**Research Report**
**KTC-16-14/SPR15-507**

# Development of an Improved Method for Determining Advisory Speeds on Horizontal Curves

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in cooperation with
Kentucky Transportation Cabinet
Commonwealth of Kentucky



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**16. Abstract**
Horizontal curves are an integral part of the highway alignment. However, a disproportionately high number of severe crashes occur on them. One method transportation agencies use to reduce the number crashes at horizontal curves is the installation of curve warning signs which post an appropriate advisory speed. Appropriate curve advisory speeds can be determined using several methods. Some of these methods are time-consuming to perform and are error-prone. The purpose of this research was to find the most efficient and accurate data collection method for determining curve advisory speeds. Several processes were developed and tested. They were then validated against the results of a manual process referred to as the Direct Method and other traditional methods (such as the ball-bank indicator), which are generally assumed to produce accurate results. Comparing the results of these methods allow researchers evaluate their accuracy and usefulness for setting advisory speeds. The results illustrate the potential of a more user-friendly methodology that allows for efficient and accurate data collection. The advisory speeds determined by this research will assist the Kentucky Transportation Cabinet to properly sign horizontal curves. Previous research suggests that posting appropriate advisory speeds results in a safer driving experience.

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## Executive Summary

Horizontal curves are an integral part of the highway alignment. However, a disproportionately high number of severe crashes occur on them [1]. One method transportation agencies use to reduce the number of crashes at horizontal curves is the installation of curve warning signs which post an appropriate advisory speed. Appropriate curve advisory speeds can be determined using several methods. Some of these methods are time-consuming to perform and are error-prone. The purpose of this research was to find the most efficient and accurate data collection method for determining curve advisory speeds. Cost effectiveness was also taken into consideration when evaluating each method's value. Several processes were developed and tested. They were then validated against the results of a manual process referred to as the Direct Method and other traditional methods (such as the ball-bank indicator), which are generally assumed to produce accurate results. Comparing the results of these methods allow researchers evaluate their accuracy and usefulness for setting advisory speeds. The results illustrate the potential of a more user-friendly methodology that allows for efficient and accurate data collection. The advisory speeds determined by this research will assist the Kentucky Transportation Cabinet properly sign horizontal curves, which previous research suggests results in a safer driving experience.

## 1. Introduction and Background

In the United States, severe crashes occur in disproportionate numbers on horizontal curves. Each year, approximately 33,000 fatalities result from crashes, with 25 percent of these taking place on horizontal curves. [3] Approximately 85 percent of the fatal crashes that occur on horizontal curves involve roadway departures due in part to vehicles moving at excessively high speeds. [12]

Warning signs posted near curves alert drivers to approaching changes in road geometry, but they do not establish an enforceable speed limit for curves. Advisory speed plaques are used to encourage speed reductions. [3] Curve warning signs and advisory speed plaques are classified as advance warning signs, and are mounted on the same sign post in advance of a curve. Other warning signs are used to inform drivers about the nature of the curves. These include supplemental curve warning signs posted at the start of the curve as well as chevrons and arrow boards located within the curve. [14]

Despite the widespread use of advance and supplemental signs, within-curve crashes remain at high levels. Over the past 20 years, numerous studies have consistently shown that drivers do not change their behavior in response to curve warning signs, nor do they comply with recommended speeds posted on advisory speed plaques. Evidence of this non-responsiveness is supported by curve crash statistics. Policies for setting advisory speeds differ from state to state and even show some variation within individual states. The methods used to calculate advisory speeds for each curve can be complex. Researchers have suggested that inconsistent advisory speeds may contribute to crashes at curves.

As such, there is a need for a clear, consistent method to set advisory speeds at horizontal curves. The method should let engineers identify when curve warning signs and advisory speeds are needed and facilitate the selections of an advisory speed that is safe and consistent and meet driver expectations. [3] This should convey a realistic message establishing driver expectancy and promote effective roadway operations. [12] The Kentucky Transportation Cabinet (KYTC) and local agencies have received training to assist them in developing consistent curve warning signs and posting appropriate advisory speeds. Equation 1 on the following page may be used to calculate the design speed for a curve.

$$v_i = \sqrt{30(r)(e+f)}$$

$$v_i = curve\ design\ speed$$
$$r = travel\ path\ radius, ft; \qquad (Eqn.\ 1)$$
$$e = superelevation\ rate, percent;$$
$$f = side\ friction$$

KYTC developed a priority list of sites based on the highest number of road departure crashes that have occurred. This list included approximately 25 percent of the state-maintained road system. The Cabinet issued a statewide curve signing project to perform ball banking on these routes which was awarded to three individual consulting firms: Neel-Shaffer; Gresham, Smith and Partners; and HDR, Inc. Each consultant firm determined the appropriate curve advisory speed for the routes in the districts they were assigned. Each firm was trained to use the digital ball-bank indicator method as a control. This method is generally viewed as effective and is commonly used by transportation agencies around the United States.

# 2. Available Methods

A number of methods have been developed to calculate curve advisory speeds. Methods currently in use include the direct method (use of the design speed equation), the ball-bank method (using either the digital or traditional ball-bank indicator), the Curve Advisory Reporting Service (CARS) System, and the Texas Roadway Analysis and Measurement Software (TRAMS). Two other methods involve leveraging data that KYTC currently gathers. They were evaluated using Highway Information System (HIS) data and a software solution using ArcGIS (the Arc Method). Each method relies on different procedures and comes with unique advantages and disadvantages. This study evaluated the six methods listed above, focusing on their practicality, efficiency, and cost-effectiveness. The following sections describe the execution of each method.

## 2.1 Direct Method

The *direct method* is based on field measurements of a curve's radius and superelevation. An equation is used to estimate the curve radius based on the offset at the middle of a 100-foot chord. The superelevation is measured at several locations through the curve. The maximum superelevation is used in the design speed calculation. (see *Eqn. 1 in Section 1)*

## 2.2 Digital Ball-Bank Indicator

The *ball-bank indicator method* is based on a set of field driving tests. During these tests, digital or traditional ball-bank indicators record data at various speeds. Like the direct method, the main steps consist of collecting data and using those data to determine curve advisory speed. The ball-bank method is based on lateral acceleration and *driver discomfort* as vehicles travel through the curve. [1, 7]

The term *ball-bank indicator* refers to an inclinometer, or an accelerometer used as an inclinometer, that is used to determine safe curve speeds for horizontal curves. [8] The traditional device consists of a curved glass tube filled with liquid which is mounted in a vehicle. A weighted ball floats in the glass tube. As the vehicle travels around a curve, the ball floats outward in the curved glass tube. Movement of the ball is measured in degrees of deflection. The magnitude of deflection reflects the combined effects of superelevation, lateral (centripetal) acceleration, and vehicle body roll. [1]

While basic analog ball-bank indicators rely on the driver or passenger to record data as they observe the ball roll, newer digital devices sense how far the ball moves and report the data accordingly. Both types of device report movement in degrees. [8]

Specific criteria for the ball-bank method vary, but are based on lateral acceleration and a measure of driver discomfort. The goal is to minimize driver discomfort as vehicles travel through curves. Engineers consider minimal driver discomfort as indicative of a safe speed. [1, 7] The Manual on Uniform Traffic Control Device (MUTCD) 2009 edition set the criteria for the ball-bank indicator as follows:

- 16 degrees for speeds of 20 mph or less
- 14 degrees for speeds of 25 to 30 mph
- 12 degrees for speeds of 35 mph and higher

These are the lowest values for which a curve is deemed uncomfortable for the driver and likely unsafe. According to the MUTCD, these values address curve geometry as well as driver behavior (e.g., driving faster than the posted advisory curve speeds). [5]

In Kentucky, curve advisory speeds currently posted utilized the ball bank indicator method. However, it is unknown when they were determined, and therefore unclear whether the criteria used was in accordance with 2009 MUTCD standards, 2003 MUTCD standards, or earlier ones.

Because the ball-bank method relies on field comparisons of speed and displacement, it is imperative that the test vehicle's speedometer is accurate. The speedometer should be calibrated using a radar gun, a laser, time-distance comparisons, or other method. The ball-bank indicator should be calibrated as well by mounting it so that it displays a 0-degree reading when the vehicle is stopped on a level surface. Typical passenger cars are best suited for this test, because other vehicles may affect the amount of body roll measured. [1]

A vehicle should make several passes through a curve to ensure the accuracy of the ball-bank indicator reading. Drivers should begin by driving at a fairly low speed; speeds are incrementally increased for each iteration of the test. On each test run, the driver must reach the test speed at a specified distance in advance of the curve's entrance and maintain that speed throughout the length of the curve. The test is repeated until the displacement of the ball-bank indicator exceeds the thresholds listed above. [1]

The curve advisory speed should be set at the highest test speed which *does not* result in a ball-bank indicator reading above the acceptable level. The advisory speed chosen, therefore, is a product of the speed limit, roadway geometry, and the digital ball-bank indicator reading. [1]

## 2.3 Curve Advisory Reporting Service (CARS)

The Curve Advisory Reporting Service (CARS) System is a road survey system that automatically records vehicle activity and determines recommended safe curve speed. Developed by Rieker Incorporated, it is marketed as the next generation ball-bank indicator. The GPS-based configuration lets users perform continuous road surveys without stopping. The vehicle travels with traffic, requiring only one pass to collect the necessary data; the system is mounted on the dashboard.(9) There are two main components: a tablet application and a web portal.(10) The system captures data that allows calculation of several parameters, including curve radius and superelevation, which assist in deriving a safe curve speed.(9)

The system adheres to Federal Highway Administration (FHWA) guidelines for determining safe curve speed; it also meets 2009 MUTCD requirements. It functions similarly to the digital ball-bank indicator in that it measures vehicle movement to measure various road features. GPS technology provides more accuracy than traditional ball-bank indicators.(10) The CARS package consists of a GPS ready Digital Ball-Bank Indicator (the RDS7-GPS-PRO), a compatible Windows Tablet, Rieker proprietary CARS Recording Software, all necessary cables, and a vehicle tablet mount. Drivers decide when to begin recording with the device, but it requires no user inputs once the recording has begun. Its operation requires only one person, and they can focus their attention on driving. If the GPS signal is lost, the system continues to record other data, but the driver must manually enter vehicle speed prior to driving in the area. Once a GPS connection has been reestablished, data collection resumes automatically.(9)

The CARS system assists in calculating the curve advisory speed by analyzing the data collected.(9) The tablet displays the calculated speed.

## 2.4 TRAMS

Texas has developed a proprietary GPS-based software program to analyze curves. The Texas Roadway Analysis and Measurement Software (TRAMS) Program utilizes deflection of a ball-bank indicator, speed, and geometric data for the curve and the highway, then plots the data on a map using GPS coordinates. (12) Similar to CARS and other methods reliant on GPS, this program collects geospatial data and then exports them to a second software tool which calculates advisory speed. (13)

The equipment required for the TRAMS program includes a GPS receiver, an electronic ball-bank indicator, and a laptop computer. The GPS receiver is used to estimate curve radius and deflection angle. The electronic ball-bank indicator is optional and is used to estimate superelevation rate. If an electronic ball-bank indicator is not used, the superelevation rate must be estimated using other means. The laptop computer facilitates data analysis and performs advisory speed calculations. (2)

The TRAMS program requires a driver to initiate data collection. Then, they must drive the vehicle around a curve at a uniform speed. The program continuously collects data from the GPS receiver and ball-bank indicator while the test vehicle is driven along the curve. (2) After a vehicle passes through a curve, the software calculates curve radius, superelevation rate, and deflection angle from the data streams. (13) Advisory speed and traffic control device selection guidelines can be determined using the radius and superelevation rate estimates, which are calculated in the Texas Curve Advisory Speed (TCAS) Excel spreadsheet (this is included in the software package). (2) Processing entails dividing the curve into a series of segments. The length of each curve segment is calculated as the product of the average test vehicle speed and the amount of time it takes to travel the segment. Segment deflection angle is calculated by computing the vehicle's heading change between the start and end of the segment. The length of each segment is divided by its deflection angle to estimate its average radius. This method often introduces excess noise into the data, and requires some filtering before the program is able to determine a good estimate of radius. A Kalman filter or regression model can be used to filter the data. Superelevation for each segment is calculated using the average of the ball-bank readings recorded as the vehicle travels along each combined segment. (13)

Depending on the test vehicle's speed, between two and 15 readings are typically obtained for each segment. These readings all occur within one pass of the vehicle, and a subsequent passes should not be necessary. After enough data have been collected, and all the geometric data for each curve segment calculated, TRAMS identifies the segment with the smallest radius. The radius, superelevation rate, and deflection angle are then used to determine the advisory speed. (13)

## 2.5 Highway Information System

Unlike the other methods described, Highway Information System (HIS) data offer a way to evaluate curves without driving them. KYTC's Division of Planning provides a GIS shapefile that transportation engineers can use to gather information. The shapefile includes information about roadway curves throughout the state. Of critical importance is a dataset that contains the geometry of each curve in degrees. This value can be used in equations to calculate advisory speed, with assumptions made for the superelevation.

## 2.6 Arc Method

The final method evaluated relies on data previously collected by KYTC. Data collection vans have been used throughout the state to gather essential data for maintenance and safety operations. This collection is a perpetual process: applicable routes are evaluated at least once every two years. Data for interstates and parkways are collected annually. A key strength of this method is the fact that these data have already been collected. Collection vans include the following hardware and software:

- Three forward facing cameras with 160-degree view of roadway/right-of-way
- Applanix 220 GPS - sub-meter accuracy XY position
- Inertial Measurement Unit - "6-axis" Gyrometer
- Pavemetrics Laser Crack Measurement System (LCMS) - downward imaging crack detection
- Dynatest Road Surface Profiler (RSP) - Inertial profiler for pavement roughness
- Mandli MESH - hardware/software solution
- Mandli DVX software

The Mandli DVX software writes various files for each session. Two of these file types are: .RAW and .GPS. These files contain information from the GPS and IMU (position, roll, pitch, yaw). The Mandli Roadview X Workstation software reports curve data at user-selected intervals in these files. Curve start/stop points are detected by changes in the vehicle position, mostly from the IMU. Driver performance significantly affects data collection and results. The curve report includes measures of radii and superelevation.

The results of the curve report include GPS, county, route, milepoint, curve radius, maximum superelevation. The report is always run twice for each route — once in each direction. For this study, the data obtained from KYTC was plotted in ArcGIS. This resulted in a data points spaced at 5-foot intervals.

The data points were used to measure the radius of curvature and calculate superelevation. The measured radius was necessary because the accuracy of this calculation is contingent on a driver's performance. As such, the calculated radius was replaced with a more accurate calculation made using ArcGIS.

# 3 Methodology

## 3.1 Data collection

The goal of this study was to identify the most cost-effective and efficient data collection method to employ at the statewide level. Several sites were chosen across the state and various methods were used to determine advisory speeds. Routes were selected to provide various types of roadway geometry. Comparisons were useful to examine the accuracy and consistency of advisory curve speeds derived from each method. The following table lists each route and the number of curves evaluated along them.

**Table 1. List of Routes, Road Segments, and Number of Curves**

| Route | County | Milepoint Range | Number of Curves Evaluated |
|---|---|---|---|
| US 60 | Clark | 15.74 - 16.75 | 6 |
| US 68 | Mercer | 15.90 - 20.00 | 15 |
| KY 11 | Powell | 0.00 - 1.40 | 10 |
| KY 15 | Powell | 0.20 – 3.08 | 17 |
| KY 44 | Bullitt | 6.96 – 8.80 | 8 |
| KY 87 | Barren | 10.65 - 12.17 | 8 |
| KY 122 | Floyd | 29.70 – 33.85 | 15 |
| KY 152 | Mercer | 0.00 - 8.26 | 22 |
| KY 420 | Franklin | 1.49 - 2.04 | 6 |
| KY 1189 | Laurel | 1.42 - 2.20 | 4 |
| KY 1355 | Garrard | 1.10 - 10.10 | 28 |
| KY 1973 | Fayette | 0.23 - 11.77 | 17 |

The digital ball-bank method, CARS, and Arc were used on all curves. HIS data were also obtained for all curves. Additionally, four of the routes were analyzed using additional methods. Table 2 lists these routes and methods used. The following sections describe the data collection process for each method.

**Table 2. Routes Including Additional Methods**

| Route | County | Direct | TRAMS | Neel-Schaffer using CARS |
|---|---|---|---|---|
| US 60 | Clark | X | | |
| KY 11 | Powell | X | | |
| KY 420 | Franklin | | | X |
| KY 1973 | Fayette | X | X | X |

### 3.1.1 Direct Method Collection Process

The Direct Method was used at three locations — in Fayette, Clark, and Powell counties. This method is the most time consuming, and therefore it was not practical to use this method for every site. Because of its time-intensive nature, it would not be an appropriate method to analyze a large number of curves. Further, the MUTCD approves of other, more efficient data collection methods. To execute this method, the curve radius was calculated by using a formula (with the middle ordinate of a 100-foot chord) and measuring the superelevation. Equation 1 (shown in Section 1) was used to calculate curve design speeds.

### 3.1.2 Digital Ball-Bank Indicator (DBBI) Collection Process

Data for this method were collected using a process developed by the Kentucky Transportation Center (KTC) — it is currently KYTC's accepted method for calculating advisory speeds on curves. KTC has developed a training course that instructs participants on setting advisory speeds. The course prescribes the following steps to establish advisory speeds:

- Curve advisory speed signs need to be posted for curves on which the appropriate advisory speed is at least *10 mph* under the speed limit.
- The curve advisory speed should be determined using MUTCD criteria.
- Once officials decide that it is appropriate to post an advisory speed, it will be set based on measurements obtained from ball-bank indicators and MUTCD criteria. The MUTCD criteria is based on the values that are considered unsafe/uncomfortable. These values suggest advisory speeds based on the magnitude of deflection measured by the ball-bank indicators:

| Speed (mph) | degrees |
|---|---|
| 20 or less | 16 |
| 25 to 30 | 14 |
| 35 and higher | 12 |

- A DBBI will be used for the measurements.
- Officials should initially drive the road in both directions at a speed *5 mph less* than the posted speed limit to identify curves where an advisory speed of *10 mph or greater* than the speed limit

is warranted. If a curve cannot be driven at this speed, adjust the speed down to an appropriate speed and collect data using the MUTCD criteria.

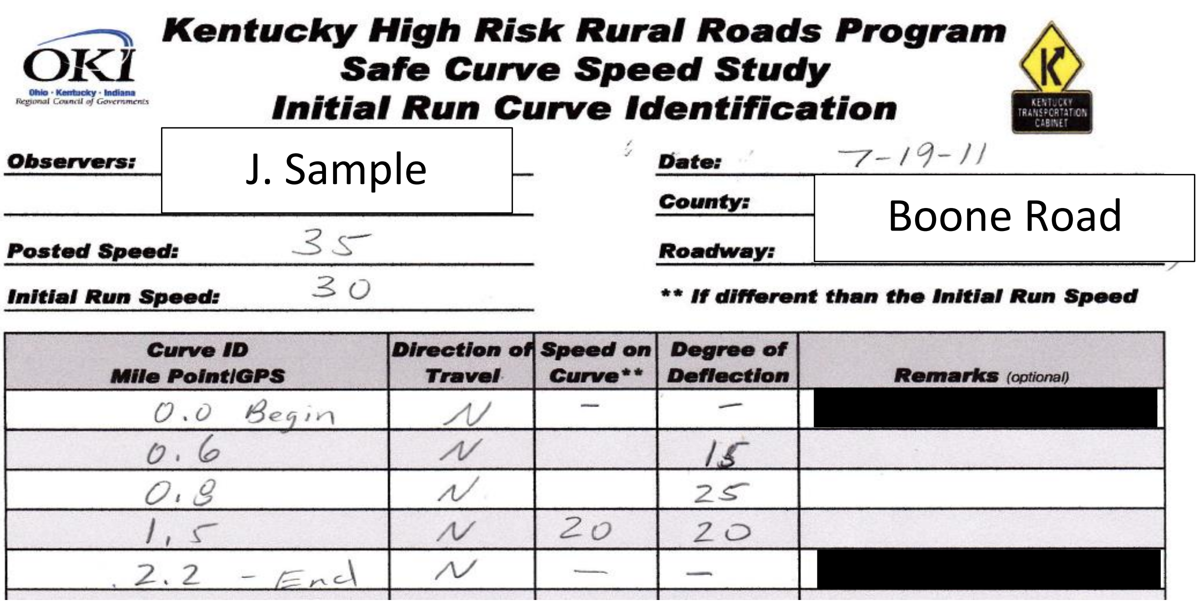
- Set the alarm-trip angle and buzzer on the DBBI to alert drivers of curves where the measurement is above the MUTCD criteria for the initial test speed (5 mph less than the speed limit).
- Use the following table to set alarm angles for the posted speed limit and initial test speed.

| Speed limit (mph) | initial test speed (mph) | alarm angle |
|---|---|---|
| 55 | 50 | 12 |
| 50 | 45 | 12 |
| 45 | 40 | 12 |
| 40 | 35 | 12 |
| 35 | 30 | 14 |
| 30 | 25 | 14 |
| 25 | 20 | 16 |

- Identify each curve (by mile point or GPS coordinates) on which the buzzer sounds. When the alarm sounds, it indicates the alarm angle has been reached (demonstrating the MUTDC criteria has been equaled or exceeded).
- For each curve identified at the initial test speed, officials should drive the curve in each direction, adjusting the speed at 5-mph increments until a measurement less than or equal to the alarm angle for that speed is reached (different advisory speeds may be set for opposing directions).
- Set the advisory speed. This should be the speed (in 5 mph increments) below the lowest test speed at which the alarm angle is exceeded.

Following is an example of a form used to record data collection.

Figure 1. Example DBBI Collection Form


OKI
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**Kentucky High Risk Rural Roads Program**
**Safe Curve Speed Study**
**Initial Run Curve Identification**

KENTUCKY TRANSPORTATION CABINET

**Observers:** J. Sample
**Date:** 7-19-11
**County:**
**Roadway:** Boone Road
**Posted Speed:** 35
**Initial Run Speed:** 30
**** If different than the Initial Run Speed**

| Curve ID Mile Point/GPS | Direction of Travel | Speed on Curve** | Degree of Deflection | Remarks (optional) |
|---|---|---|---|---|
| 0.0 Begin | N | – | – | [redacted] |
| 0.6 | N | | 15 | |
| 0.8 | N | | 25 | |
| 1.5 | N | 20 | 20 | |
| 2.2 - End | N | — | — | [redacted] |

### 3.1.3 CARS Collection Process

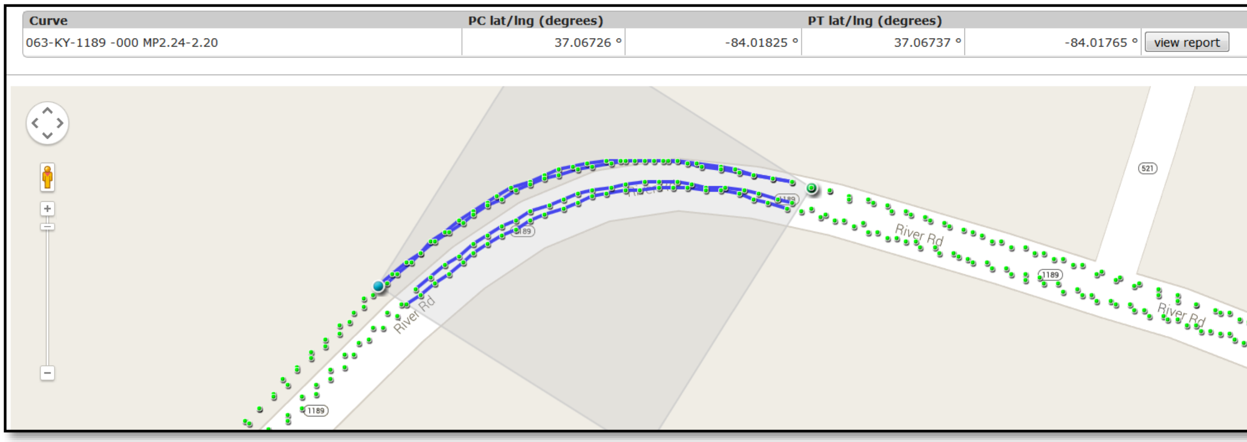
After establishing an evaluation agreement with Rieker, Inc., KTC was able to use the CARS system. Researchers obtained training for data collection and software use directly from Rieker. The training included an in-field use of the CARS system as well as a demonstration of the web-based software. Rieker suggested driving roadway segments twice in each direction — resulting in four passes per curve. On some curves, additional passes were used to analyze the consistency of the results. CARS was used on a corridor previously measured by Rieker and a Kentucky consulting firm (Neel Schaffer). The CARS system was installed in a vehicle; the system includes a GPS receiver, DBBI, and a tablet as shown in Figure 2.

Figure 2. CARS Equipment Setup in Vehicle

Before the driver started on a route, the posted speed limit was entered into the system. No further driver inputs were required. The system could be deactivated with each pass or it could be activated continuously for all four passes. Both techniques were evaluated and there was no noticeable difference in the way the data was stored. The flagging feature was used (by a passenger) to identify existing advisory speed signs. The system's reversionary mode could be used in cases where the GPS signal was weak or unavailable.

After data collection, the system can upload data to Rieker's servers if there is an internet connection available. Once uploaded, the web-based software processes the data. All of the collected data are viewable using the web application. On the website, users need to identify each curve with a polygon tool that marks the points of tangency and curvature. This process can be subjective but the "goodness of fit" metrics can be used to ensure consistent results. A value of over 98 percent is a good indication of a curve with a high degree of fit. Figure 3 illustrates the curve selection process.

Figure 3. Curve Identification Using CARS Web-Based Tool




After the curves have been identified, the CARS system calculates the advisory speed for each curve — one result for each direction. It should be noted that the GPS points (the green dots in Figure 3) are spatially joined to an invisible layer that includes the route's linear referencing data (county, route and milepoint). This is an essential process that assists in identifying unique curves and in comparing results to those derived from other methods. Figure 4 is an example analysis report the CARS system generates, with discrete records for each pass.

Figure 4. Example Analysis Report Using CARS Web-Based Tool

RIEKER inc.

**Safe Curve Speed Analysis Report**

Curve Name: 034-KY-1973 -006 MP1.38-1.45

Analysis Date: 03/24/2015 13:49

Posted Speed Limit: 55 mph

Lateral Friction Limit: 12 °

| Pass # | Curve | Travel | PC Latitude | PC Longitude | PT Latitude | PT Longitude | Fit | Avg. Test Speed | Curve Radius | Curve Length | Deflection Angle | Elevation at Apex | Min. Calculated Advisory Speed | Recommended Advisory Speed | Chevron Spacing |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Left | North east | 37.94244 ° | -84.36449 ° | 37.94349 ° | -84.36440 ° | 98.4 % | 27.6 mph | 889 ft | 394 ft | 24 ° | -1.5 % | 50.7 mph | 50 mph | 160 ft |
| 2 | Right | South | 37.94337 ° | -84.36440 ° | 37.94244 ° | -84.36449 ° | 97.3 % | 37.8 mph | 547 ft | 344 ft | 21 ° | 14.9 % | 50.1 mph | 50 mph | 120 ft |
| 3 | Right | South | 37.94336 ° | -84.36440 ° | 37.94249 ° | -84.36449 ° | 98.1 % | 30.2 mph | 587 ft | 320 ft | 25 ° | 9.6 % | 46.7 mph | 45 mph | 120 ft |
| 4 | Left | North east | 37.94246 ° | -84.36446 ° | 37.94343 ° | -84.36437 ° | 98.2 % | 25.6 mph | 980 ft | 363 ft | 20 ° | -0.7 % | 52.6 mph | 50 mph | 160 ft |

The table from the report is one of the only tables in Safe Curve Speed Analysis Report. It includes the modeled data, radius variation, side friction, and other analytics.

### 3.1.4 TRAMS

The TRAMS software was only used to analyze a portion of a single route (KY 1973 in Fayette County). The data used had been collected as part of an earlier project. It was included in this project for comparison purposes. This system uses a GPS receiver and a DBBI both connected to a laptop.

At the start of a route, a unique ID is entered into the system to identify the first curve. This ID was used to create an output file. Care was taken to keep track of the IDs so that the curve could later be identified by mile point. Indicators display if there is a connection to the DBBI and if the GPS is receiving a good signal. The user presses the spacebar at the start and end of the curve while the driver drives the route. Although the user can update the ID following this to prepare for the next curve, in some cases this was too difficult and the driver had to re-drive the curve. The software developers were contacted about the source code so that researchers could modify it, but it was unavailable. KTC also considered developing software to auto-increment the ID via message hooks; however, KYTC preferred an in-depth evaluation of the CARS system and therefore this was not done.

One KYTC district has streamlined the process of using macro-enabled spreadsheets and the TRAMS system. The comments below come from staff within this district and capture their experience with the TRAMS system:

- For the best results, drive 10 to 15 mph below the speed limit.
- For a 55 mph road, at least 20 miles of data can be collected in both directions in an hour. If the drivers are familiar with the road, more miles can be collected per hour since it is only necessary to drive below the speed limit in the curves. (Obviously, these numbers can change in areas with a higher or lower curve density.)
- All of the roads in an average sized county, with ADT values of 1000 or more, can be evaluated (data collection and analysis) in two to three days. A couple hours are required to transfer data into Excel and obtain mile points and advisory speeds.
- The procedure uses a laptop with another program called TRAMS and connecting it to a DBBI and a GPS. After connecting the devices, the roads are driven once in each direction and TRAMS saves all of the data from the DBBI and GPS. An indication must be given at the beginning and end of each curve. The data is imported into the excel file which provides the curve advisory speeds for that road.
- The accuracy of this method has been checked several times by comparing its results to those acquired using the traditional ball-bank indicator. The results have proven to be very accurate. The only problems have been the occasional loss of a GPS data and the failure to collect and record data on a few curves. Those curves were subsequently re-evaluated. The procedure has been efficient. So far, advisory signs have been posted in five counties using data from TRAMS, and two more counties are ready for sign installation.

The district has not compared TRAMS with CARS. It is recommended that staff evaluate CARS as there appear to be significant differences between procedures used in TRAMS compared to CARS.

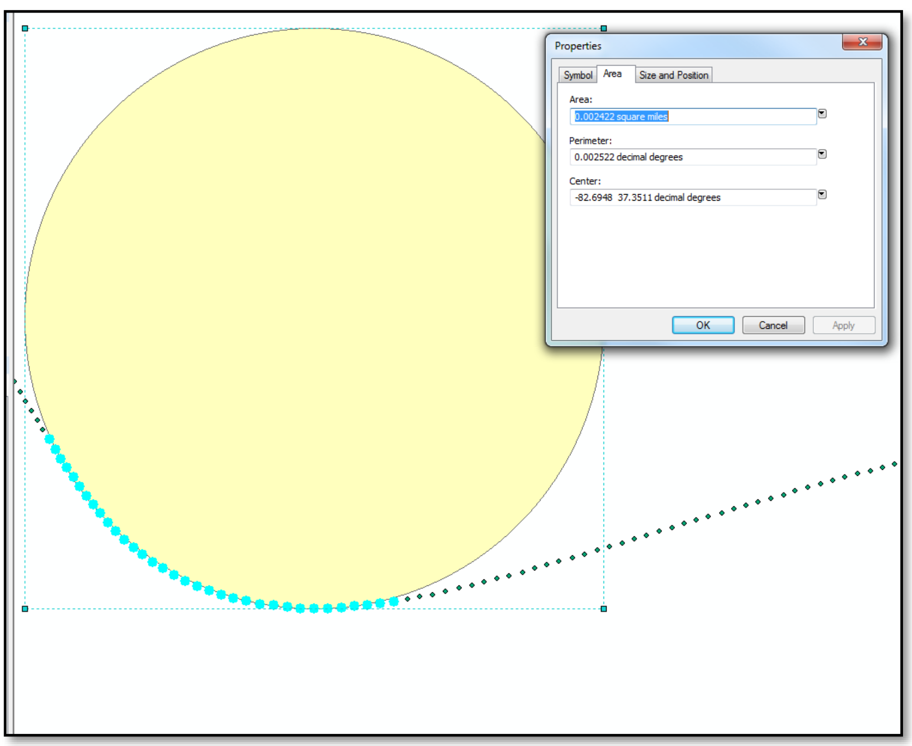
### 3.1.5 Highway Information Systems

This is not an MUTCD-approved method to determine advisory speeds. However, KYTC already collects these data so it was logical to determine whether this radius data could be used to calculate advisory speeds. Superelevation data obtained from the Arc Method (see below) were used because the HIS database lacks this information. These data are already referenced by county route and mile point, so they were easily matched to data collected using other methods. Equation 1 was used to calculate advisory speeds using the radius from HIS. Only one radius was available per curve (i.e., the impact of travel direction was not factored), however, superelevation data for each direction were available. As such, two advisory speeds were calculated one each direction. A side friction value of 0.08 was used.

### 3.1.6 Arc Method

Researchers evaluated this method to determine if existing data could be used in lieu of field data collection. Mandli Communications data were plotted in ArcGIS as data points with each point including the maximum superelevation, the direction of travel, and linear referencing data. The data points were filtered to show only one direction at a time, which allowed researchers to make a separate calculation for each direction. The start and end of a curve were identified using a method similar to what the CARS System employs — by highlighting the data points (see Figure 5).

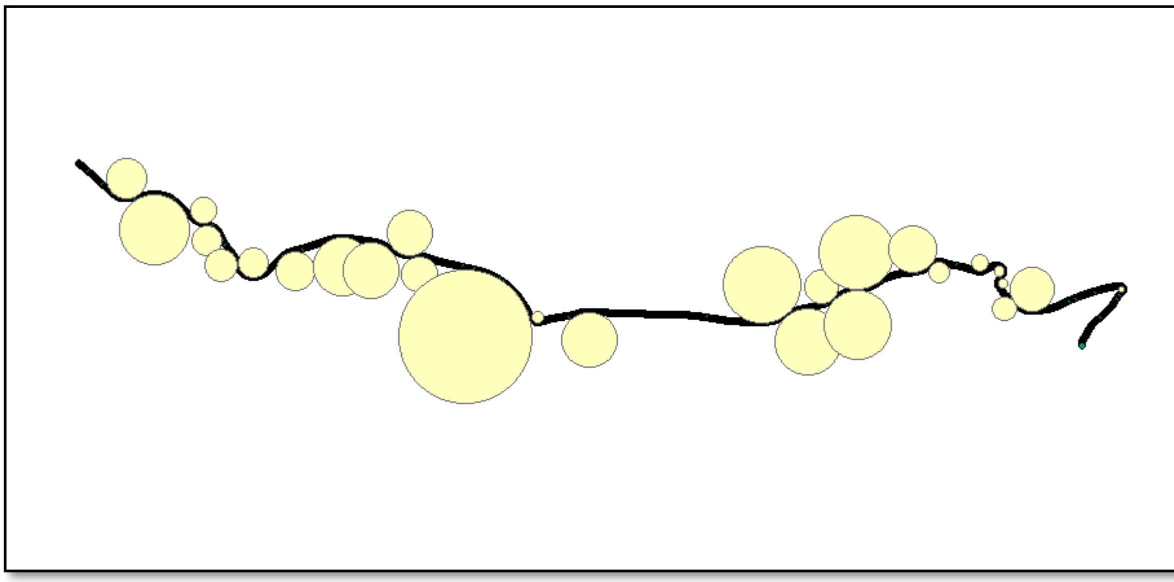
Figure 5. Curve Identification Using ArcGIS




Highlighted data points were also used to fit an osculating circle to the curve. A circle was drawn in ArcGIS and resized until it aligned with the highlighted points. The area of the circle was used to calculate a radius. Superelevation varied along the curve such that each highlighted point had a different value. Although initially the average was calculated for the highlighted points, researchers eventually determined that the median superelevation provided more consistent results.

This process was repeated for each curve and for both directions. Superelevation and radii values were referenced by county, route, and milepoint. This method typically identified more curves than were observed in the field, largely due to the changing map scale and the lack of points to relate to the roadway. Therefore, several curves identified with this method were not matched to data obtained from other methods. Figure 6 illustrates a completed route with osculating circles.

Figure 6. Completed Route Showing Osculating Circles



As before, advisory speeds were calculated using Equation 1 and a side friction value of 0.08. Advisory speeds were calculated for each curve twice because radius and superelevation were available for each direction.

## 3.2 Reconciliation of Various Methods

One of the biggest challenges in comparing advisory speeds calculated using different methods was reconciling errors that mismatched the curves. Some of the methods used the midpoint (along the road) to identify a curve's location while others included a starting and ending mile point. Moreover, not all methods identified the same number of curves. In these cases, unmatched curves were removed. In all cases, the unmatched curves had very large radii, therefore no advisory speeds were required.

A related issue was identifying the posted advisory speeds and matching them with the correct curve. This is not terribly problematic for simple situations, where there is a single curve with a posted advisory speed located just upstream of where it begins. However, in more complex situations — which occur often in Kentucky due to its uneven topography — several curves are controlled by a single *winding* road sign (W1-5). Here, researchers were took extra care to match the advisory speed to the curve. Complications also arise when additional advisory speed plaques are used (even when controlled by a W1-5 sign), when the advisory speed for one curve is lower than that of the group.

Google Street View and the HIS data were used to resolve these issues. Each route was traversed using Street View while following along with the collected data. Researchers identified locations where signs were observed or curves omitted (e.g., when they had no matches with other methods). HIS data were used to order the curves. For example, it was apparent that a mismatch had occurred when a very large radius was matched with a very shirt radius.

# 4 Results and Conclusions

KYTC officials requested that KTC identify a cost-effective, accurate, and consistent method to determine curve advisory speeds for Kentucky roads. The digital ball-bank indicator (DBBI) method is currently used throughout the state. KTC evaluated three alternative methods in detail: CARS, HIS, and ARC. The Direct Method and TRAMS were not evaluated in great detail because they are more time consuming than the other methods. KYTC would prefer using ARC or HIS (or a combination of the two) because the data are already being collected, thus reducing potential costs.

The subsequent discussion examines two parameters collected by the various methods: curve advisory speed and radius of curvature. Ultimately, the curve advisory speed is the most import result. However, the curve radius is the most influential parameter in curve advisory speed calculations (compared to side friction and superelevation), and the DBBI method fails to provide a curve radius.

Because it is currently in use, results from the DBBI method were used as a baseline to compare the CARS, ARC, and HIS methods. Each method produces a curve advisory speed rounded down to the nearest 5-mph increment. Advisory speeds were capped at 55 mph as there is no need to sign a curve if the advisory speed is at or above the speed limit. This is likely to occur on roads with large radius curves. All routes in this study had posted speed limits of 55 mph.

Advisory speeds derived from the DBBI were compared to those on the CARS report as well as those calculated using ARC and HIS. The absolute difference in calculated advisory speeds was computed for each curve, direction, and method. In other words, researchers found the difference between advisory speeds calculated using CARS, ARC, and HIS methods, respectively, and those obtained from DBBI. Appendix A has complete results along with the radii and superelevations for each curve. The absolute difference for each method was plotted in a histogram along with a cumulative percentile. Figures 7a through 7c show the histogram and percentile graphs for each method.

Figure 7a. Histogram and Percentile for DBBI compared to CARS

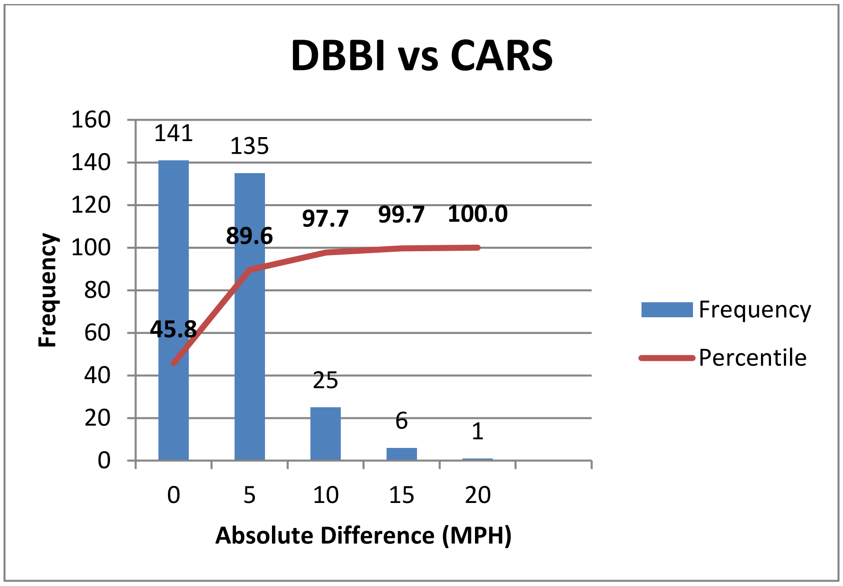



Figure 7b. Histogram and Percentile for DBBI compared to ARC

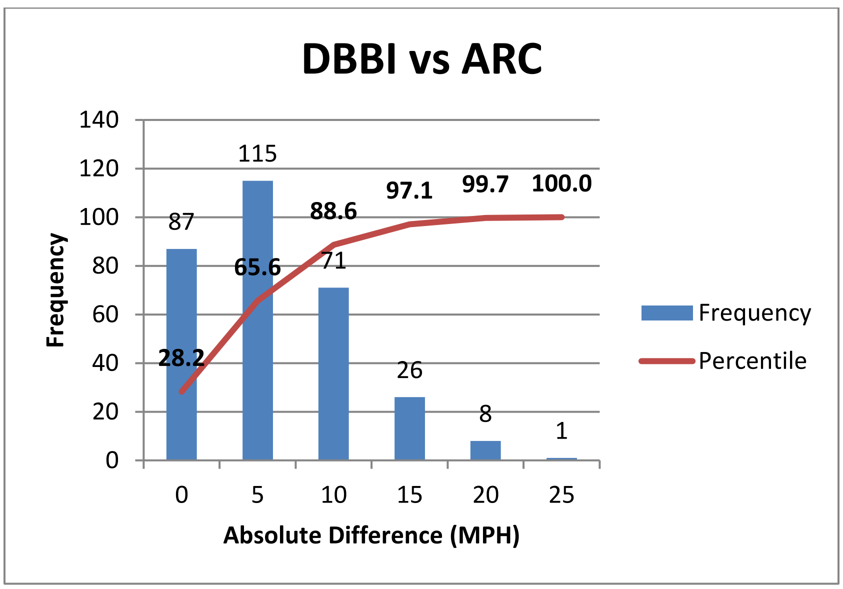
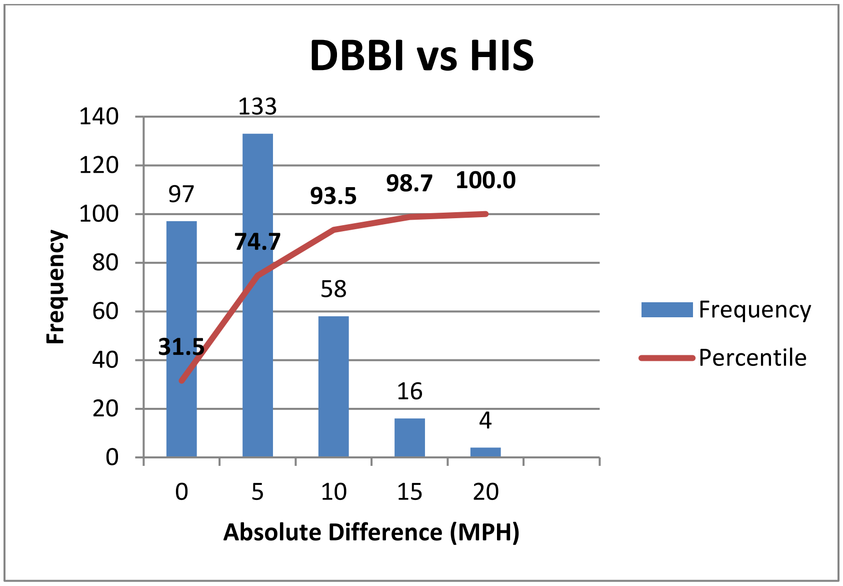


Figure 7c. Histogram and Percentile for DBBI compared to HIS




Comparing the results, it is apparent that advisory speeds calculated with the CARS System are most similar to advisory speeds obtained using the DBBI method. For nearly half of the curves (46 percent), DBBI and CARS returned the same curve advisory speed; for 90 percent of curves, the difference was within 5 mph; and for 98 percent of curves the difference was within 10 mph. These comparisons reveal the absolute difference in speeds, however; taken alone they do not indicate the directionality of the difference. The next two comparisons consider the question of directionality.

Scatterplots were created to visualize the advisory speeds calculated from the DBBI and CARS, ARC, and HIS, respectively. If two methods yielded the same advisory speed for all curves, they would be perfectly correlated. As such, all points would fall along a straight line where the x-value equals the y-value. A more objective comparison is to use the parameters or a regression equation. In this case, the data points are correlated but rather the slope and intercept can be used to compare the two data sets. Figures 8a through 8c show individual comparisons of advisory speeds calculated with DBBI and each of the other three methods.

Figure 8a. Scatter plot of Advisory Speeds for DBBI and CARS

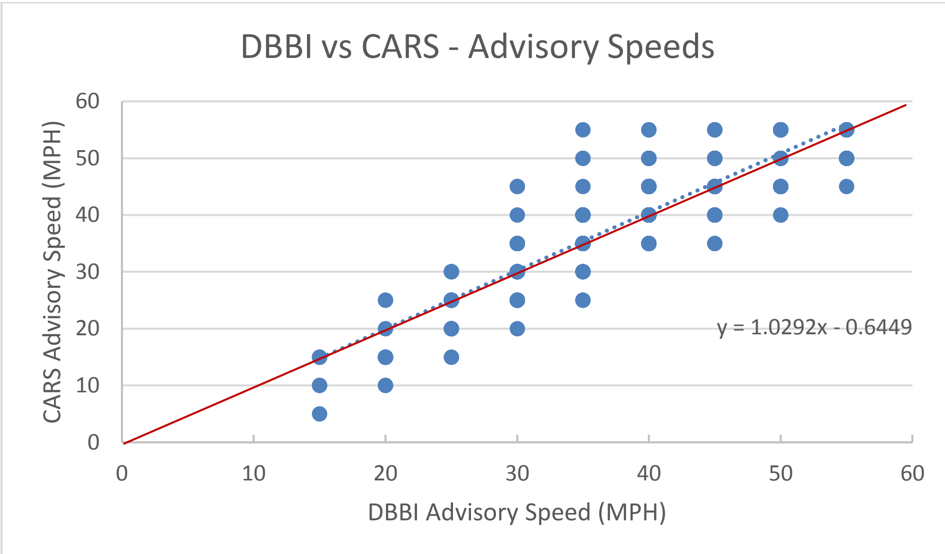



Figure 8b. Scatter plot of Advisory Speeds for DBBI and ARC

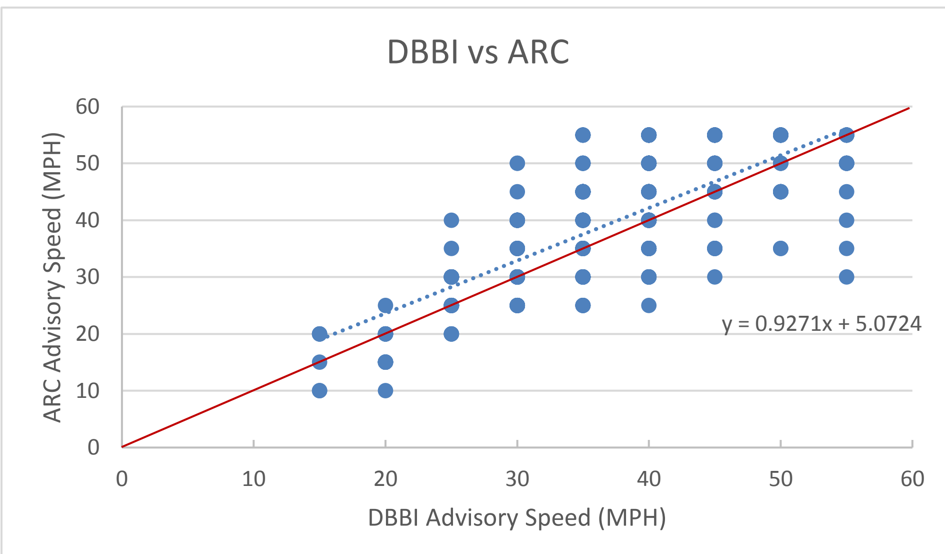
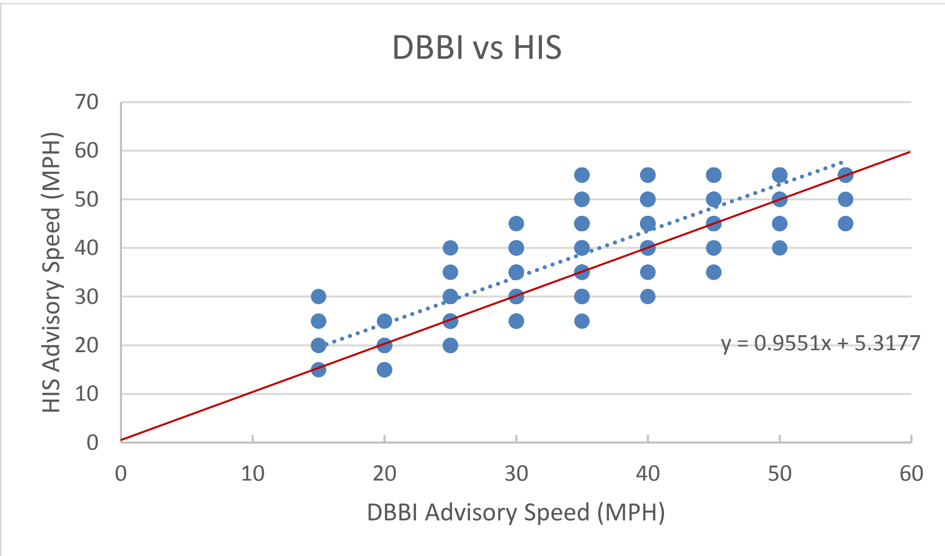


Figure 8c. Scatter plot of Advisory Speeds for DBBI and HIS




Researchers added trend lines to each set of data comparisons and the linear equations are shown. The red line represents a perfect correlation, while the dashed blue line represents the best fit linear trend. Visual inspections reveal that CARS most closely matches the DBBI — the dashed line diverges the least from the red line. This is corroborated with the inspection of the coefficient and the intercept — they are close to one and zero, respectively. A regression equation that is y = x has an intercept of zero and a slope of one. These graphs also indicate the directionality of the differences. Data points below the dashed line represent a speed lower than the DBBI advisory speed and data points above the line represent a speed higher than the advisory speed of the DBBI.

The actual difference (not absolute value) between the DBBI and each of the other three methods was computed. This value was totaled for each method. The sum represents the overall trend for the discrepancies in speeds. Table 3 summarizes these results.

**Table 3. Average Difference in Advisory Speeds (mph)***

| Direction | A | B |
|---|---|---|
| *HIS to DBBI* | 3.8 | 3.5 |
| *ARC to DBBI* | 2.5 | 2.3 |
| *CARS to DBBI* | -0.6 | -0.3 |

*Positive number indicates DBBI speed is higher

CARS showed the most promising result. The other two methods tended to return more conservative estimates, generally calculating lower curve advisory speeds than DBBI. A positive difference is preferable to a negative difference in that posting a higher advisory speed is not desirable. However, the frequency of positive errors is much higher for HIS and ARC compared to CARS. This would lead to a situation where curves are signed with lower speeds when a higher speed is in fact justified. If this happens routinely, drivers may become accustomed to disregarding advisory speeds. Nevertheless, a negative difference is still undesirable. The most significant negative differences between DBBI and CARS were reviewed. In four cases, it seemed the DBBI advisory speeds were in error based on site evaluation. Studying the potential errors in the DBBI method, however, was beyond the scope of this study.

Lastly, researchers compared the radii calculations from CARS, HIS, and ARC. Each radius calculation is based on GPS data. For each method, the curve identification requires manual selection, however a very small percentage of HIS is based on an algorithm using the change in bearing recorded in the data points. The DBBI method does not require radius so it was excluded from these comparisons. The comparisons were used to evaluate the accuracy of radius for future research.

Scatter plots were again used to compare the radius from one method to the others. Again, a diagonal line at where y = x indicates similarity in the radii. Figures 9a through 9c show the results for each comparison.

Figure 9a. Scatter Plot of Radii from CARS and ARC

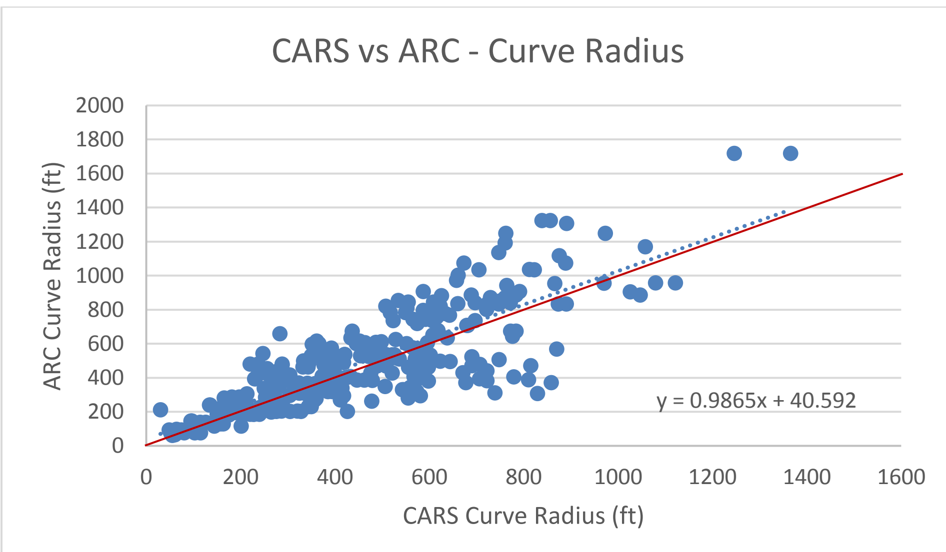


Figure 9b. Scatter Plot of Radii from CARS and HIS

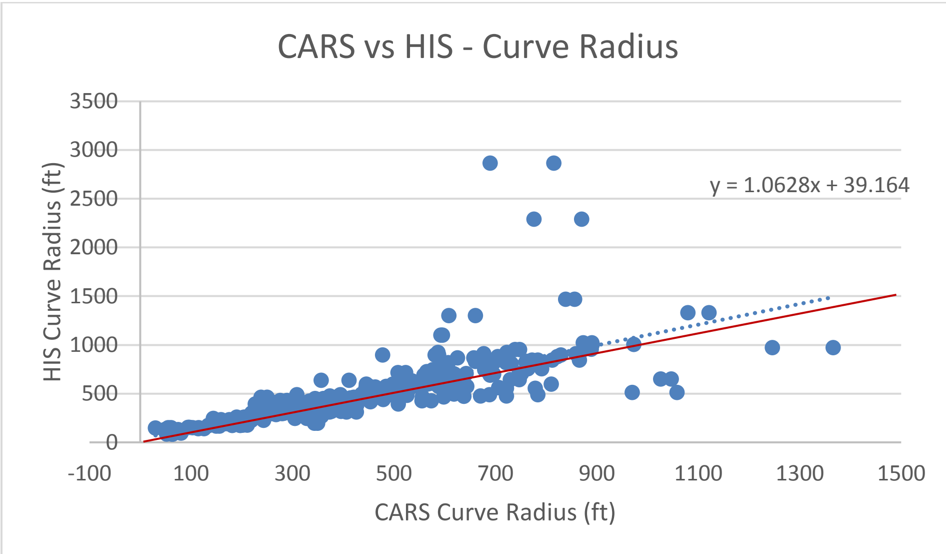
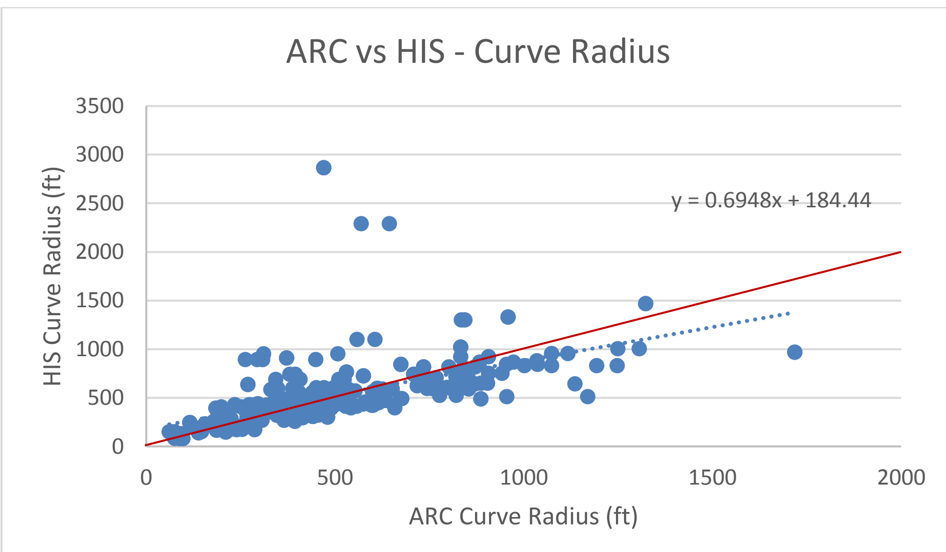



Figure 9c. Scatter Plot of Radii from ARC and HIS




As with previous comparisons, red and blue lines are used to compare the data points. Data obtained from the CARS is most similar to that derived from the ARC method. This is logical given that both methods require the manual detection of curves. This comparison also helps understand the consistency of radii calculations for future research.

# 5 Conclusions and Recommendations

The literature review, data review, and data analysis resulted in the following conclusions and recommendations.

- The DBBI method is an accurate but time-consuming method to set curve advisory speeds. In many cases, curves need to be re-run in excess of the four times recommended by the CARS system. Moreover, the DBBI method requires that each a single curve is evaluated several times in contrast to driving the entire route four times. This introduces the need to find a safe place to turn around – which can be very time-consuming.
- Due to its efficiency and accuracy, the CARS System is the best alternative to the DBBI method.
- To determine whether to replace the DBBI method with the CARS system, KYTC officials should perform a cost-benefit analysis.
- The CARS systems produces the greatest benefits when the curve frequency is high — for example, in regions with uneven topography with many horizontal curves. In areas with a low curve density, the DBBI or TRAMS methods could be a reasonable solution. As such, KYTC could consider a hybrid approach that uses both CARS and DBBI.
- District 4's modified TRAMS method should be investigated in more detail. It could potentially serve as a viable alternative to CARS — especially when curve frequency is low. It should be noted that District 4 is not a particularly mountainous district so its use in this type of road has not been tested.
- When choosing a curve assessment method, KYTC staff should be mindful of the amount of time that will be needed to complete an assessment. The CARS system minimizes and simplifies field data collection, while the DBBI method can require drivers to make several passes of each curve. This requires finding a safe location to turn around, which is often cited as the most difficult aspect of this method.

Future work should investigate potential errors in the DBBI method. Errors in this method can produce misleading comparisons to other methods. The HIS and ARC methods should still be researched as well. It is possible that, through calibration, the advisory speeds can be improved.

# 6 References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# 7 Acknowledgements

David Cain, Transportation Technologist

Chelsea Cason, Student Research Assistant

**APPENDIX A.**

LIST OF CURVES AND RESULTING ADVISORY SPEEDS

## APPENDIX A. LIST OF CURVES AND RESULTING ADVISORY SPEEDS

| | | | | | | | | | | | ADVISORY SPEED (MPH) | | | | RADIUS (FT) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ID | ROUTE | | COUNTY | BEG MP | END MP | CURVE CLASS | SIGN TYPE | PASS | TURN DIRECTION | SIGN | DBBI | CARS | HIS | ARC | CARS | HIS | ARC | MEDIAN SUPER |
| 1 | US | 60 | Clark | 15.740 | 15.790 | B | 1 | 3 | L | 55 | 55 | 55 | 55 | 50 | 1122 | 1332 | 958 | 0.02 |
| 2 | US | 60 | Clark | 15.890 | 15.930 | C | 3 | 3 | R | 40 | 45 | 45 | 50 | 45 | 565 | 725 | 575 | 0.05 |
| 3 | US | 60 | Clark | 15.970 | 16.010 | D | 3 | 3 | L | 40 | 40 | 40 | 45 | 40 | 644 | 573 | 494 | 0.04 |
| 4 | US | 60 | Clark | 16.060 | 16.090 | D | 1 | 3 | L | 40 | 40 | 40 | 50 | 45 | 602 | 590 | 534 | 0.07 |
| 5 | US | 60 | Clark | 16.210 | 16.260 | D | 1 | 3 | R | 40 | 40 | 40 | 45 | 50 | 463 | 458 | 580 | 0.08 |
| 6 | US | 60 | Clark | 16.680 | 16.750 | D | 1 | 3 | L | 40 | 40 | 45 | 45 | 50 | 611 | 609 | 768 | 0.04 |
| 7 | US | 68 | Mercer | 15.760 | 15.910 | C | 1 | 3 | R | 50 | 50 | 55 | 55 | 55 | 874 | 1023 | 833 | 0.05 |
| 8 | US | 68 | Mercer | 16.290 | 16.430 | D | 1 | 3 | R | 40 | 40 | 45 | 45 | 55 | 616 | 597 | 756 | 0.06 |
| 9 | US | 68 | Mercer | 16.860 | 17.050 | C | 1 | 3 | L | 45 | 45 | 50 | 55 | 55 | 857 | 1469 | 1323 | 0.00 |
| 10 | US | 68 | Mercer | 17.340 | 17.420 | E | 1 | 3 | R | 45 | 35 | 35 | 40 | 40 | 382 | 382 | 403 | 0.07 |
| 11 | US | 68 | Mercer | 17.550 | 17.640 | F | 5,2,2 | 3 | L | 25 | 25 | 25 | 25 | 30 | 179 | 182 | 252 | 0.04 |
| 12 | US | 68 | Mercer | 17.780 | 17.870 | C | 2 | 3 | R | | 50 | 50 | 55 | 55 | 772 | 807 | 841 | 0.06 |
| 13 | US | 68 | Mercer | 17.890 | 17.970 | E | 2 | 3 | R | 25 | 30 | 30 | 35 | 40 | 279 | 308 | 441 | 0.06 |
| 14 | US | 68 | Mercer | 18.030 | 18.110 | C | 3 | 3 | L | | 35 | 40 | 45 | 50 | 620 | 698 | 841 | 0.02 |
| 15 | US | 68 | Mercer | 18.110 | 18.190 | C | 3 | 3 | R | | 35 | 55 | 55 | 55 | 889 | 955 | 1074 | 0.07 |
| 16 | US | 68 | Mercer | 18.360 | 18.430 | E | 3 | 3 | L | 20 | 25 | 30 | 30 | 30 | 323 | 354 | 369 | 0.02 |
| 17 | US | 68 | Mercer | 18.460 | 18.540 | F | 5 | 3 | R | 20 | 25 | 25 | 25 | 30 | 202 | 176 | 254 | 0.05 |
| 18 | US | 68 | Mercer | 18.540 | 18.620 | F | 2 | 3 | L | 20 | 25 | 25 | 20 | 25 | 197 | 174 | 287 | 0.00 |
| 19 | US | 68 | Mercer | 19.330 | 19.390 | E | 3 | 3 | R | 35 | 30 | 35 | 40 | 30 | 546 | 585 | 330 | 0.02 |
| 20 | US | 68 | Mercer | 19.390 | 19.420 | E | 3 | 3 | L | 35 | 30 | 35 | 35 | 25 | 287 | 358 | 204 | 0.04 |
| 21 | US | 68 | Mercer | 19.960 | 20.040 | E | 2 | 3 | R | 25 | 30 | 30 | 35 | 30 | 268 | 345 | 291 | 0.06 |
| 22 | KY | 11 | Powell | 0.000 | 0.100 | E | 4 | 1 | R | 25 | 30 | 30 | 35 | 30 | 203 | 256 | 200 | 0.10 |
| 23 | KY | 11 | Powell | 0.100 | 0.260 | D | 4 | 1 | L | 25 | 40 | 40 | 45 | 40 | 381 | 421 | 338 | 0.09 |
| 24 | KY | 11 | Powell | 0.350 | 0.440 | D | 3N/4S | 1 | R | 35 | 40 | 40 | 45 | 40 | 447 | 458 | 387 | 0.08 |
| 25 | KY | 11 | Powell | 0.520 | 0.570 | D | 3N/4S | 1 | L | 35 | 40 | 45 | 40 | 40 | 521 | 507 | 427 | 0.05 |
| 26 | KY | 11 | Powell | 0.610 | 0.720 | E | 3 | 1 | R | 35 | 40 | 35 | 40 | 40 | 325 | 372 | 309 | 0.09 |
| 27 | KY | 11 | Powell | 0.750 | 0.850 | E | 3 | 1 | L | 35 | 35 | 35 | 35 | 30 | 268 | 285 | 224 | 0.09 |
| 28 | KY | 11 | Powell | 0.900 | 1.000 | E | 4N/3S | 1 | R | 25 | 30 | 30 | 35 | 25 | 220 | 277 | 185 | 0.08 |
| 29 | KY | 11 | Powell | 1.000 | 1.100 | D | 3N/4S | 1 | L | 25 | 40 | 45 | 30 | 30 | 509 | 485 | 469 | 0.00 |
| 30 | KY | 11 | Powell | 1.200 | 1.300 | E | 3N/4S | 1 | L | 35 | 35 | 30 | 40 | 35 | 272 | 303 | 284 | 0.10 |
| 31 | KY | 11 | Powell | 1.300 | 1.400 | C | 3 | 1 | R | 35 | 55 | 55 | 55 | 55 | 1246 | 971 | 1718 | 0.05 |

## APPENDIX A. LIST OF CURVES AND RESULTING ADVISORY SPEEDS

| | | | | | | | | | | | ADVISORY SPEED (MPH) | | | | RADIUS (FT) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ID | ROUTE | | COUNTY | BEG MP | END MP | CURVE CLASS | SIGN TYPE | PASS | TURN DIRECTION | SIGN | DBBI | CARS | HIS | ARC | CARS | HIS | ARC | MEDIAN SUPER |
| 32 | KY | 15 | Powell | 0.200 | 0.340 | E | 1 | 1 | L | 45 | 35 | 35 | 40 | 45 | 256 | 322 | 455 | 0.10 |
| 33 | KY | 15 | Powell | 0.400 | 0.650 | D | 1 | 1 | R | 45 | 40 | 45 | 45 | 50 | 752 | 707 | 852 | 0.03 |
| 34 | KY | 15 | Powell | 0.760 | 0.800 | E | 5 | 1 | L | 25 | 30 | 25 | 25 | 30 | 214 | 270 | 306 | 0.02 |
| 35 | KY | 15 | Powell | 0.850 | 0.900 | F | 5 | 1 | L | 25 | 15 | 15 | 15 | 20 | 64 | 83 | 97 | 0.06 |
| 36 | KY | 15 | Powell | 0.940 | 0.980 | F | 5 | 1 | R | 25 | 20 | 15 | 20 | 15 | 81 | 95 | 76 | 0.08 |
| 37 | KY | 15 | Powell | 1.010 | 1.050 | E | 5 | 1 | L | 25 | 30 | 25 | 30 | 30 | 263 | 363 | 297 | 0.03 |
| 38 | KY | 15 | Powell | 1.080 | 1.100 | F | 5 | 1 | R | 25 | 15 | 10 | 25 | 20 | 49 | 131 | 93 | 0.08 |
| 39 | KY | 15 | Powell | 1.110 | 1.140 | E | 5 | 1 | R | 25 | 30 | 30 | 30 | 25 | 426 | 310 | 202 | 0.05 |
| 40 | KY | 15 | Powell | 1.160 | 1.190 | E | 5 | 1 | L | 25 | 30 | 20 | 35 | 25 | 240 | 395 | 184 | 0.03 |
| 41 | KY | 15 | Powell | 1.250 | 1.330 | E | 5 | 1 | L | 25 | 30 | 30 | 35 | 40 | 230 | 258 | 394 | 0.09 |
| 42 | KY | 15 | Powell | 1.330 | 1.380 | E | 5 | 1 | R | 25 | 30 | 30 | 35 | 40 | 280 | 294 | 360 | 0.10 |
| 43 | KY | 15 | Powell | 1.400 | 1.430 | E | 5 | 1 | L | 25 | 35 | 35 | 40 | 40 | 342 | 390 | 367 | 0.07 |
| 44 | KY | 15 | Powell | 1.760 | 1.830 | D | 5 | 1 | L | 25 | 40 | 40 | 45 | 50 | 498 | 503 | 609 | 0.07 |
| 45 | KY | 15 | Powell | 2.660 | 2.730 | D | 1 | 1 | L | 45 | 40 | 45 | 40 | 55 | 689 | 490 | 886 | 0.05 |
| 46 | KY | 15 | Powell | 2.790 | 2.860 | D | 1 | 1 | R | 45 | 40 | 40 | 50 | 50 | 485 | 573 | 553 | 0.09 |
| 47 | KY | 15 | Powell | 2.940 | 3.080 | D | 1 | 1 | L | 35 | 35 | 40 | 45 | 50 | 421 | 428 | 536 | 0.09 |
| 48 | KY | 44 | Bullitt | 6.960 | 7.150 | D | 1 | 3 | L | 40 | 40 | 40 | 40 | 50 | 366 | 424 | 601 | 0.07 |
| 49 | KY | 44 | Bullitt | 7.990 | 8.150 | D | 5 | 3 | R | 35 | 45 | 45 | 50 | 55 | 517 | 585 | 783 | 0.09 |
| 50 | KY | 44 | Bullitt | 8.200 | 8.300 | E | 5 | 3 | L | 25 | 35 | 25 | 35 | 40 | 377 | 318 | 475 | 0.05 |
| 51 | KY | 44 | Bullitt | 8.350 | 8.380 | D | 5 | 3 | R | 35 | 55 | 50 | 45 | 40 | 536 | 630 | 510 | 0.05 |
| 52 | KY | 44 | Bullitt | 8.460 | 8.490 | E | 5 | 3 | R | 35 | 30 | 25 | 30 | 30 | 219 | 226 | 213 | 0.08 |
| 53 | KY | 44 | Bullitt | 8.510 | 8.570 | E | 5 | 3 | L | 35 | 30 | 35 | 40 | 45 | 343 | 347 | 463 | 0.08 |
| 54 | KY | 44 | Bullitt | 8.590 | 8.630 | E | 5 | 3 | R | 35 | 30 | 30 | 40 | 40 | 250 | 363 | 337 | 0.11 |
| 55 | KY | 44 | Bullitt | 8.710 | 8.800 | C | 5 | 3 | L | 35 | 45 | 45 | 45 | 50 | 764 | 754 | 942 | 0.02 |
| 56 | KY | 87 | Barren | 10.650 | 10.760 | D | 1 | 1 | R | 35 | 40 | 45 | 50 | 55 | 529 | 591 | 625 | 0.08 |
| 57 | KY | 87 | Barren | 10.870 | 11.000 | C | NA | 1 | R | 55 | 55 | 55 | 55 | 50 | 773 | 843 | 674 | 0.07 |
| 58 | KY | 87 | Barren | 11.200 | 11.250 | E | 5 | 1 | L | 25 | 40 | 40 | 45 | 40 | 348 | 404 | 282 | 0.11 |
| 59 | KY | 87 | Barren | 11.330 | 11.430 | D | NA | 1 | R | | 35 | 50 | 50 | 45 | 623 | 603 | 497 | 0.08 |
| 60 | KY | 87 | Barren | 11.460 | 11.560 | E | 5 | 1 | L | 25 | 40 | 35 | 40 | 35 | 262 | 295 | 275 | 0.10 |
| 61 | KY | 87 | Barren | 11.660 | 11.730 | D | 5 | 1 | R | 25 | 45 | 40 | 50 | 50 | 472 | 546 | 525 | 0.08 |
| 62 | KY | 87 | Barren | 11.990 | 12.060 | C | 5 | 1 | R | 25 | 55 | 50 | 55 | 50 | 599 | 764 | 530 | 0.10 |

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| | | | | | | | | | | | ADVISORY SPEED (MPH) | | | | RADIUS (FT) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ID | ROUTE | | COUNTY | BEG MP | END MP | CURVE CLASS | SIGN TYPE | PASS | TURN DIRECTION | SIGN | DBBI | CARS | HIS | ARC | CARS | HIS | ARC | MEDIAN SUPER |
| 63 | KY | 87 | Barren | 12.090 | 12.170 | C | NA | 1 | L | | 55 | 50 | 55 | 50 | 681 | 744 | 708 | 0.06 |
| 64 | KY | 122 | Floyd | 29.700 | 29.820 | E | 3 | 3 | L | 35 | 30 | 30 | 35 | 40 | 283 | 298 | 404 | 0.06 |
| 65 | KY | 122 | Floyd | 29.920 | 29.990 | D | 1 | 3 | R | 35 | 40 | 40 | 50 | 45 | 529 | 541 | 517 | 0.08 |
| 66 | KY | 122 | Floyd | 30.160 | 30.220 | C | 1 | 3 | R | 35 | 50 | 45 | 55 | 55 | 617 | 707 | 768 | 0.08 |
| 67 | KY | 122 | Floyd | 30.450 | 30.510 | D | 3 | 3 | L | 35 | 40 | 35 | 35 | 40 | 552 | 562 | 600 | 0.01 |
| 68 | KY | 122 | Floyd | 30.510 | 30.550 | C | 3 | 3 | R | 35 | 55 | 55 | 55 | 50 | 690 | 2865 | 470 | 0.10 |
| 69 | KY | 122 | Floyd | 31.120 | 31.160 | F | 2 | 3 | L | 20 | 20 | 10 | 20 | 20 | 97 | 153 | 147 | 0.02 |
| 70 | KY | 122 | Floyd | 32.060 | 32.130 | C | 3 | 3 | L | | 45 | 50 | 45 | 45 | 823 | 881 | 1035 | 0.00 |
| 71 | KY | 122 | Floyd | 32.330 | 32.380 | D | NA | 3 | L | 40 | 45 | 40 | 35 | 35 | 556 | 467 | 462 | 0.02 |
| 72 | KY | 122 | Floyd | 32.720 | 32.820 | D | NA | 3 | L | | 40 | 35 | 35 | 40 | 638 | 474 | 634 | 0.02 |
| 73 | KY | 122 | Floyd | 32.830 | 32.870 | F | NA | 3 | R | | 25 | 25 | 30 | 35 | 166 | 204 | 281 | 0.10 |
| 74 | KY | 122 | Floyd | 33.020 | 33.060 | F | 5 | 3 | L | 20 | 30 | 25 | 25 | 30 | 172 | 193 | 231 | 0.06 |
| 75 | KY | 122 | Floyd | 33.110 | 33.170 | F | 5 | 3 | R | 20 | 25 | 15 | 25 | 25 | 115 | 142 | 138 | 0.08 |
| 76 | KY | 122 | Floyd | 33.210 | 33.250 | F | 5 | 3 | L | 20 | 25 | 20 | 25 | 20 | 157 | 191 | 128 | 0.04 |
| 77 | KY | 122 | Floyd | 33.370 | 33.460 | D | 5 | 3 | L | 20 | 30 | 40 | 35 | 30 | 395 | 418 | 318 | 0.04 |
| 78 | KY | 122 | Floyd | 33.810 | 33.850 | F | 5 | 3 | R | 20 | 20 | 10 | 15 | 15 | 52 | 86 | 75 | 0.07 |
| 79 | KY | 152 | Mercer | 0.000 | 0.270 | F | 5 | 3 | R | 20 | 20 | 25 | 20 | 25 | | 148 | 211 | 0.02 |
| 80 | KY | 152 | Mercer | 0.290 | 0.350 | E | | 3 | L | | 30 | 30 | 25 | 30 | 304 | 302 | 416 | 0.01 |
| 81 | KY | 152 | Mercer | 0.360 | 0.420 | E | | 3 | R | | 35 | 40 | 40 | 55 | 283 | 398 | 658 | 0.08 |
| 82 | KY | 152 | Mercer | 0.430 | 0.550 | D | | 3 | L | | 35 | 40 | 40 | 50 | 634 | 526 | 777 | 0.03 |
| 83 | KY | 152 | Mercer | 0.830 | 0.910 | C | 1 | 3 | L | 50 | 45 | 50 | 55 | 55 | 658 | 868 | 973 | 0.05 |
| 84 | KY | 152 | Mercer | 1.140 | 1.240 | E | 2 | 3 | R | 30 | 35 | 35 | 40 | 45 | 288 | 403 | 475 | 0.07 |
| 85 | KY | 152 | Mercer | 1.380 | 1.440 | D | 3 | 3 | L | 35 | 35 | 35 | 40 | 40 | 345 | 451 | 488 | 0.05 |
| 86 | KY | 152 | Mercer | 1.890 | 2.000 | D | 3 | 3 | L | 35 | 40 | 45 | 45 | 40 | 508 | 567 | 536 | 0.04 |
| 87 | KY | 153 | Mercer | 2.040 | 2.230 | D | 3 | 3 | R | | 40 | 50 | 55 | 55 | 1026 | 651 | 904 | 0.08 |
| 88 | KY | 152 | Mercer | 2.490 | 2.640 | D | 3 | 3 | L | 40 | 40 | 45 | 40 | 45 | 619 | 494 | 677 | 0.04 |
| 89 | KY | 152 | Mercer | 2.890 | 3.110 | C | 3 | 3 | R | 45 | 45 | 55 | 55 | 55 | 761 | 830 | 1193 | 0.08 |
| 90 | KY | 152 | Mercer | 3.830 | 4.000 | D | 3 | 3 | L | 40 | 40 | 40 | 50 | 55 | 553 | 591 | 810 | 0.07 |
| 91 | KY | 152 | Mercer | 4.000 | 4.110 | D | 3 | 3 | R | | 40 | 45 | 45 | 50 | 526 | 481 | 534 | 0.09 |
| 92 | KY | 152 | Mercer | 4.870 | 4.970 | D | 3 | 3 | R | | 45 | 40 | 45 | 50 | 386 | 437 | 532 | 0.08 |
| 93 | KY | 152 | Mercer | 5.190 | 5.290 | C | 3 | 3 | L | 35 | 40 | 50 | 55 | 55 | 661 | 1302 | 835 | 0.06 |

## APPENDIX A. LIST OF CURVES AND RESULTING ADVISORY SPEEDS

| | | | | | | | | | | | ADVISORY SPEED (MPH) | | | | RADIUS (FT) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ID | ROUTE | | COUNTY | BEG MP | END MP | CURVE CLASS | SIGN TYPE | PASS | TURN DIRECTION | SIGN | DBBI | CARS | HIS | ARC | CARS | HIS | ARC | MEDIAN SUPER |
| 94 | KY | 152 | Mercer | 5.480 | 5.560 | C | 5 | 3 | R | | 50 | 55 | 55 | 55 | 761 | 819 | 871 | 0.09 |
| 95 | KY | 152 | Mercer | 5.820 | 5.990 | D | 5 | 3 | R | | 50 | 55 | 55 | 55 | 730 | 644 | 871 | 0.08 |
| 96 | KY | 152 | Mercer | 6.020 | 6.100 | D | 5 | 3 | L | 40 | 40 | 45 | 45 | 50 | 574 | 623 | 718 | 0.05 |
| 97 | KY | 152 | Mercer | 6.680 | 6.730 | C | 5 | 3 | L | 45 | 45 | 45 | 45 | 40 | 697 | 819 | 735 | 0.00 |
| 98 | KY | 152 | Mercer | 7.440 | 7.550 | C | 1 | 3 | L | | 50 | 55 | 50 | 55 | 973 | 1005 | 1249 | 0.02 |
| 99 | KY | 152 | Mercer | 7.860 | 7.950 | C | 1 | 3 | R | 40 | 45 | 45 | 55 | 55 | 523 | 716 | 735 | 0.07 |
| 101 | KY | 420 | Franklin | 1.490 | 1.560 | E | 5 | 1 | L | 35 | 35 | 35 | 40 | 40 | 355 | 363 | 320 | 0.09 |
| 102 | KY | 420 | Franklin | 1.590 | 1.650 | E | 2 | 1 | R | 25 | 25 | 25 | 35 | 25 | 160 | 232 | 155 | 0.11 |
| 103 | KY | 420 | Franklin | 1.710 | 1.800 | D | 1 | 1 | L | 35 | 40 | 40 | 45 | 40 | 433 | 462 | 406 | 0.08 |
| 104 | KY | 420 | Franklin | 1.880 | 1.940 | C | 3 | 1 | R | 35 | 40 | 45 | 55 | 40 | 568 | 690 | 407 | 0.07 |
| 105 | KY | 420 | Franklin | 1.950 | 2.010 | E | 3 | 1 | L | 35 | 35 | 35 | 40 | 35 | 350 | 401 | 313 | 0.09 |
| 106 | KY | 420 | Franklin | 2.040 | 2.100 | E | 1 | 1 | R | 35 | 35 | 35 | 40 | 35 | 353 | 356 | 265 | 0.07 |
| 107 | KY | 1189 | Laurel | 1.420 | 1.460 | F | 2 | 3 | R | 20 | 25 | 20 | 25 | 30 | 134 | 175 | 240 | 0.08 |
| 108 | KY | 1189 | Laurel | 1.870 | 1.920 | D | 2 | 3 | L | 30 | 30 | 35 | 35 | 40 | 454 | 418 | 528 | 0.04 |
| 109 | KY | 1189 | Laurel | 2.100 | 2.170 | D | 3 | 3 | L | 35 | 40 | 45 | 45 | 50 | 592 | 597 | 744 | 0.03 |
| 110 | KY | 1189 | Laurel | 2.200 | 2.240 | F | 2 | 3 | R | 20 | 25 | 25 | 25 | 30 | 156 | 167 | 186 | 0.09 |
| 111 | KY | 1355 | Garrard | 0.840 | 0.890 | E | | 3 | L | | 30 | 35 | 35 | 40 | 237 | 303 | 480 | 0.06 |
| 112 | KY | 1355 | Garrard | 1.060 | 1.110 | D | 1 | 3 | R | 40 | 40 | 40 | 50 | 40 | 360 | 424 | 276 | 0.13 |
| 113 | KY | 1355 | Garrard | 1.420 | 4.490 | D | 1 | 3 | L | 30 | 30 | 30 | 35 | 35 | 238 | 462 | 444 | 0.03 |
| 114 | KY | 1355 | Garrard | 1.900 | 1.940 | D | 1 | 3 | R | 45 | 45 | 40 | 50 | 55 | 401 | 441 | 529 | 0.12 |
| 115 | KY | 1355 | Garrard | 2.350 | 2.420 | E | 2 | 3 | L | 30 | 40 | 45 | 50 | 45 | 723 | 924 | 833 | 0.01 |
| 116 | KY | 1355 | Garrard | 2.470 | 2.540 | E | | 3 | L | | 30 | 30 | 30 | 25 | 328 | 247 | 202 | 0.05 |
| 117 | KY | 1355 | Garrard | 2.860 | 2.920 | F | 1 | 3 | R | 20 | 15 | 10 | 30 | 20 | 144 | 247 | 116 | 0.05 |
| 118 | KY | 1355 | Garrard | 3.140 | 3.200 | E | 1 | 3 | L | 35 | 35 | 35 | 25 | 30 | 407 | 310 | 404 | 0.01 |
| 119 | KY | 1355 | Garrard | 3.490 | 3.560 | E | 3 | 3 | L | 25 | 25 | 20 | 25 | 25 | 164 | 217 | 235 | 0.03 |
| 120 | KY | 1355 | Garrard | 3.980 | 4.060 | E | 2 | 3 | R | 30 | 30 | 30 | 35 | 40 | 270 | 311 | 377 | 0.08 |
| 121 | KY | 1355 | Garrard | 4.110 | 4.250 | C | 1 | 3 | L | 45 | 50 | 55 | 50 | 55 | 812 | 843 | 1036 | 0.03 |
| 122 | KY | 1355 | Garrard | 4.450 | 4.520 | D | 1 | 3 | R | 40 | 40 | 40 | 50 | 50 | 498 | 597 | 612 | 0.07 |
| 123 | KY | 1355 | Garrard | 4.740 | 4.830 | B | 1 | 3 | R | | 45 | 45 | 55 | 50 | 593 | 1102 | 559 | 0.08 |
| 124 | KY | 1355 | Garrard | 5.860 | 5.920 | E | 2 | 3 | L | 30 | 30 | 25 | 25 | 25 | 261 | 302 | 294 | 0.00 |
| 125 | KY | 1355 | Garrard | 6.050 | 6.180 | D | 3 | 3 | L | 35 | 35 | 35 | 30 | 35 | 385 | 415 | 529 | 0.00 |

## APPENDIX A. LIST OF CURVES AND RESULTING ADVISORY SPEEDS

| | | | | | | | | | | | ADVISORY SPEED (MPH) | | | | RADIUS (FT) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ID | ROUTE | | COUNTY | BEG MP | END MP | CURVE CLASS | SIGN TYPE | PASS | TURN DIRECTION | SIGN | DBBI | CARS | HIS | ARC | CARS | HIS | ARC | MEDIAN SUPER |
| 126 | KY | 1355 | Garrard | 6.180 | 6.320 | E | 3 | 3 | R | | 35 | 35 | 40 | 45 | 509 | 395 | 490 | 0.06 |
| 127 | KY | 1355 | Garrard | 6.700 | 6.810 | F | 2 | 3 | R | 25 | 25 | 30 | 25 | 25 | 350 | 198 | 231 | 0.04 |
| 128 | KY | 1355 | Garrard | 6.870 | 6.940 | D | 1 | 3 | L | 35 | 35 | 35 | 45 | 35 | | 651 | 385 | 0.05 |
| 129 | KY | 1355 | Garrard | 7.060 | 7.140 | D | 3 | 3 | R | 40 | 40 | 50 | 40 | 35 | 722 | 477 | 382 | 0.05 |
| 130 | KY | 1355 | Garrard | 7.490 | 7.550 | D | 2 | 3 | R | 30 | 35 | 30 | 40 | 30 | 276 | 431 | 273 | 0.06 |
| 131 | KY | 1355 | Garrard | 7.880 | 7.950 | C | 1 | 3 | L | 40 | 40 | 35 | 50 | 30 | 829 | 895 | 308 | 0.03 |
| 132 | KY | 1355 | Garrard | 8.370 | 8.410 | D | 1 | 3 | R | 40 | 40 | 45 | 45 | 35 | 507 | 597 | 348 | 0.04 |
| 133 | KY | 1355 | Garrard | 9.000 | 9.060 | D | 1 | 3 | L | 45 | 45 | 55 | 40 | 35 | 707 | 562 | 394 | 0.04 |
| 134 | KY | 1355 | Garrard | 9.370 | 9.440 | D | 1 | 3 | L | 45 | 45 | 45 | 40 | 35 | 580 | 603 | 451 | 0.02 |
| 135 | KY | 1355 | Garrard | 9.640 | 9.730 | D | 1 | 3 | R | 35 | 40 | 45 | 40 | 30 | 556 | 428 | 282 | 0.05 |
| 136 | KY | 1355 | Garrard | 9.790 | 9.870 | F | 3 | 3 | R | 35 | 35 | 30 | 35 | 35 | 314 | 322 | 347 | 0.06 |
| 137 | KY | 1355 | Garrard | 10.030 | 10.200 | D | 1 | 3 | L | 35 | 35 | 35 | 35 | 30 | 404 | 444 | 374 | 0.01 |
| 138 | KY | 1973 | Fayette | 0.230 | 0.270 | D | | 1 | L | | 35 | 35 | 40 | 25 | 357 | 637 | 269 | 0.01 |
| 139 | KY | 1973 | Fayette | 0.430 | 0.490 | D | | 1 | R | | 40 | 35 | 45 | 40 | 395 | 490 | 363 | 0.08 |
| 140 | KY | 1973 | Fayette | 0.610 | 0.690 | D | | 1 | L | | 35 | 40 | 45 | 40 | 392 | 477 | 409 | 0.07 |
| 141 | KY | 1973 | Fayette | 0.840 | 0.880 | C | | 1 | R | | 55 | 45 | 55 | 35 | 677 | 909 | 372 | 0.03 |
| 142 | KY | 1973 | Fayette | 1.320 | 1.370 | C | | 1 | R | | 40 | 40 | 55 | 30 | 478 | 895 | 262 | 0.04 |
| 143 | KY | 1973 | Fayette | 1.970 | 2.000 | F | | 1 | L | 20 | 15 | 15 | 20 | 10 | 61 | 151 | 65 | 0.02 |
| 144 | KY | 1973 | Fayette | 2.010 | 2.040 | F | 4 | 1 | R | 20 | 20 | 15 | 20 | 15 | 115 | 151 | 75 | 0.06 |
| 145 | KY | 1973 | Fayette | 2.960 | 3.010 | E | | 1 | R | | 30 | 30 | 40 | 25 | 265 | 406 | 199 | 0.05 |
| 146 | KY | 1973 | Fayette | 3.620 | 3.690 | C | | 1 | R | | 40 | 40 | 50 | 35 | 598 | 744 | 380 | 0.04 |
| 147 | KY | 1973 | Fayette | 4.270 | 4.310 | D | | 1 | R | | 40 | 45 | 40 | 35 | 722 | 556 | 441 | 0.04 |
| 148 | KY | 1973 | Fayette | 5.120 | 5.150 | C | | 1 | L | | 35 | 40 | 50 | 25 | 739 | 954 | 311 | 0.01 |
| 149 | KY | 1973 | Fayette | 7.360 | 7.410 | A | | 1 | L | | 50 | 50 | 55 | 35 | 776 | 2291 | 644 | 0.00 |
| 150 | KY | 1973 | Fayette | 9.740 | 9.780 | C | | 1 | R | 45 | 50 | 45 | 55 | 45 | 570 | 690 | 510 | 0.08 |
| 151 | KY | 1973 | Fayette | 11.180 | 11.310 | D | | 1 | L | | 40 | 50 | 40 | 50 | 970 | 512 | 955 | 0.02 |
| 152 | KY | 1973 | Fayette | 11.350 | 11.400 | E | | 1 | R | 25 | 25 | 25 | 30 | 30 | 205 | 258 | 203 | 0.07 |
| 153 | KY | 1973 | Fayette | 11.490 | 11.540 | D | | 1 | R | 35 | 40 | 40 | 45 | 40 | 479 | 441 | 384 | 0.08 |
| 154 | KY | 1973 | Fayette | 11.650 | 11.770 | D | | 1 | L | 35 | 35 | 35 | 40 | 35 | 396 | 455 | 344 | 0.05 |
| 155 | US | 60 | Clark | 15.740 | 15.790 | B | 1 | 4 | R | 55 | 55 | 55 | 55 | 55 | 1080 | 1332 | 958 | 0.05 |
| 156 | US | 60 | Clark | 15.890 | 15.930 | C | 3 | 4 | L | 40 | 45 | 45 | 55 | 45 | 588 | 725 | 575 | 0.06 |

## APPENDIX A. LIST OF CURVES AND RESULTING ADVISORY SPEEDS

| | | | | | | | | | | | ADVISORY SPEED (MPH) | | | | RADIUS (FT) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ID | ROUTE | | COUNTY | BEG MP | END MP | CURVE CLASS | SIGN TYPE | PASS | TURN DIRECTION | SIGN | DBBI | CARS | HIS | ARC | CARS | HIS | ARC | MEDIAN SUPER |
| 157 | US | 60 | Clark | 15.970 | 16.010 | D | 3 | 4 | R | 40 | 40 | 45 | 45 | 40 | 588 | 573 | 494 | 0.04 |
| 158 | US | 60 | Clark | 16.060 | 16.090 | D | 1 | 4 | R | 40 | 40 | 45 | 55 | 50 | 586 | 590 | 534 | 0.09 |
| 159 | US | 60 | Clark | 16.210 | 16.260 | D | 1 | 4 | L | 40 | 40 | 40 | 45 | 50 | 457 | 458 | 580 | 0.07 |
| 160 | US | 60 | Clark | 16.680 | 16.750 | D | 1 | 4 | R | 40 | 40 | 40 | 50 | 55 | 587 | 609 | 797 | 0.06 |
| 161 | US | 68 | Mercer | 15.760 | 15.910 | C | 1 | 4 | L | 50 | 50 | 55 | 50 | 45 | 890 | 1023 | 833 | 0.01 |
| 162 | US | 68 | Mercer | 16.290 | 16.430 | D | 1 | 4 | L | 35 | 35 | 40 | 40 | 45 | 607 | 597 | 756 | 0.01 |
| 163 | US | 68 | Mercer | 16.860 | 17.050 | C | 1 | 4 | R | 40 | 45 | 50 | 55 | 55 | 839 | 1469 | 1323 | 0.04 |
| 164 | US | 68 | Mercer | 17.340 | 17.420 | E | 1 | 4 | L | 45 | 35 | 35 | 30 | 30 | 427 | 382 | 403 | 0.01 |
| 165 | US | 68 | Mercer | 17.550 | 17.640 | F | 5,2,2 | 4 | R | 20 | 25 | 25 | 25 | 30 | 184 | 182 | 227 | 0.08 |
| 166 | US | 68 | Mercer | 17.780 | 17.870 | C | 2 | 4 | L | | 50 | 50 | 50 | 50 | 731 | 807 | 841 | 0.03 |
| 167 | US | 68 | Mercer | 17.890 | 17.970 | E | 2 | 4 | L | 25 | 30 | 30 | 30 | 35 | 288 | 308 | 441 | 0.02 |
| 168 | US | 68 | Mercer | 18.030 | 18.110 | C | 3 | 4 | R | 25 | 30 | 45 | 45 | 50 | 697 | 698 | 841 | 0.03 |
| 169 | US | 68 | Mercer | 18.110 | 18.190 | C | 3 | 4 | L | | 40 | 55 | 50 | 50 | 875 | 955 | 1117 | 0.01 |
| 170 | US | 68 | Mercer | 18.360 | 18.430 | E | 3 | 4 | R | 20 | 25 | 30 | 35 | 30 | 343 | 354 | 323 | 0.04 |
| 171 | US | 68 | Mercer | 18.460 | 18.540 | F | 5 | 4 | L | 20 | 25 | 25 | 20 | 25 | 211 | 176 | 254 | 0.01 |
| 172 | US | 68 | Mercer | 18.540 | 18.620 | F | 2 | 4 | R | 20 | 25 | 25 | 20 | 30 | 181 | 174 | 287 | 0.04 |
| 173 | US | 68 | Mercer | 19.330 | 19.390 | E | 3 | 4 | L | | 30 | 35 | 40 | 30 | 543 | 585 | 330 | 0.03 |
| 174 | US | 68 | Mercer | 19.390 | 19.420 | E | 3 | 4 | R | | 30 | 35 | 40 | 30 | 321 | 358 | 204 | 0.07 |
| 175 | US | 68 | Mercer | 19.960 | 20.040 | E | 2 | 4 | L | | 30 | 25 | 30 | 30 | 256 | 345 | 291 | 0.03 |
| 176 | KY | 11 | Powell | 0.000 | 0.100 | E | 4 | 2 | L | 25 | 30 | 30 | 35 | 30 | 207 | 256 | 200 | 0.11 |
| 177 | KY | 11 | Powell | 0.100 | 0.260 | D | 4 | 2 | R | 25 | 40 | 40 | 40 | 35 | 371 | 421 | 338 | 0.06 |
| 178 | KY | 11 | Powell | 0.350 | 0.440 | D | 3N/4S | 2 | L | 35 | 40 | 40 | 50 | 45 | 463 | 458 | 387 | 0.10 |
| 179 | KY | 11 | Powell | 0.520 | 0.570 | D | 3N/4S | 2 | R | 35 | 40 | 40 | 40 | 35 | 476 | 507 | 427 | 0.04 |
| 180 | KY | 11 | Powell | 0.610 | 0.720 | E | 3 | 2 | L | 35 | 40 | 40 | 45 | 40 | 357 | 372 | 309 | 0.11 |
| 181 | KY | 11 | Powell | 0.750 | 0.850 | E | 3 | 2 | R | 35 | 35 | 30 | 35 | 30 | 241 | 285 | 224 | 0.07 |
| 182 | KY | 11 | Powell | 0.900 | 1.000 | E | 4N/3S | 2 | L | 25 | 30 | 25 | 30 | 25 | 228 | 277 | 185 | 0.06 |
| 183 | KY | 11 | Powell | 1.000 | 1.100 | D | 3N/4S | 2 | R | 25 | 40 | 45 | 40 | 35 | 489 | 485 | 469 | 0.03 |
| 184 | KY | 11 | Powell | 1.200 | 1.300 | E | 3N/4S | 2 | R | 35 | 35 | 30 | 35 | 35 | 265 | 303 | 284 | 0.07 |
| 185 | KY | 11 | Powell | 1.300 | 1.400 | C | 3 | 2 | L | 35 | 55 | 55 | 55 | 55 | 1366 | 971 | 1718 | 0.07 |
| 186 | KY | 15 | Powell | 0.200 | 0.340 | E | 1 | 2 | R | 45 | 35 | 35 | 40 | 45 | 264 | 322 | 433 | 0.11 |
| 187 | KY | 15 | Powell | 0.400 | 0.650 | D | 1 | 2 | L | 45 | 30 | 45 | 45 | 50 | 747 | 707 | 833 | 0.03 |

## APPENDIX A. LIST OF CURVES AND RESULTING ADVISORY SPEEDS

| | | | | | | | | | | | ADVISORY SPEED (MPH) | | | | RADIUS (FT) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ID | ROUTE | | COUNTY | BEG MP | END MP | CURVE CLASS | SIGN TYPE | PASS | TURN DIRECTION | SIGN | DBBI | CARS | HIS | ARC | CARS | HIS | ARC | MEDIAN SUPER |
| 188 | KY | 15 | Powell | 0.760 | 0.800 | E | 5 | 2 | R | 25 | 35 | 25 | 30 | 35 | 358 | 270 | 365 | 0.04 |
| 189 | KY | 15 | Powell | 0.850 | 0.900 | F | 5 | 2 | R | 25 | 20 | 15 | 15 | 20 | 63 | 83 | 87 | 0.08 |
| 190 | KY | 15 | Powell | 0.940 | 0.980 | F | 5 | 2 | L | 25 | 20 | 15 | 20 | 15 | 67 | 95 | 76 | 0.07 |
| 191 | KY | 15 | Powell | 1.010 | 1.050 | E | 5 | 2 | R | 25 | 35 | 25 | 35 | 35 | 304 | 363 | 297 | 0.06 |
| 192 | KY | 15 | Powell | 1.080 | 1.100 | F | 5 | 2 | L | 25 | 20 | 15 | 20 | 15 | 75 | 131 | 93 | 0.06 |
| 193 | KY | 15 | Powell | 1.110 | 1.140 | E | 5 | 2 | L | 25 | 30 | 30 | 30 | 25 | 276 | 310 | 202 | 0.05 |
| 194 | KY | 15 | Powell | 1.160 | 1.190 | E | 5 | 2 | R | 25 | 30 | 25 | 40 | 25 | 227 | 395 | 184 | 0.06 |
| 195 | KY | 15 | Powell | 1.250 | 1.330 | E | 5 | 2 | R | 25 | 35 | 30 | 35 | 40 | 231 | 258 | 394 | 0.08 |
| 196 | KY | 15 | Powell | 1.330 | 1.380 | E | 5 | 2 | L | 25 | 35 | 35 | 40 | 45 | 301 | 294 | 414 | 0.11 |
| 197 | KY | 15 | Powell | 1.400 | 1.430 | E | 5 | 2 | R | 25 | 30 | 35 | 40 | 35 | 353 | 390 | 307 | 0.07 |
| 198 | KY | 15 | Powell | 1.760 | 1.830 | D | 5 | 2 | R | 25 | 50 | 45 | 45 | 50 | 487 | 503 | 609 | 0.08 |
| 199 | KY | 15 | Powell | 2.660 | 2.730 | D | 1 | 2 | R | 45 | 50 | 40 | 40 | 55 | 784 | 490 | 886 | 0.06 |
| 200 | KY | 15 | Powell | 2.790 | 2.860 | D | 1 | 2 | L | 45 | 35 | 40 | 55 | 55 | 452 | 573 | 616 | 0.11 |
| 201 | KY | 15 | Powell | 2.940 | 3.080 | D | 1 | 2 | R | 35 | 40 | 40 | 45 | 50 | 421 | 428 | 536 | 0.09 |
| 202 | KY | 44 | Bullitt | 6.960 | 7.150 | D | 1 | 4 | R | 40 | 40 | 40 | 45 | 55 | 352 | 424 | 597 | 0.10 |
| 203 | KY | 44 | Bullitt | 7.990 | 8.150 | D | 5 | 4 | L | 35 | 45 | 45 | 50 | 55 | 550 | 585 | 783 | 0.06 |
| 204 | KY | 44 | Bullitt | 8.200 | 8.300 | E | 5 | 4 | R | 35 | 35 | 40 | 35 | 45 | 396 | 318 | 475 | 0.09 |
| 205 | KY | 44 | Bullitt | 8.350 | 8.380 | D | 5 | 4 | L | 35 | 45 | 45 | 45 | 40 | 577 | 630 | 521 | 0.05 |
| 206 | KY | 44 | Bullitt | 8.460 | 8.490 | E | 5 | 4 | L | 35 | 30 | 25 | 30 | 30 | 243 | 226 | 213 | 0.07 |
| 207 | KY | 44 | Bullitt | 8.510 | 8.570 | E | 5 | 4 | R | 35 | 40 | 40 | 40 | 45 | 332 | 347 | 463 | 0.10 |
| 208 | KY | 44 | Bullitt | 8.590 | 8.630 | E | 5 | 4 | L | 35 | 25 | 30 | 40 | 40 | 263 | 363 | 337 | 0.09 |
| 209 | KY | 44 | Bullitt | 8.710 | 8.800 | C | 5 | 4 | R | 35 | 55 | 50 | 50 | 55 | 791 | 754 | 907 | 0.05 |
| 210 | KY | 87 | Barren | 10.650 | 10.760 | D | 1 | 2 | L | 30 | 45 | 45 | 50 | 50 | 608 | 591 | 651 | 0.07 |
| 211 | KY | 87 | Barren | 10.870 | 11.000 | C | NA | 2 | L | 55 | 55 | 55 | 55 | 50 | 784 | 843 | 674 | 0.05 |
| 212 | KY | 87 | Barren | 11.200 | 11.250 | E | 5 | 2 | R | 25 | 40 | 40 | 45 | 40 | 349 | 404 | 282 | 0.12 |
| 213 | KY | 87 | Barren | 11.330 | 11.430 | D | NA | 2 | L | | 35 | 45 | 50 | 45 | 571 | 603 | 497 | 0.08 |
| 214 | KY | 87 | Barren | 11.460 | 11.560 | E | 5 | 2 | R | 25 | 45 | 35 | 35 | 35 | 259 | 295 | 267 | 0.10 |
| 215 | KY | 87 | Barren | 11.660 | 11.730 | D | 5 | 2 | L | 25 | 50 | 45 | 50 | 45 | 488 | 546 | 525 | 0.08 |
| 216 | KY | 87 | Barren | 11.990 | 12.060 | C | 5 | 2 | L | 25 | 55 | 50 | 55 | 50 | 589 | 764 | 530 | 0.08 |
| 217 | KY | 87 | Barren | 12.090 | 12.170 | C | NA | 2 | R | | 55 | 50 | 55 | 55 | 679 | 744 | 708 | 0.09 |
| 218 | KY | 122 | Floyd | 29.700 | 29.820 | E | 3 | 4 | R | 35 | 35 | 35 | 35 | 45 | 277 | 298 | 404 | 0.10 |

**APPENDIX A. LIST OF CURVES AND RESULTING ADVISORY SPEEDS**

| ID | ROUTE | | COUNTY | BEG MP | END MP | CURVE CLASS | SIGN TYPE | PASS | TURN DIRECTION | SIGN | ADVISORY SPEED (MPH) | | | | RADIUS (FT) | | | MEDIAN SUPER |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | DBBI | CARS | HIS | ARC | CARS | HIS | ARC | |
| 219 | KY | 122 | Floyd | 29.920 | 29.990 | D | 1 | 4 | L | 35 | 40 | 40 | 40 | 40 | 529 | 541 | 517 | 0.04 |
| 220 | KY | 122 | Floyd | 30.160 | 30.220 | C | 1 | 4 | L | 35 | 45 | 45 | 45 | 45 | 643 | 707 | 768 | 0.03 |
| 221 | KY | 122 | Floyd | 30.450 | 30.510 | D | 3 | 4 | R | 35 | 45 | 40 | 45 | 50 | 445 | 562 | 600 | 0.06 |
| 222 | KY | 122 | Floyd | 30.510 | 30.550 | C | 3 | 4 | L | 35 | 55 | 50 | 55 | 45 | 815 | 2865 | 470 | 0.07 |
| 223 | KY | 122 | Floyd | 31.120 | 31.160 | F | 2 | 4 | R | 20 | 20 | 15 | 20 | 20 | 95 | 153 | 147 | 0.05 |
| 224 | KY | 122 | Floyd | 32.060 | 32.130 | C | 3 | 4 | R | | 50 | 50 | 55 | 55 | 705 | 881 | 1035 | 0.06 |
| 225 | KY | 122 | Floyd | 32.330 | 32.380 | D | NA | 4 | R | 40 | 45 | 45 | 45 | 45 | 598 | 467 | 462 | 0.08 |
| 226 | KY | 122 | Floyd | 32.720 | 32.820 | D | NA | 4 | R | | 45 | 35 | 45 | 50 | 434 | 474 | 634 | 0.07 |
| 227 | KY | 122 | Floyd | 32.830 | 32.870 | F | NA | 4 | L | | 30 | 25 | 25 | 30 | 197 | 204 | 281 | 0.05 |
| 228 | KY | 122 | Floyd | 33.020 | 33.060 | F | 5 | 4 | R | 20 | 30 | 25 | 30 | 35 | 168 | 193 | 231 | 0.12 |
| 229 | KY | 122 | Floyd | 33.110 | 33.170 | F | 5 | 4 | L | 20 | 25 | 15 | 20 | 20 | 126 | 142 | 138 | 0.03 |
| 230 | KY | 122 | Floyd | 33.210 | 33.250 | F | 5 | 4 | R | 20 | 20 | 20 | 25 | 20 | 163 | 191 | 128 | 0.06 |
| 231 | KY | 122 | Floyd | 33.370 | 33.460 | D | 5 | 4 | L | 20 | 35 | 40 | 40 | 35 | 385 | 418 | 318 | 0.06 |
| 232 | KY | 122 | Floyd | 33.810 | 33.850 | F | 5 | 4 | R | 20 | 20 | 15 | 15 | 15 | 63 | 86 | 75 | 0.06 |
| 233 | KY | 152 | Mercer | 0.000 | 0.270 | F | 5 | 4 | L | 20 | 20 | 25 | 20 | 20 | 30 | 148 | 211 | 0.02 |
| 234 | KY | 152 | Mercer | 0.290 | 0.350 | E | | 4 | R | | 30 | 30 | 35 | 40 | 297 | 302 | 387 | 0.08 |
| 235 | KY | 152 | Mercer | 0.360 | 0.420 | E | | 4 | L | | 35 | 40 | 40 | 45 | 247 | 398 | 542 | 0.06 |
| 236 | KY | 152 | Mercer | 0.430 | 0.550 | D | | 4 | R | | 40 | 40 | 45 | 55 | 623 | 526 | 821 | 0.07 |
| 237 | KY | 152 | Mercer | 0.830 | 0.910 | C | 1 | 4 | R | 50 | 55 | 50 | 55 | 55 | 626 | 868 | 883 | 0.10 |
| 238 | KY | 152 | Mercer | 1.140 | 1.240 | E | 2 | 4 | L | 30 | 35 | 35 | 40 | 45 | 288 | 403 | 481 | 0.07 |
| 239 | KY | 152 | Mercer | 1.380 | 1.440 | D | 3 | 4 | R | 35 | 35 | 35 | 45 | 55 | 361 | 451 | 615 | 0.10 |
| 240 | KY | 152 | Mercer | 1.890 | 2.000 | D | 3 | 4 | R | 35 | 40 | 45 | 50 | 50 | 464 | 567 | 606 | 0.08 |
| 241 | KY | 153 | Mercer | 2.040 | 2.230 | D | 3 | 4 | L | | 40 | 45 | 50 | 55 | 1047 | 651 | 886 | 0.05 |
| 242 | KY | 152 | Mercer | 2.490 | 2.640 | D | 3 | 4 | R | 40 | 40 | 40 | 45 | 55 | 437 | 494 | 673 | 0.08 |
| 243 | KY | 152 | Mercer | 2.890 | 3.110 | C | 3 | 4 | L | 45 | 45 | 55 | 55 | 55 | 762 | 830 | 1248 | 0.06 |
| 244 | KY | 152 | Mercer | 3.830 | 4.000 | D | 3 | 4 | R | 40 | 40 | 45 | 55 | 55 | 534 | 591 | 854 | 0.10 |
| 245 | KY | 152 | Mercer | 4.000 | 4.110 | D | 3 | 4 | L | | 40 | 50 | 45 | 45 | 521 | 481 | 534 | 0.07 |
| 246 | KY | 152 | Mercer | 4.870 | 4.970 | D | 3 | 4 | L | | 45 | 40 | 40 | 45 | 393 | 437 | 575 | 0.06 |
| 247 | KY | 152 | Mercer | 5.190 | 5.290 | C | 3 | 4 | R | 35 | 35 | 50 | 55 | 55 | 609 | 1302 | 844 | 0.11 |
| 248 | KY | 152 | Mercer | 5.480 | 5.560 | C | 5 | 4 | L | | 55 | 55 | 55 | 55 | 722 | 819 | 802 | 0.06 |
| 249 | KY | 152 | Mercer | 5.820 | 5.990 | D | 5 | 4 | L | | 50 | 55 | 50 | 55 | 747 | 644 | 1136 | 0.06 |

## APPENDIX A. LIST OF CURVES AND RESULTING ADVISORY SPEEDS

| ID | ROUTE | | COUNTY | BEG MP | END MP | CURVE CLASS | SIGN TYPE | PASS | TURN DIRECTION | ADVISORY SPEED (MPH) SIGN | DBBI | CARS | HIS | ARC | RADIUS (FT) CARS | HIS | ARC | MEDIAN SUPER |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 250 | KY | 152 | Mercer | 6.020 | 6.100 | D | 5 | 4 | R | 40 | 40 | 45 | 55 | 55 | 556 | 623 | 844 | 0.09 |
| 251 | KY | 152 | Mercer | 6.680 | 6.730 | C | 5 | 4 | R | | 45 | 45 | 55 | 50 | 607 | 819 | 735 | 0.05 |
| 252 | KY | 152 | Mercer | 7.440 | 7.550 | C | 1 | 4 | R | 45 | 50 | 55 | 55 | 55 | 891 | 1005 | 1306 | 0.05 |
| 253 | KY | 152 | Mercer | 7.860 | 7.950 | C | 1 | 4 | L | 40 | 45 | 45 | 50 | 55 | 508 | 716 | 820 | 0.06 |
| 254 | KY | 152 | Mercer | 8.190 | 8.260 | C | 1 | 4 | R | 45 | 50 | 45 | 55 | 55 | 674 | 830 | 1074 | 0.05 |
| 255 | KY | 420 | Franklin | 1.490 | 1.560 | E | 5 | 2 | R | 35 | 35 | 35 | 45 | 40 | 339 | 363 | 306 | 0.11 |
| 256 | KY | 420 | Franklin | 1.590 | 1.650 | E | 2 | 2 | L | 25 | 25 | 25 | 30 | 25 | 176 | 232 | 182 | 0.05 |
| 257 | KY | 420 | Franklin | 1.710 | 1.800 | D | 1 | 2 | R | 35 | 40 | 40 | 45 | 45 | 421 | 462 | 399 | 0.09 |
| 258 | KY | 420 | Franklin | 1.880 | 1.940 | C | 3 | 2 | L | 35 | 40 | 45 | 45 | 30 | 559 | 690 | 343 | 0.03 |
| 259 | KY | 420 | Franklin | 1.950 | 2.010 | E | 3 | 2 | R | 35 | 35 | 35 | 45 | 35 | 355 | 401 | 288 | 0.10 |
| 260 | KY | 420 | Franklin | 2.040 | 2.100 | E | 1 | 2 | L | 35 | 35 | 35 | 35 | 30 | 365 | 356 | 328 | 0.04 |
| 261 | KY | 1189 | Laurel | 1.420 | 1.460 | F | 2 | 4 | L | 20 | 25 | 20 | 25 | 30 | 136 | 175 | 240 | 0.07 |
| 262 | KY | 1189 | Laurel | 1.870 | 1.920 | D | 2 | 4 | R | 30 | 40 | 35 | 40 | 45 | 366 | 418 | 528 | 0.06 |
| 263 | KY | 1189 | Laurel | 2.100 | 2.170 | D | 3 | 4 | R | 35 | 50 | 45 | 45 | 50 | 566 | 597 | 744 | 0.05 |
| 264 | KY | 1189 | Laurel | 2.200 | 2.240 | F | 2 | 4 | L | 20 | 25 | 25 | 25 | 25 | 150 | 167 | 186 | 0.08 |
| 265 | KY | 1355 | Garrard | 0.840 | 0.890 | E | | 4 | R | | 35 | 35 | 40 | 50 | 220 | 303 | 480 | 0.10 |
| 266 | KY | 1355 | Garrard | 1.060 | 1.110 | D | 1 | 4 | L | 40 | 40 | 40 | 45 | 50 | 334 | 424 | 498 | 0.10 |
| 267 | KY | 1355 | Garrard | 1.420 | 4.490 | D | 1 | 4 | R | 30 | 30 | 30 | 35 | 30 | 250 | 462 | 430 | 0.01 |
| 268 | KY | 1355 | Garrard | 1.900 | 1.940 | D | 1 | 4 | L | 45 | 35 | 40 | 45 | 50 | 350 | 441 | 529 | 0.09 |
| 269 | KY | 1355 | Garrard | 2.350 | 2.420 | E | 2 | 4 | R | 30 | 45 | 45 | 55 | 55 | 587 | 924 | 907 | 0.03 |
| 270 | KY | 1355 | Garrard | 2.470 | 2.540 | E | | 4 | R | | 30 | 30 | 35 | 30 | 305 | 247 | 202 | 0.11 |
| 271 | KY | 1355 | Garrard | 2.860 | 2.920 | F | 1 | 4 | L | 15 | 15 | 5 | 25 | 15 | 201 | 247 | 115 | 0.02 |
| 272 | KY | 1355 | Garrard | 3.140 | 3.200 | E | 1 | 4 | R | 35 | 35 | 35 | 35 | 40 | 373 | 310 | 409 | 0.06 |
| 273 | KY | 1355 | Garrard | 3.490 | 3.560 | E | 3 | 4 | R | 25 | 25 | 20 | 25 | 25 | 162 | 217 | 218 | 0.05 |
| 274 | KY | 1355 | Garrard | 3.980 | 4.060 | E | 2 | 4 | L | 30 | 30 | 30 | 30 | 35 | 263 | 311 | 408 | 0.03 |
| 275 | KY | 1355 | Garrard | 4.110 | 4.250 | C | 1 | 4 | R | 50 | 50 | 55 | 55 | 55 | 866 | 843 | 954 | 0.07 |
| 276 | KY | 1355 | Garrard | 4.450 | 4.520 | D | 1 | 4 | L | 40 | 35 | 40 | 45 | 45 | 446 | 597 | 612 | 0.04 |
| 277 | KY | 1355 | Garrard | 4.740 | 4.830 | B | 1 | 4 | L | 45 | 40 | 50 | 50 | 35 | 596 | 1102 | 606 | 0.00 |
| 278 | KY | 1355 | Garrard | 5.860 | 5.920 | E | 2 | 4 | R | 30 | 30 | 25 | 30 | 30 | 253 | 302 | 284 | 0.04 |
| 279 | KY | 1355 | Garrard | 6.050 | 6.180 | D | 3 | 4 | R | 35 | 30 | 35 | 35 | 40 | 379 | 415 | 558 | 0.04 |
| 281 | KY | 1355 | Garrard | 6.700 | 6.810 | F | 2 | 4 | L | 25 | 25 | 30 | 20 | 20 | 344 | 198 | 231 | 0.00 |

## APPENDIX A. LIST OF CURVES AND RESULTING ADVISORY SPEEDS

| | | | | | | | | | | | ADVISORY SPEED (MPH) | | | | RADIUS (FT) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ID | ROUTE | | COUNTY | BEG MP | END MP | CURVE CLASS | SIGN TYPE | PASS | TURN DIRECTION | SIGN | DBBI | CARS | HIS | ARC | CARS | HIS | ARC | MEDIAN SUPER |
| 282 | KY | 1355 | Garrard | 6.870 | 6.940 | D | 1 | 4 | R | 35 | 35 | 35 | 55 | 40 | | 651 | 376 | 0.08 |
| 283 | KY | 1355 | Garrard | 7.060 | 7.140 | D | 3 | 4 | L | 40 | 35 | 40 | 30 | 30 | 671 | 477 | 430 | 0.00 |
| 284 | KY | 1355 | Garrard | 7.490 | 7.550 | D | 2 | 4 | L | 30 | 30 | 30 | 40 | 30 | 289 | 431 | 234 | 0.05 |
| 285 | KY | 1355 | Garrard | 7.880 | 7.950 | C | 1 | 4 | R | 40 | 40 | 40 | 55 | 40 | 588 | 895 | 449 | 0.06 |
| 286 | KY | 1355 | Garrard | 8.370 | 8.410 | D | 1 | 4 | L | 40 | 40 | 40 | 40 | 30 | 810 | 597 | 388 | 0.02 |
| 287 | KY | 1355 | Garrard | 9.000 | 9.060 | D | 1 | 4 | R | 45 | 45 | 50 | 50 | 45 | 707 | 562 | 478 | 0.09 |
| 288 | KY | 1355 | Garrard | 9.370 | 9.440 | D | 1 | 4 | R | 45 | 45 | 50 | 50 | 45 | 586 | 603 | 471 | 0.07 |
| 289 | KY | 1355 | Garrard | 9.640 | 9.730 | D | 1 | 4 | L | 35 | 35 | 40 | 30 | 25 | 574 | 428 | 319 | 0.00 |
| 290 | KY | 1355 | Garrard | 9.790 | 9.870 | F | 3 | 4 | L | 35 | 30 | 30 | 30 | 30 | 282 | 322 | 347 | 0.02 |
| 291 | KY | 1355 | Garrard | 10.030 | 10.200 | D | 1 | 4 | R | 35 | 35 | 35 | 35 | 30 | 406 | 444 | 383 | 0.01 |
| 292 | KY | 1973 | Fayette | 0.230 | 0.270 | D | | 2 | R | | 35 | 35 | 50 | 30 | 412 | 637 | 269 | 0.05 |
| 293 | KY | 1973 | Fayette | 0.430 | 0.490 | D | | 2 | L | | 40 | 40 | 45 | 40 | 309 | 490 | 377 | 0.07 |
| 294 | KY | 1973 | Fayette | 0.610 | 0.690 | D | | 2 | R | | 35 | 35 | 45 | 40 | 374 | 477 | 402 | 0.07 |
| 295 | KY | 1973 | Fayette | 0.840 | 0.880 | C | | 2 | L | | 55 | 50 | 45 | 30 | 859 | 909 | 372 | 0.00 |
| 296 | KY | 1973 | Fayette | 1.320 | 1.370 | C | | 2 | L | | 40 | 40 | 45 | 25 | 581 | 895 | 294 | 0.01 |
| 297 | KY | 1973 | Fayette | 1.970 | 2.000 | F | | 2 | R | 20 | 15 | 15 | 20 | 10 | 55 | 151 | 61 | 0.03 |
| 298 | KY | 1973 | Fayette | 2.010 | 2.040 | F | 4 | 2 | L | 20 | 20 | 15 | 20 | 10 | 103 | 151 | 75 | 0.01 |
| 299 | KY | 1973 | Fayette | 2.960 | 3.010 | E | | 2 | L | | 30 | 30 | 30 | 25 | 266 | 406 | 251 | 0.02 |
| 300 | KY | 1973 | Fayette | 3.620 | 3.690 | C | | 2 | L | | 40 | 45 | 45 | 30 | 577 | 744 | 395 | 0.02 |
| 301 | KY | 1973 | Fayette | 4.270 | 4.310 | D | | 2 | L | | 45 | 45 | 35 | 30 | 779 | 556 | 405 | 0.01 |
| 302 | KY | 1973 | Fayette | 5.120 | 5.150 | C | | 2 | R | | 50 | 40 | 55 | 45 | 748 | 954 | 507 | 0.05 |
| 303 | KY | 1973 | Fayette | 7.360 | 7.410 | A | | 2 | R | | 50 | 50 | 55 | 45 | 870 | 2291 | 569 | 0.04 |
| 304 | KY | 1973 | Fayette | 9.740 | 9.780 | C | | 2 | L | | 50 | 45 | 45 | 35 | 690 | 690 | 524 | 0.02 |
| 305 | KY | 1973 | Fayette | 11.180 | 11.310 | D | | 2 | R | | 40 | 55 | 35 | 55 | 1058 | 512 | 1170 | 0.02 |
| 306 | KY | 1973 | Fayette | 11.350 | 11.400 | E | | 2 | L | 25 | 25 | 25 | 30 | 25 | 190 | 258 | 194 | 0.04 |
| 307 | KY | 1973 | Fayette | 11.490 | 11.540 | D | | 2 | L | 35 | 35 | 35 | 35 | 25 | 418 | 441 | 295 | 0.02 |
| 308 | KY | 1973 | Fayette | 11.650 | 11.770 | D | | 2 | R | 35 | 40 | 40 | 45 | 40 | 415 | 455 | 339 | 0.10 |