GIS-Highway Safety Review (GIS-HSR) Tools for Rural Roads

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SDSU

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MPC Mountain-Plains Consortium

South Dakota DOT
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Rural Safety Challenges

- Extensive roadway network
- Limited data availability
- Low ADT – leads to high crash rates
- Varying roadway conditions and standards
- Isolated crashes

Study Objectives

- Provide a custom integration for South Dakota data and needs
- Develop a data-driven, system-wide method to identify high-risk rural locations
- Provide a model-based method of determining roadway safety
- Implement GIS techniques to analyze data spatially
- Provide a user friendly interface for practitioners

Data Requirement

- Traffic (linear features)
- State Roads (linear features)
- Vertical Curves (point features)
- Horizontal Curves (point features)
- Crashes (by year) (point features)

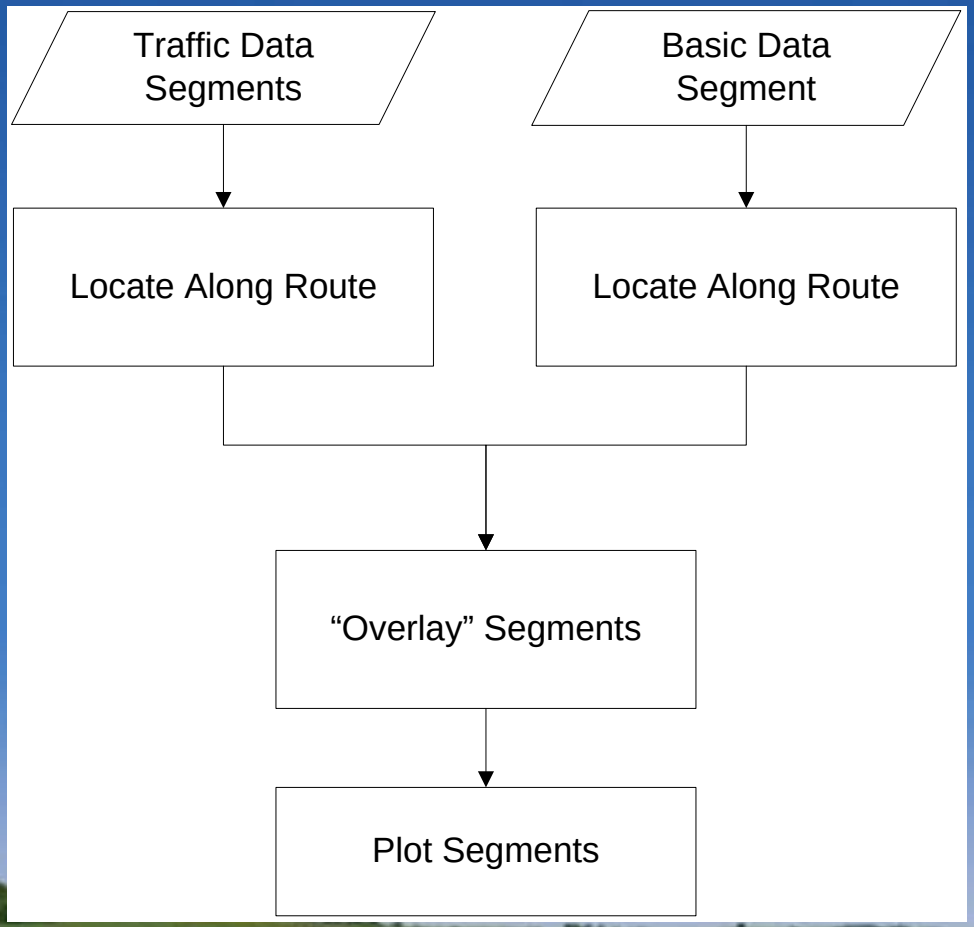
All in GIS format

Data Processing Challenges

- Varying data formats
- Non-uniform spatial representations
  - Point features
  - Linear features
- Curve information stored at PI (point of intersection) which is normally not located on the roadway.
- Crashes are not located exactly on the roadway.
- Variables may be correlated

Solutions

- Buffer and spatial join for Point data (150 ft)
- Linear referencing and overlay tool for linear data
- Remove correlated variables based on Pearson correlation test.



Methodology

Empirical Bayes (EB) method

$$E = W \times \mu + (1 - W)N$$

Where:

E is the expected crashes for an entity

W is the weight factor (0<W<1)

W=1/(1+*k* μ) and *k* is the overdispersion factor

μ is the predicted number of crashes

N is the actual number of crashes

Methodology – Safety Performance Function (SPF)

Functional Classification	Predicted Crash Count μ	Dispersion Factor k
Rural Major Collector	$= MVMT^{0.689} exp(0.577 - 0.015\ Lane\ Width + 0.048\ Speed\ Limit + 0.015\ Left\ Shoulder\ Width - 2.122\ Percent\ Trucks + 0.007\ Vertical\ Curve\ Density - 0.833\ If\ Municipal\ Funding\ Catagory)$	1.328
Rural Minor Arterial	$= MVMT^{0.869} exp(5.640 - 0.027\ Lane\ Width - 0.021\ Speed\ Limit - 0.015\ Vertical\ Curve\ Density - 0.085\ Right\ Shoulder\ Width - 1.404\ Percent\ Trucks - 0.594\ If\ Has\ Median - 0.296\ If\ Has\ Rumble\ Strip - 1.234\ If\ Municipal\ Funding\ Catagory\ )$	0.483
Rural Principal Arterial-Interstate	$= MVMT^{0.888} exp(4.954 - 0.038\ Lane\ Width - 0.013\ Speed\ Limit - 1.350\ Percent\ Trucks - 0.029\ Vertical\ Curve\ Density - 0.002\ Median\ Width - 0.430\ If\ Has\ Rumble\ Strip)$	0.616
Rural Principal Arterial-Other	$= MVMT^{0.704} exp(0.389 - 0.031\ Lane\ Width + 0.056\ Speed\ Limit - 1.832\ Percent\ Trucks + 1.087\ If\ Has\ Curb - 0.863\ If\ Municipal\ Funding\ Catagory)$	1.339

Methodology – Continuous Sliding Window

Objective

Count the number of crashes by severity within a window of certain length.

Study Increment	Fatal	Injury	PDO
1	0	1	1
2	1	1	2
3	1	1	2
4	0	2	1
5	0	1	2
6	0	2	2
7	1	2	0
8	1	0	0
9	0	0	0

Length = 10 miles
Window = 2 miles
Increment =1 mile

Methodology – Predicted Window-based Crash Frequency

Objective

Estimate the number of crashes via SPFs within a window of certain length.

$$SPFwin = SPF1 \times \frac{l1}{L} + SPF2 \times \frac{l2}{L} \ldots$$

Where:

SPFwin is SPF value for window

SPF_i is SPF value for *i*th segment

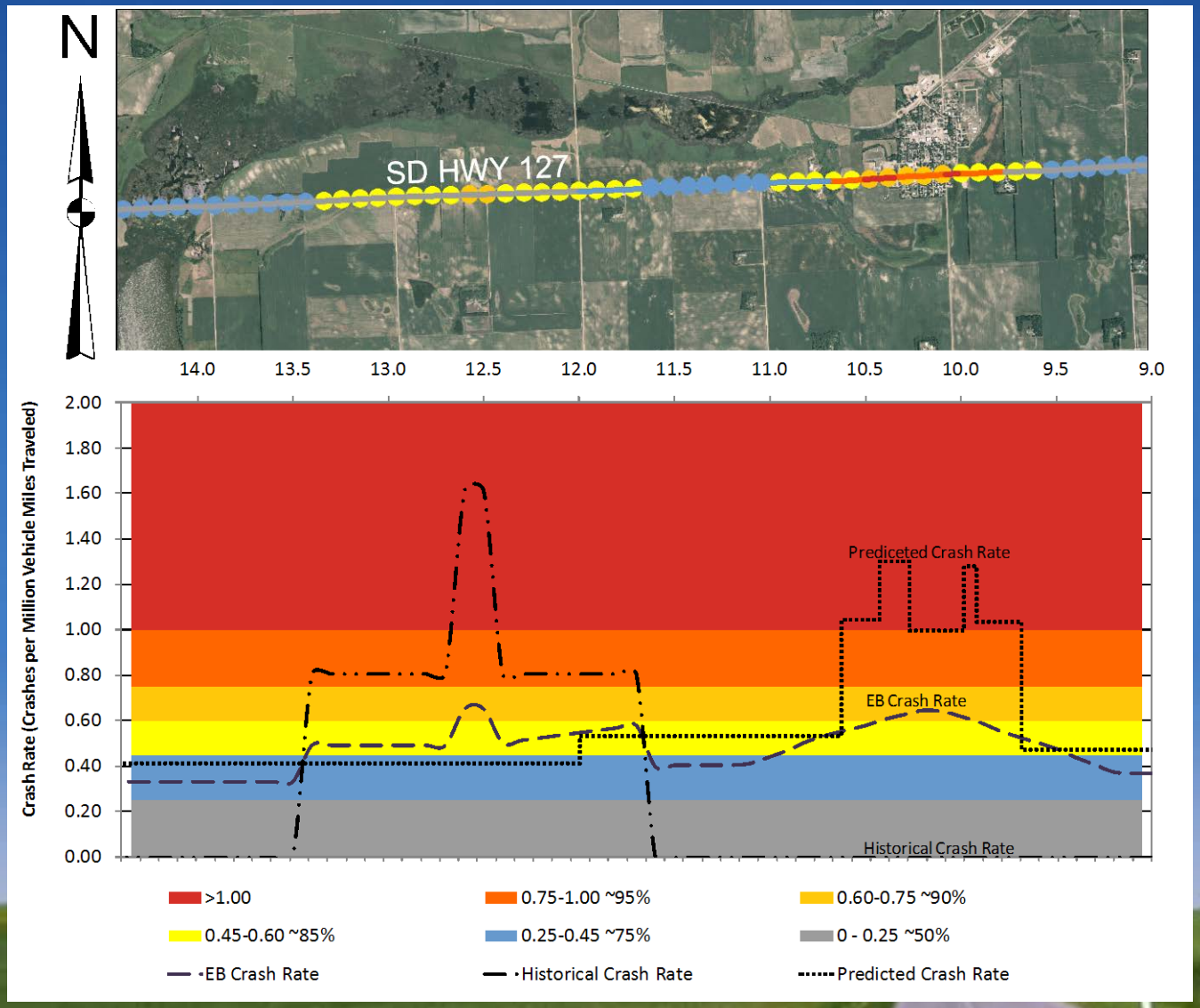
l_1 is length of first segment within window

L is the window length

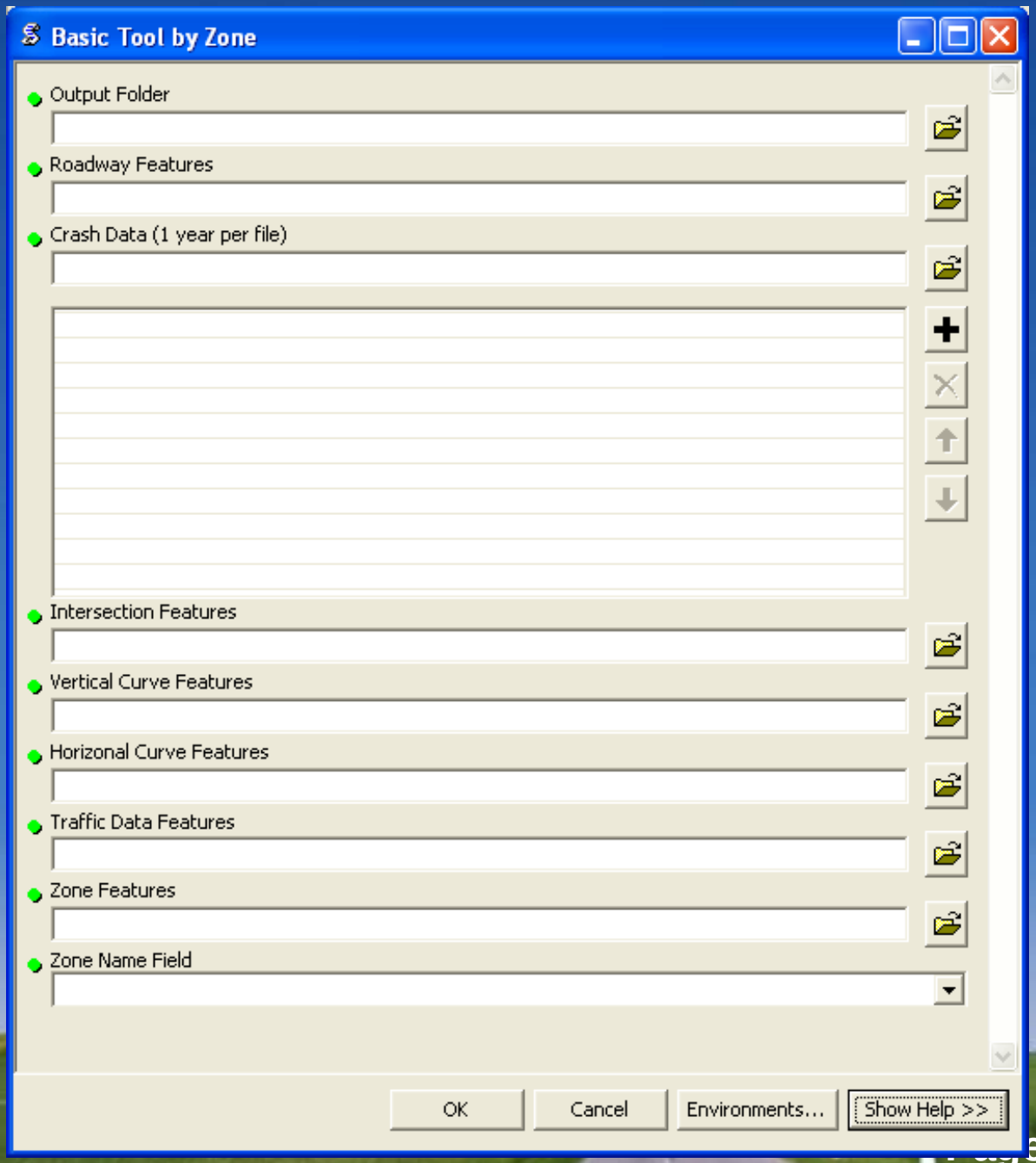
Safety Metrics

Raw Crashes	Description	Crash count normalized by spatially weighted average of ADT
	Application	Provides continuity with established methods
EB Crashes	Description	Calculated based on crash count within window and spatially weighted average of SPF value
	Application	• Primary performance metric • A compromise between predicted crash occurrence, and historical performance
Excess Crashes	Description	Difference between actual crashes within the window and predicted crash count.
	Application	• Identify location with unidentified contributing factors or Safety Improvement Potential Index • Not a substitute for the EB

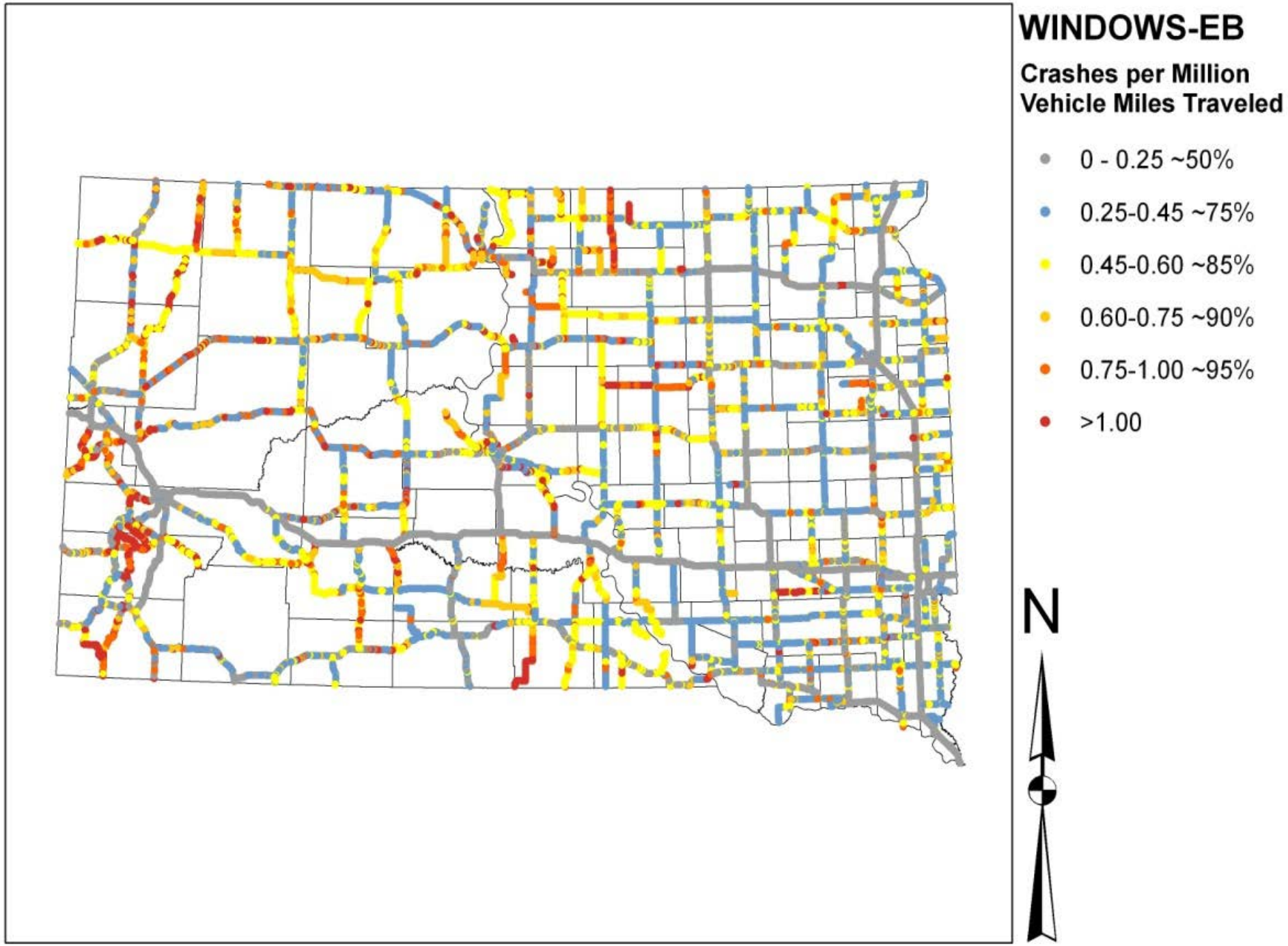
Comparison of Safety Metrics

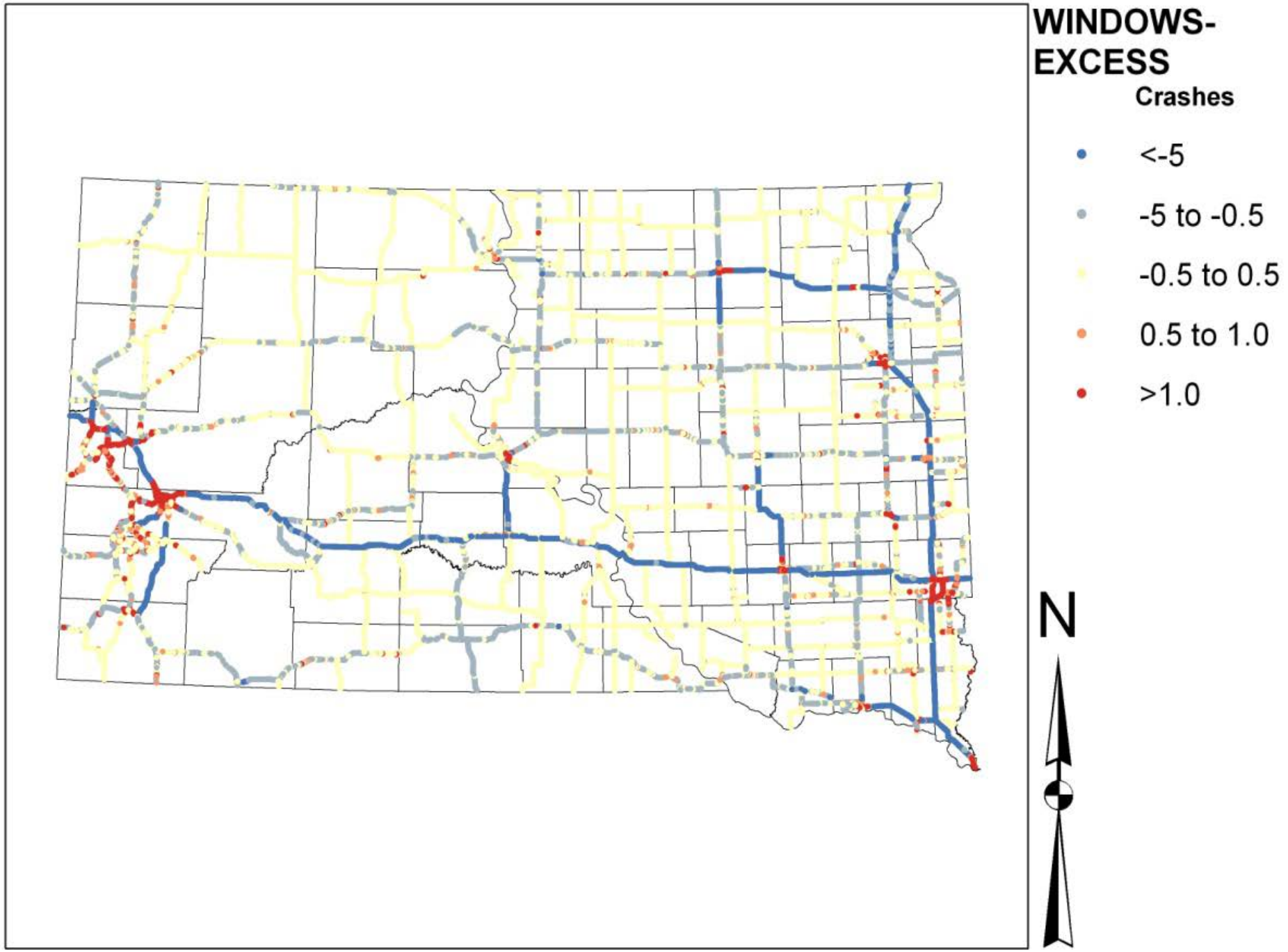


GIS-HSR Tools Interface




WINDOWS-
Crash Rate
Crashes per Million
Vehicle Miles Traveled
0 - 0.25 ~50%
0.25-0.45 ~75%
0.45-0.60 ~85%
0.60-0.75 ~90%
0.75-1.00 ~95%
>1.00
N


WINDOWS-EB
Crashes per Million
Vehicle Miles Traveled
0 - 0.25 ~50%
0.25-0.45 ~75%
0.45-0.60 ~85%
0.60-0.75 ~90%
0.75-1.00 ~95%
>1.00
N


WINDOWS-
EXCESS
Crashes
<-5
-5 to -0.5
-0.5 to 0.5
0.5 to 1.0
>1.0
N

Conclusions

- Various safety metrics, esp. EB crash estimate, provide different perspectives for rural roads safety performance evaluation.
- A sliding window technique provides a fine resolution in crash locations.
- The SD GIS-HSR Tools are developed as a data-driven approach toward identifying high-risk locations.

Questions?

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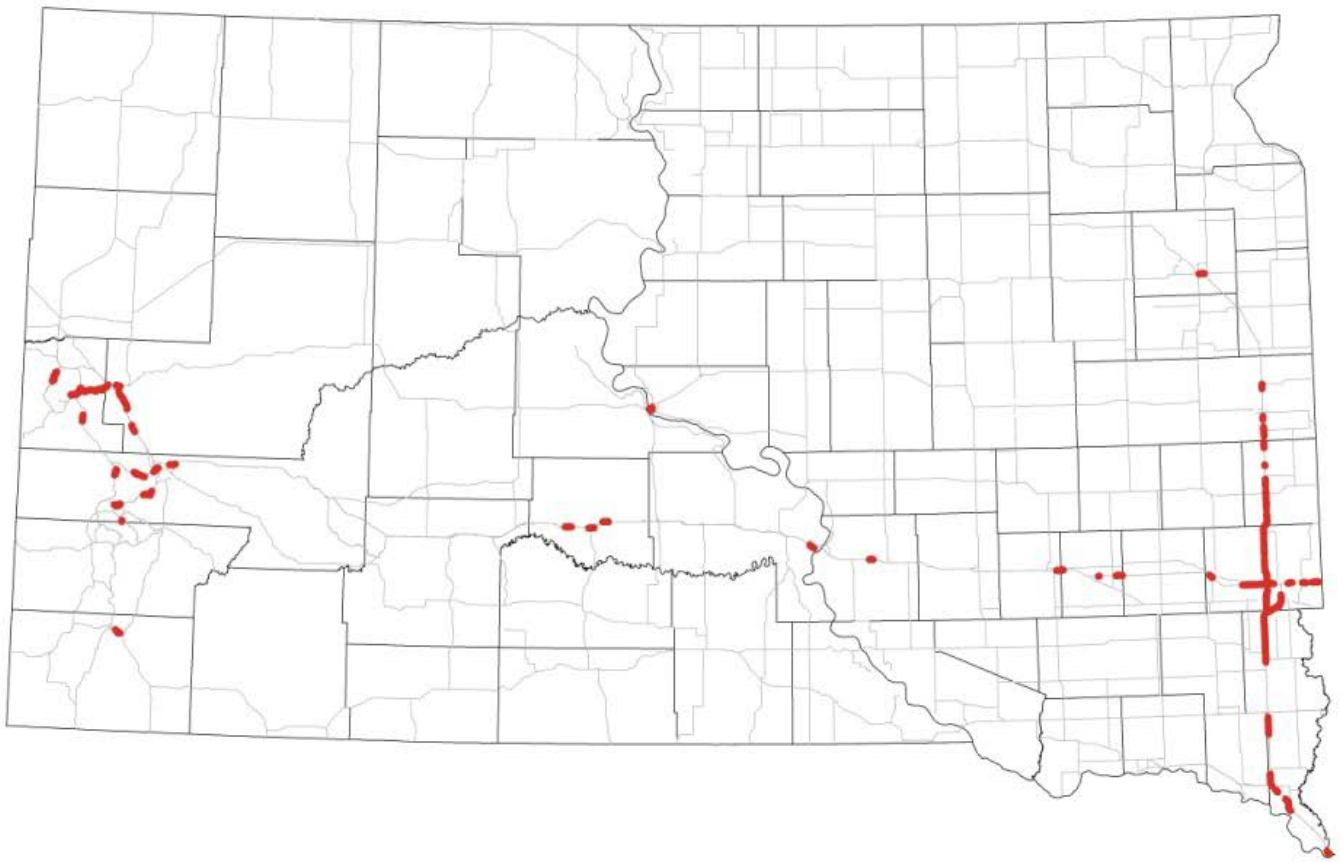
Segment Aggregation

- Output of sliding window is hard to analyze other than visually
- Segments are generated with homogenous* risk as defined by a safety metric
- Ranking of sites can be conducted easily

*Homogeneous defined as no more than 10% change

AGGREGATED SEGMENT-EB

Top 200 Segments by EB Rate



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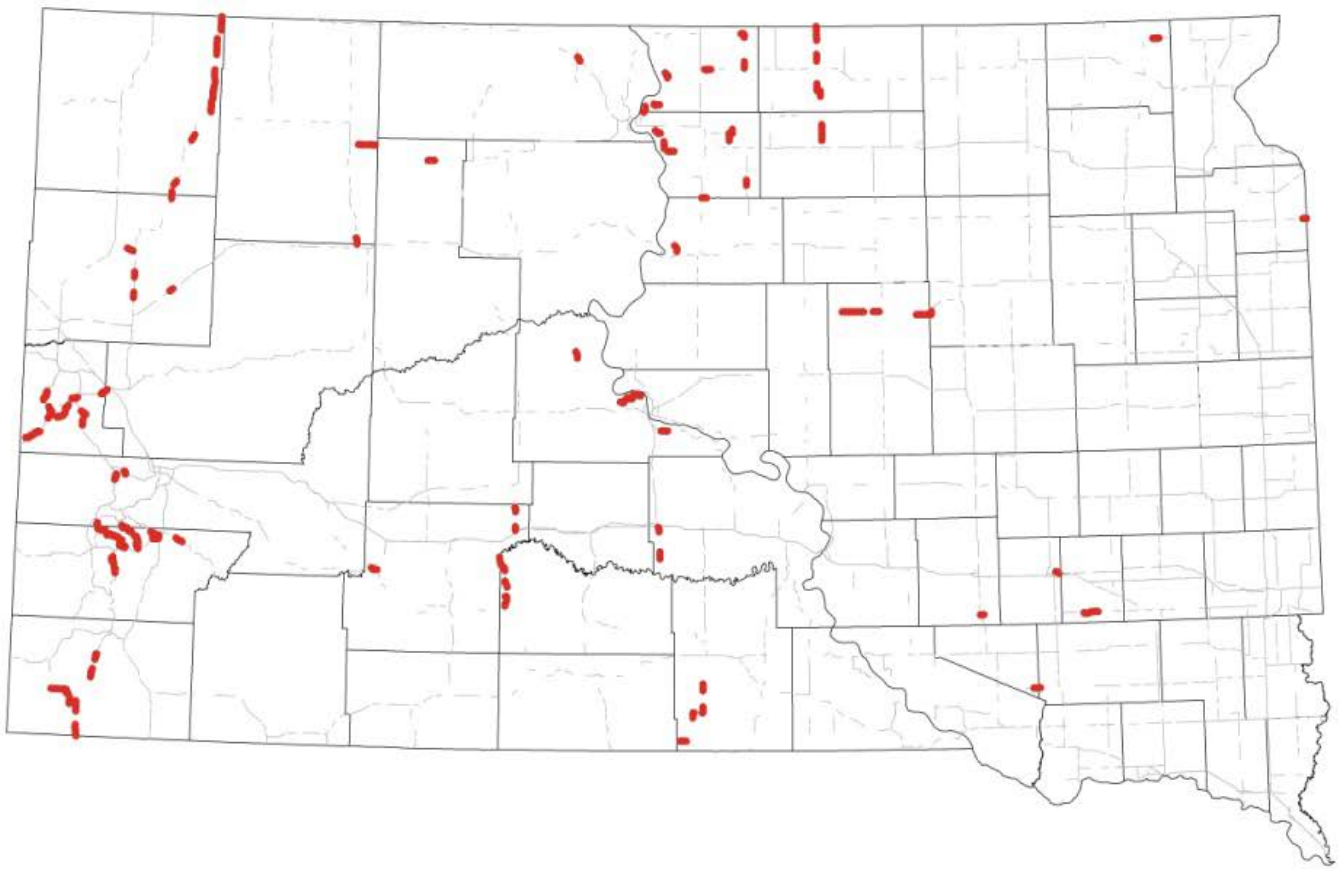
AGGREGATED SEGMENT-CR

Top 200 Segments by Crash Rate



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