Development of Site-Specific ESAL
CDOT-DTD-R-2002-9

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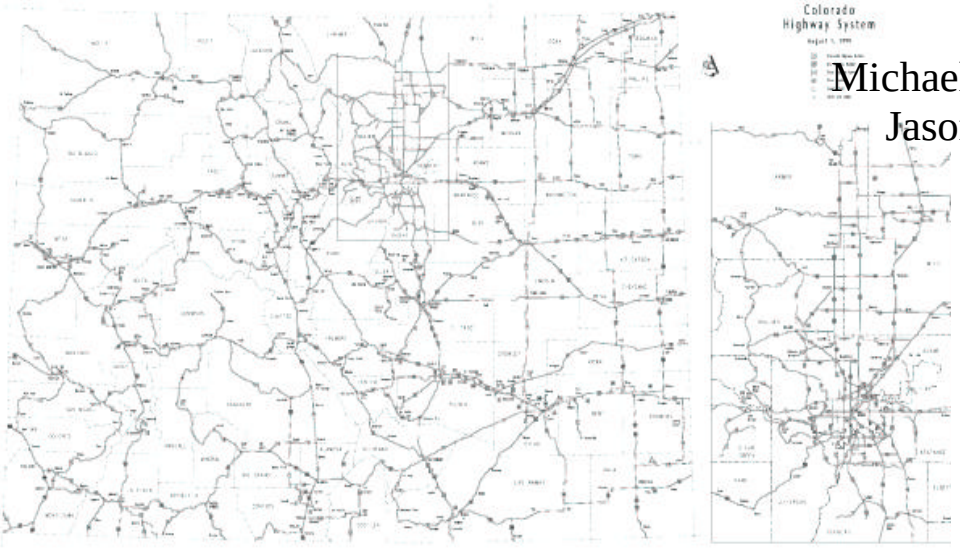
Project Manager
Ahmad Ardani, P.E.

Nichols Consulting Engineers, Chtd.

Principal Investigator
Sirous Alavi, Ph.D., P.E.



Project Engineers
Michael P. Tavares, E.I.T.
Jason Puccinelli, E.I.T.

Consultant
Earl Laird

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Dr. Sirous Alavi, the principal investigator, led the NCE project team. Mr. Michael P. Tavares and Mr. Jason Puccinelli were the project engineers. The NCE project team received valuable assistance from our traffic consultant, Mr. Earl T. Laird of TP & R. Last but not least, Ms. Robin Patroni provided administrative support.

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Acronyms

Acronym	Meaning
ADT	Average Daily Traffic
AADT	Annual Average Daily Traffic
AADT-T	Annual Average Daily Truck Traffic
AASHTO	American Association of State Highway and Transportation Officials
ATR	Automatic Traffic Recorder
AVC	Automatic Vehicle Classifier
ESAL	Equivalent Single Axle Load
FHWA	Federal Highway Administration
LTPP	Long Term Pavement Performance Program
GVW	Gross Vehicle Weight
NCE	Nichols Consulting Engineers
QC/QA	Quality Control/Quality Assurance
TMG	Traffic Monitoring Guide
TWS	Truck Weight Study
VTRIS	Vehicle Travel Information System
WIM	Weigh-in-Motion

EXECUTIVE SUMMARY

One of the key input parameters for designing new and rehabilitated pavements is traffic loading which is currently based on the number of equivalent single axle load (ESAL) applications. The Colorado Department of Transportation (CDOT) uses a generalized, averaged, and non-site-specific equivalency factor in calculating the number of ESAL applications. Furthermore, the ESAL applications are developed using a 3-bin vehicle classification scheme instead of the FHWA's recommended 13-bin classification scheme.

Lack of site-specific equivalency factors in conjunction with the use of 3-bin vehicle classification has caused under-designing and sometimes over-designing pavements based on inaccurate traffic load data. This study was approved by the CDOT's Research Implementation Committee (RIC) as a high priority research with the goal of improving the accuracy of the existing and forecasted traffic loads on CDOT's highway network.

The overall scope of this project involved examination of those resources directly related to the current statewide ESAL classification system and the generation of this final report discussing the research and analysis conducted and recommendation of procedures required for CDOT to develop and implement a more site-specific ESAL classification system.

In this study Nichols Consulting Engineers (NCE) analyzed all available CDOT permanent and portable WIM data. The analyses indicated that sampling data a few times per year may preclude the installation of new costly permanent WIMs. Adjustment factors developed for reducing the temporal bias from short duration data collection were beneficial for sites. Length data could not be expanded into the FHWA classification scheme but could be used for volume information.

NCE developed axle load spectra for each WIM data source and reviewed the historic trends of axle loads from the WIM systems. Equivalency factors were developed to apply to axle load data. Groups were based on functional classification in order to apply monitoring data to segments where no data source was available.

NCE evaluated the number of WIM data sources per functional class group and documented the number of WIM sites that will be needed to achieve a desired accuracy. A hierarchy was formulated for new data collection efforts based on functionality of roadway and number of segments that have no monitoring data. WIM data is needed for at least functional class groups rural major collector (07) and urban principal arterial other freeways (12).

NCE populated a new and more accurate ESAL design table for use in pavement design and rehabilitation activities. This will result in cost savings to CDOT by increasing the accuracy of the pavement design and rehabilitation process.

CHAPTER 1. INTRODUCTION

1.1 PROBLEM STATEMENT

Establishing, maintaining, and enhancing the statewide network of roads are among the most important goals of any state highway agency. Networks require huge investments of both financial and human resources year in and year out. Accordingly, it makes good sense to apply sound engineering practices to ensure that these resources are allocated wisely.

For designing new roadways or rehabilitating existing ones, there are alternative methodologies available to engineers, including those used by the Colorado Department of Transportation (CDOT), which call for a number of inputs that can significantly affect the design output. One of the fundamental and universally sought parameters that influences all new pavement and rehabilitation design decisions is *traffic*. For a given road segment, accurate estimates of current and projected traffic (in terms of ESALs) can result in significant cost savings, either from the standpoint of initial construction costs or future maintenance and rehabilitation costs. In other words, accurate ESAL estimates help produce better pavement thickness designs and/or more realistic determinations of the performance lives of newly constructed (or rehabilitated) pavements.

The CDOT solicitation for this project required research in "ESAL Classification System Development." This effort will result in an improvement to the existing ESAL values utilized by CDOT in pavement evaluation and design. The previous CDOT ESAL calculations were based on "generalized, averaged, and non-site-specific equivalency factors" using a 3-bin vehicle classification scheme. These vehicle classifications were:

- Passenger vehicles, types 1-3 and 0-20 feet
- Single unit trucks, types 4-7 and 20-40 feet
- Combination trucks, types 8-13 and greater than 40 feet long

The NCE team used the current "best available" Colorado load data, including WIM data, to develop new ESAL design tables to improve the accuracy of the existing and forecasted traffic loads. Development of new ESAL design tables required an overall assessment of the current traffic monitoring equipment, location of load/traffic measurement sites, and data collection/analysis procedures. This assessment involved a thorough evaluation of current CDOT traffic volume, vehicle classification, and WIM equipment, as well as data collection and analysis.

The overall assessment required a comparison of the state-of-the-art in technology versus the state-of-practice employed by CDOT. This was achieved through the identification and implementation of appropriate steps to merge the two technologies and come up with the most accurate and practical estimates of current and future ESALs on the CDOT statewide road network.

1.2 OBJECTIVES OF PROJECT

The ultimate objective of this research endeavor was "improving the accuracy of the existing and forecasted traffic loads on CDOT's managed roadways." This was achieved by making significant enhancements in the current CDOT ESAL estimation methodology through a series of tasks identified as:

- Use site-specific weight data for new ESAL table.
- Investigate adjustment factors.
- Develop network maps for each CDOT-defined zone or region (6 regions).
- Evaluate traffic monitoring site locations.
- Recommend set of core WIM sites, methodology on how to group sites, min/max number of sites and level of effort to create ESAL per vehicle factors.

1.3 PROJECT OVERVIEW

There are three major types of data collected by CDOT, namely: length, vehicle classification and vehicle weights. The research team analyzed all types of available data collected, developed representative data for the new ESAL table, and provided a methodology for collecting future data with realized significance. The provided ESAL table consisted of over 4800 roadway segments. These segments were not changed as part of this study. Each segment has start milepost, end milepost, length, AADT, AADT-T, 20-year growth factor, directional design factor, functional class, data source, and an ESAL value for both flexible and rigid pavement.

In addition to information provided in the initial ESAL table, CDOT provided classification information from six length data collectors, nine **a**utomatic **v**ehicle **c**lassifier systems (AVC), classification and weight from eleven portable **w**eigh-**i**n-**m**otion systems (WIM), ten permanent **w**eigh-**i**n-**m**otion systems (WIM) and eighteen LTPP sites. Portable WIMs usually collected a 48-hour sample of traffic. Length data collectors were either a capacitance pad or loops measuring bumper-to-bumper length of vehicles and placing them into length-defined bins.

With the number of portable and permanent data sources, classification and weight information could be assigned to *primary segments*. Primary segments utilized the measured data to calculate ESAL values. Segments with no classification or weight data utilized the most representative data source. Note that primary segments and their definitions will be described later in the report.

Accomplishment of this project required the following tasks.

Task A - Kick-Off Meeting. Review the scope and work plan at a kick-off meeting between the CDOT project team and key members of the NCE team.

Task B - Review & Analysis. Review the current traffic data collection, analysis and current CDOT practices. This included gathering and processing traffic data through quality control measures used by LTPP.

Task C – Development. Development of traffic data collection, analysis, and an ESAL table for future years utilizing information gathered under TASK A and B. Recommend set of core monitoring sites as well as level of data collection effort. This included how to group data sources and apply information.

Task D – Application. Prepare a new ESAL table for CDOT roadway network based upon new procedures and best available data. This utilized the Federal Highway Administration (FHWA) vehicle classification system (Class 1-13).

Task E – Reports. Submit quarterly, draft final report, final report and electronic files. These electronic files will be analysis of traffic data and the final ESAL table in MS Excel.

This report contains a separate chapter for Tasks A to D, as well as a final chapter with conclusions, recommendations and benefits.

CHAPTER 2. TASK A - KICK-OFF MEETING

A month after the awarding of the contract, a kick-off meeting was held between the NCE team and the CDOT project team. The purpose of the meeting was to discuss the key elements of the project, identifying the available data and establishing key contacts within the CDOT project team.

2.1 MEETING OVERVIEW

The kick-off meeting held on August 8, 2001 between the CDOT project advisory committee and key members of the NCE team was the first important step in establishing the project activities. NCE's principal investigator and technical consultant participated in the one-day meeting in Denver, Colorado with the CDOT project advisory committee to review the scope and work plan in detail. A draft agenda for this meeting was prepared by NCE and circulated among the project teams (CDOT and NCE) for their review and comments well in advance of the meeting date. A final meeting agenda based on input from the CDOT and NCE project teams was prepared and circulated just prior to the meeting date.

The meeting lasted approximately three hours, during which the NCE team became familiar with the CDOT points of contact involved in the traffic data collection and analysis. As the Western Regional Support Contractor (WRSC) for the Long Term Pavement Performance (LTPP) program, NCE has processed and stored Colorado traffic data for the past ten years. NCE had a unique familiarity with Colorado LTPP traffic data, which is already in the NCE-maintained database.

NCE asked a series of specific questions relating to current CDOT traffic data collection and analysis procedures. The NCE team took advantage of this meeting by paying close attention to CDOT's specific concerns, project needs, and philosophy. For instance, CDOT asked about the new 2002 Pavement Design Guide (which has not been implemented) and the ramifications for state highway agencies. NCE stated that the framework developed in this project could be used as initial steps toward developing load spectra.

The topics that received significant attention were the importance of getting as much monitoring data as possible to include in the new ESAL table. CDOT wanted two primary products at the end of the project, namely, site-specific ESAL values for all segments, and classification station recommendations. Please note that NCE was instructed to use the CDOT-provided traffic growth rates. Table 2.1 summarizes all the materials provided to the NCE team by CDOT.

Following the meeting, NCE prepared draft minutes for CDOT to review. Upon receiving feedback, the official minutes were sent to the project teams to establish important issues, work assignments, and decisions made at the meeting. The official minutes are found in Appendix 1.

Table 2.1. Items Provided by CDOT

Item
Locations of all data source sites.
Legend or key for state highway IDs.
Electronic copy of all segments with relevant AADT and growth factors (TraffOn.mdb)
Data from CDOT AVCs 124, 127, 201, 213, 215, 242, 245, 504, & 508.
Data from CDOT Permanent WIMs 1, 2, 3, 4, 5, 7, 8, 10, 13 & 14.
Data from CDOT Portable WIMs 10, 13, 14, 18, 19, 20, 22, 23, 24, 76, & 85.
Length data in close proximity to WIM/AVC sites (103, 109, 203, 215, 217, 231).
Permission to use CDOT data from LTPP database.
Number of lanes for each segment.
Seasonal factors methodology.
Functional class and seasonal group for each segment.
Equivalency factors for permanent and portable WIMs.

CHAPTER 3. TASK B - REVIEW & ANALYSIS

Colorado has a roadway network comprised of interstates, primary, and secondary roads. The CDOT roadway network was divided into segments, which represent sections with unique and/or geometric constraints. Satisfactory accomplishment of this task was essential to the successful implementation of the project. A thorough review of current CDOT practices pertaining to its overall traffic data program was conducted. This was done to determine the inherent problems with CDOT's use of averaged generalized 18-kip equivalency factors and associated 3-bin vehicle classification.

3.1 KEY ACTIVITIES

The following section is a description of each key activity that was performed for completion of this task.

- *Traffic data sources*. There was a review of the traffic data submitted by CDOT and extracted from LTPP database.
- *Data processing and QC process.* Data was processed and summarized into a series of graphs that helped identify poor data. Traffic composition (i.e., vehicle classification) as well as traffic levels were determined for each traffic data source.
- *Permanent, portable and snapshot analysis*. The data from several portable and permanent traffic monitoring sites along with LTPP and any other available data were identified and used to evaluate the differences between portable and permanent vehicle classification. The focus was on determining an optimized procedure for achieving consistent and reliable load equivalency data using a combination of portable and permanent equipment. Adjustment factors were also investigated. Seasonality and functional class patterns characterized by different road segments (i.e., farm-to-market, state highways, interstates, etc.) have been utilized in the new ESAL table.
- *Network map*. NCE identified all data sources on physical maps as well as electronic maps thus enabling review of the network as a whole. NCE developed network maps for each CDOT-defined region (6 regions).
- *Expanding length data*. There was a review of how vehicle length data could be utilized in the network. Recommendations were provided on how Colorado could categorize length based data (3-bin vehicle scheme) and the best ways of expanding the classification categories into the FHWA classification scheme (Class 1-13).
- *Current CDOT design process.* NCE reviewed how the number of estimated equivalent axle loads is normally calculated in the CDOT design process and assessed the current CDOT practices in ESAL determination.

3.2 TRAFFIC DATA SOURCES

The following is a description of each traffic data source that was used for completing the new ESAL table and other project tasks. Each data source provided either the volume of vehicles for a particular segment, classification distribution, or vehicle axle weights.

Appendix 2 contains a list of all the data provided to NCE: CDOT ID, database ID, location, direction, year of data, electronic filename, lanes, data availability, data omitted from analysis, and total number of days used.

3.2.1 Automatic Vehicle Classifier (AVC)

CDOT provided data from nine AVCs. These sites were from different areas of the state and were either on Interstate or State Highways. Classification data in the FHWA classification scheme was collected for both travel directions and lanes. There were approximately 365 days (year 2000–2001) of data from each site.

3.2.2 CDOT Portable WIM

CDOT provided data from eleven portable WIM sites. These sites were from different areas of the state and were either on Interstate or State Highways. Classification and weight data in the FHWA classification scheme was collected for both travel directions and all lanes. The usual data collection sample was 48 hours. This data was collected in year 2000.

3.2.3 CDOT Permanent WIM

CDOT provided data from ten permanent WIM sites. These sites were from different areas of the state and were either on interstate or state highways. Classification and weight data in the FHWA classification scheme was collected for both travel directions and all lanes. The number of days used ranged from 180 to 500 days. This data was collected in years 2000 and 2001.

3.2.4 LTPP Data

CDOT provided new data from eleven permanent LTPP WIM sites. NCE asked for permission to utilize historical information from the LTPP database. The data request was approved; subsequently all historical traffic information was also made available to us. This provided traffic data from an additional seven WIM sites. The historical LTPP data had already gone through the procedures in the LTPP Traffic Quality Control/Quality Assurance (QC/QA) in-house document. Essentially, CDOT has been providing data since the start of LTPP. This data was reviewed by a LTPP regional engineer and then questionable data was flagged. A QC packet was sent to the agency, where state personnel reviewed the flagged items and decided what should be done. Once the agency made its decision, the data was edited by LTPP and summarized for inclusion into the LTPP database.

These sites are from different areas of the state and are either on interstate or state highways. Classification and weight data was in the FHWA classification scheme collected for the LTPP test lane.

3.2.5 Length Data

CDOT provided data from six length station sites. The data came in a text format and was a composite of both directions showing daily totals by length (bumper-to-bumper length). In the past, CDOT ATRs counted in only 3-bins: passenger vehicles with an assumed length of 0-20 feet, single unit trucks 20-40 feet, and combination trucks greater than 40 feet. This data was a "true" example of 3-bin data that was discussed in the RFP. The length data in close proximity to WIM sites allowed NCE to analyze possible 3-bin to FHWA classification conversion processes.

3.3 DATA PROCESSING & QC PROCESS

NCE summarized the data into a series of graphs that helped identify unusual occurrences (7). These occurrences may be unusual volumes or unusual weights. Additionally, classification and weight data was evaluated for certain range checks. As mentioned before, Appendix 2 lists all the data provided to NCE: CDOT ID, database ID, location, direction, year of data, electronic filename, lanes, data availability, data omitted from analysis, and total number of days used.

3.3.1 Classification Data (4-Card or C-Card)

There were several primary checks on the classification data, whether it was from an AVC, portable WIM or permanent WIM (7). First, a time check was performed. If the 1:00 AM volumes were larger than the 1:00 PM volumes, there may be a problem with the clock, lane closure, equipment malfunction, or simply a special event.

The next check was four or more consecutive static volumes. If this occurs, the data may or may not be valid. Depending on the traffic volume on a given road, static volume could mean the equipment is malfunctioning.

Another check was eight or more consecutive zero volumes. This may occur due to a lane closure or some portion of the equipment has failed (i.e., axle sensor connections to equipment box).

The missing hourly volume check points out whether you have 24 hours of data for a day. If an hour was missing, the data will not be used in daily summaries since a 24 hour period was not available. This may occur at some sites due to downloading data via a modem.

Next, all fields of the classification data were reviewed for critical and non-critical errors. These errors could be incorrect state ID, incorrect direction, etc.

Finally, NCE visually reviewed plots of the data and flagged days with unusual traffic characteristics.

3.3.2 Weight Data (7-Card or W-Card)

There were several primary checks on the weight data, whether it was from a portable WIM or permanent WIM (7). One of the checks was a review of the gross vehicle weight (GVW). The number of FHWA Class 9 trucks was plotted versus their GVW. Generally, this plot has a peak at the unloaded and loaded GVW (i.e., an unloaded Class 9 was approximately 28,000 to 32,000 lbs and a loaded Class 9 was approximately 80,000 lbs). If the peaks were not where they should

be or in other terms, shifted, then this could indicate problems with equipment calibration, unique kind of truck at site, or poor pavement conditions leading to erroneous values.

Next, all fields of the weight data were checked for critical and non-critical errors. These errors could be invalid axle weights, invalid axle spacing, etc.

Finally, NCE evaluated vehicle weights and flagged items that were obviously erroneous.

3.4 PERMANENT, PORTABLE, & SNAPSHOT ANALYSES

NCE discussed with the CDOT project team the comparison of continuous WIM with random short duration counts and a sensitivity analysis of permanent data versus portable data. These items were analyzed concurrently. The following guidelines were used:

Sites were selected in close proximity to one another.

- Compared same lane and same direction.
- Designated year 2000 as the base year.
- When taking a snapshot, days were similar to portable WIM days (day of week and month).
- Used the ratio of number of days per year divided by number of days collected to expand portable and snapshot data to a yearly value.
- For LTPP sites, the classification data (4 or C-card) was not used due to problems generating the card data from the data source equipment software (Problem years were 1997, 1998, 1999 and 2000).

3.4.1 LTPP Site 080500 (SPS-5) and CDOT Portable WIM Site 10

For this example, NCE chose two sites 31 miles apart along eastbound Interstate 70 (see Figure 3.1). The SPS-5 was located in the outside lane at milepost 388. The data utilized in this example were 241 days from 1997. It was a continuous WIM system utilizing piezos and loops. A growth factor provided by CDOT was used to move the 1997 data to the base year of 2000. This data was called the "truth" and all other data sets were compared to it.

Portable site 10 was located at milepost 419. The portable data was collected in 2000 and was only 48 hours. No growth factor was needed because the data was collected in the base year.

NCE took a "snapshot" of the data from the SPS-5. This snapshot was a unique way to evaluate continuous versus portable data collection practices. For this example, two days were sampled that were similar to the portable site's days. This was called a *2 day snapshot*.

In Figure 3.2, the volumes per FHWA Class for 2000 are provided. This figures shows that portable data without adjustment factors is not equivalent to the continuous WIM. The portable data was approximately +28% off in the Average Daily Truck Traffic (ADT-T) from the truth data set. Comparing the ESALs accumulated over a year utilizing the data collected at the portable site versus the truth showed that the ESALs are +26% off from the truth (see Figure 3.3). The *2 day snapshot* was approximately +13% off in the ADT-T from the truth data set. This was slightly better than the portable data set. The *2 day snapshot* ESALs were +24% off

from the truth. Note that ESALs were calculated for the truth, the *2 day snapshot* and the portable data with historical ESALs per vehicle values for the SPS-5.

NCE investigated taking seasonal snapshots, two days from each season. This may account for any seasonal variations in traffic. An *8 day snapshot* was selected from the SPS-5. The days were like weekdays. The *8 day snapshot* was approximately –3% off from the truth. The ESALs were also –3% off from the truth. These values were closer than the portable and the *2 day snapshot*. (See Figures 3.4 to 3.6).

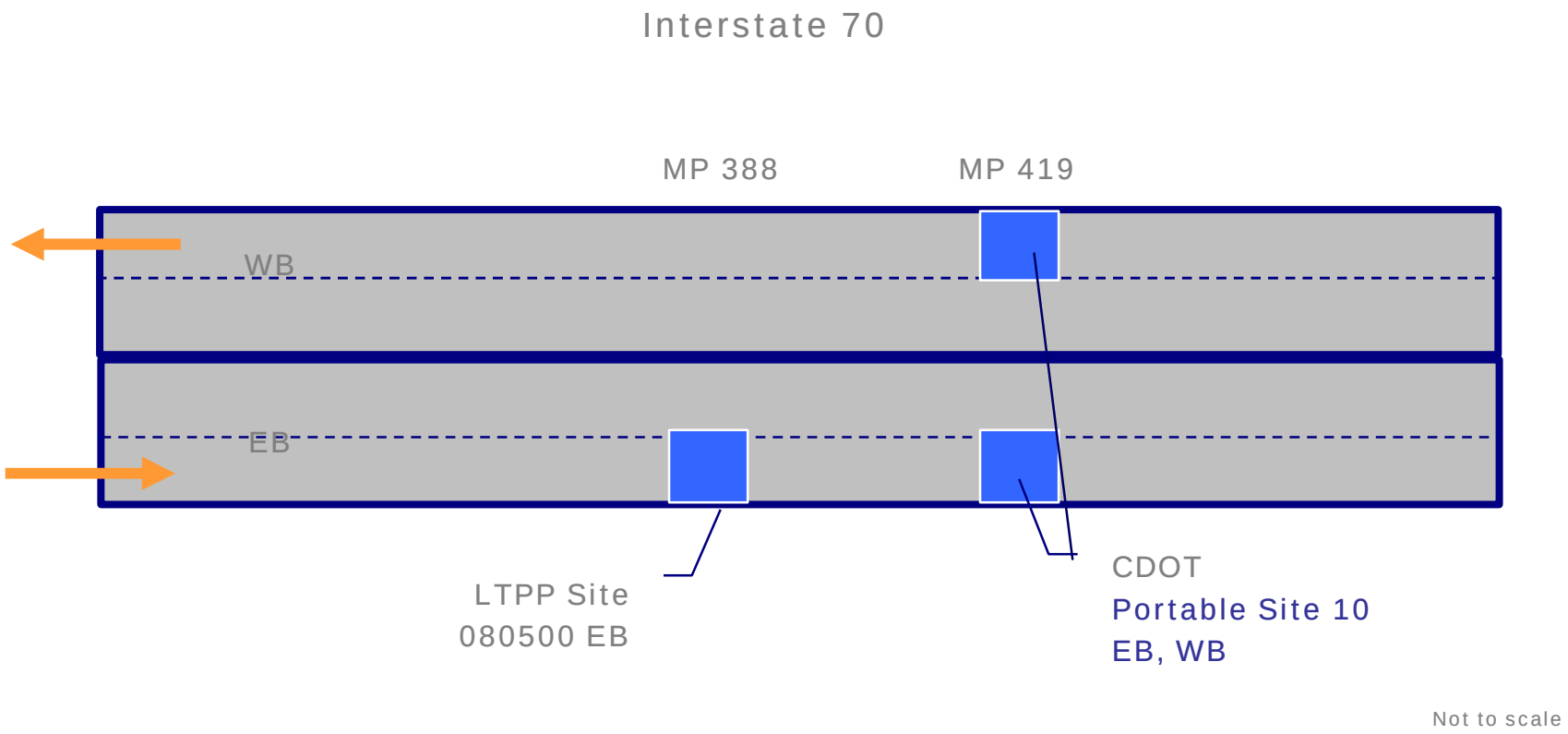


Figure 3.1. Layout of LTPP Site 080500 & CDOT Portable Site 10

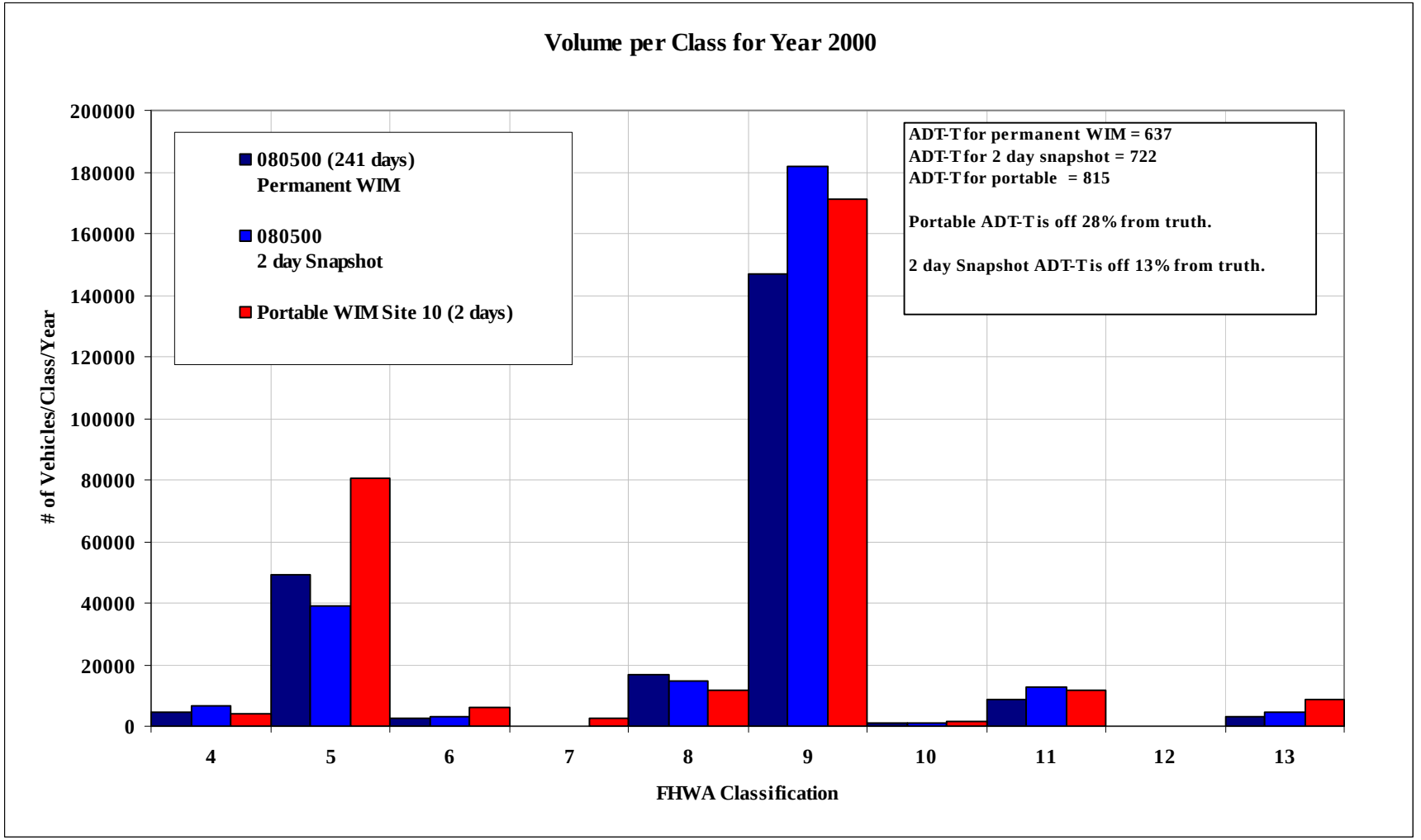


Figure 3.2. Truck Volumes per Class for LTPP Site 080500, CDOT Portable Site 10 & 2 Day Snapshot

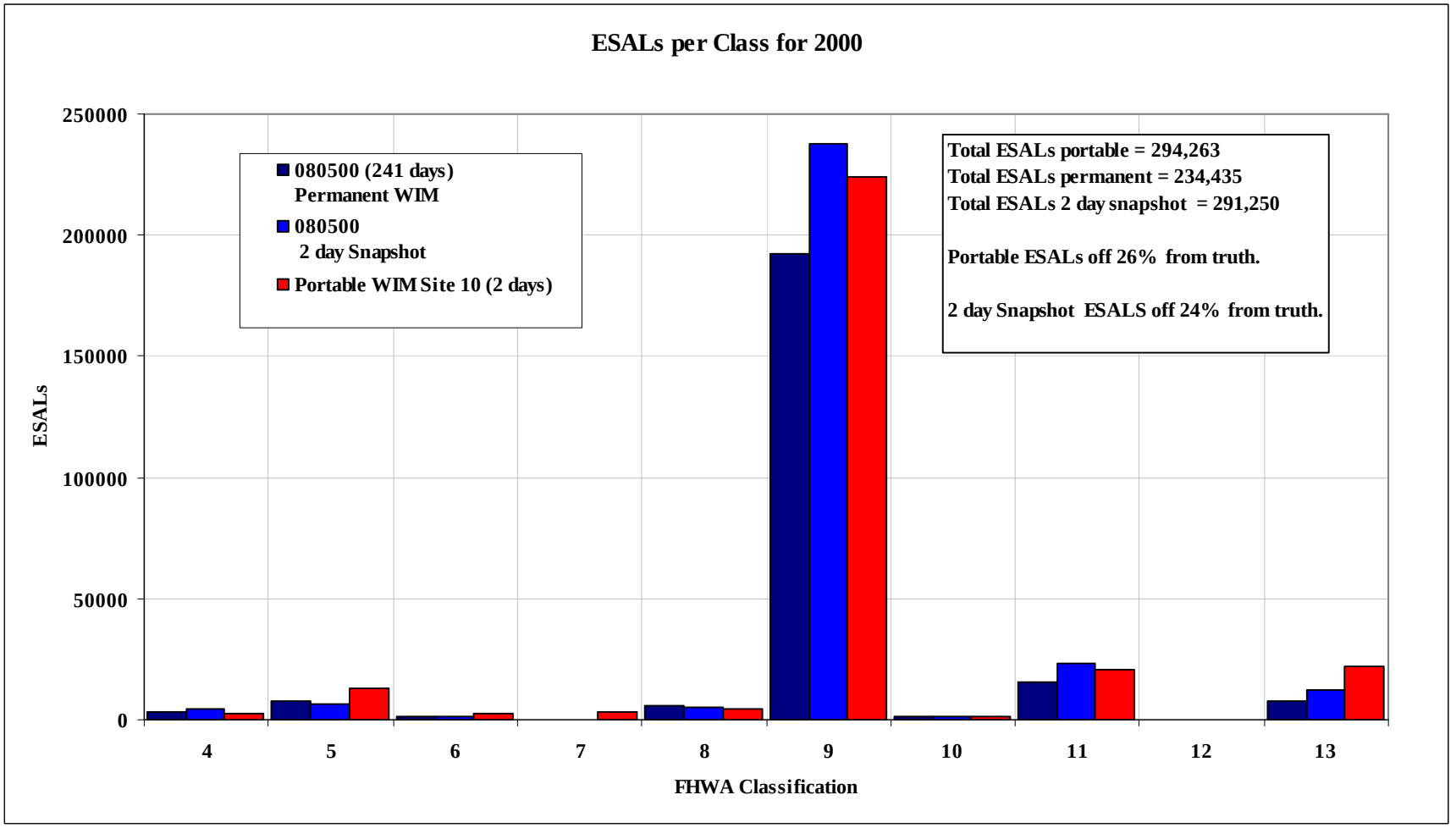


Figure 3.3. ESALs per Class for LTPP Site 080500, CDOT Portable Site 10 & 2 Day Snapshot

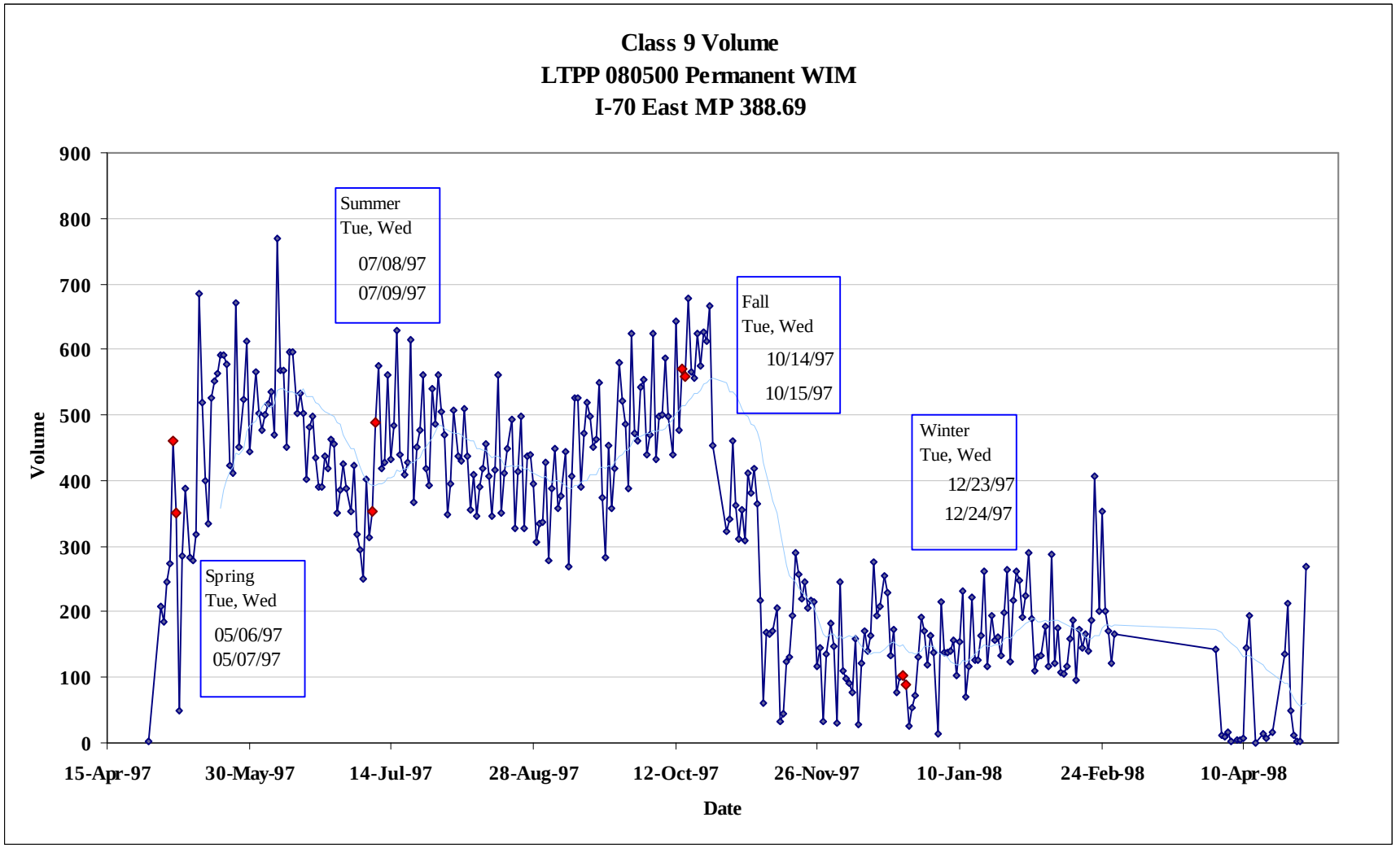


Figure 3.4. FHWA Class 9 Trucks for LTPP Site 080500 & Snapshot Days

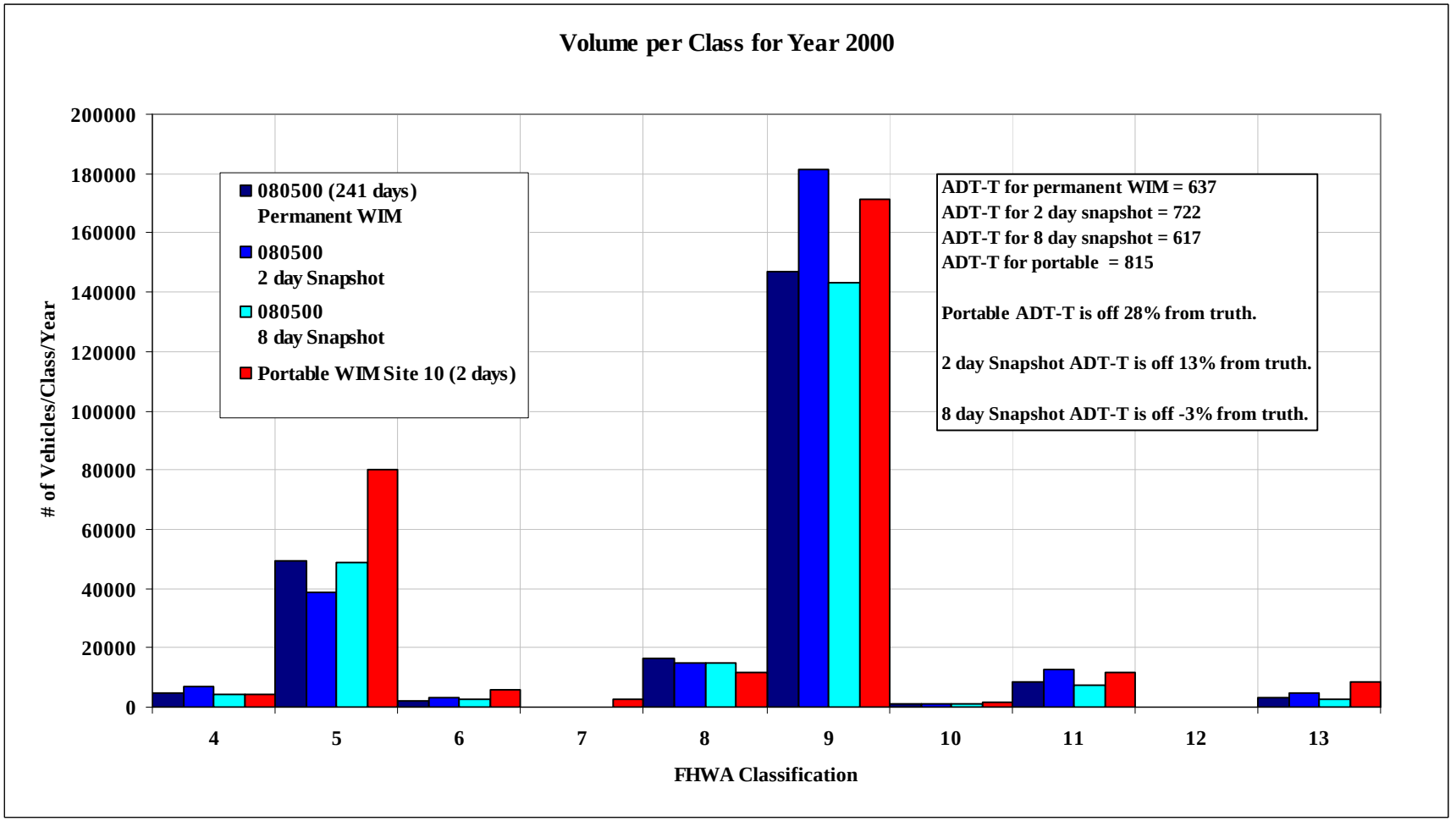


Figure 3.5. Truck Volumes per Class for LTPP Site 080500, CDOT Portable Site 10 & Snapshots

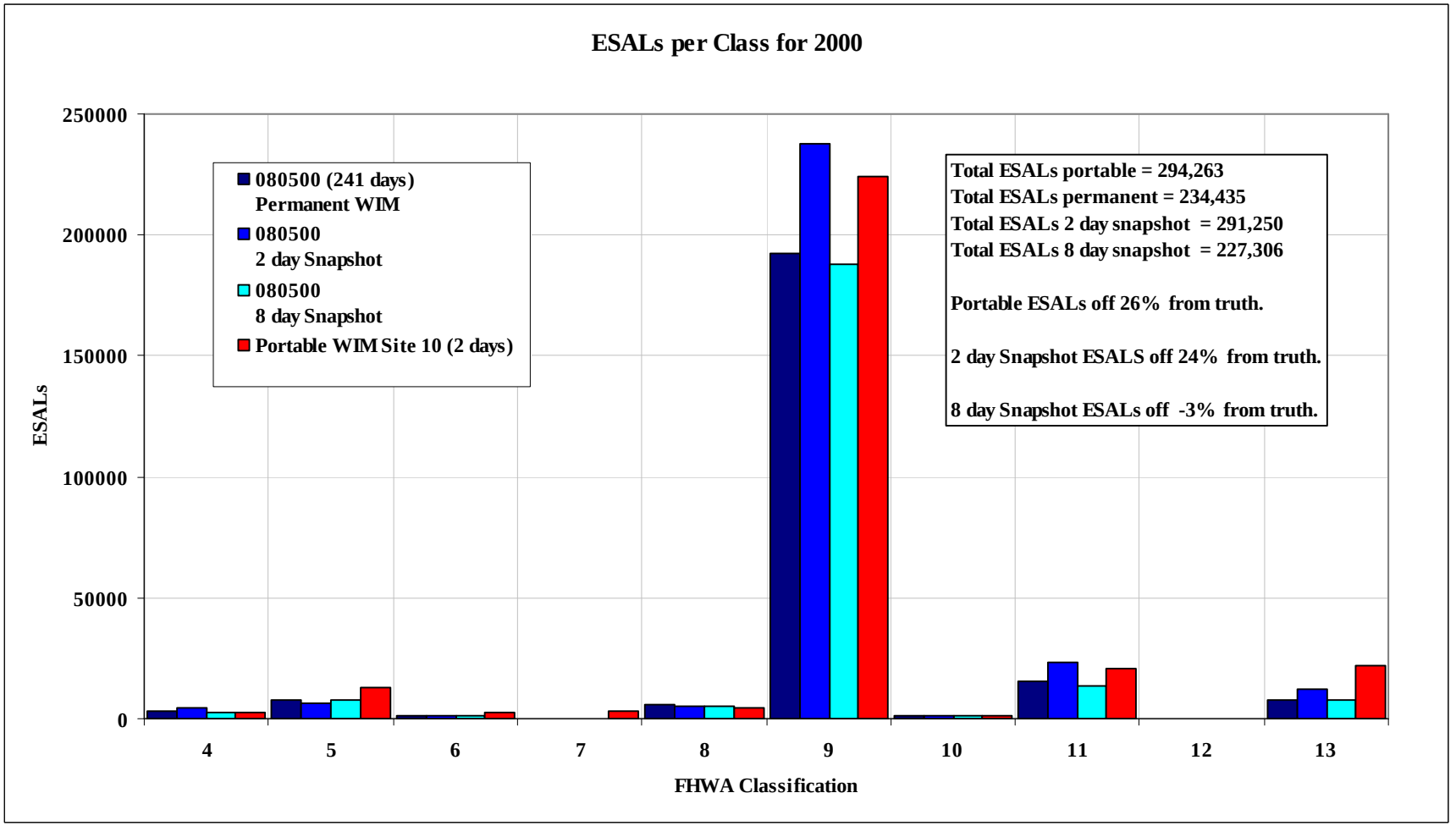


Figure 3.6. ESAL per Class for LTPP Site 080500, CDOT Portable Site 10 & Snapshots

3.4.2 LTPP Site 081053 and CDOT Portable WIM Site 19

For this example, NCE chose two sites 9 miles apart along northbound US Highway 50 (see Figure 3.7). 081053 was located in the outside lane at milepost 75.3. The data utilized in this example were 365 days from 1998. It was a continuous WIM system utilizing piezos and loops. A growth factor provided by CDOT was used to move the 1998 data to the base year of 2000. This data was called the "truth" and all other data sets were compared to it. Portable site 19 was located at milepost 84. The portable data was collected in 2000 and was only 48 hours. No growth factor was needed because the data was collected in the base year. NCE took a *2 day* and *8 day snapshot* of the truth (see Figure 3.8).

In Figure 3.9, the volumes per FHWA Class for 2000 are provided. This figure shows that portable data without adjustment factors is not equivalent to the continuous WIM. The portable data was approximately +194% off in the Average Daily Truck Traffic (ADT-T) from the truth data set. Evaluation of the ESALs accumulated over a year utilizing the data collected at the portable site versus the truth showed that the ESALs are +149% off from the truth (see Figure 3.10).

The *2 day snapshot* was approximately +52% off in the ADT-T from the truth data set. This was slightly better than the portable data set. The *2 day snapshot* ESALs were +67% off from the truth. The *8 day snapshot* was approximately +4% off from the truth. The ESALs were also +11% off from the truth. These values were closer than the portable and the *2 day snapshot*.

Note that ESALs were calculated for the truth, the *2 day snapshot* and the portable data with historical ESALs per vehicle values for LTPP Site 081053.

3.4.3 LTPP Site 080200 (SPS-2) and CDOT Permanent WIM Site 10

For this example, NCE chose two permanent WIM sites 21 miles apart along eastbound Interstate 76 (see Figure 3.11). The SPS-2 was located in the outside lane at milepost 18.4. The data utilized in this example were 247 days from 1999. It was a continuous WIM system utilizing piezos and loops. A growth factor provided by CDOT was used to move the 1999 data to the base year of 2000. This data was called the "truth" and all other data sets were compared to it. The CDOT Permanent WIM Site 10 was located at milepost 39.7. The site 10 data was collected in 2000 and was 274 days. No growth factor was needed because the data was collected in the base year. NCE took an *8 day snapshot* of the truth (see Figure 3.12).

The volumes per FHWA Class for 2000 are provided. The CDOT Permanent Site 10 data was approximately -10% off in the Average Daily Truck Traffic (ADT-T) from the truth data set. Evaluation of the ESALs accumulated over a year utilizing the data collected at site 10 versus the truth showed that the ESALs are -2% off from the truth. This indicates that these data sets were comparable. The *8 day snapshot* was approximately +15% off from the truth. The ESALs were also +15% off from the truth. These values were not closer than the site 10 data. See Figures 3.13 to 3.14.

Note that ESALs were calculated for the truth and site 10 data with historical ESALs per vehicle values for LTPP Site 080200.

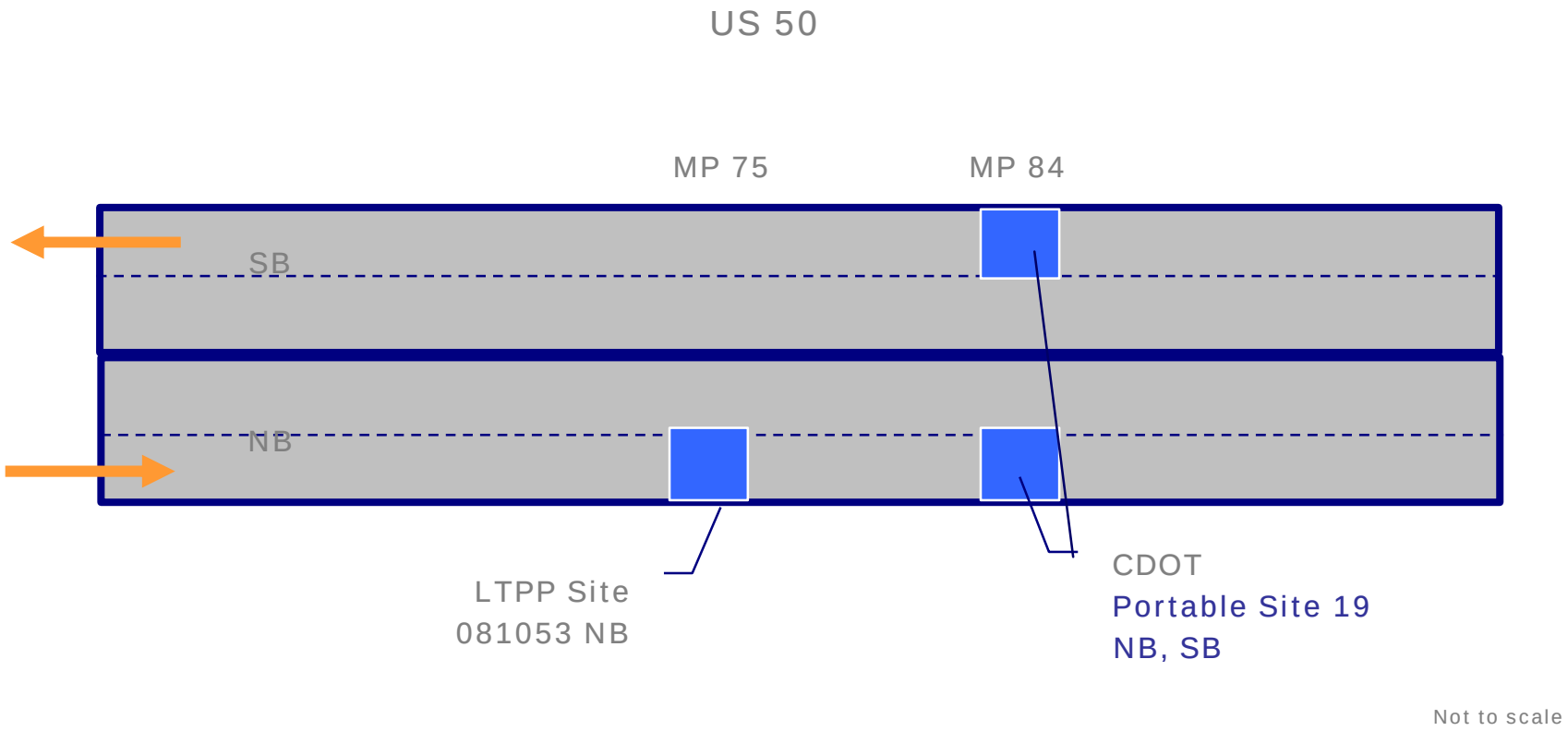


Figure 3.7. Layout of LTPP Site 081053 & CDOT Portable Site 19

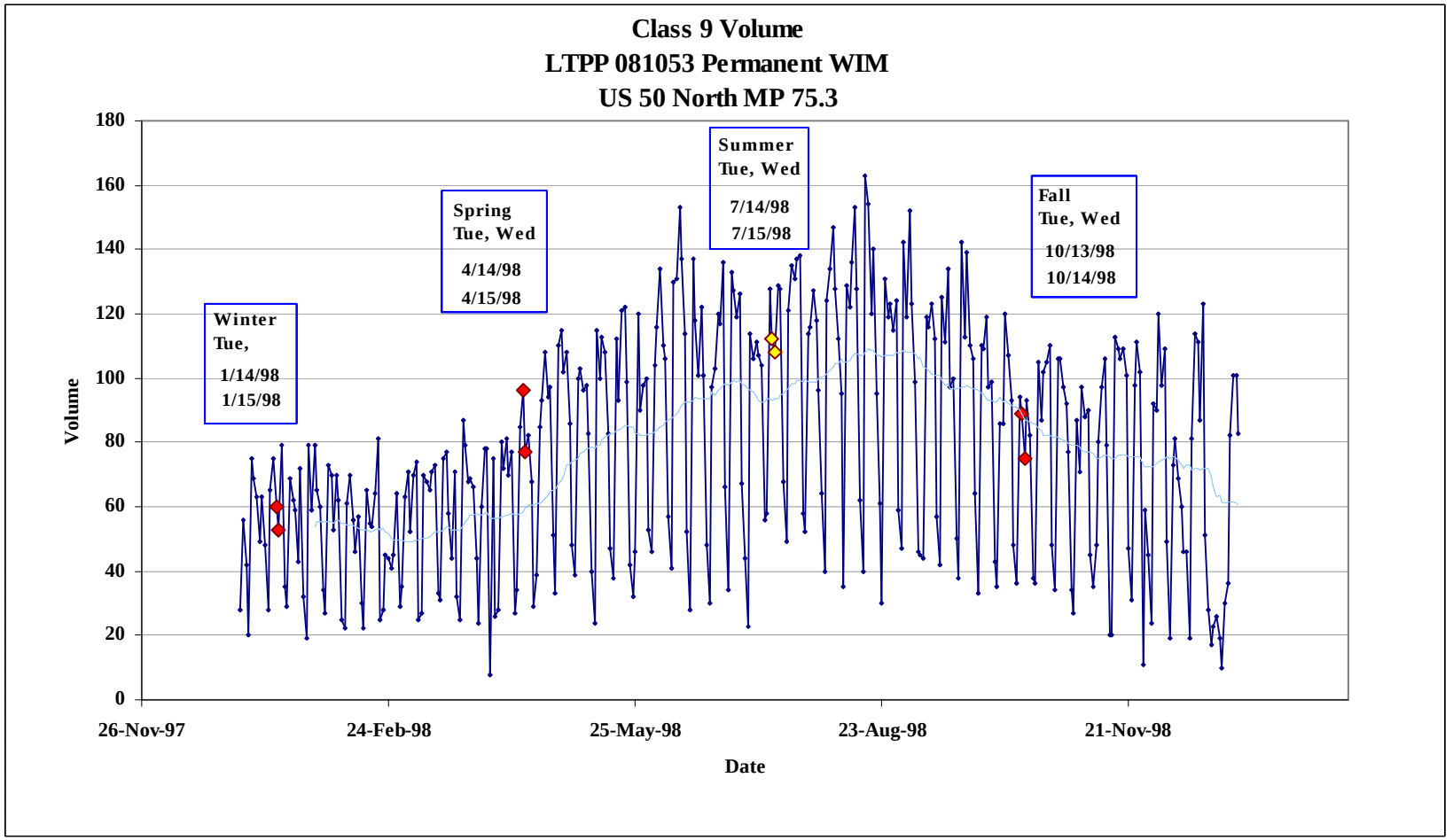


Figure 3.8. FHWA Class 9 Trucks for LTPP Site 081053 & Snapshot Days

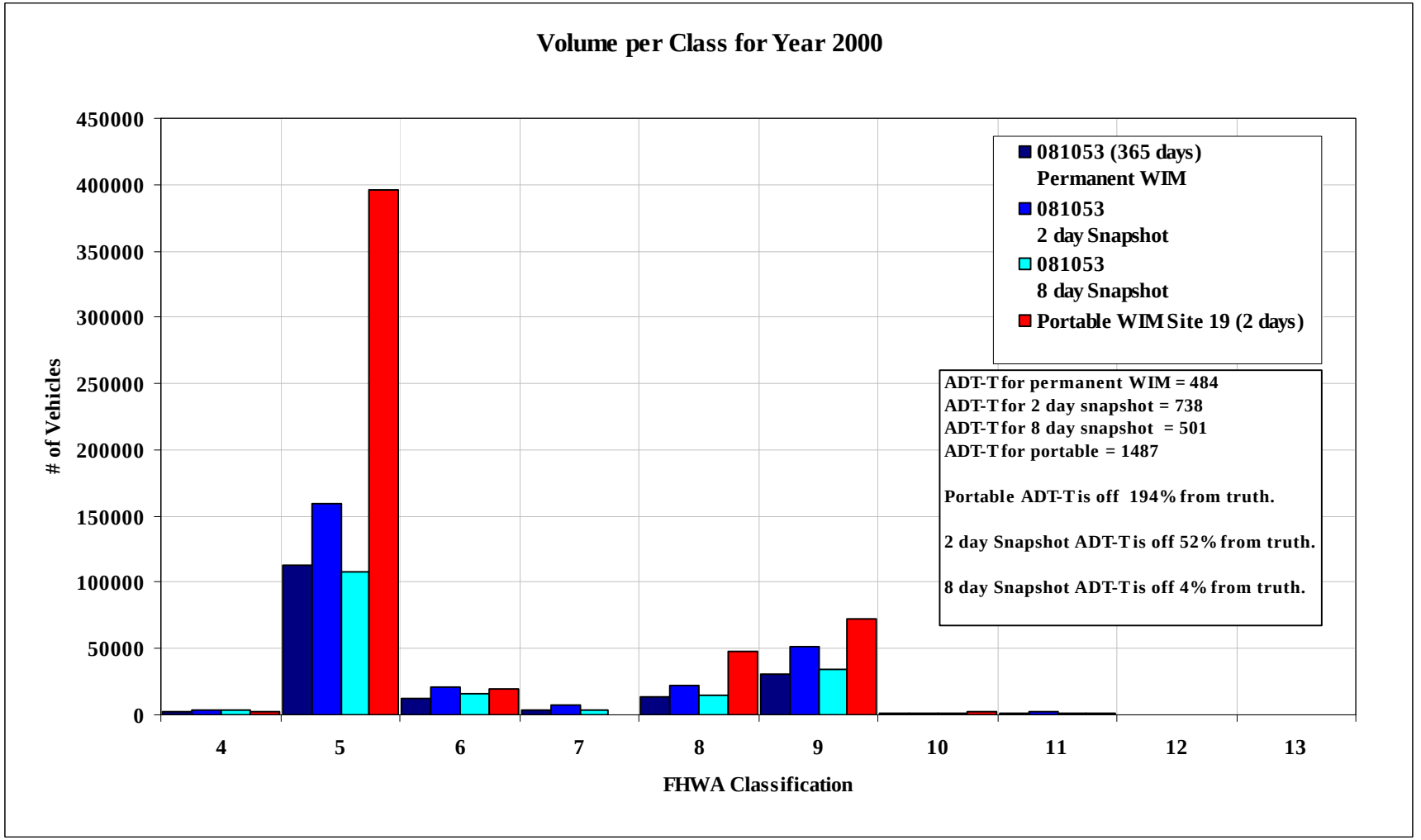


Figure 3.9. Truck Volumes per Class for LTPP Site 081053, CDOT Portable Site 19 & Snapshots

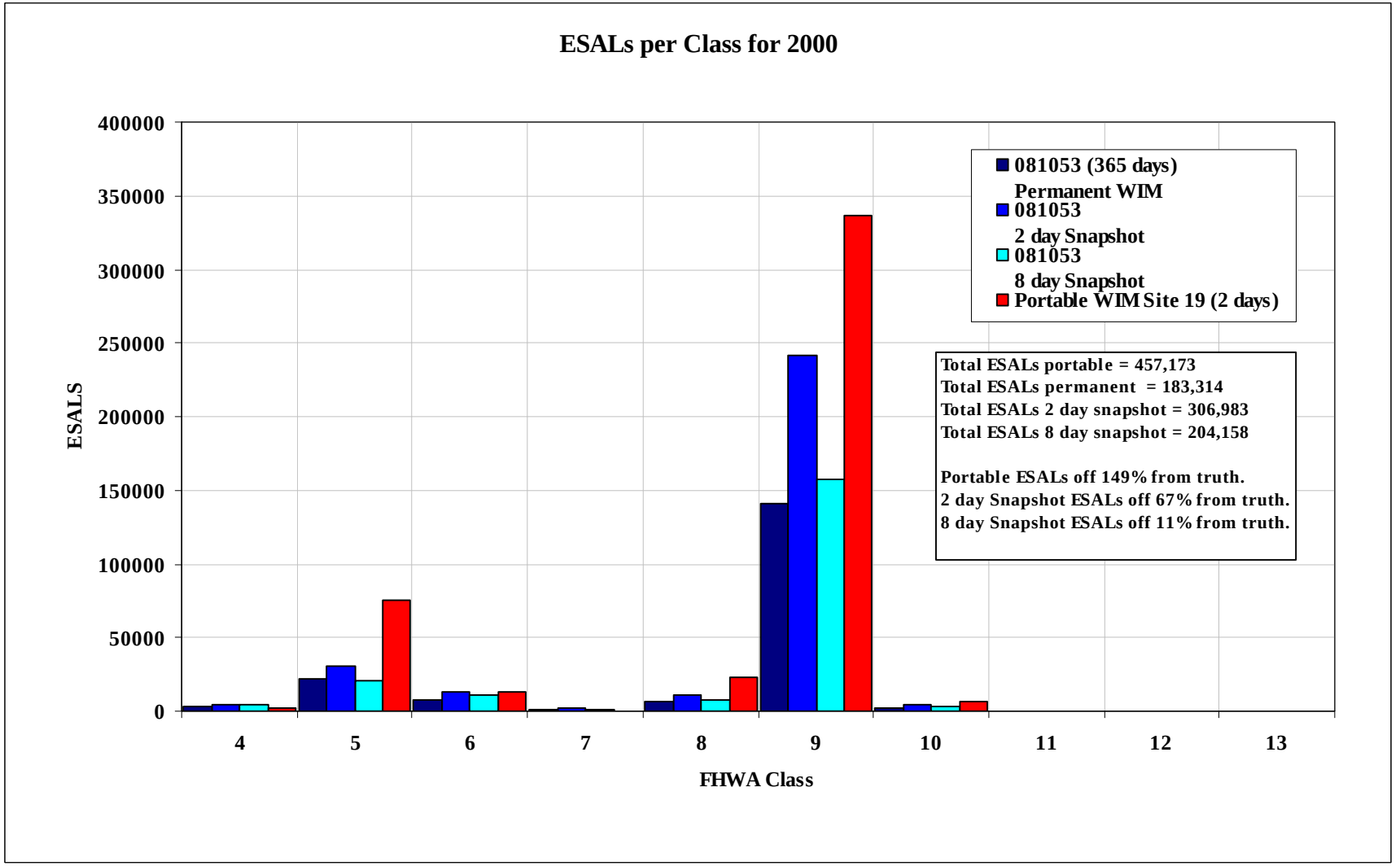


Figure 3.10. ESAL per Class for LTPP Site 081053, CDOT Portable Site 19 & Snapshots

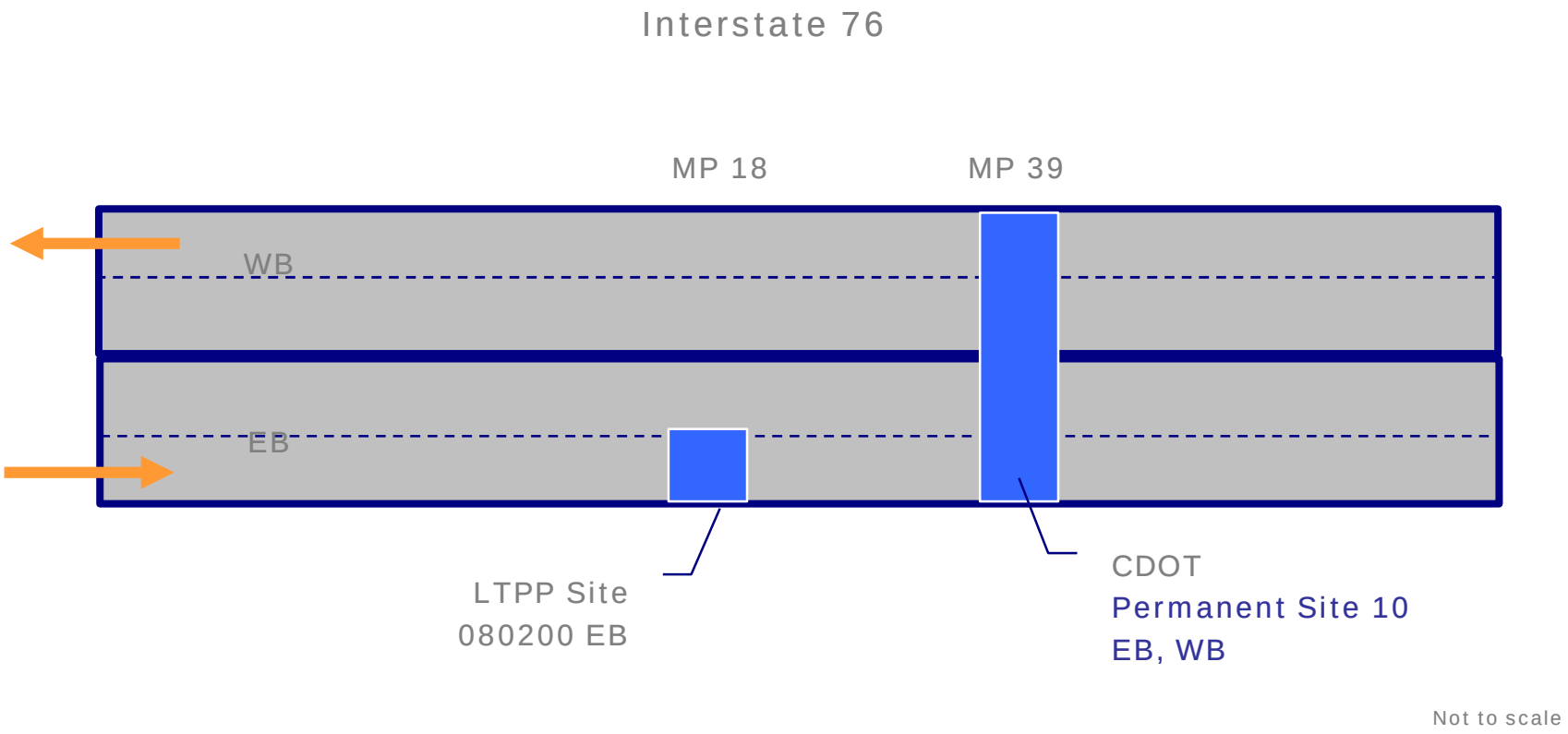


Figure 3.11. Layout of LTPP Site 080200& CDOT Permanent Site 10

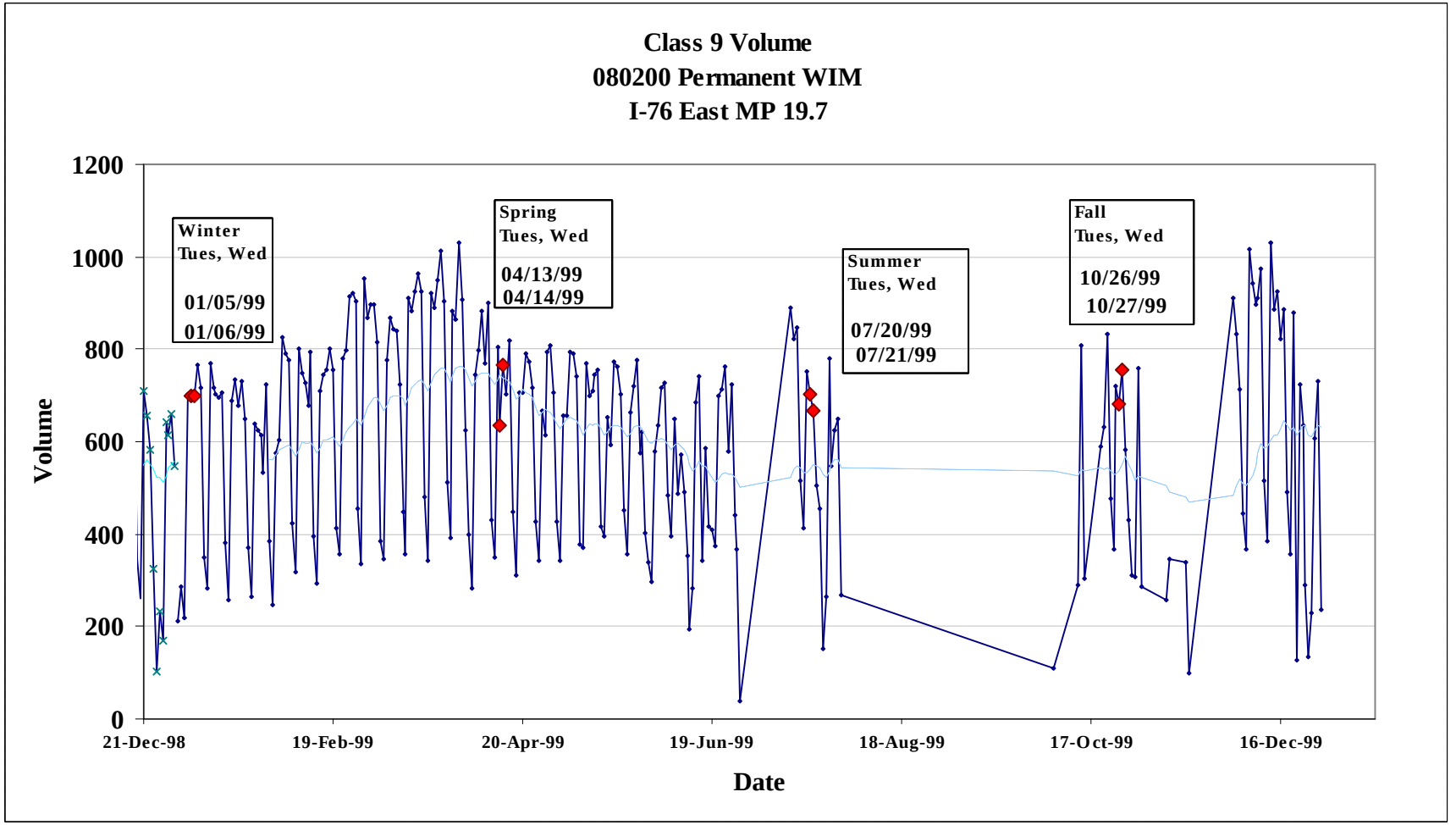


Figure 3.12. FHWA Class 9 Trucks for LTPP Site 080200 & Snapshot Days

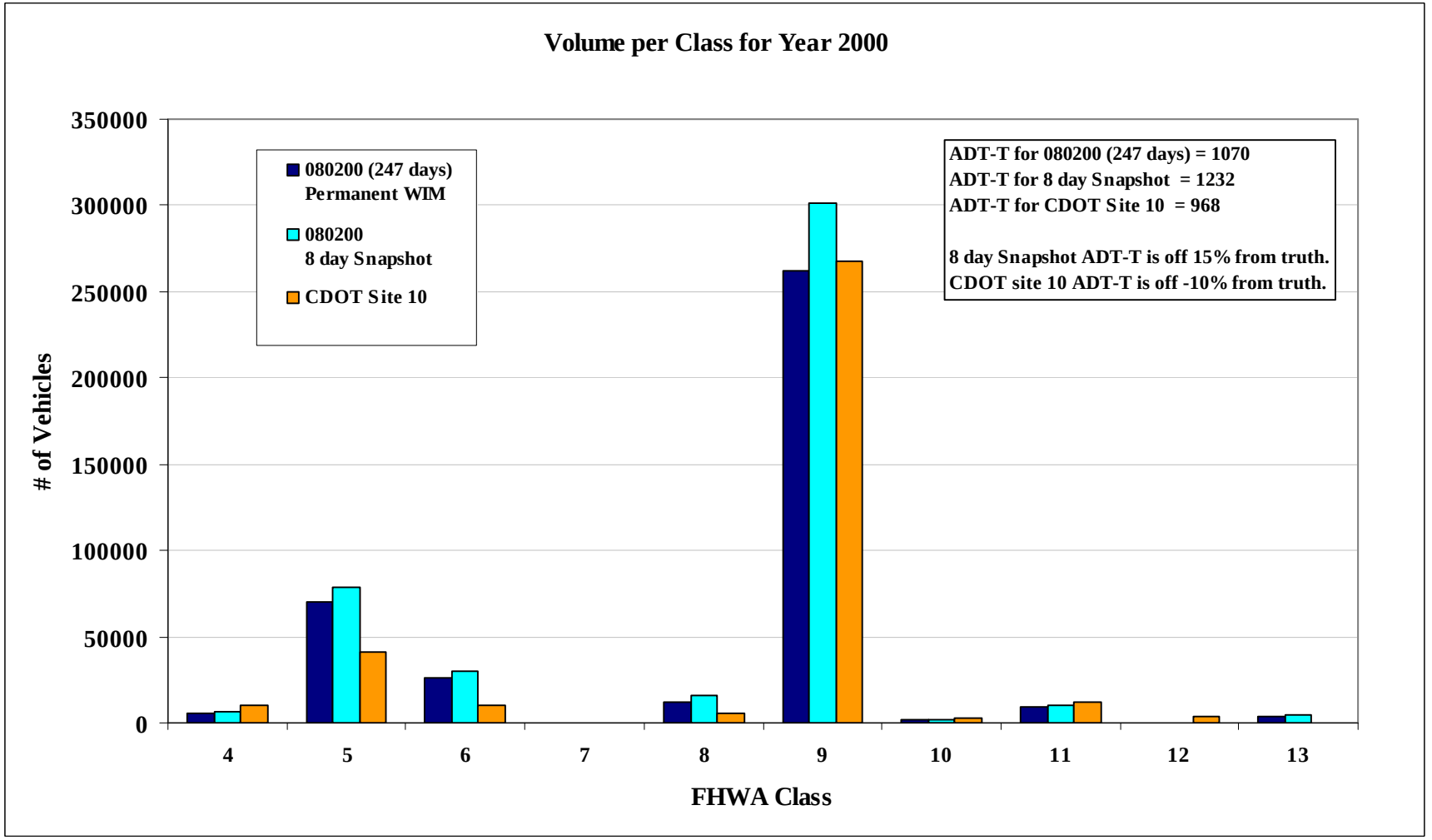


Figure 3.13. Truck Volumes per Class for LTPP Site 080200, CDOT Permanent Site 10 & Snapshots

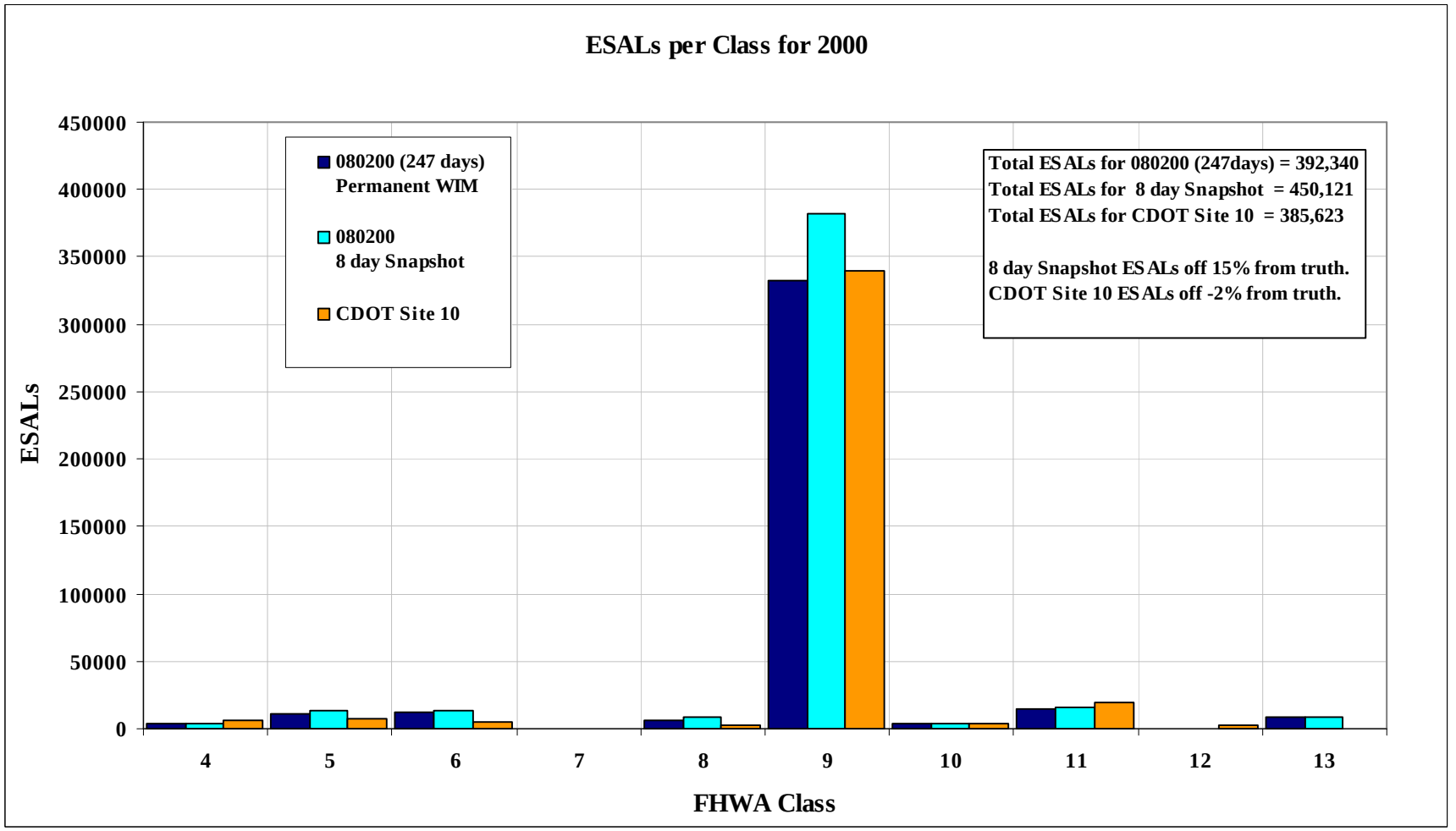


Figure 3.14. ESAL per Class for LTPP Site 080200, CDOT Permanent Site 10 & Snapshot

3.4.4 Adjustment Factors

There were a few instances where portable and permanent WIMs were in close proximity. This gave NCE the opportunity to investigate seasonal adjustment factors and the snapshot method further on four CDOT permanent WIM sites: 1, 5, 7, and 8.

Factoring techniques are one way to remove temporal bias from traffic estimations. There are numerous techniques that have been developed and utilized by agencies. Usually, factors may be developed for generalized truck classes, day of week, or monthly patterns. For the purposes of this project, NCE used a traditional factoring method discussed in Traffic Monitoring Guide 2001 (Section 4) (1). It entails averaging the daily counts for each weekday in each month for each class. The monthly class average was calculated by averaging each day of week average. These monthly class averages were then averaged for the year (Eq. 3.1). Factors were then calculated by dividing the yearly average for each class by the day of week monthly average (Eq. 3.2). The appropriate factors were then applied.

$$AADTT_y = \frac{1}{7}\sum_{day\ of\ week=1}^{7}\left[\frac{1}{12}\sum_{month=1}^{12}\left(\frac{1}{n}\sum_{1}^{n} Daily\ truck\ volume\ within\ each\ month\right)\right] \quad \text{Eq. 3.1}$$

$$Factor = {AADTT_y}\Big/{MADTT} \quad \text{Eq. 3.2}$$

$AADTT_y$ equals the annual average daily truck traffic, "n" equals the number of days of that day during a particular month (usually 4 or 5), and *MADTT* equals the monthly average day truck traffic for specific month, day and vehicle class (e.g. average truck traffic of Mondays in January).

For each site the constants were:

- Had approximately a year of continuous data with the exception of data omitted during the QC process.
- Evaluated all lanes and directions provided.
- Evaluated volume from classification and weight cards.
- *2 day* and *8 day snapshots* were selected.
- Investigated seasonal adjustment factors only on sites which exhibited truck volume seasonality.

The following tables 3.1 to 3.3 present the results of this analysis. Sites 1 and 5 did not appear to have any seasonality to the truck volumes and therefore no factors were applied. Site 1 was located on State Highway 6 at milepost 438.4 and was an east/west route. Site 5 was located on State Highway 287 at milepost 110.59 and was a north/south route. The *2 day* and *8 day*

snapshots of site 1 estimated the truck volume within 40 trucks of the truth ADT-T. The *2 day* and *8 day snapshots* of site 5 estimated the truck volume within 200 trucks of the truth ADT-T.

For sites 7 and 8, there appeared to be some seasonality to the truck volume, therefore, NCE applied factors. Site 7 especially indicated how well the factors can adjust the temporal bias to short duration data collection. For example, the non-factored *8 day snapshot* versus the factored *8 day snapshot* showed an improvement of over 20% in estimating the truck volumes. A similar event was observed with the *2 day snapshot*. For site 8, this type of improvement was also observed except for the eastbound direction 7-Card evaluation. This may be due simply to the days chosen and illustrates the inherent problems with short duration counts.

Table 3.1. CDOT Permanent WIM Sites 1 & 5 Snapshot Comparison Results

Adjustment Factors Applied	Site	Year	4-Card Data Evaluation			7-Card Data Evaluation		
			# of Days Used	ADT-T	% Difference from Truth	# of Days Used	ADT-T	% Difference from Truth
No	CDOT Perm. Site 1, EB "Truth"	2000	321	168	NA	364	165	NA
No	CDOT Perm. Site 1, EB *8 day Snapshot*	2000	8	189	13%	8	189	15%
No	CDOT Perm. Site 1, EB *2 day Snapshot*	2000	2	173	3%	2	173	5%
No	CDOT Perm. Site 1, WB "Truth"	2000	320	158	NA	364	139	NA
No	CDOT Perm. Site 1, WB *8 day Snapshot*	2000	8	175	4%	8	174	25%
No	CDOT Perm. Site 1, WB *2 day Snapshot*	2000	2	179	7%	2	179	29%
No	CDOT Perm. Site 5, NB "Truth"	2000	267	589	NA	332	581	NA
No	CDOT Perm. Site 5, NB *8 day Snapshot*	2000	8	699	19%	8	700	20%
No	CDOT Perm. Site 5, NB *2 day Snapshot*	2000	2	755	28%	2	755	30%
No	CDOT Perm. Site 5, SB "Truth"	2000	266	552	NA	332	546	NA
No	CDOT Perm. Site 5, SB *8 day Snapshot*	2000	8	657	12%	8	659	21%
No	CDOT Perm. Site 5, SB *2 day Snapshot*	2000	2	663	13%	2	663	21%

Table 3.2. CDOT Permanent WIM Site 7 Snapshot & Factored Snapshot Comparison Results

Adjustment Factors Applied	Site	Year	4-Card Data Evaluation			7-Card Data Evaluation		
			# of Days Used	ADT-T	% Difference from Truth	# of Days Used	ADT-T	% Difference from Truth
No	CDOT Perm. Site 7, EB "Truth"	2000-2001	271	269	NA	334	246	NA
No	CDOT Perm. Site 7, EB *8 day Snapshot*	2000-2001	8	355	32%	8	309	26%
Yes	CDOT Perm. Site 7, EB *8 day Snapshot*	2000-2001	8	287	7%	8	260	6%
No	CDOT Perm. Site 7, EB *2 day Snapshot*	2000-2001	2	405	51%	2	369	50%
Yes	CDOT Perm. Site 7, EB *2 day Snapshot*	2000-2001	2	316	18%	2	290	18%
No	CDOT Perm. Site 7, WB "Truth"	2000-2001	237	296	NA	300	266	NA
No	CDOT Perm. Site 7, WB *8 day Snapshot*	2000-2001	8	470	75%	8	418	57%
Yes	CDOT Perm. Site 7, WB *8 day Snapshot*	2000-2001	8	319	8%	8	267	0%
No	CDOT Perm. Site 7, WB *2 day Snapshot*	2000-2001	2	729	171%	2	686	158%
Yes	CDOT Perm. Site 7, WB *2 day Snapshot*	2000-2001	2	343	16%	2	317	19%

Table 3.3. CDOT Permanent WIM Site 8 Snapshot & Factored Snapshot Comparison Results

Adjustment Factors Applied	Site	Year	4-Card Data Evaluation			7-Card Data Evaluation		
			# of Days Used	ADT-T	% Difference from Truth	# of Days Used	ADT-T	% Difference from Truth
No	CDOT Perm. Site 8, EB "Truth"	2000-2001	222	636	NA	296	648	NA
No	CDOT Perm. Site 8, EB 8 day Snapshot	2000-2001	8	718	13%	8	691	7%
Yes	CDOT Perm. Site 8, EB 8 day Snapshot	2000-2001	8	638	0%	8	751	16%
No	CDOT Perm. Site 8, EB 2 day Snapshot	2000-2001	2	794	25%	2	794	23%
Yes	CDOT Perm. Site 8, EB 2 day Snapshot	2000-2001	2	681	7%	2	1212	87%
No	CDOT Perm. Site 8, WB "Truth"	2000-2001	231	734	NA	305	685	NA
No	CDOT Perm. Site 8, WB 8 day Snapshot	2000-2001	8	851	34%	8	859	25%
Yes	CDOT Perm. Site 8, WB 8 day Snapshot	2000-2001	8	740	1%	8	777	13%
No	CDOT Perm. Site 8, WB 2 day Snapshot	2000-2001	2	1140	79%	2	930	36%
Yes	CDOT Perm. Site 8, WB 2 day Snapshot	2000-2001	2	876	19%	2	793	16%

The previous discussion and analysis was specific to lane as well as direction. This may be too extensive. Based on CDOT recommendations, NCE evaluated one site, CDOT Permanent Site 8, in its entirety using just *weight card* information and a *composite of all lanes* to create the adjustment factors. Appendix 3 contains this work. Pages 92-93 illustrate the seasonality of the truck volumes from November 2000 to November 2001. The next graphs on pages 94-95 show the weekday/weekend truck volume variations per month and day of week variations. The table on page 96 and the graph on page 97 show the snapshot analysis without any adjustments. Pages 98-101 present a table for each month with the adjustment factors for day of week and FHWA class. Page 102 shows the affect of applying the adjustment factors to a *2 day snapshot*. Page 103 shows the affect of applying the adjustment factors to a *8 day snapshot*. The final graph on page 104 shows the results of the snapshot analysis and application of adjustment factors. Overall, the *2 day snapshot* was -28% off from the truth and the *8 day snapshot* was only -1% off from the truth. This *8 day snapshot* was closer to the truth than either of the directional *8 day snapshots* for site 8 (see Table 3.4).

Table 3.4. CDOT Permanent WIM Site 8 Snapshot & Factored Snapshot Comparison Results

Adjustment Factors Applied	Site	Year	7-Card Data Evaluation		
			# of Days Used	ADT-T	% Difference from Truth
No	CDOT Perm. Site 8, Both Directions "Truth"	2000-2001	284	1291	NA
Yes	CDOT Perm. Site 8, Both Directions 8 day Snapshot	2000-2001	8	1272	-1%
Yes	CDOT Perm. Site 8, Both Directions 2 day Snapshot	2000-2001	2	927	-28%

3.4.5 Findings of Permanent, Portable, & Snapshot Analyses

NCE evaluated several sites to compare continuous WIM with random short duration counts and a sensitivity analysis of permanent data versus portable data. The analyses indicated that sampling data a few times per year may preclude the installation of new costly permanent WIMs. The *8 day snapshot* of data (ADT-T) from sites 080500, 081053, CDOT Perm Site 5 and CDOT Permanent Site 8 were closer to the truth ADT-T than the *2 day snapshot* ADT-T.

A 2 day short duration count would only be sufficient if the site is known to have no seasonal characteristics. Without previous WIM data available or intimate knowledge of the site, NCE recommends four 2 day sessions to estimate ESALs.

Adjustment factors that adjusted the temporal bias from short duration data collection were beneficial for CDOT Permanent Site 7 (See Table 3.2) and CDOT Permanent Site 8 (See Table 3.3). The factored ADT-T was closer to the truth ADT-T than the non-factored ADT-T for every 4-Card data evaluation. However, for the eastbound direction of CDOT Permanent Site 8, the factored ADT-T from the 7-Card data evaluation was not closer to the truth ADT-T. This shows the inherent problems with short duration counts and adjustment factors.

Additionally, if CDOT could place a portable WIM close to a permanent WIM for a given amount of time, CDOT would have the opportunity to validate the *snapshot* processes.

A quadrennial plan could be developed to collect data around the state. This takes into account issues of manpower and money. Some areas would not require additional data because of the lack of seasonal characteristics.

3.5 NETWORK MAP

In order to apply the monitoring data to over 4800 segments, NCE first identified all the data sources on a physical map. This allowed us to see the network as a whole instead of just a series of rows and columns. NCE created primary segments, which were defined as a combination of segments around a data source that were within ± 30 % of the AADT-T of the data source segment. All primary segments originated at a segment where a data source was located. The classification and weight data was applied to these primary segments directly. Site-specific as well as historical weight information were used. Currently, there are 37 primary segments comprised of 427 segments. This is roughly 9% of the total number of segments originally provided to NCE. The segments have also been marked electronically on the CDOT region maps (6) and on the spreadsheet, *TraffOn*. The CDOT region maps are in Appendix 4.

CDOT requested NCE to review ± 30% AADT-T threshold. NCE investigated a ±20%, ±30% and ±40% threshold. Percentage of heavy trucks from total heavy trucks from entire network (FHWA Class 8-13), number of segments and number of primary segments are presented in Table 3.5. This showed that there was little benefit in reducing the threshold or increasing the threshold.

Table 3.5. Truck Volume Threshold Review

	±20% Threshold	±30% Threshold	±40% Threshold
Percent Heavy Trucks	19.7	25.2	32.2
Number of Segments	321	427	562
Percent of Segments	6.7	8.8	11.7
Number of Primary Segments	38	37	34

Please note that data sources on the same roadway may be in the same primary segment. This occurred on some interstate roadways, which have similar traffic for many segments. Where primary segments overlapped, one data source was given precedence. For example, CDOT portable WIM Site 85 and AVC 215 are on the same roadway. Due to the portable device having weight data, the overlapped section utilized the portable site's data.

As CDOT installs or collects WIM data at new locations around network, segments within the AADT-T 30% threshold should be populated with the new WIM data. This would extend/increase the number of primary segments and coverage of network with site-specific WIM data.

3.6 EXPANDING LENGTH DATA

Three length sites were analyzed with respect to expanding length data into the FHWA classification scheme (1-13) (see Figure 3.15). The length sites were in close proximity to a data source and were in the same primary segment. Traffic within the segment should be similar in volume and characteristics.

Length data is usually collected with a pair of loops that measures bumper to bumper distances of a vehicle. Three length bins were discussed in the RFP: Bin A = 0-20 feet, Bin B = 20-40 feet and Bin C = 40+ feet. Also, the length bins were defined as: Bin A = FHWA Class 1-3, Bin B = FHWA Class 4-7 and Bin C = FHWA Class 8-13 (see Figure 3.16).

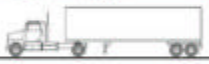
Class	Illustration	Description
1		Motorcycles
2		Passenger Cars
3		Pickups/Vans
4		Buses
5		6 tire two-axle single unit trucks
6		Three axle single unit trucks
7		Four or more axle single unit trucks
8		Four or fewer axle truck and trailer combinations
9		Five axle truck and trailer combinations
10		Six or more axle truck and trailer combinations
11		Five or fewer axle multis
12		Six axle multis
13		Seven or more axle multis
14		Errors/Unknown

Figure 3.15. FHWA Classification Scheme Illustration and Description

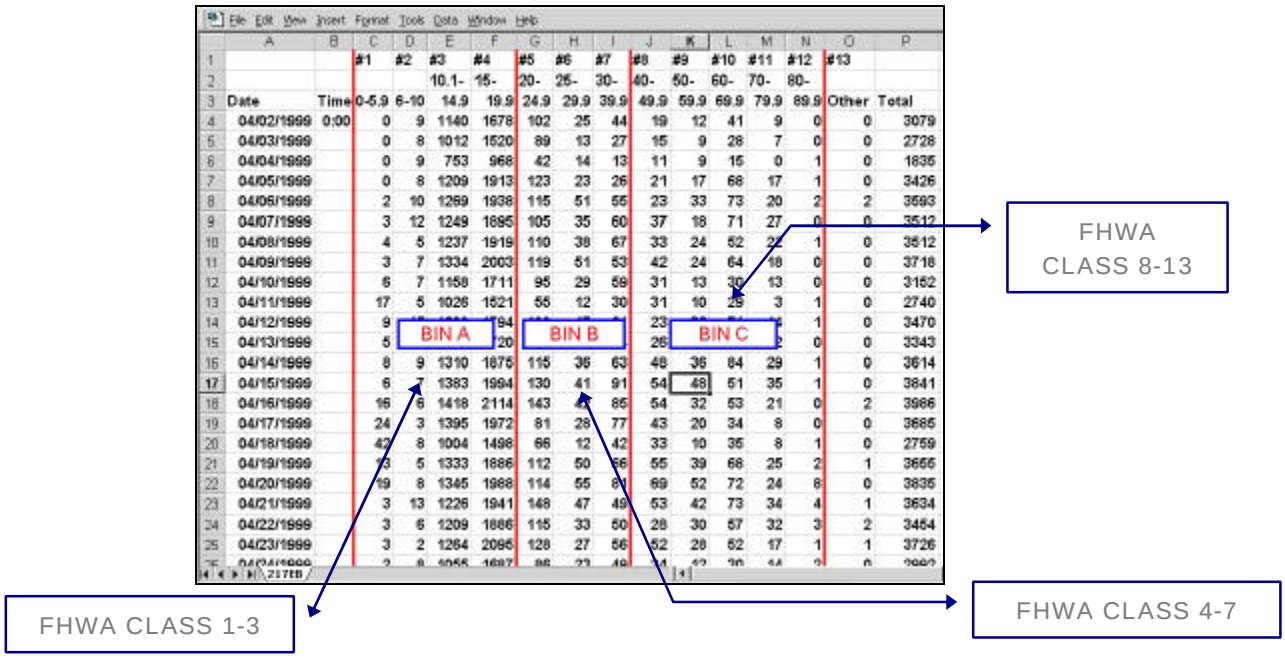


Figure 3.16. Bin Definitions

In each example, length bin counts were summarized for a period and compared with a data source. In every case, length data total volume was within ± 6% of the data sources' measured total volume. When comparing the bins, there was a large discrepancy noted between bin definition (A, B, C) and class definition (1-3, 4-7, 8-13). This indicated that CDOT would need to modify their length definition. As mentioned in the TMG, no single set of vehicle lengths work "best" for all states and no amount of fine-tuning will lead to perfect length classification. NCE recommends using the class distribution from a data source site (AVC, portable WIM or permanent WIM) and applying it to the total volume collected by the length site.

3.6.1 Comparison of Length Site 109 and CDOT Permanent Site 14

Length Site 109 was located on Interstate 70 at milepost 438.7 and CDOT Permanent Site 14 was located at milepost 365.3. These sites were approximately 73 miles apart. Both east and west directions were analyzed. In these examples, the data source was placed into Bins A, B, and C using the FHWA bin definition. These values were then compared with the values from the length site.

In the following Table 3.5 for the eastbound direction, NCE observed a +8% difference in Bin A, -14% difference in Bin B and –24% difference in Bin C. The total volume excluding errors was only off 109 vehicles or approximately 0%. Values of interest are in red font. In Table 3.6 for the westbound direction, NCE observed a +10% difference in Bin A, -2% difference in Bin B and –24% difference in Bin C. The total volume excluding errors was off 3371 vehicles or approximately 1%. Values of interest are in red font.

The item of most concern would be the difference in the Bin C value, which are the heavy combination type trucks (FHWA Class 8-13). The differences observed from this example were 10861 to 12686 trucks.

The other examples have been included in Appendix 5.

3.6.2 Findings of Expanding Length Data

Based on the information provided, a single set of vehicle lengths cannot be developed to expand the length data into the FHWA classification. However, total volume from length data did have a high level of accuracy. It is recommended that vehicle classification from a portable device be applied to total volume from the length data to expand the length data into the FHWA classification. In addition, NCE recommends that length data sites be upgraded to collect FHWA classification data or used only for total volumes and speed data.

Table 3.5. Length Site 109 and CDOT Permanent Site 14 Comparison for Eastbound Direction

Permanent WIM Data

	CLASS 1	CLASS 2	CLASS 3	CLASS 4	CLASS 5	CLASS 6	CLASS 7	CLASS 8	CLASS 9	CLASS 10	CLASS 11	CLASS 12	CLASS 13
SUM FOR DAYS PASSING QC	1201	121685	36275	1441	8636	710	9	1388	39466	347	2786	415	0
% CLASS OF BIN A	1%	57%	17%										
% CLASS OF BIN B				1%	4%	0%	0%						
% CLASS OF BIN C								1%	18%	0%	1%	0%	0%

Comparison of Bin Distributions for Permanent WIM and Length sites

	Length Site[1] 109	CDOT Perm[2] Site 14	Difference	% Difference
Total Counts for Bin A	146729	159161	12432	**8%**
Total Counts for Bin B	12258	10796	-1462	**-14%**
Total Counts for Bin C	55263	44402	-10861	**-24%**
Total Counts For Bins A-C	**214250**	**214359**	**109**	**0%**
Total Counts for Unclassified/Others	615	5481	4866	89%
Total Counts for All Vehicles	214865	219840	4975	2%

Period of Analysis

From 5/1/01 to 6/30/01

Exceptions:

5/4/01 to 5/6/01

5/12/01 to 5/13/01

5/29/01 to 6/4/01

06/14/2001

Distribution of Length Data using Permanent WIM Distribution

FHWA Classification	CLASS 1	CLASS 2	CLASS 3	CLASS 4	CLASS 5	CLASS 6	CLASS 7	CLASS 8	CLASS 9	CLASS 10	CLASS 11	CLASS 12	CLASS 13
Vehicles per class (Using Length Data)	1200	121623	36257	1440	8632	710	9	1387	39446	347	2785	415	0

Location of Sites

Length Site located on I-70 at MP 438.7

Perm. Site located on I-70 at MP 365.3

Approximately 73 miles apart

(1) Bins defined by length information (Bin A: 0'-19.9', Bin B: 20'-39.9', Bin C: 40'-90')

(2) Bins defined by FHWA classification (Bin A: Class 1-3, Bin B: Class 4-7, Bin C: Class 8-13)

Table 3.6. Length Site 109 and CDOT Permanent Site 14 Comparison for Westbound Direction

Permanent WIM Data

	CLASS 1	CLASS 2	CLASS 3	CLASS 4	CLASS 5	CLASS 6	CLASS 7	CLASS 8	CLASS 9	CLASS 10	CLASS 11	CLASS 12	CLASS 13
SUM FOR DAYS PASSING QC	1659	125715	36050	1565	10403	732	19	1392	47968	444	2836	368	0
% CLASS OF BIN A	1%	55%	16%										
% CLASS OF BIN B				1%	5%	0%	0%						
% CLASS OF BIN C								1%	21%	0%	1%	0%	0%

Comparison of Bin Distributions for Permanent WIM and Length sites

	Length Site[1] 109	CDOT Perm[2] Site 14	Difference	% Difference
Total Counts for Bin A	147142	163424	16282	**10%**
Total Counts for Bin B	12944	12719	-225	**-2%**
Total Counts for Bin C	65694	53008	-12686	**-24%**
Total Counts For Bins A-C	**225780**	**229151**	**3371**	**1%**
Total Counts for Unclassified/Others	698	14400	13702	95%
Total Counts for All Vehicles	226478	243551	17073	7%

Period of Analysis

From 5/1/01 to 6/30/01

Exceptions:
5/1/01, 5/8/01,
5/4/01 to 5/6/01,
5/12/01 to 5/13/01, 5/23/01
5/29/01 to 6/4/01
06/14/2001

Distribution of Length Data using Permanent WIM Distribution

FHWA Classification	CLASS 1	CLASS 2	CLASS 3	CLASS 4	CLASS 5	CLASS 6	CLASS 7	CLASS 8	CLASS 9	CLASS 10	CLASS 11	CLASS 12	CLASS 13
Vehicles per class (Using Length Data)	1613	123177	35537	1540	10245	752	18	1389	47840	440	2857	370	0

Location of Sites

Length Site located on I-70 at MP 438.7
Perm. Site located on I-70 at MP 365.3
Approximately 73 miles apart

(1) Bins defined by length information (Bin A: 0'-19.9', Bin B: 20'-39.9', Bin C: 40'-90')
(2) Bins defined by FHWA classification (Bin A: Class 1-3, Bin B: Class 4-7, Bin C: Class 8-13)

3.7 PROGRESS MEETING

On February 25, 2002, the NCE team flew to Denver, Colorado to discuss the progress of this project with the CDOT project team. The purpose of the meeting was to discuss the initial findings and activities. Also, this was an opportunity for the CDOT project team to provide direction to future activities.

NCE prepared a presentation for the CDOT project team. The meeting lasted approximately three hours, during which the NCE team presented their findings and CDOT asked questions.

CDOT wanted two products at the end of the project, namely, site-specific ESAL values for all segments and classification station recommendations. Please note that NCE was instructed to use the traffic growth rates provided by CDOT.

Following the meeting, NCE prepared minutes for CDOT to review. The official minutes are found in Appendix 6.

3.8 REVIEW CDOT PROCEDURES FOR ESAL CALCULATIONS

CDOT provided instructions on how cumulative ESALs would be determined for Colorado. First, a design period must be known. For this project, NCE will provide the 20-year ESAL for all segments with the base year being year 2000. The following items are the steps CDOT would use:

1) Determine ADT for midpoint of design period.
   a) Assume straight-line growth.

2) Use midpoint ADT and determine ADT for each vehicle type (CDOT 3 bin system).
   a) Passenger cars, pickup trucks.
   b) Single unit trucks.
   c) Combination trucks.

3) Multiply the number of each vehicle type by the appropriate 18-KIP equivalency factor. These values were developed in 1987.

a) Passenger cars	0.003 for flexible	0.003 for rigid
b) Single unit trucks	0.2490 for flexible	0.2850 for rigid
c) Combination trucks	1.0870 for flexible	1.6920 for rigid

4) Sum values for each pavement type. This gives you the equivalent daily single axle load.

5) Multiply the entire roadway equivalent daily single axle load by a lane factor.
   a) 2 lane = 0.60
   b) 4 lane = 0.45
   c) 6 lane = 0.30
   d) 8 lane = 0.25

6) Convert the above value from a daily value to a cumulative value by multiplying by the number of days in the design period.

Through this research project NCE developed the equivalency factors in step 3 of the above procedure for the FHWA classification system (1-13). These factors were applied directly to the primary segments and some derivative was applied to the rest of the network. As mentioned before, growth factors were supplied by CDOT.

CHAPTER 4. TASK C - DEVELOPMENT

The results from the review and analysis work were utilized for this task. Again, the primary goal was to develop 18-kip equivalency factors to reflect site-specific differences in traffic load characteristics throughout Colorado, and such factors shall reflect in the type and number of vehicles that traverse specific roadways.

A series of issues were investigated to properly develop site-specific 18-kip equivalency factors. Below is a list of the issues:

- *ESAL table development*. Reviewed classification distribution and weight data processed in previous task. Developed axle load spectra for each WIM data source. Reviewed the historic trends of axle load from the WIM systems (that have operated properly). Developed equivalency factors to apply to axle load data and created ESAL per vehicle values.
- *Group development.* Studied the spatial properties of vehicle volume and classification counts from data sources. Investigated functional class as grouping. Evaluated the number of WIM data sources per functional class group.

4.1 ESAL TABLE DEVELOPMENT

There were two main items used in the new ESAL table— classification and weight information. As mentioned before, NCE applied classification and weight data directly to the primary segments. This included the use of LTPP historical weight information. This information was "inserted" into the CDOT-provided table, *TraffOn.mdb*. The new ESAL table was renamed as ESAL2000.xls.

For the purposes of the ESAL table development, FHWA classes 1-3 weights were ignored. These vehicles usually are not weighed and contribute little to pavement damage. As an example, a 4,000 pound passenger car would generate only 0.0004 ESALs and therefore it would take roughly 6,000 passenger cars to equal the number of ESALs of one fully loaded FHWA class 9 five axle truck.

4.1.1 Classification Distribution

For the CDOT permanent WIM, portable WIM and AVCs, the distribution of traffic volume was obtained during the data processing effort. All lanes, all directions and all years provided were calculated. The AADT and AADT-T were also calculated for the data source segment.

For LTPP sites, the new classification data (4 or C-card) could not be used due to problems generating the card data from the equipment software. In order to determine percent trucks from total traffic, NCE used historical truck percentages. This historical truck percentage allowed us to calculate AADT.

4.1.2 Weight Information

Determining ESAL per vehicle factors from the weight data was more involved than the classification distribution. ESAL values can vary depending on the differences in the pavement type and structural strength of a particular section (6). This difference can be observed in Figure 4.1, where ESALs for the same axle weight with differing pavement types and terminal serviceabilities are shown. It is clear that the thickness of the pavement structure has a small effect on the ESAL calculation regardless of pavement type and using a terminal serviceability of 3.0 rather than 2.5 had a similar effect. However, pavement type, whether asphalt concrete (AC) or portland cement concrete (PCC), does have a significant impact on the ESAL calculation. Note that the PCC examples are at least 0.5 ESALs higher than the AC examples.

For LTPP sites, NCE used the known structural number or depth. Otherwise, a default of terminal serviceability of 2.5, structural number of 5 and depth of 8 inches were used. These values can be changed if requested.

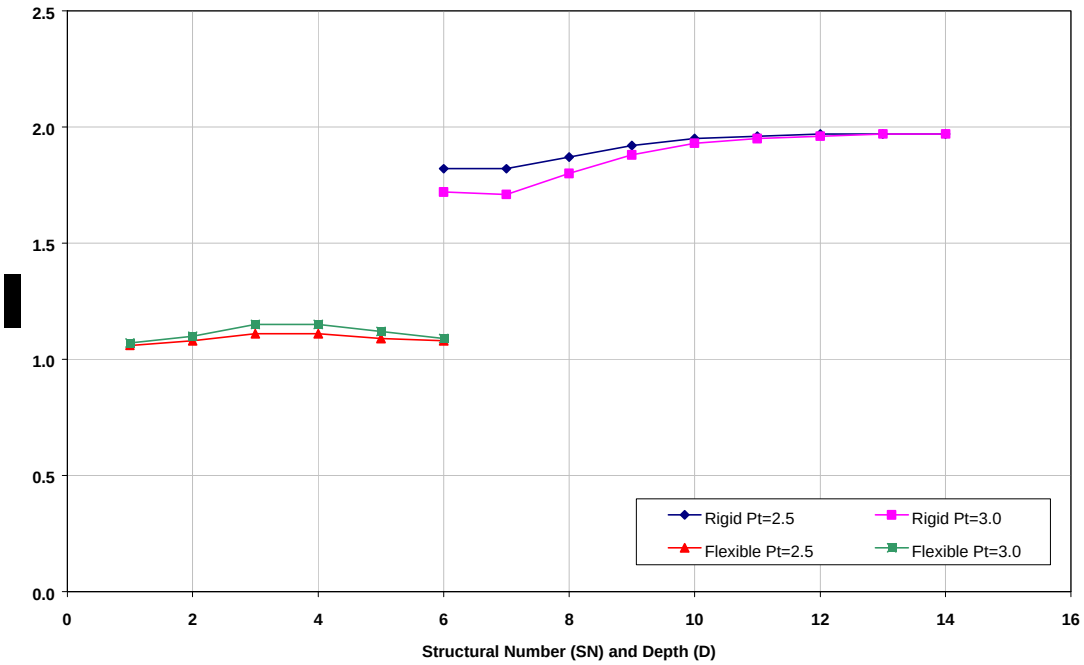


Figure 4.1. Flexible and Rigid Pavement ESALs vs. Structural Number and Depth

4.1.3 Axle Group Loads

Because of interest in the upcoming 2002 Pavement Design Guide and the use of load spectra, NCE investigated axles load for single, tandem, tridem and quad axle groups. For each site, an electronic file was produced. This file has a graph of each axle group that shows the number of axles versus the axle load weight bin (see Figure 4.2). A weight bin is similar to a class or length bin. An axle is weighed by a WIM and depending on its weight is placed in a weight bin with a

weight range of several thousand pounds. These load spectra could be used in future work. At the end of this research project, load spectra information for available sites will be provided to CDOT electronically.

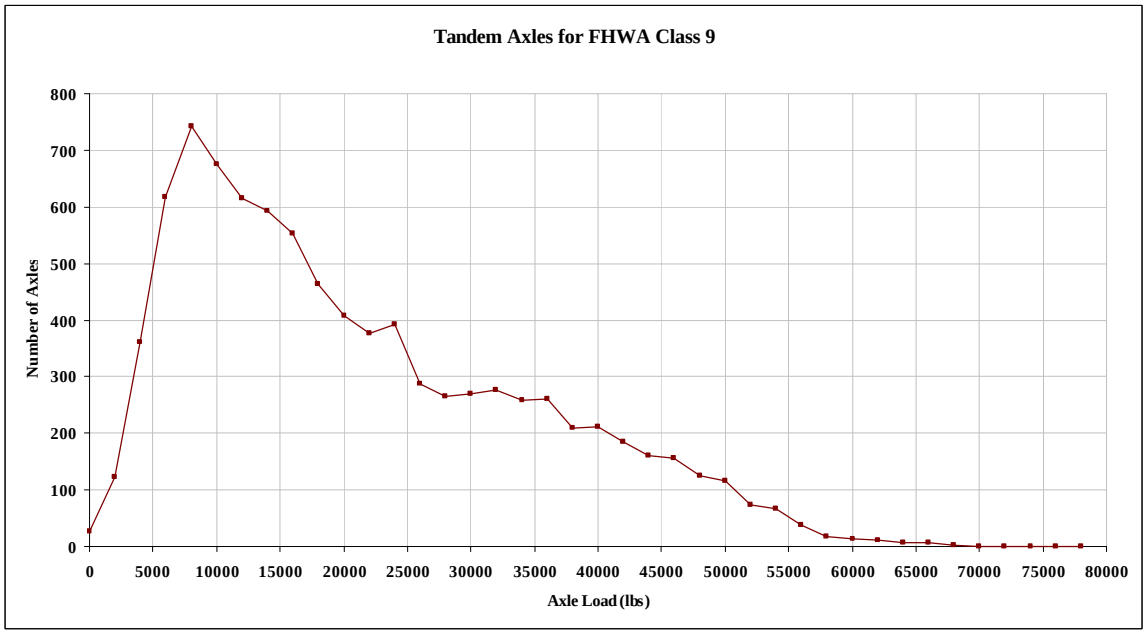


Figure 4.2. Load Spectrum Example for LTPP Site 081029 FHWA Class 9

4.1.4 Axle Load Equivalency Factors

NCE used AASHTO equations for axle load equivalency factors as presented in Appendix MM, AASHTO Volume 2 1986 (3). These factors were calculated with the default structural number or depth. These data inputs can be changed if requested.

NCE did not include axles above 10% of the axle legal limits in Colorado: Single axle weight limit is 20,000 pounds, tandem axle limit is 40,000 pounds and tridem axle weight limit is 54,000 pounds. This was done due to instances where a few axles were at an extremely high weight bin and therefore dominated the ESAL value. Axles at such a high weight would likely break and were thought to be a bad weight record. The reduction in the number of axles was less than 10% for each axle group.

By applying the axle load equivalency factors, the cumulative ESALs for each truck vehicle class (FHWA Class 4-13) were calculated.

4.1.5 ESAL Per Vehicle

ESAL per vehicle is simply the cumulative ESALs divided by the number of vehicles for each class. For sites with more than one year of data, NCE chose to provide a weighted average ESAL per vehicle value.

The reasons for providing a weighted average were due to problems identifying certain classes and the rarity of certain vehicle classes. For instance, FHWA Class 7s were very rare. The presence of Class 7s may indicate a special industry in the area that uses that type of truck, equipment problems or misclassification. Because there were few Class 7s, we generally do not consider them. The heavier trucks (e.g., FHWA Class 9) were the dominant vehicles on roadways and created the most damage.

As an example, NCE investigated LTPP Site 081029. There were 3 years of new data and 4 years of historical LTPP data. The number of Class 7s ranged from 2 to 1146 vehicles. Most of the years investigated had over 150 days of data. The ESALs per vehicle value had a range of 0.025 to 4.0. A simple average of all values could have been done but NCE chose to make the average sensitive to the number of vehicles that were weighed. Even with these efforts, the standard deviation was still large for some vehicle classes.

The following general equations were used for each truck vehicle class (4):

$$\overline{X} = \frac{\sum_{year=1}^{n} X \times \#\ of\ \ vehicles}{\sum_{year=1}^{n} \#\ of\ \ vehicles} \qquad \text{Eq. 4.1}$$

$$s = \sqrt{\frac{\sum_{year=1}^{n} \left(X - \overline{X}\right)^2}{N-1}} \qquad \text{Eq. 4.2}$$

$$COV = \frac{s}{\overline{X}} \qquad \text{Eq. 4.3}$$

where X equals the ESAL per vehicle for a particular year, $\overline{X}$ equals the weighted average, N equals the number of observations (years), s equals the standard deviation, and COV equals the coefficient of variation of the sample.

An example summary sheet has been provided in Appendix 7. In addition, all summary sheets have been provided electronically.

4.2 GROUP DEVELOPMENT

The TMG specifically discusses groups such as functional classification, geographic and route-specific alternatives (1). The discussion up until now has mainly been about the primary segments. In order to apply some derivative of the monitoring data to the other 4400 segments, NCE investigated ways to group segments. Usually, agencies use some manner of grouping to describe trends within monitored traffic data sets. For example, an agency may be interested in seasonal or day of week patterns. To understand where patterns exist and how they are distributed may be costly. In terms of creating factors for short duration type data collection and for cost-effectiveness, an agency will create groups to analyze these processes.

Depending on what is to be learned from this analysis, groups can be based on traffic, geographic or functional class similarities. For instance, CDOT categorizes its segments into seasonal factor groups when developing seasonal factors. These factors as mentioned before were to reduce the temporal bias from short duration counts.

4.2.1 Functional Classification

Groups that can be used readily are a roadway's functional classification as defined by the FHWA. Functional classification is a process by which roadways are grouped according to the character of service they provide (see Figure 4.3). For this project, CDOT provided the functional classification of every segment. Functional classification is divided into urban and rural areas due to the different characteristics observed (i.e., density, land use). Table 4.1 presents the codes of the functional classification system and subsystem areas as defined by FHWA.

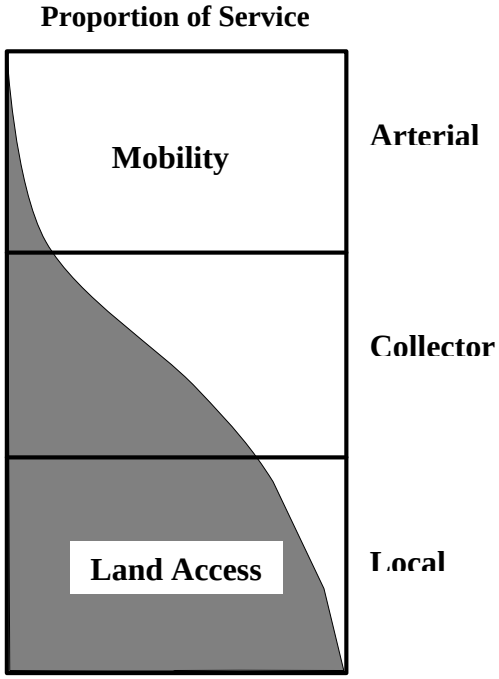


Figure 4.3. Relationship of Functionally Classified Systems in Serving Mobility and Land Access

Table 4.1. Functional Classification Codes

Rural		Urban	
	Code		**Code**
Principal Arterial-Interstate	01	Principal Arterial-Interstate	11
Principal Arterial – Other	02	Principal Arterial – Other Freeways or Expressways	12
Minor Arterial	06	Principal Arterial-Other	14
Major Collector	07	Minor Arterial	16
Minor Collector	08	Collector	17
Local System	09	Local System	19

4.2.2 Other Groups

NCE considered other group definitions:

- Combination of functional classification and truck volume.
- Combination of functional classification and CDOT regions.
- Combination of functional classification and specific roads.
- Combination of functional classification, geographic location and specific roads.

For any case, there must be intimate knowledge and professional experience of traffic in the network to define groups. The creation of groups involves balancing the need to easily define a group of roads against the desire to ensure that all roads within a given group have similar travel patterns.

4.2.2.1 Combination of Functional Classification and Truck Volume

For the combination of functional classification and truck volume grouping, the functional classification group can be divided into at least two groups based on ADT-T. These subgroups should be based on a high and low truck volume. The truck volume limit can be defined by obvious truck volume differences (e.g., several sites have an ADT-T of 1000 while the other sites have an ADT-T of 3000) or by a straightforward statistic such as average or median of truck volumes. If there are more than two obvious truck volume limits, there should be additional subgroups created (see Table 4.2). This type of group definition should be applied to all functional classifications.

Table 4.2. Example of Potential Functional Classification 01 & Truck Volume Grouping

Group	Code	Subgroup
Principal Arterial-Interstate 01	A	High ADT-T (greater than median or other user defined limit)
	B	Low ADT-T (lower than median or other user defined limit)
	X	Additional groups if needed

Although the truck volume grouping may create factors that statistically are closer (which is not guaranteed), these factors may be too narrow to represent the group. Additionally, there may be too few data sources to represent the more narrow groups. This topic is discussed in Section 4.2.3.

4.2.2.2 Combination of Functional Classification and CDOT Region

For the combination of functional classification and CDOT region grouping, the functional classification group can be divided into as many as six groups based on CDOT regions (see Table 4.3). However, like the last case, there may be too few data sources to represent the more narrow regional groups.

Table 4.3. Example of Potential Functional Classification 01 & CDOT Region Grouping

Group	Code	Subgroup
Principal Arterial-Interstate 01	A	Segments within CDOT Region 1
	B	Segments within CDOT Region 2
	C	Segments within CDOT Region 3
	D	Segments within CDOT Region 4
	E	Segments within CDOT Region 5
	F	Segments within CDOT Region 6

4.2.2.3 Combination of Functional Classification and Specific Roads

Similar to the last case, functional classification and road-specific grouping could be used to create groups. This can be done by developing road-specific groups within a functional classification (see Table 4.4). Again, there will be too few data sources to represent the more narrow groups. Additionally, subgroups would require a dense network of data sources, which may not be economically feasible.

Table 4.4. Example of Potential Functional Classification 01 & Road Specific Grouping

Group	Code	Subgroup
Principal Arterial-Interstate 01	A	Segments for Interstate 25
	B	Segments for Interstate 70
	C	All other segments
	X	Additional groups if needed

4.2.2.4 Combination of Functional Classification, Geographic Location and Specific Roads

For the combination of functional classification, geographic location and specific roads, groups can be created outside the functional classification grouping. Route-specific or region-specific groups would be made prior to utilization of the functional classification groups. For example, Interstate Highway 70 could become a group. It has nine sites covering most of the route across the state except for the metropolitan area of Denver. Another group could be developed for metropolitan areas. This grouping may again be too specific thus lacking enough data sources to represent the group. Table 4.5 shows an example of the potential groups.

Table 4.5. Example of Potential Functional Classification, Geographic Location and Road-Specific Groups

Group	Code	Description
Interstate 70	A	Road specific. Other groups could be given precedence if boundaries cross (e.g., Metropolitan Areas).
Metropolitan Areas	B	Geographic location. Could contain data source information for Denver and other urban areas.
Principal Arterial-Interstate 01	01A	Rural interstates in eastern Colorado.
Principal Arterial-Interstate 01	01B	Rural interstates in western Colorado.

4.2.3 Data Source Evaluation

One of the main goals of this project was to evaluate the number of WIM sites needed in the CDOT network. NCE has not differentiated between permanent and portable WIM sites. As discussed in this report, portable equipment can be used to obtain quality data that is typical of a permanent continuous WIM. NCE used the functional classification definition for grouping because it was a known variable for all segments and other grouping methods did not guarantee a better end product. As mentioned before, there must be intimate knowledge and professional experience of traffic in the network to define groups. The creation of groups involves balancing the need to easily define a group of roads against the desire to ensure that all roads within a given group have similar travel patterns.

In Table 4.6, the number of data sources from each function classification group is presented. These data sources can be permanent WIM, portable WIM, AVC or LTPP data. Also, these data sources may or may not have all lanes collected. Generally, for LTPP sites only the LTPP lane was submitted. As can be seen, no urban minor arterial, rural major collector, urban collector or local system had a representative data source.

Table 4.6. Number of Data Sources per Functional Classification Group

Rural	Code	Number of Data Sources	Urban	Code	Number of Data Sources
Principal Arterial-Interstate	01	11	Principal Arterial-Interstate	11	3
Principal Arterial – Other	02	12	Principal Arterial – Other Freeways or Expressways	12	1
Minor Arterial	06	4	Principal Arterial-Other	14	4
Major Collector	07	-	Minor Arterial	16	-
Minor Collector	08	1	Collector	17	-
Local System	09	-	Local System	19	-

4.2.3.1 WIM Data Sources Needed

In order to recommend a set of core WIM sites through a statistical approach, there should be an understanding of which weight variable should be compared and the desired functional classification group precision. Appendix 8 shows example calculations of determining the number of WIM data sources per group as described in the TMG. Although the statistics may seem complex, the approach is manageable.

NCE would recommend using FHWA Class 9 vehicles in the analysis because they are the most common truck in the network. Next, a decision needs be made on what weight variable (e.g., ESALs per vehicle or GVW per vehicle) should be compared and used to determine precision. The precision will be different depending on which weight variable is chosen. NCE would recommend using GVW since it is an understood quantity and does not change depending on site. ESALs, on the other hand, are dependent on pavement structure and may not be used in the future traffic work.

In Appendix 8 Example 2, NCE showed the statistics for the functional class 01 group (rural principal arterial interstate) that were calculated from five LTPP sites. These sites were located on Interstate 25 (south and north central Colorado) and Interstate 70 (west central Colorado). The average GVW weight was 50,699 lbs with a standard deviation of 2,756 lbs. If the desired GVW was within ± 10% of the GVW of a Class 9 truck (approximately 5,100 lbs), it would require three WIM sites for 80% level of confidence and four WIM sites for 95% level of confidence.

Table 4.7. Number of Segments per Functional Classification Group and Percent Coverage

		Number of Segments		
Code	**Data Sources**	**With Applicable WIM Data**	**Total ***	**Percent Coverage**
01	11	169	283	60%
02	12	107	806	13%
06	4	33	1065	3%
07	0	0	507	0%
08	1	1	75	1%
09	0	0	17	0%
11	3	44	225	20%
12	1	19	282	7%
14	4	55	1227	4%
16	0	0	287	0%
17	0	0	24	0%
19	0	0	4	0%

* 70 segments classified as two functional classifications. These segments are included in both functional classification totals. 73 segments do not have a designated functional classification.

Although this analysis indicated that only three or four WIM data sources were needed to satisfy the GVW criteria, the TMG recommends at least six sites per group. The exception to this general rule is specialty roads that have unusual loading conditions (e.g., recreational area or gravel pits). As mentioned in Appendix 8, adding more sites per group or creating new groups can achieve improvements to precision. NCE has used a minimum of six sites per group to provide recommendations for new WIM data sources.

Table 4.7 presents the functional classification groups with the number of segments with directly applicable WIM data and how that compares with the total number of segments in the functional classification group. In addition, NCE could compare which functional classification groups already had enough representative data sources (six sites) and provide insight on new WIM data sources. From the initial review of the table, it was observed that only functional classification groups 01 and 02 have more than the recommended six sites.

4.2.3.2 Selection of New WIM Sites

Potential new WIM sites are discussed in this section. As mentioned before, NCE did not differentiate between permanent and portable WIM sites. As discussed in this report, portable equipment can be used to obtain quality data that is typical of a permanent continuous WIM. Although six sites were recommended for each functional classification group, it is unlikely CDOT will be able to install equipment at such locations at local systems or minor collectors. The following is a hierarchy for investing in new WIM sites:

1. Incorporate continuous WIM that is required by the CDOT pavement warranty program. The benefits of additional WIMs can only be measured in conjunction with the location of the new equipment.

2. Add new WIM data sources to functional classification groups with greater importance given to mobility within the network. This would apply to functional classification groups 01, 02, 11, 12 and 14. As mentioned before, functional classification group 01 has enough data sources and adequate coverage (60%).

However, even though functional classification group 02 has twelve data sources, those data sources are only covering 13% of the group. NCE recommends adding four more sites (see Table 4.8) if economically feasible. These sites were identified by reviewing which routes had the most number of segments and still needed WIM data. The addition of these sites will increase coverage from 13% to 20%.

Table 4.8. Recommended New WIM Sites for Functional Classification 02

Route	WIM Location (MP)	Reference Mile Post		Miles Covered	Number of Segments Covered	Description of Location
		Beginning	Ending			
40	107.059	93.000	127.568	34.7	10	Craig to Steamboat Springs
50	252.663	210.564	277.504	66.7	21	SH 285 Jct to Texas Creek
50	452.769	452.769	467.583	14.8	8	SH 385 Jct to KS border
160	41.935	41.935	81.186	36.9	13	CO Rd 34 to CO Rd 207

For functional classification 11, NCE recommends adding at least three more sites (see Table 4.9). These sites were selected to get a minimum of six sites in this group. The addition of these sites will increase coverage from 20% to 30%.

Table 4.9. Recommended New WIM Sites for Functional Classification 11

Route	WIM Location (MP)	Reference Mile Post		Miles Covered	Number of Segments Covered	Description of Location
		Beginning	Ending			
25	12.886	11.013	15.585	4.5	7	Starkville (near NM border) to SH 160
225	0	0	11.997	12.0	8	I 25 to Arapahoe/Adams county line (Denver)
270	0	0	5.351	5.3	9	I 76 to SH 35 (Denver)

For functional classification 12, NCE recommends adding at least five more sites (see Table 4.10). These sites were selected to get a minimum of six sites in this group. The addition of these sites will increase coverage from 7 to 26%.

Table 4.10. Recommended New WIM Sites for Functional Classification 12

Route	WIM Location (MP)	Reference Mile Post		Miles Covered	Number of Segments Covered	Description of Location
		Beginning	Ending			
6	272.64	271.602	275.65	4.1	7	SH 58 to WB I-70 (Denver)
45	4.734	4.734	8.62	3.9	9	SH 96 Jct to SH 50 Jct (Pueblo)
83	2.904	0.782	5.351	7.1	21	SH 115 to SH 29 (Colorado Springs)
85	203.802	201.496	206.012	4.5	8	Littleton to Sheridan (Denver)
85	233.096	227.345	235.104	7.537	8	Commerce to Brighton (Denver)

For functional classification 14, NCE recommends adding at least two more sites (see Table 4.11). These sites were selected to get a minimum of six sites in this group. The addition of these sites will only increase coverage from 4% to 7%.

Table 4.11. Recommended New WIM Sites for Functional Classification 14

Route	WIM Location (MP)	Reference Mile Post		Miles Covered	Number of Segments Covered	Description of Location
		Beginning	Ending			
82	0.503	0.07	2.194	2.3	9	I-70 to 23rd Street (Glenwood Springs)
287	283.457	282.679	289	6.4	23	US 40 to I-76 (Denver)

3. Add new WIM data sources to functional classification groups with less mobility. These groups would be 06 (1065 segments), 07 (507 segments) and 16 (287 segments) in descending order of number of segments. These are less important than the previously mentioned functional classification groups and new data collection should be performed if economically feasible. These functional classification groups account for approximately 39% of the network.

4.2.3.3 Equipment Cost Estimates

The following section provides estimated costs for the purchase, installation, and maintenance of WIM equipment. Installation costs are based upon a contracted bid for a turn-key operation. These estimated costs did not take into consideration associated factors such as roadway maintenance, repair, and traffic delays.

There are many variables that may affect the cost of installing, maintaining and calibrating AVC and/or WIM systems. Probably the biggest variable will be the cost of obtaining power and telephone service to the site. The estimated costs for these services were based upon power and telephone service being within 20 feet of the site with an estimated total cost of $14,000. Other variables that affect costs are: site selection, site location, drainage, soil conditions, pavement conditions, in-roadway equipment configuration, city installation, full freeway limits, contractor installation costs, traffic control requirements, power and telephone line location availability, equipment calibration, available manpower usage and construction equipment usage. The actual costs will vary for each specific application, so using these estimated costs should be used for relative comparisons only.

These estimated costs are based upon information provided by various western SHAs and from a presentation of WIM Technology – Economics and Performance presented at NATMEC 1998 by Andrew J. Pratt.

WIM Cost Estimates: Estimated costs are for in-roadway sensors: A. Piezo, B. Bending Plate WIM. No portable WIM on-roadway or WIM portable equipment were considered for this estimate.

Piezo WIM:

The piezo WIM would consist of two class 1 piezoelectric sensors, two inductive loops and one temperature sensor for one lane of traffic being monitored for both directions with roadside pull boxes and conduit connection to a roadside control cabinet with power and phone line connections.

	Equipment and Installation By Private Contract	
a. Control cabinets and mounts	$6,500	
b. Pull boxes	1,100	
c. Detector loops	2,100	
d. Power service	7,000	
e. Telephone service	7,000	
f. Mobilization	3,400	
g. Traffic control	2,900	
h. Conduit	3,400	
i. Piezo type 1 cable	8,100	
j. WIM equipment	10,000	(Includes calibration acceptance testing).

Estimated costs for two lanes = $51,500. Estimate for piezoelectric for one lane is $25,750.

Estimated maintenance cost per year per lane is $5600 (includes one calibration session). Life expectancy of WIM piezoelectric in-roadway equipment is estimated at 4 years.

Bending Plate:

The bending plate WIM sensors will be installed in a construction 100- by 12- by 1-ft concrete pad in an asphalt roadway. The in-roadway sensor will consist of one bending plate frame with two bending plates with sensors, two inductive loops, and one off scale sensor installed in one lane of traffic. Also, roadside pull boxes and conduit connection to a roadside control cabinet with power and phone line connections were assumed to be available.

One lane installation cost estimates:

	Equipment and Installation By Private Contract
a. Control cabinets and mounts	$6,500
b. Pull boxes	1,100
c. Detector loops	2,100
d. Power service	7,000
e. Telephone service	7,000
f. Mobilization	3,400
g. Traffic control	6,000
h. Conduit	3,500
i. Bending plate frame and plates	14,100
j. WIM equipment	15,000 (Includes calibration acceptance testing).
k. Construction concrete pad	21,900

Estimated costs per lane = $87,600. For two lanes installation is $175,200.

Estimated yearly maintenance cost per lane is $5600 (includes one calibration session). Life expectancy for the bending plate installed in a concrete pad is estimated at 10 years.

4.2.4 Findings of Data Source Evaluation

NCE recommends six sites per group except for local systems and minor collectors. As mentioned before, improvements to precision can be accomplished by adding more sites per group or creating new groups (further breaking down a functional classification by direction, geographical area, etc.).

NCE provided a hierarchy for selecting new WIM sites. New continuous WIM sites installed as part of the pavement warranty program should be incorporated into the network. Next, sites were selected for functional classifications 02, 11, 12 and 14, which generally have greater mobility. Finally, if funds were available, functional classifications 06, 07, and 16 should be addressed in descending order of number of segments in the network.

NCE provided rough cost estimates for piezo and bending plate WIM equipment. Piezos were recognized as cheaper in total cost than bending plate systems but have a shorter life span.

As a caveat, lack of data to properly describe a particular functional class exposes the limitations of using such data in a pavement design. Without safety factors, the design ESALs for non-primary segments should be suspect. Future recommendations should be to utilize portable WIM or AVC to get design quality classification and weight.

CHAPTER 5. TASK D - APPLICATION

Based on the results of previous tasks the NCE team populated the new ESAL table named ESAL2000.xls with updated information. For a given road segment, load equivalency factors, traffic volume, and classification data were used to estimate ESALs for the base year, 10-year, and 20-year cumulative periods.

5.1 ELEMENTS OF NEW ESAL TABLE

ESAL2000.xls contains all the information provided in the original table called *TraffOn.mdb*. NCE added markers to identify primary segments, data sources, functional classes, seasonal groups, ESAL 2000, ESAL 2002, cumulative ESAL 2010, cumulative ESAL 2012, cumulative ESAL 2020 and cumulative ESAL 2022.

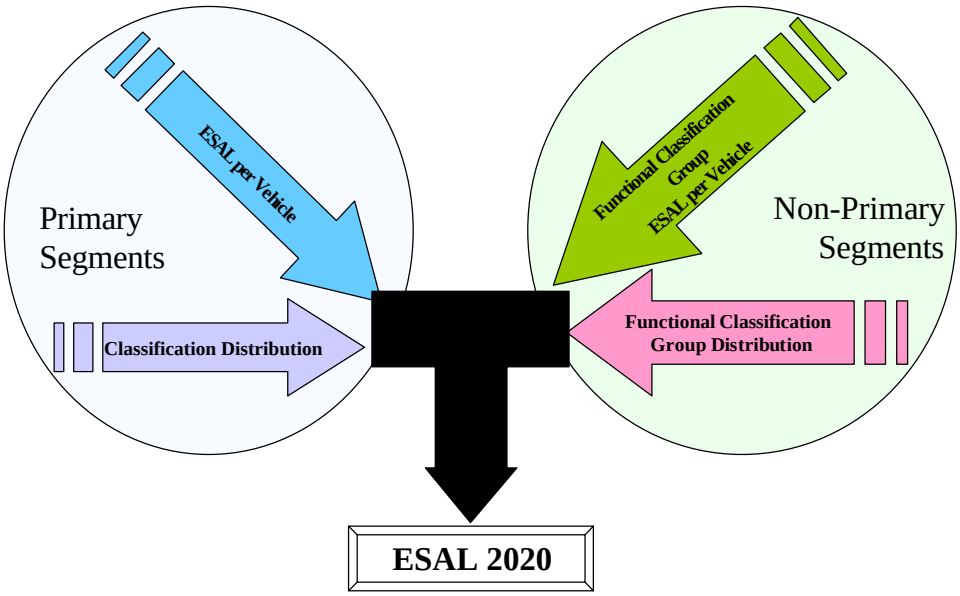


Figure 5.1. Elements of New ESAL Table

5.1.1 Classification Distribution and ESAL per Vehicle

New worksheets were added to ESAL2000.xls that contain classification distribution and ESAL per vehicle. These worksheets were named for their specific data source and functional classification group (e.g., 1053 which is LTPP site 081053 or A124 which is CDOT AVC 124). These worksheets also indicated which year and lane were used for ESAL calculations.

5.1.2 Non-Primary Segment Values

For non-primary segments, a worksheet was created for the available functional classification groups. The functional classification groups were discussed in the previous chapter. Appendix 9

contains the ESAL per vehicle values for the available functional classifications and the statewide average.

5.1.3 ESAL Calculation

The following general equation was used for all segments to calculate cumulative ESALs for the new table. The design ESALs were for the outside or travel lane. For segments where data sources were located, highest AADT-T was selected independent of direction.

$$ESAL(Year) = VOL_{segment} \times 365\ days \times CF \times LF \times [(CD4)\times(ESAL4)+(CD5)\times(ESAL5)+\ldots+(CD13)\times(ESAL13)] \quad \text{Eq. 5.1}$$

The following variables are defined as:

- *ESAL(Year)* equaled *ESAL* for base year 2000, base year 2012 cumulative ESAL 2010, cumulative ESAL 2012, cumulative ESAL 2020 or cumulative ESAL 2022.
- *VOL segment* equaled *AADT-T* from data source or from original *TraffOn* provided by CDOT.
- *CF* equaled *Cumulative Factor* calculated from growth factor information in original *TraffOn* provided by CDOT. This value moves base year ESAL to 10 and 20 year cumulative values. For base year 2000, the value was just 1.
- *LF* equaled *Lane Factor* from CDOT design practices. This values changes from an all lanes calculation to just design lane calculation. For data source segments, LF was 1 because AADT-T was taken directly from data.
- *CD(#)* equaled *Classification Distribution* percentage expressed in FHWA Class 4 to 13 for each site, functional classification group or statewide average.
- *ESAL(#)* equaled *ESAL per vehicle per class* for rigid and flexible pavements. This value was either site-specific, functional classification group or statewide average. The statewide average was used for 143 segments out of 4806 segments because no designated functional classes were assigned.

5.1.4 View of ESAL2000

As mentioned before, the ESAL2000.xls file contains worksheets with classification/ESAL information for both data source and functional classification group. Other worksheets include: *Legend* which lists the primary segments and data sources, *Ancillary Information* which provides additional information about the data sources and assumptions that were made in unique cases, and *ESAL2000* which contains the base year and cumulative ESAL values. *Legend* and *Ancillary Information* worksheets are provided in Appendix 10.

Table 5.1 shows an example of the information provided in *ESAL2000*. There are other columns in the file that have been hidden in the example in order to see detail.

The segment shown in the example, segment 4, is located on State Highway 14 from MP 144.1 to 153.6 outside of Ault (CDOT Region 4). The data source for this segment is CDOT Permanent Site 7 at MP 152. It has been bolded and has the designation 4A.

The CDOT AADT-T is used for all segments except the data source segment 4A. Classification and ESAL per vehicle are used for the data source segment and the primary segment 36. This information is on a worksheet called C004. The ESAL 2000, 2002, 2010, 2012, 2020 and 2022 is for the outside or travel lane. For the area that is not shaded green (not in primary segment 36), ESAL 2000, 2010 and 2020 are calculated using functional classification group 06 data (e.g., the segment located at MP 154).

Please note that ESAL per vehicle class were calculated using a weighted average as described in Section 4.1.5. There may be sites where flexible ESAL per vehicle factors are slightly greater than rigid ESAL per vehicle factors. For example, LTPP site (087783) is a flexible pavement site with six years of data utilized for the flexible values. The flexible ESAL per vehicle class values were calculated using the known structural number (6.4) as opposed to the default value (5.0). For the rigid values, only 1997 and 1998 were calculated at the default value of depth (8 in). If only 1997 and 1998 flexible and rigid values are compared, the rigid values are greater than the flexible values. If all years of the flexible values and the two years of rigid values are compared, the flexible values are greater than the rigid values. The LTPP data slightly skews the flexible ESAL per vehicle values. Appendix 7 presents an example of the ESAL summary sheet.

Table 5.1. Example of ESAL2000 Spreadsheet for Segment 36

route	refPt	endRefPt	length	Lanes	Lane Factors	description	AADT-TNCE	Segment	GF	Functional Class	**RIGID ESAL 2000**	**RIGID ESAL 2010**	**RIGID ESAL 2020**	**FLEXIBLE ESAL 2000**	**FLEXIBLE ESAL 2010**	**FLEXIBLE ESAL 2020**
014C	142.182	144.152	1.92	2	0.6	RD N AND S (LARIMER CO RD 901) LARIMER-WELD COUNTY LINE	1200		1.42	6	219861	266032	312203	154562	187020	219478
014C	144.152	145.107	1	2	0.6	JCT SH 257 S RD N (CO RD 17)	656	4	2.17	6	166093	263258	360422	110347	174900	239454
014C	145.107	147.02	1.98	2	0.6	RD N (CO RD 19)	656	4	1.66	6	166093	220904	275715	110347	146762	183176
014C	147.02	150.153	3.03	2	0.6	RD S (CO RD 23)	676	4	1.73	6	171157	233629	296102	113711	155216	196721
014C	150.153	151.149	1.01	2	0.6	RD N AND S (CO RD 29)	726	4	1.91	6	183817	267453	351090	122122	177688	233253
014C	**151.149**	**152.162**	**1**	**2**	**0.6**	**RD N AND S (CO RD 31)**	**510**	**4A**	**2.99**	**6**	**112561**	**224559**	**336557**	**74782**	**149190**	**223598**
014C	152.162	153.017	0.85	2	0.6	RD N AND S (CO RD 33)	655	4	2.99	6	165840	330851	495862	110179	219807	329435
014C	153.017	153.37	0.36	2	0.6	RD N (BIRCH AVE)	678	4	2.17	6	171663	272086	372510	114048	180766	247484
014C	153.37	153.622	0.17	2	0.6	JCT U.S.85 SH 85 NW AND SE	466	4	1.86	6	117987	168721	219456	78387	112093	145800
014C	153.622	154.21	0.66	2	0.6	RD N AND S (3RD AVE) LEAVE AULT CITY LIMIT	404		1.86	6	74020	105848	137677	52036	74411	96787
014C	154.21	157.35	3.04	2	0.6	RD N AND S (CO RD 37)	464		1.86	6	85013	121568	158124	59764	85463	111161
014C	157.35	159.37	2.02	2	0.6	RD N AND S (CO RD 43)	350		1.57	6	64126	82402	100678	45081	57929	70777

CHAPTER 6. SUMMATION

6.1 CONCLUSIONS

The following conclusions can be drawn from this research project:

- Analyzed permanent and portable WIM data. Snapshots of permanent WIM were also utilized to mimic short duration counts. The analyses indicated that sampling data a few times per year may preclude the installation of new costly permanent WIMs. The *8 day snapshots* of data were closer to the truth ADT-T than the *2 day snapshots* of data. (Task B)
- Adjustment factors that adjusted the temporal bias from short duration data collection were beneficial for sites. The factored ADT-T was closer to the truth ADT-T than the non-factored ADT-T in almost every case. However, for the eastbound direction of CDOT Permanent Site 8, the factored ADT-T from the 7-Card data evaluation was not closer to the truth ADT-T. This shows the inherent problems with short duration counts and adjustment factors. NCE (Task B)
- Created network maps for each CDOT-defined region. Identified all data sources on physical maps as well as electronic maps. (Task B)
- Length data could not be expanded into the FHWA classification scheme. (Task B)
- Length data could be used for volume information. (Task B)
- Documented CDOT procedure to calculate cumulative ESAL. (Task B)
- Developed axle load spectra for each WIM data source. Reviewed the historic trends of axle load from the WIM systems (that have operated properly). Developed equivalency factors to apply to axle load data. (Task C)
- Developed groups based on functional classification in order to apply monitoring data to segments where no data source was available. (Task C)
- Evaluated the number of WIM data sources per functional class group. Documented the number of WIM sites that will be needed to achieve a desired accuracy. (Task C)
- Formulated hierarchy for new data collection efforts based on functionality of roadway and number of segments that have no monitoring data. WIM data is needed for at least functional class group rural major collector (07) and urban principal arterial other freeways (12). (Task C)
- Illustrated limitations due to amount of monitoring data available. (Task C)
- Calculated base year, 10-year and 20-year ESALs for flexible and rigid pavement, where data was available. (Task D)
- Populated new and more accurate ESAL design table for use in pavement design and rehabilitation activities. This will result in cost savings to CDOT by increasing the accuracy of the pavement design and rehabilitation process. (Task D)

6.2 RECOMMENDATIONS

As a part of this research project, NCE recommends the following:

- Increasing frequency of classification and weight data collection.
- Calibration of all equipment.
- Placing portable WIM near permanent WIM sites to better study short duration vs continuous data, differences in portable vs permanent, etc.
- A quadrennial plan to collect data around the state. This will allow the capture of any seasonal trends in the data. Emphasis could be given to locations of upcoming construction.
- Integration of other sources of traffic data collected by other agencies within the state. For example, truck weights measured at state entry points or truck weights at enforcement stations within the state.
- Using portable equipment to expand length data into the FHWA classification scheme.
- Review of growth factors applied to the base year ESAL value.
- Review of segments, which might have reached total theoretical capacity based on invalid growth factor.
- Further investigation of other groups described in Section 4.2.2. (e.g., combination of functional classification, geographic location and specific roads). Substantial effort and time is needed to perform such an investigation and results could be compared to functional classification groups.
- Conversion of ESAL tables from a series of spreadsheets to an interactive database, which can be updated as new data is collected.

6.3 BENEFITS

As a part of this research project, NCE envisions the following benefits:

- First and foremost, CDOT will benefit by the overall improvement and enhancement of its traffic data collection and analysis procedures. Noticeable improvements in procedures for traffic volume counts, traffic classification, determination and assignment of ESAL levels to Colorado highway segments will be observed as a result of this project.
- CDOT will further benefit by optimizing the contribution of data from its own (as well as LTPP) WIM and AVC sites in the development of ESAL design tables.
- CDOT will also benefit by the fact that new and more accurate ESAL design tables for use in pavement design and analysis will become available for use. This will result in a significant cost savings to the department, since more accurate ESAL design tables will reduce the likelihood of under- or over- designing future new pavement and rehabilitation designs.

6.4 REFERENCES

1. Traffic Monitoring Guide, US DOT, May 1, 2001, FHWA, Washington, D.C.

2. AASHTO Guide for Design of Pavement Structures, Vol 1 1993, American Association of State Highway and Transportation Officials, Washington, D.C.

3. AASHTO Guide for Design of Pavement Structures, Vol 2 1986, American Association of State Highway and Transportation Officials, Washington, D.C.

4. Statistics With Applications to Highway Traffic Analyses, 2nd edition, revised by Dr. Daniel L. Gerlough, Dr. Matthew J. Huber, ENO Foundation for Transportation, Inc., Westport, CN, 1978, pg 46-55.

5. Vehicle Travel Information System User's Guide, Version 2.6.

6. Pavement Analysis and Design, Yang H. Huang, Prentice Hall, Englewood Cliffs, NJ 07632, 1993, pg. 282-313.

7. Guide to LTPP Traffic Data Collection and Processing, March 12, 2001, FHWA, Washington, D.C.

APPENDIX 1. MINUTES OF KICK-OFF MEETING

NICHOLS CONSULTING ENGINEERS, Chtd.

1885 S. Arlington Ave, Suite 111 • Reno NV 89509 ☎ (775) 329-4955 • FAX (775) 329-5098

M E M O R A N D U M

TO: Mr. Ahmad Ardani, P.E. **FILE:** A300.01.10 Task A
FROM: Sirous Alavi, Ph.D., P.E.
DATE: August 29, 2001
SUBJECT: Minutes of Kick-Off Meeting for ESAL Classification System Development Study – 1:00 p.m. MST – August 8, 2001

Participants: Ahmad Ardani, Bob Tenney, Rich Griffin, Doug Lang, Jay Goldbaum, Richard Zamora, Earl Laird, Sirous Alavi

The meeting was called to order by Ahmad Ardani, CDOT Project Manager, at approximately 1:15 pm and CDOT panel members and NCE project staff introduced themselves.

The agenda for the Kick-Off Meeting, prepared by NCE, was distributed to CDOT panel members several weeks in advance. The agenda is included in attachment 1.

The following is a brief summary of the discussions that took place in Denver, Colorado as recorded by NCE.

Introduction

Sirous provided background information on the NCE project team to CDOT. He also provided a sheet with project team members' roles, phone numbers, and email information. That sheet is presented again as attachment 2 in this document.

A similar sheet was given to CDOT to fill out to facilitate communication among the relevant points of contact. Attachment 3 contains the information provided by Ahmad.

Discussion of Project Scope

Project scope and objectives were discussed thoroughly. CDOT understands that NCE will develop site-specific equivalency factors using the FHWA 13-bin classification scheme of the Traffic Monitoring Guide (TMG) based on "best available data."

Jay Goldbaum asked if NCE was aware of the new 2002 Design Guide needs for load data spectrum data as compared with ESAL data. Sirous responded that NCE was aware of those activities but felt that the framework developed in this project can later be used on other research projects as initial steps in developing load spectra. Sirous also discussed that states are years away from having enough WIM data to develop realistic load spectra for their individual roadway networks. Ahmad also reminded everyone that full implementation of new 2002 Design Guide (if it even comes out on time) is probably several years away.

CDOT LTPP WIM sites are mostly out of service. Those sites still in working order will have the year 2000 data available in the near future and LTPP sheet 10s will be provided for those sites not working.

NCE needed to know what traffic data is used for pavement design. CDOT uses the direction with the heaviest traffic load data and the ADT directional split of 60% for design. CDOT wanted to know what NCE would use if both directions of weight data were provided. NCE will determine which direction is the heaviest following the design method used by CDOT. Ahmad will provide further details of the CDOT design method.

Detailed Review of Work Plan

The project work plan was discussed thoroughly by CDOT and NCE team members. Bob Tenney will provide NCE with the following traffic data in electronic format within two weeks of the meeting date:

- Approximately 4000 segments as defined by the traffic research division (not PMS segments). Each segment will contain the year 2000 AADT and AADT-T and estimates of future AADT and AADT-T data.
- Processed classification (3-bin) and WIM data for segments if available.
- Processed classification and WIM data for non-LTPP sites (twelve permanent AVCs and sixteen portable WIMs).

CDOT will also provide their methodology/techniques used to determine AADT (lane distribution, seasonal, growth factors, etc.).

CDOT emphasized that NCE does not have to provide growth factors for future traffic growth. CDOT has already developed future growth factors and NCE is to use CDOT provided factors.

NCE will perform the following tasks:

- Compare continuous WIM data with random short duration counts by taking a "snapshot" of good WIM data and applying CDOT's techniques used to determine AADT.
- Develop network map of Colorado. Flexible and Rigid ESAL values will be provided for each segment.
- Create classification stations for the network map of Colorado.
- Define core sites and indicate where information needs to be gathered.
- Recommendations on expanding 3-bin classification data to 13-bin classification data.
- Produce quarterly reports, a draft final report and a final report and traffic data in well-organized Excel files.

NCE will do sensitivity analysis of the collect traffic data versus the portable traffic data, both classification as well as weight-in-motion data. NCE will need hourly, weekday/weekend, monthly, and seasonal factors and will develop these factors, if needed, from the CDOT provided traffic data. NCE will need CDOT collected WIM and AVC calibration data to enhance this analysis. Bob Tenney has some WIM calibration data and Douglas Lang stated that WIM calibration was to be done in the very near future.

CDOT has a new roadway construction warranty program where future design data is needed and a certain predetermined number of segments will be reviewed within the next year. NCE will need to know if these warranty segments are the same as the traffic segments if NCE is to provide ESAL data for them.

CDOT stated that NCE will determine ESAL estimates for sites without WIM data. NCE will develop default values for locations where no axle weight data exists from available traffic and load data. CDOT currently uses a statewide ESAL value for segments without load data. NCE will document how estimated load values (default values) were developed for segments without load data. CDOT will have the final decision on what NCE will use to estimate load data for segments without load data.

ESAL Software Demonstration

Sirous presented the software that NCE developed for Arizona DOT in 1999. Douglas Lang stated that CDOT was developing a software package similar to what NCE offered. However, he felt that the NCE ESAL software packet was limited to just AADTs, vehicle classifications, and ESALs, where CDOT is developing a software that is going to be Web orientated and would contain other highway data needed by their department. At this time, CDOT is not interested in pursuing the development of software with NCE.

Review of NCE Wish List

Topics were discussed during the review of the work plan as listed in attachment 1.

Review of CDOT Wish List

CDOT expressed their view on project objectives as described earlier in these meeting notes.

Summary

CDOT will deliver, via email, the needed segment data within two weeks. Bob Tenney will provide the segment traffic data in electronic format.

Ahmad will be the contact person between NCE and CDOT. All questions and data will be delivered by NCE to Ahmad.

CDOT requires the following two products from NCE:

1. Site specific ESAL values for all 4000 segments.
2. Classification station recommendations from NCE.

Kick-Off Meeting concluded at 4:00 PM.

SA/rkp
Attachments

cc: Earl T. Laird, Kevin Senn, Michael P. Tavares

Attachment 1: Agenda

KICK-OFF MEETING AGENDA
August 8, 2001
1:00 p.m.-5:00 p.m.
Colorado DOT, Denver, CO

Colorado Department of Transportation
ESAL Classification System Development Study
Routing NO. 01 HAA00281

A. Introduction

B. Discussion of project scope (overview of project objectives)

C. Detailed review of work plan including schedule of deliverables

D. ESAL software demonstration

E. Review of NCE wish/question list:

1. List of names and addresses of CDOT panel members and relevant points of contact
2. Current CDOT traffic segmentation process (how many segments in the system and locations)
3. Traffic count data
4. Manual and automated traffic classification data
5. All non LTPP WIM and AVC data
6. All other appropriate data from the Traffic Analysis Unit of CDOT
7. Current CDOT seasonal, weekday/weekend traffic factors for AADT calculations
8. Current CDOT data collection, analysis and forecasting procedures
9. Available traffic forecasting models utilized by CDOT, or commonly used in Colorado
10. Specifics of CDOT's reporting requirements (i.e., quarterly reports, draft final report, final report)
11. Need for planned meetings during the life of the project

F. Review Colorado DOT wish/question list (to be discussed by CDOT)

G. Summary of action items

H. Adjournment

Attachment 2: NCE Project Team

Staff	Project Role	Phone Number	Fax Number	Email Address
Sirous Alavi	PRINCIPAL INVESTIGATOR	(775) 329-4955	(775) 329-5098	sirous@nce.reno.nv.us
Kevin Senn	Project Engineer	(775) 329-4955	(775) 329-5098	ksenn@nce.reno.nv.us
Michael Tavares	Traffic Quality Assurance Specialist	(775) 329-4955	(775) 329-5098	michael@nce.reno.nv.us
Earl Laird	Technical Consultant	(775) 882-4755	(775) 882-4565	etlaird@aol.com
Kana (Suresh) Venukanthan	Software Developer	(510) 835-4432	(510) 835-4495	suresh@nce.reno.nv.us

Attachment 3: CDOT Project Team

Staff	Project Role	Phone Number	Fax Number	Email Address
Ahmad Ardani	Manager of Rigid Pavement & Geotechnical Research Section	(303) 757-9978	(303) 757-9974	ahmad.ardani@dot.state.co.us
Bob Tenney	Traffic Analysis Unit Head	(303) 757-9448	(303) 757-9974	robert.tenney@dot.state.co.us
Doug Lang	Manager of Mobility and Traffic Analysis Section	(303) 757-9802	(303) 757-9727	doug.lang@dot.state.co.us
Jay Goldbaum	Pavement Management and Design Engineer	(303) 757-9449	(303) 757-9249	Jay.goldbaum@dot.state.co.us
Richard Zamora	Region II Materials Engineer	(719) 546-5778	(719) 546-5777	Richard.Zamora@dot.state.co.us

APPENDIX 2. INVENTORY OF DATA SOURCES

CDOT AVC Inventory-4 Card

CDOT ID	Database ID	Location	Direction	Type	Data Submittal	Electronic Filename	Lane	Time Period of Data Available	4-Card Data or Length Data (for Length sites only)		
									Data Omitted	Number of Days Included	Number of Days Omitted
124	08A124	I-25 MP 180.1	Northbound	AVC	1st	CDOT_AVC_124.xls	1	3/1/00 to 9/4/01	3/17/00 to 3/22/00; 4/2/00; 7/12/00 to 7/19/00 7/30/00 to 8/31/00; 9/8/00 to 9/14/00 4/1/01 to 4/2/01; 6/5/01 to 6/13/01; 7/3/01 7/9/01 to 7/10/01; 8/27/01 to 8/30/01	480	73
			Southbound				1		3/17/00 to 3/22/00; 4/2/00; 7/5/00 7/12/00 to 7/19/00; 7/30/00 to 9/14/00; 12/31/00 4/1/01 to 4/2/01; 6/5/01 to 6/13/01; 7/3/01 7/9/01; 7/10/01; 8/27/01 to 8/30/01; 9/4/01	470	83
127	08A127	I-25 MP 272.38	Northbound	AVC	1st	CDOT_AVC_127.xls	1	8/30/00 to 9/4/01	9/5/00 to 9/19/00; 9/27/00; 4/1/01 4/9/01 to 5/30/01; 8/8/01; 8/27/01 to 8/30/01	297	74
			Southbound				1		9/5/00 to 9/19/00; 9/27/00; 12/31/00 4/1/01; 4/9/01 to 5/30/01; 8/8/01 8/27/01 to 8/30/01; 9/4/01	295	76
201	08A201	SH 9 MP 204.1	Northbound	AVC	1st	CDOT_AVC_201.xls	1	7/8/00 to 9/4/01	7/31/00 to 8/7/00; 8/14/00 to 8/22/00; 8/31/00 4/1/01 to 4/2/01; 8/27/01 to 8/30/01	400	24
			Southbound				1		7/31/00 to 8/7/00; 8/14/00 to 8/22/00; 8/29/00 9/3/00; 9/7/00 to 9/9/00; 4/1/01 to 4/2/01 5/18/01 to 6/2/01; 7/6/01 to 8/30/01; 9/4/01	326	98
213	08A213	SH 71 MP 173.143	Northbound	AVC	1st	CDOT_AVC_213.xls	1	7/27/00 to 9/4/01	8/27/00 to 8/30/00; 4/1/01 to 4/2/01 8/27/01 to 8/30/01	395	10
			Southbound				1		8/27/00 to 8/30/00; 4/1/01 to 4/2/01 8/27/01 to 8/30/01	395	10
215	08A215	SH 85 MP 293	Northbound	AVC	1st	CDOT_AVC_215.xls	1	7/26/00 to 9/4/01	9/5/00 to 9/13/00; 4/1/01 to 4/2/01; 5/27/01 to 5/31/01; 7/12/01; 8/27/01 to 8/30/01	385	21
			Southbound				1		9/5/00 to 9/13/00; 4/1/01 to 4/2/01; 5/27/01 to 5/31/01; 7/12/01; 8/27/01 to 8/30/01	385	21
242	08A242	SH 50 MP 45.7	Eastbound	AVC	1st	CDOT_AVC_242.xls	1	7/13/00 to 9/4/01	7/20/00 to 7/21/00; 8/28/00 to 8/29/00; 10/3/00 10/10/00 to 10/11/00; 12/7/00 to 12/8/00 3/19/01 to 3/20/01; 4/1/2001; 4/4/2001 8/27/01 to 8/30/01	388	31
			Westbound				1		7/20/00 to 7/21/00; 8/15/00 to 8/17/00; 8/22/00 8/24/00; 8/28/00; 8/29/00; 9/6/00; 10/3/00 10/10/00 to 10/11/00; 12/7/00 to 12/8/00 12/31/00	380	39
245	08A245	SH 34 MP 99.3	Eastbound	AVC	1st	CDOT_AVC_245.xls	1	8/22/00 to 9/4/01	8/22/2000; 8/28/00 to 8/29/00; 2/5/01 to 2/6/01 4/1/01; 4/4/01; 8/27/01 to 8/30/01	368	11
			Westbound				1		8/22/00; 8/28/00 to 8/29/00; 12/31/00 2/5/01 to 2/6/01; 4/1/01; 4/4/01 8/27/01 to 8/30/01; 9/4/2001	366	13
504	08A504	SH 36 MP 49	Eastbound	AVC	1st	CDOT_AVC_504.xls	1	3/1/00 to 9/4/01	3/20/00 to 3/21/00; 4/2/00; 4/17/00 to 4/19/00 5/11/00 to 7/31/00; 8/28/00 to 9/4/00 9/25/00 to 10/5/00; 4/1/01; 4/5/01 6/29/01 to 7/6/01; 7/8/01 to 7/23/01	412	140
			Westbound				1		3/20/00 to 3/21/00; 4/2/00; 4/17/00 to 4/19/00 4/27/00; 5/11/00 to 7/31/00; 8/28/00 to 9/4/00 9/25/00 to 10/5/00; 12/31/00; 4/1/01; 4/5/2001 6/29/01 to 7/6/01; 7/9/01 to 7/23/01 7/27/01 to 7/31/01; 8/27/01 to 8/28/01; 9/4/01	411	141
508	08A508	SH 14 MP 137.8	Eastbound	AVC	1st	CDOT_AVC_508.xls	1	7/22/00 to 9/4/01	8/28/00 to 8/29/00; 9/4/00 to 9/9/00 9/23/00 to 10/30/00; 4/1/01; 4/6/01; 4/22/01 5/29/01 to 5/30/01; 6/9/2001 to 6/13/01 8/27/01 to 8/30/01	350	60
			Westbound				1		8/5/00; 8/28/00 to 8/29/00; 10/27/00 to 10/30/00 12/31/00; 4/1/01; 4/6/01; 4/22/01 5/29/01 to 5/30/01; 6/10/01 to 6/13/01 8/27/01 to 8/30/01; 9/4/01	388	22

CDOT Perm. WIM Inventory-4 Card

CDOT ID	Database ID	Location	Direction	Type	Data Submittal	Electronic Filename	Lane	Time Period of Data Available	4-Card Data or Length Data (for Length sites only)		
									Data Omitted	Number of Days Included	Number of Days Omitted
Site 1 Haxtun	08E001	SH 6 MP 438.4	Eastbound	CDOT PERM	1st	CDOT_Perm_001_E.xls	1	1/1/00 to 8/31/01	1/24/00; 1/26/00; 2/1/00 to 2/2/00; 2/10/00 2/14/00; 2/19/00 to 2/20/00; 3/3/00 to 3/5/00 3/23/00; 4/4/00; 4/7/00 to 4/9/00; 4/14/00 4/19/00; 5/4/00; 5/6/00 to 5/8/00; 5/15/00 5/17/00; 5/26/00 to 5/28/00; 5/30/00; 6/12/00 7/17/00; 7/19/00 to 7/20/00; 9/1/00 to 9/5/00 9/7/00; 9/13/00; 10/3/00; 10/25/00; 11/1/00 11/3/00 to 11/4/00; 12/26/00;1/30/01to 1/31/01 2/28/01; 3/22/01; 3/31/01; 4/1/01 to 4/2/01 4/21/01 to 4/22/01; 4/30/01; 5/1/01 to 5/31/01 6/30/01; 7/8/01; 7/31/01; 8/31/01	518	91
	08W001		Westbound			CDOT_Perm_001_W.xls	1	1/1/00 to 8/31/01	1/24/00; 1/26/00; 1/28/00 to 1/29/00 2/1/00 to 2/2/00; 2/10/00; 2/14/00 2/19/00 to 2/20/00; 3/3/00 to 3/5/00; 3/23/00 4/4/00; 4/7/00 to 4/9/00; 4/14/00; 4/19/00 5/4/00; 5/6/00 to 5/8/00; 5/15/00; 5/17/00 5/26/00 to 5/28/00; 5/30/00; 7/17/00 7/19/00 to 7/20/00; 9/1/00 to 9/5/00; 9/7/00 9/13/00; 10/3/00; 10/25/00; 11/1/00 11/3/00 to 11/4/00; 12/26/00;1/1/01 to 1/31/01 2/28/01; 3/22/01; 3/31/01; 4/2/01 to 4/3/01 4/21/01 to 4/22/01; 4/30/01; 5/4/01 to 5/5/01 5/31/01; 6/6/01; 6/29/01 to 6/30/01; 7/8/01 7/31/01; 8/31/01	515	94
Site 2 Airpark	08T020	I-70 MP 291.2	Eastbound	CDOT PERM	2nd	CDOT_Perm_002_E.xls	1	5/14/01 to 11/30/01	6/1/01 to 6/30/01; 7/8/01; 7/15/01 to 7/16/01; 7/21/01 7/23/01 to 8/2/01; 9/14/01 to 9/17/01; 9/29/01 to 10/1/01 10/10/01; 10/14/01; 10/23/01; 10/27/01 11/23/01 to 11/24/01	143	58
							2	5/14/01 to 11/30/01	6/1/01 to 6/30/01; 7/8/01; 7/15/01 to 7/16/01; 7/21/01 7/23/01 to 8/2/01; 8/18/01; 8/24/01; 8/26/01; 9/6/01 9/14/01 to 9/17/01; 9/29/01 to 10/1/01; 10/10/01 10/14/01; 10/23/01; 10/27/01; 11/23/01 to 11/24/01	139	62
	08T020		Westbound			CDOT_Perm_002_W.xls	1	5/14/01 to 11/30/01	6/13/01 to 6/19/01; 6/23/01; 7/8/01; 7/15/01 to 7/16/01 7/21/01; 7/23/01 to 8/2/01; 9/14/01 to 9/17/01 9/29/01 to 10/1/01; 10/10/01; 10/14/01; 10/23/01 10/27/01; 11/23/01 to 11/24/01	165	36
							2	5/14/01 to 11/30/01	6/13/01 to 6/19/01; 6/23/01; 7/8/01; 7/15/01 to 7/16/01 7/21/01; 7/23/01 to 8/2/01; 9/14/01 to 9/17/01 9/29/01 to 10/1/01; 10/10/01; 10/14/01; 10/23/01 10/27/01; 11/23/01 to 11/24/01	165	36

CDOT Perm. WIM Inventory-4 Card

CDOT ID	Database ID	Location	Direction	Type	Data Submittal	Electronic Filename	Lane	Time Period of Data Available	4-Card Data or Length Data (for Length sites only)		
									Data Omitted	Number of Days Included	Number of Days Omitted
Site 3 SH470	08E003	SH 470 MP 16	Eastbound	CDOT PERM	1st	CDOT_Perm_003_E.xls	1	1/1/00 to 7/13/01	1/24/00; 1/26/00; 2/1/00 to 2/2/00 2/8/00 to 2/10/00; 2/14/00; 2/18/00 to 2/20/00 3/3/00 to 3/5/00; 3/7/00; 3/18/00; 3/23/00 4/4/00; 4/6/00 to 4/9/00; 4/14/00; 4/19/00 5/4/00; 5/6/00 to 5/8/00; 5/15/00; 5/17/00 5/26/00 to 5/28/00; 5/30/00; 6/16/00; 6/25/00 7/17/00; 7/19/00 to 7/20/00; 8/8/00 to 8/16/00 8/23/00; 8/25/00 to 8/27/00; 9/1/00 to 9/5/00 9/7/00; 9/13/00; 10/3/00; 10/24/00 to 10/30/00 11/1/00; 11/3/00 to 11/4/00; 11/9/00 12/2/00 to 12/4/00; 12/17/00 to 12/18/00 12/26/00; 1/1/01 to 1/31/01; 2/19/01; 3/22/01 4/2/01 to 4/19/01; 4/21/01 to 4/22/01 5/4/01 to 5/5/01; 5/28/01 to 7/13/01	381	178
							2	1/1/00 to 7/13/01	1/24/00; 1/26/00; 2/1/00 to 2/2/00 2/8/00 to 2/10/00; 2/14/00; 2/18/00 to 2/20/00 3/3/00 to 3/5/00; 3/7/00; 3/18/00; 3/23/00 4/4/00; 4/6/00 to 4/9/00; 4/14/00; 4/19/00 5/4/00; 5/6/00 to 5/8/00; 5/15/00; 5/17/00 5/26/00 to 5/28/00; 5/30/00; 6/16/00; 6/25/00 7/17/00; 7/19/00 to 7/20/00; 8/8/00 to 8/16/00 8/23/00; 8/25/00 to 8/27/00; 9/1/00 to 9/5/00 9/7/00; 9/13/00; 10/3/00; 10/24/00 to 10/30/00 11/1/00; 11/3/00 to 11/4/00; 11/9/00 12/2/00 to 12/4/00; 12/17/00 to 12/18/00 12/26/00; 1/1/01 to 1/31/01; 2/19/01; 3/22/01 4/2/01 to 4/19/01; 4/21/01 to 4/22/01 5/4/01 to 5/5/01; 5/28/01 to 7/13/01	381	178

CDOT Perm. WIM Inventory-4 Card

CDOT ID	Database ID	Location	Direction	Type	Data Submittal	Electronic Filename	Lane	Time Period of Data Available	4-Card Data or Length Data (for Length sites only)		
									Data Omitted	Number of Days Included	Number of Days Omitted
Site 3 SH470	08W003	SH 470 MP 16	Westbound	CDOT PERM	1st	CDOT_Perm_003_W.xls	1	1/1/00 to 7/13/01	1/24/00; 1/26/00; 2/1/00 to 2/2/00 2/8/00 to 2/10/00; 2/14/00; 2/18/00 to 2/20/00 3/3/00 to 3/5/00; 3/7/00; 3/18/00; 3/23/00 4/4/00; 4/6/00 to 4/9/00; 4/14/00; 4/19/00 5/4/00; 5/6/00 to 5/8/00; 5/15/00; 5/17/00 5/26/00 to 5/28/00; 5/30/00; 6/16/00; 6/25/00 7/17/00; 7/19/00 to 7/20/00; 8/8/00 to 8/16/00 8/23/00; 8/25/00 to 8/27/00; 9/1/00 to 9/5/00 9/7/00; 9/13/00; 10/3/00; 10/24/00 to 10/30/00 11/1/00; 11/3/00 to 11/5/00; 11/9/00 12/2/00 to 12/4/00; 12/17/00 to 12/18/00 12/26/00; 1/1/01 to 1/31/01; 2/19/01; 3/22/01 4/2/01 to 4/19/01; 4/21/01 to 4/22/01 5/4/01 to 5/5/01; 5/28/01 to 7/13/01	380	179
							2	1/1/00 to 7/13/01	1/24/00; 1/26/00; 2/1/00 to 2/2/00 2/8/00 to 2/10/00; 2/14/00; 2/18/00 to 2/20/00 3/3/00 to 3/5/00; 3/7/00; 3/18/00; 3/23/00 4/4/00; 4/6/00 to 4/9/00; 4/14/00; 4/19/00 5/4/00; 5/6/00 to 5/8/00; 5/15/00; 5/17/00 5/26/00 to 5/28/00; 5/30/00; 6/16/00; 6/25/00 7/17/00; 7/19/00 to 7/20/00; 8/8/00 to 8/16/00 8/23/00; 8/25/00 to 8/27/00; 9/1/00 to 9/5/00 9/7/00; 9/13/00; 10/3/00; 10/24/00 to 10/30/00 11/1/00; 11/3/00 to 11/4/00; 11/9/00 12/2/00 to 12/4/00; 12/17/00 to 12/18/00 12/26/00; 1/1/01 to 1/31/01; 2/19/01; 3/22/01 4/2/01 to 4/19/01; 4/21/01 to 4/22/01 5/4/01 to 5/5/01; 5/28/01 to 7/13/01	381	178
							3	1/1/00 to 7/13/01	1/24/00; 1/26/00; 2/1/00 to 2/2/00 2/8/00 to 2/10/00; 2/14/00; 2/18/00 to 2/20/00 3/3/00 to 3/5/00; 3/7/00; 3/18/00; 3/23/00 4/4/00; 4/6/00 to 4/9/00; 4/14/00; 4/19/00 5/4/00; 5/6/00 to 5/8/00; 5/15/00; 5/17/00 5/26/00 to 5/28/00; 5/30/00; 6/16/00; 6/25/00 7/17/00; 7/19/00 to 7/20/00; 8/8/00 to 8/16/00 8/23/00; 8/25/00 to 8/27/00; 9/1/00 to 9/5/00 9/7/00; 9/13/00; 10/3/00; 10/24/00 to 10/30/00 11/1/00; 11/3/00 to 11/5/00; 11/9/00 12/2/00 to 12/4/00; 12/17/00 to 12/18/00 12/26/00; 1/1/01 to 1/31/01; 2/19/01; 3/22/01 4/2/01 to 4/19/01; 4/21/01 to 4/22/01 5/4/01 to 5/5/01; 5/28/01 to 7/13/01	381	178

CDOT Perm. WIM Inventory-4 Card

CDOT ID	Database ID	Location	Direction	Type	Data Submittal	Electronic Filename	Lane	Time Period of Data Available	4-Card Data or Length Data (for Length sites only)		
									Data Omitted	Number of Days Included	Number of Days Omitted
Site 4 Superior	08E004	SH 36 MP 43.15	Eastbound	CDOT PERM	1st	CDOT_Perm_004_E.xls	1	1/1/00 to 8/31/01	1/24/00; 1/26/00; 2/1/00 to 2/2/00; 2/7/00 to 2/8/00 2/10/00; 2/14/00; 2/18/00 to 2/20/00 2/24/00 to 2/25/00 3/3/00 to 3/5/00; 3/7/00; 3/10/00 3/18/00; 3/23/00; 3/27/00; 4/4/00; 4/6/00 to 4/9/00 4/14/00; 4/19/00; 4/27/00; 5/3/00 to 5/11/00 5/15/00; 5/17/00; 5/26/00 to 5/28/00; 5/30/00 6/6/00 to 6/8/00; 6/19/00 to 6/20/00; 7/17/00 7/19/00 to 7/20/00; 8/8/00; 9/1/00 to 9/5/00 9/7/00; 9/13/00; 10/3/00; 10/25/00 10/31/00 to 11/1/00; 11/3/00 to 11/4/00; 12/26/00 12/31/2000; 1/1/01 to 3/14/001; 3/22/01 4/2/01 to 4/19/01; 4/21/01 to 4/22/01 5/4/01 to 5/5/01; 5/28/01 to 7/3/01; 7/8/01; 7/12/01 8/8/01	405	204
							2	1/1/00 to 8/31/01	1/24/00; 1/26/00; 2/1/00 to 2/2/00; 2/8/00; 2/10/00 2/14/00; 2/18/00 to 2/20/00; 3/3/00 to 3/5/00 3/7/00; 3/23/00; 4/4/00; 4/6/00 to 4/9/00; 4/14/00 4/19/00; 5/4/00 to 5/11/00; 5/15/00; 5/17/00 5/26/00 to 5/28/00; 5/30/00; 6/16/00; 7/14/00 7/17/00; 7/19/00 to 7/20/00; 7/31/00 8/5/00 to 8/6/00; 9/1/00 to 9/5/00; 9/7/00; 9/13/00 10/3/00; 10/25/00; 10/31/00 to 11/1/00 11/3/00 to 11/4/00; 12/26/00; 12/31/00 1/1/01 to 3/14/01; 3/22/01; 4/2/01 to 4/19/01 4/21/01 to 4/22/01; 5/4/01 to 5/5/01 5/28/01 to 7/3/01; 7/8/01; 7/12/01; 8/8/01	414	195
	08W004		Westbound			CDOT_Perm_004_W.xls	1	1/1/00 to 8/31/01	1/24/00; 1/26/00; 2/1/00 to 2/2/00; 2/8/00; 2/10/00 2/14/00; 2/18/00 to 2/20/00; 3/3/00 to 3/5/00 3/7/00; 3/23/00; 3/30/00 to 5/12/00; 5/15/00; 5/17/00; 5/26/00 to 5/28/00; 5/30/00; 7/17/00 7/19/00 to 7/20/00; 9/1/00 to 9/5/00 9/7/00 to 9/13/00; 10/3/00; 10/25/00; 11/1/00 11/3/00 to 11/4/00; 12/26/00; 12/31/00 1/1/01 to 3/14/01; 3/22/01; 4/2/01 to 4/19/01 4/21/01 to 4/22/01; 5/4/01 to 5/5/01; 5/8/01 5/28/01 to 7/3/01; 7/8/01; 7/12/01; 8/8/01	390	219
							2	1/1/00 to 8/31/01	1/24/00; 1/26/00; 2/1/00 to 2/2/00; 2/8/00; 2/10/00 2/14/00; 2/18/00 to 2/20/00; 3/3/00 to 3/5/00 3/7/00; 3/23/00; 3/29/00 to 5/12/00; 5/15/00 5/17/00; 5/26/00 to 5/28/00; 5/30/00; 7/17/00 7/19/00 to 7/20/00; 9/1/00 to 9/5/00; 9/7/00 9/13/00; 10/3/00; 10/25/00; 11/1/00; 11/3/00 to 11/4/00 12/26/00; 12/30/00 to 12/31/00; 1/1/01 to 3/14/01 3/22/01; 4/2/01 to 4/19/01; 4/21/01 to 4/22/01 5/4/01 to 5/11/01; 5/28/01 to 7/3/01; 7/8/01; 7/12/01 8/1/01 to 8/31/01	353	256

CDOT Perm. WIM Inventory-4 Card

CDOT ID	Database ID	Location	Direction	Type	Data Submittal	Electronic Filename	Lane	Time Period of Data Available	4-Card Data or Length Data (for Length sites only)		
									Data Omitted	Number of Days Included	Number of Days Omitted
Site 5 Eads	08N005	SH 287 MP 110.59	Northbound	CDOT PERM	1st	CDOT_Perm_005_N.xls	1	1/1/00 to 8/31/01	1/1/00 to 1/2/00; 1/7/00 to 1/22/00; 1/24/00; 1/26/00 2/1/00to 2/2/00; 2/8/00; 2/10/00; 2/14/00; 2/18/00 to 2/20/00; 3/3/00 to 3/5/00; 3/7/00; 3/23/00 4/4/00; 4/6/00 to 4/9/00; 4/14/00; 4/19/00 5/4/00 to 5/11/00; 5/15/00; 5/17/00; 5/26/00 to 5/28/00 5/30/00; 7/17/00; 7/19/00; 7/20/00; 8/26/00 to 9/26/00 10/3/00; 10/12/00 to 10/15/00; 10/25/00; 11/1/00 11/3/00 to 11/4/00; 12/26/00; 1/31/01; 2/19/01 3/15/01 to 3/26/01; 4/2/01 to 4/19/01 4/21/01 to 4/22/01; 5/4/01 to 5/6/01; 5/19/01 to 5/28/01 6/11/01 to 6/24/01; 7/8/01; 7/14/01 to 7/19/01 8/7/01 to 8/19/01; 8/22/01 to 8/23/01	427	182
	08S005		Southbound			CDOT_Perm_005_S.xls	1	1/1/00 to 8/31/01	1/1/00 to 1/2/00; 1/7/00 to 1/22/00; 1/24/00; 1/26/00 2/1/00to 2/2/00; 2/8/00; 2/10/00; 2/14/00; 2/18/00 to 2/20/00; 3/3/00 to 3/5/00; 3/7/00; 3/23/00 4/4/00; 4/6/00 to 4/9/00; 4/14/00; 4/19/00 5/4/00 to 5/11/00; 5/15/00; 5/17/00; 5/26/00 to 5/28/00 5/30/00; 7/17/00; 7/19/00; 7/20/00; 8/26/00 to 9/26/00 10/3/00; 10/11/00 to 10/15/00; 10/25/00; 11/1/00 11/3/00 to 11/4/00; 12/26/00; 1/31/01; 2/19/01 3/15/01 to 3/26/01; 4/2/01 to 4/19/01 4/21/01 to 4/22/01; 5/4/01 to 5/6/01; 5/19/01 to 5/28/01 6/11/01 to 6/24/01; 7/8/01; 7/14/01 to 7/19/01 8/7/01 to 8/19/01; 8/22/01 to 8/23/01	426	183
Site 7 Ault	08E007	SH 14 MP 152	Eastbound	CDOT PERM	1st	CDOT_Perm_007_E.xls	1	8/3/00to 8/31/01	8/3/00; 9/1/00 to 9/5/00; 9/7/00; 9/13/00; 9/27/00; 10/3/00 10/14/00; 10/25/00 to 10/26/00; 11/1/00 11/3/00 to 11/4/00; 11/11/00 to 11/13/00; 11/16/00 12/2/00; 12/10/00 to 12/11/00; 12/13/00; 12/16/00 12/20/00; 12/26/00; 12/31/00; 1/1/01 to 1/2/01; 1/31/01 2/7/01 to 2/9/01; 2/14/01; 2/19/01; 2/26/01 to 2/27/01 3/1/01 to 3/31/01; 4/2/01 to 4/19/01; 4/21/01 to 4/22/01 5/4/01 to 5/6/01; 5/22/01 to 5/24/01; 7/8/01	298	96
	08W007		Westbound			CDOT_Perm_007_W.xls	1	8/3/00 to 8/31/01	8/3/00; 9/1/00 to 9/5/00; 9/7/00; 9/13/00; 9/27/00; 10/3/00 10/14/00; 10/25/00 to 10/26/00; 11/1/00 11/3/00 to 11/4/00; 11/11/00 to 11/13/00; 11/16/00 12/2/00; 12/10/00 to 12/11/00; 12/13/00; 12/16/00 12/20/00; 12/26/00; 12/31/00; 1/1/01 to 1/2/01; 1/31/01 2/7/01 to 2/9/01; 2/14/01; 2/19/01; 2/26/01 to 2/27/01 3/1/01 to 3/31/01; 4/2/01 to 4/19/01; 4/21/01 to 4/22/01 5/4/01 to 5/6/01; 5/22/01 to 5/24/01; 7/1/01 to 8/16/01	252	142

CDOT Perm. WIM Inventory-4 Card

CDOT ID	Database ID	Location	Direction	Type	Data Submittal	Electronic Filename	Lane	Time Period of Data Available	4-Card Data or Length Data (for Length sites only)		
									Data Omitted	Number of Days Included	Number of Days Omitted
Site 8 Laporte	08T080	SH 287 MP 353.2	Eastbound	CDOT PERM	2nd	CDOT_Perm_008_E.xls	1	11/13/00 to 11/30/01	11/13/00 to 11/16/00; 11/18/00; 12/2/00 12/12/00 to 12/13/00; 12/17/00; 12/22/00; 12/26/00 12/31/00; 1/8/01; 1/10/01; 1/16/01; 1/28/01 1/31/01 to 2/1/01; 2/3/01; 2/9/01; 2/12/01; 2/14/01 2/18/2001 to 2/19/01; 3/1/01 to 3/31/01; 4/2/01 to 4/19/01 4/21/01 to 4/22/01; 5/4/01 to 5/6/01; 6/14/01; 6/16/01 6/18/01 to 6/23/01; 6/23/01 to 8/16/01; 9/6/01 to 9/7/01 9/14/01 to 9/17/01; 11/14/01; 11/23/01 to 11/24/01	236	147
	08T080		Westbound			CDOT_Perm_008_W.xls	1	11/13/00 to 11/30/01	11/13/00 to 11/16/00; 11/18/00; 12/2/00 12/12/00 to 12/13/00; 12/17/00; 12/22/00; 12/26/00 12/31/00; 1/8/01; 1/10/01; 1/16/01; 1/28/01 1/31/01 to 2/1/01; 2/3/01; 2/9/01; 2/12/01; 2/14/01 2/18/01 to 2/19/01; 3/1/01 to 3/31/01; 4/2/01 to 4/19/01 4/21/01 to 4/22/01; 5/4/01 to 5/6/01; 7/8/01 7/30/01 to 8/16/01; 8/18/01 to 8/31/01; 9/6/01 to 9/7/01 9/14/01 to 9/17/01; 11/14/01; 11/23/01 to 11/24/01	246	137
Site 10 Keenesburg	08T100	I-76 MP 39.7	Eastbound	CDOT PERM	2nd	CDOT_Perm_010_E.xls	1	2/12/01 to 11/30/01	2/19/01; 3/1/01 to 3/31/01; 4/2/01 to 4/18/01 4/21/01 to 4/22/01; 5/4/01 to 5/6/01; 7/8/01; 8/8/01 9/14/01 to 9/17/01; 11/23/01 to 11/24/01	230	62
							2	2/12/01 to 11/30/01	2/19/01; 3/1/01 to 3/31/01; 4/2/01 to 4/18/01 4/21/01 to 4/22/01; 5/4/01 to 5/6/01; 7/8/01; 8/8/01 9/14/01 to 9/17/01; 11/23/01 to 11/24/01	230	62
	08T100		Westbound			CDOT_Perm_010_W.xls	1	2/12/01 to 11/30/01	2/19/01; 3/1/01 to 3/31/01; 4/2/01 to 4/18/01 4/21/01 to 4/22/01; 5/4/01 to 5/6/01; 7/8/01; 8/8/01 9/14/01 to 9/17/01; 11/23/01 to 11/24/01	230	62
							2	2/12/01 to 11/30/01	2/19/01; 3/1/01 to 3/31/01; 4/2/01 to 4/18/01 4/21/01 to 4/22/01; 5/4/01 to 5/6/01; 5/29/01 to 8/23/01 9/14/01 to 9/17/01; 11/23/01 to 11/24/01	145	147
Site 13 SH 40 SE of Limon	08T130	SH 40 MP 388.5	Eastbound	CDOT PERM	2nd	CDOT_Perm_013_E.xls	1	6/1/01 to 11/30/01	6/1/01 to 6/2/01; 6/4/01 to 6/18/01; 7/8/01; 7/23/01; 8/8/01 9/14/01 to 9/18/01; 11/23/01 to 11/25/01	155	28
	08T130		Westbound			CDOT_Perm_013_W.xls	1	6/1/01 to 11/30/01	6/1/01 to 6/2/01; 6/4/01 to 6/18/01; 7/8/01; 7/23/01; 8/8/01 9/14/01 to 9/18/01; 11/23/01 to 11/25/01	155	28
Site 14 I-70 @ Limon	08T140	I-70 MP 365.3	Eastbound	CDOT PERM	2nd	CDOT_Perm_014_E.xls	1	5/1/01 to 11/30/01	5/4/01 to 5/6/01; 5/12/01 to 5/13/01; 5/29/01 to 6/4/01 6/7/01; 6/14/01; 7/8/01; 8/8/01; 9/14/01 to 9/18/01 11/19/01 to 11/28/01	183	31
							2	5/1/01 to 11/30/01	5/4/01 to 5/6/01; 5/12/01 to 5/13/01; 5/29/01 to 6/4/01 6/14/01; 7/8/01; 8/8/01; 9/14/01 to 9/18/01 11/19/01 to 11/28/01	184	30
	08T140		Westbound			CDOT_Perm_014_W.xls	1	5/1/01 to 11/30/01	5/4/01 to 5/6/01; 5/12/01 to 5/13/01; 5/23/01 5/29/01 to 6/4/01; 6/14/01; 7/8/01; 8/8/01 9/14/01 to 9/18/01; 11/19/01 to 11/28/01	183	31
							2	5/1/01 to 11/30/01	5/4/01 to 5/6/01; 5/8/01; 5/12/01 to 5/13/01 5/29/01 to 6/4/01; 6/14/01; 7/8/01; 8/8/01 9/14/01 to 9/18/01; 11/19/01 to 11/28/01	182	31

CDOT Perm. WIM Inventory-7 Card

CDOT ID	Database ID	Location	Direction	Type	Data Submittal	Electronic Filename	Lane	Time Period of Data Available	7-Card Data		
									Data Omitted	Number of Days Included	Number of Days Omitted
Site 1 Haxtun	08E001	SH 6 MP 438.4	Eastbound	CDOT PERM	1st	CDOT_Perm_001_E.xls	1	1/1/00 to 8/31/01	3/31/00; 6/12/00; 1/30/01; 2/14/01 to 2/28/01 3/31/01 to 4/4/01; 4/30/01; 6/29/01; 7/31/01 8/31/01	582	27
	08W001		Westbound			CDOT_Perm_001_W.xls	1	1/1/00 to 8/31/01	1/28/00 to 1/29/00; 1/1/01 to 1/31/01 2/15/01 to 2/28/01; 3/31/01 to 4/4/01; 4/9/01 4/30/01; 5/4/01; 5/7/01; 5/31/01; 6/6/01; 6/29/01 7/31/01; 8/31/01	548	61
Site 2 Airpark	08T020	I-70 MP 291.2	Eastbound	CDOT PERM	2nd	CDOT_Perm_002_E.xls	1	5/14/01 to 11/30/01	5/14/01 to 5/31/01; 6/14/01 to 6/18/01; 7/23/01 to 8/2/01 10/15/01	166	35
							2	5/14/01 to 11/30/01	5/14/01 to 5/31/01; 6/14/01 to 6/18/01; 7/21/01 to 8/14/01	153	48
	08T020		Westbound			CDOT_Perm_002_W.xls	1	5/14/01 to 11/30/01	5/14/01 to 5/31/01; 6/14/01 to 6/19/01; 7/23/01 to 8/2/01	166	35
							2	5/14/01 to 11/30/01	5/14/01 to 5/31/01; 6/14/01 to 6/19/01; 7/23/01 to 8/2/01	166	35

CDOT Perm. WIM Inventory-7 Card

CDOT ID	Database ID	Location	Direction	Type	Data Submittal	Electronic Filename	Lane	Time Period of Data Available	7-Card Data		
									Data Omitted	Number of Days Included	Number of Days Omitted
Site 3 SH470	08E003	SH 470 MP 16	Eastbound	CDOT PERM	1st	CDOT_Perm_003_E.xls	1	1/1/00 to 7/13/01	12/18/00; 1/1/01 to 1/31/01; 2/20/01 to 2/28/01 4/1/01 to 4/19/01; 5/1/01 to 6/12/01; 6/15/01 to 6/17/01 7/4/01 to 7/13/01	444	116
							2	1/1/00 to 7/13/01	3/12/00; 12/18/00; 1/1/01 to 1/31/01; 2/19/01 to 2/28/01 4/1/01 to 4/19/01; 5/1/01 to 6/12/01; 6/15/01 to 6/17/01 7/4/01 to 7/13/01	442	118

CDOT Perm. WIM Inventory-7 Card

CDOT ID	Database ID	Location	Direction	Type	Data Submittal	Electronic Filename	Lane	Time Period of Data Available	7-Card Data		
									Data Omitted	Number of Days Included	Number of Days Omitted
Site 3 SH470	08W003	SH 470 MP 16	Westbound	CDOT PERM	1st	CDOT_Perm_003_W.xls	1	1/1/00 to 7/13/01	3/12/00; 11/5/00; 12/18/00; 1/1/01 to 1/31/01 2/19/01 to 2/28/01; 4/1/01 to 4/19/01; 5/1/01 to 6/12/01 6/15/01 to 6/17/01; 7/4/01 to 7/13/01	441	119
							2	1/1/00 to 7/13/01	3/12/00; 12/18/00; 1/1/01 to 1/31/01; 2/20/01 to 2/28/01 4/1/01 to 4/19/01; 5/1/01 to 6/12/01; 6/15/01 to 6/17/01 7/4/01 to 7/13/01	443	117
							3	1/1/00 to 7/13/01	3/12/00; 12/18/00; 1/1/01 to 1/31/01; 2/19/01 to 2/28/01 4/1/01 to 4/19/01; 5/1/01 to 6/12/01; 6/15/01 to 6/17/01 7/4/01 to 7/13/01	442	118

CDOT Perm. WIM Inventory-7 Card

CDOT ID	Database ID	Location	Direction	Type	Data Submittal	Electronic Filename	Lane	Time Period of Data Available	7-Card Data		
									Data Omitted	Number of Days Included	Number of Days Omitted
Site 4 Superior	08E004	SH 36 MP 43.15	Eastbound	CDOT PERM	1st	CDOT_Perm_004_E.xls	1	1/1/00 to 8/31/01	2/7/00; 3/10/00; 3/18/00; 3/24/00 to 3/25/00 3/27/00; 3/29/00; 4/6/00; 4/13/00; 4/27/00; 5/3/00 6/6/00 to 6/8/00; 6/19/00 to 6/20/00; 6/30/00 8/8/00; 10/31/00; 1/1/01 to 3/12/01 4/1/01 to 4/19/01; 5/28/01 to 7/3/01	463	145
							2	1/1/00 to 8/31/01	3/29/00; 4/6/00; 4/13/00; 6/16/00; 6/30/00; 7/14/00 7/31/00; 8/5/00 to 8/6/00; 10/31/00; 12/31/00 1/1/01 to 3/12/01; 4/1/01 to 4/19/01 5/28/01 to 7/3/01	471	137
	08W004		Westbound			CDOT_Perm_004_W.xls	1	1/1/00 to 8/31/01	3/29/00 to 5/11/00; 6/30/00; 1/1/01 to 3/12/01 4/1/01 to 4/19/01; 5/8/01; 5/28/01 to 7/3/01	436	172
							2	1/1/00 to 8/31/01	3/29/00 to 5/11/00; 12/30/00 to 12/31/00; 1/1/01 to 3/12/01 4/1/01 to 4/19/01; 5/5/01 to 5/11/01; 5/28/01 to 7/3/01	429	179

CDOT Perm. WIM Inventory-7 Card

CDOT ID	Database ID	Location	Direction	Type	Data Submittal	Electronic Filename	Lane	Time Period of Data Available	7-Card Data		
									Data Omitted	Number of Days Included	Number of Days Omitted
Site 5 Eads	08N005	SH 287 MP 110.59	Northbound	CDOT PERM	1st	CDOT_Perm_005_N.xls	1	1/1/00 to 8/31/01	8/26/00; 8/28/00 to 9/26/00; 10/12/00 to 10/14/00 2/19/01 to 2/28/01; 4/1/01 to 4/19/01; 8/22/01 to 8/23/01	544	65
	08S005		Southbound			CDOT_Perm_005_S.xls	1	1/1/00 to 8/31/01	8/26/00; 8/29/00 to 9/26/00; 10/11/00 to 10/14/00 2/19/01 to 2/28/01; 4/1/01 to 4/9/01; 4/11/01 to 4/20/01 4/22/01; 8/22/01 to 8/23/01	543	66
Site 7 Ault	08E007	SH 14 MP 152	Eastbound	CDOT PERM	1st	CDOT_Perm_007_E.xls	1	8/3/00to 8/31/01	8/3/00; 10/2/00; 11/1/00; 12/21/00; 2/20/01 to 2/28/01 4/1/01 to 4/19/01	362	32
	08W007		Westbound			CDOT_Perm_007_W.xls	1	8/3/00 to 8/31/01	8/3/00; 10/2/00; 11/1/00; 12/21/00; 2/20/01 to 2/28/01 4/1/01 to 4/19/01; 7/1/01 to 8/16/01	315	79

CDOT Perm. WIM Inventory-7 Card

CDOT ID	Database ID	Location	Direction	Type	Data Submittal	Electronic Filename	Lane	Time Period of Data Available	7-Card Data		
									Data Omitted	Number of Days Included	Number of Days Omitted
Site 8 Laporte	08T080	SH 287 MP 353.2	Eastbound	CDOT PERM	2nd	CDOT_Perm_008_E.xls	1	11/13/00 to 11/30/01	11/13/00 to 11/14/00; 2/19/01 to 2/28/01; 3/12/01 4/1/01 to 4/3/01; 6/14/01; 6/23/01; 6/26/01 to 8/15/01	314	69
	08T080		Westbound			CDOT_Perm_008_W.xls	1	11/13/00 to 11/30/01	11/13/00 to 11/14/00; 2/19/01 to 2/28/01; 4/1/01 to 4/3/01 7/14/01 to 8/15/01; 8/19/01 to 8/30/01	323	60
Site 10 Keenesburg	08T100	I-76 MP 39.7	Eastbound	CDOT PERM	2nd	CDOT_Perm_010_E.xls	1	2/12/01 to 11/30/01	2/12/01 to 2/14/01; 2/19/01 to 2/28/01; 4/1/01 to 4/3/01 4/18/01; 11/19/01	274	18
							2	2/12/01 to 11/30/01	2/12/01 to 2/14/01; 2/19/01 to 2/28/01; 4/1/01 to 4/3/01 4/18/01; 11/19/01	274	18
	08T100		Westbound			CDOT_Perm_010_W.xls	1	2/12/01 to 11/30/01	2/12/01 to 2/14/01; 2/19/01 to 2/28/01; 4/1/01 to 4/3/01 4/18/01	275	17
							2	2/12/01 to 11/30/01	2/12/01 to 2/14/01; 2/19/01 to 2/28/01; 4/1/01 to 4/3/01 4/18/2001; 5/30/01 to 8/12/01; 11/19/01	189	103
Site 13 SH 40 SE of Limon	08T130	SH 40 MP 388.5	Eastbound	CDOT PERM	2nd	CDOT_Perm_013_E.xls	1	6/1/01 to 11/30/01	6/5/01 to 6/7/01; 6/15/01 to 6/17/01	177	6
	08T130		Westbound			CDOT_Perm_013_W.xls	1	6/1/01 to 11/30/01	6/5/01 to 6/7/01; 6/15/01 to 6/17/01	177	6
Site 14 I-70 @ Limon	08T140	I-70 MP 365.3	Eastbound	CDOT PERM	2nd	CDOT_Perm_014_E.xls	1	5/1/01 to 11/30/01	5/7/01 to 5/9/01; 5/29/01 to 6/3/01; 9/14/01 to 9/16/01 11/19/01 to 11/27/01	193	21
							2	5/1/01 to 11/30/01	5/29/01 to 6/3/01; 9/15/01 to 9/16/01; 11/20/01 to 11/27/01	198	16
	08T140		Westbound			CDOT_Perm_014_W.xls	1	5/1/01 to 11/30/01	5/7/01 to 5/9/01; 5/30/01 to 6/3/01; 9/15/01 to 9/16/01 11/20/01 to 11/27/01	196	18
							2	5/1/01 to 11/30/01	5/29/01 to 6/3/01; 9/14/01 to 9/16/01; 9/19/01 to 9/20/01 11/20/01 to 11/27/01	195	19

CDOT Port. WIM Inventory-4 Card

CDOT ID	Database ID	Location	Direction	Type	Data Submittal	Electronic Filename	Lane	Time Period of Data Available	4-Card Data or Length Data (for Length sites only)		
									Data Omitted	Number of Days Included	Number of Days Omitted
10A	08E010	I-70 MP 419.3	Eastbound	CDOT PORT	1st	CDOT_Port_010_A.xls	All	8/8/00 to 8/11/00	8/8/00; 8/11/00	2	2
10B	08W010	I-70 MP 419.3	Westbound	CDOT PORT	1st	CDOT_Port_010_B.xls	All	8/8/00 to 8/11/00	8/8/00; 8/11/00	2	2
13A	08P013	SH 13 MP 126.2	Both	CDOT PORT	1st	CDOT_Port_013_A.xls	All	7/19/00 to 7/21/00	7/19/00;7/21/00	1	2
14T	08P014	SH 160 MP 145	Both	CDOT PORT	1st	CDOT_Port_014_T.xls	All	7/10/00 to 7/13/00	7/10/00; 7/13/00	2	2
18T	08P018	SH 550 MP 16.5	Both	CDOT PORT	1st	CDOT_Port_018_T.xls	All	7/11/00 to 7/13/00	7/11/00; 7/13/00	1	2
19N	08N019	SH 50 MP 84	Northbound	CDOT PORT	1st	CDOT_Port_019_N.xls	All	7/18/00 to 7/20/00	7/18/00; 7/20/00	1	2
19S	08S019	SH 50 MP 84	Southbound	CDOT PORT	1st	CDOT_Port_019_S.xls	All	7/18/00 to 7/20/00	7/18/00; 7/20/00	1	2
20T	08P020	SH 50 MP 335.7	Both	CDOT PORT	1st	CDOT_Port_020_T.xls	All	7/24/00 to 7/28/00	7/24/00; 7/28/00	3	2
22T	08P022	SH 285 MP 133.9	Both	CDOT PORT	1st	CDOT_Port_022_T.xls	All	8/14/00 to 8/16/00	8/14/00; 8/16/00	1	2
23T	08P023	SH 50 MP 427.7	Both	CDOT PORT	1st	CDOT_Port_023_T.xls	All	8/21/00 to 8/25/00	8/21/00; 8/23/00; 8/25/00	2	3
24T	08P024	SH 50 MP 436.8	Both	CDOT PORT	1st	CDOT_Port_024_T.xls	All	8/21/00 to 8/23/00	8/21/00; 8/23/00	1	2
76Y	08E076	I-76 MP 180.2	Eastbound	CDOT PORT	1st	CDOT_Port_076_Y.xls	All	8/15/00 to 8/17/00	8/15/00; 8/17/00	1	2
76Z	08W076	I-76 MP 180.2	Westbound	CDOT PORT	1st	CDOT_Port_076_Z.xls	All	8/15/00 to 8/17/00	8/15/00; 8/17/00	1	2
85N	08N085	SH 85 MP 272.5	Northbound	CDOT PORT	1st	CDOT_Port_085_N.xls	All	6/22/00 to 6/23/00	6/23/00	1	1
85S	08S085	SH 85 MP 272.5	Southbound	CDOT PORT	1st	CDOT_Port_085_S.xls	All	6/21/00 to 6/23/00	6/21/00; 6/23/00	1	2

CDOT Port. WIM Inventory-7 Card

CDOT ID	Database ID	Location	Direction	Type	Data Submittal	Electronic Filename	Lane	Time Period of Data Available	7-Card Data		
									Data Omitted	Number of Days Included	Number of Days Omitted
10A	08E010	I-70 MP 419.3	Eastbound	CDOT PORT	1st	CDOT_Port_010_A.xls	All	8/8/00 to 8/11/00	8/8/00; 8/11/00	2	2
10B	08W010	I-70 MP 419.3	Westbound	CDOT PORT	1st	CDOT_Port_010_B.xls	All	8/8/00 to 8/11/00	8/8/00; 8/11/00	2	2
13A	08P013	SH 13 MP 126.2	Both	CDOT PORT	1st	CDOT_Port_013_A.xls	All	7/19/00 to 7/21/00	7/19/00;7/21/00	1	2
14T	08P014	SH 160 MP 145	Both	CDOT PORT	1st	CDOT_Port_014_T.xls	All	7/10/00 to 7/13/00	7/10/00; 7/13/00	2	2
18T	08P018	SH 550 MP 16.5	Both	CDOT PORT	1st	CDOT_Port_018_T.xls	All	7/11/00 to 7/13/00	7/11/00; 7/13/00	1	2
19N	08N019	SH 50 MP 84	Northbound	CDOT PORT	1st	CDOT_Port_019_N.xls	All	7/18/00 to 7/20/00	7/18/00; 7/20/00	1	2
19S	08S019	SH 50 MP 84	Southbound	CDOT PORT	1st	CDOT_Port_019_S.xls	All	7/18/00 to 7/20/00	7/18/00; 7/20/00	1	2
20T	08P020	SH 50 MP 335.7	Both	CDOT PORT	1st	CDOT_Port_020_T.xls	All	7/24/00 to 7/28/00	7/24/00; 7/28/00	3	2
22T	08P022	SH 285 MP 133.9	Both	CDOT PORT	1st	CDOT_Port_022_T.xls	All	8/14/00 to 8/16/00	8/14/00; 8/16/00	1	2
23T	08P023	SH 50 MP 427.7	Both	CDOT PORT	1st	CDOT_Port_023_T.xls	All	8/21/00 to 8/25/00	8/21/00; 8/23/00; 8/25/00	2	3
24T	08P024	SH 50 MP 436.8	Both	CDOT PORT	1st	CDOT_Port_024_T.xls	All	8/21/00 to 8/23/00	8/21/00; 8/23/00	1	2
76Y	08E076	I-76 MP 180.2	Eastbound	CDOT PORT	1st	CDOT_Port_076_Y.xls	All	8/15/00 to 8/17/00	8/15/00; 8/17/00	1	2
76Z	08W076	I-76 MP 180.2	Westbound	CDOT PORT	1st	CDOT_Port_076_Z.xls	All	8/15/00 to 8/17/00	8/15/00; 8/17/00	1	2
85N	08N085	SH 85 MP 272.5	Northbound	CDOT PORT	1st	CDOT_Port_085_N.xls	All	6/22/00 to 6/23/00	6/23/00	1	1
85S	08S085	SH 85 MP 272.5	Southbound	CDOT PORT	1st	CDOT_Port_085_S.xls	All	6/21/00 to 6/23/00	6/21/00; 6/23/00	1	2

Length Inventory-4 Card

CDOT ID	Database ID	Location	Direction	Type	Data Submittal	Electronic Filename	Lane	Time Period of Data Available	4-Card Data or Length Data (for Length sites only)		
									Data Omitted	Number of Days Included	Number of Days Omitted
103	-			LENGTH	1st	-					
109E	-	I-70 E/O Burlington MP 438.7	Eastbound	LENGTH	2nd	-	All	4/2/99 to 2/21/00; 3/24/00 to 6/30/01	5/4/01 to 5/6/01; 5/12/01 to 5/13/01; 5/29/01 to 6/4/01 6/7/01 to 6/14/01	47	14
109W	-		Westbound	LENGTH	2nd	-	All	4/2/99 to 2/21/00; 3/24/00 to 6/30/01	5/1/01; 5/4/01 to 5/6/01; 5/8/01; 5/12/01 to 5/13/01 5/23/01; 5/29/01 to 6/4/01; 6/14/01	45	16
203N	-	SH 13 at WY State Line MP 127.17	Northbound	LENGTH	2nd	-	All	4/2/99 to 6/30/01	No Data Omitted	1	0
203S	-		Southbound	LENGTH	2nd	-	All	4/2/99 to 6/30/01	No Data Omitted	1	0
215N	-	SH 85 N/O Nunn MP 293.0	Northbound	LENGTH	2nd	-	All	4/2/99 to 2/8/0; 7/25/00 to 6/30/01	9/5/00 to 9/13/00; 4/1/01 to 4/2/01; 5/27/01 to 5/31/01	324	16
215S	-		Southbound	LENGTH	2nd	-	All	4/2/99 to 2/8/00; 7/25/00 to 6/30/01	9/5/00 to 9/13/00; 4/1/01 to 4/2/01; 5/27/01 to 5/31/01	324	16
217E	-	SH 160 W/O Bayfield MP 101.0	Eastbound	LENGTH	2nd	-					
217W	-		Westbound	LENGTH	2nd	-					
231E	-	SH 40 S/O Steamboat Springs MP 136	Eastbound	LENGTH	2nd	-					
231W	-		Westbound	LENGTH	2nd	-					

LTPP Inventory-4 Card

CDOT ID	Database ID	Location	Direction	Type	Data Submittal	Electronic Filename	Lane	Time Period of Data Available	4-Card Data or Length Data (for Length sites only)		
									Data Omitted	Number of Days Included	Number of Days Omitted
080200	080200	I-76 MP 18.4	Eastbound	LTPP		LTPP_Perm_080200.xls LTPP_Perm_080200_N.xls	1	1/1/97 to 12/29/99; 3/8/00 to 11/12/00	All data omitted	0	1343
							2	3/8/00 to 11/12/00	All data omitted	0	250
			Westbound				1	3/8/00 to 11/12/00	All data omitted	0	250
							2	3/8/00 to 12/19/00	All data omitted	0	287
080500	080500	I-70 MP 388	Eastbound	LTPP		LTPP_Perm_080500.xls	1	1/1/97 to 4/30/98	All data omitted	0	485
081029	081029	US 40 MP 69.75	Eastbound	LTPP		LTPP_Perm_081029.xls	1	7/1/94 to 7/31/94	All data omitted	0	31
			Westbound				1	7/1/94 to 7/31/94, 1/1/97 to 6/8/99	All data omitted	0	920
081047	081047	SH 160 MP 16.6	Westbound	LTPP		-					
081053	081053	US 50 MP 75.3	Northbound	LTPP		LTPP_Perm_081053.xls		1/1/97 to 9/17/99	All data omitted	0	752
081057	081057	SH 141B MP 160.75	Southbound	LTPP		-					
087781	087781	US 50 MP 402.18	Westbound	LTPP		-					
082008	082008	US 50 MP 401.93	Westbound	LTPP		-					
083032	083032	I-70 MP 95.75	Eastbound	LTPP		LTPP_Perm_083032.xls		5/1/97 to 12/31/97, 6/2/98 to 12/31/98	All data omitted	0	458
086002	086002	I-25 MP 106.35	Northbound	LTPP		LTPP_Perm_086002.xls		1/1/97 to 12/31/98 12/1/99 to 12/28/99	All data omitted	0	757
086013	086013	US 14 MP 235.3	Eastbound	LTPP		LTPP_Perm_086013.xls	1	3/8/00 to 12/31/00	All data omitted	0	299
			Westbound			LTPP_Perm_086013_N.xls	1	4/1/97 to 5/31/97; 3/8/00 to 12/31/00	All data omitted	0	360
087035	087035	I-70 MP 286.25	Eastbound	LTPP		-					
087036	087036	I-70 MP 308.55	Eastbound	LTPP		-					
087776	087776	I-70 MP 289.7	Eastbound	LTPP		LTPP_Perm_087776.xls LTPP_Perm_087776_N.xls	1	10/14/99 to 10/21/99; 1/1/00 to 12/18/00	All data omitted	0	361
							2	1/1/00 to 12/18/00	All data omitted	0	353
			Westbound				1	1/1/00 to 12/18/00	All data omitted	0	353
							2	1/1/00 to 12/18/00	All data omitted	0	353
087780	087780	US 24 MP 291.26	Westbound	LTPP		-					
087783	087783	I-70 MP 67.66	Eastbound	LTPP		LTPP_Perm_087783.xls	1	1/1/97 to 12/31/98	All data omitted	0	730
089019	089019	I-25 MP 246.5	Northbound	LTPP		LTPP_Perm_089019.xls LTPP_Perm_089019_N.xls	1	1/1/97 to 12/29/99; 3/15/00 to 12/31/00	All data omitted	0	1385
							2	3/15/00 to 12/31/00	All data omitted	0	292
			Southbound				1	3/15/00 to 12/31/00	All data omitted	0	292
							2	3/15/00 to 12/31/00	All data omitted	0	292

LTPP Inventory-4 Card

CDOT ID	Database ID	Location	Direction	Type	Data Submittal	Electronic Filename	Lane	Time Period of Data Available	4-Card Data or Length Data (for Length sites only)		
									Data Omitted	Number of Days Included	Number of Days Omitted
089020	089020	I-25 MP 256.4	Northbound	LTPP		LTPP_Perm_089020.xls LTPP_Perm_089020_N.xls	1	3/15/00 to 12/31/00	All data omitted	0	292
							2	3/15/00 to 12/31/00	All data omitted	0	292
			Southbound				1	1/1/97 to 12/29/99; 3/15/00 to 12/31/00	All data omitted	0	1385
							2	3/15/00 to 5/24/00	All data omitted	0	71

LTPP Inventory-7 Card

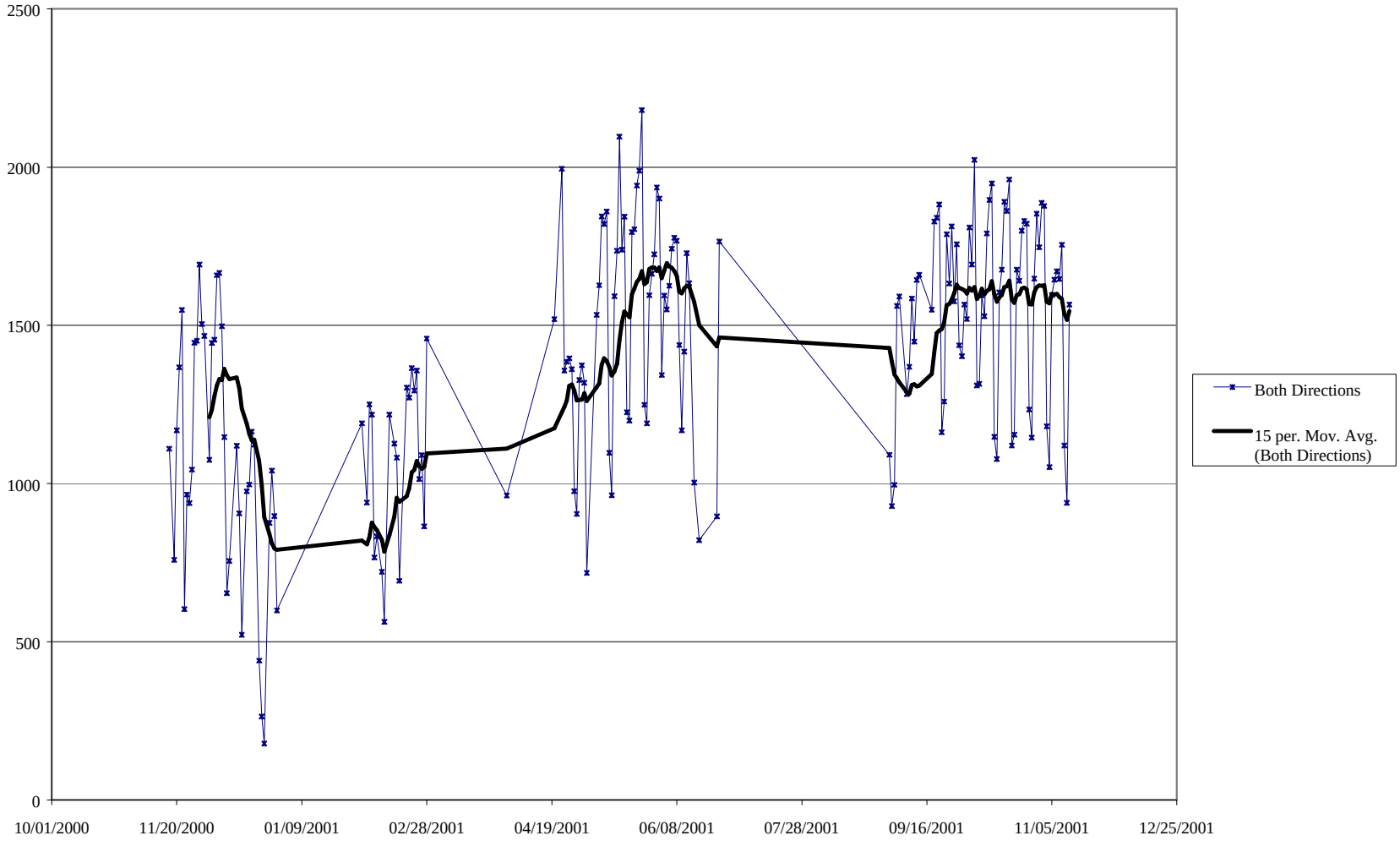
CDOT ID	Database ID	Location	Direction	Type	Data Submittal	Electronic Filename	Lane	Time Period of Data Available	7-Card Data		
									Data Omitted	Number of Days Included	Number of Days Omitted
080200	080200	I-76 MP 18.4	Eastbound	LTPP		LTPP_Perm_080200.xls LTPP_Perm_080200_N.xls	1	1/1/97 to 12/29/99; 3/8/00 to 11/12/00	10/3/97; 10/25/97; 11/1/97 to 11/3/97; 2/5/98 7/17/98 to 7/22/98; 8/25/98; 6/29/99 to 7/13/99 7/31/99 to 10/4/99; 10/6/99 to 10/12/99; 10/16/99 to 10/19/99; 11/3/99 to 11/9/99 11/12/99 to 11/15/99; 11/18/99 to 11/30/99 6/28/00 to 7/4/00; 7/11/00 to 7/16/00; 7/25/00 to 9/18/00 9/27/00 to 10/2/00; 10/6/00 to 11/2/00	1111	232
							2	3/8/00 to 11/12/00	6/28/00 to 7/4/00; 7/11/00 to 7/16/00; 7/25/00 to 8/16/00 8/18/00 to 9/6/00; 9/9/00 to 9/18/00; 9/27/00 to 10/2/00 10/6/00 to 11/2/00	150	100
			Westbound				1	3/8/00 to 11/12/00	All data omitted	0	250
							2	3/8/00 to 12/19/00	All data omitted	0	287
080500	080500	I-70 MP 388	Eastbound	LTPP		LTPP_Perm_080500.xls	1	1/1/97 to 4/30/98	1/1/97 to 4/27/97; 4/29/97 to 5/1/97; 5/31/97 10/25/97 to 10/27/97; 3/1/98 to 3/31/98; 4/2/98; 4/7/98 4/13/98; 4/15/98; 4/18/98; 4/20/98 to 4/22/98; 4/29/98	321	164
081029	081029	US 40 MP 69.75	Eastbound	LTPP		LTPP_Perm_081029.xls	1	7/1/94 to 7/31/94	No Data Omitted	31	0
			Westbound				1	7/1/94 to 7/31/94; 1/1/97 to 6/8/99	2/21/97 to 5/22/97; 6/7/97; 8/14/97 to 9/22/97	788	132
081047	081047	SH 160 MP 16.6	Westbound	LTPP		-					
081053	081053	US 50 MP 75.3	Northbound	LTPP		LTPP_Perm_081053.xls		1/1/97 to 9/17/99	5/13/97 to 5/19/97; 6/1/97 to 6/30/97; 7/11/97 to 8/9/97 9/7/97 to 10/7/97; 2/4/99 to 5/13/99; 5/15/99 to 9/17/99	423	329
081057	081057	SH 141B MP 160.75	Southbound	LTPP		-					
087781	087781	US 50 MP 402.18	Westbound	LTPP		-					
082008	082008	US 50 MP 401.93	Westbound	LTPP		-					
083032	083032	I-70 MP 95.75	Eastbound	LTPP		LTPP_Perm_083032.xls		5/1/97 to 12/31/97, 6/2/98 to 12/31/98	5/1/97 to 5/21/97; 5/24/97 to 5/29/97; 8/8/97 to 9/22/97 9/29/97 to 9/30/97; 10/22/97; 10/31/97 11/30/97 to 12/9/97; 6/2/98 to 12/31/98	158	300
086002	086002	I-25 MP 106.35	Northbound	LTPP		LTPP_Perm_086002.xls		1/1/97 to 12/31/98 12/1/99 to 12/28/99	1/1/97 to 4/14/97; 8/30/97 to 10/5/97; 10/25/97 11/1/97 to 11/29/97; 6/4/98; 6/9/98 to 12/31/98 12/4/99 to 12/7/99; 12/24/99 to 12/27/99	372	385
086013	086013	US 14 MP 235.3	Eastbound	LTPP		LTPP_Perm_086013.xls LTPP_Perm_086013_N.xls	1	3/8/00 to 12/31/00	3/8/00 to 12/31/00	0	299
			Westbound				1	4/1/97 to 5/31/97; 3/8/00 to 12/31/00	5/4/97 to 5/12/97; 3/8/00 to 12/31/00	52	308
087035	087035	I-70 MP 286.25	Eastbound	LTPP		-					
087036	087036	I-70 MP 308.55	Eastbound	LTPP		-					
087776	087776	I-70 MP 289.7	Eastbound	LTPP		LTPP_Perm_087776.xls LTPP_Perm_087776_N.xls	1	10/14/99 to 10/21/99; 1/1/00 to 12/18/00	2/29/00; 4/11/00 to 8/8/00; 11/4/00 to 11/7/00	236	125
							2	1/1/00 to 12/18/00	2/29/00; 4/11/00 to 8/8/00; 11/4/00 to 11/7/00	228	125
			Westbound				1	1/1/00 to 12/18/00	2/29/00; 5/31/00 to 8/8/00; 11/4/00 to 11/7/00	278	75
							2	1/1/00 to 12/18/00	2/29/00; 5/31/00 to 8/8/00; 11/4/00 to 11/7/00	278	75
087780	087780	US 24 MP 291.26	Westbound	LTPP		-					
087783	087783	I-70 MP 67.66	Eastbound	LTPP		LTPP_Perm_087783.xls	1	1/1/97 to 12/31/98	1/1/97 to 5/19/97; 8/12/98 to 8/17/98	585	145
089019	089019	I-25 MP 246.5	Northbound	LTPP		LTPP_Perm_089019.xls LTPP_Perm_089019_N.xls	1	1/1/97 to 12/29/99; 3/15/00 to 12/31/00	6/15/97 to 6/30/97; 8/28/97; 10/22/97 to 11/6/97; 12/4/97 12/15/97; 12/26/97; 1/22/98; 2/2/98; 5/14/98 to 6/7/98 6/17/98 to 6/18/98; 7/2/98 to 7/6/98; 11/30/98 to 12/8/98 1/22/99 to 1/31/99; 3/17/99 to 3/25/99; 5/13/99 to 5/24/99 5/29/99 to 5/31/99; 8/31/99; 9/29/99 to 9/30/99; 11/26/99 3/15/00 to 5/21/00; 5/25/00 to 5/31/00; 9/25/00 to 10/1/00 10/29/00 to 10/30/00	1184	201
							2	3/15/00 to 12/31/00	3/15/00 to 5/21/00; 5/25/00 to 5/31/00; 9/25/00 to 10/1/00 10/29/00 to 10/30/00	208	84
			Southbound				1	3/15/00 to 12/31/00	5/25/00 to 12/31/00	71	221
							2	3/15/00 to 12/31/00	5/25/00 to 12/31/00	71	221

LTPP Inventory-7 Card

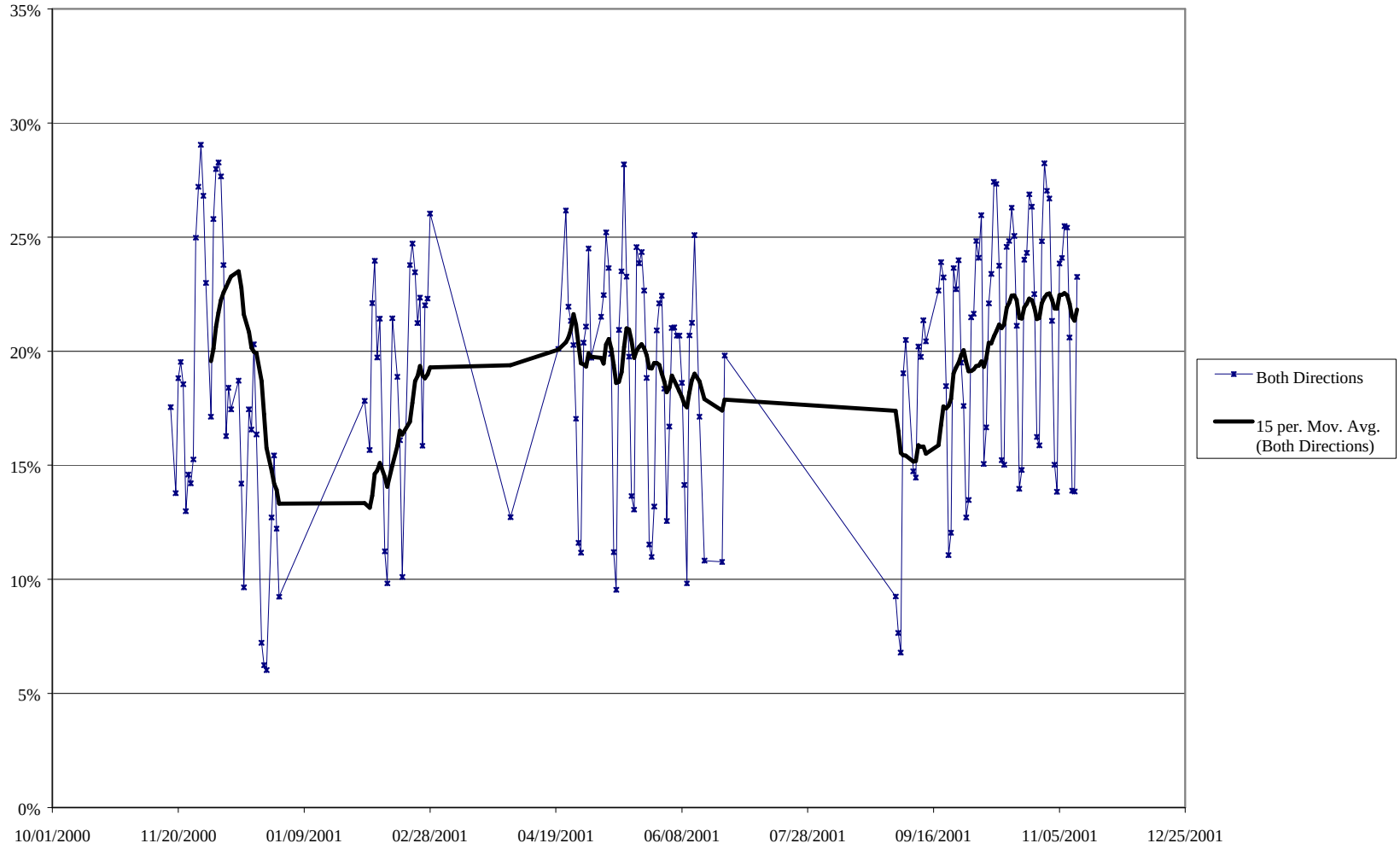
CDOT ID	Database ID	Location	Direction	Type	Data Submittal	Electronic Filename	Lane	Time Period of Data Available	7-Card Data		
									Data Omitted	Number of Days Included	Number of Days Omitted
089020	089020	I-25 MP 256.4	Northbound	LTPP		LTPP_Perm_089020.xls LTPP_Perm_089020_N.xls	1	3/15/00 to 12/31/00	3/15/00 to 5/21/00; 5/25/00 to 5/31/00; 9/25/00 to 10/1/00 10/29/00 to 10/30/00	208	84
							2	3/15/00 to 12/31/00	3/15/00 to 5/21/00; 5/25/00 to 5/31/00; 9/25/00 to 10/1/00 10/29/00 to 10/30/00	208	84
			Southbound				1	1/1/97 to 12/29/99; 3/15/00 to 12/31/00	6/15/97 to 6/30/97; 8/28/97; 10/22/97 to 11/6/97; 12/4/97 12/15/97; 12/26/97; 1/22/98; 2/2/98; 5/14/98 to 6/7/98 6/17/98 to 6/18/98; 7/2/98 to 7/6/98; 11/30/98 to 12/8/98 3/17/99 to 3/25/99; 5/13/99 to 5/24/99; 5/29/99 to 5/31/99 8/31/99; 9/29/99 to 9/30/99; 11/26/99; 5/24/00 to 12/31/00	1056	329
							2	3/15/00 to 5/24/00	No Data Omitted	71	0

APPENDIX 3. CDOT PERMANENT WIM SITE 8 SNAPSHOT RESULTS

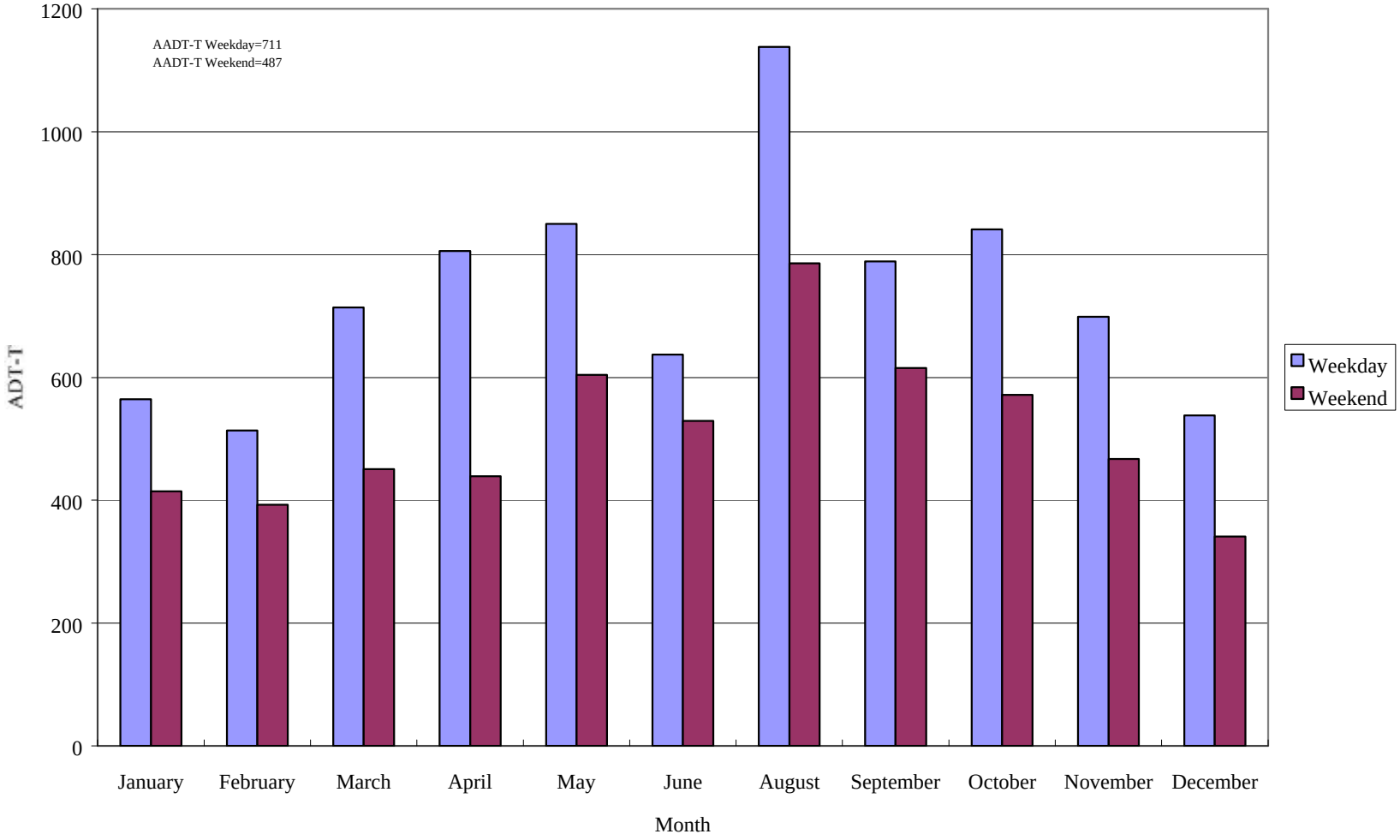
Total Trucks for CDOT Perm. Site 8



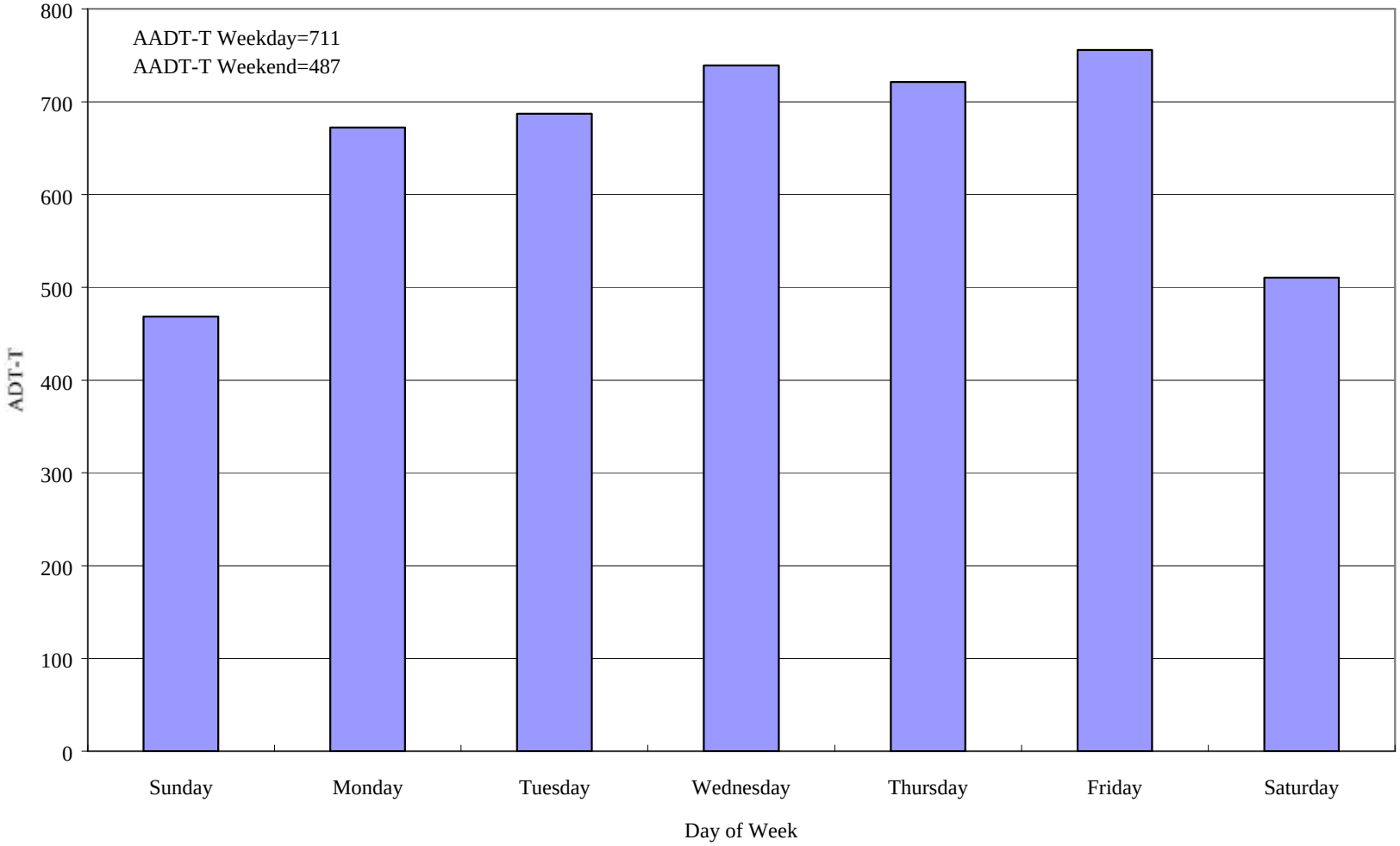
% Trucks for CDOT Perm. Site 8



Monthly ADT-T Variation at Site 8

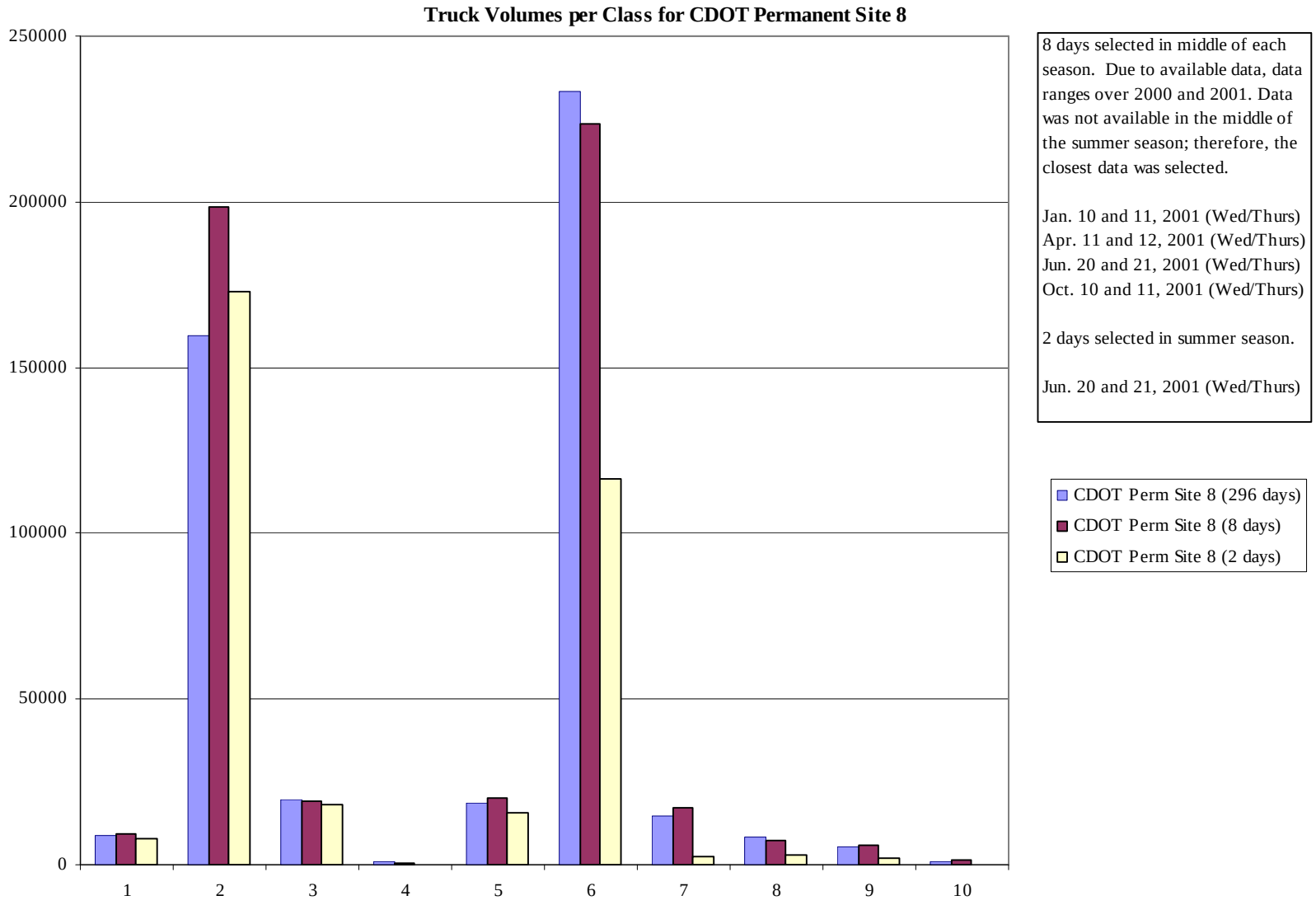


Day of Week ADT-T Variation at Site 8



Snapshot Analysis Using 7-Card Data

	year	# of days collected	Lane	FHWA Class													TOTAL VOL (Class 4-13)	ADT-T	% OFF FROM CONT. DATA
				1	2	3	4	5	6	7	8	9	10	11	12	13			
CDOT Perm. Site 8 Both Directions (284 days) 2000-2001 Volume	2000-2001	284	1	0	0	0	9041	159406	19864	1127	18872	233204	14856	8180	5506	1014	471071	1291	NA
CDOT Perm. Site 8 Both Directions (8 days) 2000-2001 Volume	2000-2001	8	1	0	0	0	9171	198606	19117	548	19893	223243	17292	7391	5840	1551	502651	1377	7%
CDOT Perm. Site 8 Both Directions (2 days) 2000-2001 Volume	2000-2001	2	1	0	0	0	7848	172828	18068	0	15695	116253	2555	3103	2190	0	338538	928	-28%


Truck Volumes per Class for CDOT Permanent Site 8
250000
200000
150000
100000
50000
0
1
2
3
4
5
6
7
8
9
10
8 days selected in middle of each season. Due to available data, data ranges over 2000 and 2001. Data was not available in the middle of the summer season; therefore, the closest data was selected.
Jan. 10 and 11, 2001 (Wed/Thurs)
Apr. 11 and 12, 2001 (Wed/Thurs)
Jun. 20 and 21, 2001 (Wed/Thurs)
Oct. 10 and 11, 2001 (Wed/Thurs)
2 days selected in summer season.
Jun. 20 and 21, 2001 (Wed/Thurs)
CDOT Perm Site 8 (296 days)
CDOT Perm Site 8 (8 days)
CDOT Perm Site 8 (2 days)

ADJUSTMENT FACTORS FOR CDOT PERMANENT SITE 8
7-CARD BOTH DIRECTIONS

Month of November

Day	Number Designation	FHWA Classification												
		1	2	3	4	5	6	7	8	9	10	11	12	13
Sunday	1	N/A	N/A	N/A	2.249	1.276	5.676	3.166	1.440	1.476	1.438	1.724	2.906	1.342
Monday	2	N/A	N/A	N/A	0.973	1.080	0.758	1.407	1.154	0.887	0.928	0.985	0.848	0.854
Tuesday	3	N/A	N/A	N/A	0.779	1.038	0.692	0.863	1.034	0.890	0.907	0.841	0.934	1.174
Wednesday	4	N/A	N/A	N/A	1.048	0.984	0.669	0.603	0.992	0.908	0.729	0.815	0.872	1.044
Thursday	5	N/A	N/A	N/A	1.080	1.033	1.014	1.439	1.039	0.947	0.959	0.784	0.727	0.652
Friday	6	N/A	N/A	N/A	1.019	0.873	1.604	2.532	1.172	0.990	1.023	0.815	0.701	0.587
Saturday	7	N/A	N/A	N/A	1.862	1.370	2.129	2.110	1.592	1.329	1.492	0.954	1.327	0.722

Month of December

Day	Number Designation	FHWA Classification												
		1	2	3	4	5	6	7	8	9	10	11	12	13
Sunday	1	N/A	N/A	N/A	2.934	2.803	6.149	7.914	2.617	1.747	3.991	2.197	5.449	N/A
Monday	2	N/A	N/A	N/A	1.500	2.893	1.237	3.166	1.949	1.221	1.717	1.263	1.419	N/A
Tuesday	3	N/A	N/A	N/A	1.384	2.464	1.165	6.331	1.838	1.023	1.681	0.700	0.793	N/A
Wednesday	4	N/A	N/A	N/A	1.059	2.963	1.287	12.662	1.570	0.774	1.330	0.684	0.636	N/A
Thursday	5	N/A	N/A	N/A	1.125	1.967	1.011	12.662	1.338	0.810	1.451	0.669	0.718	N/A
Friday	6	N/A	N/A	N/A	1.227	1.731	0.870	1.218	1.511	0.981	1.091	0.742	0.848	5.870
Saturday	7	N/A	N/A	N/A	2.076	2.057	3.075	2.638	2.546	1.444	2.146	1.350	1.956	5.870

Month of January

Day	Number Designation	FHWA Classification												
		1	2	3	4	5	6	7	8	9	10	11	12	13
Sunday	1	N/A	N/A	N/A	2.699	1.714	3.884	0.974	1.468	1.497	1.698	1.379	2.906	9.392
Monday	2	N/A	N/A	N/A	2.045	1.874	1.464	3.166	1.579	1.200	2.146	1.318	1.362	11.740
Tuesday	3	N/A	N/A	N/A	1.071	1.711	1.370	1.978	1.435	1.062	1.003	0.942	1.211	11.740
Wednesday	4	N/A	N/A	N/A	1.163	2.030	1.040	2.261	1.464	0.829	1.097	0.737	0.741	3.913
Thursday	5	N/A	N/A	N/A	1.091	1.961	0.904	1.809	1.362	0.829	1.037	0.650	0.735	N/A
Friday	6	N/A	N/A	N/A	0.947	1.247	1.401	1.583	1.270	0.901	1.219	0.854	0.753	N/A
Saturday	7	N/A	N/A	N/A	1.714	1.581	3.033	1.809	1.528	1.460	1.971	1.338	2.543	9.392

ADJUSTMENT FACTORS FOR CDOT PERMANENT SITE 8
7-CARD BOTH DIRECTIONS

Month of February

Day	Number Designation	FHWA Classification												
		1	2	3	4	5	6	7	8	9	10	11	12	13
Sunday	1	N/A	N/A	N/A	2.999	1.912	4.257	4.748	1.437	1.452	1.735	1.345	3.521	N/A
Monday	2	N/A	N/A	N/A	1.227	2.075	1.064	0.904	1.468	0.969	0.858	1.358	1.052	N/A
Tuesday	3	N/A	N/A	N/A	0.947	1.394	0.946	0.487	1.087	0.992	0.887	1.281	1.130	4.696
Wednesday	4	N/A	N/A	N/A	1.384	2.066	1.085	0.158	1.166	1.477	1.157	2.241	1.795	4.696
Thursday	5	N/A	N/A	N/A	1.396	2.477	1.267	9.497	1.285	0.967	1.050	0.782	1.064	N/A
Friday	6	N/A	N/A	N/A	1.052	2.416	1.372	3.166	1.325	1.044	1.316	1.201	0.995	N/A
Saturday	7	N/A	N/A	N/A	2.612	2.574	1.908	N/A	1.972	1.340	1.361	1.269	2.289	N/A

Month of March

Day	Number Designation	FHWA Classification												
		1	2	3	4	5	6	7	8	9	10	11	12	13
Sunday	1	N/A	N/A	N/A	2.297	1.654	2.516	0.352	0.938	1.327	1.319	1.338	3.590	2.348
Monday	2	N/A	N/A	N/A	1.588	1.268	0.912	0.250	1.123	0.883	0.837	1.067	1.064	7.044
Tuesday	3	N/A	N/A	N/A	0.973	1.089	0.731	1.266	1.236	0.847	1.183	0.717	0.848	9.392
Wednesday	4	N/A	N/A	N/A	0.982	1.067	0.875	0.745	1.203	0.764	0.743	0.838	0.884	2.348
Thursday	5	N/A	N/A	N/A	1.261	1.153	0.665	0.368	1.020	0.844	0.777	0.714	0.919	5.870
Friday	6	N/A	N/A	N/A	1.063	1.055	0.764	0.233	1.149	0.865	0.864	0.889	0.867	N/A
Saturday	7	N/A	N/A	N/A	1.901	1.782	1.677	0.337	1.495	1.340	1.304	1.180	3.468	11.740

Month of April

Day	Number Designation	FHWA Classification												
		1	2	3	4	5	6	7	8	9	10	11	12	13
Sunday	1	N/A	N/A	N/A	2.633	1.826	4.518	6.331	2.174	1.702	2.047	2.085	5.548	9.392
Monday	2	N/A	N/A	N/A	0.850	0.898	0.753	0.352	1.023	0.652	0.657	0.773	0.911	N/A
Tuesday	3	N/A	N/A	N/A	0.920	0.982	0.839	0.791	1.138	0.868	0.943	0.782	0.848	3.522
Wednesday	4	N/A	N/A	N/A	0.939	1.048	0.826	1.583	1.092	0.663	0.652	0.650	0.753	4.696
Thursday	5	N/A	N/A	N/A	0.701	0.863	0.671	0.904	0.996	0.731	0.564	0.753	0.836	9.392
Friday	6	N/A	N/A	N/A	1.038	0.940	0.842	1.055	1.148	0.950	0.806	0.975	0.984	9.392
Saturday	7	N/A	N/A	N/A	1.661	1.216	1.977	1.809	1.713	1.219	1.210	1.093	4.359	9.392

ADJUSTMENT FACTORS FOR CDOT PERMANENT SITE 8
7-CARD BOTH DIRECTIONS

Month of May

Day	Number Designation	FHWA Classification												
		1	2	3	4	5	6	7	8	9	10	11	12	13
Sunday	1	N/A	N/A	N/A	1.421	0.963	3.162	4.221	0.856	1.094	3.131	1.135	2.774	N/A
Monday	2	N/A	N/A	N/A	0.725	0.578	0.845	12.662	0.659	0.784	1.629	1.019	0.969	N/A
Tuesday	3	N/A	N/A	N/A	0.776	0.704	0.677	2.638	0.930	0.831	1.304	0.897	1.122	N/A
Wednesday	4	N/A	N/A	N/A	0.844	0.855	0.782	1.978	0.883	0.769	1.339	0.882	0.795	11.740
Thursday	5	N/A	N/A	N/A	0.833	0.840	0.769	15.828	0.798	0.920	2.772	1.047	1.174	N/A
Friday	6	N/A	N/A	N/A	0.617	0.603	0.911	N/A	0.469	0.731	1.735	0.801	0.694	9.392
Saturday	7	N/A	N/A	N/A	1.038	1.002	2.306	N/A	0.841	1.100	2.903	0.823	3.390	N/A

Month of June

Day	Number Designation	FHWA Classification												
		1	2	3	4	5	6	7	8	9	10	11	12	13
Sunday	1	N/A	N/A	N/A	1.227	0.798	1.628	N/A	0.772	2.008	7.257	2.490	4.359	N/A
Monday	2	N/A	N/A	N/A	0.991	1.099	0.363	N/A	0.950	1.437	2.903	2.135	1.197	N/A
Tuesday	3	N/A	N/A	N/A	0.835	0.853	0.532	9.497	1.357	1.186	1.842	1.180	1.387	N/A
Wednesday	4	N/A	N/A	N/A	0.810	0.874	0.469	4.748	0.969	1.231	2.785	1.817	1.144	N/A
Thursday	5	N/A	N/A	N/A	0.794	0.909	0.499	N/A	0.897	1.180	3.070	1.358	1.606	N/A
Friday	6	N/A	N/A	N/A	0.900	0.845	0.375	N/A	0.739	1.420	3.801	1.601	1.356	N/A
Saturday	7	N/A	N/A	N/A	1.285	0.847	1.419	N/A	1.067	1.725	4.277	2.101	2.543	N/A

Month of August

Day	Number Designation	FHWA Classification												
		1	2	3	4	5	6	7	8	9	10	11	12	13
Sunday	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Monday	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Tuesday	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Wednesday	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Thursday	5	N/A	N/A	N/A	0.818	0.817	0.907	N/A	1.028	1.117	1.247	1.401	0.897	N/A
Friday	6	N/A	N/A	N/A	0.469	0.365	0.814	0.352	0.251	0.655	0.649	0.553	0.469	N/A
Saturday	7	N/A	N/A	N/A	0.403	0.732	1.318	1.583	0.764	0.927	1.478	0.934	1.174	N/A

ADJUSTMENT FACTORS FOR CDOT PERMANENT SITE 8
7-CARD BOTH DIRECTIONS

Month of September

Day	Number Designation	FHWA Classification												
		1	2	3	4	5	6	7	8	9	10	11	12	13
Sunday	1	N/A	N/A	N/A	1.467	0.823	2.145	2.638	0.912	1.293	0.828	1.932	3.051	0.273
Monday	2	N/A	N/A	N/A	0.892	0.830	0.861	0.791	0.901	0.966	0.644	1.281	1.130	0.671
Tuesday	3	N/A	N/A	N/A	0.777	0.911	0.576	1.266	1.125	0.903	0.549	1.055	0.727	0.324
Wednesday	4	N/A	N/A	N/A	0.701	0.911	0.598	0.666	1.396	0.756	0.395	0.830	0.587	0.261
Thursday	5	N/A	N/A	N/A	0.782	0.925	0.537	0.309	1.256	0.848	0.447	0.838	0.671	0.268
Friday	6	N/A	N/A	N/A	0.844	0.735	0.904	0.372	0.890	0.981	0.433	1.019	0.782	0.247
Saturday	7	N/A	N/A	N/A	1.134	0.848	2.005	0.931	1.087	1.320	0.895	1.192	1.106	0.335

Month of October

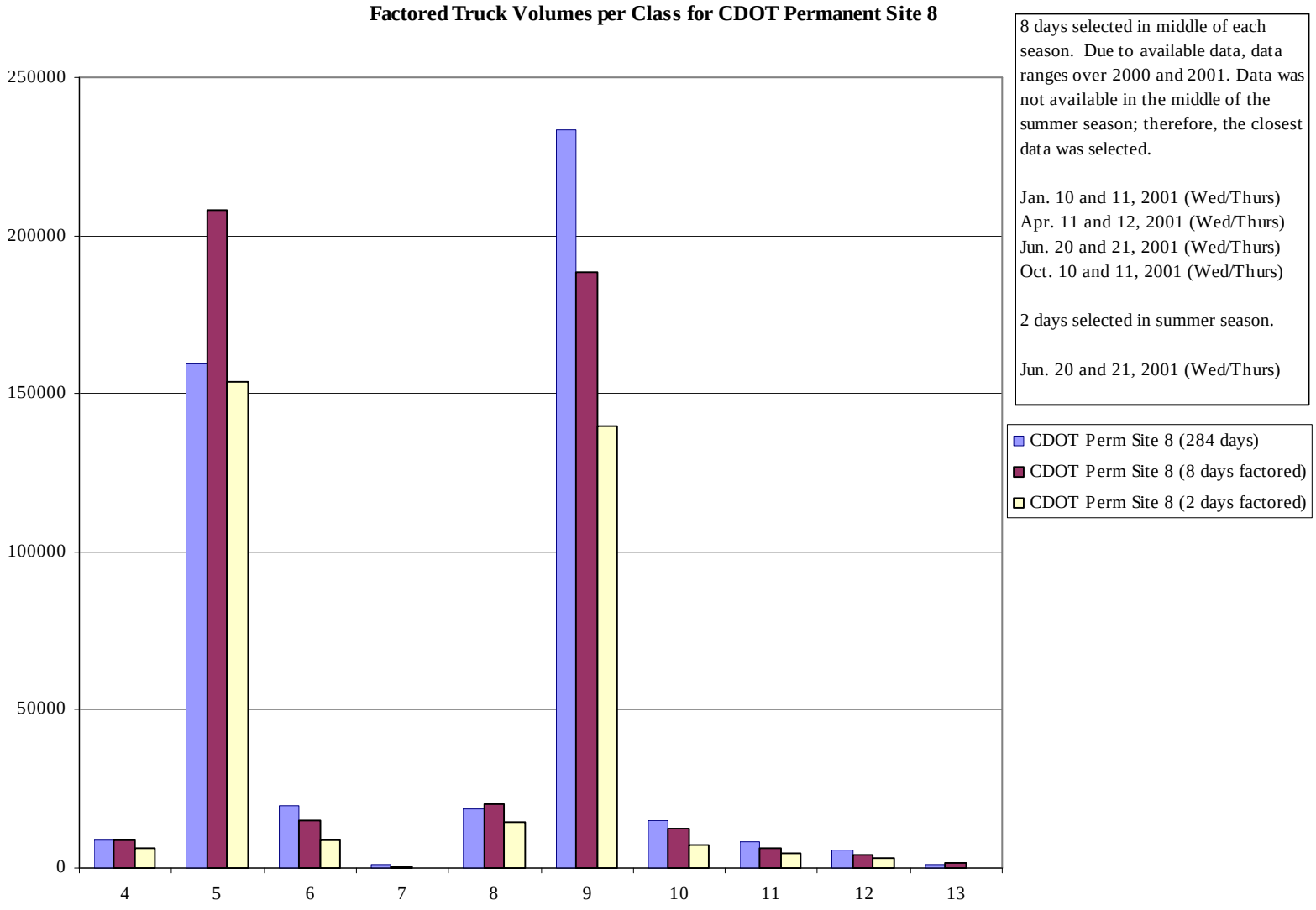
Day	Number Designation	FHWA Classification												
		1	2	3	4	5	6	7	8	9	10	11	12	13
Sunday	1	N/A	N/A	N/A	1.830	0.806	5.826	6.331	1.270	1.520	1.157	2.359	2.441	0.313
Monday	2	N/A	N/A	N/A	0.964	0.752	1.198	0.480	1.173	0.953	0.477	1.019	0.713	0.165
Tuesday	3	N/A	N/A	N/A	1.046	0.808	0.929	0.833	1.104	0.933	0.424	0.882	0.468	0.154
Wednesday	4	N/A	N/A	N/A	0.924	0.770	0.974	0.396	0.883	0.834	0.360	0.728	0.454	0.120
Thursday	5	N/A	N/A	N/A	1.080	0.653	0.958	0.844	0.739	0.888	0.499	0.879	0.565	0.181
Friday	6	N/A	N/A	N/A	0.760	0.510	1.350	1.407	0.766	0.958	0.515	0.996	0.484	0.142
Saturday	7	N/A	N/A	N/A	1.565	0.846	2.282	1.809	1.468	1.395	1.288	1.401	0.860	0.188

Applying Factors To 2 Day Snapshot of Eastbound 7-Card for CDOT Permanent Site 8

Days Selected	FHWA Class													TOTAL VOL (Class 4-13)	ADT-T	% OFF FROM CONT. DATA
	1	2	3	4	5	6	7	8	9	10	11	12	13			
June 20, 2001	0	0	0	16	455	21	0	34	341	22	15	7	0			
June 21, 2001	0	0	0	18	387	27	0	46	425	18	12	10	0			
Sum	0	0	0	34	842	48	0	80	766	41	27	17	0			
Expanded to a year	0	0	0	6288	153724	8771	0	14541	139726	7428	4885	3012	0	338374	927	-28%
CDOT Perm. Site 8 Both Directions (284 days) 2000-2001 Volume	0	0	0	9041	159406	19864	1127	18872	233204	14856	8180	5506	1014	471071	1291	

Applying Factors To 8 Day Snapshot of Eastbound 7-Card for CDOT Permanent Site 8

Days Selected	FHWA Class													TOTAL VOL (Class 4-13)	ADT-T	% DIFF. OF 8 DAY AND CONT.
	1	2	3	4	5	6	7	8	9	10	11	12	13			
January 10, 2001	0	0	0	23	832	36	2	51	599	41	21	12	12			
January 11, 2001	0	0	0	20	933	56	5	87	610	48	18	10	0			
April 11, 2001	0	0	0	29	343	50	2	44	534	36	21	11	5			
April 12, 2001	0	0	0	19	318	48	3	47	554	35	17	10	9			
June 20, 2001	0	0	0	16	455	21	0	34	341	22	15	7	0			
June 21, 2001	0	0	0	18	387	27	0	46	425	18	12	10	0			
October 10, 2001	0	0	0	29	657	56	1	75	526	29	15	11	2			
October 11, 2001	0	0	0	33	634	32	1	58	536	42	13	19	3			
Sum	0	0	0	188	4559	326	14	442	4125	271	131	91	30			
Expanded to a year	0	0	0	8556	208020	14889	639	20169	188189	12365	5963	4131	1379	464300	1272	-1%
CDOT Perm. Site 8 Both Directions (284 days) 2000-2001 Volume	0	0	0	9041	159406	19864	1127	18872	233204	14856	8180	5506	1014	471071	1291	


Factored Truck Volumes per Class for CDOT Permanent Site 8
250000
200000
150000
100000
50000
0
4
5
6
7
8
9
10
11
12
13
8 days selected in middle of each season. Due to available data, data ranges over 2000 and 2001. Data was not available in the middle of the summer season; therefore, the closest data was selected.
Jan. 10 and 11, 2001 (Wed/Thurs)
Apr. 11 and 12, 2001 (Wed/Thurs)
Jun. 20 and 21, 2001 (Wed/Thurs)
Oct. 10 and 11, 2001 (Wed/Thurs)
2 days selected in summer season.
Jun. 20 and 21, 2001 (Wed/Thurs)
CDOT Perm Site 8 (284 days)
CDOT Perm Site 8 (8 days factored)
CDOT Perm Site 8 (2 days factored)

APPENDIX 4. CDOT REGION MAPS

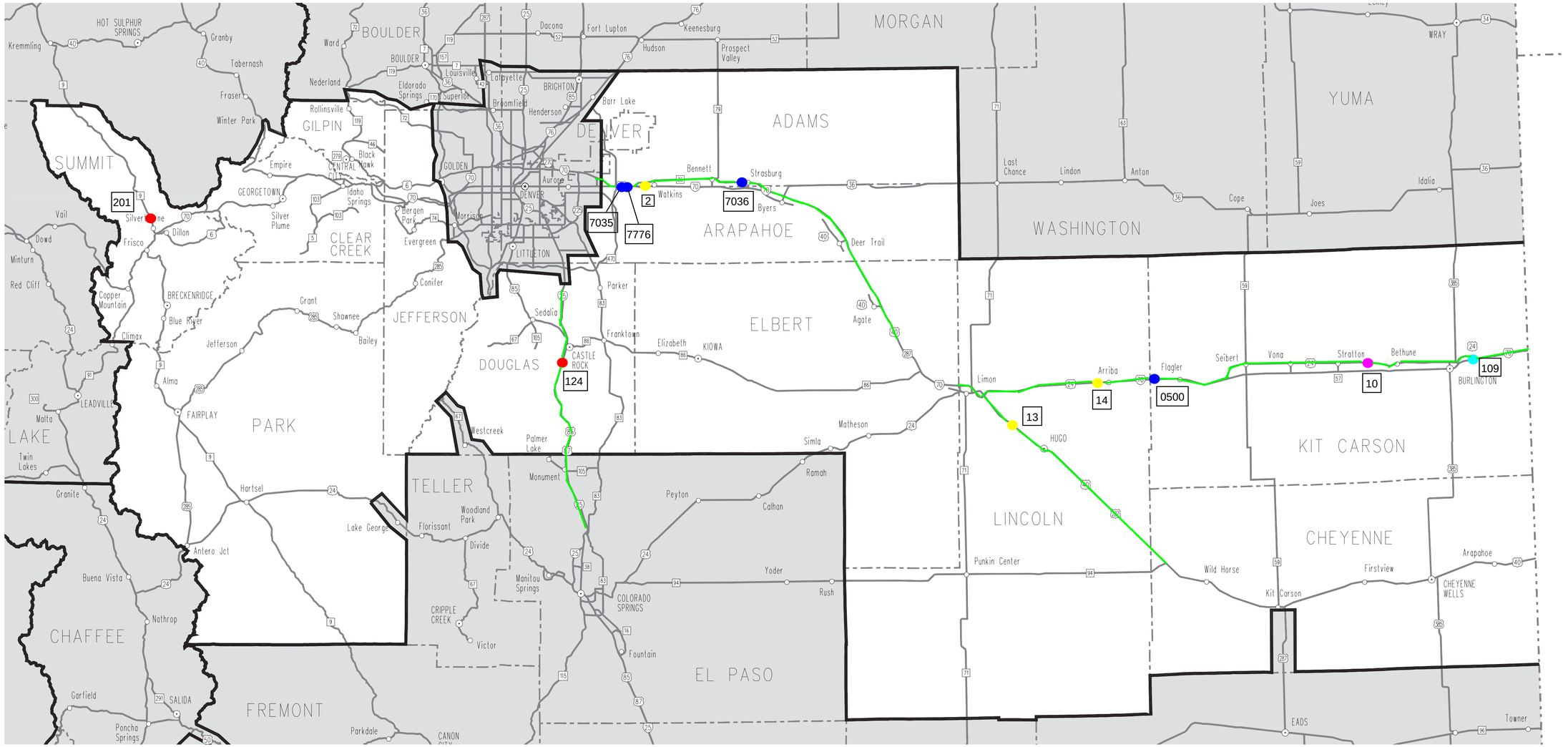
Data Sources In CDOT Region 1

CDOT ID	Database ID	Location	Direction	Type	CDOT Region
124	08A124	I-25 MP 180.1	Northbound	AVC	1
			Southbound		
201	08A201	SH 9 MP 204.1	Northbound	AVC	1
			Southbound		
10A	08E010	I-70 MP 419.3	Eastbound	CDOT PORT	1
10B	08W010	I-70 MP 419.3	Westbound	CDOT PORT	
Site 2 Airpark	08T020	I-70 MP 291.2	Eastbound	CDOT PERM	1
	08T020		Westbound		
Site 13 SH 40 SE of Limon	08T130	SH 40 MP 388.5	Eastbound	CDOT PERM	1
	08T130		Westbound		
Site 14 I-70 @ Limon	08T140	I-70 MP 365.3	Eastbound	CDOT PERM	1
	08T140		Westbound		
109E	-	I-70 E/O Burlington MP 438.7	Eastbound	LENGTH	1
109W	-		Westbound	LENGTH	
080500	080500	I-70 MP 388	Eastbound	LTPP	1
087035	087035	I-70 MP 286.25	Eastbound	LTPP	1
087036	087036	I-70 MP 308.55	Eastbound	LTPP	1
087776	087776	I-70 MP 289.7	Eastbound	LTPP	1
			Westbound		

CDOT Perm. Site
CDOT Length Site
CDOT Port. Site
CDOT AVC Site
LTPP Site
Segment
Break in segment

Transportation Region 1

August 1, 1999



segments not to scale

Data Sources In CDOT Region 2

CDOT ID	Database ID	Location	Direction	Type	CDOT Region
20T	08P020	SH 50 MP 335.7	Both	CDOT PORT	2
23T	08P023	SH 50 MP 427.7	Both	CDOT PORT	2
24T	08P024	SH 50 MP 436.8	Both	CDOT PORT	2
Site 5 Eads	08N005	SH 287 MP 110.59	Northbound	CDOT PERM	2
	08S005		Southbound		
082008	082008	US 50 MP 401.93	Westbound	LTPP	2
086002	086002	I-25 MP 106.35	Northbound	LTPP	2
087780	087780	US 24 MP 291.26	Westbound	LTPP	2
087781	087781	US 50 MP 402.18	Westbound	LTPP	2

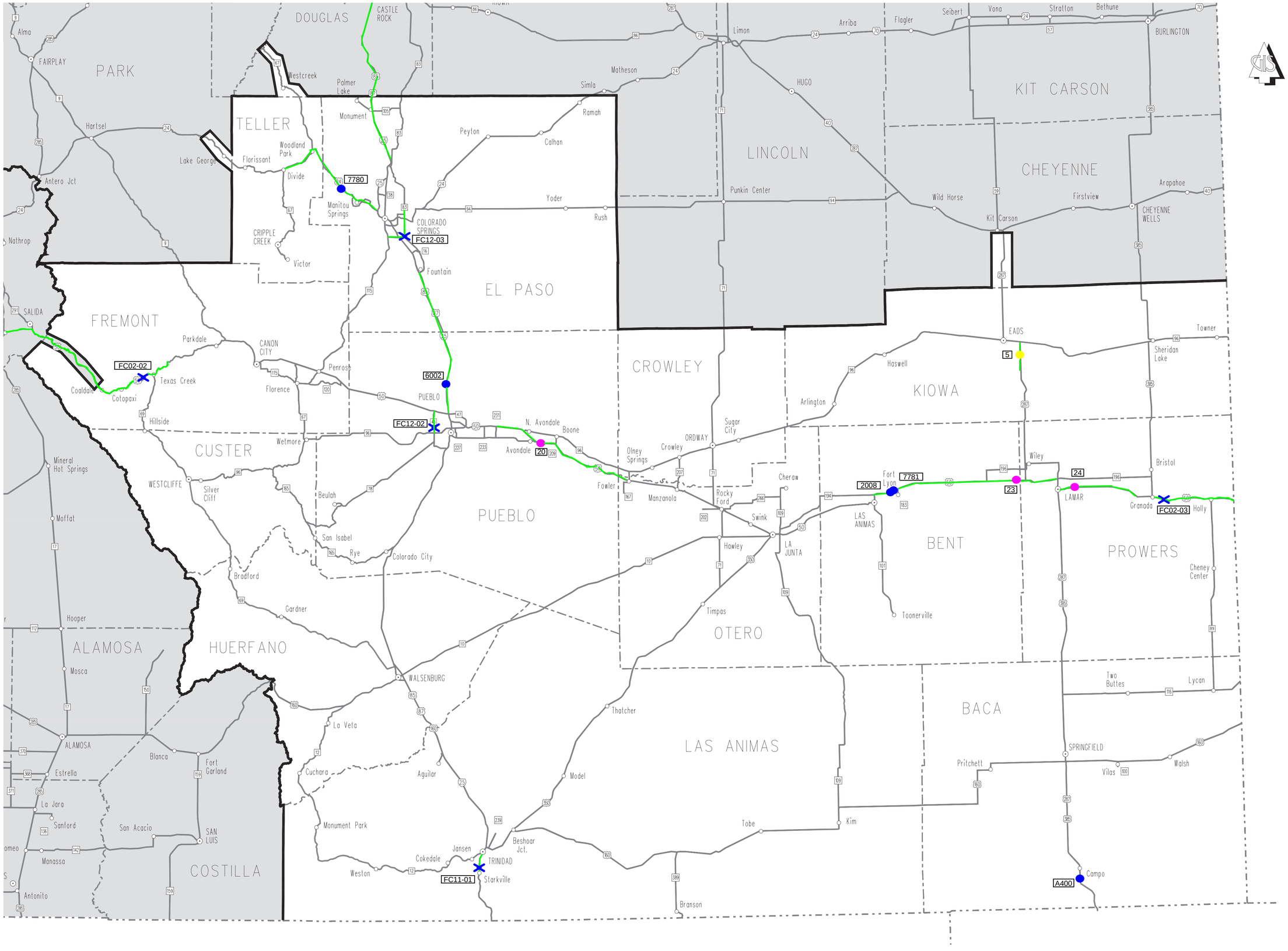
Proposed New WIM Sites

ID (Functional Class ##-##)	Location
FC02-02	US 50 MP 252.7
FC02-03	US 50 MP 452.8
FC11-01	I-25 MP 12.9
FC12-02	SH 45 MP 4.7
FC12-03	SH 83 MP 2.9

Transportation Region 2

August 1, 1999

- CDOT Perm. WIM Site
- CDOT Length Site
- CDOT Port. WIM Site
- CDOT AVC Site
- LTPP Site
- Segment
- Break in Segments
- Proposed WIM



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Data Sources In CDOT Region 3

CDOT ID	Database ID	Location	Direction	Type	CDOT Region
242	08A242	SH 50 MP 45.7	Eastbound	AVC	3
			Westbound		
13A	08P013	SH 13 MP 126.2	Both	CDOT PORT	3
19N	08N019	SH 50 MP 84	Northbound	CDOT PORT	3
19S	08S019	SH 50 MP 84	Southbound	CDOT PORT	
203N	-	SH 13 at WY State Line MP 127.17	Northbound	LENGTH	3
203S	-		Southbound	LENGTH	
231E	-	SH 40 S/O Steamboat Springs MP 136	Eastbound	LENGTH	3
231W	-		Westbound	LENGTH	
081029	081029	US 40 MP 69.75	Eastbound	LTPP	3
			Westbound		
081047	081047	SH 160 MP 16.6	Westbound	LTPP	3
081053	081053	US 50 MP 75.3	Northbound	LTPP	3
081057	081057	SH 141B MP 160.75	Southbound	LTPP	3
083032	083032	I-70 MP 95.75	Eastbound	LTPP	3
087783	087783	I-70 MP 67.66	Eastbound	LTPP	3

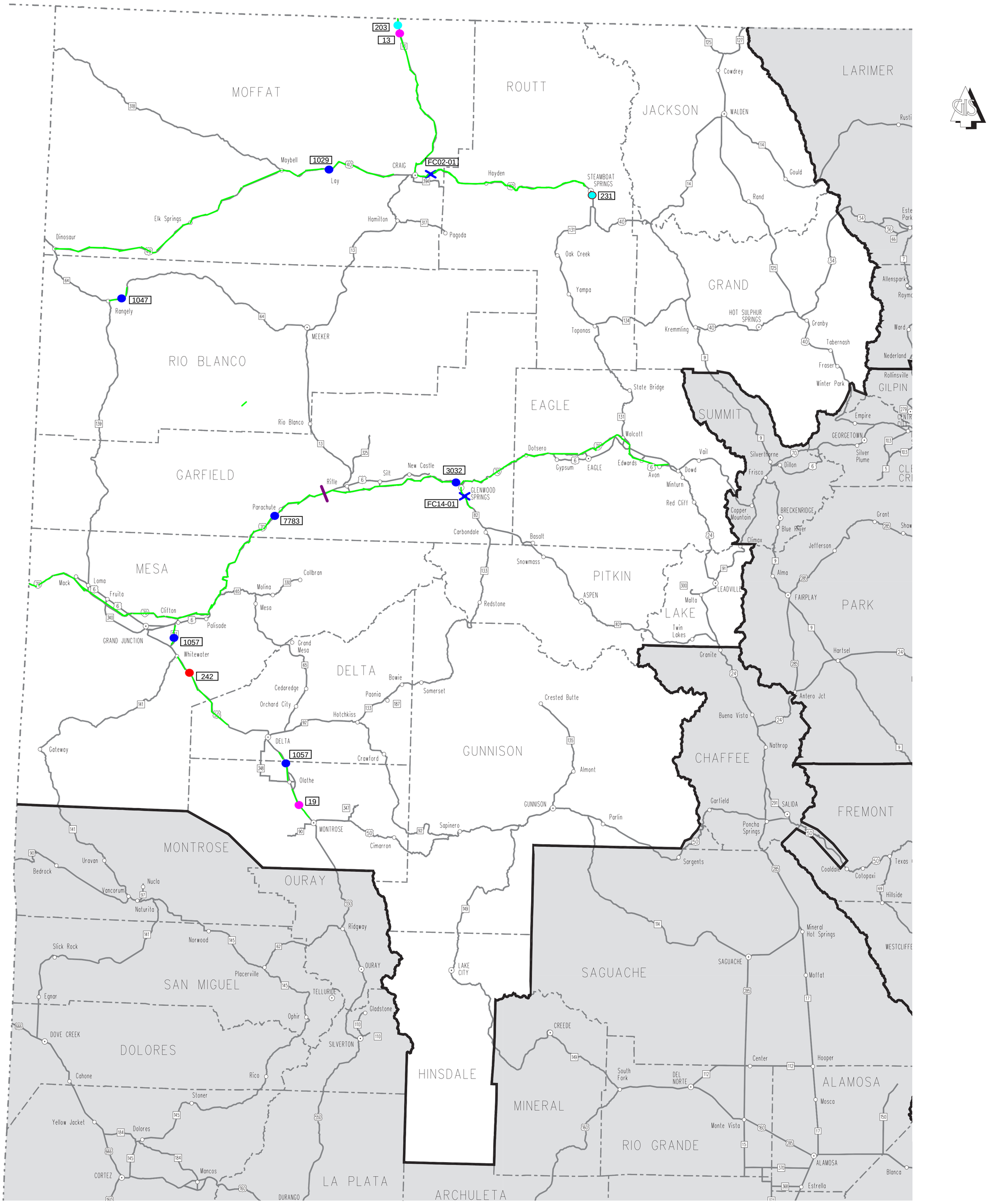
Proposed New WIM Sites

ID (Functional Class ##-##)	Location
FC02-01	US 40 MP 107.1
FC14-01	SH 82 MP 0.5

Transportation Region 3

August 1, 1999

- CDOT Perm. WIM Site
- CDOT Length Site
- CDOT Port. WIM Site
- CDOT AVC Site
- LTPP Site
- Segment
- Break in Segments
- Proposed WIM



segments are not to scale

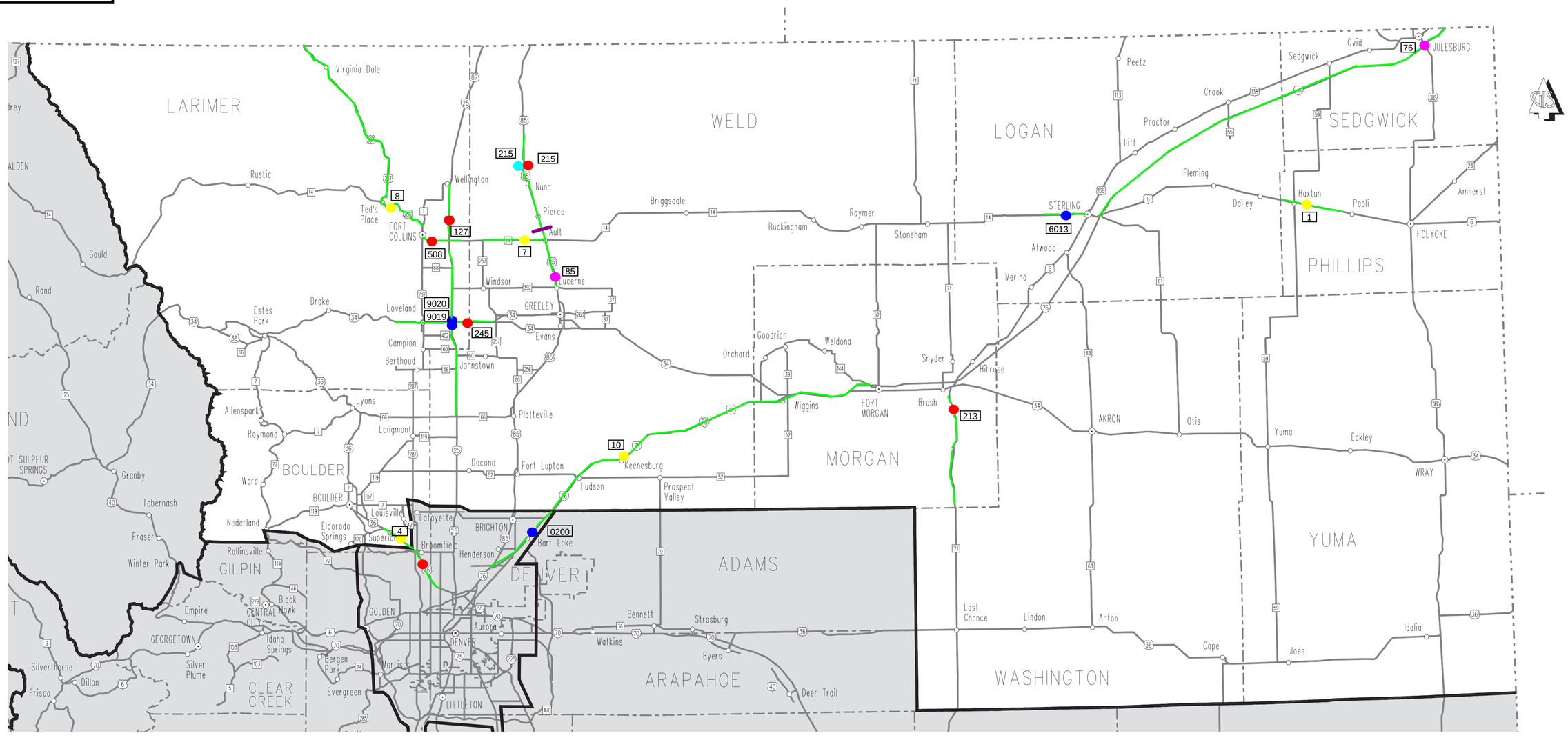
Data Sources In CDOT Region 4

CDOT ID	Database ID	Location	Direction	Type	CDOT Region
127	08A127	I-25 MP 272.38	Northbound	AVC	4
			Southbound		
213	08A213	SH 71 MP 173.143	Northbound	AVC	4
			Southbound		
215	08A215	SH 85 MP 293	Northbound	AVC	4
			Southbound		
245	08A245	SH 34 MP 99.3	Eastbound	AVC	4
			Westbound		
508	08A508	SH 14 MP 137.8	Eastbound	AVC	4
			Westbound		
76Y	08E076	I-76 MP 180.2	Eastbound	CDOT PORT	4
76Z	08W076	I-76 MP 180.2	Westbound	CDOT PORT	
85N	08N085	SH 85 MP 272.5	Northbound	CDOT PORT	4
85S	08S085	SH 85 MP 272.5	Southbound	CDOT PORT	
Site 1 Haxtun	08E001	SH 6 MP 438.4	Eastbound	CDOT PERM	4
	08W001		Westbound		
Site 4 Superior	08E004	SH 36 MP 43.15	Eastbound	CDOT PERM	4
	08W004		Westbound		
Site 7 Ault	08E007	SH 14 MP 152	Eastbound	CDOT PERM	4
	08W007		Westbound		
Site 8 Laporte	08T080	SH 287 MP 353.2	Eastbound	CDOT PERM	4
	08T080		Westbound		
Site 10 Keenesburg	08T100	I-76 MP 39.7	Eastbound	CDOT PERM	4
	08T100		Westbound		
215N	-	SH 85 N/O Nunn MP 293.0	Northbound	LENGTH	4
215S	-		Southbound	LENGTH	
086013	086013	US 14 MP 235.3	Eastbound	LTPP	4
			Westbound		
089019	089019	I-25 MP 246.5	Northbound	LTPP	4
			Southbound		
089020	089020	I-25 MP 256.4	Northbound	LTPP	4
			Southbound		

Transportation Region 4

August 1, 1999

CDOT Perm. WIM Site
CDOT Length Site
CDOT Port. WIM Site
CDOT AVC Site
LTPP Site
Segment
Break in Segments



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Data Sources In CDOT Region 5

CDOT ID	Database ID	Location	Direction	Type	CDOT Region
14T	08P014	SH 160 MP 145	Both	CDOT PORT	5
18T	08P018	SH 550 MP 16.5	Both	CDOT PORT	5
22T	08P022	SH 285 MP 133.9	Both	CDOT PORT	5
217E	-	SH 160 W/O Bayfield MP 101.0	Eastbound	LENGTH	5
217W	-		Westbound	LENGTH	

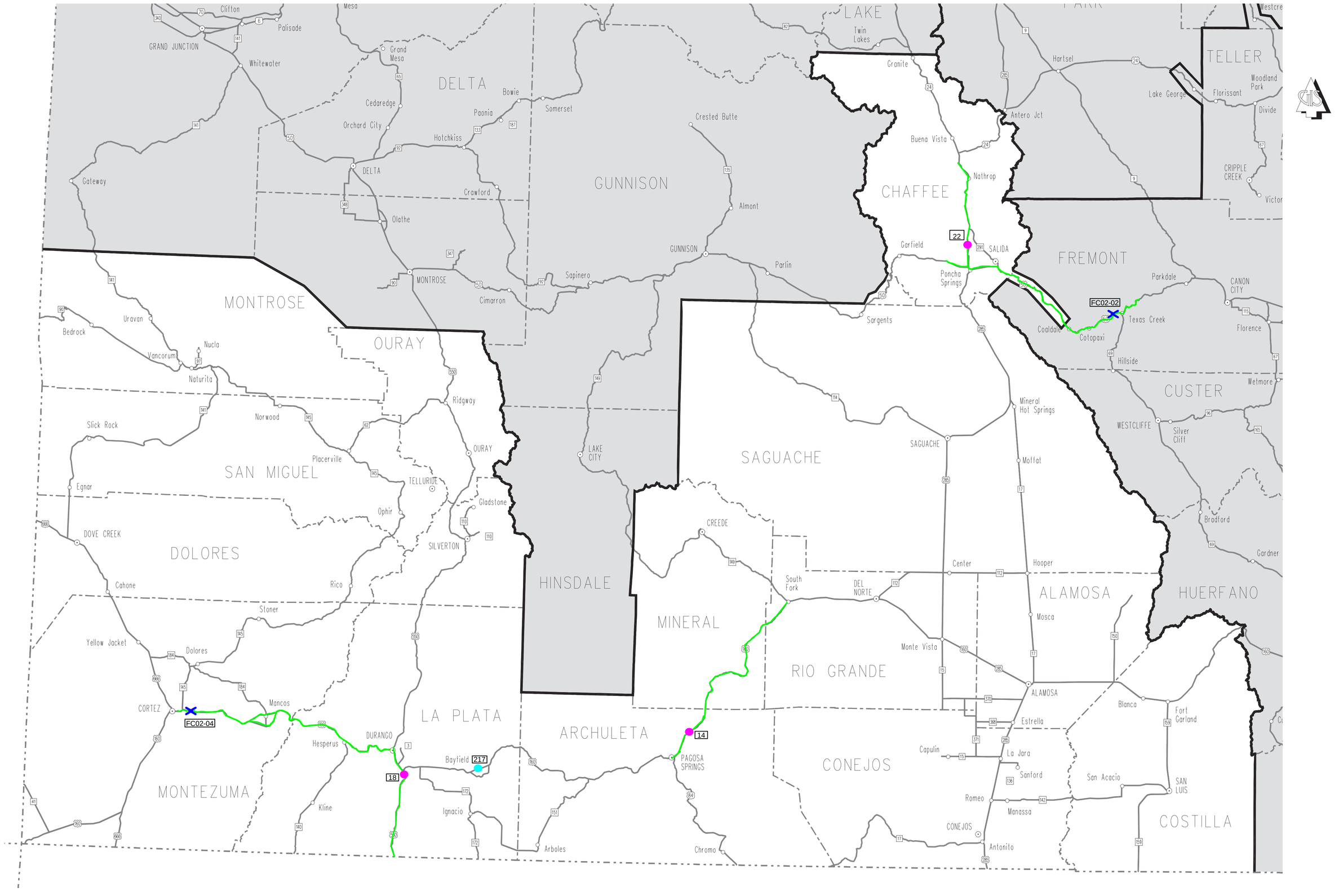
Proposed New WIM Sites

ID (Functional Class ##-##)	Location
FC02-02	US 50 MP 252.7
FC02-04	SH 160 MP 41.9

Transportation Region 5

August 1, 1999

- CDOT Perm. WIM Site
- CDOT Length Site
- CDOT Port. WIM Site
- CDOT AVC Site
- LTPP Site
- Segment
- Break in Segments
- Proposed WIM



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Data Sources In CDOT Region 6

CDOT ID	Database ID	Location	Direction	Type	CDOT Region
504	08A504	SH 36 MP 49	Eastbound Westbound	AVC	6
Site 3 SH470	08E003 08W003	SH 470 MP 16	Eastbound Westbound	CDOT PERM	6
080200	080200	I-76 MP 18.4	Eastbound Westbound	LTPP	6

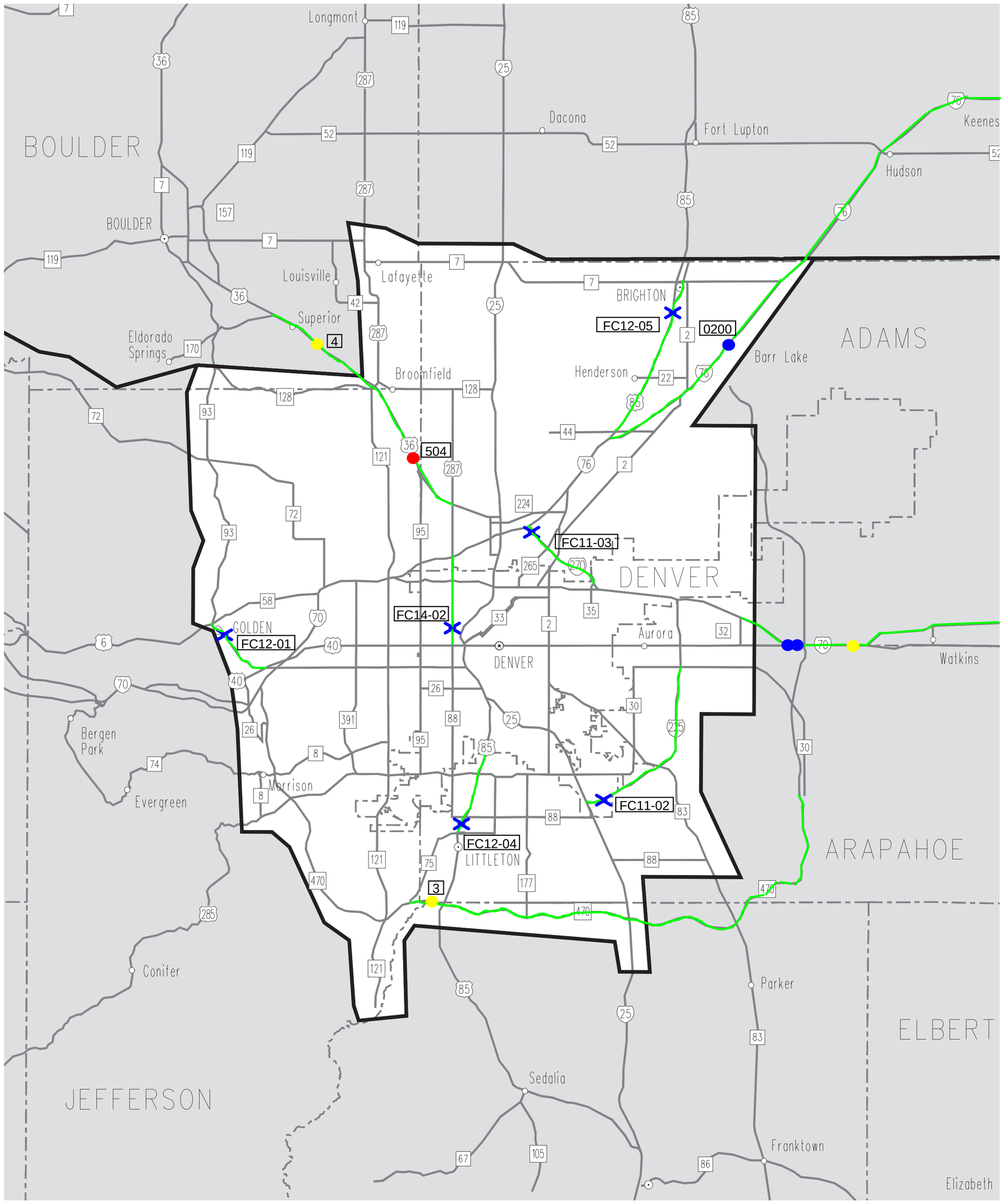
Proposed New WIM Sites

ID (Functional Class ##-##)	Location
FC11-02	SH 225 MP 0.0
FC11-03	SH 270 MP 0.0
FC12-01	SH 6 MP 272.6
FC12-04	SH 85 MP 203.8
FC12-05	SH 85 MP 233.1
FC14-02	SH 287 MP 283.5

- CDOT Perm. WIM Site
- CDOT Length Site
- CDOT Port. WIM Site
- CDOT AVC Site
- LTPP Site
- Segment
- Break in Segments
- Proposed WIM

Transportation Region 6

August 1, 1999



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APPENDIX 5. EXPANDING LENGTH DATA COMPARISONS

Length Site 203 and CDOT Portable WIM Site 13 Comparison For Northbound Direction

Portable WIM Data

	CLASS 1	CLASS 2	CLASS 3	CLASS 4	CLASS 5	CLASS 6	CLASS 7	CLASS 8	CLASS 9	CLASS 10	CLASS 11	CLASS 12	CLASS 13	CLASS 14-20
SUM FOR DAYS PASSING QC	5	176	206	2	111	4	0	18	75	7	0	0	2	42
% CLASS OF BIN A	1%	29%	34%											
% CLASS OF BIN B				0%	18%	1%	0%							
% CLASS OF BIN C								3%	12%	1%	0%	0%	0%	

Comparison of Bin Distributions for Portable WIM and Length sites

	Length Site[1] 203	CDOT Port[2] Site 13	Difference	% Difference
Total Counts for Bin A	447	387	-60	-16%
Total Counts for Bin B	64	117	53	45%
Total Counts for Bin C	97	102	5	5%
Total Counts for Bins A-C	608	606	-2	0%
Total Counts for Unclassified/Others	0	42	42	--
Total Counts for All Vehicles	608	648	40	6%

Period of Analysis

7/20/2000 (One day only)

Distribution of Length Data using Portable WIM Distribution

FHWA Classification	CLASS 1	CLASS 2	CLASS 3	CLASS 4	CLASS 5	CLASS 6	CLASS 7	CLASS 8	CLASS 9	CLASS 10	CLASS 11	CLASS 12	CLASS 13
Vehicles per class (Using Length Data)	5	177	207	2	111	4	0	18	75	7	0	0	2

Location of Sites

Length Site located on SH 13 at MP 127.17
Port. Site located on SH 13 at MP 126.2
Approximately 1 mile apart

(1) Bins defined by length information (Bin A: 0'-19.9', Bin B: 20'-39.9', Bin C: 40'-90')

(2) Bins defined by FHWA classification (Bin A: Class 1-3, Bin B: Class 4-7, Bin C: Class 8-13)

Length Site 203 and CDOT Portable WIM Site 13 Comparison For Southbound Direction

Portable WIM Data

	CLASS 1	CLASS 2	CLASS 3	CLASS 4	CLASS 5	CLASS 6	CLASS 7	CLASS 8	CLASS 9	CLASS 10	CLASS 11	CLASS 12	CLASS 13	CLASS 14-20
SUM FOR DAYS PASSING QC	13	160	199	0	114	9	2	18	86	7	1	0	3	74
% CLASS OF BIN A	2%	26%	33%											
% CLASS OF BIN B				0%	19%	1%	0%							
% CLASS OF BIN C								3%	14%	1%	0%	0%	0%	

Comparison of Bin Distributions for Portable WIM and Length sites

	Length Site[1] 203	CDOT Port[2] Site 13	Difference	% Difference
Total Counts for Bin A	497	372	-125	-34%
Total Counts for Bin B	52	125	73	58%
Total Counts for Bin C	133	115	-18	-16%
Total Counts For Bins A-C	682	612	-70	-11%
Total Counts for Unclassified/Others	2	74	72	97%
Total Counts for All Vehicles	684	686	2	0%

Period of Analysis

7/20/2000 (One day only)

Distribution of Length Data using Portable WIM Distribution

FHWA Classification	CLASS 1	CLASS 2	CLASS 3	CLASS 4	CLASS 5	CLASS 6	CLASS 7	CLASS 8	CLASS 9	CLASS 10	CLASS 11	CLASS 12	CLASS 13
Vehicles per class (Using Length Data)	14	178	222	0	127	10	2	20	96	8	1	0	3

Location of Sites

Length Site located on SH 13 at MP 127.17
Port. Site located on SH 13 at MP 126.2
Approximately 1 mile apart

(1) Bins defined by length information (Bin A: 0'-19.9', Bin B: 20'-39.9', Bin C: 40'-90')

(2) Bins defined by FHWA classification (Bin A: Class 1-3, Bin B: Class 4-7, Bin C: Class 8-13)

Length Site 215 and AVC Site 215 Comparison For Northbound Direction

AVC Data

	CLASS 1	CLASS 2	CLASS 3	CLASS 4	CLASS 5	CLASS 6	CLASS 7	CLASS 8	CLASS 9	CLASS 10	CLASS 11	CLASS 12	CLASS 13	CLASS 14-20
SUM FOR DAYS PASSING QC	1230	168442	71018	713	4402	2994	149	5760	43136	3269	256	61	321	0
% CLASS OF BIN A	0%	56%	24%											
% CLASS OF BIN B				0%	1%	1%	0%							
% CLASS OF BIN C								2%	14%	1%	0%	0%	0%	

Comparison of Bin Distributions for AVC and Length sites

	Length Site[1] 215	CDOT AVC[2] Site 215	Difference	% Difference
Total Counts for Bin A	226337	240690	14353	6%
Total Counts for Bin B	17069	8258	-8811	-107%
Total Counts for Bin C	58311	52803	-5508	-10%
Total Counts For Bins A-C	301717	301751	34	0%
Total Counts for Unclassified/Others	74	0	-74	--
Total Counts for All Vehicles	301791	301751	-40	0%

Period of Analysis

From 7/26/00 to 6/30/01

Exceptions:

9/5/00 to 9/13/00

4/1/01, 4/2/01

5/27/01 to 5/31/01

Distribution of Length Data using AVC Distribution

FHWA Classification	CLASS 1	CLASS 2	CLASS 3	CLASS 4	CLASS 5	CLASS 6	CLASS 7	CLASS 8	CLASS 9	CLASS 10	CLASS 11	CLASS 12	CLASS 13
Vehicles per class (Using Length Data)	1230	168423	71010	713	4402	2994	149	5759	43131	3269	256	61	321

Location of Sites

Length Site located on SH 85 at MP 293.0
AVC Site located on SH 85 at MP 293.0
Approximately at same location

(1) Bins defined by length information (Bin A: 0'-19.9', Bin B: 20'-39.9', Bin C: 40'-90')

(2) Bins defined by FHWA classification (Bin A: Class 1-3, Bin B: Class 4-7, Bin C: Class 8-13)

Length Site 215 and AVC Site 215 Comparison For Southbound Direction

AVC Data

	CLASS 1	CLASS 2	CLASS 3	CLASS 4	CLASS 5	CLASS 6	CLASS 7	CLASS 8	CLASS 9	CLASS 10	CLASS 11	CLASS 12	CLASS 13	CLASS 14-20
SUM FOR DAYS PASSING QC	572	164154	72671	291	3140	2605	115	3065	35753	3589	217	47	244	0
% CLASS OF BIN A	0%	57%	25%											
% CLASS OF BIN B				0%	1%	1%	0%							
% CLASS OF BIN C								1%	12%	1%	0%	0%	0%	

Comparison of Bin Distributions for AVC and Length sites

	Length Site[1] 215	CDOT AVC[2] Site 215	Difference	% Difference
Total Counts for Bin A	225719	237397	11678	5%
Total Counts for Bin B	14005	6151	-7854	-128%
Total Counts for Bin C	46702	42915	-3787	-9%
Total Counts For Bins A-C	286426	286463	37	0%
Total Counts for Unclassified/Others	59	0	-59	--
Total Counts for All Vehicles	286485	286463	-22	0%

Period of Analysis

From 7/26/00 to 6/30/01

Exceptions:

9/5/00 to 9/13/00
4/1/01, 4/2/01
5/27/01 to 5/31/01

Distribution of Length Data using AVC Distribution

FHWA Classification	CLASS 1	CLASS 2	CLASS 3	CLASS 4	CLASS 5	CLASS 6	CLASS 7	CLASS 8	CLASS 9	CLASS 10	CLASS 11	CLASS 12	CLASS 13
Vehicles per class (Using Length Data)	572	164133	72662	291	3140	2605	115	3065	35748	3589	217	47	244

Location of Sites

Length Site located on SH 85 at MP 293.0
AVC Site located on SH 85 at MP 293.0
Approximately at same location

(1) Bins defined by length information (Bin A: 0'-19.9', Bin B: 20'-39.9', Bin C: 40'-90')

(2) Bins defined by FHWA classification (Bin A: Class 1-3, Bin B: Class 4-7, Bin C: Class 8-13)

APPENDIX 6. MINUTES OF PROGRESS MEETING

NICHOLS CONSULTING ENGINEERS, Chtd.

1885 S. Arlington Ave, Suite 111 • Reno NV 89509 • (775) 329-4955 • FAX (775) 329-5098

M E M O R A N D U M

TO: Mr. Ahmad Ardani, P.E. **FILE:** A300.01.10 Task E
FROM: Sirous Alavi, Ph.D., P.E.
DATE: March 1, 2002
SUBJECT: Minutes of Progress Meeting for ESAL Classification System Development Study – 1:00 p.m. MST – February 25, 2002

Participants: Ahmad Ardani, Bob Tenney, Rich Griffin, Jay Goldbaum, Colette Negritti, Michael P. Tavares, Sirous Alavi

The following is a brief summary of the discussions that took place in Denver, Colorado as recorded by NCE.

Introduction

Ahmad Ardani, CDOT Project Manager, called the meeting to order at approximately 1:05 pm and CDOT panel members and NCE team introduced themselves.

Status of Work Accomplishments & Future Activities

NCE prepared a presentation that has been included as attachment 1.

The project scope and objectives that were discussed at the Kick-Off Meeting were reiterated. CDOT understands that NCE will develop site-specific equivalency factors using the FHWA 13-bin classification scheme of the Traffic Monitoring Guide (TMG) based on "best available data."

A table was presented to the panel that showed the CDOT deliverables to the NCE team and their quick response.

Data Processing
NCE stated that the number of vehicles and classification has been determined for each source of data provided by CDOT. All CDOT data has been through the QC process, which included classification checks such as consecutive static volumes, class vs. weight comparison and gross vehicle weight evaluation.

Permanent, Portable, Snapshot Analysis

Next, NCE discussed the comparison of continuous WIM with random short duration counts and sensitivity analysis of permanent data versus portable data. These items were analyzed concurrently. Sites were selected in close proximity to one another. NCE compared same lane and same direction. NCE designated year 2000 as the base year. When taking a snapshot, days were similar to portable WIM days (day of week and month).

NCE showed two examples to the CDOT panel. Each example showed that a 2 day snapshot of continuous WIM data and 2 days of portable WIM data was not equivalent to the permanent continuous WIM. NCE suggested that additional sampling each season could improve accuracy. In each example, NCE took 2 days each season (8 day snapshot) that was within ± 4% in truck volume (AADT-T) and within ± 11% in ESALs when compared to the permanent continuous WIM.

The CDOT panel inquired about how NCE expanded the portable WIM and snapshot data to a yearly value. NCE used the ratio of number of days per year divided by number of days collected. Also, they asked about factors such as seasonal and day of week. NCE did not apply any seasonal or day of week factors at this time.

NCE asked CDOT if it was possible for them to take more samples of data in terms of manpower and money. One idea was to create a 4 year plan to collect data for each season. Also, it was noted that some areas would not require additional data because they did not exhibit seasonal type trends. In other words, if there was no seasonality to the data, then one sample should be enough to represent a year.

NCE also discussed the possibility of CDOT placing a portable WIM close to a permanent WIM. This would provide an opportunity to validate this process.

Network Map

As mentioned before CDOT has delivered all data discussed at the Kick-Off meeting. NCE has identified all data sources on a physical map. Next, primary segments were created. Primary segments are defined as a combination of segments around a data source that are within ± 30 % of the AADT-T of the data source segment. All primary segments originate at a segment where a data source was located. Currently, there are 36 primary segments comprised of 425 segments. This is roughly 10% of the total number of segments originally provided to NCE. The segments defined on the map are also being defined on the electronic spreadsheet, TraffOn.

At the time of the meeting, NCE was using only CDOT LTPP ESAL values and applying to CDOT data. NCE was directed to use site specific weight information where it has been provided. The CDOT panel mentioned looking at the ± 30% AADT-T value as well. NCE may need to modify the current range. Additionally, NCE will create zone maps electronically that show data sources and primary segments within each zone (similar to our presentation illustration). There will be six maps corresponding to CDOT's six regions.

NCE mentioned that with additional funding a software could be developed to facilitate retrieving data from the spreadsheet as well as facilitate updating the spreadsheet. This software would be similar to the software developed for Arizona DOT in 1999.

Expanding Length Data

NCE discussed expanding length data to FHWA 13 classification. Length data is usually collected with a pair of loops that measures bumper to bumper distances of a vehicle. Three length bins were discussed in the RFP: Bin A = 0-20 feet, Bin B = 20-40 feet and Bin C = 40+ feet. Also, the length bins were defined as: Bin A = FHWA Class 1-3, Bin B = FHWA Class 4-7 and Bin C = FHWA Class 8-13.

Three examples were shown at the meeting. In each example, length bin counts were summarized for a period compared with a data source like a permanent WIM. In every case, length data total volume was within ± 6% of the CDOT data source. When comparing the bins, there was a large discrepancy noted between bin definition (A-C) and class definition (1-3, 4-7, 8-13). This indicates that CDOT would need to modify their length definition. NCE recommended using the class distribution from a data source site (AVC, portable WIM or permanent WIM) and apply to total volume collected by length site.

Summary of Action Items

The following items were identified at the progress meeting:

- Develop network maps for each CDOT defined zone or region (6 regions). Maps can be found on CDOT website.
- NCE will use site specific weight data in developing network map and ESAL table.
- Investigate ± 30 % AADT-T threshold on spreadsheet.
- Investigate truck percentage for examples shown at progress meeting. Does truck percentage also vary overtime?
- Investigate seasonal factors.
- Optimize traffic monitoring site locations. Recommend set of core sites, min/max number of sites and level of effort.

Progress Meeting concluded at 4:30 PM.

SA/mpt
Attachments
cc: Earl T. Laird, Michael P. Tavares

N/A300.01.10/task e_reports/progress report meeting/cdot progress meet notes.doc

APPENDIX 7. EXAMPLE ESAL SUMMARY SHEET FOR LTPP SITE 081029

Example ESAL Summary Sheet For LTPP Site 081029

Flexible Pavement

	Historical LTPP								*AASHTO Method*						$\overline{X}$			
Vehicle Class	***1993 ESAL per vehicle***	***1993 Number of vehicles***	***1994 ESAL per vehicle***	***1994 Number of vehicles***	***1995 ESAL per vehicle***	***1995 Number of vehicles***	***1996 ESAL per vehicle***	***1996 Number of vehicles***	***1997 ESAL per vehicle***	***1997 Number of vehicles***	***1998 ESAL per vehicle***	***1998 Number of vehicles***	***1999 ESAL per vehicle***	***1999 Number of vehicles***	***Weighted Average***	***N-1***	***s***	***Coefficient of Variation***
4	0.597	86	0.647	465	0.211	503	0.73	147	1.152	223	0.900	474	0.820	198	**0.673**	6	0.296	0.44
5	0.176	580	0.115	7459	0.093	3745	0.551	9359	0.190	19203	0.074	35131	0.106	4209	**0.165**	6	0.168	1.02
6	0.971	154	1.044	1033	0.216	1235	0.343	154	1.547	443	0.458	1561	0.842	426	**0.660**	6	0.483	0.73
7	2.983	4	3.955	28	0.025	465	0.253	58	0.723	17	0.119	1146	0.908	2	**0.174**	6	1.960	11.28
8	0.423	121	0.196	1576	0.153	512	1.093	236	0.358	1856	0.234	3608	0.162	1111	**0.265**	6	0.353	1.33
9	0.801	1157	0.835	6037	0.332	5150	0.39	312	1.082	1852	1.155	4986	0.832	2097	**0.802**	6	0.315	0.39
10	2.005	50	1.274	312	0.393	313	0.119	18	1.112	115	1.371	240	1.371	71	**1.052**	6	0.642	0.61
11	3.407	5	0.401	22	0.082	2		0	0.987	1	1.007	17	1.183	1	**0.944**	5	1.270	1.35
12	1.298	1	0.645	9	0.134	14	0.158	1	1.799	1	0.595	14	0.383	8	**0.465**	6	0.675	1.45
13		0	3.313	10	0.709	36	0.017	1	2.140	4	2.300	10	0.867	2	**1.460**	5	1.395	0.96
days	*37*		*264*		*257*		*347*		*233*		*365*		*159*					

Rigid Pavement

	Historical LTPP								*AASHTO Method*						$\overline{X}$			
Vehicle Class									***1997 ESAL per vehicle***	***1997 Number of vehicles***	***1998 ESAL per vehicle***	***1998 Number of vehicles***	***1999 ESAL per vehicle***	***1999 Number of vehicles***	***Weighted Average***	***N-1***	***s***	***Coefficient of Variation***
4	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	1.331	223	1.100	474	1.030	198	**1.142**	2	0.158	0.14
5	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	0.192	19203	0.065	35131	0.096	4209	**0.109**	2	0.067	1.04
6	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	1.792	443	0.569	1561	1.109	426	**0.886**	2	0.696	1.22
7	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	0.851	17	0.112	1146	1.464	2	**0.125**	2	1.077	9.59
8	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	0.359	1856	0.221	3608	0.157	1111	**0.249**	2	0.103	0.47
9	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	1.406	1852	1.570	4986	1.095	2097	**1.424**	2	0.255	0.16
10	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	1.586	115	2.100	240	2.188	71	**1.976**	2	0.326	0.16
11	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	0.798	1	0.922	17	1.019	1	**0.921**	2	0.111	0.12
12	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	1.887	1	0.621	14	0.348	8	**0.581**	2	0.939	1.51
13	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	2.478	4	4.031	10	1.296	2	**3.301**	2	1.617	0.40
days	***NA***	***NA***	***NA***	***NA***	***NA***	***NA***	***NA***	***NA***	***233***		***365***		***159***					

APPENDIX 8. EXAMPLES TO DETERMINE NUMBER OF WIM DATA SOURCES PER GROUP

As described in the TMG, there are several equations used to determine the number of WIM sites within a group:

$$N = \left(t_{(a/2)}\right)^2 \left(COV^2\right) / \left(D^2\right) \quad \text{Eq. A8.1}$$

$$s = \sqrt{\frac{\sum \left(X - \overline{X}\right)^2}{N-1}} \quad \text{Eq. A8.2}$$

$$COV = \frac{s}{\overline{X}} \quad \text{Eq. A8.3}$$

$$Stnd\ Err = \frac{s}{\sqrt{N}} \quad \text{Eq. A8.4}$$

$$\%\ Level\ of\ Confidence = Stnd\ Err \times t_{(a/2)} \quad \text{Eq. A8.5}$$

where N equals the number of sites in a functional class group, t equals the Student's t distribution for a selected confidence and appropriate degrees of freedom, a equals the level of confidence, *COV* equals the coefficient of variation of the sample, D equals the desired accuracy, s equals standard deviation, X equals a data value, $\overline{X}$ equals the mean of the data, and *Stnd Err* equals standard error.

Example 1— NCE assumed that a Class 9 was 55,000 lbs and 1.5 ESAL per vehicle. NCE also assumed that the standard deviation for GVW was 10,000 lbs and for ESAL was 0.25. Table A8.1 shows the effects of the number of WIM sites and the level of confidence with respect to GWV per vehicle. Table A8.2 shows the effects of the number of WIM sites and the level of confidence with respect to ESAL per vehicle.

These tables show that by simply adding more sites to the population you will improve the precision of the functional class group. The benefit of adding more sites decreases at a certain point due to the costs associated with having so many sites.

If the desired GVW was within ± 10% of the GVW of a Class 9 truck (approximately 5,500 lbs), it would require 7 WIM sites for 80% level of confidence and 15 WIM sites for 95% level of confidence. If the desired ESAL per vehicle was within ± 10% of the ESAL per vehicle (approximately 0.15 ESAL), it would require 6 WIM sites for 80% level of confidence and 13 WIM sites for 95% level of confidence. In this example, each weight variable estimated a similar number of needed WIM sites.

Table A8.1. Example of Effects of Sample Size and Level of Confidence of GVW Estimates

Number of Sites	Mean	Coefficient of Variation	Degrees of Freedom	Standard Error	80% Level of Confidence	95% Level of Confidence
	GVW	GVW		GVW	GVW	GVW
2	55,000	0.18	1	7,071	± 21,763	± 89,846
3	55,000	0.18	2	5,774	± 10,887	± 24,841
4	55,000	0.18	3	5,000	± 8,189	± 15,912
5	55,000	0.18	4	4,472	± 6,857	± 12,417
6	55,000	0.18	5	4,082	± 6,025	± 10,494
7	55,000	0.18	6	3,780	**± 5,442**	± 9,248
8	55,000	0.18	7	3,536	± 5,003	± 8,360
9	55,000	0.18	8	3,333	± 4,656	± 7,687
10	55,000	0.18	9	3,162	± 4,374	± 7,154
11	55,000	0.18	10	3,015	± 4,137	± 6,718
12	55,000	0.18	11	2,887	± 3,936	± 6,354
13	55,000	0.18	12	2,774	± 3,761	± 6,043
14	55,000	0.18	13	2,673	± 3,608	± 5,774
15	55,000	0.18	14	2,582	± 3,473	**± 5,538**
20	55,000	0.18	19	2,236	± 2,998	± 4,766
25	55,000	0.18	24	2,000	± 2,636	± 4,128
30	55,000	0.18	29	1,826	± 2,394	± 3,734

Table A8.2. Example of Effects of Sample Size and Level of Confidence of ESAL Estimates

Number of Sites	Mean	Coefficient of Variation	Degrees of Freedom	Standard Error	80% Level of Confidence	95% Level of Confidence
	ESAL per veh	ESAL per veh		ESAL per veh	ESAL per veh	ESAL per veh
2	1.500	0.17	1	0.18	± 0.54	± 2.25
3	1.500	0.17	2	0.14	± 0.27	± 0.62
4	1.500	0.17	3	0.13	± 0.20	± 0.40
5	1.500	0.17	4	0.11	± 0.17	± 0.31
6	1.500	0.17	5	0.10	**± 0.15**	± 0.26
7	1.500	0.17	6	0.09	± 0.14	± 0.23
8	1.500	0.17	7	0.09	± 0.13	± 0.21
9	1.500	0.17	8	0.08	± 0.12	± 0.19
10	1.500	0.17	9	0.08	± 0.11	± 0.18
11	1.500	0.17	10	0.08	± 0.10	± 0.17
12	1.500	0.17	11	0.07	± 0.10	± 0.16
13	1.500	0.17	12	0.07	± 0.09	**± 0.15**
14	1.500	0.17	13	0.07	± 0.09	± 0.14
15	1.500	0.17	14	0.06	± 0.09	± 0.14
20	1.500	0.17	19	0.06	± 0.07	± 0.12
25	1.500	0.17	24	0.05	± 0.07	± 0.10
30	1.500	0.17	29	0.05	± 0.06	± 0.09

Example 2— NCE shows the statistics for the functional class 01 group (rural principal arterial interstate) that were calculated from 5 LTPP sites. These sites were located on Interstate 25 (south and north central Colorado) and Interstate 70 (west central Colorado). Table A8.3 shows the site, mean Class 9 GVW, mean Class 9 ESAL, group mean, standard deviation, coefficient of variation and standard error. In Tables A8.4 and A8.5, the effects of sample size and level of confidence for GVW and ESAL are shown, similarly to the previous example. These values were taken from several years and averaged.

Table A8.3. Statistics For Functional Class 01 Group

Site	Mean Class 9 GVW	Mean Class 9 ESAL
083032	54403	1.0540
086002	50387	0.7887
087783	50904	1.0990
089019	46659	0.6027
089020	51141	0.7124
Mean	50,699	0.8514
Standard Deviation	2,756	0.2165
Coefficient of Variation	0.0544	0.2543
Standard Error of Mean	1232	0.0968

Table A8.4. Effects of Sample Size and Level of Confidence of GVW Estimates on Functional Class 01 Group

Number of Sites	Mean	Coefficient of Variation	Degrees of Freedom	Standard Error	80% Level of Confidence	95% Level of Confidence
	GVW	GVW		GVW	GVW	GVW
2	50,699	0.05	1	1,949	5,997	24,758
3	50,699	0.05	2	1,591	**3,000**	6,845
4	50,699	0.05	3	1,378	2,256	**4,385**
5	50,699	0.05	4	1,232	1,889	3,422
6	50,699	0.05	5	1,125	1,660	2,892
7	50,699	0.05	6	1,042	1,500	2,549
8	50,699	0.05	7	974	1,378	2,304
9	50,699	0.05	8	919	1,283	2,118
10	50,699	0.05	9	871	1,205	1,971
11	50,699	0.05	10	831	1,140	1,851
12	50,699	0.05	11	795	1,085	1,751
13	50,699	0.05	12	764	1,037	1,665
14	50,699	0.05	13	736	994	1,591
15	50,699	0.05	14	711	957	1,526
20	50,699	0.05	19	616	826	1,313
25	50,699	0.05	24	551	726	1,137
30	50,699	0.05	29	503	660	1,029

Table A8.5. Effects of Sample Size and Level of Confidence of ESAL Estimates on Functional Class 01 Group

Number of Sites	Mean	Coefficient of Variation	Degrees of Freedom	Standard Error	80% Level of Confidence	95% Level of Confidence
	ESAL per veh	ESAL per veh		ESAL per veh	ESAL per veh	ESAL per veh
2	0.8514	0.25	1	0.15	0.47	1.95
3	0.8514	0.25	2	0.12	0.24	0.54
4	0.8514	0.25	3	0.11	0.18	0.34
5	0.8514	0.25	4	0.10	0.15	0.27
6	0.8514	0.25	5	0.09	0.13	0.23
7	0.8514	0.25	6	0.08	0.12	0.20
8	0.8514	0.25	7	0.08	0.11	0.18
9	0.8514	0.25	8	0.07	0.10	0.17
10	0.8514	0.25	9	0.07	0.09	0.15
11	0.8514	0.25	10	0.07	0.09	0.15
12	0.8514	0.25	11	0.06	0.09	0.14
13	0.8514	0.25	12	0.06	**0.08**	0.13
14	0.8514	0.25	13	0.06	0.08	0.12
15	0.8514	0.25	14	0.06	0.08	0.12
20	0.8514	0.25	19	0.05	0.06	0.10
25	0.8514	0.25	24	0.04	0.06	0.09
30	0.8514	0.25	29	0.04	0.05	**0.08**

If the desired GVW was within ± 10% of the GVW of a Class 9 truck (approximately 5,100 lbs), it would require 3 WIM sites for 80% level of confidence and 4 WIM sites for 95% level of confidence. If the desired ESAL per vehicle was within ± 10% of the ESAL per vehicle (approximately 0.08 ESAL), it would require 13 WIM sites for 80% level of confidence and 30 WIM sites for 95% level of confidence. In this example, the difference between using the GVW versus the ESAL per vehicle variables and estimating the number of WIM sites was the mean and standard deviation.

APPENDIX 9. ESAL PER VEHICLE FOR FUNCTIONAL CLASS GROUPS

Functional Class 1-ESAL per Vehicle for Flexible Pavements

Data Source	ESAL/Vehicle									
	FHWA Class. 4	**FHWA Class. 5**	**FHWA Class. 6**	**FHWA Class. 7**	**FHWA Class. 8**	**FHWA Class. 9**	**FHWA Class. 10**	**FHWA Class. 11**	**FHWA Class. 12**	**FHWA Class. 13**
080500[1]	0.7073	0.0834	0.3749	0.0603	0.3345	1.4997	1.0542	2.1062	0.8364	3.1634
083032	0.4346	0.0946	0.3133	0.1342	0.3063	1.0540	0.5999	1.5116	0.7495	1.0647
086002[1]	0.5088	0.1874	0.2538	0.1231	0.2438	0.7887	0.5571	1.1147	0.5688	1.0495
087783[1]	0.4929	0.1188	0.4481	0.3261	0.2996	1.0990	0.9812	1.9909	0.8093	3.0583
089019[1]	0.2498	0.0742	0.3047	0.0970	0.2150	0.6027	0.5700	0.7655	0.4625	0.5779
089020[1]	0.2536	0.0599	0.3437	0.0997	0.1996	0.7124	0.6692	0.8644	0.4747	0.6182
C002[2]	0.5484	0.1646	0.4849	0.9430	0.5086	1.2884	0.9179	1.3820	0.8267	-
C010[2]	0.6170	0.1933	0.4225	1.2736	0.4037	1.0787	0.9632	1.6332	0.8708	1.3153
C014[2]	0.6803	0.1295	0.2830	0.7825	0.3071	1.3590	0.9137	1.6810	0.9573	-
P010[3]	0.4577	0.0382	0.2819	0.2365	0.2056	0.8227	0.3024	1.3349	0.8476	1.1244
P076[3]	1.1009	0.0398	0.7595	1.0281	0.2729	1.9982	1.2613	2.6896	3.2512	1.7024
Observations	11	11	11	11	11	11	11	11	11	9
Mean	***0.5501***	***0.1076***	***0.3882***	***0.4640***	***0.2997***	***1.1185***	***0.7991***	***1.5522***	***0.9686***	***1.5656***
Standard Deviation	0.2355	0.0558	0.1439	0.4506	0.0926	0.4049	0.2794	0.5637	0.7750	0.9202
Coefficient of Variation	0.4280	0.5185	0.3707	0.9711	0.3088	0.3620	0.3496	0.3631	0.8001	0.5878

[1]ESAL per vehicle reported is the weighted average of several years of data.

[2]ESAL per vehicle reported is the average of several months of data. The data is also the average of both directions of data.

[3]ESAL per vehicle reported is the average of 1-3 days of data. The data is also the average of both directions of data.

Functional Class 1-ESAL per Vehicle for Rigid Pavements

Data Source	ESAL/Vehicle									
	FHWA Class. 4	**FHWA Class. 5**	**FHWA Class. 6**	**FHWA Class. 7**	**FHWA Class. 8**	**FHWA Class. 9**	**FHWA Class. 10**	**FHWA Class. 11**	**FHWA Class. 12**	**FHWA Class. 13**
080500[1]	0.7286	0.0682	0.5336	0.1523	0.2762	2.2312	1.6686	1.9836	1.4957	1.8129
083032[1]	0.6225	0.1557	0.7251	0.1205	0.3580	2.0541	1.7004	2.0538	0.9200	7.5034
086002[1]	0.6134	0.0750	0.3574	0.2287	0.3053	1.3903	1.1466	1.1592	0.6872	1.2713
087783[1]	0.4443	0.0630	0.4706	0.1407	0.2268	1.1014	0.9532	1.1720	0.5834	1.5484
089019[1]	0.2768	0.0758	0.4611	0.1482	0.2354	0.9738	1.1050	0.8091	0.5245	0.8801
089020[1]	0.2820	0.0586	0.5012	0.1356	0.2158	1.1280	1.1860	0.8431	0.5238	0.9199
C002[2]	0.6626	0.1643	0.7178	1.6983	0.6029	2.0368	1.6211	1.3601	0.9232	-
C010[2]	0.7956	0.1932	0.6470	2.3506	0.4429	1.7032	1.6838	1.6120	0.9459	2.4359
C014[2]	0.8516	0.1280	0.4129	1.1827	0.3444	2.1554	1.6177	1.6581	1.0632	-
P010[3]	0.5206	0.0374	0.4409	0.5583	0.2368	1.2893	0.5635	1.3062	0.9567	2.1429
P076[3]	1.4294	0.0395	1.1392	2.6938	0.2931	3.0930	2.0784	2.6861	3.7285	2.8302
Observations	11	11	11	11	11	11	11	11	11	9
Mean	***0.6570***	***0.0962***	***0.5824***	***0.8554***	***0.3216***	***1.7415***	***1.3931***	***1.5130***	***1.1229***	***2.3420***
Standard Deviation	0.3180	0.0543	0.2210	0.9735	0.1156	0.6425	0.4354	0.5633	0.9094	1.9210
Coefficient of Variation	0.4839	0.5638	0.3795	1.1381	0.3594	0.3689	0.3125	0.3723	0.8098	0.8203

[1]ESAL per vehicle reported is the weighted average of several years of data.

[2]ESAL per vehicle reported is the average of several months of data. The data is also the average of both directions of data.

[3]ESAL per vehicle reported is the average of 1-3 days of data. The data is also the average of both directions of data.

Functional Class 2-ESAL per Vehicle for Flexible Pavements

Data Source	ESAL/Vehicle									
	FHWA Class. 4	**FHWA Class. 5**	**FHWA Class. 6**	**FHWA Class. 7**	**FHWA Class. 8**	**FHWA Class. 9**	**FHWA Class. 10**	**FHWA Class. 11**	**FHWA Class. 12**	**FHWA Class. 13**
081053[1]	0.4751	0.0753	0.3616	0.0906	0.2166	0.7356	0.7267	0.4566	0.3459	0.8365
087780[1]	0.8478	0.4483	0.5852	0.1356	0.4896	1.4337	1.2066	2.0423	1.3988	2.3590
C004[2]	0.6646	0.1981	0.7523	1.9265	0.4990	0.9562	0.9290	1.0556	0.9363	-
C005[2]	0.5333	0.0986	0.2665	0.8081	0.2477	1.3707	0.9528	1.6061	0.7918	-
C013	0.5627	0.1117	0.4204	0.4332	0.3115	1.5299	1.3569	1.8039	0.9332	1.9014
P014[3]	1.2796	0.0273	0.6833	0.3660	0.3749	1.2177	0.7715	2.1854	1.5684	-
P018[3]	0.5062	0.0444	0.5748	2.7408	0.2513	1.0412	1.1143	0.5661	0.8761	-
P019[3]	0.5291	0.0307	0.3409	0.5563	0.1291	0.9651	0.4695	1.0634	0.5664	-
P020[3]	0.5377	0.0297	0.3918	0.2187	0.2045	1.2096	1.2257	0.9460	0.6201	-
P022[3]	0.5135	0.0347	0.6739	2.7491	0.1765	1.5934	1.1854	0.2227	1.9632	-
P023[3]	0.9279	0.0405	0.4248	0.9983	0.2655	1.6631	1.6202	-	-	-
P024[3]	0.4015	0.0253	0.4227	0.3070	0.1566	0.9803	0.7690	-	-	-
Observations	12	12	12	12	12	12	12	10	10	3
Mean	***0.6482***	***0.0970***	***0.4915***	***0.9442***	***0.2769***	***1.2247***	***1.0273***	***1.1948***	***1.0000***	***1.6990***
Standard Deviation	0.2510	0.1218	0.1561	0.9785	0.1215	0.2952	0.3181	0.6850	0.4986	0.7812
Coefficient of Variation	0.3872	1.2548	0.3176	1.0363	0.4387	0.2411	0.3097	0.5733	0.4986	0.4598

[1]ESAL per vehicle reported is the weighted average of several years of data.

[2]ESAL per vehicle reported is the average of several months of data. The data is also the average of both directions of data.

[3]ESAL per vehicle reported is the average of 1-3 days of data.

Functional Class 2-ESAL per Vehicle for Rigid Pavements

Data Source	ESAL/Vehicle									
	FHWA Class. 4	**FHWA Class. 5**	**FHWA Class. 6**	**FHWA Class. 7**	**FHWA Class. 8**	**FHWA Class. 9**	**FHWA Class. 10**	**FHWA Class. 11**	**FHWA Class. 12**	**FHWA Class. 13**
081053[1]	0.4611	0.0397	0.4804	0.0931	0.1808	0.9736	1.1373	0.4048	0.3792	1.5928
087780[2]	-	-	-	-	-	-	-	-	-	-
C004[3]	0.9228	0.1967	1.1401	3.9761	0.5618	1.5437	1.6552	1.0314	1.1441	-
C005[3]	0.7011	0.0977	0.3957	1.6095	0.2838	2.1756	1.7067	1.5863	0.8861	-
C013[3]	0.6843	0.1105	0.5968	0.7482	0.3502	2.3918	2.3322	1.7854	1.0441	2.1130
P014[4]	1.9260	0.0267	1.0416	0.3528	0.4757	1.8500	1.3604	2.1789	1.8923	-
P018[4]	0.6617	0.0437	0.8477	2.7855	0.2694	1.6552	2.0675	0.5443	1.0133	-
P019[4]	0.6979	0.0302	0.5255	1.5961	0.1368	1.5113	0.8546	1.0267	0.6256	-
P020[4]	0.7758	0.0291	0.5674	0.2279	0.2191	1.8706	2.1150	0.9175	0.7323	-
P022[4]	0.6324	0.0344	0.9877	4.7133	0.1902	2.5162	1.9418	0.2136	2.2154	-
P023[4]	1.3123	0.0399	0.6132	1.7166	0.2659	2.6366	2.9547	-	-	-
P024[4]	0.6095	0.0251	0.6639	0.8177	0.1876	1.5822	1.3834	-	-	-
Observations	11	11	11	11	11	11	11	9	9	2
Mean	***0.8532***	***0.0612***	***0.7145***	***1.6942***	***0.2838***	***1.8824***	***1.7735***	***1.0765***	***1.1036***	***1.8529***
Standard Deviation	0.4179	0.0534	0.2492	1.5397	0.1317	0.5037	0.5941	0.6602	0.5926	0.3678
Coefficient of Variation	0.4899	0.8726	0.3488	0.9088	0.4642	0.2676	0.3350	0.6132	0.5370	0.1985

[1]ESAL per vehicle reported is the weighted average of several years of data.

[2]ESAL per vehicle not available for rigid pavements.

[3]ESAL per vehicle reported is the average of several months of data. The data is also the average of both directions of data.

[4]ESAL per vehicle reported is the average of 1-3 days of data.

Functional Class 6-ESAL per Vehicle for Flexible Pavements

Data Source	ESAL/Vehicle									
	FHWA Class. 4	**FHWA Class. 5**	**FHWA Class. 6**	**FHWA Class. 7**	**FHWA Class. 8**	**FHWA Class. 9**	**FHWA Class. 10**	**FHWA Class. 11**	**FHWA Class. 12**	**FHWA Class. 13**
081047[1]	0.7669	0.1626	1.0868	2.5167	0.2876	1.1967	1.5124	0.8157	1.1163	3.3130
C007[2]	0.5263	0.1948	0.5789	1.6590	0.4958	1.1218	1.1455	1.2620	1.6602	1.5404
P013[3]	0.3180	0.0481	0.1008	0.6189	0.0895	0.7446	0.6661	-	-	0.7361
P085[3]	0.6909	0.0418	0.6512	1.3302	0.5724	1.4954	1.3809	-	-	2.4241
Observations	4	4	4	4	4	4	4	2	2	4
Mean	***0.5755***	***0.1119***	***0.6044***	***1.5312***	***0.3613***	***1.1396***	***1.1762***	***1.0388***	***1.3883***	***2.0034***
Standard Deviation	0.1989	0.0784	0.4038	0.7875	0.2176	0.3089	0.3724	0.3156	0.3846	1.1124
Coefficient of Variation	0.3456	0.7007	0.6681	0.5143	0.6022	0.2710	0.3166	0.3038	0.2770	0.5553

[1]ESAL per vehicle reported is the weighted average of several years of data.

[2]ESAL per vehicle reported is the average of several months of data.

[3]ESAL per vehicle reported is the average of 1-3 days of data.

Functional Class 6-ESAL per Vehicle for Rigid Pavements

Data Source	ESAL/Vehicle									
	FHWA Class. 4	**FHWA Class. 5**	**FHWA Class. 6**	**FHWA Class. 7**	**FHWA Class. 8**	**FHWA Class. 9**	**FHWA Class. 10**	**FHWA Class. 11**	**FHWA Class. 12**	**FHWA Class. 13**
081047[1]	-	-	-	-	-	-	-	-	-	-
C007[2]	0.6564	0.1941	0.8471	3.2385	0.5488	1.7547	1.9613	1.2604	1.8835	2.9267
P013[3]	0.3628	0.0474	0.1476	1.7165	0.0908	1.1828	1.2489	-	-	1.0536
P085[3]	0.9483	0.0415	0.9937	3.7146	0.7490	2.3532	2.4872	-	-	4.8193
Observations	3	3	3	3	3	3	3	1	1	3
Mean	***0.6558***	***0.0943***	***0.6628***	***2.8899***	***0.4629***	***1.7636***	***1.8991***	***1.2604***	***1.8835***	***2.9332***
Standard Deviation	0.2927	0.0865	0.4522	1.0437	0.3374	0.5852	0.6215	#DIV/0!	#DIV/0!	1.8829
Coefficient of Variation	0.4463	0.9166	0.6822	0.3611	0.7289	0.3318	0.3272	#DIV/0!	#DIV/0!	0.6419

[1]ESAL per vehicle not available for rigid pavements.

[2]ESAL per vehicle reported is the average of several months of data.

[3]ESAL per vehicle reported is the average of 1-3 days of data.

Functional Class 8-ESAL per Vehicle for Flexible Pavements

Data Source	ESAL/Vehicle									
	FHWA Class. 4	**FHWA Class. 5**	**FHWA Class. 6**	**FHWA Class. 7**	**FHWA Class. 8**	**FHWA Class. 9**	**FHWA Class. 10**	**FHWA Class. 11**	**FHWA Class. 12**	**FHWA Class. 13**
C001[1]	0.2315	0.1431	0.4264	0.9717	0.2432	1.1713	0.8969	0.6351	0.4009	-
Observations	1	1	1	1	1	1	1	1	1	0
Mean	***0.2315***	***0.1431***	***0.4264***	***0.9717***	***0.2432***	***1.1713***	***0.8969***	***0.6351***	***0.4009***	***#DIV/0!***
Standard Deviation	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Coefficient of Variation	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

[1]ESAL per vehicle reported is the average of several months of data. The data is also the average of both directions of data.

Functional Class 8-ESAL per Vehicle for Rigid Pavements

Data Source	ESAL/Vehicle									
	FHWA Class. 4	**FHWA Class. 5**	**FHWA Class. 6**	**FHWA Class. 7**	**FHWA Class. 8**	**FHWA Class. 9**	**FHWA Class. 10**	**FHWA Class. 11**	**FHWA Class. 12**	**FHWA Class. 13**
C001[1]	0.2392	0.1416	0.6111	1.5129	0.2574	1.8823	1.5932	0.6208	0.4260	-
Observations	1	1	1	1	1	1	1	1	1	0
Mean	***0.2392***	***0.1416***	***0.6111***	***1.5129***	***0.2574***	***1.8823***	***1.5932***	***0.6208***	***0.4260***	***#DIV/0!***
Standard Deviation	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Coefficient of Variation	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

[1]ESAL per vehicle reported is the average of several months of data. The data is also the average of both directions of data.

Functional Class 11-ESAL per Vehicle for Flexible Pavements

Data Source	ESAL/Vehicle									
	FHWA Class. 4	**FHWA Class. 5**	**FHWA Class. 6**	**FHWA Class. 7**	**FHWA Class. 8**	**FHWA Class. 9**	**FHWA Class. 10**	**FHWA Class. 11**	**FHWA Class. 12**	**FHWA Class. 13**
80200[1]	0.3789	0.0870	0.3026	0.1209	0.3889	0.6158	0.5777	1.0286	0.4818	0.4638
87035[2]	-	-	-	-	-	-	-	-	-	-
87776[1]	0.4674	0.0318	0.3143	0.0675	0.2338	0.8937	0.6165	1.0681	0.6529	0.7800
Observations	2	2	2	2	2	2	2	2	2	2
Mean	***0.4232***	***0.0594***	***0.3084***	***0.0942***	***0.3113***	***0.7548***	***0.5971***	***1.0483***	***0.5674***	***0.6219***
Standard Deviation	0.0626	0.0391	0.0083	0.0377	0.1097	0.1965	0.0274	0.0280	0.1210	0.2236
Coefficient of Variation	0.1479	0.6581	0.0268	0.4003	0.3524	0.2603	0.0459	0.0267	0.2133	0.3595

[1]ESAL per vehicle reported is the weighted average of several years of data.

[2]ESAL per vehicle not available for flexible pavements.

Functional Class 11-ESAL per Vehicle for Rigid Pavements

Data Source	ESAL/Vehicle									
	FHWA Class. 4	**FHWA Class. 5**	**FHWA Class. 6**	**FHWA Class. 7**	**FHWA Class. 8**	**FHWA Class. 9**	**FHWA Class. 10**	**FHWA Class. 11**	**FHWA Class. 12**	**FHWA Class. 13**
80200[1]	0.5196	0.1047	0.4360	0.1241	0.4846	1.1045	1.1734	1.3058	0.5863	1.4013
87035[1]	1.0949	0.1390	1.1145	0.2359	0.3701	3.1991	3.1162	1.7865	1.0579	2.8320
87776[1]	0.5041	0.0309	0.4346	0.0844	0.2502	1.3334	1.0159	1.0186	0.6908	1.1645
Observations	3	3	3	3	3	3	3	3	3	3
Mean	***0.7062***	***0.0915***	***0.6617***	***0.1481***	***0.3683***	***1.8790***	***1.7685***	***1.3703***	***0.7783***	***1.7993***
Standard Deviation	0.3367	0.0552	0.3922	0.0785	0.1172	1.1490	1.1698	0.3880	0.2477	0.9022
Coefficient of Variation	0.4768	0.6036	0.5927	0.5301	0.3183	0.6115	0.6614	0.2831	0.3183	0.5014

[1]ESAL per vehicle reported is the weighted average of several years of data.

Functional Class 12-ESAL per Vehicle for Flexible Pavements

Data Source	ESAL/Vehicle									
	FHWA Class. 4	**FHWA Class. 5**	**FHWA Class. 6**	**FHWA Class. 7**	**FHWA Class. 8**	**FHWA Class. 9**	**FHWA Class. 10**	**FHWA Class. 11**	**FHWA Class. 12**	**FHWA Class. 13**
C003	0.320981	0.14192	0.68751	1.185115	0.821908	1.053257	0.7896274	0.5623232	0.5319431	-
Observations	1	1	1	1	1	1	1	1	1	0
Mean	***0.3210***	***0.1419***	***0.6875***	***1.1851***	***0.8219***	***1.0533***	***0.7896***	***0.5623***	***0.5319***	***#DIV/0!***
Standard Deviation	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Coefficient of Variation	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Functional Class 12-ESAL per Vehicle for Rigid Pavements

Data Source	ESAL/Vehicle									
	FHWA Class. 4	**FHWA Class. 5**	**FHWA Class. 6**	**FHWA Class. 7**	**FHWA Class. 8**	**FHWA Class. 9**	**FHWA Class. 10**	**FHWA Class. 11**	**FHWA Class. 12**	**FHWA Class. 13**
C003	0.362693	0.139697	1.01082	1.838786	1.087051	1.708701	1.3280812	0.5456727	0.5651494	-
Observations	1	1	1	1	1	1	1	1	1	0
Mean	***0.3627***	***0.1397***	***1.0108***	***1.8388***	***1.0871***	***1.7087***	***1.3281***	***0.5457***	***0.5651***	***#DIV/0!***
Standard Deviation	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Coefficient of Variation	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Functional Class 14-ESAL per Vehicle for Flexible Pavements

Data Source	ESAL/Vehicle									
	FHWA Class. 4	**FHWA Class. 5**	**FHWA Class. 6**	**FHWA Class. 7**	**FHWA Class. 8**	**FHWA Class. 9**	**FHWA Class. 10**	**FHWA Class. 11**	**FHWA Class. 12**	**FHWA Class. 13**
81029[1]	0.6735	0.1651	0.6604	0.1738	0.2646	0.8016	1.0520	0.9438	0.4653	1.4598
81057[2]	2.0480	0.8120	0.6700	-	0.4200	1.5160	1.7140	2.0940	0.4720	-
086013[1]	0.5501	0.1029	0.3032	0.1501	0.3047	1.2708	0.9690	0.6232	1.0652	1.4252
C008[3]	0.7345	0.2312	0.6343	0.4587	0.6792	1.3191	1.2113	1.7860	1.5500	0.8188
Observations	4	4	4	3	4	4	4	4	4	3
Mean	***1.0015***	***0.3278***	***0.5670***	***0.2609***	***0.4171***	***1.2269***	***1.2366***	***1.3617***	***0.8881***	***1.2346***
Standard Deviation	0.7019	0.3270	0.1765	0.1717	0.1867	0.3027	0.3338	0.6919	0.5232	0.3605
Coefficient of Variation	0.7008	0.9977	0.3113	0.6583	0.4477	0.2467	0.2699	0.5081	0.5892	0.2920

[1]ESAL per vehicle reported is the weighted average of several years of data.

[2]ESAL per vehicle reported is from one year of data.

[3]ESAL per vehicle reported is from one month of data.

Functional Class 14-ESAL per Vehicle for Rigid Pavements

Data Source	ESAL/Vehicle									
	FHWA Class. 4	**FHWA Class. 5**	**FHWA Class. 6**	**FHWA Class. 7**	**FHWA Class. 8**	**FHWA Class. 9**	**FHWA Class. 10**	**FHWA Class. 11**	**FHWA Class. 12**	**FHWA Class. 13**
81029[1]	1.1420	0.1087	0.8864	0.1254	0.2492	1.4243	1.9760	0.9209	0.5811	3.3008
81057[2]	-	-	-	-	-	-	-	-	-	-
086013[3]	0.6277	0.0488	0.9427	1.6450	0.4377	2.3181	2.8978	1.3645	2.9890	-
C008[4]	0.9002	0.2297	0.8775	0.9039	0.8367	1.9769	1.9948	1.7832	1.7578	1.4078
Observations	3	3	3	3	3	3	3	3	3	2
Mean	***0.8900***	***0.1291***	***0.9022***	***0.8914***	***0.5079***	***1.9064***	***2.2895***	***1.3562***	***1.7760***	***2.3543***
Standard Deviation	0.2573	0.0922	0.0354	0.7599	0.3000	0.4511	0.5268	0.4312	1.2040	1.3385
Coefficient of Variation	0.2891	0.7140	0.0392	0.8524	0.5906	0.2366	0.2301	0.3179	0.6779	0.5685

[1]ESAL per vehicle reported is the weighted average of several years of data.

[2]ESAL per vehicle not available for rigid pavements.

[3]ESAL per vehicle reported is from one month of data.

Statewide Average-ESAL per Vehicle for Flexible Pavements

Data Source	ESAL/Vehicle									
	FHWA Class. 4	**FHWA Class. 5**	**FHWA Class. 6**	**FHWA Class. 7**	**FHWA Class. 8**	**FHWA Class. 9**	**FHWA Class. 10**	**FHWA Class. 11**	**FHWA Class. 12**	**FHWA Class. 13**
080500	0.7073	0.0834	0.3749	0.0603	0.3345	1.4997	1.0542	2.1062	0.8364	3.1634
083032	0.4346	0.0946	0.3133	0.1342	0.3063	1.0540	0.5999	1.5116	0.7495	1.0647
086002	0.5088	0.1874	0.2538	0.1231	0.2438	0.7887	0.5571	1.1147	0.5688	1.0495
087783	0.4929	0.1188	0.4481	0.3261	0.2996	1.0990	0.9812	1.9909	0.8093	3.0583
089019	0.2498	0.0742	0.3047	0.0970	0.2150	0.6027	0.5700	0.7655	0.4625	0.5779
089020	0.2536	0.0599	0.3437	0.0997	0.1996	0.7124	0.6692	0.8644	0.4747	0.6182
C002	0.5484	0.1646	0.4849	0.9430	0.5086	1.2884	0.9179	1.3820	0.8267	1.9822
C010	0.6170	0.1933	0.4225	1.2736	0.4037	1.0787	0.9632	1.6332	0.8708	1.3153
C014	0.6803	0.1295	0.2830	0.7825	0.3071	1.3590	0.9137	1.6810	0.9573	-
P010	0.4577	0.0382	0.2819	0.2365	0.2056	0.8227	0.3024	1.3349	0.8476	1.1244
P076	1.1009	0.0398	0.7595	1.0281	0.2729	1.9982	1.2613	2.6896	3.2512	1.7024
081053	0.4751	0.0753	0.3616	0.0906	0.2166	0.7356	0.7267	0.4566	0.3459	0.8365
087780	0.8478	0.4483	0.5852	0.1356	0.4896	1.4337	1.2066	2.0423	1.3988	2.3590
C004	0.6646	0.1981	0.7523	1.9265	0.4990	0.9562	0.9290	1.0556	0.9363	-
C005	0.5333	0.0986	0.2665	0.8081	0.2477	1.3707	0.9528	1.6061	0.7918	-
C013	0.5627	0.1117	0.4204	0.4332	0.3115	1.5299	1.3569	1.8039	0.9332	1.9014
P014	1.2796	0.0273	0.6833	0.3660	0.3749	1.2177	0.7715	2.1854	1.5684	-
P018	0.5062	0.0444	0.5748	2.7408	0.2513	1.0412	1.1143	0.5661	0.8761	-
P019	0.5291	0.0307	0.3409	0.5563	0.1291	0.9651	0.4695	1.0634	0.5664	-
P020	0.5377	0.0297	0.3918	0.2187	0.2045	1.2096	1.2257	0.9460	0.6201	-
P022	0.5135	0.0347	0.6739	2.7491	0.1765	1.5934	1.1854	0.2227	1.9632	-
P023	0.9279	0.0405	0.4248	0.9983	0.2655	1.6631	1.6202	-	-	-
P024	0.4015	0.0253	0.4227	0.3070	0.1566	0.9803	0.7690	-	-	-
081047	0.7669	0.1626	1.0868	2.5167	0.2876	1.1967	1.5124	0.8157	1.1163	3.3130
C007	0.5263	0.1948	0.5789	1.6590	0.4958	1.1218	1.1455	1.2620	1.6602	1.5404
P013	0.3180	0.0481	0.1008	0.6189	0.0895	0.7446	0.6661	-	-	0.7361
P085	0.6909	0.0418	0.6512	1.3302	0.5724	1.4954	1.3809	-	-	2.4241
C001	0.2315	0.1431	0.4264	0.9717	0.2432	1.1713	0.8969	0.6351	0.4009	-
080200	0.3789	0.0870	0.3026	0.1209	0.3889	0.6158	0.5777	1.0286	0.4818	0.4638
087035	-	-	-	-	-	-	-	-	-	-
087776	0.4674	0.0318	0.3143	0.0675	0.2338	0.8937	0.6165	1.0681	0.6529	0.7800
C003	0.32098	0.14192	0.68751	1.18512	0.82191	1.05326	0.78963	0.56232	0.53194	-
081029	0.6735	0.1651	0.6604	0.1738	0.2646	0.8016	1.0520	0.9438	0.4653	1.4598
081057	2.0480	0.8120	0.6700	-	0.4200	1.5160	1.7140	2.0940	0.4720	-
086013	0.5501	0.1029	0.3032	0.1501	0.3047	1.2708	0.9690	0.6232	1.0652	1.4252
C008	0.7345	0.2312	0.6343	0.4587	0.6792	1.3191	1.2113	1.7860	1.5500	0.8188
Observations	35	35	35	34	35	35	35	31	31	22
Mean	***0.6153***	***0.1289***	***0.4739***	***0.7555***	***0.3263***	***1.1486***	***0.9614***	***1.2852***	***0.9371***	***1.5325***
Standard Deviation	0.3351	0.1457	0.1991	0.7803	0.1567	0.3264	0.3331	0.6057	0.5893	0.8666
Coefficient of Variation	0.5446	1.1304	0.4202	1.0328	0.4801	0.2842	0.3465	0.4713	0.6289	0.5655

Statewide Average-ESAL per Vehicle for Rigid Pavements

Data Source	ESAL/Vehicle									
	FHWA Class. 4	FHWA Class. 5	FHWA Class. 6	FHWA Class. 7	FHWA Class. 8	FHWA Class. 9	FHWA Class. 10	FHWA Class. 11	FHWA Class. 12	FHWA Class. 13
080500	0.7286	0.0682	0.5336	0.1523	0.2762	2.2312	1.6686	1.9836	1.4957	1.8129
083032	0.6225	0.1557	0.7251	0.1205	0.3580	2.0541	1.7004	2.0538	0.9200	7.5034
086002	0.6134	0.0750	0.3574	0.2287	0.3053	1.3903	1.1466	1.1592	0.6872	1.2713
087783	0.4443	0.0630	0.4706	0.1407	0.2268	1.1014	0.9532	1.1720	0.5834	1.5484
089019	0.2768	0.0758	0.4611	0.1482	0.2354	0.9738	1.1050	0.8091	0.5245	0.8801
089020	0.2820	0.0586	0.5012	0.1356	0.2158	1.1280	1.1860	0.8431	0.5238	0.9199
C002	0.6626	0.1643	0.7178	1.6983	0.6029	2.0368	1.6211	1.3601	0.9232	2.0748
C010	0.7956	0.1932	0.6470	2.3506	0.4429	1.7032	1.6838	1.6120	0.9459	2.4359
C014	0.8516	0.1280	0.4129	1.1827	0.3444	2.1554	1.6177	1.6581	1.0632	-
P010	0.5206	0.0374	0.4409	0.5583	0.2368	1.2893	0.5635	1.3062	0.9567	2.1429
P076	1.4294	0.0395	1.1392	2.6938	0.2931	3.0930	2.0784	2.6861	3.7285	2.8302
081053	0.4611	0.0397	0.4804	0.0931	0.1808	0.9736	1.1373	0.4048	0.3792	1.5928
087780	-	-	-	-	-	-	-	-	-	-
C004	0.9228	0.1967	1.1401	3.9761	0.5618	1.5437	1.6552	1.0314	1.1441	-
C005	0.7011	0.0977	0.3957	1.6095	0.2838	2.1756	1.7067	1.5863	0.8861	-
C013	0.6843	0.1105	0.5968	0.7482	0.3502	2.3918	2.3322	1.7854	1.0441	2.1130
P014	1.9260	0.0267	1.0416	0.3528	0.4757	1.8500	1.3604	2.1789	1.8923	-
P018	0.6617	0.0437	0.8477	2.7855	0.2694	1.6552	2.0675	0.5443	1.0133	-
P019	0.6979	0.0302	0.5255	1.5961	0.1368	1.5113	0.8546	1.0267	0.6256	-
P020	0.7758	0.0291	0.5674	0.2279	0.2191	1.8706	2.1150	0.9175	0.7323	-
P022	0.6324	0.0344	0.9877	4.7133	0.1902	2.5162	1.9418	0.2136	2.2154	-
P023	1.3123	0.0399	0.6132	1.7166	0.2659	2.6366	2.9547	-	-	-
P024	0.6095	0.0251	0.6639	0.8177	0.1876	1.5822	1.3834	-	-	-
081047	-	-	-	-	-	-	-	-	-	-
C007	0.6564	0.1941	0.8471	3.2385	0.5488	1.7547	1.9613	1.2604	1.8835	2.9267
P013	0.3628	0.0474	0.1476	1.7165	0.0908	1.1828	1.2489	-	-	1.0536
P085	0.9483	0.0415	0.9937	3.7146	0.7490	2.3532	2.4872	-	-	4.8193
C001	0.2392	0.1416	0.6111	1.5129	0.2574	1.8823	1.5932	0.6208	0.4260	-
080200	0.5196	0.1047	0.4360	0.1241	0.4846	1.1045	1.1734	1.3058	0.5863	1.4013
087035	1.0949	0.1390	1.1145	0.2359	0.3701	3.1991	3.1162	1.7865	1.0579	2.8320
087776	0.5041	0.0309	0.4346	0.0844	0.2502	1.3334	1.0159	1.0186	0.6908	1.1645
C003	0.3627	0.1397	1.0108	1.8388	1.0871	1.7087	1.3281	0.5457	0.5651	-
081029	1.1420	0.1087	0.8864	0.1254	0.2492	1.4243	1.9760	0.9209	0.5811	3.3008
081057	-	-	-	-	-	-	-	-	-	-
086013	0.6277	0.0488	0.9427	1.6450	0.4377	2.3181	2.8978	1.3645	2.9890	-
C008	0.9002	0.2297	0.8775	0.9039	0.8367	1.9769	1.9948	1.7832	1.7578	1.4078
Observations	33	33	33	33	33	33	33	29	29	20
Mean	***0.7264***	***0.0896***	***0.6839***	***1.3087***	***0.3643***	***1.8213***	***1.6856***	***1.2737***	***1.1318***	***2.3016***
Standard Deviation	0.3528	0.0600	0.2628	1.2847	0.2135	0.5746	0.6099	0.5769	0.7818	1.5600
Coefficient of Variation	0.4858	0.6697	0.3843	0.9816	0.5861	0.3155	0.3618	0.4529	0.6908	0.6778

APPENDIX 10. LEGEND AND ANCILLARY INFORMATION FROM ESAL2000.XLS

LEGEND WORKSHEET

Data Source	Segment Designation	Data Source Label
AVC 124	8	8A
AVC 127	10	10A
AVC 213	26	26A
AVC 215	30	30A
AVC 242	15	15A
AVC 245	11	11A
AVC 504	12	12B
AVC 508	3	3A
CDOT Perm. Site 1	1	1A
CDOT Perm. Site 10	27	27B
CDOT Perm. Site 13	14	14A
CDOT Perm. Site 14	25	25A
CDOT Perm. Site 2	24	24C
CDOT Perm. Site 3	36	36A
CDOT Perm. Site 4	12	12A
CDOT Perm. Site 5	34	34A
CDOT Perm. Site 7	4	4A
CDOT Perm. Site 8	35	35A
CDOT Port. Site 10	25	25C
CDOT Port. Site 13	2	2A
CDOT Port. Site 14	32	32A
CDOT Port. Site 18	37	37A
CDOT Port. Site 19	17	17A
CDOT Port. Site 20	18	18A
CDOT Port. Site 22	33	33A
CDOT Port. Site 23	19	19B
CDOT Port. Site 24	20	20A
CDOT Port. Site 76	28	28A
CDOT Port. Site 85	29	29A
LTPP Site 080200	27	27A
LTPP Site 080500	25	25B
LTPP Site 081029	13	13A
LTPP Site 081047	21	21A
LTPP Site 081053	16	16A
LTPP Site 081057	31	31A
LTPP Site 083032	23	23A
LTPP Site 086002	7	7A
LTPP Site 086013	5	5A
LTPP Site 087035	24	24A
LTPP Site 087036	24	24D
LTPP Site 087776	24	24B
LTPP Site 087780	6	6A
LTPP Site 087783	22	22A
LTPP Sites 082008/087781	19	19A
LTPP Sites 089019/089020	9	9A

ANCILLARY INFORMATION WORKSHEET

Comments on ESAL2000 Table

1. Non-primary segments (identified as one functional class by CDOT): Used Functional Class averages for vehicle distribution and ESAL per vehicle information. Used segment specific AADT-T which was provided by CDOT. The lane factor, also provided by CDOT, was used to estimate AADT-T in the design lane.

2. Non-primary segments (not identified as one functional class by CDOT): Some segments are classified as two functional classes or are not classified as a functional class at all. For both of these cases, the statewide averages for vehicle distribution and ESAL per vehicle information were used. The AADT-T used was segment specific and provided by CDOT. The lane factor, also provided by CDOT, was used to estimate AADT-T in the design lane.

3. Non Data Source Primary Segments (WIM): Used data sources for vehicle distribution and ESAL per vehicle information. The AADT-T used was segment specific and provided by CDOT. The lane factor, also provided by CDOT, was used to estimate AADT-T in the design lane.

4. Non Data Source Primary Segments (AVC): Used data sources for vehicle distribution. Functional Class averages were used for ESAL per vehicle information. The AADT-T used was segment specific and provided by CDOT. The lane factor, also provided by CDOT, was used to estimate AADT-T in the design lane.

5. Non Data Source Primary Segments (WIMS with only historical data: 081047, 081057, 087035, and 087780): Used data sources for vehicle distribution. Data sources with only historical data provide ESAL per vehicle information for only one surface type (flexible or rigid). ESAL per vehicle information from the data source was used, where available. However, for the surface type unavailable from the data source, functional class averages were used for ESAL per vehicle information. The AADT-T used was segment specific and provided by CDOT. The lane factor, also provided by CDOT, was used to estimate AADT-T in the design lane.

6. Data Source Segments (WIM): Used data sources for vehicle distribution, design lane AADT-T and ESAL per vehicle information.

7. Data Source Segments (WIMs with only historical data: 081047, 081057, 087035 and 087780): Used data sources for vehicle distribution and design lane AADT-T. Data sources with only historical data provide ESAL per vehicle information for only one surface type (flexible or rigid). ESAL per vehicle information from the data source was used, where available. However, for the surface type unavailable from the data source, functional class averages were used for ESAL per vehicle information.

8. Data Source Segments (AVC): Used data sources for vehicle distribution and design lane AADT-T. Used Functional Class averages for ESAL per vehicle information.

ANCILLARY INFORMATION WORKSHEET

Comments on ESAL2000 Table

9. Segments lacking information: Segments that are lacking key variables in the ESAL calculations. Spreadsheet is setup to populate ESAL cells when key variables are entered by CDOT.

10. Because lane factors were not provided for segments with 3 lanes of travel, assumptions had to be made in order to develop design lane AADT-T. To do this, NCE made the conservative assumption that 100% of the directional volume was in the outside lane. Therefore, multiplying the total AADT-T (provided by CDOT) by the directional distribution produced an estimate of the design lane AADT-T.

11. For Portable Site 22, a lane distribution factor was not available due to the roadway having 3 lanes of travel. In order to derive an AADT-T for all lanes of travel, NCE selected the direction of travel which had the greatest AADT-T in the outside lane as the direction with only one lane of travel. In this case the northbound was selected as the direction with only one lane of travel. With this assumption the total AADT-T for all lanes of travel could be obtained by dividing the northbound AADT-T by the directional distribution.

12. For Permanent Site 8, a lane distribution factor was not available due to the roadway having 3 lanes of travel. In order to derive an AADT-T for all lanes of travel, NCE selected the direction of travel which had the greatest AADT-T in the outside lane as the direction with only one lane of travel. In this case the westbound was selected as the direction with only one lane of travel. With this assumption the total AADT-T for all lanes of travel could be obtained by dividing the westbound AADT-T by the directional distribution.

13. For segments with 5 lanes, NCE made the assumption that the design lane carried 100% of the directional volume. Therefore, the design volume was obtained by multiplying the total AADT-T by the directional distribution.

14. For segments with 7 lanes, NCE made the assumption that the design lane carried 80% of the directional volume. Therefore, the design volume was obtained by multiplying the total AADT-T by the 80% of the directional distribution.

15. Data was not available from the following data sources: 082008, 087781, and 087036. 082008 and 087781 are located in close proximity to one another and are within the same primary segment as Portable Site 23. Vehicle distribution and ESAL per vehicle information used for these two data sources were obtained from Portable Site 23. The AADT-T used was segment specific and provided by CDOT. The lane factor, also provided by CDOT, was used to estimate AADT-T in the design lane. The same procedure was followed for 087036 using vehicle distribution and ESAL per vehicle information from Permanent Site 2; which is located in the same primary segment. The AADT-T used was segment specific and provided by CDOT. The lane factor, also provided by CDOT, was used to estimate AADT-T in the design lane.

ANCILLARY INFORMATION WORKSHEET

Comments on ESAL2000 Table

16. The roadway at the AVC 127 data source was classified as both Functional Class 1 and 11. For the ESAL calculations, the ESAL per vehicle information used was from the Functional Class 1 averages.

17. There are some data sources that are in close proximity with one another and are located within the same primary segment. For two permanent WIM data sources located in the same primary segment, vehicle distribution and ESAL per vehicle information from the closest data source was applied to the non data source primary segments along with the segment specific AADT-T and lane factor both provided by CDOT. At locations where a permanent WIM and a portable WIM are in close proximity and occupy the same primary segment the vehicle distribution and ESAL per vehicle information from the permanent WIM were used for all non data source primary segments. As before, NCE made use of CDOT provided segment specific AADT-T and lane factors. Lastly, there are some cases where a permanent WIM and an AVC share the same primary segment. In this case the permanent WIM was used to obtain vehicle distribution and ESAL per vehicle information. The AADT-T was obtained through the use of CDOT lane factors and AADT-T.