

# Network Screening

*Prioritizing safety network-wide*

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# Objectives

- Understand the randomness of crash data
- To understand the Highway Safety Manual's network screening methodology
- To learn about KYTC's replacement for CRF as a way to prioritize safety
- To become aware of the strengths and weaknesses of this methodology

# Utility Pole Impacts



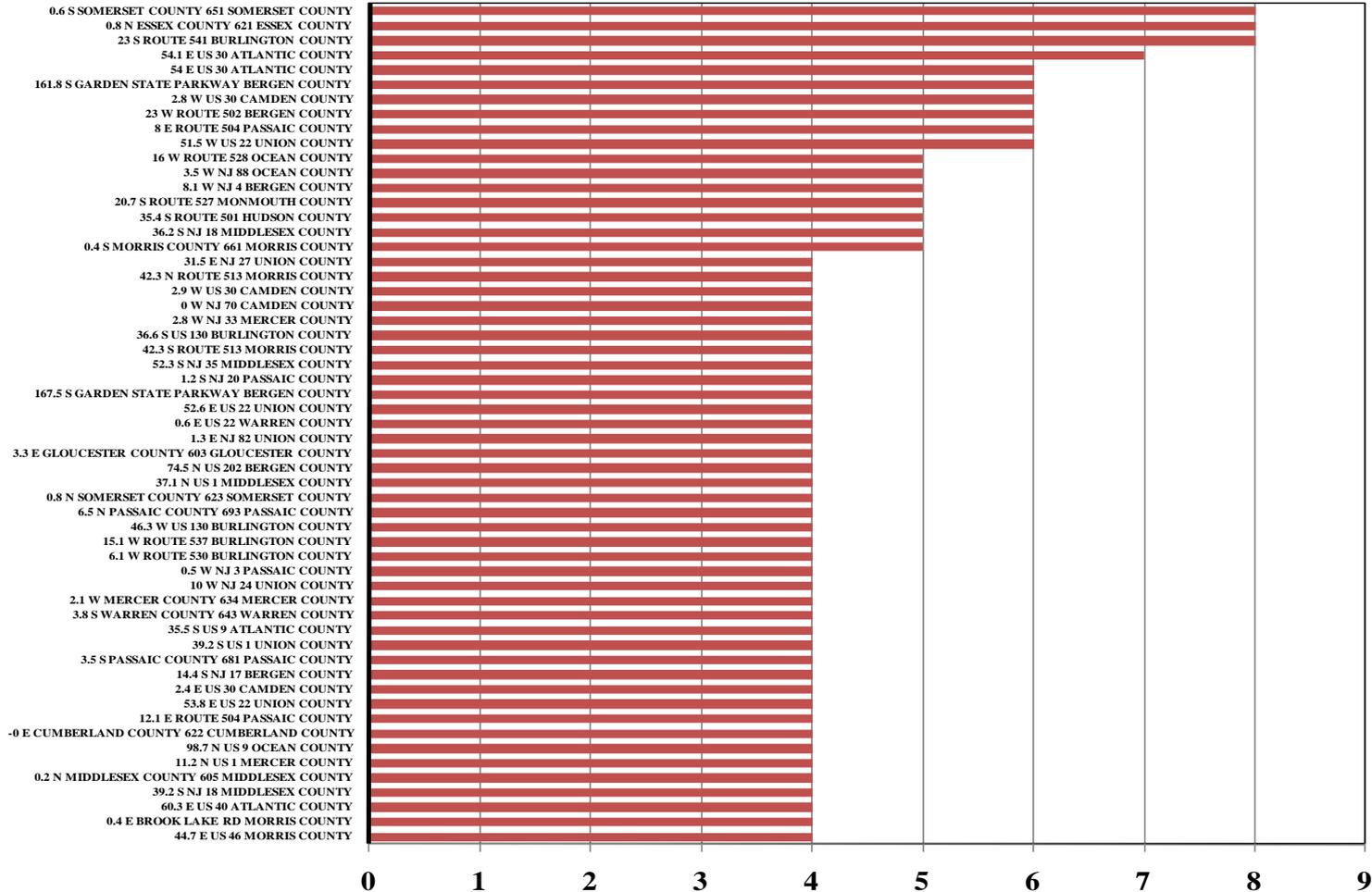
# Analysis

- Objectives
  - Identify “Hot Spot” Pole Impact Locations
- Methods
  - State Crash Data (2003-2005)
    - Location determined by:
      - County, Roadway
      - Direction of Travel
      - Mile Post (1/10 mile)



# Occupants in Utility Pole Impacts

## State Crash Data 2003-2005

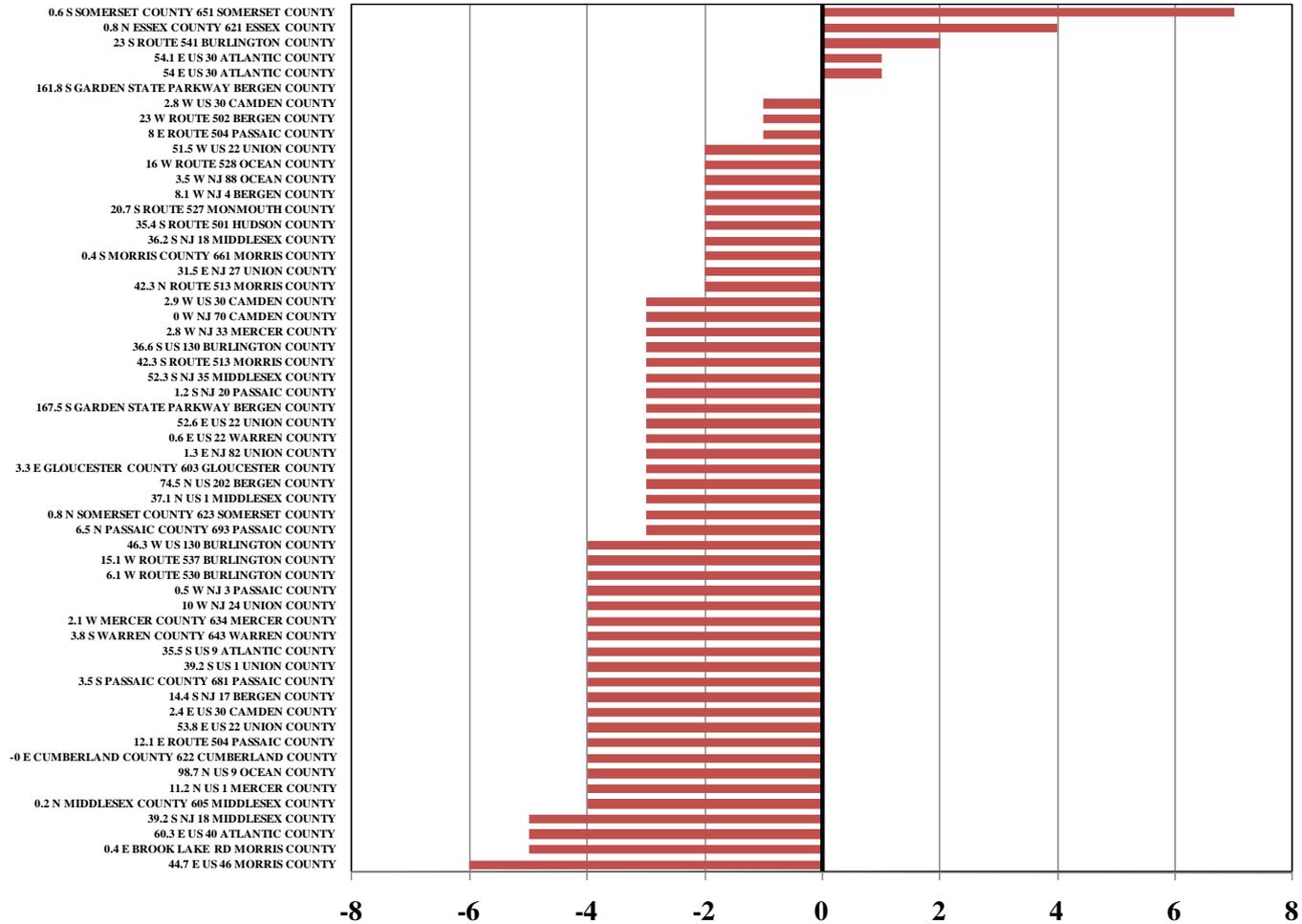


# Interventions

- Move poles away from roadway
- Bury the cables
- Protective guardrail

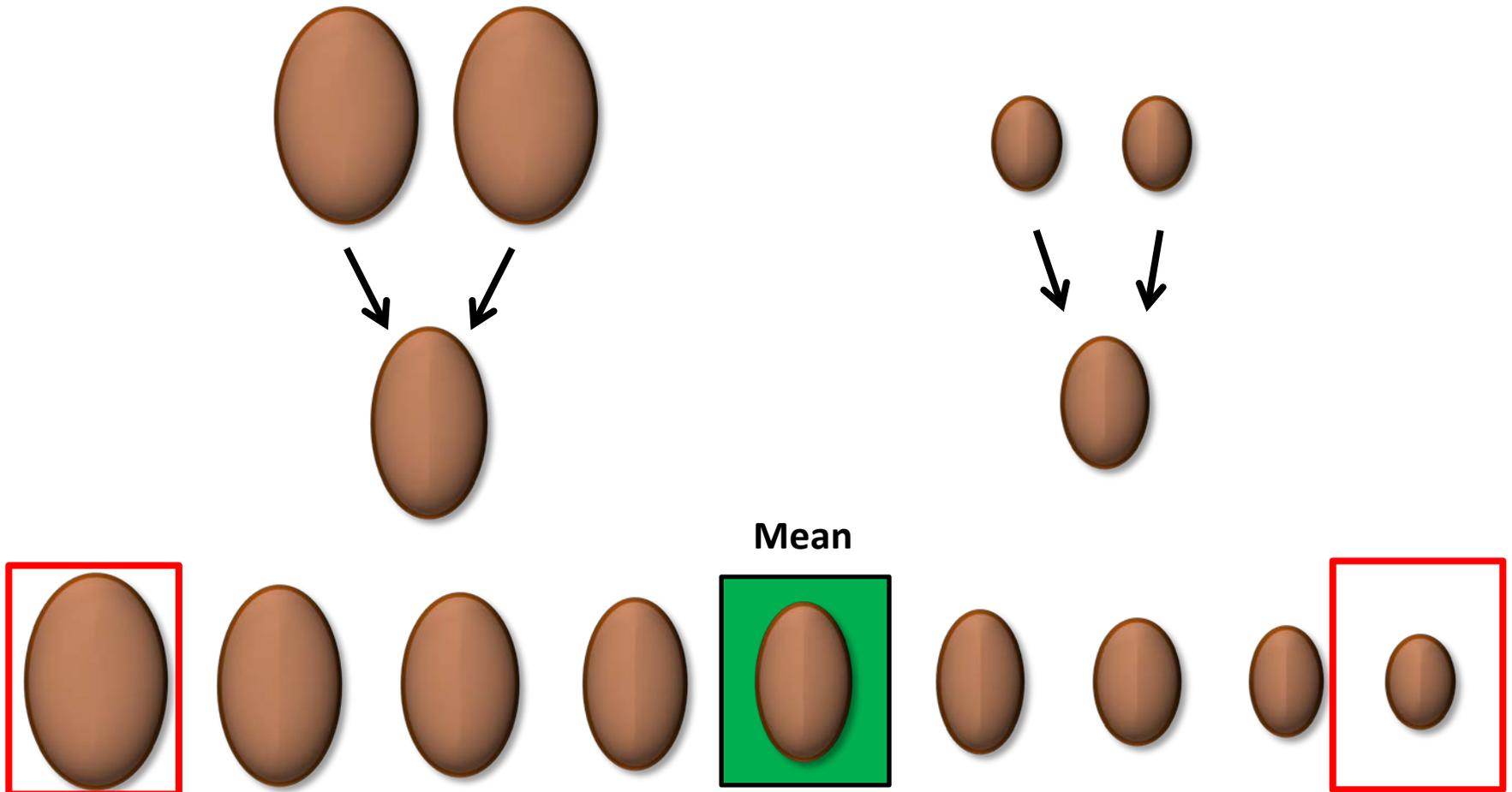


# Change in Occupant Exposure



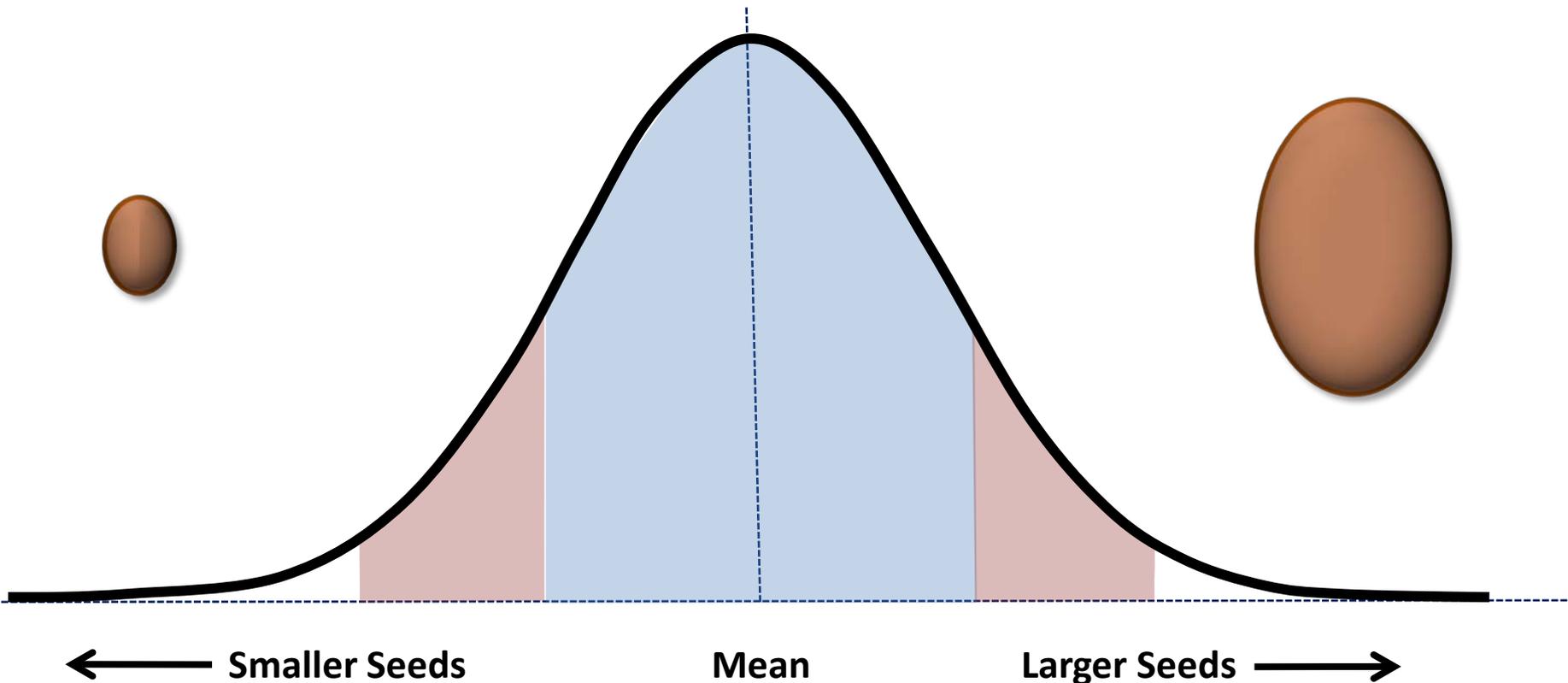
# Regression To The Mean

- Sir Francis Galton, 1887
  - Sweet pea seed size in successive generations



# Regression to the Mean

- It is a statistical phenomenon resulting from repeated observations of the same subject occurring with random error around a “True Mean” - Barnett, Van der Pols, and Dobson(2005)



# Kentucky Roadway



AADT = 15,000  
Crashes (5 years) = 50  
Crash Rate = 179  
Length = 1.0 mile

$$\text{Crash Rate} = \frac{\text{Crashes} * 100 M}{\text{Length} * 365 * \text{Years} * \text{AADT}}$$

# Kentucky Roadway

Casinos save lives!!!



AADT = 15,000  
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$$\text{Crash Rate} = \frac{\text{Crashes} * 100 M}{\text{Length} * 365 * \text{Years} * \text{AADT}}$$

AADT = 30,000  
 Crashes (5 years) = 85  
 Crash Rate = 155  
 Length = 1.0 mile

# Network Screening

- System wide analysis of safety
- Buildup is an example of network screening
  - Uses a moving window to rate the safety of roadway spots and sections
- A way to prioritize many sections with respect to safety
- Useful in systemic analysis

# How is the Network Screening Applied by KYTC?

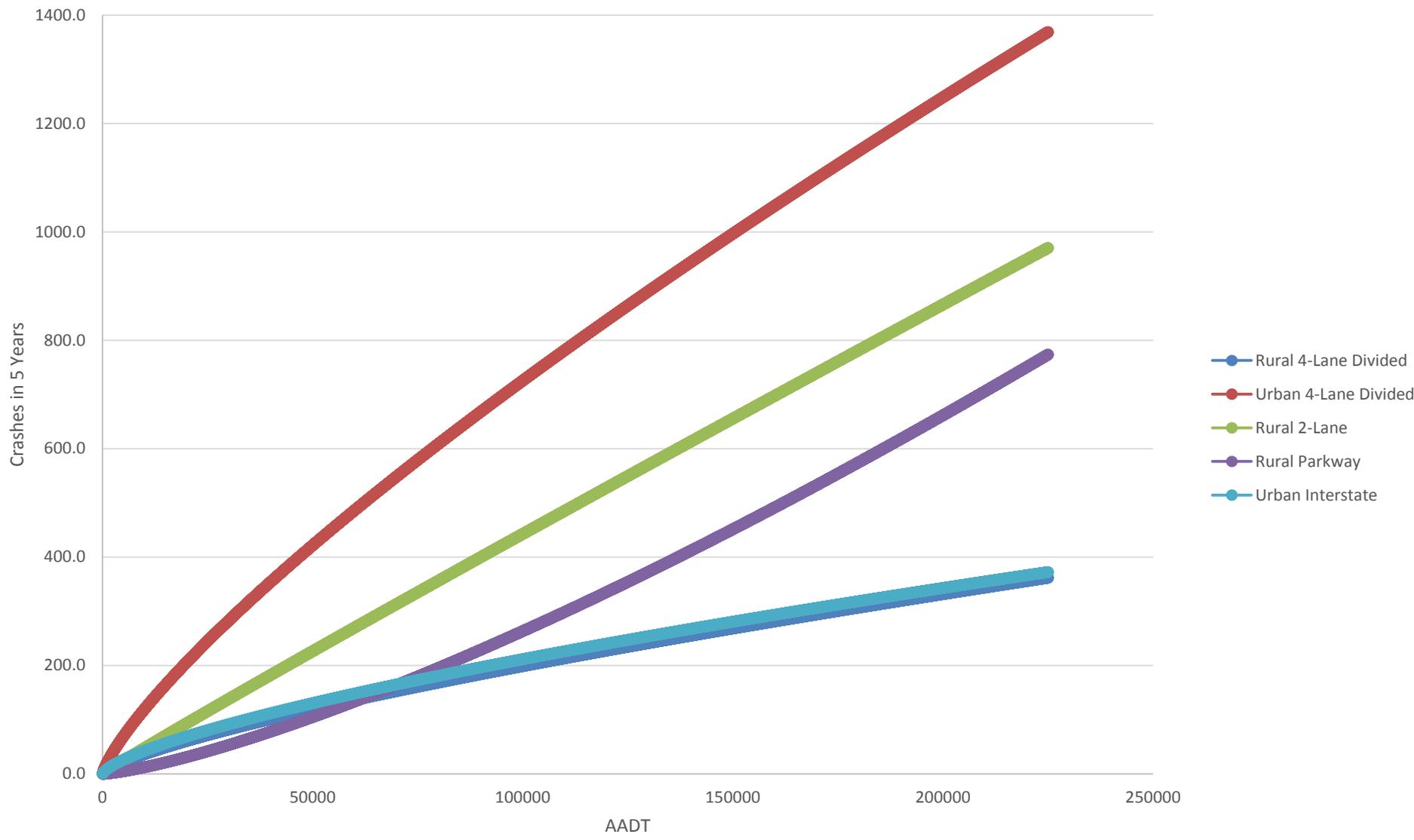
- Identify sites with the most potential for reduction in crash frequency or severity
- Identify factors contributing to crashes and associated potential countermeasures to address these issues
- Conduct economic appraisals of potential improvements and prioritizing projects
- Evaluate the crash reduction benefits of implemented treatments

# Regression Model – Safety Performance Function

$$SPF = AADT^b \times L \times e^a$$

where:  $SPF$  = predicted number of crashes  
 $L$  = section length  
 $a$  and  $b$  are coefficients that describe the behavior between length, AADT and the estimated number of crashes

# SPF Comparison



# SPF Model Process

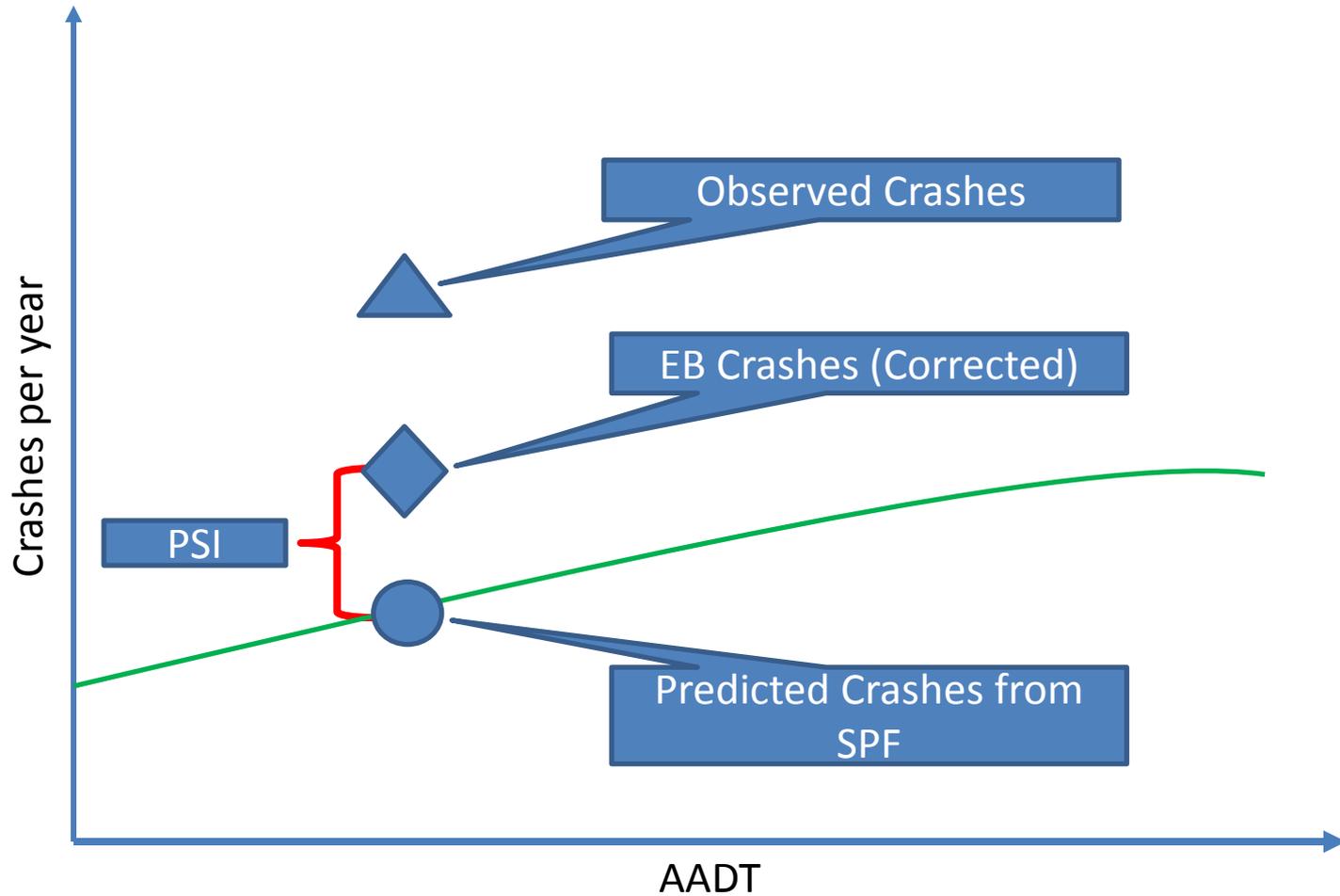
- Input:
  - section length
  - AADT
  - Number of crashes
    - Severity, Crash Type
- Output
  - a, b, overdispersion parameter

# Empirical Bayes Estimate

Crashes (corrected for regression to the mean)

$$EB = (\text{Weight}) \times \text{SPF} + (1 - \text{Weight}) \times \text{Observed Crashes}$$

# Potential for Safety Improvement



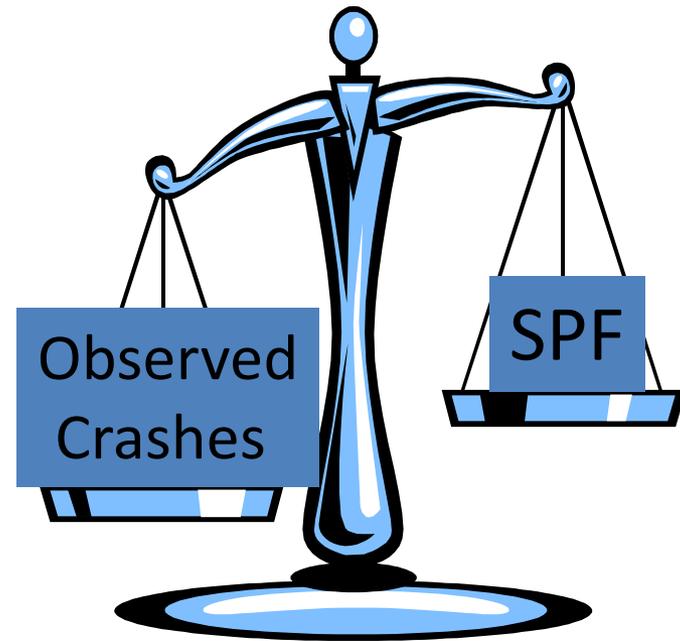
# Empirical Bayes Weight

$$Weight = \frac{1}{1 + (SPF \times Y) / \Phi}$$

where:  $SPF$  = predicted number of crashes/year  
 $Y$  = time frame in years  
 $\Phi$  = overdispersion parameter

# Overdispersion

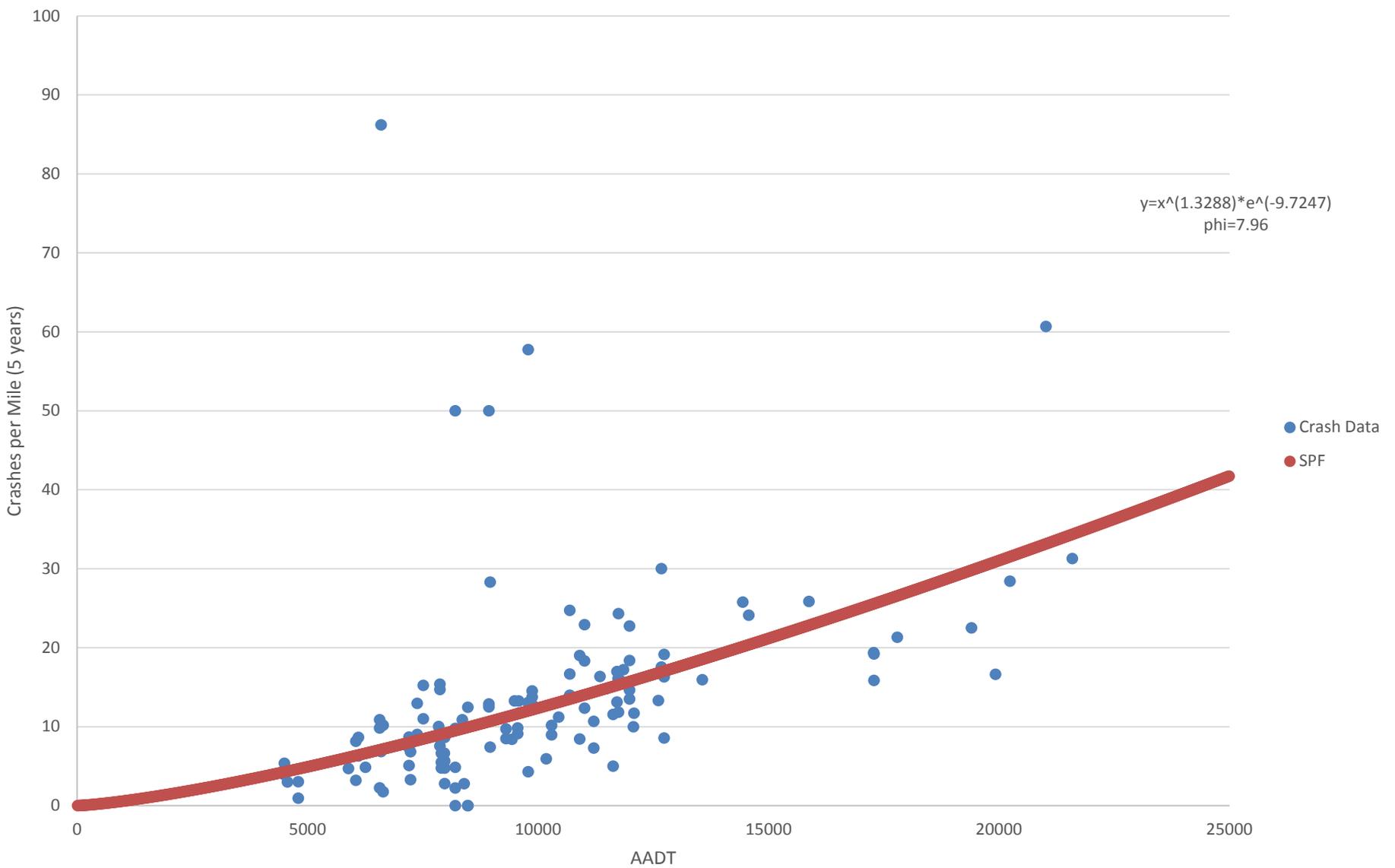
- High  $\phi$   $\rightarrow$  SPF good representation on data
- Low  $\phi$   $\rightarrow$  greater reliance on crash data\*



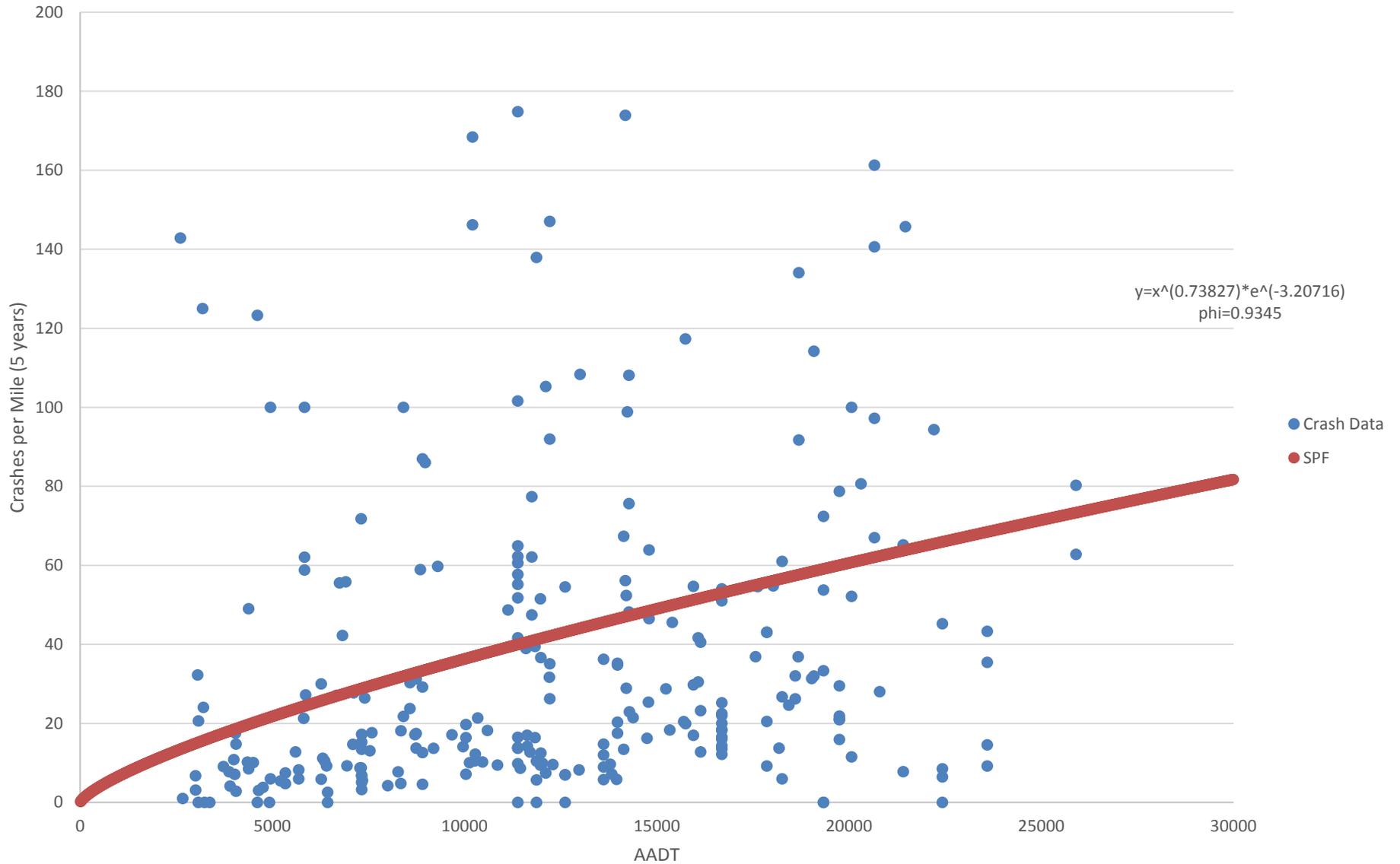
# Examples of Overdispersion Effect

- Rural Parkway
    - $\Phi=7.96$
    - Average Model Weight\*: 0.41
  - Rural 4-Lane Divided
    - $\Phi=0.93$
    - Average Model Weight\*: 0.03
  - Parkways are more homogenous
- \*model weight is site specific and a function of predicted crashes

# SPF and Crash Data - Rural Parkway



# SPF and Crash Data - Rural 4-Lane Divided



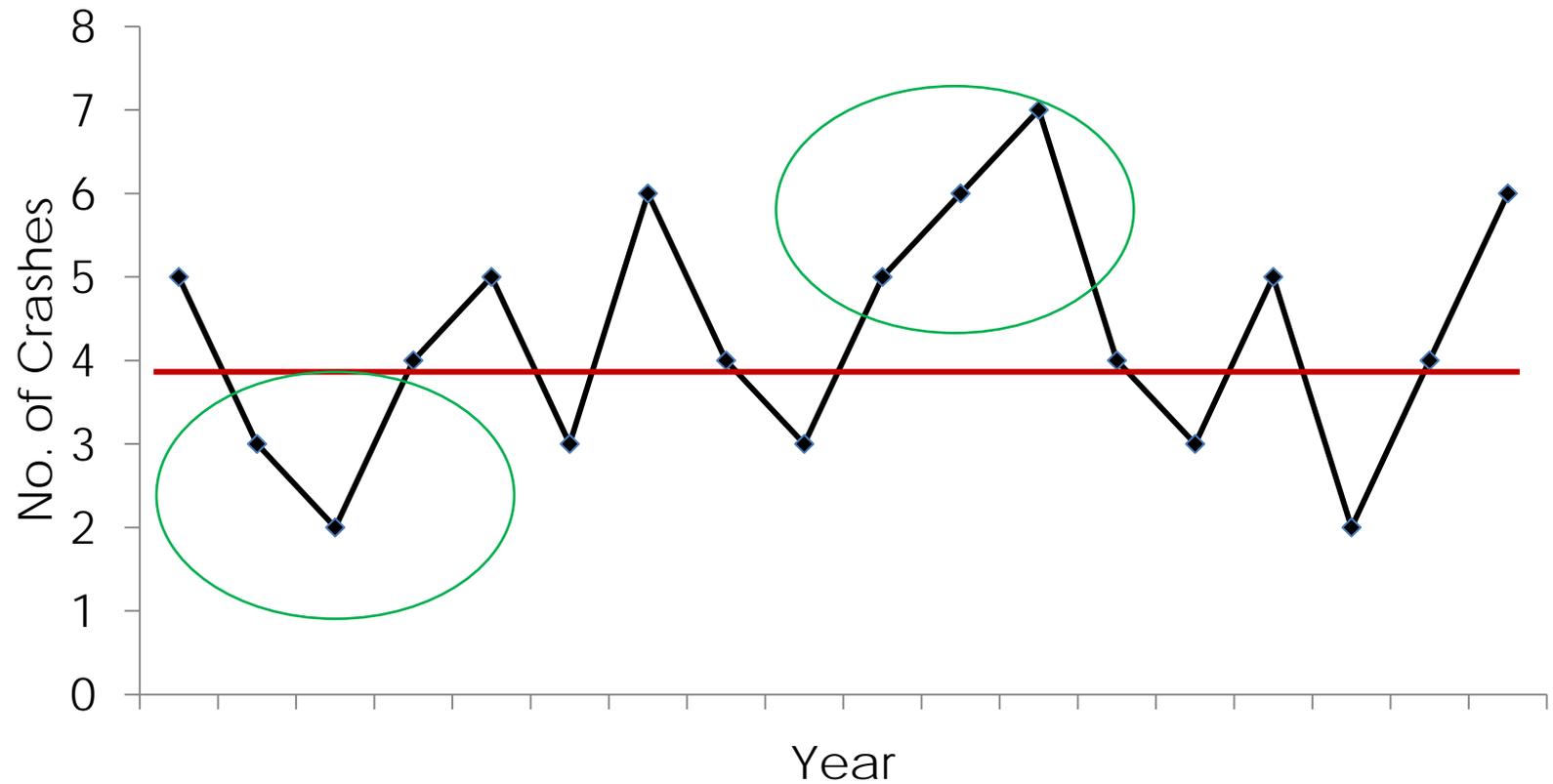
# Potential for Crash Reduction

- PCR = Corrected Crashes – SPF
- Positive PCR indicates a potential for improvement
  - The section is experiencing more crashes than the model predicts even after accounting for regression to the mean

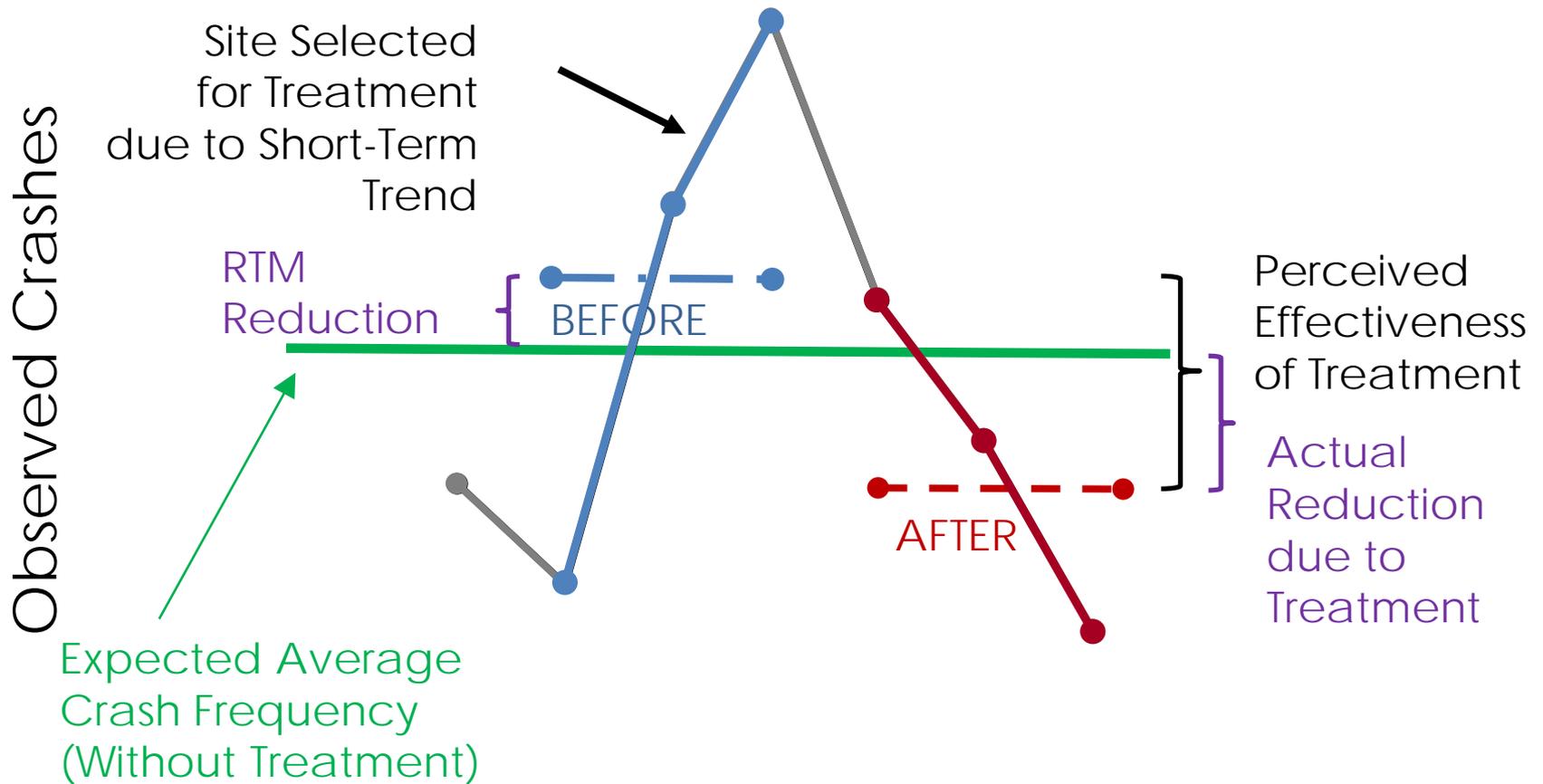
# Cautions

- SPF is a statistical model
- Crashes are random events
- Crash locations can be incorrect
- Consider human factors
- Use engineering judgment
  - As a function of the cost of the improvement

# Regression to the Mean



# Regression to the Mean



# Other Terms for PCR

- Delta
- SWP – Sites with promise
- N-Expected
- PSI – Potential Safety Improvement

PCR is preferred as it characterizes the units

# KYTC's Experience with PCR

- Cable guardrail prioritization
- Road departure plan
- High Surface Friction treatment locations
- General SPF development

# Future of PCR

- Replace CRFs
- Document SPFs in KTC's Rates Report
- Create SPFs for base conditions
  - Currently developed SPFs by functional class and highway type
- PCR Calculator
  - Batch (planning)
  - Site specific (project level)

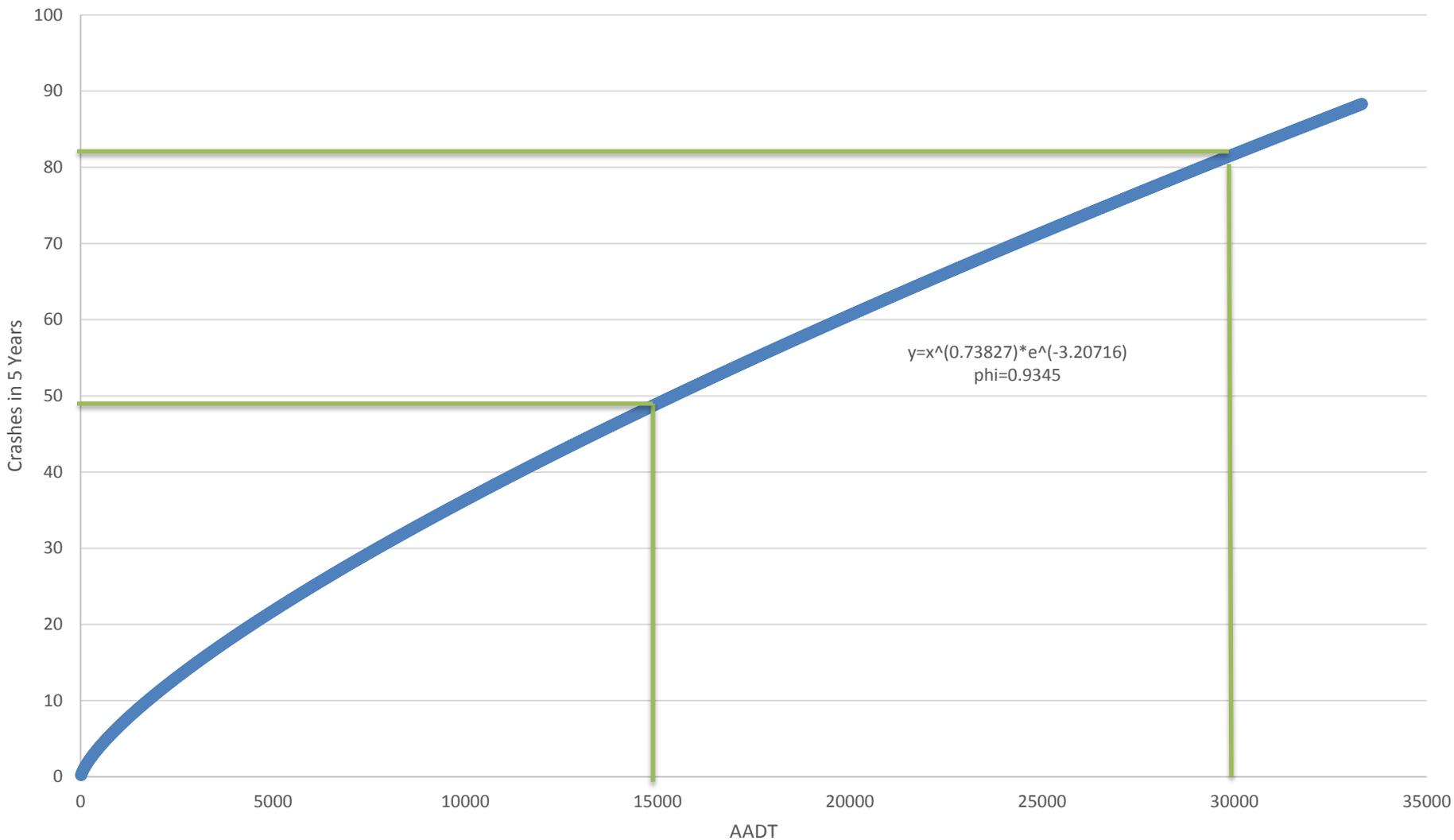
# Casino Revisited

AADT = 15,000  
Crashes (5 years) = 50  
Crash Rate = 179  
Length = 1.0 mile

AADT = 30,000  
Crashes (5 years) = 85  
Crash Rate = 155  
Length = 1.0 mile



# Rural 4-Lane Divided SPF



# Casino Revisited

## Before

- AADT = 15,000
- Crashes (5 years) = 50
- Length = 1.0 mile
- SPF = 49.0
- $W = 0.019^*$
- Corrected = 50.0
- PCR = 1.0

## After

- AADT = 30,000
- Crashes (5 years) = 85
- Length = 1.0 mile
- SPF = 81.7
- $W = 0.011^*$
- Corrected = 85.0
- PCR = 3.2

\*low model weight

# Before and After

	AADT	SPF	Observed	Crash Rate	Weight	Corrected	CRF	PCR
Before Casino	15000	49.0	50	182.6	0.019	50.0	1.077	1.0
After Casino	30000	81.7	85	155.3	0.011	85.0	0.998	3.2

# CRF and PCR

- PCR is similar to CRF in that the higher the PCR, the higher the potential benefit
- CRF and PCR do not have the same magnitude
- CRF is typically calculated along side of PCR for legacy reasons
- CRF is being phased out

# 7 of top 25 PCR are top 25 CRF list

## 20 of top 25 PCR are in top 100 CRF

SiteID	AADT	Observed	Length	PCR	Crash Rate	CRF
671	38672	252	0.957	156.2	373.1	2.83
512	14243	178	0.513	150.8	1334.9	10.13
29	3316	90	0.389	79.1	3823.1	29.03
472	13324	105	0.643	74.6	671.6	5.10
340	10037	74	0.249	63.3	1622.4	12.32
536	15052	120	1.423	49.2	307.0	2.33
611	18691	85	0.634	47.7	393.0	2.98
253	8451	50	0.125	44.7	2593.5	19.69
375	10894	61	0.533	39.4	575.6	4.37
347	10204	50	0.342	36.5	785.1	5.96
559	15742	63	0.537	35.1	408.4	3.10
652	22426	40	0.088	33.7	1110.6	8.43
631	20309	135	1.674	31.9	217.6	1.65
555	15526	55	0.477	30.5	406.9	3.09
473	13518	70	0.94	26.8	301.9	2.29
669	38407	68	0.427	25.9	227.2	1.72
522	14516	31	0.1	25.7	1170.2	8.88
662	25551	31	0.073	25.4	910.7	6.91
308	9364	27	0.03	25.3	5266.5	39.98
533	14833	38	0.255	25.1	550.5	4.18
647	22206	82	0.869	24.8	232.8	1.77
537	15052	27	0.075	22.9	1310.5	9.95
535	14935	36	0.265	22.6	498.4	3.78
273	8887	37	0.414	22.6	551.0	4.18

Spearman's  
Rho of 0.72

SiteID	AADT	Observed	Length	PCR	Crash Rate	CRF
6	2605	20	0.035	18.3	12019.6	91.25
308	9364	27	0.03	25.3	5266.5	39.98
137	6268	3	0.005	2.8	5245.2	39.82
25	3234	17	0.064	15.1	4500.6	34.17
29	3316	90	0.389	79.1	3823.1	29.03
633	20581	8	0.006	7.5	3549.8	26.95
120	6088	9	0.023	8.1	3521.9	26.74
7	2605	7	0.049	5.9	3004.9	22.81
253	8451	50	0.125	44.7	2593.5	19.69
23	3183	1	0.008	0.8	2151.8	16.34
663	25551	17	0.019	15.4	1918.8	14.57
31	3492	9	0.074	7.4	1908.4	14.49
160	6814	9	0.043	7.6	1683.1	12.78
340	10037	74	0.249	63.3	1622.4	12.32
594	17790	14	0.027	12.3	1597.1	12.13
65	4608	9	0.073	7.2	1466.0	11.13
306	9299	10	0.044	8.3	1339.2	10.17
512	14243	178	0.513	150.8	1334.9	10.13
560	15742	25	0.066	21.3	1318.5	10.01
537	15052	27	0.075	22.9	1310.5	9.95
117	5920	19	0.137	15.1	1283.7	9.75
525	14602	18	0.057	15.0	1185.0	9.00
553	15456	5	0.015	4.2	1181.7	8.97
522	14516	31	0.1	25.7	1170.2	8.88

# Comparison of PCR<sub>s</sub>

- PCR<sub>s</sub> should be compared across similar highway types or functional class
- PCR<sub>s</sub> already account for AADT

# Example of PCR Comparison

- A rural 2-lane undivided PCR of 4 can be compared to a rural 2-lane undivided PCR of 12.5
- The first site has less potential for improvement

# Comparing PCRs from Different Highway Types

- Currently it is not recommended
- PCRs should be comparable but there are some unknowns
  - Higher class roads tend to have larger (negatively and positively) PCRs
  - AADT is accounted for, however it seems to increase the scale
- There should be a way to normalize this scale

# Cost Benefit

- PCR could be used as the denominator in a cost-benefit ratio
- Rural 2-lane road with PSI = 2.8; 5 Miles
- Urban Interstate with PSI = 35.1; 20 miles
  
- More research is recommended for this approach

# Future Work

- Baseline SPFs
- Determine a methodology to compare PSIs from different SPFs
- Outlier detection
- Standard error (site based)

# QUESTIONS?