8. APPENDIX A: MINNESOTA CRSP APPROACH COUNTY LEVEL INPUT DATA

8.1 Rural Horizontal Curves

A more detailed analysis highlighting the data input required to generate the criterion of each risk factor in the elements are described as follow:

**Curve Radius** It was discussed in the previous section of this chapter that curve radius data were collected on district level. A range of curve radii in each district that had an over-representation in severe crashes (i.e. fatal and major injury) on secondary paved rural roadways was selected. Plots in Figures 1 and 2 illustrate the percentage of horizontal curves along with percentage of severe (fatal and major injury) roadway departure crashes on those horizontal curves of the radii shown for Iowa DOT District 4 (containing Dallas County) and 6 (containing Buchanan County), respectively.

![Histogram of Curve Radii](image)

*Figure 1: District 4 severe roadway departure crashes on curves and curve radius.*
Figure 2: District 6 severe roadway departure crashes on curves and curve radius.

The project team made a subjective decision for the selection of the over-represented ranges. The over-represented range marked by the box in each plot shows that approximately 70 percent of the severe roadway departure crashes in District 4 occurred on horizontal curves with radius ranging between 400 and 1100 feet compared to 42 percent between 700 feet and 1100 feet in District 6. Rural curves in Buchanan and Dallas counties were assessed according to the criteria determined from district analysis. Therefore, a curve radius satisfying the criteria of the over-represented range received a star.

Traffic Volume AADT on curves was another characteristic collected at the district level. Figures 3 and 4 show the percentage of horizontal curves in each district (District 4 and 6 respectively) and percentage of severe (fatal and major injury) roadway departure crashes by AADT on these curves.
Figure 3: District 4 severe roadway departure crashes on curves and curve AADT.

Figure 4: District 6 severe roadway departure crashes on curves and curve AADT.
Every roadway network has a range of traffic volume that is over-represented in relation to the frequency of curve-related crashes. In District 4, horizontal curves in the volume range of 200 and 800 vpd accounted for 68 percent of severe roadway departure crashes. However, the curves in the volume range of 800 and 1600 vpd in District 6 resulted in 55 percent of the severe roadway departure crashes. These results were then used as input criteria for the evaluation of rural curves in Buchanan and Dallas counties. A star was assigned to each curve that met the criteria.

**Intersection in Curve** Visualization technique, ArcMap, was used to determine if an intersection was present at a spatial proximity of 150 feet of the curve location. One paved intersection could be within a 150 feet radius of multiple horizontal curves. Hence, horizontal curves with an intersection received a star.

**Visual Trap** The presence of a visual trap increases the risk of being involved in a crash and these curves were assigned a star. They usually exist when a minor obstacle or object continues on a tangent. Visual traps were recorded from Google StreetView images.

**Crash Experience** Crash data from the Iowa DOT database was used to determine if a horizontal curve experienced a severe crash (i.e. fatal and major injury) during the five year analysis period (from 2008 until 2012). Curves that experienced a severe crash received a star.

### 8.2 STOP-Controlled Intersections

Intersections were evaluated using the seven risk factors identified by the CRSP methodology. The input data required to define these risk factors included the following:

**Skew Angle** The skew angle of an intersection was measured using the measurement tools available in ArcMap. According to the Minnesota CRSP report, skewed intersections have a higher risk to experience a crash. Therefore, an intersection received a star if it had a skewed approach greater than 15 degrees measured from the base (90 degrees).

**Intersection On/Near Curve** It was determined if an intersection was located on or near (within 150 feet) a horizontal curve. This risk factor differs from the one identified for horizontal curves by the range of intersections around a curve. In other words, an intersection point might have one or more horizontal curves within 150 feet radius. A star was assigned for an intersection located on or near a curve.

**Commercial Development** The presence of a commercial development (other than residence or a farm) was recorded in any quadrant of an intersection. An intersection with a commercial development received a star since it increased the level of risk.

**Distance to Previous Stop Sign** As noted in the CRSP report, drivers frequently lose attention when driving for longer distances with no stop sign. Therefore, the presence of a stop sign within five miles on the paved approach of an intersection which is part of the roadway network and/or has Google StreetView images was determined. A star was given to an intersection when its minor leg approach did not have a stop sign within five miles.

**AADT Ratio** Traffic volume data were collected for the major and minor approaches of each intersection in the two counties. The ratio of the minor intersection-leg AADT to major intersection-leg AADT was then computed for every intersection. An intersection-leg with the minimum AADT was identified as the minor approach while the major approach had the maximum AADT. There were three different scenario calculations of the AADT ratio and they included the following:
• For 3-leg intersections: the average value of AADT on the main approach was computed since there is traffic flow on both legs of the intersection. The minimum AADT value from both the main approach and intersecting road was divided by the maximum value.

• For 4-leg intersections: the average value of AADT on both the main and intersecting legs of the intersection was determined and the AADT ratio was then computed.

• For local roadways intersecting with arterial roadways: the average value of AADT was first determined for the local roadways only. This is because the arterial road, for instance an interstate or US highway, intersecting with the local roadway was a one-way ramp generating flow into the traffic stream. The AADT ratio was then calculated.

Referring to the county system in the Minnesota CRSP approach, there was a range of ADT ratio more prone to severe crashes than others. It was recognized that intersections with an ADT ratio between 0.4 and 0.8 received a star (there was no justification for the selected over-represented range). On the other hand, the same criteria was applied in both Buchanan and Dallas counties due to the unavailability of AADT ratio information in the Iowa DOT electronic database and since there is a reasonable similarity in the data compared to the counties in Minnesota. It was not possible to create a plot of intersection frequency on district level in Iowa (Districts 4 and 6) for different ranges of AADT ratios.

**Railroad Crossing on Minor Approach** This risk factor used to systemically rank rural stop-controlled intersection was determined using ArcMap. An intersection received a star if a railroad crossing was located within 500 feet of the intersection since the level of risk to be involved in a crash would increase.

**Crash History** Any rural stop-controlled intersection in Buchanan and Dallas counties that experienced a crash (any type of crash) during the five year period analysis (i.e. from 2008 to 2012) was assigned a star.

### 8.3 Rural Segments
The identification of segments in each county helps in determining the corridors/segments that have higher level of risk to experience a severe roadway departure crash. The input data requirements for the five risk factors to complete the prioritization process included the following:

**AADT Range** As noted previously, traffic volume and severe (fatal and major injury) roadway departure crash data on segments were also collected at the district level (Districts 4 and 6). The plots in Figures 5 and 6 show the percentage of secondary rural paved roadways by AADT along with the percentage of severe roadway departure crashes for Iowa DOT Districts 4 and 6. Segments that had an over-representation in the severe roadway departure crashes were highlighted on the plots. It could be observed that approximately 20 percent of the rural segments in District 4 with an AADT between 600 and 1400 vpd experienced 31 percent of the severe roadway departure crashes. Similarly, 35 percent of the segments in District 6 with an AADT between 600 and 1600 vpd had an over-representation of severe roadway departure crashes by 55 percent. These results were then applied to the segments identified in Buchanan and Dallas counties.
Access Density The impact of access points on the risk level of every segment in Buchanan and Dallas counties was evaluated through access density. Access density was calculated by dividing the total access points in a defined road segment by the total length of the segment (access point per mile). The average
access density in Buchanan and Dallas counties were 8.87 and 12.94 respectively. Roadway segments with access density greater than the computed average values received a star.

**Roadway Departure Crash Density** Average roadway departure crashes per mile per year for the segments in each county were computed (considering crash data from 2008 until 2012). The defined segments on the secondary paved two-lane rural roadways in both counties (Buchanan and Dallas) had an average roadway departure crash density of 0.058 crashes per mile per year (including all roadway departure crash types). These results are fairly similar to the Otter Tail County in Minnesota with 0.08 roadway departure crashes per mile per year. Any segment experiencing a road departure density higher than the average value received a star.

**Critical Radius Curve Density** At risk curve locations identified also impact the risk level of segments. The total number of critical curves was calculated (previously mentioned in the horizontal curves section) per mile for each segment in the two counties. These values were compared to the district-level average critical radius curve density (0.144 critical curves per mile in District 4 versus 0.075 critical curves per mile in District 6). If the critical radius curve density of a segment was greater than the average district value then it received a star.

**Edge Risk Assessment** The level of risk involved when vehicles leave the travel lane was assessed and categorized with the help of a rating system that was developed by the Minnesota DOT. A rating of one was received if a roadway segment had a usable shoulder and what was considered a reasonable clear zone. A rating of two was received if the road segment had little or no usable shoulder but a reasonable clear zone. A rating of two was also applied for roadways with a usable shoulder but fixed objects in the clear zone. Finally, a rating of three was given to a roadway segment if it had no usable shoulder and fixed objects in the clear zone. Segments were assigned a star if they had an edge risk assessment rating of two or three.