US-23 Flex Route Phase 2
Alternative Analysis Report

March 2021

FlexRoute23

Table of Contents

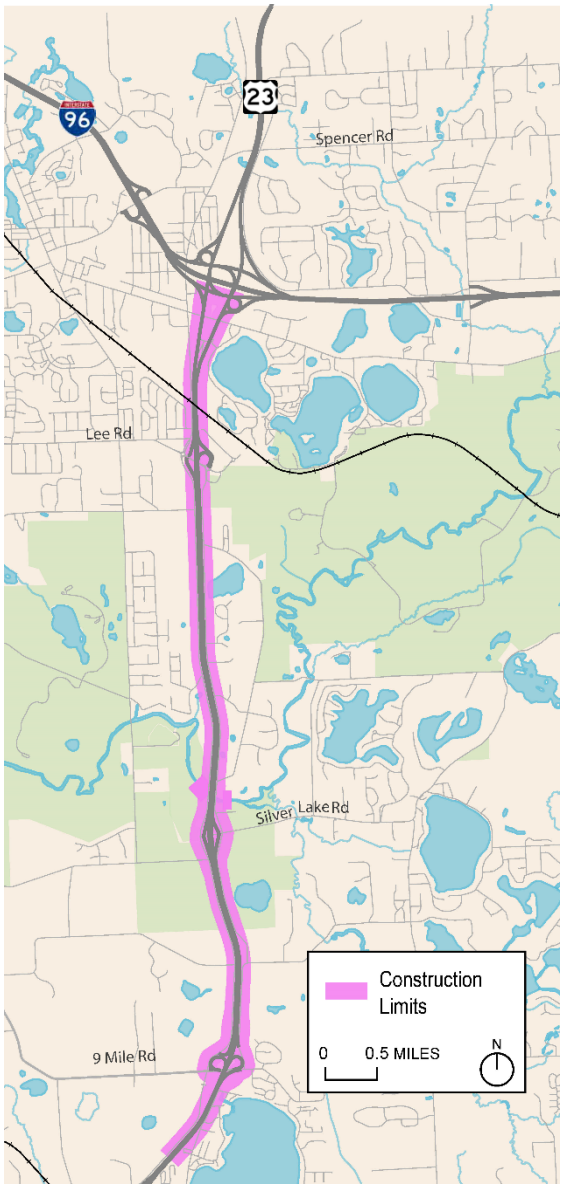
List of Figures

List of Tables

1 Introduction

The US-23 Flex Route Phase 2 project proposes extending the US-23 Flex Route to the north from its current terminus, in-between the Eight Mile Road and M-36 (9 Mile Road) interchanges, to I-96 as shown in **Figure 1**. In addition to determing the exact limits of the US-23 Flex Route extension, alternatives were considered for the US-23 interchanges at Silver Lake Road and M-36 (9 Mile Road). This report documents the alternatives considered for the US-23 Flex Route, the M-36 (9 Mile Road) interchange, and the Silver Lake Road interchange. The traffic, roadway, and bridge impacts are summarized for each alternative in order to reach a preferred alternative for the US-23 corridor.

Figure 1: Construction Limits



2 Southbound US-23

The existing southbound US-23 study area corridor consists of two through lanes from north of the US-23 interchange with I-96 to north of Barker Road, approximately 8 miles. The southbound US-23 mainline gains an additional lane beginning south of M-36 (9 Mile Road) during the AM peak period when the existing Flex Lane is open.

Along the primary segment of southbound US-23, access is limited to a right-hand and left-hand exit ramp to I-96, I-96 entrance ramp, and Lee Road, Silver Lake Road, M-36 (9 Mile Road), 8 Mile Road entrance and exit ramps. These exits also provide access to and from Whitmore Lake Road and Fieldcrest Drive, which run along US-23 for a majority of the study corridor and provide access to numerous local roads and neighborhoods.

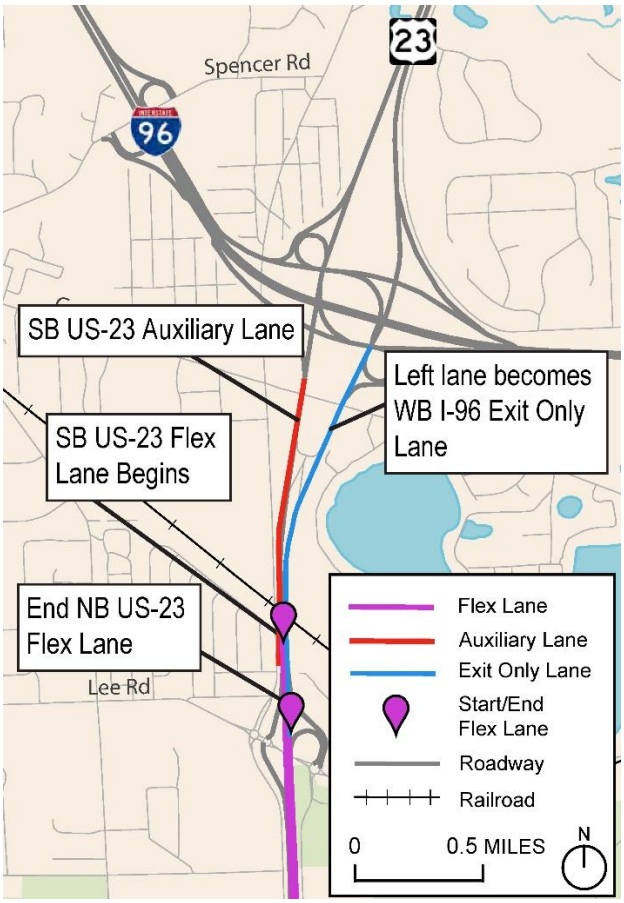
2.1 Alternatives Considered

There were two alternatives analyzed for the southbound US-23 corridor. In Alternative 1, the southbound US-23 Flex Lane would begin just south of the eastbound I-96 exit ramp and would continue to the existing US-23 Flex Lane south of M-36 (9 Mile Road). This alternative is shown in **Figure 2**.

Figure 2: Alternative 1 SB US-23 Corridor

In Alternative 2b, the southbound US-23 Flex Lane would begin just south of the railroad bridge located south of the I-96 interchange. An auxiliary lane would be added along southbound US-23 from the eastbound I-96 entrance ramp to the Lee Road exit ramp. The auxiliary lane would be approximately 4,500 feet in length allowing vehicles to maneuver to the correct lane in order to access the US-23 mainline or the Lee Road exit ramp. This alternative is shown in **Figure 3**.

Figure 3: Alternative 2b SB US-23 Corridor



A third alternative, Alternative 2a, was initially considered in addition to the two alternatives previously discussed. The southbound US-23 corridor for this alternative was identical to the proposed Alternative 2b. Alternative 2a was modified in the northbound direction when compared to Alternative 2b. The northbound differences in Alternative 2a and 2b are discussed in the Northbound US-23 section.

In addition to these changes, both alternatives feature ramp modifications which are discussed later in this document.

2.2 Evaluation

2.2.1 Traffic Impacts

The two build alternatives utilized a Flex Lane along US-23 in the southbound direction in the AM peak period. As documented in the *US-23 Flex Route Phase 2 Traffic Analysis Report,* the Flex Lane would provide a noticeable reduction in travel time along US-23 southbound in the direction of peak travel in the morning.

The AM travel time along US-23 southbound from Spencer Road (north of I-96) to 8 Mile Road would be reduced by 9.3 minutes when compared to the Future No-Build

model, as shown in **Table 1**. The additional lane in the southbound direction in the AM peak period helps to reduce congestion along US-23 in both Alternative 1 and 2b.

Table 1: Southbound US-23 Travel Time Comparison

Direction	US-23 Freeway Segment	Distance (miles)	FNB (min)	Alt. 1 (min)	Diff (Alt. 1-FNB)	Alt 2b (min)	Diff (Alt. 2b-FNB)
AM Southbound	Spencer Rd to I-96	0.89	3.89	0.83	-3.06	0.83	-3.06
	I-96 to Lee Rd	1.16	4.40	1.09	-3.31	1.10	-3.30
	Lee Rd to Silver Lake Rd	2.26	3.90	2.05	-1.85	2.05	-1.85
	Silver Lee Rd to M-36 (9 Mile Rd)	1.48	2.46	1.35	-1.11	1.34	-1.12
	M-36 (9 Mile Rd) to 8 Mile Rd	0.91	0.82	0.83	0.01	0.83	0.00
	Southbound US-23	**6.70**	**15.46**	**6.15**	**-9.32**	**6.15**	**-9.32**
PM Southbound	Spencer Rd to I-96	0.89	0.80	0.79	-0.01	0.79	-0.01
	I-96 to Lee Rd	1.16	2.26	1.09	-1.17	1.08	-1.18
	Lee Rd to Silver Lake Rd	2.26	2.07	2.05	-0.02	2.08	0.01
	Silver Lee Rd to M-36 (9 Mile Rd)	1.48	1.35	1.36	0.01	1.35	0.00
	M-36 (9 Mile Rd) to 8 Mile Rd	0.91	0.81	0.83	0.02	0.82	0.01
	Southbound US-23	**6.70**	**7.29**	**6.14**	**-1.15**	**6.14**	**-1.17**

The freeway segment LOS is greatly improved with the additional US-23 Flex Lane in the southbound direction in the AM peak period. Major congestion is expected to occur in the Future No-Build Alternative where the eastbound I-96 Collector Distributor (C/D) entrance ramp merges with southbound US-23. This is expected to result in a bottleneck location with slower speeds shown from the eastbound I-96 C/D entrance ramp to the M-36 (9 Mile Road) interchange. This bottleneck is resolved in the build alternatives by adding additional capacity with the Flex Route Extension in Alternative 1 and the auxiliary lane and Flex Route Extension in Alternative 2b. The complete traffic analysis results are detailed in the *US-23 Flex Route Phase 2 Traffic Analysis Report.*

2.2.2 Roadway Impacts

The extension of the US-23 Flex Lane would have no additional right-of-way impacts. Drainage impacts were also considered as implementation of the southbound Flex Lane requires widening the median shoulder which increases the amount of impervious area. However, based on the net change in impervious area there should be available room within the right-of-way to accommodate the additional runoff. The current southbound travel lanes would remain 12 feet wide and the Flex Lane will be 11 feet wide. The

proposed 11-foot-wide Flex Lane is acceptable by FHWA per the *US-23 Flex Route Phase 2 Preliminary Scoping Report*."

2.2.3 Bridge Impacts

Several bridges would potentially be impacted by this project. Due to the median widening, the southbound bridge over the Huron River, north of the Silver Lake Road interchange, would need to be modified. A mussel survey was conducted and found federally protected Snuffbox mussels. These mussels would be moved prior to construction and MDOT will coordinate with the U.S. Fish and Wildlife Service.

The Grand River Avenue bridge over southbound US-23, just south of I-96, will require rehabilitation but will not be replaced. The US-23 existing inside and outside shoulder width will remain the same in the southbound direction and are provided in **Table 2**. The southbound bridge over Silver Lake Road will require widening for flex lane/shoulder width, plus other rehabilitation items. The US-23 bridge over M-36 (9 Mile Road) will be replaced. This is due to poor condition and a needed alignment shift, but it must be wider to accommodate the wider shoulders/flex lanes anyway.

In addition, the existing railroad bridge over southbound US-23 between I-96 and Lee Road restricts the number of lanes that can be constructed. However, both alternatives negate having to the replace the bridge while being able to reduce congestion and improve safety. The existing and proposed shoulder widths for southbound US-23 under the railroad bridge are provided in **Table 2**. The proposed shoulder widths along US-23 at this location will require a design exception.

Table 2: Southbound Paved Shoulder Width under CSX railroad bridge and Grand River Bridge

Structure	Description	Inside Shoulder		Outside Shoulder	
		Existing	Proposed	Existing	Proposed
X01-47013	SB US-23 under CSX railroad	8 ft	5.75 ft	10 ft	6.75 ft
S05-47013	SB US-23 under Grand River	16 ft	16 ft*	7 ft*	7 ft*

ft – feet
*shoulder is adjacent to an auxiliary lane

2.3 Comparison and Selection

After a comparison between impacts to travel time and congestion, Alternative 2b is the Preferred Alternative in the southbound US-23 direction. With this alternative, the Flex Lane will start just north of the Lee Road exit ramp and south of the CSX railroad bridge. An auxiliary lane will be added along southbound US-23 between the eastbound I-96 entrance ramp and the Lee Road exit ramp. The addition of the auxiliary lane will allow vehicles to enter US-23 southbound from eastbound I-96 and exit to Lee Road without having to change lanes. The auxiliary lane will be approximately 4,500 feet in length allowing vehicles to maneuver to the correct lane in order to access the US-23 mainline or the Lee Road exit ramp. The traffic analysis showed that both Alternative 1

and 2b reduced travel time considerably when compared to the Future No-Build condition for the segment along US-23 southbound between the I-96 interchange and Lee Road. Alternative 2b was chosen to move forward as the Preferred Alternative because of the addition of the auxiliary lane between I-96 and Lee Road reduces the number of conflicts with merging traffic onto southbound US-23. Congestion is also reduced at the eastbound I-96 entrance ramp, which was identified in the Future No-Build condition as causing a bottleneck on the ramp itself as well as southbound US-23.

3 Northbound US-23

The existing northbound US-23 study area corridor consists of two through lanes from south of Barker Road to north of the US-23 and I-96 interchange, approximately 8 miles. The northbound mainline gains an additional lane beginning south of the study area to north of 8 Mile Road interchange during the PM peak period when the existing Flex Lane is open. The northbound US-23 Flex Lane provides additional capacity in the afternoon peak period but also creates a bottleneck as the three travel lanes on US-23 are reduced to two travel lanes, approximately six miles before reaching the US-23 and I-96 interchange. The extension of the US-23 Flex Lane further north would allow for the additional capacity to be maintained along US-23 and eliminate the lane reduction during peak period conditions.

Along the primary segment of northbound US-23, access is limited to a right-hand exit ramp to Barker Road, and right-hand entrance and exit ramps at 8 Mile Road, M-36 (9 Mile Road), Silver Lake Road, Lee Road, and I-96. The US-23 and I-96 interchange provides a left-hand exit for vehicles to access I-96 westbound. These exits also provide access to and from Whitmore Lake Road and Fieldcrest Drive, which run along US-23 for a majority of the study corridor and provide access to numerous local roads and neighborhoods.

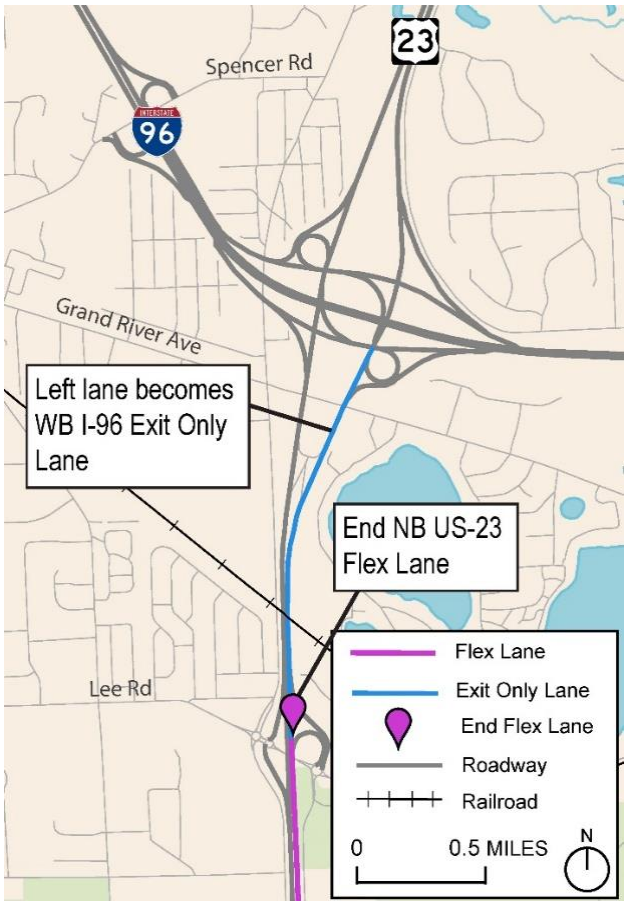
3.1 Alternatives Considered

There were two alternatives analyzed for the northbound US-23 corridor. In Alternative 1, the northbound US-23 Flex Lane would begin at the existing US-23 Flex Lane south of M-36 (9 Mile Road) and would continue north until it turns into the existing westbound I-96 exit ramp deceleration lane. This alternative is shown in **Figure 4**.

Figure 4: Alternative 1 NB US-23 Corridor

In Alternative 2b, the northbound US-23 Flex Lane would begin at the existing Flex Lane south of M-36 (9 Mile Road) and would continue north to the Lee Road interchange, at which point the lane would transition into a full-time lane until it turns into the existing westbound I-96 exit ramp. This alternative is shown in **Figure 5**.

Figure 5: Alternative 2b NB US-23 Corridor



A similar alternative, Alternative 2a, which featured an altered ending point for the northbound Flex Lane was examined. The northbound Flex Lane in Alternative 2a ends just north of the railroad bridge with the left lane transitioning into the I-96 westbound exit only lane. This alternative was developed in response to potential concerns with Alternative 1 regarding impacts to the railroad bridge and how a long northbound general-purpose lane might classify the segment into a capacity increase project. The two concerns were determined not to be an issue with the longer general-purpose lane between Lee Road and I-96. Therefore, Alternative 2b was selected to move forward as the longer northbound general-purpose lane provides a 24-hour benefit to users between Lee Road and I-96 compared to the shorter general-purpose lanes recommended in Alternative 1 and 2a.

In addition to these changes both alternatives feature ramp modifications which are discussed later in this document.

3.2 Evaluation

3.2.1 Traffic Impacts

The two build alternatives utilize a Flex Lane along US-23 in the northbound direction in the PM peak period. As documented in the *US-23 Flex Route Phase 2 Traffic Analysis Report,* the Flex Lane would provide a noticeable reduction in travel time along northbound US-23 in the afternoon peak period.

The PM travel time along northbound US-23 from 8 Mile Road to Spencer Road (north of I-96) would be reduced by 6.7 minutes when compared to the Future No-Build model, as shown in **Table 3**. The additional lane in the northbound direction in the PM peak period helps to reduce congestion along US-23 and provides similar reductions in travel time in both Alternative 1 and 2b.

Table 3: Northbound US-23 Travel Time Comparison

Direction	Freeway Segment	Distance (miles)	FNB (min)	Alt. 1 (min)	Diff (Alt. 1-FNB)	Alt 2b (min)	Diff (Alt. 2b-FNB)
AM Northbound	8 Mile Rd to M-36 (9 Mile Rd)	0.76	1.11	0.67	-0.44	0.67	-0.44
	M-36 (9 Mile Rd) to Silver Lake Rd	1.45	1.32	1.32	0.00	1.33	0.01
	Silver Lake Rd to Lee Rd	2.31	2.11	2.12	0.01	2.11	0.00
	Lee Rd to I-96	1.27	1.21	1.19	-0.02	1.14	-0.07
	I-96 to Spencer Rd	1.08	0.96	0.96	0.00	0.96	0.00
	Northbound US-23	**6.87**	**6.72**	**6.27**	**-0.45**	**6.21**	**-0.51**
PM Northbound	8 Mile Rd to M-36 (9 Mile Rd)	0.76	1.29	0.68	-0.61	0.68	-0.61
	M-36 (9 Mile Rd) to Silver Lake Rd	1.45	2.23	1.31	-0.92	1.31	-0.92
	Silver Lake Rd to Lee Rd	2.31	6.44	2.10	-4.34	2.09	-4.35
	Lee Rd to I-96	1.27	2.70	1.19	-1.51	1.18	-1.52
	I-96 to Spencer Rd	1.08	1.00	1.74	0.74	1.75	0.75
	Northbound US-23	**6.87**	**13.66**	**7.00**	**-6.64**	**7.01**	**-6.65**

The freeway segment LOS is greatly improved with the additional US-23 Flex Lane in the northbound direction during the PM peak period.

The Future No-Build PM model resulted in major congestion along northbound US-23. The traffic from the Lee Road entrance ramp to northbound US-23 is expected to cause slower travel speeds and longer travel times along northbound US-23 in the PM peak.

The northbound US-23 Flex Lane provides an additional lane of capacity in both alternatives, reduces congestion, and results in higher travel speeds and shorter travel times. The complete traffic analysis results are detailed in the *US-23 Flex Route Phase 2 Traffic Analysis Report*.

3.2.2 Roadway Impacts

The extension of the northbound US-23 Flex Lane would have no additional right-of-way impacts. Drainage impacts were also considered as implementation of the southbound Flex Lane requires widening the median shoulder which increases the amount of impervious area. However, based on the net change in impervious area, there should be available room within the right-of-way to accommodate the additional runoff. The current northbound travel lanes would remain 12 feet wide and the Flex Lane would be 11 feet wide. The proposed 11-foot-wide Flex Lane is acceptable by FHWA per the *US-23 Flex Route Phase 2 Preliminary Scoping Report.*

3.2.3 Bridge Impacts

Several bridges would be potentially be impacted by this project. Due to the median widening, the northbound bridge over the Huron River, north of the Silver Lake Road interchange, would need to be modified. A mussel survey was conducted and found federally protected Snuffbox mussels. These mussels would need to be moved prior to construction and MDOT will coordinate with the U.S. Fish and Wildlife Service.

The Grand River Avenue bridge over northbound US-23, just south of I-96, will require rehabilitation, but will not be replaced. The US-23 existing inside shoulder width would be reduced in the northbound direction along US-23 as shown in **Table 4**. The northbound bridge over Silver Lake Rd will require widening for flex lane/shoulder width, plus other rehabilitation items. The US-23 bridge over M-36 (9 Mile Road) will be replaced. This is due to poor condition and a needed alignment shift, but it must be wider to accommodate the wider shoulders/flex lanes anyway.

In addition, the existing railroad bridge over northbound US-23 between I-96 and Lee Road restricts the number of lanes that can be constructed. However, both alternatives negate having to replace the bridge while reducing congestion and improving safety. The existing and proposed shoulder widths for northbound US-23 under the railroad bridge are provided in **Table 4**. The proposed shoulder widths along US-23 at this location would require a design exception.

Table 4: Northbound Paved Shoulder Width under CSX railroad bridge and Grand River Bridge

Structure	Description	Inside Shoulder		Outside Shoulder	
		Existing	Proposed	Existing	Proposed
S06-47013	NB US-23 under Grand River	12 ft	8.16 ft*	8 ft*	8 ft*
X01-47013	NB US-23 under CSX railroad	8 ft	5.75 ft	10 ft	6.75 ft

ft – feet
*shoulder is adjacent to an auxiliary lane

3.3 Comparison and Selection

Alternative 2b is the Preferred Alternative for northbound US-23. The Flex Lane will continue northbound along US-23 until reaching the Lee Road interchange, at which point it would transition into a full-time lane before turning into the existing westbound I-96 exit ramp. Alternative 2b was chosen as the Preferred Alternative because it provides additional full-time capacity between the Lee Road interchange and I-96 when compared to Alternative 1. Alternative 1 continued the northbound US-23 Flex Lane north of the Lee Road interchange and provided a shorter left lane exit only lane for vehicles traveling to westbound I-96. The Preferred Alternative will allow for increased length of the left lane exit only lane when the Flex Lane is closed during off peak hours. The Preferred Alternative will also add additional capacity between the two interchanges as this location was a bottleneck source for northbound congestion in the Future No-Build analysis.

4 M-36 (9 Mile Road) Interchange

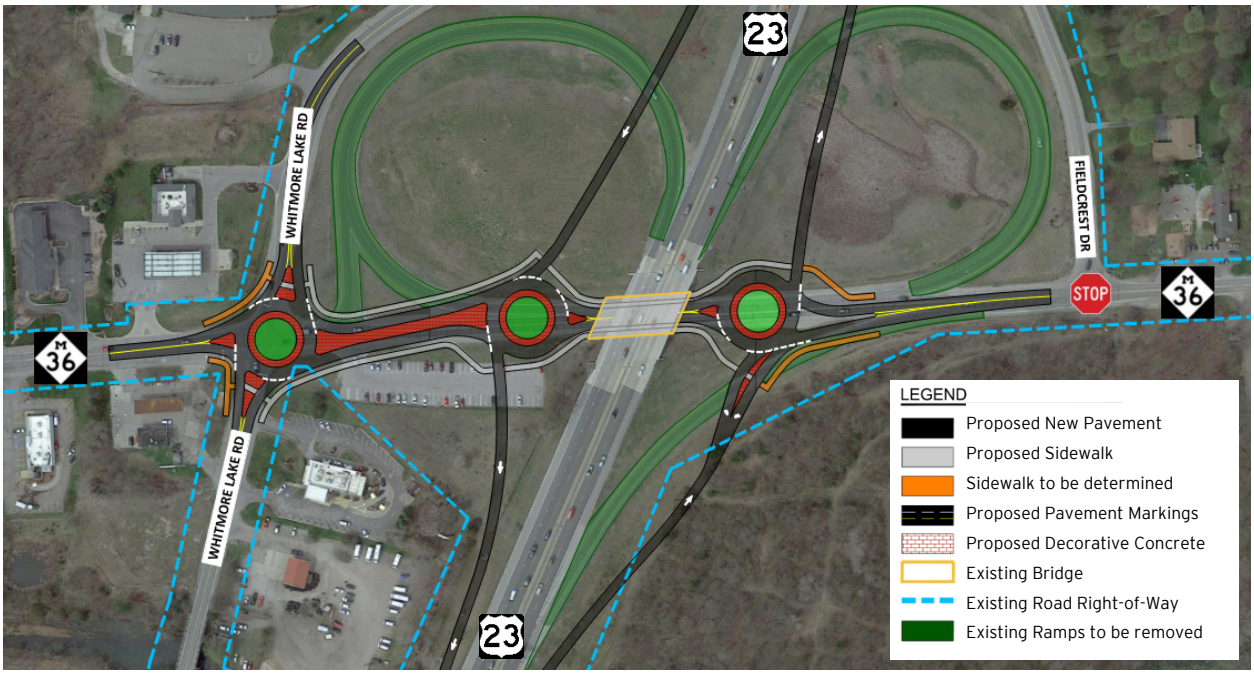
The existing M-36 (9 Mile Road) interchange is a partial cloverleaf configuration with a single lane loop and directional ramps. This interchange serves M-36 (9 Mile Road), Whitmore Lake Road, Fieldcrest Drive, and the M-36 (9 Mile Road) park and ride lot. The southbound US-23 exit ramp is stop-controlled at Whitmore Lake Road. The northbound US-23 exit ramps to M-36 (9 Mile Road) are directional ramps to both M-36 (9 Mile Road) eastbound and westbound by way of two separate exit ramps. Both ramps are uncontrolled and allow for vehicles to merge onto M-36 (9 Mile Road). The northbound US-23 entrance ramp is uncontrolled and is accessed from Fieldcrest Drive. M-36 (9 Mile Road) and Fieldcrest Drive is a T-intersection with the southbound approach being stop-controlled. The M-36 (9 Mile Road) and Whitmore Lake Road intersection located just west of US-23 is a four-way stop-controlled intersection with a flashing red signal.

4.1 Alternatives Considered

A single alternative was considered for this interchange. The alternative for this interchange is a series of three single-lane roundabouts as shown in **Figure 6**. The park and ride lot that is located along M-36 (9 Mile Road) will be relocated off of Whitmore

Lake Road. In addition, a 10-foot non-motorized pathway will be constructed on both sides of M-36 (9 Mile Road) and through the roundabouts.

Figure 6: M-36 (9 Mile Road) Layout



4.2 Evaluation

4.2.1 Traffic Impacts

As documented in the *US-23 Flex Route Phase 2 Traffic Analysis Report,* the M-36 (9 Mile Road) interchange showed overall operational improvement with the roundabout configuration in the build alternative compared to the unsignalized intersections in the Future No-Build condition. The build alternative would allow southbound US-23 traffic to exit directly to M-36 (9 Mile Road), while the current configuration directs vehicles to access Whitmore Lake Road from southbound US-23 and then travel through two unsignalized intersections in order to access M-36 (9 Mile Road). The traffic analysis results in **Table 5** compare the delay experienced at each of the three intersections along M-36 (9 Mile Road) in the Future No-Build condition as well as Alternative 1. The complete traffic analysis results are detailed in the *US-23 Flex Route Phase 2 Traffic Analysis Report*.

Table 5: Intersection Delay Comparison along M-36 (9 Mile Road)

Intersection	Intersection Delay (seconds/vehicle)	
	Future No-Build	Alternative 1
Whitmore Lake Rd & M-36 (9 Mile Road)	28.5 (30.1)	5.9 (5.8)
SB US-23 Ramp & M-36 (9 Mile Road)	22.8 (43.7)	7.6 (7.1)
NB US-23 Ramp & M-36 (9 Mile Road)	3.3 (8.0)	6.0 (8.9)

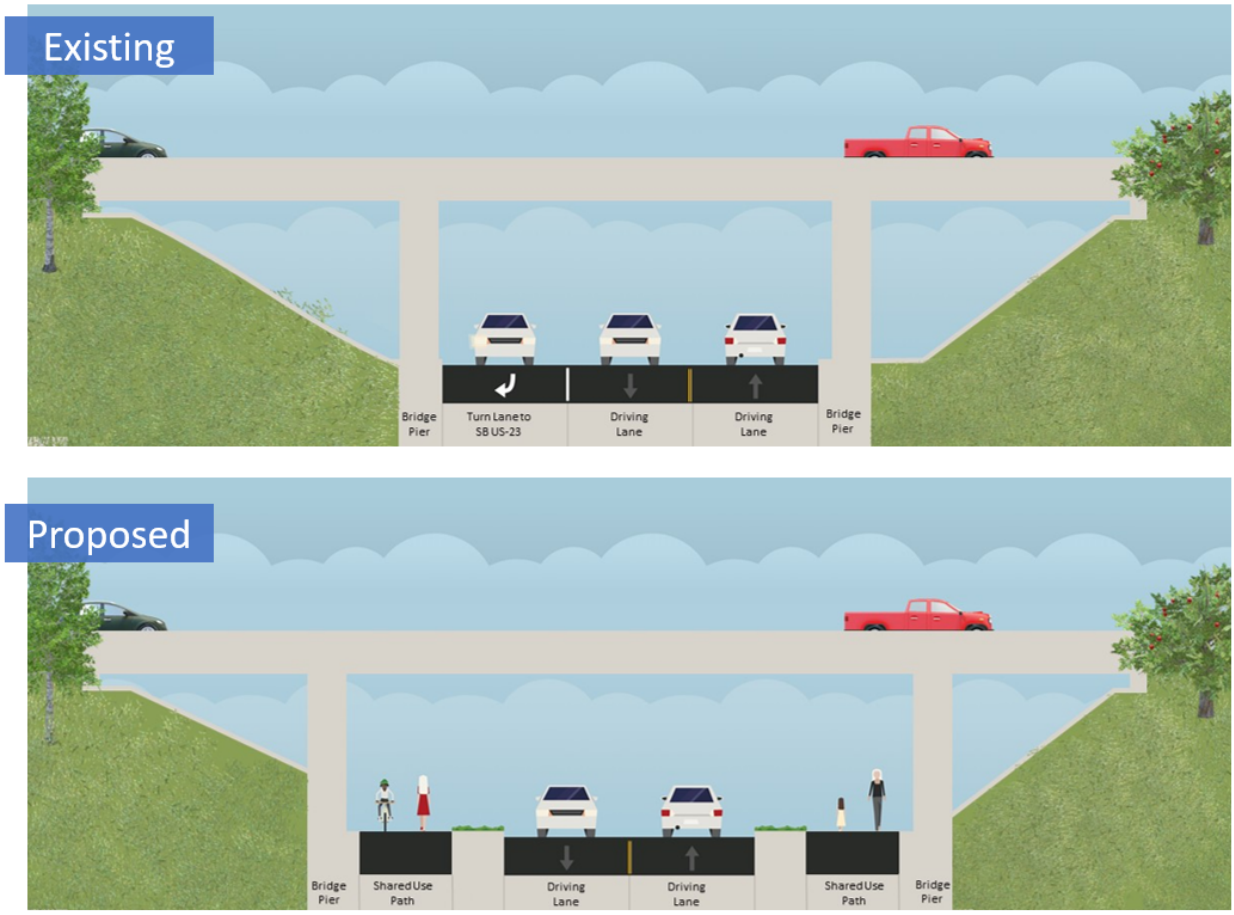
AM (PM) delay

4.2.2 Roadway Impacts

This alternative may require additional right-of-way near the Whitmore Lake Road and M-36 (9 Mile Road) roundabout and for the northbound US-23 exit ramp. In order to confirm the exact amount of right-of-way needed, additional design and right-of-way survey must be completed. The park and ride lot that is located along M-36 (9 Mile Road) will be relocated east of Whitmore Lake Road and north of M-36 (9 Mile Road).

The improvements along M-36 (9 Mile Road) will include a 10-foot wide non-motorized pathway on both sides of the roadway including through the roundabouts. **Figure 7** shows the cross-section comparison between the existing configuration on M-36 (9 Mile Road) under US-23 and the proposed configuration.

Figure 7: M-36 (9 Mile Road) Existing and Proposed Cross-Section



4.2.3 Bridge Impacts

The construction of roundabouts at this location by itself does not result in bridge impacts. However, two new US-23 bridges over M-36 (9 Mile Road) will need to be built in order to accommodate the added width of the US-23 Flex Lane. The reconstructed bridges will also allow for a 10-foot wide non-motorized pathway on both sides of M-36 (9 Mile Road).

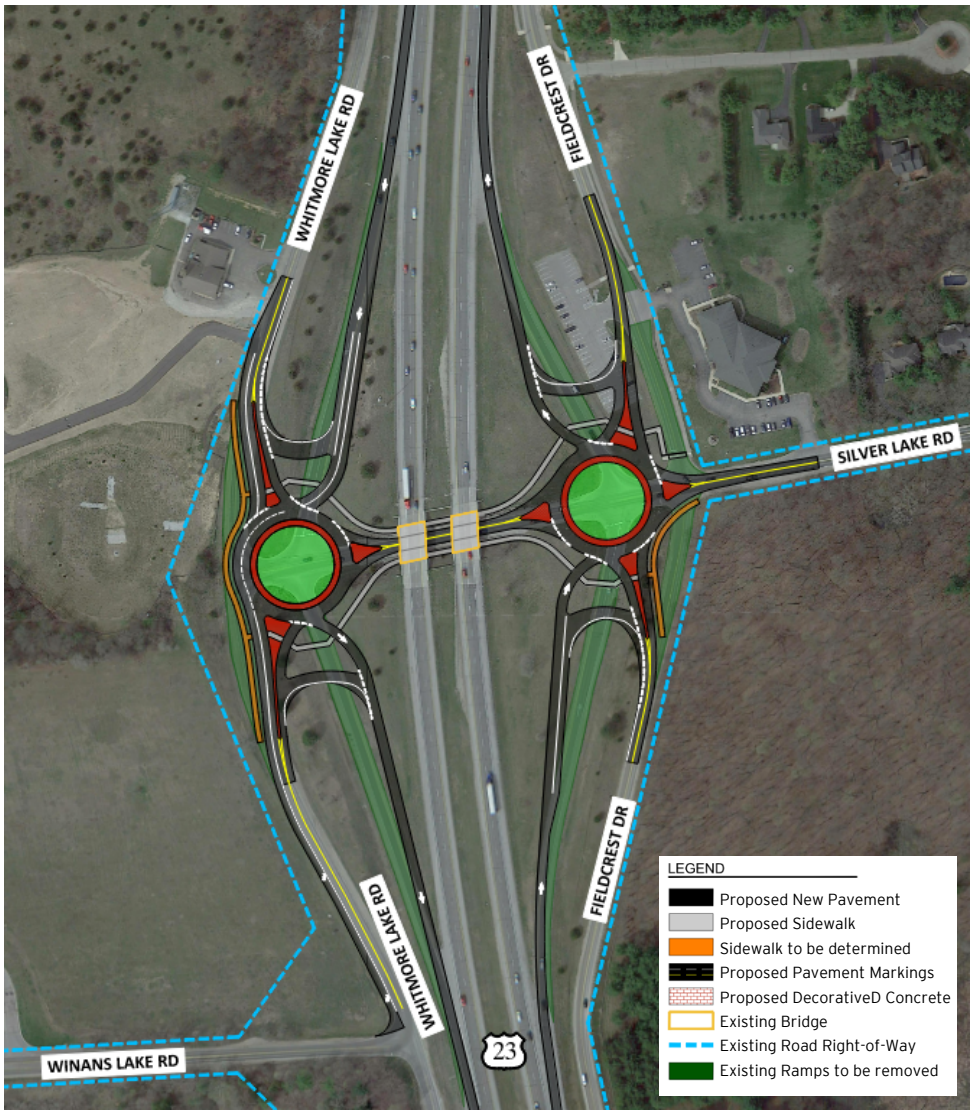
5 Silver Lake Road Interchange

The existing interchange is a tight diamond configuration with single lane ramps intersecting with Silver Lake Road. The interchange includes closely spaced intersections at Whitmore Lake Road and Fieldcrest Drive. This interchange serves Silver Lake Road, Whitmore Lake Road, and Fieldcrest Drive. The two service drive intersections are all-way stops, while the two interchange ramp intersections have stop signs for the exit ramp traffic only.

5.1 Alternatives Considered

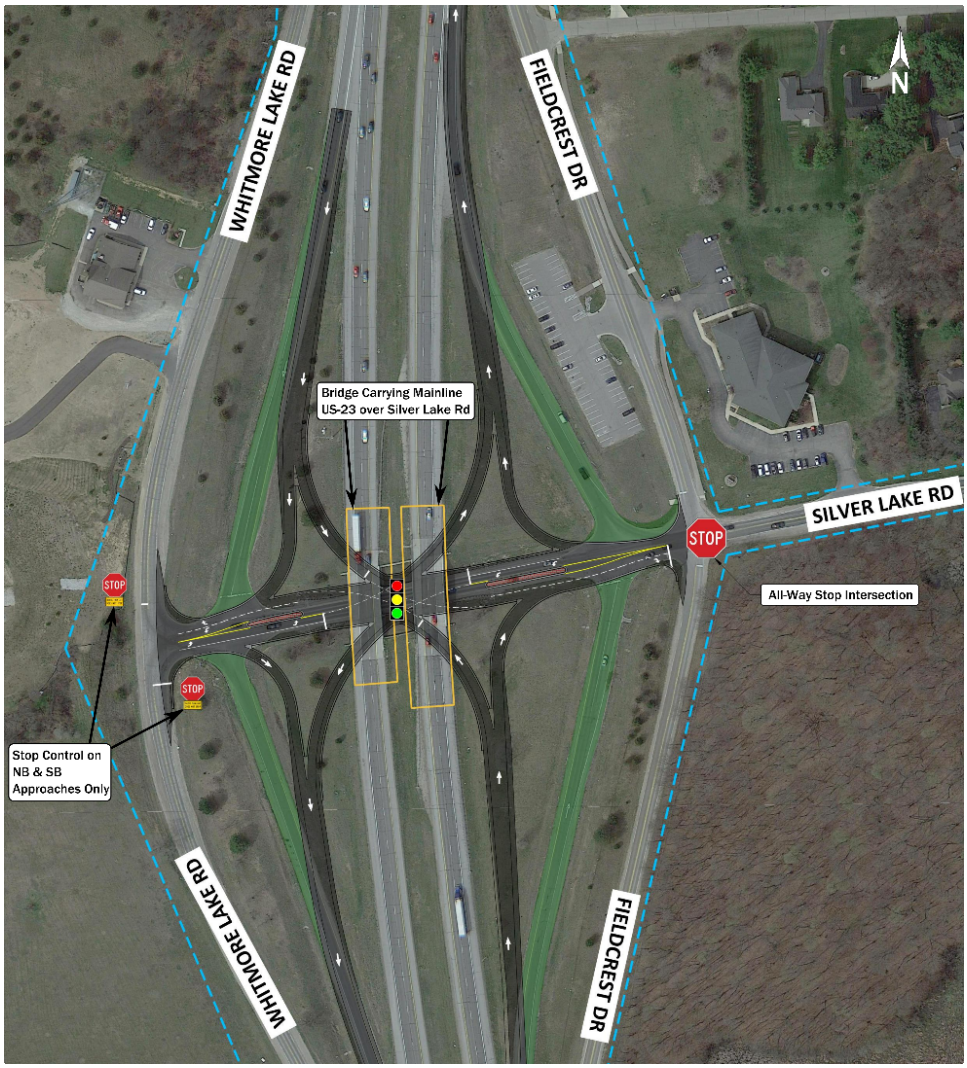
There were two alternatives evaluated for this interchange. Alternative 1 includes a roundabout at each ramp terminal intersection that incorperate Whitmore Lake Road and Fieldcrest Drive, as shown in **Figure 8**. The closely spaced intersections at Whitmore Lake Road and Fieldcrest Drive are eliminated in this alternative and become tied into the proposed roundabouts.

Figure 8: Silver Lake Road Interchange Alternative 1



Alternative 2 consists of a Single Point Urban Interchange (SPUI) with a signal under the bridge as shown in **Figure 9.** The SPUI configuration allows for additional spacing between the US-23 interchange at Silver Lake Road and the frontage roads at Whitmore Lake Road and Fieldcrest Drive when compared to the existing configuration.

Figure 9: Silver Lake Road Interchange Alternative 2



5.2 Evaluation

5.2.1 Traffic Impacts

As documented in the *US-23 Flex Route Phase 2 Traffic Analysis Report,* the Silver Lake Road interchange during the AM peak period showed noticeable improvement at the Whitmore Lake Road and Silver Lake Road intersection in Alternative 1 (roundabouts at the ramp terminal and frontage roads) compared to the Future No-Build and Alternative 2 (SPUI). The Whitmore Lake Road and Silver Lake Road intersection operated similarly in the Future No-Build and Alternative 2 models. The SPUI configuration in Alternative 2 provides more space between the US-23 interchange at Silver Lake Road and the frontage road at Whitmore Lake Road, but the closely spaced intersections still cause queueing and delay, especially on the eastbound approach at the SPUI intersection as vehicle queueing spills back into the Whitmore Lake Road intersection.

In the PM peak period, the Silver Lake Road interchange experiences less delay in Alternative 1 and 2 compared to the Future No-Build model. Both build alternatives produced similar delays in the PM peak period for the intersections along Silver Lake Road. The intersection analysis results along Silver Lake Road for the Existing, Future No-Build, and both build alternatives are provided in **Table 6**.

Table 6: Silver Lake Road Intersection Analysis Results

	Intersection Operations							
	AM Delay (LOS)				PM Delay (LOS)			
	EX	FNB	SPUI	RAB	EX	FNB	SPUI	RAB
Whitmore Lake Rd	25.3 (D)	47.5 (E)	45.9 (E)	12.2 (B)	15.9 (C)	29.5 (D)	22.6 (C)	11.7 (B)
US-23 SB	5.4 (A)	5.8 (A)	18.9 (C)		24.3 (C)	56.7 (F)	17.0 (C)	
US-23 NB	5.6 (A)	6.5 (A)		10.8 (B)	37.1 (E)	86.6 (F)		22.3 (C)
Fieldcrest Dr	13.9 (B)	21.2 (C)	21.1 (C)		16.8 (C)	20.1 (C)	25.7 (D)	

Delay = seconds per vehicle; EX = Existing; FNB = Future No Build; RAB = Roundabout

5.2.2 Roadway Impacts

Several factors were considered when analyzing roadway impacts between Alternatives 1 and 2 for the Silver Lake Road interchange. The factors included the estimated construction costs, traffic signal costs, lighting, signing, long term maintenance, right-of-way impacts, and impacts during construction. The breakdown of each factor's impact for each alternative along with estimated cost associated with the improvements are provided in **Table 7**. In-depth cost estimates are provided in Section 9 of the *US-23 Flex Route Phase 2 Final Scoping Report (March 2021).*

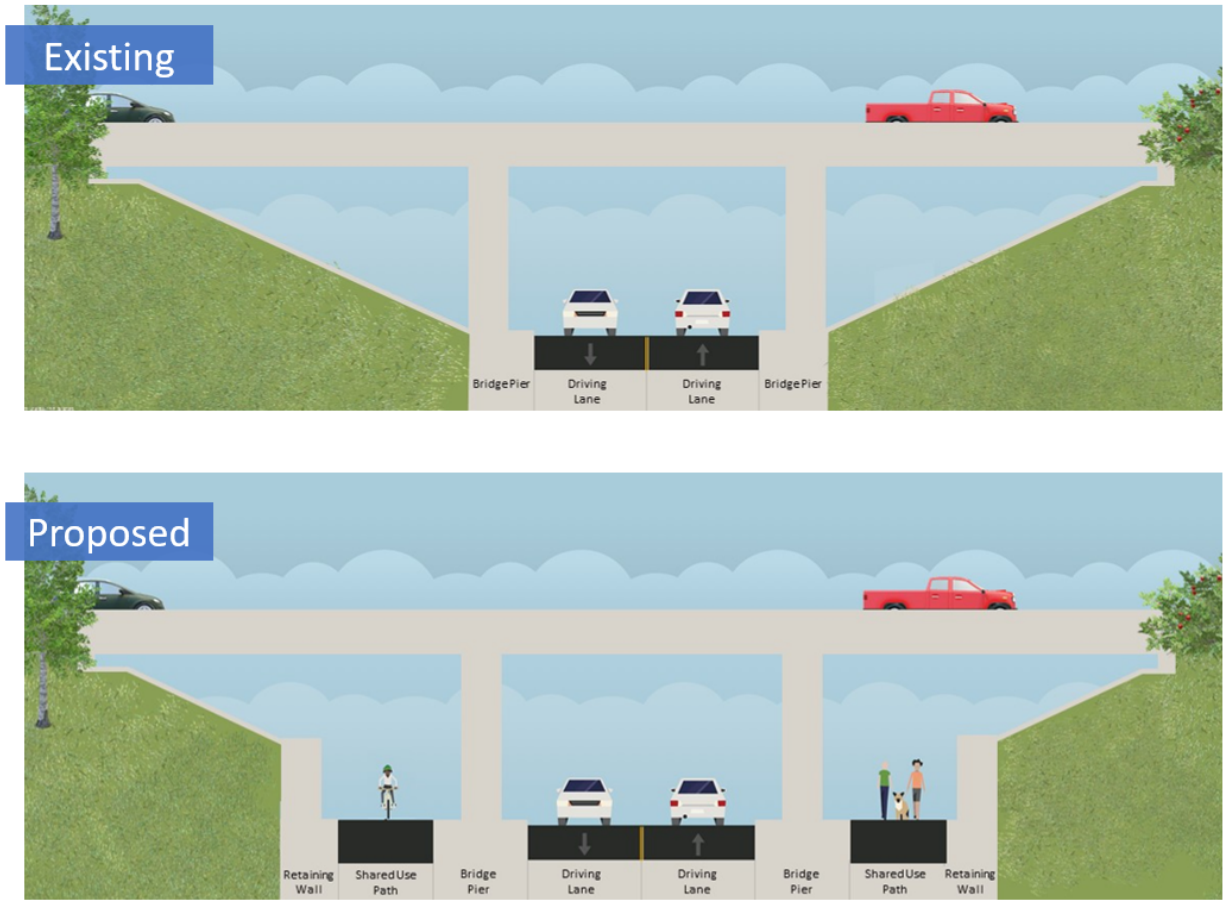
The estimated roadway cost of constructing the two roundabouts (Alternative 1) on Silver Lake Road is slightly higher when compared to the SPUI alternative (Alternative 2), but the total estimated construction cost of the roundabouts is approximately half the cost of the SPUI in large part because of the cost of the bridge required for a SPUI. Alternative 1 would require a lower overall long-term maintenance cost when compared to Alternative 2, and the construction impacts would be higher for Alternative 2 in large part due to the construction of the required bridge on US-23. Alternative 1 also has an impact to the park and ride lot which is not present in Alternative 2. Under Alternative 1, the park and ride lot would be expanded to the north to replace parking spots removed for the roundabout. The driveway would also be moved to the north.

Table 7: Roadway Impacts for Silver Lake Road interchange

	Alternative 1 (roundabouts)	Alternative 2 (SPUI)
Interchange Road Cost	• $2.010M	• $1.791M
Signalization Costs	• $360k construction cost for Rectangular Rapid Flashing Beacons (RRFB) for pedestrians • $675k construction cost for two HAWKs • $855k for combination	• $400k construction cost for one signal at the SPUI
Street Lighting	• $265k	• $265k
Signing	• $70k	• $35k
Carpool lot impacts	• $135k to relocate carpool lot	• No impacts or cost
Total Construction Costs	• $4.7M • (includes HAWK/RRFB combo)	• $9.7M
Long-Term Maintenance Cost	• Lower Overall Costs • Lower bridge maintenance costs • $1k-$10k/year RFB/HAWK maintenance cost • $1k/year potential landscaping costs within roundabout • $5k/year lighting costs	• Higher Overall Costs • Higher bridge maintenance costs • $5k-$10k/year signal maintenance cost • $5k/year lighting costs
Right-of-Way Requirements	• No right-of-way purchase expected	• No right-of-way purchase expected
Construction/MOT Impacts	• Medium impact/complexity for widening bridges and needing to cut into paved slope for Shared-Use Paths on Silver Lake Rd	• Higher impact/complexity with construction of the SPUI bridge

The improvements along Silver Lake Road will include a 10-foot wide non-motorized pathway on both sides of the roadway including through the roundabouts. Figure 10 shows the cross-section comparison between the existing configuration on Silver Lake Road under US-23 and the proposed configuration.

Figure 10: Silver Lake Road Existing and Proposed Cross-Section



5.2.3 Bridge Impacts

In both alternatives, the US-23 bridges over Silver Lake road are planned to be widened to accommodate the Flex Lane. However, Alternative 2 would require a longer bridge for both northbound and southbound US-23 in order to allow space for the entrance and exit ramps to converge to a single signalized intersection. The estimated cost for constructing the bridges in Alternative 1 is approximately $975,000 and the cost for Alternative 2 is approximately $7.19 million. Along with the increased cost of the bridges in Alternative 2, long-term maintenance costs are also higher due to the size of the bridges in Alternative 2.

5.3 Comparison and Selection

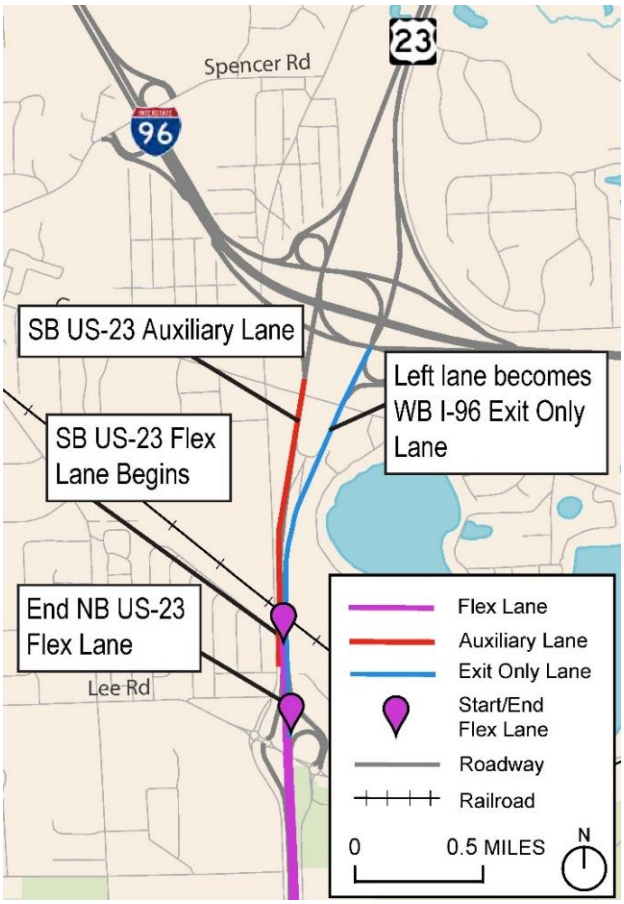
Based on the traffic analysis results, as well as the roadway and bridge impacts, the Preferred Alternative for the Silver Lake Road interchange is Alternative 1. This alternative allows for each US-23 ramp terminal intersection and nearby frontage road to be combined into a single roundabout. The two roundabouts on Silver Lake Road eliminates the closely spaced intersections and vehicle queueing spill back as

experienced in Alternative 2. Alternative 1 also provides lower long-term maintenance costs and significantly less bridge construction cost when compared to the SPUI configuration in Alternative 2. A complete comparison matrix comparing both alternatives for Silver Lake Road is provided in **Appendix A**.

6 Conclusion

The US-23 Flex Route Phase 2 study examined a variety of alternatives for both the beginning and ending segments of the Flex Route as well as interchange configurations along US-23 at M-36 (9 Mile Road) and Silver Lake Road. The examination of the alternatives took into consideration multiple factors such as traffic operations, roadway impacts, bridge impacts, environmental impacts, etc. The Preferred Alternative for the start of the US-23 southbound Flex Lane as well as the end of the US-23 northbound Flex Lane is shown in **Figure 11**. The full time use of the southbound auxiliary lane between the eastbound I-96 entrance ramp and the Lee Road exit ramp reduces the number of conflicts with merging traffic onto southbound US-23. Congestion is also reduced at the eastbound I-96 entrance ramp, which was identified in the Future No-Build condition as causing a bottleneck on the ramp itself as well as southbound US-23.

Figure 11: US-23 Flex Lane Preferred Alternative



The Preferred Alternative for the interchange at US-23 and Silver Lake Road is to construct two roundabouts located at the US-23 ramp terminal intersections. The ability to combine each ramp terminal intersection and the nearby frontage road into a roundabout intersection eliminated the closely spaced intersection issues as identified in the SPUI alternative. The roundabout alternative at Silver Lake Road also resulted in a much lower construction cost for the two bridges on US-23 as well as less long-term maintenance costs in the future.

The Preferred Alternative for the interchange at US-23 and M-36 (9 Mile Road) is to construct three roundabouts at Whitmore Lake Road and the two ramp terminal intersections. The roundabout alternative along M-36 (9 Mile Road) resulted in less operational delay at the intersections and also provided direct access to M-36 (9 Mile Road) for vehicles exiting US-23 southbound.

Appendix A – Silver Lake Road Interchange Comparison Matrix

Silver Lake Road Interchange Comparison

	Single-Point Urban Interchange (SPUI)	Roundabout (RAB)
US-23 Bridge Cost	• $7.186M (replacement)	• $1.356M (widening)
Interchange Road Cost	• $1.791M	• $2.010M
Signalization Costs	• $400k construction cost for one signal at the SPUI	• $360k construction cost for Rectangular Rapid Flashing Beacons (RRFB) for pedestrians • $675k construction cost for two HAWKs • $855k for combination
Street Lighting	• $265k	• $265k
Signing	• $35k	• $70k
Carpool lot impacts	• No impacts or cost	• $135k to relocate carpool lot
Total Construction Costs	• $9.7M	• $4.7M (includes HAWK/RRFB combo)
Long-Term Maintenance Cost	• Higher Overall Costs • Higher bridge maintenance costs • $5k-$10k/year signal maintenance cost • $5k/year lighting costs	• Lower Overall Costs • Lower bridge maintenance costs • $1k-$10k/year RFB/HAWK maintenance cost • $1k/year potential landscaping costs within roundabout • $5k/year lighting costs
Right-of-Way Requirements	• No right-of-way purchase expected	• No right-of-way purchase expected
Vehicular Operations (See next page for Intersection Operations Results)	• Operations are acceptable (LOS D or better) for the off ramps • Close proximity of frontage road intersections creates operational issues at the frontage roads • Signalization at frontage roads not recommended due to signal spacing and coordination challenges • Eastbound Silver Lake Road vehicle queuing from the SPUI spills back into the Whitmore Lake Road intersection.	• RODEL analysis indicates LOS A operations for all approaches • VISSIM analysis indicates a LOS C operations for all approaches
Vehicular Safety	• Higher potential for angle crashes compared to roundabout (more severe crash type)	• Main crash types are rear-end and side swipe same (less severe crash types)
Non-Motorized Access	• Could accommodate adjacent non-motorized paths on both sides with replacement bridge	• Could accommodate adjacent non-motorized paths on both sides with modifications to the existing slope walls
Non-Motorized Safety	• Provides stop-controlled pedestrian access at most legs • Additional approaches can be signalized to enhance safety for pedestrians • Simple single-direction crossings • Dedicated pedestrian phases	• Simple single-direction crossings • Vehicles may be moving slower than in a SPUI • Consider Rectangular Rapid Flashing Beacons (RRFB) on approaches as well as refuges on all splitter islands • Does not provide stop-controlled pedestrian access

	Single-Point Urban Interchange (SPUI)	Roundabout (RAB)
Potential Environmental Impacts	• None anticipated	• None anticipated
Potential Utility Conflicts	• None anticipated	• None anticipated
Construction/MOT Impacts	• Higher impact/complexity with construction of the SPUI bridge	• Medium impact/complexity for widening bridges and needing to cut into paved slope for Shared-Use Paths on Silver Lake Rd

	Intersection Operations									
	AM Delay (LOS)					PM Delay (LOS)				
	EX	FNB	SPUI	RAB	RAB*	EX	FNB	SPUI	RAB	RAB*
Whitmore Lake Rd	25.3 (D)	47.5 (E)	45.9 (E)	12.2 (B)	5.1 (A)	15.9 (C)	29.5 (D)	22.6 (C)	11.7 (B)	5.8 (A)
US-23 SB	5.4 (A)	5.8 (A)	18.9 (C)			24.3 (C)	56.7 (F)	17.0 (C)		
US-23 NB	5.6 (A)	6.5 (A)		10.8 (B)	6.1 (A)	37.1 (E)	86.6 (F)		22.3 (C)	6.8 (A)
Fieldcrest Dr	13.9 (B)	21.2 (C)	21.1 (C)			16.8 (C)	20.1 (C)	25.7 (D)		

Delay = seconds/vehicle
*Roundabout (RAB) results are from RODEL.
All other results are from Vissim.