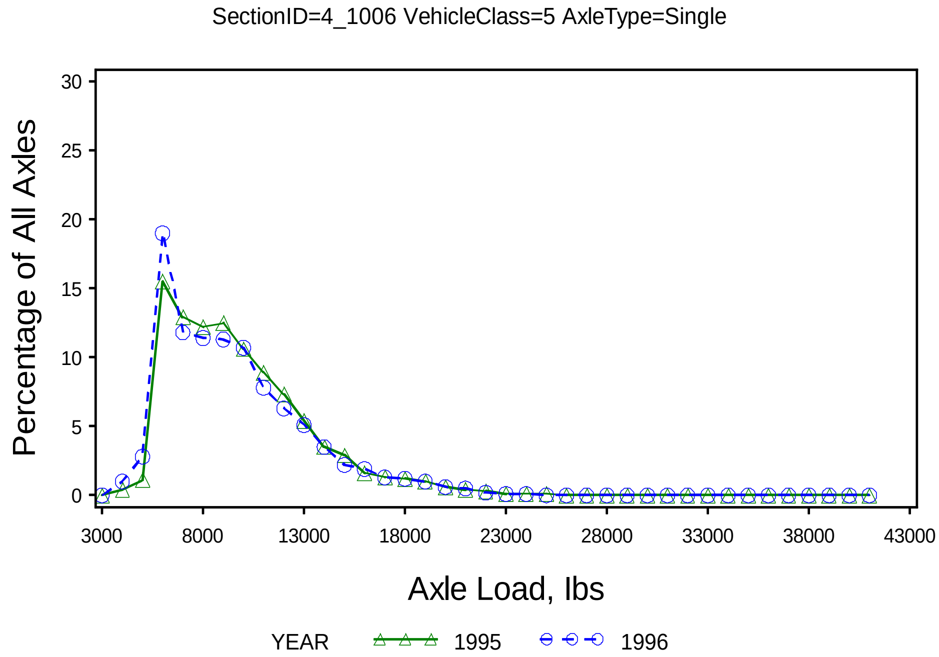


Figure E-15. Plot of Single-Axle Load for Site 4_1006 (Vehicle Class 5).

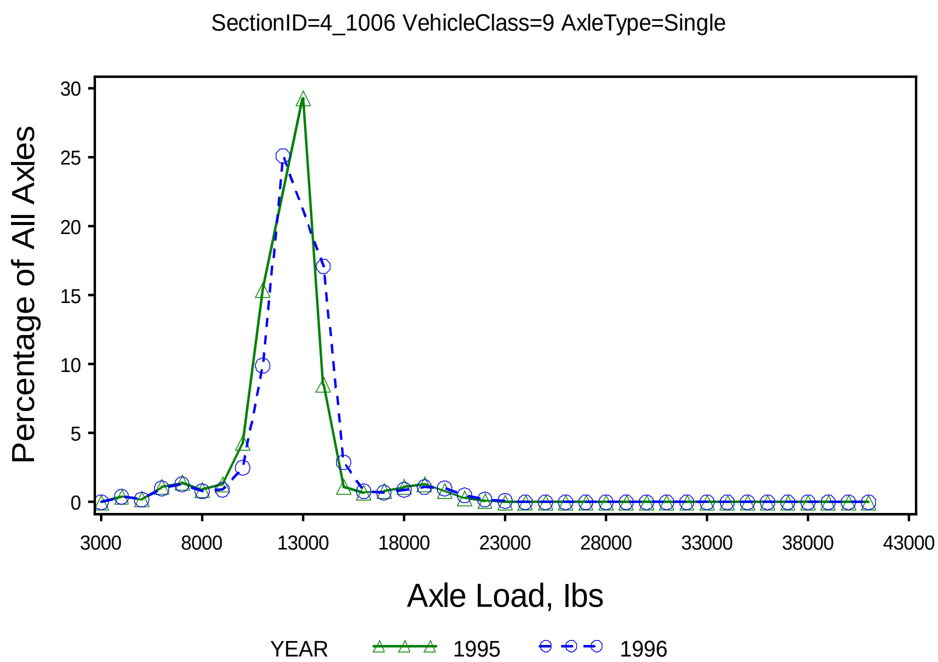


Figure E-16. Plot of Single-Axle Load for Site 4_1006 (Vehicle Class 9).

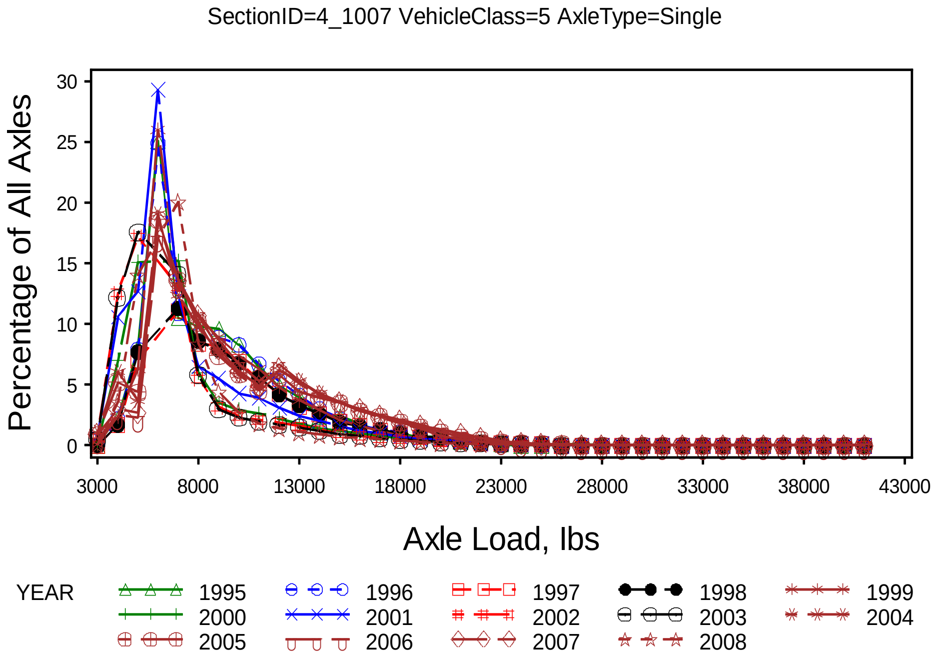


Figure E-17. Plot of Single-Axle Load for Site 4_1007 (Vehicle Class 5).

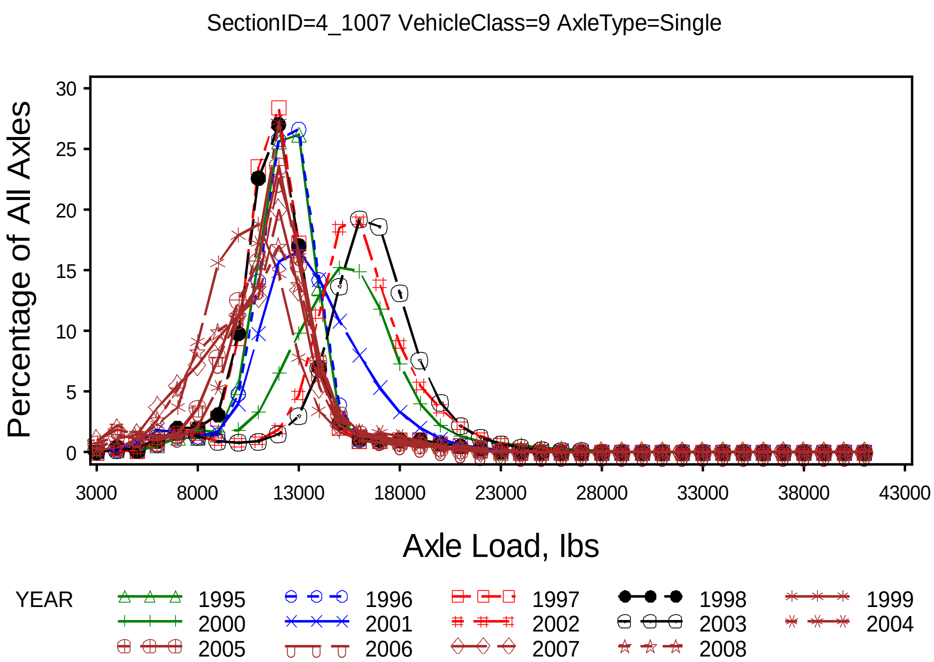


Figure E-18. Plot of Single-Axle Load for Site 4_1007 (Vehicle Class 9).

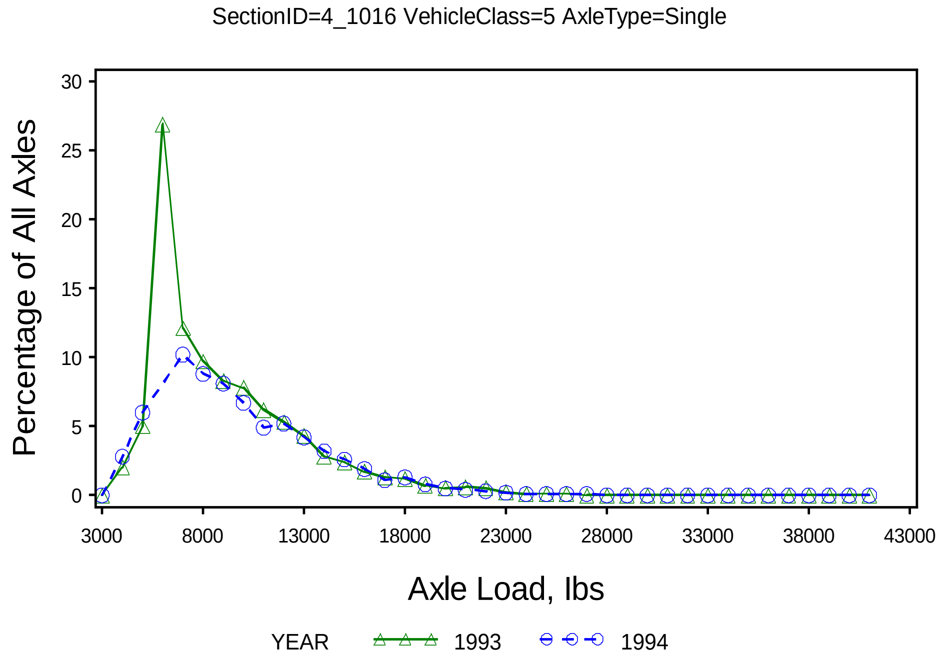


Figure E-19. Plot of Single-Axle Load for Site 4_1016 (Vehicle Class 5).

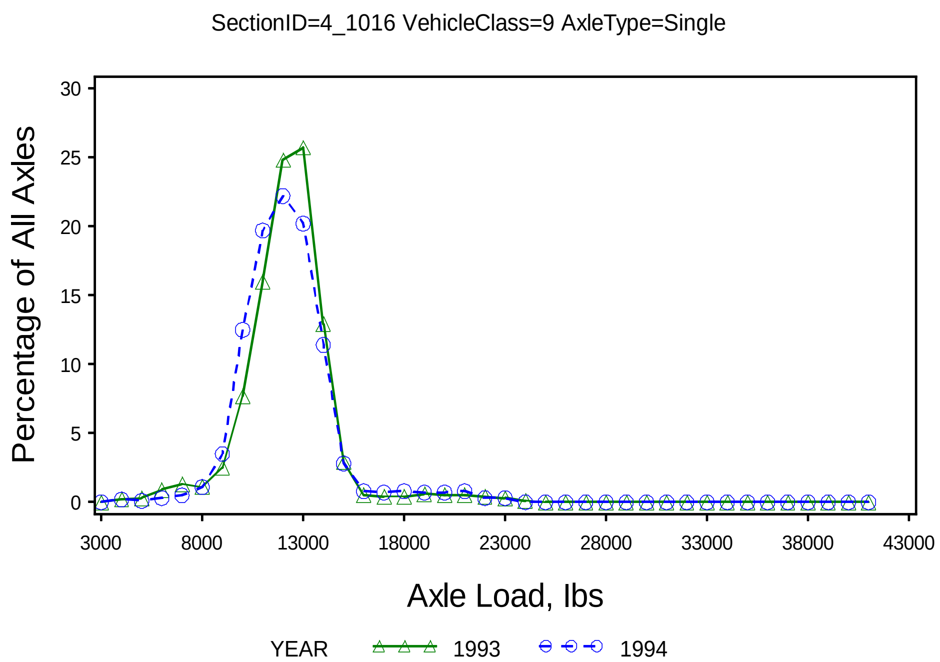


Figure E-20. Plot of Single-Axle Load for Site 4_1016 (Vehicle Class 9).

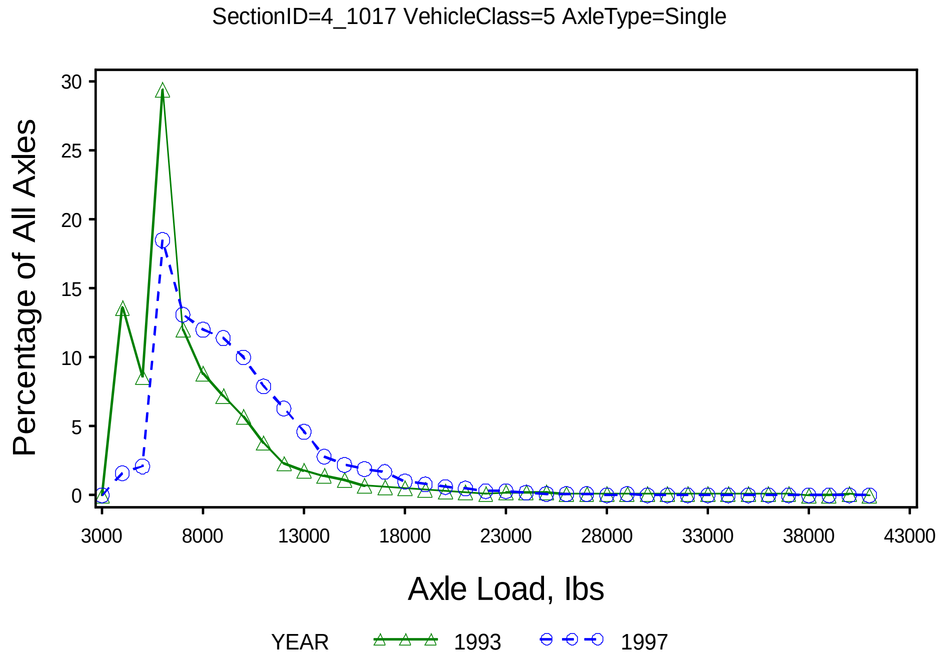


Figure E-21. Plot of Single-Axle Load for Site 4_1017 (Vehicle Class 5).

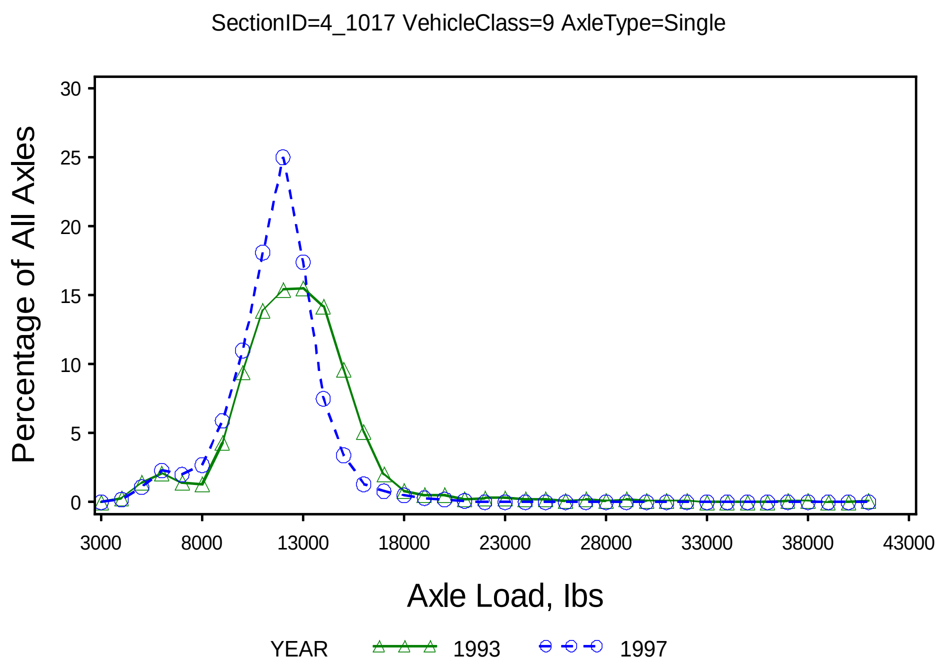


Figure E-22. Plot of Single-Axle Load for Site 4_1017 (Vehicle Class 9).

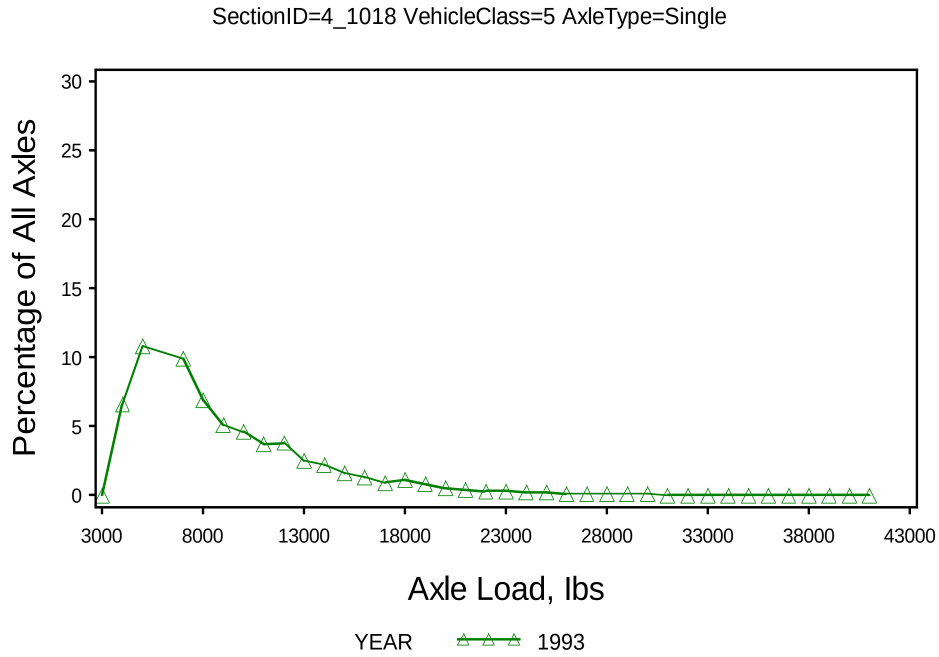


Figure E-23. Plot of Single-Axle Load for Site 4_1018 (Vehicle Class 5).

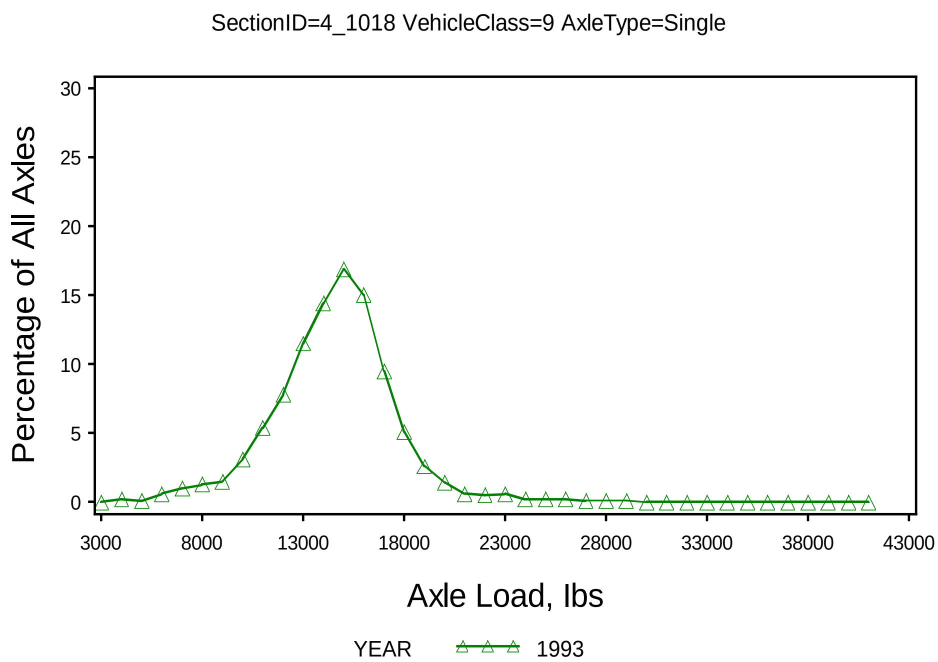


Figure E-24. Plot of Single-Axle Load for Site 4_1018 (Vehicle Class 9).

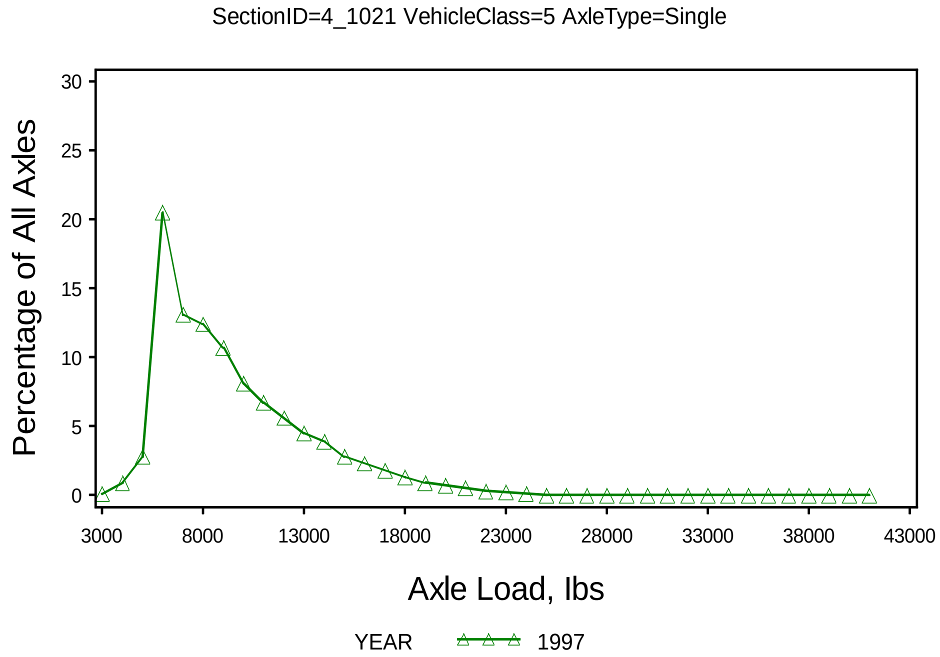


Figure E-25. Plot of Single-Axle Load for Site 4_1021 (Vehicle Class 5).

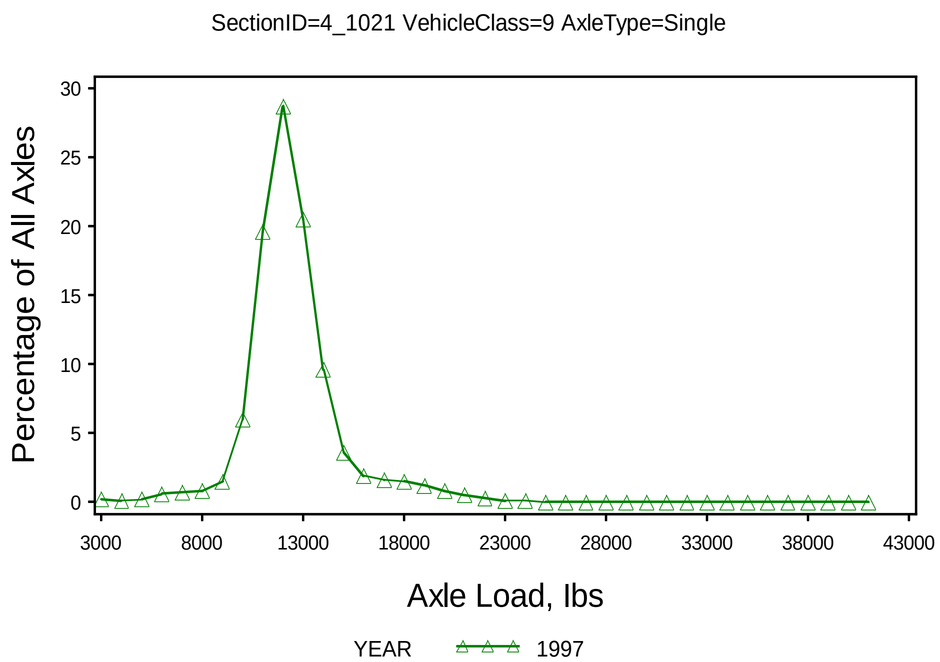


Figure E-26. Plot of Single-Axle Load for Site 4_1021 (Vehicle Class 9).

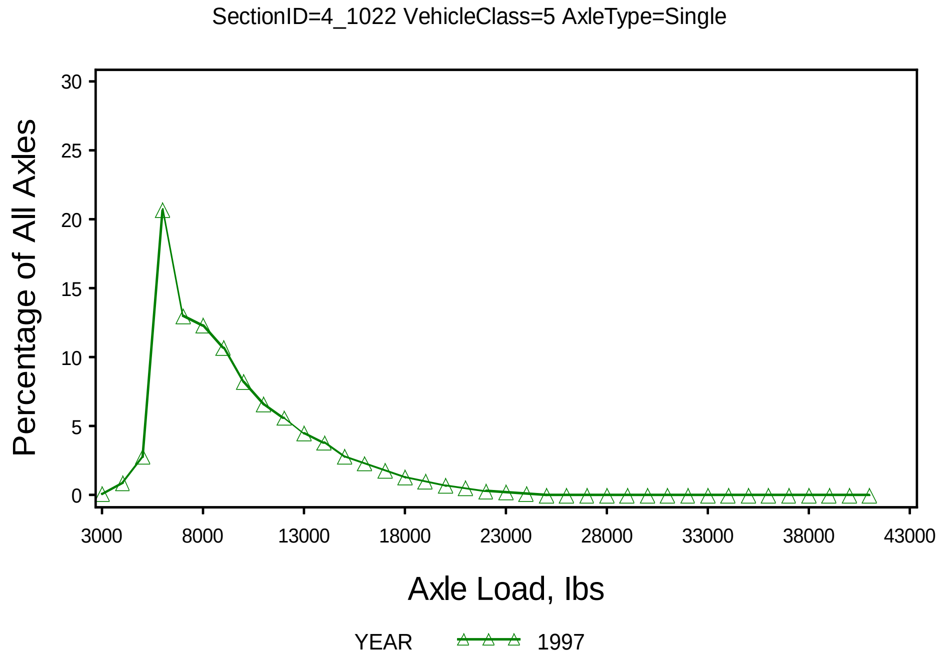


Figure E-27. Plot of Single-Axle Load for Site 4_1022 (Vehicle Class 5).

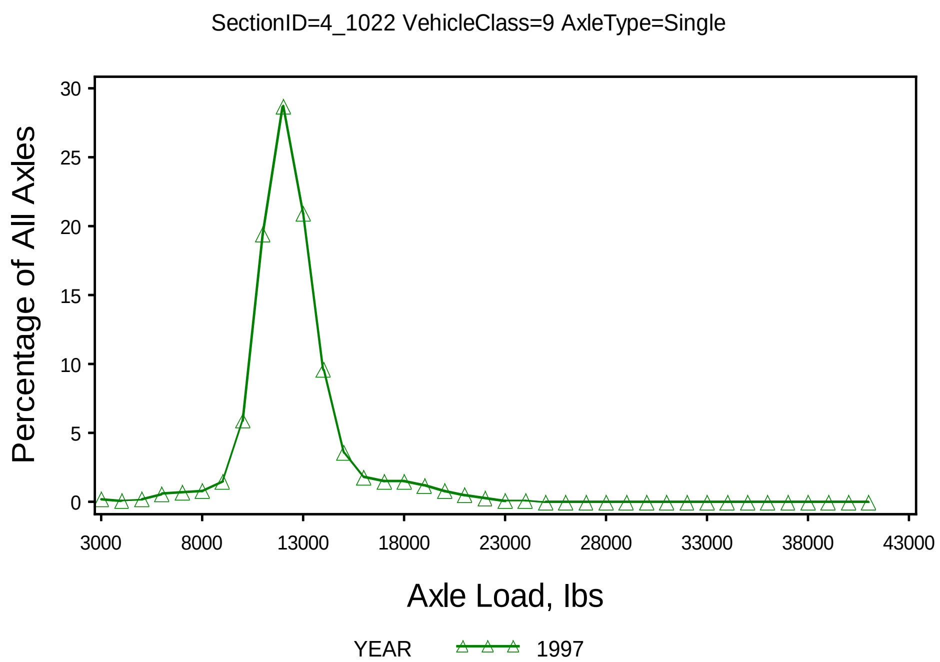


Figure E-28. Plot of Single-Axle Load for Site 4_1022 (Vehicle Class 9).

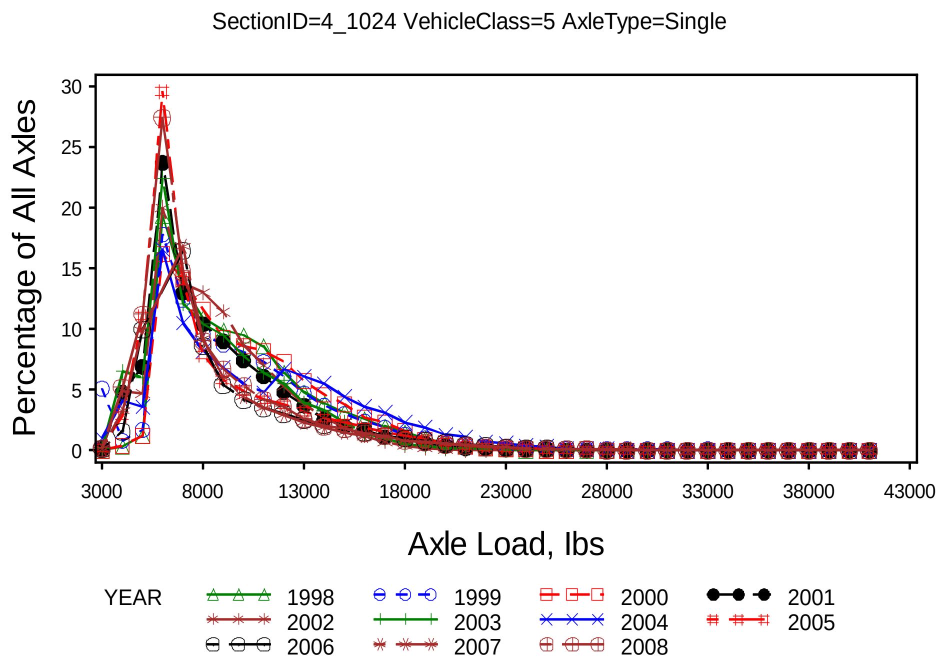


Figure E-29. Plot of Single-Axle Load for Site 4_1024 (Vehicle Class 5).

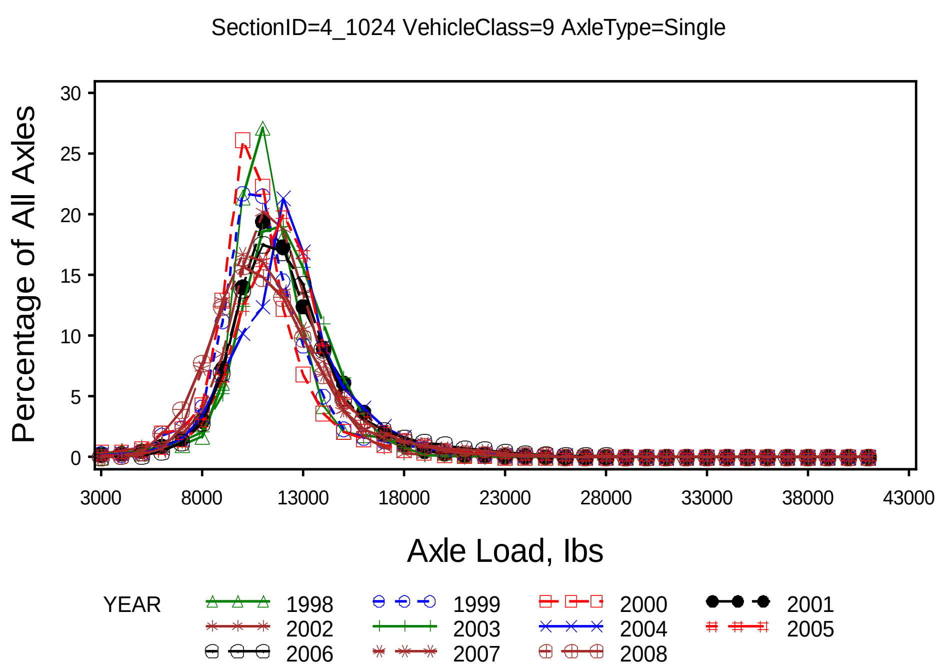


Figure E-30. Plot of Single-Axle Load for Site 4_1024 (Vehicle Class 9).

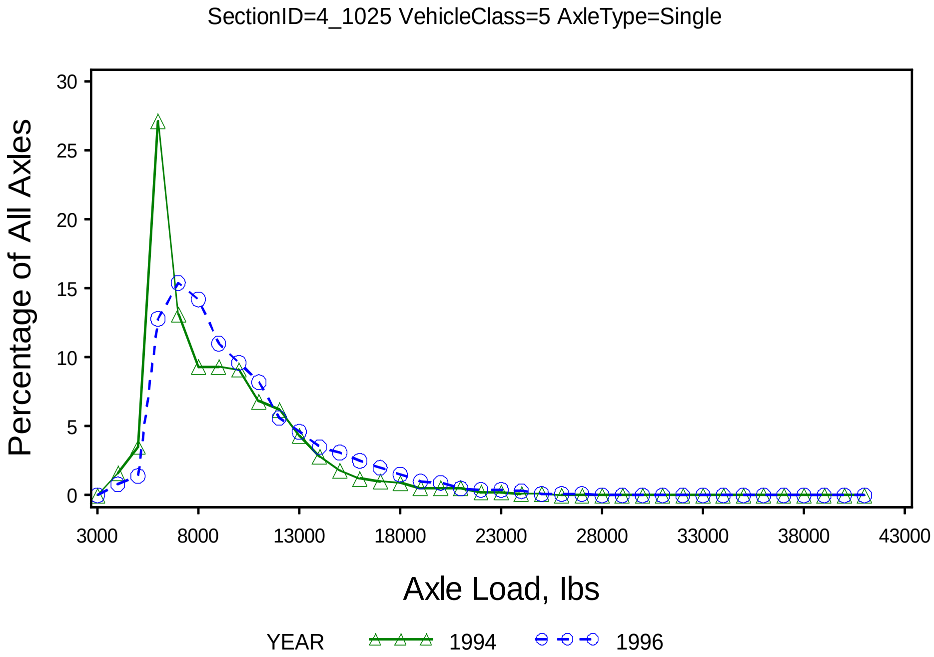


Figure E-31. Plot of Single-Axle Load for Site 4_1025 (Vehicle Class 5).

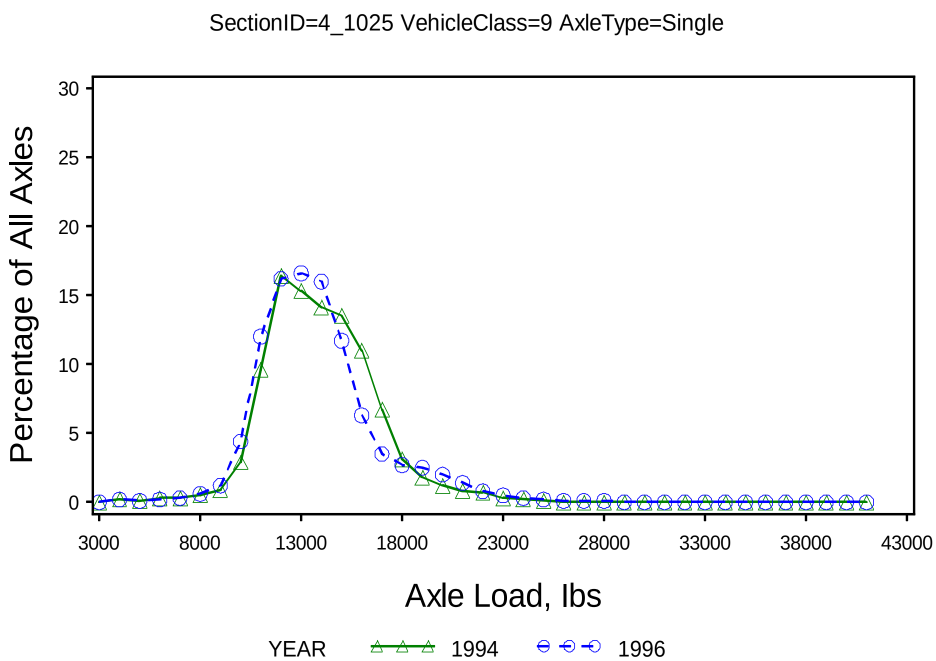


Figure E-32. Plot of Single-Axle Load for Site 4_1025 (Vehicle Class 9).

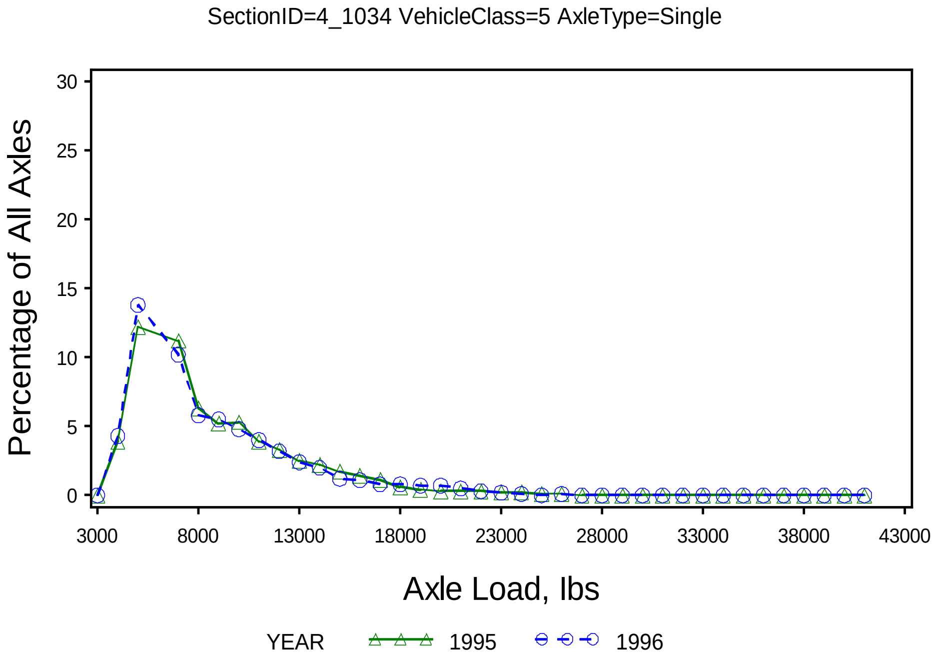


Figure E-33. Plot of Single-Axle Load for Site 4_1034 (Vehicle Class 5).

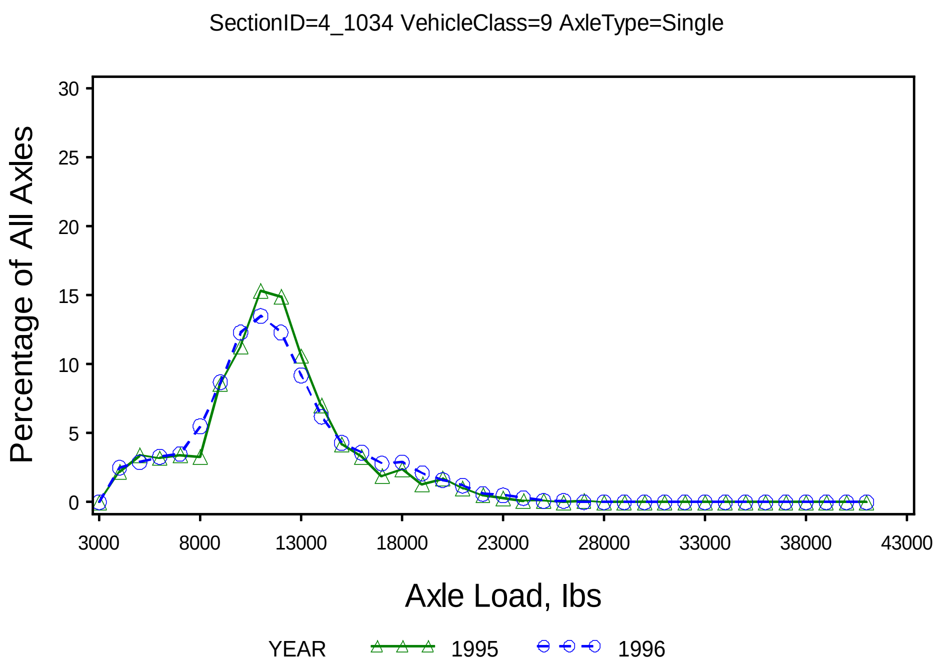


Figure E-34. Plot of Single-Axle Load for Site 4_1034 (Vehicle Class 9).

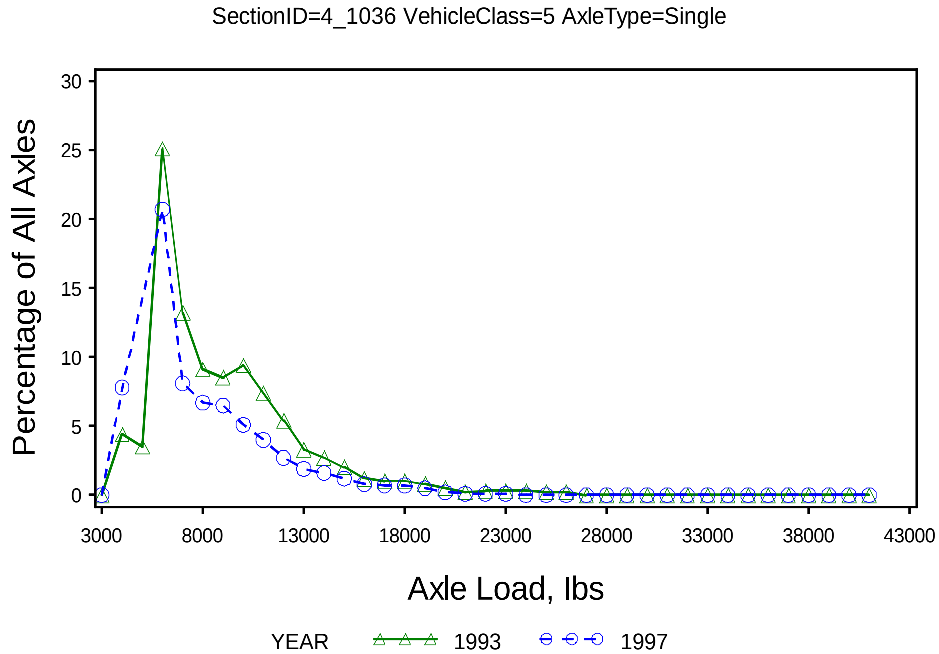


Figure E-35. Plot of Single-Axle Load for Site 4_1036 (Vehicle Class 5).

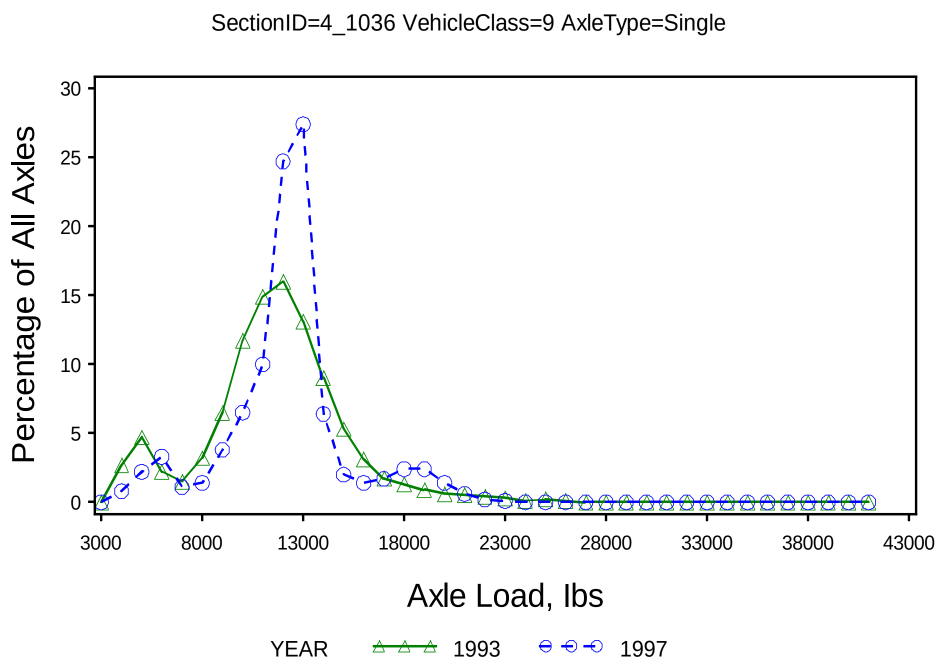


Figure E-36. Plot of Single-Axle Load for Site 4_1036 (Vehicle Class 9).

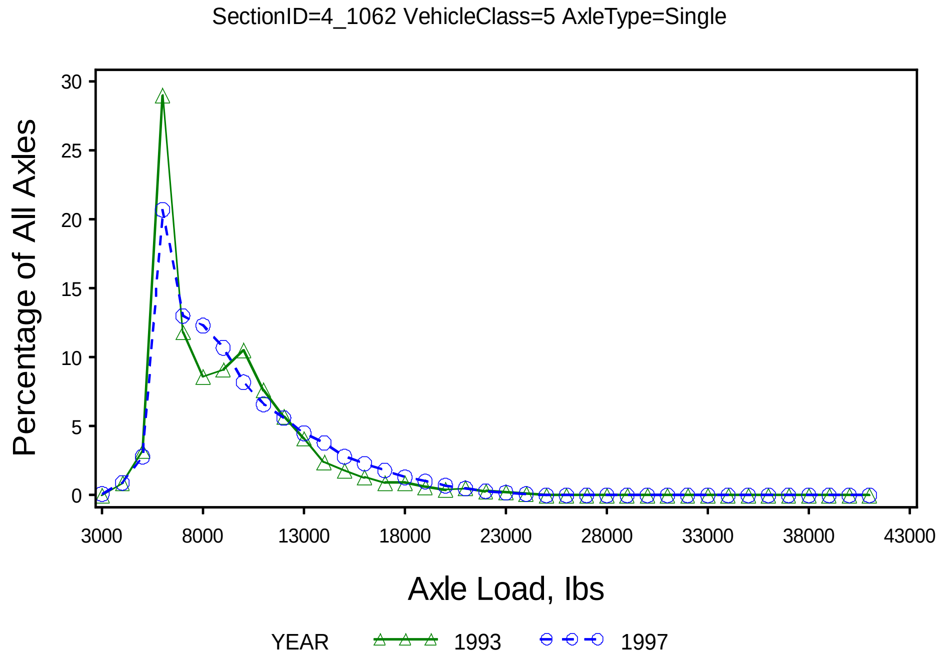


Figure E-37. Plot of Single-Axle Load for Site 4_1062 (Vehicle Class 5).

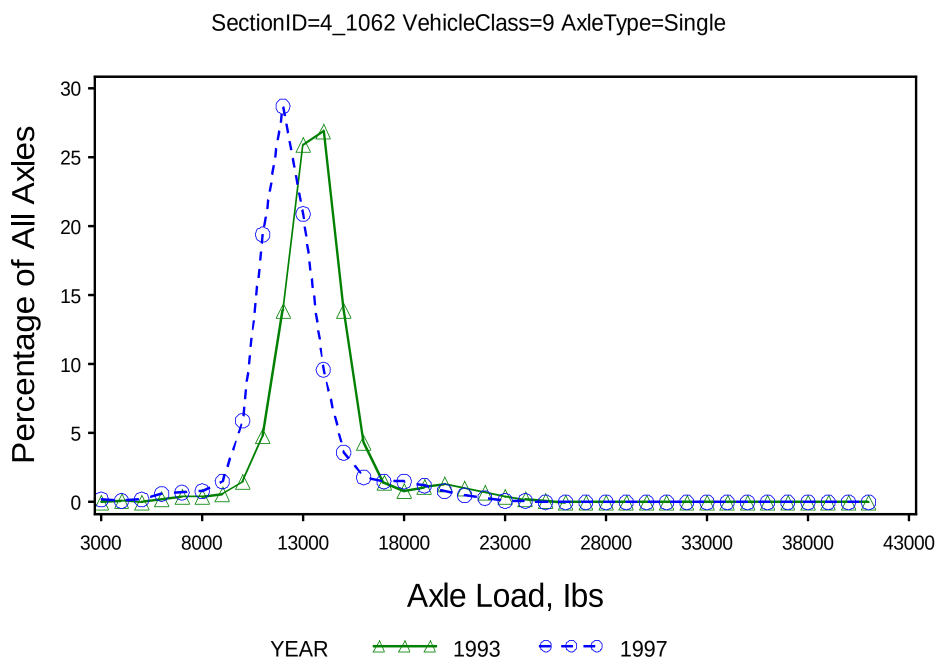


Figure E-38. Plot of Single-Axle Load for Site 4_1062 (Vehicle Class 9).

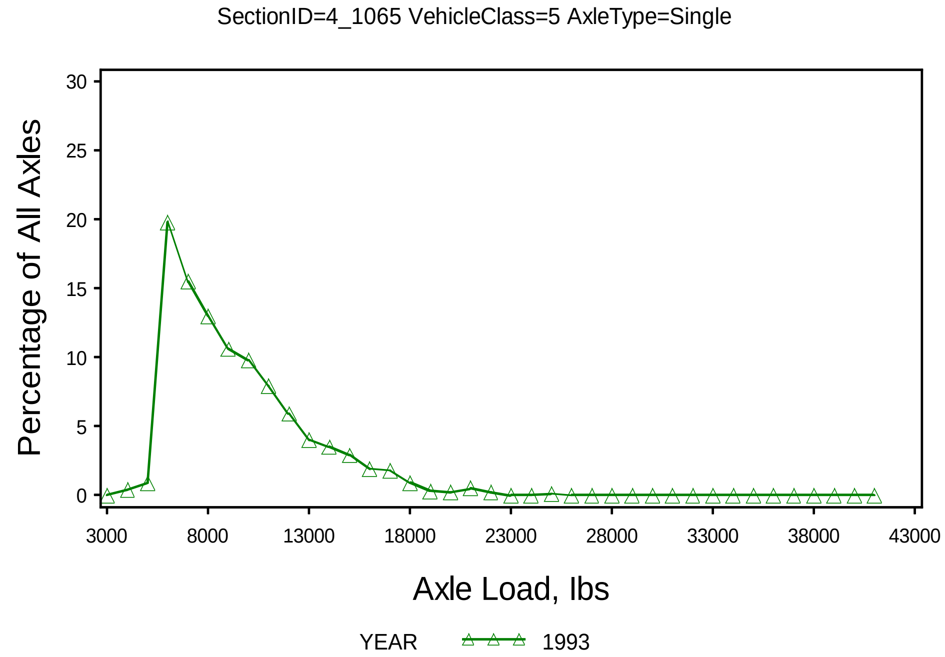


Figure E-39. Plot of Single-Axle Load for Site 4_1065 (Vehicle Class 5).

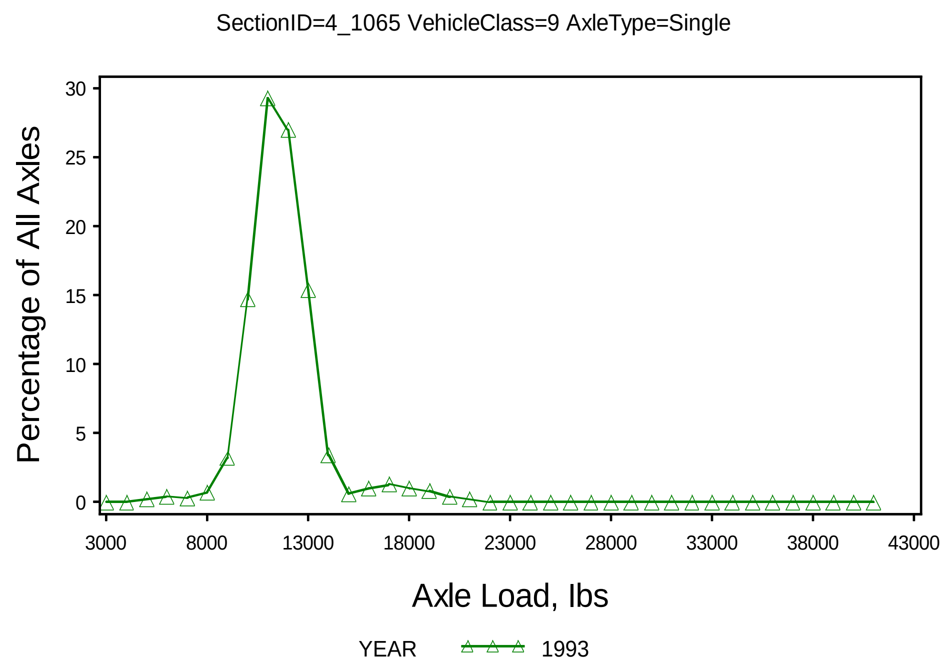


Figure E-40. Plot of Single-Axle Load for Site 4_1065 (Vehicle Class 9).

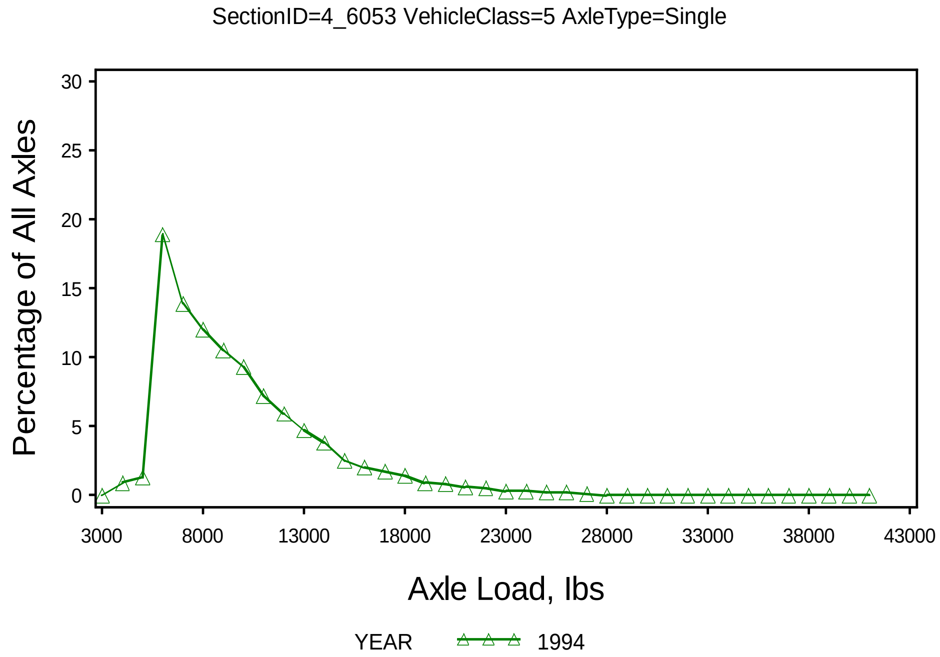


Figure E-41. Plot of Single-Axle Load for Site 4_6053 (Vehicle Class 5).

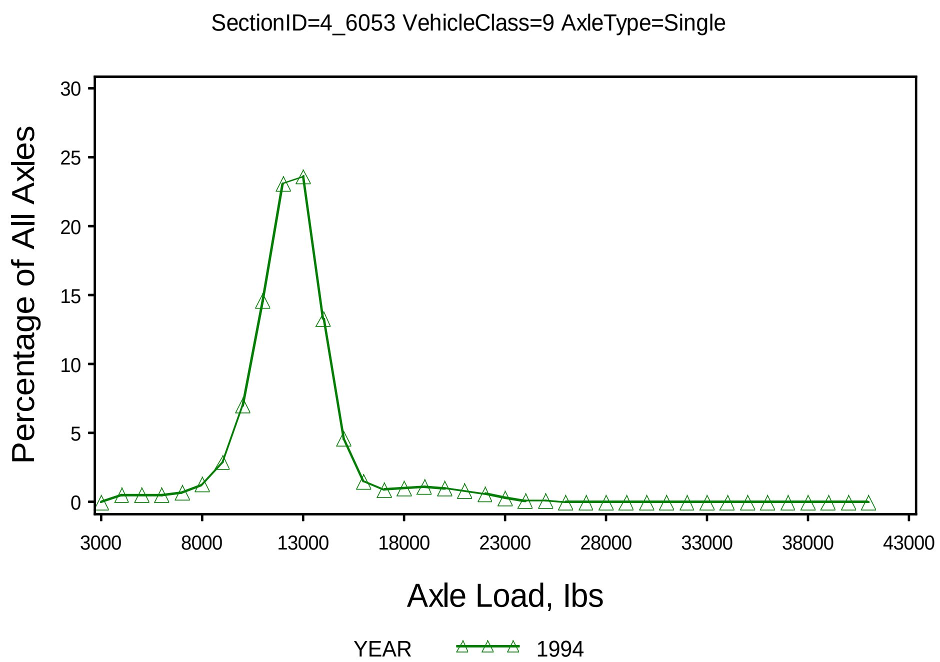


Figure E-42. Plot of Single-Axle Load for Site 4_6053 (Vehicle Class 9).

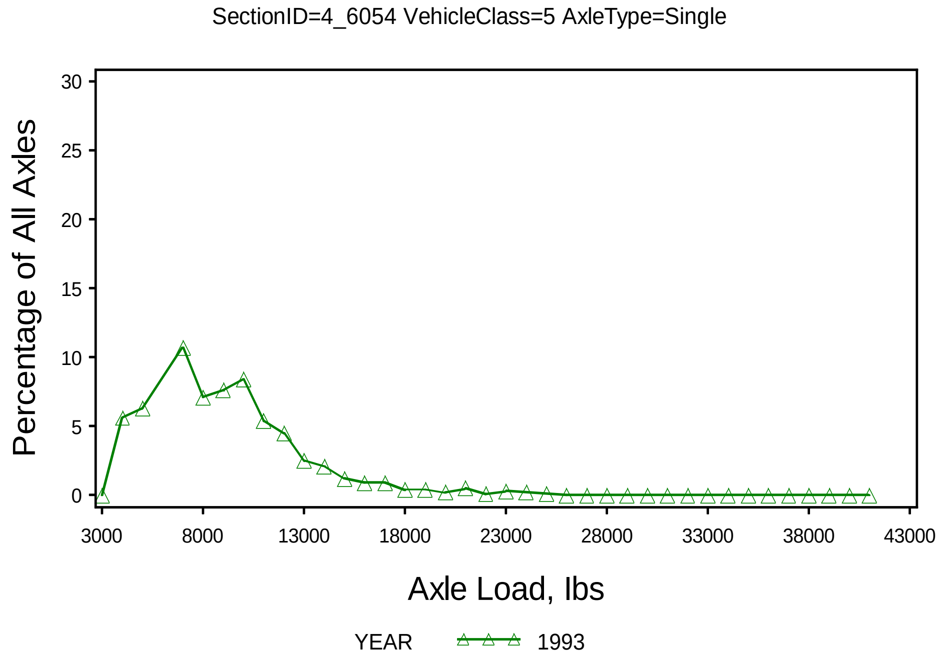


Figure E-43. Plot of Single-Axle Load for Site 4_6054 (Vehicle Class 5).

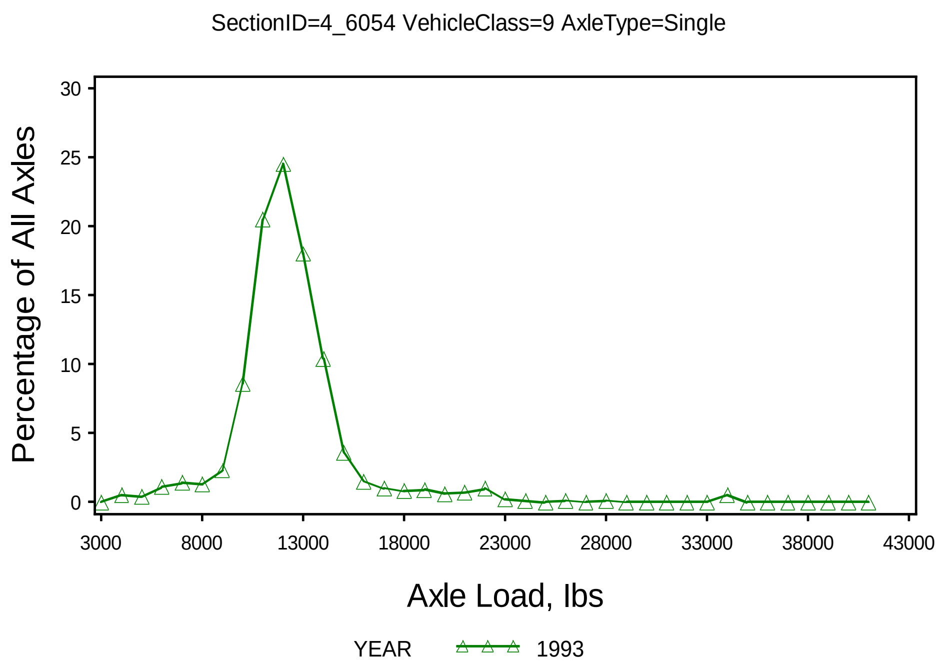


Figure E-44. Plot of Single-Axle Load for Site 4_6054 (Vehicle Class 9).

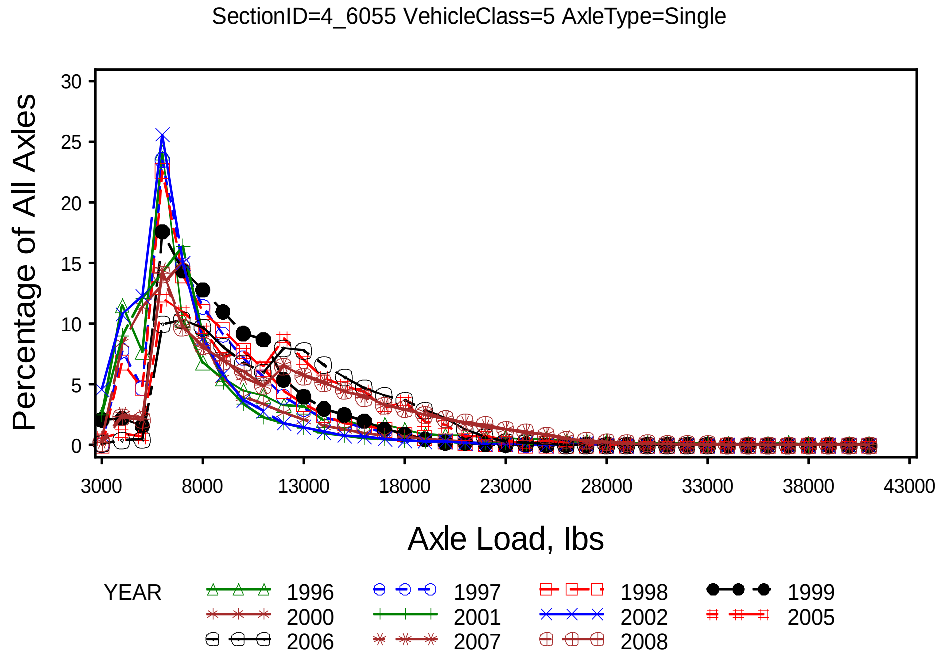


Figure E-45. Plot of Single-Axle Load for Site 4_6055 (Vehicle Class 5).

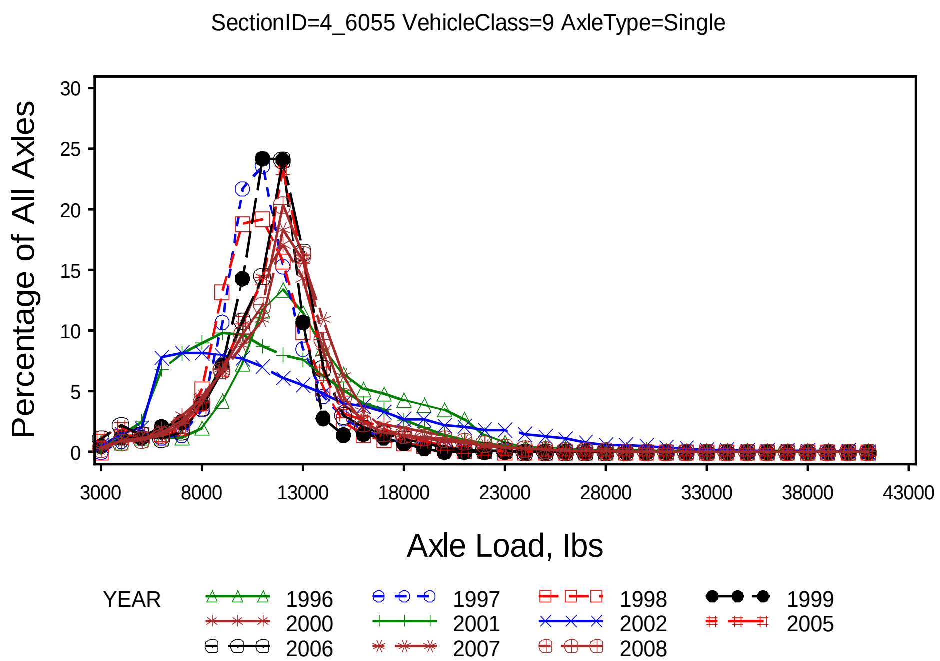


Figure E-46. Plot of Single-Axle Load for Site 4_6055 (Vehicle Class 9).

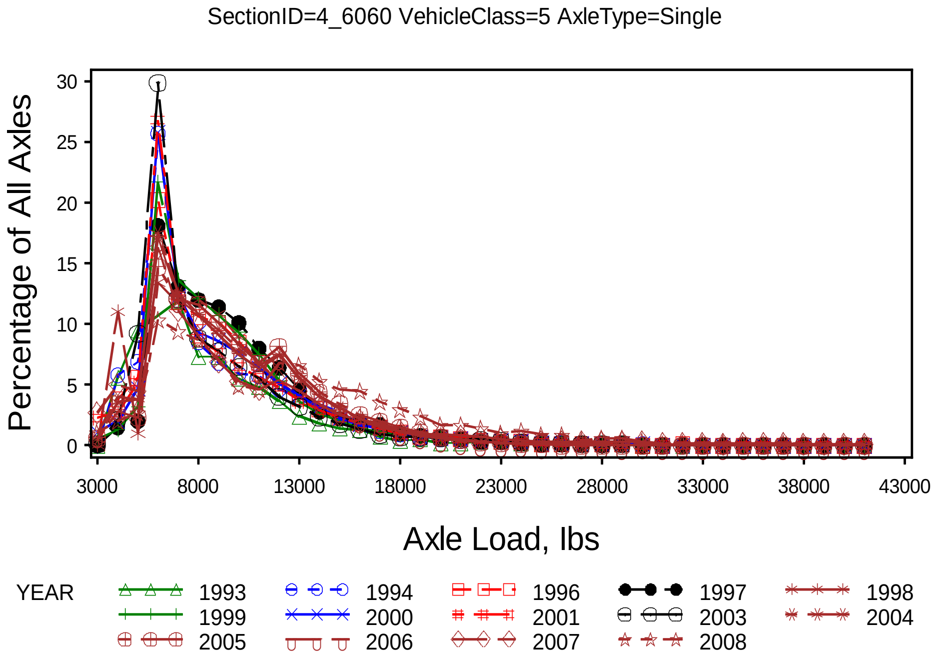


Figure E-47. Plot of Single-Axle Load for Site 4_6060 (Vehicle Class 5).

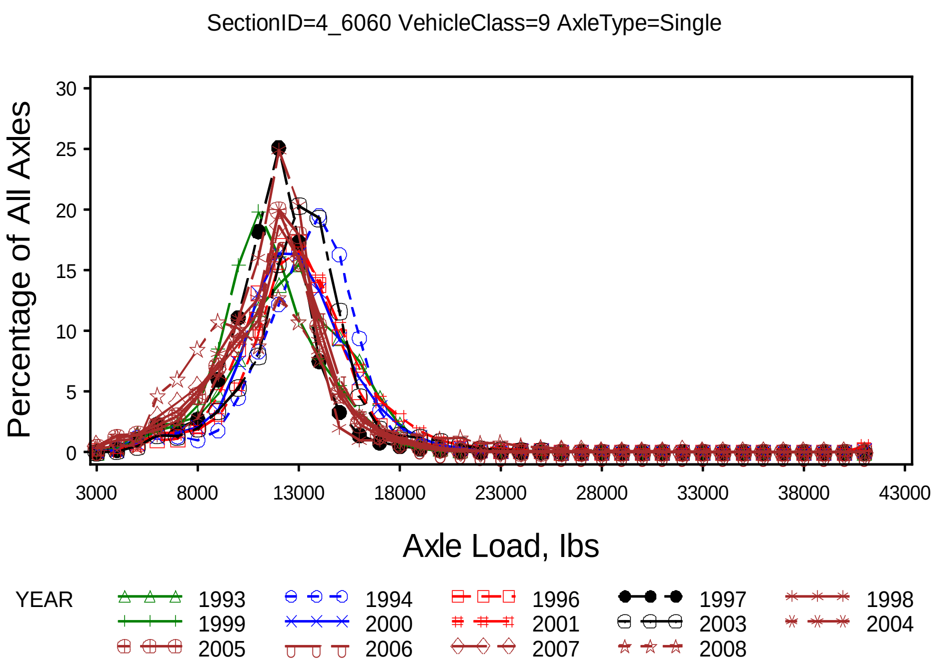


Figure E-48. Plot of Single-Axle Load for Site 4_6060 (Vehicle Class 9).

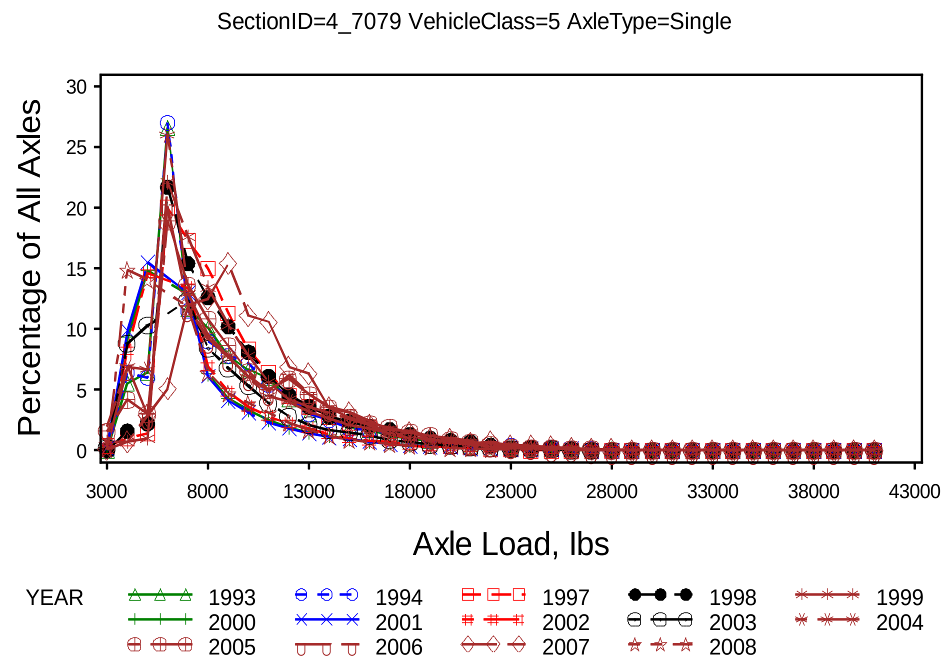


Figure E-49. Plot of Single-Axle Load for Site 4_7079 (Vehicle Class 5).

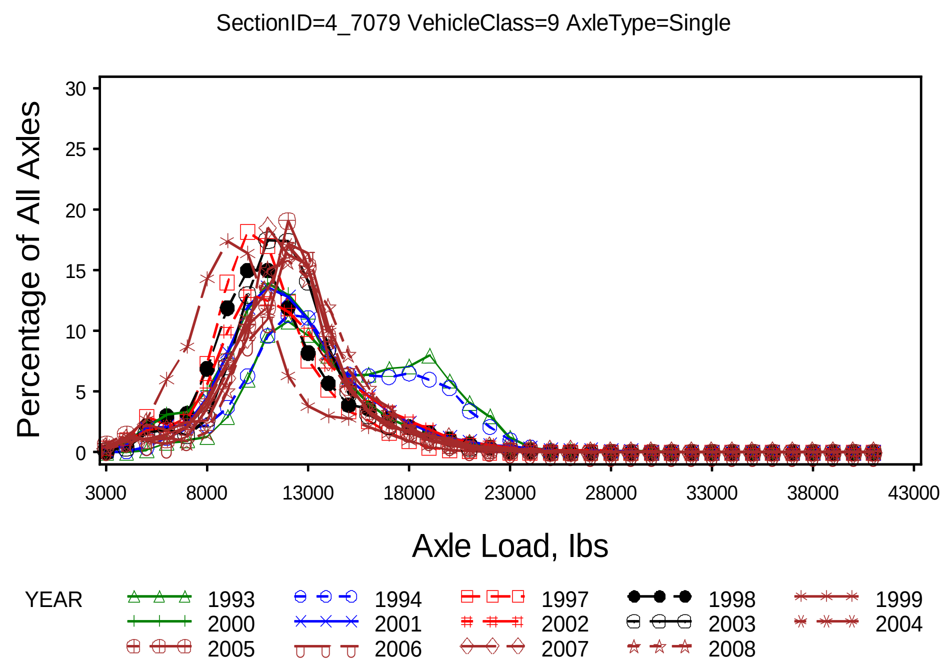


Figure E-50. Plot of Single-Axle Load for Site 4_7079 (Vehicle Class 9).

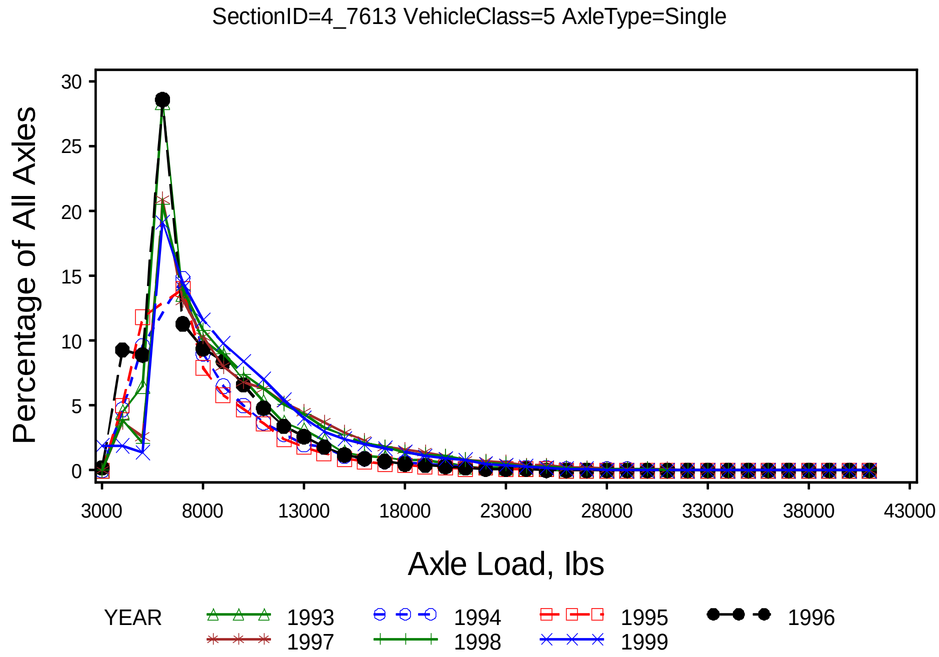


Figure E-51. Plot of Single-Axle Load for Site 4_7613 (Vehicle Class 5).

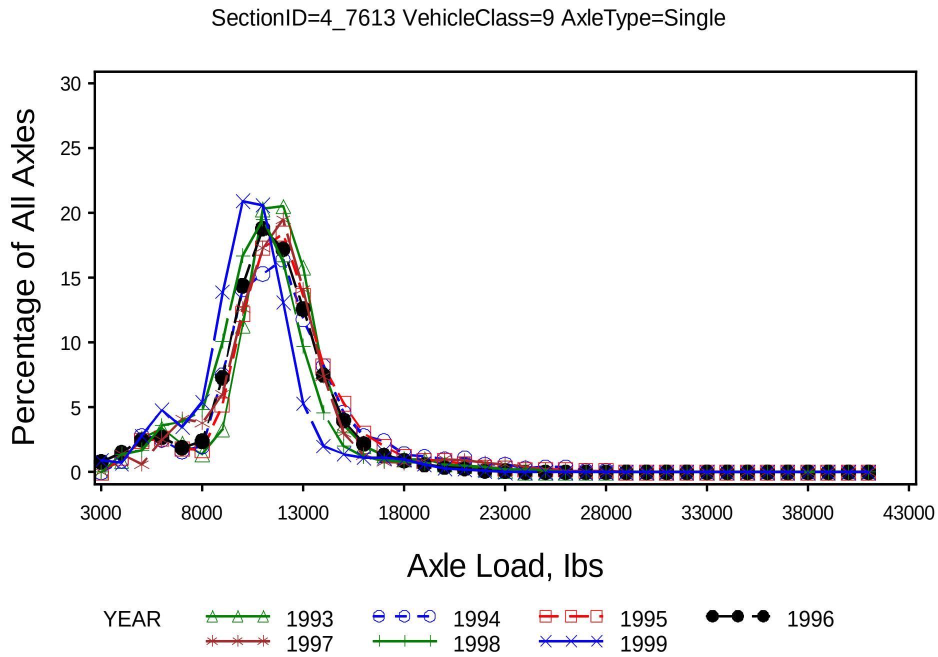


Figure E-52. Plot of Single-Axle Load for Site 4_7613 (Vehicle Class 9).

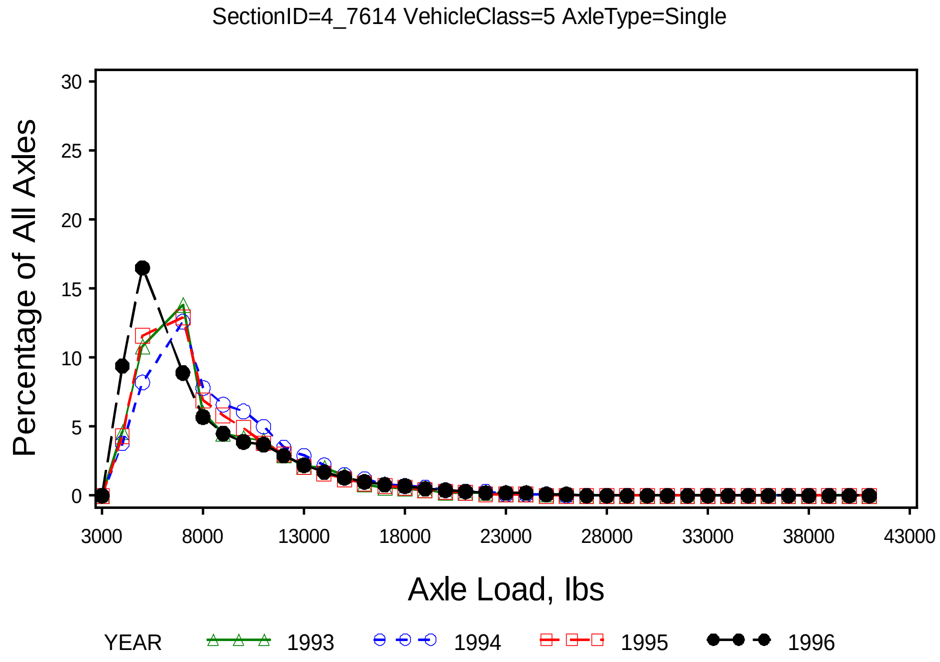


Figure E-53. Plot of Single-Axle Load for Site 4_7614 (Vehicle Class 5).

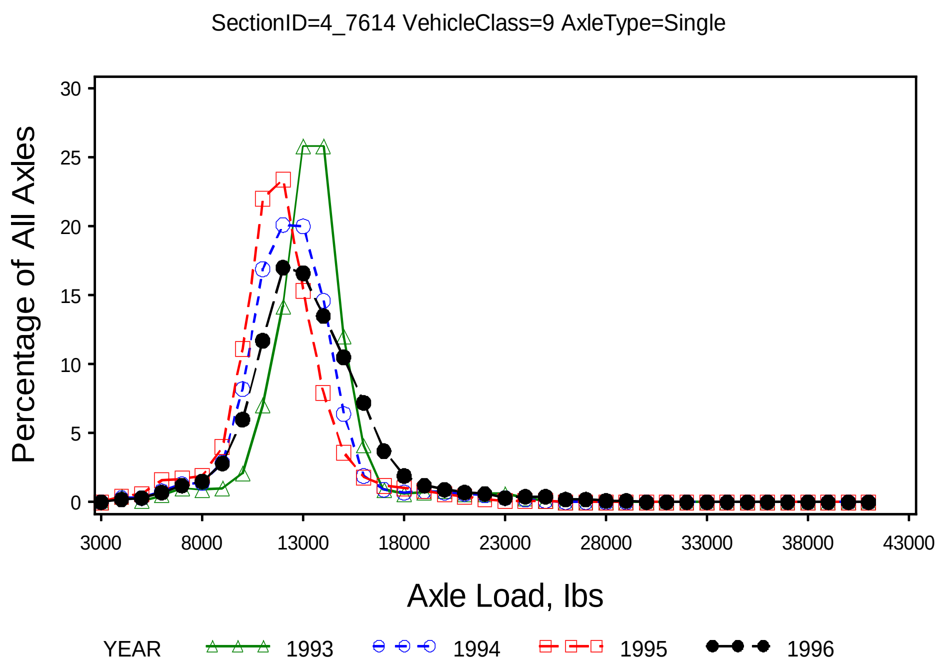


Figure E-54. Plot of Single-Axle Load for Site 4_7614 (Vehicle Class 9).

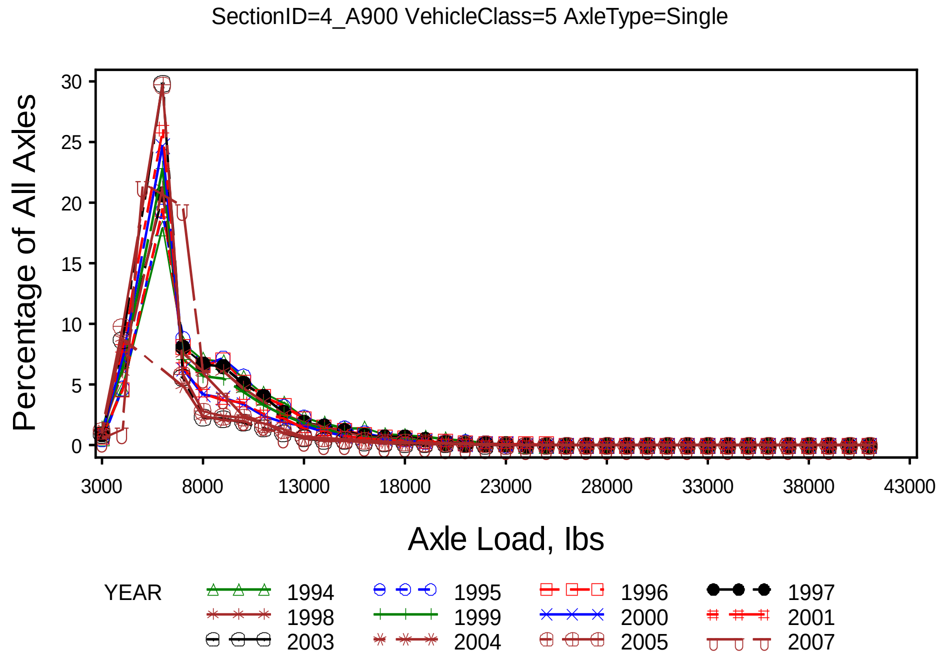


Figure E-55. Plot of Single-Axle Load for Site 4_A900 (Vehicle Class 5).

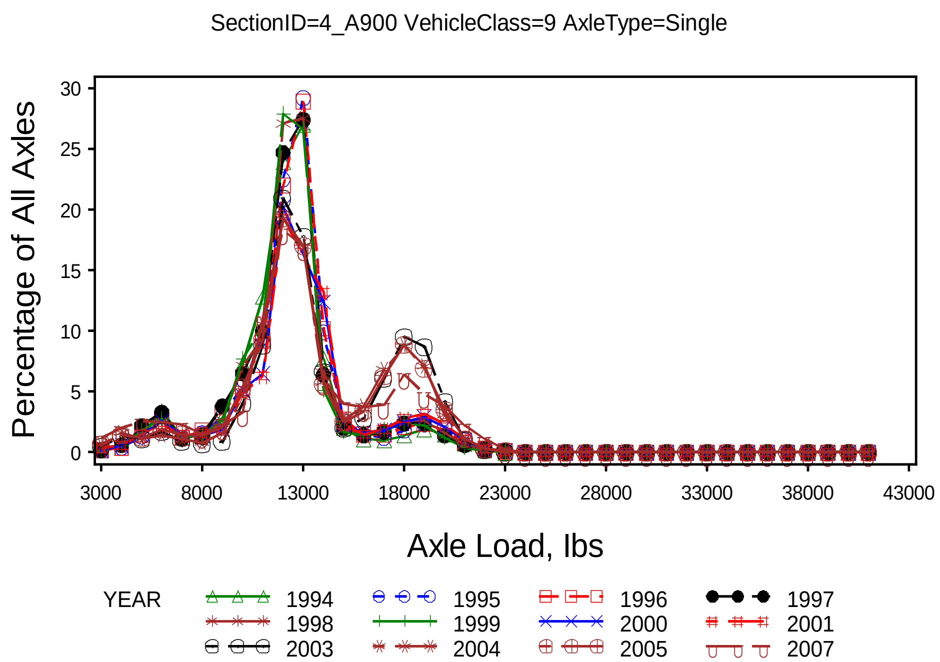


Figure E-56. Plot of Single-Axle Load for Site 4_A900 (Vehicle Class 9).

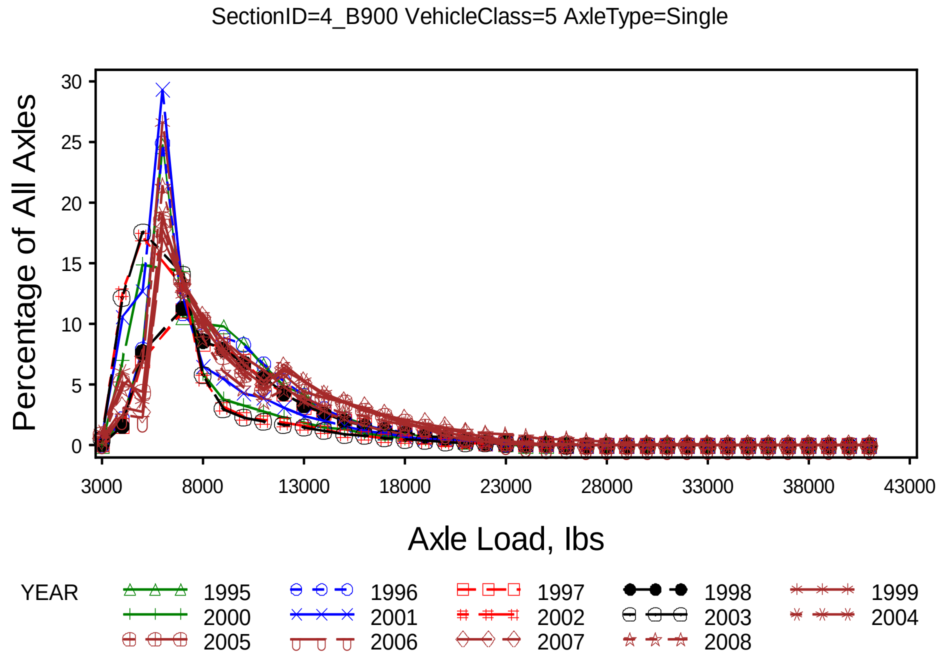


Figure E-57. Plot of Single-Axle Load for Site 4_B900 (Vehicle Class 5).

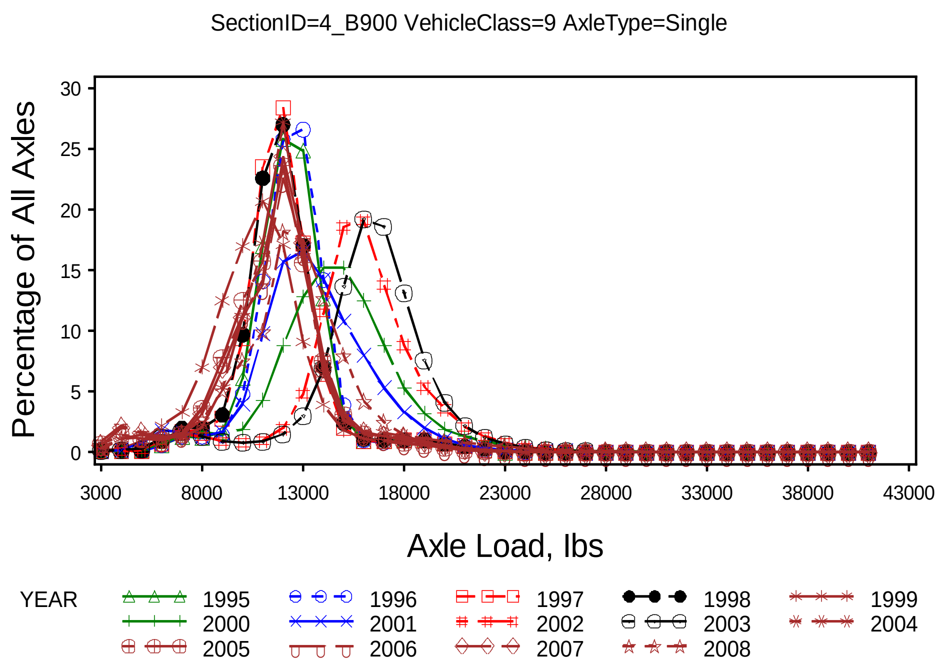


Figure E-58. Plot of Single-Axle Load for Site 4_B900 (Vehicle Class 9).

AXLE LOAD DISTRIBUTION PLOTS FOR CLASS 9 TRUCKS

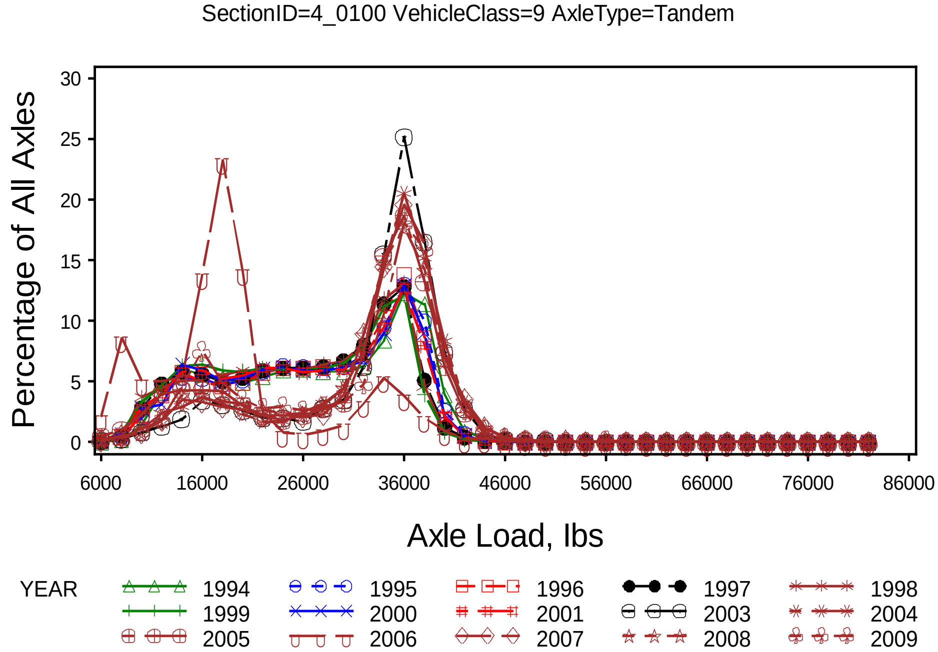


Figure E-59. Plot of Tandem-Axle Load for Site 4_0100 (Vehicle Class 9).

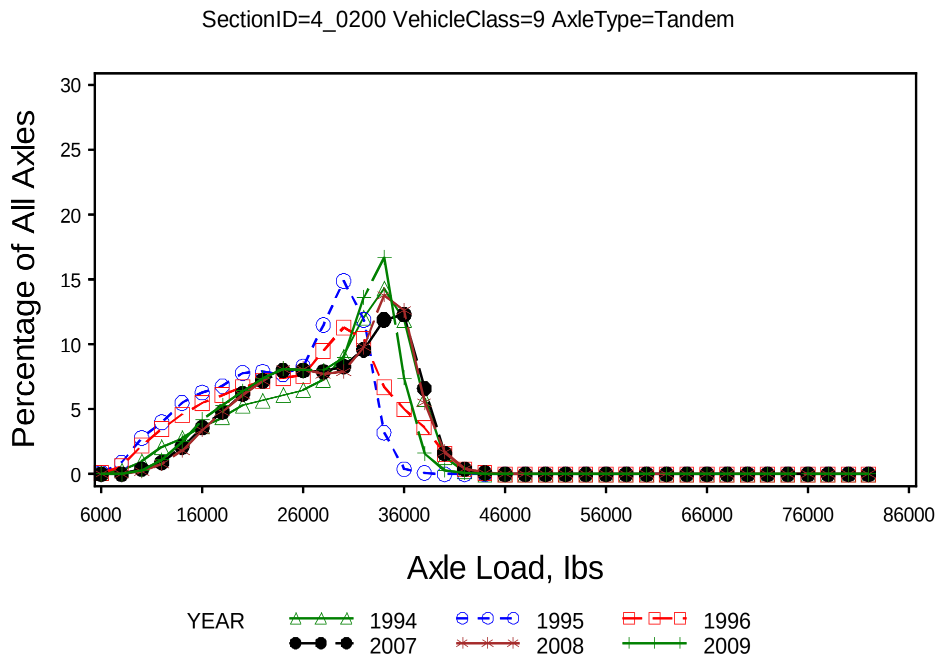


Figure E-60. Plot of Tandem-Axle Load for Site 4_0200 (Vehicle Class 9).

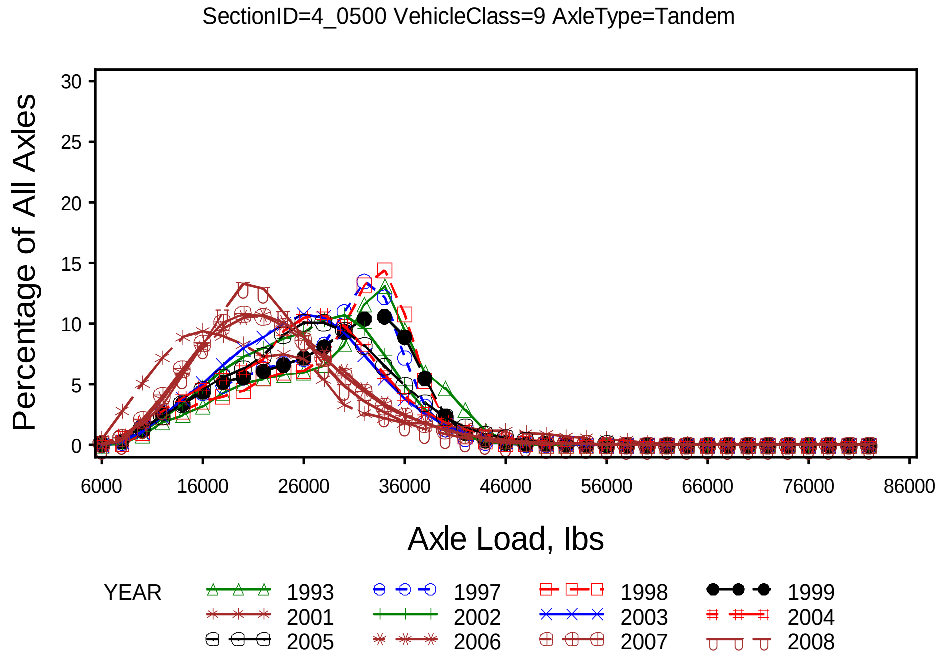


Figure E-61. Plot of Tandem-Axle Load for Site 4_0500 (Vehicle Class 9).

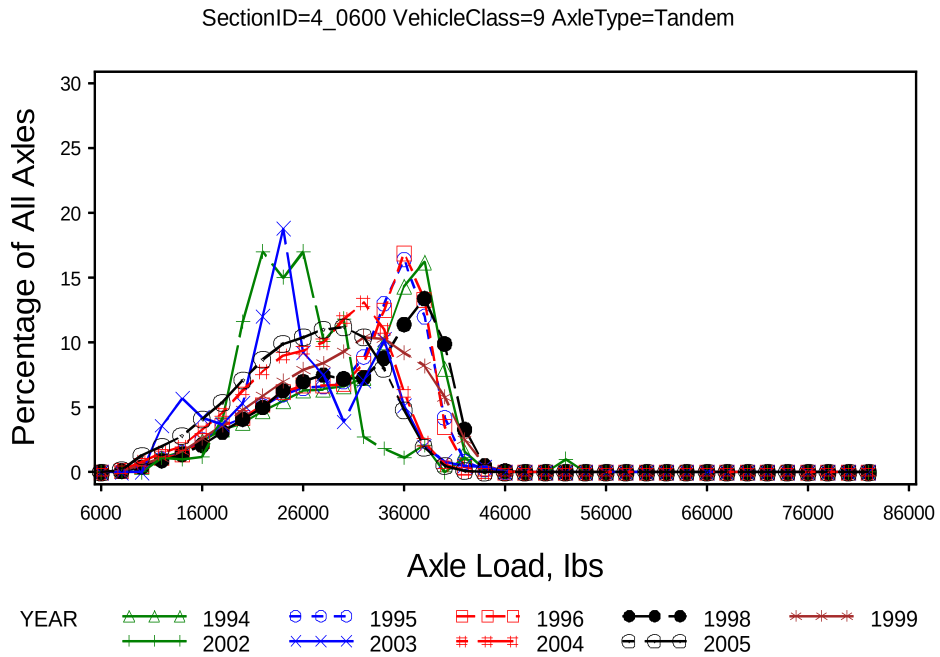


Figure E-62. Plot of Tandem-Axle Load for Site 4_0600 (Vehicle Class 9).

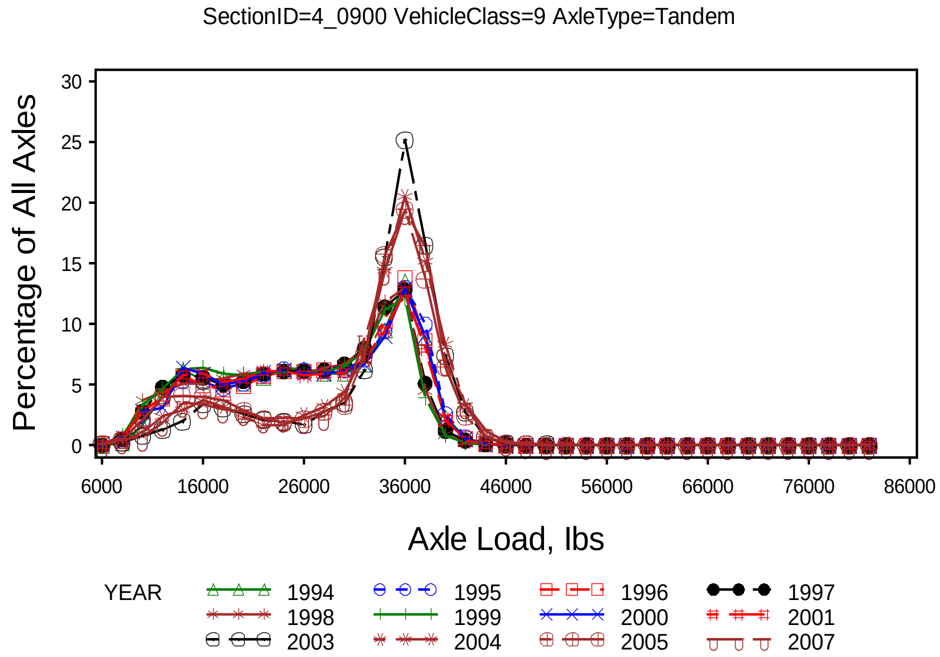


Figure E-63. Plot of Tandem-Axle Load for Site 4_0900 (Vehicle Class 9).

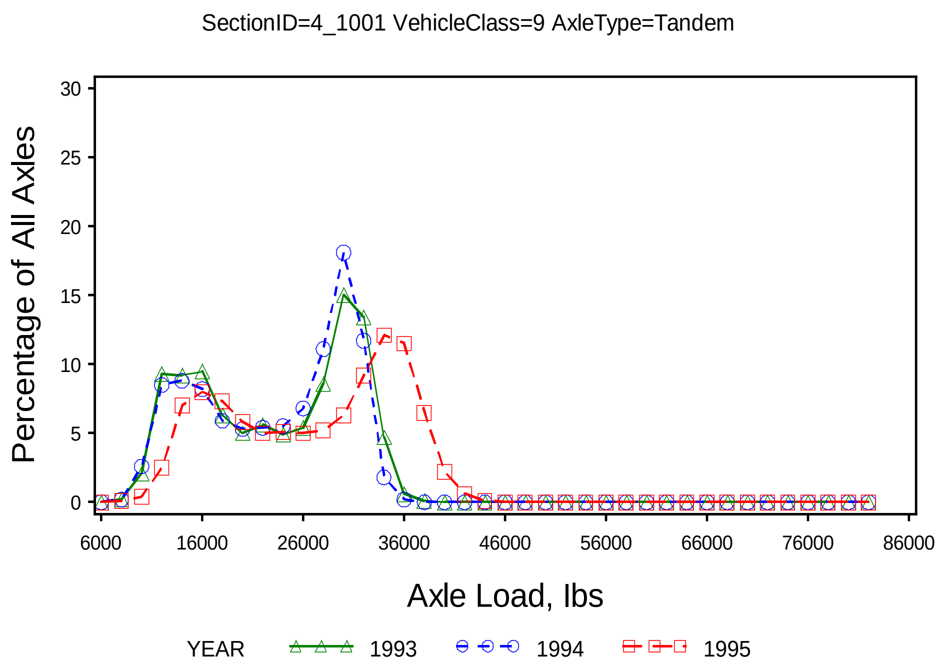


Figure E-64. Plot of Tandem-Axle Load for Site 4_1001 (Vehicle Class 9).

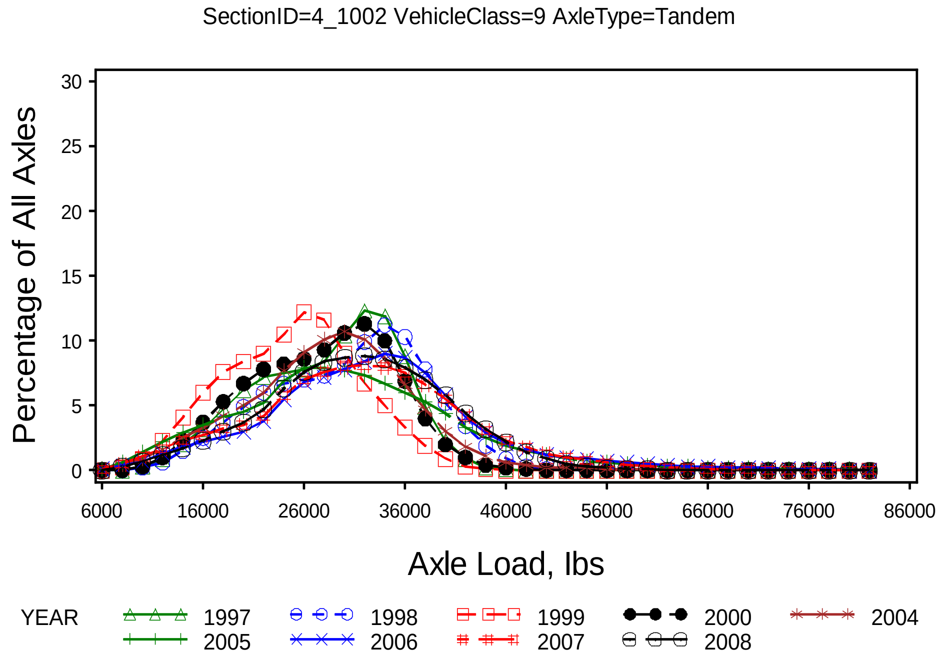


Figure E-65. Plot of Tandem-Axle Load for Site 4_1002 (Vehicle Class 9).

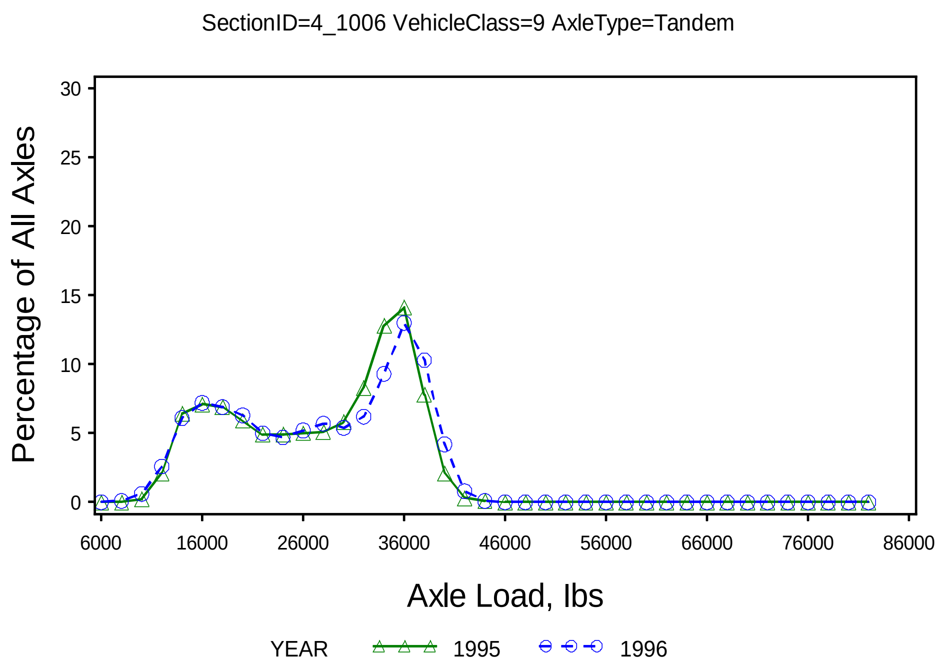


Figure E-66. Plot of Tandem-Axle Load for Site 4_1006 (Vehicle Class 9).

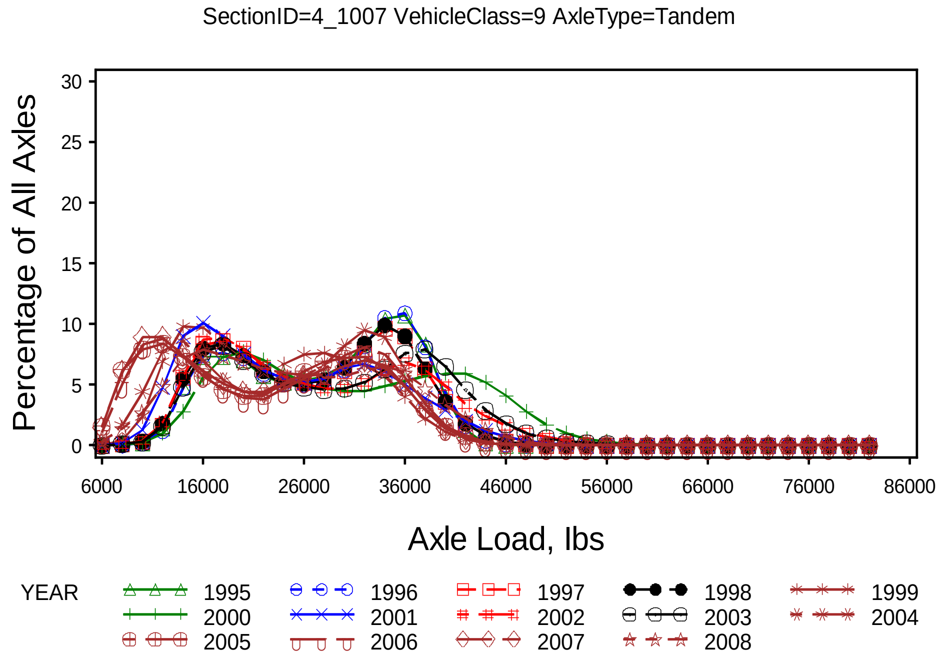


Figure E-67. Plot of Tandem-Axle Load for Site 4_1007 (Vehicle Class 9).

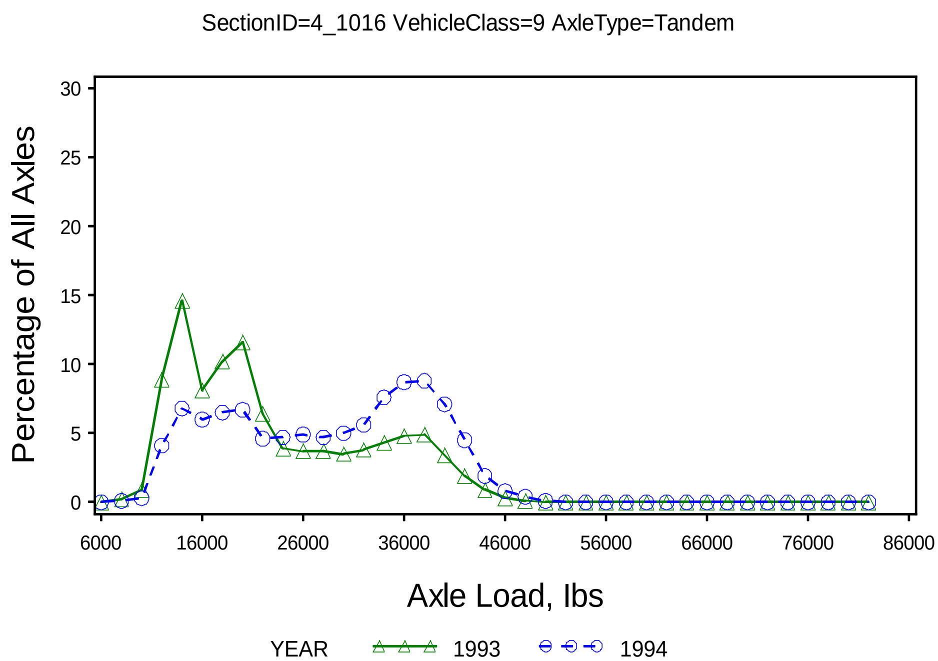


Figure E-68. Plot of Tandem-Axle Load for Site 4_1016 (Vehicle Class 9).

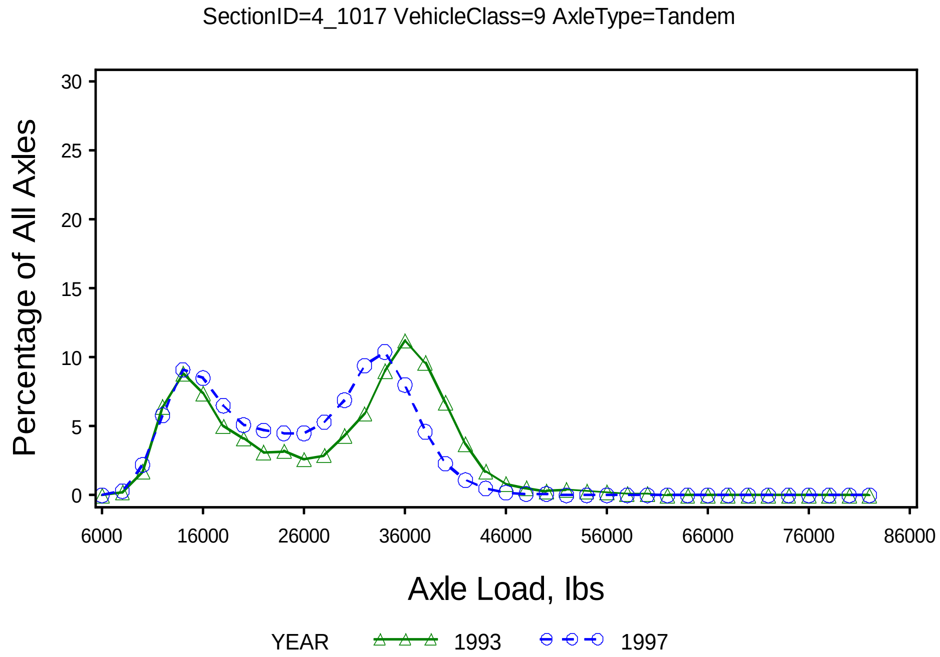


Figure E-69. Plot of Tandem-Axle Load for Site 4_1017 (Vehicle Class 9).

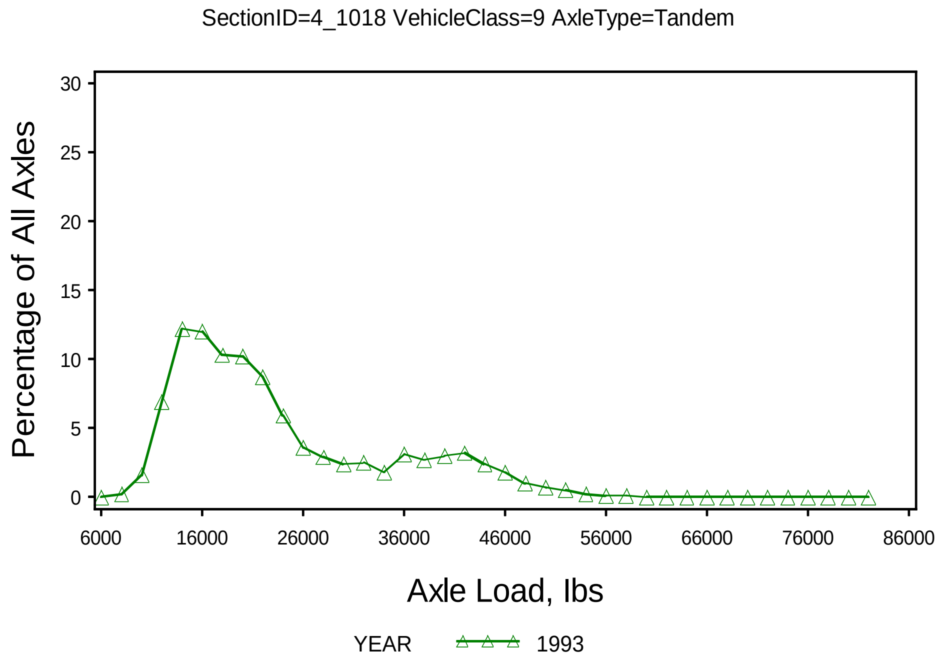


Figure E-70. Plot of Tandem-Axle Load for Site 4_1018 (Vehicle Class 9).

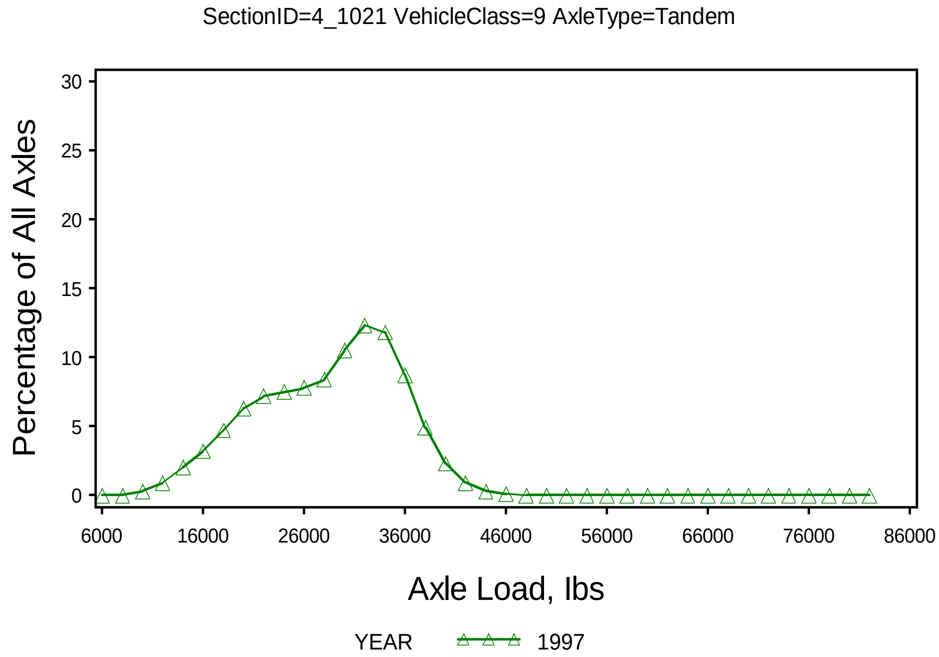


Figure E-71. Plot of Tandem-Axle Load for Site 4_1021 (Vehicle Class 9).

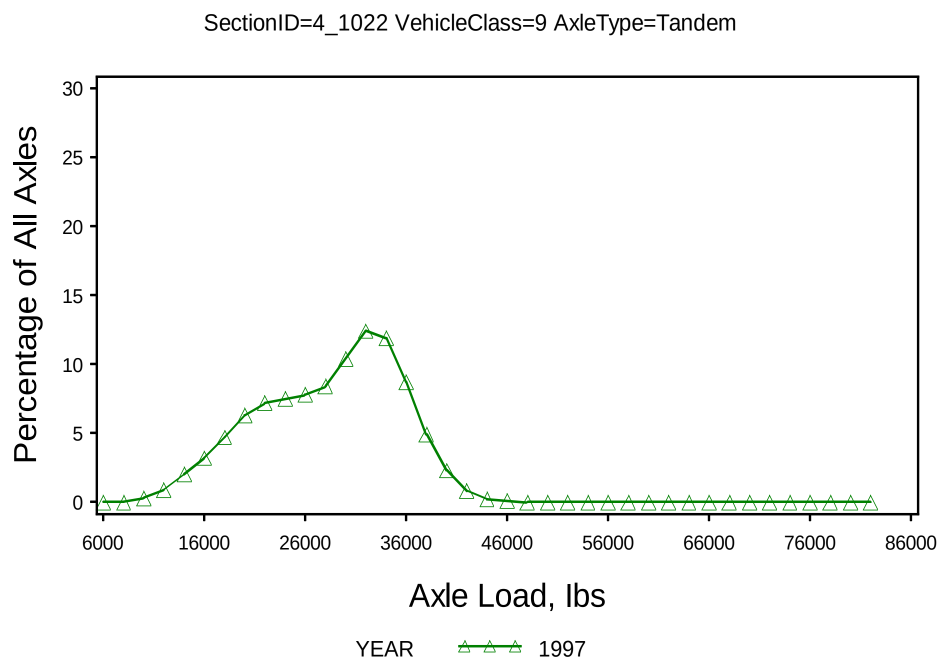


Figure E-72. Plot of Tandem-Axle Load for Site 4_1022 (Vehicle Class 9).

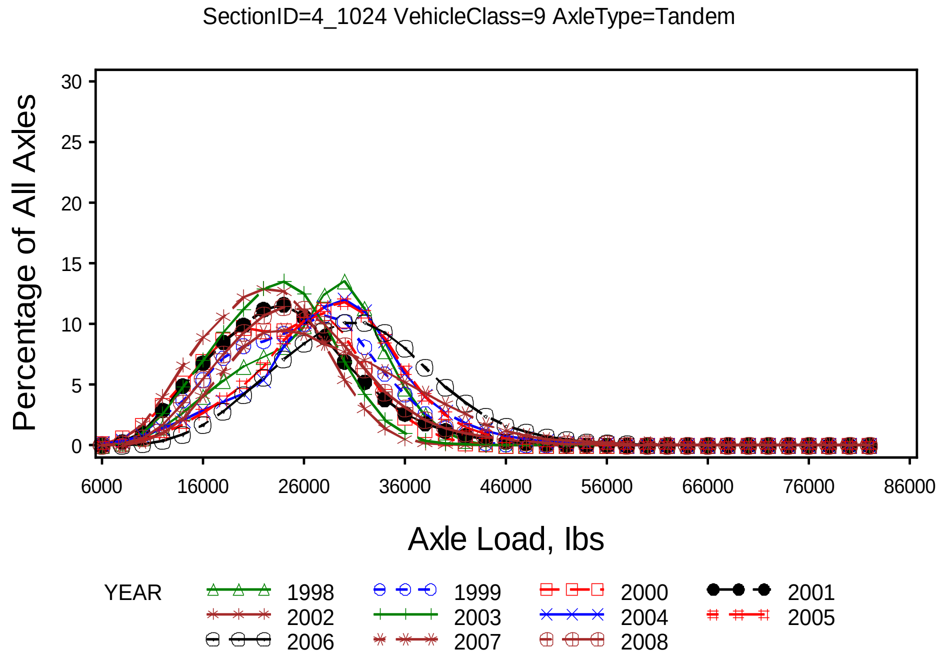


Figure E-73. Plot of Tandem-Axle Load for Site 4_1024 (Vehicle Class 9).

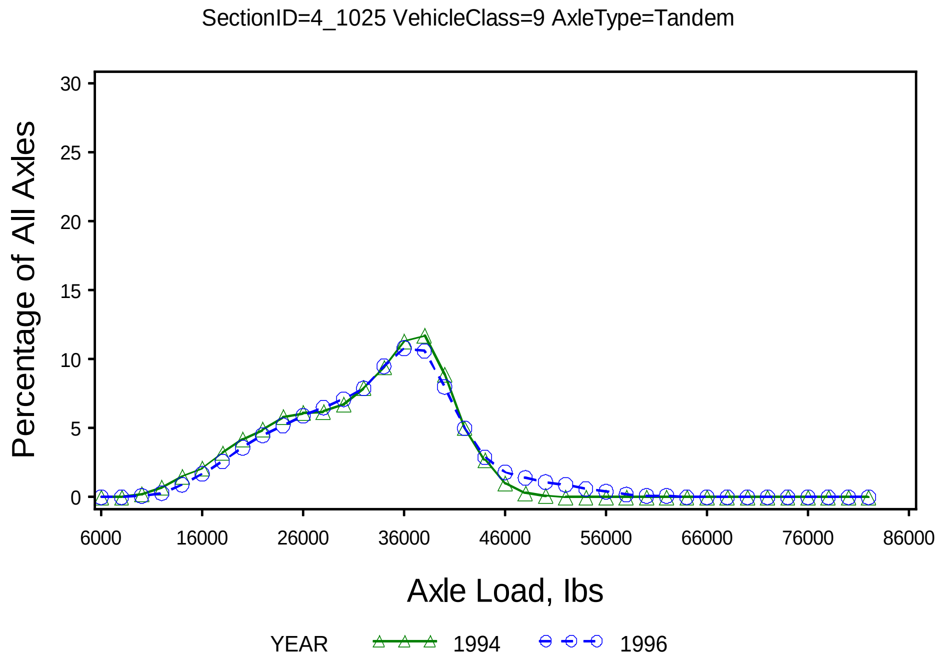


Figure E-74. Plot of Tandem-Axle Load for Site 4_1025 (Vehicle Class 9).

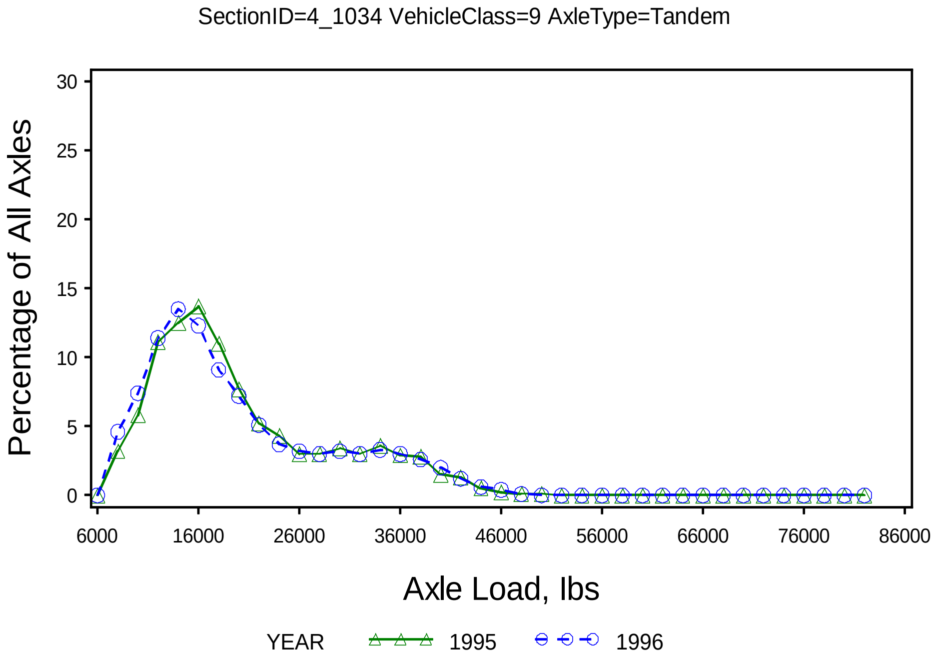


Figure E-75. Plot of Tandem-Axle Load for Site 4_1034 (Vehicle Class 9).

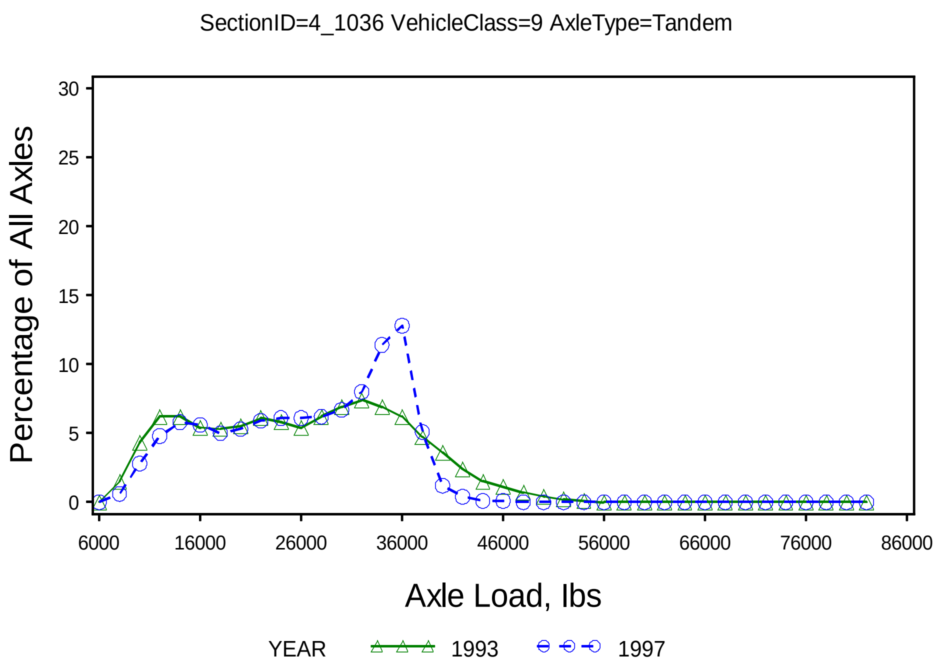


Figure E-76. Plot of Tandem-Axle Load for Site 4_1036 (Vehicle Class 9).

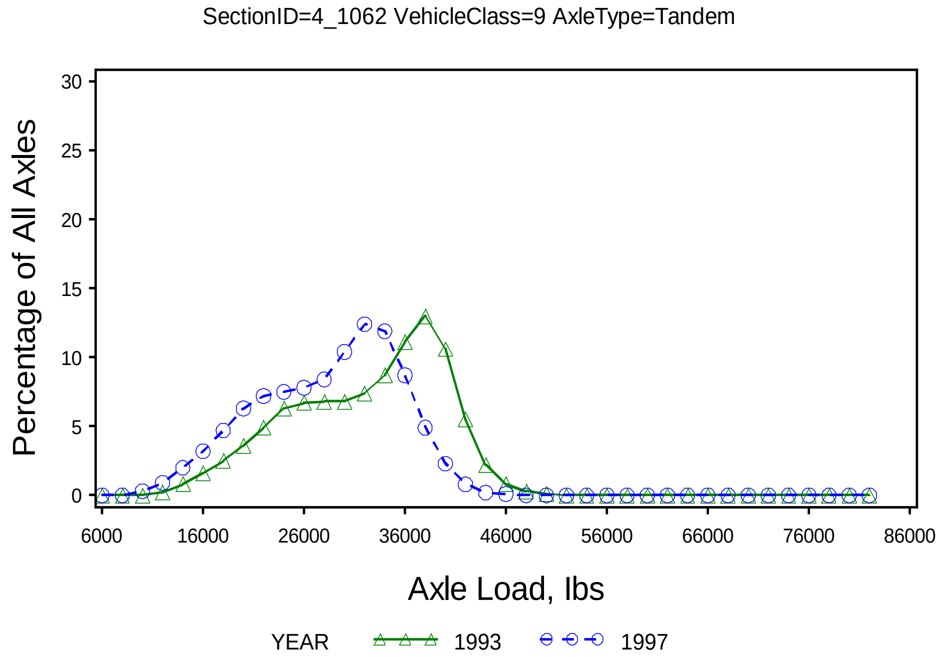


Figure E-77. Plot of Tandem-Axle Load for Site 4_1062 (Vehicle Class 9).

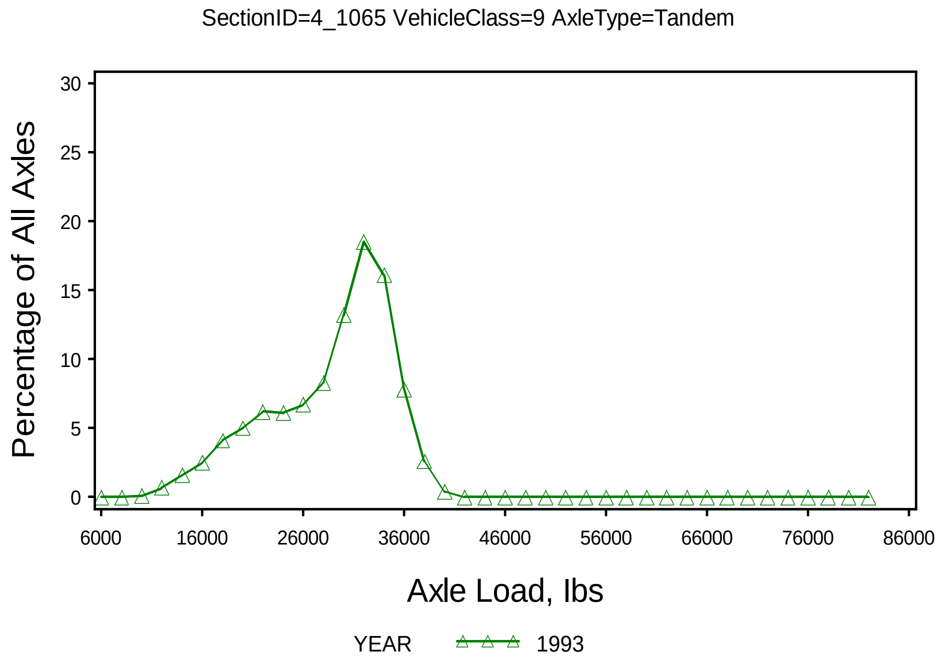


Figure E-78. Plot of Tandem-Axle Load for Site 4_1065 (Vehicle Class 9).

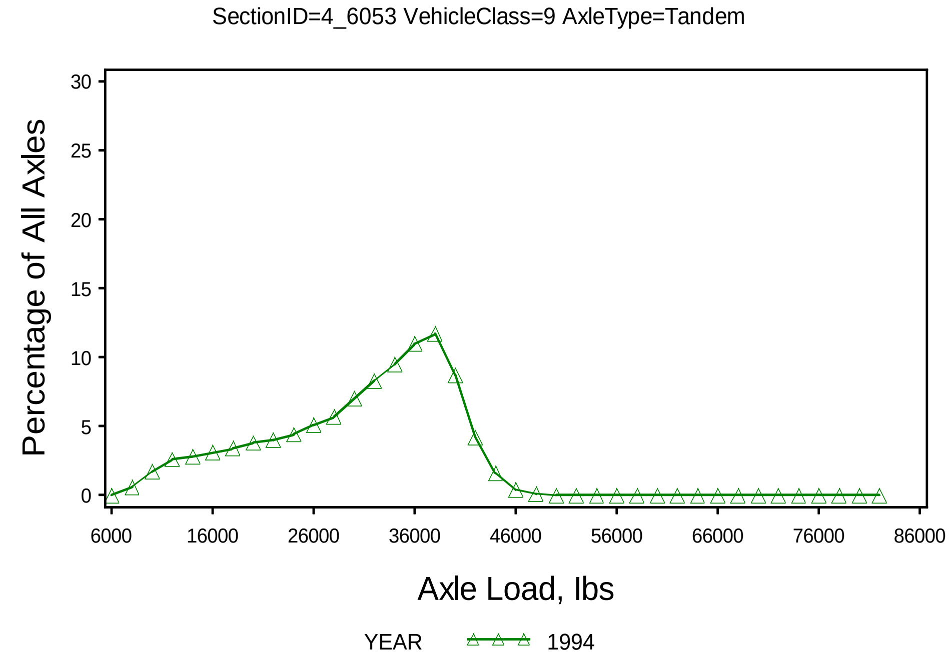


Figure E-79. Plot of Tandem-Axle Load for Site 4_6053 (Vehicle Class 9).

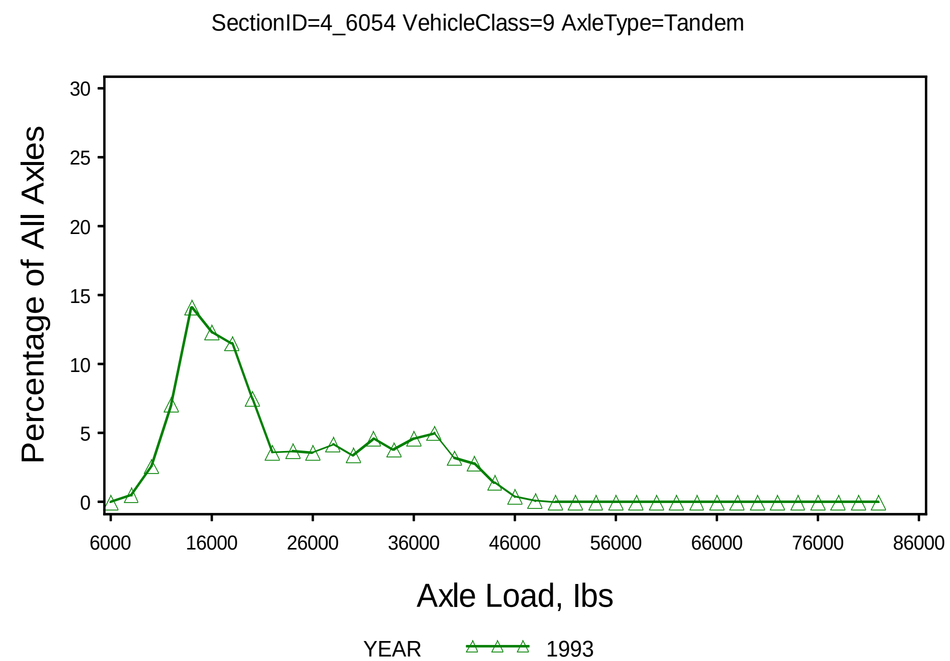


Figure E-80. Plot of Tandem-Axle Load for Site 4_6054 (Vehicle Class 9).

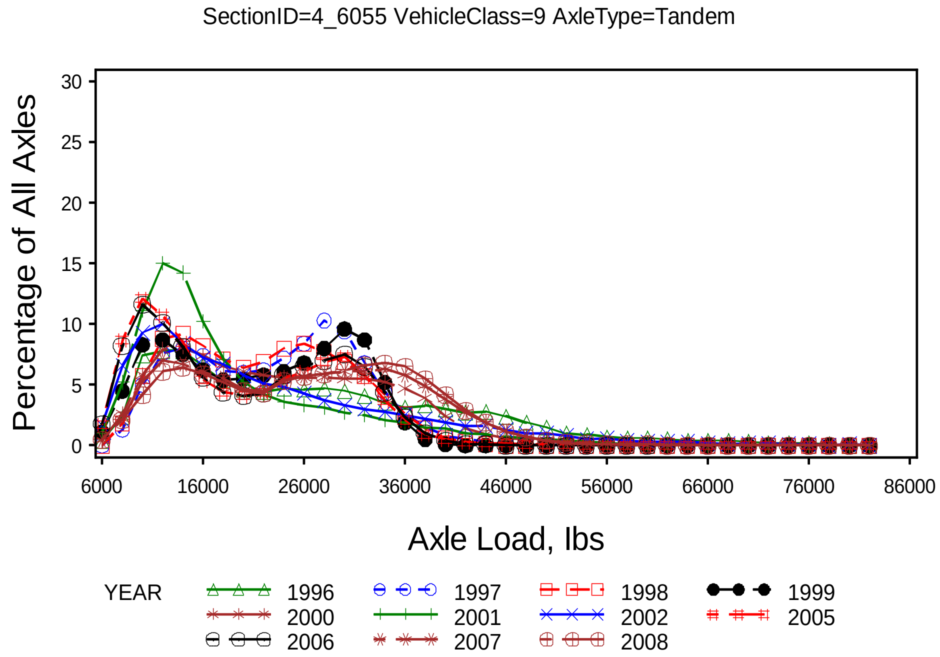


Figure E-81. Plot of Tandem-Axle Load for Site 4_6055 (Vehicle Class 9).

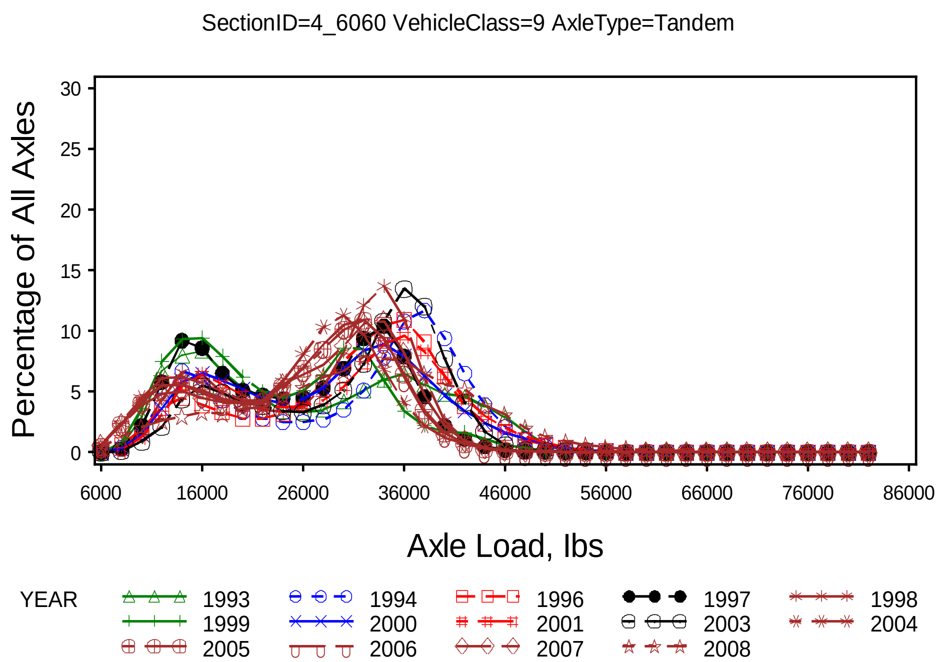


Figure E-82. Plot of Tandem-Axle Load for Site 4_6060 (Vehicle Class 9).

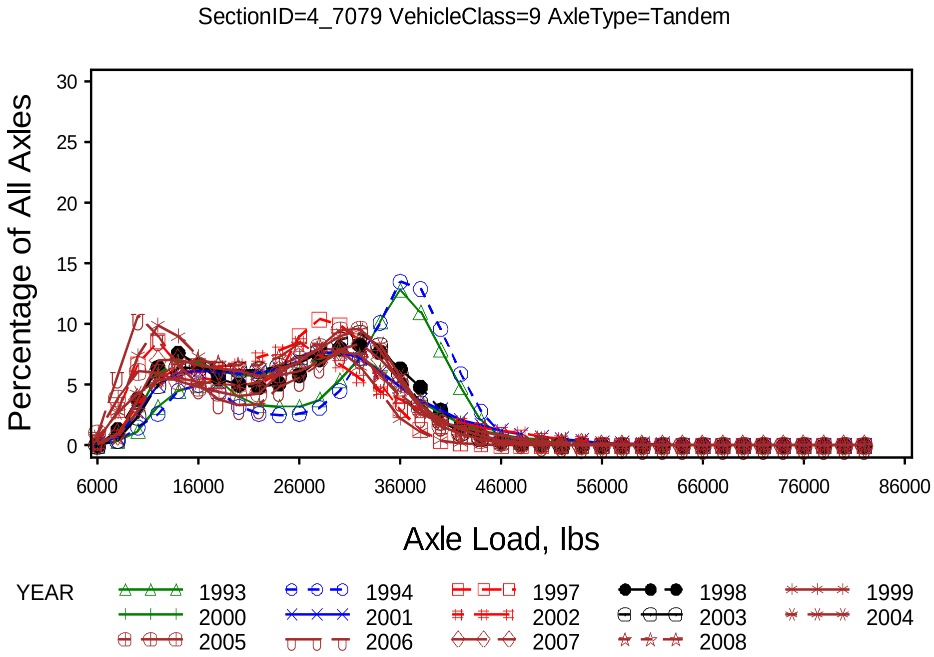


Figure E-83. Plot of Tandem-Axle Load for Site 4_7079 (Vehicle Class 9).

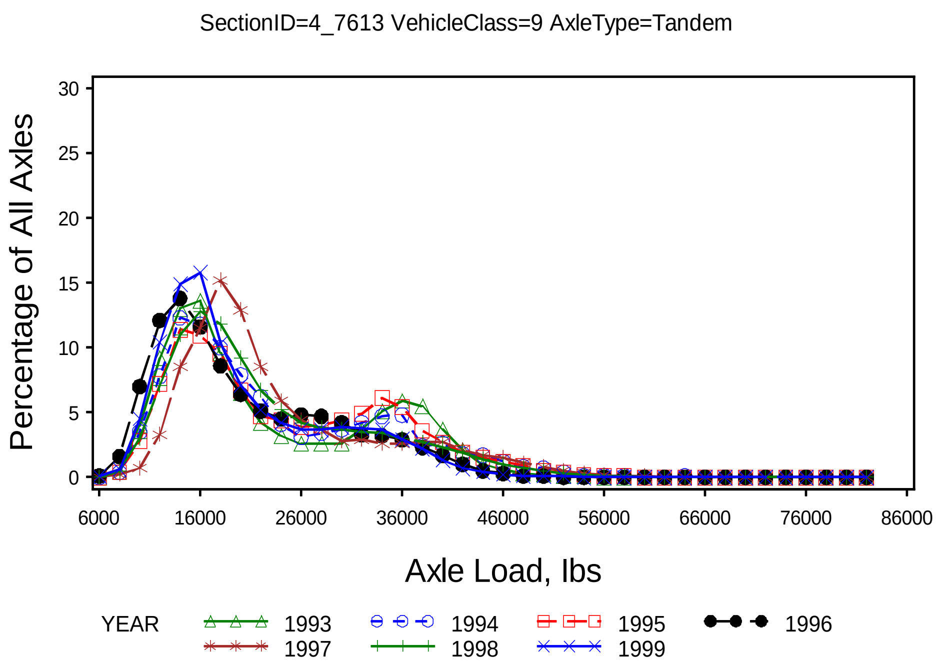


Figure E-84. Plot of Tandem-Axle Load for Site 4_7613 (Vehicle Class 9).

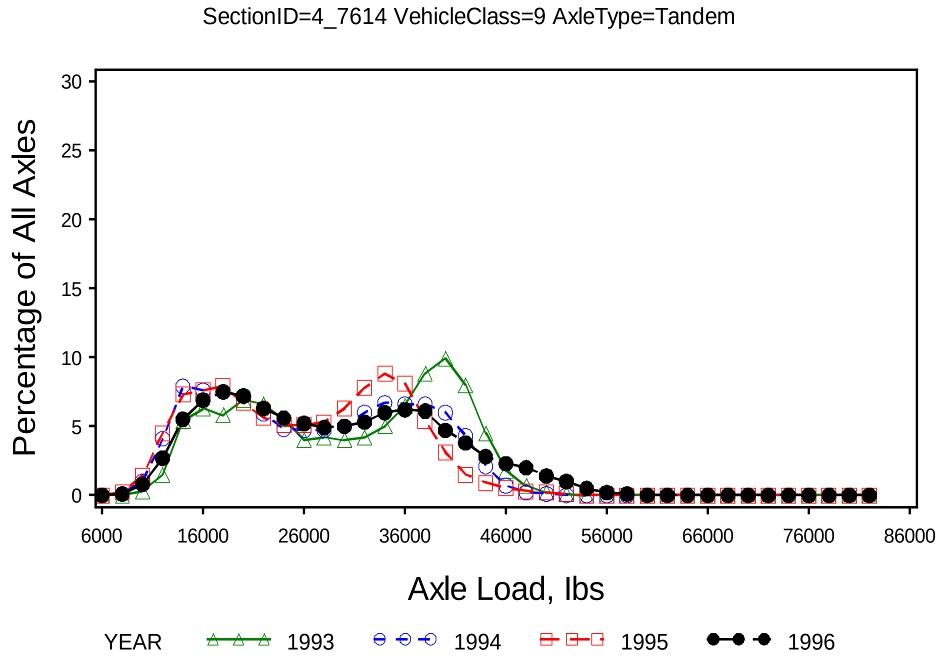


Figure E-85. Plot of Tandem-Axle Load for Site 4_7614 (Vehicle Class 9).

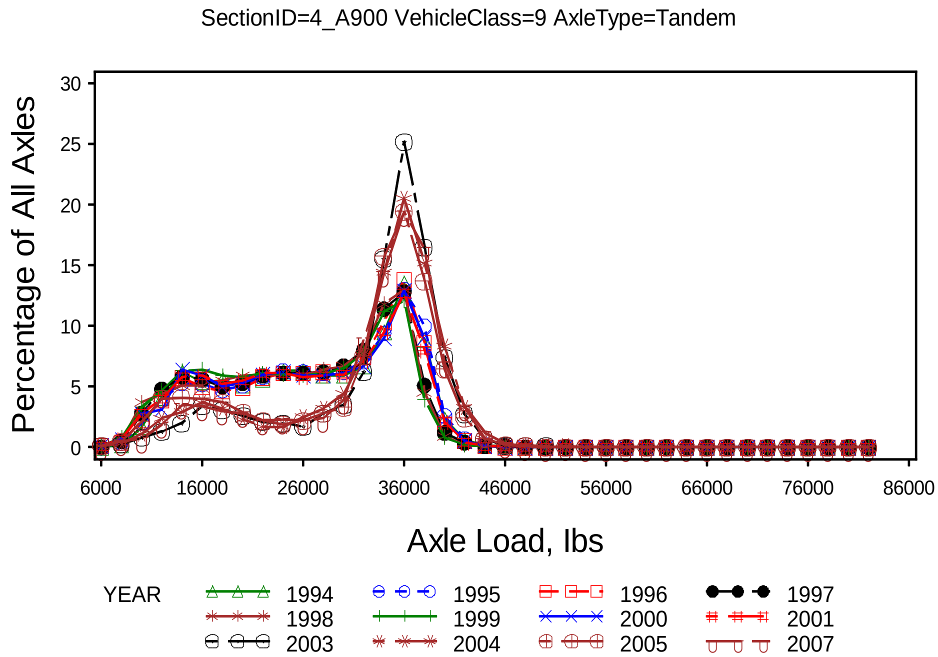


Figure E-86. Plot of Tandem-Axle Load for Site 4_A900 (Vehicle Class 9).

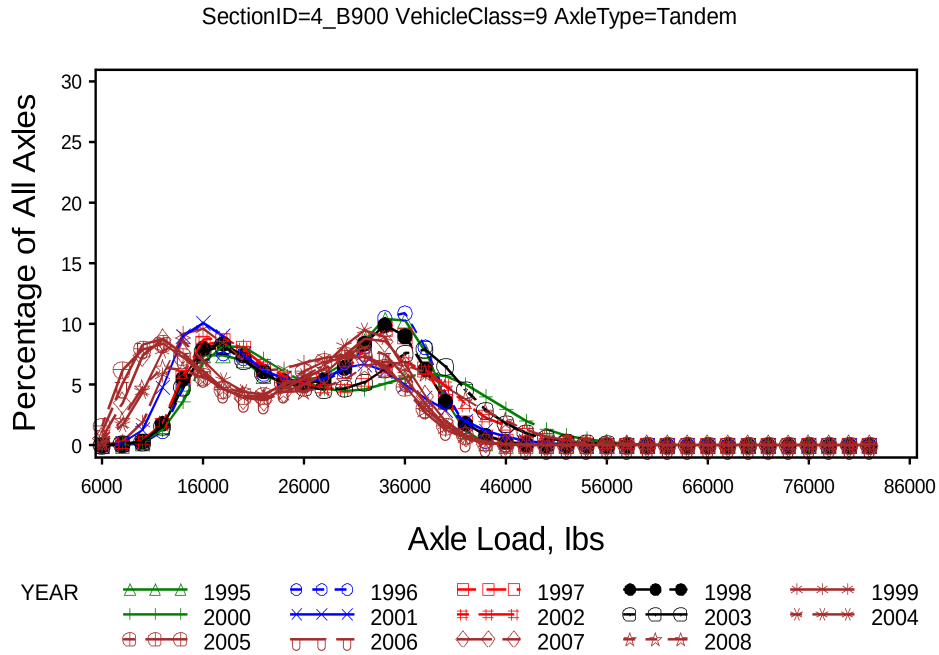


Figure E-87. Plot of Tandem-Axle Load for Site 4_B900 (Vehicle Class 9).

APPENDIX F. SUMMARY OF AXLES-PER-TRUCK DATA USED FOR ANALYSIS

This appendix presents plots of axles-per-truck data for Arizona projects that had the required data. Note that not all of the data presented in this appendix were included in this analysis, as some data were deemed atypical, anomalous, or erroneous.

AXLE-PER-TRUCK PLOTS FOR CLASS 5 TRUCKS

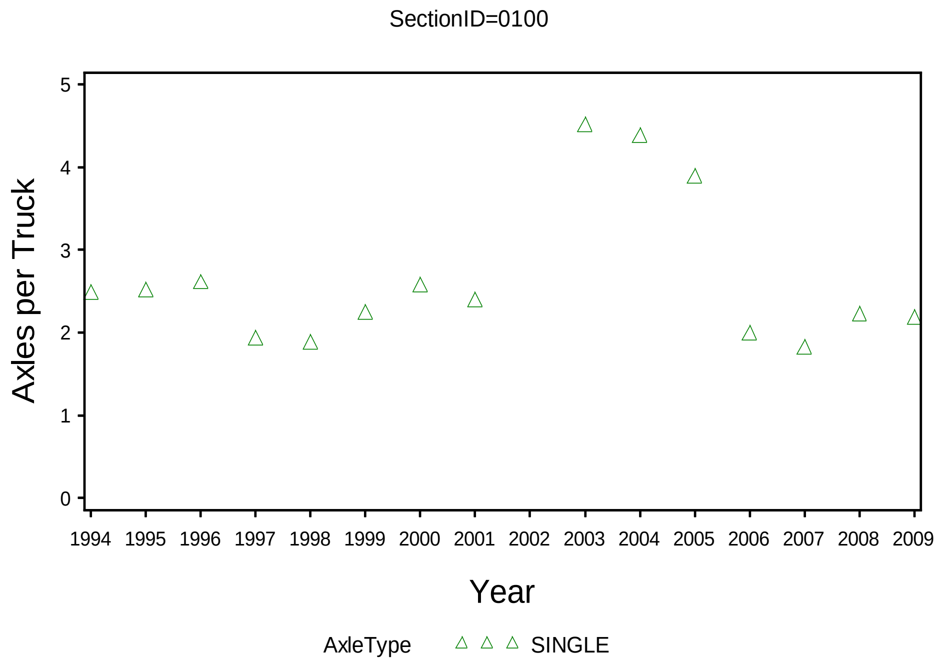


Figure F-1. Plot of Axles per Truck for Site 4_0100 (Vehicle Class 5).

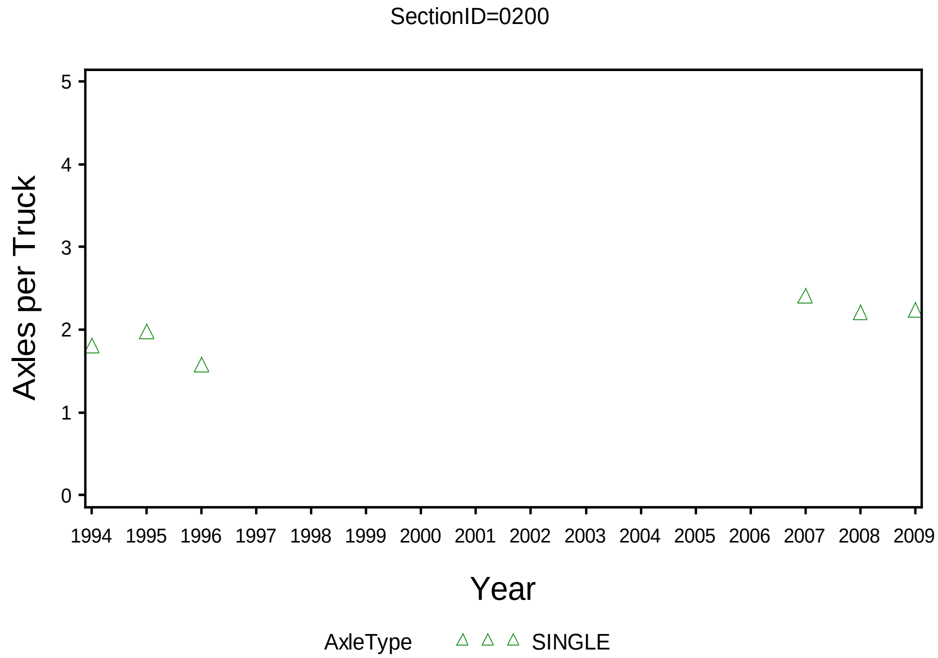


Figure F-2. Plot of Axles per Truck for Site 4_0100 (Vehicle Class 5).

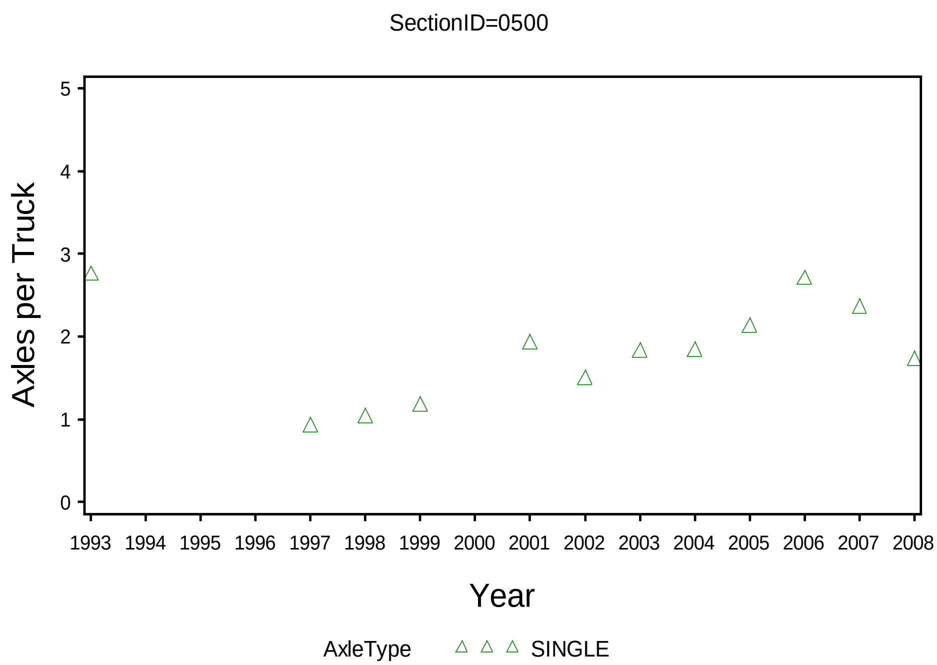


Figure F-3. Plot of Axles per Truck for Site 4_0500 (Vehicle Class 5).

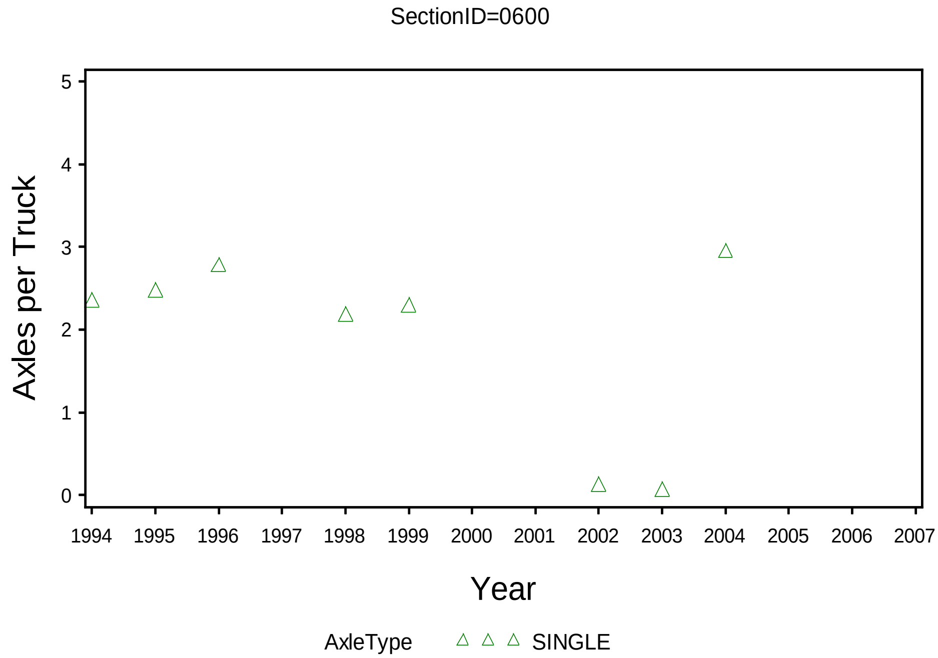


Figure F-4. Plot of Axles per Truck for Site 4_0500 (Vehicle Class 5).

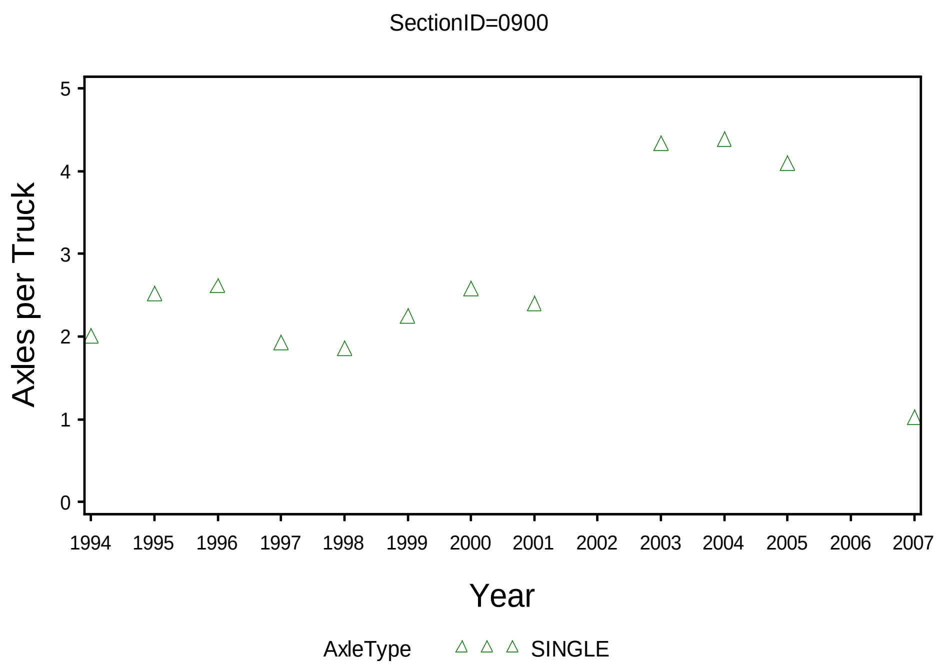


Figure F-5. Plot of Axles per Truck for Site 4_0900 (Vehicle Class 5).

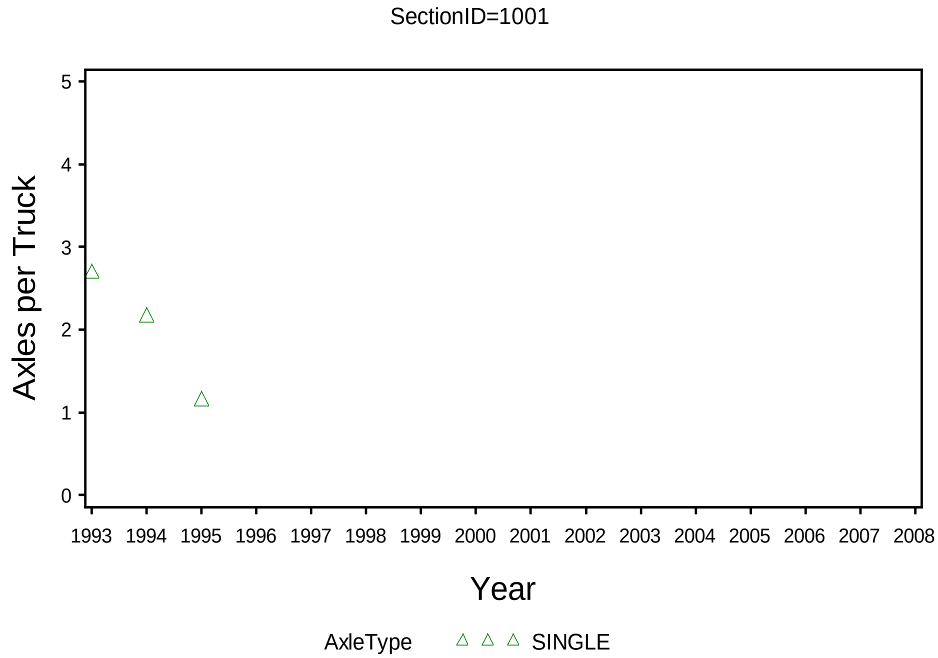


Figure F-6. Plot of Axles per Truck for Site 4_1001 (Vehicle Class 5).

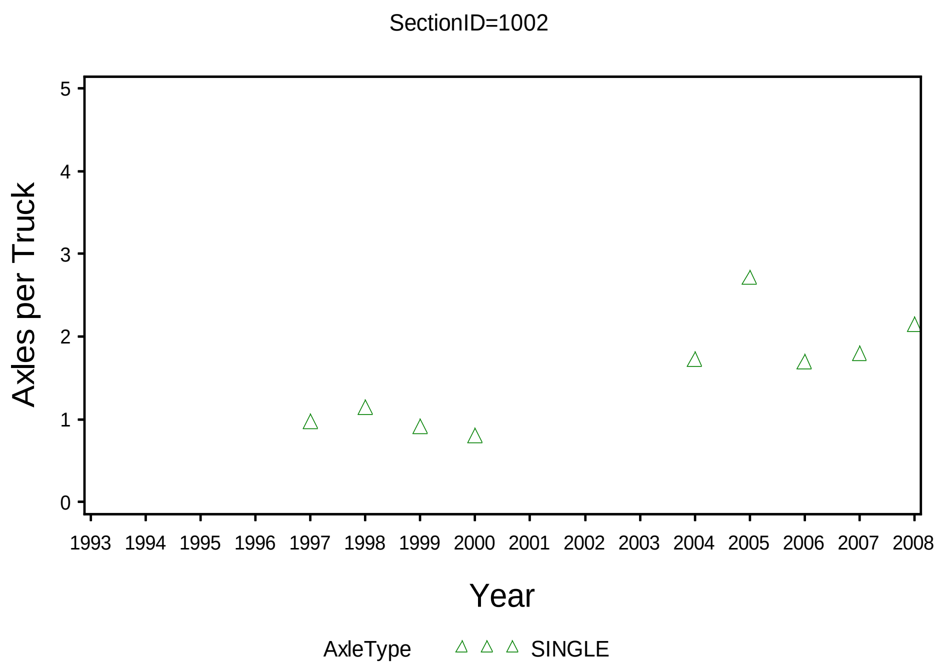


Figure F-7. Plot of Axles per Truck for Site 4_1002 (Vehicle Class 5).

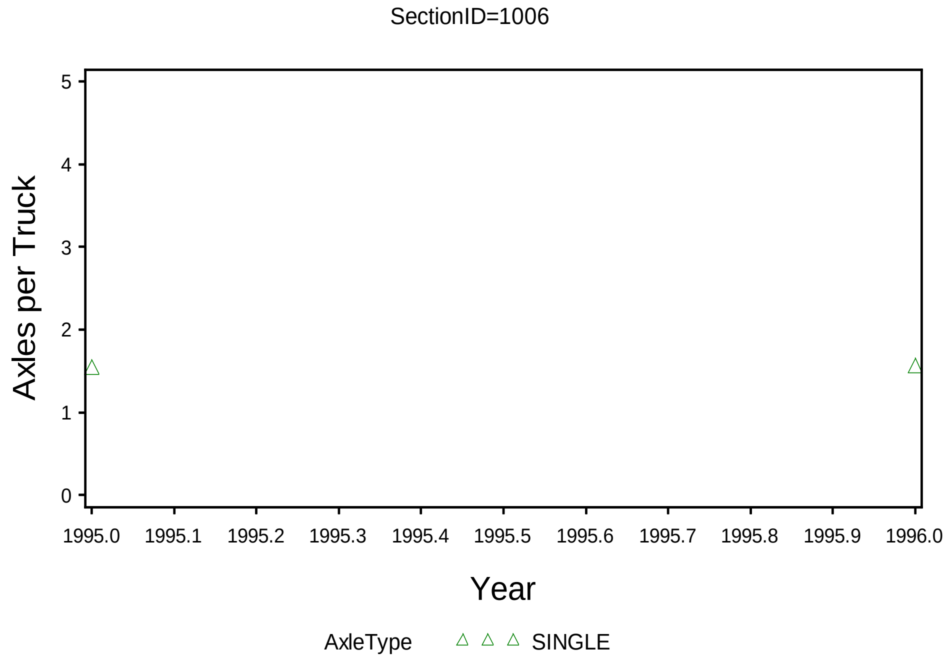


Figure F-8. Plot of Axles per Truck for Site 4_1006 (Vehicle Class 5).

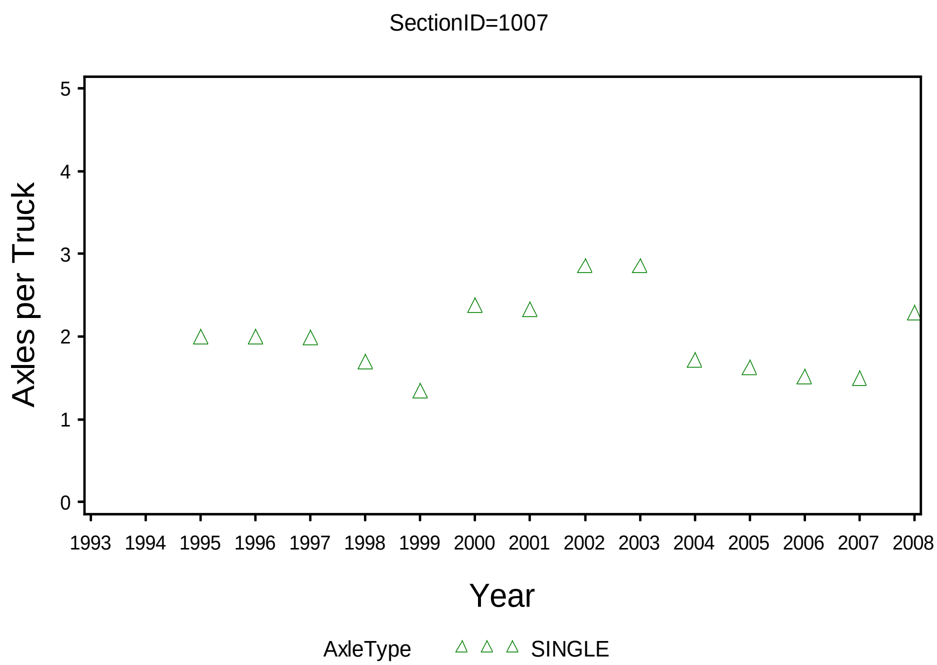


Figure F-9. Plot of Axles per Truck for Site 4_1007 (Vehicle Class 5).

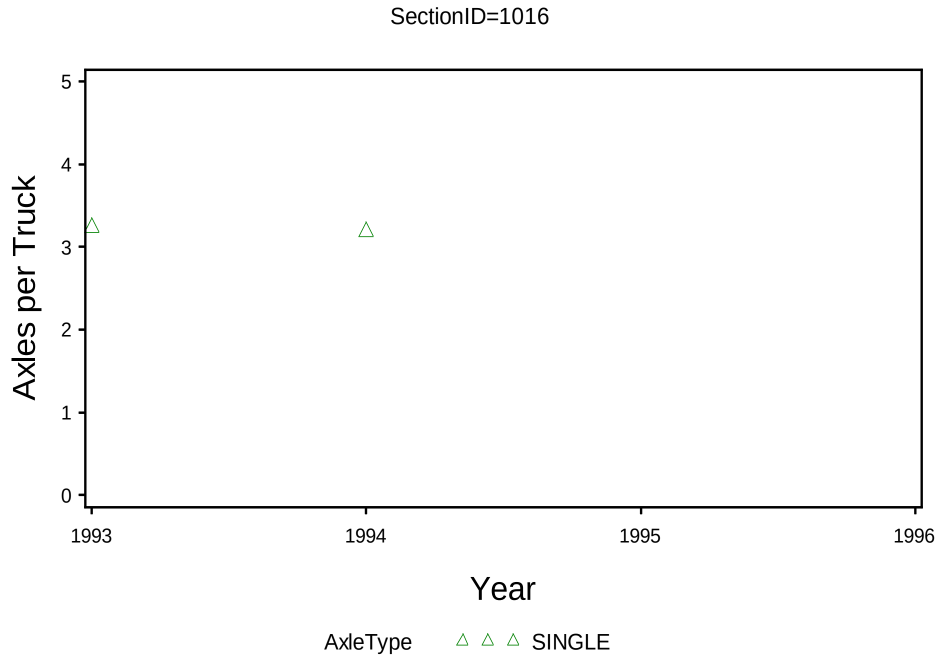


Figure F-10. Plot of Axles per Truck for Site 4_1016 (Vehicle Class 5).

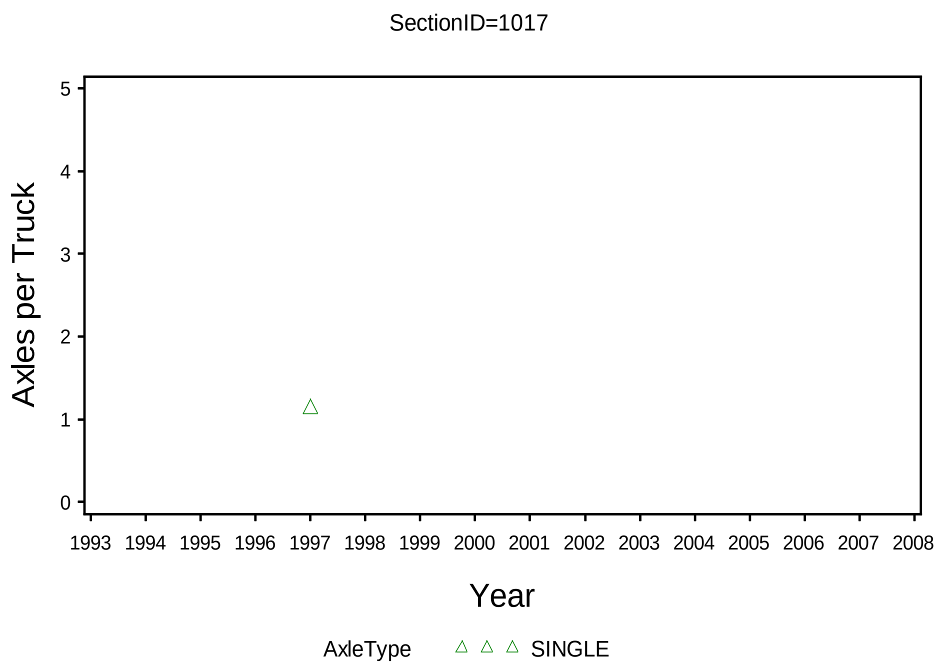


Figure F-11. Plot of Axles per Truck for Site 4_1017 (Vehicle Class 5).

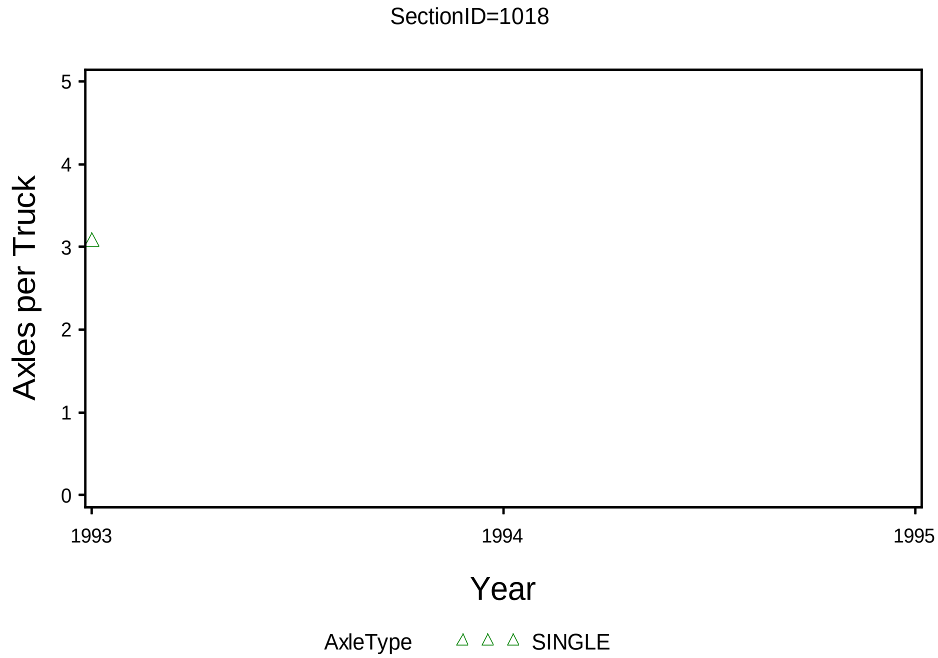


Figure F-12. Plot of Axles per Truck for Site 4_1018 (Vehicle Class 5).

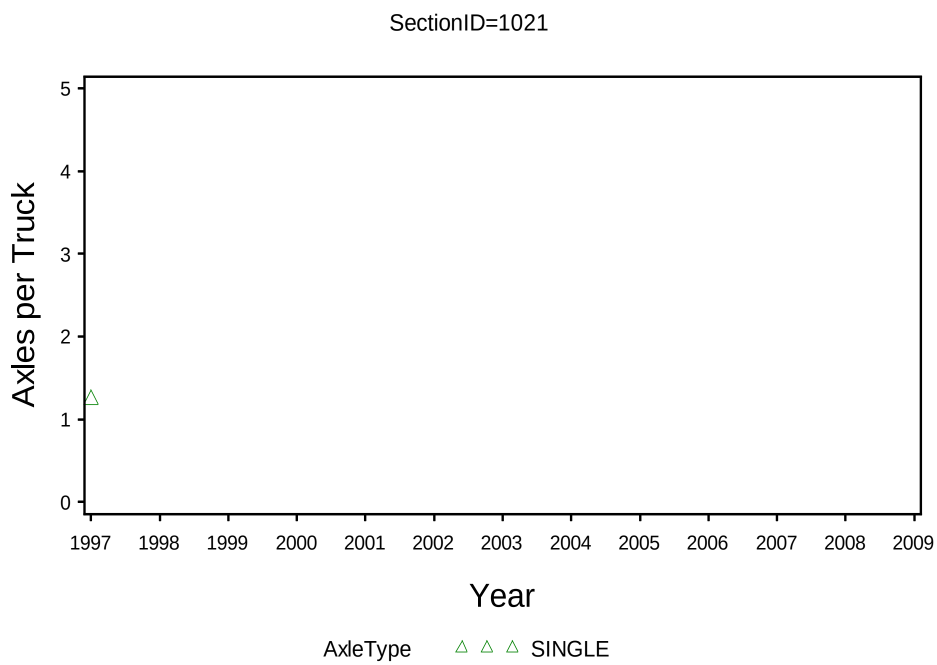


Figure F-13. Plot of Axles per Truck for Site 4_1021 (Vehicle Class 5).

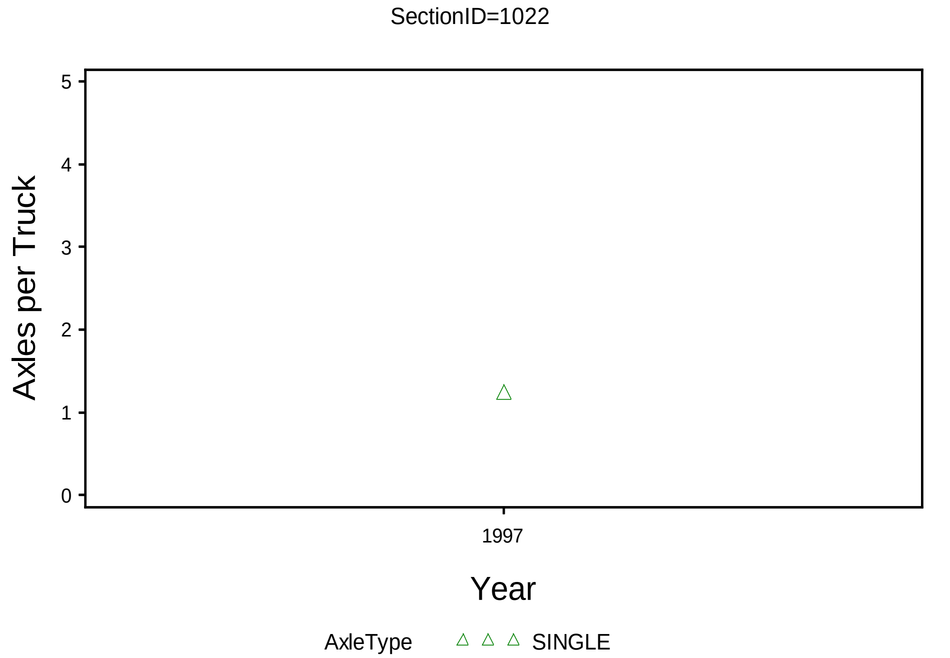


Figure F-14. Plot of Axles per Truck for Site 4_1022 (Vehicle Class 5).

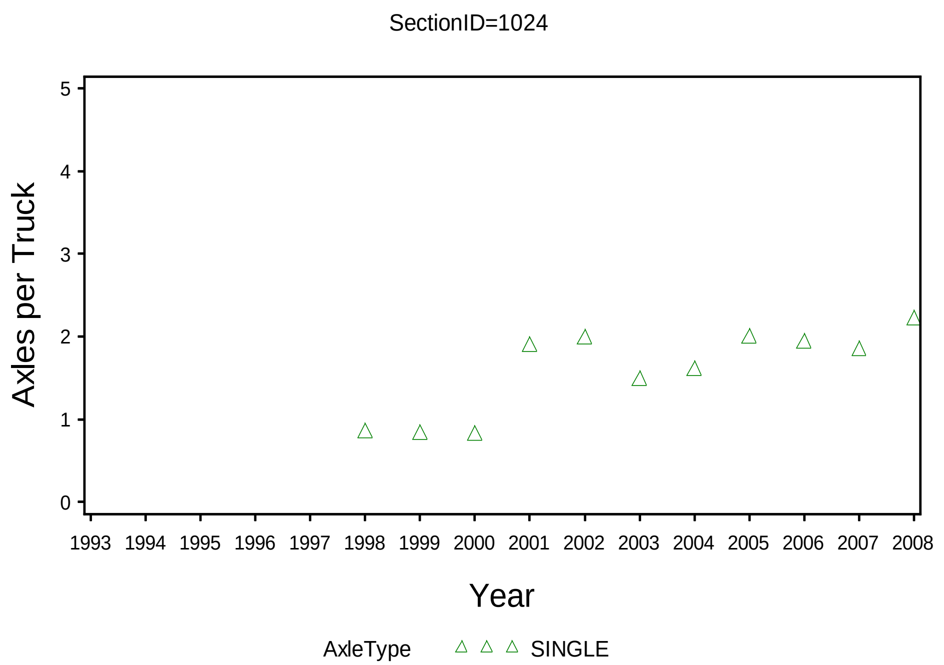


Figure F-15. Plot of Axles per Truck for Site 4_1024 (Vehicle Class 5).

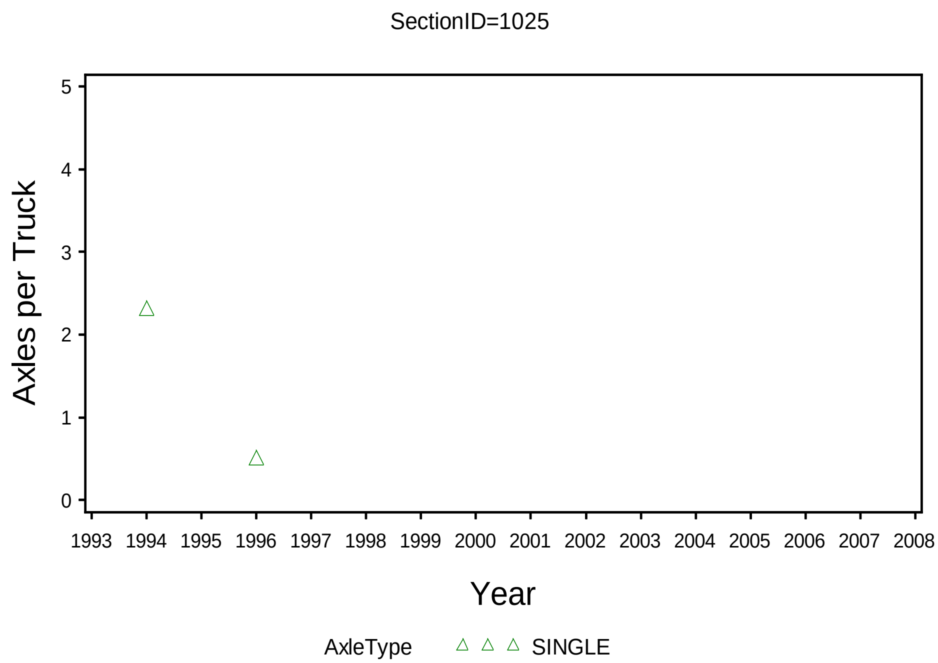


Figure F-16. Plot of Axles per Truck for Site 4_1025 (Vehicle Class 5).

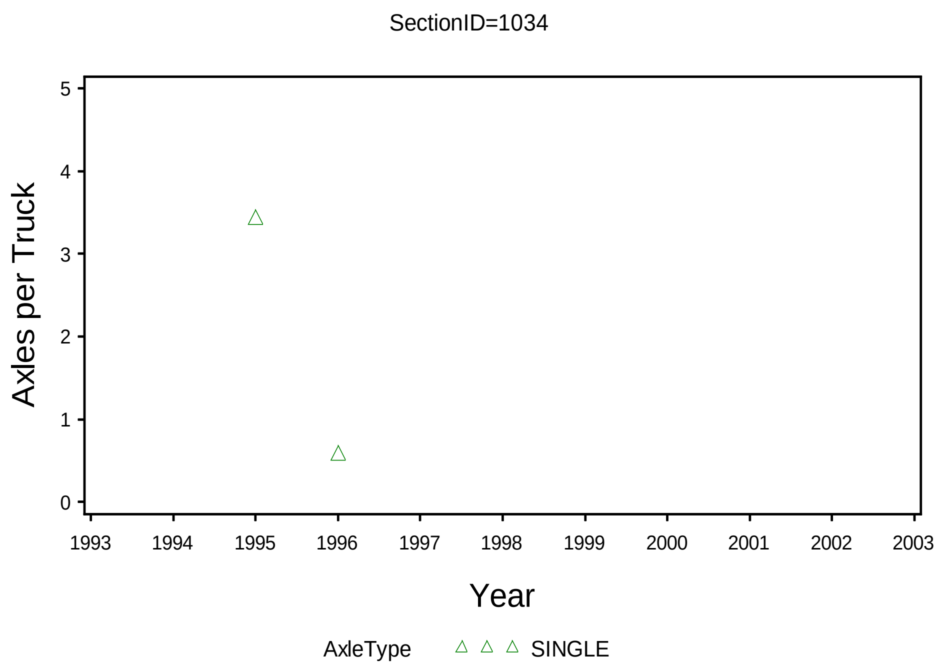


Figure F-17. Plot of Axles per Truck for Site 4_1034 (Vehicle Class 5).

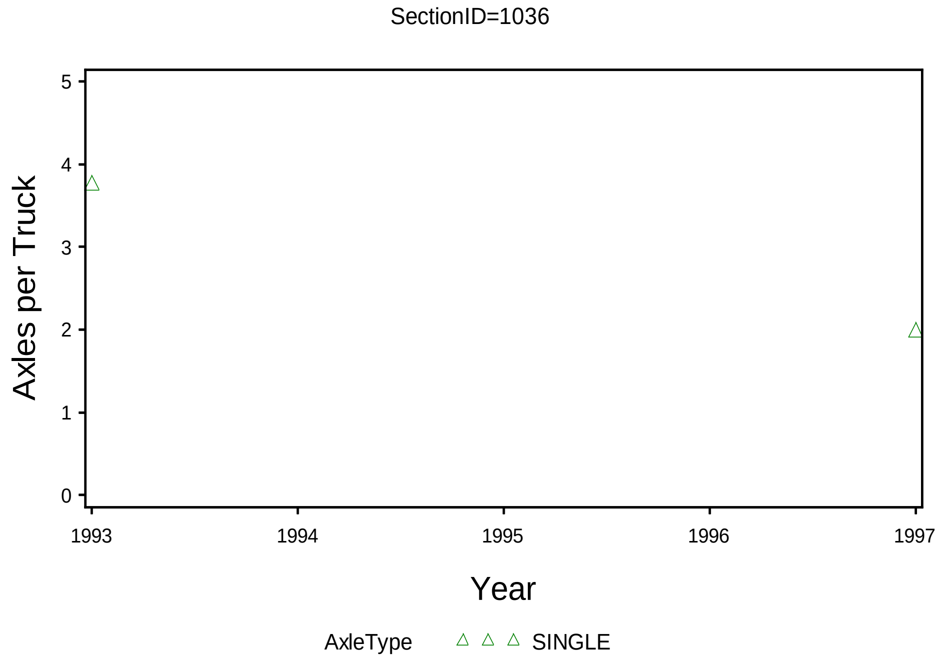


Figure F-18. Plot of Axles per Truck for Site 4_1036 (Vehicle Class 5).

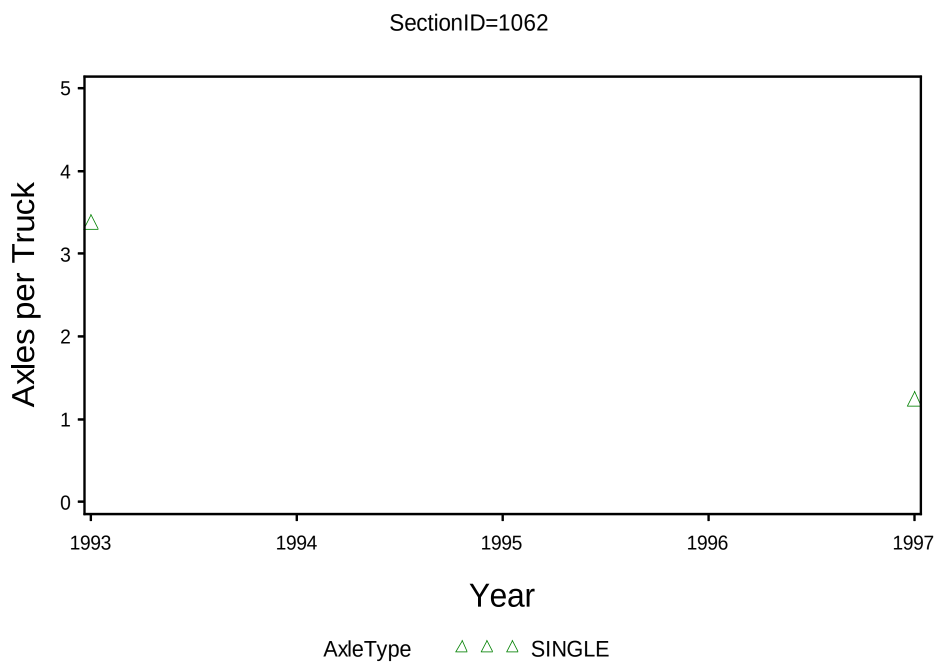


Figure F-19. Plot of Axles per Truck for Site 4_1062 (Vehicle Class 5).

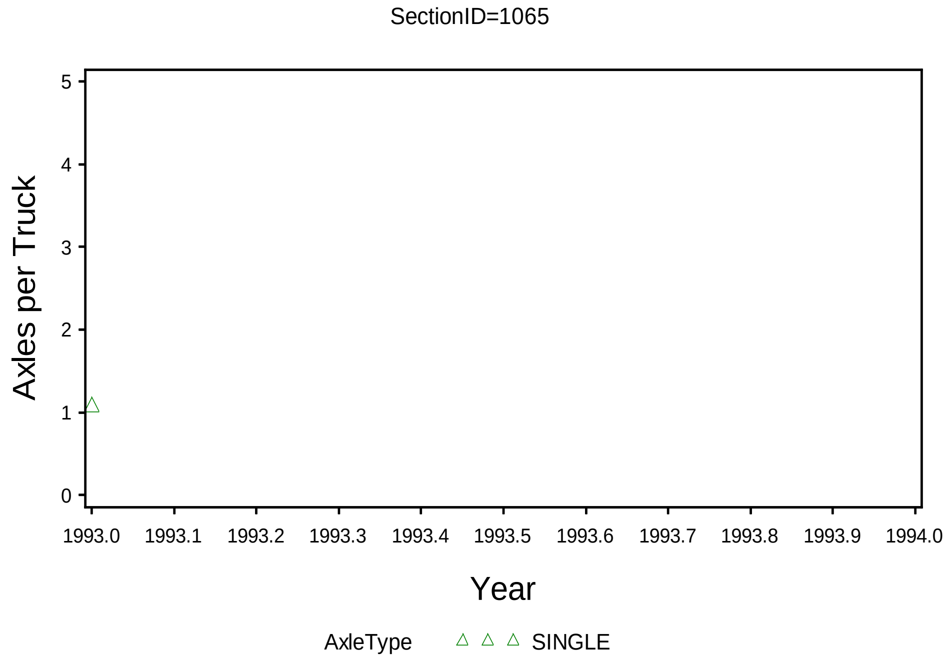


Figure F-20. Plot of Axles per Truck for Site 4_1065 (Vehicle Class 5).

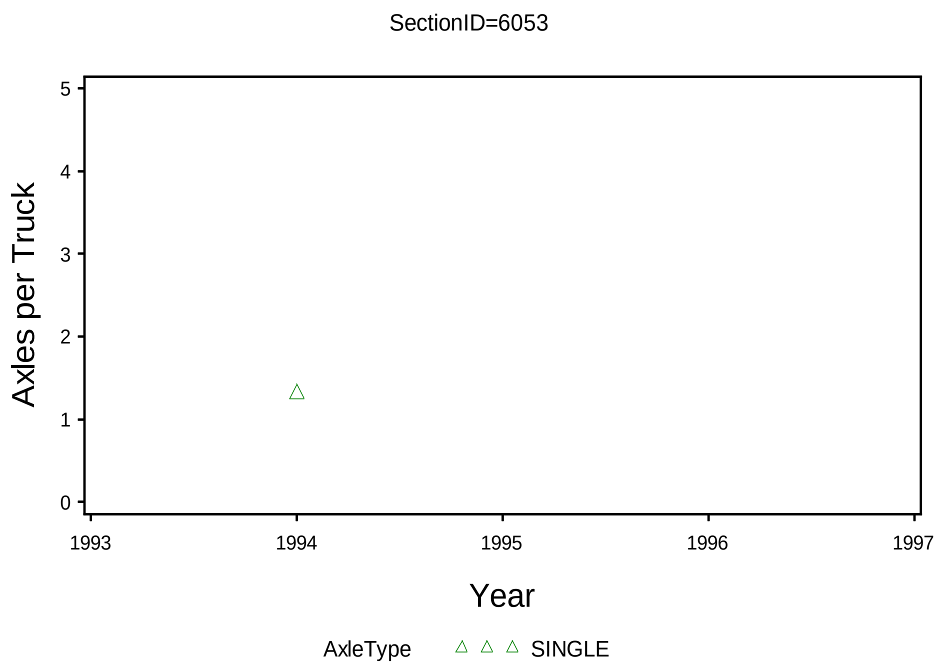


Figure F-21. Plot of Axles per Truck for Site 4_6053 (Vehicle Class 5).

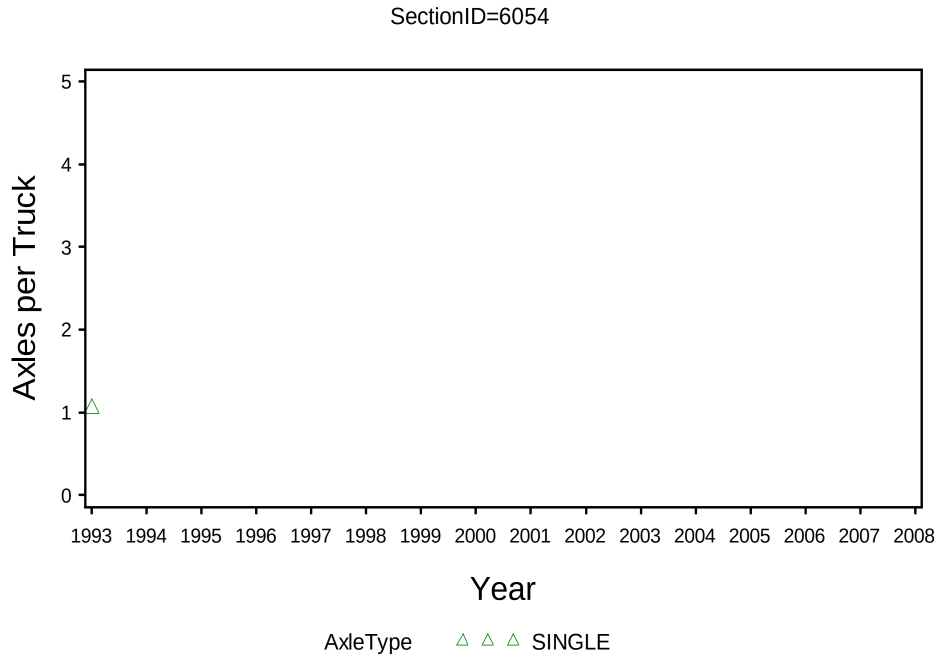


Figure F-22. Plot of Axles per Truck for Site 4_6054 (Vehicle Class 5).

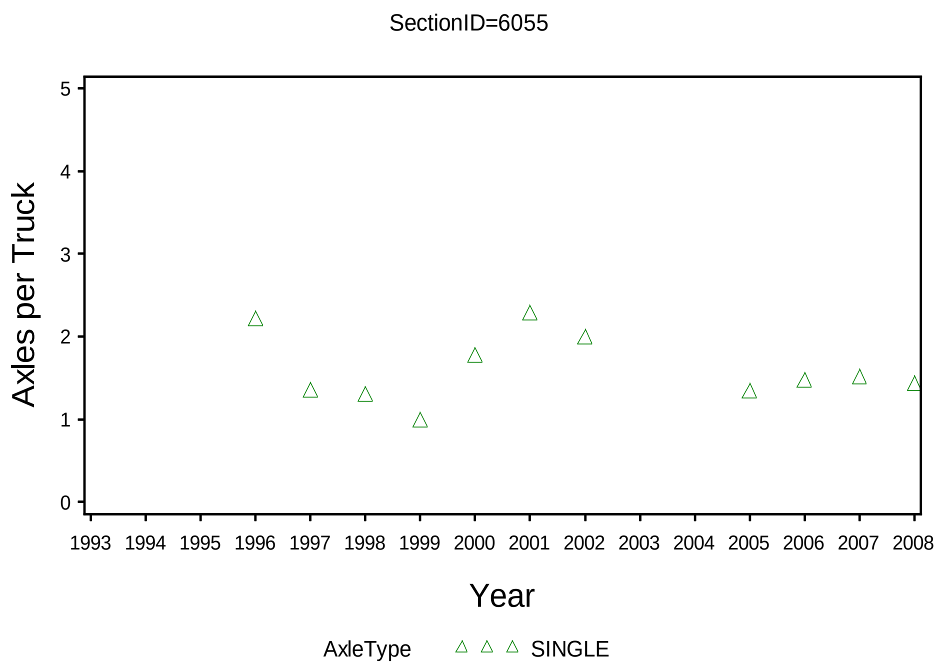


Figure F-23. Plot of Axles per Truck for Site 4_6055 (Vehicle Class 5).

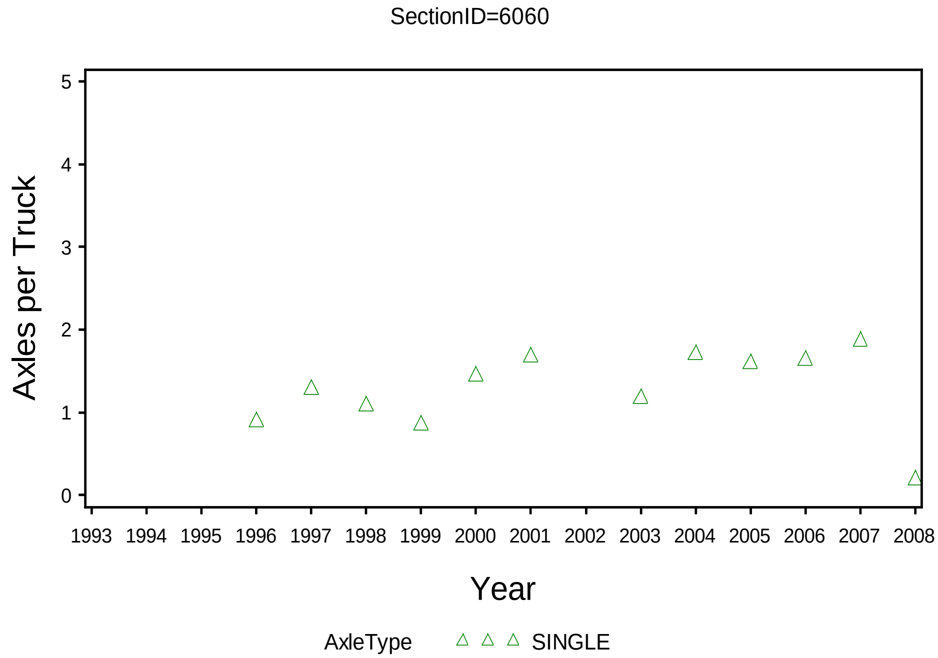


Figure F-24. Plot of Axles per Truck for Site 4_6060 (Vehicle Class 5).

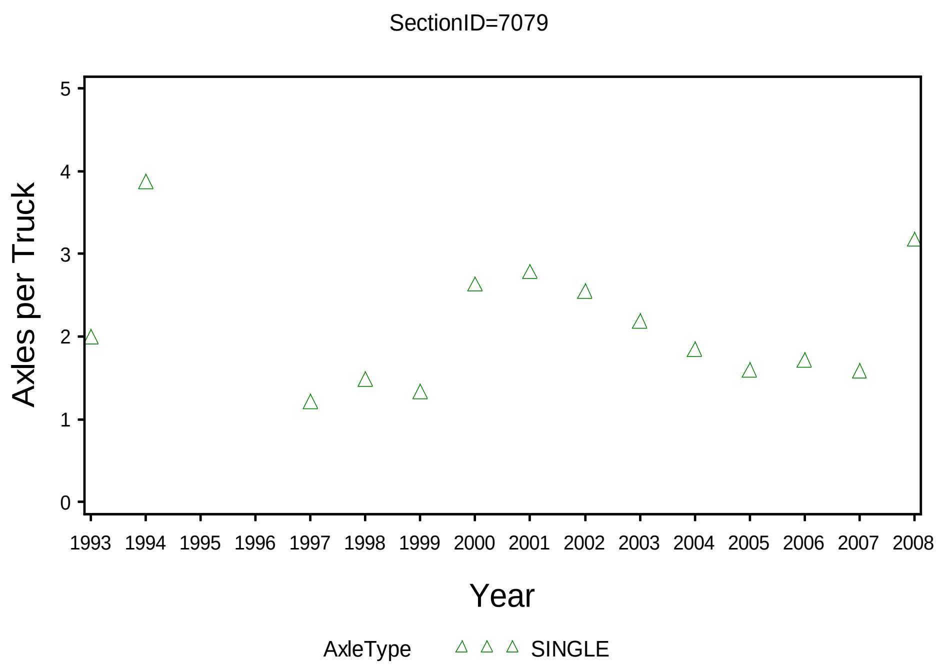


Figure F-25. Plot of Axles per Truck for Site 4_7079 (Vehicle Class 5).

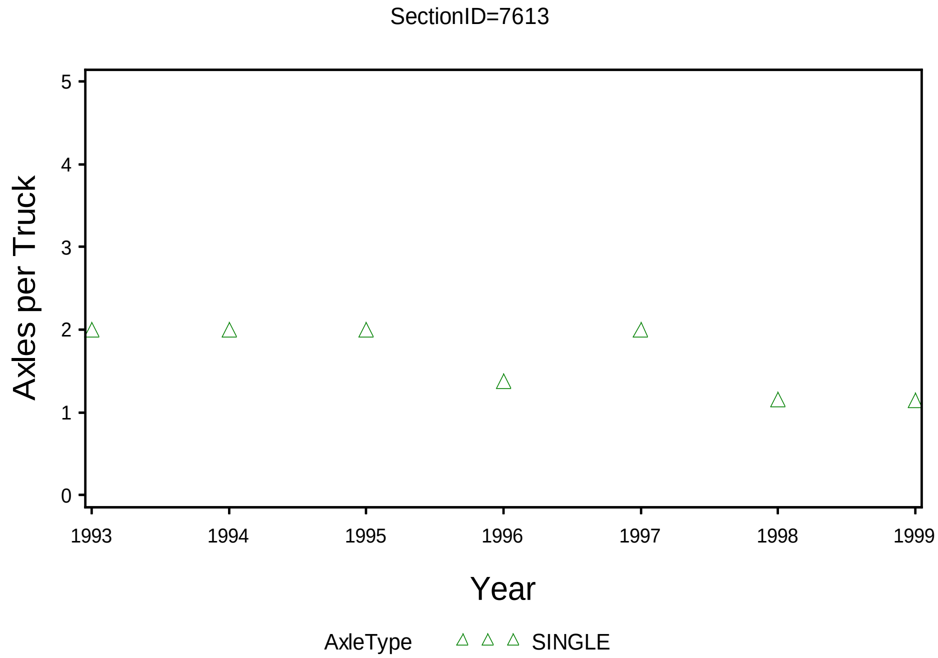


Figure F-26. Plot of Axles per Truck for Site 4_7613 (Vehicle Class 5).

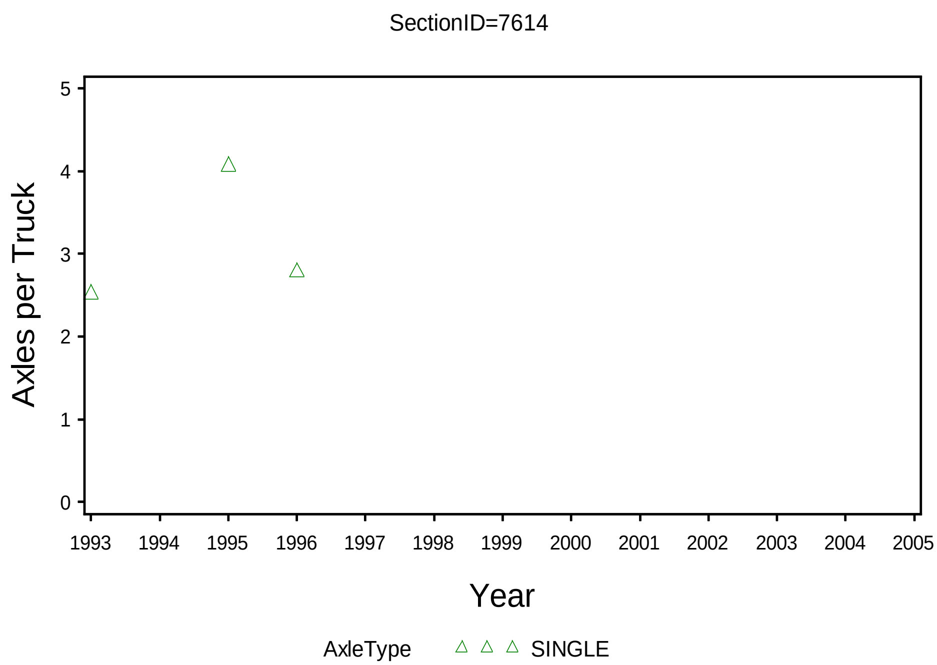


Figure F-27. Plot of Axles per Truck for Site 4_7614 (Vehicle Class 5).

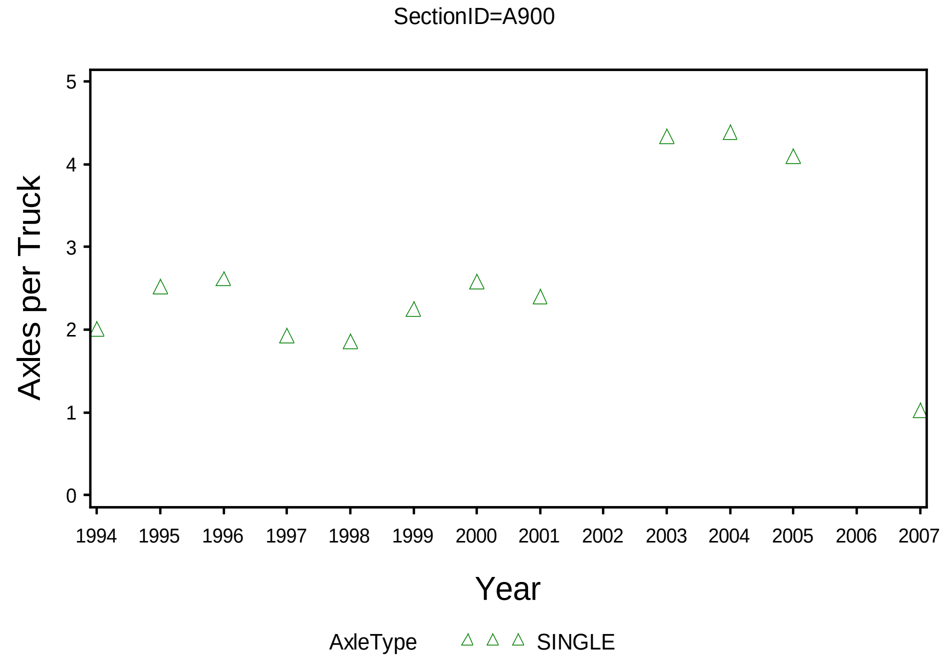


Figure F-28. Plot of Axles per Truck for Site 4_A900 (Vehicle Class 5).

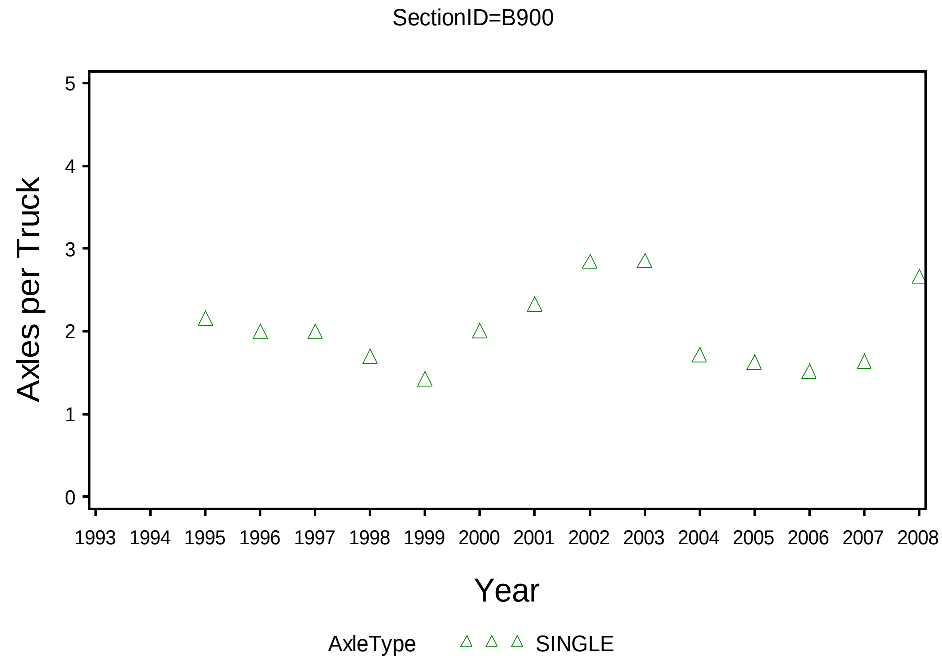


Figure F-29. Plot of Axles per Truck for Site 4_B900 (Vehicle Class 5).

AXLE-PER-TRUCK PLOTS FOR CLASS 9 TRUCKS

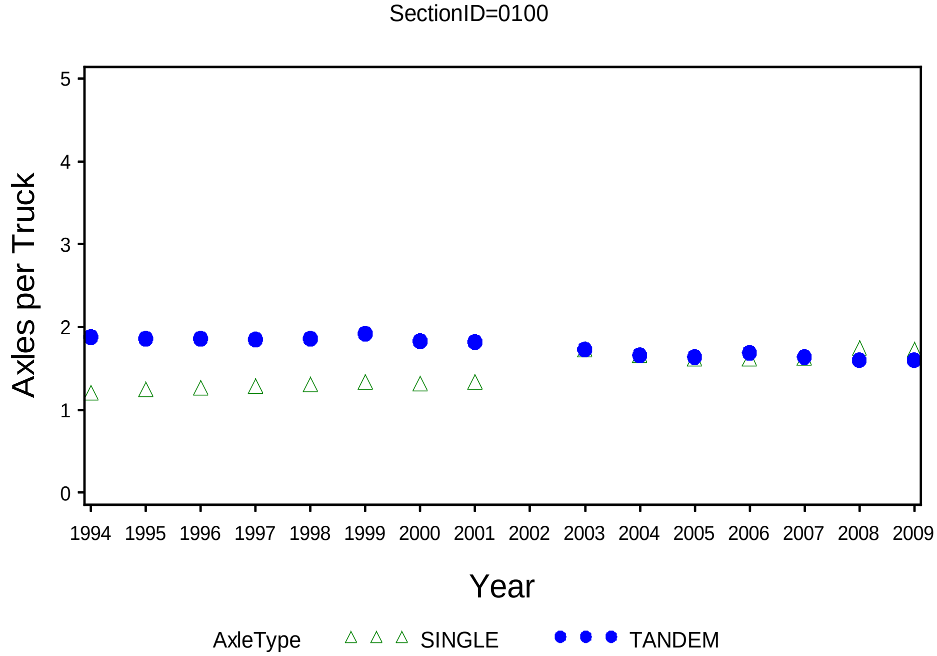


Figure F-30. Plot of Axles per Truck for Site 4_0100 (Vehicle Class 9).

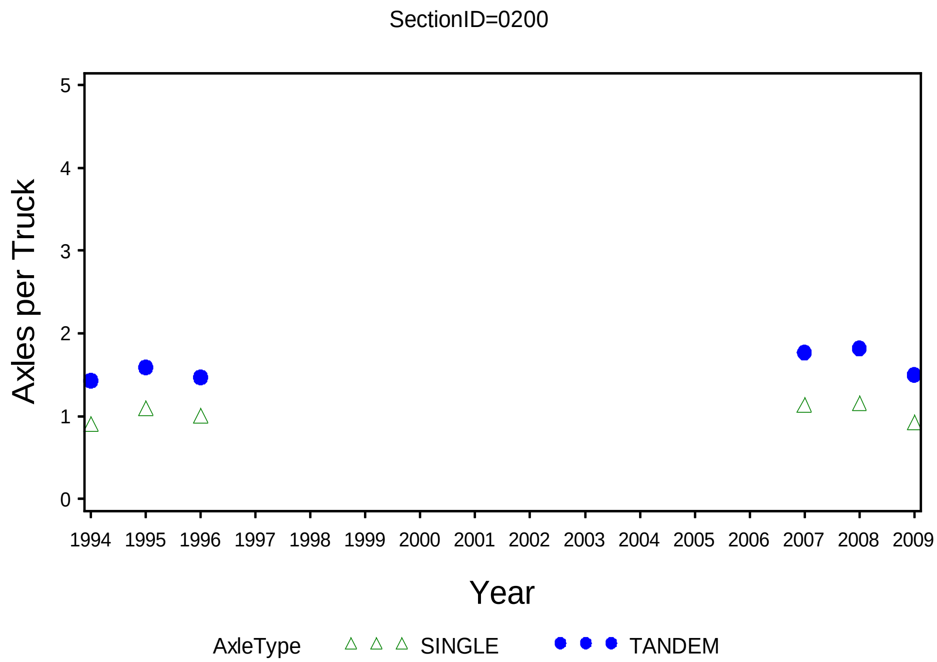


Figure F-31. Plot of Axles per Truck for Site 4_0200 (Vehicle Class 9).

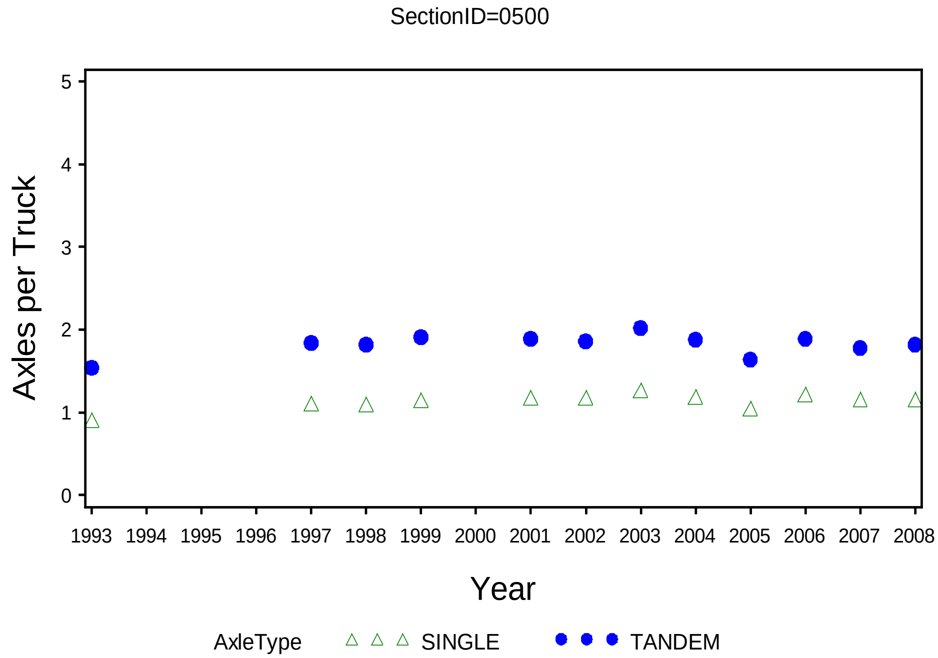


Figure F-32. Plot of Axles per Truck for Site 4_0500 (Vehicle Class 9).

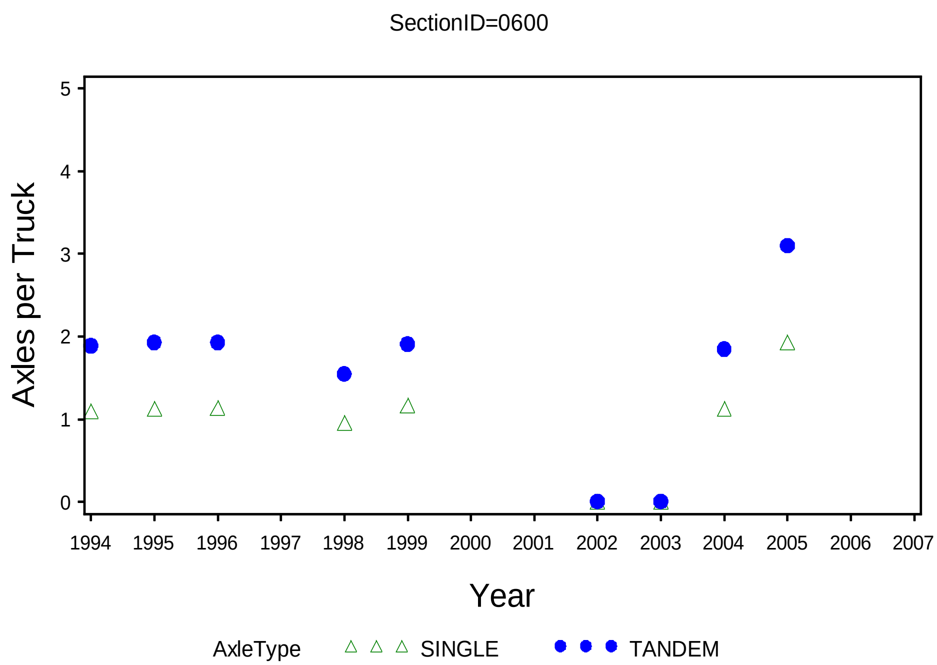


Figure F-33. Plot of Axles per Truck for Site 4_0600 (Vehicle Class 9).

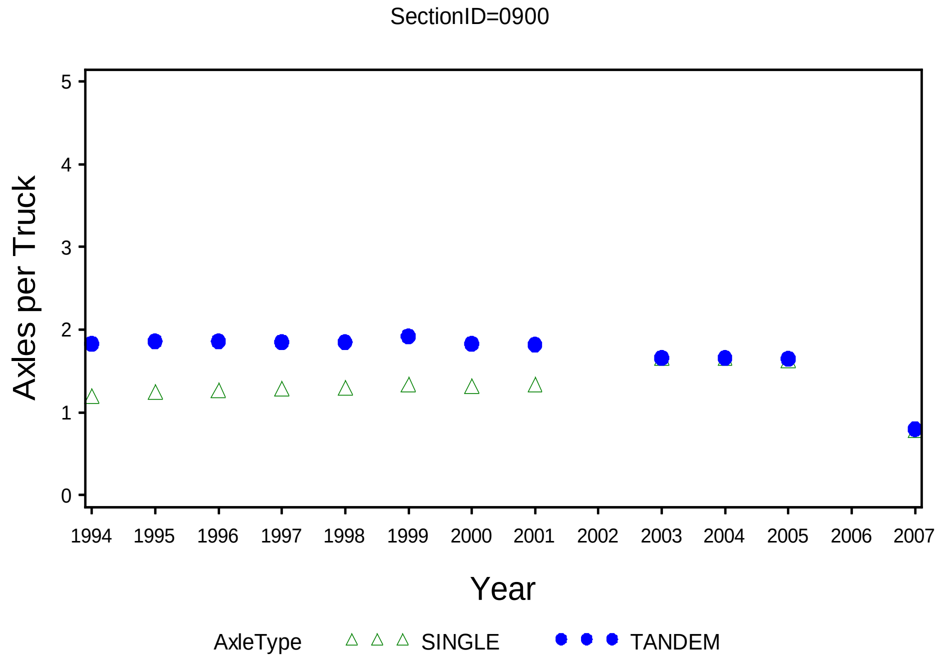


Figure F-34. Plot of Axles per Truck for Site 4_0900 (Vehicle Class 9).

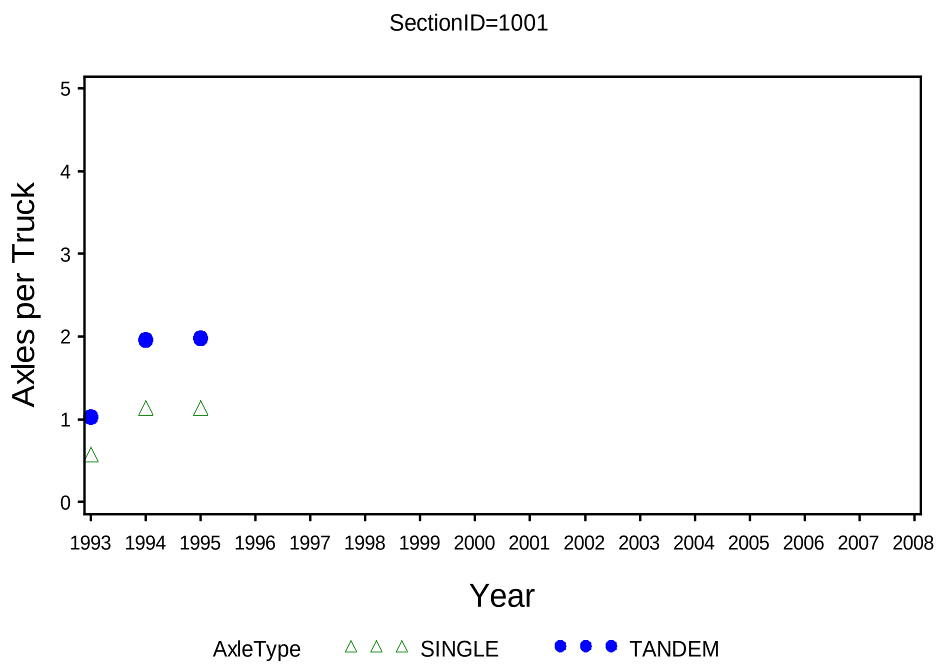


Figure F-35. Plot of Axles per Truck for Site 4_1001 (Vehicle Class 9).

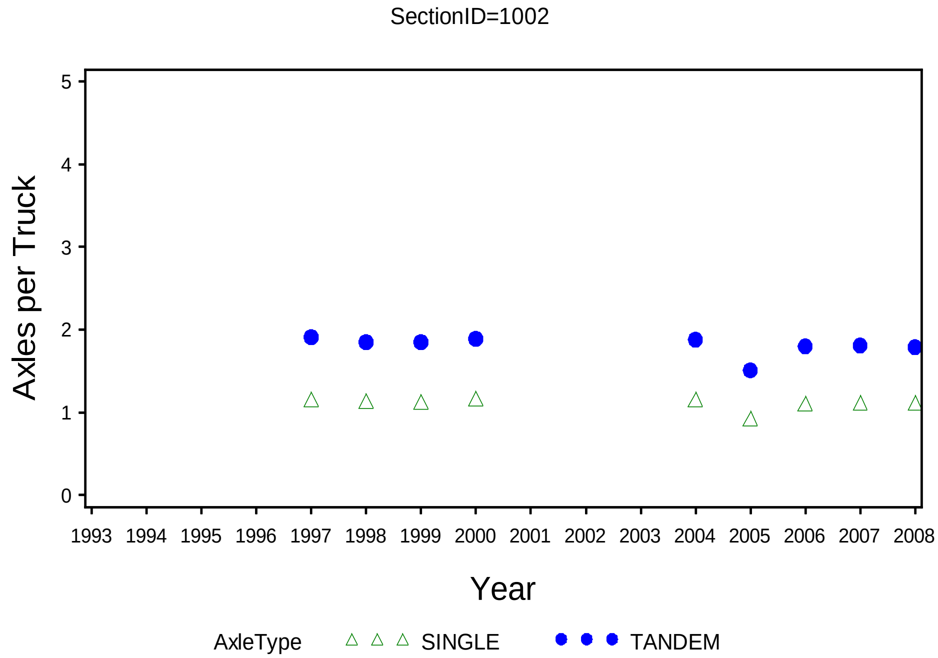


Figure F-36. Plot of Axles per Truck for Site 4_1002 (Vehicle Class 9).

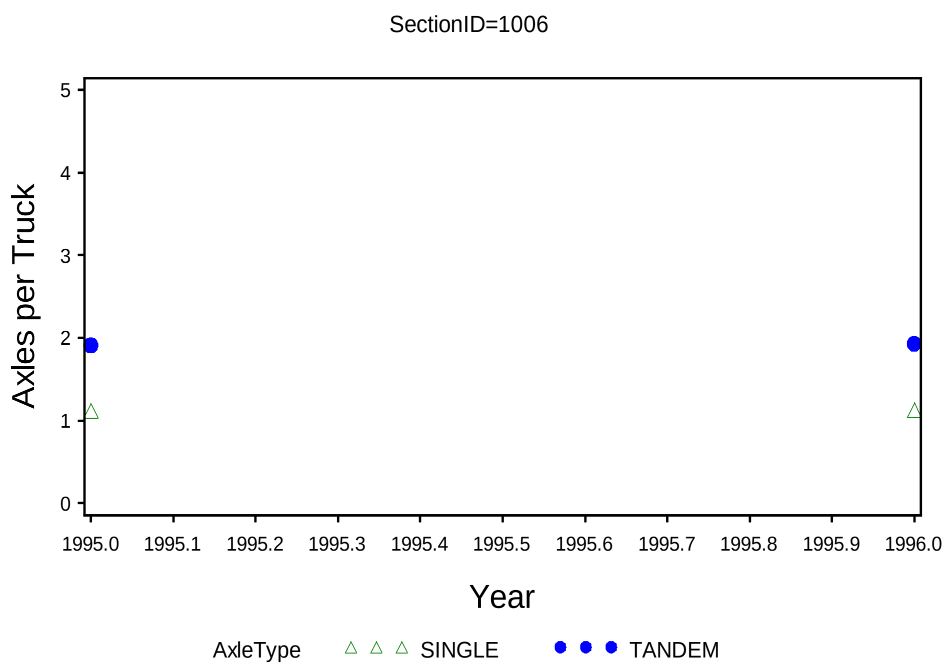


Figure F-37. Plot of Axles per Truck for Site 4_1006 (Vehicle Class 9).

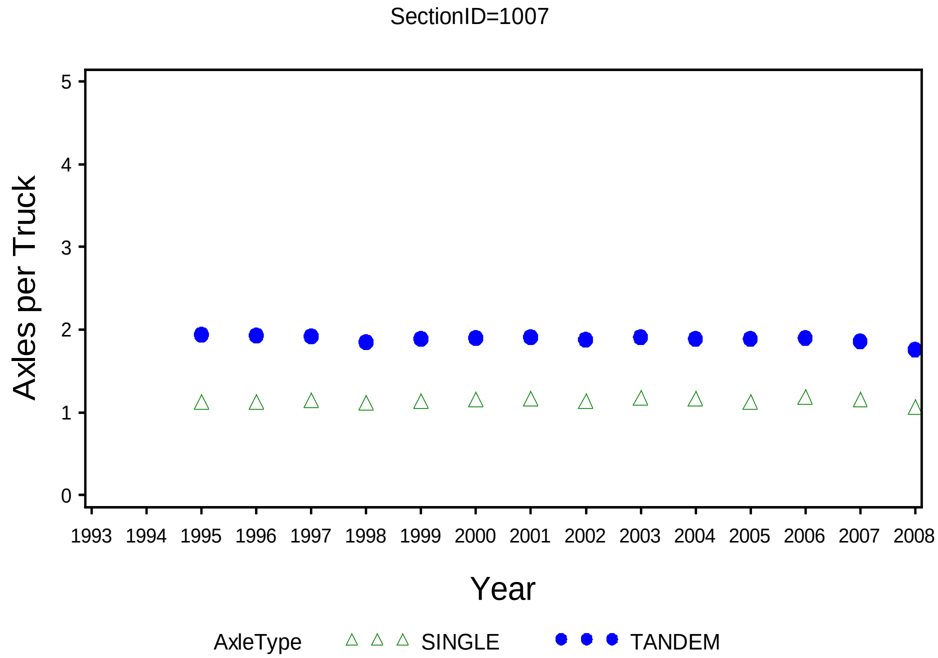


Figure F-38. Plot of Axles per Truck for Site 4_1007 (Vehicle Class 9).

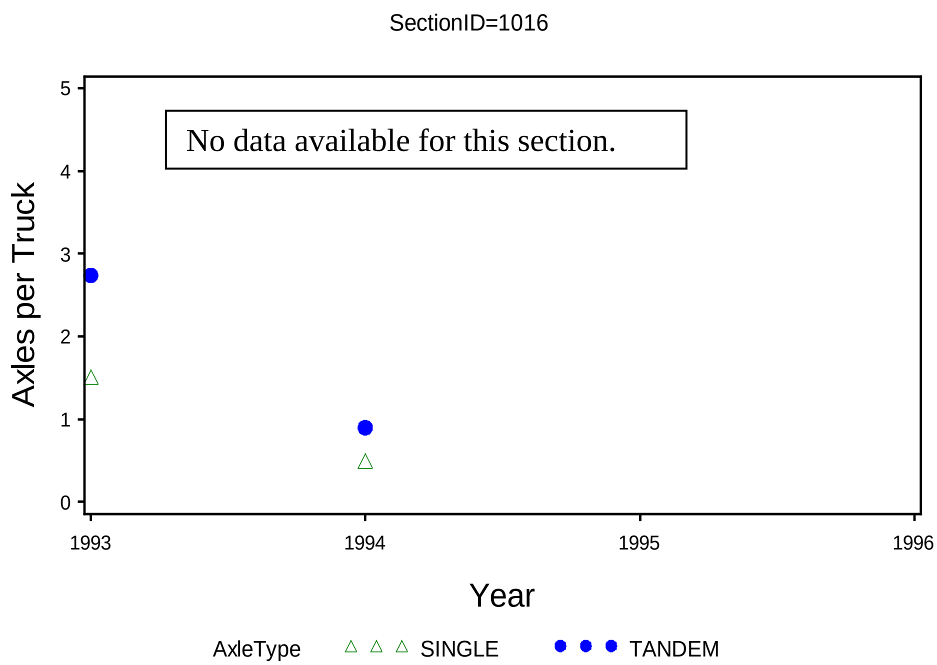


Figure F-39. Plot of Axles per Truck for Site 4_1016 (Vehicle Class 9).

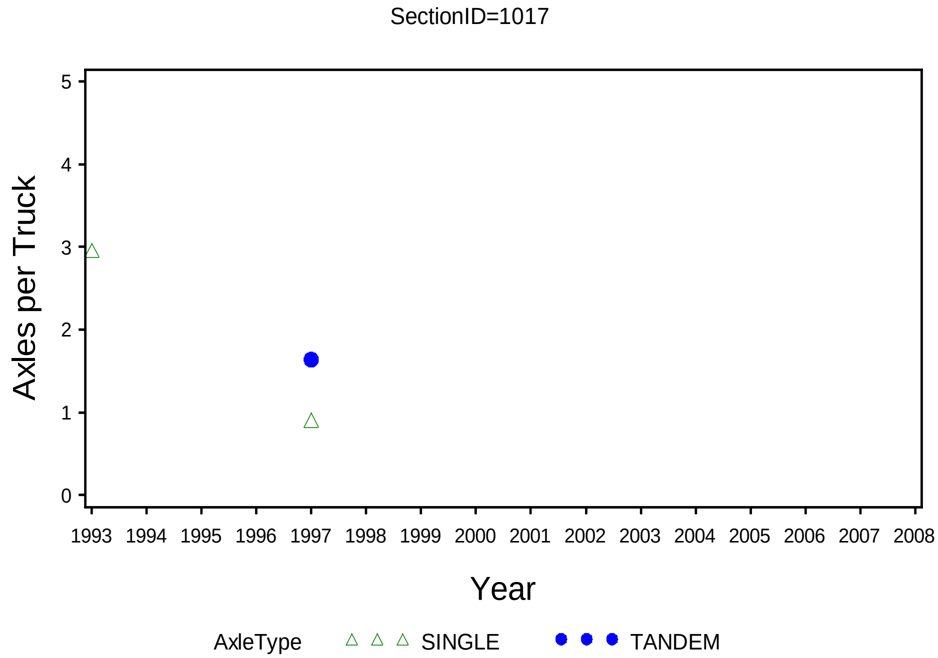


Figure F-40. Plot of Axles per Truck for Site 4_1017 (Vehicle Class 9).

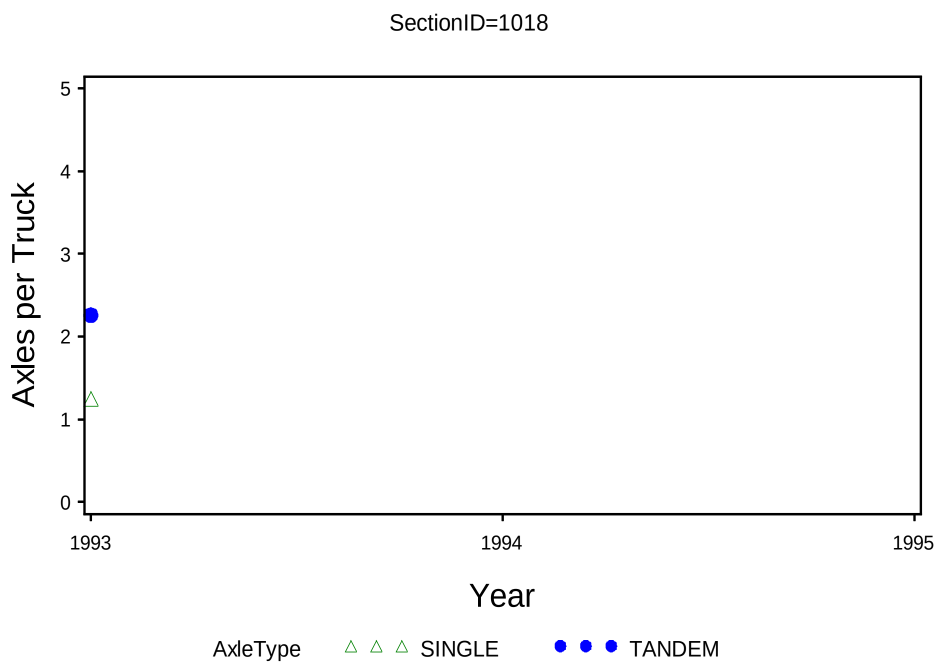


Figure F-41. Plot of Axles per Truck for Site 4_1018 (Vehicle Class 9).

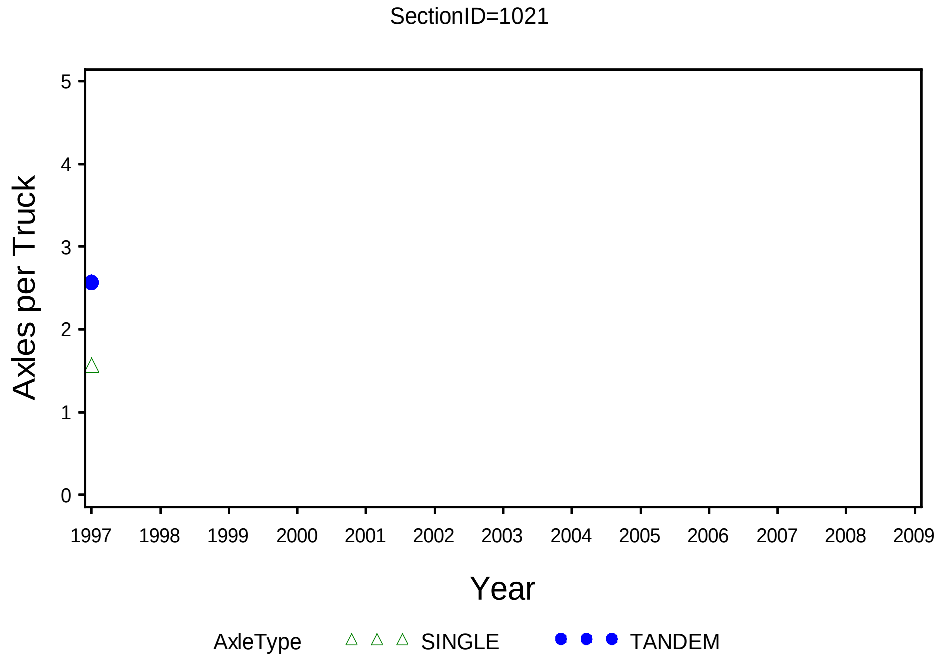


Figure F-42. Plot of Axles per Truck for Site 4_1021 (Vehicle Class 9).

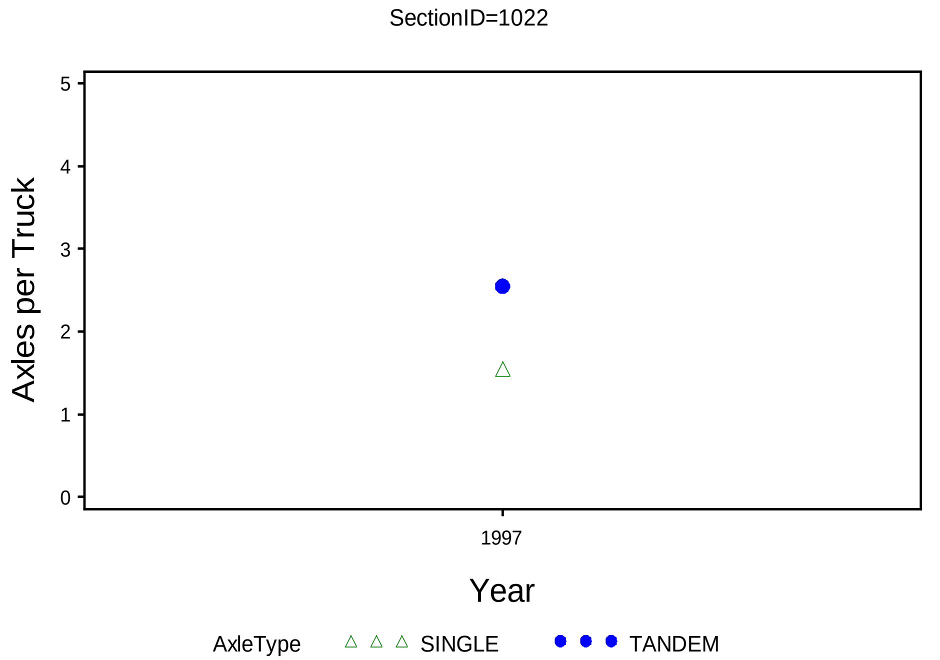


Figure F-43. Plot of Axles per Truck for Site 4_1022 (Vehicle Class 9).

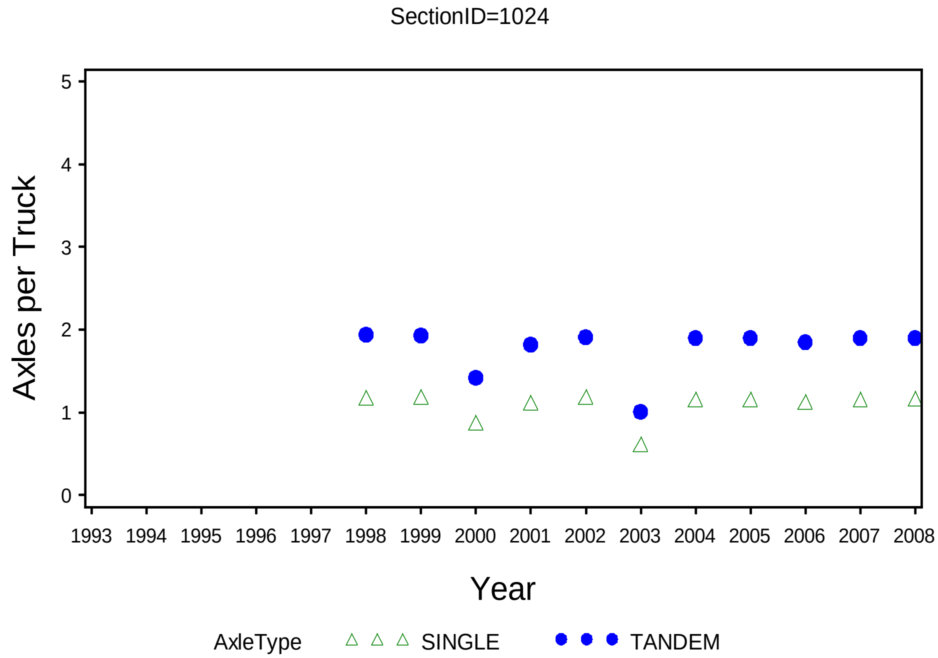


Figure F-44. Plot of Axles per Truck for Site 4_1024 (Vehicle Class 9).

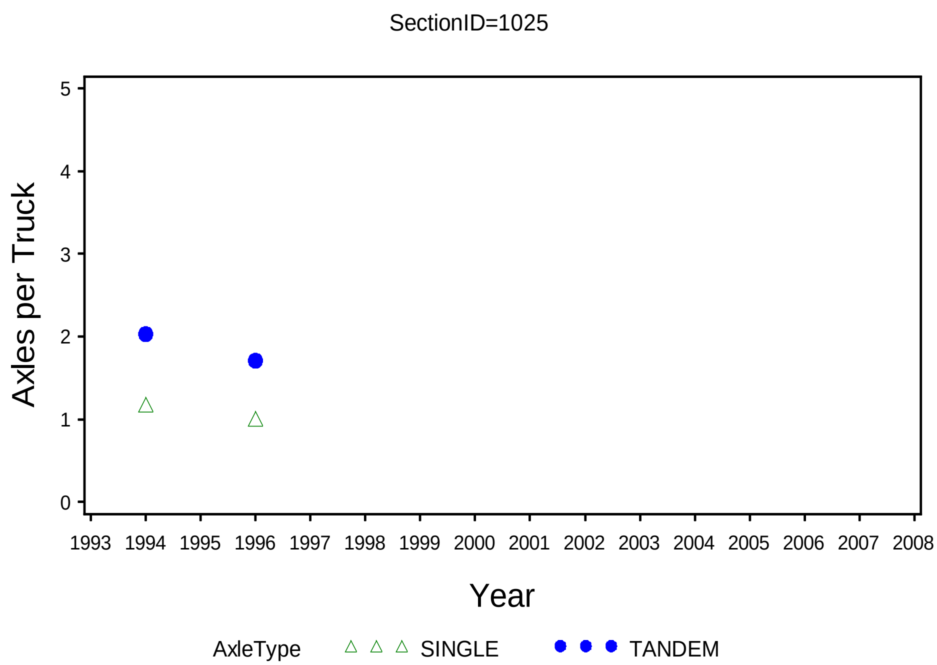


Figure F-45. Plot of Axles per Truck for Site 4_1025 (Vehicle Class 9).

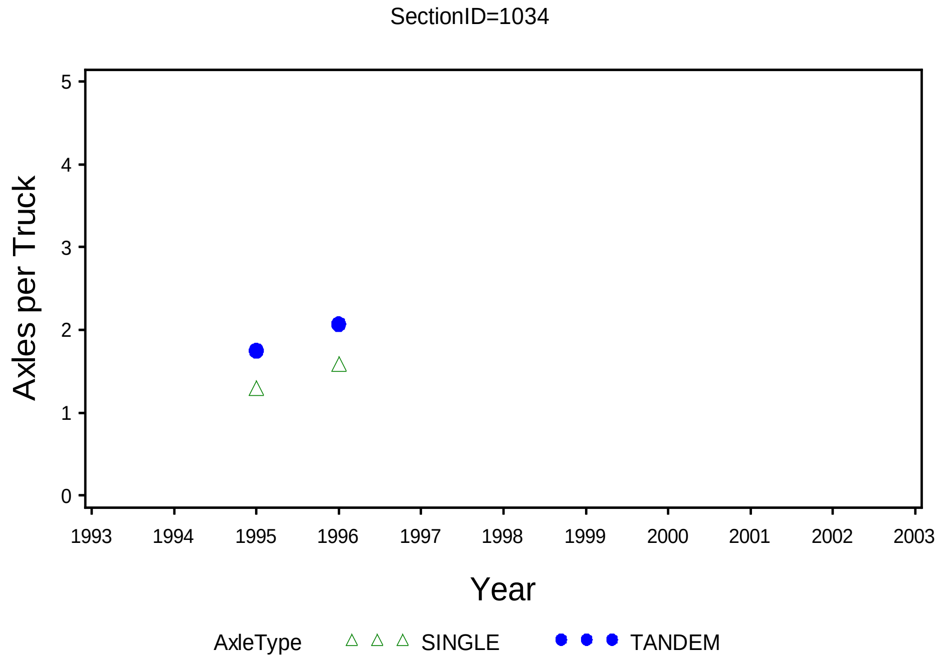


Figure F-46. Plot of Axles per Truck for Site 4_1034 (Vehicle Class 9).

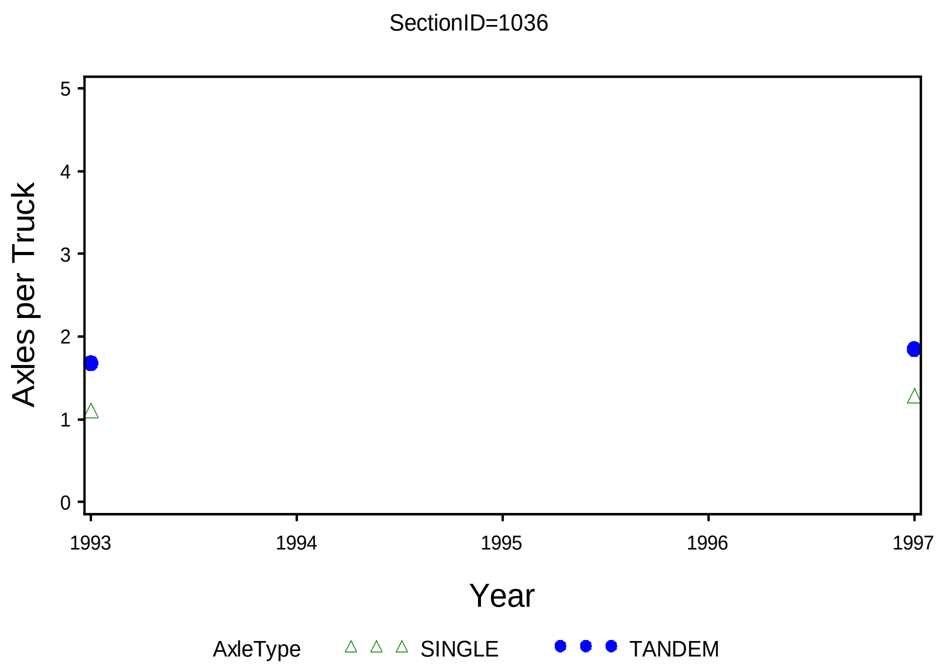


Figure F-47. Plot of Axles per Truck for Site 4_1036 (Vehicle Class 9).

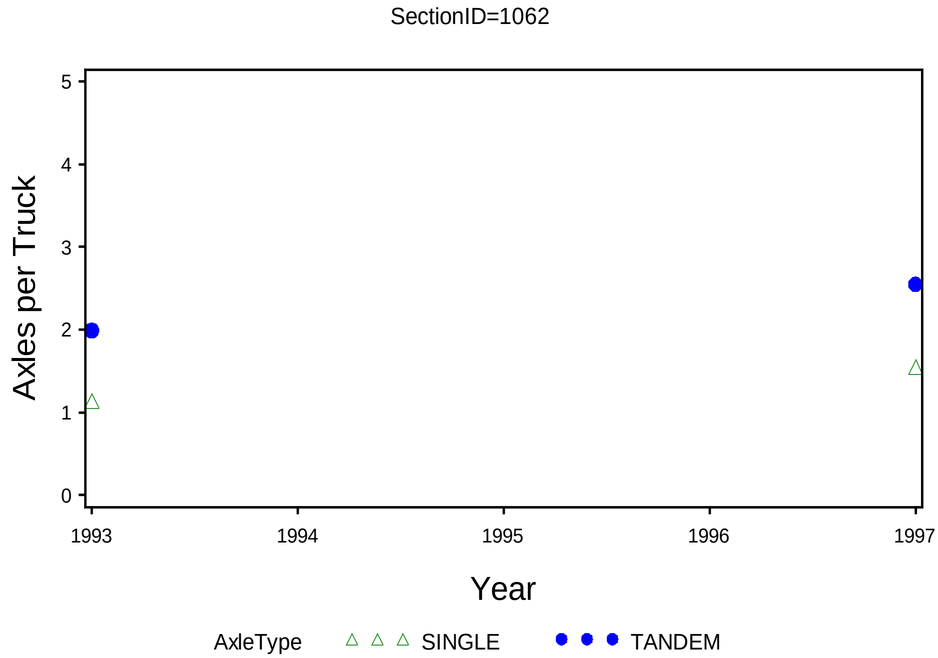


Figure F-48. Plot of Axles per Truck for Site 4_1062 (Vehicle Class 9).

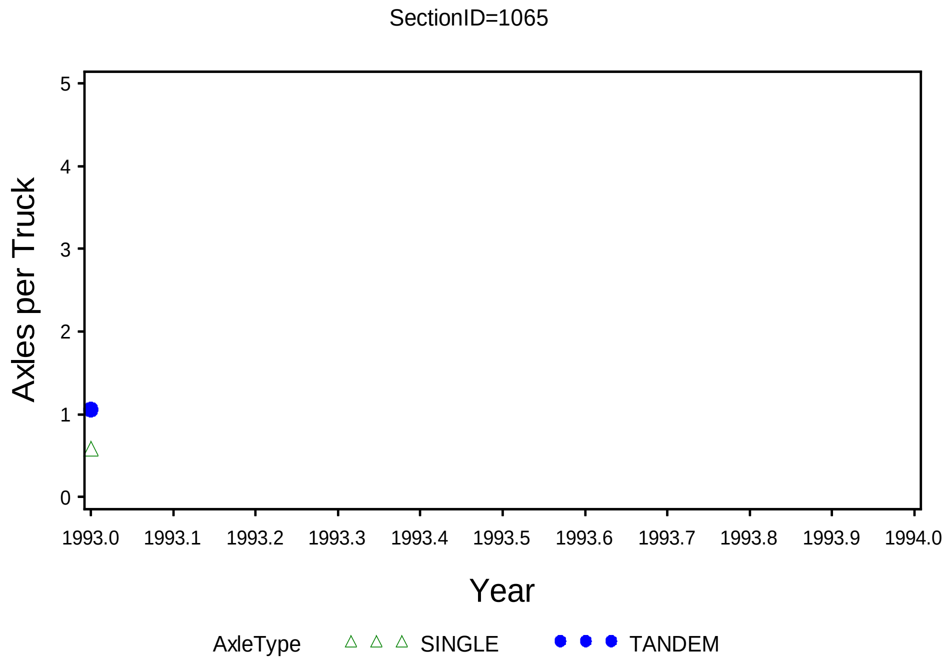


Figure F-49. Plot of Axles per Truck for Site 4_1065 (Vehicle Class 9).

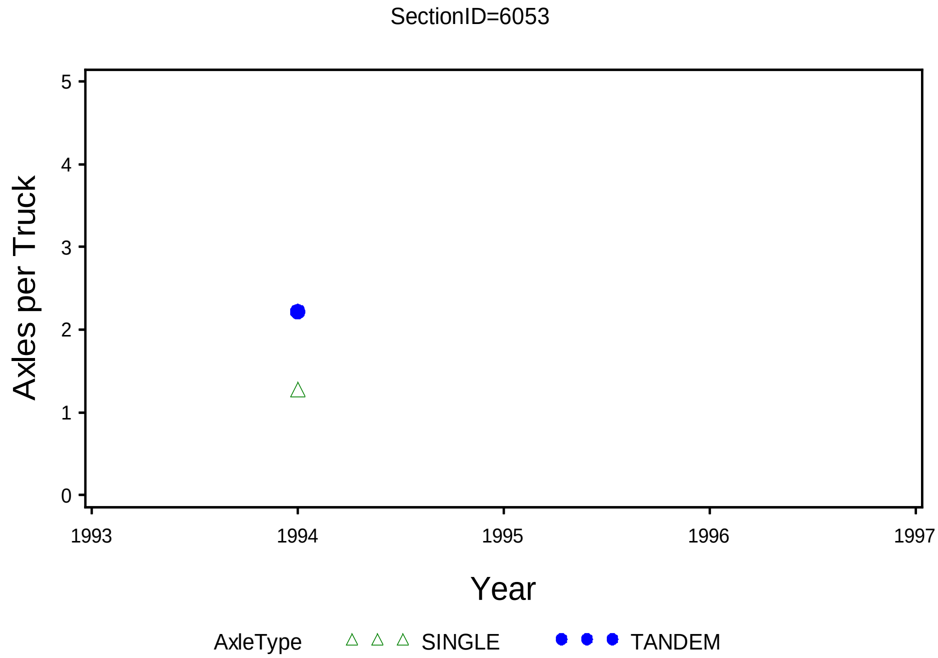


Figure F-50. Plot of Axles per Truck for Site 4_6053 (Vehicle Class 9).

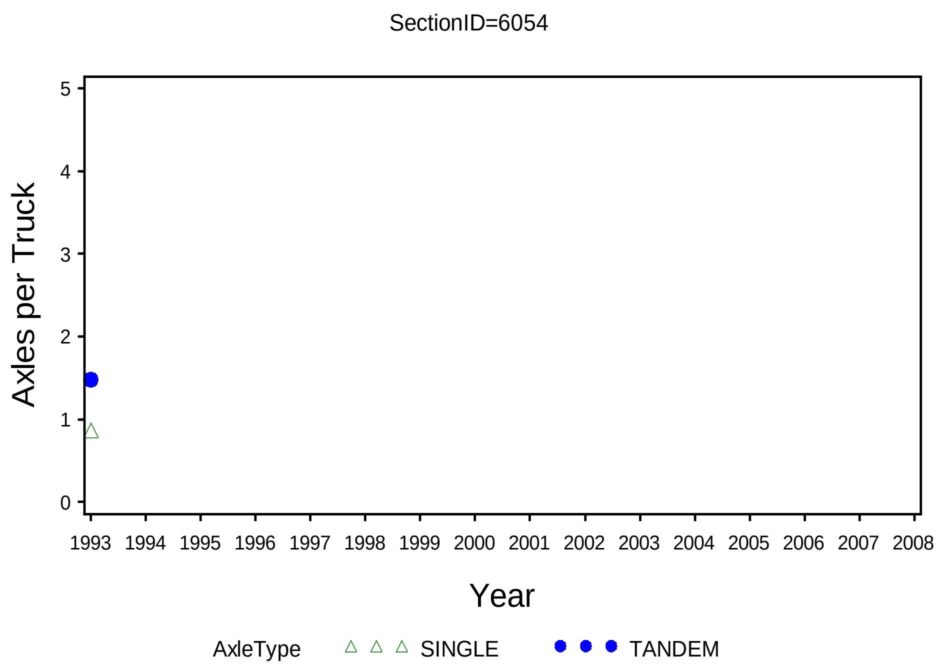


Figure F-51. Plot of Axles per Truck for Site 4_6054 (Vehicle Class 9).

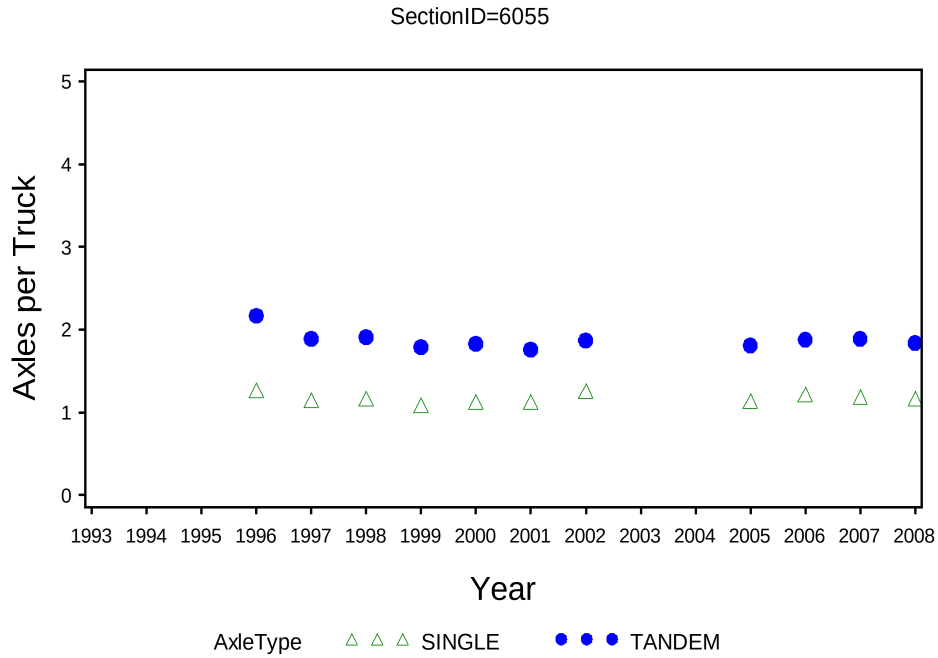


Figure F-52. Plot of Axles per Truck for Site 4_6055 (Vehicle Class 9).

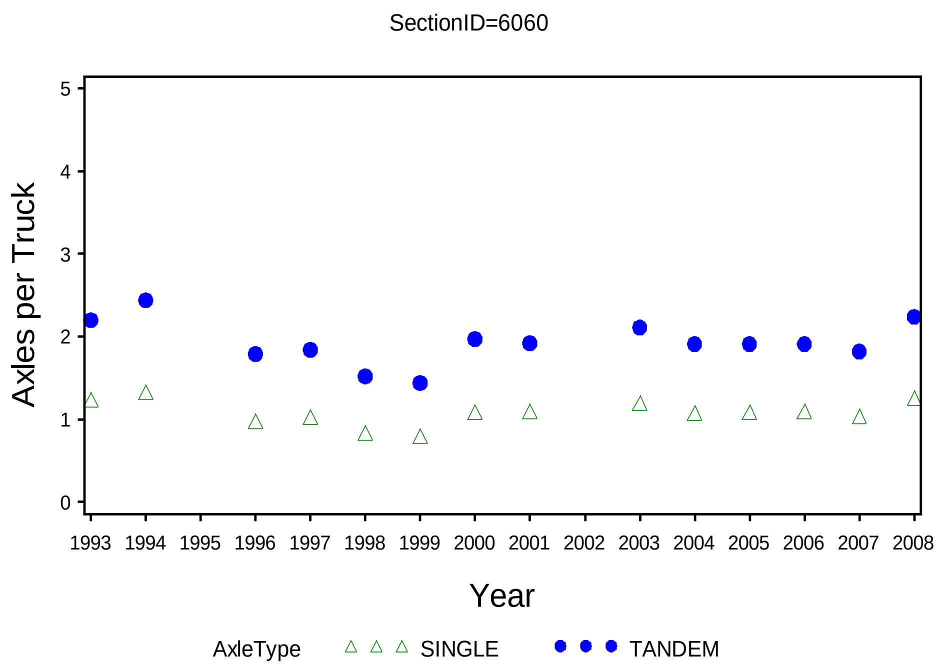


Figure F-53. Plot of Axles per Truck for Site 4_6060 (Vehicle Class 9).

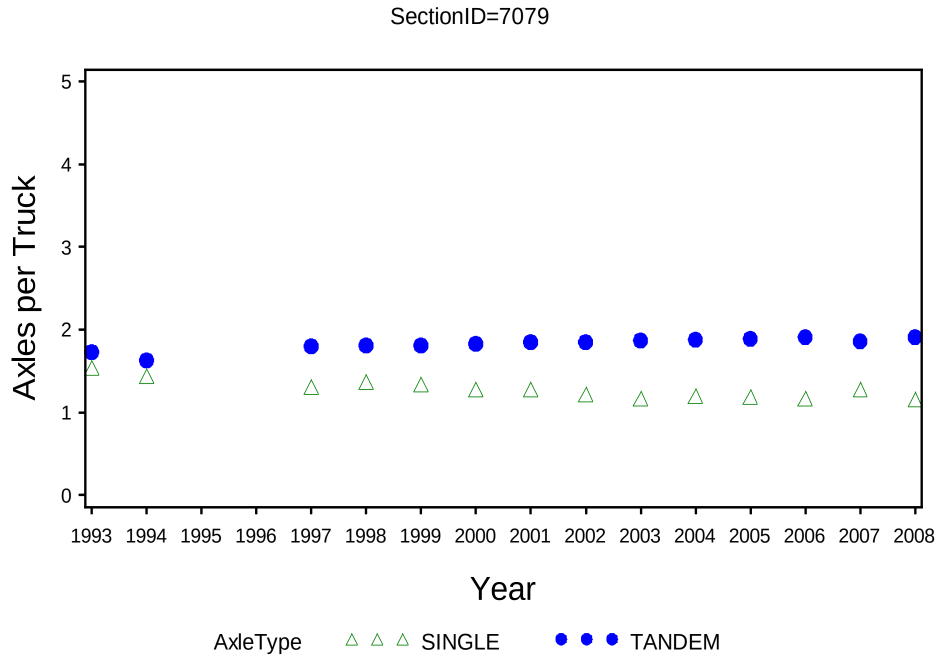


Figure F-54. Plot of Axles per Truck for Site 4_7079 (Vehicle Class 9).

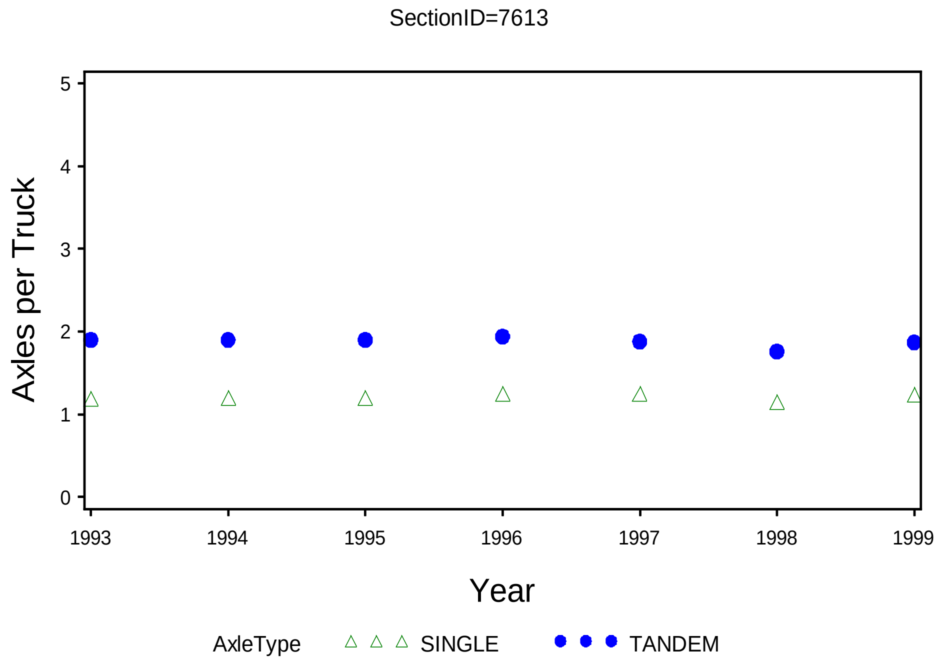


Figure F-55. Plot of Axles per Truck for Site 4_7613 (Vehicle Class 9).

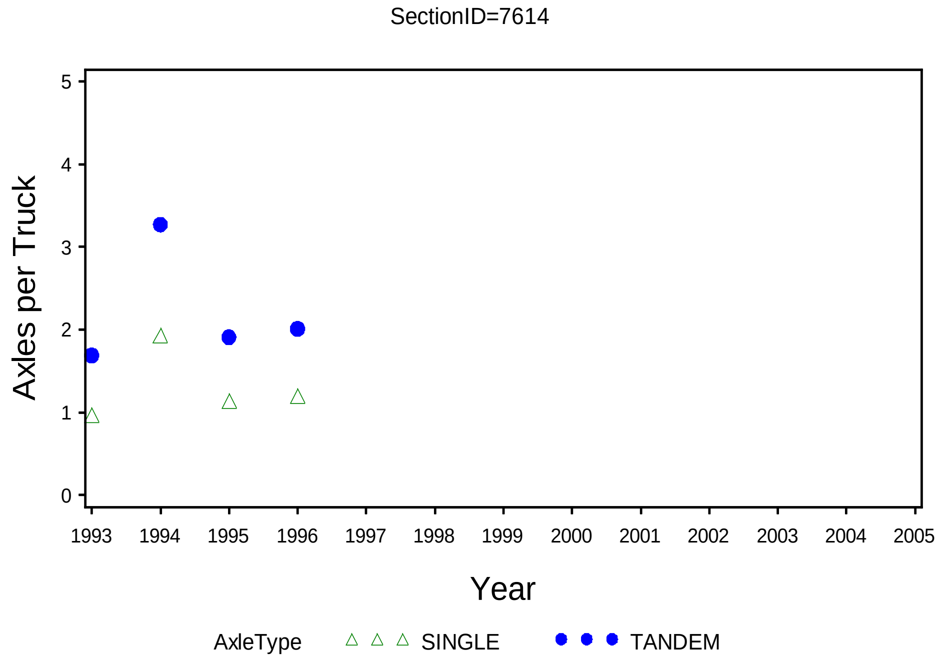


Figure F-56. Plot of Axles per Truck for Site 4_7614 (Vehicle Class 9).

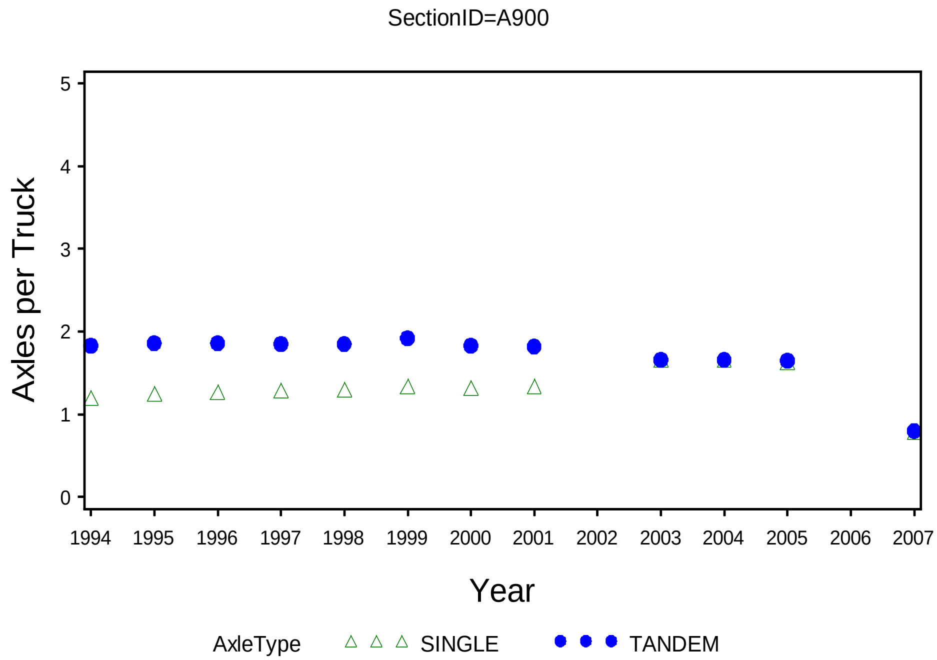


Figure F-57. Plot of Axles per Truck for Site 4_A900 (Vehicle Class 9).

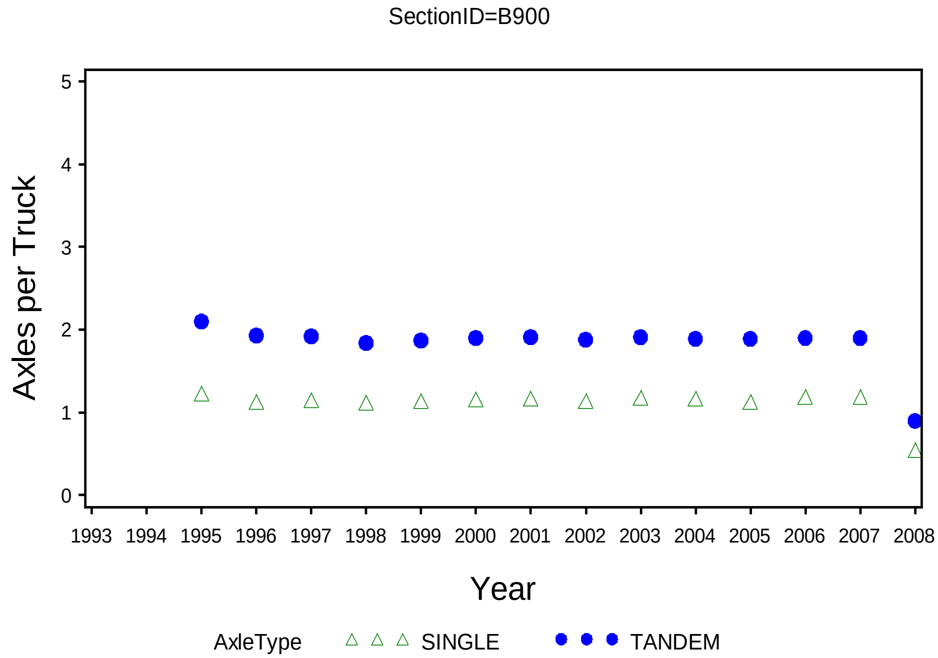


Figure F-58. Plot of Axles per Truck for Site 4_B900 (Vehicle Class 9).

APPENDIX G. RECOMMENDED ADOT BUSINESS PROCESS OVERVIEW FOR MEPDG AND PAVEMENT MANAGEMENT SYSTEM

Recommended Business Process Overview for MEPDG and PMS

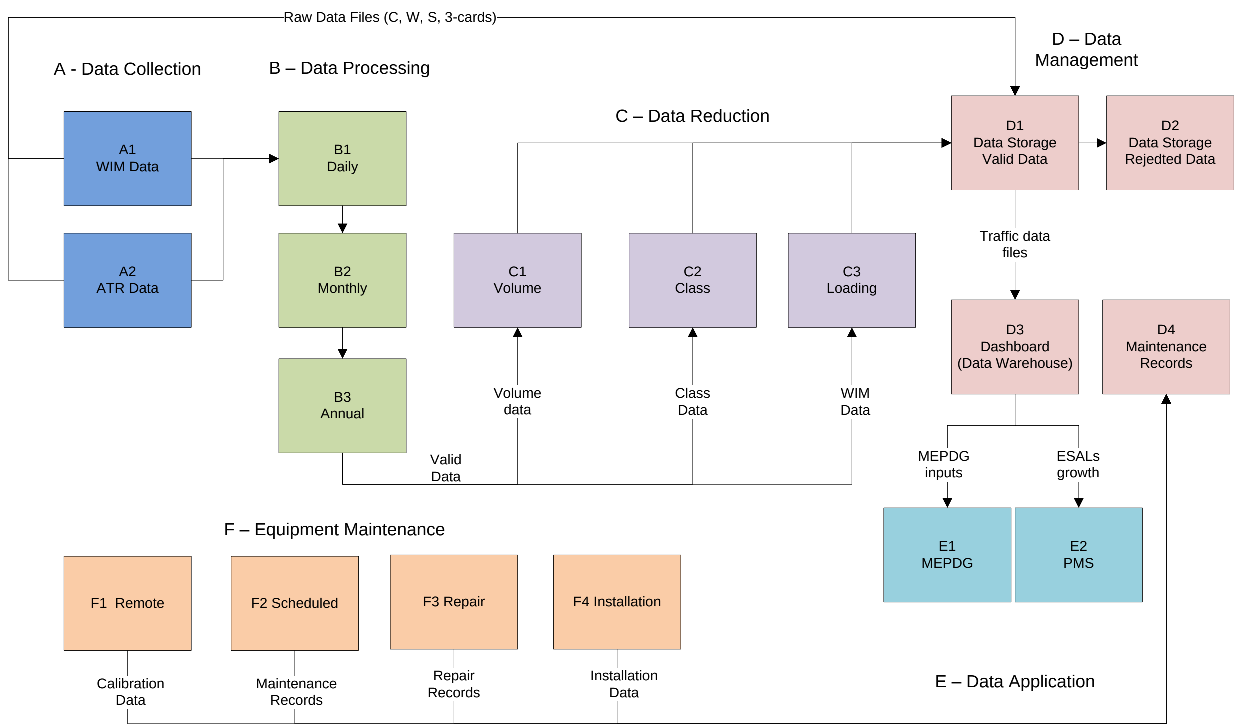


Figure G-1. Flowchart 1 for Recommended Business Process for MEPDG and Pavement Management System.

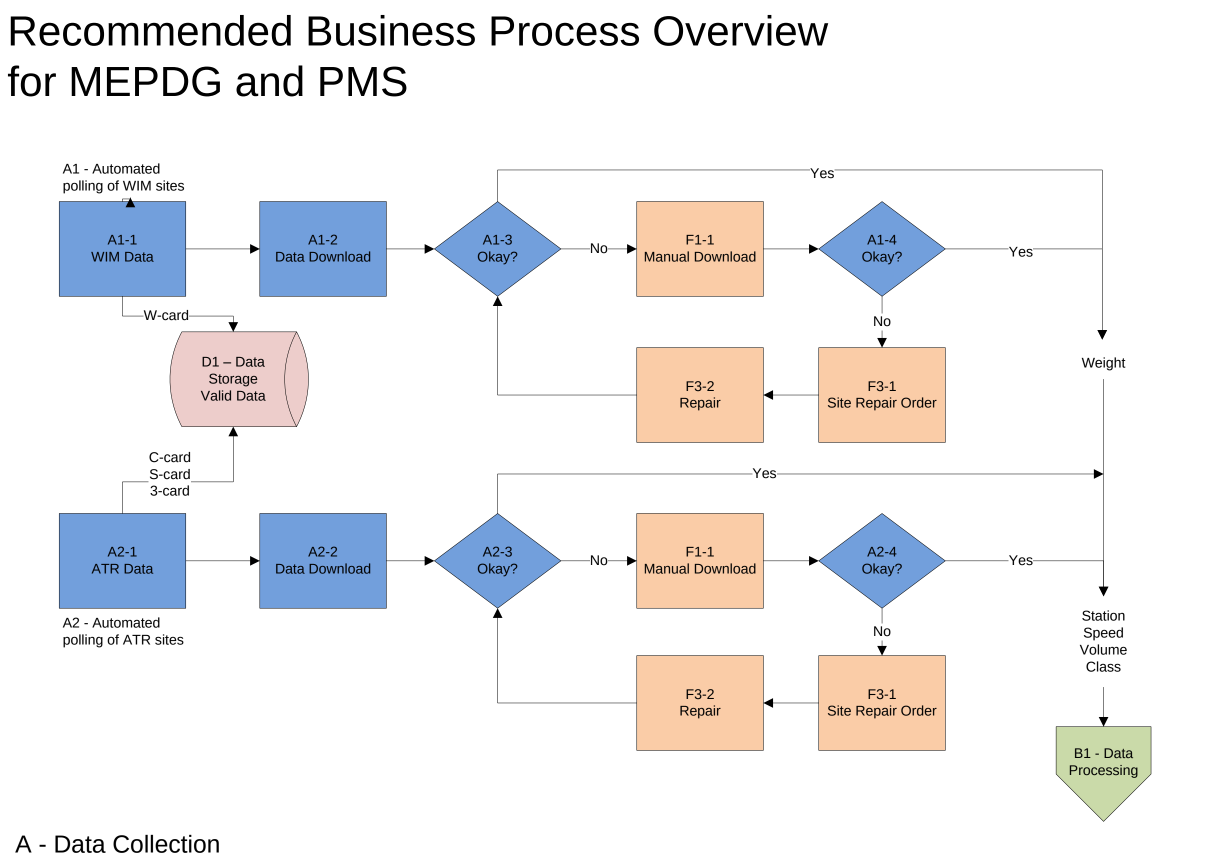


Figure G-2. Flowchart 2 for Recommended Business Process for MEPDG and Pavement Management System.

Recommended Business Process Overview for MEPDG and PMS

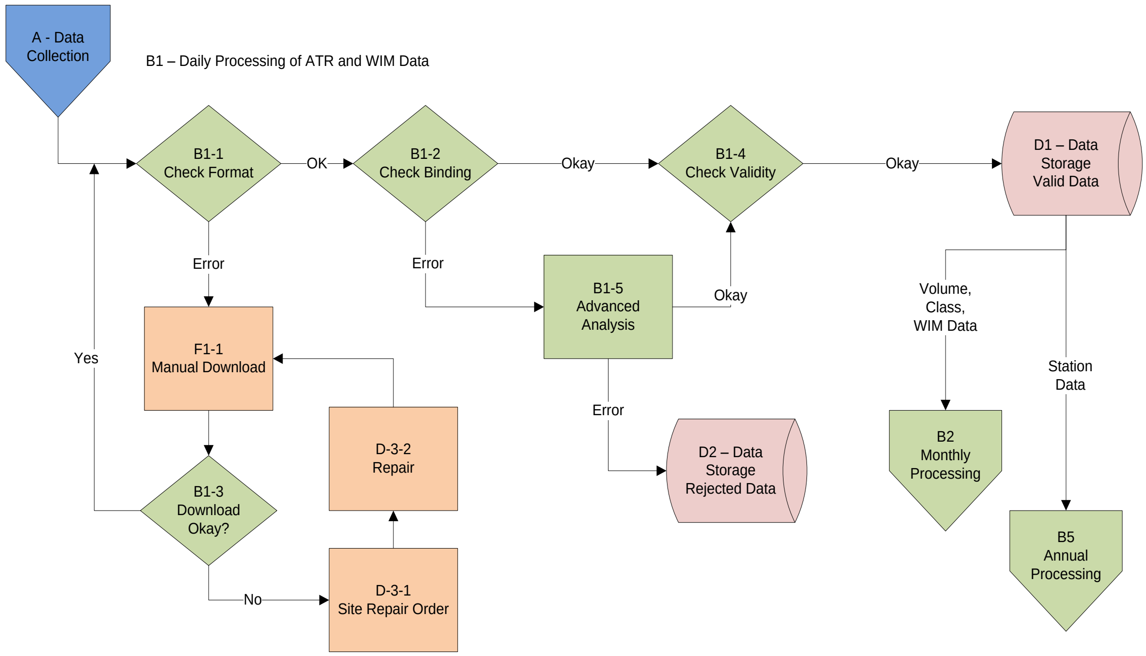
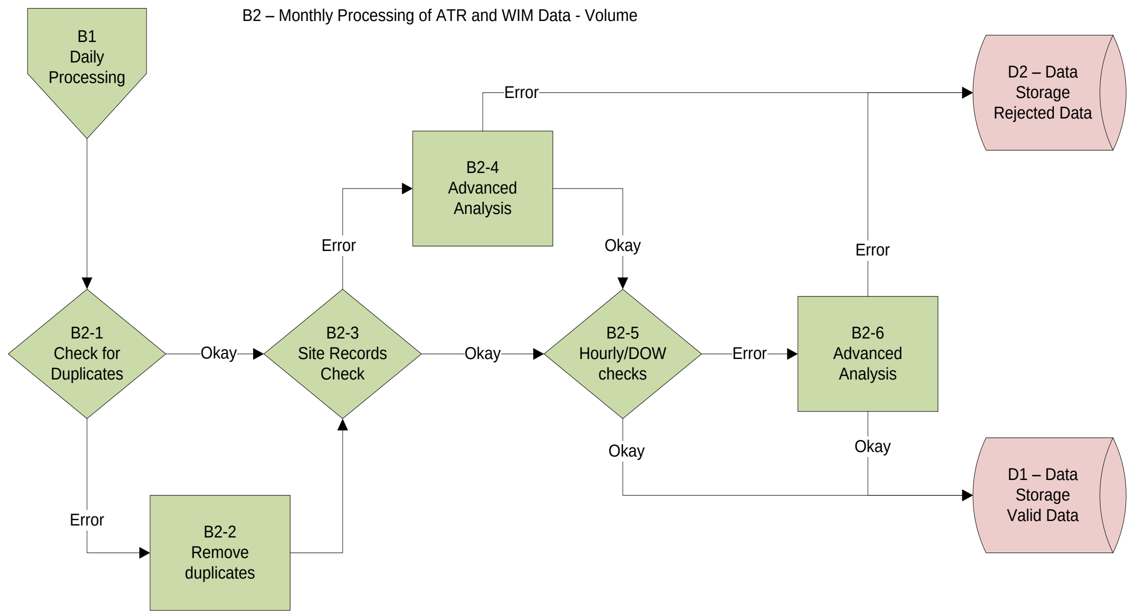


Figure G-3. Flowchart 3 for Recommended Business Process for MEPDG and Pavement Management System.

Recommended Business Process Overview for MEPDG and PMS



B - Data Processing and Quality Assurance

Figure G-4. Flowchart 4 for Recommended Business Process for MEPDG and Pavement Management System.

Recommended Business Process Overview
for MEPDG and PMS

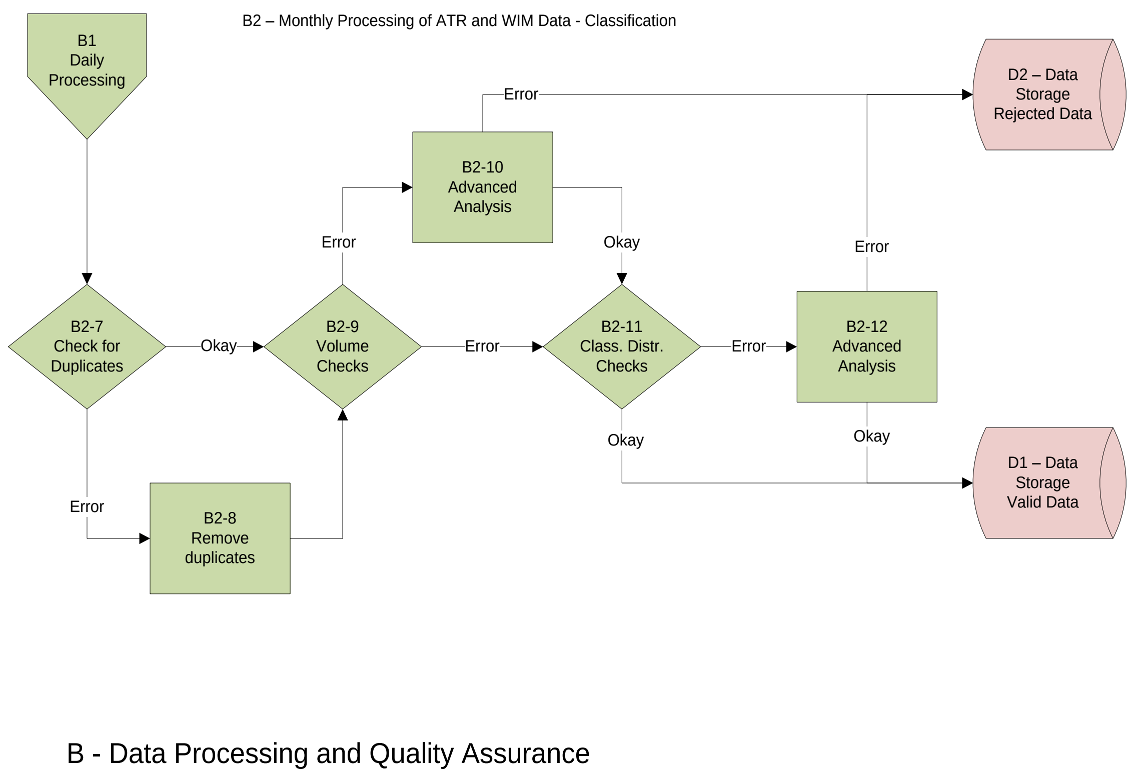


Figure G-5. Flowchart 5 for Recommended Business Process for MEPDG and Pavement Management System.

Recommended Business Process Overview for MEPDG and PMS

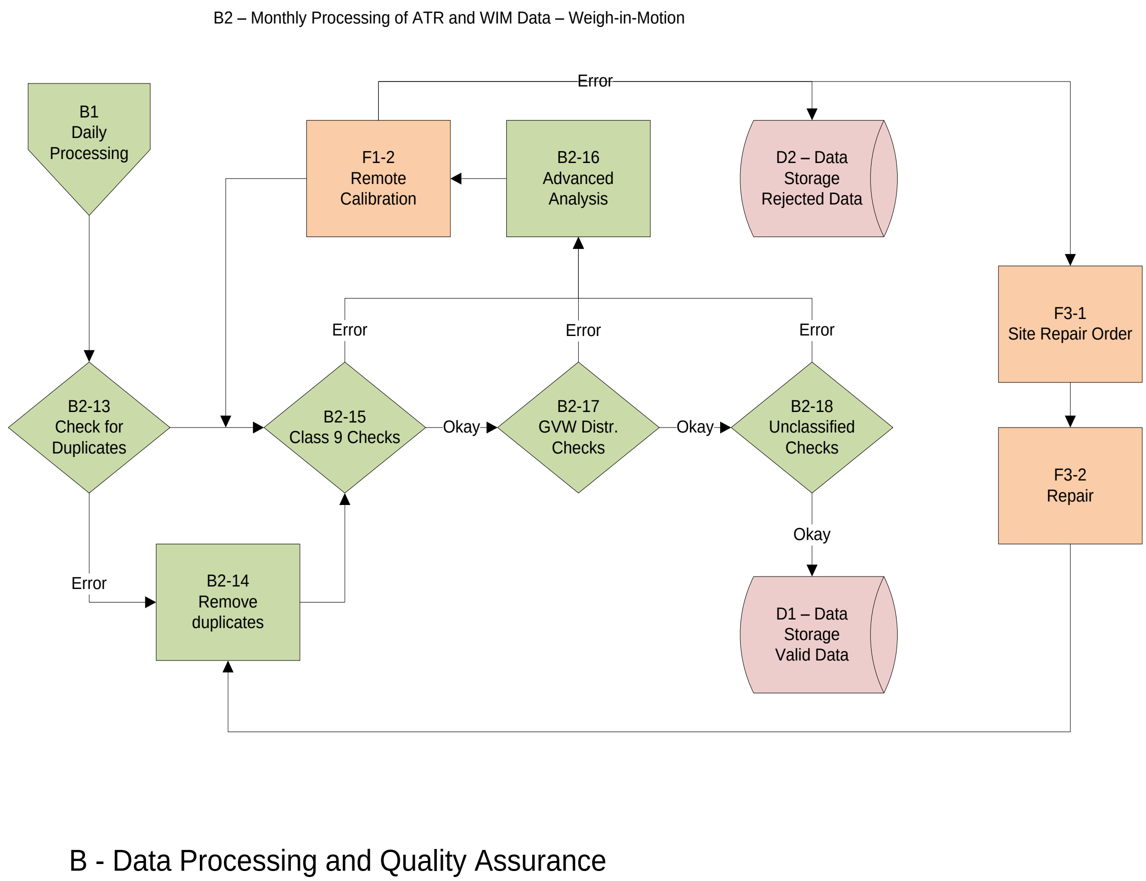
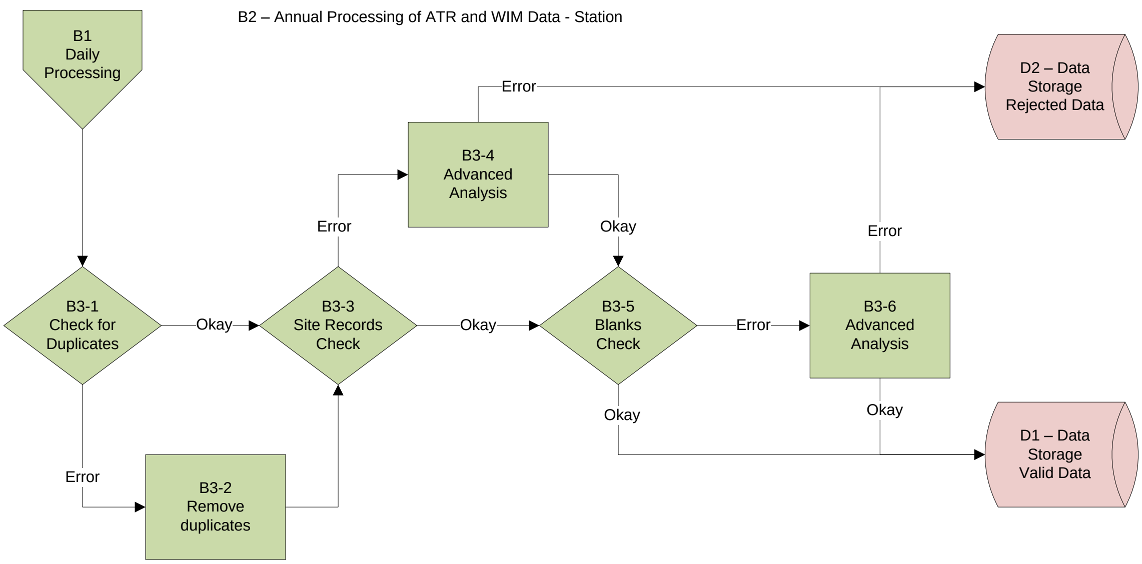


Figure G-6. Flowchart 6 for Recommended Business Process for MEPDG and Pavement Management System.

Recommended Business Process Overview for MEPDG and PMS



B - Data Processing and Quality Assurance

Figure G-7. Flowchart 7 for Recommended Business Process for MEPDG and Pavement Management System.

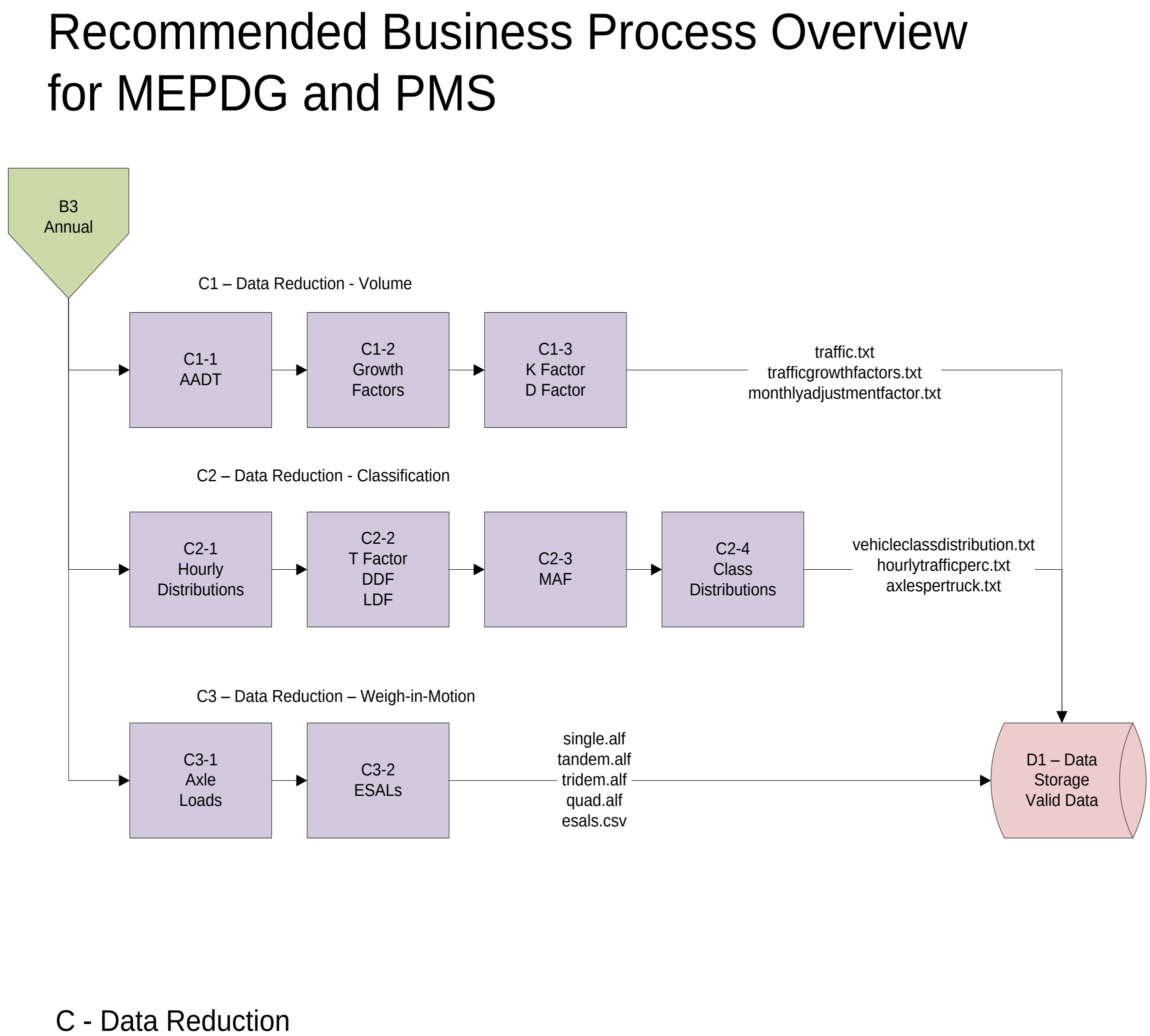


Figure G-8. Flowchart 8 for Recommended Business Process for MEPDG and Pavement Management System.

Recommended Business Process Overview for MEPDG and PMS

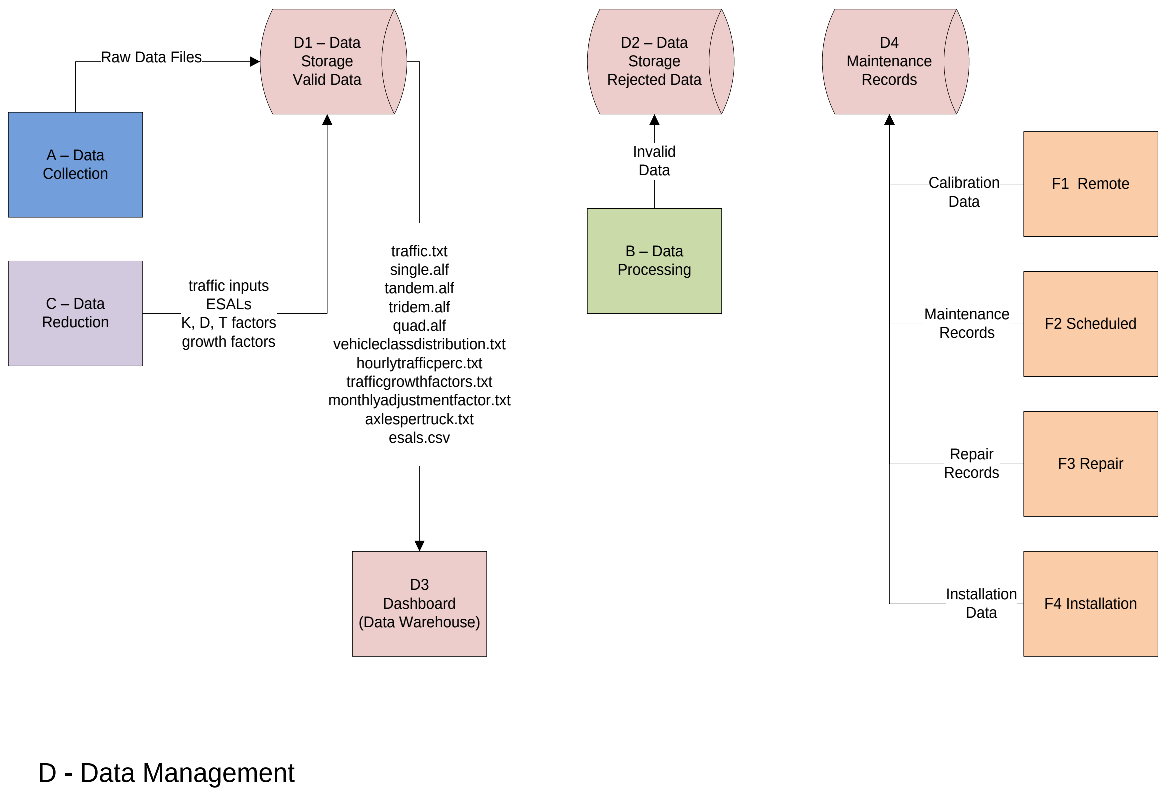
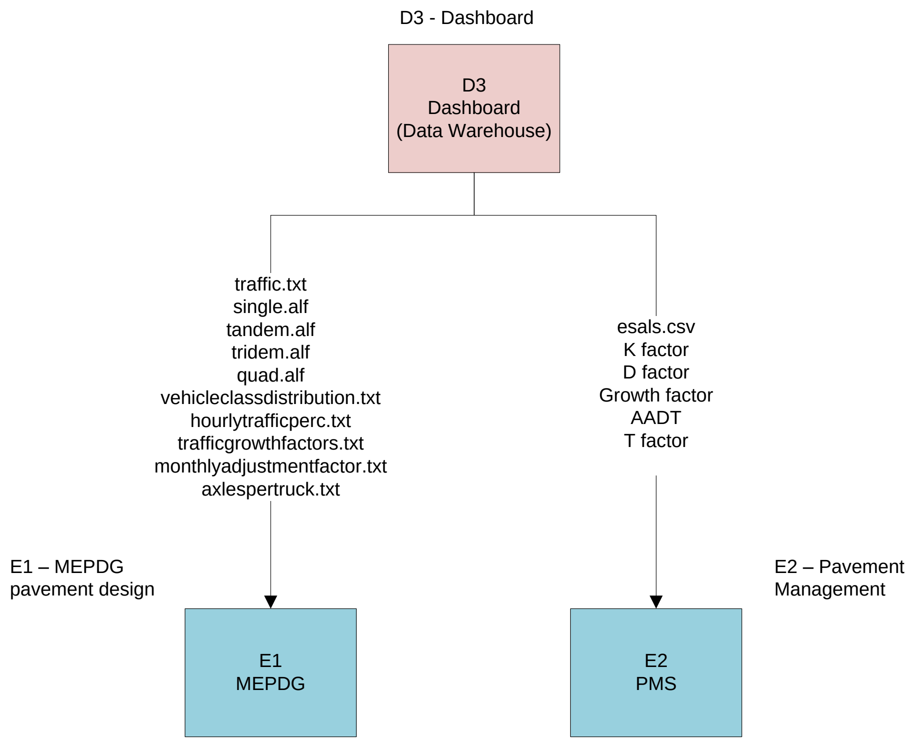


Figure G-9. Flowchart 9 for Recommended Business Process for MEPDG and Pavement Management System.

Recommended Business Process Overview for MEPDG and PMS



E – Data Application

Figure G-10. Flowchart 10 for Recommended Business Process for MEPDG and Pavement Management System.

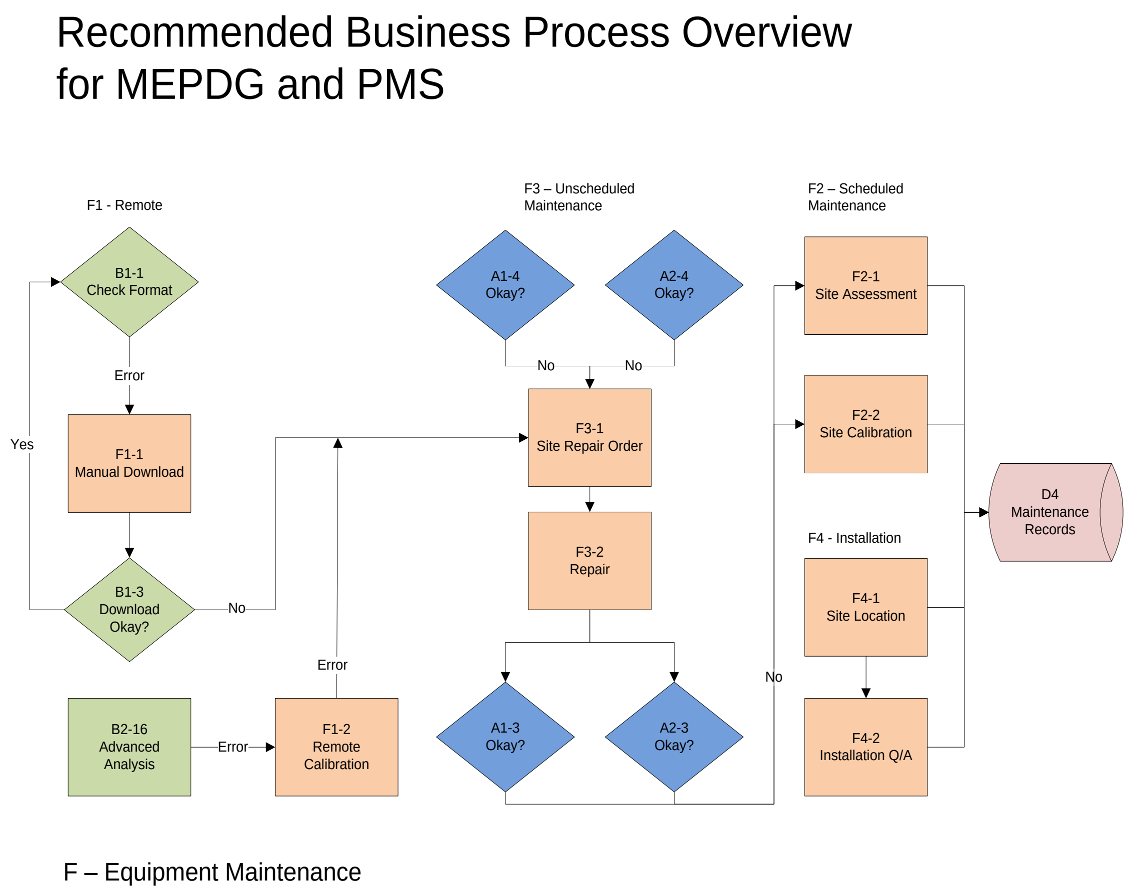


Figure G-11. Flowchart 11 for Recommended Business Process for MEPDG and Pavement Management System.

Table G-1. List of Business Processes.

Box No.	Description	Box No.	Description
A	Data Collection	B3-2	Remove Duplicates
A1	WIM Data	B3-3	Site Records Check
A1-1	WIM Data Polling	B3-4	Advanced Analysis
A1-2	WIM Data Download	B3-5	Blanks Check
A1-3	Download Okay?	B3-6	Advanced Analysis
A1-4	Manual Download Okay?	C	Data Reduction
A2	ATR Data	C1	Volume
A2-1	ATR Data Polling	C1-1	AADT
A2-2	ATR Data Download	C1-2	Growth Factors
A2-3	Download Okay?	C1-3	K, D Factors
A2-4	Manual Download Okay?	C2	Classification
B	Data Processing and Quality Assurance	C2-1	Hourly Distributions
B1	Daily	C2-2	T Factor, Design Direction Factor, Design Lane Factor
B1-1	Format Check	C2-3	Monthly Adjustment Factors
B1-2	Binding Check	C2-4	Class Distributions
B1-3	Download Okay?	C3	Weigh-in-Motion
B1-4	Validity Check	C3-1	Axle Loads
B1-5	Advanced Analysis	C3-2	ESALs
B2	Monthly	D	Data Management
B2-1	Duplicate Check	D1	Data Storage – Valid Data
B2-2	Remove Duplicates	D2	Data Storage – Rejected Data
B2-3	Site Records Check	D3	Dashboard (Data Warehouse)
B2-4	Advanced Analysis	D4	Maintenance Records
B2-5	Hourly/DOW Checks	E	Data Application
B2-6	Advanced Analysis	E1	MEPDG Pavement Design
B2-7	Duplicate Check	E2	Pavement Management
B2-8	Remove Duplicates	F	Equipment Maintenance
B2-9	Volume Check	F1	Remote Maintenance
B2-10	Advanced Analysis	F1-1	Manual Download
B2-11	Classification Distribution Checks	F1-2	Remote Calibration
B2-12	Advanced Analysis	F2	Scheduled Maintenance
B2-13	Duplicate Check	F2-1	Site Assessment
B2-14	Remove Duplicates	F2-2	Site Calibration
B2-15	Class 9 Checks	F3	Unscheduled Maintenance (Repair)
B2-16	Advanced Analysis	F3-1	Site Repair Order
B2-17	GVW Distribution Checks	F3-2	Site Repair
B2-18	Unclassified/Class 15 Checks	F4	Installation
B3	Annual	F4-1	Site Location
B3-1	Duplicate Check	F4-2	Site Installation Q/A