Research Report
KTC-02-30/SPR-256-01-1F

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KENTUCKY HIGHWAY RATING SYSTEM

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Kentucky Highway Rating System

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16. Abstract

This study had two goals: 1. Formulate a new method for generating roadway adequacy ratings; 2. Construct an appropriate data set and then test the method by comparing it to the results of the HPMS-AP method. The recommended methodology builds on the previous methodology, the HPMS-AP. However, the recommended differs from the HPMS-AP in that it incorporates crash data into the adequacy rating and increases the relative weight given to indicators of roadway safety for the appropriate functional classification of highways. The software for the proposed highway rating system is in a format that permits "what if" scenarios. The comparison of the proposed method with the HPMS-AP shows the former more effectively identifies the roads with inadequacies.

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Executive Summary

The Kentucky Transportation Cabinet uses roadway adequacy ratings as one tool in its efforts to prioritize proposed highway improvements. Without an accurate method for measuring roadway adequacy, it is difficult to efficiently allocate the Commonwealth's limited resources to the most needed projects. In this report, we present the results of a study whose purpose was the creation of a new method for generating roadway adequacy ratings.

The specific goals of this study were twofold:

1. formulate a new method for generating roadway adequacy ratings; and
2. construct an appropriate data set and then test the method by comparing it to the results of the HPMS-AP method.

The proposed method can be used to assist with the identification and prioritization of long-range transportation needs. The state can then direct its scarce resources to the projects most likely to improve the overall performance of the transportation system.

These ratings have three components—a measure of roadway condition, a measure of safety, and a measure of capacity. The three component measures are combined into an overall quantitative measure and all proposed projects can then be ranked with the combined measure.

In recent years roadway adequacy ratings have been generated by a software Analytical Package (AP) that was a component of the Highway Performance Monitoring System (HPMS). The HPMS is maintained by the Federal Highway Administration and will continue as a system to which states annually submit data to report condition and performance data on the nation's highway system.

The HPMS-AP was an additional software package that FHWA developed in the early 1980s that used the HPMS data to help analyze the condition and needs of the highway system. In the mid 1990s FHWA dropped the AP component from the HPMS program. As a result, KYTC now needs a process that can generate ratings from current HPMS data as extracted from HIS files and augmented by the HPMS calculation routines.

Working with the Kentucky Transportation Center, this advisory committee has devised a new rating method. The recommended methodology, described in this report, builds on the previous methodology—the analytical package of the Highway Performance Monitoring System (HPMS-AP). It differs in several respects, however, from the previous methodology in that it incorporates crash data and increases the relative weight given to indicators of roadway safety for the functional classification of highways where this was appropriate.

In all, there are seven major differences between the HPMS-AP and the proposed adequacy rating system.

1. The new Safety Index uses Crash Data to calculate a Critical Rate Factor for each Evaluation Section. It retains measures of the other factors of safety.

2. The new Safety Index is allocated more of the 100 possible points, while Condition and Service Indices are allocated proportionately fewer. However, the allocation varies by functional class.

3. The Condition Index now has only one factor—pavement condition. Previously the HPMS condition index included pavement type and a subjective assessment of drainage adequacy in addition to pavement condition

4. In the HPMS-AP, the evaluation sections were determined by the number of lanes, functional class, nonattainment/attainment area, pavement type, type of operation (one or two way), and median (divided or undivided). In the new, evaluation sections are determined by the number of lanes, functional class, nonattainment/attainment area, county line, and a new three category classification of median—a protected median or an unprotected with 40 or more feet of median (highest rating), other unprotected median (intermediate rating), and no median (lowest rating).

5. To better distinguish between safe and unsafe conditions, the Evaluation Sections use a more detailed measure of median type. Three types of medians are identified: a protected median or an unprotected with 40 or more feet of median (highest rating), other unprotected median (intermediate rating), and no median (lowest rating).

6. The points allocated to the three indices vary more by functional class. Thus, safety is allocated 25 of 100 points on interstates and 55 of 100 on collectors.

7. The points allocated to the factors that make up the safety index also vary more by functional class. Thus, 12 points are allocated to lane width on collectors but only 4 on interstates.

8. The new method eliminates differences in appraisal weights based on AADT.

After constructing a data set based on the new sections and program, we tested the new method for rating highway adequacy.

In comparing the two methods, we addressed two questions: (1) Does the new method more clearly separate the roads most in need of repair from those with flaws. This is important because a relatively small percentage of highway sections can be worked on in any given year and therefore those most clearly in need must be identified. Moreover, a method that clearly separates the worst 10-15 percent from the rest is useful for political as well as analytical reasons. (2) Does the accent on safety slight the contribution of condition and service. A balanced system is needed to ensure that a state meets all its obligations.

In answer to the first question, we observed that the scores are more distributed throughout the categories, a result in line with greater separation. In fact, despite having nearly identical means: 80.3 for the HPMS-AP and 80.4 for the new method, they have standard deviations that differ significantly. As expected the standard deviation for the new method is larger than that for the old—12.5 points to 10.5.

The wider distribution of scores facilitates the identification of the roads with the more severe problems. Thus, under the old method 1.1 percent of the sections had scores below 50. Under the new method 3.7 percent have scores below 50. Similarly, 13.5 percent had scores below 70 under the old and 19.8 have scores below 70 with the new. Since the new has more in the bottom categories, it follows that the percentage of the old in the intermediate categories from 70 to 79.9 percent will be greater under the old than the new system. Indeed, under the new only 18.7 percent are in the intermediate categories compared to 24.7 percent under the old.

Taken together, these results suggest that the new method will facilitate prioritization by more clearly separating the roads most in need from those with some flaws.

We turn now to our second question. Does the accent on safety slight the contributions of condition and service to the composite index? To begin, it appears to have little effect on the relative contribution of service to the total score of a section. Under the HPMS, the average section score for service was 20 points. Under the new method, the average section received 19.6—an almost identical score. The condition index, however, now contributes less to the final score—an average of 23.5, where previously it contributed an average of 39.2. Its contribution tends to vary by functional class.Yet it still can lead to a lower score, as the average condition score (23.5) for a section is significantly less than the highest possible score on the four types of road (40 points for interstates, 35 for other principal arterials, 30 for minor arterials, and 30 for collectors.)

Overall, the results suggest that the measures for condition and service are sufficiently large and sufficiently variable to prevent the changes in the safety index from overwhelming the contribution of condition and service to the assessment of highway adequacy.

The new method appears to be an improvement over the old; however it is still being developed and assessed by the Kentucky Transportation Cabinet. It appears to have several advantages over the HPMS-AP:

1. It increases the contribution of measures of safety
2. It uses more objective indicators for condition and safety including crash data for the latter;
3. It more clearly demarcates the sections in greatest need of improvement from the more highly rated sections;
4. It leaves ample room for condition and service to influence the prioritization of roadway projects.

I. Introduction

The Kentucky Transportation Cabinet's Division of Planning is pursuing the development of roadway adequacy ratings to assist with the identification and prioritization of long-range transportation needs. These ratings have three components—the roadway condition index, the safety index, and the service index. Each of the three is comprised of several measures. For example, the service index contains measures of volume to capacity and access control. The three component indices are combined into an overall quantitative measure of adequacy and all proposed projects can then be ranked with the combined measure.

In this report, we present the results of a study whose purpose was the creation of a new method for generating roadway adequacy ratings. This method can be used to prioritize proposed highway projects. The state can then direct its scarce resources to the projects most likely to improve the transportation system. Without an accurate method for measuring roadway adequacy, it is difficult to efficiently allocate the Commonwealth's limited resources to the most needed projects.

The specific goals of this project were twofold:

1. formulate a new method for generating roadway adequacy ratings; and
2. construct an appropriate data set and then test the method by comparing it to the results of the HPMS-AP method.

In recent years roadway adequacy ratings have been generated by a software Analytical Package (AP) that was a component of the Highway Performance Monitoring System (HPMS). The HPMS is maintained by the Federal Highway Administration, and will continue as a system to which states annually submit data to report condition and performance data on the nation's highway system.

The HPMS-AP was an additional software package that FHWA developed in the early 1980s that used the HPMS data to help analyze the condition and needs of the highway system. In the mid 1990's FHWA dropped the AP component from the HPMS program. As a result, KYTC now needs a process that can generate ratings from current HPMS data as extracted from HIS files and augmented by the HPMS calculation routines.

Working with the Kentucky Transportation Center, this advisory committee has devised a new rating method. The recommended methodology, described in this report, builds on the previous methodology—the analytical package (AP) of the Highway Performance Monitoring System (HPMS). It differs in several respects, however, from the previous methodology in that it incorporates crash data and increases the relative weight given to indicators of roadway safety—for functional classifications of highways where this was appropriate.

In the next section of this report, we offer a thorough description of the HPMS-AP, because the method we recommend is similar to it in most respects. With the structure of the HPMS-AP clarified, the advantages of the new method proposed by the committee will become apparent.

II. Review of Current Systems

The first step in the process of developing a new method for roadway adequacy ratings was to clarify how HPMS-AP ratings are derived. In addition we sought information from other states on their approaches to highway adequacy ratings. Since many states used the HPMS-AP, we obtained information on it. We also ran some library searches but obtained very little information. We supplemented that with interviews with officials from several states. First we discuss the HPMS-AP and then the findings from the literature searches and the interviews.

The Highway Section Structure of the HPMS-AP

The HPMS-AP produces a numerical index that can be used to assess the current effectiveness of a given section of roadway. The higher the score of a highway section on the index, the less in need of repair or reconstruction a given section is. Thus, sections with lower scores are more in need of repair and reconstruction than sections with higher scores.

The HPMS sections are constructed from information stored in the files of the Highway Information System (HIS). In the Highway Information System, a specific road is broken down into sections with break points that indicate the end of one section and the beginning of another. The sections can vary in length.

There are 43 inventory types, or groupings, of data attributes in the HIS. The inventory types are divided into fields that reflect pertinent characteristics of the inventory type.

The section lengths on a given roadway will differ from field to field. Section lengths in the HIS depend on the field being measured and the attributes being measured. A section ends and another begins whenever an attribute changes. For example, if the field concerns the attribute of shoulder width, the break point for a section on a given roadway is the reference point where the shoulder width changes.

Each inventory type has fields with one or more attributes that can serve as the breakpoints for storing specific pieces of information. In the HPMS-AP, if the field concerns the attributes of the median, the break point for a section occurs when one or more of the three measured attributes of a median changes. The three attributes measured for median are type of median, width of median, and type of roadway. A section will end and another begin whenever there is a change, such as a change in the type of median, the width of median, or the type of roadway.

Since there are 43 inventory types and many more fields measuring attributes of differing length, it is necessary to use a limited set of fields to establish the rating evaluation sections, which are also known as the EV sections. The HPMS will use these EV sections to store applicable data for each section.

The current EV sections used by the HPMS-AP are based on the following limited subset of criteria: pavement type, number of lanes, median (divided or undivided), functional class, type of operation (one way or two way), and whether or not the road is in a nonattainment area. Each of these critera can initiate a breakpoint for the end of a section and the start of a new one and each of the sections on a roadway has a mile marker beginning and end point. In Kentucky, there are 27,000 miles of state maintained roads. These are divided into 16,000 sections. Thus, the average section is approximately 1.7 miles in length, though the individual section sizes vary greatly from .002 miles to 28.6 miles.

With the EV sections established, the data from the appropriate mile markers on a given road in the fields of the HIS can be assigned to each EV section in the HPMS. This can be done even when the fields have sections with beginning and endpoints that differ from those in the HPMS. If the HIS data has several breakpoints along a section of roadway for which the HPMS has only one section, then an average for the HIS data can be entered. For example, if the HIS data coded two sections for median width along a stretch of highway that is one EV section in the HPMS, one HIS section with a median of 8 feet and one HIS section with a median of 12 feet, the HPMS could assign a median of 10 feet to the HPMS EV section. These averages are computed as user defined within the HPMS.

<u>Literature Review and Interviews Regarding Practices</u>

Literature Search

Laura Whayne, the head librarian at the Kentucky Transportation Center's Library, which is part of the University of Kentucky's Library System, conducted a literature search. She used these phrases for her search: Highway Performance Monitoring System, HPMS, Evaluation Section, highway rating, and highway prioritization. From these searches we obtained only a few relevant documents.

From those studies and related interviews with state planning officials several conclusions were drawn. (1) The states are fitting their rating systems to their particular needs. (2) Many states emphasize pavement conditions. (3) They are frequently prioritizing at the district and local level, rather than statewide. (4) They are merging multiple databases (*1,2,3,4,5,6*).

A study published in the Transportation Research Record illustrates some of these themes and presents the steps usually taken to prioritize roadway projects. It concerned the method used in Gainesville, Florida (*1*).

1. Criteria are identified through established standards and by the city's experienced public works staff and engineering and planning divisions (e.g., safety, surface condition, base, drainage, pavement width, level of service, and so on)
2. The roadway network system is divided into homogeneous segments.

3. A total deficiency point value is assigned to each roadway segment.
4. Cost estimates are prepared for the improvement of each roadway segment.
5. Tables are prepared for the present and future roadway network improvement program.

States are relying increasingly on multiple data files. Arizona, for example, has adopted a data system that allows any ArcView equipped agency in the state to access the HPMS database. Other databases available through the same database include bridges, motor vehicle crashes, traffic counts, national highway system roads, functionally classified roads, at-grade rail crossings, and feature inventory databases (*6*).

The state of Iowa provided another valuable source of information--the 2001 Iowa Primary Road Sufficiency Log. It contains a detailed account of their methodology, with the exception of how they determine highway segment lengths. Iowa classifies its roadway sections as rural, municipal, and suburban. Unlike other states, they use a tolerability adjustment to lower the scores of roadway sections that are below defined tolerability levels. They place a heavy emphasis on safety factors, which they measure in the rural sections with the following items: surface width, shoulder type and width, stopping sight restrictions, and accidents. They do not use accidents to assess adequacy for either municipal or suburban type sections (*4*).

Interviews

We also conducted interviews with the appropriate officials at some state highway agencies.

Florida's method for highway rating reflects the state concern for intermodal facilities, especially at ports, as well as a concern for economic development. According to Bob McCullough with the Florida Department of Transportation (DOT), Florida uses a Decision Support System to prioritize highway projects. It combines quantitative indicators of five factors: safety, level of service, pavement condition, intermodal connectivity, and economic development.

In contrast, the Arizona DOT has a more narrowly focused approach with an emphasis on pavement condition. We talked to Mary Lynn Tischer, director of Transportation Planning. Currently, they take a Pavement Serviceability Rating (PSR), which is taken by a mechanical device that measures roughness and smoothness by calibrating deviations in the roadway surface. But they also look at level of service (LOS), which is derived from the range of values of the volume/capacity ratio (v/c).

Arizona also relies on multiple data bases, which are used to develop various performance measures. These are collected throughout the year and are stored in individual databases. These databases are integrated in the Highway Performance Monitoring System (HPMS) database. The HPMS database is then incorporated into the Arizona DOT Geographical Information System (GIS).

New Mexico's approach was the least standardized. Thomas Koglin of New Mexico DOT said that New Mexico did not use sufficiency ratings statewide. The district engineers prioritize the projects, because they know which roads need work. He said decisions are mostly based on pavement conditions, not capacity or other factors when selecting projects. He also said that sufficiency ratings tend to be used with prioritizing bridge repairs.

III. Some Advisory Committee Decisions

Before attending to the details of the new highway adequacy rating method, the committee addressed some basic issues. One of the first decisions concerned the roads to be rated with the new system. At the October 29, 2001 meeting, the advisory committee concluded that functional classification will be used for rating roadways rather that the State Primary Roadway System. The specific classifications to be rated are rural and urban interstates, other principal arterials, minor arterials, most urban collectors, and rural major collectors. The decision was made to classify roadway section by functional classification, with ratings NOT being obtained for: non state maintained urban collectors, rural minor collectors and rural and urban local roads.

It was also decided that the new system would use crash data in the categories of the safety component index. As in the HPMS, the three component indexes comprising the composite index will be roadway condition, safety, and service. However, the categories or factors that make up the component indices would be altered. The categories would be as follows:

- Condition Index
  - Pavement Condition
- Safety Index
  - Lane Width
  - Shoulder Width
  - Median Type
  - Alignment Adequacy (rural only)
  - Critical Rate Factor
- Service Index
  - Volume to Capacity Ratio
  - Access Control

It was also decided at the October 29 and the November 30 meetings that the above set of categories in the new highway rating system would require a new process for determining section breaks. After lengthy discussion among the group as to what data was best used to determine section breaks, the following fields were selected.

- Attainment / Nonattainment
- Functional Classification
- Number of through lanes
- Median Characteristics (see comments below)
- County Line

The county line field was added so that section breaks occur at a county line. Finally, the median definition factor was changed and will be discussed in the next paragraph.

The evaluation section break characteristics that stimulated that most discussion were those for the median. Originally, the section breaks were to be determined by whether the median was divided or undivided. However, upon further discussion, the committee concluded that some types of medians provided greater protection to the driving public. After long and careful consideration, the committee settled on the following characteristics from safest type to least safe for medians:

- Protected or unprotected median with 40' or greater width
- Other unprotected (less than 40' width)
- None

Discussion on whether to make major intersections a part of the evaluation section breaks proved to be unproductive, as no reasonable methodology for differentiating major from minor intersections could be determined. Therefore, major intersections will not serve as an evaluation section break.

The committee concluded that the above was a workable method for creating section breaks that will include crash data. Whenever there is a change in one or more of the characteristics a new section begins. Table III-1 contrasts the current with the proposed fields for constructing the evaluation sections.

Table III-1. A Comparison of the HPMS-AP and Proposed Fields for Creating Evaluation sections

HPMS-AP

1. Pavement type
2. Number of lanes
3. Median (divided or undivided)
4. Functional class
5. Type of operation (one-way or two-way)
6. Nonattainment/ attainment area

Proposed

1. Number of lanes
2. Functional class
3. Median characteristics
    a. protected or unprotected median with 40' or greater width
    b. other unprotected
    c. none
4. Nonattainment/attainment
5. County line

Computing the Critical Rate Factor

The Kentucky Transportation Center has developed a systematic procedure to identify highway locations and sections with abnormally high rates or numbers of traffic crashes. It has two components: (1) the average number of crashes for a type of road; (2) a critical crash rate above which it can be said that a type of road has significantly more crashes than the average for the type of road. The number of crashes on each evaluation section is divided by the critical crash number. If the number is greater than one, then there is a statistically significant likelihood that the section has a safety problem.

Average and critical rates have been calculated for state-maintained roads having known traffic volumes, route numbers, and mileposts. Rates are provided in terms of crashes per 100 million vehicle-miles (C/100 MVM). A computer program using both crash data from the crash data base and roadway characteristics information from the HPMS file was used to calculate rates for the state-maintained system.

The following formula was used to calculate critical crash rates:

$$Cc = Ca + K(sqrt(Ca/M)) + 1/(2/M)$$

Where:

Cc = critical crash rate for type of road,
Ca = average crash rate for type of road
Sqrt = square root
K = constant related to level of statistical significance selected (a probability of 0.995 was used wherein K = 2.576), and
M = exposure (for sections, M was in terms of 100 vehicle-miles (100 MVM); for spots, M was in terms of million vehicles).

To determine the critical number of crashes, the following formula was used:

$$Nc = Na + K(sqrt(Na)) + 0.5$$

Where:

Nc = critical number of crashes and
Na = average number of crashes

A critical crash rate is computed for each section. The existence of a safety problem can be ascertained by dividing the actual number of crashes for the section by the critical number of crashes. As noted, a ratio greater than 1 suggests a statistically significant safety problem.

IV. The Categories in the Three Component Indices

The composite index is the sum of the three component indices. The three components are highway condition, highway safety, and level of service (volume/capacity ratio and access). Each component index has one or more indicators of its current effectiveness.

Before a road section can be given a score it is necessary to give each category in each of the three component indices a score. The three component indices are then added together to generate the composite index, which is the section's total score. A road in perfect condition is scored 100, with actual scores ranging from 0 to 100.

Table IV-1. HPMS and Proposed Categories for the Condition, Safety and Service Indices

HPMS	Proposed
Condition Index	Condition Index
Pavement Condition	Pavement Condition
Pavement Type	
Drainage adequacy	
Safety Index	Safety Index
Lane Width	Lane Width
Shoulder Width	Shoulder Width
Median Width	Median Type
Alignment adequacy (rural)	Horizontal Alignment adequacy (rural)
	Critical Rate Factor
Service Index	Service Index
Volume/Capacity ratio	Volume/Capacity Ratio
Access Control	Access Control

While a perfect score for any type of road--rural or urban, interstate, arterial, or collector--is always a 100, the various categories (e.g. critical rate factor) can carry different weights depending on the functional class and rural or urban location. Table 3 presents the proposed rural road component and category weight factors for the four functional classifications. The points (weights) allocated to the categories in the three indices vary across the functional classifications. For example, safety categories are allocated 25 of the 100 points on interstates and 55 of the 100 on collectors. Points allocated to the categories that make up the safety index can also vary. Thus 12 points are allocated to lane width on collectors but only 4 on interstates.

The advisory committee concluded that safety was a higher weighted performance measure on collectors and minor arterials. Conversely, pavement condition and service were higher weighted performance measures on principal arterials and interstates. The committee also decided that critical rate (which incorporates the ratio of the number of crashes that occurred to the statistically adjusted expected number of crashes on a specific section of highway) was the most important element in the assessment of safety. The HPMS-AP used assessment of the sections' geometrics only and ignored crash data when constructing its safety index. In the proposed safety index, in contrast, approximately half the points for safety in each functional classification are allocated to critical rate.

Table IV-2: Proposed Rural Component Indices and Category Weight Factors

	Interstate	Other Principal Arterial	Minor Arterial	Major Collector
Pavement Condition Index	**40**	**35**	**30**	**30**
Condition	40	35	30	30
Safety Index	**25**	**35**	**45**	**55**
Lane Width	4	6	10	12
Shoulder Width	2	3	4	5
Median type	2	0	0	0
Alignment	4	9	10	10
Critical rate	13	17	21	28
Service Index	**35**	**30**	**25**	**15**
V/C Ratio	35	25	20	15
Access control	0	5	5	0
Total	**100**	**100**	**100**	**100**

Table IV-3 presents the proposed urban road component index and category weight factors for the four functional classifications. The committee decided to omit horizontal alignment from the urban safety index. Table IV-3 also differs somewhat from the rural table in some other regards, but overall reflects similar weights. Safety in urban areas is allocated more points than it was in the HPMS-AP. Moreover, safety is deemed more likely to be a problem for collectors and minor arterials than for minor interstates and other principal arterials.

Table IV-3: Proposed <u>Urban</u> Component Indices and Category Weight Factors

	Interstate	Other Principal Arterial	Minor arterial	Collector
Pavement Condition Index	30	30	30	30
Condition	30	30	30	30
Safety Index	30	35	45	55
Lane Width	8	12	16	12
Shoulder Width	4	0	0	0
Median type	2	5	6	5
Critical rate	16	18	23	30
Service Index	40	35	25	15
V/C Ratio	40	25	20	15
Access control	0	5	5	0
Total	100	100	100	100

V. Computing an EV Section's Total Score

Each section of highway to be rated will have a total score, which is the sum of the scores for each category. That is, the sum of the score for pavement condition, lane width, shoulder width, median type, horizontal alignment (rural only), critical rate, volume capacity ratio, and access control. The numbers in tables IV-2 and IV-3 are the *highest* scores attainable for each category. Many sections of course will have categories with some shortcomings and will receive therefore lower than perfect scores in those categories.

The rating process begins with a measurement for each category. These are measured in various ways, although some are quite straightforward. Lane width for example is measured in feet. Pavement condition on the other hand is measured with the International Roughness Index (IRI). The measure for critical rate is a ratio of the number of accidents divided by the statistically adjusted expected number of accidents.

Once the first measures for each EV section on each category are taken and given a HIS classification, they are converted into an appraisal rate (See V-1 and V-2.). Each category then has a decimal score ranging from 0.0 to 1.0. This score is then multiplied by the number of points in the Category Weight. This means that a road in perfect condition will receive all the points in the category, while a road in the worst condition will get none. A road of intermediate quality will receive some points but not all.

Some Changes in the Appraisal Rates.

The advisory committee decided to alter some of the appraisal rates to reflect recent research on crashes. The factors in question are: shoulder width, lane width, access control, and median width and type. In the HPMS, there was a general rule that wider was better. Therefore wider lanes and wider shoulders would receive higher appraisal rates and more points for the factor. Empirical research does not support this general rule in all situations. The committee adopted several changes in appraisal rates to reflect the new knowledge.

Shoulder Width

The evidence on the effect of shoulder width on number and severity of crashes is somewhat confusing and contradictory. The reason for this is that the wide shoulders can have opposing effects. On the one hand they give the driver more room in which to recover after straying from the driving lane. But at the same time they also encourage faster driving and voluntary shoulder stops, both of which are associated with accidents. Further complicating analysis of the impact of shoulder widening is the tendency of roadway improvement projects to make a variety of related improvements when widening shoulders. Thus changes in crash rate and severity may be attributable to wider lanes, wider shoulders, improvements in geometrics, removal of hazards and the like.

Hauer conducted a comprehensive analysis of all the empirical research studies (up to the year 2000) of the relationship between accidents and shoulder width. He reached the following related conclusions. (1) Several studies suggest that shoulder width is more beneficial to safety at higher traffic volumes. (2) There is an indication that roads with wider shoulders tend to have more severe accidents. (3) There is an indication that wider shoulders are associated with fewer run-off-the-road and opposite direction accidents, which are 40-60 percent of all accidents. Wider shoulders may be associated with more of the "other" accidents. (4) For injury accidents there is a certain shoulder width (perhaps between 6-8 feet) beyond which the number of injury accidents increases (*7*).

In regard to Kentucky roads Zegeer et al (1981) found that after 8 feet there was no decrease in accidents. Widening shoulders from five to eight feet appeared to produce the greatest decrease in accidents (*8*).

The committee concluded that, taken together, Hauer's findings suggest that road shoulders become increasingly safer up to 6 to 8 feet. But shoulders in the 6-8 foot range should not be considered less adequate than wider shoulders, especially on roads with lower volumes and speeds (*7*).

Lane Width

The evidence for the effect of lane width on safety is less contradictory. Hauer summarizes it succinctly. "While accident rates seem to diminish as lane width increases up to 11 feet, a further increase to 12 feet gives an indication of a slight increase in accident rates." The reason for this may be increased speed of travel. The implication is to consider 11 and 12-foot lanes as equally acceptable on all roads but interstates (*7*).

Access Control

Access control is regulated limitation of public access to and from properties abutting the highway. Proper access management can provide much safer and more efficient traffic flow along arterials, collectors, and local streets. Numerous studies have consistently shown that the more access points per mile, the higher the accident rate. Access management techniques reduce the number of conflict points. In doing so, they improve traffic flow (*9*).

Access management can be either full control of access or partial control. In a 1993 study, Stover and associates offer an estimate of the impact of one common partial control strategy. "Increasing the signalized intersection spacing to uniform intervals of one-half mile and the use of a non-transversable median to restrict left-turns will increase the capacity of a four-lane urban arterial by about 50% as compared to quarter-mile signal spacing and unrestricted left-turns. This is the same increase in capacity that can be obtained by widening a four-lane divided arterial to six lanes" (*10*).

Median Type and Width

Research on median type and width clearly indicates that wider medians decrease the number of accidents. It also shows that barriers decrease the number of fatal accidents, and to a lesser extent the number of injury accidents. A study of Jersey-type median barriers by the Institute of Transportation Studies of the University of California, Irvine found that the frequency of nonfatal and noninjury accidents was basically unchanged after barrier installation. But the frequency of fatal accidents decreased by 36 percent and the number of fatalities by 43 percent (*11*).

In 1997, CALTRANS decided to install barriers on high-volume freeways with medians up to 75 feet. The change is expected to cut the number of fatal cross median accidents in half (*12*).

The advisory committee confronted another issue in regard to appraisal rates. The HPMS assigned appraisal rates by the ADDT of the functional classifications. For minor arterials, there was a distinction between roads with greater than 2000 AADT and those with less than 2000 AADT. For interstates the dividing line was 6000 AADT. Collectors had three divisions—greater than 1000, 400-1000, and less than 400 AADT.

Sometimes the distinctions produce different appraisal rates. For example, on rural collectors the rates assigned to the categories varied between the three AADT categories. So a road with a shoulder width of 2-3 feet with an AADT greater than 1000 receives an appraisal weight of .4, while a collector with an AADT of less than 400 and a 2-3 foot shoulder gets a weight of .7.

We contacted FHWA to discuss the HPMS volume breaks in the functional classes. According to Beverly Harrison of the FHWA the AADT volume breaks were set in the mid 1980s and were based on traffic volumes at that time. She said that the FHWA has not updated the volume breaks, but she thought they should be revised based upon the general increase in traffic nationwide and the particular conditions in the states. In her opinion, the traffic volume break points need to be changed by the officials in the states. FHWA does not intend to update the AADT volume breaks, now that no longer supports the Analytical Process.

<u>AADT Volume Breaks</u>

After discussing the best way to update the AADT volume breaks, the advisory committee decided to eliminate the AADT volume breaks in each of the functional classes. The volume breaks contributed little to differences in adequacy ratings, as there were relatively few differences within each functional class. Moreover, the volume to capacity ratio takes current volume into account. For these reasons, the committee decided that the new appraisal rates would apply to all roads within the functional classes, regardless of volume as measured by AADT.

Table V-1. Proposed Rural Appraisal Rates and HIS Classifications for Each Category

Factors and HIS classifications		Functional System Interstate	Other Principal Arterials	Minor Arterials	Collectors
Pavement Condition (IRI)					
0.00	0.25	1.00	1.00	1.00	1.00
25.01	50.00	0.95	0.95	0.95	0.95
50.01	80.00	0.85	0.85	0.85	0.90
80.01	115.00	0.75	0.75	0.80	0.85
115.01	145.00	0.70	0.70	0.75	0.80
145.01	165.00	0.50	0.50	0.75	0.75
165.01	180.00	0.40	0.40	0.50	0.70
180.01	200.00	0.20	0.20	0.30	0.50
200.01	210.00	0.10	0.10	0.10	0.30
210.01	244.00	0.00	0.00	0.00	0.10
Greater than 244.00		0.00	0.00	0.00	0.00
Lane Width					
12'. or greater		1.00	1.00	1.00	1.00
11.0	11.9	0.80	1.00	1.00	1.00
10.0	10.0	0.50	0.60	0.80	0.80
9.0	9.9	0.00	0.00	0.20	0.40
8.99 or less		0.00	0.00	0.00	0.00
Shoulder Width					
12.0' or greater		1.00	1.00	1.00	1.00
10.0	11.9	1.00	1.00	1.00	1.00
8.0	9.9	1.00	1.00	1.00	1.00
6.0	7.9	0.70	1.00	1.00	1.00
4.0	5.9	0.30	0.80	0.80	0.80
2.0	3.9	0.10	0.40	0.70	0.60
0.0	1.9	0.00	0.00	0.00	0.00
Horizontal Alignment Adequacy					
1		1.00	1.00	1.00	1.00
2		0.70	0.70	0.70	0.90
3		0.00	0.40	0.40	0.50
4		0.00	0.00	0.00	0.00
Volume to Capacity Ratio					
Less than 0.20		1.00	1.00	1.00	1.00
0.20	0.39	0.95	0.95	0.95	0.95
0.40	0.49	0.90	0.90	0.90	0.95
0.50	0.59	0.85	0.85	0.85	0.90
0.60	0.64	0.80	0.80	0.80	0.85
0.65	0.69	0.75	0.75	0.75	0.80
0.70	0.74	0.70	0.70	0.70	0.75
0.75	0.79	0.60	0.60	0.60	0.70
0.80	0.84	0.50	0.50	0.50	0.60
0.85	0.89	0.40	0.40	0.40	0.50
0.90	0.94	0.20	0.20	0.20	0.30
0.95	0.99	0.10	0.10	0.00	0.00
1.00 or greater		0.00	0.00	0.00	0.00
Access Control					
Full			1.00	1.00	
Partial			0.60	0.60	
None			0.00	0.00	
Critical Rate Factor					
0.00	0.90	1.00	1.00	1.00	1.00
0.91	1.10	0.80	0.80	0.80	0.80
1.11	1.65	0.40	0.40	0.40	0.40
Greater than 1.65		0.00	0.00	0.00	0.00
Median Type					
Protected		1.00			
Unprotected <40' width		0.70			
None		0.00			

Table V-2. Proposed Urban Appraisal Rates and HIS Classification for Each Factor

Factors and Classifications		HIS Interstate	Other Principal Arterials	Minor Arterials	Collectors
		Functional System			
Pavement Condition (IRI)					
0.00	0.25	1.00	1.00	1.00	1.00
25.01	50.00	0.90	0.95	0.95	0.95
50.01	80.00	0.80	0.85	0.90	0.90
80.01	115.00	0.70	0.75	0.85	0.85
115.01	145.00	0.60	0.70	0.80	0.80
145.01	165.00	0.50	0.60	0.70	0.75
165.01	180.00	0.40	0.40	0.60	0.70
180.01	200.00	0.20	0.20	0.50	0.50
200.01	210.00	0.10	0.10	0.30	0.30
210.01	244.00	0.00	0.00	0.10	0.10
Greater than 244.00		0.00	0.00	0.00	0.00
Lane Width					
12'. Or greater		1.00	1.00	1.00	1.00
11.0	11.9	0.90	0.90	1.00	1.00
10.0	10.0	0.50	0.70	0.80	0.85
9.0	9.9	0.25	0.40	0.70	0.70
8.99 or less		0.00	0.00	0.00	0.00
Shoulder Width					
12.0' or greater		1.00			
10.0	11.9	1.00			
8.0	9.9	1.00			
6.0	7.9	1.00			
4.0	5.9	0.50			
2.0	3.9	0.30			
0.0	1.9	0.00			
Volume to Capacity Ratio					
Less than 0.20		1.00	1.00	1.00	1.00
0.20	0.39	1.00	1.00	1.00	1.00
0.40	0.49	1.00	1.00	1.00	1.00
0.50	0.59	0.95	0.95	1.00	1.00
0.60	0.64	0.90	0.90	1.00	1.00
0.65	0.69	0.85	0.85	0.95	1.00
0.70	0.74	0.80	0.80	0.90	1.00
0.75	0.79	0.70	0.70	0.85	0.95
0.80	0.84	0.60	0.60	0.80	0.90
0.85	0.89	0.50	0.50	0.70	0.85
0.90	0.94	0.40	0.40	0.60	0.80
0.95	1.00	0.30	0.30	0.50	0.70
1.01	1.10	0.20	0.20	0.40	0.60
1.11	1.20	0.10	0.10	0.30	0.50
1.21	1.30	0.00	0.00	0.20	0.40
1.31	1.40	0.00	0.00	0.15	0.30
1.41	1.50	0.00	0.00	0.10	0.20
1.51	2.00	0.00	0.00	0.05	0.10
Greater than 2.00		0.00	0.00	0.00	0.05
Access Control					
Full			1.00	1.00	
Partial			0.60	0.60	
None			0.00	0.00	
Critical Rate Factor					
0.00	0.90	1.00	1.00	1.00	1.00
0.91	1.10	0.80	0.80	0.80	0.80
1.11	1.65	0.40	0.40	0.40	0.40
Greater than 1.65		0.00	0.00	0.00	0.00
Median Type					
Protected		1.00	1.00	1.00	1.00
Unprotected <40' width		0.00	0.60	0.60	0.60
None		0.00	0.00	0.00	1.00

An Example

Table V-3 presents a detailed breakdown of the scoring for a section of rural minor arterial. To obtain the numerical score for pavement condition on a rural arterial, one first obtains the section's IRI, which is reported in the HIS classification as a number (e.g. 65). Table V-3 then converts the IRI into the corresponding appraisal rate (an IRI of 65 has an appraisal rate of .85).

The appraisal rate is then multiplied by the category weight factor, which V-3 shows is 30 for a rural minor arterial. Thus, for this particular segment, the score for pavement condition would be 25.50 (30 x .85). A similar process is repeated for each category. The scores are then summed into the composite score.

Table V-3. Example of Proposed Scoring of a Section of a Rural Minor Arterial

1. Condition Index	Total = 30	HIS Classification	Appraisal Rate Factor	Score
• Pavement Condition	(30)	IRI of 65	.85	25.50
2. Safety Index	**Total = 45**			
• Lane width	(10)	10 feet	.80	8.00
• Shoulder width	(04)	10-11 feet	1.00	4.00
• Median width	(00)			
• Horizontal Alignment Adequacy (rural only)	(10)	horizontal = 2	.70	4.00
• Critical Rate Factor	(21)	.95	.80	16.80
3. Service Index	**Total = 25**			
• V/C Ratio	(20)	V/C ratio = .20-.39	.95	19.00
• Access Control	(05)	Partial	.60	3.00
			Composite Index	**77.00**

VI. Data Management and Software Issues

Advisory committee discussion concerning the logistical requirements for the software development of the new Highway Rating System revolved around the parties who would be responsible for the HPMS extract. Specifically, it was determined that Planning would provide Information Technology with the HPMS extract in a flat file format. This offer by Planning significantly reduces the amount of effort that will be required for software mapping by Information Technology.

With Planning producing the HPMS extract, it will be possible to inspect the extract for adequate quality as it is formulated, with data problems being addressed by the division that uses the data exclusively.

Planning noted that when the software for the Highway Rating System is developed, they would like to have it in a format that permits "what if" scenarios. It will be possible to do this with a query/forecasting and reporting platform. This will give planners great flexibility. They will be able to deliver results of ad hoc analyses in a user-friendly format. For example, should it be determined in the future that on a rural interstate the pavement condition should comprise more than 40% of the rating. The software will allow planning to easily change the weight without entering into the logistics of the software code.

Information technology working in concert with Planning and the Kentucky Transportation Center would then accomplish the following tasks:

1. Accommodate the receipt and retrieval of data from the Division of Planning after the latter complete the determination of the EV segments.
2. Conduct trial runs of highway adequacy ratings.
3. Populate the results into the HIS system.
4. Provide a query/forecasting and reporting system.

See appendix 1 for an example of the output for the roads in a county.

VII. Comparing the HPMS-AP to the New Prioritization Method

The function of a prioritization method is to distinguish the roads in need of repair from those that are less than perfect, but also less in need of repair. The new method is designed to do this, while at the same time incorporating crash data into the safety index to better identify unsafe roads. There are other differences as well, which are listed in table VII-1. The measure of median type is more detailed and reflects the known safety advantages of protected medians. In addition safety is allocated more of the 100 points on collectors.

Table VII-1. Major Differences between the HPMS-AP and New Adequacy Rating Systems

1. The new Safety Index uses Crash Data to establish a Critical Rate Factor for Each Evaluation Section. It retains measures of the other factors of safety.

2. The new Safety Index is allocated more of the 100 possible points, while Condition and Service Indices are allocated proportionately fewer

3. The Condition Index now has only one factor—pavement condition. Previously the HPMS condition index included pavement type and a subjective assessment of drainage adequacy in addition to pavement condition

4. In the HPMS-AP, the evaluation sections were based on number of lanes, functional class, nonattainment/attainment area, pavement type, type of operation (one or two way), and median (divided or undivided). In the new, evaluation sections are based the first three, county line, and a new three category classification of median—a protected median or an unprotected with 40 or more feet of median (highest rating), other unprotected median (intermediate rating), and no median (lowest rating).

5. To better distinguish between safe and unsafe conditions, the Evaluation Sections use a more detailed measure of median type.

6. The points allocated to the three indices vary more by functional class. Thus, safety is allocated 25 of 100 points on interstates and 55 of 100 on collectors.

7. The points allocated to the factors that make up the safety index also vary more by functional class. Thus, 12 points are allocated to lane width on collectors but only 4 on interstates.

8. The new method eliminates differences in appraisal weights based on AADT.

In comparing the two methods, we address two questions: (1) Does the new method more clearly separate the roads most in need of repair from those with flaws. This is important because less than 15 percent of highway sections can be worked on in any given year and therefore those most clearly in need must be identified. A method that clearly separates the worst 5-10 percent from the rest is useful for political as well as analytical reasons. (2) Does the accent on safety slight the contribution of condition and service. A balanced system is needed to ensure that a state meets all its obligations. We turn to the first question.

Table VII-2 compares the HPMS-AP composite scores from 1997 (the last year the HPMS-AP was run in Kentucky) to the composite scores from the new method in 2002. Due to highway construction and reconstruction the total number of sections rose from 8472 in 1997 to 9341 in 2002.

The scores are more distributed throughout the categories, a result in line with greater separation. In fact, despite having nearly identical means: 80.3 for the HPMS-AP and 80.4 for the new method, they have standard deviations that differ significantly. As expected the standard deviation for the new method is larger than that for the old—12.5 points to 10.5.

The wider distribution of scores facilitates the identification of the roads with the more severe problems. Thus, under the old method 1.1 percent of the sections had scores below 50. Under the new method 3.7 percent have scores below 50. Similarly, 13.5 percent had scores below 70 under the old and 19.8 have scores below 70 with the new. Since the new has more in the bottom categories, it follows that the percentage of the old in the intermediate categories from 70 to 79.9 percent will be greater under the old than the new system. Indeed, with the new adequacy rating method only 18.7 percent are in the intermediate categories compared to 24.7 percent under the old.

Taken together, these results suggest that the new method will facilitate prioritization by more clearly separating the roads most in need from those with some flaws.

Table VII-2. A Comparison of the Distribution of Composite Scores of the Old and New Prioritization Methods

	Old		New	
Composite Index Score	Number	Percent	Number	Percent
10 to 19.9	0	0.0	5	.05
20 to 24.9	0	0.0	5	.05
25 to 29.9	1	.01	9	.10
30 to 34.9	1	.01	24	.26
35 to 39.9	6	.07	42	.45
40 to 44.9	16	.19	99	1.06
45 to 49.9	68	.80	161	1.72
50 to 54.9	147	1.74	189	2.02
55 to 59.9	268	3.16	358	3.83
60 to 64.9	272	3.21	507	5.43
65 to 69.9	365	4.31	447	4.79
70 to 74.9	686	8.10	598	6.40
75 to 79.9	1405	16.58	1149	12.30
80 to 84.9	2154	25.43	1920	20.55
85 to 89.9	1878	22.17	2272	24.32
90 to 94.9	1061	12.52	1432	15.33
95 to 97.95	144	1.70	124	4.39
Total	8472	100%	9341	100%
Mean	80.3		80.4	
S.D.	10.5		12.5	

We turn now to our second issue. Does the accent on safety slight the contributions of condition and service to the composite index? Clearly, it has little effect on the contribution of service to the overall score for a section of roadway. In 1997, the average section was assigned 20 points for service. In 2002, it received 19.58. The condition index, however, now contributes less—23.5 versus 39.2 on the HPMS. Yet it still appears to make a substantial contribution to a section's overall rating, as 23.5 is substantially less than the number of points possible for condition on the four types of highways. In other words, a road in poor condition, is still likely to receive a low score overall.

Taken together, it appears that the changes in the condition and service indices are sufficient to prevent the changes in the safety index from distorting the contribution of condition and service to the assessment of highway adequacy. Crash data is used but other factors still contribute substantially to the prioritization score.

VIII. Conclusion

The new method appears to be an improvement over the old; however it is still being developed and assessed by the Kentucky Transportation Cabinet. To enhance flexibility, it is being programmed to allow room for changes, such as different weights for the factors in the indices and different appraisal rates.

The new method for determining EV sections will make it possible to use the crash data effectively. In addition, it will be possible to share the data with Area Development Districts and the cities and counties.

While not a finished product, it will be used to prioritize projects in the future. It appears to have several advantages over the HPMS-AP:

1. It increases the contribution of measures of safety;
2. It uses more objective indicators including crash data to assess highway safety;
3. It more clearly demarcates the sections in greatest need of improvement from the more highly rated sections;
4. It leaves ample room for condition and service to influence the prioritization of roadway projects.

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Appendix 1

The attached table is an example of the output for the state maintained highways in County 1. For each road segment it presents the beginning mile point, the ending mile point, and the functional class. It then gives the factor category score on each factor, the total points available for the highest possible score, and the actual points allocated for each of the eight factors: IRI, land width, access median, shoulder, alignment, critical rate factor, and volume to capacity ratio. The sum of the seven actual scores is the final rating score.

County	Route	BMP	EMP	Desc Begin	Functional	IRI			Lane Width			Access			Median			Shoulder			Alignment		
						IRI	Availabe	Actual	Lane W	Availabe	Actual	Access C	Availabe	Actual	Median	Availabe	Actual	Should W	Availabe	Actual	H Align	Availabe	Actual
4	KY0358	7.984	8.177	US 60	7	108	30	25.50	13	12	12.00	3	0	0.00	3	0	0.00	10	5	5.00	1	10	10.00
4	KY0358	8.177	8.339	SECOND STREET	7	108	30	25.50	11	12	12.00	3	0	0.00	3	0	0.00	10	5	5.00	1	10	10.00
4	KY0358	8.339	8.528	FOURTH STREET	7	108	30	25.50	11	12	12.00	3	0	0.00	3	0	0.00	10	5	5.00	1	10	10.00
4	US0062	0	0.139	CARLISLE COUNTY LINE	7	111	30	25.50	11	12	12.00	3	0	0.00	3	0	0.00	10	5	5.00	1	10	10.00
4	US0062	0.139	0.614	.139 MI N OF CARLISLE C	7	111	30	25.50	11	12	12.00	3	0	0.00	3	0	0.00	10	5	5.00	1	10	10.00
4	KY0358	8.528	8.884	SIXTH STREET	7	108	30	25.50	10	12	9.60	3	0	0.00	3	0	0.00	3	5	3.00	1	10	10.00
4	KY0358	8.884	13.48	NCL OF LACENTER	7	108	30	25.50	10	12	9.60	3	0	0.00	3	0	0.00	3	5	3.00	1	10	10.00
4	US0062	1.662	1.689	1.662 MI N OF CARLISLE	7	133	30	24.00	10	12	9.60	3	0	0.00	3	0	0.00	3	5	3.00	1	10	10.00
4	KY0286	0	14.42	KY 121	7	91	30	25.50	10	12	9.60	3	0	0.00	3	0	0.00	3	5	3.00	2	10	9.00
4	KY0121	8.133	8.269	SCL OF WICKLIFFE	6	98	30	24.00	11	10	10.00	3	5	0.00	3	0	0.00	4	4	3.20	1	10	10.00
4	KY0121	0	0.151	CARLISLE COUNTY LINE	6	142	30	22.50	11	10	10.00	3	5	0.00	3	0	0.00	4	4	3.20	1	10	10.00
4	KY0121	0.151	8.133	N END OF MAYFIELD CR	6	142	30	22.50	11	10	10.00	3	5	0.00	3	0	0.00	4	4	3.20	1	10	10.00
4	KY0358	13.482	13.53	KY 473 EAST	7	112	30	25.50	9	12	4.80	3	0	0.00	3	0	0.00	2	5	3.00	1	10	10.00
4	KY0473	7.565	8.6	US 60 EAST	7	114	30	25.50	9	12	4.80	3	0	0.00	3	0	0.00	3	5	3.00	1	10	10.00
4	KY0473	14.515	14.56	KY 358	7	114	30	25.50	9	12	4.80	3	0	0.00	3	0	0.00	3	5	3.00	1	10	10.00
4	KY1105	11.448	11.68	WCL OF BANDANA	7	96	30	25.50	9	12	4.80	3	0	0.00	3	0	0.00	3	5	3.00	1	10	10.00
4	US0051	4.892	7.306	N END OF WILLOW SLOU	2	109	35	26.25	11	6	6.00	3	5	0.00	3	0	0.00	6	3	3.00	1	9	9.00
4	US0060	7.143	10.62	ECL OF BARLOW	2	106	35	26.25	11	6	6.00	3	5	0.00	3	0	0.00	4	3	2.40	1	9	9.00
4	KY0121	8.269	8.549	KY 286	6	98	30	24.00	18	10	10.00	3	5	0.00	3	0	0.00	0	4	0.00	1	10	10.00
4	KY1105	0	11.45	NCL OF BARLOW	7	120	30	24.00	9	12	4.80	3	0	0.00	3	0	0.00	3	5	3.00	2	10	9.00
4	US0051	4.13	4.262	NCL OF WICKLIFFE	2	126	35	24.50	11	6	6.00	3	5	0.00	3	0	0.00	4	3	2.40	1	9	9.00
4	US0060	15.442	16.94	.394 MILE EAST OF KY 47	2	131	35	24.50	11	6	6.00	3	5	0.00	3	0	0.00	4	3	2.40	1	9	9.00
4	KY0121	8.549	8.609	.600 MILE SOUTH OF US :	6	98	30	24.00	15	10	10.00	3	5	0.00	3	0	0.00	0	4	0.00	1	10	10.00
4	US0060	0.22	0.32	FOURTH STREET	2	104	35	26.25	11	6	6.00	3	5	0.00	3	0	0.00	4	3	2.40	2	9	6.30
4	US0060	0.32	0.518	SIXTH STREET	2	104	35	26.25	11	6	6.00	3	5	0.00	3	0	0.00	4	3	2.40	2	9	6.30
4	US0060	6.289	6.575	BROADWAY	2	106	35	26.25	11	6	6.00	3	5	0.00	3	0	0.00	4	3	2.40	1	9	9.00
4	KY0473	8.6	14.52	MCCRACKEN COUNTY L	7	114	30	25.50	9	12	4.80	3	0	0.00	3	0	0.00	3	5	3.00	3	10	5.00
4	US0051	2.117	2.486	2.117 MI N OF CARLISLE	2	107	35	26.25	12	6	6.00	3	5	0.00	3	0	0.00	8	3	3.00	3	9	3.60
4	US0060	0.518	6.289	COUNTY FARM ROAD	2	106	35	26.25	11	6	6.00	3	5	0.00	3	0	0.00	4	3	2.40	2	9	6.30
4	US0060	11.202	15.44	ECL OF LACENTER	2	131	35	24.50	11	6	6.00	3	5	0.00	3	0	0.00	4	3	2.40	2	9	6.30
4	US0062	0.614	1.662	.614 MI N OF CARLISLE C	7	133	30	24.00	10	12	9.60	3	0	0.00	3	0	0.00	4	5	4.00	4	10	0.00
4	US0051	4.262	4.892	S END OF WILLOW SLOU	2	104	35	26.25	10	6	3.60	3	5	0.00	3	0	0.00	0	3	0.00	1	9	9.00
4	US0051	3.832	4.13	SHORT STREET	2	126	35	24.50	12	6	6.00	3	5	0.00	3	0	0.00	10	3	3.00	2	9	6.30
4	US0051	7.306	8.297	SOUTH END OF OHIO RI\	2	104	35	26.25	11	6	6.00	3	5	0.00	3	0	0.00	0	3	0.00	2	9	6.30
4	US0051	1.937	2.117	1.937 MI N OF CARLISLE	2	107	35	26.25	12	6	6.00	3	5	0.00	2	0	0.00	8	3	3.00	4	9	0.00
4	KY0473	14.555	14.81	KY 358 NORTH	7	114	30	25.50	9	12	4.80	3	0	0.00	3	0	0.00	3	5	3.00	4	10	0.00
4	US0051	2.916	3.327	2.916 MI N OF CARLISLE	2	155	35	17.50	13	6	6.00	3	5	0.00	3	0	0.00	10	3	3.00	2	9	6.30
4	US0060	0	0.22	GREEN STREET	2	104	35	26.25	11	6	6.00	3	5	0.00	3	0	0.00	5	3	2.40	1	9	9.00
4	US0060	10.622	11.2	KY 358	2	98	35	26.25	11	6	6.00	3	5	0.00	3	0	0.00	4	3	2.40	1	9	9.00
4	US0051	3.327	3.39	BROADWAY	2	155	35	17.50	13	6	6.00	3	5	0.00	3	0	0.00	0	3	0.00	1	9	9.00
4	US0051	2.486	2.916	2.486 MI N OF CARLISLE	2	155	35	17.50	12	6	6.00	2	5	2.50	3	0	0.00	4	3	2.40	4	9	0.00

						IRI			Lane Width			Access			Median			Shoulder			Alignment		
County	Route	BMP	EMP	Desc Begin	Functional	IRI	Availabe	Actual	Lane W	Availabe	Actual	Access C	Availabe	Actual	Median	Availabe	Actual	Should W	Availabe	Actual	H Align	Availabe	Actual
4	US0051	3.39	3.507	COURT STREET	2	171	35	14.00	13	6	6.00	3	5	0.00	3	0	0.00	0	3	0.00	1	9	9.00
4	US0051	0	1.937	CARLISLE COUNTY LINE	2	107	35	26.25	11	6	6.00	3	5	0.00	3	0	0.00	8	3	3.00	3	9	3.60
4	US0060	6.575	7.143	KY 1105	2	106	35	26.25	11	6	6.00	3	5	0.00	3	0	0.00	4	3	2.40	4	9	0.00
4	US0051	3.661	3.832	THIRD STREET	2	126	35	24.50	12	6	6.00	3	5	0.00	3	0	0.00	0	3	0.00	4	9	0.00
4	US0051	3.507	3.661	FOURTH STREET	2	171	35	14.00	18	6	6.00	3	5	0.00	3	0	0.00	0	3	0.00	1	9	9.00
18	KY0094	8.56	8.678	.118 MI WEST OF WUL OI	7	73	30	27.00	10	12	9.60	3	0	0.00	3	0	0.00	5	5	4.00	1	10	10.00
18	US0641	1.678	2.155		16	76	30	27.00	12	20	20.00	3	0	0.00	3	5	0.00	0	0	0.00	0	0	0.00
18	US0641	12.348	17.44	KY 1824	2	65	35	29.75	12	6	6.00	2	5	2.50	1	0	0.00	10	3	3.00	1	9	9.00
18	KY0121	13.693	13.78	CLARKS RIVER BRIDGE	16	107	30	25.50	11	20	20.00	3	0	0.00	3	5	0.00	3	0	0.00	0	0	0.00
18	KY0121	0	13.69	TENNESSEE STATE LINE	7	110	30	25.50	10	12	9.60	3	0	0.00	3	0	0.00	3	5	3.00	2	10	9.00
18	KY0094	10.749	10.98	POPLAR STREET	16	122	30	24.00	11	20	20.00	3	0	0.00	3	5	0.00	8	0	0.00	0	0	0.00
18	KY0094	0	8.56	GRAVES COUNTY LINE	7	73	30	27.00	10	12	9.60	3	0	0.00	3	0	0.00	2	5	3.00	2	10	9.00
18	KY0094	8.728	9.101	DORAN ROAD	16	92	30	25.50	10	20	17.00	3	0	0.00	3	5	0.00	5	0	0.00	0	0	0.00
18	KY0121	13.778	13.89	.085 MI N OF CLARKS RIV	16	107	30	25.50	10	20	17.00	3	0	0.00	3	5	0.00	6	0	0.00	0	0	0.00
18	KY0822	0.73	1.17		16	108	30	25.50	10	20	17.00	3	0	0.00	3	5	0.00	2	0	0.00	0	0	0.00
18	KY2075	0	0.21	KY 94	16	115	30	25.50	10	20	17.00	3	0	0.00	3	5	0.00	3	0	0.00	0	0	0.00
18	KY2075	0.21	1.36	.210 MILE N OF US 641XA	16	115	30	25.50	10	20	17.00	3	0	0.00	3	5	0.00	3	0	0.00	0	0	0.00
18	KY2075	1.36	1.678		16	115	30	25.50	10	20	17.00	3	0	0.00	3	5	0.00	3	0	0.00	0	0	0.00
18	KY0299	3.103	6.691	JUNCTION WITH KY 121	7	96	30	25.50	9	12	4.80	3	0	0.00	3	0	0.00	2	5	3.00	1	10	10.00
18	KY0299	6.691	10.67	.605 MILE NORTH OF PAI	7	96	30	25.50	9	12	4.80	3	0	0.00	3	0	0.00	2	5	3.00	1	10	10.00
18	KY0893	14.608	15.89	KY 783	7	106	30	25.50	9	12	4.80	3	0	0.00	3	0	0.00	3	5	3.00	1	10	10.00
18	KY0094	10.146	10.29	EIGHTH STREET	16	158	30	21.00	11	20	20.00	3	0	0.00	3	5	0.00	0	0	0.00	0	0	0.00
18	KY0094	10.585	10.75	SECOND STREET	16	158	30	21.00	13	20	20.00	3	0	0.00	3	5	0.00	8	0	0.00	0	0	0.00
18	KY0094	10.976	11.07	EUL OF MURRAY	16	122	30	24.00	10	20	17.00	3	0	0.00	3	5	0.00	8	0	0.00	0	0	0.00
18	US0641	9.396	9.71	.270 MILE NORTH OF KY	14	111	30	22.50	12	16	16.00	3	5	0.00	2	6	3.60	10	0	0.00	0	0	0.00
18	KY0783	5.743	8.1	KY 94	7	129	30	24.00	9	12	4.80	3	0	0.00	3	0	0.00	2	5	3.00	1	10	10.00
18	FS7158	0	0.515		16	115	30	25.50	9	20	14.00	3	0	0.00	3	5	0.00	0	0	0.00	0	0	0.00
18	FS7164	0	0.7		16	115	30	25.50	9	20	14.00	3	0	0.00	3	5	0.00	0	0	0.00	0	0	0.00
18	KY0121	13.89	14.08	.197 MI N OF CLARKS RIV	16	107	30	25.50	10	20	17.00	3	0	0.00	3	5	0.00	6	0	0.00	0	0	0.00
18	US0641	6.501	6.607	BEGIN 4 LANES	14	70	30	25.50	12	16	16.00	3	5	0.00	3	6	0.00	3	0	0.00	0	0	0.00
18	KY1327	0.935	1.516		16	117	30	24.00	9	20	14.00	3	0	0.00	3	5	0.00	2	0	0.00	0	0	0.00
18	KY1550	4.555	6.4	SWUL OF MURRAY	17	103	30	25.50	9	20	14.00	3	0	0.00	3	5	0.00	3	0	0.00	0	0	0.00
18	US0641	0	0.626		16	123	30	24.00	9	20	14.00	3	0	0.00	3	5	0.00	0	0	0.00	0	0	0.00
18	US0641	0.626	0.694	KY 121	16	123	30	24.00	9	20	14.00	3	0	0.00	3	5	0.00	4	0	0.00	0	0	0.00
18	US0641	0.694	0.916	.068 MILE NORTH OF KY	16	123	30	24.00	9	20	14.00	3	0	0.00	3	5	0.00	4	0	0.00	0	0	0.00
18	US0641	0.916	0.996	.290 MILE NORTH OF KY	16	123	30	24.00	9	20	14.00	3	0	0.00	3	5	0.00	4	0	0.00	0	0	0.00
18	US0641	0.996	1.135	ROSE BERRY BRANCH C	16	123	30	24.00	9	20	14.00	3	0	0.00	3	5	0.00	4	0	0.00	0	0	0.00
18	US0641	1.135	1.182	SYCAMORE STREET	16	123	30	24.00	9	20	14.00	3	0	0.00	3	5	0.00	4	0	0.00	0	0	0.00
18	US0641	1.182	1.222	.047 MILE NORTH OF SYC	16	123	30	24.00	9	20	14.00	3	0	0.00	3	5	0.00	4	0	0.00	0	0	0.00
18	KY1550	6.4	6.968	KY 822 (SOUTH 16TH STF	17	103	30	25.50	9	20	14.00	3	0	0.00	3	5	0.00	3	0	0.00	0	0	0.00
18	KY0121	15.133	15.65	BAILEY ROAD	2	88	35	26.25	10	6	3.60	3	5	0.00	3	0	0.00	4	3	2.40	1	9	9.00

						IRI			Lane Width			Access			Median			Shoulder			Alignment		
County	Route	BMP	EMP	Desc Begin	Functional	IRI	Availabe	Actual	Lane W	Availabe	Actual	Access C	Availabe	Actual	Median	Availabe	Actual	Should W	Availabe	Actual	H Align	Availabe	Actual
18	KY0094	10.495	10.59	US 641X (FOURTH STREE	16	158	30	21.00	11	20	20.00	3	0	0.00	3	5	0.00	14	0	0.00	0	0	0.00
18	US0641	8.916	9.126	BEE CREEK BRIDGE	14	111	30	22.50	12	16	16.00	3	5	0.00	3	6	0.00	0	0	0.00	0	0	0.00
18	US0641	9.126	9.396	BEE CREEK BRIDGE	14	111	30	22.50	12	16	16.00	3	5	0.00	3	6	0.00	0	0	0.00	0	0	0.00
18	US0641	1.222	1.678	.087 MILE NORTH OF SY(	16	123	30	24.00	9	20	14.00	3	0	0.00	3	5	0.00	0	0	0.00	0	0	0.00
18	KY0783	0	5.743	KY 893	7	118	30	24.00	9	12	4.80	3	0	0.00	3	0	0.00	2	5	3.00	3	10	5.00
18	KY0094	11.073	24.21	CLARKS RIVER OVERFL(	6	102	30	24.00	10	10	8.00	3	5	0.00	3	0	0.00	4	4	3.20	3	10	4.00
18	KY2594	0	0.798		17	149	30	21.00	9	20	14.00	3	0	0.00	3	5	0.00	3	0	0.00	0	0	0.00
18	US0641	2.155	2.873		16	121	30	24.00	12	20	20.00	3	0	0.00	3	5	0.00	0	0	0.00	0	0	0.00
18	KY0121	14.075	14.59	US 641	14	103	30	22.50	10	16	12.80	3	5	0.00	3	6	0.00	8	0	0.00	0	0	0.00
18	US0641	5.667	5.764	SUL OF MURRAY	14	86	30	22.50	10	16	12.80	3	5	0.00	3	6	0.00	6	0	0.00	0	0	0.00
18	US0641	5.764	6.417	.097 MI NORTH OF SUL O	14	86	30	22.50	10	16	12.80	3	5	0.00	3	6	0.00	3	0	0.00	0	0	0.00
18	US0641	6.417	6.501	COLBURN BRANCH CUL	14	86	30	22.50	10	16	12.80	3	5	0.00	3	6	0.00	3	0	0.00	0	0	0.00
18	KY0893	15.891	18.92		7	106	30	25.50	9	12	4.80	3	0	0.00	3	0	0.00	3	5	3.00	0	10	0.00
18	KY0094	9.101	9.249	BROACH AVENUE	16	92	30	25.50	15	20	20.00	3	0	0.00	3	5	0.00	9	0	0.00	0	0	0.00
18	KY0774	0	0.483		17	131	30	24.00	10	20	17.00	3	0	0.00	3	5	0.00	4	0	0.00	0	0	0.00
18	KY0121	15.648	24.16	WUL OF MURRAY	2	72	35	29.75	10	6	3.60	3	5	0.00	3	0	0.00	4	3	2.40	1	9	9.00
18	US0641	9.71	12.35	KY 2075	2	82	35	26.25	12	6	6.00	3	5	0.00	1	0	0.00	10	3	3.00	1	9	9.00
18	KY0748	0	0.307		17	107	30	25.50	8	20	0.00	3	0	0.00	3	5	0.00	2	0	0.00	0	0	0.00
18	US0641	0	0.206	TENNESSEE STATE LINE	2	80	35	29.75	12	6	6.00	3	5	0.00	3	0	0.00	10	3	3.00	2	9	6.30
18	KY0821	0	0.506		16	205	30	9.00	9	20	14.00	3	0	0.00	3	5	0.00	2	0	0.00	0	0	0.00
18	US0641	0.206	5.667	NCL OF HAZEL	2	80	35	29.75	10	6	3.60	3	5	0.00	3	0	0.00	3	3	1.20	2	9	6.30
18	US0641	6.607	7.169	KY 1550	14	70	30	25.50	12	16	16.00	3	5	0.00	3	6	0.00	0	0	0.00	0	0	0.00
18	US0641	8.143	8.916	KY 1327 (CHESTNUT STR	14	70	30	25.50	12	16	16.00	3	5	0.00	3	6	0.00	0	0	0.00	0	0	0.00
18	KY1327	1.54	2.035	.024 MILE E KY 748 (16TH	16	150	30	21.00	12	20	20.00	3	0	0.00	3	5	0.00	0	0	0.00	0	0	0.00
18	KY0094	8.678	8.728	WUL OF MURRAY	16	92	30	25.50	10	20	17.00	3	0	0.00	3	5	0.00	5	0	0.00	0	0	0.00
18	US0641	7.169	8.143	KY 821	14	70	30	25.50	12	16	16.00	3	5	0.00	3	6	0.00	0	0	0.00	0	0	0.00
18	KY0121	14.59	15.06	BRINN ROAD	14	103	30	22.50	10	16	12.80	3	5	0.00	3	6	0.00	8	0	0.00	0	0	0.00
18	KY0094	10.29	10.45	SIXTH STREET	16	158	30	21.00	14	20	20.00	3	0	0.00	3	5	0.00	0	0	0.00	0	0	0.00
18	KY1327	1.516	1.54		16	150	30	21.00	12	20	20.00	3	0	0.00	3	5	0.00	0	0	0.00	0	0	0.00
18	KY0822	0	0.73		17	86	30	25.50	10	20	17.00	3	0	0.00	3	5	0.00	2	0	0.00	0	0	0.00
18	KY0094	10.023	10.15	NINTH STREET	16	158	30	21.00	14	20	20.00	3	0	0.00	3	5	0.00	18	0	0.00	0	0	0.00
18	KY0094	10.446	10.5	FIFTH STREET	16	158	30	21.00	19	20	20.00	3	0	0.00	3	5	0.00	8	0	0.00	0	0	0.00
18	KY0121	15.056	15.13	.066 MILE NORTH OF BRI	14	103	30	22.50	10	16	12.80	3	5	0.00	3	6	0.00	5	0	0.00	0	0	0.00
18	KY0094	9.249	10.02	KY 822 SOUTH	16	158	30	21.00	11	20	20.00	3	0	0.00	3	5	0.00	0	0	0.00	0	0	0.00
20	US0062	0	13.05	US 51	7	100	30	25.50	10	12	9.60	3	0	0.00	3	0	0.00	3	5	3.00	2	10	9.00
20	KY0121	0	9.714	GRAVES COUNTY LINE	6	109	30	24.00	11	10	10.00	3	5	0.00	3	0	0.00	7	4	4.00	1	10	10.00
20	KY0123	7.439	7.703	WCL OF BARDWELL	7	118	30	24.00	10	12	9.60	3	0	0.00	3	0	0.00	1	5	0.00	1	10	10.00
20	KY0080	0	2.562	HICKMAN COUNTY LINE	7	114	30	25.50	9	12	4.80	3	0	0.00	3	0	0.00	2	5	3.00	1	10	10.00
20	KY0123	6.034	7.39	KY 1741	7	118	30	24.00	9	12	4.80	3	0	0.00	3	0	0.00	5	5	4.00	1	10	10.00
20	KY0080	10.153	15.01	ECL OF MILBURN	7	113	30	25.50	9	12	4.80	3	0	0.00	3	0	0.00	2	5	3.00	2	10	9.00
20	KY0080	2.562	2.936	KY 1772	7	120	30	24.00	9	12	4.80	3	0	0.00	3	0	0.00	2	5	3.00	1	10	10.00