DRAFT Memorandum

SRF No. 16586

To: Jes Conz
City of Williston

From: SRF Consulting Group

Date: January 5, 2024

Subject: P334 Task 2.3 – Systemic Analysis

Task 2.3: Systemic Analysis

Introduction

The Williston Infrastructure Safety Action Plan (Safety Action Plan) relies on a thorough understanding of motor vehicle, heavy vehicle, bicycle, motorcycle, and pedestrian crash trends to inform strategic investments in safety improvements aimed at decreasing crashes and eliminating severe crashes (fatal and incapacitating injury crashes) on roadways throughout the study area (Williston Municipal Boundary).

This technical memorandum documents the High-Injury Network (HIN) for the Williston study area. A HIN consists of the roadway corridors where a majority of severe crashes are occurring. This moves beyond typical historical crash analysis and allows for a better description of the types of roadways and intersections in the Williston study area where users are the most at risk. The HIN systemic analysis allows the City of Williston to proactively work to minimize the occurrence and severity of crashes into the future.

In addition to the development of a HIN, the Safety Action Plan will also rely on crash profiles, which considers crash types, crash attributes, roadway characteristics, land use context, and road user behavior (as applicable) to identify the most prevalent factors of severe crashes in the area to inform implementation recommendations. Crash profiles will be developed after review of the crash analysis (task 2.2) and the systemic analysis, including the HIN as identified herein (task 2.3).

Definitions

What is a high injury network (HIN)? The HIN identifies streets or locations where a high number of severe crash concentrations have occurred along a corridor-level segment for the most recent 5-year period (2018-2022). The high injury network street represents a prioritized subset of Williston's overall transportation network, focusing on streets with the highest prevalence of severe crashes.

What are sliding windows? There are various methodologies to develop a HIN. The sliding window methodology within a 0.5-mile or 1.0-mile window sliding along a corridor in 0.1-mile increments.

What is the KABCO injury scale? The KABCO scale consists of five crash severities that are used as an industry shorthand when discussing crash severity. Table *1* includes descriptions of each of the codes and categorizes them into severe and non-severe groups.

Table 1. KABCO Injury Scale

Severe (more injurious)	Non-Severe (less injurious)
K - involves a fatal injury	**B** - non-incapacitating injury
A - incapacitating injury (serious injury)	**C** - possible injury
	O - no injury or a property damage-only (PDO) crash

The project team utilized crash data provided by the North Dakota Department of Transportation (NDDOT) for 2018-2022 in the 5-table format (Crash Master, Unit, Pedestrian, Operator, and Occupant) to create mode-specific HINs for each of the following modes:

- Automobile (passenger automobile and/or light vehicle)
- Heavy Vehicle
- Pedestrian
- Bike (pedalcycle)
- Motorcycle

Utilizing the Unit Configuration field from the Unit crash table and the Pedestrian Injury, Operator Injury, and Occupant Injury fields from the Pedestrian, Operator, and Occupant crash tables, respectively, the project team recorded the Most Severe Injury (MSI) suffered by a person using each of the five modes. For example, if a passenger car with a driver (operator) and two passengers (occupants) strikes a person walking in a crosswalk (pedestrian) and the pedestrian is killed (K), the driver receives a non-incapacitating injury (B), and the two passengers are suspected of having minor injuries (C), the MSI for someone in an automobile would be a minor injury (B), the MSI for a pedestrian would be a fatality (K), and the MSI for the other modes (heavy vehicle, cyclist, an motorcycle) would be null.

Developing a High Injury Network

The development of an HIN consists of four steps: creating short and long windows from a base road network, assigning crashes to long windows, calculating short and long window scores, and setting a minimum short window crash score threshold for inclusion in the final selection. All four steps are described below.

Creating the Short and Long Windows from the Base Network

The first step in developing the base HIN is to simplify the City of Williston's roadway centerline shapefile to create contiguous corridors from the street segments. For example, 11th Street E. and 11th Street W. are converted from separate shorter segments to a single merged contiguous 11th Street corridor. In the example shown in Figure 1, the main corridor is shown as a black line at the top of the diagram and measures 0.73 miles long.

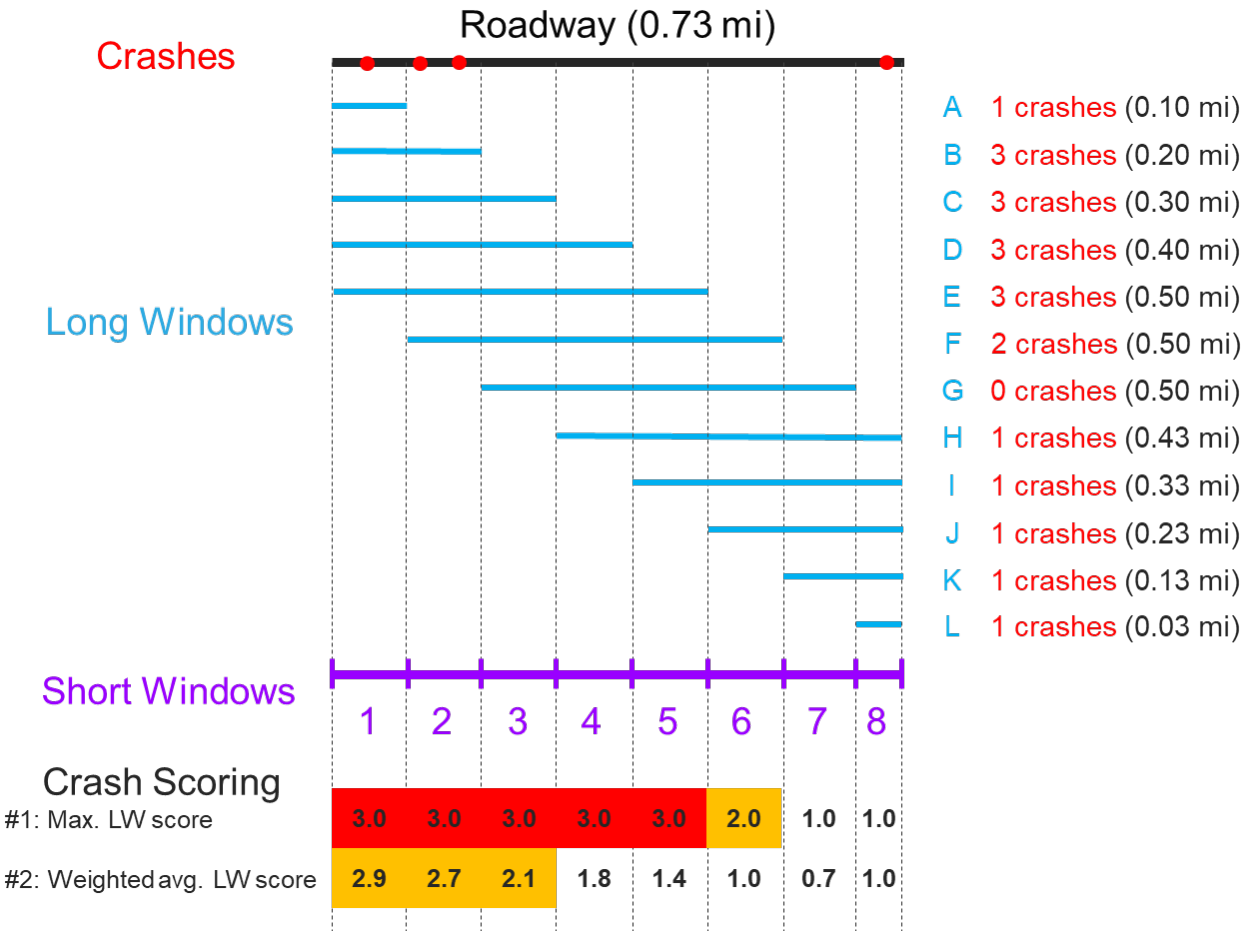


Figure 1. Diagram Illustrating the Sliding Window Analysis

The corridors are then split into 0.1-mile segments called "short windows". These short windows (represented by the purple line segments at the bottom of the diagram in Figure 1) are the same length as the increment by which the sliding window slides. The short windows are split from the corridor starting at one end (in this case, on the left end) which sometimes results in one short

window being shorter than the others as is the case with 0.03-mile-long Short Window 8 in the example above.

The sliding windows, often referred to as "long windows", are created by merging short windows in overlapping groups of five or ten to create 0.5- or 1.0-mile-long windows, respectively. In the diagram shown in Figure 1, the long windows are 0.5-miles in length and therefore consists of up to five short windows. As they get closer to the ends of the corridor, the long windows (represented by the blue line segments in the middle of the diagram in Figure 1) decrease in length. In the example, long windows A, B, C, D, H, I, J, K, and L are shorter than the standard 0.5 miles to ensure that each short window has the same number of long windows overlapping it.

Assigning Crashes to Long Windows

Once the long windows have been created from the short windows, the individual crashes are mapped to the long windows. To account for the width of the road, minor inaccuracies in the coordinates assigned to each crash, and discrepancies in the geometries representing roads in different data sets, a buffer of 50 meters is used when joining the crashes to the long windows. While using a buffer helps reduce the number of crashes that are unintentionally left off of a long window, it does increase the likelihood of crashes being assigned to too many long windows – especially at intersections and in locations where two roads run parallel to each other such as frontage roads along freeways. The effects of this over-assignment of crashes to long windows can be mitigated by manual exclusion of short windows that have been assigned an erroneously high crash score and/or the usage of certain score-calculation methods (as discussed in the next section).

Calculating Crash Scores

Once the crash points have been joined to the long windows, the crash score for each long window is calculated based on the number and severity of crashes that are joined to it. The long window crash scores are, in turn, used to calculate the short window crash scores.

In the example shown in Figure 1, the long window crash score (shown in red on the righthand side of the figure) simply reflects the quantity of crashes (shown as red dots along the black line representing the study corridor) that lie within a given long window. In other words, one crash equates to one point as opposed to the relative weights (shown in **Error! Reference source not found.**) that are assigned to each severity in the actual analysis. There are two main scoring methods used when conducting HIN analyses:

- **Maximum Associated Long Window Score Method** - the maximum long window score is just that, the maximum score of crashes of any of the long windows. In Figure 1, short window six has a maximum long window score of 2.0, which comes from long window F. In the example shown in Figure 1, and based on maximum long window score, if the threshold for inclusion in the HIN is set to 2.0, six short windows (1, 2, 3, 4, 5, and 6) have scores above the threshold (3.0, 3.0, 3.0, 3.0, 3.0, and 2.0, respectively), resulting in a total of 0.6 miles included in the HIN.

- **Length-Weighted-Average Long Window Score Method** - the length-weighted-average long window score is calculated by assigning the average score of all long windows associated with a short window (weighted by the long windows' respective lengths) as the short window score. Weighted-average long window crash scores provide a finer resolution than the maximum long window crash scores as evidenced by the gradual decrease of the short window scores as they get further from a crash. In the example shown in Figure 1, if the threshold for inclusion in the HIN is set to 2.0, three short windows (1, 2, and 3) have scores above the threshold (2.9, 2.7, and 2.1, respectively), resulting in a total of 0.3 miles included in the HIN.

The project team elected to use the length-weighted-average long window crash score method instead of the maximum long window score method because the weighted-average crash scoring method performs better in smaller networks with sparser crashes like Williston's by minimizing the over-selection of street segments (as is often the case when using 1.0-mile-long windows and lower thresholds) and providing the highest granularity for Williston's HIN. To maintain the focus on the most harmful crashes despite their relative infrequency, only the K, A, and B crashes are considered in the score calculations. To further reduce the likelihood of less severe (and far more prevalent) crash types overshadowing the most harmful crash types, two additional measures are employed: the K and A crashes are given a relative weight of 3 and the B crashes are given a weight of 1; and the B crashes are excluded entirely from the passenger automobiles/light vehicles crash score calculations (Auto B crashes outnumber the Auto K and A crashes by nearly a factor of ten).

Table 2: Most Severe Injury (MSI) by Mode

Mode	K	A	B	C	O	Total
Auto	3	20	200	112	2,268	2,614
Motorcycle	3	16	18	6	18	62
Pedestrian	0	7	13	4	10	34
Cyclist	0	1	5	3	1	10
Heavy Vehicle	0	0	3	1	136	140

Setting a Threshold for Inclusion in the HIN

The HIN is identified using crash score thresholds across the study area. The project team uses the following rough targets to recommend thresholds, which vary by mode:

- **Coverage of severe (KA) crashes** - does about 40-50 percent or more of severe crashes comprise the HIN? (without sacrificing other targets)
- **Mileage or extent of HIN streets and intersections**- can the HIN streets and intersections be kept to less than about 1-3% of the network?
- **Natural breaks** - does increasing or decreasing the threshold result in a significant change in severe crash density on the network? Are there natural breaks in the data where severe crash density dramatically changes?

- **Minimum threshold** - thresholds that are too low dilute the meaning of HIN. The project team typically advises a minimum threshold to yield tangible visual results on the overall multimodal network. Given the context of Williston, the team recommends a minimum crash score threshold of at least 4.0 for all modes, which implies a special pattern of at least two or more crashes over the past five years.

These minimum recommendations are based on using a maximum long window score. Weighted average window scores perform differently, but the principle is the same: minimum thresholds are set high enough to imply a spatial pattern of severe crashes. HIN segment status should not be driven by just one severe crash.

The four targets above are sometimes at odds with one another and should be balanced. For example, covering 50 percent or more of KA crashes may define an unreasonable number of miles contributing to the HIN, or a minimum crash score threshold too low to provide a tangible spatial pattern. The project team recommends erring toward a higher minimum crash score threshold to provide a more targeted draft HIN. Moving forward, refinement with City staff and stakeholders can help strategically refine HIN crash score thresholds to align with the City of Williston's goals and priorities.

Crashes for both cyclists and heavy vehicles are sufficiently infrequent and sparsely distributed that there are no corridors with scores above the minimum meaningful threshold of 3.0 (corresponding to more than one K or A crash or more than three B crashes). In cases such as the heavy vehicle and cyclist HINs where few or no street segments are highlighted by the modal HIN, it is recommended that the HIN results be supplemented with proactive or systemic methods to help identify safety needs in areas with few or no identified HIN streets. Proactive or systemic methods to identify safety needs may include physical roadway attributes, operational configurations, adjacent land use, and/or stakeholder feedback to identify dangerous locations for multimodal transportation users in the Safety Action Plan study area. When a sufficient number of street segments have been identified by the HIN, as is the case for the other three modes (automobile, pedestrian, and motorcycle), it is recommended that unique thresholds be identified for each mode.

The following table shows how many miles of the network and how many crashes and severe crashes would be on the HIN at each threshold. The current recommendation(s) for thresholds in each modal section:

Table 3. Threshold Setting Metrics Comparison

Mode	Total Network Miles	Total KAB* Crashes	Threshold	Network Miles Selected	KAB* Crashes Selected
Automobiles	226.1	23	4	10.4 (4.6%)	23 (100%)
Pedestrians	226.1	20	4	0.7 (0.3%)	20 (100%)
Motorcycles	226.1	37	4	3.6 (1.6%)	37 (100%)
Cyclists	226.1	6	4	0 (0%)	0 (0%)
Heavy Vehicles	226.1	3	4	0 (0%)	0 (0%)

Overview of Results

All Modes

Figure 2 shows the HIN for all modes. Higher scores are concentrated along and adjacent to US Highway 2 from 58th Street W., continuing south from 26th Street E. along US Highway 2 Business/Main St through Downtown Williston. Prominent east/west corridors are centered on US Highway 2 and include 42nd Street, 34th Street, 18th Street, and 11th Street. The HIN is primarily within the southeastern part of the city, east of the 16th Avenue W. corridor and south of the 58th Street corridor.

Context Insights

- Functional classification: HIN is concentrated on higher-order streets, mainly minor and principal arterials, including intersections of such streets and segments.
- Jurisdictions: Both State (US Highway 2) and Williston (local) are included.
- Land use: While not limited to commercial corridors, commercial businesses are the predominant land use along the HIN corridors and at HIN intersections.
- Access management: US Highway 2 is unique from other HIN corridors, as it is a two-lane divided roadway with a frontage road along much of its length on the HIN. Intersections are further complicated with the proximity of the frontage road. Other HIN corridors are generally characterized with frequent public and private access points. In

most cases, access spacing is less than spacing recommended in the City's Transportation Plan[1].

- Proximity to Williston areas of interest: 33 of the 38 (87 percent) areas of interest preliminarily identified by the project team and City of Williston staff are located within 0.25-miles of the HIN for all modes. The HIN proximity to certain areas of interest indicates that many people traveling throughout the city may be traversing on or across portions of the multimodal transportation system with higher safety risk. This includes people (residents, visitors, and commuters) traveling to and from places such as:

    - Raymond Family Community Center
    - Williams County Veterans Services
    - Williams County Courthouse
    - Fire Station #1
    - Fire Station #2
    - Williston Rural Fire Department
    - Hospital
    - U.S. Post Office (2)
    - Public Library
    - Williston City Hall
    - Harmon Park
    - Dakota Park
    - Davidson Park
    - Westlawn Park
    - The Area Recreation Center (ARC)
    - Moose Park
    - Railroad Park
    - Recreation Park
    - Williston Train Station
    - Northwest Dakota Public Transit
    - Rickard Elementary School
    - Williston Middle School
    - ASB Innovation Academy
    - Trinity Christian School
    - Bakken Elementary School
    - Wilkinson Elementary School
    - St. Joseph's Elementary School
    - North Star Human Service Zone
    - Williston State College

    There are also numerous shared use paths and on-street bicycle facilities crossing, running along, or leading directly to the HIN for all modes. See Figure 3 for more detail.

[1] The Williston Regional Transportation Plan recommends no more than four access points per mile for principal arterials and no more than eight access points per mile for minor arterials.

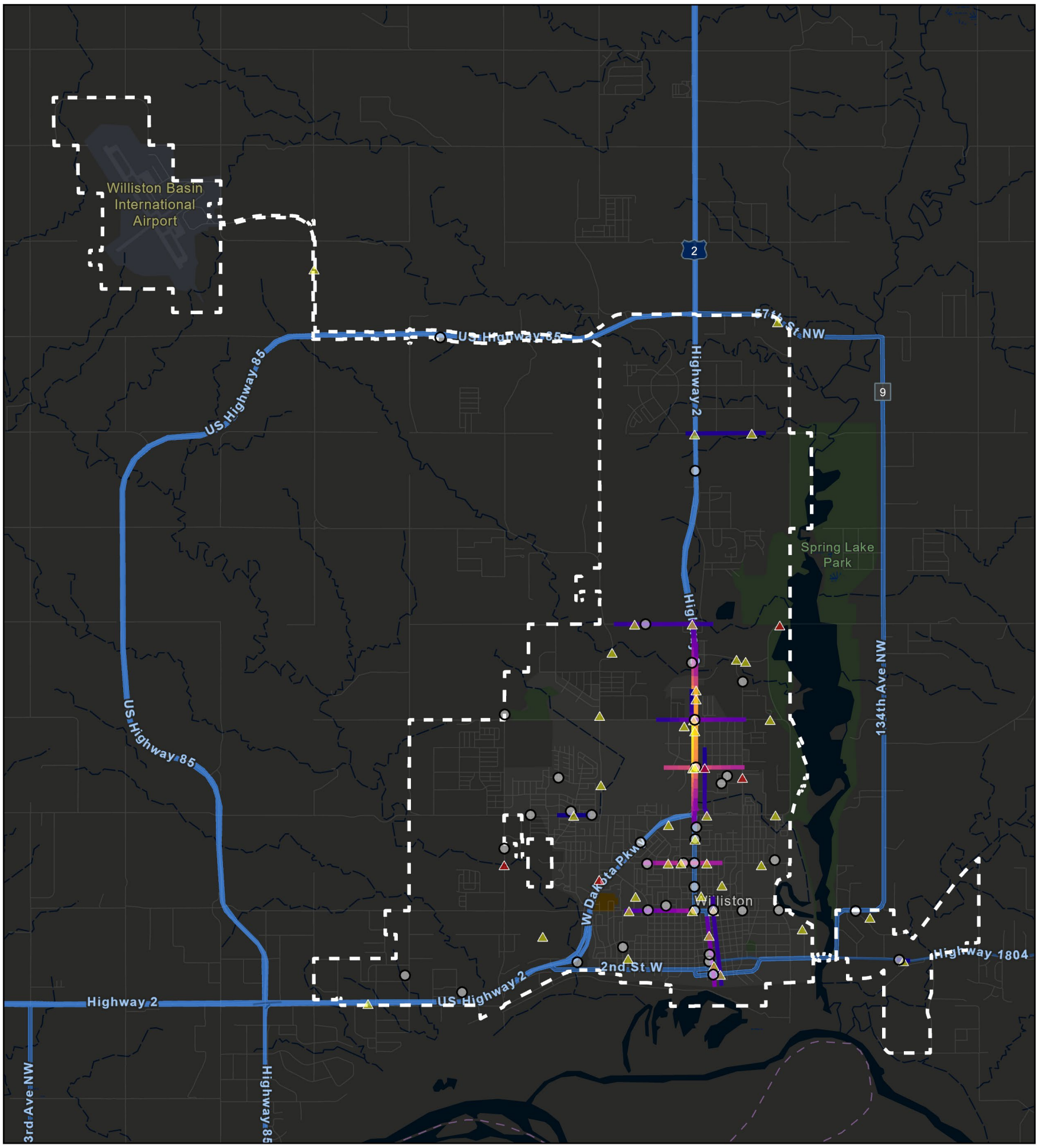
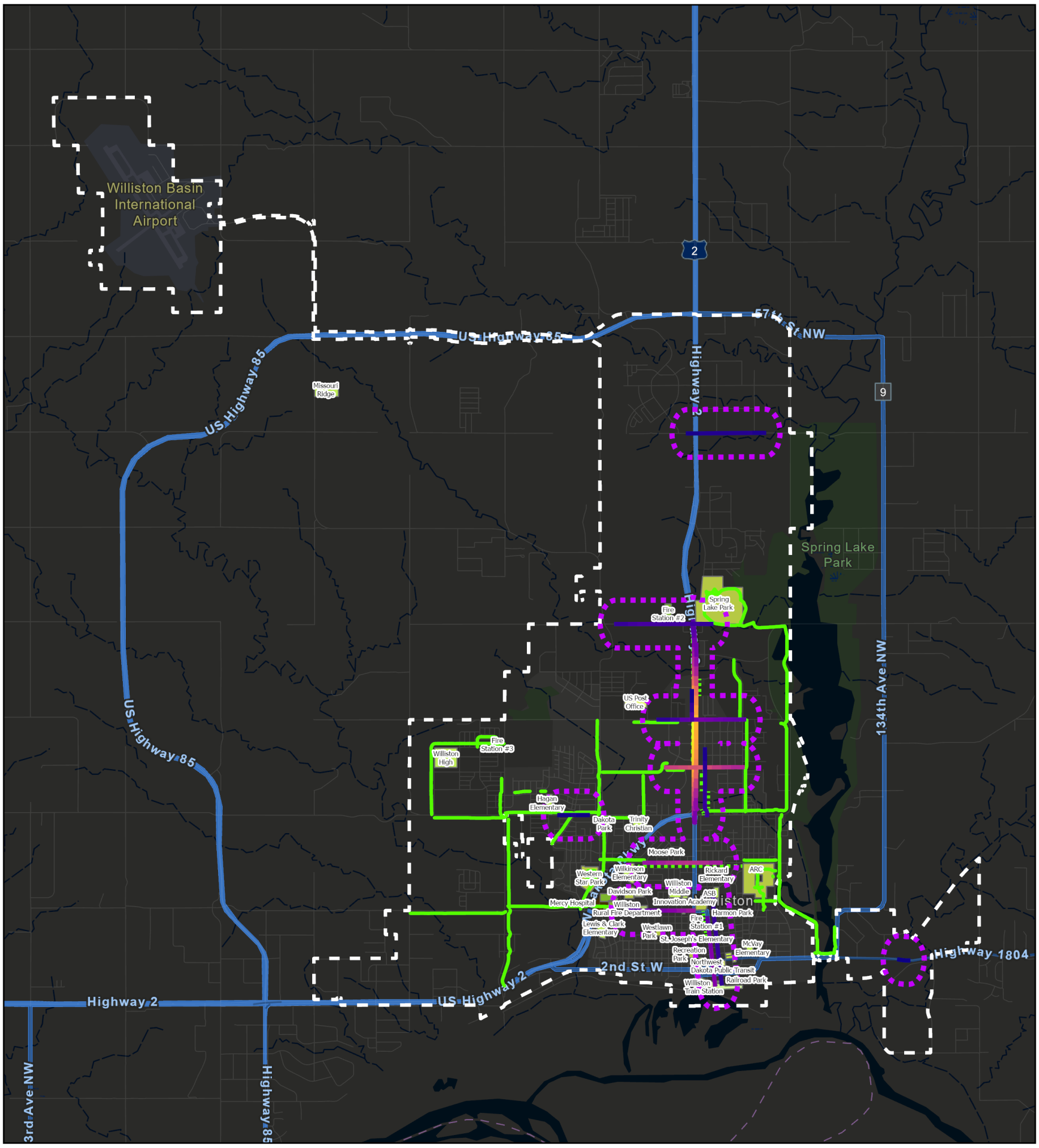
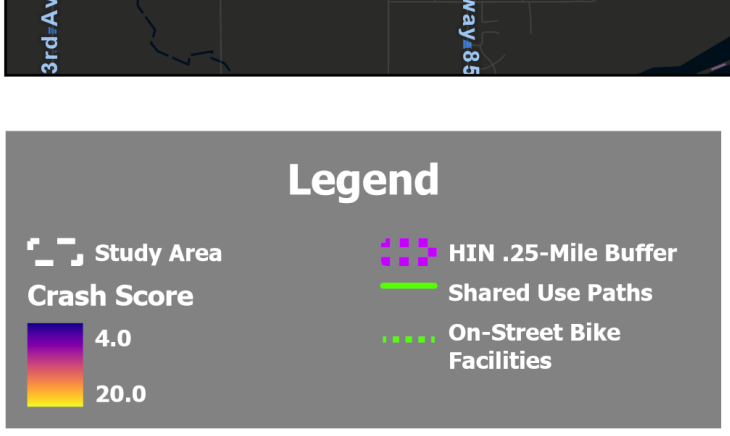


Figure 2: HIN – All Modes





All Modes High-Injury Street Segments' Proximity to Williston Areas of Interest

Figure 3: HIN - All Modes and Areas of Interest

Automobiles

Figure 4 shows the HIN for automobiles (as the mode experiencing most severe collision in crash). Higher scores are concentrated on US Highway 2 south of 58th Street and north of 26th Street. Notable east/west corridors cross US Highway 2 and include 58th Street, 42nd Street, 34th Street, and 18th Street.

Context Insights

- Functional classification: HIN is concentrated on higher-order streets, minor and principal arterials, including intersections of such streets and segments.
- Jurisdiction: Both State and Williston (local) are included, with a strong focus on US Highway 2.
- Land use: Commercial land use dominates the US Highway 2 corridor and around identified intersections.
- Access management: US Highway 2 is unique from other HIN corridors, as it is a two-lane divided roadway with a frontage road along much of its length on the HIN. Intersections are further complicated with the proximity of the frontage road. Other HIN corridors are generally characterized with frequent public and private access points. In most cases, access spacing is less than spacing recommended in the City's Transportation Plan.
- Proximity to Williston areas of interest: 18 of the 38 (47 percent) areas of interest preliminarily identified by the project team and City of Williston staff are located within 0.25-miles of the HIN for automobiles. The HIN proximity to certain areas of interest indicates that many people traveling to these locations by automobile may be traversing on or across portions of the multimodal transportation system with higher safety risk. This includes people (residents, visitors, and commuters) traveling to and from places such as:
    - Raymond Family Community Center
    - Fire Station #1
    - Fire Station #2
    - Hospital
    - U.S. Post Office
    - Public Library
    - Harmon Park
    - Davidson Park
    - Westlawn Park
    - The Area Recreation Center (ARC)
    - Moose Park
    - Spring Lake Park
    - Williston Middle School
    - Wilkinson Elementary School

- Williston State College

There are several shared use paths and on-street bicycle facilities crossing, running along, or leading directly to the HIN for all modes. See Figure 5 for more detail.

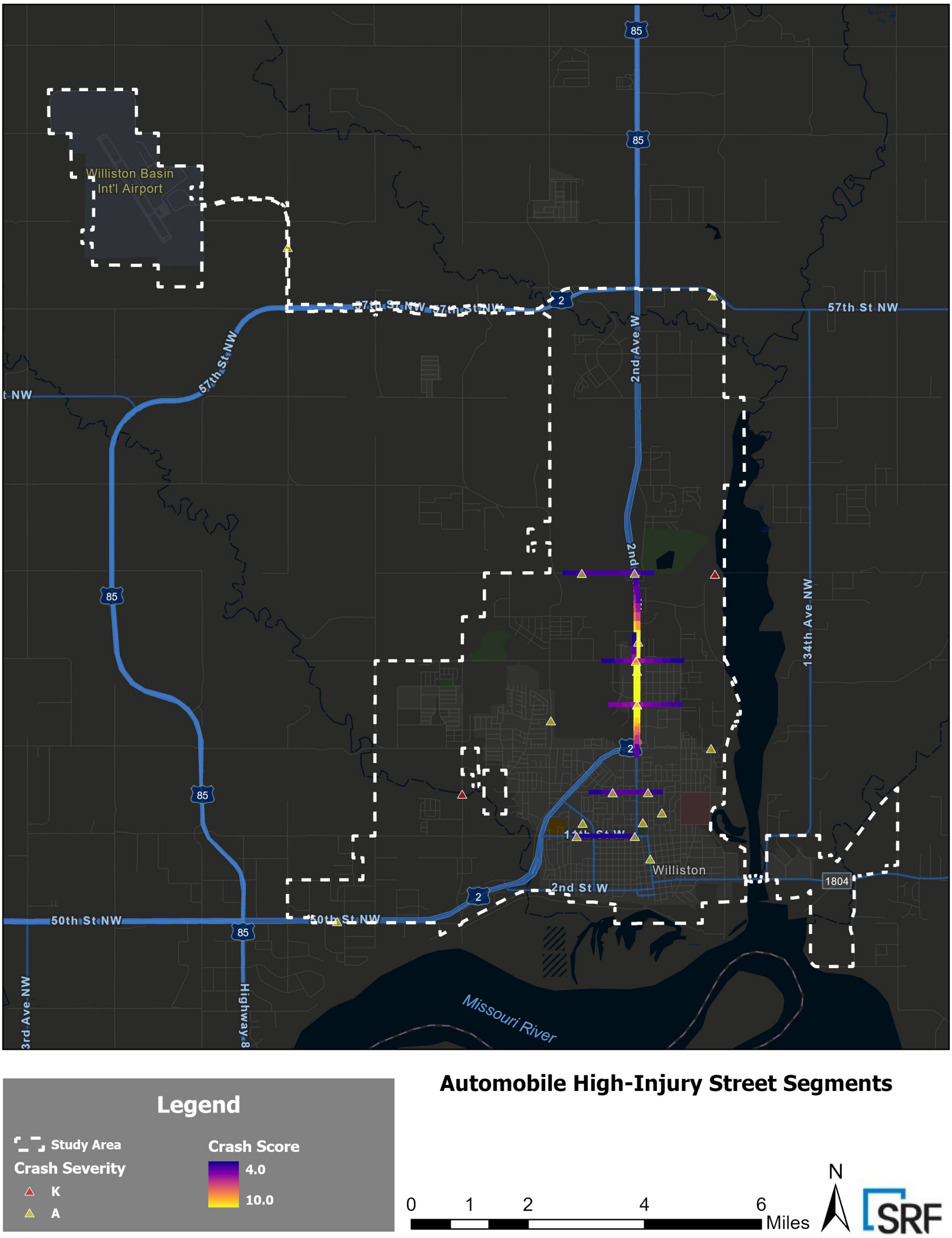


Figure 4: HIN - Automobiles

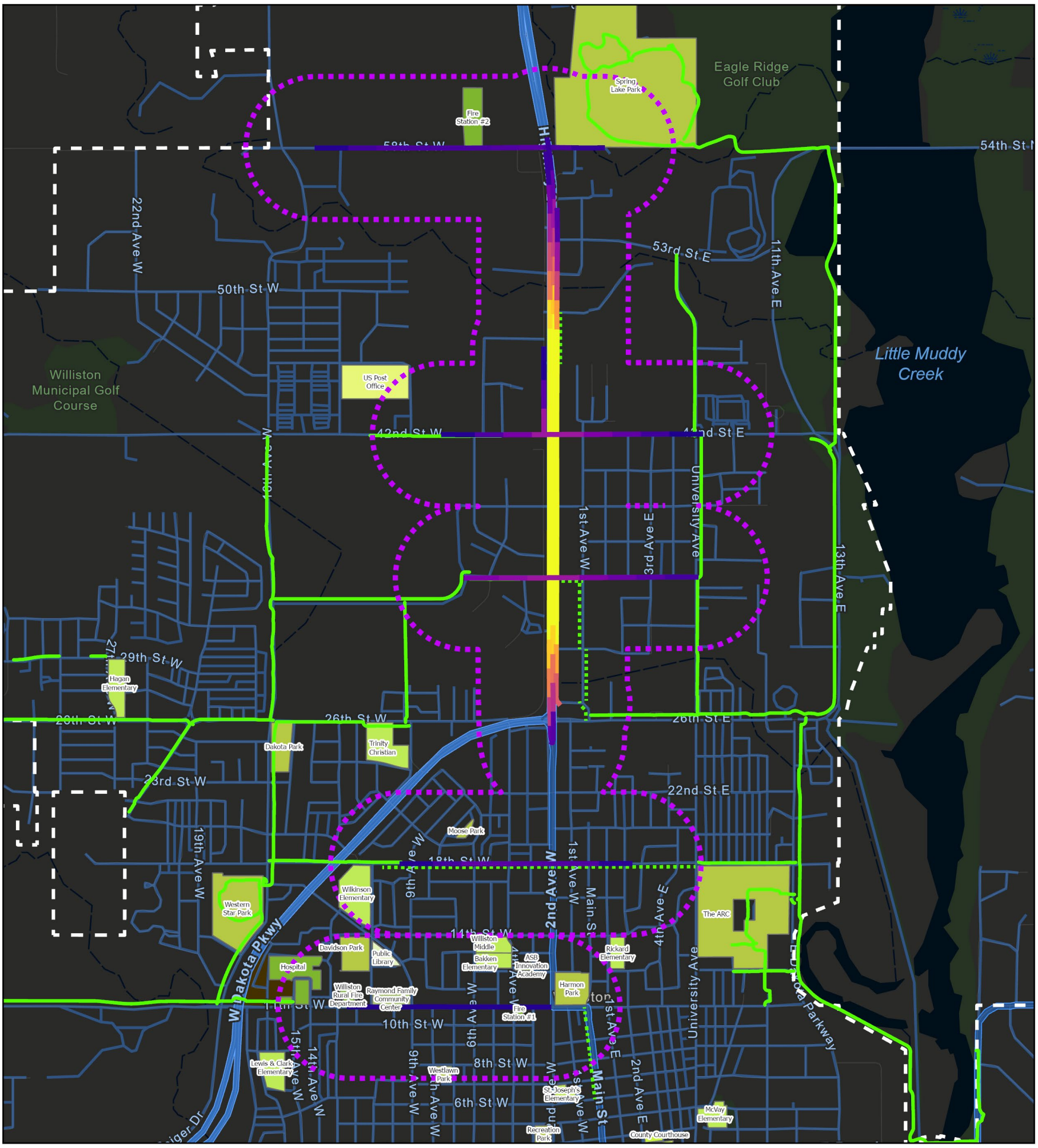


Figure 5: HIN - Automobiles and Areas of Interest

Pedestrians

Figure 6 is the HIN for pedestrians (as the mode experiencing most severe collision in crash). Higher scores are concentrated on US Highway 2 Business/Main St generally south of 11th Street and north of the Amtrak rail station.

Context Insights

- Functional classification: HIN is concentrated on a minor arterial.
- Jurisdiction: US Highway 2/Main Street as identified on the HIN is both State and Williston (local).
- Land use: Downtown commercial land use dominates the higher-scoring section of Main Street south of 4th Street, and residential/commercial mix from 11th Street W. south to 4th Street.
- Access management: Main St is characterized with frequent public and private access points. In most cases, access spacing is less than spacing recommended in the City's Transportation Plan.
- Proximity to Williston areas of interest: 13 of the 38 (34 percent) areas of interest preliminarily identified by the project team and City of Williston staff are located within 0.25-miles of the HIN for pedestrians. The HIN proximity to certain areas of interest indicates that many people traveling on foot to these locations and within the central business district (centered around Main Street from 11th Street to 1st Street S.) may be traversing on or across portions of the multimodal transportation system with higher safety risk. This includes people (residents, visitors, and commuters) traveling to and from businesses, residences, and places such as:
    - Williams County Veterans Services
    - Williams County Courthouse
    - Fire Station #1
    - U.S. Post Office
    - Williston City Hall
    - Harmon Park
    - Railroad Park
    - Recreation Park
    - Williston Train Station
    - Northwest Dakota Public Transit
    - Rickard Elementary School
    - St. Joseph's Elementary School
    - North Star Human Service Zone.

  There are also on-street bicycle facilities on Main Street from 6th Street to 11th Street. See Figure 7 for more detail.

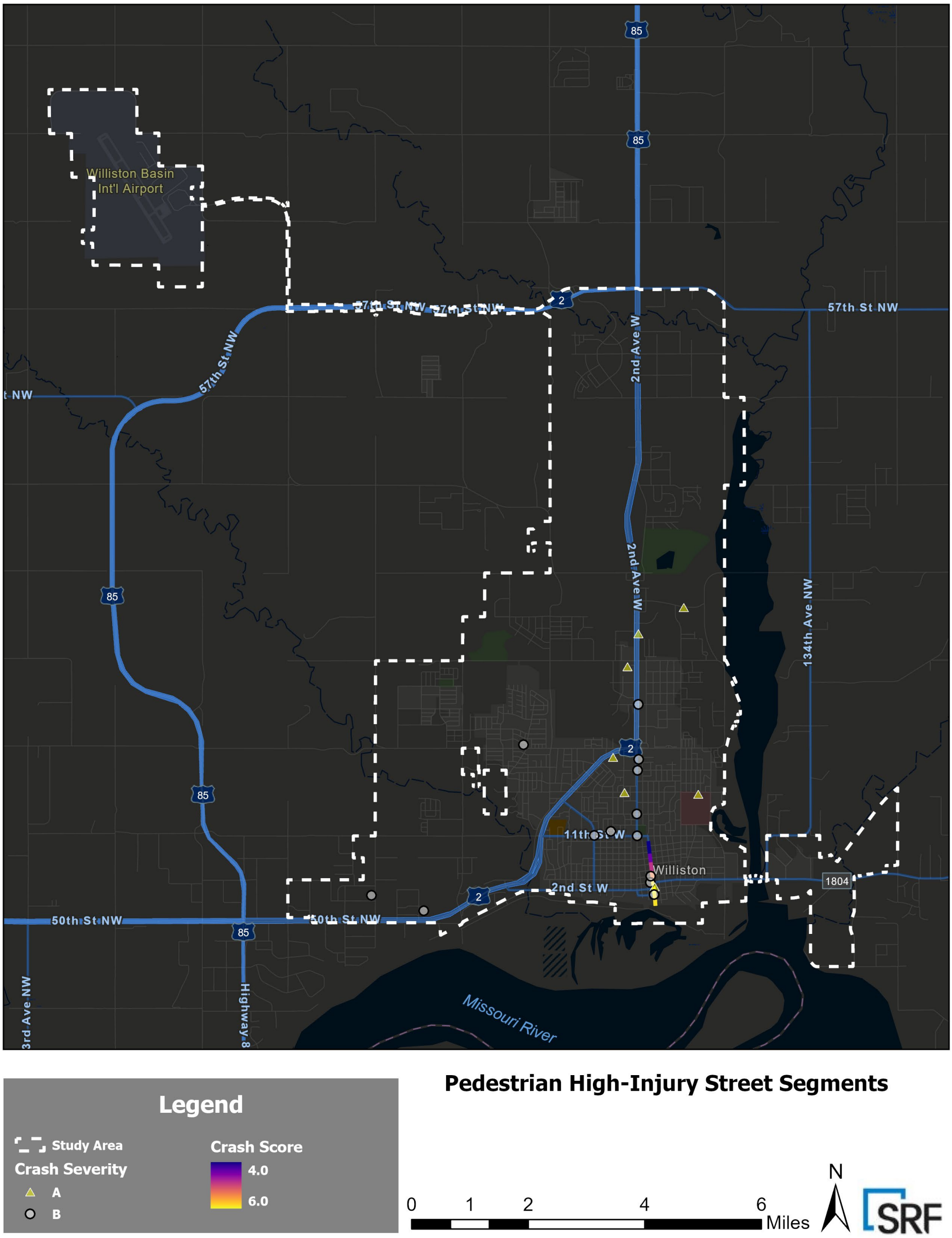


Figure 6: HIN - Pedestrian

Figure 7: HIN - Pedestrian and Areas of Interest

Motorcycles

Figure 8 is the HIN for motorcycles (as the mode experiencing most severe collision in crash). Higher scores are concentrated east and west of US Highway 2 on 34th St and on 1st Ave W south of 34th St to 26th St E. Other notable corridors include US Highway 2 Business/Main St from 11th St south to the Amtrak train station, and 56th St from US Highway 2 east to Oil Ave.

Context Insights

- Functional classification: HIN is concentrated on minor arterials, except for one local street (1st Ave W).
- Jurisdiction: US Highway 2/Main Street. as identified on the HIN is both state and local jurisdiction, but the remaining corridors are subject to City jurisdiction.
- Land use: Commercial and industrial land uses characterize most of the HIN corridors, except for a mix of commercial and residential along Main St in Downtown.
- Access management: All the minor arterials in the HIN generally allow access points in excess of the maximum spacing recommended in the City's Transportation Plan.
- Proximity to Williston areas of interest: 14 of the 38 (37 percent) areas of interest preliminarily identified by the project team and City of Williston staff are located within 0.25-miles of the HIN for motorcycles. The HIN proximity to certain areas of interest indicates that people traveling to these locations by motorcycle may be traversing on or across portions of the multimodal transportation system with higher safety risk. This includes people (residents, visitors, and commuters) traveling to and from places such as:

    - Williams County Veterans Services
    - Williams County Courthouse
    - U.S. Post Office
    - Williston City Hall
    - Harmon Park
    - Dakota Park
    - Railroad Park
    - Recreation Park
    - Williston Train Station
    - Northwest Dakota Public Transit
    - Rickard Elementary School
    - Hagan Elementary School
    - St. Joseph's Elementary School
    - North Star Human Service Zone

There are also some shared use paths and on-street bicycle facilities crossing, running along, or leading directly to the HIN for motorcycles. See Figure 9 for more detail.

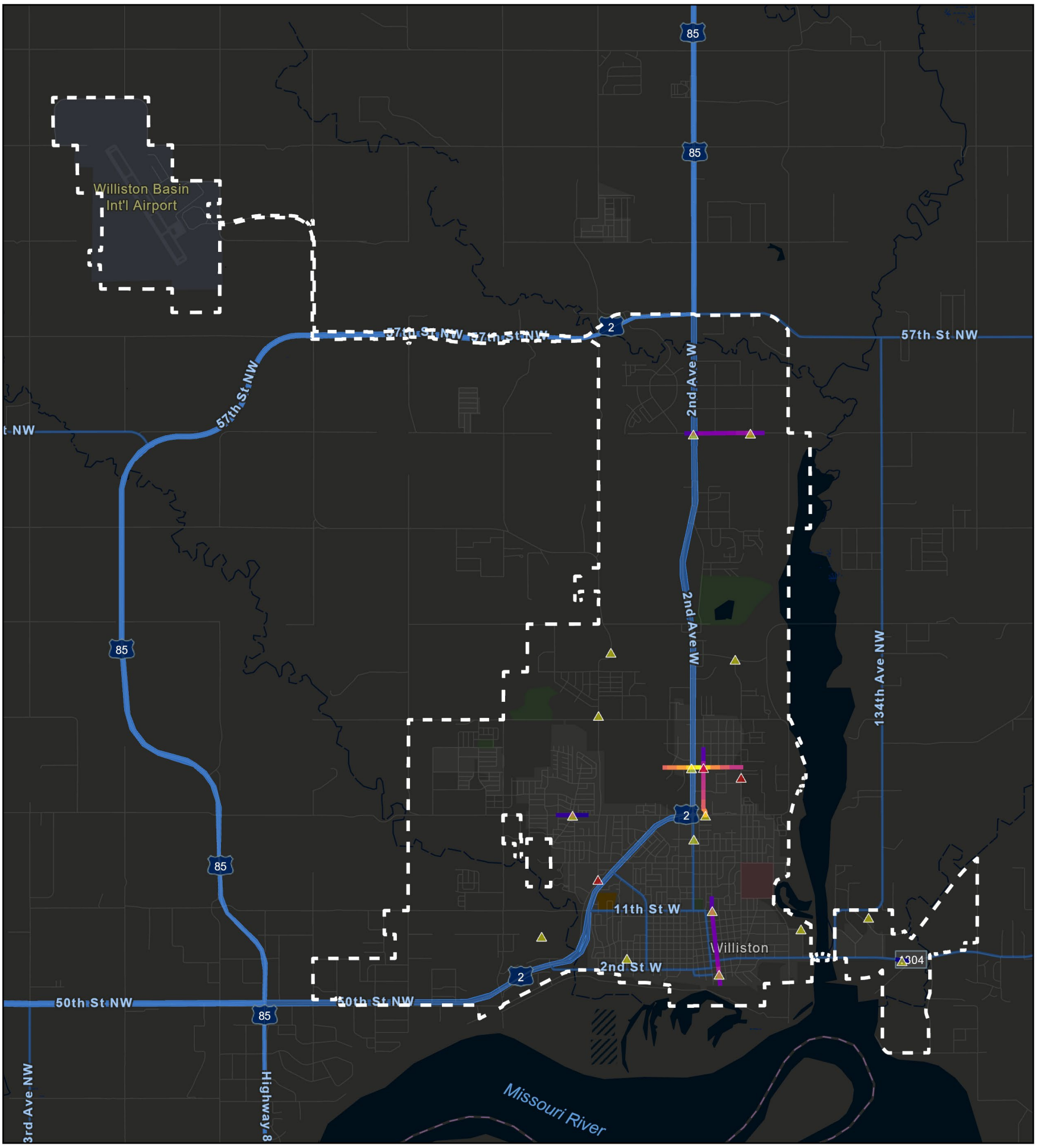


Figure 9: HIN - Motorcycle

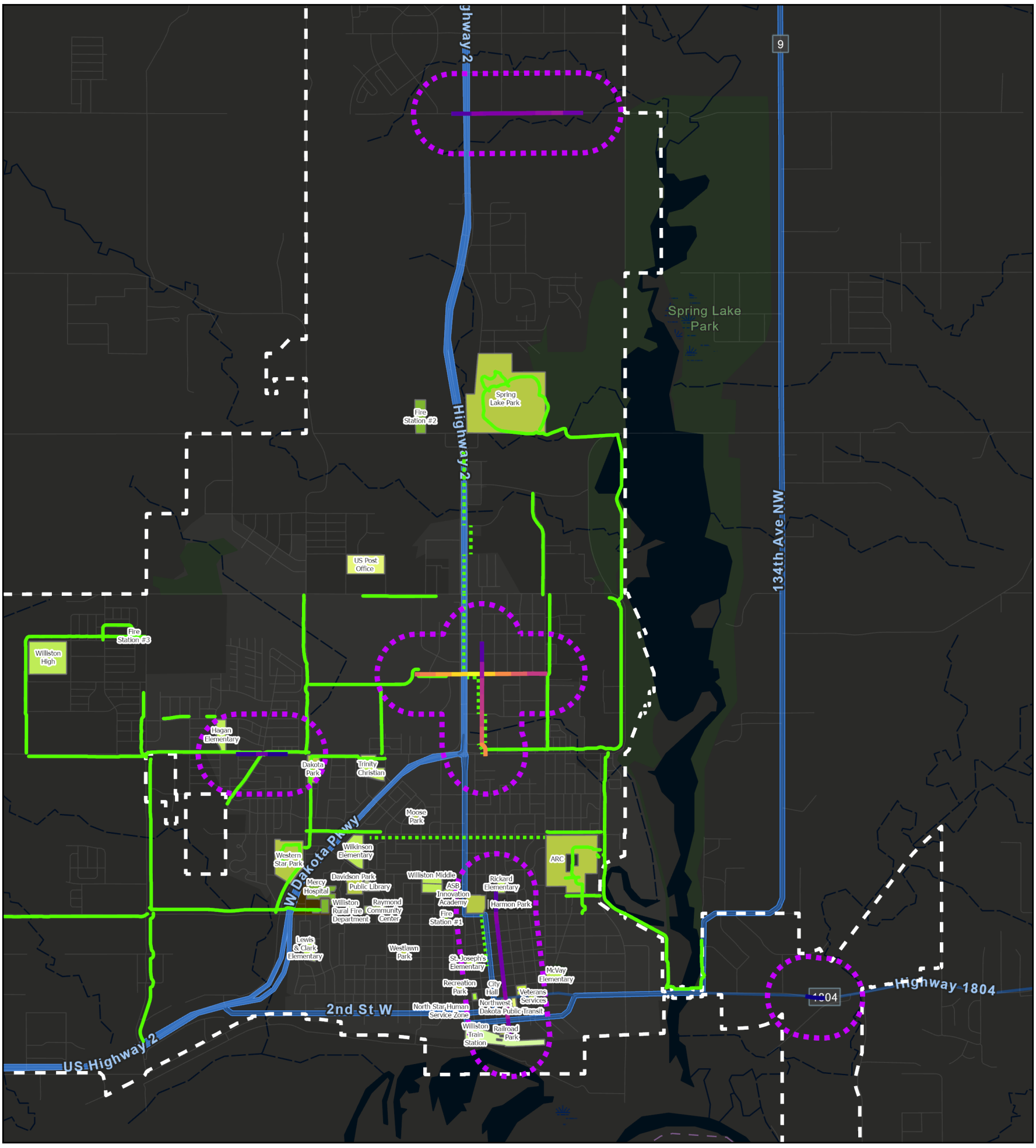


Figure 10: HIN Motorcycle and Areas of Interest

Cyclists

Figure 11 is the HIN for bicycles (as the mode experiencing most severe collision in crash). Severe crash data is insufficient in the five-year window (2018-2022) to confidently identify any HIN streets or intersections. However, if there is an interest in including non-severe crashes (Cs and Os — possible injury and no injury/property damage only), a greater spatial understanding of bicycle crashes on the City's network may be gained.

Heavy Vehicles

Figure 12 is the HIN for heavy vehicles (as the mode experiencing most severe collision in crash). Severe crash data is insufficient in the five-year window (2018-2022) to identify any HIN streets or intersections. However, if there is an interest in including non-severe crashes (Cs and Os — possible injury and no injury/property damage only), a greater spatial understanding of bicycle crashes on the City's network may be gained.

Crash Profile Ideas

- What is heavy vehicle contribution to HIN?
- US Highway 2 from 26th St north to 58th St, less 26th St intersection (to be reconstructed).
- Intersections at 4-lane divided Hwy with frontage roads
- Any HIN areas adjacent to parks or schools?
- Main St (11th to Amtrak) – pedestrians and motorcycles

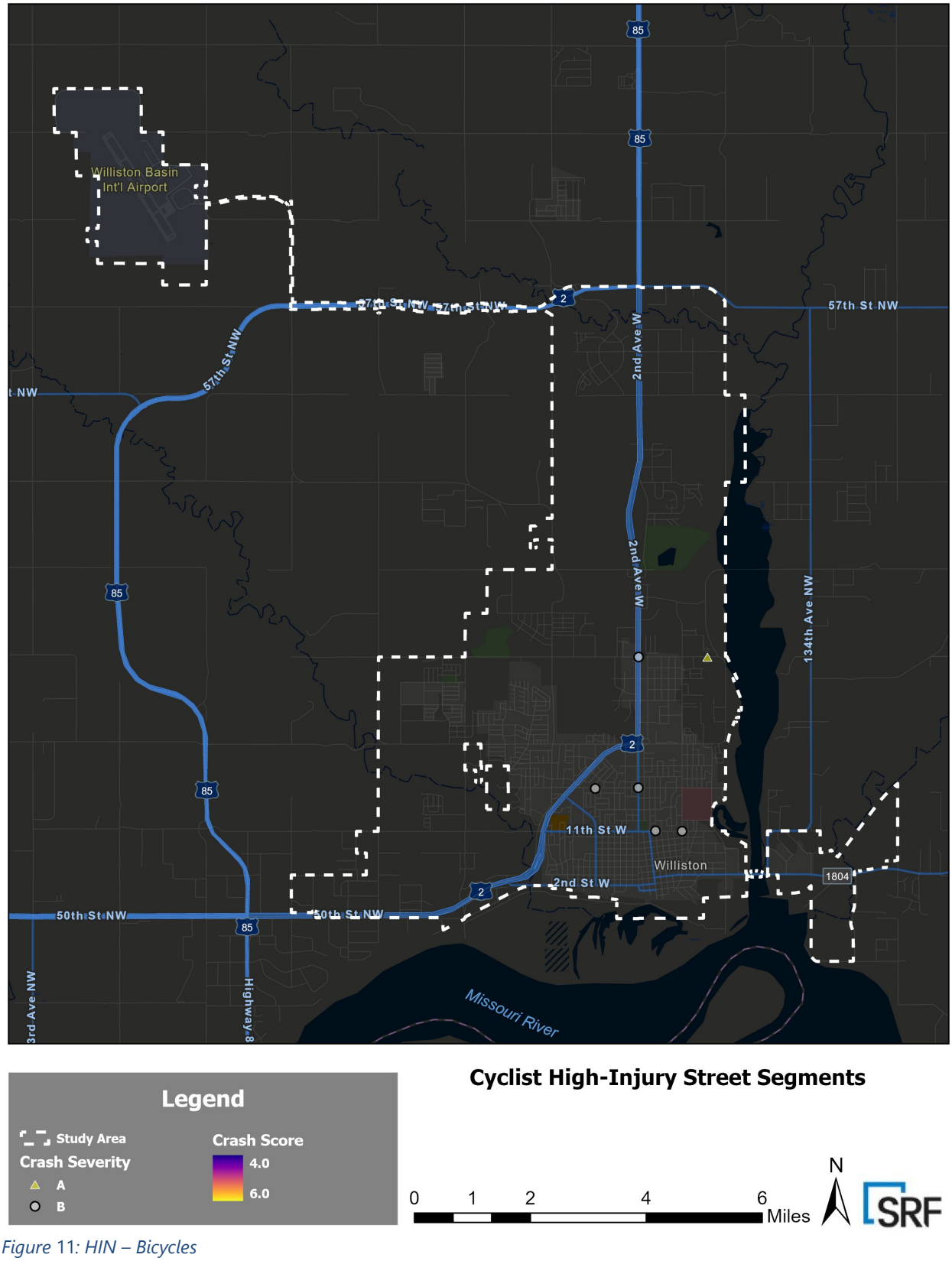


Figure 11: HIN – Bicycles

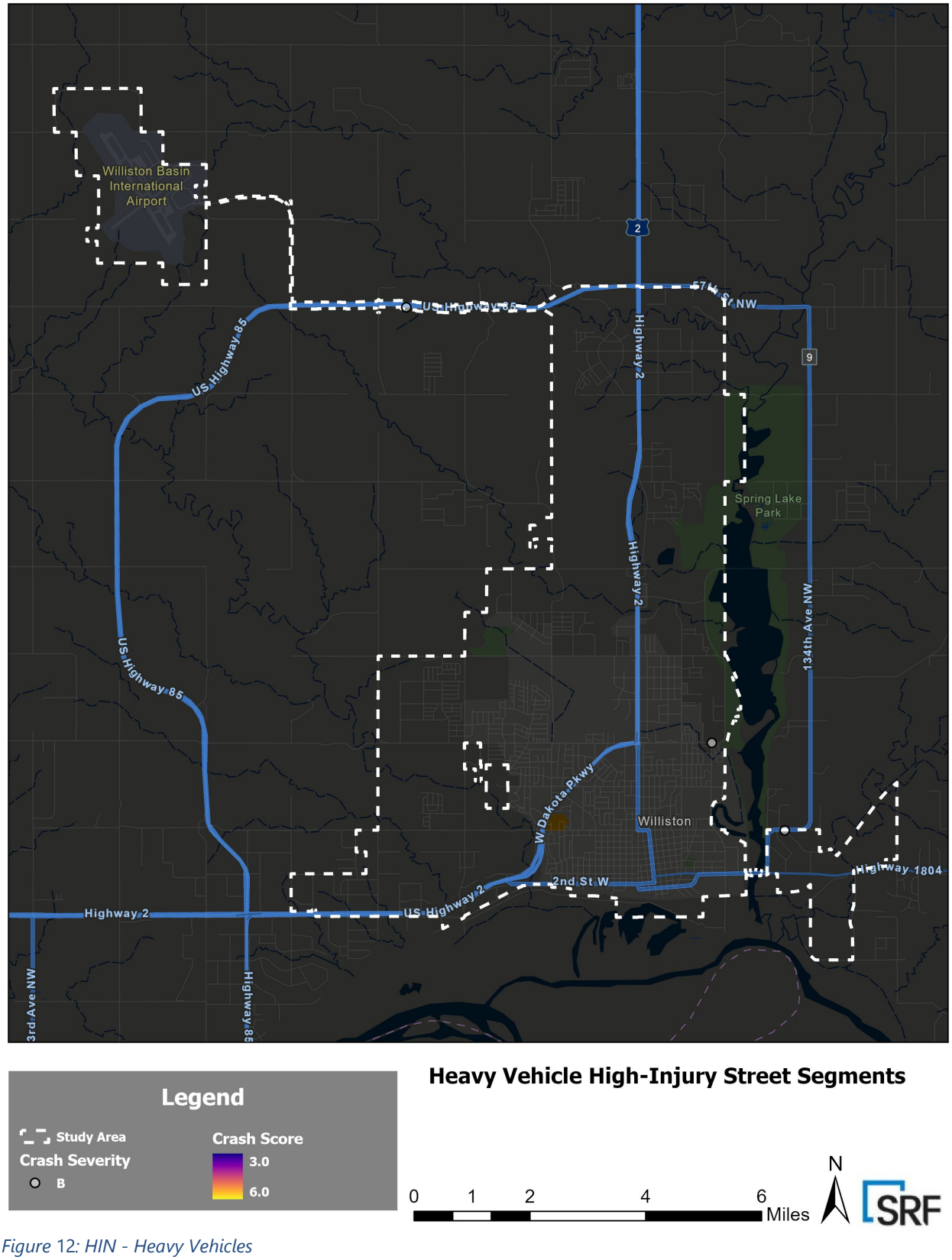


Figure 12: HIN - Heavy Vehicles