Intersection Control Evaluation

Lor Ray Drive at Howard Drive

in North Mankato, Nicollet County, Minnesota

Mankato/North Mankato Area Planning Organization

SRF Consulting Group, Inc. | Engineers Planners Designers

October 2016

SRF No. 016 09243

Intersection Control Evaluation

Lor Ray Drive at Howard Drive

Proposed Letting Date: TBD

Report Certification:

I hereby certify that this report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

Scott C. Poska	47068
Print Name	Reg. No.
	10-31-16
Signature	Date

Approved:

	11/15/16
City of North Mankato City Engineer	Date

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Introduction

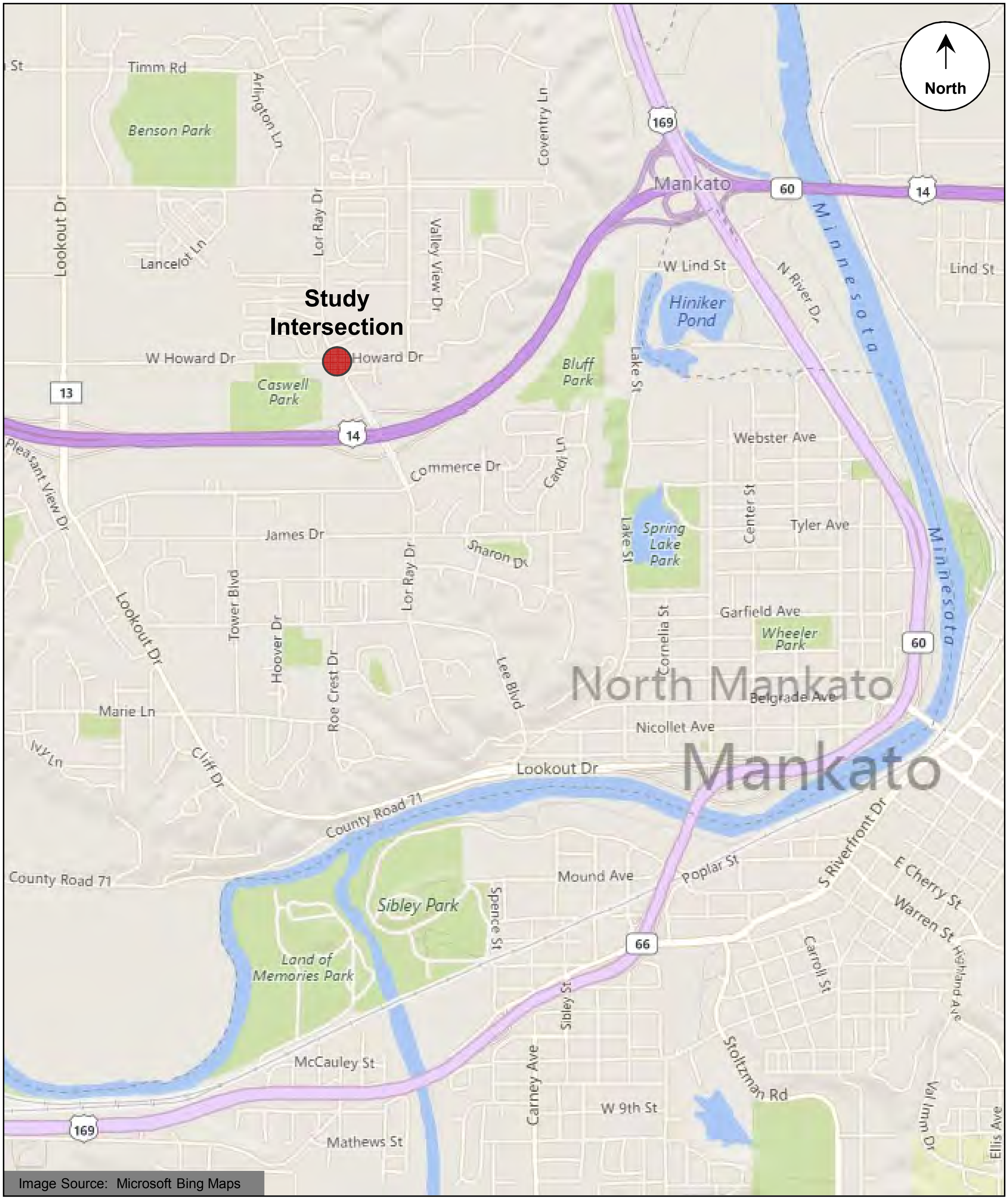
This report contains the intersection control evaluation results for the Lor Ray Drive at Howard Drive intersection in North Mankato, Nicollet County, Minnesota (see Figure 1). The purpose of the evaluation was to analyze the intersection control alternatives for the intersection to identify the long-term preferred intersection control. The following intersection control alternatives were considered applicable and are analyzed within this report:

- All-Way Stop Control
- Roundabout Control
- Traffic Signal Control

A mini-roundabout variation was also explored. According to *Mini-Roundabouts Technical Summary* (Federal Highway Administration, 2010), mini-roundabouts are best suited/most efficient in lower speed environments, and are generally recommended for intersections where the total entering daily traffic volume does not exceed approximately 15,000 vehicles. The intersection currently has 12,300 entering vehicles and is forecasted to be 15,900 by 2036. Large vehicles, including school buses, are typically required to over-run the fully traversable central island, and high volumes of large vehicles will significantly reduce the capacity of a mini-roundabout, and may lead to rapid wear of the roadway markings. Based on these factors, the mini-roundabout option was not analyzed further at the study intersection.

A detailed warrants analysis, operational analysis, safety analysis, and planning-level cost analysis were performed to determine the preferred intersection control alternative. In addition to these analyses, other factors considered for this evaluation that were applicable to determining the long-term preferred intersection control included:

- Right-of-Way Considerations
- Transportation System Considerations
- Pedestrian and Bicycle Considerations
- Local Acceptance



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Study Intersection

Intersection Control Evaluation
Lor Ray Drive at Howard Drive

Figure 1

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Existing Intersection Characteristics

Existing Conditions

The study intersection is located in the City of North Mankato, Nicollet County north of T.H. 14, as shown in Figure 1. Lor Ray Drive is a five-lane divided roadway south of the study intersection through the T.H. 14 interchange and is a three-lane undivided roadway to the north. Lor Ray Drive is a city street with a speed limit of 30 mph and is functionally classified as a Minor Arterial. Howard Drive is a two-lane undivided roadway with a speed limit of 30 mph. Howard Drive is a city street and is functionally classified as a Major Collector west of Lor Ray Drive and a Local road to the east of Lor Ray Drive. The intersection of Lor Ray Drive and Howard Drive is currently all-way stop controlled. There are bicycle and pedestrian accommodations on both sides of Lor Ray Drive and Howard Drive with marked pedestrian crossings at the intersection. The adjacent area has primarily residential and industrial land uses. Lor Ray Drive, including the intersection at Howard Drive, was reconstructed in 2000. The existing lane configurations for the Lor Ray Drive at Howard Drive intersection are listed in Table 1 below and are shown in Figure 2.

Table 1. Existing Conditions

Leg	Configuration
Northbound Lor Ray Drive	One left-turn lane, one thru lane, and one right-turn lane
Southbound Lor Ray Drive	One left-turn lane, one thru lane, and one shared thru/right-turn lane
Eastbound Howard Drive	One left-turn lane, one thru lane, and one right-turn lane
Westbound Howard Drive	One left-turn lane and one shared thru/right-turn lane

Crash History

Crash data was obtained from the Minnesota Crash Mapping Analysis Tool (MnCMAT) database for a five-year period from 2011 to 2015. There were seven recorded crashes at the study intersection during the analysis period. Detailed crash data is provided in the Appendix. This results in a crash rate of 0.31 crashes per million entering vehicles, which is below the statewide average of 0.35 for all-way stop controlled intersections and the critical crash rate of 0.58 (0.95 level of confidence) for this intersection.

H:\Projects\09000\9243\CAD_BIM\Graphics\9243 Figure 2 - Existing Conditions.dgn

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Existing Conditions

Intersection Control Evaluation
Lor Ray Drive at Howard Drive

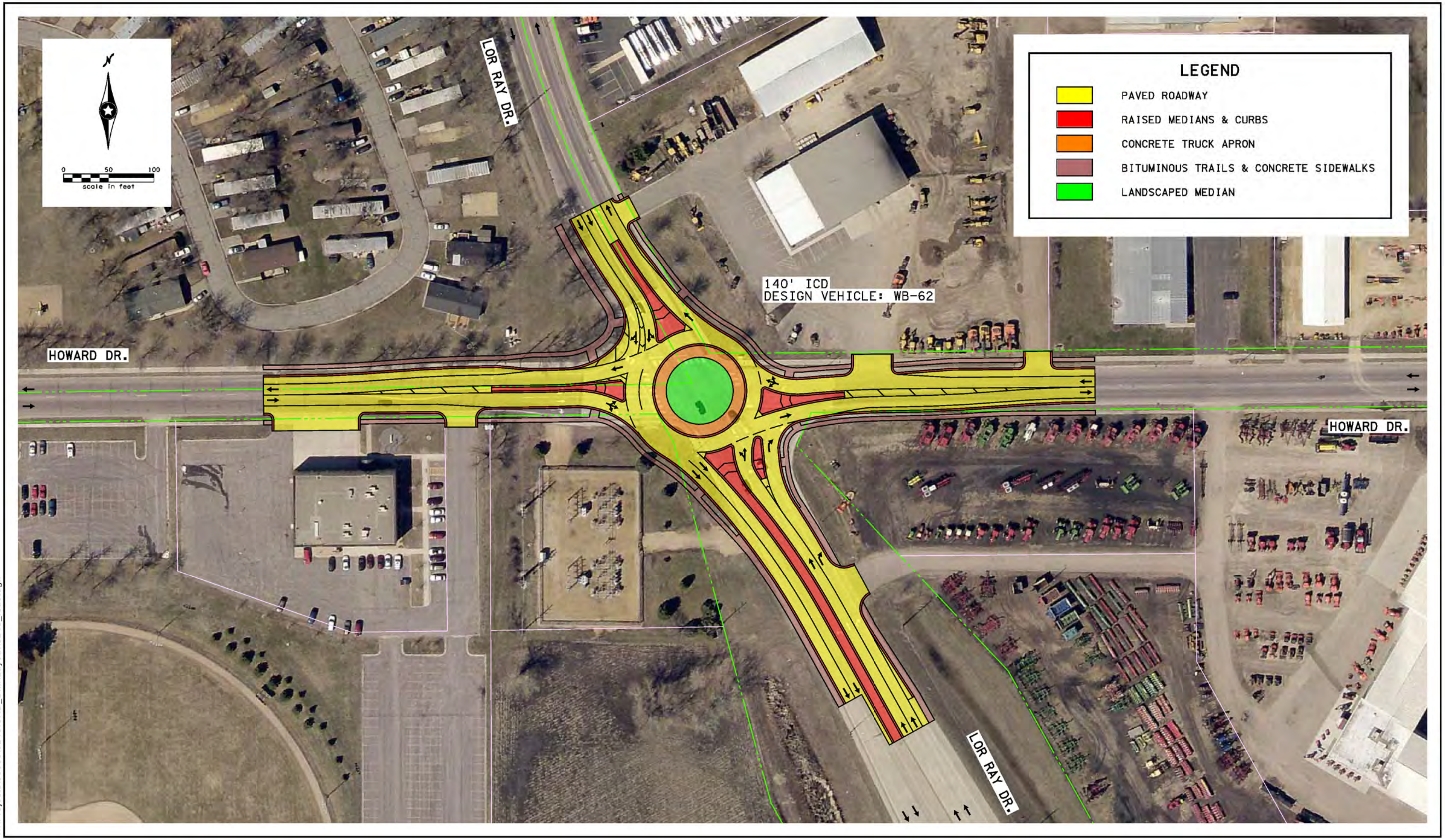
Figure 2

Future Conditions

Based on discussions with City staff in the summer of 2016, no short-term improvements to Lor Ray Drive, Howard Drive, or the study intersection are planned. As part of the City's adopted 2015 Comprehensive Plan, future land uses in the vicinity of the study intersection were updated to commercial land uses. This may include retail, office, hotel, restaurant, and convenience store type uses. Additionally, a new elementary school is planned at the intersection of Lor Ray Drive and Carlson Drive as well as possible expansion of Caswell Park. However, no formal development plans have been submitted for these areas. Nonetheless, future development will necessitate an intersection control change to support traffic growth. For the alternatives analysis, the existing lane configurations under all-way stop control (listed in Table 1 and shown in Figure 2) were assumed to be the same for the traffic signal control alternative. The lane configurations for the roundabout control alternative are listed in Table 2 below and are shown in Figure 3.

Table 2. Proposed Lane Configurations for Roundabout Control Alternative

Leg	Configuration
Northbound Lor Ray Drive	One shared thru/left-turn lane and one channelized right-turn lane
Southbound Lor Ray Drive	One shared thru/left-turn lane and one shared thru/right-turn lane
Eastbound Howard Drive	One shared lane (all movements)
Westbound Howard Drive	One shared lane (all movements)



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Roundabout Control Alternative

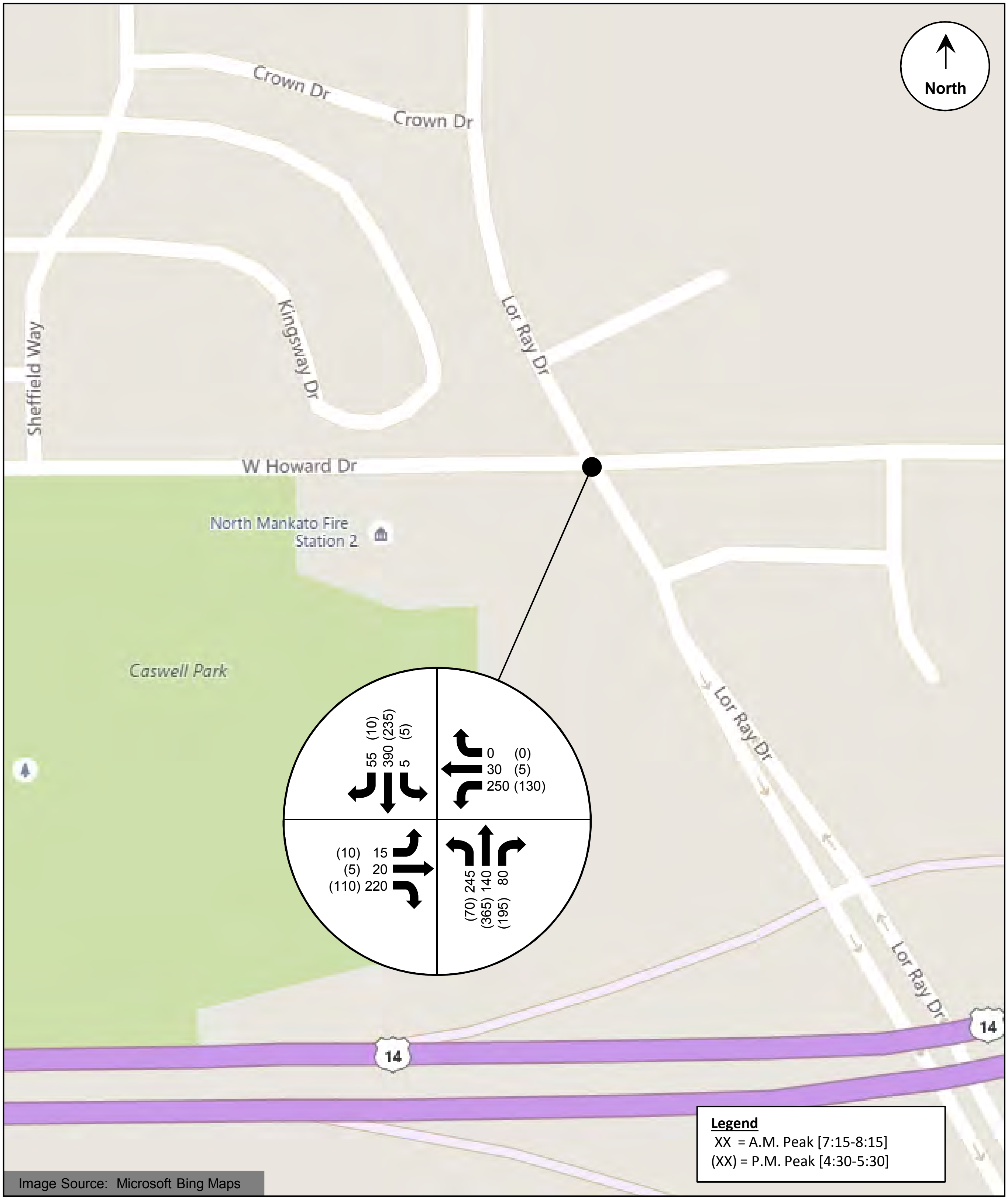
Intersection Control Evaluation

Lor Ray Drive at Howard Drive

Figure 3

Traffic Volumes

Hourly traffic volumes including the existing a.m. and p.m. peak hour were collected in early April 2016 by the City of Mankato prior to the closure of T.H. 169 and are shown in Figure 4. Pedestrian and bicycle volumes were also collected. Growth rates from the MAPO 2045 Transportation Plan were used to determine Forecasted Year 2036 peak hour turning movement volumes, which are shown in Figure 5. Due to anticipated land use changes in the area adjacent to the study intersection, forecasted yearly growth rates of 1.4% for Lor Ray Drive (Minor Arterial) and 1.7% for Howard Drive (Major Collector) were used. These rates capture some, but not all, of the proposed commercial, recreational, and educational land uses, discussed previously, in the vicinity of the intersection since no formal development plans have been submitted.



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Existing Year 2016 Volumes

Intersection Control Evaluation
Lor Ray Drive at Howard Drive

Figure 4

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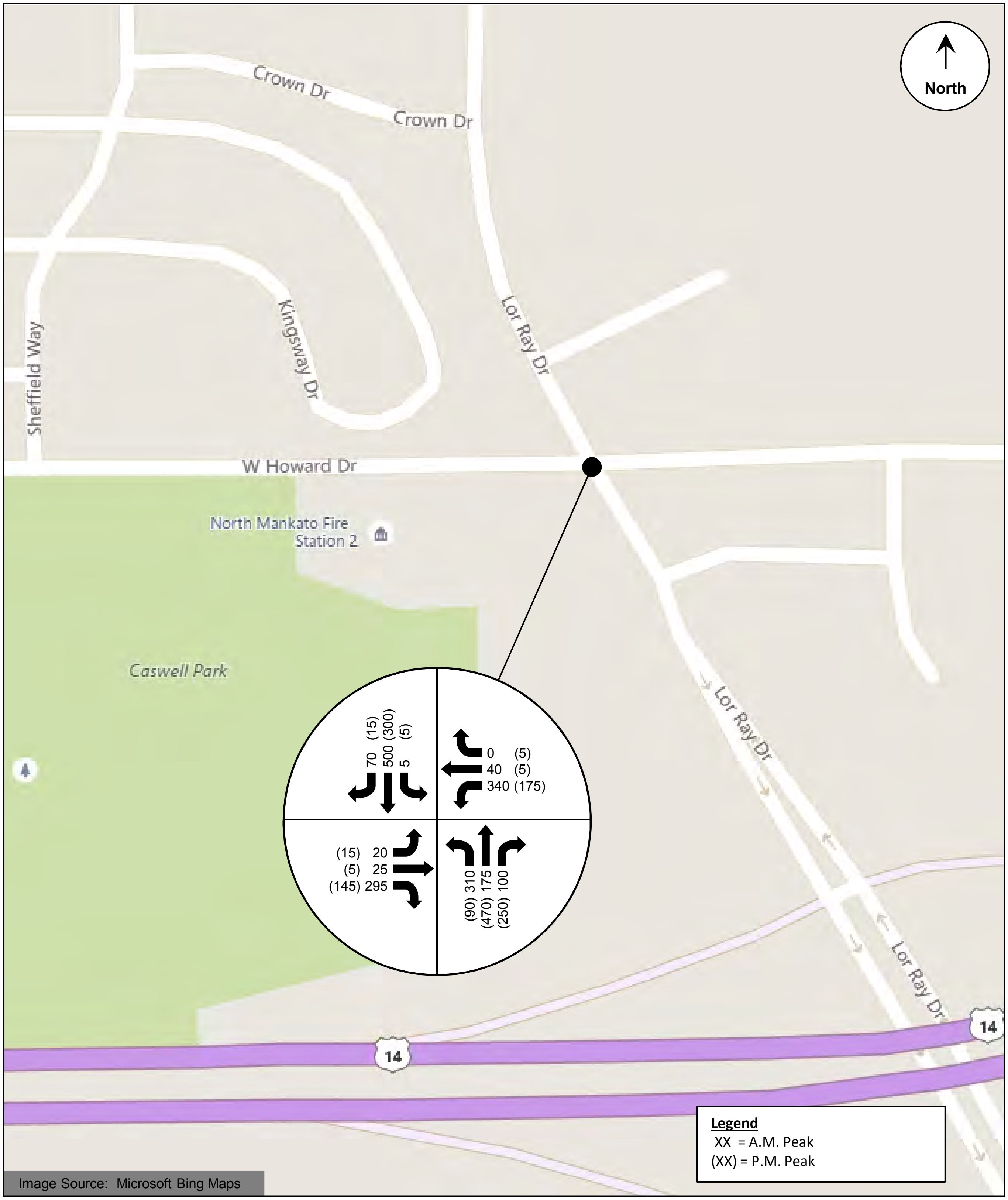

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Forecasted Year 2036 Volumes

Figure 5

Intersection Control Evaluation

Lor Ray Drive at Howard Drive

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Analysis of Alternatives

The analysis of the all-way stop control, traffic signal control, and roundabout control alternatives included a warrants analysis, operational analysis, planning-level crash analysis, and a planning-level cost analysis. Existing Year 2016 and Forecasted Year 2036 volumes with proposed lane configurations discussed previously were used for the analysis.

Warrants Analysis

A warrants analysis was performed for the traffic signal control alternative as outlined in the February 2015 *Minnesota Manual on Uniform Traffic Control Devices* (MN MUTCD). The signal warrants analysis was based on the assumptions shown in Table 3.

Table 3. Warrants Analysis Assumptions

Leg	Geometry	Speed
Northbound Mainline (Lor Ray Drive)	2 or more approach lanes	30 mph
Southbound Mainline (Lor Ray Drive)	2 or more approach lanes	30 mph
Eastbound Minor Street (Howard Drive)	1 approach lane	30 mph
Eastbound Minor Street (Howard Drive)	1 approach lane	30 mph

Because of the low thru and right-turn volumes compared to the left-turn volumes on the westbound approach, it was considered a one lane approach, and similarly the eastbound approach was considered a one lane approach due to the low thru and left-turn volumes compared to the right-turn volumes. Table 4 provides a summary of the results of the warrants analysis. The detailed warrants analysis can be found in the Appendix.

Table 4. Warrants Analysis Results

MN MUTCD Warrant	Hours Required	Year 2016 Volumes		Forecasted Year 2036 Volumes	
		Hours Met	Warrant Met	Hours Met	Warrant Met
Warrant 1A: Minimum Vehicular Volume	8	3	No	5	No
Warrant 1B: Interruption of Continuous Traffic	8	0	No	4	No
Warrant 1C: Combination of Warrants	8	3	No	7	No
Warrant 2: Four-Hour Volume	4	2	No	4	Yes
Warrant 3B: Peak-Hour Volume	1	0	No	2	Yes
Multi-way Stop Applications Condition C	8	7	No	10	Yes

Warrants 4-9 were investigated but were determined to be not applicable. Results of the warrants analysis indicate that Existing Year 2016 volumes do not satisfy any MN MUTCD traffic signal warrants, while Forecasted Year 2036 volumes satisfy the MN MUTCD warrant requirements for traffic signal Warrants 2 and 3B.

Operational Analysis

An initial planning-level analysis was performed for the roundabout control alternative based on Highway Capacity Manual methods found in *NCHRP Report 672 Roundabouts: An Informational Guide, Second Edition* (Transportation Research Board, 2010). The analysis involved testing the theoretical capacity of a single-lane roundabout against the Forecasted Year 2036 entering and circulating volumes. As shown in Chart 1, the Forecasted Year 2036 volumes exceed the theoretical capacity of a single-lane roundabout. Therefore, the roundabout alternative included additional lanes needed to support the traffic volumes and match into the existing roadway layout.

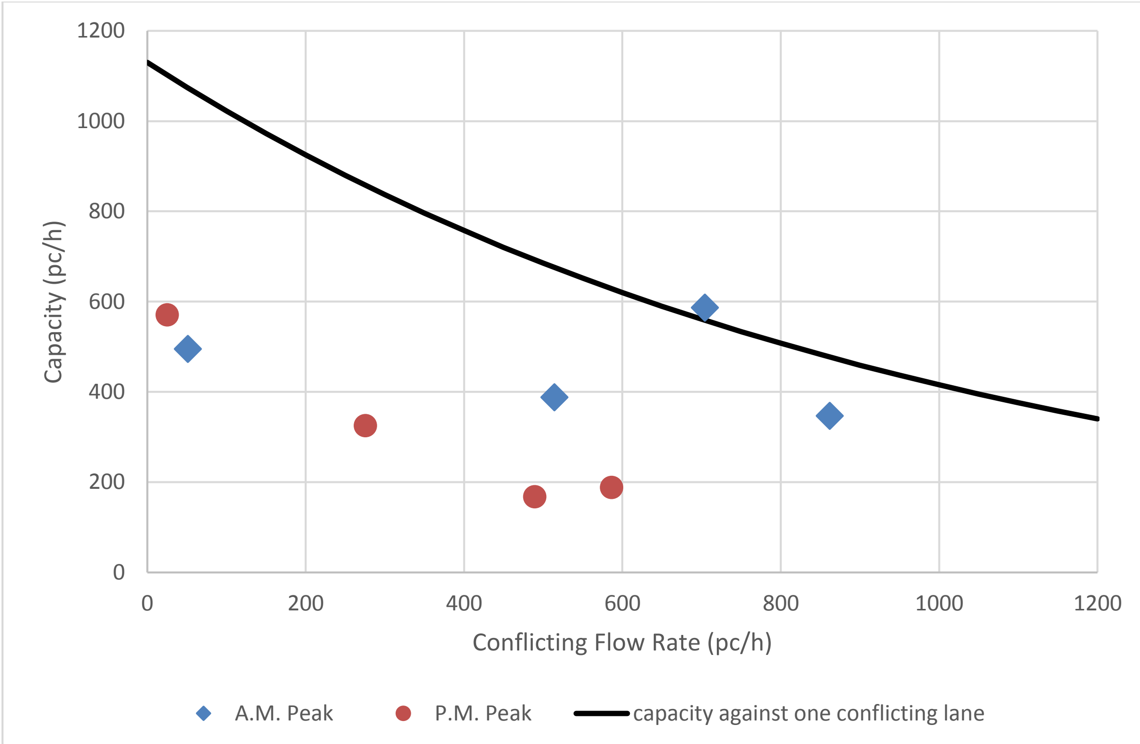


Chart 1. Single-Lane Roundabout Entry Lane Capacity (Forecasted Year 2036 volumes)

Operational analysis of the roundabout control alternative was performed using RODEL and Highway Capacity Software (HCS). RODEL is a software program that is based on existing roundabout operational research and uses an empirical formula method to determine roundabout delay based on geometric features and traffic flows. RODEL is the current MnDOT accepted analysis tool for evaluating roundabouts. HCS is based on methodologies found in the 2010 Highway Capacity Manual (HCM) which is considered a conservative approach to determining the capacity of a roundabout. It is important to note that RODEL and HCS only report "stop" or "control" delay. Therefore, in order to determine the total delay, "geometric" delay, or delay due to vehicle deceleration and acceleration through an intersection, must be added to the "stop" or "control" delay.

The detailed operational analysis of all-way stop control and traffic signal control was performed using methods outlined in the 2010 HCM using Synchro/SimTraffic. Synchro/SimTraffic is capable of calculating various measures of effectiveness such as control delay, queuing, and total travel time impacts. SimTraffic results are reported for the analysis.

The operational analysis identified a Level of Service (LOS), which indicates how well an intersection is operating based on average delay per vehicle. Intersections are given a ranking from LOS A to LOS F. LOS A indicates the best traffic operation and LOS F indicates an intersection where demand exceeds capacity. LOS A through LOS D are generally considered acceptable. RODEL results for a Confidence Level (CL) of 50% and 85% were determined. 50% CL results are typically used for roundabout analysis while the 85% CL results indicate the sensitivity of the roundabout design. When a substantial degradation in LOS is expected from 50% CL to 85% CL, designers should exercise caution in the design of the roundabout to ensure adequate capacity is provided.

Tables 5 and 6 provide a summary of the operational analysis for Existing Year 2016 and Forecasted Year 2036 conditions, respectively. Detailed operational analysis results can be found in the Appendix.

Table 5. Existing Year 2016 Operational Analysis Results

Alternative	Analysis Tool		A.M. Peak		P.M. Peak	
			Delay (1) (sec/veh)	LOS	Delay (1) (sec/veh)	LOS
All-Way Stop Control	Synchro/SimTraffic		26/**51**	D/**F**	4/5	A/A
Traffic Signal Control	Synchro/SimTraffic		14/22	B/C	6/13	A/B
Roundabout Control	HCS 2010		10/13	A/B	6/7	A/A
	RODEL	50% CL	4/6	A/A	5/7	A/A
		85% CL	6/10	A/A	8/11	A/B

(1) Control/stop delay is reported. Overall results are followed by the worst approach results.

Table 6. Forecasted Year 2036 Operational Analysis Results

Alternative	Analysis Tool		A.M. Peak		P.M. Peak	
			Delay (1) (sec/veh)	LOS	Delay (1) (sec/veh)	LOS
All-Way Stop Control	Synchro/SimTraffic		**>100/>100**	**F/F**	6/6	A/A
Traffic Signal Control	Synchro/SimTraffic		26/28	C/C	7/15	A/B
Roundabout Control	HCS 2010		16/29	C/D	8/10	A/A
	RODEL	50% CL	6/9	A/A	7/10	A/B
		85% CL	10/21	B/C	16/25	C/D

(1) Control/stop delay is reported. Overall results are followed by the worst approach results.

Results of the operational analysis indicate that under the existing all-way stop control, the westbound approach operates with an unacceptable level of service during the a.m. peak. Under Forecasted Year 2036 conditions, the all-way stop control alternative would continue to operate with unacceptable levels of service in the a.m. peak, therefore the all-way stop control alternative was not considered further as a viable alternative. The traffic signal control and roundabout control alternatives would operate with acceptable levels of service under forecasted conditions. The traffic signal control alternative would be best suited to accommodate additional traffic volumes by signal retiming and/or lane use changes if future commercial, recreational, and educational land uses, discussed previously, are fully realized. The roundabout control alternative would require reconstruction to provide additional capacity.

Safety Analysis

A crash analysis was performed to determine the projected crashes per year for Year 2016 and Forecasted Year 2036 conditions for the study intersection. Crash rates from the MnDOT Green Sheets (2011 to 2015 data) were used for the crash analysis of the alternatives. According to *NCHRP Report 672 Roundabouts: An Informational Guide, Second Edition* (Transportation Research Board, 2010), the conversion of an all-way stop controlled intersection to a roundabout has an insignificant impact on safety. Therefore, the crash rate for all-way stop control was used for the roundabout control alternative. A summary of the crash analysis is shown in Table 7.

Table 7. Crash Analysis Results

Alternative	Intersection AADT (2016)	Intersection AADT (2036)	Crash Rate	Projected Crashes/Year (2016)	Projected Crashes/Year (2036)
Traffic Signal Control	12,300	15,900	0.52	3	4
Roundabout Control			0.35	2	3

Based on the results of the crash analysis, the roundabout control alternative is anticipated to have slightly less crashes than the traffic signal control alternative.

Studies have determined that the installation of a roundabout can improve overall safety of an intersection when compared to other forms of intersection control. Roundabouts typically have fewer conflict points than conventional intersections and the geometry of a roundabout induces lower speeds for vehicles approaching and traversing an intersection. With lower speeds, the severity of the crashes is decreased. A roundabout virtually eliminates right-angle and left-turn head-on crashes. Studies have shown the frequency of injury crashes is reduced more than property damage only crashes.

At a roundabout, drivers must be aware of traffic traveling around the circle when merging on or off the roundabout. Conversely, drivers at a traditional intersection must be aware of vehicles at all approaches and the movements they are making. This issue is most prevalent at stop-controlled intersections where there is not a traffic signal to control vehicle movements.

Planning-Level Cost Analysis

Capital Costs

The traffic signal control alternative can utilize the existing geometric conditions, therefore the cost for this alternative would only be the cost of installing a traffic signal system, along with ADA improvements. The roundabout control alternative would require substantial reconstruction at and leading up to the intersection, which results in a much higher cost than the traffic signal control alternative.

Operation and Maintenance Costs

Traffic signals typically have higher operation and maintenance costs than roundabouts because of the electricity required to operate the signal and routine maintenance required to keep the signal in operation. Operation and maintenance costs associated with a roundabout can vary depending on the amount of illumination required or landscaping alternatives used for the center island.

A cost analysis summary is shown in Table 8. Detailed cost analysis results can be found in the Appendix.

Table 8. Cost Analysis Summary

Alternative	Capital Costs (1)	Operation/Maintenance Costs (annual)
Traffic Signal Control	$300,000	$4,000-$6,000
Roundabout Control	$1,490,000	$500-$1,000

(1) Does not include engineering or right-of-way costs.

Alternatives Assessment

Right-of-Way Considerations

The roadway geometry for the traffic signal control alternative would use existing conditions and therefore no additional right-of-way would be expected. Construction of a roundabout at the study intersection would require additional right-of-way in all four quadrants of the intersection. The right-of-way impacts in the northwest and southeast quadrants would be minimal, while the impacts in the northeast and southwest quadrants would be more significant. In the southwest quadrant, the roundabout control alternative would result in the roadway and sidewalk moving closer to the power distribution facility.

Transportation System Considerations

There is an existing traffic signal approximately 900 feet south of the study intersection at the Lor Ray Drive and T.H. 14 north ramps intersection, and another a quarter mile farther south at the Lor Ray Drive and Commerce Drive intersection. The traffic signal control alternative would extend the continuity of this type of intersection control along Lor Ray Drive. There are several roundabouts west of the study intersection at T.H. 14 interchanges. No significant queues are expected with either the traffic signal control or roundabout control alternatives.

Pedestrian and Bicycle Considerations

Currently, there are sidewalks on both sides of all legs of the study intersection. Caswell Park and Dakota Meadows Middle School in the adjacent area contribute to high pedestrian activity. Pedestrian accommodations can be provided regardless of selected intersection control. The design of a roundabout allows pedestrians to cross one direction of traffic at a time with a refuge space in the middle of each leg of the roundabout, and these short crossing distances and reduced travel speeds of traffic improve pedestrian safety. Their route is slightly longer since they are kept to the outside of the inscribed circle. The design of signalized intersections can create a safe environment for pedestrian crossings with the use of pedestrian signal phasing. This phasing allows pedestrians to safely cross an intersection while vehicular movements are served. Although signalized intersections can provide indications showing pedestrian right-of-way, potential conflicts can come from red-light running through vehicles and permissive turning traffic.

Local Acceptance

Drivers are familiar with traveling through signalized intersections since there are many intersections in the area under this type of traffic control. Drivers are also familiar with traveling through roundabout controlled intersections since there are many existing roundabouts throughout the Mankato area including two roundabouts a mile west at the T.H. 14 and Lookout Drive interchange.

Conclusions and Recommendations

The following conclusions are provided for this intersection control evaluation for the Lor Ray Drive at Howard Drive intersection in North Mankato, Nicollet County, Minnesota:

- *Warrants Analysis*
  Results of the warrants analysis indicate that Existing Year 2016 volumes do not satisfy any traffic signal warrants, while Forecasted Year 2036 volumes satisfy the MN MUTCD warrant requirements for traffic signal Warrants 2 and 3B.

- *Operational Analysis*
  Results of the operational analysis indicate that all-way stop is not a viable alternative. The traffic signal control and roundabout control alternatives would operate with acceptable levels of service under forecasted conditions.

- *Safety Analysis*
  Based on the results of the crash analysis, the roundabout control alternative is anticipated to have slightly less crashes than the traffic signal control alternative. Roundabouts typically have fewer conflict points than conventional intersections and the geometry of a roundabout induces lower speeds for vehicles approaching and traversing an intersection. With lower speeds, the severity of the crashes is decreased.

- *Planning-Level Cost Analysis*
  The traffic signal control alternative can utilize the existing geometric conditions, therefore the cost for this alternative would only be the cost of installing a traffic signal system, along with ADA improvements, which would be approximately $300,000. The roundabout control alternative would require substantial reconstruction at and leading up to the intersection, which results in a much higher cost estimate of approximately $1,490,000. Traffic signals typically have higher operation and maintenance costs because of the electricity required to operate the signal and routine maintenance required to keep the signal in operation. Operation and maintenance costs associated with a roundabout can vary depending on the amount of illumination required or landscaping alternatives used for the center island.

- *Right-of-Way Considerations*
  The roadway geometry for the traffic signal control alternative would use existing conditions and therefore no additional right-of-way would be expected. Construction of a roundabout at the study intersection would require additional right-of-way in all four quadrants of the intersection. The right-of-way impacts in the northwest and southeast quadrants would be minimal, while the impacts in the northeast and southwest quadrants would be more significant.

- *Transportation System Considerations*
  There is an existing traffic signal approximately 900 feet south of the study intersection at the Lor Ray Drive and T.H. 14 north ramps intersection, and one quarter mile farther

south there is another traffic signal. There are several roundabouts west of the study intersection at T.H. 14 interchanges. The traffic signal control alternative would extend the intersection control continuity along Lor Ray Drive.

- *Pedestrian and Bicycle Considerations*
  The design of signalized intersections can take pedestrian crossings and safety into consideration with the use of pedestrian signal phasing. The design of a roundabout allows pedestrians to cross one direction of traffic at a time on each leg of the roundabout. Their route is slightly longer since they are kept to the outside of the inscribed circle.

- *Local Acceptance*
  Drivers are familiar with traveling through signalized intersections since there are many intersections in the area under this type of traffic control. Drivers are also familiar with traveling through roundabout controlled intersections since there are many existing roundabouts throughout the Mankato area including two roundabouts a mile west at the T.H. 14 and Lookout Drive interchange.

A decision matrix was developed to help evaluate the key factors and is provided on the following page. Based on the results of this Intersection Control Evaluation, both the traffic signal control and roundabout control alternatives are viable options for the Lor Ray Drive at Howard Drive intersection. Roundabout control is recommended since this type of control is anticipated to have slightly less crashes than the traffic signal control alternative. Roundabouts typically have fewer conflict points than conventional intersections and the geometry of a roundabout induces lower speeds for vehicles approaching and traversing an intersection. With lower speeds, the severity of the crashes is decreased. Drivers are familiar with roundabout control since there are many existing roundabouts throughout the Mankato area including two roundabouts a mile west at the T.H. 14 and Lookout Drive interchange. Consideration should be made during the design of the roundabout for future capacity needs that may be necessary if proposed future commercial, recreational, and educational land uses are fully realized. These considerations would include additional right of way needs in addition to utility relocations.

Alternatives Decision Matrix: Lor Ray Drive at Howard Drive

Factor		All-Way Stop Control	Traffic Signal Control	Roundabout Control	Recommended Alternative(s) Based on Factor
Warrants Analysis	2016	• AWSC warrant not met	• Existing Year 2016 volumes do not meet traffic signal control warrants	N/A	Roundabout Control
	2036	• AWSC warrant met	• Forecasted Year 2036 volumes meet traffic signal control warrants	N/A	All-Way Stop Control Traffic Signal Control Roundabout Control
Operational Analysis	2016	• Lowest p.m. peak delay • Unacceptable a.m. peak LOS	• Acceptable LOS	• Acceptable LOS	Traffic Signal Control Roundabout Control
	2036	• Unacceptable a.m. peak LOS	• Acceptable LOS	• Acceptable LOS	Traffic Signal Control Roundabout Control
Additional Capacity for Future Growth		Forecasted Year 2036 volumes are over capacity	Additional capacity can be realized by signal retiming and/or lane use adjustments.	Additional capacity would require reconstruction of portions of the roundabout.	Traffic Signal Control
Safety Analysis	Pro(s):	N/A	• Signal indications show vehicle right-of-way	• Least number of crashes expected • Lower vehicle speeds through intersection	Roundabout Control
	Con(s):	N/A	• Slightly more crashes expected than roundabout	• Drivers select acceptable gaps	
Cost Analysis	Pro(s):	N/A	• Lower capital costs ($300,000) than roundabout control	• Lower operation/maintenance costs than traffic signal control	Traffic Signal Control
	Con(s):	N/A	• Higher operation/maintenance costs than roundabout control	• Higher capital costs ($1,490,000) than traffic signal control • Requires substantial reconstruction	
Right-of-Way	Pro(s):	N/A	• No ROW impacts	none	Traffic Signal Control
	Con(s):	N/A	none	• Requires additional ROW in all four quadrants	
Transportation System Considerations	Pro(s):	N/A	• Provides control continuity along Lor Ray Drive	• Matches control of roundabouts at nearby T.H. 14 interchanges	Traffic Signal Control Roundabout Control
	Con(s):	N/A	none	none	
Pedestrian and Bicycle Considerations	Pro(s):	N/A	• Pedestrian pushbuttons and signal phasing	• Pedestrian refuge islands • Lower vehicles speeds through intersection	Traffic Signal Control Roundabout Control
	Con(s):	N/A	• Pedestrian signal phasing can lead to a false sense of security	• Longer pedestrian route • No pedestrian phase	
Local Acceptance	Pro(s):	N/A	• Familiar to drivers	• Familiar to drivers	Traffic Signal Control Roundabout Control
	Con(s):	N/A	none	none	

Appendix

- 2011-2015 Crash History
- Existing Year 2016 Warrants Analysis
- Forecasted Year 2036 Warrants Analysis
- Existing Year 2016 Detailed Operational Analysis
- Forecasted Year 2036 Detailed Operational Analysis
- Detailed Cost Analysis

2011-2015 Crash History

Crash Detail Report

Lor Ray Drive and Howard Drive

Report Version 1.0 March 2010

Crash ID:	110590205	**Date:**	02/28/2011	**Time:**	1358
County:	NICOLLET	**City:**	NORTH MANKATO		

Sys: 05-MSAS
Route: 28550255 000+00.805

Severity:	PROPERTY DAMAGE	**First Event:**	ON ROADWAY
Road Type:	4_6 LANES UNDIV 2_WAY	**To Junction:**	4-LEGGED INTERSECTION
Road Char:	STRAIGHT AND LEVEL	**Traffic Device:**	STOP SIGN 4-WAY
Crash Type:	COLL W/MV IN TRANSPORT	**Speed Limit:**	30
Surf Cond:	DRY	**Diagram:**	SIDESWIPE PASSING
Light Cond:	DAYLIGHT	**Officer:**	
Weather 1:	CLEAR	**Reliability:**	CONFIDENT
Weather 2:	NOT SPECIFIED	**# of Vehicles:**	2.00

	Unit 1	Unit 2	Unit 3
Trav Dir:	EAST	E	
Veh Act:	RIGHT TURN	RIGHT TURN	
Veh Type:	PASSENGER CAR	TRUCK W/ SEMI TRAILER	
Age:	44	26	
Gender:	F	M	
Cond:	NORMAL	NORMAL	
Cont Fact 1	NO IMPROPER DRIVING	NO IMPROPER DRIVING	
Cont Fact 2	NOT SPECIFIED	NOT SPECIFIED	

Crash ID:	112410151	**Date:**	08/25/2011	**Time:**	1451
County:	NICOLLET	**City:**	NORTH MANKATO		

Sys: 05-MSAS
Route: 28550255 000+00.805

Severity:	NON-INCAPACITATING INJURY	**First Event:**	ON ROADWAY
Road Type:	4_6 LANES UNDIV 2_WAY	**To Junction:**	4-LEGGED INTERSECTION
Road Char:	STRAIGHT AND LEVEL	**Traffic Device:**	STOP SIGN 4-WAY
Crash Type:	COLL W/PEDALCYCLE	**Speed Limit:**	30
Surf Cond:	DRY	**Diagram:**	HEAD ON
Light Cond:	DAYLIGHT	**Officer:**	
Weather 1:	CLEAR	**Reliability:**	CONFIDENT
Weather 2:	NOT SPECIFIED	**# of Vehicles:**	1.00

	Unit 1	Unit 2	Unit 3
Trav Dir:	EAST	NW	
Veh Act:	START TRAFFIC	STRAIGHT AHEAD	
Veh Type:	PICKUP TRUCK	BICYCLE	
Age:	57	45	
Gender:	M	M	
Cond:	NORMAL	NORMAL	
Cont Fact 1	DISTRACTION	NO IMPROPER DRIVING	
Cont Fact 2	NOT SPECIFIED	NOT SPECIFIED	

Crash ID:	120810087	**Date:**	03/21/2012	**Time:**	1510
County:	NICOLLET	**City:**	NORTH MANKATO		

Sys: 05-MSAS
Route: 28550255 000+00.805

Severity:	PROPERTY DAMAGE	**First Event:**	ON ROADWAY
Road Type:	3 LANES UNDIVIDED	**To Junction:**	INTERSECTION-RELATED
Road Char:	STRAIGHT AND LEVEL	**Traffic Device:**	STOP SIGN 4-WAY
Crash Type:	COLL W/MV IN TRANSPORT	**Speed Limit:**	30
Surf Cond:	DRY	**Diagram:**	RIGHT ANGLE
Light Cond:	DAYLIGHT	**Officer:**	
Weather 1:	CLOUDY	**Reliability:**	CONFIDENT
Weather 2:	NOT SPECIFIED	**# of Vehicles:**	2.00

	Unit 1	Unit 2	Unit 3
Trav Dir:	N	E	
Veh Act:	START TRAFFIC	STRAIGHT AHEAD	
Veh Type:	VAN OR MINIVAN	VAN OR MINIVAN	
Age:	86	38	
Gender:	F	F	
Cond:	NORMAL	NORMAL	
Cont Fact 1	FAIL TO YIELD ROW	NO IMPROPER DRIVING	
Cont Fact 2	NOT SPECIFIED	NOT SPECIFIED	

Crash ID:	122050074	**Date:**	07/22/2012	**Time:**	1147
County:	NICOLLET	**City:**	NORTH MANKATO		

Sys: 05-MSAS
Route: 28550117 000+00.806

Severity:	PROPERTY DAMAGE	**First Event:**	ON ROADWAY
Road Type:	4_6 LANES UNDIV 2_WAY	**To Junction:**	NON-JUNCTION
Road Char:	STRAIGHT AND LEVEL	**Traffic Device:**	STOP SIGN 4-WAY
Crash Type:	COLL W/MV IN TRANSPORT	**Speed Limit:**	30
Surf Cond:	DRY	**Diagram:**	SIDESWIPE PASSING
Light Cond:	DAYLIGHT	**Officer:**	
Weather 1:	CLEAR	**Reliability:**	CONFIDENT
Weather 2:	NOT SPECIFIED	**# of Vehicles:**	2.00

	Unit 1	Unit 2	Unit 3
Trav Dir:	N	N	
Veh Act:	STRAIGHT AHEAD	STRAIGHT AHEAD	
Veh Type:	PICKUP TRUCK	PASSENGER CAR	
Age:	38	87	
Gender:	M	F	
Cond:	NORMAL	NORMAL	
Cont Fact 1	NO IMPROPER DRIVING	IMPROPER LANE	
Cont Fact 2	NOT SPECIFIED	IMPROPER TURN	

Crash ID:	132490096	**Date:**	09/03/2013	**Time:**	1645
County:	NICOLLET	**City:**	NORTH MANKATO		

Sys: 05-MSAS
Route: 28550117 000+00.812

Severity:	PROPERTY DAMAGE	**First Event:**	ON ROADWAY
Road Type:	4_6 LANES UNDIV 2_WAY	**To Junction:**	4-LEGGED INTERSECTION
Road Char:	STRAIGHT AND LEVEL	**Traffic Device:**	STOP SIGN 4-WAY
Crash Type:	COLL W/MV IN TRANSPORT	**Speed Limit:**	30
Surf Cond:	DRY	**Diagram:**	RIGHT ANGLE
Light Cond:	DAYLIGHT	**Officer:**	
Weather 1:	CLEAR	**Reliability:**	CONFIDENT
Weather 2:	NOT SPECIFIED	**# of Vehicles:**	2.00

	Unit 1	Unit 2	Unit 3
Trav Dir:	W	S	
Veh Act:	LEFT TURN	STRAIGHT AHEAD	
Veh Type:	SPORT UNTILITY VEHICLE	PICKUP TRUCK	
Age:	48	29	
Gender:	F	M	
Cond:	NORMAL	NORMAL	
Cont Fact 1	NO IMPROPER DRIVING	DISREGARD TRAFFIC DEVICE	
Cont Fact 2	NOT SPECIFIED	FAIL TO YIELD ROW	

Crash ID:	141900191	**Date:**	07/09/2014	**Time:**	1938
County:	NICOLLET	**City:**	NORTH MANKATO		

Sys: 05-MSAS
Route: 28550117 000+00.812

Severity:	POSSIBLE INJURY	**First Event:**	ON ROADWAY
Road Type:	4_6 LANES UNDIV 2_WAY	**To Junction:**	4-LEGGED INTERSECTION
Road Char:	STRAIGHT AND LEVEL	**Traffic Device:**	STOP SIGN 4-WAY
Crash Type:	COLL W/PEDALCYCLE	**Speed Limit:**	30
Surf Cond:	DRY	**Diagram:**	NOT APPLICABLE
Light Cond:	SUNSET	**Officer:**	
Weather 1:	CLEAR	**Reliability:**	CONFIDENT
Weather 2:	NOT SPECIFIED	**# of Vehicles:**	1.00

	Unit 1	Unit 2	Unit 3
Trav Dir:	W	E	
Veh Act:	STRAIGHT AHEAD	STRAIGHT AHEAD	
Veh Type:	VAN OR MINIVAN	BICYCLE	
Age:	72	37	
Gender:	F	F	
Cond:	NORMAL	NORMAL	
Cont Fact 1	FAIL TO YIELD ROW	NO IMPROPER DRIVING	
Cont Fact 2	NOT SPECIFIED	NOT SPECIFIED	

Crash ID:	150500116	**Date:**	02/19/2015	**Time:**	0815
County:	NICOLLET	**City:**	NORTH MANKATO		

Sys: 05-MSAS
Route: 28550117   000+00.812

Severity:	PROPERTY DAMAGE	**First Event:**	ON ROADWAY
Road Type:	4_6 LANES UNDIV 2_WAY	**To Junction:**	INTERSECTION-RELATED
Road Char:	STRAIGHT AND LEVEL	**Traffic Device:**	STOP SIGN 4-WAY
Crash Type:	COLL W/MV IN TRANSPORT	**Speed Limit:**	30
Surf Cond:	DRY	**Diagram:**	LEFT TURN INTO TRAFFIC
Light Cond:	DAYLIGHT	**Officer:**	
Weather 1:	CLEAR	**Reliability:**	CONFIDENT
Weather 2:	NOT SPECIFIED	**# of Vehicles:**	2.00

	Unit 1	Unit 2	Unit 3
Trav Dir:	N	NE	
Veh Act:	STRAIGHT AHEAD	LEFT TURN	
Veh Type:	PICKUP TRUCK	VAN OR MINIVAN	
Age:	59	21	
Gender:	M	M	
Cond:	NORMAL	NORMAL	
Cont Fact 1	NO IMPROPER DRIVING	FAIL TO YIELD ROW	
Cont Fact 2	NOT SPECIFIED	OTHER VEHICLE DEFECT	

Selection Filter:

WORK AREA: Statewide - FILTER: CRASH_YEAR('2011','2012','2013','2014','2015'), TRAFFIC_CONTROL_DEVICE_CODE('03') - SPATIAL FILTER APPLIED

Analyst:

Luke James

Notes:

Existing Year 2016 Warrants Analysis

WARRANTS ANALYSIS Existing Year 2016

Consulting Group, Inc.

Lor Ray Drive at Howard Drive
Intersection Control Evaluation Studies
MAPO

Background Information		Speed (mph)	Lanes	Approach	
Location :	MAPO				
Date:	9/28/2016	30	2 or more	Major Approach 1:	Northbound Lor Ray Drive
Analysis Prepared By:	Luke James	30	2 or more	Major Approach 3:	Southbound Lor Ray Drive
Population Less than 10,000:	No	30	1	Minor Approach 2:	Eastbound Howard Drive
Seventy Percent Factor Used:	No	30	1	Minor Approach 4:	Westbound Howard Drive

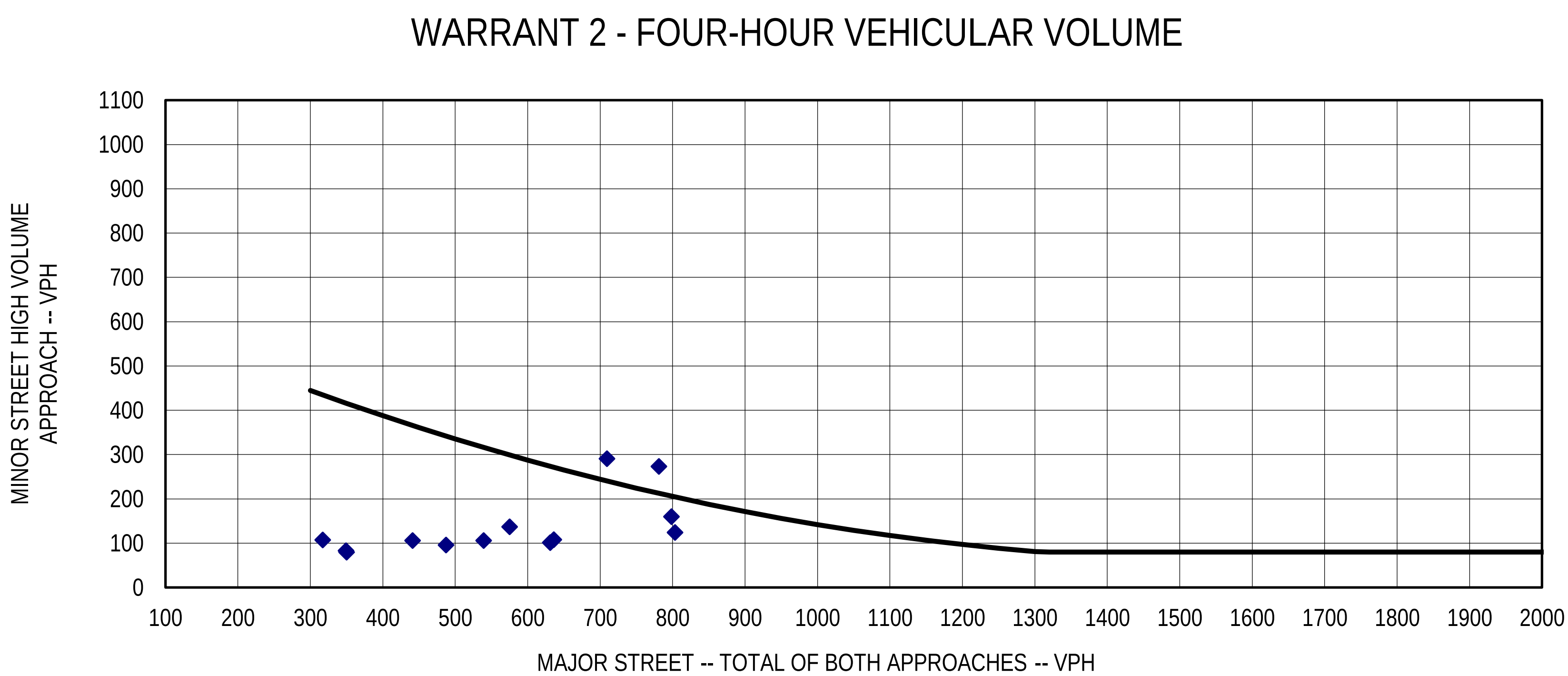
Warrants Analysis: Warrants 1A, 1B and 1C

Hour	Major Approach 1	Major Approach 3	Total 1 + 3	Warrant Met		Minor Approach 2	Minor Approach 4	Largest Minor App.	Warrant Met		Met Same Hours		Combination		MWSA (C)	
				600	900				150	75	Condition A	Condition B	A	B	300	200
6 - 7 AM	128	189	317			15	107	107		X					X	
7 - 8 AM	346	435	781	X		168	273	273	X	X	X		X	X	X	X
8 - 9 AM	342	233	575			137	134	137		X			X		X	X
9 - 10 AM	194	156	350			80	61	80		X					X	
10 - 11 AM	208	141	349			56	83	83		X					X	
11 - 12 AM	307	134	441			106	64	106		X					X	
12 - 1 PM	352	187	539			106	102	106		X					X	X
1 - 2 PM	321	166	487			58	96	96		X					X	
2 - 3 PM	442	194	636	X		105	108	108		X					X	X
3 - 4 PM	496	213	709	X		291	113	291	X	X	X		X		X	X
4 - 5 PM	575	223	798	X		160	139	160	X	X	X		X	X	X	X
5 - 6 PM	600	203	803	X		120	124	124		X			X	X	X	X
6 - 7 PM	433	198	631	X		80	101	101		X					X	
											3	0	5	3	7	

Warrant Summary

Warrant and Description		Hours Met	Hours Required	Met/Not Met
Warrant 1A:	Minimum Vehicular Volume	3	8	Not Met
Warrant 1B:	Interruption of Continuous Traffic	0	8	Not Met
Warrant 1C:	Combination of Warrants	3	8	Not Met
Warrant 2:	Four-Hour Vehicular Volume	2	4	Not Met
Warrant 3B:	Peak Hour	0	1	Not Met
MWSA (C):	Multiway Stop Applications Condition C	7	8	Not Met

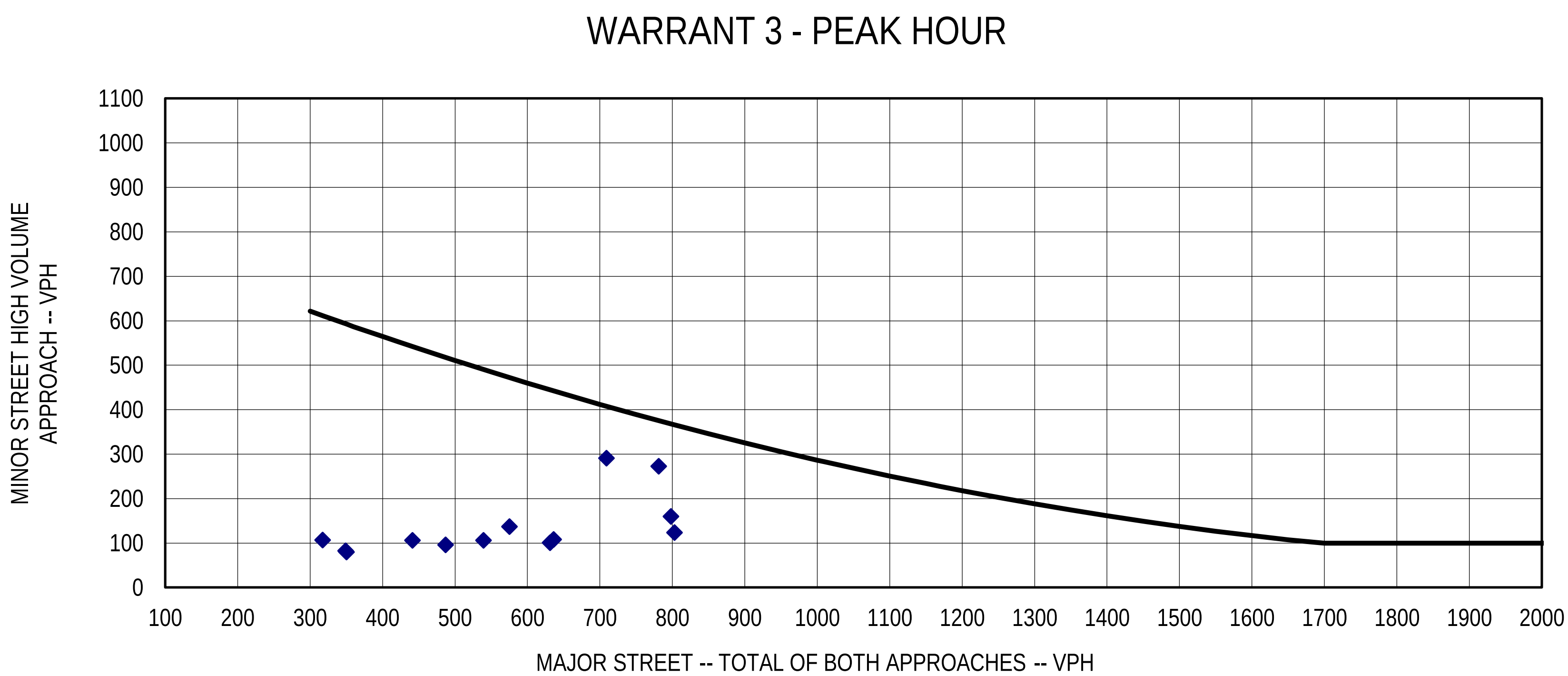
Warrants Analysis: Warrant 2



Number of Hours Satisfying Requirements:	2

Notes: 1. 115 VPH APPLIES AS THE LOWER THRESHOLD VOLUME FOR A MINOR STREET APPROACH WITH TWO OR MORE LANES AND 80 VPH APPLIES AS THE LOWER THRESHOLD VOLUME FOR A MINOR STREET APPROACHING WITH ONE LANE.

Warrants Analysis: Warrant 3



Number of Hours Satisfying Requirements:	0

Notes: 1. 150 VPH APPLIES AS THE LOWER THRESHOLD VOLUME FOR A MINOR STREET APPROACH WITH TWO OR MORE LANES AND 100 VPH APPLIES AS THE LOWER THRESHOLD VOLUME FOR A MINOR STREET APPROACHING WITH ONE LANE.

Forecasted Year 2036 Warrants Analysis

SRF Consulting Group, Inc.

WARRANTS ANALYSIS

Forecasted Year 2036

Lor Ray Drive at Howard Drive

Intersection Control Evaluation Studies

MAPO

Background Information

		Speed (mph)	Lanes	Approach	
Location :	MAPO				
Date:	9/28/2016	30	2 or more	Major Approach 1:	Northbound Lor Ray Drive
Analysis Prepared By:	Luke James	30	2 or more	Major Approach 3:	Southbound Lor Ray Drive
Population Less than 10,000:	No	30	1	Minor Approach 2:	Eastbound Howard Drive
Seventy Percent Factor Used:	No	30	1	Minor Approach 4:	Westbound Howard Drive

Warrants Analysis: Warrants 1A, 1B and 1C

Hour	Major Approach 1	Major Approach 3	Total 1 + 3	Warrant Met 600	Warrant Met 900	Minor Approach 2	Minor Approach 4	Largest Minor App.	Warrant Met 150	Warrant Met 75	Met Same Hours Condition A	Met Same Hours Condition B	Combination A	Combination B	MWSA (C) 300	MWSA (C) 200
6 - 7 AM	164	242	406			20	143	143		X					X	
7 - 8 AM	443	557	1000	X	X	225	366	366	X	X	X	X	X	X	X	X
8 - 9 AM	438	298	736	X		184	180	184	X	X	X		X	X	X	X
9 - 10 AM	248	200	448			107	82	107		X					X	
10 - 11 AM	266	180	446			75	111	111		X					X	
11 - 12 AM	393	172	565			142	86	142		X			X		X	X
12 - 1 PM	451	239	690	X		142	137	142		X			X		X	X
1 - 2 PM	411	212	623	X		78	129	129		X			X		X	X
2 - 3 PM	566	248	814	X		141	145	145		X			X	X	X	X
3 - 4 PM	635	273	908	X	X	390	151	390	X	X	X	X	X	X	X	X
4 - 5 PM	736	285	1021	X	X	214	186	214	X	X	X	X	X	X	X	X
5 - 6 PM	768	260	1028	X	X	161	166	166	X	X	X	X	X	X	X	X
6 - 7 PM	554	253	807	X		107	135	135		X			X	X	X	X
											5	4	10	7	10	

Warrant Summary

Warrant and Description		Hours Met	Hours Required	Met/Not Met
Warrant 1A:	Minimum Vehicular Volume	5	8	Not Met
Warrant 1B:	Interruption of Continuous Traffic	4	8	Not Met
Warrant 1C:	Combination of Warrants	7	8	Not Met
Warrant 2:	Four-Hour Vehicular Volume	4	4	Met - Warrant 2 Satisfied
Warrant 3B:	Peak Hour	2	1	Met - Warrant 3B Satisfied
MWSA (C):	Multiway Stop Applications Condition C	10	8	Met - Multiway Stop Applications

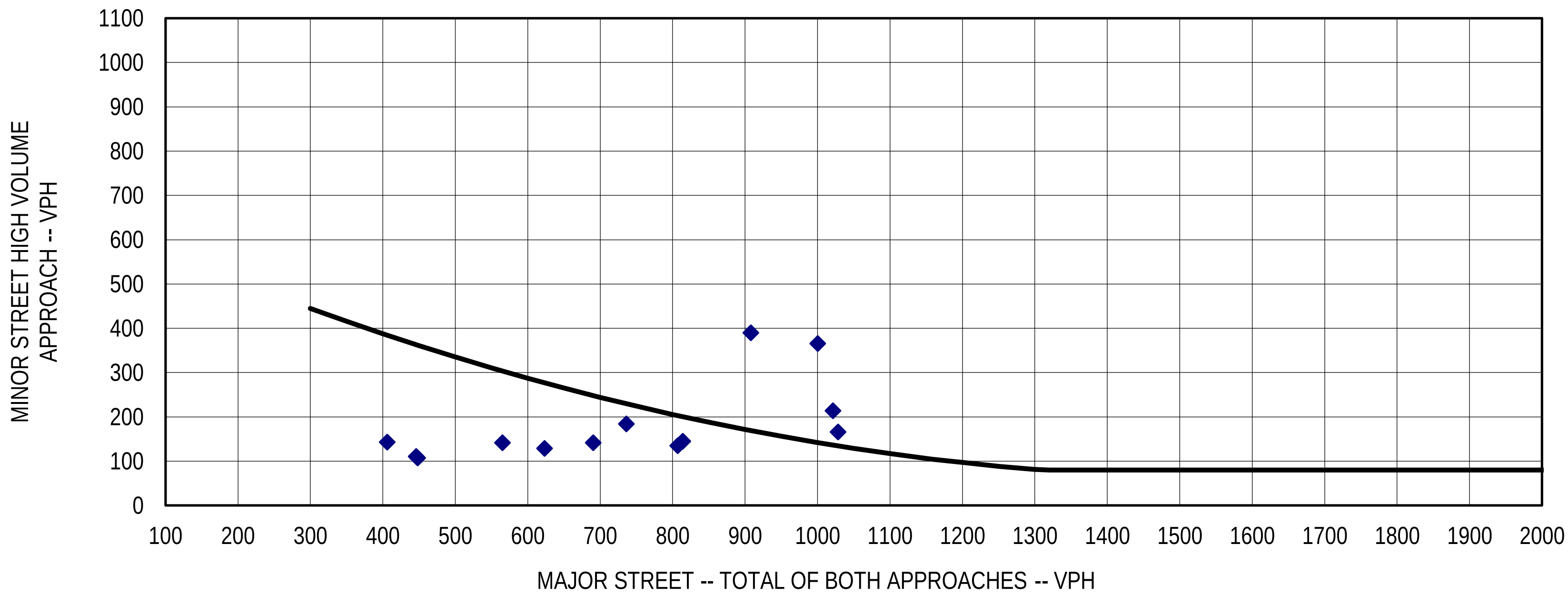
![SRF Consulting Group, Inc.]

WARRANTS ANALYSIS Forecasted Year 2036

Lor Ray Drive at Howard Drive
Intersection Control Evaluation Studies
MAPO

Warrants Analysis: Warrant 2

WARRANT 2 - FOUR-HOUR VEHICULAR VOLUME



Number of Hours Satisfying Requirements:	4

Notes: 1. 115 VPH APPLIES AS THE LOWER THRESHOLD VOLUME FOR A MINOR STREET APPROACH WITH TWO OR MORE LANES AND 80 VPH APPLIES AS THE LOWER THRESHOLD VOLUME FOR A MINOR STREET APPROACHING WITH ONE LANE.

SRF Consulting Group, Inc.

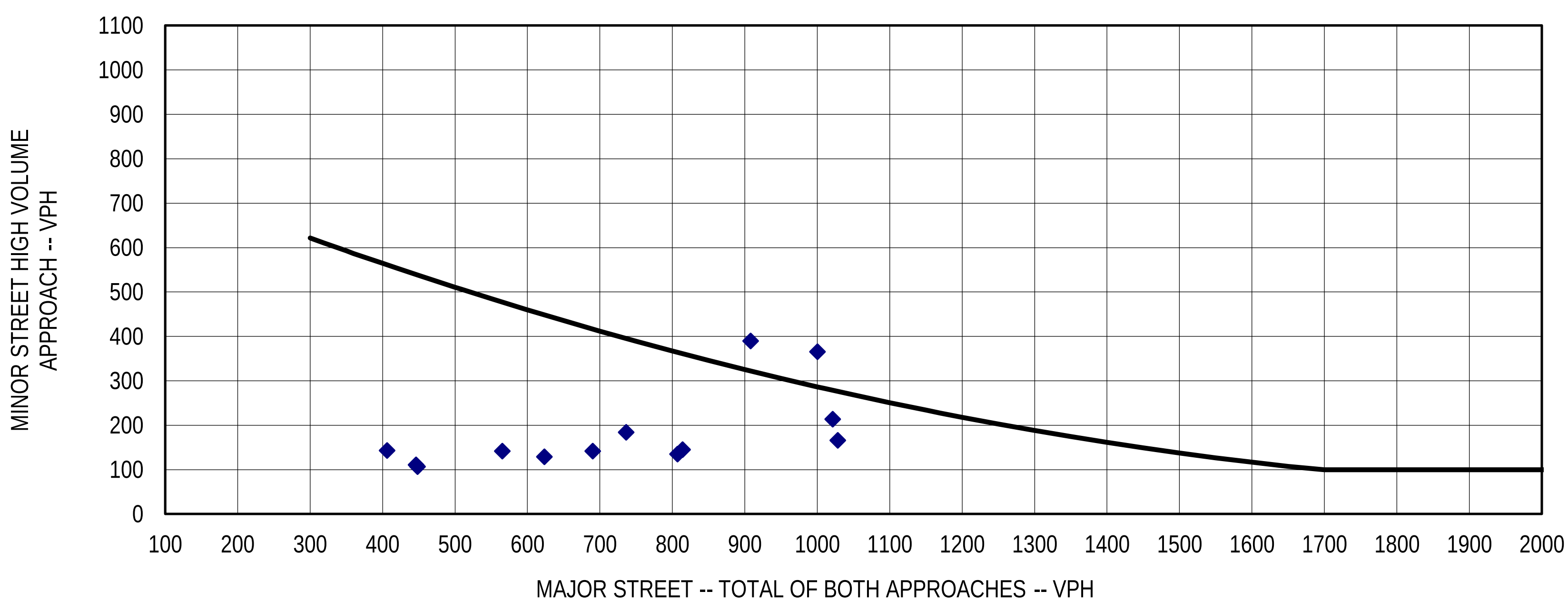
WARRANTS ANALYSIS

Forecasted Year 2036

Lor Ray Drive at Howard Drive
Intersection Control Evaluation Studies
MAPO

Warrants Analysis: Warrant 3

WARRANT 3 - PEAK HOUR



Number of Hours Satisfying Requirements:	2

Notes: 1. 150 VPH APPLIES AS THE LOWER THRESHOLD VOLUME FOR A MINOR STREET APPROACH WITH TWO OR MORE LANES AND 100 VPH APPLIES AS THE LOWER THRESHOLD VOLUME FOR A MINOR STREET APPROACHING WITH ONE LANE.

Existing Year 2016 Detailed Operational Analysis

All-Way Stop Control

1: Lor Ray Drive & Howard Drive Performance by approach

Approach	EB	WB	NB	SB	All
Denied Delay (hr)	0.2	0.2	0.2	0.1	0.8
Denied Del/Veh (s)	3.2	3.1	1.8	0.8	2.0
Total Delay (hr)	0.8	4.0	3.5	3.0	11.3
Total Del/Veh (s)	11.3	51.3	26.7	24.0	27.9
Stop Delay (hr)	0.7	4.0	3.3	2.5	10.5
Stop Del/Veh (s)	10.2	51.3	25.2	19.9	25.9
Total Stops	256	280	387	418	1341
Stop/Veh	0.99	1.00	0.83	0.92	0.92

Intersection: 1: Lor Ray Drive & Howard Drive

Movement	EB	EB	EB	WB	WB	NB	NB	SB	SB	SB
Directions Served	L	T	R	L	TR	L	T	L	T	TR
Maximum Queue (ft)	40	57	143	231	317	301	203	31	229	194
Average Queue (ft)	14	18	66	117	83	113	57	4	109	71
95th Queue (ft)	39	48	118	235	364	277	225	20	194	165
Link Distance (ft)		954			966		954		966	
Upstream Blk Time (%)										
Queuing Penalty (veh)										
Storage Bay Dist (ft)	150		80	150		300		180		180
Storage Blk Time (%)			7	20		6	0		2	0
Queuing Penalty (veh)			3	6		9	1		6	1

1: Lor Ray Drive & Howard Drive Performance by approach

Approach	EB	WB	NB	SB	All
Denied Delay (hr)	0.1	0.1	0.1	0.0	0.4
Denied Del/Veh (s)	3.4	3.4	0.6	0.5	1.2
Total Delay (hr)	0.1	0.2	1.2	0.6	2.1
Total Del/Veh (s)	4.0	5.6	6.7	7.8	6.5
Stop Delay (hr)	0.1	0.2	0.5	0.3	1.1
Stop Del/Veh (s)	3.3	4.5	3.1	3.7	3.5
Total Stops	127	134	429	246	936
Stop/Veh	0.99	0.99	0.68	0.95	0.81

Intersection: 1: Lor Ray Drive & Howard Drive

Movement	EB	EB	EB	WB	WB	NB	NB	SB	SB	SB
Directions Served	L	T	R	L	TR	L	T	L	T	TR
Maximum Queue (ft)	33	31	67	80	34	52	129	30	93	53
Average Queue (ft)	9	4	36	41	5	24	58	5	49	23
95th Queue (ft)	32	21	57	66	25	43	94	23	77	49
Link Distance (ft)		954			966		954		966	
Upstream Blk Time (%)										
Queuing Penalty (veh)										
Storage Bay Dist (ft)	150		80	150		300		180		180
Storage Blk Time (%)			0							
Queuing Penalty (veh)			0							

Existing Year 2016 Detailed Operational Analysis

Traffic Signal Control

1: Lor Ray Drive & Howard Drive Performance by approach

Approach	EB	WB	NB	SB	All
Denied Delay (hr)	0.2	0.3	0.3	0.1	0.9
Denied Del/Veh (s)	3.5	3.4	2.0	0.9	2.2
Total Delay (hr)	0.8	2.0	1.6	2.6	7.0
Total Del/Veh (s)	10.9	25.0	12.2	20.4	17.1
Stop Delay (hr)	0.7	1.8	1.3	2.0	5.8
Stop Del/Veh (s)	9.5	22.1	10.1	15.8	14.1
Total Stops	225	235	260	292	1012
Stop/Veh	0.88	0.81	0.56	0.63	0.69

Intersection: 1: Lor Ray Drive & Howard Drive

Movement	EB	EB	EB	WB	WB	NB	NB	SB	SB	SB
Directions Served	L	T	R	L	TR	L	T	L	T	TR
Maximum Queue (ft)	50	83	128	225	160	214	106	28	227	215
Average Queue (ft)	13	19	58	117	27	86	33	3	126	72
95th Queue (ft)	42	60	102	197	112	159	77	19	206	174
Link Distance (ft)		954			966		954		966	
Upstream Blk Time (%)										
Queuing Penalty (veh)										
Storage Bay Dist (ft)	150		80	150		300		180		180
Storage Blk Time (%)		0	2	5	0	0			2	0
Queuing Penalty (veh)		1	1	2	0	0			6	1

1: Lor Ray Drive & Howard Drive Performance by approach

Approach	EB	WB	NB	SB	All
Denied Delay (hr)	0.1	0.1	0.1	0.0	0.4
Denied Del/Veh (s)	3.8	3.8	0.6	0.5	1.3
Total Delay (hr)	0.2	0.5	1.2	0.7	2.7
Total Del/Veh (s)	6.3	14.0	6.6	10.4	8.3
Stop Delay (hr)	0.2	0.5	0.7	0.5	1.9
Stop Del/Veh (s)	5.6	12.7	3.9	7.5	5.9
Total Stops	110	100	203	125	538
Stop/Veh	0.87	0.74	0.32	0.48	0.46

Intersection: 1: Lor Ray Drive & Howard Drive

Movement	EB	EB	EB	WB	WB	NB	NB	SB	SB	SB
Directions Served	L	T	R	L	TR	L	T	L	T	TR
Maximum Queue (ft)	39	31	67	122	31	69	177	35	142	111
Average Queue (ft)	8	4	37	55	4	26	75	4	60	17
95th Queue (ft)	30	21	59	97	20	53	142	21	111	58
Link Distance (ft)		954			966		954		966	
Upstream Blk Time (%)										
Queuing Penalty (veh)										
Storage Bay Dist (ft)	150		80	150		300		180		180
Storage Blk Time (%)			0	0					0	0
Queuing Penalty (veh)			0	0					0	0

Existing Year 2016 Detailed Operational Analysis

Roundabout Control (HCS)

ROUNDABOUT REPORT

General Information		**Site Information**	
Analyst	*Luke James*	Intersection	*Lor Ray Drive at Howard Drive*
Agency or Co.	*SRF Consulting Group, Inc.*	E/W Street Name	*Howard Drive*
Date Performed	*8/5/2016*	N/S Street Name	*Lor Ray Drive*
Time Period	*A.M. Peak*	Analysis Year	*2016*
Peak Hour Factor	*1.00*	Project ID	*9243*

Project Description:

Volume Adjustment and Site Characteristics

	EB				WB				NB				SB			
	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R	U
Number of Lanes (N)	0	1	0		0	1	0		0	1	1		0	2	0	
Lane Assignment			LTR				LTR		LT		R		LT		TR	
Right-Turn Bypass	None				None				None				None			
Conflicting Lanes	1				1				1				1			
Volume (V), veh/h	15	20	220	0	250	30	0	0	245	140	80	0	5	390	55	0
Heavy Veh. Adj. (f_{HV}), %	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Pedestrians Crossing	0				0				0				0			

Critical and Follow-Up Headway Adjustment

	EB			WB			NB			SB		
	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Critical Headway (sec)	5.1929	5.1929	5.1929	5.1929	5.1929	5.1929	5.1929	5.1929	5.1929	5.1929	5.1929	5.1929
Follow-Up Headway (sec)	3.1858	3.1858		3.1858	3.1858		3.1858	3.1858		3.1858	3.1858	

Flow Computations

	EB			WB			NB			SB		
	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Circulating Flow (V_c), pc/h	658			408			40			536		
Exiting Flow (V_{ex}), pc/h	107			337			158			877		
Entry Flow (V_e), pc/h		260			286		393	82		216	243	
Entry Volume veh/h		255			280		385	80		212	238	

Capacity and v/c Ratios

	EB			WB			NB			SB		
	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Capacity (c_{PCE}), pc/h		585			751		1085	1085		661	661	
Capacity (c), veh/h		574			737		1064	1064		649	649	
v/c Ratio (X)		0.44			0.38		0.36	0.08		0.33	0.37	

Delay and Level of Service

	EB			WB			NB			SB		
	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Lane Control Delay (d), s/veh		13.4			9.8		7.1	4.0		9.8	10.6	
Lane LOS		B			A		A	A		A	B	
Lane 95% Queue		2.3			1.8		1.7	0.2		1.4	1.7	
Approach Delay, s/veh	13.41			9.75			6.57			10.22		
Approach LOS, s/veh	B			A			A			B		
Intersection Delay, s/veh	9.52											
Intersection LOS	A											

ROUNDABOUT REPORT

General Information		Site Information	
Analyst	*Luke James*	Intersection	*Lor Ray Drive at Howard Drive*
Agency or Co.	*SRF Consulting Group, Inc.*	E/W Street Name	*Howard Drive*
Date Performed	*8/5/2016*	N/S Street Name	*Lor Ray Drive*
Time Period	*P.M. Peak*	Analysis Year	*2016*
Peak Hour Factor	*1.00*	Project ID	*9243*

Project Description:

Volume Adjustment and Site Characteristics

	EB				WB				NB				SB			
	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R	U
Number of Lanes (N)	0	1	0		0	1	0		0	1	1		0	2	0	
Lane Assignment			LTR				LTR		LT		R		LT		TR	
Right-Turn Bypass	None				None				None				None			
Conflicting Lanes	1				1				1				1			
Volume (V), veh/h	10	5	110	0	130	5	0	0	70	365	195	0	5	235	10	0
Heavy Veh. Adj. (f_{HV}), %	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Pedestrians Crossing	0				0				0				0			

Critical and Follow-Up Headway Adjustment

	EB			WB			NB			SB		
	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Critical Headway (sec)	5.1929	5.1929	5.1929	5.1929	5.1929	5.1929	5.1929	5.1929	5.1929	5.1929	5.1929	5.1929
Follow-Up Headway (sec)	3.1858	3.1858		3.1858	3.1858		3.1858	3.1858		3.1858	3.1858	

Flow Computations

	EB			WB			NB			SB		
	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Circulating Flow (V_c), pc/h	378			453			20			209		
Exiting Flow (V_{ex}), pc/h	209			87			383			485		
Entry Flow (V_e), pc/h		127			138		444	199		120	135	
Entry Volume veh/h		125			135		435	195		118	132	

Capacity and v/c Ratios

	EB			WB			NB			SB		
	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Capacity (c_{PCE}), pc/h		775			718		1107	1107		917	917	
Capacity (c), veh/h		760			704		1085	1085		899	899	
v/c Ratio (X)		0.16			0.19		0.40	0.18		0.13	0.15	

Delay and Level of Service

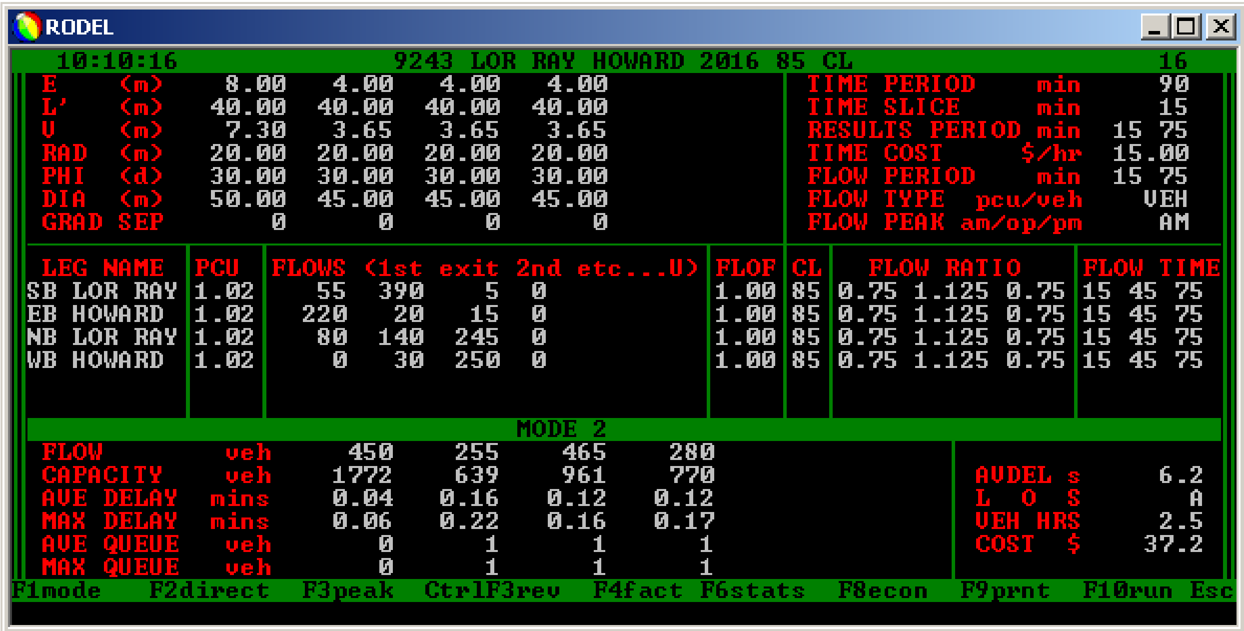
	EB			WB			NB			SB		
	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Lane Control Delay (d), s/veh		6.5			7.3		7.5	4.9		5.3	5.4	
Lane LOS		A			A		A	A		A	A	
Lane 95% Queue		0.6			0.7		2.0	0.7		0.4	0.5	
Approach Delay, s/veh	6.48			7.29			6.73			5.35		
Approach LOS, s/veh	A			A			A			A		
Intersection Delay, s/veh	6.47											
Intersection LOS	A											

Existing Year 2016 Detailed Operational Analysis

Roundabout Control (RODEL)

```
RODEL
 10:10:16              9243 LOR RAY HOWARD 2016 50 CL                16
 E    (m)     8.00    4.00    4.00    4.00      TIME PERIOD     min     90
 L'   (m)    40.00   40.00   40.00   40.00      TIME SLICE      min     15
 V    (m)     7.30    3.65    3.65    3.65      RESULTS PERIOD min   15 75
 RAD  (m)    20.00   20.00   20.00   20.00      TIME COST      $/hr  15.00
 PHI  (d)    30.00   30.00   30.00   30.00      FLOW PERIOD     min  15 75
 DIA  (m)    50.00   45.00   45.00   45.00      FLOW TYPE  pcu/veh     VEH
 GRAD SEP        0       0       0       0      FLOW PEAK am/op/pm      AM

 LEG NAME   PCU   FLOWS (1st exit 2nd etc...U) FLOF CL   FLOW RATIO    FLOW TIME
SB LOR RAY 1.02     55  390    5   0            1.00 50 0.75 1.125 0.75 15 45 75
EB HOWARD  1.02    220   20   15   0            1.00 50 0.75 1.125 0.75 15 45 75
NB LOR RAY 1.02     80  140  245   0            1.00 50 0.75 1.125 0.75 15 45 75
WB HOWARD  1.02      0   30  250   0            1.00 50 0.75 1.125 0.75 15 45 75

                                 MODE 2
 FLOW         veh       450     255     465     280
 CAPACITY     veh      1975     842    1164     973          AVDEL s       4.4
 AVE DELAY   mins      0.04    0.10    0.08    0.09          L  O  S         A
 MAX DELAY   mins      0.05    0.14    0.11    0.11          VEH HRS       1.8
 AVE QUEUE    veh         0       0       1       0          COST  $      26.5
 MAX QUEUE    veh         0       1       1       0
F1mode   F2direct  F3peak  CtrlF3rev  F4fact F6stats  F8econ  F9prnt  F10run Esc
```

```
RODEL
 10:10:16              9243 LOR RAY HOWARD 2016 50 CL                17
 E    (m)     8.00    4.00    4.00    4.00      TIME PERIOD     min     90
 L'   (m)    40.00   40.00   40.00   40.00      TIME SLICE      min     15
 V    (m)     7.30    3.65    3.65    3.65      RESULTS PERIOD min   15 75
 RAD  (m)    20.00   20.00   20.00   20.00      TIME COST      $/hr  15.00
 PHI  (d)    30.00   30.00   30.00   30.00      FLOW PERIOD     min  15 75
 DIA  (m)    50.00   45.00   45.00   45.00      FLOW TYPE  pcu/veh     VEH
 GRAD SEP        0       0       0       0      FLOW PEAK am/op/pm      PM

 LEG NAME   PCU   FLOWS (1st exit 2nd etc...U) FLOF CL   FLOW RATIO    FLOW TIME
SB LOR RAY 1.02     10  235    5   0            1.00 50 0.75 1.125 0.75 15 45 75
EB HOWARD  1.02    110    5   10   0            1.00 50 0.75 1.125 0.75 15 45 75
NB LOR RAY 1.02    195  365   70   0            1.00 50 0.75 1.125 0.75 15 45 75
WB HOWARD  1.02      0    5  130   0            1.00 50 0.75 1.125 0.75 15 45 75

                                 MODE 2
 FLOW         veh       250     125     630     135
 CAPACITY     veh      2213     989    1175     949          AVDEL s       5.0
 AVE DELAY   mins      0.03    0.07    0.11    0.07          L  O  S         A
 MAX DELAY   mins      0.04    0.09    0.15    0.09          VEH HRS       1.6
 AVE QUEUE    veh         0       0       1       0          COST  $      23.6
 MAX QUEUE    veh         0       0       1       0
F1mode   F2direct  F3peak  CtrlF3rev  F4fact F6stats  F8econ  F9prnt  F10run Esc
```



RODEL

10:10:16 9243 LOR RAY HOWARD 2016 85 CL 16

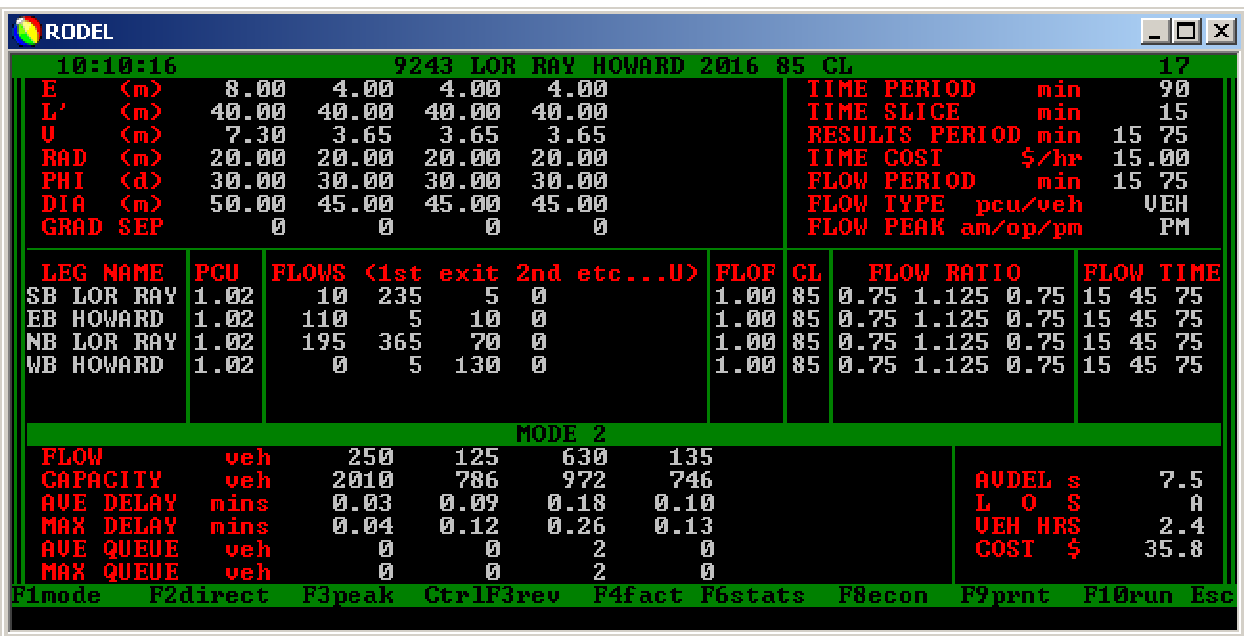
E	(m)	8.00	4.00	4.00	4.00	TIME PERIOD min	90
L'	(m)	40.00	40.00	40.00	40.00	TIME SLICE min	15
V	(m)	7.30	3.65	3.65	3.65	RESULTS PERIOD min	15 75
RAD	(m)	20.00	20.00	20.00	20.00	TIME COST $/hr	15.00
PHI	(d)	30.00	30.00	30.00	30.00	FLOW PERIOD min	15 75
DIA	(m)	50.00	45.00	45.00	45.00	FLOW TYPE pcu/veh	VEH
GRAD SEP		0	0	0	0	FLOW PEAK am/op/pm	AM

LEG NAME	PCU	FLOWS (1st exit 2nd etc...U)				FLOF	CL	FLOW RATIO			FLOW TIME		
SB LOR RAY	1.02	55	390	5	0	1.00	85	0.75	1.125	0.75	15	45	75
EB HOWARD	1.02	220	20	15	0	1.00	85	0.75	1.125	0.75	15	45	75
NB LOR RAY	1.02	80	140	245	0	1.00	85	0.75	1.125	0.75	15	45	75
WB HOWARD	1.02	0	30	250	0	1.00	85	0.75	1.125	0.75	15	45	75

MODE 2

FLOW	veh	450	255	465	280		
CAPACITY	veh	1772	639	961	770	AVDEL s	6.2
AVE DELAY	mins	0.04	0.16	0.12	0.12	L O S	A
MAX DELAY	mins	0.06	0.22	0.16	0.17	VEH HRS	2.5
AVE QUEUE	veh	0	1	1	1	COST $	37.2
MAX QUEUE	veh	0	1	1	1		

F1mode F2direct F3peak CtrlF3rev F4fact F6stats F8econ F9prnt F10run Esc



RODEL

10:10:16 9243 LOR RAY HOWARD 2016 85 CL 17

E	(m)	8.00	4.00	4.00	4.00	TIME PERIOD min	90
L'	(m)	40.00	40.00	40.00	40.00	TIME SLICE min	15
V	(m)	7.30	3.65	3.65	3.65	RESULTS PERIOD min	15 75
RAD	(m)	20.00	20.00	20.00	20.00	TIME COST $/hr	15.00
PHI	(d)	30.00	30.00	30.00	30.00	FLOW PERIOD min	15 75
DIA	(m)	50.00	45.00	45.00	45.00	FLOW TYPE pcu/veh	VEH
GRAD SEP		0	0	0	0	FLOW PEAK am/op/pm	PM

LEG NAME	PCU	FLOWS (1st exit 2nd etc...U)				FLOF	CL	FLOW RATIO			FLOW TIME		
SB LOR RAY	1.02	10	235	5	0	1.00	85	0.75	1.125	0.75	15	45	75
EB HOWARD	1.02	110	5	10	0	1.00	85	0.75	1.125	0.75	15	45	75
NB LOR RAY	1.02	195	365	70	0	1.00	85	0.75	1.125	0.75	15	45	75
WB HOWARD	1.02	0	5	130	0	1.00	85	0.75	1.125	0.75	15	45	75

MODE 2

FLOW	veh	250	125	630	135		
CAPACITY	veh	2010	786	972	746	AVDEL s	7.5
AVE DELAY	mins	0.03	0.09	0.18	0.10	L O S	A
MAX DELAY	mins	0.04	0.12	0.26	0.13	VEH HRS	2.4
AVE QUEUE	veh	0	0	2	0	COST $	35.8
MAX QUEUE	veh	0	0	2	0		

F1mode F2direct F3peak CtrlF3rev F4fact F6stats F8econ F9prnt F10run Esc

Forecasted Year 2036 Detailed Operational Analysis

All-Way Stop Control

1: Lor Ray Drive & Howard Drive Performance by approach

Approach	EB	WB	NB	SB	All
Denied Delay (hr)	0.3	14.5	6.0	0.2	21.0
Denied Del/Veh (s)	3.2	137.2	36.4	1.1	40.2
Total Delay (hr)	5.0	31.0	20.7	12.5	69.3
Total Del/Veh (s)	53.0	317.2	126.4	78.0	134.1
Stop Delay (hr)	5.0	32.3	21.1	12.2	70.6
Stop Del/Veh (s)	53.3	330.0	128.7	75.9	136.7
Total Stops	348	229	525	582	1684
Stop/Veh	1.03	0.65	0.89	1.01	0.91

Intersection: 1: Lor Ray Drive & Howard Drive

Movement	EB	EB	EB	WB	WB	NB	NB	NB	SB	SB	SB
Directions Served	L	T	R	L	TR	L	T	R	L	T	TR
Maximum Queue (ft)	230	453	180	250	1012	400	936	870	129	661	280
Average Queue (ft)	31	128	118	246	774	302	442	259	10	278	174
95th Queue (ft)	137	440	200	283	1202	502	1121	960	83	621	319
Link Distance (ft)		954			966		954	954		966	
Upstream Blk Time (%)					43		26	11		1	
Queuing Penalty (veh)					0		0	0		0	
Storage Bay Dist (ft)	150		80	150		300			180		180
Storage Blk Time (%)		0	44	97		57	1			36	29
Queuing Penalty (veh)		0	21	39		103	4			129	80

1: Lor Ray Drive & Howard Drive Performance by approach

Approach	EB	WB	NB	SB	All
Denied Delay (hr)	0.2	0.2	0.1	0.0	0.5
Denied Del/Veh (s)	3.4	3.3	0.6	0.5	1.3
Total Delay (hr)	0.2	0.4	2.3	0.8	3.8
Total Del/Veh (s)	5.1	7.2	10.1	9.3	9.0
Stop Delay (hr)	0.2	0.3	1.4	0.5	2.4
Stop Del/Veh (s)	4.2	6.0	6.2	5.0	5.7
Total Stops	164	191	565	306	1226
Stop/Veh	1.00	0.99	0.68	0.95	0.81

Intersection: 1: Lor Ray Drive & Howard Drive

Movement	EB	EB	EB	WB	WB	NB	NB	NB	SB	SB	SB
Directions Served	L	T	R	L	TR	L	T	R	L	T	TR
Maximum Queue (ft)	38	31	82	93	33	62	236	15	31	115	66
Average Queue (ft)	12	6	42	49	10	28	95	0	5	58	28
95th Queue (ft)	37	26	68	79	34	51	177	7	22	94	56
Link Distance (ft)		954			966		954	954		966	
Upstream Blk Time (%)											
Queuing Penalty (veh)											
Storage Bay Dist (ft)	150		80	150		300			180		180
Storage Blk Time (%)			0				0			0	
Queuing Penalty (veh)			0				0			0	

Forecasted Year 2036 Detailed Operational Analysis

Traffic Signal Control

1: Lor Ray Drive & Howard Drive Performance by approach

Approach	EB	WB	NB	SB	All
Denied Delay (hr)	0.3	0.4	0.3	0.2	1.2
Denied Del/Veh (s)	3.4	3.3	2.0	1.0	2.2
Total Delay (hr)	1.8	3.6	5.0	5.9	16.2
Total Del/Veh (s)	18.4	32.7	30.5	36.0	30.4
Stop Delay (hr)	1.6	3.0	4.3	4.8	13.8
Stop Del/Veh (s)	16.6	28.0	26.6	29.4	25.9
Total Stops	303	303	368	453	1427
Stop/Veh	0.87	0.77	0.63	0.77	0.75

Intersection: 1: Lor Ray Drive & Howard Drive

Movement	EB	EB	EB	WB	WB	NB	NB	SB	SB	SB
Directions Served	L	T	R	L	TR	L	T	L	T	TR
Maximum Queue (ft)	100	270	179	249	434	389	521	78	430	279
Average Queue (ft)	20	41	88	167	75	175	104	6	201	159
95th Queue (ft)	71	154	155	269	285	353	366	46	332	280
Link Distance (ft)		954			966		954		966	
Upstream Blk Time (%)										
Queuing Penalty (veh)										
Storage Bay Dist (ft)	150		80	150		300		180		180
Storage Blk Time (%)		1	13	17	0	8	0		14	6
Queuing Penalty (veh)		2	7	7	0	16	0		50	17

1: Lor Ray Drive & Howard Drive Performance by approach

Approach	EB	WB	NB	SB	All
Denied Delay (hr)	0.2	0.2	0.1	0.0	0.6
Denied Del/Veh (s)	3.8	3.7	0.7	0.6	1.4
Total Delay (hr)	0.3	0.9	1.8	1.1	4.2
Total Del/Veh (s)	7.5	17.0	8.1	12.7	10.2
Stop Delay (hr)	0.3	0.8	1.1	0.8	3.0
Stop Del/Veh (s)	6.6	15.4	4.7	9.4	7.3
Total Stops	144	143	283	175	745
Stop/Veh	0.88	0.76	0.35	0.54	0.50

Intersection: 1: Lor Ray Drive & Howard Drive

Movement	EB	EB	EB	WB	WB	NB	NB	SB	SB	SB
Directions Served	L	T	R	L	TR	L	T	L	T	TR
Maximum Queue (ft)	44	33	80	153	37	86	236	33	168	134
Average Queue (ft)	13	6	42	75	6	32	108	5	83	26
95th Queue (ft)	39	25	66	126	26	64	194	24	142	83
Link Distance (ft)		954			966		954		966	
Upstream Blk Time (%)										
Queuing Penalty (veh)										
Storage Bay Dist (ft)	150		80	150		300		180		180
Storage Blk Time (%)			0	0			0		0	0
Queuing Penalty (veh)			0	0			0		0	0

Forecasted Year 2036 Detailed Operational Analysis

Roundabout Control (HCS)

ROUNDABOUT REPORT

General Information		Site Information	
Analyst	Luke James	Intersection	Lor Ray Drive at Howard Drive
Agency or Co.	SRF Consulting Group, Inc.	E/W Street Name	Howard Drive
Date Performed	8/5/2016	N/S Street Name	Lor Ray Drive
Time Period	A.M. Peak	Analysis Year	2036
Peak Hour Factor	1.00	Project ID	9243

Project Description:

Volume Adjustment and Site Characteristics

	EB				WB				NB				SB			
	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R	U
Number of Lanes (N)	0	1	0		0	1	0		0	1	1		0	2	0	
Lane Assignment			LTR				LTR		LT		R		LT		TR	
Right-Turn Bypass	None				None				None				None			
Conflicting Lanes	1				1				1				1			
Volume (V), veh/h	20	25	295	0	340	40	0	0	310	175	100	0	5	500	70	0
Heavy Veh. Adj. (f_{HV}), %	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Pedestrians Crossing	0				0				0				0			

Critical and Follow-Up Headway Adjustment

	EB			WB			NB			SB		
	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Critical Headway (sec)	5.1929	5.1929	5.1929	5.1929	5.1929	5.1929	5.1929	5.1929	5.1929	5.1929	5.1929	5.1929
Follow-Up Headway (sec)	3.1858	3.1858		3.1858	3.1858		3.1858	3.1858		3.1858	3.1858	

Flow Computations

	EB			WB			NB			SB		
	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Circulating Flow (V_c), pc/h	862			514			51			704		
Exiting Flow (V_{ex}), pc/h	133			428			199			1158		
Entry Flow (V_e), pc/h		347			388		495	102		276	311	
Entry Volume veh/h		340			380		485	100		271	305	

Capacity and v/c Ratios

	EB			WB			NB			SB		
	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Capacity (c_{PCE}), pc/h		477			675		1074	1074		559	559	
Capacity (*c*), veh/h		468			662		1053	1053		548	548	
v/c Ratio (X)		0.73			0.57		0.46	0.09		0.49	0.56	

Delay and Level of Service

	EB			WB			NB			SB		
	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Lane Control Delay (d), s/veh		29.2			15.4		8.6	4.3		15.3	17.3	
Lane LOS		D			C		A	A		C	C	
Lane 95% Queue		5.8			3.7		2.5	0.3		2.7	3.4	
Approach Delay, s/veh	29.20			15.39			7.87			16.33		
Approach LOS, s/veh	D			C			A			C		
Intersection Delay, s/veh	15.84											
Intersection LOS	C											

 HCS 2010™ 6.70 Roundabouts Generated: 9/19/2016 9:13 AM

ROUNDABOUT REPORT

General Information		Site Information	
Analyst	*Luke James*	Intersection	*Lor Ray Drive at Howard Drive*
Agency or Co.	*SRF Consulting Group, Inc.*	E/W Street Name	*Howard Drive*
Date Performed	*8/5/2016*	N/S Street Name	*Lor Ray Drive*
Time Period	*P.M. Peak*	Analysis Year	*2036*
Peak Hour Factor	*1.00*	Project ID	*9243*

Project Description:

Volume Adjustment and Site Characteristics

	EB				WB				NB				SB			
	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R	U
Number of Lanes (N)	0	1	0		0	1	0		0	1	1		0	2	0	
Lane Assignment			LTR				LTR		LT		R		LT		TR	
Right-Turn Bypass	None				None				None				None			
Conflicting Lanes	1				1				1				1			
Volume (V), veh/h	15	5	145	0	175	5	5	0	90	470	250	0	5	300	15	0
Heavy Veh. Adj. (f_{HV}), %	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Pedestrians Crossing	0				0				0				0			

Critical and Follow-Up Headway Adjustment

	EB			WB			NB			SB		
	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Critical Headway (sec)	5.1929	5.1929	5.1929	5.1929	5.1929	5.1929	5.1929	5.1929	5.1929	5.1929	5.1929	5.1929
Follow-Up Headway (sec)	3.1858	3.1858		3.1858	3.1858		3.1858	3.1858		3.1858	3.1858	

Flow Computations

	EB			WB			NB			SB		
	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Circulating Flow (V_c), pc/h	489			586			25			275		
Exiting Flow (V_{ex}), pc/h	265			112			500			632		
Entry Flow (V_e), pc/h		168			189		571	255		153	173	
Entry Volume veh/h		165			185		560	250		150	170	

Capacity and v/c Ratios

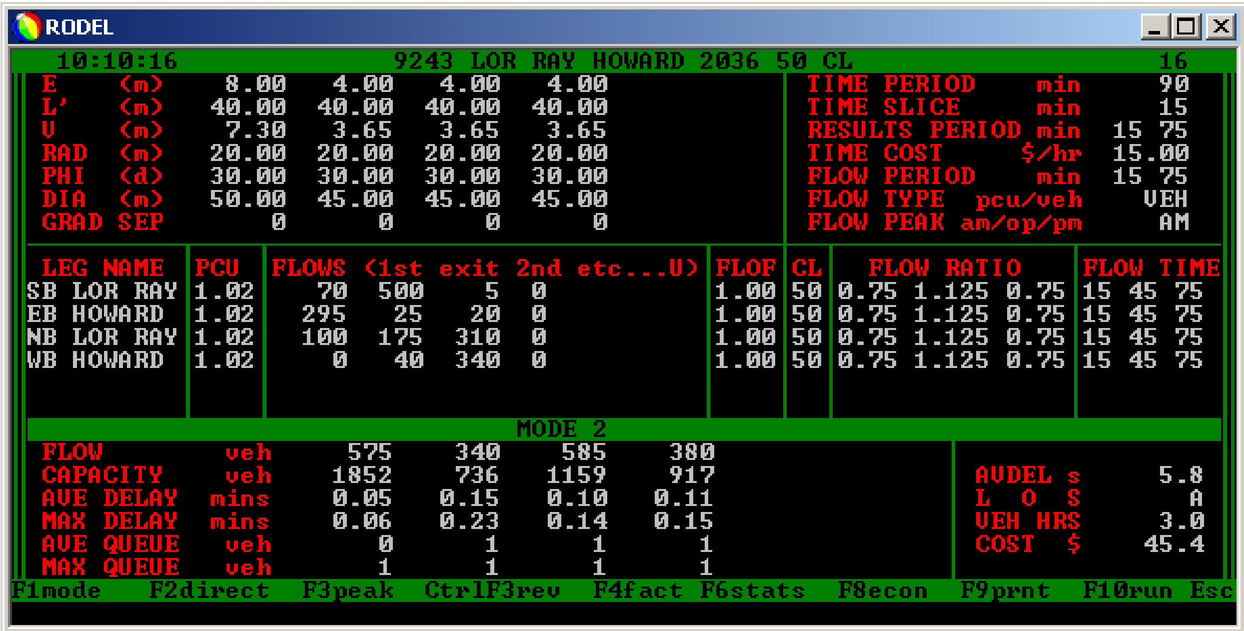
	EB			WB			NB			SB		
	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Capacity (c_{PCE}), pc/h		693			629		1102	1102		858	858	
Capacity (c), veh/h		679			616		1080	1080		841	841	
v/c Ratio (X)		0.24			0.30		0.52	0.23		0.18	0.20	

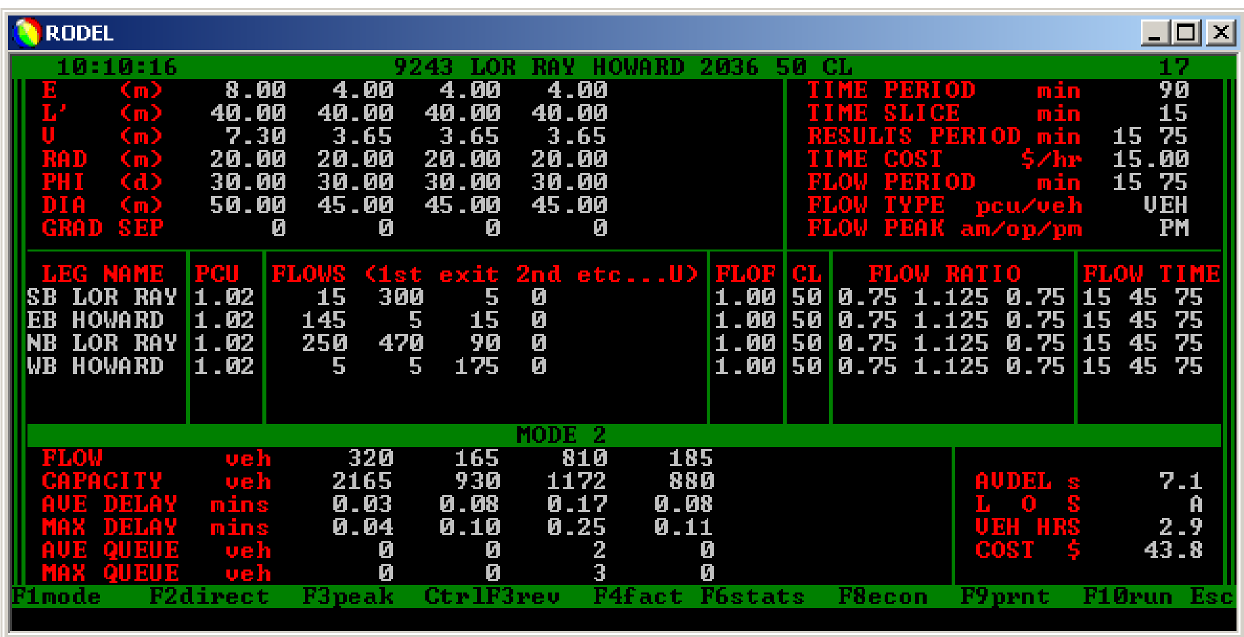
Delay and Level of Service

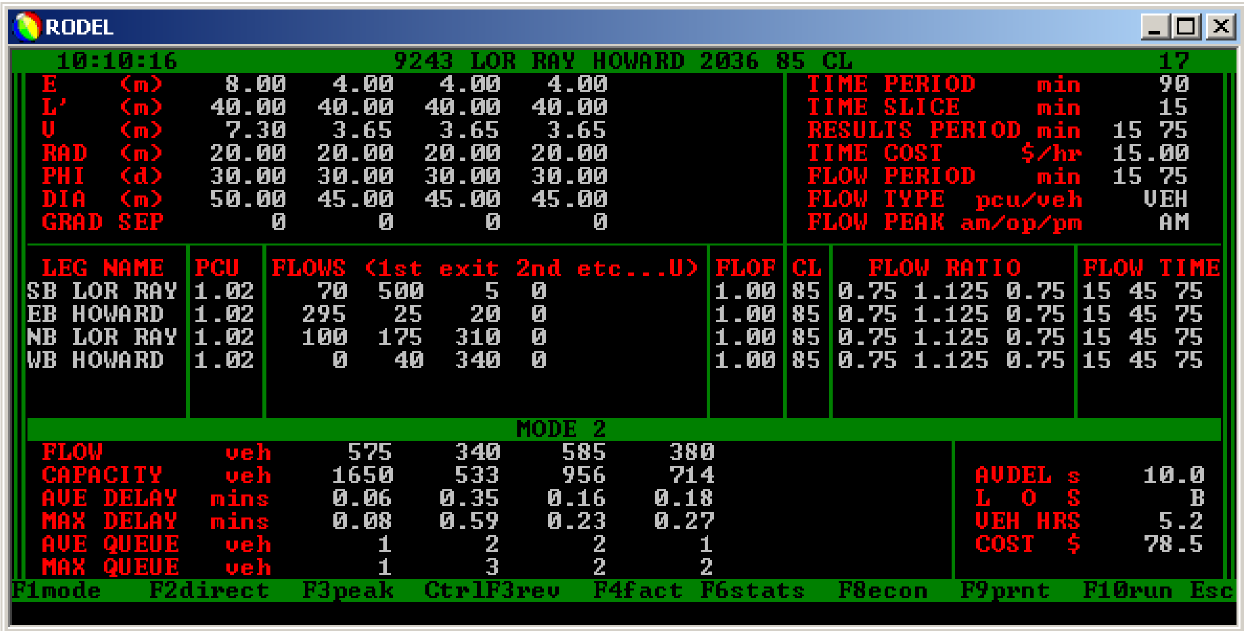
	EB			WB			NB			SB		
	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Lane Control Delay (d), s/veh		8.2			9.8		9.5	5.5		6.1	6.4	
Lane LOS		A			A		A	A		A	A	
Lane 95% Queue		0.9			1.3		3.1	0.9		0.6	0.8	
Approach Delay, s/veh	8.20			9.84			8.23			6.24		
Approach LOS, s/veh	A			A			A			A		
Intersection Delay, s/veh	8.00											
Intersection LOS	A											

Forecasted Year 2036 Detailed Operational Analysis

Roundabout Control (RODEL)


RODEL
10:10:16 9243 LOR RAY HOWARD 2036 50 CL 16
E (m) 8.00 4.00 4.00 4.00
L' (m) 40.00 40.00 40.00 40.00
V (m) 7.30 3.65 3.65 3.65
RAD (m) 20.00 20.00 20.00 20.00
PHI (d) 30.00 30.00 30.00 30.00
DIA (m) 50.00 45.00 45.00 45.00
GRAD SEP 0 0 0 0
TIME PERIOD min 90
TIME SLICE min 15
RESULTS PERIOD min 15 75
TIME COST $/hr 15.00
FLOW PERIOD min 15 75
FLOW TYPE pcu/veh VEH
FLOW PEAK am/op/pm AM
LEG NAME PCU FLOWS (1st exit 2nd etc...U) FLOF CL FLOW RATIO FLOW TIME
SB LOR RAY 1.02 70 500 5 0 1.00 50 0.75 1.125 0.75 15 45 75
EB HOWARD 1.02 295 25 20 0 1.00 50 0.75 1.125 0.75 15 45 75
NB LOR RAY 1.02 100 175 310 0 1.00 50 0.75 1.125 0.75 15 45 75
WB HOWARD 1.02 0 40 340 0 1.00 50 0.75 1.125 0.75 15 45 75
MODE 2
FLOW veh 575 340 585 380
CAPACITY veh 1852 736 1159 917
AVE DELAY mins 0.05 0.15 0.10 0.11
MAX DELAY mins 0.06 0.23 0.14 0.15
AVE QUEUE veh 0 1 1 1
MAX QUEUE veh 1 1 1 1
AVDEL s 5.8
L O S A
VEH HRS 3.0
COST $ 45.4
F1mode F2direct F3peak CtrlF3rev F4fact F6stats F8econ F9prnt F10run Esc


RODEL
10:10:16 9243 LOR RAY HOWARD 2036 50 CL 17
E (m) 8.00 4.00 4.00 4.00
L' (m) 40.00 40.00 40.00 40.00
V (m) 7.30 3.65 3.65 3.65
RAD (m) 20.00 20.00 20.00 20.00
PHI (d) 30.00 30.00 30.00 30.00
DIA (m) 50.00 45.00 45.00 45.00
GRAD SEP 0 0 0 0
TIME PERIOD min 90
TIME SLICE min 15
RESULTS PERIOD min 15 75
TIME COST $/hr 15.00
FLOW PERIOD min 15 75
FLOW TYPE pcu/veh VEH
FLOW PEAK am/op/pm PM
LEG NAME PCU FLOWS (1st exit 2nd etc...U) FLOF CL FLOW RATIO FLOW TIME
SB LOR RAY 1.02 15 300 5 0 1.00 50 0.75 1.125 0.75 15 45 75
EB HOWARD 1.02 145 5 15 0 1.00 50 0.75 1.125 0.75 15 45 75
NB LOR RAY 1.02 250 470 90 0 1.00 50 0.75 1.125 0.75 15 45 75
WB HOWARD 1.02 5 5 175 0 1.00 50 0.75 1.125 0.75 15 45 75
MODE 2
FLOW veh 320 165 810 185
CAPACITY veh 2165 930 1172 880
AVE DELAY mins 0.03 0.08 0.17 0.08
MAX DELAY mins 0.04 0.10 0.25 0.11
AVE QUEUE veh 0 0 2 0
MAX QUEUE veh 0 0 3 0
AVDEL s 7.1
L O S A
VEH HRS 2.9
COST $ 43.8
F1mode F2direct F3peak CtrlF3rev F4fact F6stats F8econ F9prnt F10run Esc



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RODEL
 10:10:16                9243 LOR RAY HOWARD 2036 85 CL                  17
 E     (m)    8.00    4.00    4.00    4.00     TIME PERIOD     min     90
 L'    (m)   40.00   40.00   40.00   40.00     TIME SLICE      min     15
 V     (m)    7.30    3.65    3.65    3.65     RESULTS PERIOD min  15  75
 RAD   (m)   20.00   20.00   20.00   20.00     TIME COST     $/hr  15.00
 PHI   (d)   30.00   30.00   30.00   30.00     FLOW PERIOD     min 15  75
 DIA   (m)   50.00   45.00   45.00   45.00     FLOW TYPE  pcu/veh     VEH
 GRAD SEP        0       0       0       0     FLOW PEAK am/op/pm      AM
 LEG NAME  PCU   FLOWS (1st exit 2nd etc...U)  FLOF  CL  FLOW RATIO       FLOW TIME
SB LOR RAY 1.02      70   500     5   0        1.00  85  0.75 1.125 0.75  15 45 75
EB HOWARD  1.02     295    25    20   0        1.00  85  0.75 1.125 0.75  15 45 75
NB LOR RAY 1.02     100   175   310   0        1.00  85  0.75 1.125 0.75  15 45 75
WB HOWARD  1.02       0    40   340   0        1.00  85  0.75 1.125 0.75  15 45 75
                                  MODE 2
 FLOW          veh      575     340     585     380
 CAPACITY      veh     1650     533     956     714           AVDEL s      10.0
 AVE DELAY    mins     0.06    0.35    0.16    0.18           L  O  S         B
 MAX DELAY    mins     0.08    0.59    0.23    0.27           VEH HRS       5.2
 AVE QUEUE     veh        1       2       2       1           COST  $      78.5
 MAX QUEUE     veh        1       3       2       2
F1mode   F2direct  F3peak  CtrlF3rev  F4fact F6stats  F8econ  F9prnt  F10run Esc
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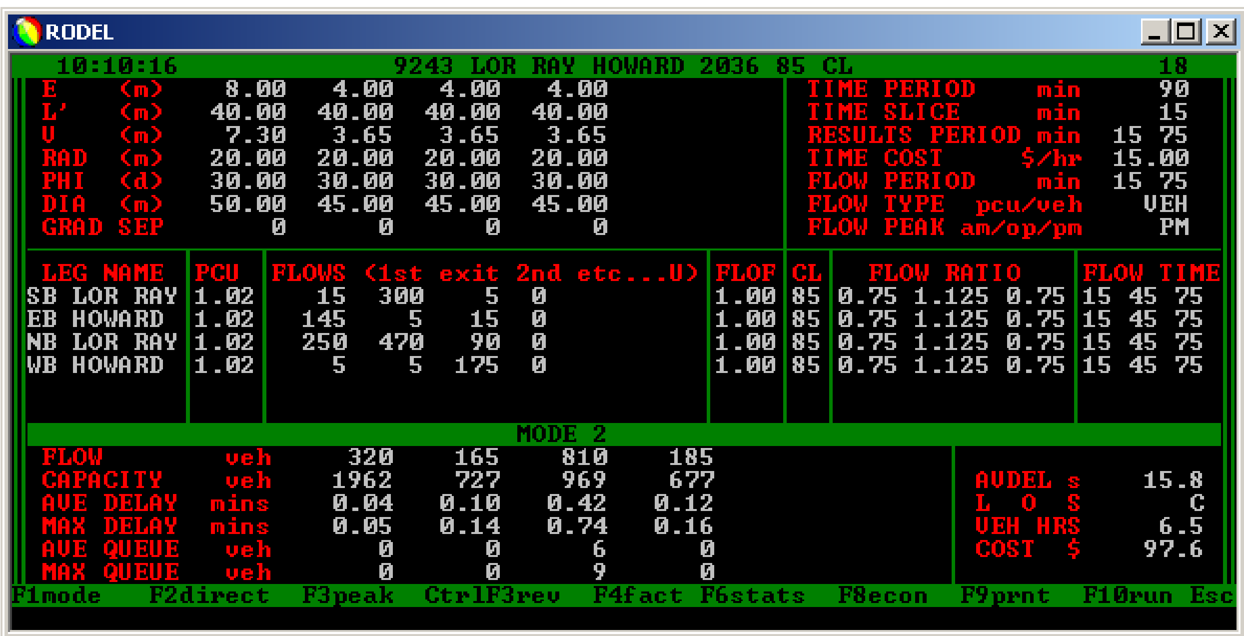

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RODEL
 10:10:16                9243 LOR RAY HOWARD 2036 85 CL                  18
 E     (m)    8.00    4.00    4.00    4.00     TIME PERIOD     min     90
 L'    (m)   40.00   40.00   40.00   40.00     TIME SLICE      min     15
 V     (m)    7.30    3.65    3.65    3.65     RESULTS PERIOD min  15  75
 RAD   (m)   20.00   20.00   20.00   20.00     TIME COST     $/hr  15.00
 PHI   (d)   30.00   30.00   30.00   30.00     FLOW PERIOD     min 15  75
 DIA   (m)   50.00   45.00   45.00   45.00     FLOW TYPE  pcu/veh     VEH
 GRAD SEP        0       0       0       0     FLOW PEAK am/op/pm      PM
 LEG NAME  PCU   FLOWS (1st exit 2nd etc...U)  FLOF  CL  FLOW RATIO       FLOW TIME
SB LOR RAY 1.02      15   300     5   0        1.00  85  0.75 1.125 0.75  15 45 75
EB HOWARD  1.02     145     5    15   0        1.00  85  0.75 1.125 0.75  15 45 75
NB LOR RAY 1.02     250   470    90   0        1.00  85  0.75 1.125 0.75  15 45 75
WB HOWARD  1.02       5     5   175   0        1.00  85  0.75 1.125 0.75  15 45 75
                                  MODE 2
 FLOW          veh      320     165     810     185
 CAPACITY      veh     1962     727     969     677           AVDEL s      15.8
 AVE DELAY    mins     0.04    0.10    0.42    0.12           L  O  S         C
 MAX DELAY    mins     0.05    0.14    0.74    0.16           VEH HRS       6.5
 AVE QUEUE     veh        0       0       6       0           COST  $      97.6
 MAX QUEUE     veh        0       0       9       0
F1mode   F2direct  F3peak  CtrlF3rev  F4fact F6stats  F8econ  F9prnt  F10run Esc
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Detailed Cost Analysis

SRF Consulting Group, Inc. ENGINEERS PLANNERS DESIGNERS

Concept Cost Estimate (based upon 2016 bid price information)

Prepared By: SRF Consulting Group, Inc., Date 10/2016

						Lor Ray Drive at Howard Drive	
ITEM DESCRIPTION				**UNIT**	**UNIT PRICE**	**EST. QUANTITY**	**EST. AMOUNT**
PAVING AND GRADING COSTS							
GrP 1	Excavation - common & subgrade			cu. yd.	$7.00	7,300	$51,100
GrP 2	Granular Subgrade (CV)			cu. yd.	$14.00	4,400	$61,600
GrP 3	County Road Pavement		(1)	sq. yd.	$32.00	8,760	$280,320
GrP 4	Concrete Median		(1)	sq. yd.	$40.00	860	$34,400
GrP 5	Walk / Trail		(1)	sq. yd.	$25.00	1,460	$36,500
GrP 6	ADA Pedestrian Curb Ramp			each	$800.00	28	$22,400
GrP 7	Concrete Curb and Gutter			lin. ft.	$12.00	5,060	$60,720
GrP 8	Removals - Pavement			sq. yd.	$2.50	12,080	$30,200
SUBTOTAL PAVING AND GRADING COSTS:							**$577,240**
DRAINAGE, UTILITIES AND EROSION CONTROL							
Dr 1	Local Utilities - Sanitary Sewers			lin. ft.			
Dr 2	Local Utilities - Watermains			lin. ft.			
Dr 3	Water Quality Ponds			l.s.			
Dr 5	Drainage - urban (10-30%)			30%			$173,000
Dr 6	Turf Establishment & Erosion Control			10%			$58,000
Dr 7	Landscaping						
SUBTOTAL DRAINAGE, UTILITIES AND EROSION CONTROL							**$231,000**
SIGNAL AND LIGHTING COSTS							
SGL 1	Signals (permanent)			each	$200,000		
SGL 2	At Grade Intersection Lighting (permanent - non signa			each	$10,000	12	$120,000
SUBTOTAL SIGNAL AND LIGHTING COSTS:							**$120,000**
SIGNING & STRIPING COSTS							
SGN 1	Mainline Signing (C&D)			mile	$20,000	0.4	$8,000
SGN 2	Mainline Striping			mile	$10,000	0.4	$4,000
SUBTOTAL SIGNING & STRIPING COSTS:							**$12,000**
SUBTOTAL CONSTRUCTION COSTS:							**$940,240**
MISCELLANEOUS COSTS							
M 1	Mobilization			6%			$56,000
M 2	Non Quantified Minor Items (10% to 30%)			20%			$188,000
M 3	Temporary Pavement & Drainage			2%			$19,000
M 4	Traffic Control			4%			$38,000
SUBTOTAL MISCELLANEOUS COSTS:							**$301,000**
ESTIMATED TOTAL CONSTRUCTION COSTS without Contingency:							**$1,241,240**
1	Contingency or "risk" (10% to 30%)			20%			$248,000
ESTIMATED TOTAL CONSTRUCTION COSTS PLUS CONTINGENCY:							**$1,489,240**

OTHER PROJECT COSTS:				
R/W ACQUISITIONS	Lump Sum			
DESIGN ENG. & CONSTRUCTION ADMIN.	Lump Sum			
SUBTOTAL OTHER PROJECT COSTS				
TOTAL PROJECT COST (based upon 2016 bid price information)				**$1,489,240**

INFLATION COST (CURRENT YR. TO YR. OF OPE	Years	3%		
TOTAL PROJECT COST (OPENING YEAR DOLLARS)				**$1,489,240**

NOTE: (1) Includes aggregate base class 5.

MAJOR ITEMS NOT INCLUDED:
- Local utilities (sanitary sewer or watermain)
- Water quality ponds or other BMPs
- R/W acquisitions
- Engineering design fees
- Inflation