SHIFT
KENTUCKY AHEAD

Safety Measure

Overview

- Purpose of the Study
- Previous SHIFT Safety Formulas
- Areas for Improvement
- Highway Safety Manual (HSM) Methods
- New SHIFT Safety Formula
- Comparison of New and Old Methods/Case Studies

Purpose

- KYTC planners desire robust safety methods to support both network screening and project prioritization components of SHIFT.

- In the past, KYTC has used rankings of roadway segments based on Critical Rate Factor (CRF), which is a measure of a roadway's variance from the average crash rate.

- KYTC has also used crash frequency and density measures that are heavily dependent on project length.

- KYTC has recognized the need to employ the more statistically robust approaches presented in the HSM to rank highway projects as part of SHIFT.

Previous Safety Formulas

Statewide: 15%   Regional: 15%

Statewide Score = 15% * Crash History Safety Measure (CHSM) for Segments or Intersections :

Regional Score = 15% * Crash History Safety Measure (CHSM) for Segments or Intersections :

Segment (L>0.2): CHSM = $0.25*((CD*L)_{\dagger scaled}) + 0.25*(CRF_{\dagger\ scaled}) + 0.50*(CF_{\dagger scaled})$

Intersection (L<=0.2): CHSM = $0.5*(CF_{\dagger scaled}) + 0.5*(CRF_{\dagger scaled})$

Measure	Description	Summary Method All crash data summarized over 5 yrs. 2011-2015	Source
CD*L	CD: Crash Density L: Project Length	Total # crashes 5 yr / cumulative length of roadway for facility type statewide Ending mile point minus beginning mile point	Crash Database PIF
CRF	Critical Rate Factor	Length Weighted Avg	Crash Database
CF	Crash Frequency	# of crashes over 5 yr period	Crash Database

$\dagger$Scaled - The percentile rank of the value. Converts value to score of 0 to 100.

# Limitations of Previous Approach

- CRF is outdated
  - Crashes and AADT are not linear
  - Sites with low AADTs tend to move to the top
  - No accounting for sites with zero crashes
  - Crash rates may be misleading
- Arbitrary weighting between the three components
- Crash reductions at different facility types should count the same (a life is a life)
- Length of a project should not (totally) drive the decision
- Segments and intersections should be modeled differently

Highway Safety Manual Methodologies

- Safety Performance Function (SPF): regression equation modeling crashes based on AADT and length (for homogenous sections)
  - Crashes = L*f(AADT)
  - Volume only for intersections
- If a project section or intersection is not similar to the reference group used to develop the SPF, must adjust
  - Adjustment Factors (AF): Account for differences in crashes when a segment varies from base conditions
  - Crashes = L*f(AADT)*AF
- Empirical Bayes (EB) Method: Combines adjusted SPF crash predictions with historical crash data to combat **regression to the mean** and **selection bias**

SPF Development
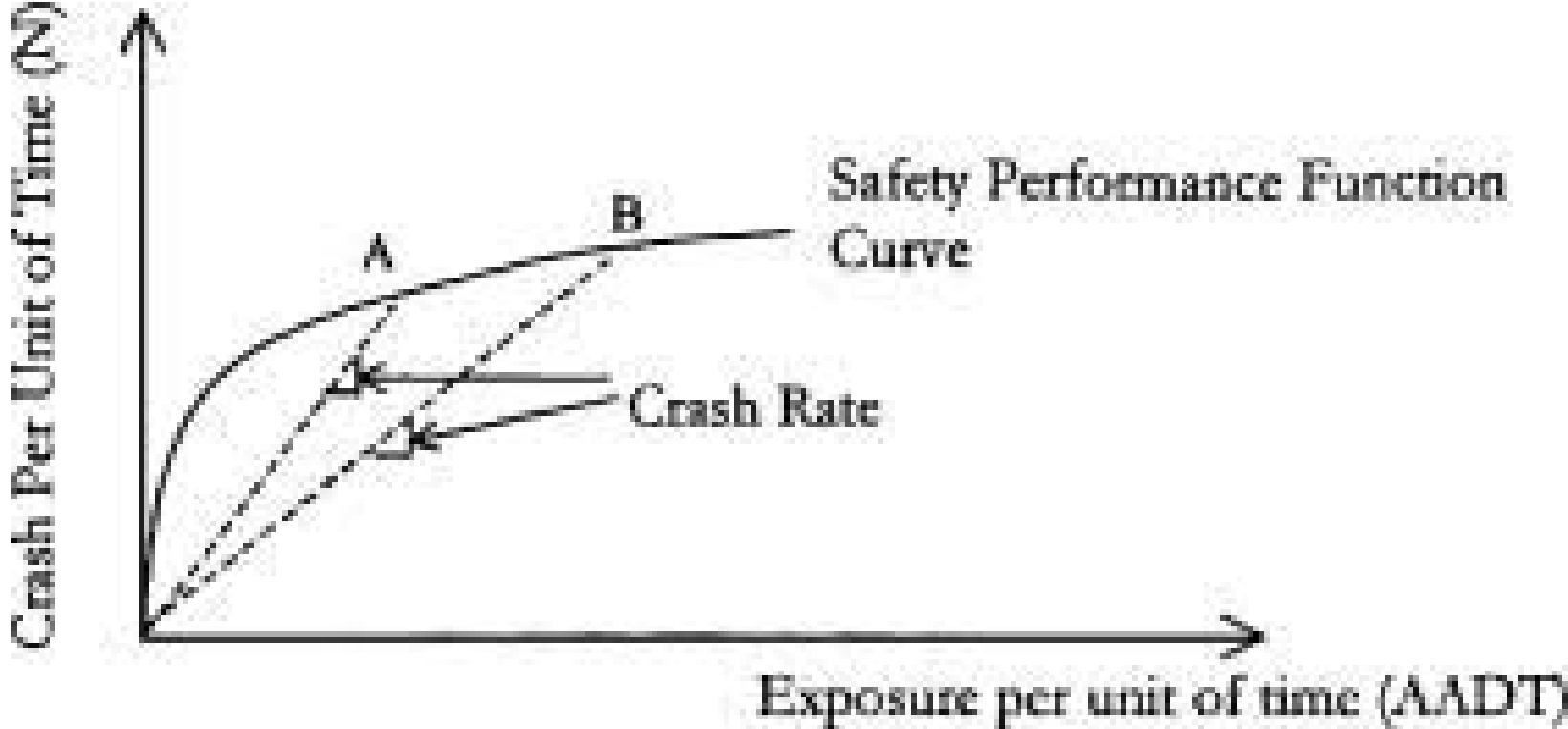
Safety Performance Function (SPF)

$$Crashes = L * e^a * AADT^b * AF$$

Crashes = SPF crash prediction

L = Length of segment

AADT = annual average daily traffic

a & b = regression coefficients

AF = adjustment factor

Empirical Bayes (EB) Method

$$Expected\ Crashes = w * SPF\ Crashes\ + (1-w) * Actual\ Crashes$$

w = weight (based on overdispersion parameter from calibrated SPF)

SPF Crashes = predicted crashes on a segment from SPF

Actual Crashes = total historic crashes on a segment

*For SPFs with poor correlation, the weight parameter is lower, which places greater emphasis on historic crash data

Potential for Crash Reduction (PCR)

$$PCR = EB\ Expected\ Crashes\ - SPF\ Predicted\ Crashes$$

- Compares crashes on a segment to crashes that would be expected on that segment
- Positive PCR = more crashes **than would be expected**
- Negative PCR = Fewer crashes **than would be expected**

Potential for Crash Reduction (PCR)
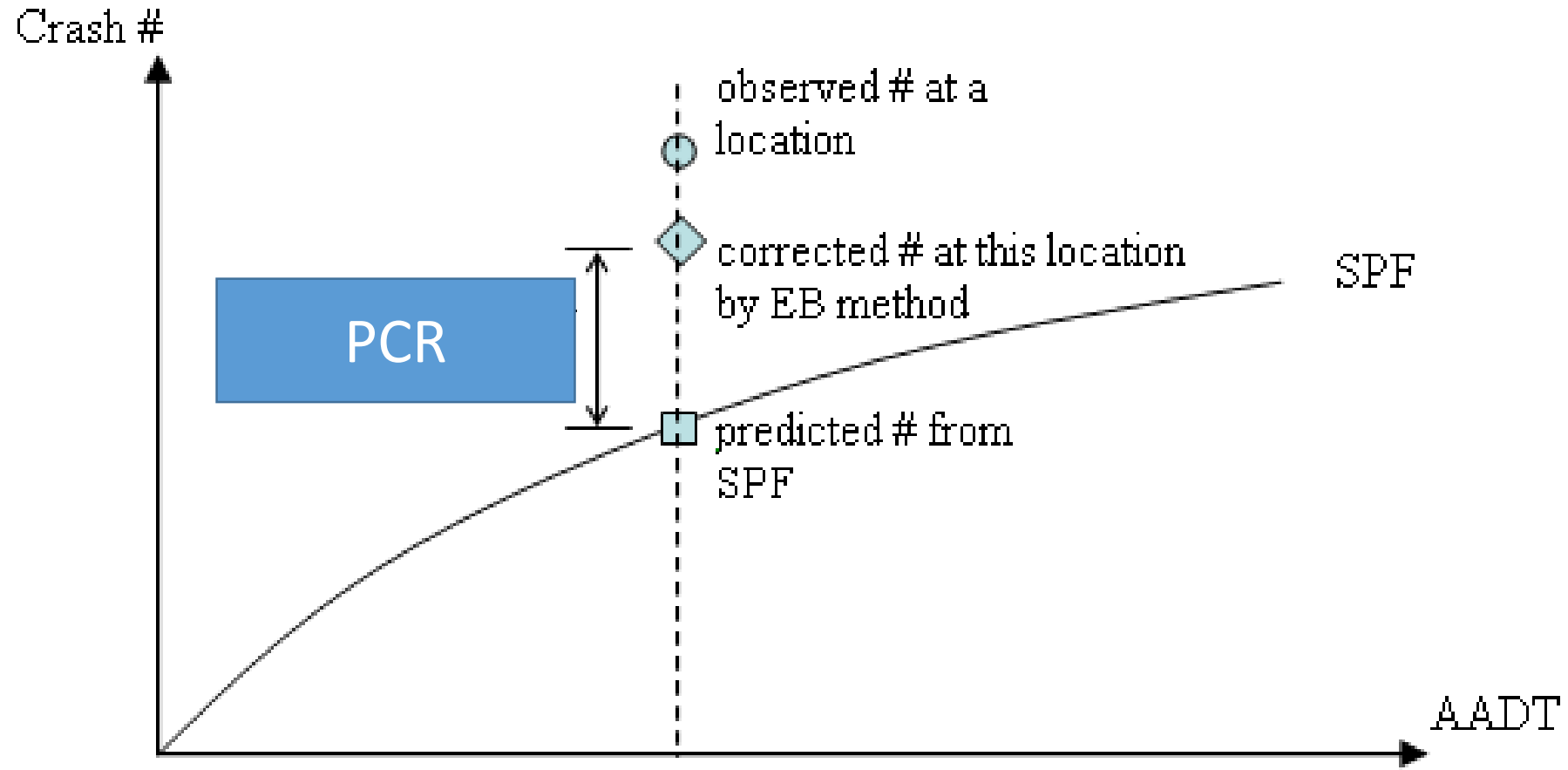
New Ranking Method

- Sum PCRs for all segments and intersections in a PIF's boundary
- Develop area of influence boundary for interchange projects
- Rank all projects by **PCR**
- Can now tell actual difference between projects easily (e.g., two closely ranked may be vastly different)

SPF and AF Development

- Rural two-lanes
- Rural multilane divided
- Rural multilane undivided
- Urban two-lanes
- Urban multilane divided

- Urban multilane undivided
- Rural Interstate/Parkway
- Urban Interstate/Parkway
- Ramps
- Intersections

Base Conditions used to Determine PCR of Rural 2 Lane Roads

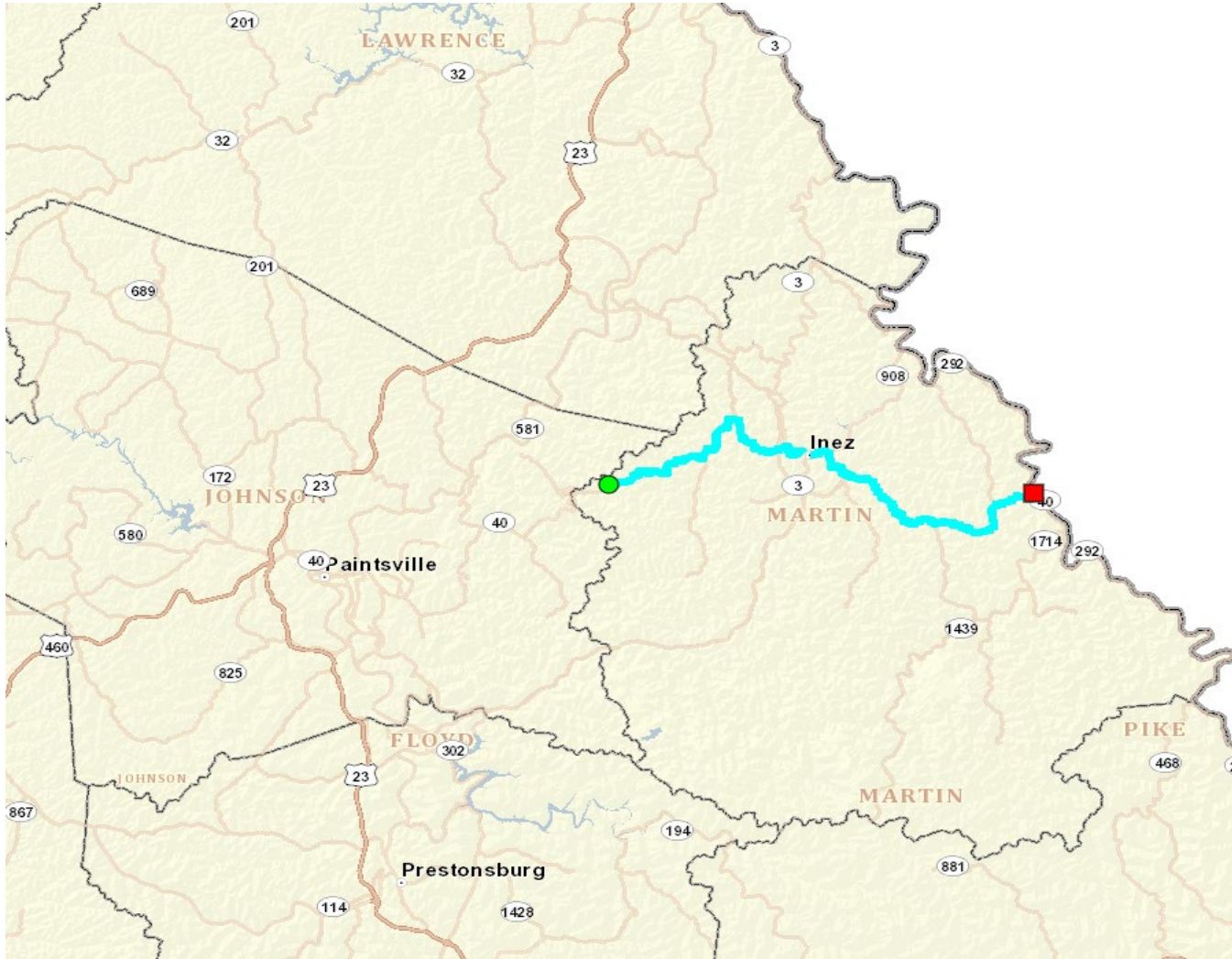|	
Lane Width	9'
Shoulder Width	3'
Horizontal Curve	Class A
Grade	Class A
Median	No
Intersection	No

Description	
Horizontal Curve	Grade
A ---0.0-3.4 Degrees	A ---0.0-0.4 %
B ---3.5-5.4 Degrees	B ---0.5-2.4 %
C ---5.5-8.4 Degrees	C ---2.5-4.4 %
D ---8.5-13.9 Degrees	D ---4.5-6.4 %
E ---14.0-27.9 Degrees	E ---6.5-8.4 %
F ---28.0 + Degrees	F ---8.5+%

Top 5 Ranking in Old Method

Eval County	Eval Route	Project Length	AADT	Project Type	SHIFT Score (Max 100)	Crash History	Critical Rate Factor (CRF)	CRF-Scale (%)	Crash Frequency (CF)	CF-Scale (%)	Crash Density (CD)	CD*L-Scale (%)	Crash History Measure (%)	PCR_Total	Rank Old	Rank New
Martin	080-KY-0040 -000	17.9	3305	RELOCA-TION(O)	71.1	14.8	4.2	99	191	99	4.7	98	99	-112	1	616
Barren	005-US-0031E -000	11.1	5922	MAJOR WIDEN-ING(O)	55.3	14.4	4.1	98	217	97	7.6	94	96	11	2	73
McLean	075-KY-0136 -000	22.6	1405	RECON-STRUC-TION (O)	79.1	14.0	3	96	114	91	4.7	97	93	-15	3	558
Fleming	035-KY-0032 -000	7.3	4779	SAFETY(P)	79.9	14.0	1.8	87	109	95	7.6	96	93	-14	4	541
	005-KY-			MAJOR												

County: Martin
Route: 080-KY-0040 -000
Old Rank: 1 ;New Rank : 616

Project Length	17.9 (3rd longest)
AADT	3300
Project Type	Relocation
CD/CD*L Scale	4.7/98%
CF/CF Scale	191/99%
CRF/CRF Scale	4.2/99%
Crash History Measure	99%
PCR	-112 (-112 min, 123 max)

County: Barren
Route: 005-US-0031E -000
Old Rank: 2; New Rank : 73

Project Length	11.1 (9th longest)
AADT	5900
Project Type	Reconstruction
CD/CD*L Scale	7.6/94%
CF/CF Scale	217/97%
CRF/CRF Scale	4.1/98%
Crash History Measure	96%
PCR	11 (-112 min, 123 max)

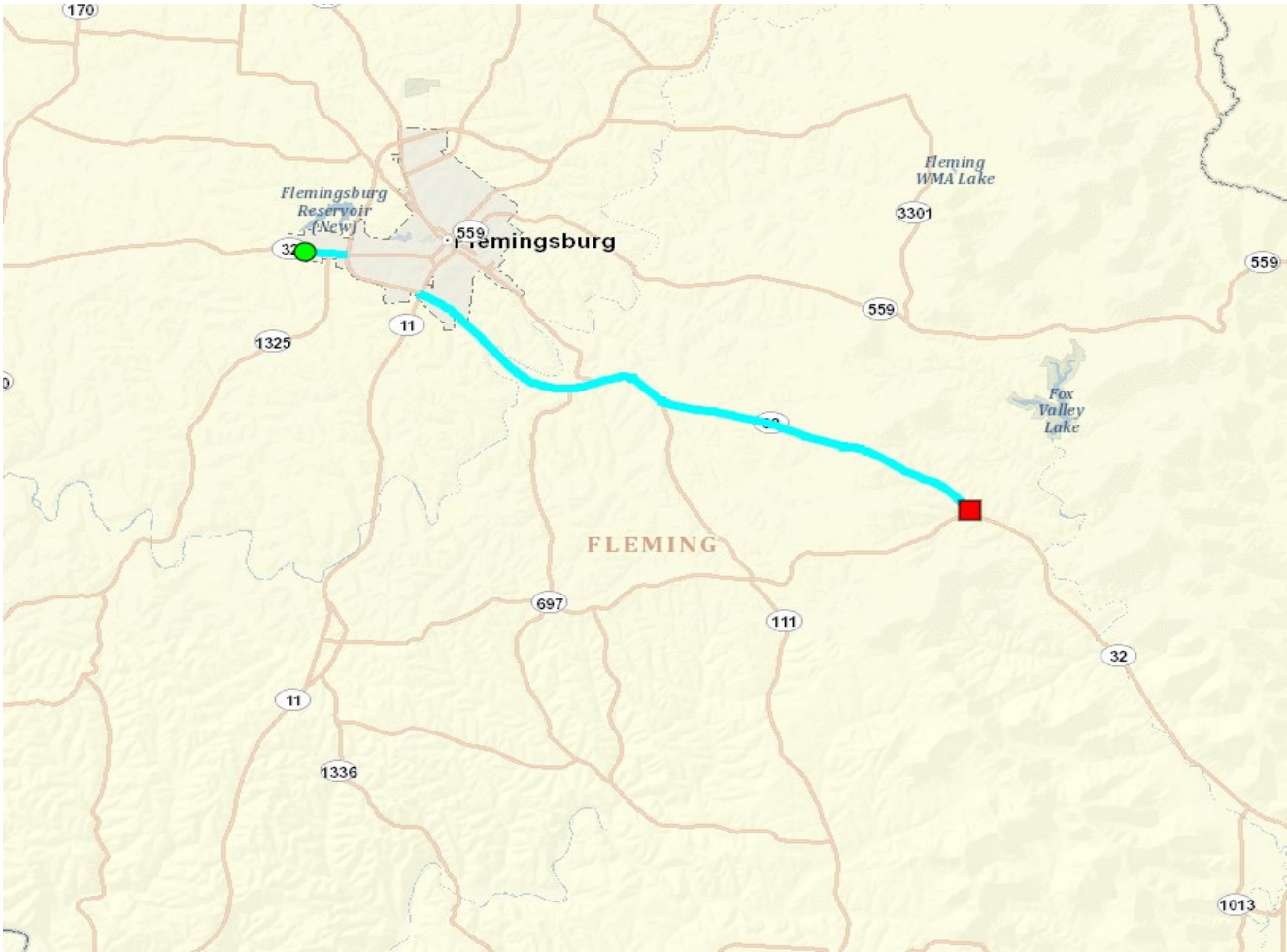# County: McLean
Route: 075-KY-0136 -000
Old Rank: 3; New Rank : 558

Project Length	22.6 (The longest)
AADT	1400
Project Type	Reconstruction
CD/CD*L Scale	4.7/97%
CF/CF Scale	114/91%
CRF/CRF Scale	3/96%
Crash History Measure	93%
PCR	-15 (-112 min, 123 max)

County: Fleming
Route: 035-KY-0032 -000
Old Rank: 4; New Rank : 541

Project Length	7.3 (35th longest)
AADT	4800
Project Type	Safety (P)
CD/CD*L Scale	7.6/96%
CF/CF Scale	109/95%
CRF/CRF Scale	2/87%
Crash History Measure	96%
PCR	-14 (-112 min, 123 max)

County: Barren
Route: 005-KY-0090 -000
Old Rank: 5 ; New Rank : 553

|	
Project Length	**7.4 (34th longest)**
AADT	9700
Project Type	Major Widening
CD/CD*L Scale	7.6/89%
CF/CF Scale	170/95%
CRF/CRF Scale	3/95%
Crash History Measure	**93%**
PCR	**-14.5 (-112 min, 123 max)**

Top 5 Ranking in New Method

Eval County	Eval Route	Project Length	AADT	Project Type	SHIFT Score (Max 100)	Crash History	Critical Rate Factor (CRF)	CRF-Scale (%)	Crash Frequency (CF)	CF-Scale (%)	Crash Density (CD)	CD*L-Scale (%)	Crash History Measure (%)	PCR_Total	Rank New	Rank OLD
Adair	001-KY-0055 -000	10.1	1600	Recon-struction	71.1	13.9	8.4	100	255	93	4.7	84	93	123	1	7
Wood-ford	120-KY-0169 -000	3	3400	Recon-struction	71.5	8.6	1.7	60	109	65	4.7	40	58	85	2	188
Calloway	018-US-0641 -000	5.7	6500	MAJOR WIDEN-ING(O)	90.2	13.4	1.8	80	205	96	7	84	89	80.5	3	16
Breathitt	013-KY-0015 -000	1.2	14000	Major widening	86.1	13.2	4.2	98	170	97	7	60	88	73	4	20
Jessa-mine	057-KY-0169 -000	10.5	2200	NEW ROUTE(O)	28.1	13.1	10.3	99	325	89	4.7	73	87	59	5	22

County: Adair
Route: 001-KY-0055 -000
New Rank: 1; Old Rank: 7
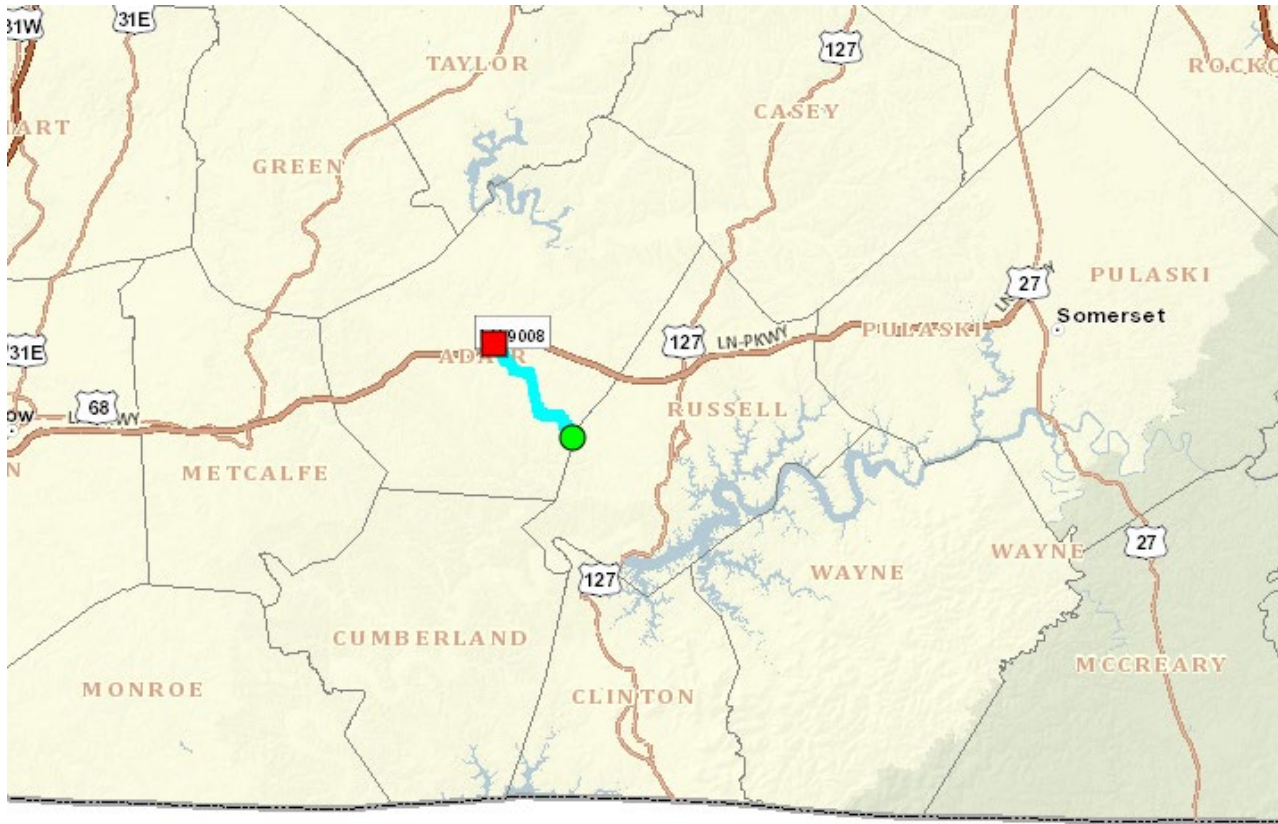
Project Length	10.1
AADT	1600
Project Type	Reconstruction
CD/CD*L Scale	4.7/84%
CF/CF Scale	255/93%
CRF/CRF Scale	8.4/100%
Crash History Measure	93%
PCR	123 (-112 min, 123 max)

County: Woodford
Route: 120-KY-0169 -000
New Rank: 2; Old Rank: 188
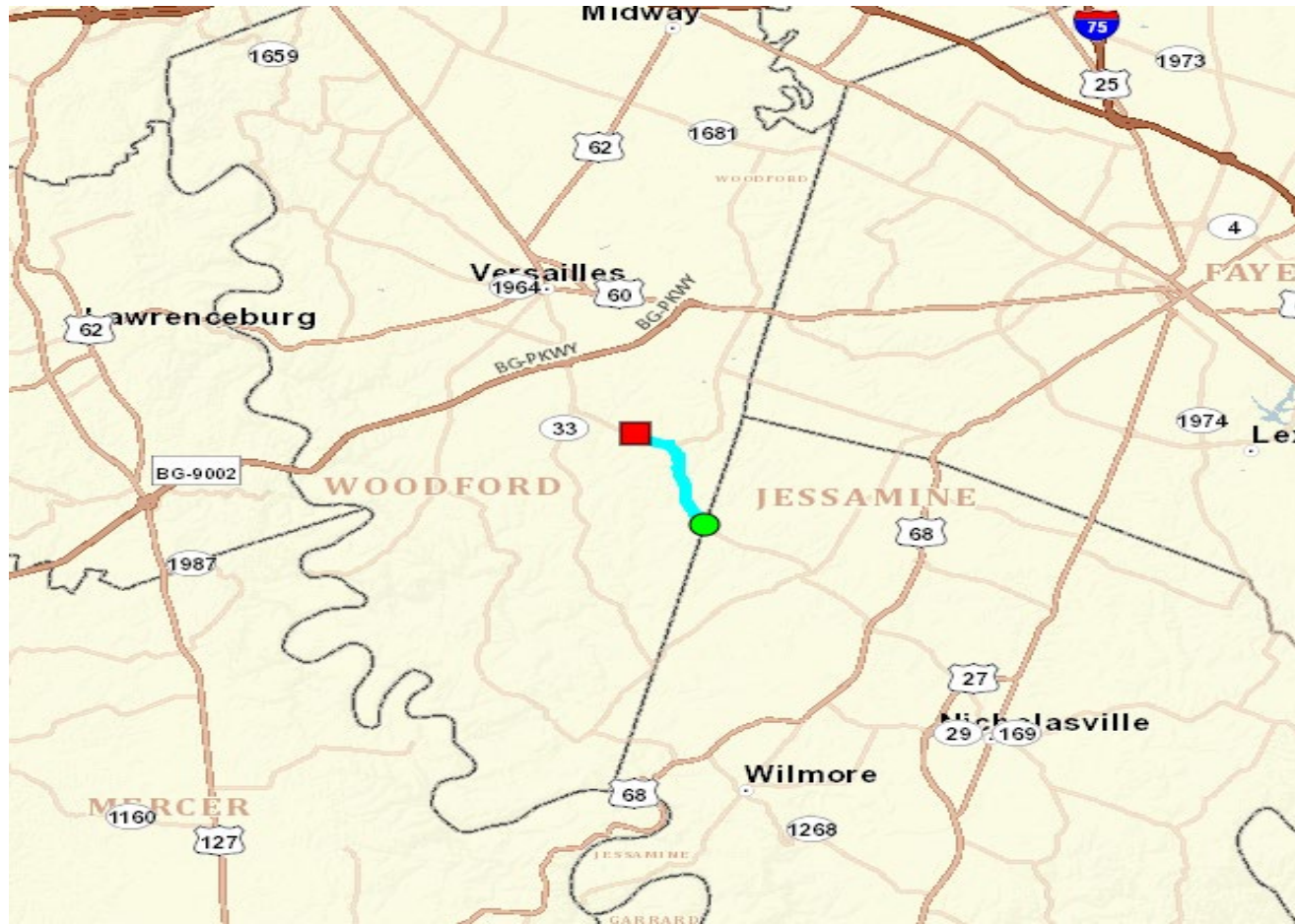
Project Length	3
AADT	3400
Project Type	Reconstruction
CD/CD*L Scale	4.7/40%
CF/CF Scale	109/65%
CRF/CRF Scale	1.7/60%
Crash History Measure	58%
PCR	85 (-112 min, 123 max)

County: Calloway
Route: 018-US-0641 -000
New Rank: 3; Old Rank: 16

Project Length	5.7
AADT	6500
Project Type	Major Widening
CD/CD*L Scale	7/84%
CF/CF Scale	205/96%
CRF/CRF Scale	1.8/80%
Crash History Measure	89%
PCR	80.5 (-112 min, 123 max)

County: Breathitt
Route: 013-KY-0015 -000
New Rank: 4; Old Rank: 20
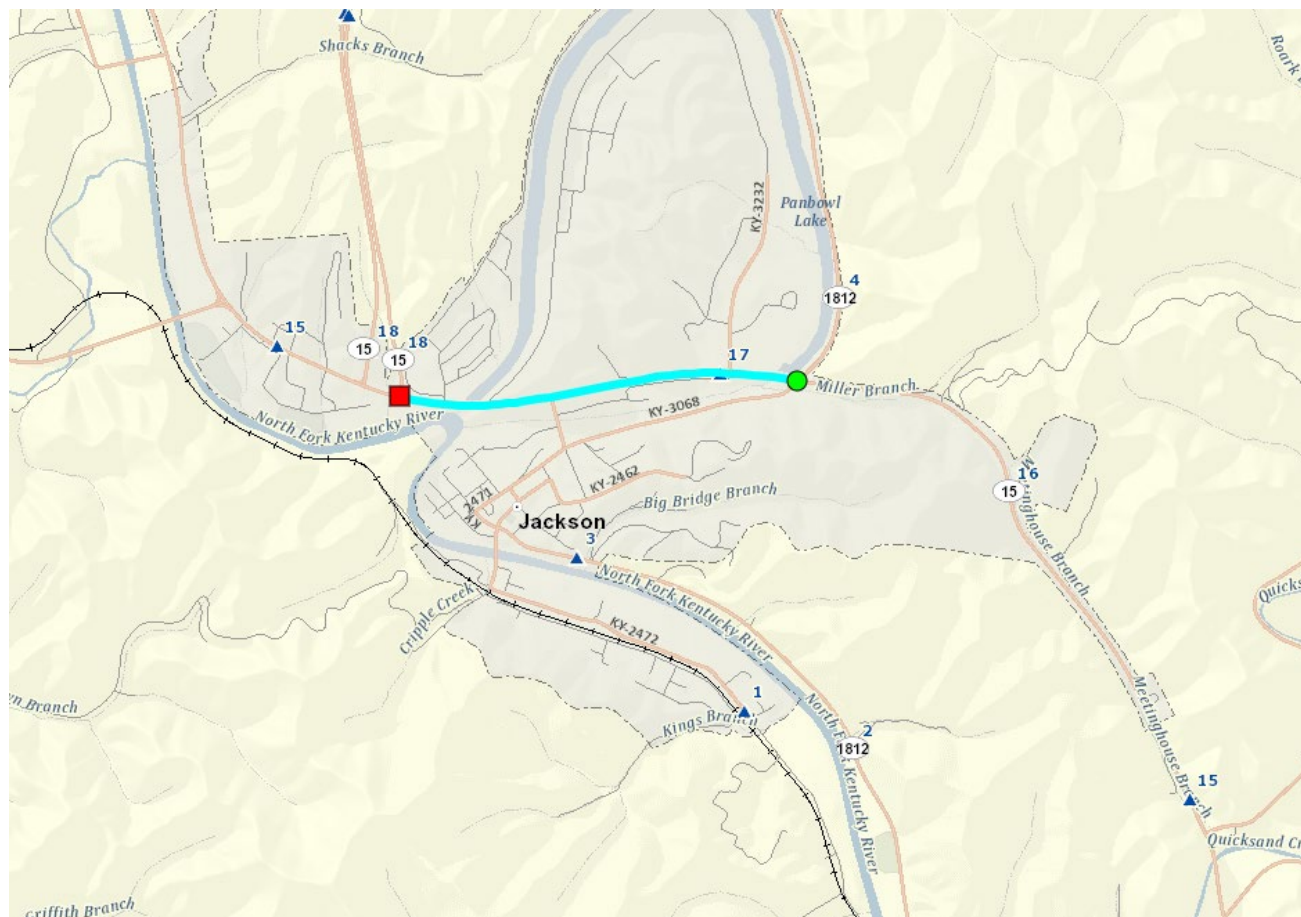
Project Length	1.2
AADT	14000
Project Type	Major Widening
CD/CD*L Scale	7/60%
CF/CF Scale	170/97%
CRF/CRF Scale	4.2/98%
Crash History Measure	88%
PCR	73 (-112 min, 123 max)

County: Jessamine
Route: 057-KY-0169-000
New Rank: 5; Old Rank: 22
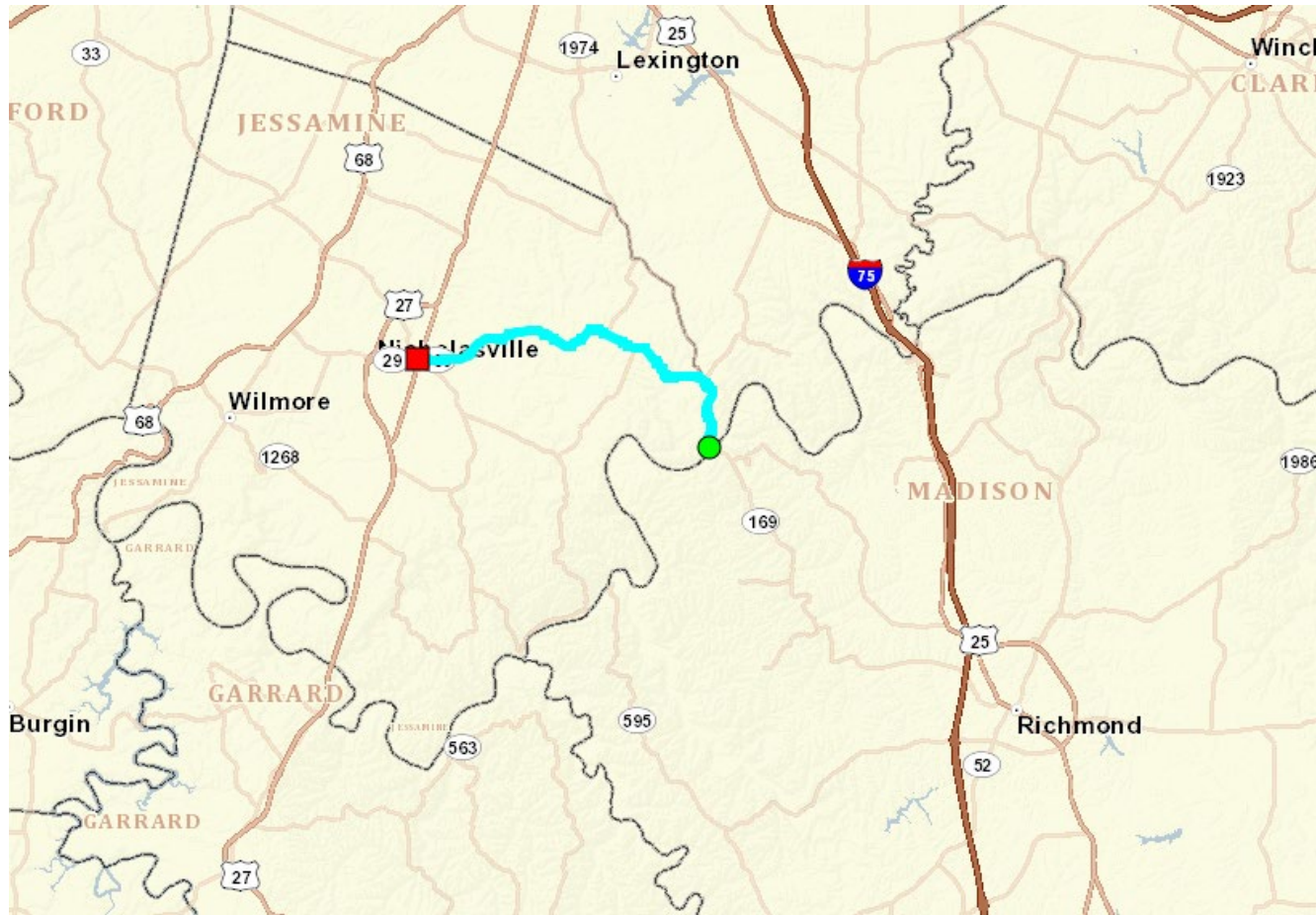
Project Length	**10.5**
AADT	2200
Project Type	New Route
CD/CD*L Scale	4.7/73%
CF/CF Scale	325/89%
CRF/CRF Scale	10.3/99%
Crash History Measure	**87%**
PCR	**59** (-112 min, 123 max)