



# LONG TERM PAVEMENT PERFORMANCE TRAFFIC MONITORING PROTOCOL

For the Technical Direction of the LTPP Program



**Program Area:** Traffic Monitoring  
**Date:** April 1998  
**Subject:** Revised Data Collection Plan for LTPP Test Sites

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This report describes the Long Term Pavement Performance (LTPP) program's revised traffic data collection plan. The intent of the revised plan is to improve the overall quality of the LTPP traffic loading estimates by shifting the emphasis from the volume of data collected to the quality of data collected.

## BACKGROUND

The LTPP program is aware that several participating agencies have been unable to supply the originally requested traffic loading information at LTPP test sites because of resource constraints. As a result, some portions of the original LTPP experiment lack the data necessary to support the analytical tests that had originally been planned. In addition, substantial new Federal resources are not available to carry out traffic (or other) data collection activities at LTPP test sites.

Therefore, FHWA-LTPP is currently restructuring the LTPP experiment to make the best use of available State, Provincial, and Federal resources. As part of the restructuring effort, the requirements for the collection, review, and submittal of traffic data are being changed.

The data collection plan described in this document is to be followed at each LTPP site until those sites stop being monitored as part of the LTPP tests or until permanent data collection equipment at the site fails. If the equipment installed at the site fails, discussions with the appropriate LTPP representative will be necessary to determine whether, for that particular site, the cost of repairing or reinstalling traffic data collection equipment is warranted. This decision will vary from site to site, depending on the importance of a site to the overall LTPP experiment; the availability of other experimental data at that site; and the cost of replacing the equipment, including any needed pavement rehabilitation.

In addition to this data collection protocol, another guideline is being developed to provide more specific guidance on the installation, calibration, and use of automatic vehicle classification (AVC) and weigh-in-motion (WIM) equipment.

## **INTRODUCTION TO THE REVISED TRAFFIC DATA COLLECTION (MONITORING) PLAN**

Analysis of the traffic load data that have already been submitted to LTPP has allowed LTPP to better understand the effects of different sampling plans on the accuracy of annual load statistics. The plan recommended here results from that analysis and is intended to provide LTPP with the best possible analytical results from the least costly data collection effort.

The analysis results showed that reasonably accurate estimates of annual loading rates can be computed from fairly small samples of data (see table 1), given two provisions:

- The data accurately measure the traffic using the roadway at the time of the data collection effort (accurate results can be obtained if the equipment is well calibrated and operating properly).
- The road in question does not experience unusually high levels of traffic or loading variation.

Because of these findings, the revised traffic data collection plan differs from the initial LTPP plan in that it requires considerably fewer days of monitored traffic loading data from most sites, but places more emphasis on the quality of those data. **Particular emphasis is placed on the calibration of the equipment**, including manual review of equipment performance at the data collection site.

## **REVISED DATA COLLECTION PLAN**

The LTPP program is reclassifying LTPP test sites into five categories. These categories correlate with the amount of data being collected (in all LTPP categories) and the types of analyses that will be performed. The new categories of LTPP test sites are<sup>1</sup>:

- SPS-1 and 2.
- SPS-5, 6, and 8.
- GPS-1, 2, 3, 4, 5, 6B, 6C, 6S, 7B, 7C, and 9. SPS-9 (overlay only) is also included in this group.
- SPS-7 and 9 (new construction).
- Case study sections (including SPS-3, 4, and GPS-6A, 6D, 7A, 7D, and 7S).

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<sup>1</sup> Please see other LTPP documentation, such as *Immediate Test Section Monitoring Adjustments*, dated October 13, 1997, for a more detailed description of these categories.

Traffic data collection resources will be most heavily focused on the Specific Pavement Study (SPS) sites that will provide the basic inputs for the development of mechanistic models for pavement design and rehabilitation. LTPP tests that are ending and/or test sections that are being removed from further pavement performance data collection (e.g., that are being reconstructed in a manner that does not fit within one of the General Pavement Study (GPS) experiments) will not require continued traffic monitoring; however, all valid data previously collected will remain available through the LTPP Information Management System (IMS).

**Table 1. Summary of expected errors for selected sampling plans.**

Sampling Plan		Expected Bias to the Annual Estimate	Expected Error (percent)	95 Percent Confidence Interval
Classification	WIM			
1 weekday	1 weekday	+20	45	200
1 weekend day	1 weekend day	-50	55	50
2 weekdays	2 weekdays	+20	45	100
1 week	1 week	0	30	50
1 week during each of four seasons	1 week during each of four seasons	0	30	50
1 weekday and 1 weekend day per season for four seasons	1 weekday and 1 weekend day per season for four seasons	0	35	80
Continuous	1 weekday	0	30	50
Continuous	2 weekdays	0	25	50
Continuous	1 weekday and 1 weekend day	0	25	50
Continuous	1 week	0	25	40
Continuous	1 weekday during each of four seasons	0	12	30
Continuous	2 weekdays during each of four seasons	0	10	25
Continuous	1 week during each of four seasons	0	8	20

All values are expressed as a percentage of annual load.

*Source: Results of the Empirical Analysis of Alternative Data Collection Sampling Plans for Estimating Annual Vehicle Loads at LTPP Test Sites, July 1997.*

Table 2 shows the revised data collection plan. Participating agencies have some flexibility in modifying these data collection plans at individual sites if they can show that the data collection plan they propose for a given site meets the desired level of accuracy. This flexibility is intended to allow agencies to tailor the data collection plan to their own equipment and staffing abilities.

At the same time, any alternative plan should maintain the accuracy and precision of the equivalent-single-axle-load (ESAL) estimate. This allows agencies with LTPP sites that have been proven to have stable, repeatable traffic patterns to reduce their data collection efforts because of the effect that repeatability has on the accuracy of annual load estimation. Alternative data collection plans should be submitted to the appropriate LTPP Regional Contractor’s Office Coordinator (RCOC) for approval prior to implementation.

**Table 2. Summary of recommended minimum data collection plans.**

Required Data Accuracy and Precision	Recommended Minimum Data Collection Plan	Apply Plan to These Sites
Measure loads  (not sample-based estimates)	Continuous <sup>2</sup> WIM	SPS-1, SPS-2
$\pm 25$ percent  with 95 percent confidence, the load estimate is $\pm 50$ percent	Continuous <sup>2</sup> Vehicle Classification Data  2 Days of WIM / year	SPS-5, 6, 8, and 9A overlay  Most GPS experiments (GPS-1, 2, 3, 4, 5, 6B, 6C, 6S, 7B, 7C, and 9)
$\pm 45$ percent  with 95 percent confidence, the load estimate is within $\pm 200$ percent	1 Week of Vehicle Class / 2 years  1 Day of WIM/2 years	SPS-7 and 9A (new construction)

At the vast majority of sites, the data collection plan should be viewed as the minimum data collection effort required to meet the stated levels of precision. Participating agencies may wish to collect more traffic information than is required under this plan, both because they are interested in obtaining more accurate traffic loading estimates at those sites for their own research and analysis, and because, in some cases, more extensive data collection efforts may cost the same as the required LTPP effort. Participating agencies are encouraged to collect more than the minimum requested data, particularly where permanent data collection equipment has already been installed or where equipment will be installed as part of the agency’s own data collection program.

In some cases (where traffic is particularly variable), agencies are requested to collect additional days of traffic data to meet the required data collection accuracy. Additional traffic data will

<sup>2</sup> LTPP acknowledges that no data collection device collects data at all times throughout the year. As a result, “continuous” data collection is defined as use of a device that is intended to operate during the year and to which the State highway agency (SHA) commits the resources necessary to both monitor the quality of the data being produced and to fix problems quickly upon determination that the equipment is not functioning correctly.

improve the loading estimates computed for a site and thus will improve the quality of research performed with the LTPP data base.

Participating agencies are also encouraged to install and operate permanent equipment and sensors at LTPP test sites, even when such equipment is not specifically required by the LTPP data collection plans. Tests have shown that permanently installed WIM equipment often operates more reliably than portable equipment, even when not operated continuously (particularly for WIM sensors, where flush mounting of the sensors can only be accomplished in “permanent” installations). Permanently installed equipment also allows participating agencies to more easily observe traffic variations over time and, if necessary, to collect additional data at modest expense to account for that variation in both the LTPP loading estimates and the agency’s own data collection and reporting system.

## **DETAILS OF THE DATA COLLECTION PLAN**

**For SPS-1 and 2 sites**, a continuously<sup>3</sup> operating WIM device is required. This level of data collection is needed to provide the accurate traffic loading measurements needed for the development of mechanistic and mechanistic/empirical design models and to provide the base data needed to understand the intricacies of the interactions among pavement, load, and environment.

In addition to the continuous WIM data collection effort, the participating agency should perform on-site scale calibration at least twice each year (see the LTPP protocol, *Traffic Data Collection Equipment Calibration*) and should monitor the output of the WIM equipment to determine whether additional calibration is needed. If the scale fails or experiences calibration drift, the agency should plan to repair the equipment within 2 months, with shorter repair times whenever possible. WIM data should not be submitted to LTPP for times during which the scale is not calibrated.

The WIM equipment should be kept in operation as long as physical conditions allow. As the physical condition of the roadway begins to cause problems with scale operation, participating agencies should discuss with their LTPP regional office (their RCOC) the need for continued operation of that site and the maintenance and repair activities needed to keep that scale operational. Decisions about the replacement of the WIM equipment and any required pavement rehabilitation will be made by LTPP and the participating agency on the basis of the status of the SPS experiment, the status of other test data for that SPS site, and the cost of the required repair/replacement effort.

**For SPS-5, 6, and 8 sites**, the expense of a continuously operating WIM device is not warranted, given the limitations in data collection resources and the availability of the other independent variables needed for some research tasks. Thus, for these sites, the minimum recommended data collection effort is 2 days of vehicle weight data plus the data from a continuously<sup>4</sup> operating

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<sup>3</sup> See footnote 2 for “continuous” data collection.

<sup>4</sup> See footnote 2 for definition of “continuous” data collection.

AVC. This data collection plan yields an expected error in the estimate of annual load of roughly 25 percent, with 95 percent confidence that the annual load estimate is within  $\pm 50$  percent.

On-site WIM calibration is required immediately before the start of the WIM data collection effort. Calibration and/or validation of the AVC equipment must also be performed twice per year. (The AVC equipment must be initially calibrated, and then its proper operation must be validated at least twice per year. One of these two validation efforts can occur at the same time as the WIM scale calibration.)

Beyond the basic 2-day WIM sample, the participating agency is expected to collect additional site-specific weight data if an agency review of the site's traffic characteristics determines that either:

- Weekend loads per vehicle (by class) are significantly<sup>5</sup> different than weekday loads, or
- Seasonal loads per vehicle change significantly<sup>6</sup> (e.g., if a weight restriction is placed on that road during parts of the year).

The agency must use monitoring data collected for LTPP to determine the need for additional WIM data collection. (For example, the agency must have collected some weekend weight data at the site to determine whether weekend and weekday weights per vehicle are similar or are significantly<sup>7</sup> different. Similar criteria are applied to seasonal loads per truck by vehicle classification, so that data are collected at least once during the four different seasons of the year.) For cases in which agencies have previously collected data requested for LTPP test sites, this analysis can be easily performed with existing LTPP data. Where data have not already been collected to detect these differences, agencies are requested to collect these data and submit them as part of the LTPP traffic data submittal.

If either seasonal or weekday/weekend differences exist, the participating agency should commit to collecting data during the periods that are anticipated to be different, in addition to the required 48-hour sample (e.g., collecting 1 weekend of weight data, or 2 days' worth of data during a different season). Finally, if significant changes are measured<sup>8</sup> from one year to the next, the agency is requested to collect a second 48-hour sample of WIM data (at least 3 months separated from the first sample) to help determine the cause of that change.

The review of available LTPP load data showed that at a majority of sites, significant variations were not a problem. However, for the 20 percent of the sites where significant variations in the

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<sup>5</sup> "Significantly" is defined as a difference of more than 10 percent in the mean gross vehicle weight (GVW) for those vehicle classes that make up 75 percent of the ESAL loading at that site.

<sup>6</sup> See the previous definition of "significant" in footnote 5.

<sup>7</sup> See the previous definition of "significant" in footnote 5.

<sup>8</sup> "Significant changes" are defined as a positive or negative change of 10 percent or more in the mean GVW per vehicle, by vehicle classification, for the three truck classes that make up the highest percentage of loads (defined by an ESAL/day calculation) at a site. This is designed to determine if the loaded/unloaded condition of "important" trucks at that site has changed, or if a change in commodity shift has take place.

traffic stream occur, a small increase in traffic data collection can significantly improve the accuracy of annual and seasonal loading estimates.

Participating agencies should follow these data collection plans until new data collection guidelines are issued by LTPP or until pavement performance data will no longer be collected at that test site.

If the permanently installed AVC equipment at the test site fails, the classifier should be repaired and/or replaced within 2 months. However, if the site is scheduled to be placed “out of test” (i.e., the test pavement has served its research life and will soon be removed from the experiment), the participating agency and LTPP may decide not to replace the equipment. This decision will be made on a case-by-case basis, given the needs of LTPP, those of the agency, and the cost and difficulty of replacing the data collection equipment. If a WIM scale is replaced by an AVC, the RCOC will provide additional instructions (on a case-by-case basis) regarding whether or not to collect additional WIM data at that site.

**For GPS-1, 2, 3, 4, 5, 6B, 6C, 6S, 7B, 7C, and 9 experiments and SPS-9 overlay sites,** the traffic data collection required is similar to that required for SPS-5, 6, and 8 sites. That is, the minimum recommended data collection effort is 2 days of vehicle weight data plus the data from a continuously<sup>9</sup> operating AVC. At least twice a year, the operation of the AVC should be validated and any necessary adjustments should be made to ensure the accuracy of the classification counts. Calibration of the WIM data collection device should also occur immediately before its use. (See the LTPP protocol, *Traffic Data Collection Equipment Calibration*.)

As with the earlier data collection requirements, additional WIM data collection is required if data collection experience shows that truck loading patterns are not consistent<sup>10</sup> throughout the year and/or that there is seasonal or day-of-week variation in truck weights. However, the agency may use data from elsewhere in the State or Province in addition to LTPP collected data to make these determinations. If high weekday/weekend or seasonal variations exist, the agency should collect additional WIM data at the site to determine the size of these differences.

For these sites, LTPP has relaxed the 2-month repair criteria. Instead, the agency should notify the RCOC that a specific piece of equipment has failed and should work with the RCOC to determine whether the expected life span of that test pavement, the availability of data for that site, and the needs of the LTPP analysis effort warrant replacement of that equipment; whether a less costly data collection effort can be substituted for that equipment; or whether traffic data collection can be discontinued.

**SPS-7 and 9 (new construction) sites** require less traffic data collection. At these sites, an absolute minimum of at least 1 week of vehicle classification data and at least 1 day of vehicle weight data are required every 2 years. This minimum will provide some measure of the day-of-week truck volume pattern at the site and will allow at least a crude understanding of day-of-

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<sup>9</sup> See footnote 2 for definition of “continuous” data collection.

<sup>10</sup> See the previous definition of “significant change” in footnote 5.

week differences at a site. Research has shown that at most sites, day-of-week differences are a major source of bias in estimating annual loads. Additional vehicle classification data collection is requested (but not required) of the participating agencies at some point during the life of the experimental pavements to measure seasonal differences.

As with the other data collection efforts, on-site AVC and WIM calibration is required whenever data are collected.

The result of this data collection should be an estimate within roughly  $\pm 50$  percent of the true loading value, 68 percent of the time. Ninety-five percent of the estimates should be within roughly a factor of 2 of the real loading rate. Not surprisingly, annual estimates computed from these data will be more accurate for sites that experience relatively little seasonal variation in heavy truck traffic and that have similar weekday and weekend loading characteristics per truck. The accuracy of load estimates for sites with substantial day-of-week or seasonal variation is likely to be at the higher end of the expected error bounds.

The remaining LTPP test sections (**most SPS-3 and 4, and GPS-6A, 6D, 7A, 7D, and 7S sites**) are expected to be out-of-test during 1998 and, therefore, will not require traffic data collection. However, on a case-by-case basis, the LTPP and participating agencies may develop site-specific data collection plans to provide updated traffic loading estimates for sites because of continuing research interests in those sites.

## **EQUIPMENT SELECTION: PERMANENT VERSUS PORTABLE EQUIPMENT**

It is up to the individual agency to determine which type of sensor it will use for any given data collection effort at each LTPP test site. Both permanent and portable sensors have strengths and weaknesses when used to collect weight and classification data. However, the LTPP Expert Task Group (ETG) on Traffic Data Collection and Analysis strongly recommends the use of permanently mounted sensors whenever possible, even when only short-duration counts are being taken. While compliance with this recommendation requires a fairly substantial up-front capital investment for each LTPP test site, the LTPP ETG believes that, in most cases, correctly operating permanent equipment yields more reliable results, particularly for weigh-in-motion data. Permanent equipment also reduces the cost of repeated equipment set-up, allows longer data collection efforts, uses less staff time per data collection session, and reduces the exposure of data collection personnel to hazardous situations (e.g., the need to provide traffic control during portable sensor placement or the placement of data collection sensors in the roadway without traffic control).

Still, there are times when use of portable equipment is more cost-effective and reliable than permanent equipment. Consequently, LTPP accepts data from both types of equipment, but it requires that the accurate performance of that equipment at each LTPP test site, for each LTPP data collection session, be ensured through the application of calibration/validation plans.<sup>11</sup> These plans ensure the quality of data provided to LTPP regardless of the type of equipment being used.

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<sup>11</sup> See the LTPP Traffic Data Collection Calibration Protocol.

## **TRAFFIC DATA COLLECTION EQUIPMENT LOCATION**

The data collection site should be in the LTPP lane and located directly upstream or downstream from the LTPP test section. Where it is not possible to place equipment in such a location, the participating agency should work with the RCOC to select the best potential location to ensure that the traffic being measured can be directly related to the loads the test section is experiencing.

For the best results, select a location that is as smooth and flat as possible, with no ruts or potholes. Ruts and potholes will cause both axles and road tubes to bounce, which can create erroneous (or missed) axle hits, suggesting an inaccurate number of axles per vehicle. These errors would prevent an AVC from correctly categorizing vehicles. Similarly, WIM accuracy is adversely affected by the dynamics of bouncing axles, and the more the axles bounce, the more difficult it is to provide accurate weights.

If the pavement immediately upstream or downstream from the test section is not suitable for placing traffic data collection sensors, it is permissible to move the sensors farther away from the test section. However, the benefits of moving the sensors to a section of pavement that is more conducive to traffic counting must be balanced against the possibility that traffic conditions in the test lane will change between the test site and a remote location. Sites should be chosen to both minimize these differences and to permit effective sensor operation. The overall intent of the data collection effort is to provide the best possible measurement of traffic crossing the test section. Therefore, participating agencies are discouraged from moving the data collection site to a location that is separated from the test site by an intersection or road junction, because such a junction can significantly change the traffic stream. These changes may include differences in total traffic volume, vehicle mix, and lane distribution.

When in doubt, discuss the advantages and disadvantages of potential data collection locations with the appropriate RCOC staff.

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