

WISCONSIN DEPARTMENT OF TRANSPORTATION

**USH 41 EXPANSION -
WINNEBAGO COUNTY:
ROAD SAFETY AUDIT**



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USH 41 EXPANSION - WINNEBAGO COUNTY: ROAD SAFETY AUDIT

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*USH 41 EXPANSION – WINNEBAGO COUNTY
ROAD SAFETY AUDIT*



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1.0 INTRODUCTION

1.1 Background

USH 41 in Winnebago County is a major transportation corridor linking the Fox Valley to Milwaukee, Madison, Green Bay and Northern Wisconsin. The corridor was initially designed for rural traffic but now serves local economic development in Oshkosh, Neenah and their surrounding towns. The USH 41 corridor also provides the only high-speed route which crosses the Lake Butte des Morts/Fox River system. This creates high levels of demand at interchanges and increasing the potential for conflicts between long-distance traffic (including trucks associated with the industrial areas along the freeway), local traffic, and non-motorized traffic near the interchanges. Average annual daily traffic levels reported in 2005 ranged from 55,000 to 75,000 vehicles and are forecasted to increase to a range from 90,000 to 115,000 vehicles by 2035. Trucks are expected to compose up to 15 percent of the traffic. The project location is shown in FIGURE 1.1.

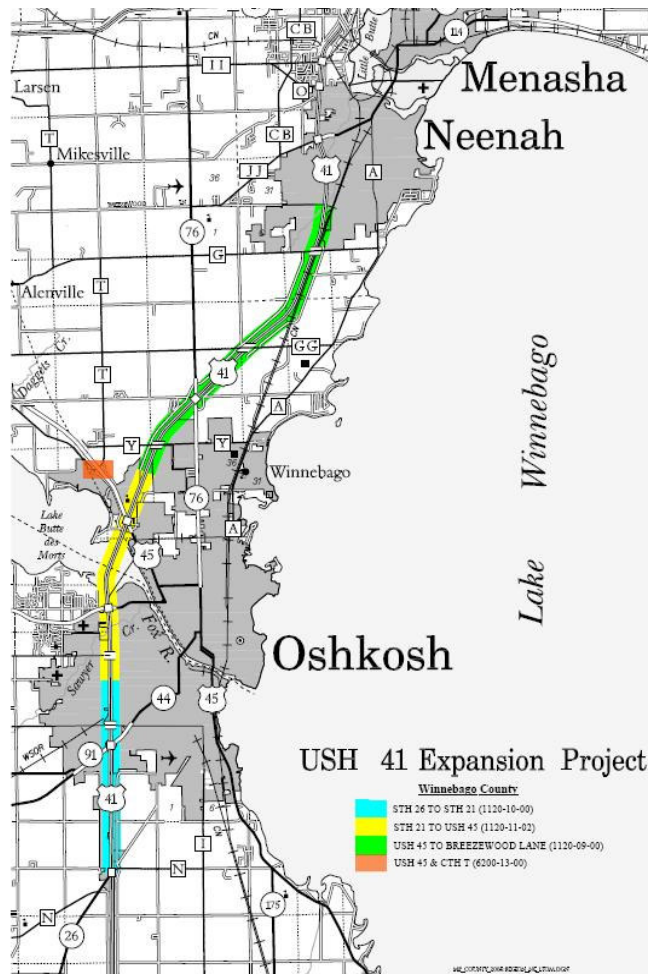


FIGURE 1.1 PROJECT LOCATION

The expansion and upgrades, described in Section 1.4 below, are currently in the preliminary design phase. The expansion and upgrades are scheduled for construction beginning in 2009 to 2014. Programmed construction costs are about \$292 million.

Opus International Consultants was retained by the Wisconsin Department of Transportation (WisDOT) to perform a road safety audit (RSA) of the proposed improvements to USH 41 from STH 26 to Breezewood Lane in Winnebago County. This report discusses the findings of the RSA.

1.2 Road Safety Audits

A RSA is a formal safety performance examination of an existing or future road or intersection by an independent RSA team. RSAs help to promote road safety by identifying safety issues at the design and implementation stages, promoting awareness of safe design practices, integrating multimodal safety concerns, and considering human factors in the design.

1.3 Reminder

The RSA team has conducted this audit to the best of its professional abilities within the time available and by referring to available information. While every attempt has been made to identify significant safety issues, the design team and the project owner are reminded that responsibility for the design, construction, and performance of the project remains with the engineers of record.

1.4 Audit Scope

The Wisconsin Department of Transportation (WisDOT) is currently planning to expand USH-41 and upgrade interchanges between STH 26 and Breezewood Lane. This staged project is currently at various design stages ranging from 60 percent complete on the north end and about 50 percent complete towards the south end. The following seven interchanges will be upgraded:

- Breezewood Lane
- USH 45
- STH 21
- 9th Avenue
- STH 44
- STH 26

The Lake Butte des Morts Causeway Bridge will also be upgraded to meet current standards. Included within the expansion are roundabout intersections at Breezewood Lane, STH 76, USH 45, STH 21 and 9th Avenue. Roundabouts are also proposed for the frontage roads at CTH E.

1.5 Audit Team and Process

The audit team and the project material on which the audit was based are described in *Section 1*.

Site visits were conducted in June 2007 to gain an understanding of the existing conditions and surroundings, as well as to identify existing safety concerns. Notes of the site visits are included in *Section 2*.

A RSA framework was applied in both the audit analysis and presentation of findings. The expected frequency and severity of crashes caused by each safety issue have been identified and rated according to the categories shown in TABLES 1.1 and 1.2. These two risk elements were then combined to obtain a risk assessment on the basis of the matrix shown in TABLE 1.3. Consequently, each safety issue is assessed on the basis of a ranking between F (highest risk and highest priority) and A (lowest risk and lowest priority).

For each safety issue identified, possible mitigation measures have been suggested. The suggestions have focused on measures that can be cost-effectively implemented at the current design stage, and consequently include few geometric changes.

TABLE 1.1 FREQUENCY RATING

ESTIMATED		EXPECTED CRASH FREQUENCY (per audit item)	FREQUENCY RATING
EXPOSURE	PROBABILITY		
high	high	10 or more crashes per year	<i>Frequent</i>
medium	high		
high	medium	1 to 9 crashes per year	<i>Occasional</i>
medium	medium		
low	high	less than 1 crash per year, but more than 1 crash every 5 years	<i>Infrequent</i>
high	low		
low	medium	less than 1 crash every 5 years	<i>Rare</i>
medium	low		
low	low		

TABLE 1.2 SEVERITY RATING

TYPICAL CRASHES EXPECTED (per audit item)	EXPECTED CRASH SEVERITY	SEVERITY RATING
crashes involving high speeds or heavy vehicles, pedestrians, or bicycles	probable fatality or incapacitating injury	<i>Extreme</i>
crashes involving medium to high speed; head-on, crossing, or off-road crashes	moderate to severe injury	<i>High</i>
crashes involving medium to low speeds; left-turn and right-turn crashes	minor to moderate injury	<i>Moderate</i>
crashes involving low to medium speeds; rear-end or sideswipe crashes	property damage only or minor injury	<i>Low</i>

TABLE 1.3 CRASH RISK ASSESSMENT

FREQUENCY RATING	SEVERITY RATING			
	<i>Low</i>	<i>Moderate</i>	<i>High</i>	<i>Extreme</i>
<i>Frequent</i>	C	D	E	F
<i>Occasional</i>	B	C	D	E
<i>Infrequent</i>	A	B	C	D
<i>Rare</i>	A	A	B	C

Crash Risk Ratings:

A: minimal risk level

D: significant risk level

B: low risk level

E: high risk level

C: moderate risk level

F: extreme risk level



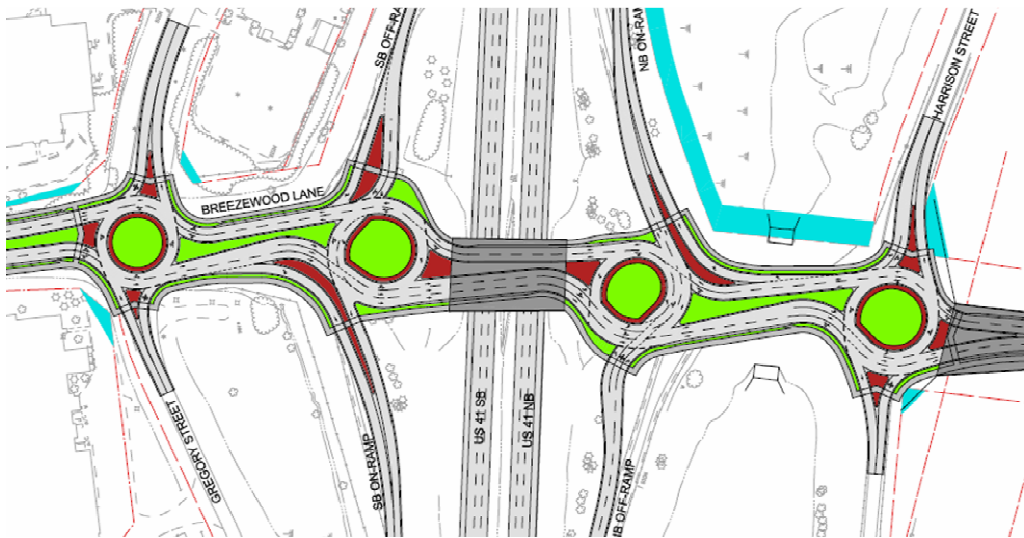
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2.0 AUDIT FINDINGS

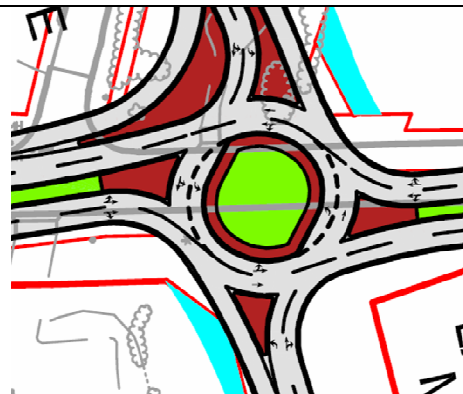
2.1 Safety Benefits of the New Design

Improvements to USH 41 are motivated by the goal of reducing congestion and traffic crashes between long-distance/industrial traffic and local/pedestrian traffic in Winnebago County. In addition, the freeway and many features of its design already incorporate many features that are expected to substantially improve traffic safety in the area:

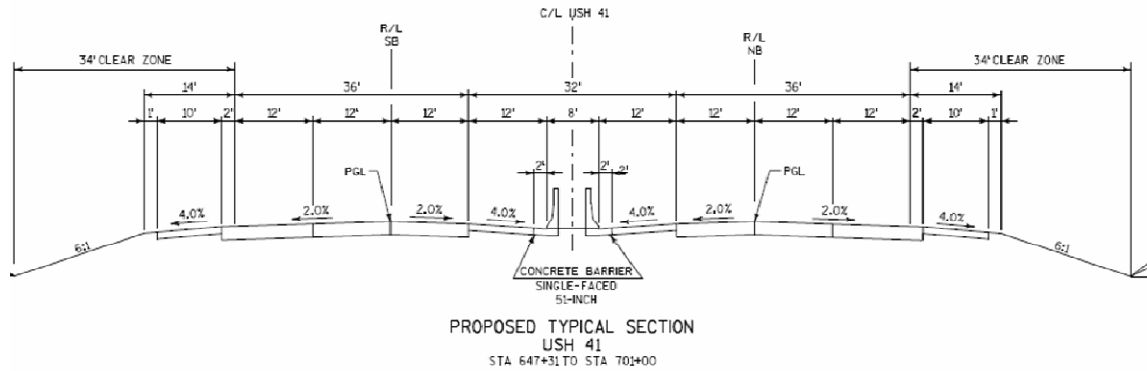
Use of innovative interchange design: The design includes sixteen roundabouts at interchanges and intersections along USH 41, all of which are planned to improve both safety and operations. Although some safety issues associated with roundabout configurations have been identified, the use of the roundabouts should reduce both the potential for high-speed conflicts and delays at associated at-grade intersections. Roundabouts result in a moderate reduction in crash frequency, especially for left-turn and angle crashes, and a high reduction of the severity of all crashes.



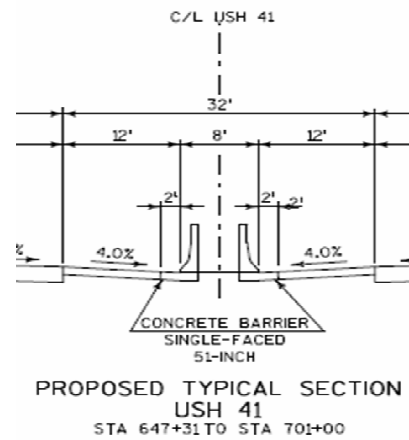
Proposed pavement markings: The multi-lane roundabouts will utilize a spiral striping pattern. These types of markings have been found to be extremely effective in guiding drivers through multi-lane roundabout.



Median barriers: USH 41 in Winnebago County was identified¹ as having a high number of median crossover crashes. The implementation of continuous concrete median barriers on the corridor should significantly reduce the number of median crossover crashes and their severity throughout the corridor. Specifically, the median barrier will help to prevent head-on crashes associated with median crossover crashes.



Generous geometry and a roadside clear zone on USH 41: The USH 41 corridor includes a wider twelve foot shoulder. This is wider than the existing six foot shoulder. These design elements can be expected to contribute to safety by a moderate reduction in crash frequency and a high reduction in crash severity due to the recovery room/refuge.

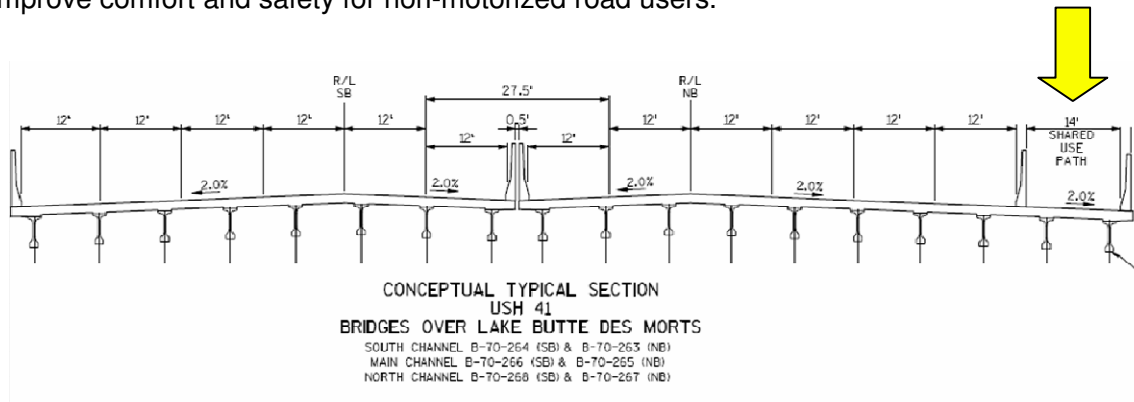


¹ Noyce, D.A., R.J. McKendry; *Analysis of Median Crossover Crashes in Wisconsin*; Traffic Operations and Safety Laboratory, University of Wisconsin-Madison, 2005.

Ramp upgrades: Auxiliary lanes and longer acceleration/deceleration lanes at ramp entrances and exits. These improvements should help to reduce rear-end, weaving, and truck crashes near the ramps.

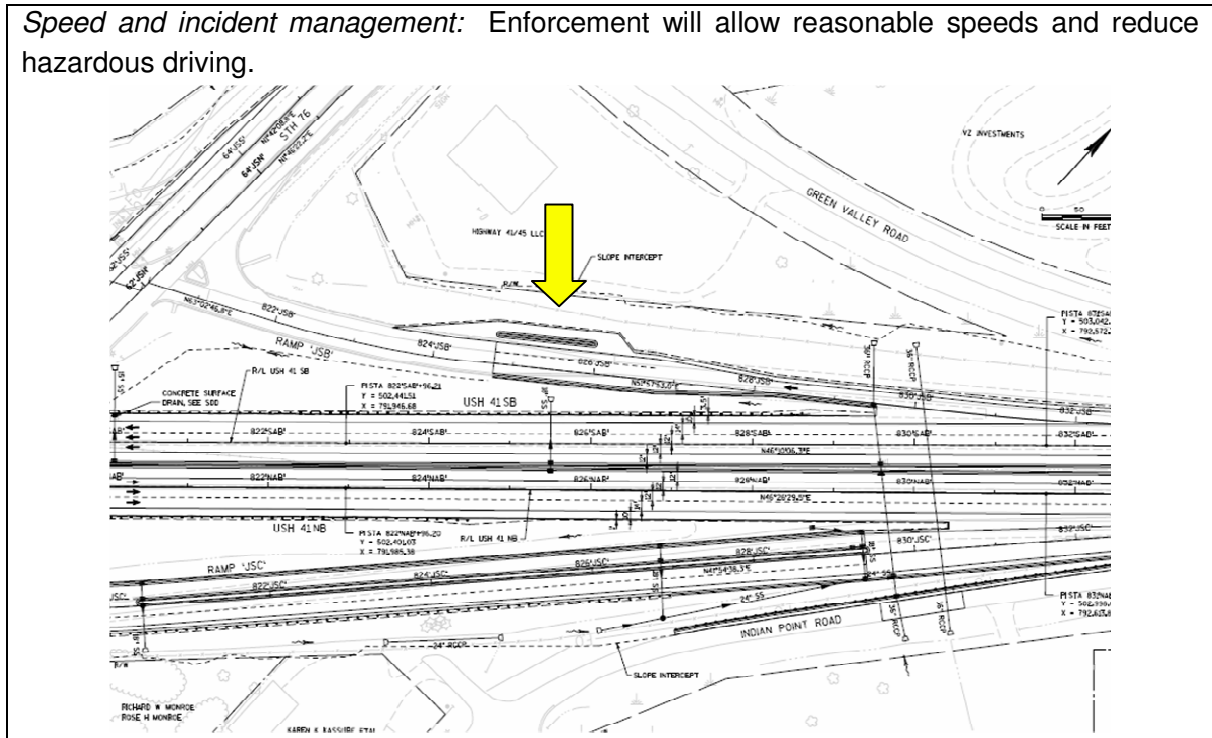


Non-motorized facilities: The planned improvements will provide a more complete and continuous network of sidewalks near all roundabout interchanges. Crosswalks and bicycle facilities will be provided at each of the intersections. A shared use path will also be provided on the USH 41 Bridge over the Lake Butte des Morts. These improvements are expected to improve comfort and safety for non-motorized road users.



Continuity with North section: There may be a reduction in crash frequency, at the transition, due to continuity. Continuity provides drivers with familiarity of the roadway throughout a transition.

Speed and incident management: Enforcement will allow reasonable speeds and reduce hazardous driving.



2.2 Summary of Audit Findings

Six main safety issues were identified, all of which have a low to significant risk rating. The six main issues and suggested alternatives are described in detail in Section 5 (*Issues and Suggestions*), and are summarized in TABLE 2.1.

TABLE 2.1 SUMMARY OF RSA SAFETY ISSUES AND SUGGESTIONS

SAFETY ISSUE (Number and Description)	Risk Rating	Suggestions
1. Roundabout design and operations		
1a High speed right-turn conflicts with pedestrians and bicyclists.	D	<ul style="list-style-type: none"> Offset pedestrian crossings Active warning devices
1b Limited vertical sight distance on roundabout approach.	C	<ul style="list-style-type: none"> Flatten the vertical curve Lighting on the approaches Overhead lane use signs Extend the splitter island Curve warning/delineation
1c Limited horizontal sight distance on frontage roads.		

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SAFETY ISSUE (Number and Description)		Risk Rating	Suggestions
1d	Left-turn pavement arrows		<ul style="list-style-type: none"> ▪ Proposed “Fish-hook” arrows for signs and markings
1e	Non-circular apron	B	<ul style="list-style-type: none"> ▪ Implement circular aprons
2. Roadside safety			
2a	Utility poles close to USH 41 and frontage road	D	<ul style="list-style-type: none"> ▪ Relocate utility poles ▪ Provide barrier protection
2b	Close spacing between USH 41 and frontage roads	D	<ul style="list-style-type: none"> ▪ Provide cable guard rail ▪ Edgeline rumble strips
3. STH 21 Interchange			
Conflicts between northbound USH 41 off-ramp and eastbound STH 21.		B	<ul style="list-style-type: none"> ▪ Addition of a bypass lane for northbound traffic. ▪ Staggered yield lines on three lane approaches
4. USH 45 Interchange			
Southbound USH 45 off-ramp: Ramp F bridge may block visibility		B	<ul style="list-style-type: none"> ▪ Relocate the bridge supports
5. Lake Butte des Morts Bridge			
5a	Weather related issues	C	<ul style="list-style-type: none"> ▪ Automatic anti-icing system ▪ Real-time road weather information system ▪ Warning markers
5b	Non-motorized road users		<ul style="list-style-type: none"> ▪ Higher barrier between shared use path and USH 41 ▪ Railing along slope ▪ Roadway lighting
6. Ramp geometry			
6a	Steep side slopes on off-ramp	C	<ul style="list-style-type: none"> ▪ Provide a barrier ▪ Rumble strips ▪ Enhanced delineation
6b	Sight distance at right turn channelization islands	B	<ul style="list-style-type: none"> ▪ Reconfigure the right-turn channelization islands to reduce turning radius
6c	Lack of parallel lanes for acceleration lanes at Breezewood Lane	C	<ul style="list-style-type: none"> ▪ Provide a parallel acceleration lane

2.3 CONCLUSION

Six safety issues have been identified in this design-stage road safety audit. Suggestions for improvements have been identified and are described in this report. The owner and design team are invited to consider the suggested changes. To complete the audit process, the owner and design team may prepare a short written response to the issues and options outlined in this report.

3.0 ROAD SAFETY AUDIT TEAM AND MATERIALS

Project: USH 41 Capacity Expansion Study, Winnebago County, WI

Audit Team Members: Jeffrey S. Bagdade, P.E. Opus International Consultants
Raheem Dilgir, P.Eng, PTOE Opus International Consultants
Scott Nelson, P.E. WisDOT NE Region
Matthew Haefs, P.E. WisDOT NE Region
Marie Treazise, EIT WisDOT BHO

Project Owner: Wisconsin Department of Transportation

Design Team: Wisconsin Department of Transportation

Review Stage: Planning Stage

Start Up Meeting: June 25, 2007

Preliminary Findings Meeting: June 28, 2007

Attended by: Wisconsin Department of Transportation
Opus International Consultants

Project Documents Available for the Audit:

Design Drawings

- 1120-09-00 - North Section - USH 45 to Breezewood Lane (updated January 29, 2007)
- 1120-11-02 – Central Section – STH 21 to USH 45 (updated July 19, 2006)

Corridor Analysis

- 1120-11-01 - USH 41 Corridor Study (May 2002)
- Roundabout feasibility study completed by Ourston Roundabouts and Strand.

Other Materials

- Aerial photographs of site
- WisDOT Photo Log
- Year 2035 Traffic Operations Analysis
- USH 41 Crash Analysis (2003-2005) – included collision diagrams and trend summary sheets for each intersection and interchange ramps.
- Crash reduction factors for proposed roundabouts.

All documents were provided prior to or at the start-up meeting of June 25, 2007.

4.0 SITE VISIT NOTES

Project Name: USH 41 Expansion - Winnebago County

Site Visit Dates: Monday, June 25, 2007, 3:30 to 5:30 PM, clear and dry
Wednesday, June 27, 2007 10:00 AM to 2:00 PM, clear and dry

Land Uses: USH 41 runs through residential, industrial, and commercial areas through the Cities of Oshkosh and Neenah, Wisconsin.

Road User Characteristics:

A high proportion of trucks were observed on USH 41 and at interchanges. During the morning and afternoon peak periods, congestion and directional queuing was observed at several of the interchanges and at the frontage road intersections. Few pedestrians or bicyclists were observed on connecting roads during site visits.

A large number of recreational and unfamiliar road users regularly use the corridor as USH 41 is a primary route from Milwaukee and Madison to northern Wisconsin. Additionally the corridor is a main route to the EAA Air Show in Oshkosh and to Green Bay Packers games.

Road and Roadside Physical Characteristics:

A four lane divided highway, USH 41, accommodates entering and exiting traffic using short acceleration and deceleration lanes. Six-foot wide shoulders are present on both sides in both directions (*right*). The posted speed limit is 65 mph. Approach alignments are generally straight and level.



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5.0 ROAD SAFETY AUDIT ISSUES AND SUGGESTIONS

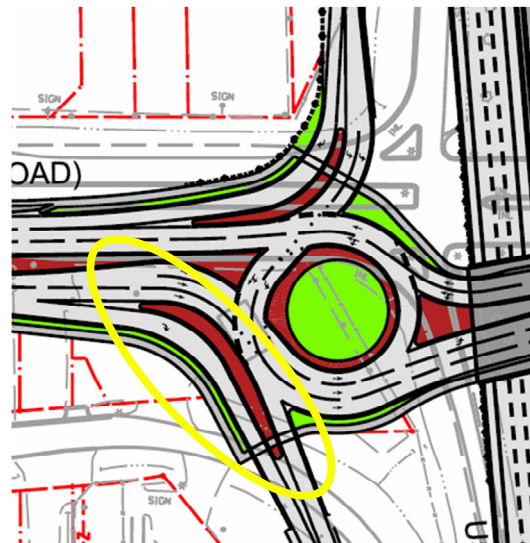
5.1 Safety Issue 1: Roundabout Design and Operations

Safety Issue 1(a) Description:

High speed right-turn conflicts with pedestrians and bicyclists

High speed right-turn bypass lanes are planned at several of the planned roundabouts on the corridor. These are primarily being utilized on the on- and off-ramps to maximize the operational performance of the roundabouts.

On several of the bypass lanes which are being planned for freeway on-ramps, crosswalks are proposed to be located near the end of these high speed right-turn lanes. The location of these crosswalks may result in conflicts with pedestrians due to the limited visibility of the crosswalk and the increased speeds.



STH 21 & USH 41 SB On-ramp

NCHRP 572² states roundabout exits have a higher percentage of vehicles that do not yield to pedestrians than roundabout entries, suggesting that the design of the exit should be carefully considered to ensure vehicle speeds are reasonable and that good sight lines exist between drivers and pedestrians.

This issue exists at the following locations:

- STH 21 & SB USH 41 Ramps
- Breezewood Lane & Northbound USH 41 Ramps
- Breezewood Lane & Southbound USH 41 Ramps

² Rodegerts, L., et al; *NCHRP 572: Roundabouts in the United States* Transportation Research Board of the National Academies, Washington, DC, 2007.

Expected Crash Types: pedestrian and bicycle collisions

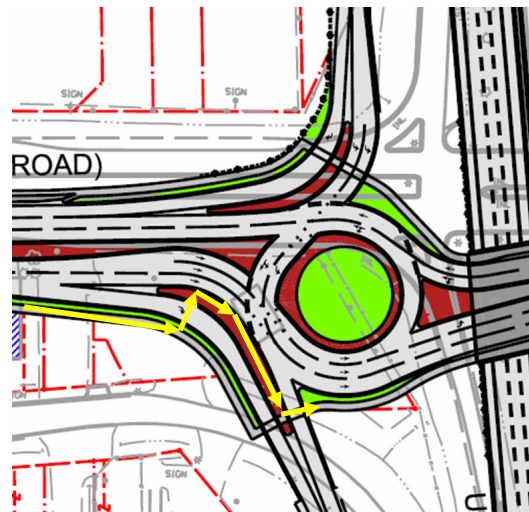
Expected Frequency: infrequent

Expected Severity: extreme

Risk Rating: D (significant risk level)

Opportunities for Improvement

1. *Offset Pedestrian Crossings:* Offsetting the pedestrian crosswalk will improve the visibility of the crosswalk and alert drivers of pedestrians before accelerating speeds on the on-ramp (right). It is suggested that fencing or pedestrian railing be used to formally channelize the pedestrians through the offset crossing.



2. *Introduction of Active Warning Devices:* If the crosswalk cannot be moved, it is suggested that a flashing yellow beacon may be placed on the pedestrian warning sign adjacent to the crosswalk. It is suggested that if a flashing yellow beacon is used in these locations that it should be pushbutton actuated.

Safety Issue 1(b) Description:

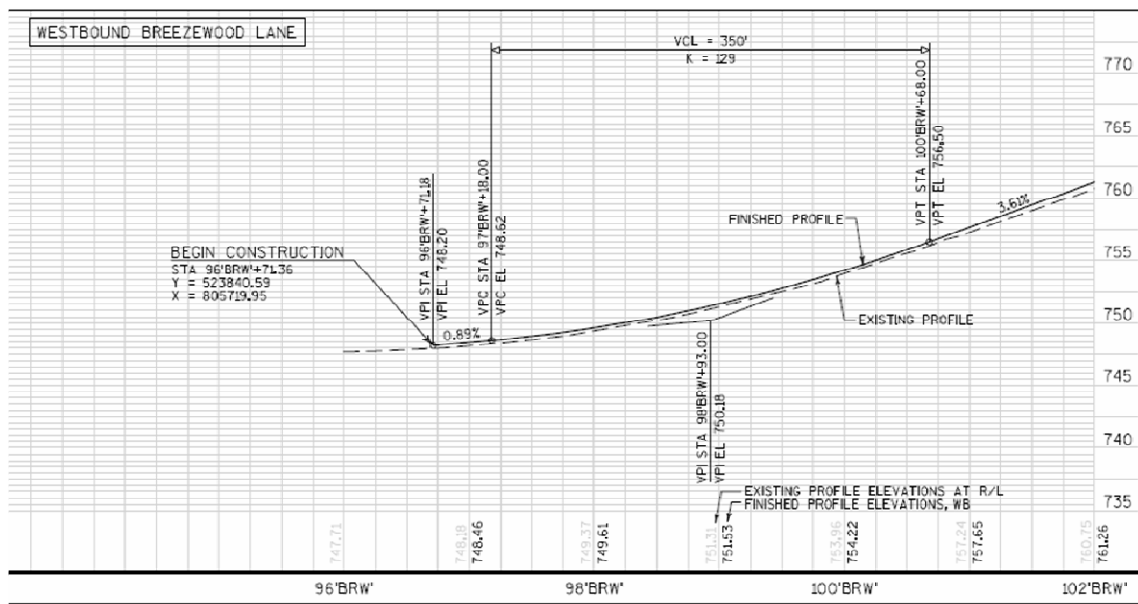
Limited vertical sight distance on roundabout approaches

Several of the roundabouts throughout the corridor are planned for locations where they will be located on the crest of a vertical curve. These locations will provide for limited sight distance on the approaches which may increase the risk of rear-end collisions on the roundabout approaches. While the vertical sight distance to the existing signalized intersections is not necessarily adequate, drivers have the benefit of being able to see the overhead signal mast arms on the approaches



SB Koeller & 9th Avenue

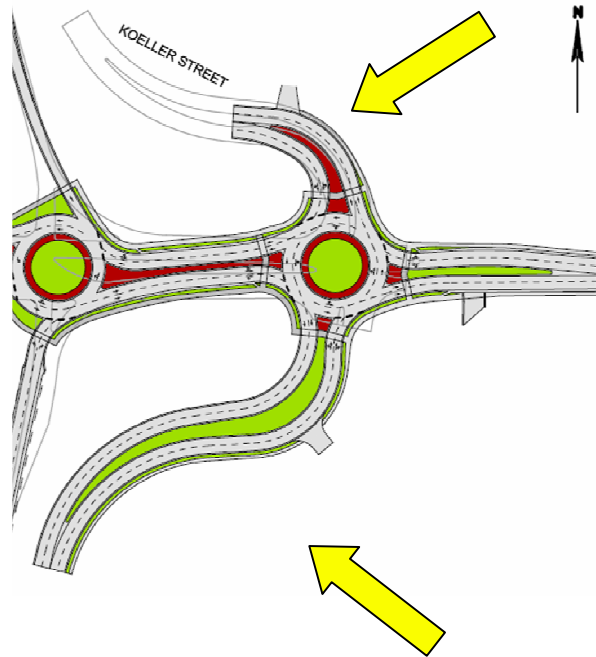
The photo (right) illustrates an example of an intersection with existing sight distance restrictions on the approaches location. The below figure illustrates the proposed vertical curve on the approach to a roundabout at Breezewood Lane.



Safety Issue 1(c) Description:

Limited horizontal sight distance on frontage roads

The limited sight distance due to horizontal curves may increase the risk of sideswipe and rear-end collisions approaching a roundabout. A horizontal curve on an approach reduces decision sight distance and approaching drivers' ability to see and react to the roundabout.



Expected Crash Types: off-road, rear end and right angle collisions


Expected Frequency: occasional

Expected Severity: moderate

Risk Rating: C (moderate risk level)

Opportunities for Improvement:

Safety Issue		Suggestions
1b	1c	
√	√	<i>Flatten the vertical curves:</i> Reducing vertical and horizontal grades will improve sight distance and provide drivers with increased reaction time.
√	√	<i>Lighting on the approaches:</i> Lighting is generally considered beneficial at intersections to improve sight distance and night-time visibility. It is suggested that lighting be provided on all roundabout approaches which include horizontal and vertical curves.

Safety Issue		Suggestions
1b	1c	
	√	<i>Overhead lane use signs:</i> To enhance driver guidance, overhead lane use and/or freeway guide signs may be posted on roundabout approaches to clearly indicate to drivers the required movements for the desired lane. Overhead signing may reduce driver confusion and changing lanes close to the roundabouts, decreasing sideswipe and rear-end collisions.
	√	<i>Extend the splitter islands:</i> This should help to warn drivers that they are approaching a roundabout even though it may not be fully visible due to a horizontal curve.
	√	<i>W1-8 (Chevron) signs:</i> Chevron signs may be posted to provide additional emphasis and guidance to drivers on horizontal curves. Chevron signs may be used as an alternate or supplement to standard delineators on curves. 

Safety Issue 1(d) Description:

Left-turn pavement arrows

The use of left-turn arrows in roundabouts may encourage unfamiliar drivers to make wrong way maneuvers on to the roundabouts. From a human factors perspective, utilizing left-turn pavement violates driver expectancy.



Expected Crash Types: head-on collisions

Expected Frequency: infrequent

Expected Severity: high

Risk Rating: C (moderate risk level)

Opportunities for Improvement

“Fish-hook” arrows: The proposed “Fish-hook” arrow design for signs and markings (*below*) can be used for driver guidance on the approaches to roundabouts. The WisDOT Northeast Region is already utilizing this arrow design on the Claude Allouez Roundabout in De Pere on STH 57 (*below*).



Safety Issue 1(e) Description:

Raised Non-Circular Apron:

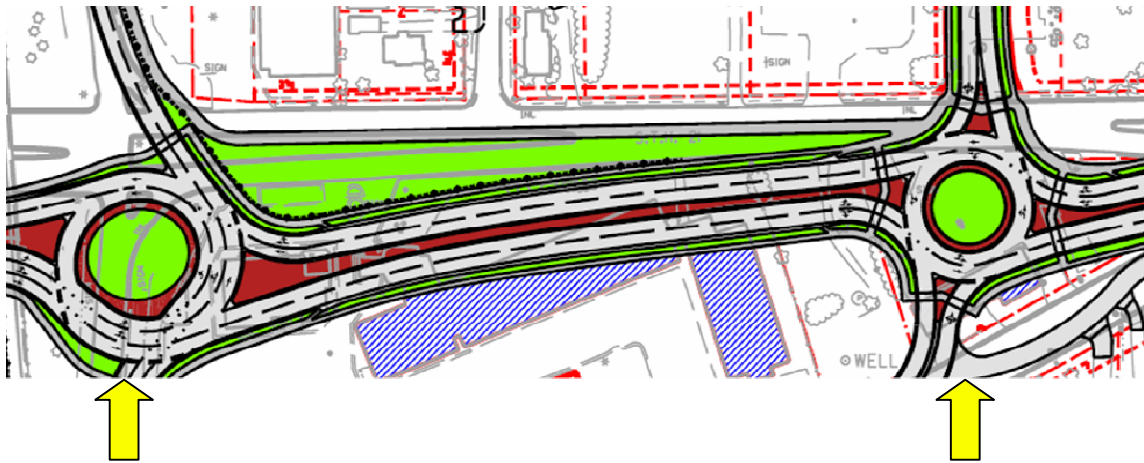
The central islands of several roundabouts utilize a raised non-circular apron. While the non-circular shape is critical when utilizing spiral striping, the raised non-circular shape may cause drivers to hit the curb or drift out of the lane due to the inconsistency with neighboring roundabouts. Additionally, once roundabouts open it is not uncommon for the road agency to have to make minor modifications to the pavement markings. By providing a raised non-circular apron, it will be more difficult and expensive to make minor modifications to the roundabout.

Expected Crash Types: fixed object and weaving collisions

Expected Frequency: occasional

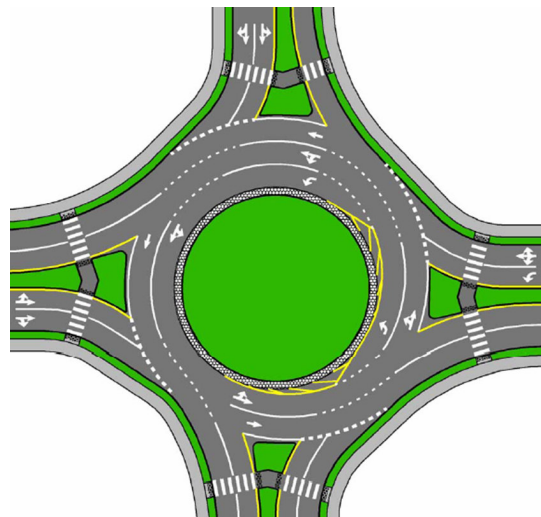
Expected Severity: low

Risk Rating: B (low risk level)



Opportunities for Improvement

Implement circular aprons: Circular aprons may be used at all roundabouts for consistency. Pavement markings can be used to align or add lanes around the apron (*right*). Pavement markings are a low cost application method to make minor modifications to the apron.

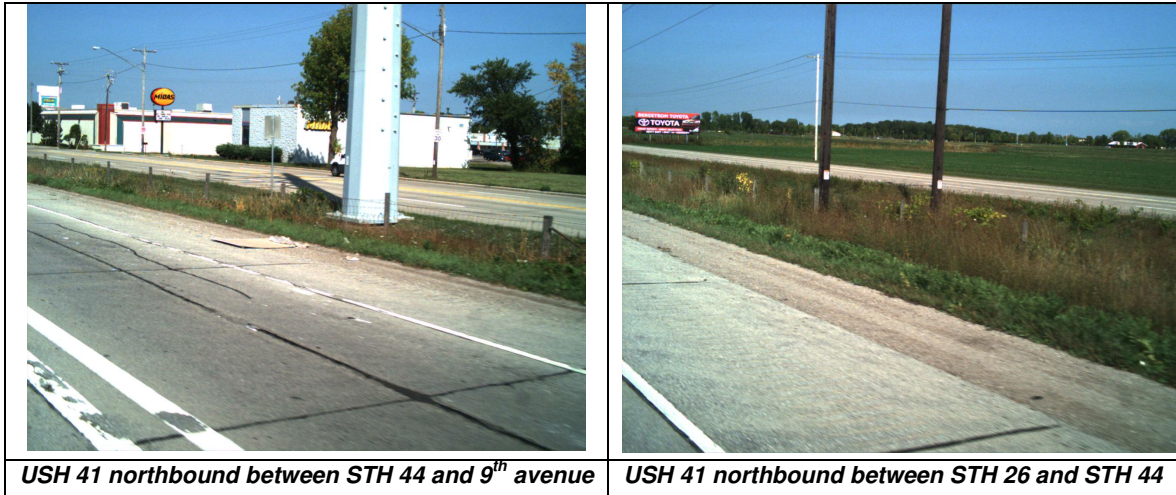


5.2 Safety Issue 2: Roadside Safety

Safety Issue 2(a) Description:

Utility poles close to USH 41 and Frontage Roads

Utility poles adjacent to northbound USH 41 and the east frontage road are located within the clear zone. Due to their proximity to the roadway, drivers are likely to strike one of these fixed objects if they lose control and depart the roadway. The severity of these crashes is increased due to the high speeds which vehicles are traveling on USH 41. If a vehicle traveling at high speeds strikes a utility pole, a severe crash may occur.



Expected Crash Types: head-on and fixed object collisions

Expected Frequency: occasional

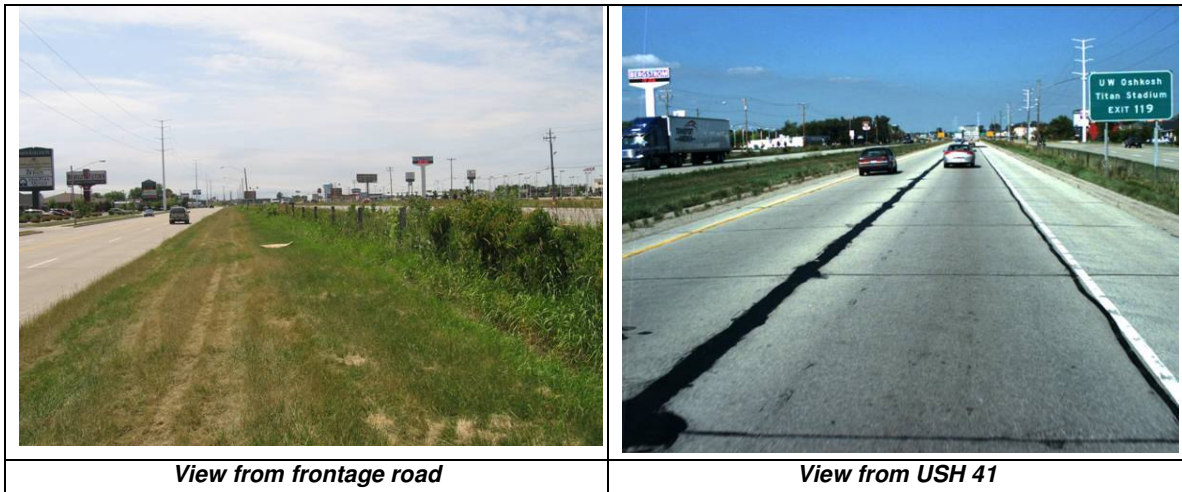
Expected Severity: high

Risk Rating: D (significant risk level)

Safety Issue 2(b) Description:

Close spacing between USH 41 and frontage roads

Due to the close proximity of USH 41 to the frontage road, vehicles which lose control and exit the roadway may cross over the median resulting in head-on collisions. This close proximity is present on several sections of the corridor.



Expected Crash Types: head-on and fixed object collisions

Expected Frequency: occasional

Expected Severity: high

Risk Rating: D (significant risk level)

Opportunities for Improvement

1. *Relocate utility poles:* Relocate utility poles out of the clear zone to reduce the possibility of fixed object collisions between vehicles and the utility poles.
2. *Provide barrier protection of fixed objects:* If relocating the utility poles is infeasible, it is suggested that a barrier such as guardrail be provided to shield the fixed object. Guardrail will decrease the severity rating and the possibility of a severe injury due to a fixed object collision.
3. *Provide cable guard rail or barrier:* To prevent vehicles from crossing over the median between USH 41 and the frontage roads, it is suggested that cable guard rail or barrier be considered. Cable guard rail or barrier will help to prevent head-on collisions related to these median crossovers.

4. *Edgeline rumble strips*: It is suggested that shoulder rumble strips be used on the corridor. It is also suggested that these rumble strips be supplemented by painting edgelines over the rumble strips. The presence of paint on the vertical rumble strip faces provides enhanced delineation, particularly during wet weather.

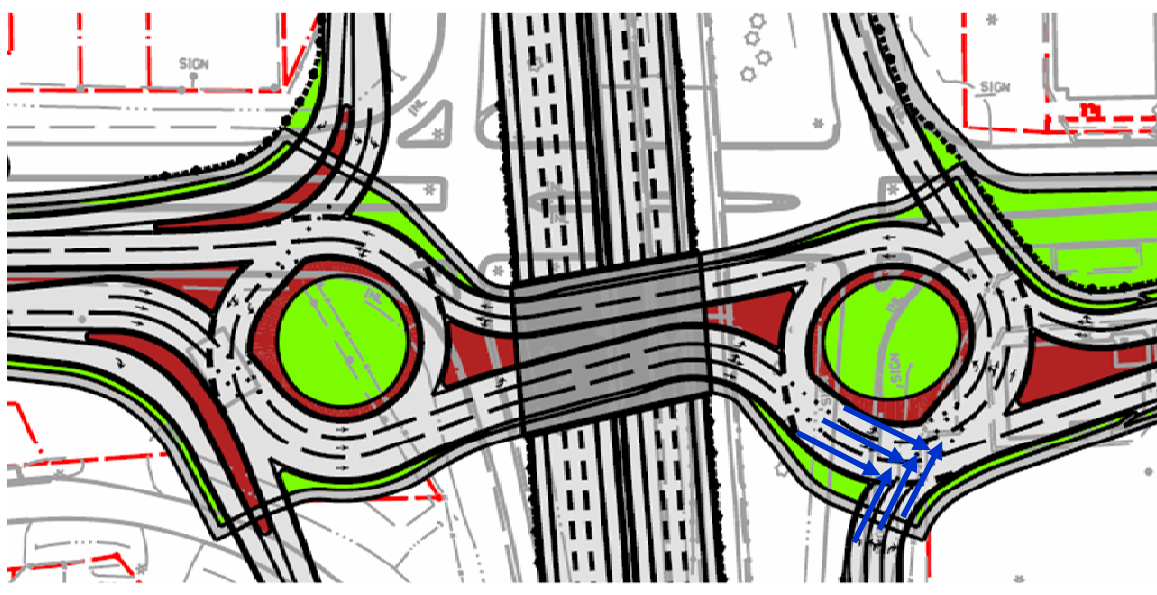
5.3 Safety Issue 3: STH 21 Interchange

Safety Issue 3 Description:

Conflicts between northbound USH 41 off-ramp and eastbound STH 21

Three lanes of traffic on the USH 41 northbound off-ramp may conflict with three lanes of traffic traveling eastbound on STH 21 through this roundabout. This potential conflict is of concern due to the potential for eastbound STH 21 to operate in more of a free flow condition due to the low volume of traffic which will be within the roundabout when it enters. This will likely increase speeds for traffic on eastbound STH 21 within the roundabout and decrease available gaps for drivers entering the roundabout. Due to these higher than expected speeds and fewer than expected gaps, drivers may choose inopportune times to enter the roundabout.

Additionally, the proposed three lane entrance is likely to generate intersection sight distance restrictions for drivers in the right lane on the USH 41 northbound off-ramp. It will likely be extremely difficult for drivers within this lane to see traffic within the roundabout and choose an inadequate gap to enter the roundabout. Sight distance will be further decreased if a large truck or van is stopped in the left or center lane.



Expected Crash Types: angle and sideswipe collisions

Expected Frequency: occasional

Expected Severity: low

Risk Rating: B (low risk level)

Opportunities for Improvement

1. *Addition of a Bypass Lane:* A bypass lane may be considered for northbound right-turn traffic. A bypass lane will reduce the number of conflict points within the roundabout. It will also help to increase sight distance for northbound drivers entering the roundabout.

2. *Staggered yield lines on three lane approaches:* Staggered yield lines will improve intersection sight distance on the northbound approach to the roundabout. It will also decrease the chances of a heavy vehicle blocking the view of through traffic for a vehicle in the right lane.

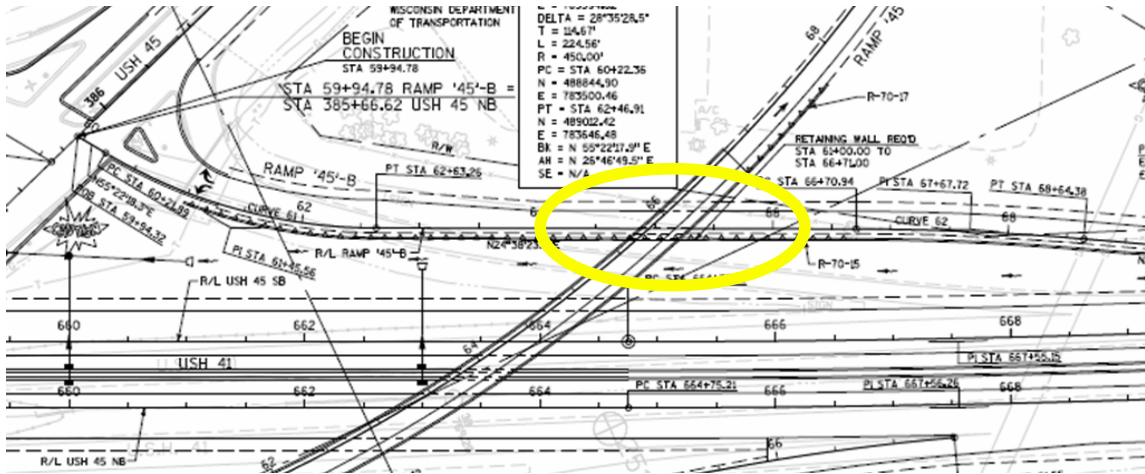
5.4 Safety Issue 4: USH 45 Interchange

Safety Issue 4 Description:

Southbound USH 45 off-ramp: Ramp F bridge may block visibility

The location of the bridge supports for Ramp F may block driver's sight distance for vehicles traveling on Ramp B. This will reduce decision sight distance and reaction time for drivers approaching the roundabout which is proposed for the intersection of this ramp and USH 45. As a result, this sight distance restriction may result in rear-end collisions.

USH 41 EXPANSION – WINNEBAGO COUNTY
ROAD SAFETY AUDIT



Expected Crash Types: rear end collisions

Expected Frequency: occasional

Expected Severity: low

Risk Rating: B (low risk level)

Opportunities for Improvement

Relocate the bridge support: It is suggested that relocating the bridge support further away from Ramp B to allow for enhanced sight distance of the roundabout. Enhanced sight distance will result in a additional reaction time and will therefore reduce the possibility of rear-end collisions occurring on this ramp

5.5 Safety Issue 5: Lake Butte des Morts Bridge

Safety Issue 5(a) Description:

Weather Related Issues

USH 41 is the only high-speed route across the Lake Butte des Morts/Fox River system near Oshkosh. The Lake Butte des Morts Bridge spans about 1,300 feet over the lake. The bridge is prone to poor weather conditions. Due to its location, the bridge is prone to snow drifts. In addition, drivers may fail to anticipate the frequent icy conditions on the bridge which regularly occur throughout the winter months. Visibility may be unexpectedly and intermittently reduced in foggy areas.

To address these weather related issues, FOG OR BLOWING SNOW warning signs have been provided on both the northbound and southbound approaches to the bridge. The beacons on these signs are activated manually by enforcement or maintenance personnel.



USH 41 northbound fog signs



USH 41 southbound Lake Butte des Morts Bridge

Expected Crash Types: off road and fixed object collisions

Expected Frequency: occasional

Expected Severity: moderate

Risk Rating: C (moderate risk level)

Opportunities for Improvement

1. *Automatic anti-icing system:* Improved pavement friction may be achieved using automatic anti-icing system on bridges. Higher pavement friction may decrease the chances of drivers losing control of the vehicle, especially on icy and wet pavement.

2. *Real-time road weather information system:* A real-time road weather information system will inform drivers of road conditions and advise drivers to slow down. The more drivers are informed the more cautious drivers will become of the icy and foggy conditions on the bridge. Cautious drivers will result in slower speeds, fewer injuries and fewer collisions.

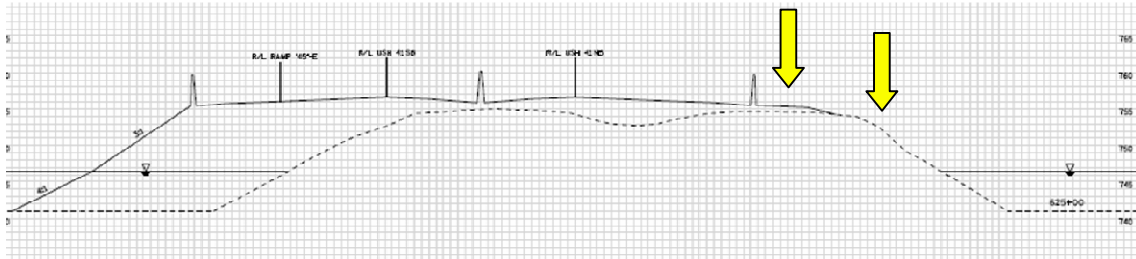
3. *Icy road warning markers.* Several agencies are currently testing pavement markers which change color as the road surface freezes. The markers are embedded into the road about ¼ inch below the road surface. When the temperature of the road surface is above freezing, the markers are grey and translucent. As the road surface temperature nears the freezing point (around 37° F) the markers begin to change colour. At 32° the markers have completely changed color. These markings provide visual cues about the temperature of the road surface to both motorists and maintenance staff

Safety Issue 5(b) Description:

Non-motorized road users

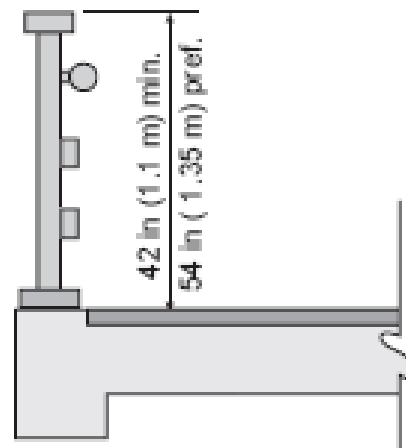
The shared use path along the Lake Butte des Morts Bridge has a barrier between the motorized vehicles and the path. The proposed barrier is 42 inches high. This barrier could pose a risk for bicyclists if they were to fall. Bicyclists are typically seated at least 42 inches off the ground and they could potentially fall over barrier into high speed traffic on USH 41.

No barrier exists between the path and Lake Butte des Morts. In some areas there is a drop greater than 30 feet. This drop may result in pedestrians and bicyclists unintentionally sliding into the lake.



Opportunities for Improvement

1. *Higher barrier between shared use path and USH 41:* It is suggested that a 54 inch high barrier³ is be used due to the high speeds of traffic along Lake Butte des Morts Bridge. This will reduce the risk that a bicyclist who falls will not fall over the barrier.
2. *Railing along slope:* Due to the drop off of up to 30 feet between the shared use path and the lake, it is suggested that a 54 inch railing⁴ is used (right).
3. *Roadway lighting:* Lighting is generally considered beneficial to provide improved sight distance and night time visibility.



Proposed Railing between shared-use path and Lake Butte des Morts

³ Wisconsin Department of Transportation, *Wisconsin Bicycle Facility Design Handbook*, January 2004, pg. 4-82

⁴ Wisconsin Department of Transportation, *Wisconsin Bicycle Facility Design Handbook*, January 2004, pg. 4-73 Figure 4-120

Expected Crash Types: off road and fixed object collisions

Expected Frequency: occasional

Expected Severity: moderate

Risk Rating: C (moderate risk level)

5.6 Safety Issue 6: Ramp Geometry

Safety Issue 6(a) Description:

Steep Side Slopes on Off-Ramps

It was observed that the off-ramps at STH 44 and STH 26 have steep side slopes. These steep slopes do not have any barrier system to block drivers from proceeding off the slope into the ravine below. This condition increases the risk of a rollover crash resulting from a lane departure.



USH 41 Southbound Off Ramp at STH 26

Expected Crash Types: run-off-road and overturn collisions

Expected Frequency: occasional

Expected Severity: moderate

Risk Rating: C (moderate risk level)

Opportunities for Improvement

1. *Provide a Barrier:* It is suggested that a barrier such as guardrail be provided to prevent drivers who depart the roadway from travelling down the steep side slope. Guardrail will decrease the severity rating and the possibility of a severe injury due to an overturn collision.
2. *Rumble Strips:* To alert drivers who have left the travel lane and entered the shoulder, shoulder rumble strips may be considered. NCHRP Report 500 (*Volume 6: A Guide for Addressing Run-Off-Road Collisions*) cites several before/after studies of the effectiveness of shoulder rumble strips, and concludes that a “best guess” estimate is a 20- to 30-percent reduction in single-vehicle run-off-road collisions on rural freeways.
3. *Enhanced Delineation:* Chevron (W1-8) signs may be posted to provide additional emphasis and guidance to drivers. Chevron signs may be used as an alternate or supplement to standard delineators on curves.

Safety Issue 6(b) Description:

Sight Distance at Right Turn Channelization Islands

A review of the crash data for the corridor indicated disproportionately high numbers of rear ends at right turn channelization islands. The first issue identified at the channelization islands is the intersection sight distance between right-turners and approaching through traffic. The combination skewed intersections at STH 26, STH 44 and STH 76 requires drivers to look over their shoulder while looking for a gap in cross traffic.



Right Turn Channelization Island on STH 26 and USH 41 Northbound On-Ramp

While most cases the right-turn channelization islands was designed for a high speed right-turn, a Yield sign is present causing vehicles to unexpectedly slow down and yield for a gap in traffic. This further increases the risk for a rear end crash.

Expected Crash Types: rear-end crashes

Expected Frequency: occasional

Expected Severity: low

Risk Rating: B (low risk level)

Opportunities for Improvement

Reconfigure the right-turn channelization islands to reduce turning radius

Realigning the right turn channelization islands (as shown on the right) to reduce the turn radius, will reduce the unexpected stops and have the added benefits in terms of accommodating safer pedestrian crossings if pedestrian facilities are ever added to these locations. It is noted that a redesigned right-turn channelization island must still be able to accommodate trucks and buses.



Example of a right-turn channelization island with the proposed configuration STH 59/164 and CTH D in Waukesha County

Safety Issue 6(c) Description:

Lack of Parallel Lanes for Acceleration Lanes at Breezewood Lane

The interchange ramps at Breezewood Lane did not include parallel acceleration and deceleration lanes on southbound USH 41. The short tapered acceleration and deceleration lanes limit drivers' ability to accelerate to highway speed before merging into the right through lane. Slower vehicles especially such as trucks, may interfere with through traffic on USH 41, increasing the risk of rear-end and sideswipe collisions. Drivers who fail to merge may leave the travel lane, resulting in off-road and fixed object collisions.

Expected Crash Types:	rear end collisions
Expected Frequency:	occasional
Expected Severity:	moderate
Risk Rating:	C (moderate risk level)

Opportunity for Improvement

Provide a parallel acceleration lane: A parallel acceleration lane on USH 41 for entering traffic on southbound USH 41 at the Breezewood may be considered. This will allow merging drivers to accelerate for a longer distance before merging into the right lane on USH 41. Longer acceleration lanes are present at all other interchanges on the corridor and may particularly assist older drivers, whose ability to view mainline traffic may be compromised.

5.7 Other Suggestions

Below are several additional corridor-wide suggestions which were discussed by the RSA team. Each of these suggestions is designed to further enhance safety along the corridor.

Freeway Signing Issues

- In order to maximize the visibility and conspicuity of the freeway guide signs it is suggested that a combination of ASTM Type IV and Type XI sheeting be used. The Type VI sheeting should be used for the background while Type XI sheeting should be used for the legend. This is based on recommendations from the referenced Texas Transportation Institute⁵ study.
- To further increase sign conspicuity and legibility it is suggested that the use of Clearview be considered for positive contrast guide signs on the USH 41 corridor.

⁵ P.J. Carlson. *Legibility of Microprismatic Sheeting and Clearview Alphabet: Summary Report*. Project Summary Report. 0-4049-S. Texas Transportation Institute, College Station, TX. October 2003.

- Provide overhead freeway guide signs on the cross streets. This will help to enhance the conspicuity of the interchanges in particular on STH 26, STH 44 and STH 76 where no roundabouts are planned.
- To minimize weaving on the approaches to the USH 45 interchange it is suggested that lane-use signing which utilize a modified diagrammatic guide signing be used. These guide signs match the number of arrowheads with the number of lanes at the sign's location. This will help drivers understand the complex lane-use maneuvers associated with the option-lane exits which are being proposed for this interchange. An example is illustrated on the following page.



Example of a Modified Diagrammatic Interchange Guide Sign

Lighting Related Issues

Current design drawings do not show luminaires at any location along the USH 41 main line. Lighting is proposed for the roundabouts but not the unsignalized intersections on the cross streets. The absence of lighting limits approaching drivers' awareness of changes in alignment, at complex interchanges and at decision points, where conflicts with vehicles are most likely to occur. This increases the risk of rear end and angle crashes near these locations which increases the need for intersection lighting.

Glare Related Issues

The presence of two-way frontage roads on both sides of USH 41 increases the risk of headlight glare from opposing traffic. This has been identified as an issue by WisDOT on the west side of USH 41 between Breezewood Lane and STH 76 and a glare screen has been installed on that section. It is suggested that glare screens be considered throughout the rest of the corridor.

Signal Visibility

The use of a single overhead signal head limits signal (and intersection) conspicuity for drivers approaching the intersection, and may limit signal visibility for drivers whose view of the single overhead display is compromised by a tall vehicle (such as a truck) ahead, or affected by a bright rising or setting sun. Drivers who fail to observe the signal display increase the risk of angle and rear-end collisions. The risk is also increased for older drivers, whose visual and decision-making abilities are reduced. It is suggested that multiple overhead signals be provided on multi-lane approaches and at locations where the signal is the first after a long stretch without a traffic signal.

Signal Operations

When reviewing the crash data it was identified that the intersection of STH 44 and the USH 41 northbound on-ramps experienced 17 left-turn crashes between 2003 and 2005. To address this issue, it is suggested that protected-only left-turn phasing be considered for this movement.



Eastbound STH 44 at USH 41 NB On-Ramp

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- Road Safety Engineering
- Transportation Planning
- Traffic Operations
- Transit and Sustainability
- Community and School Safety
- Asset Management