MOORHEAD DOWNTOWN GRADE SEPARATION STUDY: EXISTING AND FUTURE CONDITIONS REPORT

TECHNICAL MEMORANDUM #1

KLJ

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MOORHEAD
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MINNESOTA DEPARTMENT OF TRANSPORTATION

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PROJECT BACKGROUND

Two Burlington Northern Santa Fe Railroad (BNSF) subdivisions pass through downtown Moorhead. These subdivisions are the KO Subdivision, which is located between Main Avenue and Center Avenue, and the Prosper Subdivision, which is located between Center Avenue and 1st Avenue North.

Figure 1 - Vehicles Clearing After a Train Event in Downtown Moorhead

The current *Moorhead Downtown Grade Separation Study* is being completed to identify and evaluate alternatives for a potential vehicle-rail grade separation in downtown Moorhead, Minnesota. A downtown grade separation is being pursued to alleviate train induced delays and conflicts experienced by motorized and non-motorized traffic as a result of frequent train events. This study is a continuation of detailed grade separation analyses that have recently been completed and detailed in the *Downtown Moorhead Railroad Grade Separation Feasibility Study* (2008) and the *Trunk Highway 10/75/Center Avenue Corridor Studies* (2013).

FHWA Grade Separation Criteria

The Federal Highway Administration (FHWA) has published criteria for the consideration of vehicle-rail grade separations in the *Railroad-Highway Grade Crossing Handbook* (2007). These criteria will be used throughout this study to determine where a downtown grade-separation is justified; they will also be used in the alternative screening and comparative evaluation process.

The criteria includes the following two tiers of justification.

- ***Tier 1 Criteria:*** Highway-rail grade crossings should be considered for grade separation or otherwise eliminated across the railroad right of way whenever one or more of the criteria is met.
- ***Tier 2 Criteria:*** Highway-rail grade crossings should be considered for grade separation across the railroad right of way whenever the cost of grade separation can be economically justified based on fully allocated life-cycle costs with one or more of the criteria met.

In short, the two tiers have the same criteria with differing thresholds. Tier 1 has increased thresholds to indicate a heightened need for grade separation. There are 11 Tier 1 criteria and 12 Tier 2 criteria. The criteria are:

Figure 2 - Tier 1 and 2 Thresholds for Justification of Grade Separation

Tier 1	Tier 2
I. Designated Interstate Highway System	I. Designated National Highway System
II. Full Access	II. Partial Access Control
III. Highway Speed Equals or Exceeds 70 mph	III. Highway Speed Equals or Exceeds 55mph
IV. Average Annual Daily Traffic Exceeds 100,000	IV. Average Annual Daily Traffic Exceeds 50,000
V. Train Speed Exceeds 110 mph	V. Train Speed Exceeds 100 mph
VI. 150 or More Trains per Day or 300 Million Gross Tons per Year	VI. 75 or More Trains per Day or 150 Million Gross Tons per Year
VII. Average of 75 or More Passenger Trains per Day	VII. Average of 50 or More Passenger Trains per Day
VIII. Crossing Exposure* Exceeds 1 Million	VIII. Crossing Exposure* Exceeds 500,000
IX. Passenger Train Crossing Exposure** Exceeds 800,000	IX. Passenger Train Crossing Exposure** Exceeds 400,000
X. Expected Accident Frequency*** for Active Devices with Gates Exceeds 0.5	X. Expected Accident Frequency*** for Active Devices with Gates Exceeds 0.2
XI. Vehicle Delay Exceeds 40 Vehicle Hours per Day	XI. Vehicle Delay Exceeds 30 Vehicle Hours per Day
	XII. Engineering Study Indicates Absence of Grade Separation Results in Level of Service Below Intended Design Level 10% or More of the Time

*Crossing exposure is the product of the number of trains per day and Average Daily Traffic (ADT).
**Passenger train crossing exposure is the product of the number of passenger trains per day and ADT.
***Expected Accident Frequency is calculated using the U.S. DOT Accident Prediction Formula including Five-Year Accident History.

RELEVANT PREVIOUS STUDIES

This section of the report details all relevant studies completed at the railroad crossings in downtown Moorhead over the past 10 years. Studies are listed in chronological order highlighting the natural progression of analysis and improvements. This does not include Long Range Transportation Plans, which incorporated many of the findings of the reports noted below.

Moorhead Quiet Zone Implementation, February 2008

Figure 3 - Pedestrian Safety Improvements Along 8th Street

In 2008, a train horn quiet zone was implemented in the City of Moorhead downtown area along the Burlington Northern Santa Fe (BNSF) Railway's Prosper and KO subdivisions. This quiet zone has provided relief from the train horns for many of the residents and businesses located within the downtown area. Significant safety improvements for pedestrians near the crossings were also made throughout the quiet zone to reduce potential pedestrian and train vehicle conflicts.

Downtown Moorhead Railroad Grade Separation Feasibility Study, July 2008

In 2008, a study was performed to evaluate the feasibility of constructing a new railroad grade separation in downtown Moorhead. Needs for a railroad grade separation identified in this study included decreasing the number of train-vehicle exposures in downtown Moorhead, improving safety for pedestrians and bicyclists, reducing delays to emergency response times, and reducing traffic congestion and delays for vehicles traveling in downtown Moorhead.

The analysis of crossing locations was divided into two stages: Fatal Flaw Screening and Comparison Screening. For each stage of analysis, decision criteria were established and matrices were developed to help organize and evaluate the data. Fatal flaw analysis involved the following considerations:

- ***Lack of Continuity:*** Does the street corridor provide continuity from the North to South part of the City?
- ***Vehicle Train Exposure:*** Does the crossing meet the minimum daily train-vehicle crash exposures?
- ***Significant Site Constraints:*** Can a grade separation be constructed without significant impacts to buildings, property or other infrastructure?
- ***Planned Crossing Closures:*** Is the crossing scheduled to remain open in the future?

During the fatal flaw analysis, the following street crossings were discarded: 4th, 5th, 6th and 10th. The street crossings at 8th, 11th and 14th were carried forward. The comparative cost analysis evaluated the remaining alternatives in the areas of property impacts, safety, emergency vehicle access, traffic capacity/mobility, constructability and design, environmental impacts, cost/economics and railroad issues. The following conclusions were determined in this study:

- 11th Street and 14th Street are the most feasible locations for a railroad grade separation.
- From constructability and operational standpoints, a railroad grade separation at either 11th Street or 14th Street is feasible. However, it would be difficult to construct the temporary shoofly tracks at 14th Street without incurring significant costs or impacting BNSF operations.
- 11th Street is the more favorable location for a railroad grade separation, based on direct comparisons using the eight main criteria categories developed for this study.
- Underpass crossing alternatives appear to be the optimal crossing configuration; an overpass alternative would need to be approximately 28-30 feet into the air due to the 23-foot track clearance requirements and the associated bridge structure depth.

Campbell Technology Corporation – Quiet Zone Operational Improvements Study, May 2011

In May 2011, the City of Moorhead requested that Campbell Technology Corporation (CTC) review the quiet zone preemption operations at six intersections within the downtown area to see if adjustments could be made to minimize delays, improve the efficiency of the roadway network and maintain safety. This study recommended the following improvements:

- Immediate improvements: track clearance green time and preemption anomaly correction.
- Short-term improvements: pedestrian treatments, traffic signal coordination, roadway vehicle detection, track clearance arrow, gate down circuit, battery back-up and left-turn signal improvements.
- Long-term improvements: dedicated turn-lanes, traffic management plan during flooding incidents and grade separation.

MnDOT TH 10, TH 75 and Moorhead-Center Avenue Corridor Studies, July 2013

Moorhead Downtown Roadway/Rail System Analysis

As an appendage of the corridor studies, an analysis was conducted for varying roadway modifications that could be made to improve the operations of the adjacent roadway network with respect to the at-grade rail crossings at 8th, 11th and 14th Streets. This involved data collection, model development, alternative development and alternative assessment.

Five improvement alternatives were developed as part of this analysis including revising one-way directionality of 11th Street and 14th Street (in downtown only), intersection turn-lane improvements surrounding grade crossings, jurisdictional turn-back alternatives and finally a grade crossing at 11th Street. The results of this analysis produced eight geometric intersection improvements that will be implemented in 2015. This study also recommended a grade crossing be studied further.

TH 75 Reroute Analysis

As the project progressed, additional discussion began regarding a potential jurisdictional transfer of TH 75 to an alternate route. This analysis was completed due to poor mobility, safety issues, and a number of access points north of I-94 that are not suitable for the Trunk Highway system. In addition, these issues are difficult to mitigate given the developed nature of the area. Therefore, six reroute options were evaluated to determine the quantitative and qualitative benefits or impacts resulting from the potential jurisdictional transfer of TH 75 to an alternative corridor alignment (refer to Figure 4).

This discussion is relevant to the Downtown Moorhead Grade Separation Study because if the trunk highway system is removed from downtown Moorhead, MnDOT is removed from the list of vested stakeholders for the project. Additionally, to transfer a road from one jurisdiction to another requires financial compensation which could potentially help fund the grade separation project.

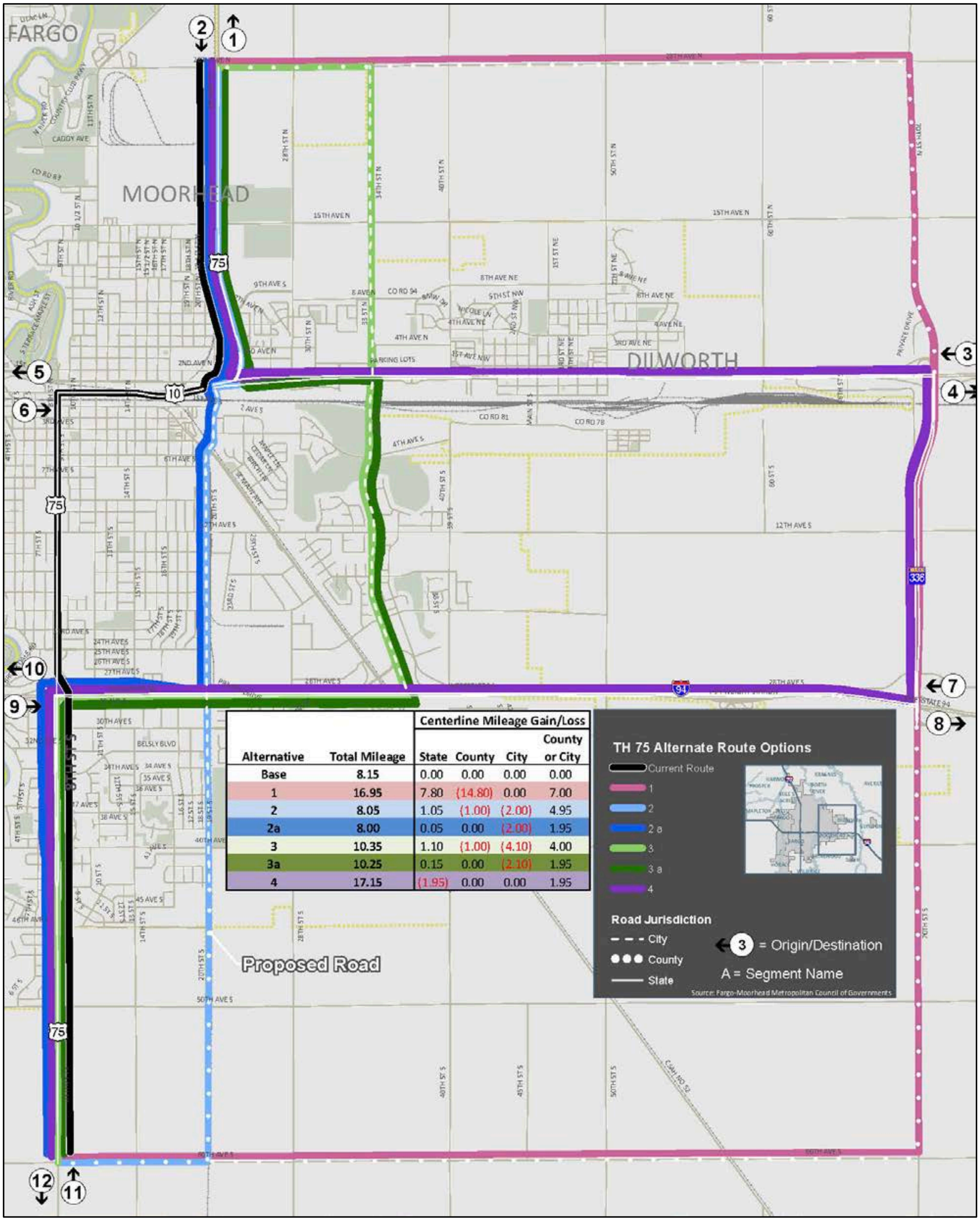
In order to test the feasibility of these alternatives, a preliminary screening evaluation was performed. The evaluation involved the following mix of quantitative and qualitative measurements:

- Jurisdictional mileage changes
- Planning level cost estimates
- Land use compatibility between routes
- Origin-destination patterns of traffic in the area between select locations
- Corridor safety comparison
- Travel times between defined termini
- Potential traffic diversion
- Corridor access comparison
- Potential operation benefits or concerns

The results of the analysis concluded the current alignment of TH 75 provides a range of benefits, from operational to land use, when compared to reroute options outside of downtown Moorhead. This was primarily due to the results of the origin destination study that indicated the majority of traffic on TH 75 has an origin or destination in Moorhead and does not continue on TH 75 through the city. Maintaining the current alignment also provides cost benefits. Finally, discussions with Clay County in 2002 indicate that they oppose rerouting TH 75. More recent discussion have not taken place. In summary, for the purposes of the current Downtown Grande Separation Study, TH 75 will continue through downtown through the study horizon.

Per the recently completed TH 10/TH 75 Corridor Study and as a follow up to the imminent corridor investment management strategy (CIMS) project, Moorhead, Metro COG and MnDOT will more closely examine the potential shift of the TH 10/75 designation to follow the alignment of the potential grade separation. This will be analyzed at a later date once a preferred alignment for the grade separation is selected.

Figure 4 - TH 75 Reroute Options

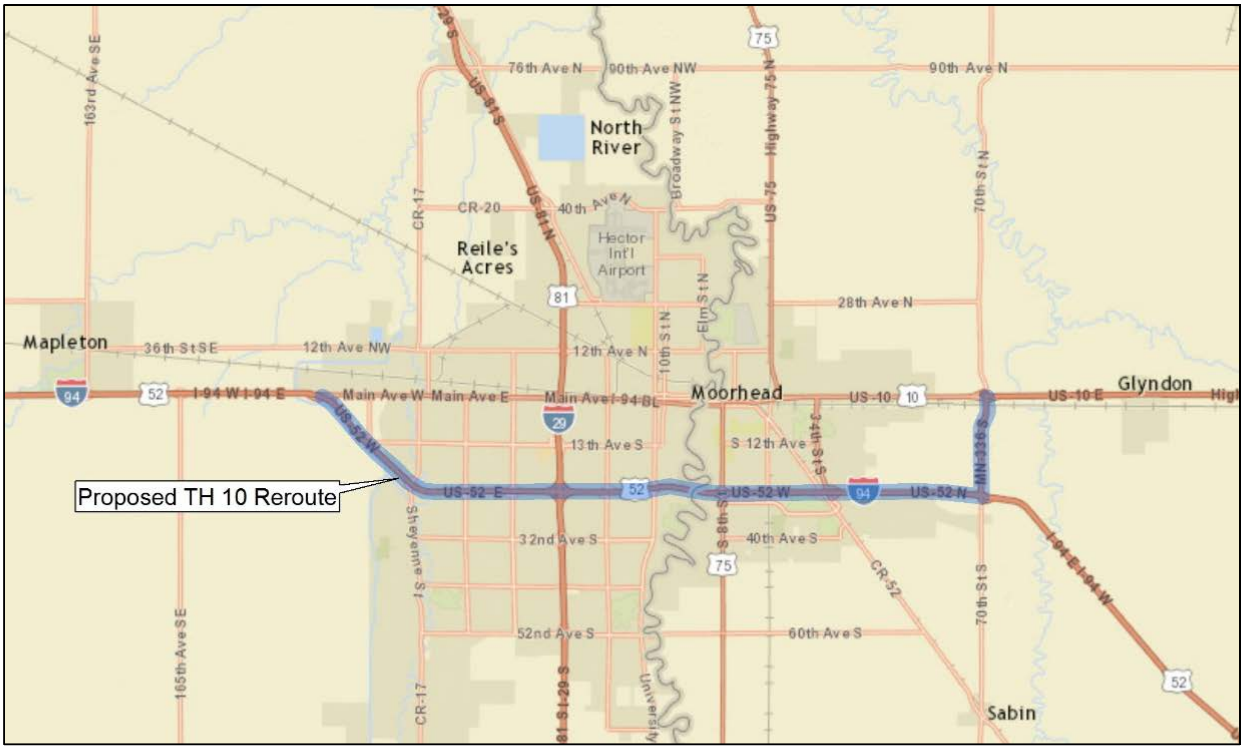


Alternative	Total Mileage	Centerline Mileage Gain/Loss State	County	City	County or City
Base	8.15	0.00	0.00	0.00	0.00
1	16.95	7.80	(14.80)	0.00	7.00
2	8.05	1.05	(1.00)	(2.00)	4.95
2a	8.00	0.05	0.00	(2.00)	1.95
3	10.35	1.10	(1.00)	(4.10)	4.00
3a	10.25	0.15	0.00	(2.10)	1.95
4	17.15	(1.95)	0.00	0.00	1.95

Trunk Highway 10 Jurisdiction Transfer, Ongoing

Since 2000, there have been discussions regarding rerouting Trunk Highway 10 to run concurrently with Interstate 94 through West Fargo, Fargo and Moorhead until it meets with Minnesota Trunk Highway 336 east of Moorhead (See Figure 5).

Figure 5 - Proposed TH 10 Reroute



Discussions dating back to 2000 including the North Dakota Department of Transportation (NDDOT) and MnDOT indicate that NDDOT, MnDOT, City of Fargo, City of West Fargo and City of Moorhead were willing to work toward such a reroute of Trunk Highway 10, as long as this reroute is mutually beneficial for all impacted jurisdictions. At this time, no formal decision has been made, nor has a detailed operations and safety based traffic study been performed.

During discussions with the Study Review Committee, the following key items were discussed pertaining to a potential TH 10 turnback:

- Since the reconstruction of TH 336, interregional traffic patterns currently transfer from TH 10 to I-94 via TH 336, and vice versa.
- The Main Avenue Bridge is currently jointly owned by MnDOT and NDDOT, and under a turn back scenario ownership would need to be considered;
- Past discussion between NDDOT, Fargo, West Fargo, and Metro COG indicated that if a turn back of US Highway 10 in North Dakota occurred, Main Avenue could remain on the National Highway System (NHS) in North Dakota and on the NDDOT Secondary Regional System. This would create connectivity issues as a NHS route cannot terminate at a state border.
- In 2002, Clay County documented its opposition to such a transfer. No recent discussions have not been conducted.

Rerouting of TH 10 is still a consideration, however with TH 75 still through downtown, rerouting TH 10 has minimal impacts to the stakeholders involved with the current Downtown Grade Separation Study. Thus, this discussion becomes unrelated to the overall goals and objectives of this study and will not be discussed within this report moving forward.

STUDY AREA

This study will focus on the traffic impacts associated with a downtown grade separation at 8th Street, 11th Street or 14th Street at both the Prosper and KO subdivisions since previous studies have identified these three roadways as the most feasible locations for a vehicle-rail grade separation. However, other roadways in downtown Moorhead will also be considered in technical analyses to better understand the impacts that a grade separation at any of the aforementioned roadways would have on area traffic patterns.

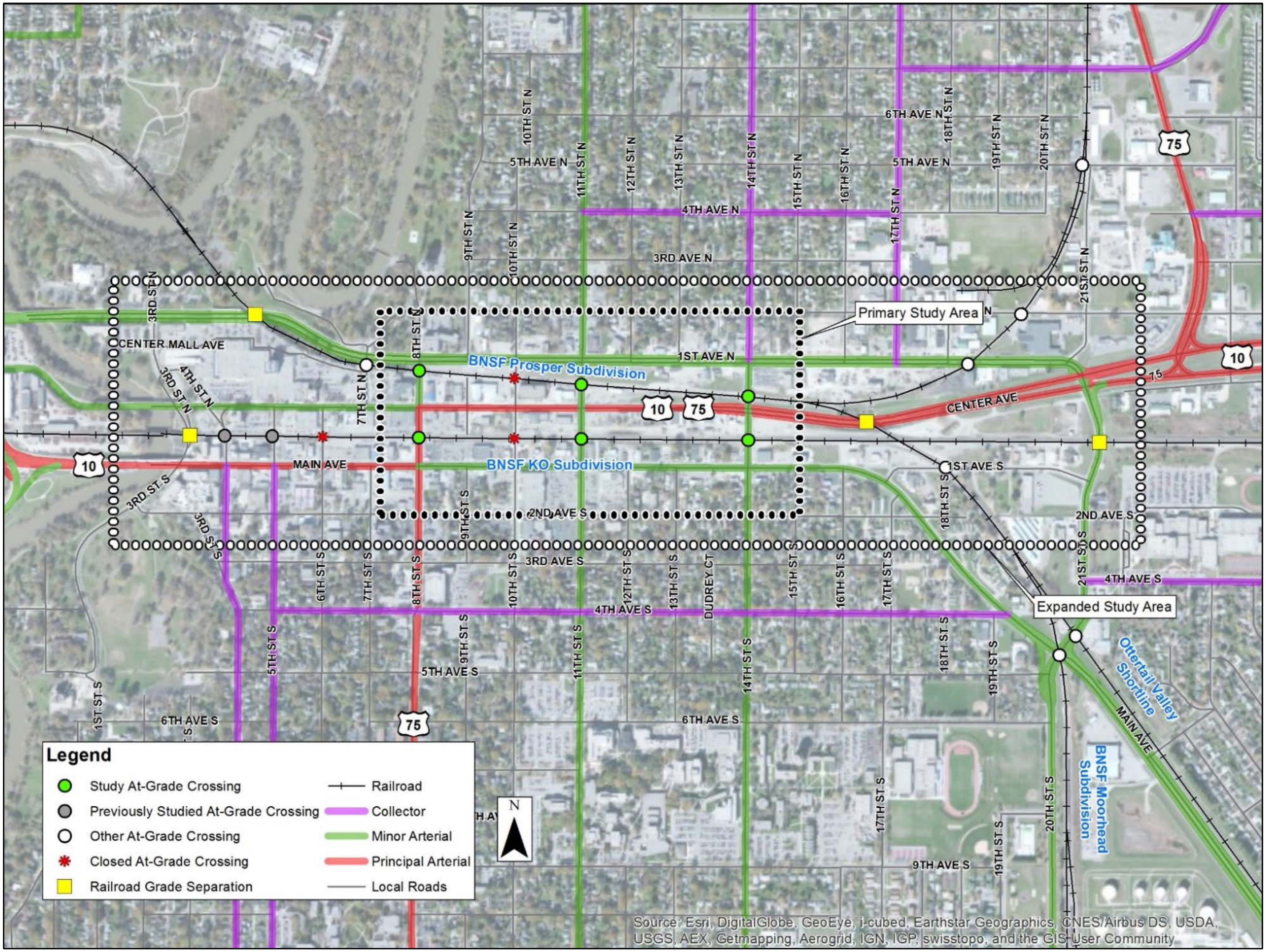
FHWA Grade Separation Criteria I, II, II - Roadway Designation, Access Control and Highway Speeds

The first three FHWA grade separation criteria at context specific attributes. None of the study corridors are on the national highway network, have access standards requiring grade separation or have speeds exceeding 55 mph to meet even Tier 2 requirements.

Conclusion – Criteria Not Met

The study area can be seen in Figure 6.

Figure 6 - Study Area Map



Existing Vehicle-Rail Grade Separations

There are four existing vehicle-rail grade separations in or near downtown Moorhead. Grade separations on 3rd Street and 21st Street provide north-south connectivity across the KO Subdivision, and grade separations on Center Avenue and 1st Avenue North provide east-west connectivity across the Prosper Subdivision.

Study Crossings

There are currently nine at-grade railroad crossings in downtown Moorhead along five different roadways. Since the 8th Street, 11th Street and 14th Street crossings of the KO and Prosper Subdivisions were carried forward as part of the *Downtown Moorhead Railroad Grade Separation Feasibility Study*, analyses in this report will focus on these locations. These crossings will be referred to as "study crossings" throughout the remainder of this report.

Study Intersections

Detailed operational and safety analysis presented in this memorandum was performed at the following intersections, and will be described later in this report:

- 8th Street and 1st Avenue North
- 8th Street and Center Avenue
- 8th Street and Main Avenue
- 11th Street and 1st Avenue North
- 11th Street and Center Avenue
- 11th Street and Main Avenue
- 14th Street and 1st Avenue North
- 14th Street and Center Avenue
- 14th Street and Main Avenue

These high-volume, high-priority intersections are the locations most affected by existing train activity and potential grade separation alternatives.

TRAIN ACTIVITY

Through Trains

Through train traffic information was provided by the MnDOT Office of Freight. According to MnDOT Freight, the KO and Prosper lines experience a combined eighty-five (85) trains per day, twelve (12) of which are oil trains; split equally between the Prosper and KO lines. The projected volume of 85 trains per day is consistent with external rail counts just west of the study area. According to FRA data, there are fifty-two (52) trains on KO Line through Casselton, ND and thirty-one (31) trains on the Prosper Line through New Rockford, ND. There are no connecting rail lines or depots for trains to be added/dropped between these cities and Moorhead. This equates to a total of 83 trains and a 63% split in favor of the KO Line. Using this distribution, the 85 trains through downtown Moorhead are split 53 on the KO line and 32 on the Prosper line.

FHWA Grade Separation Criteria VII and IX – Passenger Train Volume and Crossing Exposure

Although there is an Amtrak station located in downtown Fargo along the Prosper line, this station carries fewer than 5 passenger trains per day on average. Under any reasonable growth scenario these volumes will not come close to meeting the passenger train volume (volumes exceeding 50 and 75 trains per day) and crossing exposure criteria (exposure exceeding 500,000 and 800,000) by 2040.

Conclusion – Criteria Not Met

Blockages

According to Federal Railroad Administration official rail reports and the past six months of train movement data from BNSF, the KO and Prosper lines experience approximately 67 and 59 trains movements respectively each day. Discrepancies between MnDOT and external train volumes versus train counts by FRA and BNSF are the result of local switching movements, which are common in downtown Moorhead.

For the purposes of the Downtown Moorhead Grade Separation project, evaluating both the number of through trains and local movements are very valuable due to the delay implications of each. Switch delays are often more frustrating than delays induced by through trains, as motorist do not know how long they will last. This creates motorist frustration and often leads to risk-taking maneuvers to avoid delays.

Figure 7 – Example of Train Blockage

A switch is a back and forth local movement. Switches are typically counted twice but only block a crossing once (i.e. gates are down the entire or most of the switch maneuver). To estimate the total number of rail crossing blockages, the train movements produced by FRA and BNSF were subtracted from the through train data from MnDOT Freight and divided by two. This produces 7 local switch blockages on the KO line and 14 on the Prosper line.

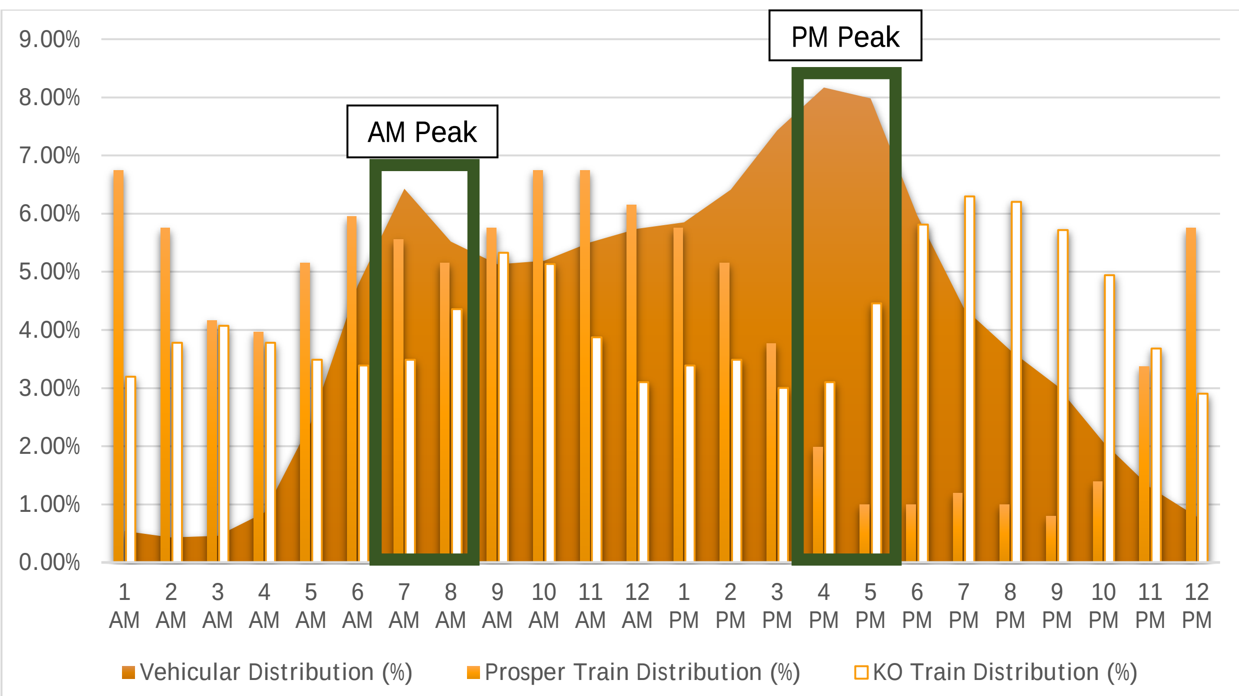
It is important to note that not all local movements are not always back and forth switch maneuvers. Based upon field observations, some local movements are one directional movements with a locomotive and sometimes a small number of boxcars. The blockage methodology is still sound because the one directional local movements produce much lower amounts of delay compared to back and forth switch movements or through trains. Thus, dividing by two and applying the same amount of delay to all movements is still a reasonable approach. The amount of delay applied to each movement is discussed in the next section.

Train Activity Patterns

MnDOT, FRA and BNSF data was supplemented with field data collected on July 23-24, 2014. The field data was used for two purposes: to determine the average train delay on each track and to determine the daily distribution of trains. This information is vital for estimating delays. According to the field data, the KO line induced an average train delay of 3.9 minutes whereas the Prosper line induced an average train delay of 5.9 minutes. Field data for delay per blockage for all movements was used as this data is already an aggregation of train delay and switch maneuver delay. Separating the two datasets would reduce an already small dataset, making it less reliable.

The daily distribution was smoothed to account for the small sample size of train data collected. This approach mitigates potential for dramatic contrasts in highs and lows in the data. This was accomplished using a weighted moving average methodology. Refer to Figure 8 for an illustration of the daily train distributions correlated with daily vehicular traffic distributions. The daily vehicular traffic distributions are 10-year averages taken throughout Minnesota from the *MnDOT Procedure Manual for Forecasting Traffic on Minnesota's Highways*.

Figure 8 - Daily Rail and Traffic Distributions



FHWA Grade Separation Criteria V – Trains Speed

According to the US DOT and FRA crossing report, the KO Line has a maximum speed of 35 mph and the Prosper Line has a maximum speed is 25 mph, neither of which justify a grade separation on their own. The variation in speeds may help explain the differentiation in delays at the two crossings. However, casual observations indicate that trains rarely get up to speeds of 35 mph on the KO line through the highly active Moorhead city center.

Conclusion – Criteria Not Met

Train Projections

Freight demands will continue to increase train traffic through the 2040 study horizon. The following quotes from the *North Dakota State Freight Plan* (2014) and the *Minnesota Comprehensive Statewide Freight and Passenger Rail Plan* (2010) highlight future freight needs relevant to the KO and Prosper lines.

Minnesota Comprehensive Statewide Freight and Passenger Rail Plan:

- *"The most significant changes in [statewide freight] volumes are forecast to occur on the BNSF mainline between Minneapolis and Fargo, ND…"*

North Dakota State Freight Plan:

- *"North Dakota's oil and natural gas production is expected to double by 2017, and to continue to rise for the next 10 to 15 years…"*
- *"North Dakota's increasing agricultural production will result in higher volumes of freight; in-bound seed, fertilizer, machinery, fuel, etc. and outbound bulk commodities, processed agricultural products, etc."*
- *"Spin-off industries [in North Dakota] producing equipment, supplies, and technology supporting the state's growing agricultural, manufacturing and energy sectors will create new freight movements and significantly increase the volume of freight"*

The following growth assumptions were provided by MnDOT Freight:

- Oil train volumes would grow by 10% until the year 2023; then flatten due to uncertainty in oil prices, future Bakken production estimates, and pipeline construction.
- Freight (non-oil) volumes would grow by 2% per year from the base year to 2040.

This forecasting methodology aligned with reports produced by the FRA that indicate the total growth in rail traffic is typically between 2-3%.

FHWA Grade Separation Criteria VI – Train Volumes or Gross Tonnage

Using the growth assumptions established by MnDOT Freight, by 2040 the KO and Prosper lines will carry 93 and 58 trains per day respectively. According to the FHWA train volume warrant, train volumes of 150 and 75 trains per day are required to meet Tier 1 and 2 respectively. The KO line meets Tier 2 criteria by the year 2028 and does not meet Tier 1 criteria. The Prosper Line does not meet either Tier.

Conclusion – Criteria Met on KO Line in the Future

To estimate future blockages, a blockage rate per through train was developed for existing conditions and applied for future conditions. This produced 12 and 24 blockages for the KO and Prosper lines in 2040 respectively.

Summary

In summary, the established rail blockage methodology applies multiple sources of reliable yet incomplete data; FRA and BNSF rail movements, MnDOT Office of Freight through train movements, field data and upstream rail counts. The output is an aggregation of the best available data to be used in the following ways:

- Through trains used to evaluate FHWA grade separation warrants related to train volume.
- Blockages used to forecast delay for FHWA grade separation delay and exposure warrants. This data will also be used in the model to estimate trip redistribution.

Table 1 below illustrates the proposed through trains and blockages for existing and future conditions.

Table 1 – Existing and Future Train Activity

Traffic Conditions	Rail Line	Train Movements	Through Trains	Switch Blockages	Total Blockages	% Switch Blockages
2014	Prosper Subdivision	[1]59	[2]32	14	46	29.7%
	KO Subdivision	[1]67	[2]53	7	60	11.7%
2040	Prosper Subdivision	107	58	24	82	29.7%
	KO Subdivision	118	93	12	105	11.7%

[1]From FRA Reports

[2]MnDOT Office of Freight Data Calibrated to Upstream Distributions between the KO and Prosper Lines

VEHICULAR TRAFFIC ACTIVITY

Existing Traffic Volumes

Existing ADT and peak hour intersection turning volumes were obtained from previous studies completed in 2013, which is considered recent enough to accurately reflect 2014 conditions. Existing ADT and peak hour turning volumes can be seen in Figure 14.

2040 Traffic Volumes

Projected 2040 ADTs were obtained from the Fargo-Moorhead travel demand model. 2040 ADT information was used to project 2040 AM and PM peak hour intersection turning movements using the method presented in *National Cooperative Highway Research Program Report 765: Analytical Travel Forecasting Approaches for Project-Level Planning and Design* (2014). Projected 2040 ADT and intersection turning volumes can be seen in Figure 15.

FHWA Grade Separation Criteria IV – Average Daily Traffic Volumes

All crossings have 2014 and 2040 daily traffic volumes less than 50,000 ADT, the minimum threshold required to meet FHWA Criteria IV to justify installation of a grade separation.

Conclusion – Criteria Not Met

Figure 9 – 2014 Traffic Volumes

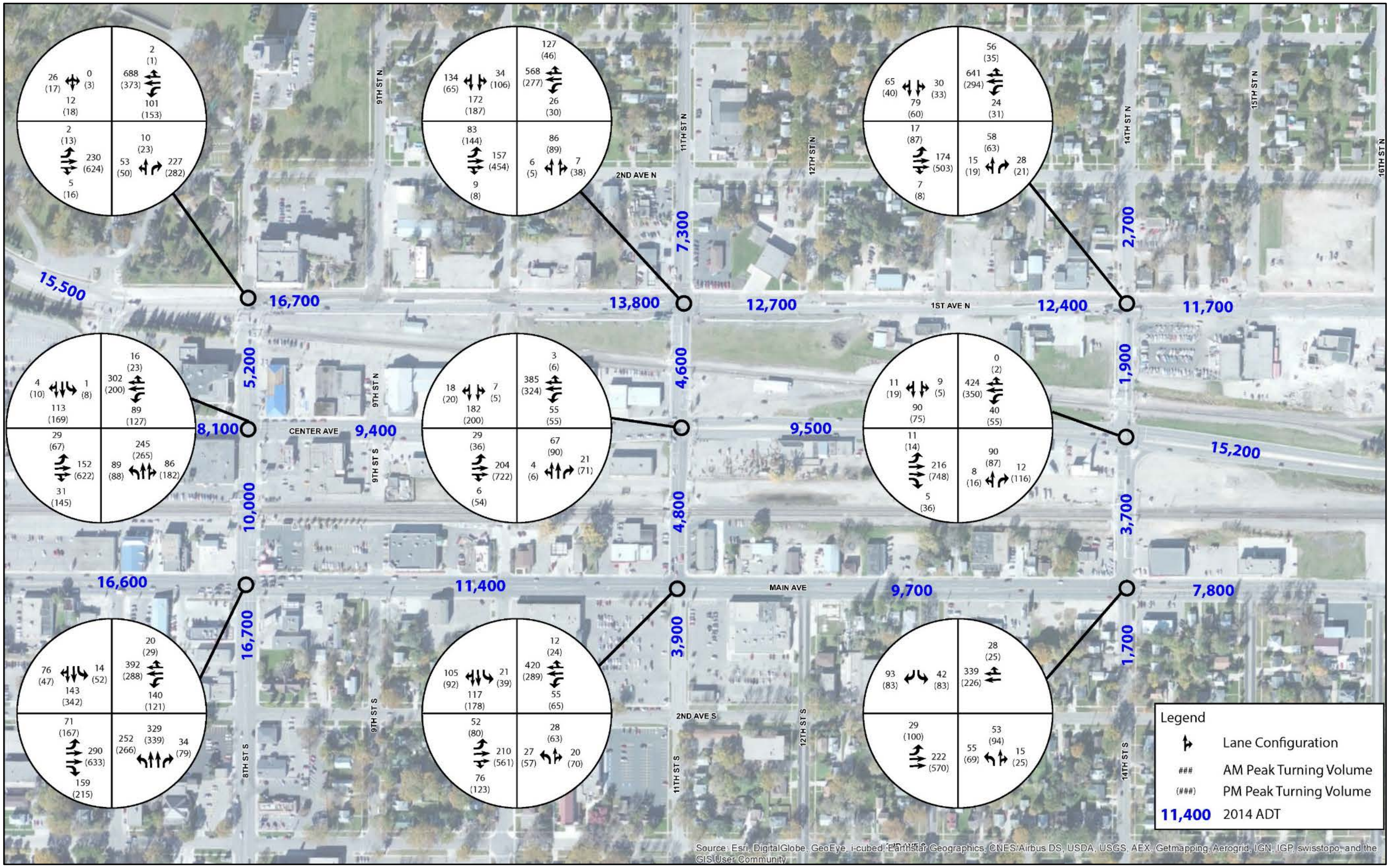
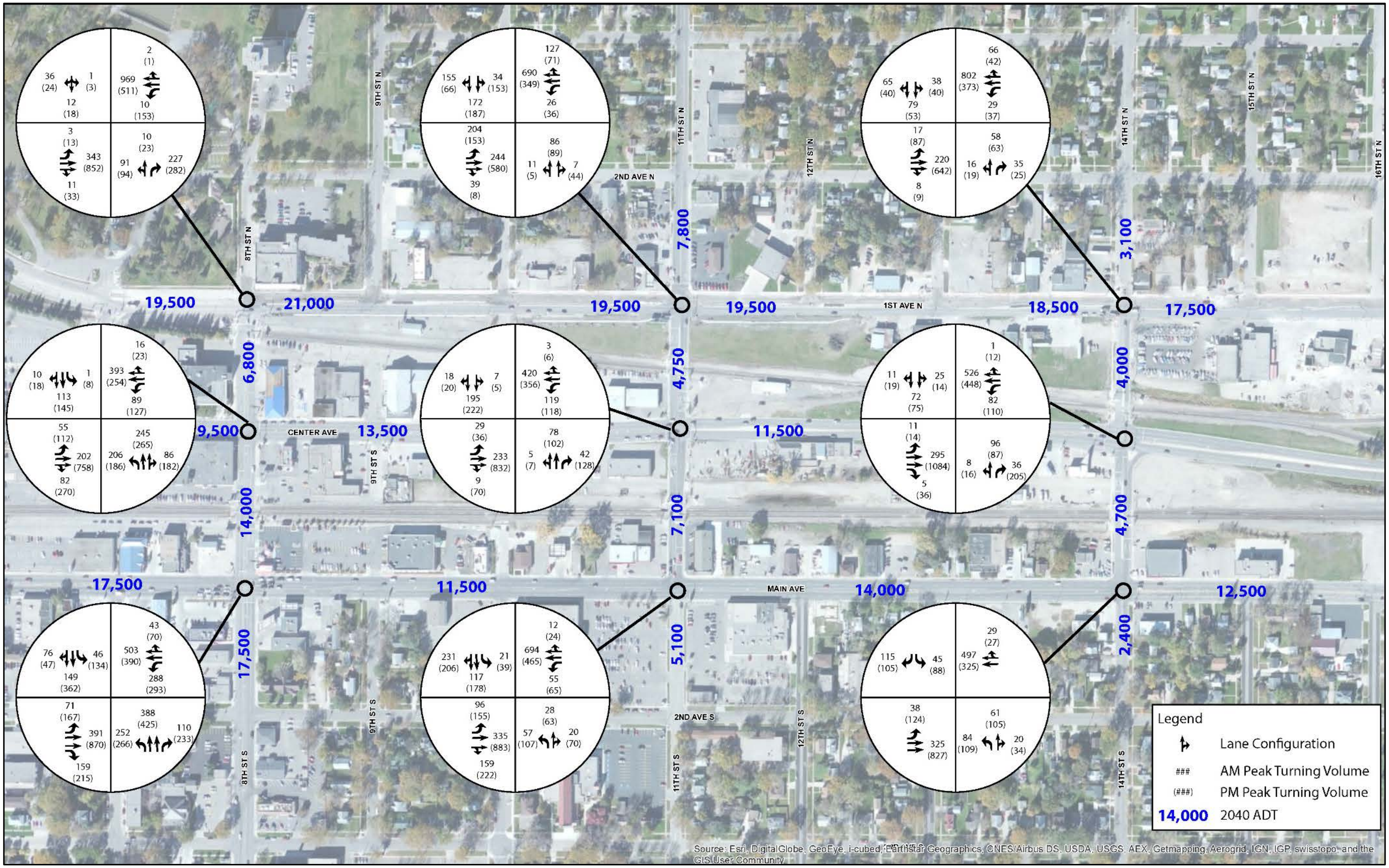


Figure 10 – 2040 Traffic Volumes



TRAFFIC DELAY AND OPERATIONS

Traffic operations were evaluated in the study area under existing and 2040 conditions. This included daily train-related delay that is expected at each crossing, as well as at-grade crossing intersection capacity analysis when trains are not present during the AM and PM peak hours.

Train Induced Delays

The lack of grade separation in downtown Moorhead means that motorists have few options other than waiting for trains to pass. Diverting to 3rd or 21st Street railroad underpasses requires significant increases to overall travel time that mitigates the benefits for most drivers. Many drivers still choose the known delay associated with rerouting to 3rd or 21st in favor of the unknown length of delay waiting for the train to pass, with the potential for a second train to come. For the purposes of calculating baseline train delay it was assumed that these vehicles did not reroute because these routes rarely provided time savings.

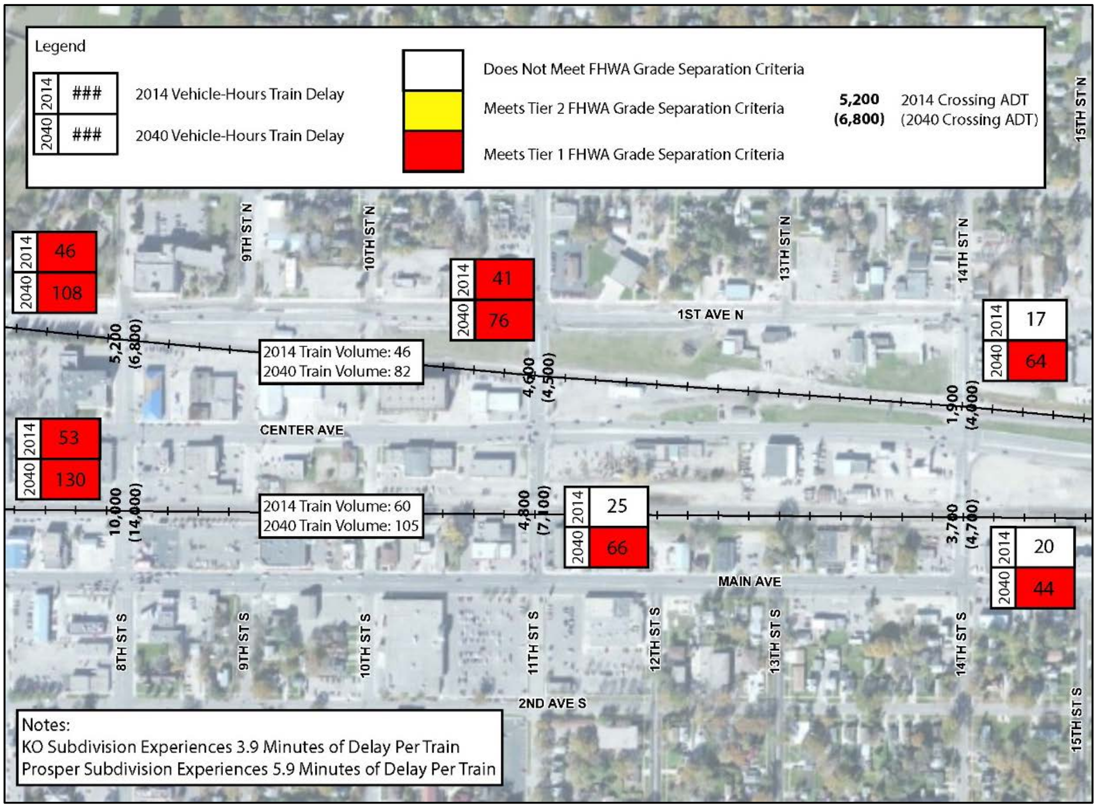
Figure 11 - Congestion After a Train Event

The Fargo-Moorhead regional travel demand model aggregates and extrapolates the AM peak period, PM peak period and off-peak periods to forecast traffic volumes and estimate volume/capacity ratios for each roadway link. Because train traffic does not peak in a similar fashion as vehicular traffic, the extrapolation process in the travel demand model would not accurately replicate when rail delays occur. Thus, an independent daily delay model was developed specifically for the purposes of estimating rail delay in downtown Moorhead. This model incorporates vehicular and train patterns, volumes and growth scenarios to estimate delays. The following assumptions were used to develop this model:

- Daily rail and vehicle distributions from Figure 8 were used for existing and future scenarios.
- Delay per train remains constant under each scenario.
- An even vehicular distribution rate was assumed within each hour to account for often inconsistent train times and unknown future train schedules.

Figure 12 illustrates the existing and future daily hours of delay at each crossing.

Figure 12 - Daily Train Induced Delays



FHWA Grade Separation Criteria XI – Train Induced Delays

As illustrated in Figure 12, three of the six study crossings already meet FHWA Tier 1 delay requirements (40 vehicle hours per day) to justify a grade separation. By 2040, all six crossings will meet Tier 1 requirements with the most delayed crossing accumulating delays over three times the Tier 1 threshold.

Conclusion – Criteria Met at KO and Prosper Lines Under Existing and Future Conditions

It is important to note that although the highest delays are forecasted to occur at 8th Street, this is strictly tied to current traffic patterns. Once a grade separation is established at either of the three arterials, traffic patterns will shift. In other words, the total amount of delay illustrated in Figure 12 is correlated and should be considered on a downtown network-wide level rather than on a crossing by crossing basis.

Intersection Capacity Analysis

Intersection capacity analysis evaluates the level of service (LOS) at intersections based on traffic volumes entering the intersection over a peak period. LOS is a measure, which qualitatively describes intersection operations using letter grades between LOS "A" and LOS "F". LOS "A" indicates good traffic flow with little intersection delay and LOS "F" indicates a total breakdown of traffic flow with long intersection delays. LOS "F" is also assigned when demand exceeds capacity. The LOS thresholds as defined by the Highway Capacity Manual (HCM) can be seen in Table 1. According to MnDOT standards, intersections and approaches at LOS "E" or worse are considered operationally deficient in accordance with MnDOT standards.

Table 2 - Highway Capacity Manual Level of Service

Control Delay (sec/veh)		Volume < Capacity	Volume > Capacity
Unsignalized	Signalized		
≤ 10	≤ 10	A	F
> 10-15	> 10-20	B	F
> 15-25	> 20-35	C	F
> 25-35	> 35-55	D	F
> 35-50	> 55-80	E	F
> 50	> 80	F	F

A microsimulation model was developed to evaluate peak hour operations. Microsimulation models simulate traffic operations based upon user defined input and driver behavior algorithms built into the software. Microsimulation models are powerful tools when dealing with railroad crossings because they emulate the arrival of trains and subsequent queue blockages and operational deficiencies.

There are two operations scenarios: when trains are present and when they are not. Intuitively the operations under each scenario functions dramatically differently. When train movements occur, several vehicular movements are blocked at the study intersections. The way the model was developed, when train blockages occur delays accumulate at the railroad crossing until queues extend into the intersection and vehicles are forced to wait at the intersection.

Vehicular rerouting wasn't considered in the analysis because the intersection turning movement counts include train movements where vehicles rerouted. Also as noted before, the reroute options available for motorists provided minimal time savings.

Planned Improvements

The City of Moorhead is currently in year one of a two year project to improve intersection operations in downtown Moorhead via signal phasing, signal timing and turn lane improvements. Specifically, the following turn-lane improvements will be constructed in 2015. These were considered in the existing conditions analysis:

- Construct a northbound right-turn lane at 8th Street/Main Avenue.
- Construct an eastbound right-turn lane at 8th Street/Main Avenue.
- Construct a southbound right-turn lane at 11th Street/Main Avenue.
- Construct a northbound right-turn lane at 11th Street/Center Avenue.
- Lengthen the westbound left-turn lane at 11th Street/Center Avenue.
- Convert the northbound outside thru lane to a dedicated right-turn lane at 11th Street/1st Avenue.

Capacity Analysis

Under 2014 existing conditions, all intersections operate at LOS "C" or better with the exception of 8th Street and Center Avenue which operates at a LOS "E" during the PM peak hour due to the delays and blockages from the railroad. This intersection operates at an acceptable level if train delays were not present.

In 2040, all intersections operate at LOS "D" or better with the exception of 8th Street and Main Avenue which operate at LOS "F" during the PM peak hour. Once again, the train delays significantly deteriorate intersection operations at these locations.

Figure 13 - Level of Service During Existing AM and PM Peak

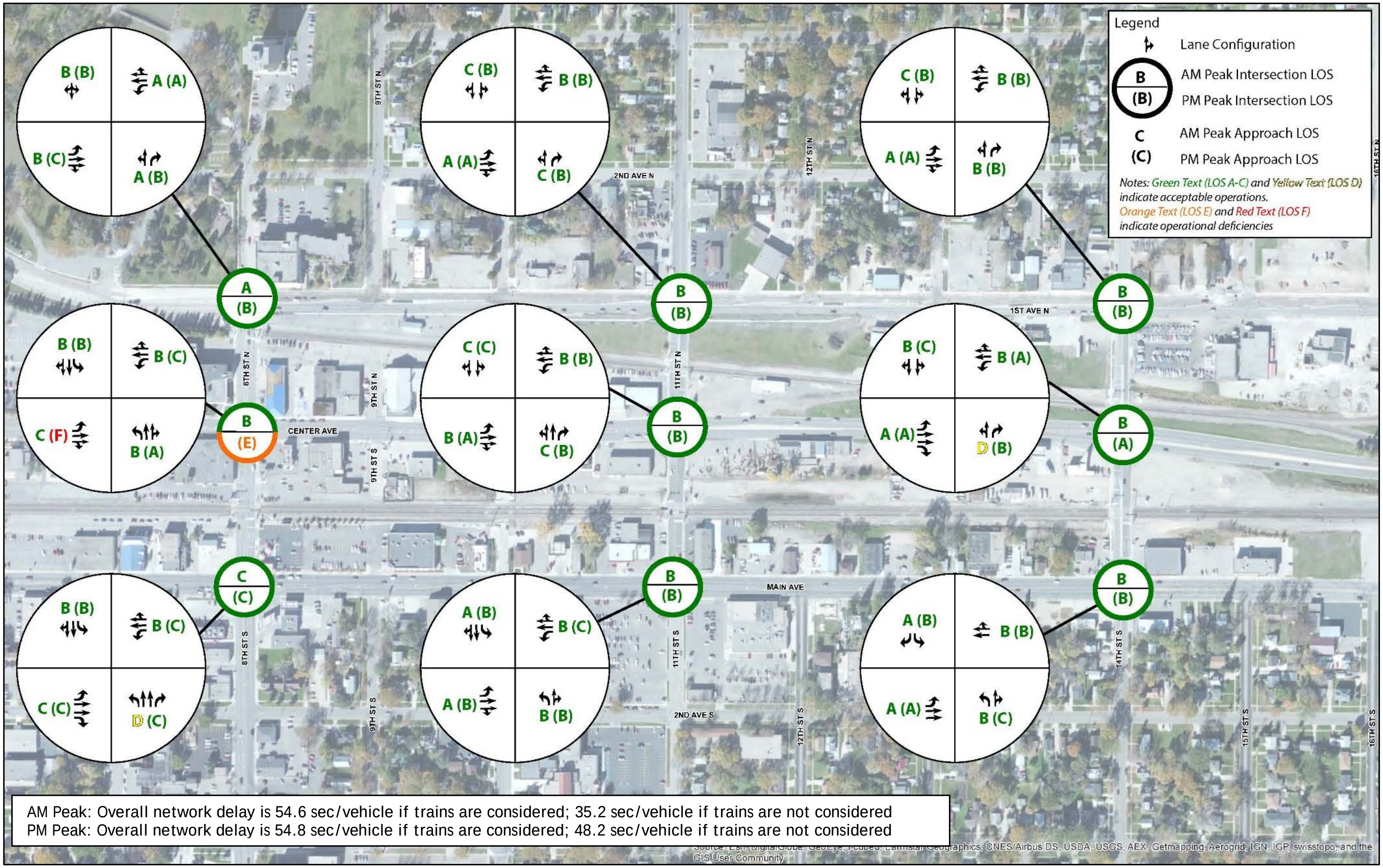
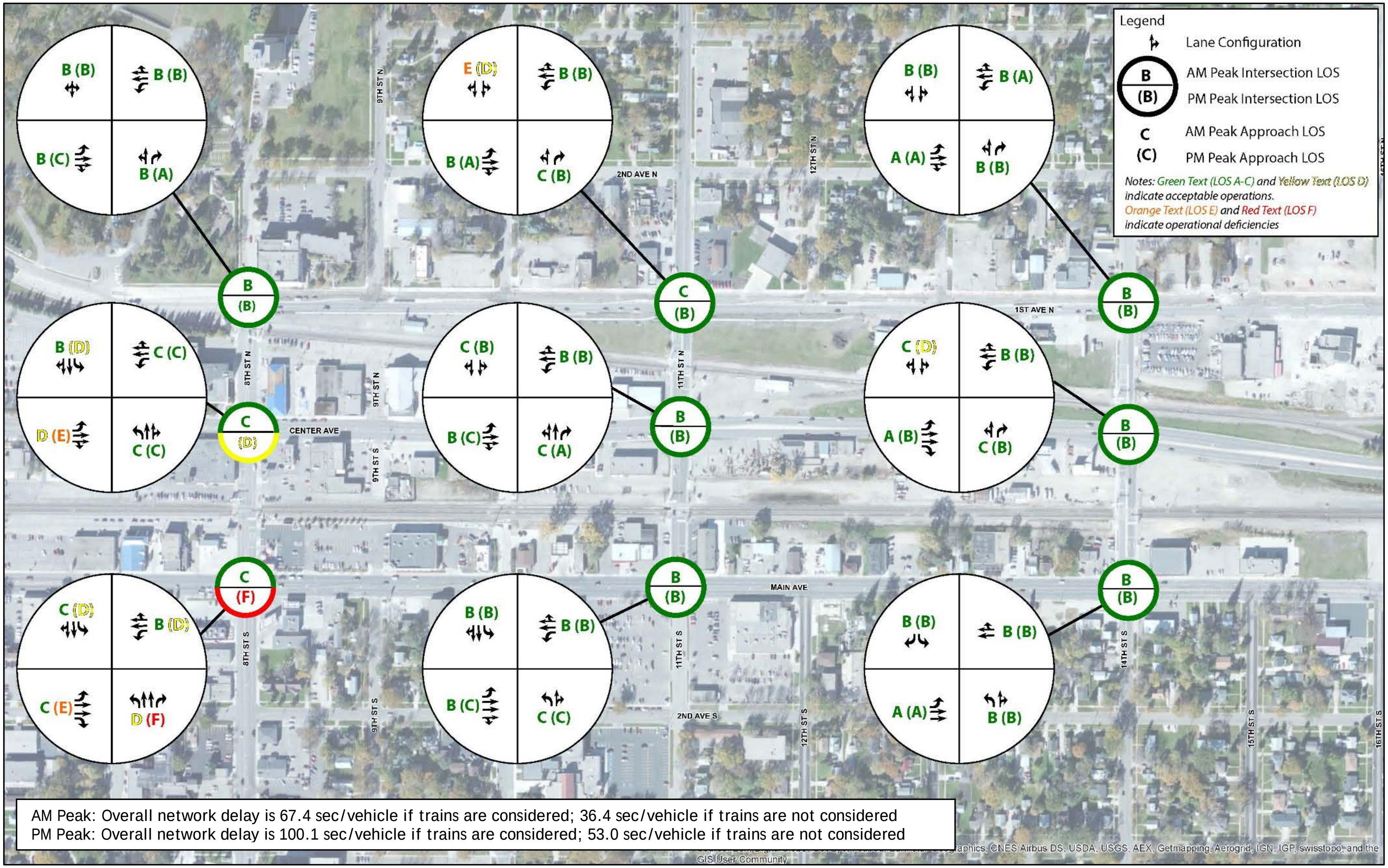


Figure 14 - Level of Service during 2040 AM and PM Peak



SAFETY

Data from the National Highway Traffic Safety Administration indicates that a motorist is 20 times more likely to die in a crash involving a train than in a collision involving another motor vehicle. Therefore, it is imperative that the risk for vehicle-train collisions is minimized while working to achieve other goals such as reducing traffic delays and minimizing the impacts that train activity has on surrounding homes and businesses.

Railroad-Vehicle Crash Exposure

FHWA Grade Separation Criteria VIII – Crossing Exposure

As discussed in the Project Background section of the report, FHWA guidelines state that a grade separation should be considered at locations where crossing exposure (product of vehicular crossing ADT and number of trains) exceeds 1,000,000 for Tier 1 and 500,000 for Tier 2. 2014 and 2040 exposures were calculated for all study at-grade crossings, and can be seen in Figure 15.

Under existing vehicle and train volumes, a grade separation is justified only at 8th Street and the KO Subdivision using the Tier 2 grade separation criteria. By 2040, the 8th Street/KO crossing will meet Tier 1 criteria and the 8th Street/Prosper and 11th Street/KO crossings will meet Tier 2 criteria. The Prosper Line at 8th Street meeting Tier 2 criteria by 2036.

Conclusion – Criteria Met at KO and Prosper Lines Under Existing and Future Conditions

Similar to train induced delay, the highest exposure is forecasted to occur at 8th Street. This is strictly tied to current traffic patterns. Once a grade separation is established at either of the three arterials, traffic patterns will shift. In other words, the total amount of exposure is correlated and should be considered on a downtown network-wide level rather than on a crossing by crossing basis.

Figure 15 - Existing and 2040 Railroad-Vehicle Crash Exposure

Crash History

Train-Related Crash History

Vehicle-train crash data for the 8th Street, 11th Street and 14th Street crossings of the KO and Prosper Subdivisions was obtained from MnDOT and the *Downtown Moorhead Railroad Grade Separation Feasibility Study* (2008). MnDOT only maintains 10 years of crash data so train related crash data prior to 2004 was taken from the 2008 Feasibility Study.

Since 1976, the crash history at each of the study crossings is:

Table 3 - Crash History at Study Crossings (1976-2014)

	8th Street		11th Street		14th Street[1]
	KO Subdivision	Prosper Subdivision	KO Subdivision	Prosper Subdivision	Before 2004
Total Crashes	**15**	**6**	**4**	**4**	**3**
Injuries	*6*	*2*	*2*	*0*	*0*
Fatalities	*2*	*0*	*1*	*0*	*0*

[1]Data prior to 2004 at 14th Street was unclear whether the three crashes occurred at the KO or Prosper Subdivisions.

According to the MnDOT dataset, zero crashes have occurred since 2006. This is likely attributable to the safety improvements associated with quiet zone implementation.

FRA Train Accident Prediction

The United States Department of Transportation (USDOT) developed a train accident prediction model, which can be used to predict the number of annual train-vehicle collisions at public at-grade crossings. The FRA developed the *Web Accident Prediction System*, which implements the USDOT accident prediction model with the consideration of the most recent 5 years of crash data at any public at-grade crossing.

Using the FRA Web Accident Prediction System, the predicted number of train-vehicle crashes at each of the study crossings is illustrated in Table 3.

Table 4 - Predicted Annual Train-Vehicle Crash Frequency

Street	Rail Line	Predicted Collisions Per Year
8th Street	KO Subdivision	0.041
	Prosper Subdivision	0.053
11th Street	KO Subdivision	0.042
	Prosper Subdivision	0.038
14th Street	KO Subdivision	0.095
	Prosper Subdivision	0.030

FHWA Grade Separation Criteria X - Expected Accident Frequency

FHWA grade-separation Criteria X states that at-grade crossings should be considered when the following crash frequencies are predicted:

- Tier 1 – Predicted crash frequency is 0.5 crashes per year or higher
- Tier 2 – Predicted crash frequency is 0.2 crashes per year or higher

Based on the predicted crash frequencies at each of the study crossings, no crossing meets the crash frequency criteria for grade separation.

Conclusion – Criteria Not Met

Critical Crash Analysis

Crash data was obtained from MnDOT for 2011-2013 to identify any study intersection or study roadway segment with potential safety issues. Only the potential crossing corridors of 8th, 11th and 14th Streets were studied to identify any crash trends that would be mitigated or amplified upon construction of a grade separation in downtown Moorhead.

Crash analysis was performed using MnDOT's critical crash analysis methodology, which identifies locations as hazardous if crash rates are statistically higher than rates found at similar locations. This is accomplished by determining the *critical crash rate*, which is a function of the amount of exposure and the random nature of crashes. A location is only considered hazardous if the crash rate at that location is higher than the critical crash rate. A location could have a crash rate above the system average and be considered non-hazardous as long as the crash rate is below the critical crash rate for that location.

See Figure 16 and Table 4 for critical crash analysis results. The only location with a crash rate higher than the critical crash rate is the intersection of 8th Street and Main Avenue, highlighting a need for safety improvements at this location.

Figure 16 - Critical Crash Analysis

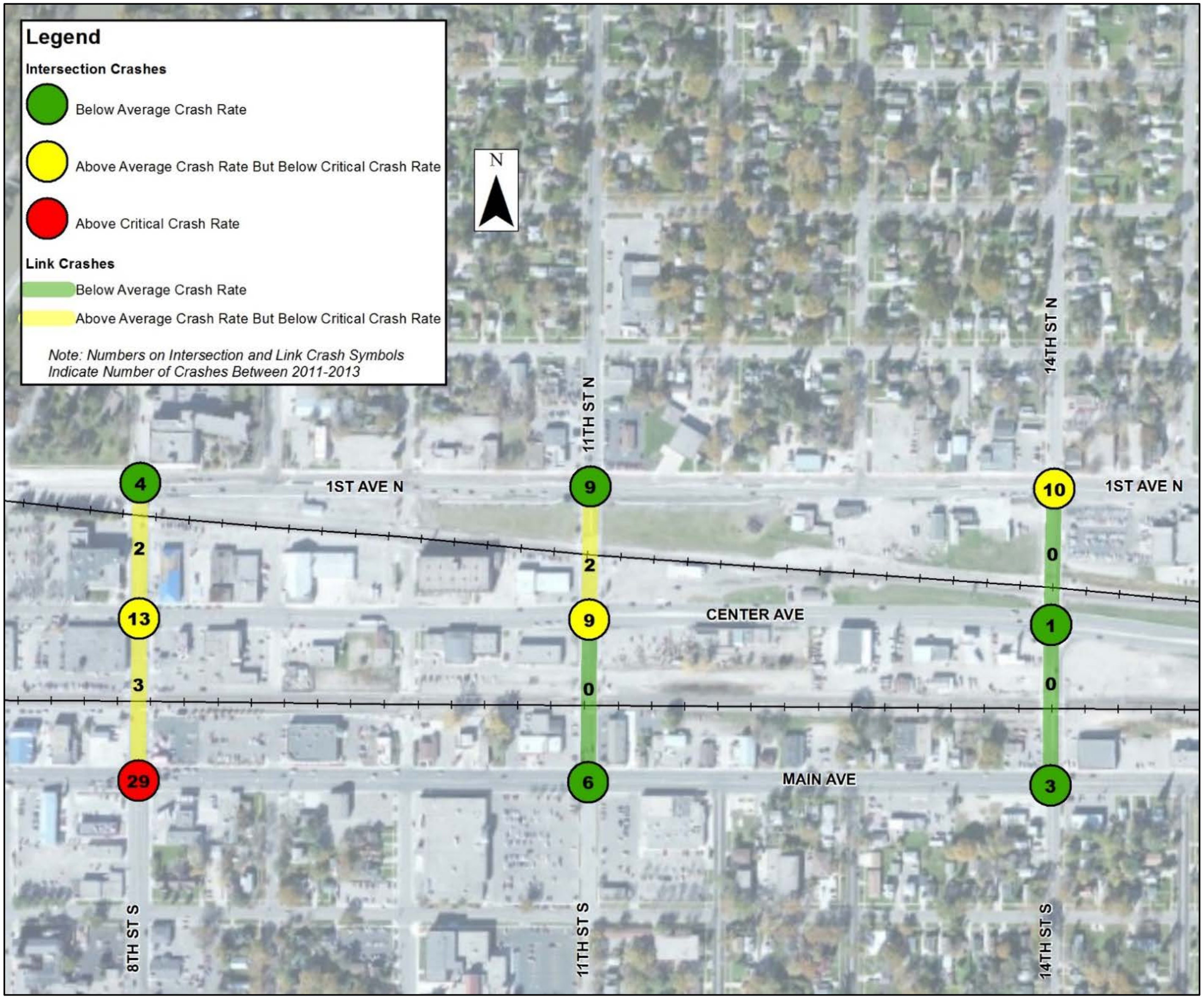
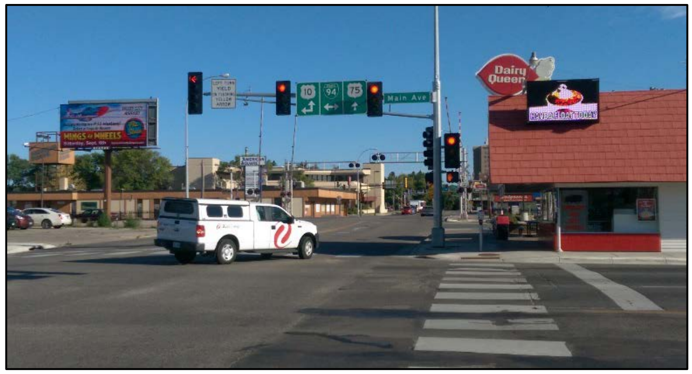


Table 5 – Critical Crash Analysis

	Location	Description	Total Number of Crashes	Crash Rate	Critical Crash Rate	Crash Type							
						1	2+9	3	4+7	5	6	8	0/90/98/99
						Rear End	Wide Swipe	Left Turn	ROR Left Right	Right Angle	Right Turn	Head On	Other
Intersections	8th Street and 1st Avenue N	Signalized, Low Volume, Low Speed	4	0.19	0.74	2	0	0	0	1	0	0	1
						50%	0%	0%	0%	25%	0%	0%	25%
	8th Street and Center Avenue	Signalized, Low Volume, Low Speed	13	***0.73***	0.76	3	1	1	0	6	1	0	1
						23%	8%	8%	0%	46%	8%	0%	8%
	8th Street and Main Avenue	Signalized, Low Volume, Low Speed	29	***0.97***	0.69	9	3	2	1	11	2	0	1
						31%	10%	7%	3%	38%	7%	0%	3%
	11th Street and 1st Avenue N	Signalized, Low Volume, Low Speed	9	0.43	0.74	2	2	1	1	3	0	0	0
						22%	22%	11%	11%	33%	0%	0%	0%
	11th Street and Center Avenue	Signalized, Low Volume, Low Speed	9	***0.58***	0.79	2	0	0	0	6	0	0	1
						22%	0%	0%	0%	67%	0%	0%	11%
	11th Street and Main Avenue	Signalized, Low Volume, Low Speed	6	0.37	0.78	0	0	0	0	6	0	0	0
						0%	0%	0%	0%	100%	0%	0%	0%
	14th Street and 1st Avenue N	Signalized, Low Volume, Low Speed	10	***0.64***	0.77	2	0	2	0	5	0	0	1
						20%	0%	20%	0%	50%	0%	0%	10%
	14th Street and Center Avenue	Signalized, Low Volume, Low Speed	1	0.07	0.79	1	0	0	0	0	0	0	0
						100%	0%	0%	0%	0%	0%	0%	0%
	14th Street and Main Avenue	Signalized, Low Volume, Low Speed	3	0.24	0.82	1	0	1	0	1	0	0	0
						33%	0%	33%	0%	33%	0%	0%	0%
Segments	8th Street - Center Avenue to 1st Avenue N	Urban 4 Lane Undivided	2	***5.10***	7.61	0	0	0	1	1	0	0	0
						0%	0%	0%	50%	50%	0%	0%	0%
	8th Street - Main Avenue to Center Avenue	5 Lane Undivided	3	***3.13***	5.42	1	1	0	0	1	0	0	0
						33%	33%	0%	0%	33%	0%	0%	0%
	11th Street - Center Avenue to 1st Avenue N	Urban 4 Lane Undivided	2	***5.76***	8.03	1	0	0	0	1	0	0	0
						50%	0%	0%	0%	50%	0%	0%	0%
	11th Street - Main Avenue to Center Avenue	Urban 4 Lane Undivided	0	0.00	7.15	0	0	0	0	0	0	0	0
						-	-	-	-	-	-	-	-
	14th Street - Center Avenue to 1st Avenue N	Urban 4 Lane Undivided	0	0.00	12.45	0	0	0	0	0	0	0	0
						-	-	-	-	-	-	-	-
	14th Street - Main Avenue to Center Avenue	Urban 4 Lane Undivided	0	0.00	7.96	0	0	0	0	0	0	0	0
						-	-	-	-	-	-	-	-
Intersections: Statewide Crash Rate (Signalized, Low Volume, Low Speed)				0.54	Notes:								
Segments: Statewide Crash Rate (5 Lane Undivided)				0.86	***Bold Italics*** indicate location crash rate is higher than the state average for that type of facility								
Segments: Statewide Crash Rate (Urban 4 Lane Undivided)				0.63	Red indicates location crash rate is higher than the critical crash rate								

Crash Trends

Figure 17 - 8th Street and Main Avenue

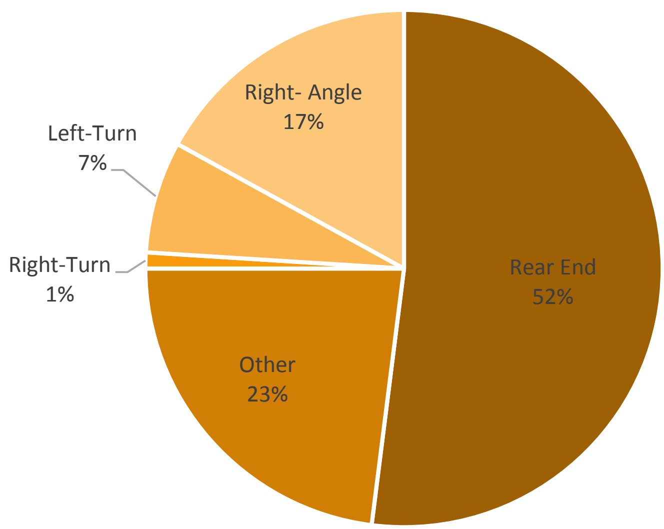


Trend analysis was conducted at all intersections to identify patterns. Upon review of the crash data throughout the study area, the following trends emerged:

- Forty-nine (49) of the crashes (44%) in the study area were right-angle crashes (does not include left-turn crashes).
- Twenty-nine (29) of the crashes (26%) in the study area were rear-end crashes.

Every intersection with enough crashes to exhibit a trend experienced the crash pattern noted above. Downtown urban settings where signal spacing is dense and stop-and-go traffic progression is common, typically experience high rear-end crash rates. However, compared to the state average of 52%, the 26% rear-end crash distribution is relatively low. Construction of a grade separation may reduce congestion and improve traffic congestion, mitigating the rear-end crash potential.

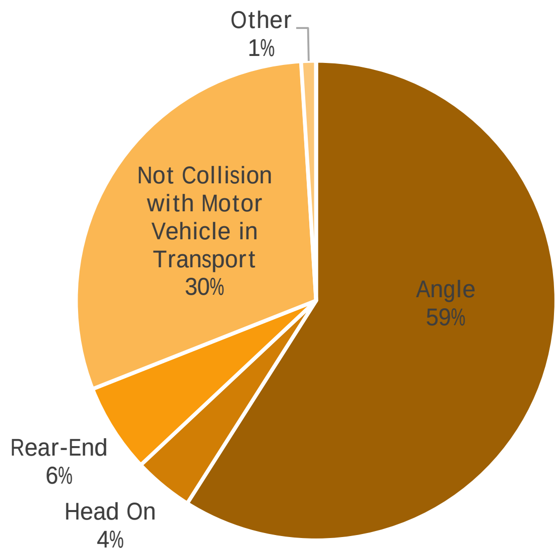
Figure 18 - Crash Distribution for Urban Signalized Intersections



Source: MnDOT, *Traffic Safety Fundamentals Handbook*, 2008

The right-angle crash trend is more than 2.5 times the State average for urban signalized intersections, making this trend particularly alarming. According to NCHRP Report 500 *A Guide for Reducing Collisions at Signalized Intersections*, right-angle crashes produced 59% of fatalities at signalized intersections, even though the percentage of these crash types is low relative to other crash types.

Figure 19 - Manner of Collision for Fatal Crashes at Signalized Intersections



Source: NCHRP, A Guide for Reducing Collisions at Signalized Intersections, 2004

Signals are designed to prevent right-angled crashes from conflicting directions. This means that the right-angled crash trend occurs when a motorist disobeys the traffic signal or the signal is operating in a fashion that the driver cannot meet the stopping requirements. Conscience disregard for traffic signals is common in areas where long delays and subsequent motorist frustration are similarly common. Casual observations found that motorists often disobey traffic signals in the study area when train blockages occur to reroute and avoid delays. Thus it can be deduced that the motorist frustration caused by train delays is interrelated to risk taking behavior and an increase in crash potential.

Signal timing, specifically all red and yellow clearance intervals may contribute to angled crashes. Increasing clearance intervals may improve safety at signalized intersections where the existing yellow and all red change intervals do not allow drivers adequate time to react to the reassignment of right-of-way or clear the intersection before opposing traffic enters. Other more extreme intersection improvement strategies may include roundabouts, which eliminate angled crashes altogether. Although this type of strategy is unlikely in a downtown setting where right-of-way is limited. Improvement strategies will be discussed in later sections of the report.

Planned Improvements

Improvements generated from this corridor study that have/will be implemented in 2014 and 2015 include left-turn phasing, signal timing and turn lane improvements. These improvements have the potential to reduce angled crashes and improve operations indirectly reducing rear-end crashes. Therefore, crash patterns should be monitored to determine if the improvements in fact reduce the crash rate at the study intersections.

EMERGENCY VEHICLE CONSIDERATIONS

The presence of trains on the Prosper and KO lines in downtown Moorhead creates a barrier for emergency responders. While this is true for law enforcement and EMTs/paramedics, this is a particular problem for firefighters. The fire station is located north of the Prosper Line, northwest of the 11th Street and 1st Avenue intersection (Refer to Figure 20). According to Fire Chief Rich Duysen this fire station received 2,600 calls in 2013, 2/3 of which were medical assistance.

Figure 20 - Proximity of Fire Station to Prosper Subdivision Line

In late April, the Moorhead Fire Department began noting every time a fire truck was delayed by a train. Between April 23, 2014 and September 1, 2014 the Fire department had experienced nearly nine calls per month where the emergency response time was delayed due to train activity. This included ten calls for medical assistance and three fires over the four month span.

The national standard for emergency response is five minutes. The size of a fire is thought to double every 60 seconds (*Firetactics, July 4, 2007)*. When a heart stops, brain damage can occur within four to six minutes (American Heart Association, 2014). These statistics underscore the importance of timely, unimpeded response routes for emergency vehicles. These statistics become particularly alarming considering the average train delay on the Prosper and KO lines are 5.9 and 3.9 minutes respectively and occur 67 and 59 times a day. It can be a matter of life or death and when a train is present on the Prosper or KO lines impeding the movement of emergency responders.

MULTIMODAL

In urban areas, walking and biking is an important component of the transportation system. Enhancing the ability of travelers to walk or bike involves not only providing the infrastructure but also linking urban design, streetscapes and land use to encourage walking and biking. Designing roadways to accommodate all types of users is commonly termed “Complete Streets.” This type of roadway design approach offers many benefits.

- Streets designed with sidewalks, raised medians, traffic-calming measures and treatments for travelers with disabilities improves pedestrian safety. Research has shown that sidewalks alone reduce vehicle-pedestrian crashes by 88%.
- Multiple studies have found a direct correlation between the availability of walking and biking options and obesity rates. The Centers for Disease Control and Prevention recently

named adoption of complete streets policies as a recommended strategy to prevent obesity.
- Complete streets offer inexpensive transportation alternatives to roadways users. A recent study found that most families spend far more on transportation than on food.
- A recent study found that people who live in walkable communities are more likely to be socially engaged and trusting than residents living in less walkable communities.

Transit is a major component to complete streets as it provides a transportation alternative for pedestrians and bicyclists travelling long distances. Increased transit usage reduces the number of single-occupancy vehicles on the system, decreasing overall congestion. Transit also provides transportation to those who are physically or economically unable to travel by personal automobile, such as children, the elderly, individuals with disabilities and low-income families.

A full downtown multimodal plan will be developed as part of this project once the optimal grade separation location has been identified. The new grade separation will include pedestrian and bicycle facilities. The multimodal plan will ensure that that these new facilities integrate harmoniously with the surrounding pedestrian and bicycle system and mitigate existing deficiencies in downtown Moorhead so that the new facilities can be easily accessed.

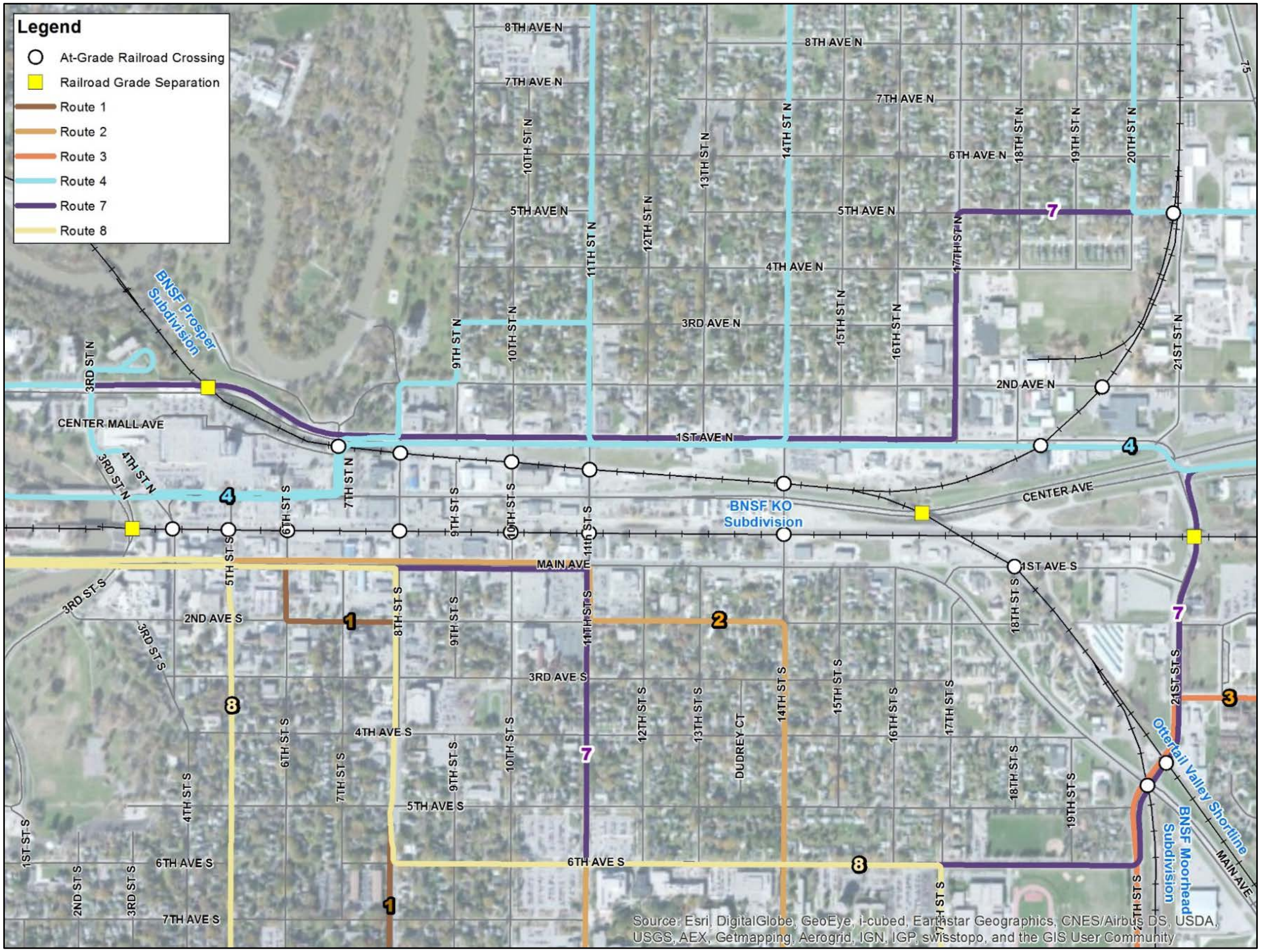
Transit Network

MATBUS has made a series of major route changes and modifications to its operations in Downtown Moorhead since 2007. These changes have served to reduce as many at grade conflicts made by MATBUS routes as possible. In doing so, MATBUS has managed to improve delays once experienced due to train events. However, MATBUS has also managed to create large pockets of downtown which no longer receive the same level of service as in the past. Portions of Main Avenue, Center Avenue, and First Avenue now received far less transit service than in the past, serving to access to and from major downtown business and retail destinations (including areas of low income and minority households). Even with modifications made by MATBUS, operations in downtown are negatively impacted by the lack of a grade separated crossing for automobiles.

Of the seven transit routes in Moorhead, only one (Route 4) crosses the KO or Prosper Subdivisions between the Red River and 21st Street. Route 4 crosses the Prosper Subdivision on 7th Street. The existing transit network in downtown Moorhead can be seen in Figure 21.

For five (5) days between May 9 and May 13, 2011 MATBUS operators recorded every time they were delayed by trains. Results from this study indicate that only 5.6% of the time, Route 4 is impeded by trains. However, when they are impeded, the average delay is 3.6 minutes on average with a maximum delay of 10 minutes.

Figure 21 - Moorhead Transit Network



Bicycle Network

Facilities: There are currently few bicycle facilities in downtown Moorhead, with no north-south bicycle facilities between the Red River and 21st Street. The Moorhead City Code states that bicyclists cannot use sidewalks downtown; this is common practice since riding on busy streets is typically undesirable for novice bicyclists (See Figure 28).

Figure 22 - Bicyclists Using the Sidewalk on 1st Avenue North

Second (2nd) Avenue North is signed as a shared roadway for east-west bicyclists. There are also are east-west bicycle lanes south of downtown along 7th Avenue South, providing access the Minnesota State University – Moorhead (MSUM) campus, but there is no connectivity to these facilities from downtown.

The Red River Greenway includes shared-use paths along the Red River, with linkages to similar facilities in Fargo, however the closest bicycle facility connection to these shared-use paths is from 2nd Avenue North or bike lanes along 7th Avenue South.

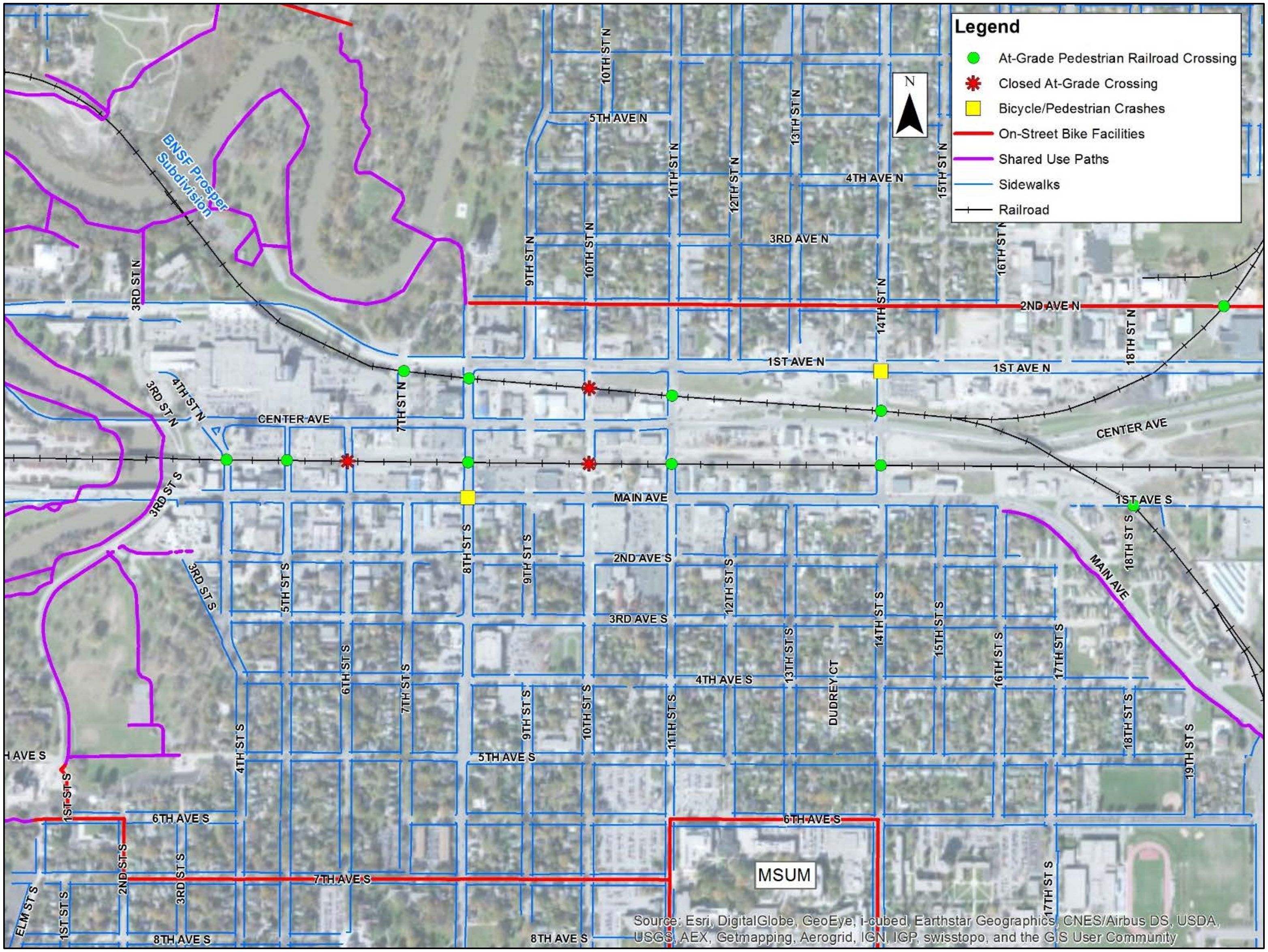
Past Proposed Improvements: Bicycle lanes are located around the MSUM campus, including along 11th and 14th Streets. A linkage between the MSUM bicycle facilities and downtown along 11th Street is listed as a short-term improvement in the *Fargo-Moorhead Bicycle and Pedestrian Plan* (2011). The type of facility was not identified in the report.

Bicycle facility recommendations were made in the *Trunk Highway 10/75/Center Avenue Corridor Studies* (2013). Relevant recommendations from this study are illustrated in Table 5:

Table 6 - Recommended Bicycle Facilities From TH 10/75/Center Avenue Corridor Studies

Roadway	Termini	Proposed Facility
Center Avenue	Red River to 4th Street	Bicycle Lane
4th Street	Center Avenue to 2nd Avenue South	Widen sidewalk to a shared-use path or implement shared lanes
2nd Avenue South	4th Street to 11th Street	Widen sidewalk to a shared-use path

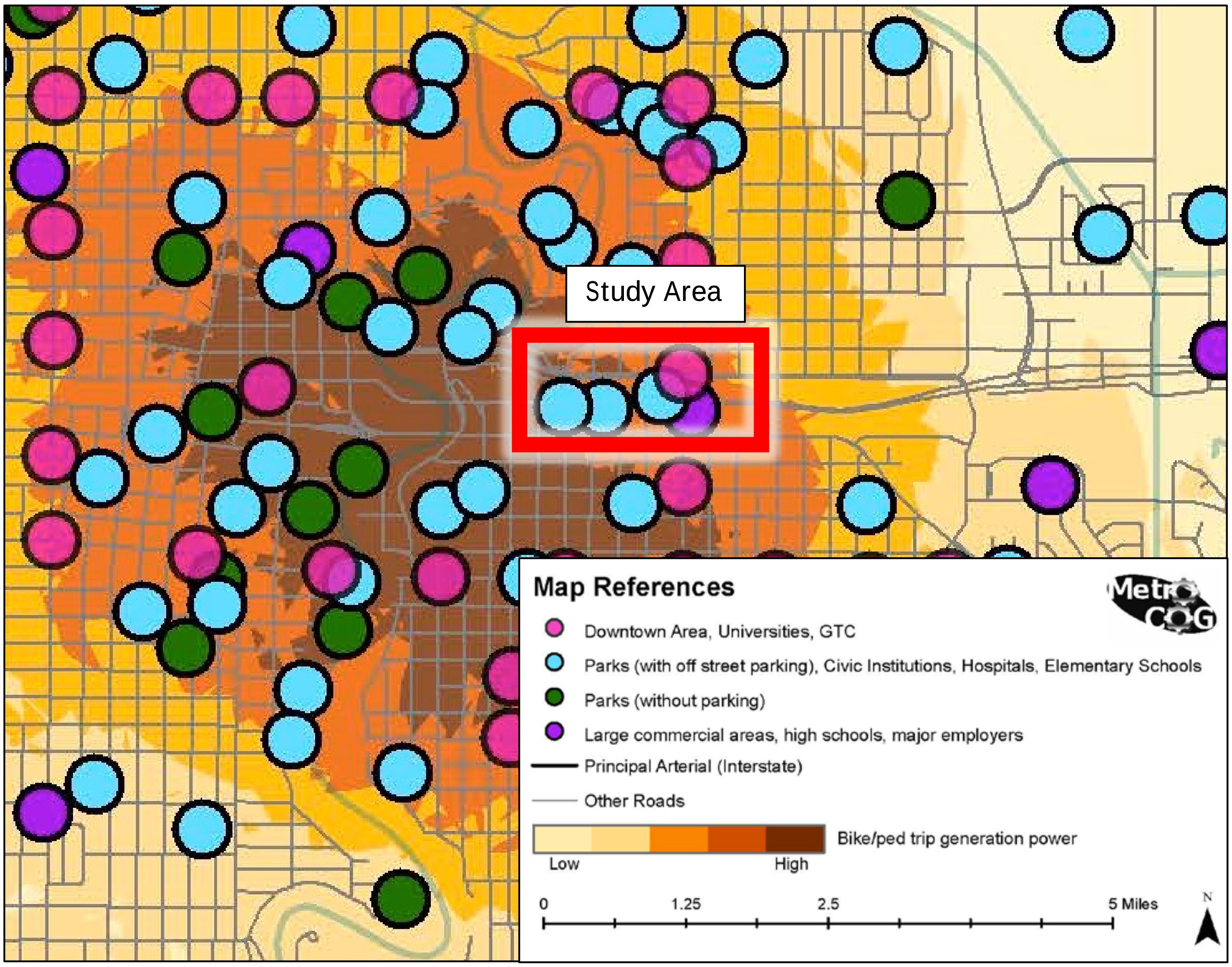
Figure 23 - Existing Bicycle Facilities



Barriers: When bicyclists do ride through downtown on the roadway, they face the same train delays as motorists, however the railroad crossing surface creates far more challenges for bicyclists. The worn and uneven railroad crossing surfaces increase the potential for a fall or a blown tire. This usually requires bicyclists to slow down, potentially interfering with motorist expectancy.

Generators: Downtown Moorhead is predominantly void of bicycle facilities. With downtown acting as the heart of the city, this creates a major connectivity gap for the entire city and connection to Fargo. This also stymies bicycle access to the vast number of generators in downtown Moorhead (refer to Figure 24).

Figure 24 - Pedestrian and Bicycle Generators

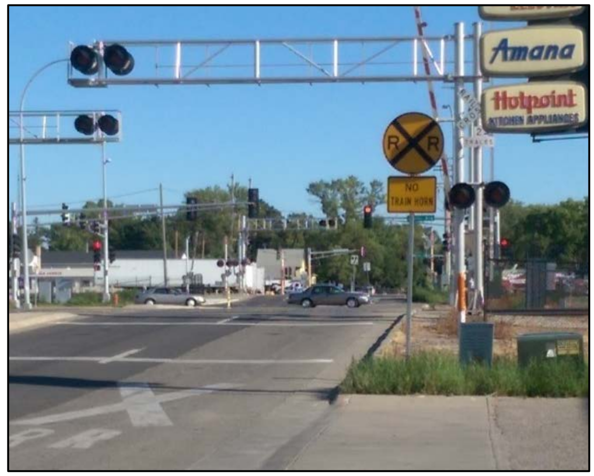


Source: FM Metro COG, *2011 Fargo-Moorhead Metropolitan Bicycle and Pedestrian Plan*, 2011

Pedestrian Network

Pedestrian Facilities: Unlike the bicycle network, downtown Moorhead has a very high degree of pedestrian connectivity. This includes sidewalks on both sides of the road along nearly every roadway in the study area. The only exceptions include the east side of both 11th Street and 14th Street between Main Avenue and 1st Avenue North. These areas are notable because they cross both the KO and Prosper lines.

Figure 25 - Absence of Sidewalks along East Side of 14th Street



Barriers: The railroad acts as a major barrier for pedestrian travel. Between the Red River and 14th Street, there are nine pedestrian at-grade crossings. Pedestrian crossings are present at both the KO and Prosper Subdivisions along 8th Street, 11th Street and 14th Street. Other downtown crossings are located on 4th and 5th Streets at the KO Subdivision and on 7th Street at the Prosper Subdivision. While the rail delays are frustrating, the greatest barriers are located where local roadways are closed on 6th and 10th Streets as part of the downtown quiet zone implementation. This creates long circuitous routes for pedestrians.

Figure 26 - Example of Pedestrian Deficiencies along 11th Street

Pedestrian Comfort: A person's decision to walk is influenced by many factors, including distance, perceived safety and comfort, convenience and visual interest of the route. When sidewalks abut the roadway, pedestrians feel exposed and vulnerable when walking directly adjacent to the travel lane. Vehicle noise, exhaust and the sensation of passing vehicles reduce pedestrian comfort. Factors that improve pedestrian comfort include a separation from moving traffic and a reduction in speed.

Many sidewalks along the corridor do not have a buffer zone. While wide grass buffers are desirable for pedestrian comfort and aesthetic reasons, they are likely unrealistic at many locations throughout the study area due to right-of-way limitations. More like, a narrow buffer of stamped concrete or street furniture (lights, trash receptacles, signs, trees, etc.) can be used to offer a buffer for pedestrians.

Accessibility: The sidewalks along the corridor are not compliant with multiple Americans with Disabilities Act (ADA) standards. First, many of the existing curb ramps are not compliant with current detectable warning panel and side slope requirements. Second, a large number of driveways within the study area have deficient side slopes at driveways (2 percent maximum cross-slope). Steep grades at driveways potentially draw pedestrians in wheelchairs into the street.

Pedestrian and Bicycle Crashes

Safety is critical when developing an appealing pedestrian and bicycle network. According to national studies, pedestrians represent a disproportionate percentage of road-related fatalities, and thus, special focus should be given to addressing these safety concerns. Bicycle and pedestrian crash data for 2009-2013 was obtained from MnDOT. Only two crashes involving a vehicle and a pedestrian or bicyclist were reported in the study period. One crash at 8th Street and Main Avenue involved a vehicle and a pedestrian and one crash at 14th Street and 1st Avenue North involved a vehicle and a bicyclist. No clear cause was found for the crash at the 8th Street and Main Avenue. The bicycle crash at 14th Street and 1st Avenue occurred at a location void of bicycle facilities.

Figure 27 - Bicyclist Riding Around Gates

Planned Improvements

The downtown improvement project referenced in the Traffic Delay Operations and Safety sections of the report, will also include curb ramp, sideslope and pedestrian buffer improvements at many, but not all, study intersections to improve accessibility.

GRADE SEPARATION ALTERNATIVE ANALYSIS

Analysis was performed to determine the traffic impacts that a new railroad grade separation at 8th Street, 11th Street or 14th Street. This analysis included the following:

- Traffic pattern shifts
- Reduction to network-wide train-related delays
- Reduction to network-wide vehicle-train crash exposure

This analysis was conducted solely on preexisting grade separation alternatives. Detailed alternative development, refinement and evaluation will be conducted once a purpose and need statement has been crafted and adopted.

Traffic Modeling

Traffic pattern shifts associated with the three grade separation routes were determined using the Fargo-Moorhead regional travel demand model (TDM). To perform analyses using the travel demand model, travel time penalties were added to all roadway links with at-grade railroad crossings in the study area. This was done to model the impact that daily train delays have on route-choice decision making in downtown Moorhead.

The FM TDM generates traffic projections and volume/capacity ratios by aggregating AM peak period, PM peak period and off-peak periods and extrapolating this data to represent the entire day. In a similar fashion, travel time penalties were added to roadway links with at-grade railroad crossings based on the amount of train activity occurring during these same periods. The assigned travel time penalties are average delays that are experienced throughout each of the analyzed time periods.

Below is an example of how travel time penalties were calculated for the at-grade crossings of the KO subdivision during the AM peak period:

- During the AM peak period, trains are present for approximately 15.3% of the time
- The average gate closure time during each train event at the KO subdivision is 3.9 minutes. It is assumed that vehicles arrive at the crossing in a linear fashion, and the first vehicles arriving during a train event will experience the entire 3.9 minute delay, where the last vehicle will experience a 0 minute delay. Therefore, the *average* train delay experienced by arriving vehicles is 3.9/2 = 1.95 minutes
- The assigned penalty on roadway links with at-grade crossings at KO subdivision crossings is: 0.153 x 1.95 = 0.30 minutes

The above methodology was used to assign travel time penalties to all study crossings of both the KO and Prosper Subdivisions. Penalties were calculated for both existing and future 2040 conditions to account for the forecasted increase in train induced delays.

Travel time penalties were also added to at grade crossings with the BNSF Moorhead Subdivision and the Ottertail Valley Shortline based on FRA daily train data as these crossings also influence driver behavior in downtown Moorhead. Gate closure times for these crossings were based on the train speed limits, assuming a train is 1.5 miles long (based on a thorough review of train and car lengths).

Traffic Pattern Shifts

The crossing ADT at each of the study crossings for each alternative under 2014 and 2040 conditions can be seen in Figure 30 and Figure 31, respectively.

During the modelling process, it was clear that the amount of traffic drawn to the 11th and 14th Street crossings were limited by the one-way roadway configurations south of the study area. Currently 11th Street is a southbound one way from 2nd to 12th Avenues South and 14th Street is a northbound one-way from 12th Avenue South to Main Avenue (refer to Figure 28). This resulted in circuitous routes and increased travel times. This limited the potential benefit of these alternative routes because the TDM is designed to assign traffic to the fastest route. It is recommended that elimination of the one-ways be studied to fully understand the potential benefits provided by grade separation at 11th and 14th Streets.

Figure 28 – Funnel Effect Caused by Existing One-Way Roadway Configurations with Grade Separation at 11th Street

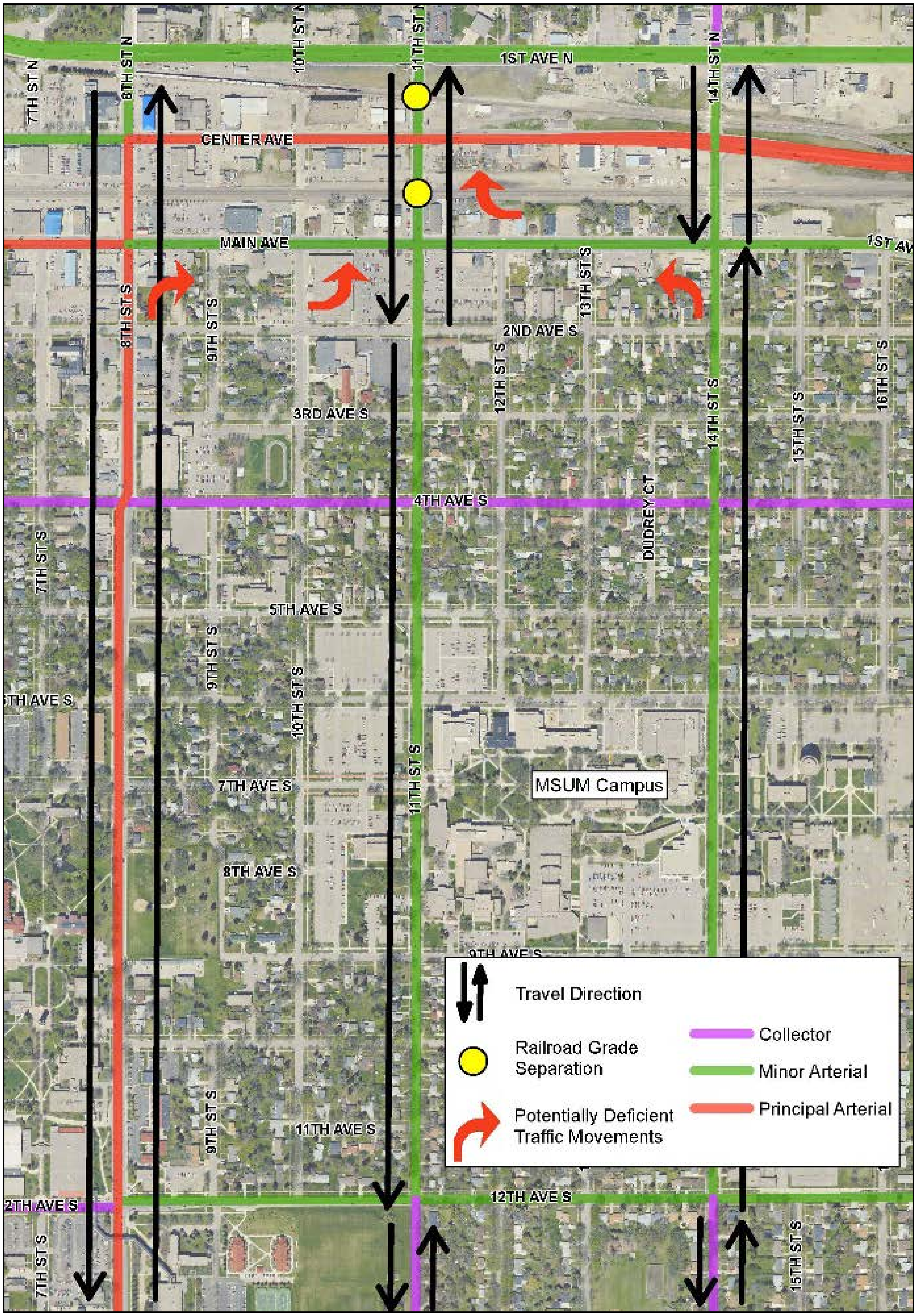


Figure 29 – Funnel Effect Caused by Existing One-Way Roadway Configurations with Grade Separation at 14th Street

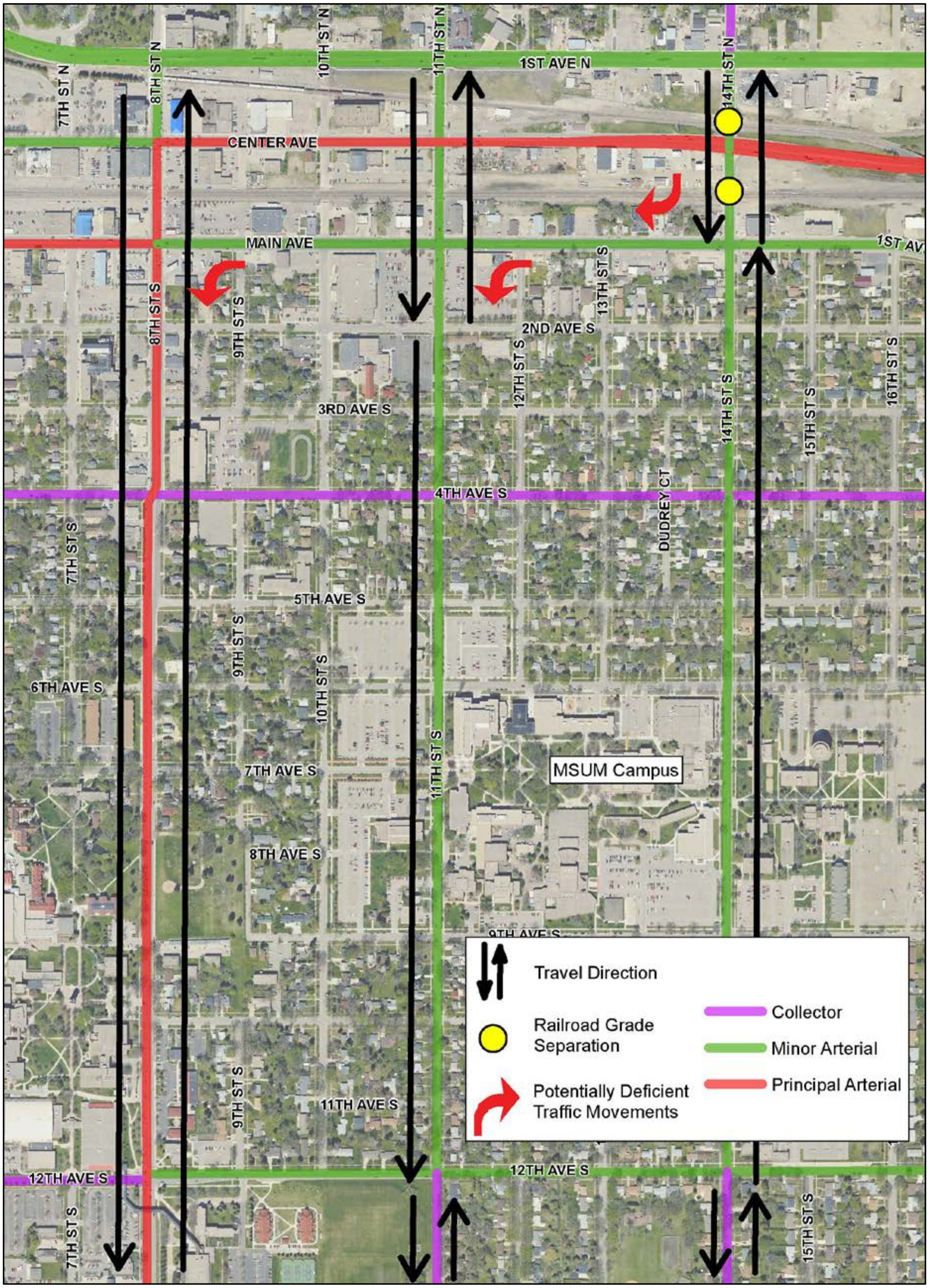


Figure 30 - 2014 Crossing ADT

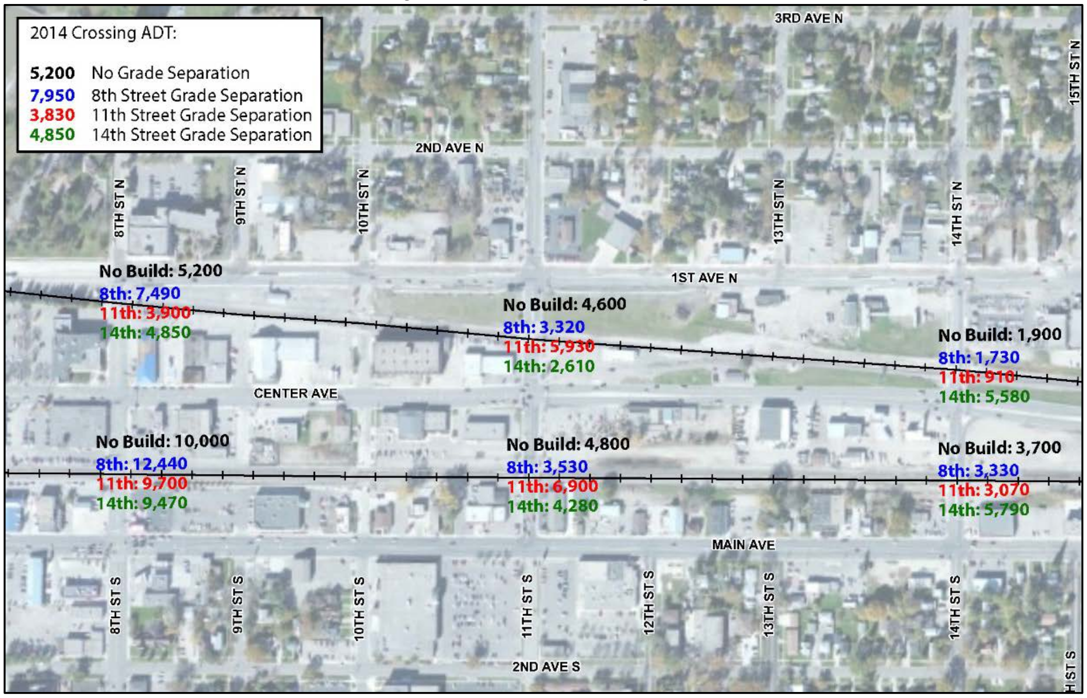
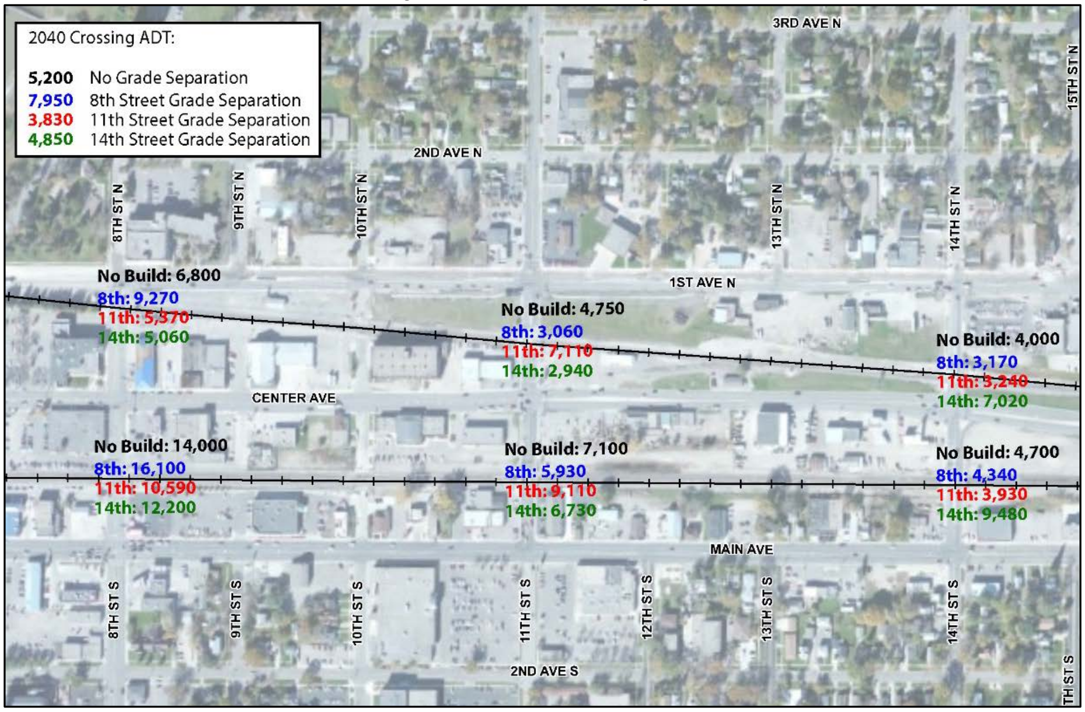


Figure 31 - 2040 Crossing ADT



Train-Related Delay Reduction

The overall train-related delay reduction in downtown Moorhead as a result of a new grade separation was calculated for each of the alternatives. This was done for both 2014 and 2040 traffic conditions. Overall delay reduction was calculated using the daily train delay model discussed in the "*Train Activity*" section of this report.

Results from this analysis can be seen in Table 6.

The delays illustrated in Table 6 only illustrate train delay. This does not account for the circuitous routes required to access a particular grade separation. This is important to note because of the presence of one-way traffic flow on 11th and 14th Streets as noted above.

Under both 2014 and 2040 traffic conditions, all grade separation alternatives would result in area-wide time savings (see Table 6). The 8th Street grade separation alternative would result in the most delay reduction, followed by the 11th Street alternative, with the 14th Street alternative having the least delay reduction.

Table 7 - 2014 and 2040 Train Induced Delay

Crossing	2014 Train Related Delay (Vehicle-Hours)						
	Grade Separation Alternative						
	No Grade Separation	Grade Separation at 8th Street	Difference Compared to No Grade Separation	Grade Separation at 11th Street	Difference Compared to No Grade Separation	Grade Separation at 14th Street	Difference Compared to No Grade Separation
8th/KO	53	0	-53	51	-2	50	-3
8th/Prosper	46	0	-46	35	-11	43	-3
11th/KO	25	19	-6	0	-25	23	-2
11th/Propser	41	30	-11	0	-41	23	-18
14th/KO	20	18	-2	16	-4	0	-20
14th Prosper	17	15	-2	8	-9	0	-17
Overall Change in Train Related Delay			**-120**		**-92**		**-63**

Crossing	2040 Train Related Delay (Vehicle-Hours)						
	Grade Separation Alternative						
	No Grade Separation	Grade Separation at 8th Street	Difference Compared to No Grade Separation	Grade Separation at 11th Street	Difference Compared to No Grade Separation	Grade Separation at 14th Street	Difference Compared to No Grade Separation
8th/KO	130	0	-130	98	-32	113	-17
8th/Prosper	108	0	-108	85	-23	80	-28
11th/KO	66	55	-11	0	-66	62	-4
11th/Propser	76	49	-27	0	-76	47	-29
14th/KO	44	40	-4	36	-8	0	-44
14th Prosper	64	50	-14	51	-13	0	-64
Overall Change in Train Related Delay			**-294**		**-218**		**-186**

Exposure Reduction

The network-wide exposure reduction as a result of each of the grade separation alternatives was calculated. This analysis considered all crossings of the KO and Prosper Subdivisions in downtown Moorhead (including crossings at 4th Street and 5th Street).

Table 8 - Exposure Reduction from Grade Separation at Study Intersections

Alternative	2014	Exposure Change	2040	Exposure Change
No Grade Separation	1,850,000	-	4,630,000	-
Grade Separation at 8th Street	810,000	-1,040,000	2,170,000	-2,460,000
Grade Separation at 11th Street	1,210,000	-640,000	2,830,000	-1,800,000
Grade Separation at 14th Street	1,360,000	-490,000	3,290,000	-1,340,000

The 8th Street grade separation alternative is forecasted to result in the largest exposure reduction, followed by the 11th Street alternative, with the 14th alternative having the least exposure reduction. Again, these values are influenced by the one-way configurations of 11th and 14th Streets to the south of the study area.

Preliminary Alternative Comparison

The 8th, 11th and 14th Street alternatives were ranked using the same criteria that were used in the *Downtown Moorhead Railroad Grade Separation Feasibility Study* (2008). Some criteria used in the previous study have not yet been evaluated as part of this existing and future conditions report, but will be evaluated in subsequent stages of this current study.

The following criteria were evaluated as part of the previous study and re-evaluated in this study:

- Safety
- Emergency Vehicle Access
- Mobility and Connectivity
- Railroad Issues

The criteria that have not been re-evaluated at this stage of this study are:

- Property Impacts
- Constructability and Design
- Environmental Impacts
- Cost

Results from the alternatives comparison analysis can be seen in Table 8 and Table 9. Note that any criteria that were not re-evaluated in this current study maintain the same results that were found in the previous study. Early analysis indicates this data is still valid. However, this information will be reaffirmed or revised as the study proceeds forward.

When all criteria are considered, the 11th Street grade separation alternative scores highest of the three alternatives, followed by the 14th Street alternative, with the 8th Street alternative scoring the lowest. These results are consistent with those from the *Downtown Moorhead Railroad Grade Separation Feasibility Study*.

Figure 32 – Illustration of Challenges with 8th Street Alternative

In summary, 8th Street scored very poorly in constructability and design, property impacts and railroad issues which limit the feasibility to build this alternative. Cursory analysis indicates that this alternative does benefit the greatest volume of vehicles although this route has no connectivity to the north. It is anticipated that once two-way traffic conversion is considered on 11th and 14th Streets south of the study area, these traffic benefits will be reduced. As noted previously, the one-way configurations on 11th and 14th Streets creates circuitous routes and increases travel times for this movement and results and reduced modelled traffic forecasts on these routes.

14th Street is the furthest from the heart of the City where traffic demand is greatest and has limited connected to the north. These two factors combine to result in lowest benefits in terms overall reduction to motorist delay and global crossing exposure reduction. Additionally, construction of this alternative would be challenging considering the close proximity of Center Avenue and the Prosper Line on 14th Street. Finally this alternative would incur challenges constructing temporary shoofly tracks without impacting train operations due to the intersection of the KO Line and Moorhead Subdivision Line/Otter Tail Valley Railroad Spur just east of 14th Street.

Cursory analysis indicates that 11th Street is the optimal balance of constructability and traffic operational benefits. This alternative also has the greatest connectivity to the north, is closest to the fire station and has the fewest property and railroad impacts of the three alternatives. This alternative scored 93% and 37% higher than the 8th Street and 14th Street alternatives respectively.

Figure 33 – Illustration of Challenges with 14th Street Alternative

A one-way conversion analysis of 11th and 14th Street will be studied later in the project to fully understand potential benefits offered by a grade separation at these locations. Furthermore, this study will serve to identify the improvement needs and challenges faced from this conversion as this improvement will have widespread impacts to neighboring property owners, including MSUM.

Table 9 - Alternatives Comparison (1 of 2)

Screening Criteria	Screening Criteria Description	8th Street Crossing		11th Street Crossing		14th Street Crossing	
Property Impacts		**Sub-Category Rating**		**Sub-Category Rating**		**Sub-Category Rating**	
Potential Business Relocation and Residential Impacts	The number and type of properties impacted by the construction of the grade separation	1	Potential impacts to 14 commercial properties	3	Potential impacts to 11 commercial properties	2	Potential impacts to 13 commercial properties
Category Ranking		**1**		**3**		**2**	
Safety							
Crash History (2008 - Present)	Fatalities/ Injuries/ Property Damage	1	0 reported crashes	1	0 reported crashes	1	0 reported crashes
Conflict Potential	Global Crossing Exposure Reduction	5	2014: 1,040,000 2040: 2,460,000	4	2014: 640,000 2040: 1,800,000	3	2014: 490,000 2040: 1,340,000
Category Ranking		**3**		**2.5**		**2**	
Emergency Vehicle Access							
Unrestricted Access and Optimized Routes	Unrestricted access across railroad tracks and best route for emergency vehicles	3	Emergency vehicles will have unrestricted access from Main Avenue to 1st Avenue North (higher traffic volumes on 8th Street between 1st Avenue North and Main Avenue)	5	Emergency vehicles will have unrestricted access from Main Avenue to 1st Avenue North. The fire station is also in close proximity to the 11th Street Corridor	4	Emergency vehicles will have unrestricted access from Main Avenue to 1st Avenue North (Lack of north-south connectivity on 14th Avenue)
Category Ranking		**3**		**5**		**4**	
Mobility and Connectivity							
Train Delay Reduction	Daily reduction in hours of train induced delay	5	2014: 120 vehicle-hours reduced 2040: 294 vehicle-hours reduced	4	2014: 92 vehicle-hours reduced 2040: 218 vehicle-hours reduced	3	2014: 63 vehicle-hours reduced 2040: 186 vehicle-hours reduced
Network-Wide Connectivity	North-south connectivity	1	8th Street dead-ends at 2nd Avenue North	5	Full north-south connectivity for 2 miles both north and south	3	14th Street dead-ends at 15th Avenue North
Proximity to Downtown	Proximity to major generators and attractions in downtown	5	Closest to downtown core area	4	Near downtown core area	2	Furthest from downtown core area
Category Ranking		**3.5**		**4.5**		**2.5**	

Note: higher numbers are associated with greater benefits

Table 10 – *Alternative Comparison (2 of 2)*

Screening Criteria	Screening Criteria Description	8th Street Crossing		11th Street Crossing		14th Street Crossing	
Constructability and Design		**Sub-Category Rating**		**Sub-Category Rating**		**Sub-Category Rating**	
Grade Separation	Ease of grade separation construction	1	A grade separation on the Prosper Line will be difficult to construct due to close proximity with 1st Avenue North	3	Center Avenue (TH 10) will have to be lowered to match underpass or separated from 11th Street with continuous tunnel	3	A grade separation on the Prosper Line will be difficult to construct due to its close proximity to Center Avenue
Utilities	Impacts of grade separation to storm sewer, sanitary sewer and water	1	High impact to existing utilities and services to adjacent properties during construction No good location for on-site retention pond	3	Moderate impact to existing utilities and services to adjacent properties during construction Location available for on-site retention pond Potential upgrade of storm sewer back to river is longer	4	Low impact to existing utilities and services to adjacent properties during construction Location available for on-site retention pond Potential upgrade of storm sewer back to river is longest
Intersecting Streets	How are Main Avenue, Center Avenue or 1st Avenue North affected	1	Alignment of 1st Avenue North would be affected by grade separation of Prosper Line	5	Deep cut at Main Avenue and 1st Avenue North	2	Connection to Center Avenue requires longer/taller retaining walls Impacts to 11th Street during shoofly construction
Category Ranking		**1**		**4**		**3**	
Environmental Impacts							
Cultural Resources	Properties determined to be potential historically / architecturally significant	*Cultural resources, ecological impacts, socioeconomic impacts, environmental justice, hazardous materials, noise quality and air quality will all require analysis as part of an EA or an EIS*					
Cost							
ROW Costs	Preliminary land appraisal costs and acres per square feet of land needed	1	Highest	3	Lowest (Similar to 14th Street)	3	Lowest (Similar to 11th Street)
Construction, Engineering and Administration Costs	Estimated (non-detailed costs)	1	Highest	3	Lowest	2	Middle
Category Ranking		**1**		**3**		**2.5**	
Railroad Issues							
Shoo-fly Construction	Ease of shoofly construction and track alignment	1	Significant impact to six buildings, parking and 1st Avenue North	4	Potential impact to two buildings and private parking lots for KO Line	3	Shoo-flies for both lines are difficult to construct and operate due to switches/ turnouts east of 14th Street
Category Ranking		**1**		**4**		**3**	
Overall Ranking		13.5		26		19	

Note: higher numbers are associated with greater benefits

CONCLUSION

In conclusion, multiple warrants FHWA grade separation criteria is met and multiple promising alternatives exist. Figure 34 and Figure 35 illustrate which FHWA criteria is met and when at each rail line. Figure 36, Figure 37 and Figure 38 illustrate the preliminary benefits of the three alternatives studied in this report.

Figure 34 – Grade Separation Criteria Met For KO Line

*Crossing exposure is the product of the number of trains per day and Average Daily Traffic (ADT).
**Passenger train crossing exposure is the product of the number of passenger trains per day and ADT.
***Expected Accident Frequency is calculated using the U.S. DOT Accident Prediction Formula including Five-Year Accident History.

Figure 35 – Grade Separation Criteria Met For Prosper Line

Tier 1	Tier 2
I. Designated Interstate Highway System	I. Designated National Highway System
II. Full Access	II. Partial Access Control
III. Highway Speed Equals or Exceeds 70 mph	III. Highway Speed Equals or Exceeds 55mph
IV. Average Annual Daily Traffic Exceeds 100,000	IV. Average Annual Daily Traffic Exceeds 50,000
V. Train Speed Exceeds 110 mph	V. Train Speed Exceeds 100 mph
VI. 150 or More Trains per Day or 300 Million Gross Tons per Year	VI. 75 or More Trains per Day or 150 Million Gross Tons per Year
VII. Average of 75 or More Passenger Trains per Day	VII. Average of 50 or More Passenger Trains per Day
VIII. Crossing Exposure* Exceeds 1 Million	VIII. Crossing Exposure* Exceeds 500,000
IX. Passenger Train Crossing Exposure** Exceeds 800,000	IX. Passenger Train Crossing Exposure** Exceeds 400,000
X. Expected Accident Frequency*** for Active Devices with Gates Exceeds 0.5	X. Expected Accident Frequency*** for Active Devices with Gates Exceeds 0.2
XI. Vehicle Delay Exceeds 40 Vehicle Hours per Day	XI. Vehicle Delay Exceeds 30 Vehicle Hours per Day
	XII. Engineering Study Indicates Absence of Grade Separation Results in Level of Service Below Intended Design Level 10% or More of the Time

LEGEND

Meets Criteria under Future Conditions

Meets Criteria under 2014 Conditions

*Crossing exposure is the product of the number of trains per day and Average Daily Traffic (ADT).
**Passenger train crossing exposure is the product of the number of passenger trains per day and ADT.
***Expected Accident Frequency is calculated using the U.S. DOT Accident Prediction Formula including Five-Year Accident History.

Figure 36 - Traffic Impacts from 8th Street Grade Separation

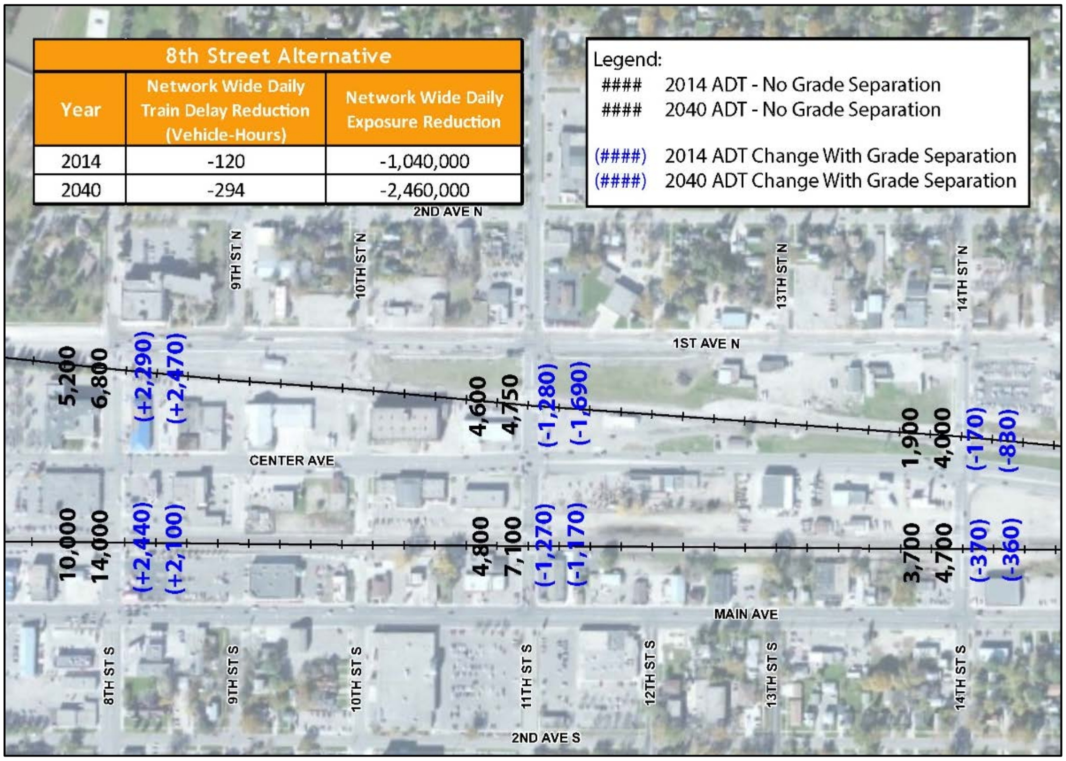


Figure 37 - Traffic Impacts from 11th Street Grade Separation

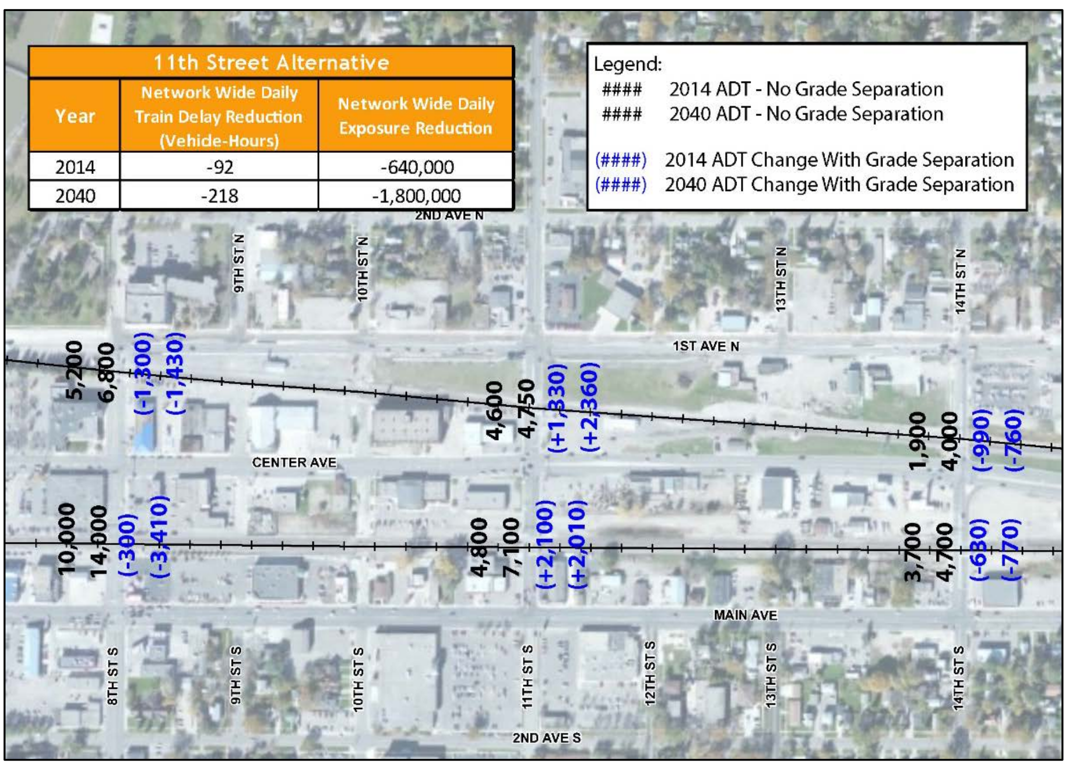
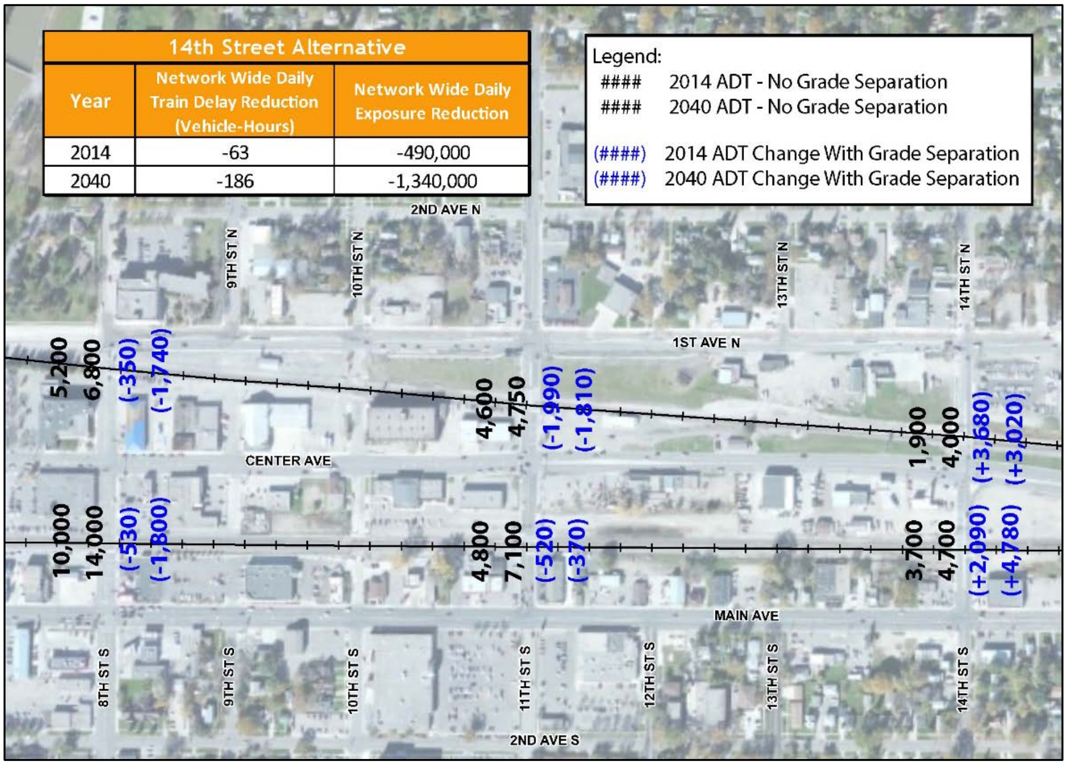


Figure 38 - Traffic Impacts from 14th Street Grade Separation



NEXT STEPS

This report is the first phase of the project, the following list is a brief summary of the next steps planned for this project:

- Purpose and Need and Environmental Review: development of the purpose and need statement, scoping, public involvement and alternatives development and analysis will all be completed to allow for a seamless transition into a NEPA documentation phase. The alternatives analysis will consider all feasible and prudent alternatives and screen the alternatives on their ability to meet the purpose and need and avoid or minimize impacts to the social, economic and natural environments. The team will develop design criteria and a methodology to screen the alternatives to ensure consistent application of the NEPA evaluation process.
- Alternative Refinement and Analysis: once alternatives have been screened through the purpose and need process, remaining alternatives will be refined through a planning level design process. This step will involve reviewing each alternative in the areas of roadway design, landowner impacts, utility impacts, costs, drainage, etc. A detailed cost benefit analysis will use this information to quantify these details into a dollar amount for comparison purposes.
- Studies to Surrounding Roadway System: the study area of the project is specific to the downtown Moorhead; however, traffic implications of a new grade separation would be felt throughout the entire city. The following two studies will be completed once alternatives are screened to ensure the remaining alternatives can be properly accommodated if a grade separation is constructed:
    - One-Way Conversion Study: A one-way conversion analysis of 11th and 14th Street will be studied later in the project to fully understand potential benefits offered by a grade separation at these locations. Furthermore, this study will serve to identify the improvement needs and challenges faced from this conversion as this improvement will have widespread impacts to neighboring property owners, including MSUM.

- Multimodal Plan: A full downtown multimodal plan will be developed as part of this project once the optimal grade separation location has been identified. The new grade separation will include pedestrian and bicycle facilities. The multimodal plan will ensure that that these new facilities integrate harmoniously with the surrounding pedestrian and bicycle system and mitigate existing deficiencies in downtown Moorhead so that the new facilities can be easily accessed.

- Funding Assessment: finally funding strategies will be investigated for potential next steps. This will include a review and evaluation of standard federal, state and local funding sources typically utilized for implementation projects, competitive grant programs based on solicitation processes, federal and state programs that focus on safety and finally public/private partnership scenarios.