Seasonal Truck Volume Patterns in Washington State

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For many years states have collected year-round traffic volume information at specific sites in order to measure traffic patterns as they change throughout the year. Because of a lack of data that showed otherwise, it was assumed that all vehicle types had seasonal patterns that were similar to those observed for total traffic. In the 1980s advances in computer and sensor technology allowed states to expand this traditional data collection process to include volumes by vehicle classification and truck weights. The preliminary results of an analysis of the seasonal volume patterns for different vehicle classes in the state of Washington are presented. In Washington trucks have very different travel patterns from automobiles. In addition, the various truck types often have different seasonal patterns. The factors that are needed to convert 24- or 48-hr weekday vehicle classification counts to average annual daily estimates of truck volumes by classification vary from truck type to truck type and from site to site. As might be expected, higher-volume roads have more stable seasonal patterns. Lower-volume roads show greater variability from month to month and from year to year. The stability of seasonal patterns is also affected by the volume of vehicles within specific vehicle classes. In general, the greater the volume within a specific vehicle class, the more stable that pattern is from year to year. The lower the volume in a particular class, the less stable is that pattern. Examples of the common types of truck volume patterns are shown, the effects of two vehicle classification schemes on the patterns observed are described, and the implications of those patterns on geometric and pavement design are discussed briefly.

This paper summarizes the seasonal truck traffic patterns that were discovered when traffic volume trends were examined at 26 sites in the state of Washington. The work is being performed as part of an FHWA project entitled "Getting Better Truck Flows and Loads for Pavement Management." The project should be completed by mid-1993. Data for this paper were collected with four-bin vehicle length classifiers at 23 sites and weigh-in-motion (WIM) scales at three sites.

Because of variations in the lengths of vehicles within specific FHWA vehicle classes, the four length classes do not directly relate to the 13 FHWA vehicle classes. The contents of the four length categories generally include the following vehicles:

Bin	*Vehicle Type*
1	Cars, pickups, and short single-unit trucks (< 26 ft)
2	Cars and trucks pulling trailers, long single-unit trucks, and recreational vehicles (RVs) (26 to 39 ft)
3	Combination trucks (39 to 65 ft)
4	Multitrailer trucks (> 65 ft)

One to four calendar years of data were available at each of the 26 sites.

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COMPARISON AMONG VEHICLE CLASSES

One of the primary objectives of this project is to determine whether truck traffic volumes follow seasonal patterns that are similar to automobile traffic. If trucks are different, are seasonal adjustments specific to each truck class necessary to accurately estimate annual average daily truck volumes? To answer such questions, the research team developed normalized seasonal traffic flows for all four vehicle length classes. The normalized flows were computed for weekdays (Tuesday through Thursday), weekends (Saturday and Sunday), and complete weeks. One factor was computed for each vehicle class for each month. The factors were developed in accordance with the procedures described in a recently accepted report from AASHTO (*1*).

For the sake of brevity, only the weekday patterns are discussed in this paper. The remaining factors will be discussed in the project report. Weekday patterns are discussed in this paper because state highway agencies most commonly convert weekday counts (lasting from 1 to 3 days) to average annual totals when estimating annual conditions.

The project findings reveal that the four vehicle classes collected by the permanent length classifying equipment have very different seasonal patterns, regardless of the volume or functional classification of the roadway or the geographic location of the site. In general, the longer truck categories show less seasonal variation (i.e., month-to-month changes in daily traffic volumes) than the short truck and automobile classifications. In addition, traffic volumes of Bin 2 vehicles (mostly larger single-unit trucks and RVs) tend to vary the most by season. This variance appears to be attributable to the recreational vehicles in this category.

Figures 1 and 2 illustrate the differences in seasonal truck volume patterns among vehicle classes. The monthly volume patterns on these charts, shown as the ratio of monthly average weekday volumes (MAWDT) to average annual daily volumes (AADT), are typical of the patterns found at many sites. The exact locations and sizes of seasonal peaks and valleys often shift from site to site, but the basic shapes of the four curves are reasonably similar.

The characteristics and magnitudes of the differences in seasonal volume patterns for the vehicle classes are discussed in the following.

GEOGRAPHIC AND FUNCTIONAL ROADWAY DISTRIBUTIONS

One of the findings expected from this study was that the functional classification of the road and the location of each

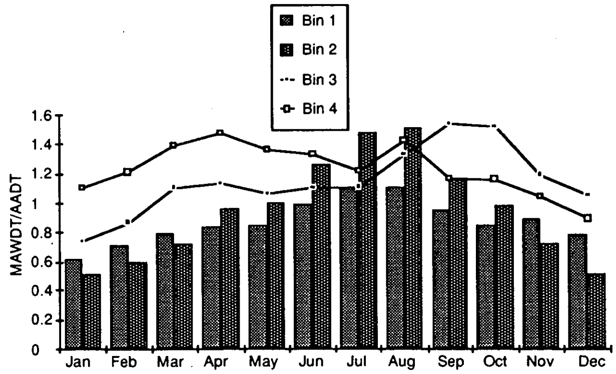

FIGURE 1 MAWDT/AADT for Site 61, 1991.

data collection site would significantly influence the traffic patterns observed at that site. This is indeed the case, and the findings are biased toward the geographic and functional distribution of the sites available for analysis.

Because 14 of the 26 sites (53.4 percent) are on the Interstate system, the project data base is heavily weighted toward the Interstate. The remaining sites are 10 principal arterials, 1 collector, and 1 minor arterial. Ten of the sites are within urban area boundaries; however, because of the relatively small sizes of some of these urban areas, some of these counters display traffic volume patterns that are more characteristic of rural recreational routes.

Because of the distribution of counter locations, the findings of this study are weighted toward the higher-volume rural roads in the state. Although a number of urban Interstate sites exist in the analysis data set, few urban arterial sections are instrumented with permanent vehicle classifiers. This reflects the fact that the Washington State Department of Transportation (WSDOT) operates few roads other than freeways in urban areas. (Local jurisdictions operate and maintain most urban arterials.) The overrepresentation of higher-volume rural roads in the analysis data base reflects WSDOT's concern with that group of roads. However, this distribution of equipped sites does limit the usefulness of conclusions concerning traffic trends on lower-volume rural highways and urban arterials.

In general, the higher the functional classification of the road is, the higher the traffic volumes in all vehicle classes. And the higher the traffic volumes are, the lower the variation in traffic levels from month to month and from year to year. Conversely, the lower the functional classification of the road is, the lower the traffic volume (particularly in the longer truck categories) and the more unstable the traffic volume pattern, both from month to month and from year to year. Some low-volume roads show reasonable stability in their traffic volume patterns, but a much greater degree of variation is present on these facilities.

The impact of location can also be seen in the traffic volume patterns observed in the data. For example, data from counters in areas subject to heavy recreational traffic show extreme seasonal patterns in Bin 2 vehicle volumes. Data from nonrecreational sites may show minor volume increases in Bin 2 vehicles during peak recreational periods but not to the degree found at recreational sites. In agricultural areas, the longer truck categories show traffic volume peaks that are not present in other parts of the state.

The geographic influences change from one vehicle class to the next. For example, the recreational routes show increased automobile volumes (i.e., Bin 1) in the peak recreational periods, but not to the extent (in percentage terms) experienced by vehicles in Bin 2, which contains most of the recreational vehicles. Similarly, the two longer truck classes (Bins 3 and 4) are only minimally affected by the recreational peaks. Figures 1 and 2 show examples of these differences at two sites with fairly extreme seasonal variability.

The counter site that provided the data for Figure 2 is on a rural primary arterial near Washington's south-central border with Oregon. It displays the fairly high seasonality of the rural area, and the seasonal variation of longer truck classes (Bins 3 and 4) is much flatter than the seasonal variation for either automobiles or small trucks and recreational vehicles (Bins 1 and 2). The longer trucks counted at this site actually show a fairly high degree of variation in comparison with those counted at other locations because of an agricultural harvest haul that occurs in the late summer and early fall.

Figure 3 illustrates the volume patterns at a high-volume urban Interstate location. As expected, the seasonal volume patterns for all four vehicle classes show less month-to-month variation than those in the rural site in Figure 2, although recreational vehicle traffic still increases significantly during the summer months. At this urban site, the ratio of MAWDT to AADT for the two longer truck classes never falls below 1.0. This shows that the weekday traffic volumes tend to be

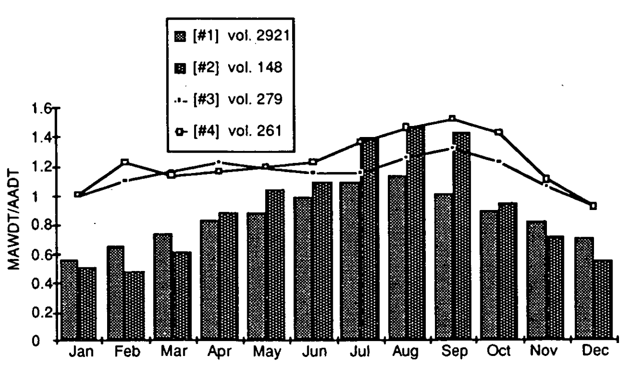

FIGURE 2 MAWDT/AADT for Site 41, 1991.

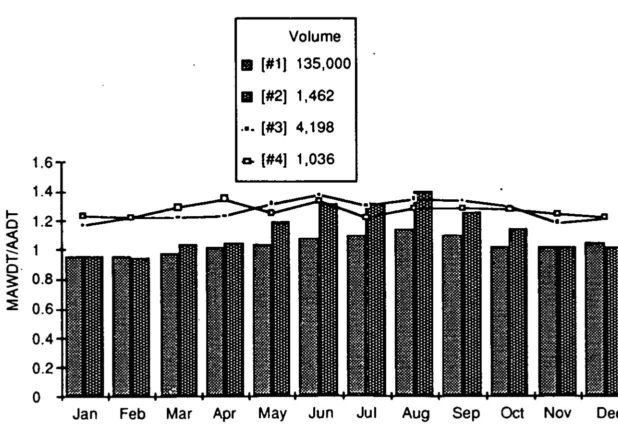

FIGURE 3 MAWDT/AADT for Site 809, 1989.

fairly constant throughout the year and that the weekday volumes tend to be consistently higher than the weekend volumes. Both of these facts are important in estimating average annual conditions from either weekday or weekend traffic counts.

Figure 4 illustrates some of the problems that occur when seasonal factors are calculated for lower-volume roads. In this case, the volumes of longer trucks are so small that relatively small changes in daily truck volumes cause the seasonal factor ratio (MAWDT/AADT) to reach fairly large values. For Figure 4, this ratio reaches 2.5.

With the low levels of traffic volume of a site like that of Figure 4 (AADT for Bin 4 is 14 vehicles per day), relatively small changes in volume significantly affect the computed seasonal factors. The results are highly variable seasonal factors, because the factors for any given month can be very different from year to year for a specific site, or between two similar sites. High variability complicates the search for groups of roadway sections that have similar traffic volume patterns, and it reduces the accuracy of AADT estimates produced with short-duration counts and seasonal adjustment factors. This problem is accentuated by larger classification schemes. That is, the FHWA 13-category classification scheme will produce a greater number of highly variable vehicle class seasonal factors than the four-length bin categories shown in Figure 4.

13-BIN VERSUS 4-BIN CLASSIFICATION SCHEMES

When the Strategic Highway Research Program introduced its revised traffic data collection plan, several state highway agencies indicated that they would use permanent 4- or 6-bin length classifiers to compute seasonal factors for 13-bin axle classification counts conducted with short-duration portable traffic counting equipment. This approach to seasonal factoring assumes that vehicles in the 13-bin axle categories follow volume patterns that are similar to the patterns found in the 4-bin data. It also assumes that all of the 13-bin truck categories fit cleanly into the length bins (i.e., that the axle bins are simply subsets of the length bins) and that each of the axle-based categories within a length bin follows the same pattern as that length bin (i.e., all of the FHWA categories that would be part of Length Bin 4 have similar seasonal patterns). All of these assumptions are also dependent on the length limits selected by each state for its length categories.

To test these theories, the seasonal volume patterns of the 13-bin vehicle categories were compared. WIM vehicle records were used to compute 13-bin daily volume records by vehicle class. These records were then used to compute monthly patterns based on the ratio of MAWDT/AADT. Figures 5 and 6 illustrate the resulting patterns for the truck categories (Bins 4 through 13) of the FHWA 13-bin classification scheme. As with the four length bins discussed, these patterns vary from site to site. Unfortunately, only three WIM sites in Washington had been operating for a complete year at the time of the analysis, so the differences in patterns caused by geographic and functional classification changes cannot be explored in this paper.

It is apparent from looking at Figures 5 and 6 that the 13 categories have very different seasonal patterns. This is particularly true if the categories containing RV traffic are compared with the categories that contain primarily commercial trucks. (In Washington, single-unit RVs tend to be classified as Axle Bin 4 "Buses," and vehicles pulling RV trailers tend to be classified as Axle Bin 8 "Four or Less Axle Combinations.") Recreational traffic has very high peaking characteristics, whereas commercial vehicle traffic has more consistent traffic volume patterns. Not surprisingly, the distribution of traffic between weekdays and weekends is also very different for the two types of travel.

For large commercial trucks (Axle Bins 9, 10, and 11, in particular), the seasonal factor MAWDT/AADT rarely falls below 1.0. This ratio reflects the fact that more commercial vehicle traffic occurs on the weekdays than on the weekends. Thus, even when some decrease in volume occurs in winter, the average weekday for the month is often higher than the average annual condition, which includes the lower weekend traffic volumes.

This phenomenon is not true for RV traffic. Much of the recreational traffic takes place on weekends, so with the exception of the summer months, the ratio of average monthly weekday to average annual condition tends to be less than 1.0. This pattern is illustrated best by Axle Bin 4 in Figure 5, which also shows an extremely high seasonal factor in July. This significant increase (the factor is greater than 4.0) is because of both the very large increase in RV traffic in the summer and the fact that the 4th of July holiday was on a

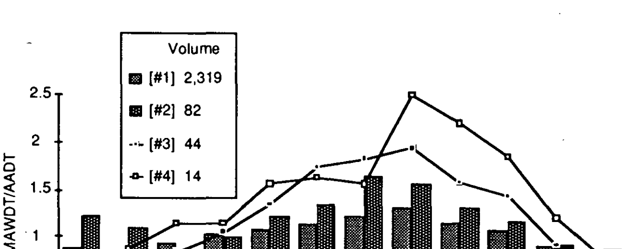

FIGURE 4 MAWDT/AADT for Site 820, 1990.

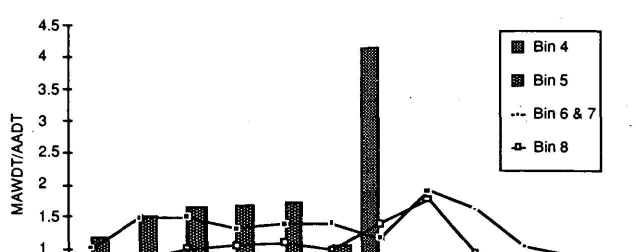

FIGURE 5 Seasonal traffic patterns of FHWA vehicle classifications for rural Interstate in western Washington, smaller truck categories.

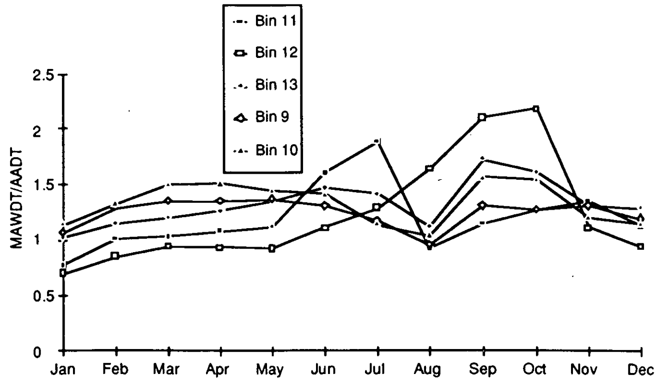

FIGURE 6 Seasonal traffic patterns of FHWA vehicle classifications for rural Interstate in western Washington, larger truck categories.

Thursday during the year illustrated. Thus, the "average" July weekday included a very high volume of RVs.

The very large seasonal pattern in this group is also attributable to the low volume of RVs on the average annual day: many RVs are normally on the road in the summer, but few are present during the rest of the year. Thus, the annual average volume is quite small. This makes the denominator in the ratio of MAWDT/AADT small, and consequently a relatively modest increase in traffic volumes can result in fairly large seasonal factors.

When these disparate vehicle class patterns are combined into a smaller number of categories (for example, the four length classes), the individual peak traffic movements shown in Figures 5 and 6 are "dampened"—that is, the monthly volume patterns change less from month to month. The large increase in RVs still produces a travel peak in July and August, but the MAWDT/AADT is much lower. Dampening occurs for two basic reasons. The first is that the patterns for different vehicle types have different peaks. Therefore, volumes for some vehicle types within a composite vehicle class increase, whereas others decrease or stay constant. Thus, in some cases, the absolute increase in traffic volumes is not as large as the increase for some vehicle types. The second reason is that even if the total volume increase is the same as or greater than that for any vehicle category, the combined vehicle group has a much higher total volume (the denominator in the ratio) than the individual vehicle category, and thus the computed factor is lower.

An example of the dampening effect can be seen in Axle Bin 8 in Figure 5. This axle bin contains both relatively large numbers of commercial vehicles (small tractor semitrailer combinations) and some RVs (primarily large vans and pickups pulling large trailers). The effect is that the lack of RVs in the winter months lowers the seasonal factor below 1.0, but the presence of commercial vehicles prevents that value from being very far below 1.0. In the summer, when large numbers of RVs are present, the seasonal factor increases well beyond 1.0, but because the volume of background commercial traffic is fairly large, the ratio of MAWDT/AADT (greater than 1.5) is considerably smaller than that in Axle Bin 4, the other vehicle class containing RVs.

The dampening effect can be significant if a vehicle class that is "different" from the other classes in its length bin is only a small proportion of the total volume for that combined classification. In this case, even an extremely large percentage increase in the vehicle category with smaller volumes is insignificant in comparison with the larger background traffic volumes. The result is a seasonal factor that reflects the total class, not the smaller vehicle category.

The primary drawback to this dampening effect is that it masks the actual vehicle patterns that are occurring on the road. But the dampening effect is not all bad. One of its significant advantages is that the seasonal factors for the larger vehicle categories tend to be more stable. Thus they are more capable of predicting total traffic volume. They simply do not estimate the vehicle mix within that volume with a high level of precision.

In summary, by combining specific vehicle types in larger classes, the volume patterns at a site tend to become more stable. However, this stability masks a variety of fluctuations in the volumes of specific types of vehicles. The end result is often a stable factor that does not accurately represent specific traffic volume patterns.

WEEKDAY VERSUS WEEKEND TRAFFIC

Another analysis examined the differences in traffic volumes between weekdays and weekends. This analysis included investigations of whether all classes of trucks had a specific weekly pattern and whether more truck traffic occurred on specific days. As indicated, the results showed that in most cases Saturday and Sunday traffic volumes differ significantly from weekday traffic volumes. In the majority of cases, weekday traffic volumes are higher than weekend volumes—especially for the longer truck classes, in which large commercial vehicles dominate. However, for classes with a high percentage of RVs, weekend volumes are consistently higher than weekday volumes.

As part of this analysis the project team also tried to determine the elements that constitute a "weekday." The researchers computed the average weekday three different ways, depending on the definition of the weekend/weekday split. (They computed and compared Monday to Friday weeks, Monday to Thursday weeks, and Tuesday to Thursday weeks.) The conclusion drawn from these analyses is that in some locations and in some months, the incorporation of either Monday or Friday in the weekday estimate is appropriate, and in other locations or months, traffic volumes on these days are statistically different from those of Tuesday through Thursday. For the sake of consistency, analyses performed for this paper assume that weekdays are only Tuesday through Thursday. This may be a conservative assumption, but the decision greatly simplified the performance of the analyses.

STABILITY OF FACTORS OVER TIME

The analysis of monthly to average annual traffic ratios over time showed that in general, the greater the traffic volume is on a road (or within a classification), the more stable the monthly ratio of weekday traffic to annual average condition. That is, average monthly traffic volume patterns for Interstates and heavily traveled principal arterials are reasonably

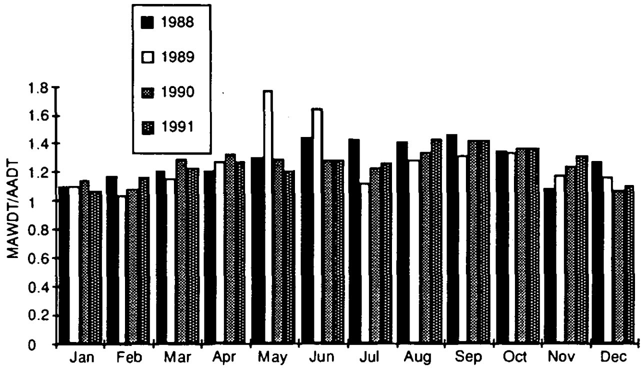

FIGURE 7 MAWDT/AADT for Bin 4 at Site 1, Interstate 5.

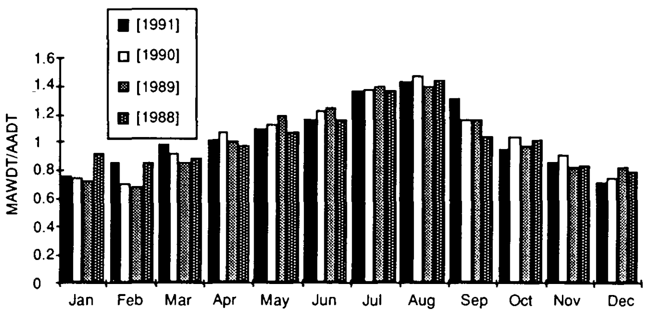

FIGURE 8 MAWDT/AADT for Bin 2 at Site 1, Interstate 5.

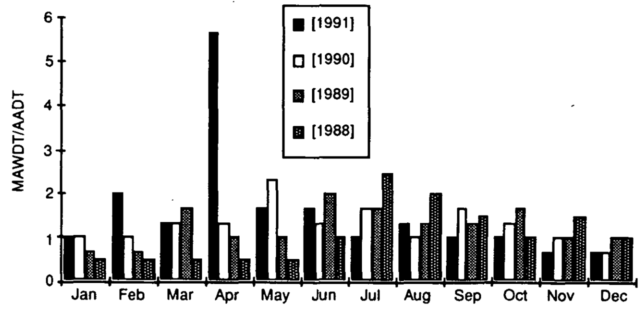

FIGURE 9 MAWDT/AADT for Bin 4, State Route 410.

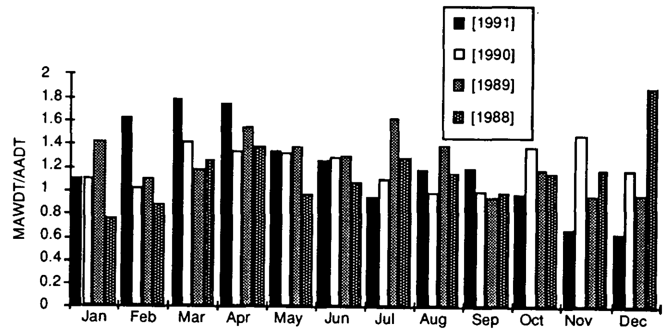

FIGURE 10 MAWDT/AADT for Bin 2, State Route 410.

stable over time (from year to year). Traffic patterns on lower-volume roads are often unstable from one year to the next. Although some low-volume sites have stable monthly factors, others have factors that vary considerably from year to year.

The actual monthly factors computed for low-volume roads may change significantly from one year to another, but the general volume patterns remain reasonably constant (for example, there is a consistent peaking pattern for each counting location that can be associated with summer or harvest period travel, but the timing and size of those peaks and valleys tend to vary from year to year.) The data also revealed that different roadways within the same geographic area or functional classification often have very different monthly factors, even though the shapes of their seasonal traffic volume patterns are similar.

Figures 7 and 8 show examples of changes in monthly to annual ratios from one year to another at a high-volume site. Figures 9 and 10 shows these ratios at a lower-volume site.

SUMMARY

The analyses described indicate that in most cases, an unadjusted 24-hr vehicle classification count is a poor estimate of average annual conditions. At most sites, an unadjusted 24-hr weekday count will consistently overestimate the average number of longer trucks traveling that road.

Except during the peak recreational travel periods, unadjusted weekday counts will significantly underestimate the average annual volume of RVs using the roadway. If counts are taken during peak recreational periods, weekday counts will overestimate the average annual RV volumes.

A comparison of the length Bin 1 patterns with the other three classifications shows that in most cases, the use of traditional seasonal factors to adjust short-duration truck volumes is inappropriate for estimating average annual truck volumes. The analyses show that during most portions of the year, the seasonal adjustments for different vehicle classes are different. Where the monthly adjustments for both total volume and individual vehicle classes are above or below 1.0, the factor based on total volume will improve the AADT estimate, although this improvement is rarely as good as that produced by a class-specific factor. Where one factor is above 1.0 and the other is below 1.0, the adjustment based on total volume will provide an estimate of total truck traffic that is worse than the unfactored volume estimate.

REFERENCE

1. *Guidelines for Traffic Data Programs.* AASHTO, Washington, D.C.