WISCONSIN DEPARTMENT OF TRANSPORTATION

BLUEMOUND ROAD CORRIDOR:

ROAD SAFETY AUDIT

OPUS

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Opus International Consultants Inc.

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1.0 INTRODUCTION

1.1 Background

Bluemound Road (USH 18) is a state highway located in Waukesha County, Wisconsin. The corridor provides access to the commercial and residential areas of the City of Brookfield, Town of Brookfield and the Village of Elm Grove. Average daily traffic levels reported in 2003 were about 40,000 vehicles per day on Bluemound Road.

The Wisconsin Department of Transportation (WisDOT) is currently planning to upgrade Bluemound Road between Moorland Road and Barker Road. The Bluemound Road corridor has consistently been designated a high crash corridor for several years by WisDOT. Many elements of WisDOT's planned upgrades are being proposed in response to these designations as the project is being funded through the Highway Safety Improvement Program (HSIP). The project is targeting the mid-block median openings and the signalized intersections.

The proposed design was chosen with regard for environmental, engineering and budgetary constraints. An extensive public consultation process was conducted to identify and address concerns with the proposed design expressed by the City of Brookfield, Town of Brookfield, Village of Elm Grove, Waukesha County, the local business owners and the public.

The project is currently in the detailed design phase (plans 60-90% complete) and is scheduled to be submitted for PS&E in August 2007. The upgrades are scheduled to be constructed in 2008.

1.2 Road Safety Audits

A road safety audit is a formal safety performance examination of an existing or future road or intersection by an independent audit team. Road safety audits 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 audit 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 Project and Scope

The scope of the planned improvements will include:

- Modifications to the mid-block median openings;
- Improvements to the intersection turn lanes;
- Upgrades to the signal displays at several intersections; and,
- Changes in the corridor signal timing and coordination.

1.5 Audit Team and Process

The audit team and the project material on which the audit was based are described in SECTION 3.

Site visits were conducted in March 2007 to gain an understanding of the existing conditions and surroundings. Notes on the site visits are contained in TABLE 3.1.

A road safety audit 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	*frequent*
medium	high		
high	medium	1 to 9 crashes per year	*occasional*
medium	medium		
low	high		
high	low	less than 1 crash per year, but more than 1 crash every 5 years	*infrequent*
low	medium		
medium	low	less than 1 crash every 5 years	*rare*
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	*extreme*
crashes involving medium to high speed; head-on, crossing, or run-off-road crashes	moderate to severe injury	*high*
crashes involving medium to low speeds; left-turn and right-turn crashes	minor to moderate injury	*moderate*
crashes involving low to medium speeds; rear-end or sideswipe crashes	property damage only or minor injury	*low*

TABLE 1.3 CRASH RISK ASSESSMENT

FREQUENCY RATING	SEVERITY RATING			
	Low	*Moderate*	*High*	*Extreme*
Frequent	C	D	E	F
Occasional	B	C	D	E
Infrequent	A	B	C	D
Rare	A	A	B	C

Crash Risk Ratings:

A: lowest risk level
B: low risk level
C: moderate-low risk level
D: moderate-high risk level
E: high risk level
F: highest risk level

2.0 AUDIT FINDINGS

2.1 Safety Benefits of the Proposed Improvements

The Bluemound Road corridor has consistently been designated a high crash corridor for several years by WisDOT. The Bluemound Corridor Road Safety Audit is motivated by the safety-related goal of reducing conflicts between vehicles by improving access management, traffic signal programming, road design, and storage.

Many elements of WisDOT's planned upgrades are being proposed in response to these designations as the project is being funded through the Highway Safety Improvement Program (HSIP). In addition, the Corridor and many features of its design already incorporate many features that are expected to substantially improve traffic safety. TABLE 2.1 outlines the safety benefits of the proposed design.

TABLE 2.1 SAFETY BENEFITS OF THE PROPOSED DESIGN

DESCRIPTION	BENEFIT	DETAILS
Improved Access Management	The enhancements to access management along the corridor should improve safety by: • Reducing the number of conflict points between Bluemound Road and the intersecting driveways. • Reducing the number of driveways on the corridor. • Restricting turning movements into and out of driveways. • Encouraging shared access between parcels as a means to direct traffic to the safest possible nearby access point. • Moving driveways away from intersections. • Improving sight distance.	 

DESCRIPTION	BENEFIT	DETAILS
Protected-Only Left-Turns	The proposed design includes several intersections which the signal phasing is to be converted from protected-permissive to protected-only. The use of protected-only left-turn phasing reduces the potential for: • High speed crashes involving left-turning vehicles which choose inadequate gaps in the opposing through traffic. • Left-turn movements which conflict with pedestrians	
Removal of the Marcus Drive Signal	Removal of the signal at Marcus Drive and relocating it to Jennifer is expected to improve the signal operations at Barker Road by reducing the interference due to the close distance between the intersections.	
Upgraded Signals	The additional near-side and far-left supplemental signal displays are expected to increase the visibility and conspicuity of the traffic signals. The new signal timing and coordination is expected to improve traffic flow along the corridor.	

DESCRIPTION	BENEFIT	DETAILS
Improved Left-Turn Storage Capacity	The improved left-turn capacity will eliminate the issue of having left-turn queues extending into the through lanes. This will reduce the risk for rear end crashes.	
Providing a Continuous Right-Turn Lane	The continuous right-turn lanes provide drivers with an area to decelerate outside of the through lanes at mid-block locations prior to turning onto a minor street or driveway. These lanes reduce the risk for rear end crashes.	

2.2 RSA Issues and Suggestions

Safety issues and suggestions associated with the proposed improvements are discussed in SECTION 4, and summarized in TABLE 2.2.

TABLE 2.2 SUMMARY OF RSA SAFETY ISSUES AND SUGGESTIONS

SAFETY ISSUE (number and description)		RISK RATING	SUGGESTIONS
1	A high frequency of rear end right-turn crashes are occurring on northbound Barker as a result of limited sight distance due to the shape of the right-turn channelizing island.	C	• Reconfigure the channelized right-turn island • NO TURN ON RED

SAFETY ISSUE (number and description)		RISK RATING	SUGGESTIONS
2	The close proximity of the opposing turn lanes in the dual restricted median openings limits sight distance for vehicles making left and u-turns.	C	Increase the distance between median openings to at least 100-feet and preferably 150-feet. • Marcus Drive – See Issue 3 • Elizabeth Drive – Move the westbound median opening to line up with the east driveway near the Acura dealers. • Regency Court – Move the westbound median opening to line up with Regency Court.
3	Eastbound left-turns into Pano's can conflict with vehicles queued back from the signal at Barker Road.	C	• Close the median opening for eastbound Bluemound into Pano's • Close the direct left-turn lane for Jennifer and create a single eastbound restricted median opening between Jennifer and Marcus. • Move the proposed signal at Jennifer to the east so it is aligned with the northeast corner of the Menards parking lot.
4	Restricted access to businesses with no alternate route may encourage drivers to make illegal maneuvers to reach their final destination.	C	• Fiserv Drive – Move the eastbound median opening to the driveway between Kmart and Boston Market. Provide a westbound median opening at Fiserv Drive. • Patrick Drive – Provide a westbound median opening.
5	The existing median opening configuration makes it more difficult for drivers to make u-turns. U-turns are likely to increase as a result of the project.	C	Consider using a more of a rounded nose design for the median openings.

SAFETY ISSUE (number and description)		RISK RATING	SUGGESTIONS
6	Pedestrian facilities on Bluemound Road are incomplete.	D	As part of the 2012 reconstruction project consider working with the local agencies to complete the pedestrian network.
7	The use of single overhead mounted signal can limit the conspicuity of the intersection. Motorists behind a large vehicle may have difficulty seeing the signal display until close to the intersection.	C	• Provide multiple overhead signals for through movements. • Provide reflective strips on the backplates for the westbound approach at Barker due to visual interference between the signals and the overhead guide sign structure. • Increase the bottom height of the far-side left-turn signals.

2.3 Conclusions

Seven 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

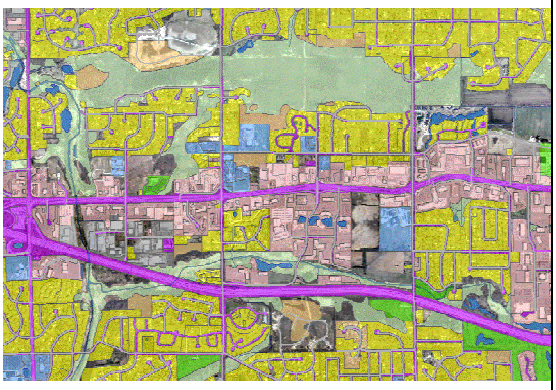
Location	City of Brookfield, Town of Brookfield and Village of Elm Grove, WI
Audit Team	Jeffrey Bagdade, P.E. (Opus International Consultants) Margaret Gibbs, P.Eng., PTOE (Opus International Consultants) Nicole Thompson, E.I.T. (Opus International Consultants) Michael Woods (Opus International Consultants)
Project Owner	Wisconsin Department of Transportation
Design Team	Wisconsin Department of Transportation
Review Date	March 20-22, 2007
Audit Stage	Design
Start Up Meeting	March 20, 2007
Attended by	Wisconsin Department of Transportation Earth Tech Opus International Consultants

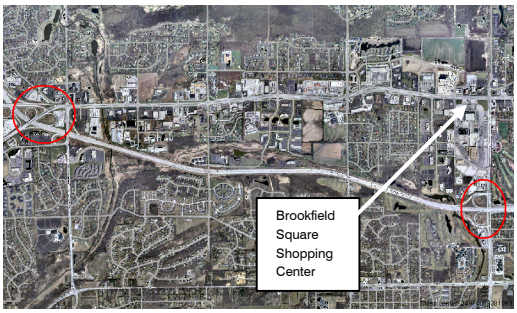
Project Documents Available for the Audit:

- Design Drawings dated March 6, 2007.
- MV4000 crash reports (2003-2005) provided by the Wisconsin Department of Transportation.
- Speed Study SZ-2-2001-186 for USH 18 from Barker to Moorland provided by the Wisconsin Department of Transportation dated December 2006.
- *Safety Analysis Report – Bluemound Road Corridor Analysis* from Earth Tech dated January 2005.
- *Improvement Analysis Report – Bluemound Road Corridor Analysis* from Earth Tech dated April 2005.
- *Traffic Signal Timing Analysis Report and Overall Project Summary Analysis* from Earth Tech dated July 2005.

All documents were provided prior to or at the RSA workshop of March 20-22, 2007.

TABLE 3.1 NOTES OF SITE VISIT

CHARACTERISTIC	DETAILS	ILLUSTRATION OR COMMENT
Classification	Major Arterial (part of USH 18)	--
Jurisdiction	Wisconsin Department of Transportation	--
Land Use	The surrounding land use for the Bluemound Rd. corridor is zoned primarily as commercial/retail or office as indicated by the violet colors. The yellow indicates residential, mostly single family with some multi-family use included.	
Road User Characteristics	The primarily road users for the Bluemound Rd. corridor were passenger cars most likely commuting to the mall/shops or various office locations in Brookfield and Elm Grove. Pedestrians, bicyclists and transit were also observed using Bluemound Road. Large trucks utilize the corridor to make deliveries and as an alternate route to I-94.	

CHARACTERISTIC	DETAILS	ILLUSTRATION OR COMMENT
Influences	• The circle to the left is the I-94 and Barker Rd. interchange. A Park and Ride is located off the ramp. • The circle to the right represents the Moorland and I-94 interchange. • Many of vehicles utilizing the Bluemound and Moorland intersection are likely associated with retail activity near the Brookfield Square Shopping Center.	
Horizontal Alignment	Generally straight with some horizontal curves	
Vertical Alignment	Generally level except for the area near the Bluemound and Barker intersection	
Laning	Bluemound Road is an eight lane divided highway. The right lanes are currently restricted use for buses and right-turns only.	

CHARACTERISTIC	DETAILS	ILLUSTRATION OR COMMENT
Median Breaks	Mid-block bi-directional median breaks are present on the corridor. There is potential for interference between median breaks and through traffic. The breaks generate accelerating, decelerating, and turning traffic close to the intersection.	
Accesses	Many commercial driveways are located along the corridor.	
Speeds	45 mph on Bluemound Road	During site visits, traffic appeared to travel at speeds consistent with the posted speed limits.
Pedestrian Facilities	The pedestrian network is currently incomplete. A continuous sidewalk is located on the south side of Bluemound Road. On the north side the sidewalks are present in some areas while not in others. This may be due to a lack of jurisdictional cooperation.	
Bicycle Facilities	Designated Bicycle Facilities such as lanage do not currently exist. Bicyclists were observed riding either in right-lanes of Bluemound Rd. or on the sidewalks.	

CHARACTERISTIC	DETAILS	ILLUSTRATION OR COMMENT
Transit Facilities	Waukesha County Metro buses are present along Bluemound Rd. Transit facilities consist primarily of signage. A park and ride lot is located at the intersection of Barker and Bluemound.	

4.0 ROAD SAFETY AUDIT ISSUES AND SUGGESTIONS

4.1 Safety Issue 1: Rear End Crashes in Right-Turn Channelization Islands

Safety Issue 1a: A high frequency of rear end right-turn crashes are occurring on northbound Barker as a result of limited sight distance due to the shape of the right-turn channelizing island.

Safety Issue 1a Description: A review of the crash data for the intersection of Barker and Bluemound indicated that 49 rear end crashes were occurring within the northbound right-turn channelization island. The first issue identified at the channelization island is the intersection sight distance between right-turners and approaching through traffic. The combination of a horizontal curve on Bluemound and the drivers requirement to look back impacts the sight distance.

Right-turn Channelization Island on Northbound Barker

Next, this right-turn channelization island 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. The crosswalk is located behind the point where vehicles are supposed to yield. When pedestrians are present, drivers typically have to slow down twice, once to yield for crossing pedestrians and the second time to yield to through traffic.

Weave Section between I-94 and Bluemound on Northbound Barker

Finally there is a weave section on northbound Barker between the I-94 interchange and Bluemound Road. As a result drivers were observed weaving into the right-turn lane close to Bluemound Road and abruptly slowing down for either a crossing pedestrian or the yield sign.

Safety Issue 1b: Several other right-turn channelization islands along the corridor also experienced similar patterns of rear end crashes.

Safety Issue 1b Description: The crash data provided by WisDOT indicated that rear end crashes also occurred at many of the other right-turn channelization islands along the corridor. These occurred for several of the same reasons as discussed in Safety Issue 1(a).

Expected Crash Types: rear-end crashes

Expected Frequency: occasional

Expected Severity: frequent

Risk Rating: C (moderate-high risk level)

Opportunities for Improvement

Safety Issue		Suggestions	
1a	**1b**		
√	√	*1. 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. It is noted that a redesigned right-turn chanelization 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 Cleveland in Waukesha County*

Safety Issue		Suggestions	
1a	**1b**		
√	√	*2. No Turn on Red* Several of the right-turn channelization islands will be signalized as part of this project. It is suggested that NO TURN ON RED restrictions be considered for the northbound Barker and Bluemound approaches due to the high frequency of rear end crashes.  It is suggested that the following approaches be monitored once the improvements are implemented to determine if NO TURN ON RED restrictions should be considered: • Bluemound and Barker (eastbound and southbound approaches) • Bluemound and Calhoun (northbound and southbound approaches) • Bluemound and Thomas Lane (northbound approach) • Bluemound and Moorland (all approaches)	

4.2 Safety Issue 2: Proximity of the dual-restricted median openings

Safety Issue 2 Description: Current design drawings indicate an extremely short distance between the opposing turn lanes within the dual restricted median openings. This layout can limit the view of opposing through traffic for drivers turning left or making a u-turn. Opposing vehicles waiting to turn left partly block sightlines between left-turn drivers and opposing through traffic (especially vehicles in the left through lane). This view of oncoming traffic can be further obstructed when a large truck is in the opposing turn lane. Drivers who cannot see approaching vehicles may attempt to turn left across the path of an oncoming vehicle, which may increase the risk of left-turn collisions. FIGURE 4.1 below illustrates this safety issue.

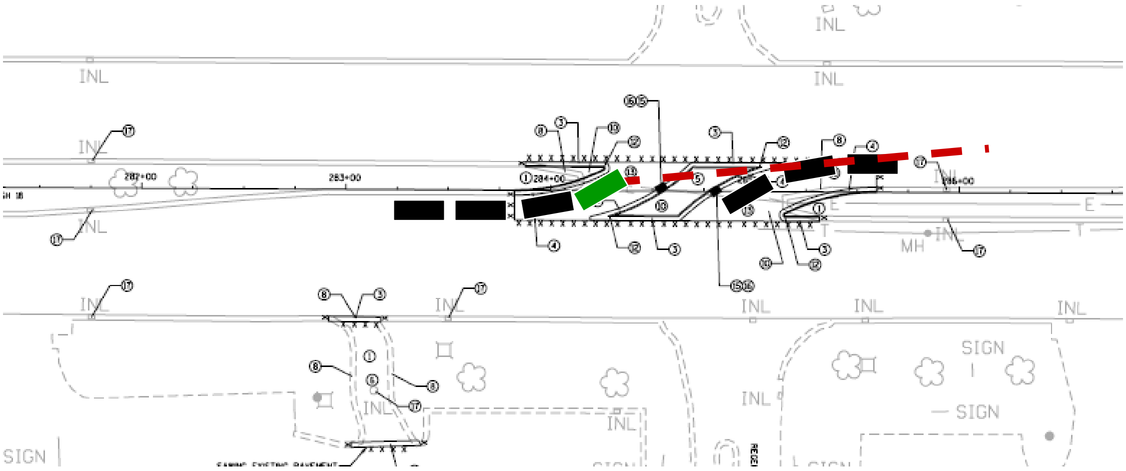


FIGURE 4.1 PROPOSED MEDIAN NOSE CONFIGURATION

Expected Crash Types:	left-turn and rear-end collisions
Expected Frequency:	occasional
Expected Severity:	high
Risk Rating:	C (moderate-high risk level)

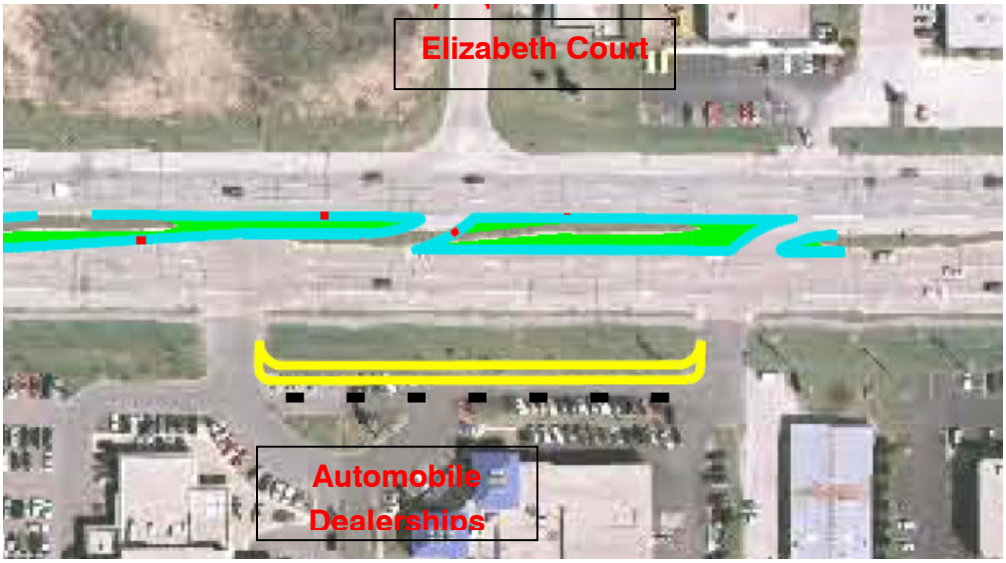
Opportunities for Improvement

Increase the distance between the median openings to at least 100-feet and preferably 150-feet. This will enhance the sight distance for drivers looking to make left- or u-turn within the dual restricted median openings. By enhancing the sight distance the risk of left-turn and read end collisions will be significantly reduced.

Marcus Drive
See Issue 3

Elizabeth Drive

The westbound median opening may be moved to the east to line up with the east driveway of the automobile dealerships. By moving this driveway, the sight distance will be enhanced, the automobile dealership will not lose their direct access to Bluemound Road and the existing driveway layout will not need to be changed.



Regency Court

At this intersection it is suggested that the westbound median opening may be moved to the east to line up with Regency Court. By moving this driveway, the sight distance will be enhanced and direct access can be provided to Regency Court.

4.3 Safety Issue 3: Eastbound left-turns at Marcus Drive

Safety Issue 3 Description: On westbound Bluemound Road the queue from the signal at Barker regularly extends 450 feet (according to the Earth Tech reports) which is beyond the existing signal at Marcus Drive. This was one of the reasons why the traffic signal at Marcus Drive is proposed to be relocated to the intersection of Bluemound and Jennifer.

Once the signal is relocated, eastbound drivers turning left at a median break into Pano's will have to cross four opposing lanes of traffic. This maneuver may generate eastbound left-turn and rear end conflicts with opposing through vehicles. The potential for collisions is further increased when drivers turn left through the traffic queued back from the signal at Barker Road. This in combination with the issues associated with the close proximity of the proposed dual restricted median openings which were discussed in Safety Issue 2, makes this eastbound left-turn movement a concern.

Expected Crash Types: left-turn and rear end crashes

Expected Frequency: occasional

Expected Severity: moderate

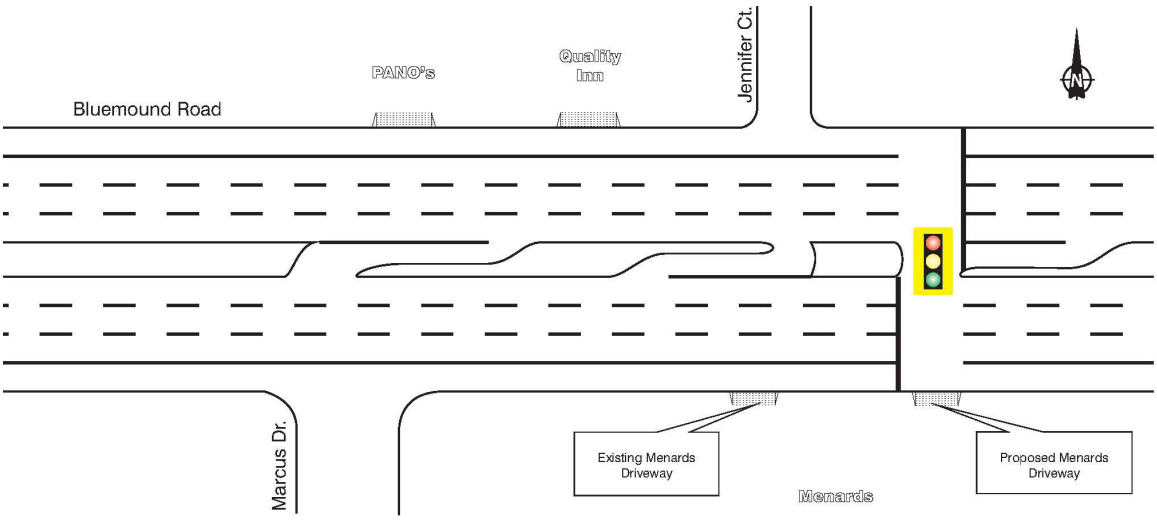
Risk Rating: C (moderate-high risk level)

Opportunities for Improvement

The RSA team identified three suggestions that can be considered to enhance safety at this intersection:

- Close the median opening for eastbound Bluemound into Pano's.
- Close the direct left-turn lane for Jennifer and create a single eastbound restricted median opening between Jennifer and Marcus.
- Move the proposed signal at Jennifer to the east so it is aligned with the northeast corner of the Menards parking lot.

These changes which are illustrated on the following page will provide reasonable access to all of the businesses along this section of Bluemound Road while eliminating the need for drivers to cross four lanes of opposing traffic through the queue for Barker Road. In addition this will increase the distance between this signal and the Barker Road signal which should help with the corridor progression. While this change may not be feasible for this project, it should be considered for the 2012 Bluemound Road reconstruction project.



Bluemound Road near Marcus Drive

4.4 Safety Issue 4: Mid-Block Accesses

Safety Issue 4 Description: Restricting access to these sites may cause drivers to take indirect routes, make U-turns at signalized intersections, or drive through parking lots, to reach the sites. Indirect routes may increase volumes on other roads that may not have sufficient capacity; U-turns at signalized intersections are illegal and may contribute to an increased risk of collision at the intersection (particularly with a conflicting right-turn movement); parking lots are not intended for through traffic, and through traffic, which is likely to be traveling at higher speeds, may conflict with pedestrians walking to and from their vehicles, and vehicles entering and exiting parking stalls. Locations in which these observations apply include:

- Fiserv Drive
- Patrick Drive
- Brookfield Square Entrance / North Shore Bank

Expected Crash Types: sideswipe and rear-end collisions

Expected Frequency: occasional

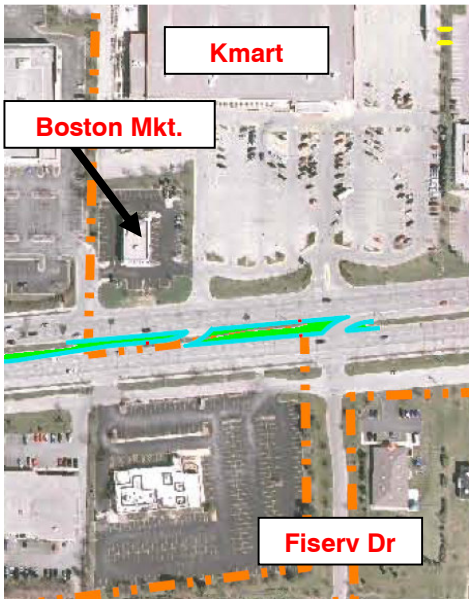
Expected Severity: moderate

Risk Rating: C (moderate-high risk level)

Opportunities for Improvement

Fiserv Drive
Realigning proposed median breaks to provide direct access to the K-Mart and Boston Market driveways and Fiserv Drive would reduce the need for drivers to access these sites indirectly. This layout is illustrated on the following page.

Patrick Boulevard
Realigning proposed median breaks to provide direct access to Partick Boulevard would reduce the need for drivers to access these sites indirectly. This will allow for direct access to Patrick Boulevard and the undeveloped parcel. This layout is illustrated below.

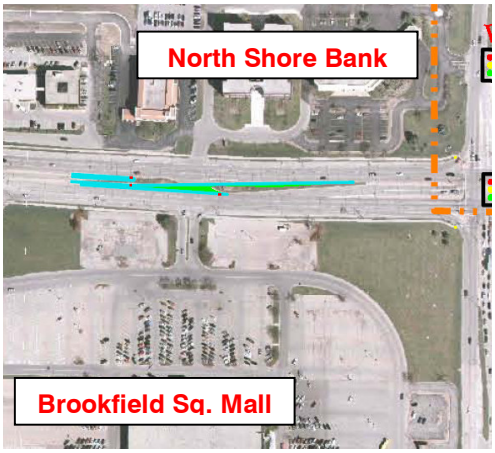


Bluemound Road near Fiserv Drive

Bluemound Road near Patrick Blvd.

Brookfield Square Entrance / North Shore Bank

Although the audited design included closure of the existing bidirectional median opening, serving Brookfield Square Mall and the North Shore Bank *(right),* the design team asked the RSA team to comment on the safety implications of keeping the median opening. A review of crashes and roadway geometry near this median opening suggests that it should be closed for the following reasons:



Bluemound Road near
Brookfield Square Entrance / North Shore Bank

- A history of angle and left-turn crashes within the existing median opening indicates that the opening is a safety issue;
- The close proximity of the median opening to two signalized intersections may result in interference with intersection operations;
- Limited space for left-turn storage availability for a median opening for North Shore Bank; and,
- Drivers turning left at the median opening through traffic queued at the adjacent intersection may conflict with opposing through traffic, particularly

when queued vehicles block sightlines between left-turn and through vehicles.

To discourage illegal turning maneuvers and cut-through traffic it is also suggested that improved access be provided to the North Shore Bank site via Main Street and/or the proposed extension of Watertown Plank Road.

4.5 Safety Issue 5: U-Turns at Median Openings

Safety Issue Description: The proposed configuration of the median openings makes it more difficult for drivers to make u-turns. U-turns are likely to increase along the corridor as a result of the proposed changes. As a result crashes associated with drivers making u-turns are also likely to increase.

When auditing the designs, two items were identified within the designs related to u-turns at the median openings. The first item was related to the shape (Safety Issue 5a) of the median openings while the second was related to the signing (Safety Issue 5b).

Safety Issue 5a: With the changes in geometrics for the corridor, it is expected that the volumes of u-turning vehicles along the corridor will increase due to the elimination of many of the direct left-turn on to Bluemound Road. The proposed median nose configuration may orient vehicles to make left-turns. U-turns within the proposed median configuration may be more difficult due to the pointed median nose (*below*).

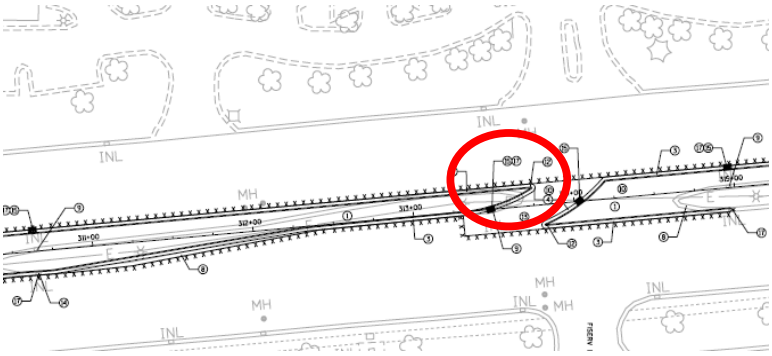


FIGURE 4.2 PROPOSED MEDIAN NOSE CONFIGURATION

Safety Issue 5b: Guide signing was included within the provided design drawings to inform drivers of the maneuver required to make a left-turn on to Bluemound Road.

Expected Crash Types: rear-end, left-turn and sideswipe collisions

Expected Frequency: occasional

Expected Severity: moderate

Risk Rating: C (moderate-high risk level)

Opportunities for Improvement

It is suggested that a more rounded nose configuration be considered for the median openings on Bluemound Road. A more rounded nose will make it easier for drivers to make u-turns.

It is also suggested that upgrades that guide signing be provided along Bluemound Road which directs drivers to and through the proposed median u-turns. The example located on the following page illustrates the standard signing scheme used by the Michigan Department of Transportation[1] for unsignalized median left-turn and u-turn crossovers.

[1] *Traffic and Safety Notes: Notes 101A to 1102A*; Michigan Department of Transportation, Traffic and Safety Division, September 2006.

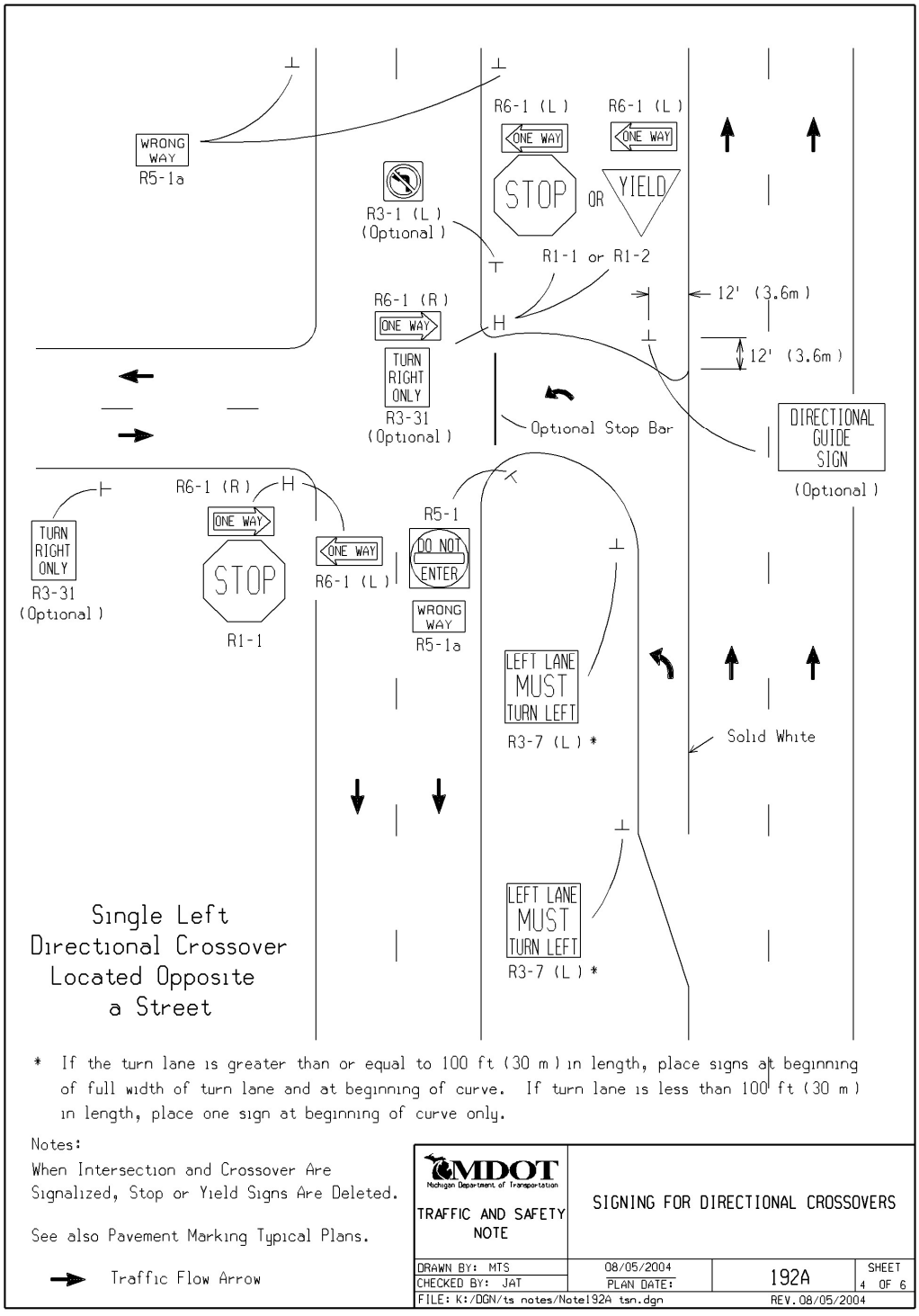


FIGURE 4.3 MICHIGAN DOT TYPICAL SIGNING FOR MEDIAN CROSSOVERS

4.6 Safety Issue 6: Accommodating Pedestrians

Safety Issue Description: The pedestrian facilities along Bluemound Road are incomplete. During site visits, moderate pedestrian volumes were observed. Pedestrian traffic appeared to be generated by the transit stops, office buildings, many strip malls and fast food restaurants. While continuous pedestrian facilities are provided on the south side of Bluemound Road, the network is not complete on the north side. As a result, pedestrians were observed walking in the street and crossing at locations where drivers do not expect to see pedestrians.

Pedestrian on the North Side of Bluemound Road

Transit Stop on Bluemound Road

Expected Crash Types: pedestrian collisions

Expected Frequency: infrequent

Expected Severity: extreme

Risk Rating: D (significant-high risk level)

Opportunities for Improvement

As part of the 2012 reconstruction project consider working with the local agencies to complete the pedestrian network on Bluemound Road.

4.7 Safety Issue 7: Signal Displays

Safety Issue 7 Description: 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. The risks associated with limited signal and intersection conspicuousness is greatest at the intersection with Barker Road, where drivers' view of the intersection on several approaches is limited by vertical and horizontal curves. 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.

Southbound Barker at Bluemound

Eastbound Bluemound at Calhoun

Expected Crash Types: rear end and angle collisions

Expected Frequency: occasional

Expected Severity: moderate

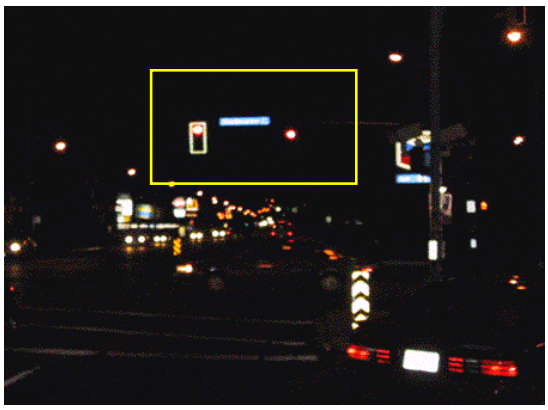
Risk Rating: C (moderate-high risk level)

Opportunities for Improvement

1. Provide a redundant signal display on each approach. The use of multiple overhead signal displays on a single approach enhances signal conspicuousness, provides redundancy in the event of signal failure or damage, and may improve signal visibility. Redundancy may be achieved by providing multiple signal overhead heads (such as one signal head over each approach lane).

Source: Iowa DOT

2. Provide signal backplates with reflective borders. The effectiveness of a yellow reflective border is shown below. The reflective border renders the signal more conspicuous under both daytime and night-time conditions. By outlining the perimeter of the backplate, the reflective tape also enables drivers to more easily distinguish the relative position of the lighted lens, assisting elderly and color-blind drivers who have poor color perception. Reflective borders on signal backplates have received interim approval from the FHWA.



*signals with (left) and without (right) reflective border at night**

signals with reflective border in daytime

3. Increase the bottom height of the far-side left-turn signals

By mounting these signals higher above the approach lanes, signal visibility improves for approaching drivers. Higher mounting heights will also reduce visual obstruction by large vehicles stopped at the intersection.

4.8 Other Safety Issues

Street Lighting
Currently, street lighting is provided on Bluemound Road between Brookfield Road and Moorland Road. No street lighting is provided between Brookfield Road and Barker Road. The absence of lighting on this section limits approaching drivers' awareness of the median openings and commercial driveways. It also limits sight distance at these unsignalized intersections, where conflicts with vehicles (slowing and turning) are most likely to occur. The changes in vertical alignment along this section of the corridor limit drivers' ability to anticipate median opening configurations and driveway locations. Possible conflicts at these locations increase the need for intersection lighting.

Curb Lane Signing
The existing curb lane signs do not allow for bicycles. As these signs will be replaced due to changes in the MUTCD with regards to diamond lanes, the audit team reviewed the existing sign design and a proposed sign design. The existing sign design utilizes text to allow buses and right turns only.

It is suggested that symbols for both buses and bikes be utilized on these signs to increase their clarity. The figure below illustrates a possible design for this sign.

Existing Sign Design

Suggested Sign Design

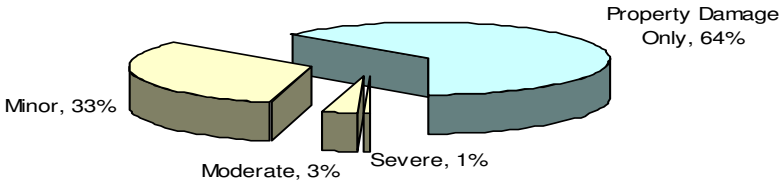
Plaza 173 Driveways

The design team asked the RSA team to review two possible driveway layouts for the Brookfield Road accesses to Plaza 173. It is suggested that the new driveway be located at the north end of the Plaza 173's lot. The reason is to prevent conflicts between drivers entering and exiting Plaza 173 and the left-turn lanes on Brookfield Road.

APPENDIX A
COLLISION ANALYSIS

Police collision reports were provided by the Wisconsin DOT, and were supplemented by a collision data summary. Annually, 199 collisions were recorded at or near intersections, while 120 collisions were recorded at mid-block area. As summarized, about 37 percent of the collisions resulted in at least one non-fatal injury. The remainder of the collisions involved property damage only. No fatalities were reported during the study period.

FIGURE A-1 COLLISION SEVERITY DISTRIBUTION



A.1 Collision Types

Collision type distributions are summarized in FIGURE A-2/A-3 and TABLE A-1/A-2. A review of the collision types shows that rear end collisions predominated, representing 71 percent of intersection collisions and 29 percent of mid-block collisions. Sideswipe, angle, and left turn collisions represented 5 to 15 percent of reported intersection collisions and 16 to 29 percent of reported mid-block collisions.

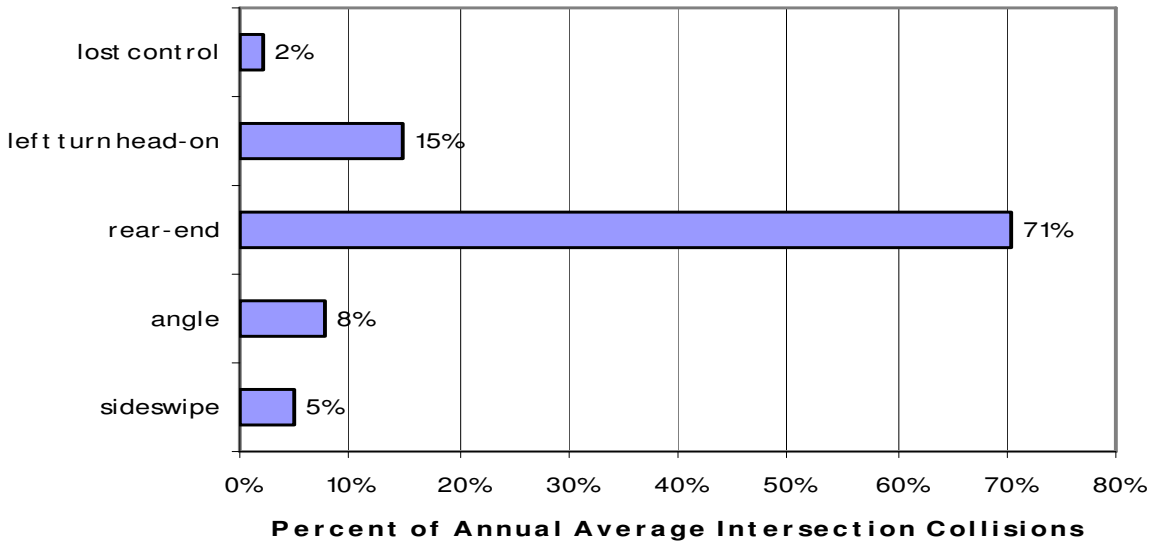


FIGURE A-2 Intersection Collision Type Distribution

TABLE A-1 COLLISION TYPE DISTRIBUTION

Location	Ped/Bike	Sideswipe	Angle	Rear-end	Left-turn	Fixed Object	Lost Control	Total	% of Total
Barker	0	1	3	33	3	0	1	41	21%
Moorland/Pilgrim	0	0	0	19	2	0	0	21	11%
Thomas	0	2	1	9	3	0	0	15	8%
Executive	0	0	0	5	1	0	1	7	4%
Calhoun	0	2	1	18	2	1	0	24	12%
Corporate/Woeffel	0	1	0	14	3	0	0	18	9%
Brookfield	1	2	0	21	7	0	2	33	17%
Janacek	0	1	0	5	1	0	0	7	4%
Marcus	0	1	3	11	5	0	0	20	10%
Ruf	0	0	7	4	2	0	0	13	7%
TOTAL	1	10	15	139	29	1	4	199	100%

TABLE A-2 MID-BLOCK COLLISION TYPE DISTRIBUTION

Location	Ped/Bike	Sideswipe	Angle	Rear-end	Left-turn	Head - On	Fixed Object	Lost Control	Total	% of Total
Barker - Marcus	0	0	0	0	0	0	0	0	0	0%
Marcus - Jennifer	0	0	3	1	1	0	0	0	5	5%
Jennifer - Elizabeth	0	0	0	1	0	0	0	0	1	1%
Elizabeth - Janacek	0	0	1	2	0	0	0	0	3	3%
Janacek - Brookfield	0	2	3	4	3	0	0	0	12	11%
Brookfield - Corporate/Woeffel	0	6	8	4	6	0	1	1	26	24%
Corporate/Woeffel - Calhoun	0	4	7	7	4	0	1	0	23	21%
Calhoun - Thomas	0	3	3	1	0	0	0	0	7	6%
Thomas - Ruff	0	1	2	7	3	1	0	1	15	14%
Ruff - Executive	0	0	4	4	1	0	1	0	10	9%
Executive - Main	0	2	1	2	0	0	1	1	7	6%
Main - Moorland/Pilgrim	0	1	3	2	3	0	1	1	11	10%
TOTAL	0	19	35	35	21	1	5	4	120	100%

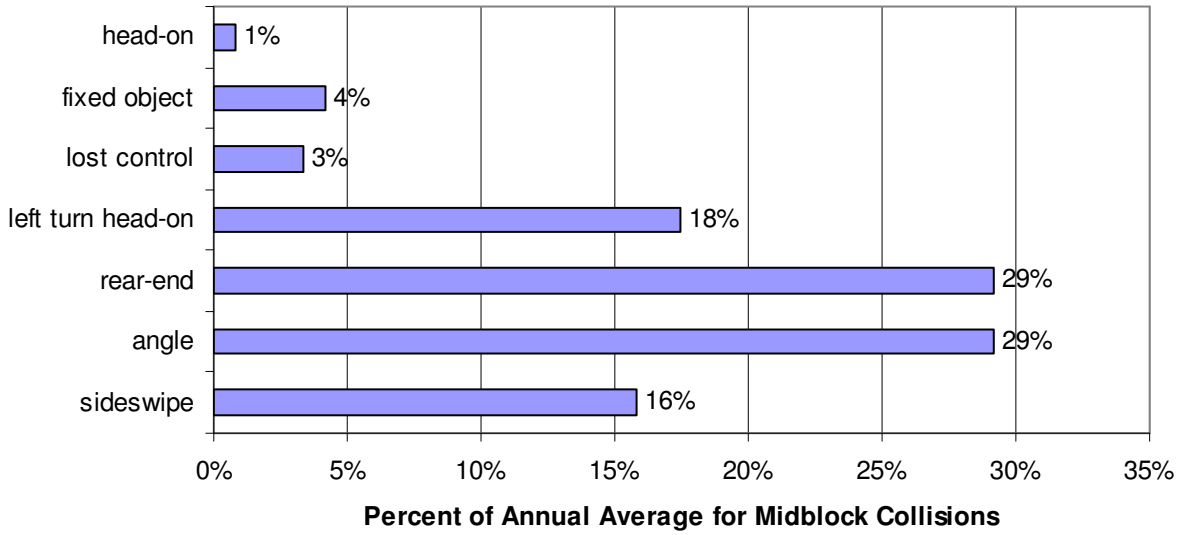
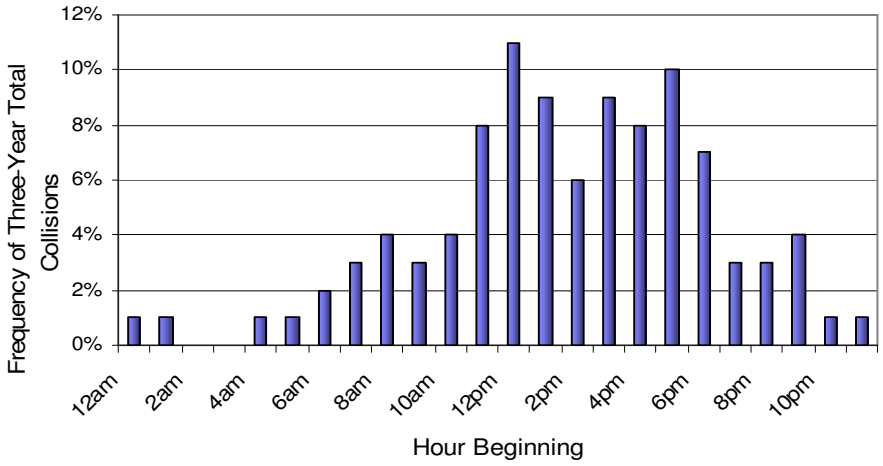
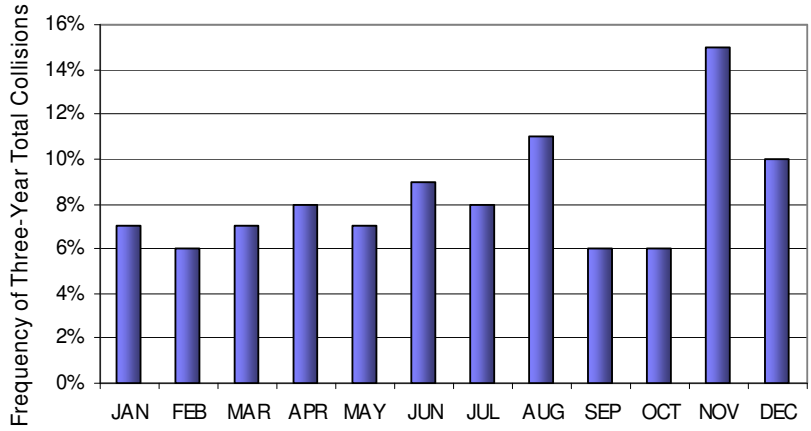


FIGURE A-3 INTERSECTION COLLISION TYPE DISTRIBUTION



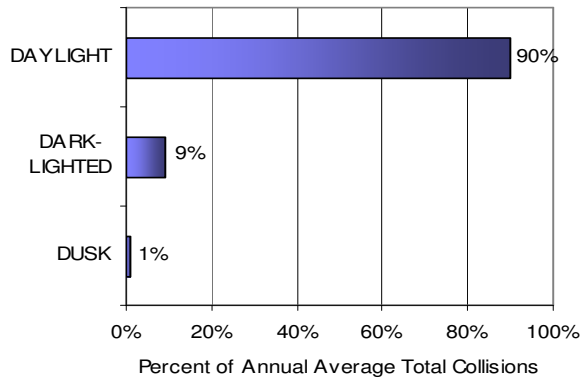
Hour

The highest hourly frequencies occurred between 12:00 pm and 1:00 pm, possibly due to the lunch/day shopper crowd and between 5:00 pm and 6:00 pm which is the peak of afternoon rush hour traffic.

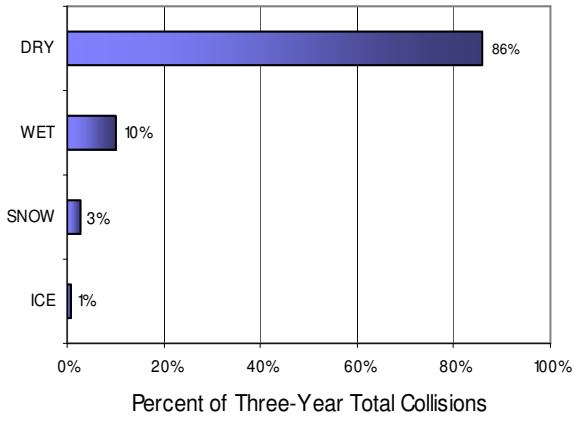


Month

Monthly distributions do not show strong seasonal trends



Lighting



Road Condition

Well over half of all reported collisions occurred in daylight and on dry pavement. These distributions, which are broadly consistent with environmental conditions, suggest that environmental conditions are not substantial contributors to collisions reported in this corridor.

FIGURE A-4 ENVIRONMENTAL COLLISION TRENDS

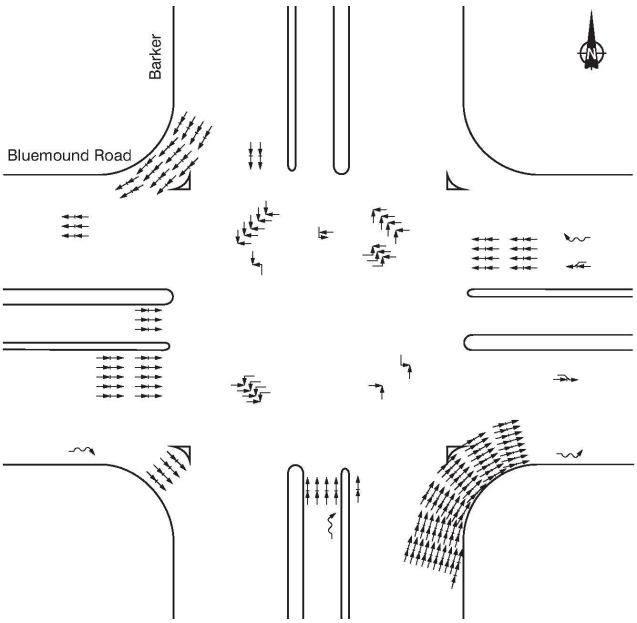


FIGURE A-5 COLLISION DISTRIBUTION: BLUEMOUND AND BARKER

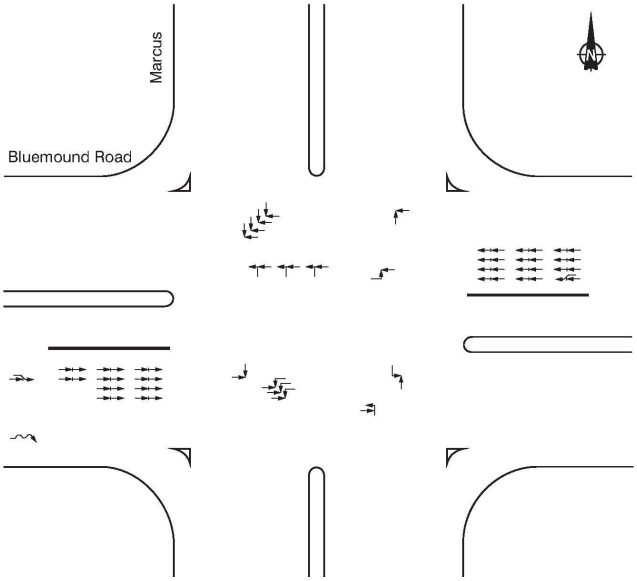


FIGURE A-6 COLLISION DISTRIBUTION: BLUEMOUND AND MARCUS

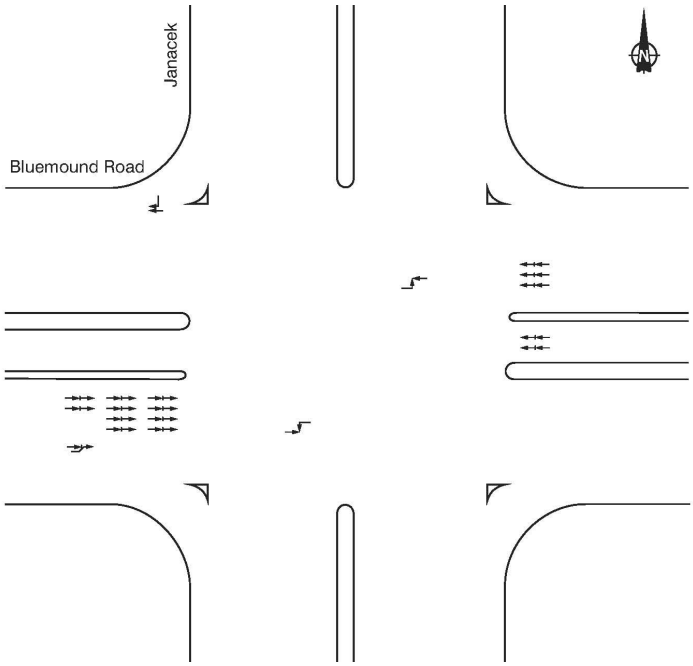


FIGURE A-7 COLLISION DISTRIBUTION: BLUEMOUND AND JANACEK

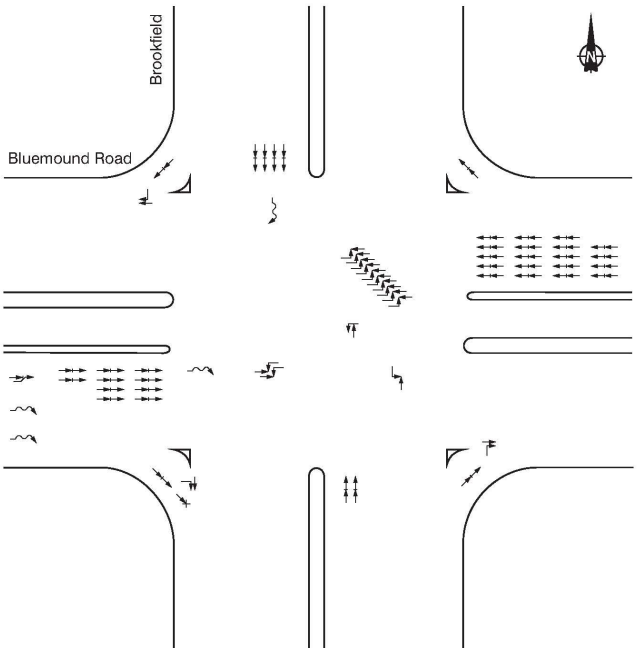


FIGURE A-8 COLLISION DISTRIBUTION: BLUEMOUND AND BROOKFIELD

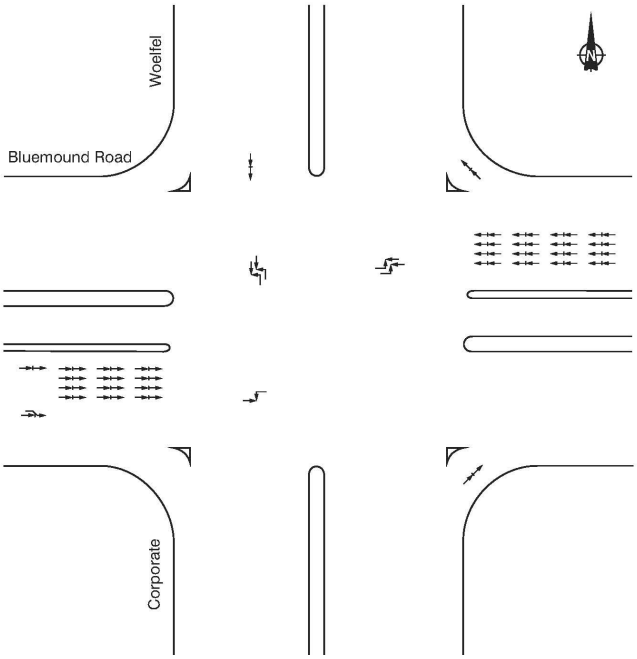


FIGURE A-9 COLLISION DISTRIBUTION: BLUEMOUND AND CORPORATE/WOELFEL

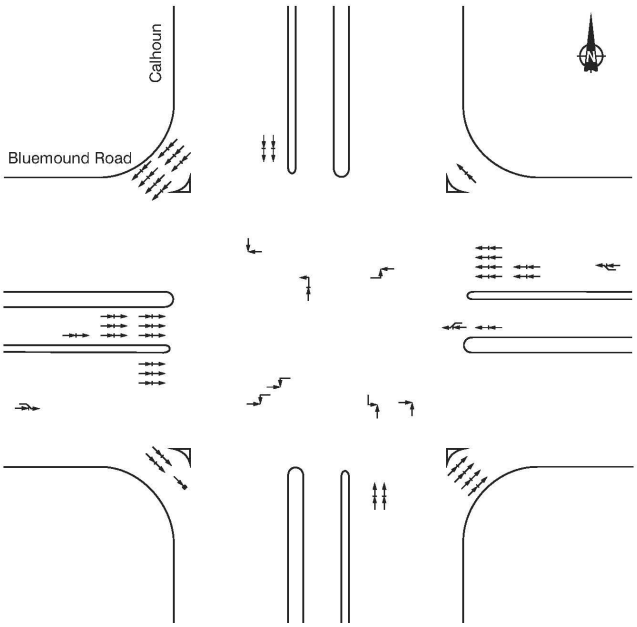


FIGURE A-10 COLLISION DISTRIBUTION: BLUEMOUND AND CALHOUN

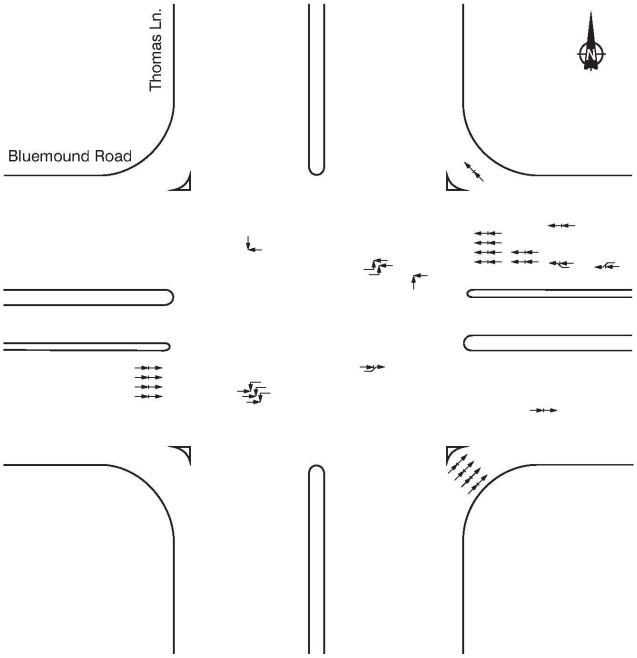


FIGURE A-11 COLLISION DISTRIBUTION: BLUEMOUND AND THOMAS

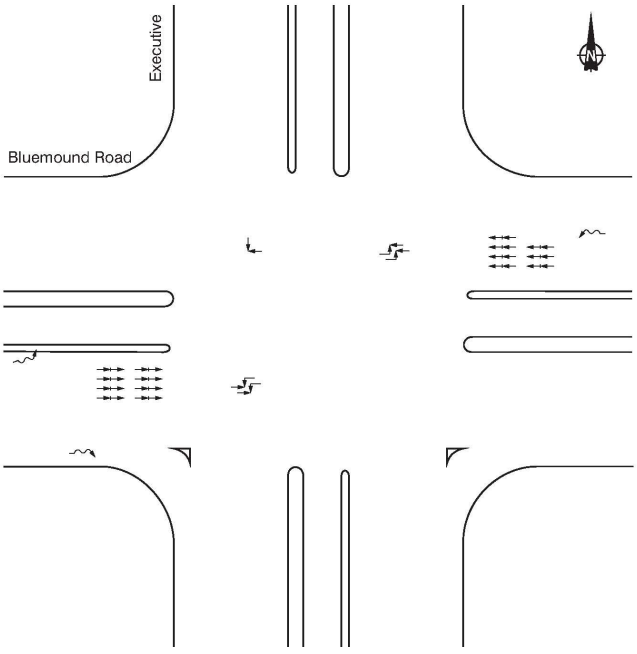


FIGURE A-12 COLLISION DISTRIBUTION: BLUEMOUND AND EXECUTIVE

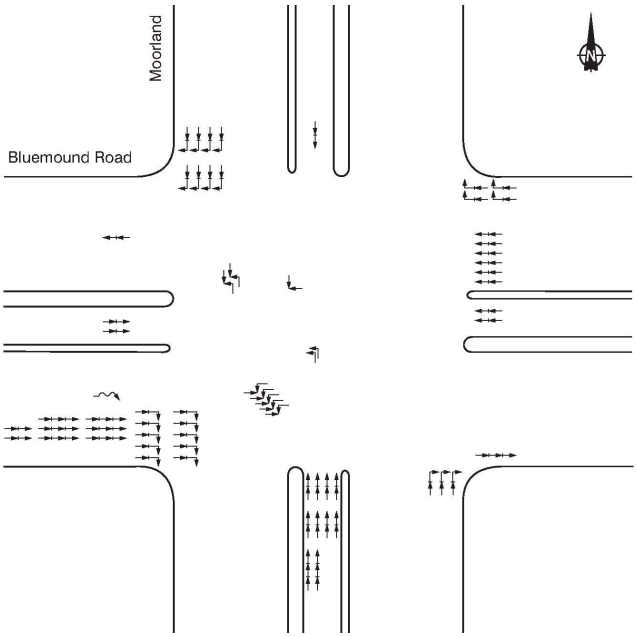


FIGURE A-13 COLLISION DISTRIBUTION: BLUEMOUND AND MOORLAND

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