FINAL Report

Traffic Operations Report, Missoula— East and West I-90 Corridor Study Phase 2

Prepared for

Montana Department of Transportation

July 2007

CH2MHILL

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Submitted to

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Contents

Appendixes

Tables

Figures

Purpose

This memorandum addresses traffic updates to the ***FINAL REPORT, Interstate 90, Missoula East-West Corridor Study (Phase 1), Project No. IM90-2(104)94, UPN 4855, April 16, 2004,*** for the Orange Street and Van Buren Street Interchanges, as these two interchanges are the subject of Phase 2 project development.

Background

The ***FINAL REPORT, Interstate 90, Missoula East-West Corridor Study (Phase 1), Project No. IM90-2(104)94, UPN 4855, April 16, 2004,*** served as a comprehensive evaluation of the I-90 corridor from Milepost 94 (west of the DeSmet Interchange) to Milepost 110 (just east of the Bonner Interchange). The Phase 1 study identified deficiencies related to traffic operations, physical features (geometry), and noise.

Immediate needs for intersection improvements were identified at the following interchange (ramp terminal) locations:

- Orange Street eastbound ramps
- Van Buren Street westbound ramps
- Van Buren Street eastbound ramps

Additionally, geometric modifications including interchange reconfiguration, implementation of a collector-distributor roadway system and auxiliary lanes were identified as possible treatments to accommodate the interrelated operation of the closely spaced Orange Street and Van Buren Street interchanges.

Phase 2 of this study will expand on the previous analysis performed at the Orange Street and Van Buren Street interchanges to determine appropriate mitigation strategies and preliminary design improvements.

Traffic Volume Validation

Automatic traffic recorder (ATR) counts were collected at each of the subject ramp terminals and associated cross streets. The directional link counts were collected during late March and early April 2006 for a continuous 48-hour period at each location. Counts were collected mid-week under typical traffic conditions and avoided the University of Montana Spring vacation from March 27 through March 31.

The 2006 counts were compared to the 2002 traffic data and the long-term growth rates calculated for the Phase 1 study. The comparison was initiated to validate the previous growth projections and determine if further adjustments were appropriate. A possible contributor to amending the original forecast involves development within the Rattlesnake Canyon area north of the Van Buren Street interchange.

Tables 1 and 2 summarize the volume comparison between 2002 and 2006 for the AM and PM peak hours, respectively.

TABLE 1
AM Peak Hour Volume and Growth Rate Comparison at the Van Buren Interchange

	2002 AM Peak (vehicles per hour)	2006 AM Peak (vehicles per hour) *	2002 to 2006 Annual Average Growth	2000 to 2025 Annual Average Growth
Van Buren Northbound				
South of Interchange	260	267	0.7%	1.4%
Between Ramps	204	219	1.9%	1.2%
North of Interchange	177	177	0.0%	1.0%
Van Buren Southbound				
North of Interchange	657	640	-0.7%	1.4%
Between Ramps	731	753	0.7%	0.8%
South of Interchange	861	892	0.9%	0.5%
Van Buren Interchange Ramps				
Eastbound Off-ramp	189	235	6.1%	1.5%
Eastbound On-ramp	116	115	-0.1%	2.2%
Westbound Off-ramp	200	242	5.3%	1.4%
Westbound On-ramp	152	178	4.3%	2.2%

* 1.0484 factor applied to the March 2006 counts as a seasonal adjustment to align with October 2002 counts. (Source: MDT 2004 Automatic Recorder, Average Weekday Monday to Thursday Volumes, Station A-67, U-8115 on Van Buren Street, south of Poplar in Missoula.)

TABLE 2
PM Peak Hour Volume and Growth Rate Comparison at the Van Buren Interchange

	2002 PM Peak (vehicles per hour)	2006 PM Peak (vehicles per hour)*	2002 to 2006 Annual Average Growth	2000 to 2025 Annual Average Growth
Van Buren Northbound				
South of Interchange	799	905	3.3%	1.4%
Between Ramps	730	810	2.8%	1.2%
North of Interchange	646	668	0.8%	1.0%
Van Buren Southbound				
North of Interchange	354	395	2.9%	1.4%
Between Ramps	424	470	2.7%	0.8%
South of Interchange	515	620	5.1%	0.5%

TABLE 2
PM Peak Hour Volume and Growth Rate Comparison at the Van Buren Interchange

	2002 PM Peak (vehicles per hour)	2006 PM Peak (vehicles per hour)*	2002 to 2006 Annual Average Growth	2000 to 2025 Annual Average Growth
Van Buren Interchange Ramps				
Eastbound Off-ramp	211	283	8.5%	1.5%
Eastbound On-ramp	190	275	11.1%	2.2%
Westbound Off-ramp	159	159	0.0%	1.4%
Westbound On-ramp	173	228	7.9%	2.2%

* 1.0484 factor applied to the March 2006 counts as a seasonal adjustment to align with October 2002 counts. (Source: MDT 2004 Automatic Recorder, Average Weekday Monday to Thursday Volumes, Station A-67, U-8115 on Van Buren Street, south of Poplar in Missoula.)

During the AM peak hour, traffic volumes along Van Buren Street have remained similar to 2002 levels, equating to growth rates of -0.7 to 1.9 percent per year. The calculated Phase 1 growth rates are generally more conservative (higher) than the observed growth.

The growth rates on the I-90 ramps ranged from -0.1 to 6.1 percent. Although the growth rates are high, the absolute change in volumes is only in the range of 0 to 40 vehicles (over the last 4 years). The calculated Phase 1 growth rates are generally lower.

During the PM peak hour, traffic volumes along Van Buren Street have increased by an average of 3 percent per year over 2002 levels. The calculated Phase 1 growth rates are generally lower than the observed growth, which range from 0.5 to 1.4 percent growth per year.

The growth rates on the I-90 ramps ranged from 0 to 11.1 percent. The calculated Phase 1 growth rates are significantly lower than the observed growth, with the exception of the westbound off-ramp. The eastbound on-ramp exhibited the greatest increase of 85 vehicles during the peak hour, with an associated 11.1 percent per year growth.

Tables 3 and 4 summarize the volume comparison between 2002 and 2006 for the AM and PM peak hours, respectively, at the Orange Street interchange.

During the AM peak hour, traffic volumes surrounding the Orange Street interchange have remained similar to 2002 levels. Overall, the area has exhibited a slight decline in traffic volumes over the last several years. The eastbound ramps, however, depict a positive growth rate. The absolute volume changes along the ramps are approximately 30 vehicles. The calculated Phase 1 growth rates are generally more conservative (higher) than the observed growth.

The PM peak hour exhibits a similar decreasing volume trend, with slightly higher usage of the eastbound ramps. The calculated Phase 1 growth rates are generally more conservative (higher) than the observed growth.

TABLE 3
AM Peak Hour Volume and Growth Rate Comparison at the Orange Street Interchange

	2002 AM Peak (vehicles per hour)	2006 AM Peak (vehicles per hour) *	2002 to 2006 Annual Average Growth	2000 to 2025 Annual Average Growth
Orange Northbound				
South of Interchange	201	194	-0.9%	1.1%
Between Ramps	99	81	-4.6%	2.2%
Orange Southbound				
Between Ramps	440	358	-4.7%	1.6%
South of Interchange	814	568	-7.5%	1.9%
Orange Interchange Ramps				
Eastbound Off-ramp	375	399	1.6%	3.3%
Eastbound On-ramp	104	135	7.5%	0.1%
Westbound Off-ramp	440	358	-4.7%	1.6%
Westbound On-ramp	99	81	-4.6%	2.2%

* 1.0484 factor applied to the March 2006 counts as a seasonal adjustment to align with October 2002 counts. (Source: MDT 2004 Automatic Recorder, Average Weekday Monday to Thursday Volumes, Station A-67, U-8115 on Van Buren Street, south of Poplar in Missoula.)

TABLE 4
PM Peak Hour Volume and Growth Rate Comparison at the Orange Street Interchange

	2002 PM Peak (vehicles per hour)	2006 PM Peak (vehicles per hour)*	2002 to 2006 Annual Average Growth	2000 to 2025 Annual Average Growth
Van Buren Northbound				
South of Interchange	644	476	-6.5%	1.1%
Between Ramps	305	223	-6.7%	2.2%
Van Buren Southbound				
Between Ramps	320	262	-4.5%	1.6%
South of Interchange	568	371	-8.7%	1.9%
Van Buren Interchange Ramps				
Eastbound Off-ramp	250	317	6.7%	3.3%
Eastbound On-ramp	342	407	4.7%	0.1%
Westbound Off-ramp	320	262	-4.5%	1.6%
Westbound On-ramp	305	223	-6.7%	2.2%

* 1.0484 factor applied to the March 2006 counts as a seasonal adjustment to align with October 2002 counts. (Source: MDT 2004 Automatic Recorder, Average Weekday Monday to Thursday Volumes, Station A-67, U-8115 on Van Buren Street, south of Poplar in Missoula.)

Traffic Forecast Updates

The Phase 1 growth rates for individual traffic movements were calculated based on the MDT travel demand model output for Year 2000 and Year 2025. The travel demand model incorporates the projected roadway network and land use projections to forecast the long-term traffic demand.

The validation indicates that the projected growth does not occur steadily over the forecast horizon, as the model-derived rates differ from those observed. Review of current traffic volume trends (MDT Station A-67) show that minimal growth has occurred on an annual, daily and peak hour basis. Growth rates oscillate year to year, with an overall low growth trend. Thus, the long-term projections should remain consistent with the MDT model unless significant land use and transportation system changes occur.

To capture the short-term growth patterns, 2005 traffic volumes were derived as follows:

- Calculate the 2002 to 2006 annual growth rates
- Apply the rates over 3 years at each of the existing 2002 turn movements
- Balance the traffic volumes.

2005 traffic volumes for the AM and PM peak hour are depicted in Figures 1 and 2.

The 2030 traffic volumes were developed as follows:

- Calculate the annual growth rate used for Phase 1, from the travel demand model (2000 to 2025)
- Apply the rates over 28 years at each of the existing 2002 turn movements
- Develop the final 2030 AM and PM peak hour volumes and balance

2030 traffic volumes for the AM and PM peak hour are depicted in Figures 3 and 4.

Application of the growth rates to the 2002 turning movement counts minimizes the potential for compounding any assumptions made within the forecasting process.

Traffic Operations Review

A traffic operations review for existing (2005) and forecast year (2030) conditions was performed for the Orange Street and Van Buren Street Interchanges in accordance with the ***Traffic Methodology and Assumptions, Missoula—East & West I-90 Corridor Study—Phase 1 Technical Memorandum, February 28, 2003***, developed under Phase 1 and included as Exhibit 4 to the ***FINAL REPORT, Interstate 90, Missoula East-West Corridor Study (Phase 1), Project No. IM90-2(104)94, UPN 4855, April 16, 2004***. Appendix A of this document provides relevant updates to the ***Traffic Methodology and Assumptions, Missoula—East & West I-90 Corridor Study—Phase 1 Technical Memorandum, February 28, 2003,*** for purposes of the Phase 2 evaluation.

Existing (2005) and Future (2030) Traffic Operations

Signal Warrant Analysis

A traffic signal warrant analysis was performed in accordance with the Manual on Uniform Traffic Control Devices (MUTCD) (FHWA, 2003) guidelines for each of the four ramp terminal intersections. Based on the results, two of the four ramp termini warrant signals in the existing year. The east-bound ramps and Orange Street, and the eastbound ramps and Van Buren Street satisfy Warrant 8 and Warrants 1, 2, and 8, respectively (MUTCD Warrant 1 Eight-Hour Vehicular Volume, Warrant 2 Four-Hour Vehicular Volume, Warrant 8 Roadway Network). It was determined, based on further evaluation, that a traffic signal will be warranted at the westbound ramps and Van Buren Street by 2016 (a straight line interpolation between the existing and future 2030 year volumes was used to establish 2016 volumes), while the westbound ramps and Orange Street will not warrant a signal during the study time frame. As Warrant 8, criteria B concerning nonnormal business day traffic is not a mandatory condition and traffic data was not collected in this regard, this condition was not used in justifying this signal warrant. Refer to Appendix B for signal warrant analysis calculations.

Local Intersection Operations

Existing 2005 and future 2030 local intersection operations consisted of analyzing the intersection operations at the I-90 ramp terminals located at Orange Street and Van Buren Street. The software package, Synchro 6.0, was used for analysis of the existing (2005) and future 2030 No Build and Build conditions for both the AM and PM peak hours.

In the existing year (2005), all ramp terminal intersections are stop controlled. In the AM peak hour, three of the four ramp terminals are operating below the Level of Service (LOS) C threshold. All ramp terminal intersections, except the westbound ramps and Orange Street, experience unacceptable delays. In the PM peak hour, both Van Buren Street ramp terminals operate at LOS F, while the Orange Street intersections are acceptable.

In 2030, under No Build conditions, 2030 forecast volumes are analyzed under the existing (2005) lane configurations. Operations degrade further, compared to the existing conditions, for both AM and PM peak hours in this scenario. All ramp termini perform below the LOS threshold for both peak hours. Results for 2005 and 2030 No Build conditions are displayed in Figures 5 and 6.

The 2030 Build scenario assumes that all local intersections that meet signal warrants are signalized, but lane configurations remain the same. Based on these operational characteristics, all signalized ramp terminal intersections during both the AM and PM peak hours perform at an acceptable LOS, while the westbound ramps and Orange Street intersection performs at a LOS D in both the AM and PM peak with all-way stop control (AWSC). Two-way stop control (TWSC) was tested at this intersection, and while the AM peak performs at the same LOS as the AWSC condition, the PM peak hour results in an LOS F. The primary movement during the AM peak hour is the westbound off ramp, while during the PM peak hour the approaches are nearly balanced with a slightly higher northbound approach. Exhibit 10-15 as depicted in the *Highway Capacity Manual* (Transportation Research Board, 2000) suggests that an AWSC is the appropriate treatment for the forecast traffic volumes in this case. Figures 7 and 8 summarize the future 2030 No Build and Build traffic operations results.

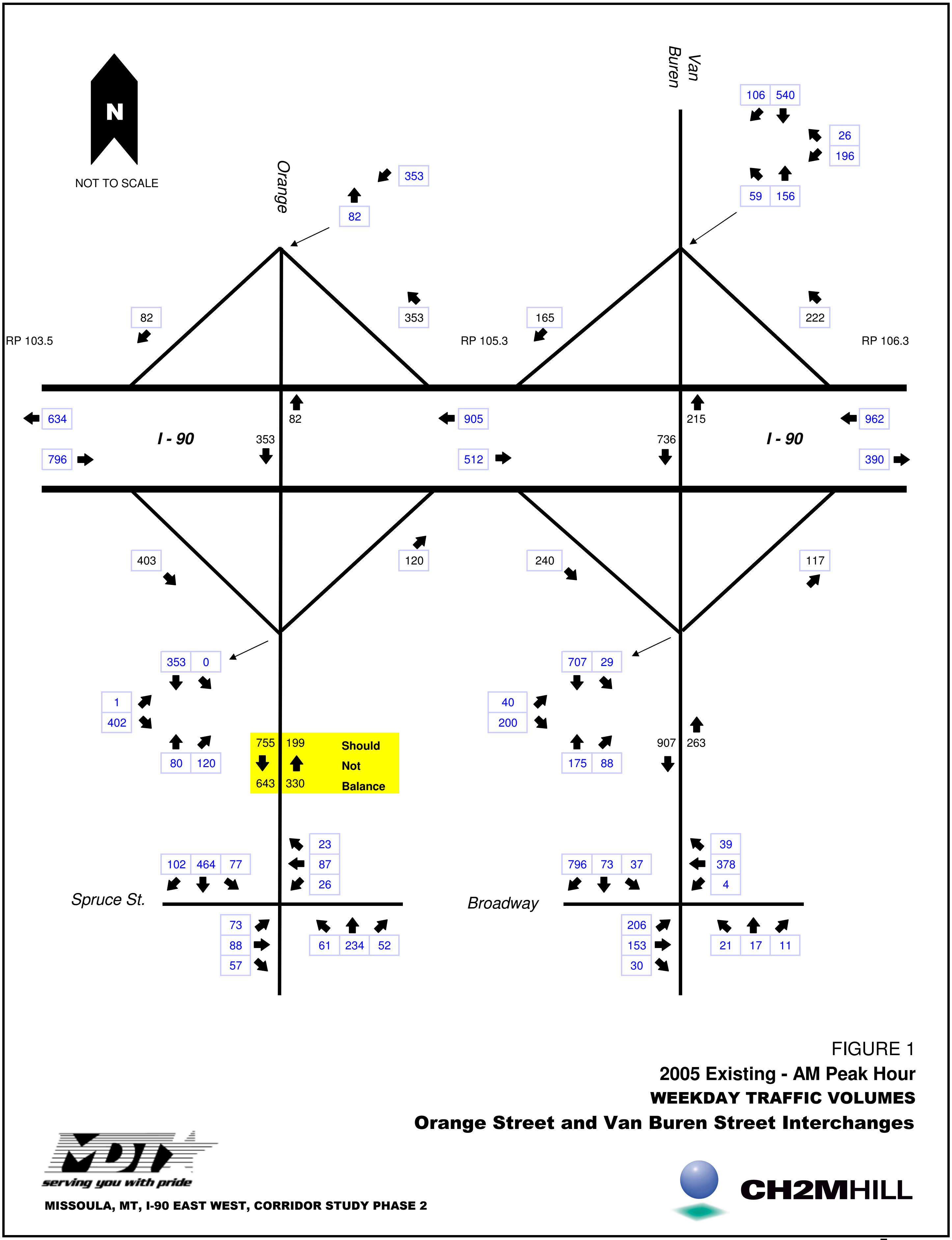

FIGURE 1

2005 Existing - AM Peak Hour

WEEKDAY TRAFFIC VOLUMES

Orange Street and Van Buren Street Interchanges

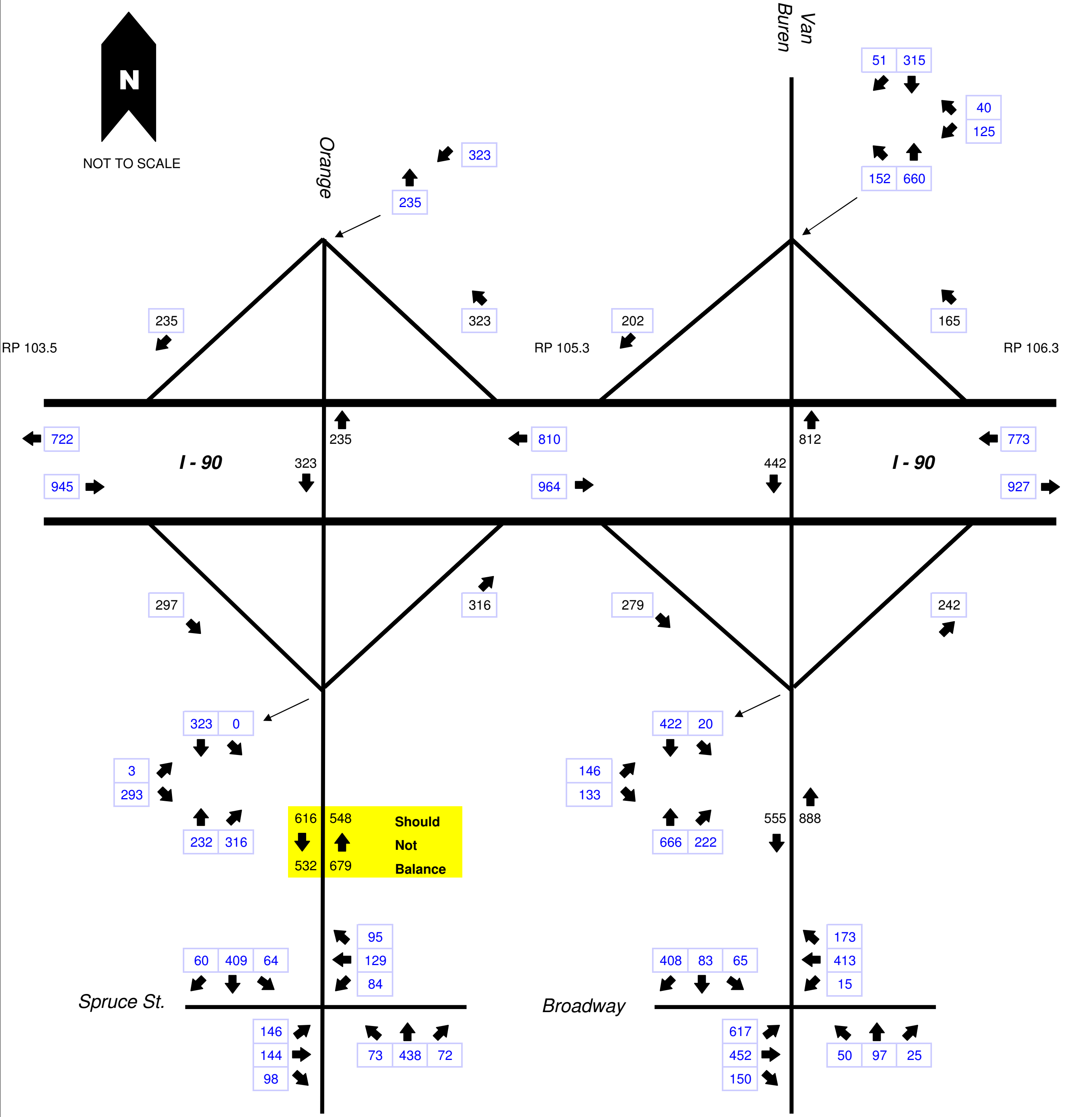

FIGURE 2

2005 Existing - PM Peak Hour

WEEKDAY TRAFFIC VOLUMES

Orange Street and Van Buren Street Interchanges

serving you with pride

MISSOULA, MT, I-90 EAST WEST, CORRIDOR STUDY PHASE 2

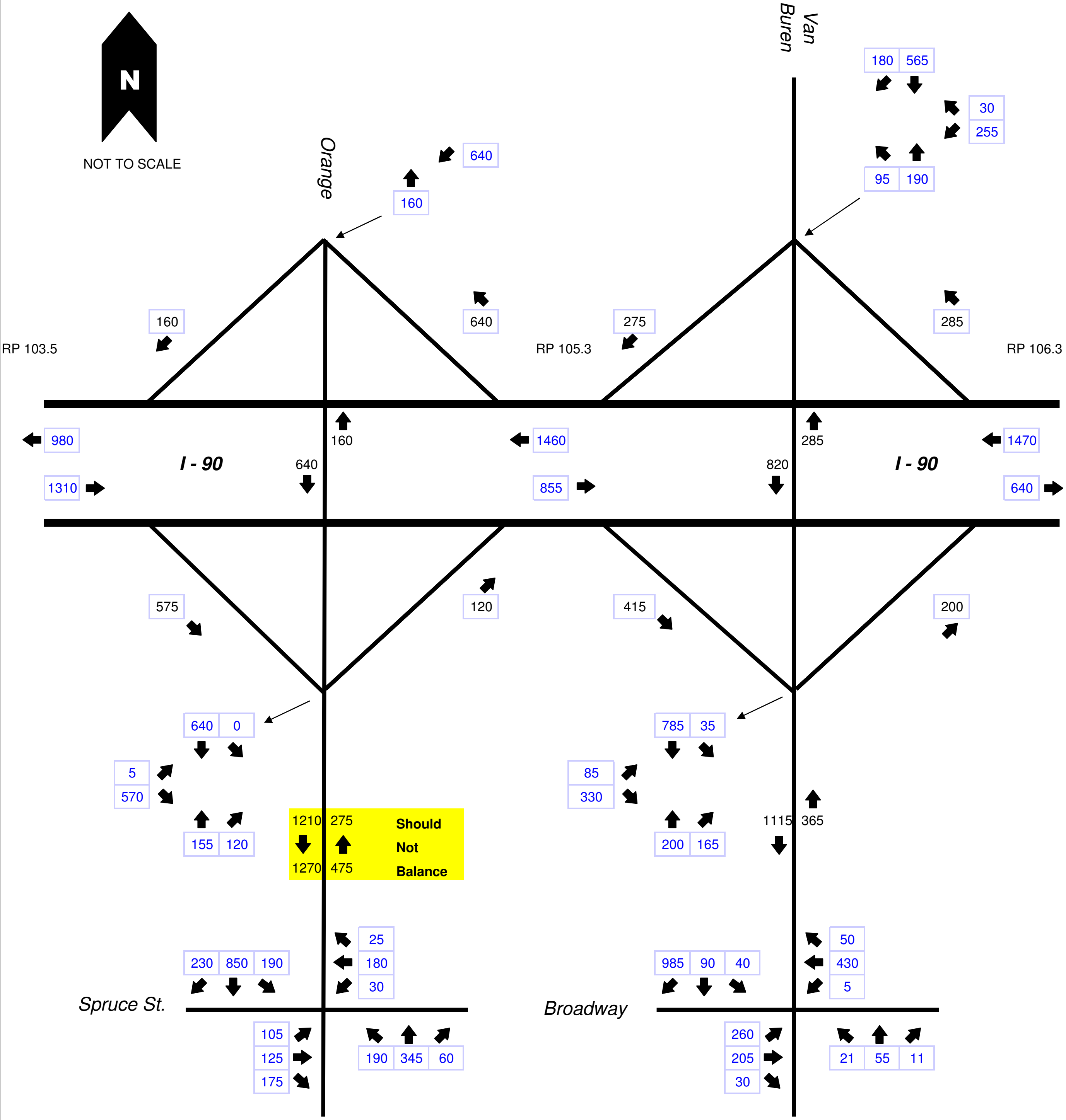

FIGURE 3

2030 No Build - AM Peak Hour

WEEKDAY TRAFFIC VOLUMES

Orange Street and Van Buren Street Interchanges

serving you with pride

MISSOULA, MT, I-90 EAST WEST, CORRIDOR STUDY PHASE 2

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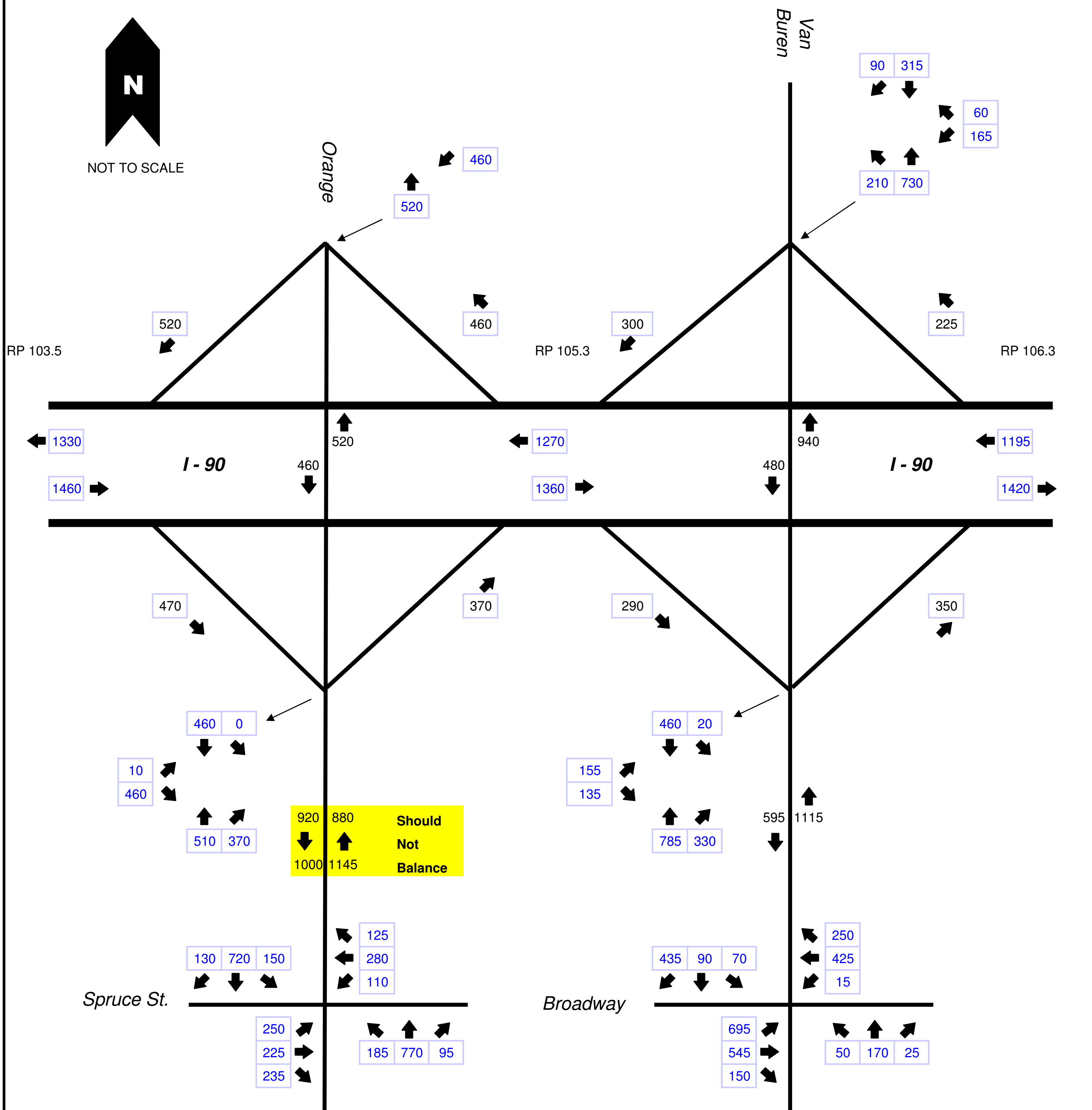

FIGURE 4

2030 No Build - PM Peak Hour

WEEKDAY TRAFFIC VOLUMES

Orange Street and Van Buren Street Interchanges

serving you with pride

MISSOULA, MT, I-90 EAST WEST, CORRIDOR STUDY PHASE 2

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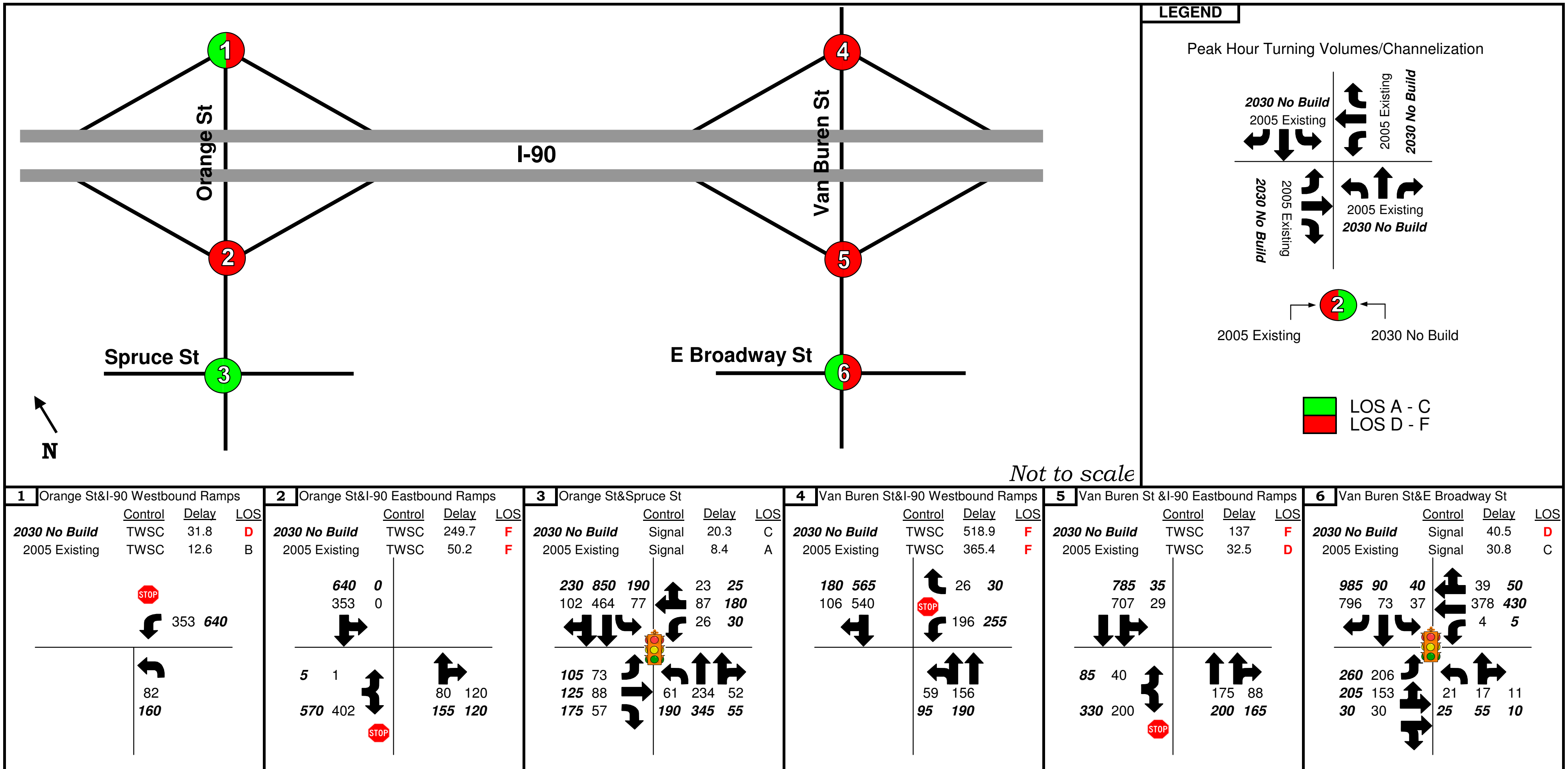

NOTES

Intersection Number

LOS Level of Service

TWSC Two-way stop controlled intersection

AWSC All-way stop controlled intersection

Signal Control

Stop controlled intersection

Signalized intersection

Intersection Signalized as part of build

Turning Movement Direction

Existing and Future Lane Geometry

Channelization

Channelization remains the same between the Existing and Future scenarios

*Intersections at Spruce and Broadway are reported for information only. They are not part of the Phase 2 scope.

Figure 5

AM Peak 2005 Existing and 2030 No Build Intersection LOS, Delay, and Lane Geometry

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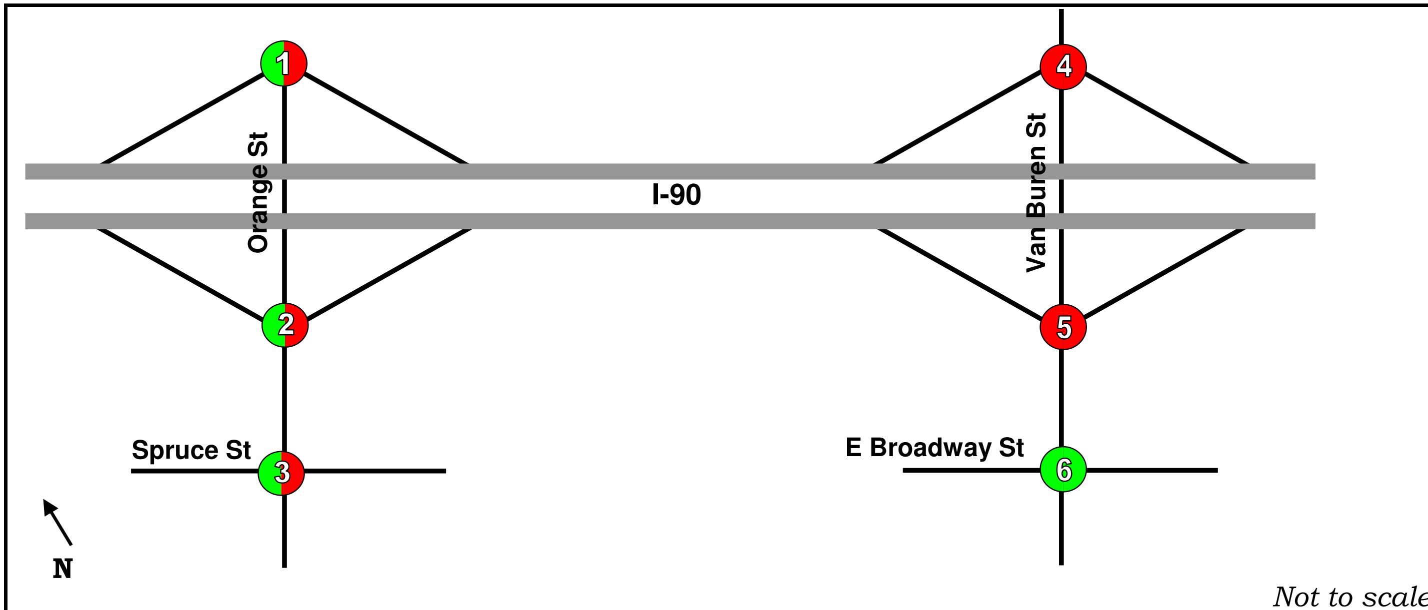
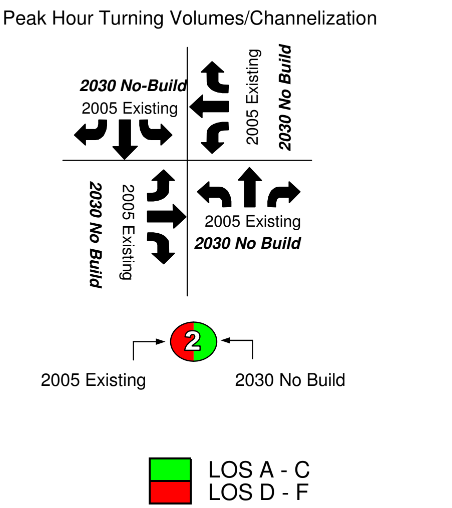


LEGEND



1 Orange St&I-90 Westbound Ramps

	Control	Delay	LOS
2030 No Build	TWSC	73.3	F
2005 Existing	TWSC	14.2	B

2 Orange St&I-90 Eastbound Ramps

	Control	Delay	LOS
2030 No Build	TWSC	57	F
2005 Existing	TWSC	15.1	C

3 Orange St&Spruce St

	Control	Delay	LOS
2030 No Build	Signal	39.5	D
2005 Existing	Signal	13	B

4 Van Buren St&I-90 Westbound Ramps

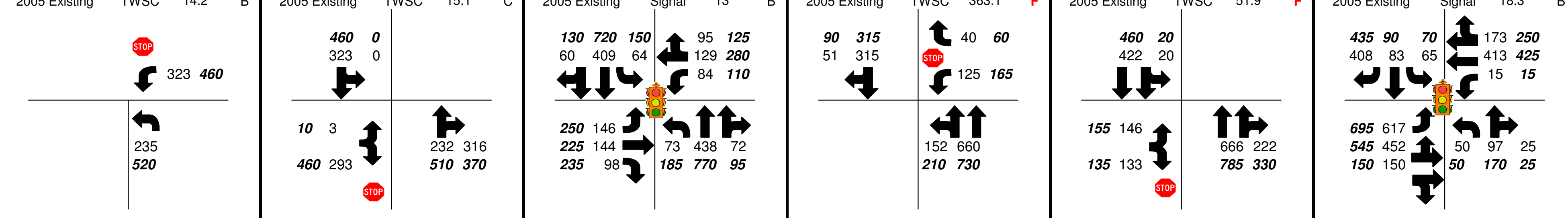
	Control	Delay	LOS
2030 No Build	TWSC	>1000	F
2005 Existing	TWSC	363.1	F

5 Van Buren St &I-90 Eastbound Ramps

	Control	Delay	LOS
2030 No Build	TWSC	94.9	F
2005 Existing	TWSC	51.9	F

6 Van Buren St&E Broadway St

	Control	Delay	LOS
2030 No Build	Signal	29.7	C
2005 Existing	Signal	18.3	B



NOTES

2 Intersection Number

LOS Level of Service
TWSC Two-way stop controlled intersection
AWSC All-way stop controlled intersection

Signal Control

STOP Stop controlled intersection

Signalized intersection

Intersection Signalized as part of build

Turning Movement Direction

Existing and Future Lane Geometry

Channelization

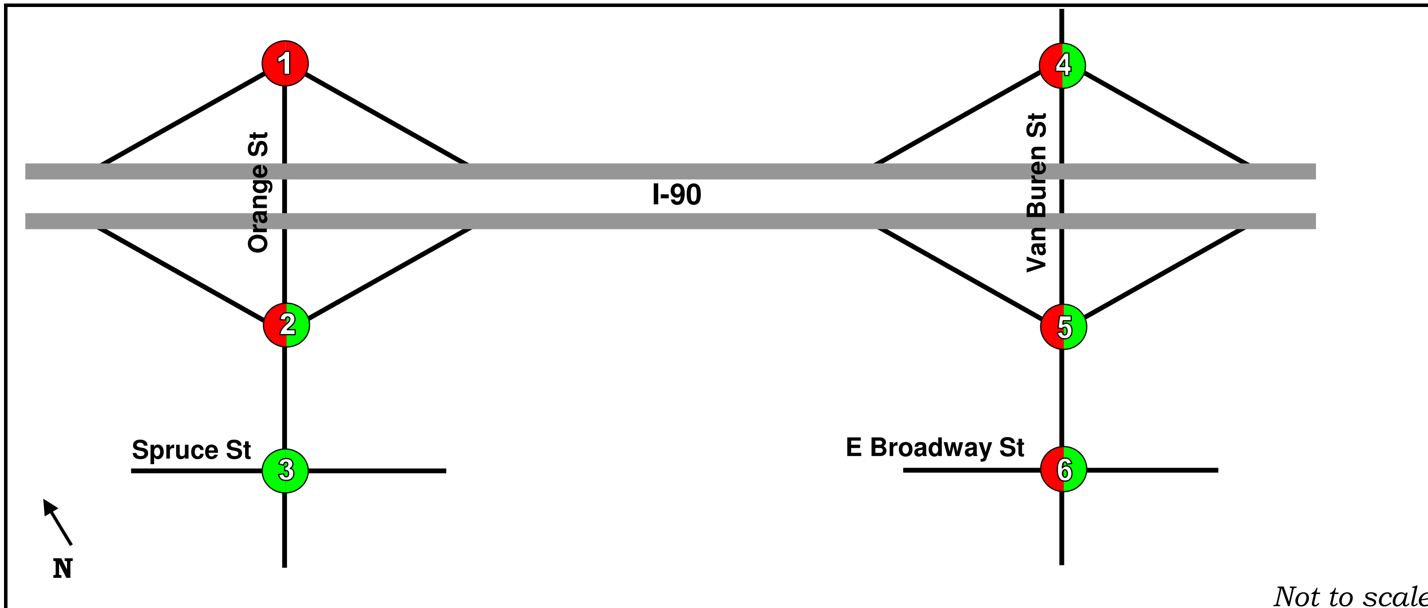
Channelization remains the same between the Existing and Future scenarios

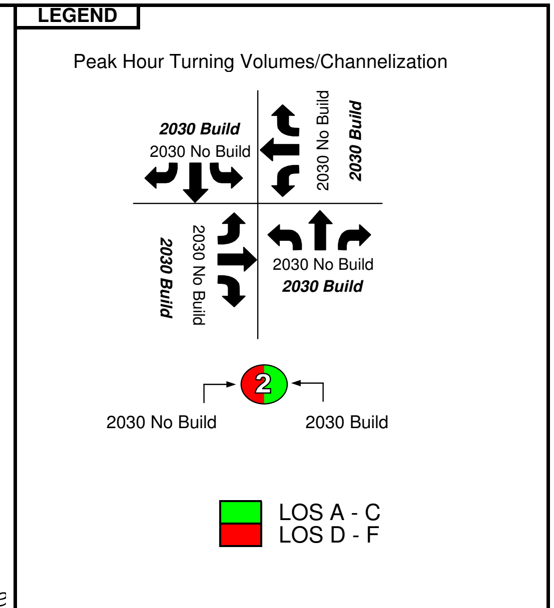
*Intersections at Spruce and Broadway are reported for information only. They are not part of the Phase 2 scope.

Figure 6

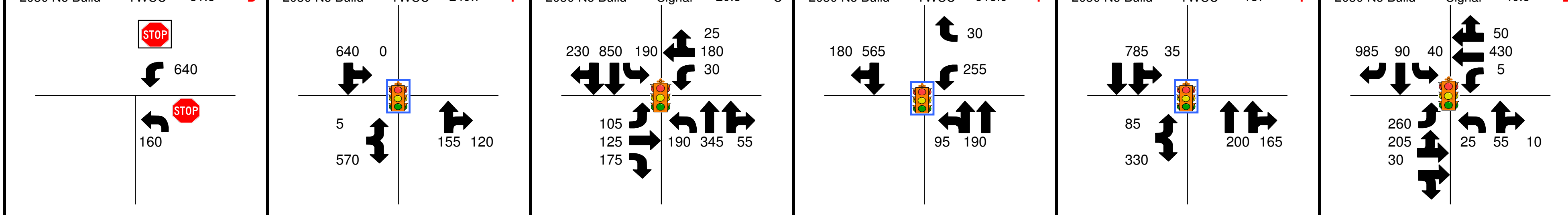
PM Peak 2005 Existing and 2030 No Build Intersection LOS, Delay, and Lane Geometry

Missoula - East & West I-90 Corridor Study - Phase 2





#	Intersection	Scenario	Control	Delay	LOS
1	Orange St&I-90 Westbound Ramps	***2030 Build***	AWSC	32.7	D
		2030 No Build	TWSC	31.8	D
2	Orange St&I-90 Eastbound Ramps	***2030 Build***	Signal	23.7	C
		2030 No Build	TWSC	249.7	F
3	Orange St&Spruce St	***2030 Build***	Signal	19.5	B
		2030 No Build	Signal	20.3	C
4	Van Buren St&I-90 Westbound Ramps	***2030 Build***	Signal	18.2	B
		2030 No Build	TWSC	518.9	F
5	Van Buren St &I-90 Eastbound Ramps	***2030 Build***	Signal	17.4	B
		2030 No Build	TWSC	137	F
6	Van Buren St&E Broadway St	***2030 Build***	Signal	33.5	C
		2030 No Build	Signal	40.5	D



NOTES

Intersection Number

LOS Level of Service
TWSC Two-way stop controlled intersection
AWSC All-way stop controlled intersection

Signal Control

STOP Stop controlled intersection

STOP Stop controlled movement as part of build

Signalized intersection

Intersection Signalized as part of build

Turning Movement Direction

Existing and Future Lane Geometry

Channelization

Channelization remains the same between the No Build and Build scenarios

Volumes

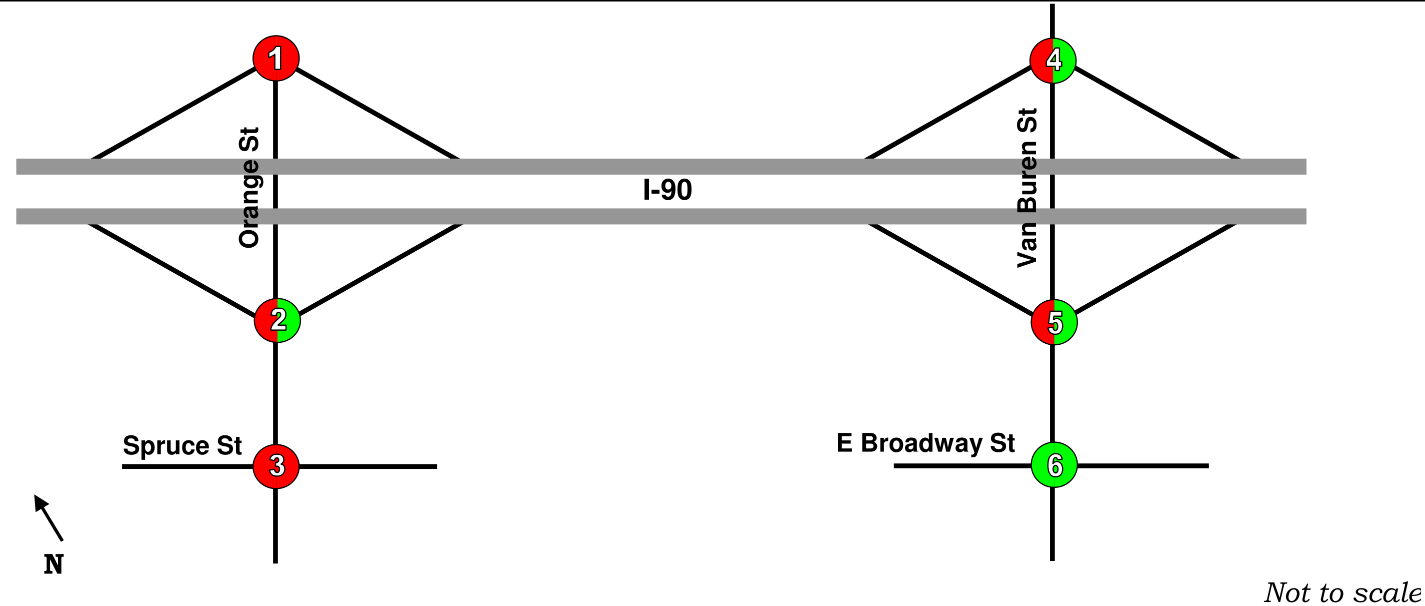
Volumes remain the same between the No build and Build scenarios

*Intersections at Spruce and Broadway are reported for information only. They are not part of the Phase 2 scope.

Figure 7

AM Peak 2030 No Build and 2030 Build Intersection LOS, Delay, and Lane Geometry

Missoula - East & West I-90 Corridor Study - Phase 2



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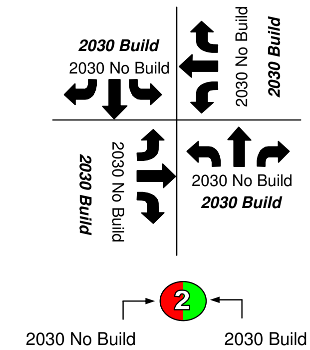
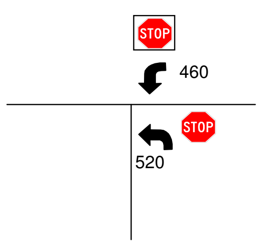
Peak Hour Turning Volumes/Channelization



LOS A - C
LOS D - F

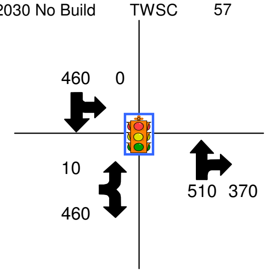
1 Orange St&I-90 Westbound Ramps

	Control	Delay	LOS
2030 Build	AWSC	30.2	D
2030 No Build	TWSC	73.3	F



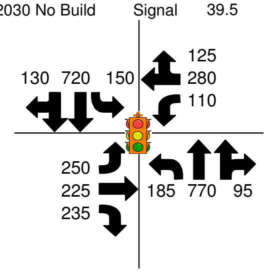
2 Orange St&I-90 Eastbound Ramps

	Control	Delay	LOS
2030 Build	Signal	10.5	B
2030 No Build	TWSC	57	F



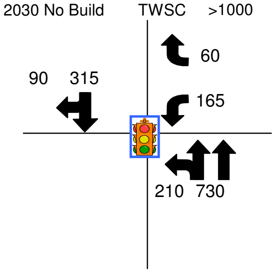
3 Orange St&Spruce St

	Control	Delay	LOS
2030 Build	Signal	39.1	D
2030 No Build	Signal	39.5	D



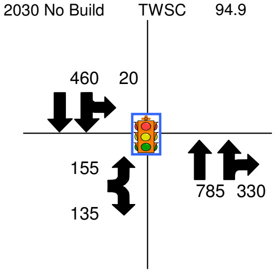
4 Van Buren St&I-90 Westbound Ramps

	Control	Delay	LOS
2030 Build	Signal	9.0	A
2030 No Build	TWSC	>1000	F



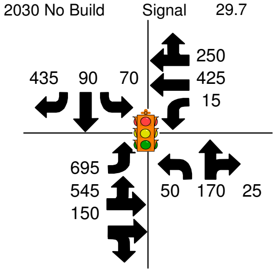
5 Van Buren St &I-90 Eastbound Ramps

	Control	Delay	LOS
2030 Build	Signal	11.4	B
2030 No Build	TWSC	94.9	F



6 Van Buren St&E Broadway St

	Control	Delay	LOS
2030 Build	Signal	28.7	C
2030 No Build	Signal	29.7	C



NOTES

2 Intersection Number

LOS Level of Service

TWSC Two-way stop controlled intersection

AWSC All-way stop controlled intersection

Signal Control

STOP Stop controlled intersection

STOP Stop controlled movement as part of build

Signalized intersection

Intersection Signalized as part of build

Turning Movement Direction

Existing and Future Lane Geometry

Channelization

Channelization remains the same between the No Build and Build scenarios

Volumes

Volumes remain the same between the No build and Build scenarios

*Intersections at Spruce and Broadway are reported for information only. They are not part of the Phase 2 scope.

Figure 8

PM Peak 2030 No Build and 2030 Build Intersection LOS, Delay, and Lane Geometry

Missoula - East & West I-90 Corridor Study - Phase 2

Roundabout Analysis

As an alternative to signalized intersections, a roundabout analysis was also performed at each of the four ramp terminals using the SIDRA software package. Several different concepts and lane configurations were considered for the roundabout analysis. At Orange Street, the existing lane geometry was used for analysis to create single-lane roundabouts at the westbound and eastbound I-90 ramps. A single-lane five-leg roundabout, combining the eastbound and westbound ramps at one intersection (similar to a single point urban interchange configuration), was also considered. A schematic illustration of this concept is provided in Figure 9. At Van Buren Street, both dual lane roundabouts (accommodating the existing lane geometry) and single lane roundabouts were reviewed. A summary of the volume to capacity (v/c) ratios and delays for each of these scenarios is listed in Tables 5 and 6 with a comparison to the signalized/unsignalized operations results from the *Highway Capacity Manual* (Transportation Research Board, 2000) as reported by Synchro.

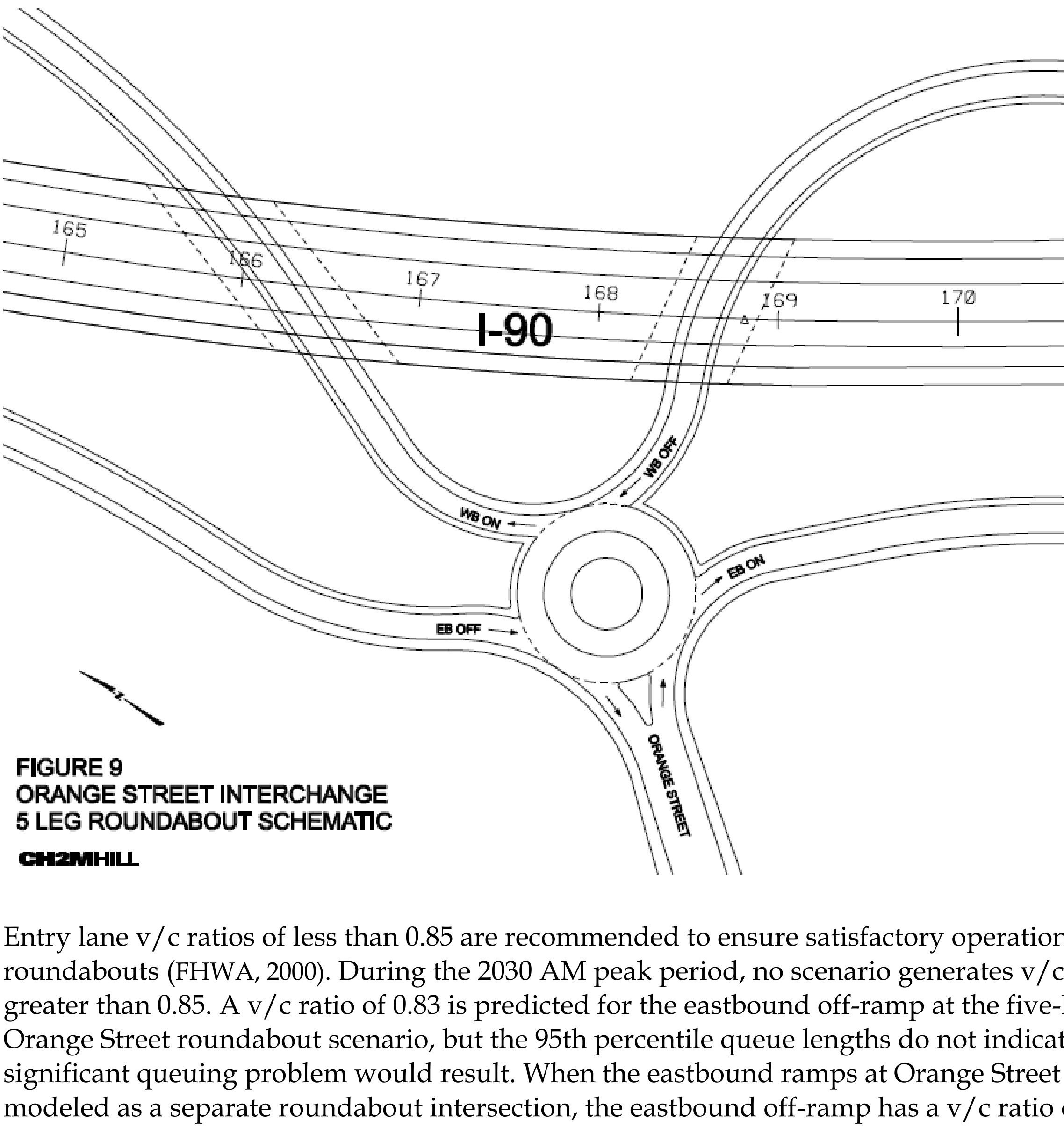


FIGURE 9
ORANGE STREET INTERCHANGE
5 LEG ROUNDABOUT SCHEMATIC

Entry lane v/c ratios of less than 0.85 are recommended to ensure satisfactory operations of roundabouts (FHWA, 2000). During the 2030 AM peak period, no scenario generates v/c ratios greater than 0.85. A v/c ratio of 0.83 is predicted for the eastbound off-ramp at the five-leg Orange Street roundabout scenario, but the 95th percentile queue lengths do not indicate a significant queuing problem would result. When the eastbound ramps at Orange Street are modeled as a separate roundabout intersection, the eastbound off-ramp has a v/c ratio of 0.75.

TABLE 5
2030 AM Build Comparison of Signals/AWSC to Roundabouts at Ramp Terminals

	Orange Street/ Westbound Ramps		Orange Street/ Eastbound Ramps		Orange St Combined Ramp Five-Leg Roundabout		Van Buren Street/ Westbound Ramps		Van Buren Street/ Eastbound Ramps	
	V/C	Delay (sec)	V/C	Delay (sec)	V/C	Delay (sec)	V/C	Delay (sec)	V/C	Delay (sec)
Eastbound										
FHWA	NA	NA	0.64	9.9	0.78	18.3	NA	NA	0.64	13.7
FHWA (dual lane)							NA	NA	0.26	2.7
SIDRA	NA	NA	0.75	19.8	0.83	19.2	NA	NA	0.62	14.8
SIDRA (dual lane)							NA	NA	0.52	7.22
Synchro (HCM report)	NA	NA	0.89	38.3	NA	NA	NA	NA	0.87	49.5
Westbound										
FHWA	0.65	9.1	NA	NA	0.65	9.1	0.32	5.1	NA	NA
FHWA (dual lane)							0.15	1.9	NA	NA
SIDRA	0.53	5.6	NA	NA	0.54	5.0	0.28	5.74	NA	NA
SIDRA (dual lane)							0.21	6.82	NA	NA
Synchro (HCM report)	0.93	38.1	NA	NA	NA	NA	0.74	42.9	NA	NA
Northbound										
FHWA	0.15	3.5	0.22	3.2	0.27	4.0	0.27	4.1	0.36	4.9
FHWA (dual lane)							0.14	1.7	0.18	1.9
SIDRA	0.10	4.1	0.18	0.4	0.18	2.8	0.18	1.4	0.31	1.1
SIDRA (dual lane)							0.11	2.4	0.15	2.1
Synchro (HCM report)	0.29	11.1	0.30	6.6	NA	NA	0.22	6.3	0.16	2.8
Southbound										
FHWA	NA	NA	0.50	4.9	NA	NA	0.85	20.1	0.75	11.4
FHWA (dual lane)							0.40	2.8	0.38	2.4
SIDRA	NA	NA	0.39	0.0	NA	NA	0.78	13.7	0.50	0.2
SIDRA (dual lane)							0.77	11.4	0.26	0.9
Synchro (HCM report)	NA	NA	0.72	18.5	NA	NA	0.66	10.9	0.43	8.3

Dual lane indicates the size of the roundabout, as dictated by the largest entry width.

At locations with a dual-entry, the max V/C ratio is reported for the approach.

Details of SIDRA and FHWA analysis can be found in Appendix C.

TABLE 6
2030 PM Build Comparison of Signals/AWSC to Roundabouts at Ramp Terminals

	Orange Street/ Westbound Ramps		**Orange Street/ Eastbound Ramps**		**Orange St Combined Ramp Five-Leg Roundabout**		**Van Buren Street/ Westbound Ramps**		**Van Buren Street/ Eastbound Ramps**	
Approach	**V/C**	**Delay (sec)**	**V/C**	**Delay (sec)**	**V/C**	**Delay (sec)**	**V/C**	**Delay (sec)**	**V/C**	**Delay (sec)**
Eastbound										
FHWA	NA	NA	0.47	5.9	0.57	8.8	NA	NA	0.35	5.9
FHWA (dual lane)							NA	NA	0.16	2.1
SIDRA	NA	NA	0.53	11.5	0.59	7.1	NA	NA	0.33	6.0
SIDRA (dual lane)							NA	NA	0.32	6.2
Synchro (HCM report)	NA	NA	0.66	41.4	NA	NA	NA	NA	0.77	46.5
Westbound										
FHWA	0.55	8.8	NA	NA	0.55	8.8	0.40	9.4	NA	NA
FHWA (dual lane)							0.15	2.5	NA	NA
SIDRA	0.54	10.0	NA	NA	0.56	9.5	0.39	13.1	NA	NA
SIDRA (dual lane)							0.16	8.5	NA	NA
Synchro (HCM report)	0.79	26.8	NA	NA	NA	NA	0.65	42.0	NA	NA
Northbound										
FHWA	0.48	5.6	0.67	7.4	0.81	14.2	0.87	18.7	1.13	83.6
FHWA (dual lane)							0.44	2.6	0.55	3.5
SIDRA	0.32	4.0	0.56	0.4	0.59	2.9	0.57	0.9	0.94	10.1
SIDRA (dual lane)							0.43	1.8	0.45	2.4
Synchro (HCM report)	0.86	33.0	0.71	5.6	NA	NA	0.53	3.1	0.52	4.3
Southbound										
FHWA	NA	NA	0.34	3.7	NA	NA	0.45	6.6	0.42	5.1
FHWA (dual lane)							0.21	2.1	0.21	1.9
SIDRA	NA	NA	0.28	0.0	NA	NA	0.45	9.1	0.29	0.2
SIDRA (dual lane)							0.45	3.8	0.15	0.9
Synchro (HCM report)	NA	NA	0.35	4.5	NA	NA	0.31	4.4	0.22	6.0

Dual lane indicates the size of the roundabout, as dictated by the largest entry width.

At locations with a dual-entry, the max V/C ratio is reported for the approach.

Details of SIDRA and FHWA analysis can be found in Appendix C.

At the westbound ramps and Van Buren Street, the southbound approach to a single-lane roundabout would result in a v/c ratio of 0.78; however, when this intersection is modeled as a two-lane roundabout, the southbound v/c ratio improves to 0.77. The improvement is marginal because the capacity for the southbound approach was not increased; a single-lane entry was retained for this approach, while both the northbound and westbound approaches were modeled for dual-lane entry.

In the 2030 PM scenario, a v/c ratio of 0.94 is computed for the northbound approach at the eastbound ramps and Van Buren Street when modeled as a single-lane roundabout. When a dual-lane roundabout is modeled, this value drops to 0.45. Based on the operational analyses, dual-lane roundabouts on Van Buren Street are better suited to accommodate the forecast traffic volumes.

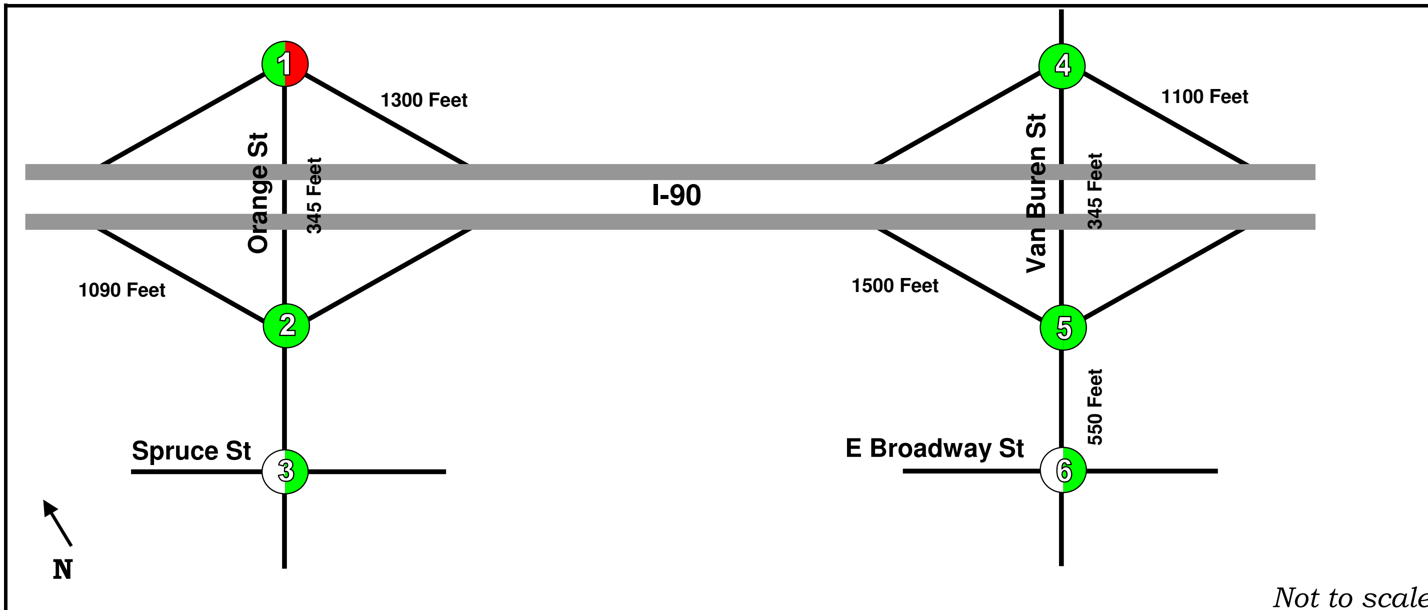
To help validate the SIDRA results, a roundabout analysis using the FHWA guidelines was also performed. Generally, the analysis using the FHWA analysis heeds similar results as the SIDRA analysis with a couple exceptions. Most notable is the Van Buren Street and westbound ramp intersection. In the PM peak hour, the northbound approach has a v/c ratio exceeding the 0.85 threshold under the FHWA analysis while the SIDRA result is 0.57. In the AM peak hour, the southbound approach at this location indicates a v/c ratio of 0.85, placing it at the operational threshold, while the SIDRA result is 0.78.

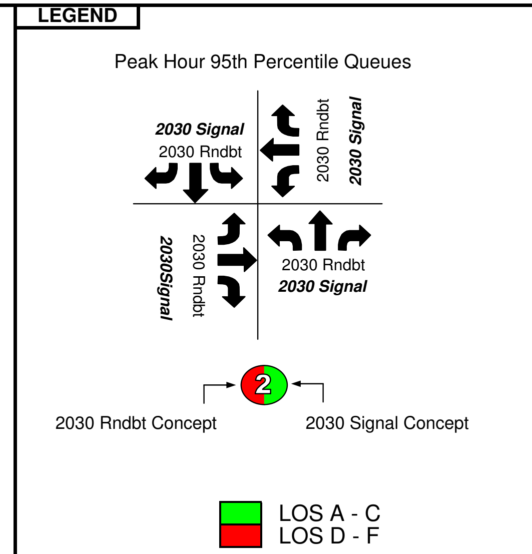
Overall, the roundabout alternative performs better than the traffic signal at each location. In the case of the AWSC intersection at Orange Street and the westbound ramps, the roundabout performs significantly better in both the AM and PM peaks. These results assume a single lane roundabout will be needed at Orange Street ramp terminals while a dual lane roundabout would ultimately be required at the Van Buren Street ramp terminals. Further design analysis will need to be performed in order to determine which locations can support a roundabout layout under existing land use constraints. Also, although the design of a five-leg Single Point Urban Interchange (SPUI) roundabout at the Orange Street interchange produces acceptable results, this option does not result in improvements over the conventional roundabout configurations. Also, the construction cost implications associated with ramp alignment modifications and structural elements would likely be significant. As a result, the SPUI roundabout at Orange Street is not considered further in this review.

Queues

95th percentile queuing characteristics of signalized ramp terminals vs. roundabouts are summarized in Figures 10 and 11. In nearly all cases, queue lengths are less with roundabout control. Exceptions include the northbound approach at the eastbound ramps and Orange Street during the PM peak hour and the northbound approach at the eastbound ramps at Van Buren Street during the AM peak hour. However, these differences are relatively minor and the current intersection spacing would adequately accommodate the longer queue lengths noted.

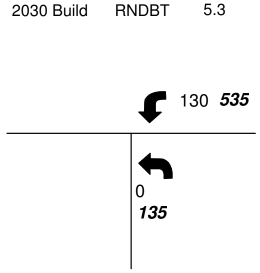
Of additional concern at the eastbound ramps and Van Buren Street is the proximity of East Broadway Street approximately 550 feet to the south. This intersection is currently signalized and operates reasonably well in both the 2030 AM and PM peak hours (LOS C); however, an extensive queue is evident during the AM peak hour for the southbound right turn movement. In fact, this calculated queue of 990 feet exceeds the available length of approximately 550 feet between the eastbound ramp terminal and East Broadway Street. Intersection improvements at





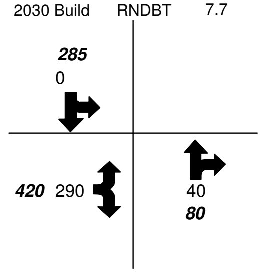
1 Orange St&I-90 Westbound Ramps

	Control	Delay	LOS
2030 Build	AWSC	32.7	D
2030 Build	RNDBT	5.3	A



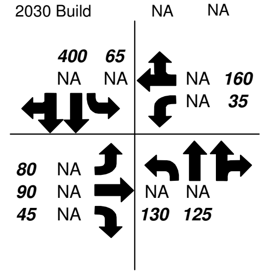
2 Orange St&I-90 Eastbound Ramps

	Control	Delay	LOS
2030 Build	Signal	23.7	C
2030 Build	RNDBT	7.7	A



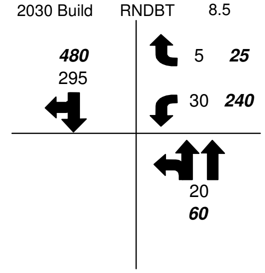
3 Orange St&Spruce St

	Control	Delay	LOS
2030 Build	Signal	19.5	B
2030 Build	NA	NA	NA



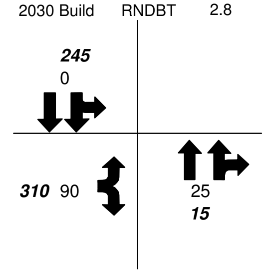
4 Van Buren St&I-90 Westbound Ramps

	Control	Delay	LOS
2030 Build	Signal	18.2	B
2030 Build	RNDBT	8.5	A



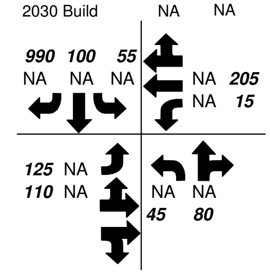
5 Van Buren St &I-90 Eastbound Ramps

	Control	Delay	LOS
2030 Build	Signal	17.4	B
2030 Build	RNDBT	2.8	A



6 Van Buren St&E Broadway St

	Control	Delay	LOS
2030 Build	Signal	33.5	C
2030 Build	NA	NA	NA



NOTES

Intersection Number

LOS Level of Service
TWSC Two-way stop controlled intersection
AWSC All-way stop controlled intersection

-Results for roundabouts on Van Buren are based on a dual-lane circle

-Queue lengths are reported in feet

*Queue for AWSC intersection at Orange Street & I-90 WB Ramps estimated using average two-minute arrivals

*Intersections at Spruce and Broadway are reported for information only. They are not part of the Phase 2 scope.

Turning Movement Direction

Existing and Future Lane Geometry

Channelization

Channelization remains the same between the No Build and Build scenarios

Figure 10

AM Peak 2030 Build Roundabout vs. Traffic Signal Comparison of 95th Percentile Queue Lengths

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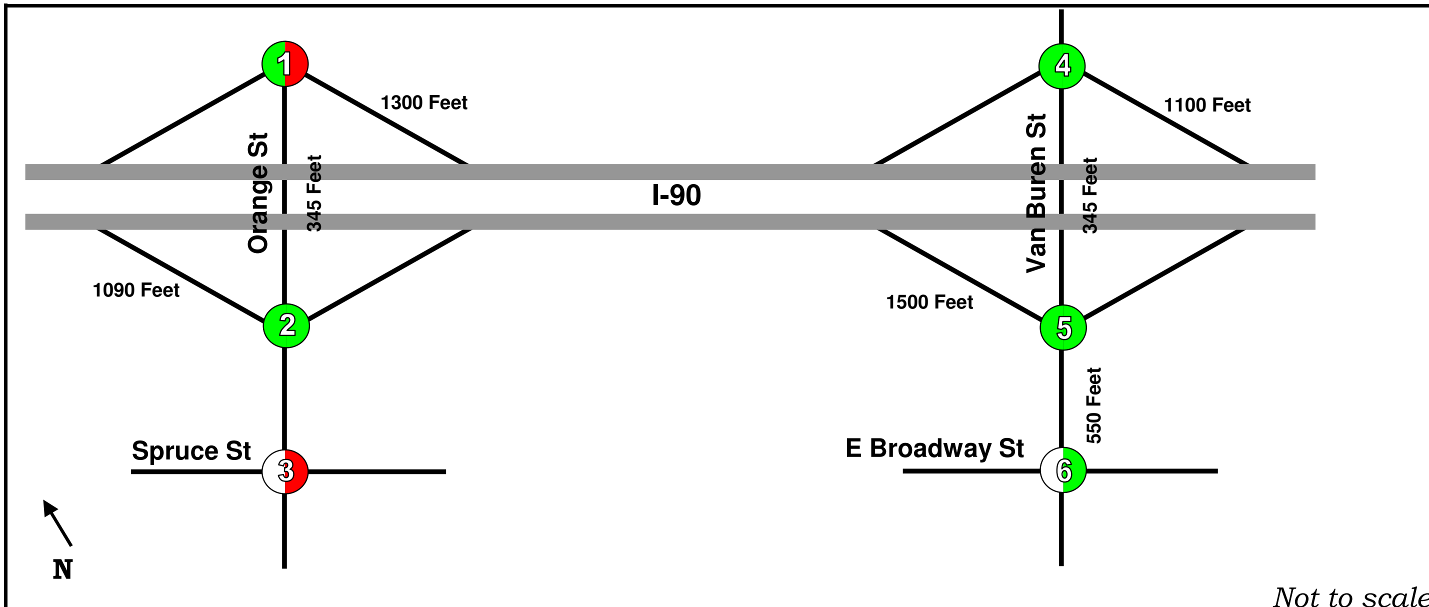
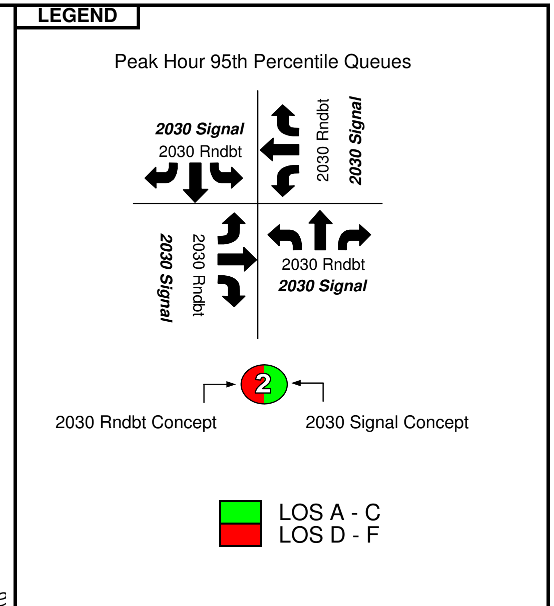




1	Orange St&I-90 Westbound Ramps		
	Control	Delay	LOS
2030 Build	AWSC	30.2	D
2030 Build	RNDBT	6.8	A

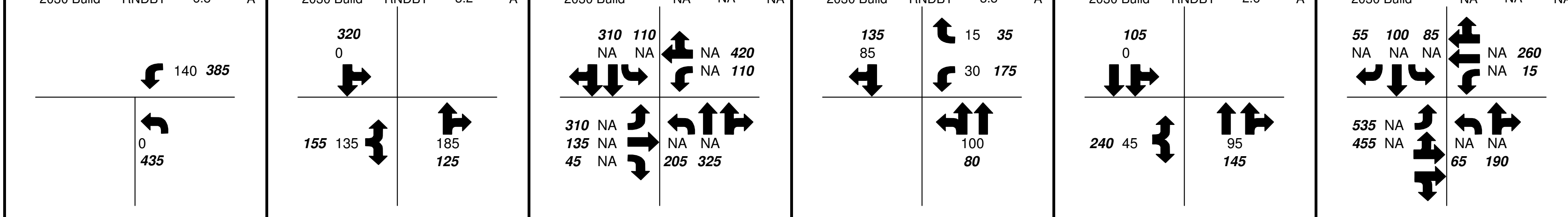
2	Orange St&I-90 Eastbound Ramps		
	Control	Delay	LOS
2030 Build	Signal	10.5	B
2030 Build	RNDBT	3.2	A

3	Orange St&Spruce St		
	Control	Delay	LOS
2030 Build	Signal	39.1	D
2030 Build	NA	NA	NA

4	Van Buren St&I-90 Westbound Ramps		
	Control	Delay	LOS
2030 Build	Signal	9	A
2030 Build	RNDBT	3.3	A

5	Van Buren St &I-90 Eastbound Ramps		
	Control	Delay	LOS
2030 Build	Signal	11.4	B
2030 Build	RNDBT	2.6	A

6	Van Buren St&E Broadway St		
	Control	Delay	LOS
2030 Build	Signal	28.7	C
2030 Build	NA	NA	NA



NOTES

Intersection Number

LOS Level of Service

TWSC Two-way stop controlled intersection

AWSC All-way stop controlled intersection

-Results for roundabouts on Van Buren are based on a dual-lane circle

-Queue lengths are reported in feet

Turning Movement Direction

Existing and Future Lane Geometry

Channelization

Channelization remains the same between the No Build and Build scenarios

*Queue for AWSC intersection at Orange Street & I-90 WB Ramps estimated using average two-minute arrivals

*Intersections at Spruce and Broadway are reported for information only. They are not part of the Phase 2 scope.

Figure 11

PM Peak 2030 Build Roundabout vs. Traffic Signal Comparison of 95th Percentile Queue Lengths

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this location are not included in the current scope of work. However this condition appears to be easily correctable through lane reconfiguration of the southbound approach to include a shared southbound right turn/thrrough lane, in addition to the exclusive left and right turn lanes.

Ramp Operations

Exit ramps must provide sufficient distance for vehicles to exit the highway and decelerate to the design speed of the controlling ramp curvature. Beyond the controlling curve sufficient distance must be provided to decelerate to a stop condition at the exit ramp terminal. Both ramp grade and vehicle queue length must be considered in determining the required ramp length to accommodate these elements. Table 7 provides a summary of 2030 No Build conditions for both the Van Buren Street and Orange Street exit ramps. The table indicates that all exit ramps, with the exception of the eastbound off-ramp at Van Buren Street, are impacted by excessive queue lengths under the 2030 No Build condition. These queue lengths reduce the available deceleration distance to less than that required by *A Policy on Geometric Design of Highways and Streets* (AASHTO, 2004) for the given ramp speed and gradient. The bold type noted in Table 7 identifies where these impacts are expected.

TABLE 7
2030 No Build I-90 Ramp Queue Impacts

Ramp	Ramp Length (feet)	Taper Length (feet)	Available Decel and Storage (feet)	95th Percentile Queue (feet)	Remaining Decel Length (feet)	*Required Decel Length (feet)
Orange Street						
Eastbound Off AM Peak	1241	153	1088	825	**263**	775
Eastbound Off PM Peak	1241	153	1088	320	**768**	775
Westbound Off AM Peak	1313	176	1137	280	**857**	862
Westbound Off PM Peak	1313	176	1137	350	**787**	862
Van Buren Street						
Eastbound Off AM Peak	1604	149	1455	460	995	774
Eastbound Off PM Peak	1604	149	1455	290	1165	774
Westbound Off AM Peak	1072	161	911	585	**326**	775
Westbound Off PM Peak	1072	161	911	NA	**<0**	775

* Adjusted for grade. Decel distance includes length prior to controlling curve plus length required to stop.
NA – queue exceeds ramp length

Consistent with Phase 1 conclusions, the above results reflect substantial queue impacts to available ramp deceleration distances. In nearly all cases, except the eastbound Van Buren Street off-ramp, impacts are evident without improvements.

Traffic signal or roundabout control at the Orange Street and Van Buren Street ramp terminals will improve this situation under 2030 Build conditions. Under traffic signal control, queue impacts are still observed on the exit ramps; however, they are much less severe. An exception exists at the westbound off-ramp and Orange Street where the AWSC condition produces longer queue lengths than under existing conditions. When roundabouts are employed queue impacts are avoided. These impacts are summarized in Tables 8 and 9.

TABLE 8
2030 Build (Signal/AWSC) I-90 Ramp Queue Impacts

Ramp	Ramp Length (feet)	Taper Length (feet)	Available Decel and Storage (feet)	95th Percentile Queue (feet)	Remaining Decel Length (feet)	*Required Decel Length (feet)
Orange Street						
Eastbound Off AM Peak	1241	153	1088	420	**668**	775
Eastbound Off PM Peak	1241	153	1088	155	933	775
Westbound Off AM Peak	1313	176	1137	535	**602**	862
Westbound Off PM Peak	1313	176	1137	385	**752**	862
Van Buren Street						
Eastbound Off AM Peak	1604	149	1455	310	1145	774
Eastbound Off PM Peak	1604	149	1455	240	1215	774
Westbound Off AM Peak	1072	161	911	240	**671**	775
Westbound Off PM Peak	1072	161	911	175	**736**	775

* Adjusted for grade. Decel distance includes length prior to controlling curve plus length required to stop.

TABLE 9
2030 Build (Roundabout) I-90 Ramp Queue Impacts

Ramp	Ramp Length (feet)	Taper Length (feet)	Available Decel and Storage (feet)	95th Percentile Queue (feet)	Remaining Decel Length (feet)	*Required Decel Length (feet)
Orange Street						
Eastbound Off AM Peak	1241	153	1088	290	798	775
Eastbound Off PM Peak	1241	153	1088	135	953	775
Westbound Off AM Peak	1313	176	1137	130	1007	862
Westbound Off PM Peak	1313	176	1137	140	997	862
Van Buren Street						
Eastbound Off AM Peak	1604	149	1455	90	1365	774
Eastbound Off PM Peak	1604	149	1455	45	1410	774
Westbound Off AM Peak	1072	161	911	30	881	775
Westbound Off PM Peak	1072	161	911	30	881	775

* Adjusted for grade. Decel distance includes length prior to controlling curve plus length required to stop.

As reported in the Phase 1 Report, entry tapers and gap acceptance lengths are generally acceptable for the existing on-ramps at Orange Street and Van Buren Street; however, significantly insufficient ramp acceleration distances were noted. These findings are summarized in Table 10. AASHTO indicates that the geometrics of the ramp proper should be such that motorists may attain a speed within 5 mph of the operating speed of the freeway by the time they reach the point where the left edge of the ramp joins the traveled way of the freeway. The distance needed for acceleration in advance of this point of convergence is governed by the speed differential between the operating speed on the entrance curve of the ramp and the operating speed of the highway. Insufficient ramp acceleration and deceleration lengths may suggest either ramp geometric improvements, or auxiliary lane enhancements to accommodate speed changes, vehicle storage, weaving, and truck climbing. Detailed acceleration and deceleration computations are provided in Appendix D. These computations assume attaining a highway speed of 70 mph and are adjusted for grade. Additional length to accommodate heavy vehicle operations is not included.

TABLE 10
Ramp Acceleration

Ramp	Measured Acceleration Length (feet)	Required Acceleration Length (feet) *
Orange Street		
Eastbound On-ramp	1214	1550
Westbound On-ramp	943	1300
Van Buren Street		
Eastbound On-ramp	1032	1516
Westbound On-ramp	928	1470

* Adjusted for grade. Accel distance includes length prior to controlling curve plus length required to reach 70 mph.

Interstate 90 Freeway Operations

The Interstate 90 (I-90) study area for Phase 2 of this project includes the mainline section west of the Orange Street interchange to the mainline section east of the Van Buren Street interchange. Both eastbound and westbound AM and PM peak hour operations were analyzed for existing 2005 and future 2030 No Build conditions. Existing and future 2030 No Build operations were based on the current I-90 lane configuration of two lanes in each direction.

HCS2000, a software program based on the principles of the *Highway Capacity Manual*, was used for the mainline and ramp merge/diverge analysis of the existing and future (2030) conditions. Tables 11 and 12 provide a summary of the AM and PM peak hour operations on I-90 for both the existing 2005 and future 2030 No Build conditions. A LOS threshold of B or better is MDT's goal for freeway operations.

Currently, all existing mainline, merge, and diverge segments in the study area operate acceptably during both AM and PM peak hours.

In the future 2030 No Build condition, all mainline and merge and diverge areas show an increase in density (worse LOS). However, the decreases were not significant enough to reduce LOS below the LOS B threshold. Figures 12 and 13 provide a graphical summary of all freeway analysis.

Based on the favorable freeway operations noted above, a Build option for freeway operations was not evaluated. However, if an auxiliary lane was implemented between the Orange Street and Van Buren Street interchanges to mitigate the insufficient acceleration and deceleration lengths, a ramp-weave would be created. In the westbound direction, the measured weaving distance of approximately 2,950 feet would be in excess of that considered critical, or 2,500 feet. However in the eastbound direction, the weaving length is approximately 2,300 feet. Analysis of 2030 traffic volumes indicates that the eastbound weaving section would operate as LOS A and LOS B under AM peak hour and PM peak hour conditions, respectively.

TABLE 11
Summary of Existing and Future No Build Scenarios–AM Peak Hour Freeway Operations

		2005 Existing		2030 No Build	
I-90 Segment	**Type**	**Density (pc/mi/h)**	**LOS**	**Density (pc/mi/h)**	**LOS**
Eastbound					
West End Study to Orange St Off	Basic	6.9	A	10.8	A
Orange St Off-ramp	Diverge	11.4	B	16.3	B
Orange St Off to On	Basic	3.4	A	6.0	A
Orange St On-ramp	Merge	6.7	A	9.4	A
Orange St On to Van Buren Off	Basic	7.3	A	10.6	B
Van Buren St Off-ramp	Diverge	7.3	A	10.6	B
Van Buren Off to On	Basic	2.4	A	3.7	A
Van Buren St On-ramp	Merge	5.4	A	7.5	A
Van Buren St On to East End Study	Basic	3.4	A	5.3	A
Westbound					
East End Study to Van Buren St Off	Basic	8.3	A	12.0	B
Van Buren St Off-ramp	Diverge	13.3	B	18.0	B
Van Buren St Off to On	Basic	6.4	A	9.7	A
Van Buren St On-ramp	Merge	9.8	A	14.3	B
Van Buren St On to Orange St Off	Basic	12.6	B	17.8	B
Orange St Off-ramp	Diverge	12.6	B	17.8	B
Orange St Off to On	Basic	4.7	A	6.6	A
Orange St On-ramp	Merge	7.0	A	9.7	A
Orange St On to West End Study	Basic	5.5	A	8.0	A

TABLE 12
Summary of Existing and Future No Build Scenarios–PM Peak Hour Freeway Operations

		2005 Existing		2030 No Build	
I-90 Segment	**Type**	**Density**	**LOS**	**Density**	**LOS**
Eastbound					
West End Study to Orange St Off	Basic	8.0	A	12.1	B
Orange St Off-ramp	Diverge	12.8	B	17.9	B
Orange St Off to On	Basic	5.4	A	8.1	A
Orange St On-ramp	Merge	10.4	B	13.9	B
Orange St On to Van Buren Off	Basic	11.9	B	15.8	B
Van Buren St Off-ramp	Diverge	11.9	B	15.8	B
Van Buren Off to On	Basic	5.8	A	8.9	A
Van Buren St On-ramp	Merge	10.8	B	14.8	B
Van Buren St On to East End Study	Basic	7.8	A	11.7	B

TABLE 12
Summary of Existing and Future No Build Scenarios–PM Peak Hour Freeway Operations

		2005 Existing		2030 No Build	
I-90 Segment	**Type**	**Density**	**LOS**	**Density**	**LOS**
Westbound					
East End Study to Van Buren St Off	Basic	6.2	A	9.5	A
Van Buren St Off-ramp	Diverge	10.6	B	14.9	B
Van Buren St Off to On	Basic	4.9	A	7.8	A
Van Buren St On-ramp	Merge	8.3	A	12.3	B
Van Buren St On to Orange St Off	Basic	10.9	B	15.5	B
Orange St Off-ramp	Diverge	10.9	B	15.5	B
Orange St Off to On	Basic	3.9	A	6.4	A
Orange St On-ramp	Merge	7.2	A	12.5	B
Orange St On to West End Study	Basic	5.8	A	10.6	A

Field Data Review

In order to further assess the effects of the previously identified design deficiencies, additional field data was collected. Two primary data collection efforts were completed. The first involves documentation of vehicular speeds while the second addresses origin-destination patterns between the Orange Street and Van Buren Street interchanges. These elements are discussed in detail in the following paragraphs.

Speed Differential

Speed and volume data were collected on I-90 at three locations (both directions for each lane) and also on four of the eight ramps at the Orange and Van Buren Street interchanges. L2 Data Collection (of Boise, ID) used both radar and tube technology to collect this data which was recorded over a 24-hour period broken down by 15 minute intervals. Mainline speed data was collected between the Orange Street and Van Buren Street interchanges, and immediately east and west of the study area. The speed data is reflective of an average lane speed for each 15 minute period. Ramp data was collected on the eastbound on-ramp and westbound off-ramp at the Orange Street interchange, and at the eastbound off-ramp and westbound on-ramp at the Van Buren Street interchange. Tubes were placed at approximately ¾ of the overall ramp length from the terminal intersection end (near the ramp merge/diverge area). Unlike the mainline data, ramp speed data was collected on a per vehicle basis.

The average daily speed summary on the mainline indicates that the outer lanes (Lane 2) in both directions of travel have lower average speeds than that of the inner lanes (Lane 1). Lane 2 speeds vary by as little as 1 mph (eastbound between the interchanges) to as much as 8 mph (eastbound east of the Van Buren interchange) compared to Lane 1. See Figure 14 for a complete summary. The posted speed limit west of the Orange Street interchange is 75 mph for vehicles, 65 mph for trucks. The posted speed limit changes from 75 mph to 65 mph for vehicles and remains 65 mph for trucks midway between the interchanges. The posted speed limit east of Van Buren Street is 65 mph for both vehicles and trucks. Generally, the data indicates that average speeds on the mainline do not deviate significantly from the posted speed limits in the area; however, a speed differential between lanes is evident.

Substantially lower speeds are noted on the ramps. Both on-ramps report daily speed averages of 20+ mph below that of the mainline, while the off-ramps posted average speeds of about 10 mph less than that of the mainline. This data aligns reasonably well with the computed speeds of the respective ramp controlling curves.

Origin-Destination Data

It has been suggested that many motorists travel between interchanges (i.e., entering the Interstate at either Van Buren or Orange Street and exiting at the next location). An auxiliary lane would benefit this condition as ramp to ramp movements would be removed from the through traffic resulting in less mainline turbulence. In order to assess this condition, origin-destination (O-D) data on the Orange Street and Van Buren Street ramps were collected during a three hour period in the morning (6:30 AM to 9:30 AM) and evening (3:30 PM to 6:30 PM) based on a license plate matching technique. Nearly 5500 plate entries were collected with a 95 percent readability rate. Of specific interest in the data set were those movements observed between the Orange Street and Van Buren Street interchanges – in other words, the Orange Street eastbound on-ramp to Van Buren Street eastbound off-ramp and the Van Buren Street westbound on-ramp to the Orange Street westbound off-ramp. This data collection effort concluded that most vehicles counted have destinations beyond these interchanges. Only about seven percent of the vehicles are making the eastbound movement between the interchanges, while approximately three percent are making the westbound movement during the AM and PM peak periods (6:30 AM to 9:30 AM and 3:30 PM to 6:30PM). A complete summary of the origin-destination results is provided in Appendix E.

Conclusions

Based upon the evaluation completed herein, as well as that conducted under Phase 1 of this project, design improvements should be programmed for the Orange Street and Van Buren Street interchanges. The following improvements are recommended based upon the traffic operations and design review conducted herein.

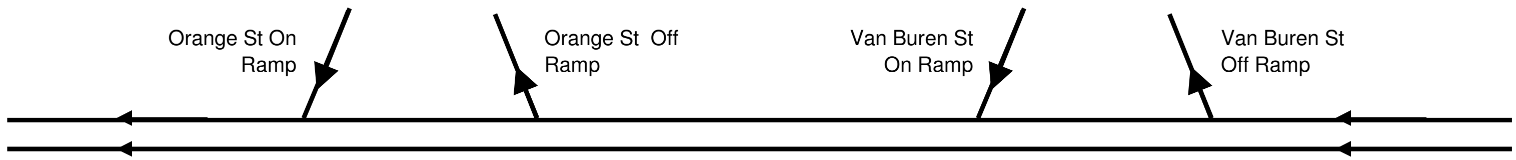
Ramp Terminal Intersections

Traffic control improvements at the ramp terminals are needed. The single lane roundabout alternative performs better than the traffic signal and AWSC at the Orange Street interchange. Benefits achieved by the roundabouts at this location include significantly reduced queue lengths at the ramp terminal intersections, less vehicular delay, and improved v/c ratios. Table 13 reiterates these results as identified previously in this document. Figure 15 illustrates the single lane roundabout configuration at the Orange Street ramp terminals.

At the Van Buren Street interchange a dual lane roundabout would be required to accommodate 2030 traffic demand. This is appropriate as the single lane roundabout produces v/c ratios that exceed recommended thresholds at each of the northbound ramp terminal approaches for the 2030 PM peak hour and at the southbound approach to the westbound ramps in the 2030 AM peak hour. Dual lane approaches at these locations improve v/c ratios to well within recommended limits. As noted previously, circulatory roadway width is dictated by

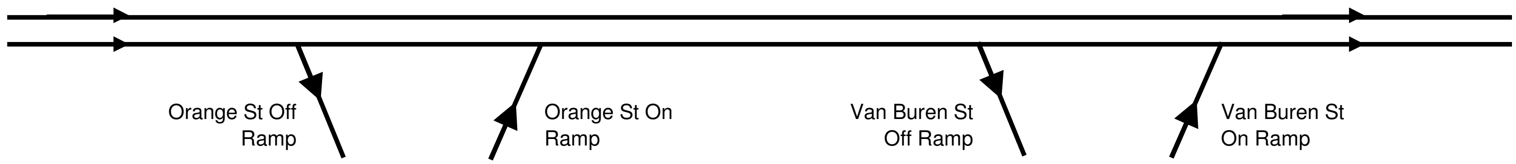
2005 Existing	**LOS**	A	A	A	B	B	A	A	B	A
	Density	5.5	7.0	4.7	12.6	12.6	9.8	6.4	13.3	8.3
	Volume	634	82	552	353	905	165	740	222	962
2030 No Build	**LOS**	A	A	A	B	B	B	A	B	B
	Density	8.0	9.7	6.6	17.8	17.8	14.3	9.7	18.0	12.0
	Volume	980	160	820	640	1460	275	1185	285	1470

Location



Segment Type	Basic	Merge 1500' LA: 755'	Basic	Diverge 1500' LD: 175'	Basic	Merge 1500' LA: 750'	Basic	Diverge 1500' LD: 165'	
Segment Type	Basic	LD: 170' Diverge 1500'	Basic	LA: 625' Merge 1500'	Basic	LD: 280' Diverge 1500'	Basic	LA: 600' Merge 1500'	

Location



2005 Existing	**LOS**	A	B	A	A	A	A	A	A	A
	Density	6.9	11.4	3.4	6.7	7.3	7.3	2.4	5.4	3.4
	Volume	796	403	393	120	513	240	273	117	390
2030 No Build	**LOS**	A	B	A	A	B	B	A	A	A
	Density	10.8	16.3	6	9.4	10.6	10.6	3.7	7.5	5.3
	Volume	1310	575	735	120	855	415	440	200	640

ASSUMPTIONS

- Freeway: 13% trucks /buses, 0% RV's
- Peak Hour Factor: 0.90 (or used existing PHF if greater) for 2030 No Build
- Driver Population Factor: 0.98
- Level Terrain is assumed for all segments
- Measured FFS: 73 mph
- Freeway FFS for ramp junction analysis is the corresponding mainline FFS
- Ramp FFS: 35 mph
- Interchange Density: 1 intersection / mile

LEGEND

Basic mainline segment
Merge or Diverge segment
Overlapping influence area

Existing and build lane configuration

Density is measured in passenger cars / mile / lane

N

Not to Scale

FFS: Free Flow Speed
LA: Length of Acceleration lane
LD: Length of Deceleration lane
LOS: Level of Service
N/A: Not applicable to segment

Figure 12
2005 AM Peak Existing and 2030 No Build Conditions
Missoula -- East & West I-90 Corridor Study -- Phase 2

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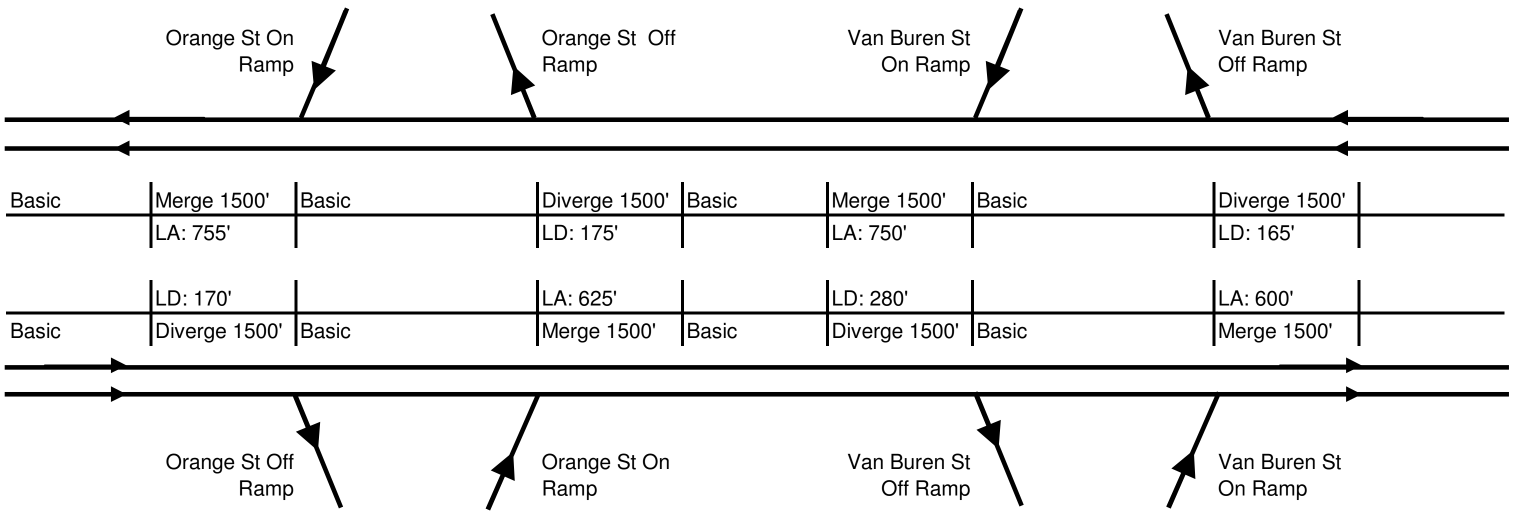
2005 Existing	**LOS**	A	A	A	B	B	A	A	B	A
	Density	5.8	7.2	3.9	10.9	10.9	8.3	4.9	10.6	6.2
	Volume	722	235	487	323	810	202	608	165	773
2030 No Build	**LOS**	A	B	A	B	B	B	A	B	A
	Density	10.6	12.5	6.4	15.5	15.5	12.3	7.8	14.9	9.5
	Volume	1330	520	810	460	1270	300	970	225	1195

Location: Orange St On Ramp; Orange St Off Ramp; Van Buren St On Ramp; Van Buren St Off Ramp



Segment Type	Basic	Merge 1500' LA: 755'	Basic	Diverge 1500' LD: 175'	Basic	Merge 1500' LA: 750'	Basic	Diverge 1500' LD: 165'	
Segment Type	Basic	LD: 170' Diverge 1500'	Basic	LA: 625' Merge 1500'	Basic	LD: 280' Diverge 1500'	Basic	LA: 600' Merge 1500'	

Location: Orange St Off Ramp; Orange St On Ramp; Van Buren St Off Ramp; Van Buren St On Ramp

2005 Existing	**LOS**	A	B	A	B	B	B	A	B	A
	Density	8	12.8	5.4	10.4	11.9	11.9	5.8	10.8	7.8
	Volume	945	297	648	316	964	279	685	242	927
2030 No Build	**LOS**	B	B	A	B	B	B	A	B	B
	Density	12.1	17.9	8.1	13.9	15.8	15.8	8.9	14.8	11.7
	Volume	1460	470	990	370	1360	290	1070	350	1420

ASSUMPTIONS

- Freeway: 13% trucks /buses, 0% RV's
- Peak Hour Factor: 0.90 (or used existing PHF if greater) for 2030 No Build
- Driver Population Factor: 0.98
- Level Terrain is assumed for all segments
- Measured FFS: 73 mph
- Freeway FFS for ramp junction analysis is the corresponding mainline FFS
- Ramp FFS: 35 mph
- Interchange Density: 1 intersection / mile

LEGEND

Basic mainline segment
Merge or Diverge segment
Overlapping influence area

Existing and build lane configuration

Density is measured in passenger cars / mile / lane

N

Not to Scale

FFS: Free Flow Speed
LA: Length of Acceleration lane
LD: Length of Deceleration lane
LOS: Level of Service
N/A: Not applicable to segment

Figure 13
2005 PM Peak Existing and 2030 No Build Conditions
Missoula -- East & West I-90 Corridor Study -- Phase 2

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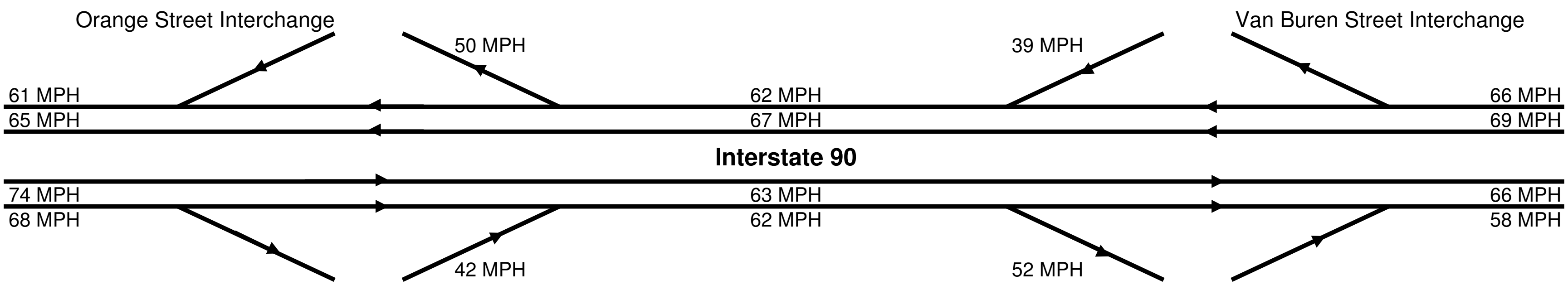

Figure 14
Existing I-90 Daily Speed Averages
Missoula -- East & West I-90 Corridor Study -- Phase 2

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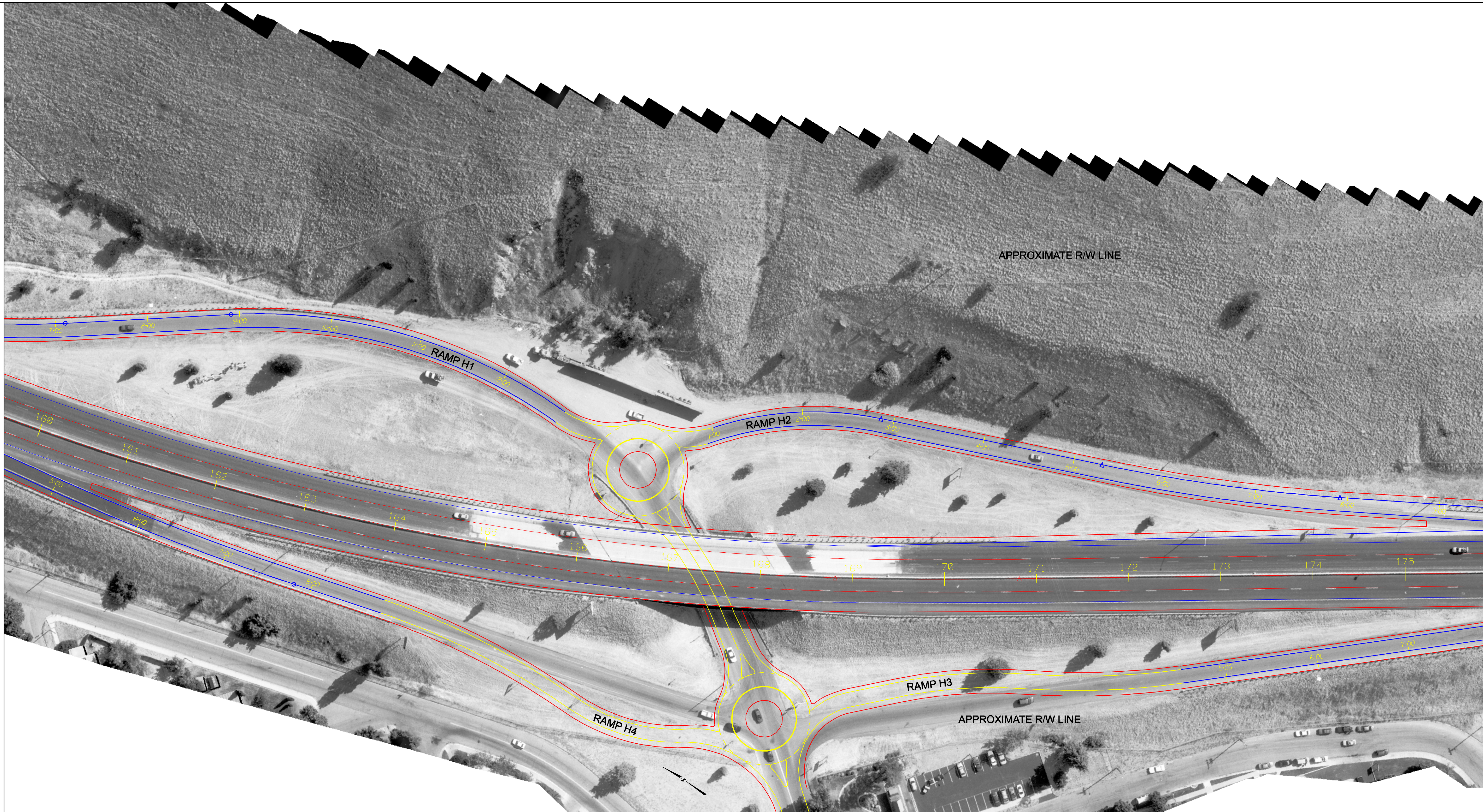

FIGURE 15 - ORANGE STREET RAMP TERMINAL IMPROVEMENTS

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the maximum entry width. Additionally, the existing four-lane section on Van Buren Street readily accommodates this lane configuration. Table 14 summarizes results of the individual measures as compared to the traffic signal option.

TABLE 13
Orange Street 2030 Build Comparison of Signals to Roundabouts at Ramp Terminals

	Orange Street/Westbound Ramps – AM Peak			Orange Street/Westbound Ramps – PM Peak			Orange Street/Eastbound Ramps – AM Peak			Orange Street/Eastbound Ramps – PM Peak		
Approach	**V/C**	**Delay (sec)**	**Queue (ft)**	**V/C**	**Delay (sec)**	**Queue (ft)**	**V/C**	**Delay (sec)**	**Queue (ft)**	**V/C**	**Delay (sec)**	**Queue (ft)**
Eastbound												
FHWA	NA	NA	NA	NA	NA	NA	0.64	9.9	130	0.47	5.9	65
SIDRA	NA	NA	NA	NA	NA	NA	0.75	19.8	290	0.53	11.5	135
Synchro (HCM report)	NA	NA	NA	NA	NA	NA	0.89	38.3	420	0.66	41.4	155
Westbound												
FHWA	0.65	9.1	135	0.55	8.8	90	NA	NA	NA	NA	NA	NA
SIDRA	0.53	5.6	130	0.54	10.0	140	NA	NA	NA	NA	NA	NA
Synchro (HCM report)	0.93	38.1	535 *	0.79	26.8	385*	NA	NA	NA	NA	NA	NA
Northbound												
FHWA	0.15	3.5	15	0.48	5.6	70	0.22	3.2	25	0.67	7.4	150
SIDRA	0.10	4.1	0	0.32	4.0	0	0.18	0.4	40	0.56	0.4	185
Synchro (HCM report)	0.29	11.1	135*	0.86	33.0	435*	0.30	6.6	80	0.71	5.6	125
Southbound												
FHWA	NA	NA	NA	NA	NA	NA	0.50	4.9	75	0.34	3.7	40
SIDRA	NA	NA	NA	NA	NA	NA	0.39	0.0	0	0.28	0.0	0
Synchro (HCM report)	NA	NA	NA	NA	NA	NA	0.72	18.5	285	0.35	4.5	320

*AASHTO method used to determine queue length

The SIDRA and FHWA analysis reflects roundabout conditions while the Synchro analysis is associated with signals/AWSC.

TABLE 14
Van Buren Street 2030 Build Comparison of Signals to Roundabouts at Ramp Terminals

	Van Buren Street/Westbound Ramps – AM Peak			Van Buren Street/Westbound Ramps – PM Peak			Van Buren Street/Eastbound Ramps – AM Peak			Van Buren Street/Eastbound Ramps – PM Peak		
Approach	**V/C**	**Delay (sec)**	**Queue (ft)**	**V/C**	**Delay (sec)**	**Queue (ft)**	**V/C**	**Delay (sec)**	**Queue (ft)**	**V/C**	**Delay (sec)**	**Queue (ft)**
Eastbound												
FHWA (dual lane)	NA	NA	NA	NA	NA	NA	0.26	2.7	30	0.16	2.1	15
SIDRA (dual lane)	NA	NA	NA	NA	NA	NA	0.52	7.22	90	0.32	6.2	45
Synchro (HCM report)	NA	NA	NA	NA	NA	NA	0.87	49.5	310	0.77	46.5	240

TABLE 14
Van Buren Street 2030 Build Comparison of Signals to Roundabouts at Ramp Terminals

	Van Buren Street/Westbound Ramps – AM Peak			Van Buren Street/Westbound Ramps – PM Peak			Van Buren Street/Eastbound Ramps – AM Peak			Van Buren Street/Eastbound Ramps – PM Peak		
Approach	**V/C**	**Delay (sec)**	**Queue (ft)**	**V/C**	**Delay (sec)**	**Queue (ft)**	**V/C**	**Delay (sec)**	**Queue (ft)**	**V/C**	**Delay (sec)**	**Queue (ft)**
Westbound												
FHWA (dual lane)	NA	NA	NA	NA	NA	NA	0.26	2.7	30	0.16	2.1	15
FHWA (dual lane)	0.15	1.9	15	0.15	2.5	15	NA	NA	NA	NA	NA	NA
SIDRA (dual lane)	0.21	6.82	30*	0.16	8.5	30*	NA	NA	NA	NA	NA	NA
Synchro (HCM report)	0.74	42.9	240*	0.65	42.0	175*	NA	NA	NA	NA	NA	NA
Northbound												
FHWA (dual lane)	0.14	1.7	15	0.44	2.6	60	0.18	1.9	20	0.55	3.5	95
SIDRA (dual lane)	0.11	2.4	20	0.43	1.8	100	0.15	2.1	25	0.45	2.4	95
Synchro (HCM report)	0.22	6.3	60	0.53	3.1	80	0.16	2.8	15	0.52	4.3	145
Southbound												
FHWA (dual lane)	0.40	2.8	50	0.21	2.1	20	0.38	2.4	50	0.21	1.9	25
SIDRA (dual lane)	0.77	11.4	295	0.45	3.8	85	0.26	0.9	0	0.15	0.9	0
Synchro (HCM report)	0.66	10.9	480	0.31	4.4	135	0.43	8.3	245	0.22	6.0	105

* Movement with longest queue reported
The SIDRA and FHWA analysis reflects roundabout conditions while the Synchro analysis is associated with signals/AWSC.

At a recent public meeting for this project, the vast majority of public comment supported roundabouts at both interchange locations. However, concern was generated relative to the dual lane configuration at the Van Buren Street interchange as related to pedestrian and bicycle traffic. This concern is legitimate as additional conflict points are introduced with multiple lanes. In this regard, the public desire would be to phase in the dual lane roundabout when needed as opposed to an immediate implementation. Single lane roundabout operations were tested at the Van Buren Street ramp terminals for 2005 AM and PM peak hour conditions. Results indicate favorable operations can be achieved during this period with the exception of the northbound approach to the eastbound ramps where the v/c threshold of 0.85 would be exceeded. This is primarily due to the relatively heavy northbound right turn movement (to I-90) at this location. A right turn bypass lane (slip lane) could be developed to mitigate this issue in the interim and allow the single roundabout to operate within the v/c threshold. In general, right turn bypass lanes are not conducive to bicycle and pedestrian activity as additional conflict points and higher speeds are introduced (FHWA, 2000). Design could accommodate an initial single lane operation with provisions for an ultimate dual lane configuration as depicted by Figures 16 and 17, respectively.

The performance of a roundabout is affected by its proximity to signalized intersections. If a signalized intersection is very close to the roundabout, it causes vehicles to arrive in closely spaced platoons and allows the roundabout to operate more efficiently (FHWA, 2000). As noted previously no queue impacts are anticipated as a result of the roundabout intersections; however, improvements at the intersection of Van Buren Street and East Broadway Street

FIGURE 16 - VANBUREN STREET RAMP TERMINAL IMPROVEMTNS, PHASE 1

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FIGURE 17 - VAN BUREN STREET RAMP TERMINAL IMPROVEMENTS, PHASE 2

CH2MHILL

SCALE 100:1

should be programmed to avoid excessive queueing as identified in the traffic operations review. Other non-traffic related issues may preclude development of roundabouts including right-of-way encroachment impacts at both locations, and impacts of Gregory Park at the westbound Van Buren Street ramp terminal. These items will need to be further examined during design development.

Ramp Geometry

It is apparent that substandard design elements exist related to ramp geometry at the Orange Street and Van Buren Street interchanges. Most notable of these deficiencies is with regard to ramp acceleration lengths. In this case, AASHTO indicates that the geometrics of the ramp proper should be such that motorists may attain a speed within 5 mph of the operation speed of the freeway by the time they reach the point where the left edge of the ramp joins the traveled way of the freeway. Studies have shown that, regardless of average speed on the highway, the more a vehicle deviates from the average speed, the greater its chances of becoming involved in a crash. Recently recorded field conditions indicate that a 5 mph deviation (between lane 1 and lane 2) exists in the westbound direction between the Orange Street and Van Buren Street ramps and an 8 mph deviation exists in the eastbound direction immediately east of the Van Buren Street interchange. These conditions are consistent with the findings that both on-ramps at Van Buren Street do not meet desirable design standards for ramp acceleration lengths (total assumed from stop condition). In fact, the westbound on-ramp at Van Buren Street is approximately 550 feet short and the eastbound on-ramp is nearly 500 feet short of meeting these required acceleration lengths. Improvements in the form of improved ramp geometrics should be developed that will address these inadequacies. In each case a parallel type entrance could be developed to facilitate acceleration. In the westbound direction, the structure over Rattlesnake Creek and West Greenough Drive may need to be modified to accomplish this objective. The cost effectiveness of this measure should be examined during preliminary design. If extensive structural improvements are required, the benefit of achieving desired ramp acceleration may be marginal.

While the geometry at the Orange Street on-ramps also exhibits substandard design elements, the field recorded speed data does not appear to confirm that an acceleration problem exists as the deviation between lanes 1 and 2 in the eastbound direction is only 1 mph immediately east of the Orange Street interchange and 4 mph in the westbound direction immediately to the west of the Orange Street interchange.

As demonstrated by Table 9, all queue impacts related to the associated Van Buren Street and Orange Street exit ramps can be mitigated by developing roundabouts at the ramp terminals as opposed to traffic signals or AWSC conditions.

Auxiliary Lanes

With the improvements to the ramp terminal intersections and ramp geometry noted above, auxiliary lanes should not be required. If alternative methods of traffic control are provided at the ramp terminal intersections, an auxiliary lane in westbound direction may be required to facilitate ramp acceleration and deceleration between the Orange Street and Van Buren Street interchanges.

Works Cited

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Federal Highway Administration. 2003. *Manual on Uniform Traffic Control Devices*. U. S. Department of Transportation, Federal Highway Administration, Washington, D.C.

FHWA. See Federal Highway Administration.

HCS, Highway Capacity Software. Synchro 6.0/Simtraffic 6.0.

Transportation Research Board. 2000. *Highway Capacity Manual*. Washington, D.C.

Appendix A

Revised Methods and Assumptions for Phase 2

Traffic Methodology and Assumptions, Missoula—East & West I-90 Corridor Study—Phase 1 and 2

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COPIES:

DATE: February 28, 2003
Revision: May 9, 2006

Purpose

This memorandum addresses the traffic methodology and assumptions for the East & West I-90 Corridor Study, Phase 1 and 2. Upon concurrence, this memorandum will be used as the foundation for the analysis and will be incorporated into the final report.

Methodology and Assumptions–Phase 1

Analysis Time Periods

This study will analyze two separate years, Existing (2002) and Future No Build year based on Forecasting, in both the AM and PM peak hours. The study will also analyze special event traffic using November 23, 2002 (University football game), as a model for the Orange and Van Buren Interchanges in both the AM and PM peak hours for the event.

Based on analysis of 2002 existing freeway data the following peak hours have been determined:
AM Peak Hour 7 a.m. – 8 a.m.
PM Peak Hour 5 p.m. – 6 p.m.

Special Event (November 23, 2002) peak hours as follows for the Orange and Van Buren Interchanges:
AM Peak 10:15 a.m. – 11:15 a.m.
PM Peak 3:30 p.m. – 4:30 p.m.

Project Limits Area

The geographic area for the Corridor Study is between RM 94.414 and RM 110.00 in Missoula, Montana. The project area contains seven (7) full-service interchanges:

DeSmet (RM 96.34) Airway Blvd. (RM 99.96) Reserve Street (RM101.71) Orange Street (RM 104.78)
Van Buren Street (RM 105.63) East Missoula (RM 107.27)
Bonner (RM 109.22)

The Affected Area

Sixteen (16) freeway mainline links, twenty-nine (29) freeway merge/diverge segments, and eighteen (18) existing intersections and ramp terminals are the subject of this study. The affected intersections are listed below.

- I-90 Eastbound On/Off-Ramp at DeSmet Interchange
- I-90 Westbound On/Off-Ramp at DeSmet Interchange
- Old U.S. Highway 10 at U.S. Highway 10
- Cartage Road at U.S. Highway 93
- I-90 Eastbound On/Off-Ramp at Airway Blvd. Interchange
- I-90 Eastbound On/Off-Ramp at Reserve Street Interchange
- Michael Road at U.S. Highway 93
- I-90 Westbound On/Off-Ramp at Reserve Street Interchange
- I-90 Eastbound On/Off-Ramp at Orange Street Interchange
- I-90 Westbound On/Off-Ramp at Orange Street Interchange
- West Spruce Street at North Orange Street
- I-90 Eastbound On/Off-Ramp at Van Buren Street Interchange
- I-90 Westbound On/Off-Ramp at Van Buren Street Interchange
- South Van Buren Avenue at U.S. Highway 12
- I-90 Eastbound On/Off-Ramp at East Missoula Interchange
- I-90 Westbound On/Off-Ramp at East Missoula Interchange
- I-90 Eastbound On/Off-Ramp at Bonner Interchange
- I-90 Westbound On/Off-Ramp at Bonner Interchange

Operational Analysis Software

Three principal tools will be applied in this study:

HCS 2000 software will be used for freeway capacity analysis, weaving, ramps, and ramp junctions.

CORSIM software will be used to evaluate freeway flow operations with measurements of travel time and queue lengths on mainline I-90.

SYNCHRO/SIMTRAFFIC software 5.0 will be used to evaluate local ARTERIAL street intersection traffic operations at the study signalized and unsignalized intersections. LOS and delay will be evaluated in comparison to the MDT desired acceptable LOS “C”. If applicable, the influences of pedestrian and bicycle volumes on the subject intersections will also be identified.

Operational Assumptions and Analysis

In all cases, existing conditions will represent year 2002. Traffic volumes for 2002 will be developed using current available data and will be adjusted to achieve a network balance.

Freeway Data and Methodology:

- Highway Capacity Software (HCS, 2000) will be used to evaluate freeway mainline/merge/diverge/weaving segments.
- Existing general-purpose peak hour freeway traffic volumes were obtained from MDT.
- Accident data was compiled by MDT for the period 1999 to 2001. If determined to be appropriate, the data will be supplemented with additional data from MDT. I-90 will be analyzed for four overall conditions, Existing 2002 AM and PM peak hours and Future No Build AM and PM peak hours.

Arterials/Intersections Data:

- Existing AM and PM peak hour turning movement counts were collected by CH2M HILL for the subject intersections. Intersection geometry was collected from MDT record drawings and field reviews.
- Current intersection signal timing will be supplied by the respective agency maintaining the intersection (MDT and/or City of Missoula).

Intersection Analysis Methods:

- Operational analysis will be provided for the existing and future No Build year conditions, as well as the event operational analysis adjacent to the Orange and Van Buren Interchanges.
- The AM and PM peak hours will be determined from existing traffic counts.
- Synchro/Simtraffic software, which implements Highway Capacity Manual methods[1], will analyze intersections (signalized and unsignalized).
- For the intersection analysis, intersection delay and associated LOS results will be reported. A ramp queuing analysis will be conducted to determine the potential for ramp queues spillover into the freeway mainline.

Traffic Analysis Assumptions

Tables 1 and 2 provide the analysis assumptions for freeway mainline, freeway merge/diverge, signalized, and unsignalized intersections.

[1] Transportation Research Board Special Report 209, Highway Capacity Manual, updated 2000.

Table 1. HCS 2000 Assumptions for Freeway Mainline and Merge/Diverge Analysis–Phase 1			
Freeway Mainline		**AM**	**PM**
	Peak-hour factor, PHF	Based on data, otherwise 0.90	Based on data, otherwise 0.90
	Number of through lanes, N	2	2
	Terrain	Level or Rolling, grade analysis may be required	Level or Rolling, grade analysis may be required
	Trucks and buses (%)	Based on data	Based on data
	RVs (%)	0	0
	Driver population adjustment, f_P	TBD (0.90 to 1.00) recommend 0.98	TBD (0.90 to 1.00) recommend 0.98
	Free-flow speed (FFS) type	Base	Base
	Measured FFS (mph)	-	-
	Base FFS (mph)	70	70
	Lane width (ft), LW	12.0	12.0
	Right shoulder lateral clearance (ft), LC	6.0	6.0
	Interchange density (int./mile), ID	TBD (calculated)	TBD (calculated)
	Rural freeways?	Dependent on location (Yes or No)	Dependent on location (Yes or No)
Freeway Merge/Diverge		**AM**	**PM**
	Freeway Data		
	Number of lanes on freeway, N	2	2
	Free-flow speed (mph), s_{FF}	Based on adjacent mainline section HCS file	Based on adjacent mainline section HCS file
	Peak-hour factor, PHF	Based on data, otherwise 0.90	Based on data, otherwise 0.90
	Terrain	Level or Rolling, grade analysis may be required	Level or Rolling, grade analysis may be required
	Trucks and buses (%)	Based on data	Based on data
	RVs (%)	0	0
	Driver population adjustment, f_P	TBD (0.90 to 1.00) recommend 0.98	TBD (0.90 to 1.00) recommend 0.98
	On-Ramp Data		
	Free-flow speed (mph), s_{FR}	35 - regular ramps 25 - loop ramps	35 - regular ramps 25 - loop ramps
	Number of lanes on ramp, N	1 - 2	1 - 2
	Length of first acceleration lane (ft), LA or LA1	TBD	TBD
	Length of second acceleration lane (ft), LA2	TBD	TBD

Table 1. HCS 2000 Assumptions for Freeway Mainline and Merge/Diverge Analysis–Phase 1			
	Peak-hour factor, PHF	Based on data, otherwise 0.90	Based on data, otherwise 0.90
	Terrain	Level or Rolling, grade analysis may be required	Level or Rolling, grade analysis may be required
	Trucks and buses (%)	Based on data	Based on data
	RVs (%)	0	0
	Driver population adjustment, f_P	TBD (0.90 to 1.00) recommend 0.98	TBD (0.90 to 1.00) recommend 0.98
	Off-Ramp Data		
	Free-flow speed (mph), s_{FR}	35 - regular ramps 25 - loop ramps	35 - regular ramps 25 - loop ramps
	Number of lanes on ramp, N	1	1
	Length of first deceleration lane (ft), LD or LD1	TBD	TBD
	Length of second deceleration lane (ft), LD2	TBD	TBD
	Peak-hour factor, PHF	Based on data, otherwise 0.90	Based on data, otherwise 0.90
	Terrain	Level or Rolling, grade analysis may be required	Level or Rolling, grade analysis may be required
	Trucks and buses (%)	Based on data	Based on data
	RVs (%)	0	0
	Driver population adjustment, f_P	TBD (0.90 to 1.00) recommend 0.98	TBD (0.90 to 1.00) recommend 0.98
	Adjacent Ramp Data		
	Position of adjacent ramp	TBD (upstream or downstream)	TBD (upstream or downstream)
	Type of adjacent ramp	TBD (on or off)	TBD (on or off0
	Distance to adjacent ramp (ft)	TBD	TBD
	Peak-hour factor, PHF	TBD (0.90 to 1.00)	TBD (0.90 to 1.00)
	Terrain	Level or Rolling, grade analysis may be required	Level or Rolling, grade analysis may be required
	Trucks and buses (%)	Based on data	Based on data
	RVs (%)	0	0
	Driver population adjustment, f_P	TBD (0.90 to 1.00) recommend 0.98	TBD (0.90 to 1.00) recommend 0.98

Table 2. HCS 2000 Assumptions for Signalized and Unsignalized Intersection Analysis – Phase 1			
Signalized Intersections		**AM**	**PM**
	Duration (hours)	TBD (0.25 or 1.0)	TBD (0.25 or 1.0)
	Peak-hour factor, PHF	Based on data	Based on data
	Right turns on red	10% - shared 20% - exclusive	10% - shared 20% - exclusive
	Average queue spacing (ft)	25.0	25.0
	Arrival type	3	3
	Unit extension (sec)	3.0	3.0
	Start-up lost time (sec)	2.0	2.0
	Extension of effective green (sec)	2.0	2.0
	Minimum green time (sec), per phase	10.0	10.0
	Yellow and all-red time (sec), per phase	4.0	4.0
	Ideal saturation flow rate (pcphgpl)	1900	1900
	Lane width (ft)	Based on record drawings	Based on record drawings
	Percent heavy vehicles (%)	Based on data	Based on data
	Percent grade (%)	Based on record drawings	Based on record drawings
	Parking maneuvers per hour	None	None
	Bus stops per hour	0 to 2, dependent on location	0 to 2, dependent on location
	Conflicting bikes and pedestrians per hour	Based on data, otherwise HCS methodology	Based on data, otherwise HCS methodology
Unsignalized Intersections		**AM**	**PM**
	Duration (hours)	TBD (0.25 or 1.0)	TBD (0.25 or 1.0)
	Peak-hour factor, PHF	Based on data	Based on data
	Percent heavy vehicles (%)	Based on data	Based on data
	<u>TWSC</u>		
	Percent grade (%)	Based on record drawings	Based on record drawings
	Saturation flow rate (vph)	1700	1700
	Pedestrian flow (ped/hr)	Based on data, otherwise HCS assumptions	Based on data, otherwise HCS assumptions
	Upstream signal data?	No	No

Intersection Level of Service (LOS)

The transportation analysis performed for this project focuses on the evaluation of freeway operations as well as intersection traffic operations.

Traffic operations will be assessed based on intersection level of service (LOS) and queue length analyses. Intersection LOS and queue length analyses for unsignalized and signalized right-angle intersections will be performed using methods consistent with the Highway Capacity Manual (HCM) 2000 edition reported from Synchro/SimTraffic.

Under the HCM methodology, delay is calculated differently between unsignalized and signalized intersections. The primary reason for this is that drivers expect different levels of performance between signalized and unsignalized intersections. Since stop-controlled intersections do not necessarily control all movements allowed at the intersection, delay is calculated only for those movements that must stop and wait until a sufficient gap is available. Therefore, for unsignalized intersections, delay is reported by movement in terms of average seconds per vehicle and a corresponding letter grade. The range of letter grades, as they relate to seconds of delay and traffic flow characteristics are presented in Table 3.

Table 3. Level of Service Criteria for Unsignalized TWSC and AWSC Intersections

Level of Service	Average Delay (seconds per vehicle)	Traffic Flow Characteristics
A	< 10	Little or no traffic delays
B	> 10 - ≤15	Short traffic delays
C	> 15 - ≤ 25	Average traffic delays
D	> 25 - ≤ 35	Long traffic delays
E	> 35 - ≤ 50	Very long traffic delays
F	> 50	Queuing on minor approaches and not enough gaps of suitable size to allow safe crossing of major street. Signalization should be investigated at this point, but warrant must be satisfied before implementation.

TWSC – Two-way stop-controlled
AWSC – All-way stop-controlled

Source: HCM, Transportation Research Board, 2000

For signalized intersections, all movements are controlled by the traffic signal system. The signal assigns the right-of-way to each movement or approach and allocates green time in a way that attempts to minimize the average delay experienced by all vehicles moving through the intersection. Because of the way the signal controls delay for all movement in an attempt to minimize the delay for the entire intersection, it is reported in terms of seconds of average approach delay for the entire intersection and letter grade. Intersection LOS will be determined based on influences of balanced volume-to-capacity ratios.

Table 4, presents the range of letter grades for signalized intersections and the corresponding ranges of delay and traffic flow characteristics.

Table 4. Level of Service Criteria for Signalized Intersections		
Level of Service	**Average Delay (seconds per vehicle)**	**Traffic Flow Characteristics**
A	$\leq$ 10	Most vehicles arrive during the green phase and do not stop at all
B	> 10 to $\leq$ 20	More vehicles stop, causing higher delay
C	> 20 to $\leq$ 35	Vehicle stopping is significant, but many still pass through the intersection without stopping
D	> 35 to $\leq$ 55	Many vehicles stop, and the influence of congestion becomes more noticeable
E	> 55 to $\leq$ 80	Very few vehicles pass through without stopping
F	> 80	Considered unacceptable to most drivers; intersection is not necessarily over capacity even though arrivals exceed capacity of lane groups

Source: HCM, Transportation Research Board, 2000

Intersection operations will be evaluated using Synchro, which requires more detailed input than HCS, but is capable of evaluating a system of interconnected intersections, as opposed to a group of isolated ones. This type of analysis is important for arterials whose intersections are closely spaced because, under heavy congestion, the queues and delays from adjacent intersections can affect each other. Therefore, when intersections are evaluated as coordinated signals, Synchro accounts for uniform vehicle arrival, which increases the vehicle throughput.

Methodology and Assumptions—Phase 2

Phase 2 of this study will expand upon the previous analysis performed at the Orange Street and Van Buren Street Interchanges to determine appropriate mitigation strategies and preliminary design improvements.

Analysis Time Periods

This study will analyze 2 separate years, Existing (2005) and Future (2030). Analyses will be performed for both the AM and PM peak hours. The study will analyze the No Build and three build alternatives listed below:

- Ramp terminal signalization at the Orange Street interchange
- Ramp terminal signalization at the Van Buren Street interchange
- Ramp terminal signalization at both the Orange Street and Van Buren Street interchanges

Project Limits Area

The Phase 2 geographical area will encompass the Van Buren Street and Orange Street interchanges.

The Affected Area

Ten (10) freeway mainline links, eight (8) freeway merge/diverge segments, and four (4) existing ramp terminals are the subject of this study. The affected intersections are listed below.

- I-5 Eastbound On/Off-Ramp at Orange Street Interchange
- I-5 Westbound On/Off-Ramp at Orange Street Interchange

- I-5 Eastbound On/Off-Ramp at Van Buren Street Interchange
- I-5 Westbound On/Off-Ramp at Van Buren Street Interchange

Operational Analysis Software

Three principal tools will be applied in this study:

HCS 2000 software will be used for freeway capacity analysis, weaving, ramps, and ramp junctions.

CORSIM software will be used to evaluate freeway flow operations with measurements of travel time and queue lengths on mainline I-90.

SYNCHRO/SIMTRAFFIC software 6.0 will be used to evaluate local ARTERIAL street intersection traffic operations at the study signalized and unsignalized intersections. LOS and delay will be evaluated with comparison to the MDT desired acceptable LOS "C". If applicable, the influences of pedestrian and bicycle volumes on the subject intersections will also be identified.

Operational Assumptions and Analysis

In all cases, existing conditions will represent year 2005. Traffic volumes for 2005 will be developed using current available data and will be adjusted to achieve a network balance.

Refer to the technical memorandum dated April 28, 2006, entitled, *Traffic Volume Data, Missoula–East & West I-90 Corridor Study–Phase 2*, for a discussion of the proposed updates to the post-processing analysis for the phase 2 traffic volumes.

Freeway Data and Methodology:

- Highway Capacity Software (HCS, 2000) will be used to evaluate freeway mainline/merge/diverge/weaving segments.
- Existing general-purpose peak hour freeway traffic volumes were obtained from MDT.

Arterials/Intersections Data:

- See Phase 1 for details
- Additional 2006 24-hour counts were collected for Phase 2

Intersection Analysis Methods:

- Operational analysis will be provided for the existing and future No Build year conditions, as well as the alternative operational analysis for the Van Buren and Orange Street interchange areas.
- Synchro 6.0/Simtraffic 6.0 software, which implements Highway Capacity Manual methods[2], will analyze intersections (signalized and unsignalized).
- For the intersection analysis, intersection delay and associated LOS results will be reported. A ramp queuing analysis will be conducted to determine the potential for ramp queues spillover into the freeway mainline.

[2] Transportation Research Board Special Report 209, Highway Capacity Manual, updated 2000.

Traffic Analysis Assumptions

Tables 5 and 6 provide the analysis assumptions for freeway mainline, freeway merge/diverge, signalized, and unsignalized intersections for Phase 2.

Table 5. HCS 2000 Assumptions for Freeway Mainline and Merge/Diverge Analysis – Phase 2

Freeway Mainline	**AM**	**PM**
Peak-hour factor, PHF	Existing - Based on data, otherwise 0.90; 2030 - 0.90 or existing if higher	Existing - Based on data, otherwise 0.90; 2030 - 0.90 or existing if higher
Number of through lanes, N	2	2
Terrain	Level or Rolling, grade analysis may be required	Level or Rolling, grade analysis may be required
Trucks and buses (%)	Based on data	Based on data
RVs (%)	0	0
Driver population adjustment, f_P	TBD (0.90 to 1.00) recommend 0.98	TBD (0.90 to 1.00) recommend 0.98
Free-flow speed (FFS) type	Base	Base
Measured FFS (mph)	-	-
Base FFS (mph)	70	70
Lane width (ft), LW	12.0	12.0
Right shoulder lateral clearance (ft), LC	6.0	6.0
Interchange density (int./mile), ID	TBD (calculated)	TBD (calculated)
Rural freeways?	Dependent on location (Yes or No)	Dependent on location (Yes or No)

Table 6. HCS 2000 Assumptions for Freeway Mainline and Merge/Diverge Analysis – Phase 2

Freeway Merge/Diverge	**AM**	**PM**
Freeway Data		
Number of lanes on freeway, N	2	2
Free-flow speed (mph), s_{FF}	Based on adjacent mainline section HCS file	Based on adjacent mainline section HCS file
Peak-hour factor, PHF	Existing - Based on data, otherwise 0.90; 2030 - 0.90 or existing if higher	Existing - Based on data, otherwise 0.90; 2030 - 0.90 or existing if higher
Terrain	Level or Rolling, grade analysis may be required	Level or Rolling, grade analysis may be required
Trucks and buses (%)	Based on data	Based on data
RVs (%)	0	0
Driver population adjustment, f_P	TBD (0.90 - 1.00) recommend 0.98	TBD (0.90 - 1.00) recommend 0.98
On-Ramp Data		
Free-flow speed (mph), s_{FR}	35 - regular ramps 25 - loop ramps	35 - regular ramps 25 - loop ramps
Number of lanes on ramp, N	1 – 2	1 – 2
Length of first acceleration lane (ft), LA or LA1	TBD	TBD
Length of second acceleration lane (ft), LA2	TBD	TBD
Peak-hour factor, PHF	Existing - Based on data, otherwise 0.90; 2030 - 0.95	Existing - Based on data, otherwise 0.90; 2030 - 0.95

Terrain	Level or Rolling, grade analysis may be required	Level or Rolling, grade analysis may be required
Trucks and buses (%)	Based on data	Based on data
RVs (%)	0	0
Driver population adjustment, f_P	TBD (0.90 to 1.00) recommend 0.98	TBD (0.90 to 1.00) recommend 0.98
Off-Ramp Data		
Free-flow speed (mph), s_{FR}	35 - regular ramps 25 - loop ramps	35 - regular ramps 25 - loop ramps
Number of lanes on ramp, N	1	1
Length of first deceleration lane (ft), LD or LD1	TBD	TBD
Length of second deceleration lane (ft), LD2	TBD	TBD
Peak-hour factor, PHF	Existing - Based on data, otherwise 0.90; 2030 - 0.95	Existing - Based on data, otherwise 0.90; 2030 - 0.95
Terrain	Level or Rolling, grade analysis may be required	Level or Rolling, grade analysis may be required
Trucks and buses (%)	Based on data	Based on data
RVs (%)	0	0
Driver population adjustment, f_P	TBD (0.90 to 1.00) recommend 0.98	TBD (0.90 to 1.00) recommend 0.98
Adjacent Ramp Data		
Position of adjacent ramp	TBD (upstream or downstream)	TBD (upstream or downstream)
Type of adjacent ramp	TBD (on or off)	TBD (on or off0
Distance to adjacent ramp (ft)	TBD	TBD
Peak-hour factor, PHF	Existing - TBD (0.90 to 1.00); 2030 - 0.95	Existing - TBD (0.90 to 1.00); 2030 - 0.95
Terrain	Level or Rolling, grade analysis may be required	Level or Rolling, grade analysis may be required
Trucks and buses (%)	Based on data	Based on data
RVs (%)	0	0
Driver population adjustment, f_P	TBD (0.90 to 1.00) recommend 0.98	TBD (0.90 to 1.00) recommend 0.98

Signalized and unsignalized intersections assumptions are listed in Table 7.

Table 7. HCS 2000 Assumptions for Signalized and Unsignalized Intersection Analysis – Phase 2

Signalized Intersections	AM	PM
Duration (hours)	TBD (0.25 or 1.0)	TBD (0.25 or 1.0)
Peak-hour factor, PHF	Existing - Based on data; 2030 - 0.90 or existing if higher	Existing - Based on data; 2030 - 0.90 or existing if higher
Right turns on red	10% - shared 20% - exclusive	10% - shared 20% - exclusive
Average queue spacing (ft)	25.0	25.0
Arrival type	3	3
Unit extension (sec)	3.0	3.0
Start-up lost time (sec)	2.0	2.0
Extension of effective green (sec)	2.0	2.0
Minimum green time (sec), per phase	7.0	7.0
Yellow and all-red time (sec), per phase	5.0	5.0

	Ideal saturation flow rate (pcphgpl)	1900	1900
	Lane width (ft)	Based on record drawings	Based on record drawings
	Percent heavy vehicles (%)	Based on data	Based on data
	Percent grade (%)	Based on record drawings	Based on record drawings
	Parking maneuvers per hour	None	None
	Bus stops per hour	0 to 2, dependent on location	0 to 2, dependent on location
	Conflicting bikes and pedestrians per hour	Based on data, otherwise HCS methodology	Based on data, otherwise HCS methodology

Table 8. HCS 2000 Assumptions for Signalized and Unsignalized Intersection Analysis

Unsignalized Intersections		**AM**	**PM**
	Duration (hours)	TBD (0.25 or 1.0)	TBD (0.25 or 1.0)
	Peak-hour factor, PHF	Existing - Based on data; 2030 - 0.90 or existing if higher	Existing - Based on data; 2030 - 0.90 or existing if higher
	Percent heavy vehicles (%)	Based on data	Based on data
	<u>TWSC</u>		
	Percent grade (%)	Based on record drawings	Based on record drawings
	Saturation flow rate (vph)	1900	1900
	Pedestrian flow (ped/hr)	Based on data, otherwise HCS assumptions	Based on data, otherwise HCS assumptions
	Upstream signal data?	No	No

Intersection Level of Service (LOS)

Phase 1 methodology will be applied.

Appendix B

Signal Warrant Analysis

WARRANT 1—Eight-Hour Vehicular Volume—Condition A, Minimum Vehicular Volume

		NOT SATISFIED	
	Requirement (100% Column)	Actual 7,8,12,2-6	
Major Street – Both Approaches – One lane	500 vph	503 vph 531 vph 432 vph 456 vph	505 vph 588 vph 716 vph 476 vph
Minor Street – Highest Approach – One lane	150 vph	124 vph 171 vph 182 vph 176 vph	220 vph 305 vph 368 vph 258 vph

WARRANT 1—Eight-Hour Vehicular Volume—Condition B, Interruption of Continuous Traffic

		NOT SATISFIED	
	Requirement (100% Column)	Actual 7,8,12,2-6	
Major Street – Both Approaches – One lane	750 vph	503 vph 531 vph 432 vph 456 vph	505 vph 588 vph 716 vph 476 vph
Minor Street – Highest Approach – One lane	75 vph	124 vph 171 vph 182 vph 176 vph	220 vph 305 vph 368 vph 258 vph

WARRANT 1—Eight-Hour Vehicular Volume—Condition A, Minimum Vehicular Volume (80%)

		SATISFIED	
	Requirement (80% Column)	Actual 7,8,12,2-6	
Major Street – Both Approaches – One lane	400 vph	503 vph 531 vph 432 vph 456 vph	505 vph 588 vph 716 vph 476 vph
Minor Street – Highest Approach – One lane	120 vph	124 vph 171 vph 182 vph 176 vph	220 vph 305 vph 368 vph 258 vph

WARRANT 1—Eight-Hour Vehicular Volume—Condition B, Interruption of Continuous Traffic (80%)

NOT SATISFIED

	Requirement (80% Column)	Actual 7,8,12,2-6	
Major Street – Both Approaches – One lane	600 vph	503 vph 531 vph 432 vph 456 vph	505 vph 588 vph 716 vph 476 vph
Minor Street – Highest Approach – One lane	60 vph	124 vph 171 vph 182 vph 176 vph	220 vph 305 vph 368 vph 258 vph

WARRANT 2—Four-Hour Vehicular Volume

NOT SATISFIED

	Requirement	Actual (3 – 6pm)
Major Street – Both Approaches – One lane	Satisfy Figure 4C-1 from the 2003 MUTCD	505 vph 588 vph 716 vph 476 vph
Minor Street – Highest Approach – One lane		220 vph 305 vph 368 vph 258 vph

WARRANT 3—Peak Hour

NOT SATISFIED

	Requirement	
Major Street – Both Approaches – One lane	Satisfy Figure 4C-3 from the 2003 MUTCD, and related criteria	716 vph
Minor Street – Highest Approach – One lane		368 vph

WARRANT 4—Pedestrian Volume

NOT SATISFIED

	Requirement	Actual
Crossing Major Street	100 peds/hr for 4 hrs or 190 peds in 1 hour	No
Gaps in traffic stream w/o median	< 60 gaps/hr during above hours	N/A
Gaps in traffic stream w/median	< 60 gaps/hr during above hours for each direction of traffic	N/A

WARRANT 5—School Crossing

	Requirement	NOT SATISFIED Actual
Major Street	Established School Crossing	No

WARRANT 6—Coordinated Signal System

	Requirement	NOT SATISFIED Actual
One Way Street	Traffic signals spaced > 1,000 feet apart	N/A
Two Way Street	Traffic signals spaced > 1,000 feet apart	No

WARRANT 7—Crash Experience

Requirement	NOT SATISFIED Actual
Adequate trial of alternatives has failed	N/A
Five or more correctable crashes in a 12-month period	No
For any 8 hours 80% of Warrant 1, Condition A OR B is met	No

WARRANT 8—Roadway Network

Requirement	SATISFIED Actual
Intersection of two or more major routes	Yes
Existing entering volume > 1,000 vph during peak hour	Yes
5-year projected traffic volumes that meet one or more of Warrants 1-3	Yes (Warrants 1 & 2)
Existing entering volume > 1,000 vph for each of any 5 hours of non-normal business day	No data

WARRANT 1—Eight-Hour Vehicular Volume–Condition A, Minimum Vehicular Volume

		NOT SATISFIED	
	Requirement (100% Column)	Actual 11am-6pm	
Major Street – Both Approaches – One lane	500 vph	157 vph 198 vph 179 vph 220 vph	223 vph 252 vph 239 vph 203 vph
Minor Street – Highest Approach – One lane	150 vph	83 vph 84 vph 106 vph 120 vph	195 vph 208 vph 259 vph 102 vph

WARRANT 1—Eight-Hour Vehicular Volume–Condition B, Interruption of Continuous Traffic

		NOT SATISFIED	
	Requirement (100% Column)	Actual 11am-6pm	
Major Street – Both Approaches – One lane	750 vph	157 vph 198 vph 179 vph 220 vph	223 vph 252 vph 239 vph 203 vph
Minor Street – Highest Approach – One lane	75 vph	83 vph 84 vph 106 vph 120 vph	195 vph 208 vph 259 vph 102 vph

WARRANT 1—Eight-Hour Vehicular Volume–Condition A, Minimum Vehicular Volume (80%)

		NOT SATISFIED	
	Requirement (80% Column)	Actual 11am-6pm	
Major Street – Both Approaches – One lane	400 vph	157 vph 198 vph 179 vph 220 vph	223 vph 252 vph 239 vph 203 vph
Minor Street – Highest Approach – One lane	120 vph	83 vph 84 vph 106 vph 120 vph	195 vph 208 vph 259 vph 102 vph

WARRANT 1—Eight-Hour Vehicular Volume–Condition B, Interruption of Continuous Traffic (80%)

		NOT SATISFIED	
	Requirement (80% Column)	Actual 11am-6pm	
Major Street – Both Approaches – One lane	600 vph	157 vph 198 vph 179 vph 220 vph	223 vph 252 vph 239 vph 203 vph
Minor Street – Highest Approach – One lane	60 vph	83 vph 84 vph 106 vph 120 vph	195 vph 208 vph 259 vph 102 vph

WARRANT 2—Four-Hour Vehicular Volume

		NOT SATISFIED
	Requirement	Actual (3 – 6pm)
Major Street – Both Approaches – One lane	Satisfy Figure 4C-1 from the 2003 MUTCD	220 vph 223 vph 252 vph 239 vph
Minor Street – Highest Approach – One lane		120 vph 195 vph 208 vph 259 vph

WARRANT 3—Peak Hour

		NOT SATISFIED
	Requirement	
Major Street – Both Approaches – One lane	Satisfy Figure 4C-3 from the 2003 MUTCD, and related criteria	259 vph
Minor Street – Highest Approach – One lane		239 vph

WARRANT 4—Pedestrian Volume

		NOT SATISFIED
	Requirement	Actual
Crossing Major Street	100 peds/hr for 4 hrs or 190 peds in 1 hour	No
Gaps in traffic stream w/o median	< 60 gaps/hr during above hours	N/A
Gaps in traffic stream w/median	< 60 gaps/hr during above hours for each direction of traffic	N/A

WARRANT 5—School Crossing

		NOT SATISFIED
	Requirement	Actual
Major Street	Established School Crossing	No

WARRANT 6—Coordinated Signal System

		NOT SATISFIED
	Requirement	Actual
One Way Street	Traffic signals spaced > 1,000 feet apart	N/A
Two Way Street	Traffic signals spaced > 1,000 feet apart	No

WARRANT 7—Crash Experience

	NOT SATISFIED
Requirement	Actual
Adequate trial of alternatives has failed	N/A
Five or more correctable crashes in a 12-month period	No
For any 8 hours 80% of Warrant 1, Condition A OR B is met	No

WARRANT 8—Roadway Network

	NOT SATISFIED
Requirement	Actual
Intersection of two or more major routes	Yes
Existing entering volume > 1,000 vph during peak hour	No
5-year projected traffic volumes that meet one or more of Warrants 1-3	No
Existing entering volume > 1,000 vph for each of any 5 hours of non-normal business day	No data

WARRANT 1—Eight-Hour Vehicular Volume–Condition A, Minimum Vehicular Volume

		NOT SATISFIED	
	Requirement (100% Column)	Actual (7,8,11,12,3–6)	
Major Street – Both Approaches –One lane	500 vph	600 vph 630 vph 365 vph 340 vph	435 vph 465 vph 460 vph 355 vph
Minor Street – Highest Approach – One lane	150 vph	190 vph 145 vph 215 vph 255 vph	340 vph 360 vph 520 vph 230 vph

WARRANT 1—Eight-Hour Vehicular Volume–Condition B, Interruption of Continuous Traffic

		NOT SATISFIED	
	Requirement (100% Column)	Actual (7,8,11,12,3–6)	
Major Street – Both Approaches – One lane	750 vph	600 vph 630 vph 365 vph 340 vph	435 vph 465 vph 460 vph 355 vph
Minor Street – Highest Approach – One lane	75 vph	190 vph 145 vph 215 vph 255 vph	340 vph 360 vph 520 vph 230 vph

WARRANT 1—Eight-Hour Vehicular Volume–Condition A, Minimum Vehicular Volume (80%)

		NOT SATISFIED	
	Requirement (80% Column)	Actual (7,8,11,12,3–6)	
Major Street – Both Approaches – One lane	400 vph	600 vph 630 vph 365 vph 340 vph	435 vph 465 vph 460 vph 355 vph
Minor Street – Highest Approach – One lane	120 vph	190 vph 145 vph 215 vph 255 vph	340 vph 360 vph 520 vph 230 vph

WARRANT 1—Eight-Hour Vehicular Volume–Condition B, Interruption of Continuous Traffic (80%)

NOT SATISFIED

	Requirement (80% Column)	Actual (7,8,11,12,3–6)	
Major Street – Both Approaches – One lane	600 vph	600 vph 630 vph 365 vph 340 vph	435 vph 465 vph 460 vph 355 vph
Minor Street – Highest Approach – One lane	60 vph	190 vph 145 vph 215 vph 255 vph	340 vph 360 vph 520 vph 230 vph

WARRANT 2—Four-Hour Vehicular Volume

NOT SATISFIED

	Requirement	Actual (Between 7a, 3-5p)
Major Street – Both Approaches – One lane	Satisfy Figure 4C-1 from the 2003 MUTCD	600 vph 435 vph 465 vph 460 vph
Minor Street – Highest Approach – One lane		190 vph 340 vph 360 vph 520 vph

WARRANT 3—Peak Hour

NOT SATISFIED[1]

	Requirement	Actual
Major Street – Both Approaches – One lane	Satisfy Figure 4C-3 from the 2003 MUTCD	460 vph
Minor Street – Highest Approach – One lane		520 vph

[1] Not Satisfied due to lack of traffic generator (office complex, etc) near vicinity of intersection

WARRANT 4—Pedestrian Volume

	Requirement	NOT SATISFIED Actual
Crossing Major Street	100 peds/hr for 4 hrs or 190 peds in 1 hour	No
Gaps in traffic stream w/o median	< 60 gaps/hr during above hours	N/A
Gaps in traffic stream w/median	< 60 gaps/hr during above hours for each direction of traffic	N/A

WARRANT 5—School Crossing

	Requirement	NOT SATISFIED Actual
Major Street	Established School Crossing	No

WARRANT 6—Coordinated Signal System

	Requirement	NOT SATISFIED Actual
One Way Street	Traffic signals spaced > 1,000 feet apart	N/A
Two Way Street	Traffic signals spaced > 1,000 feet apart	No

WARRANT 7—Crash Experience

Requirement	NOT SATISFIED Actual
Adequate trial of alternatives has failed	N/A
Five or more correctable crashes in a 12-month period	No
For any 8 hours 80% of Warrant 1, Condition A OR B is met	No

WARRANT 8—Roadway Network

Requirement	NOT SATISFIED Actual
Intersection of two or more major routes	Yes
Existing entering volume > 1,000 vph during peak hour	No
5-year projected traffic volumes that meet one or more of Warrants 1-3	NA (did not meet first criteria)
Existing entering volume > 1,000 vph for each of any 5 hours of non-normal business day	No data

WARRANT 1—Eight-Hour Vehicular Volume–Condition A, Minimum Vehicular Volume

		SATISFIED	
	Requirement (100% Column)	Actual 7,8,12,2-6	
Major Street – Both Approaches – Two or more lanes	600 vph	996 vph 956 vph 938 vph 1035 vph	1223 vph 1218 vph 1258 vph 1089 vph
Minor Street – Highest Approach – One lane	150 vph	235 vph 295 vph 155 vph 172 vph	208 vph 222 vph 280 vph 220 vph

WARRANT 1—Eight-Hour Vehicular Volume–Condition B, Interruption of Continuous Traffic

		SATISFIED	
	Requirement (100% Column)	Actual 7,8,12,2-6	
Major Street – Both Approaches – Two or more lanes	900 vph	996 vph 956 vph 938 vph 1035 vph	1223 vph 1218 vph 1258 vph 1089 vph
Minor Street – Highest Approach – One lane	75 vph	235 vph 295 vph 155 vph 172 vph	208 vph 222 vph 280 vph 220 vph

WARRANT 1—Eight-Hour Vehicular Volume–Condition A, Minimum Vehicular Volume (80%)

		SATISFIED	
	Requirement (80% Column)	Actual 7,8,12,2-6	
Major Street – Both Approaches – Two or more lanes	480 vph	996 vph 956 vph 938 vph 1035 vph	1223 vph 1218 vph 1258 vph 1089 vph
Minor Street – Highest Approach – One lane	120 vph	235 vph 295 vph 155 vph 172 vph	208 vph 222 vph 280 vph 220 vph

WARRANT 1—Eight-Hour Vehicular Volume–Condition B, Interruption of Continuous Traffic (80%)

		SATISFIED	
	Requirement (80% Column)	Actual 7,8,12,2-6	
Major Street – Both Approaches – Two or more lanes	720 vph	996 vph 956 vph 938 vph 1035 vph	1223 vph 1218 vph 1258 vph 1089 vph
Minor Street – Highest Approach – One lane	60 vph	235 vph 295 vph 155 vph 172 vph	208 vph 222 vph 280 vph 220 vph

WARRANT 2—Four-Hour Vehicular Volume

		SATISFIED
	Requirement	Actual (Between 3pm – 6pm)
Major Street – Both Approaches – Two or more lanes	Satisfy Figure 4C-1 from the 2003 MUTCD	1223 vph 1218 vph 1258 vph 1089 vph
Minor Street – Highest Approach – One lane		208 vph 222 vph 280 vph 220 vph

WARRANT 3—Peak Hour

		NOT SATISFIED[2]
	Requirement	Actual
Major Street – Both Approaches – Two or more lanes	Satisfy Figure 4C-3 from the 2003 MUTCD, and related criteria	1258 vph
Minor Street – Highest Approach – One lane		280 vph

WARRANT 4—Pedestrian Volume

		NOT SATISFIED
	Requirement	Actual
Crossing Major Street	100 peds/hr for 4 hrs or 190 peds in 1 hour	No
Gaps in traffic stream w/o median	< 60 gaps/hr during above hours	N/A
Gaps in traffic stream w/median	< 60 gaps/hr during above hours for each direction of traffic	N/A

[2] Not Satisfied due to lack of traffic generator (office complex, etc) near vicinity of intersection

WARRANT 5—School Crossing

	NOT SATISFIED	
	Requirement	Actual
Major Street	Established School Crossing	No

WARRANT 6—Coordinated Signal System

	NOT SATISFIED	
	Requirement	Actual
One Way Street	Traffic signals spaced > 1,000 feet apart	N/A
Two Way Street	Traffic signals spaced > 1,000 feet apart	No

WARRANT 7—Crash Experience

Requirement	NOT SATISFIED Actual
Adequate trial of alternatives has failed	N/A
Five or more correctable crashes in a 12-month period	No
For any 8 hours 80% of Warrant 1, Condition A OR B is met	No

WARRANT 8—Roadway Network

Requirement	SATISFIED Actual
Intersection of two or more major routes	Yes
Existing entering volume > 1,000 vph during peak hour	Yes
5-year projected traffic volumes that meet one or more of Warrants 1-3	Yes
Existing entering volume > 1,000 vph for each of any 5 hours of non-normal business day	No data

Van Buren Street @ WB Ramps Existing 2006

WARRANT 1—Eight-Hour Vehicular Volume–Condition A, Minimum Vehicular Volume

NOT SATISFIED

	Requirement (100% Column)	Actual 7,8,12,2-6	
Major Street – Both Approaches – Two or more lanes	600 vph	802 vph 845 vph 825 vph 772 vph	1055 vph 984 vph 1120 vph 950 vph
Minor Street – Highest Approach – Two or more lanes	200 vph	242 vph 161 vph 126 vph 130 vph	156 vph 154 vph 156 vph 134 vph

WARRANT 1—Eight-Hour Vehicular Volume–Condition B, Interruption of Continuous Traffic

NOT SATISFIED

	Requirement (100% Column)	Actual 7,8,12,2-6	
Major Street – Both Approaches – Two or more lanes	900 vph	802 vph 845 vph 825 vph 772 vph	1055 vph 984 vph 1120 vph 950 vph
Minor Street – Highest Approach – Two or more lanes	100 vph	242 vph 161 vph 126 vph 130 vph	156 vph 154 vph 156 vph 134 vph

WARRANT 1—Eight-Hour Vehicular Volume–Condition A, Minimum Vehicular Volume (80%)

NOT SATISFIED

	Requirement (80% Column)	Actual 7,8,12,2-6	
Major Street – Both Approaches – Two or more lanes	480 vph	802 vph 845 vph 825 vph 772 vph	1055 vph 984 vph 1120 vph 950 vph
Minor Street – Highest Approach – Two or more lanes	160 vph	242 vph 161 vph 126 vph 130 vph	156 vph 154 vph 156 vph 134 vph

WARRANT 1—Eight-Hour Vehicular Volume–Condition B, Interruption of Continuous Traffic (80%)

SATISFIED

	Requirement (80% Column)	Actual 7,8,12,2-6	
Major Street – Both Approaches – Two or more lanes	720 vph	802 vph 845 vph 825 vph 772 vph	1055 vph 984 vph 1120 vph 950 vph
Minor Street – Highest Approach – Two or more lanes	80 vph	242 vph 161 vph 126 vph 130 vph	156 vph 154 vph 156 vph 134 vph

WARRANT 2—Four-Hour Vehicular Volume

NOT SATISFIED

	Requirement	Actual (Between 3pm – 6pm)
Major Street – Both Approaches – Two or more lanes	Satisfy Figure 4C-1 from the 2003 MUTCD	1055 vph 984 vph 1120 vph 950 vph
Minor Street – Highest Approach – Two or more lanes		156 vph 154 vph 156 vph 134 vph

WARRANT 3—Peak Hour

NOT SATISFIED

	Requirement	Actual
Major Street – Both Approaches – Two or more lanes	Satisfy Figure 4C-3 from the 2003 MUTCD, and related criteria	1120 vph
Minor Street – Highest Approach – Two or more lanes		156 vph

WARRANT 4—Pedestrian Volume

NOT SATISFIED

	Requirement	Actual
Crossing Major Street	100 peds/hr for 4 hrs or 190 peds in 1 hour	No
Gaps in traffic stream w/o median	< 60 gaps/hr during above hours	N/A
Gaps in traffic stream w/median	< 60 gaps/hr during above hours for each direction of traffic	N/A

WARRANT 5—School Crossing

NOT SATISFIED

	Requirement	Actual
Major Street	Established School Crossing	No

WARRANT 6—Coordinated Signal System

NOT SATISFIED

	Requirement	Actual
One Way Street	Traffic signals spaced > 1,000 feet apart	N/A
Two Way Street	Traffic signals spaced > 1,000 feet apart	No

WARRANT 7—Crash Experience

NOT SATISFIED

Requirement	Actual
Adequate trial of alternatives has failed	N/A
Five or more correctable crashes in a 12-month period	No
For any 8 hours 80% of Warrant 1, Condition A OR B is met	No

WARRANT 8—Roadway Network

NOT SATISFIED

Requirement	Actual
Intersection of two or more major routes	Yes
Existing entering volume > 1,000 vph during peak hour	Yes
5-year projected traffic volumes that meet one or more of Warrants 1-3	No
Existing entering volume > 1,000 vph for each of any 5 hours of non-normal business day	No data

WARRANT 1—Eight-Hour Vehicular Volume–Condition A, Minimum Vehicular Volume

	Requirement (100% Column)	NOT SATISFIED Actual 7,8,12,2-6	
Major Street – Both Approaches – Two or more lanes	600 vph	860 vph 895 vph 875 vph 840 vph	1070 vph 1050 vph 1235 vph 1005 vph
Minor Street – Highest Approach – Two or more lanes	200 vph	280 vph 205 vph 165 vph 160 vph	195 vph 185 vph 185 vph 160 vph

WARRANT 1—Eight-Hour Vehicular Volume–Condition B, Interruption of Continuous Traffic

	Requirement (100% Column)	NOT SATISFIED Actual 7,8,12,2-6	
Major Street – Both Approaches – Two or more lanes	900 vph	860 vph 895 vph 875 vph 840 vph	1070 vph 1050 vph 1235 vph 1005 vph
Minor Street – Highest Approach – Two or more lanes	100 vph	280 vph 205 vph 165 vph 160 vph	195 vph 185 vph 185 vph 160 vph

WARRANT 1—Eight-Hour Vehicular Volume–Condition A, Minimum Vehicular Volume (80%)

	Requirement (80% Column)	SATISFIED Actual 7,8,12,2-6	
Major Street – Both Approaches – Two or more lanes	480 vph	860 vph 895 vph 875 vph 840 vph	1070 vph 1050 vph 1235 vph 1005 vph
Minor Street – Highest Approach – Two or more lanes	160 vph	280 vph 205 vph 165 vph 160 vph	195 vph 185 vph 185 vph 160 vph

WARRANT 1—Eight-Hour Vehicular Volume–Condition B, Interruption of Continuous Traffic (80%)

		SATISFIED	
	Requirement (80% Column)	Actual 7,8,12,2-6	
Major Street – Both Approaches – Two or more lanes	720 vph	860 vph 895 vph 875 vph 840 vph	1070 vph 1050 vph 1235 vph 1005 vph
Minor Street – Highest Approach – Two or more lanes	80 vph	280 vph 205 vph 165 vph 160 vph	195 vph 185 vph 185 vph 160 vph

WARRANT 2—Four-Hour Vehicular Volume

		SATISFIED
	Requirement	Actual (Between 3pm – 6pm)
Major Street – Both Approaches – Two or more lanes	Satisfy Figure 4C-1 from the 2003 MUTCD	1070 vph 1050 vph 1235 vph 1005 vph
Minor Street – Highest Approach – Two or more lanes		195 vph 185 vph 185 vph 160 vph

WARRANT 3—Peak Hour

		NOT SATISFIED
	Requirement	Actual
Major Street – Both Approaches – Two or more lanes	Satisfy Figure 4C-3 from the 2003 MUTCD, and related criteria	1235 vph
Minor Street – Highest Approach – Two or more lanes		185 vph

WARRANT 4—Pedestrian Volume

		NOT SATISFIED
	Requirement	Actual
Crossing Major Street	100 peds/hr for 4 hrs or 190 peds in 1 hour	No
Gaps in traffic stream w/o median	< 60 gaps/hr during above hours	N/A
Gaps in traffic stream w/median	< 60 gaps/hr during above hours for each direction of traffic	N/A

WARRANT 5—School Crossing

		NOT SATISFIED
	Requirement	Actual
Major Street	Established School Crossing	No

WARRANT 6—Coordinated Signal System

		NOT SATISFIED
	Requirement	Actual
One Way Street	Traffic signals spaced > 1,000 feet apart	N/A
Two Way Street	Traffic signals spaced > 1,000 feet apart	No

WARRANT 7—Crash Experience

	NOT SATISFIED
Requirement	Actual
Adequate trial of alternatives has failed	N/A
Five or more correctable crashes in a 12-month period	No
For any 8 hours 80% of Warrant 1, Condition A OR B is met	No

WARRANT 8—Roadway Network

	SATISFIED
Requirement	Actual
Intersection of two or more major routes	Yes
Existing entering volume > 1,000 vph during peak hour	Yes
5-year projected traffic volumes that meet one or more of Warrants 1-3	Yes
Existing entering volume > 1,000 vph for each of any 5 hours of non-normal business day	No data

WARRANT 1—Eight-Hour Vehicular Volume–Condition A, Minimum Vehicular Volume

		SATISFIED	
	Requirement (100% Column)	Actual 7,8,12,2-6	
Major Street – Both Approaches – Two or more lanes	600 vph	910 vph 950 vph 945 vph 915 vph	1165 vph 1140 vph 1345 vph 1090 vph
Minor Street – Highest Approach – Two or more lanes	200 vph	345 vph 250 vph 205 vph 200 vph	240 vph 225 vph 225 vph 200 vph

WARRANT 1—Eight-Hour Vehicular Volume–Condition B, Interruption of Continuous Traffic

		SATISFIED	
	Requirement (100% Column)	Actual 7,8,12,2-6	
Major Street – Both Approaches – Two or more lanes	900 vph	910 vph 950 vph 945 vph 915 vph	1165 vph 1140 vph 1345 vph 1090 vph
Minor Street – Highest Approach – Two or more lanes	100 vph	345 vph 250 vph 205 vph 200 vph	240 vph 225 vph 225 vph 200 vph

WARRANT 1—Eight-Hour Vehicular Volume–Condition A, Minimum Vehicular Volume (80%)

		SATISFIED	
	Requirement (80% Column)	Actual 7,8,12,2-6	
Major Street – Both Approaches – Two or more lanes	480 vph	910 vph 950 vph 945 vph 915 vph	1165 vph 1140 vph 1345 vph 1090 vph
Minor Street – Highest Approach – Two or more lanes	160 vph	345 vph 250 vph 205 vph 200 vph	240 vph 225 vph 225 vph 200 vph

WARRANT 1—Eight-Hour Vehicular Volume–Condition B, Interruption of Continuous Traffic (80%)

		SATISFIED	
	Requirement (80% Column)	Actual 7,8,12,2-6	
Major Street – Both Approaches – Two or more lanes	720 vph	910 vph 950 vph 945 vph 915 vph	1165 vph 1140 vph 1345 vph 1090 vph
Minor Street – Highest Approach – Two or more lanes	80 vph	345 vph 250 vph 205 vph 200 vph	240 vph 225 vph 225 vph 200 vph

WARRANT 2—Four-Hour Vehicular Volume

		SATISFIED
	Requirement	Actual (Between 3pm – 6pm)
Major Street – Both Approaches – Two or more lanes	Satisfy Figure 4C-1 from the 2003 MUTCD	1165 vph 1140 vph 1345 vph 1090 vph
Minor Street – Highest Approach – Two or more lanes		240 vph 225 vph 225 vph 200 vph

WARRANT 3—Peak Hour

		NOT SATISFIED
	Requirement	Actual
Major Street – Both Approaches – Two or more lanes	Satisfy Figure 4C-3 from the 2003 MUTCD, and related criteria	1345 vph
Minor Street – Highest Approach – Two or more lanes		225 vph

WARRANT 4—Pedestrian Volume

		NOT SATISFIED
	Requirement	Actual
Crossing Major Street	100 peds/hr for 4 hrs or 190 peds in 1 hour	No
Gaps in traffic stream w/o median	< 60 gaps/hr during above hours	N/A
Gaps in traffic stream w/median	< 60 gaps/hr during above hours for each direction of traffic	N/A

WARRANT 5—School Crossing

	Requirement	NOT SATISFIED Actual
Major Street	Established School Crossing	No

WARRANT 6—Coordinated Signal System

	Requirement	NOT SATISFIED Actual
One Way Street	Traffic signals spaced > 1,000 feet apart	N/A
Two Way Street	Traffic signals spaced > 1,000 feet apart	No

WARRANT 7—Crash Experience

Requirement	NOT SATISFIED Actual
Adequate trial of alternatives has failed	N/A
Five or more correctable crashes in a 12-month period	No
For any 8 hours 80% of Warrant 1, Condition A OR B is met	No

WARRANT 8—Roadway Network

Requirement	SATISFIED Actual
Intersection of two or more major routes	Yes
Existing entering volume > 1,000 vph during peak hour	Yes
5-year projected traffic volumes that meet one or more of Warrants 1-3	Yes
Existing entering volume > 1,000 vph for each of any 5 hours of non-normal business day	No data

Appendix C

SIDRA and FHWA Roundabout Analysis

Assign each entry leg a number going counter-clockwise around the roundabout as illustrated by figure on the right. Enter data into shaded areas below for each entry leg roundabout has.
For each entry leg present at least one pce/hr must be shown entering or exiting roundabout for the leg. If roundabout has less than five entry legs, then enter zero in the shaded areas for the entry legs not used. (Note: Use of the tab key will toggle through all the data input shaded areas.)
To get accurate results from this spreadsheet the calculated V/C value should not exceed 0.85.

Entering (veh/hr)
(Roundabouts with 3, 4 or 5 legs)

Exiting (veh/hr)

	X1	X2	X3	X4	X5	Entering pce/hr	Circulating pce/hr
E1	0	0	0	0	0	0	934
E2	60	0	0	160	0	318	0
E3	0	200	0	30	0	329	318
E4	110	540	0	0	0	780	373
E5	0	0	0	0	0	0	0

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TOTAL ENTERING ROUNDABOUT (pce/hr) ***1,427***

CAPACITY AT AN ENTRY OF A ROUNDABOUT

	E1	E2	E3	E4	E5
Inscribed diameter, D (m)	0	40	40	40	
Entry width, e (m)	0	4	4	4	
Approach width, v (m)	0	4	4	4	
Entry angle, Q (degrees)	0	30	30	30	
Entry radius, r (m)	0	20	20	20	
Average effective flare length, l' (m)	0	40	40	40	
Peak Hour Factor (PHF)	0.90	0.72	0.72	0.85	
% Single-Unit Truck or Bus	0.00%	0.00%	0.00%	0.00%	
% Truck With Trailer	0.00%	4.00%	3.00%	2.00%	

		E1	E2	E3	E4	E5	
ENTRY CAPACITY (pce/hr) C=Qe		**#DIV/0!**	**1,212**	**1,039**	**1,009**		
	V/C	**#DIV/0!**	**0.26**	**0.32**	**0.77**		
CONTROL DELAY (sec/veh)	**d**	**#DIV/0!**	**4.0**	**5.1**	**14.5**		
LEVEL OF SERVICE		**#DIV/0!**	**A**	**A**	**B**		**Compared to an unsignalized intersection**
LEVEL OF SERVICE		**#DIV/0!**	**A**	**A**	**B**		**Compared to a signalized intersection**
QUEUE LENGTH 95th percentile (veh)		**#DIV/0!**	**1.1**	**1.4**	**8.0**		

Van Buren at Westbound Ramps - Existing AM Peak - Single Entry

Circulating flow across the entry, Qc (pce/hr)	934	0	318	373	0
S	#DIV/0!	0.00	0.00	0.00	
M	0.00	0.14	0.14	0.14	
X2	#DIV/0!	4.00	4.00	4.00	
F	#DIV/0!	1212.00	1212.00	1212.00	
tp	1.50	1.44	1.44	1.44	
fc	#DIV/0!	0.54	0.54	0.54	
k	#DIV/0!	1.00	1.00	1.00	
Entering flow, qe (pce/hr)	0	318	329	780	0

Definitions:

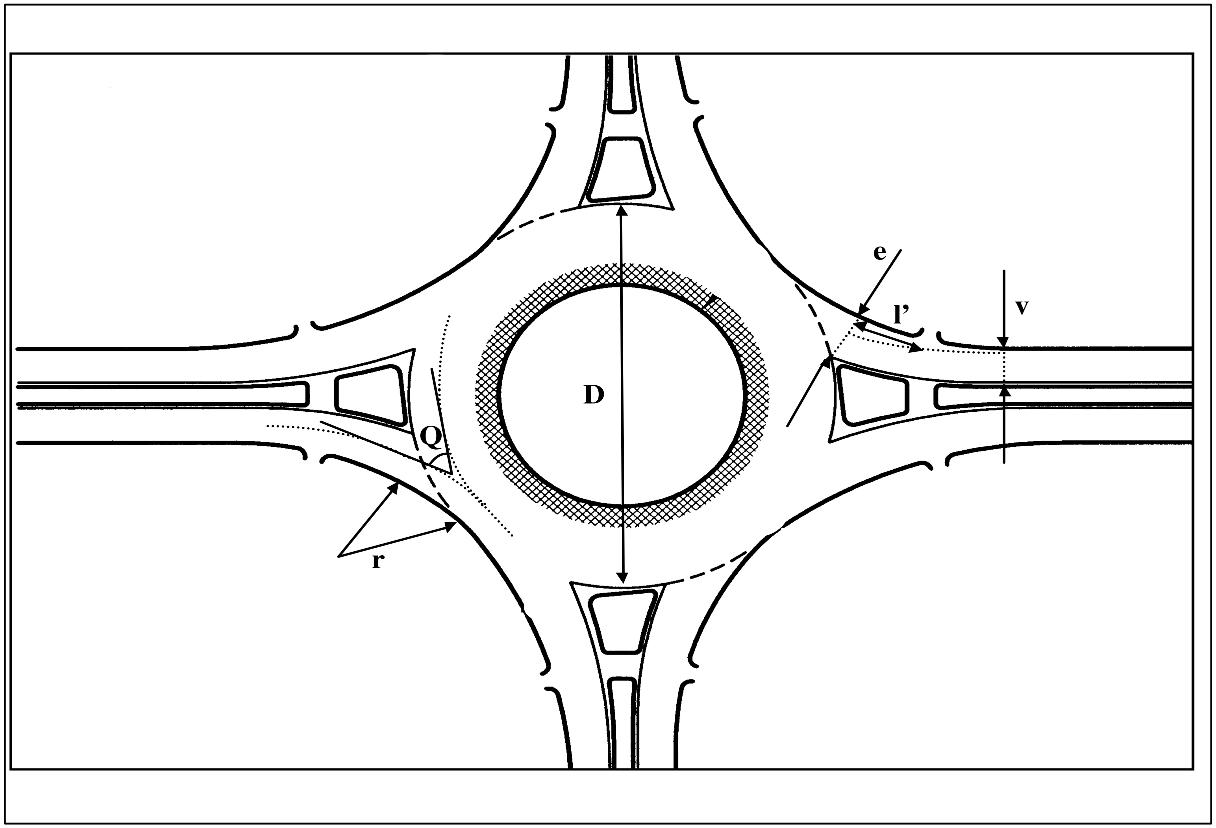
pce/hr - passenger car equivalent per hour
Inscribed Diameter, D - the diameter of the largest circle that can be inscribed within the junction outline
Entry Width, e - measured at the point of maximum entry deflection, from the left hand end of give-way line along a normal to the nearside curb
Approach Width, v - measured at a point in the approach upstream from any entry flare, from the median line (or edge of travelway on dual lane roads) to the nearside curb, along a normal
Entry Angle, Q - serves as a geometric proxy for the conflict angle between entering and circulating streams.
Entry Radius, r - measured as the minimum radius of curvature of the nearside curbline at entry
Average Effective Flare Length, l' - measured along a curve offset from curbline a distance of (e-v)/2 starting from line where e is measured to intersection with a projected curve offset from median a distance v.

Entering flow, qe=V
Sharpness of Flare, S=1.6*(e-v)/l'
M=exp{(D-60)/10}
X2=v+(e-v)/(1+2*S)
F=303*X2
tp=1+.5/(1+M)
fc=.21*tp*(1+.2*X2)
k=1-.00347*(Q-30)-.978*{(1/r)-.05}
Qe=k*(F-fc*Qc) or Qe=0 when fc*Qc>F
d=3600/C+900*T*[V/C-1+sqrt{(V/C-1)^2+(3600/C)*(V/C)/450*T}] where T=analysis time period, hours (T=0.25 for a 15-minute period)
Queue length 95th percentile = 900*T*{V/C-1+sqrt[(1-V/C)^2+(3600/C)*(V/C)/150*T]}*(C/3600) where T is the same as defined for d above

References:

Transportation Research Board, *Highway Capacity Manual,* National Research Council,
Special Report 209, Third edition, Washington, D.C., 1998.

United Kingdom Department of Transport, *Geometric Design of Roundabouts,* Design
Manual for Roads and Bridges, Volume 6, United Kingdom, 1993.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l'
v
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Assign each entry leg a number going counter-clockwise around the roundabout as illustrated by figure on the right. Enter data into shaded areas below for each entry leg roundabout has.
For each entry leg present at least one pce/hr must be shown entering or exiting roundabout for the leg. If roundabout has less than five entry legs, then enter zero in the shaded areas for the entry legs not used. (Note: Use of the tab key will toggle through all the data input shaded areas.)
To get accurate results from this spreadsheet the calculated V/C value should not exceed 0.85.

Entering (veh/hr)
(Roundabouts with 3, 4 or 5 legs)

	Exiting (veh/hr) X1	X2	X3	X4	X5	Entering pce/hr	Circulating pce/hr
E1	0	0	0	0	0	0	484
E2	155	0	0	660	0	925	0
E3	0	125	0	40	0	187	925
E4	55	315	0	0	0	402	318
E5	0	0	0	0	0	0	0

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TOTAL ENTERING ROUNDABOUT (pce/hr) ***1,514***

CAPACITY AT AN ENTRY OF A ROUNDABOUT

	E1	E2	E3	E4	E5
Inscribed diameter, D (m)	0	40	40	40	
Entry width, e (m)	0	4	4	4	
Approach width, v (m)	0	4	4	4	
Entry angle, Q (degrees)	0	30	30	30	
Entry radius, r (m)	0	20	20	20	
Average effective flare length, l' (m)	0	40	40	40	
Peak Hour Factor (PHF)	0.90	0.89	0.90	0.93	
% Single-Unit Truck or Bus	0.00%	0.00%	0.00%	0.00%	
% Truck With Trailer	0.00%	1.00%	2.00%	1.00%	
ENTRY CAPACITY (pce/hr) C=Qe	**#DIV/0!**	**1,212**	**708**	**1,039**	
V/C	**#DIV/0!**	**0.76**	**0.26**	**0.39**	
CONTROL DELAY (sec/veh) d	**#DIV/0!**	**11.8**	**6.9**	**5.6**	
LEVEL OF SERVICE	**#DIV/0!**	**B**	**A**	**A**	Compared to an unsignalized intersection
LEVEL OF SERVICE	**#DIV/0!**	**B**	**A**	**A**	Compared to a signalized intersection
QUEUE LENGTH 95th percentile (veh)	**#DIV/0!**	**7.9**	**1.1**	**1.8**	

Van Buren at Westbound Ramps - Existing PM Peak - Single Entry

Circulating flow across the entry, Qc (pce/hr)	484	0	925	318	0
S	#DIV/0!	0.00	0.00	0.00	
M	0.00	0.14	0.14	0.14	
X2	#DIV/0!	4.00	4.00	4.00	
F	#DIV/0!	1212.00	1212.00	1212.00	
tp	1.50	1.44	1.44	1.44	
fc	#DIV/0!	0.54	0.54	0.54	
k	#DIV/0!	1.00	1.00	1.00	
Entering flow, qe (pce/hr)	0	925	187	402	0

Definitions:

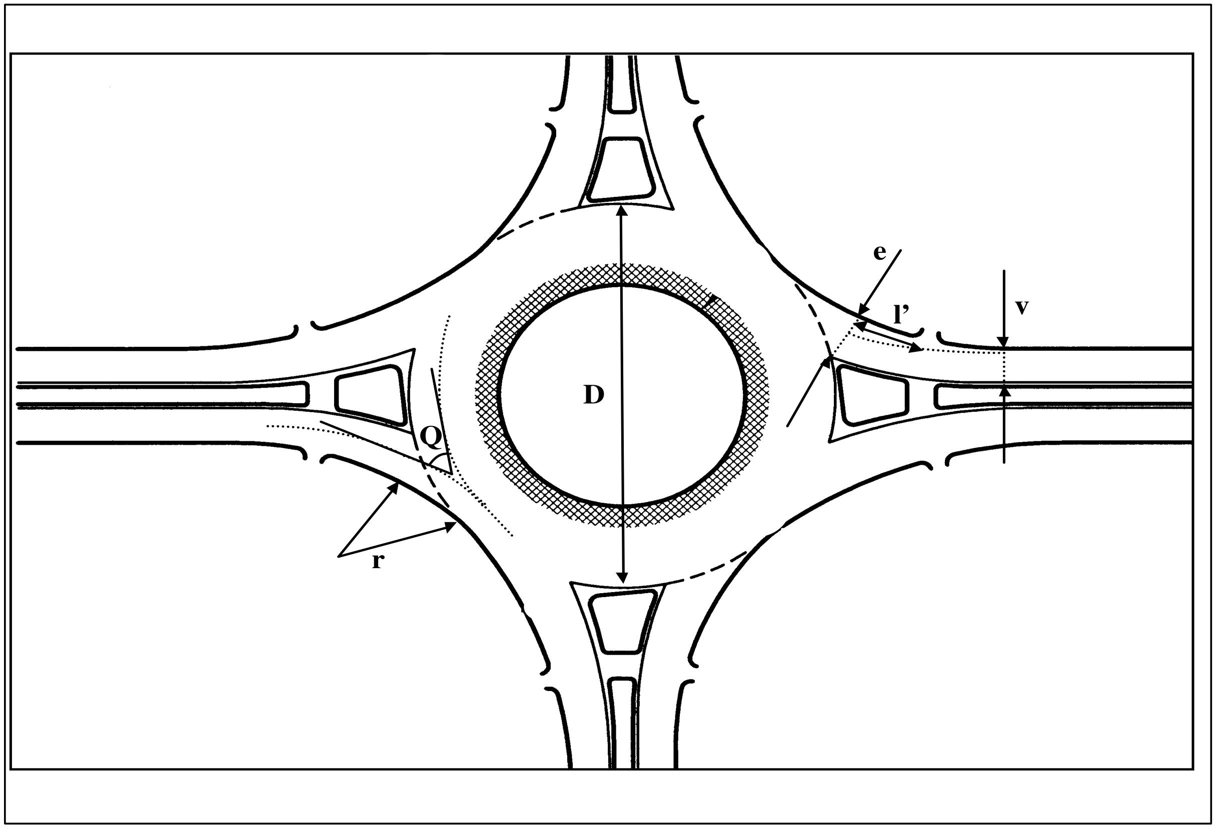
pce/hr - passenger car equivalent per hour
Inscribed Diameter, D - the diameter of the largest circle that can be inscribed within the junction outline
Entry Width, e - measured at the point of maximum entry deflection, from the left hand end of give-way line along a normal to the nearside curb
Approach Width, v - measured at a point in the approach upstream from any entry flare, from the median line (or edge of travelway on dual lane roads) to the nearside curb, along a normal
Entry Angle, Q - serves as a geometric proxy for the conflict angle between entering and circulating streams.
Entry Radius, r - measured as the minimum radius of curvature of the nearside curbline at entry
Average Effective Flare Length, l' - measured along a curve offset from curbline a distance of (e-v)/2 starting from line where e is measured to intersection with a projected curve offset from median a distance v.

Entering flow, qe=V
Sharpness of Flare, S=1.6*(e-v)/l'
M=exp{(D-60)/10}
X2=v+(e-v)/(1+2*S)
F=303*X2
tp=1+.5/(1+M)
fc=.21*tp*(1+.2*X2)
k=1-.00347*(Q-30)-.978*{(1/r)-.05}
Qe=k*(F-fc*Qc) or Qe=0 when fc*Qc>F
d=3600/C+900*T*[V/C-1+sqrt{(V/C-1)^2+(3600/C)*(V/C)/450*T}] where T=analysis time period, hours (T=0.25 for a 15-minute period)
Queue length 95th percentile = 900*T*{V/C-1+sqrt[(1-V/C)^2+(3600/C)*(V/C)/150*T]}*(C/3600) where T is the same as defined for d above

References:

Transportation Research Board, *Highway Capacity Manual,* National Research Council, Special Report 209, Third edition, Washington, D.C., 1998.

United Kingdom Department of Transport, *Geometric Design of Roundabouts,* Design Manual for Roads and Bridges, Volume 6, United Kingdom, 1993.



e
l'
v
D
Q
r

Assign each entry leg a number going counter-clockwise around the roundabout as illustrated by figure on the right. Enter data into shaded areas below for each entry leg roundabout has.
For each entry leg present at least one pce/hr must be shown entering or exiting roundabout for the leg. If roundabout has less than five entry legs, then enter zero in the shaded areas for the entry legs not used. (Note: Use of the tab key will toggle through all the data input shaded areas.)
To get accurate results from this spreadsheet the calculated V/C value should not exceed 0.85.

Entering (veh/hr)
(Roundabouts with 3, 4 or 5 legs)

Exiting (veh/hr)	X1	X2	X3	X4	X5	Entering pce/hr	Circulating pce/hr
E1	0	200	0	40	0	316	881
E2	1	0	90	175	0	305	88
E3	0	0	0	0	0	0	255
E4	0	710	30	0	0	881	1
E5	0	0	0	0	0	0	0

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TOTAL ENTERING ROUNDABOUT (pce/hr) ***1,502***

CAPACITY AT AN ENTRY OF A ROUNDABOUT

	E1	E2	E3	E4	E5
Inscribed diameter, D (m)	40	40	0	40	
Entry width, e (m)	4	4	0	4	
Approach width, v (m)	4	4	0	4	
Entry angle, Q (degrees)	30	30	0	30	
Entry radius, r (m)	20	20	0	20	
Average effective flare length, l' (m)	40	40	0	40	
Peak Hour Factor (PHF)	0.76	0.88	0.92	0.84	
% Single-Unit Truck or Bus	0.00%	0.00%	0.00%	0.00%	
% Truck With Trailer	0.00%	1.00%	0.00%	0.00%	

	E1	E2	E3	E4	E5	
ENTRY CAPACITY (pce/hr) C=Qe	**732**	**1,164**	**#DIV/0!**	**1,211**		
V/C	**0.43**	**0.26**	**#DIV/0!**	**0.73**		
CONTROL DELAY (sec/veh) d	**8.6**	**4.2**	**#DIV/0!**	**10.4**		
LEVEL OF SERVICE	**A**	**A**	**#DIV/0!**	**B**		**Compared to an unsignalized intersection**
LEVEL OF SERVICE	**A**	**A**	**#DIV/0!**	**B**		**Compared to a signalized intersection**
QUEUE LENGTH 95th percentile (veh)	**2.2**	**1.1**	**#DIV/0!**	**6.9**		

Van Buren at Eastbound Ramps - Existing AM Peak - Single Entry

Circulating flow across the entry, Qc (pce/hr)	881	88	255	1	0
S	0.00	0.00	#DIV/0!	0.00	
M	0.14	0.14	0.00	0.14	
X2	4.00	4.00	#DIV/0!	4.00	
F	1212.00	1212.00	#DIV/0!	1212.00	
tp	1.44	1.44	1.50	1.44	
fc	0.54	0.54	#DIV/0!	0.54	
k	1.00	1.00	#DIV/0!	1.00	
Entering flow, qe (pce/hr)	316	305	0	881	0

Definitions:

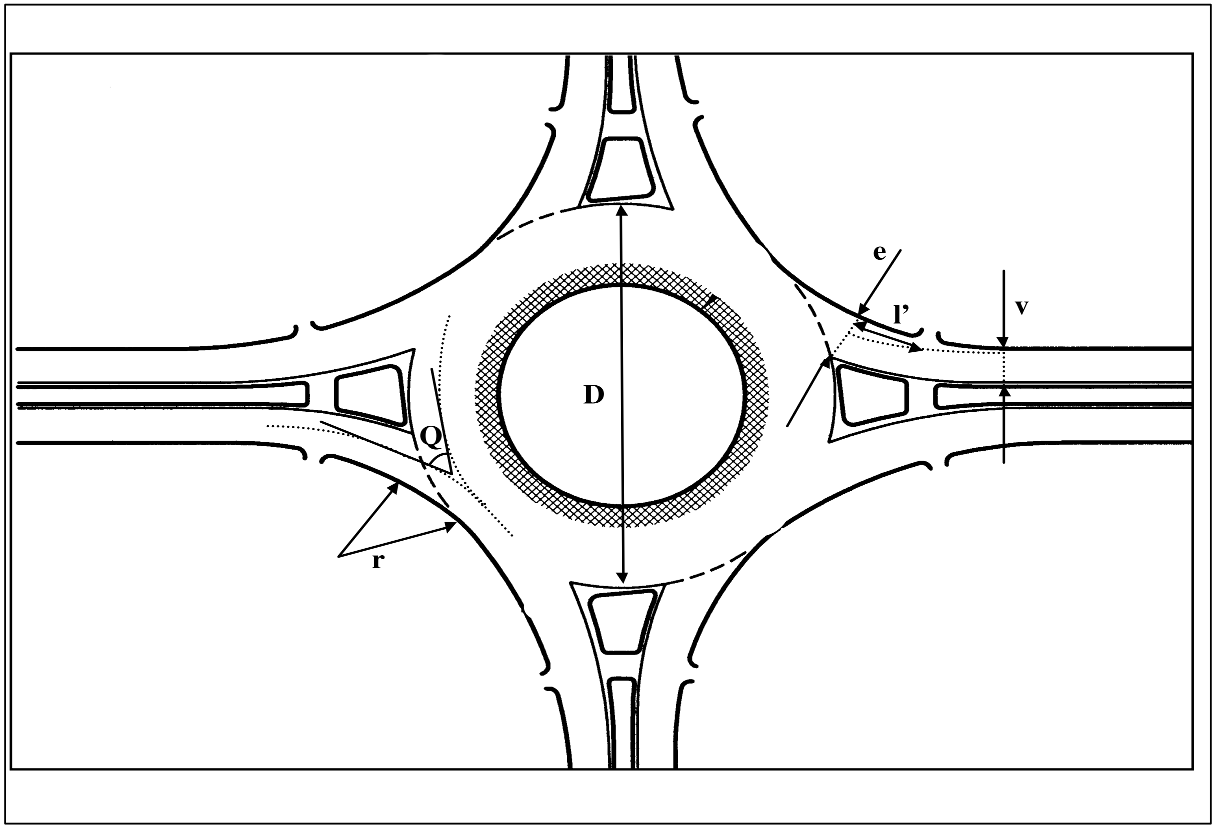
pce/hr - passenger car equivalent per hour
Inscribed Diameter, D - the diameter of the largest circle that can be inscribed within the junction outline
Entry Width, e - measured at the point of maximum entry deflection, from the left hand end of give-way line along a normal to the nearside curb
Approach Width, v - measured at a point in the approach upstream from any entry flare, from the median line (or edge of travelway on dual lane roads) to the nearside curb, along a normal
Entry Angle, Q - serves as a geometric proxy for the conflict angle between entering and circulating streams.
Entry Radius, r - measured as the minimum radius of curvature of the nearside curbline at entry
Average Effective Flare Length, l' - measured along a curve offset from curbline a distance of (e-v)/2 starting from line where e is measured to intersection with a projected curve offset from median a distance v.

Entering flow, qe=V
Sharpness of Flare, S=1.6*(e-v)/l'
M=exp{(D-60)/10}
X2=v+(e-v)/(1+2*S)
F=303*X2
tp=1+.5/(1+M)
fc=.21*tp*(1+.2*X2)
k=1-.00347*(Q-30)-.978*{(1/r)-.05}
Qe=k*(F-fc*Qc) or Qe=0 when fc*Qc>F
d=3600/C+900*T*[V/C-1+sqrt{(V/C-1)^2+(3600/C)*(V/C)/450*T}] where T=analysis time period, hours (T=0.25 for a 15-minute period)
Queue length 95th percentile = 900*T*{V/C-1+sqrt[(1-V/C)^2+(3600/C)*(V/C)/150*T]}*(C/3600) where T is the same as defined for d above

References:

Transportation Research Board, *Highway Capacity Manual,* National Research Council,
Special Report 209, Third edition, Washington, D.C., 1998.

United Kingdom Department of Transport, *Geometric Design of Roundabouts,* Design
Manual for Roads and Bridges, Volume 6, United Kingdom, 1993.



e
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Assign each entry leg a number going counter-clockwise around the roundabout as illustrated by figure on the right. Enter data into shaded areas below for each entry leg roundabout has. **For each entry leg present at least one pce/hr must be shown entering or exiting roundabout for the leg.** If roundabout has less than five entry legs, then enter zero in the shaded areas for the entry legs not used. (Note: Use of the tab key will toggle through all the data input shaded areas.)

To get accurate results from this spreadsheet the calculated V/C value should not exceed 0.85.

Entering (veh/hr)
(Roundabouts with 3, 4 or 5 legs)

	Exiting (veh/hr) X1	X2	X3	X4	X5	Entering pce/hr	Circulating pce/hr
E1	0	135	0	150	0	327	468
E2	1	0	225	670	0	1,006	193
E3	0	0	0	0	0	0	925
E4	0	425	20	0	0	468	1
E5	0	0	0	0	0	0	0

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TOTAL ENTERING ROUNDABOUT (pce/hr) ***1,801***

CAPACITY AT AN ENTRY OF A ROUNDABOUT

	E1	E2	E3	E4	E5
Inscribed diameter, D (m)	40	40	0	40	
Entry width, e (m)	4	4	0	4	
Approach width, v (m)	4	4	0	4	
Entry angle, Q (degrees)	30	30	0	30	
Entry radius, r (m)	20	20	0	20	
Average effective flare length, l' (m)	40	40	0	40	
Peak Hour Factor (PHF)	0.88	0.90	0.90	0.97	
% Single-Unit Truck or Bus	0.00%	0.00%	0.00%	0.00%	
% Truck With Trailer	1.00%	1.00%	0.00%	2.00%	

	E1	E2	E3	E4	E5	
ENTRY CAPACITY (pce/hr) C=Qe	**957**	**1,107**	**#DIV/0!**	**1,211**		
V/C	**0.34**	**0.91**	**#DIV/0!**	**0.39**		
CONTROL DELAY (sec/veh) d	**5.7**	**24.5**	**#DIV/0!**	**4.8**		
LEVEL OF SERVICE	**A**	**C**	**#DIV/0!**	**A**		**Compared to an unsignalized intersection**
LEVEL OF SERVICE	**A**	**C**	**#DIV/0!**	**A**		**Compared to a signalized intersection**
QUEUE LENGTH 95th percentile (veh)	**1.5**	**14.1**	**#DIV/0!**	**1.9**		

Van Buren at Eastbound Ramps - Existing PM Peak - Single Entry

Circulating flow across the entry, Qc (pce/hr)	468	193	925	1	0
S	0.00	0.00	#DIV/0!	0.00	
M	0.14	0.14	0.00	0.14	
X2	4.00	4.00	#DIV/0!	4.00	
F	1212.00	1212.00	#DIV/0!	1212.00	
tp	1.44	1.44	1.50	1.44	
fc	0.54	0.54	#DIV/0!	0.54	
k	1.00	1.00	#DIV/0!	1.00	
Entering flow, qe (pce/hr)	327	1,006	0	468	0

Definitions:

pce/hr - passenger car equivalent per hour
Inscribed Diameter, D - the diameter of the largest circle that can be inscribed within the junction outline
Entry Width, e - measured at the point of maximum entry deflection, from the left hand end of give-way line along a normal to the nearside curb
Approach Width, v - measured at a point in the approach upstream from any entry flare, from the median line (or edge of travelway on dual lane roads) to the nearside curb, along a normal
Entry Angle, Q - serves as a geometric proxy for the conflict angle between entering and circulating streams.
Entry Radius, r - measured as the minimum radius of curvature of the nearside curbline at entry
Average Effective Flare Length, l' - measured along a curve offset from curbline a distance of (e-v)/2 starting from line where e is measured to intersection with a projected curve offset from median a distance v.

Entering flow, qe=V
Sharpness of Flare, S=1.6*(e-v)/l'
M=exp{(D-60)/10}
X2=v+(e-v)/(1+2*S)
F=303*X2
tp=1+.5/(1+M)
fc=.21*tp*(1+.2*X2)
k=1-.00347*(Q-30)-.978*{(1/r)-.05}
Qe=k*(F-fc*Qc) or Qe=0 when fc*Qc>F
d=3600/C+900*T*[V/C-1+sqrt{(V/C-1)^2+(3600/C)*(V/C)/450*T}] where T=analysis time period, hours (T=0.25 for a 15-minute period)
Queue length 95th percentile = 900*T*{V/C-1+sqrt[(1-V/C)^2+(3600/C)*(V/C)/150*T]}*(C/3600) where T is the same as defined for d above

References:

Transportation Research Board, *Highway Capacity Manual,* National Research Council,
Special Report 209, Third edition, Washington, D.C., 1998.

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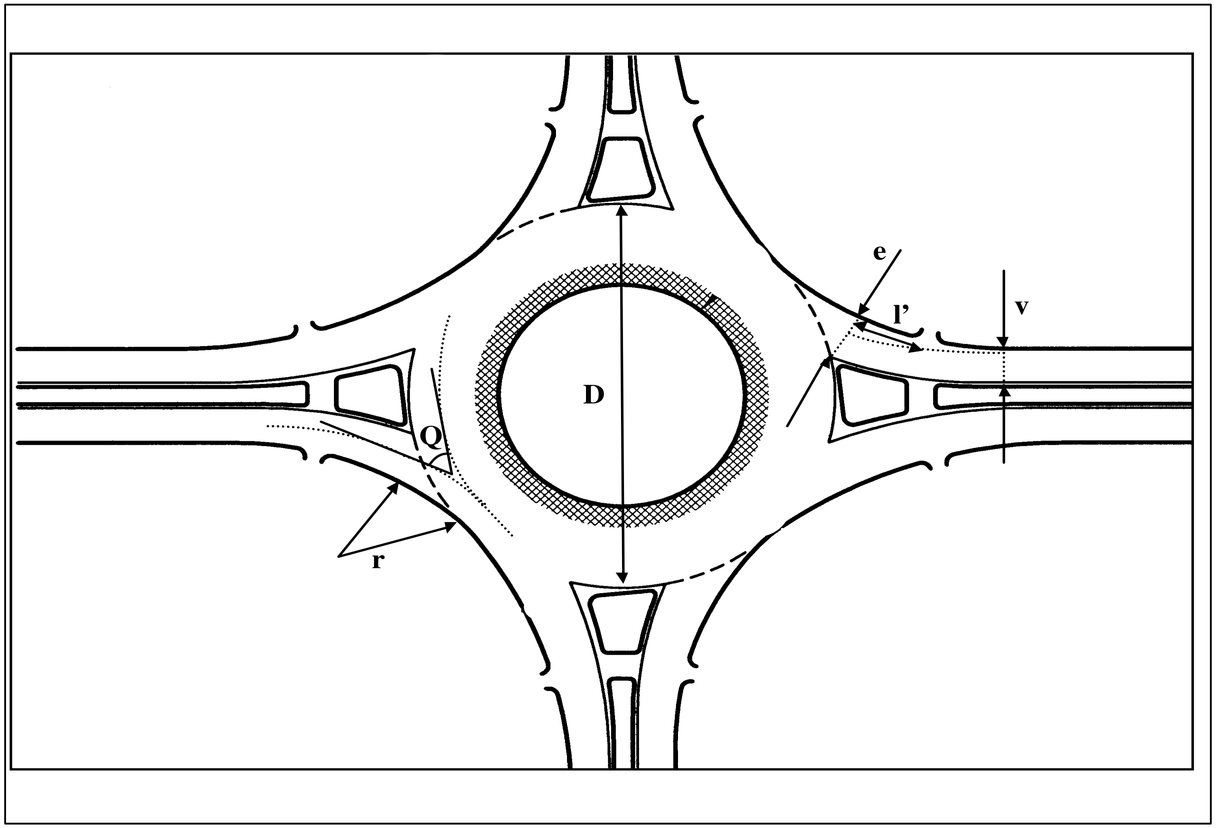
e
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D
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Assign each entry leg a number going counter-clockwise around the roundabout as illustrated by figure on the right. Enter data into shaded areas below for each entry leg roundabout has. **For each entry leg present at least one pce/hr must be shown entering or exiting roundabout for the leg.** If roundabout has less than five entry legs, then enter zero in the shaded areas for the entry legs not used. (Note: Use of the tab key will toggle through all the data input shaded areas.)

To get accurate results from this spreadsheet the calculated V/C value should not exceed 0.85.

Entering (veh/hr)
(Roundabouts with 3, 4 or 5 legs)

	Exiting (veh/hr)					Entering	Circulating
	X1	X2	X3	X4	X5	pce/hr	pce/hr
E1	0	0	0	0	0	0	725
E2	160	0	0	0	0	187	0
E3	0	640	0	0	0	725	187
E4	0	0	0	0	0	0	0
E5	0	0	0	0	0	0	0

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TOTAL ENTERING ROUNDABOUT (pce/hr) ***912***

CAPACITY AT AN ENTRY OF A ROUNDABOUT

	E1	E2	E3	E4	E5
Inscribed diameter, D (m)		40	40		
Entry width, e (m)		4	4		
Approach width, v (m)		4	4		
Entry angle, Q (degrees)		30	30		
Entry radius, r (m)		20	20		
Average effective flare length, l' (m)		40	40		
Peak Hour Factor (PHF)	0.90	0.90	0.90	0.90	
% Single-Unit Truck or Bus	0.00%	0.00%	0.00%	0.00%	
% Truck With Trailer	0.00%	5.00%	2.00%	0.00%	
ENTRY CAPACITY (pce/hr) C=Qe	**#DIV/0!**	**1,212**	**1,110**		
V/C	**#DIV/0!**	**0.15**	**0.65**		
CONTROL DELAY (sec/veh) d	**#DIV/0!**	**3.5**	**9.1**		
LEVEL OF SERVICE	**#DIV/0!**	**A**	**A**		Compared to an unsignalized intersection
LEVEL OF SERVICE	**#DIV/0!**	**A**	**A**		Compared to a signalized intersection
QUEUE LENGTH 95th percentile (veh)	**#DIV/0!**	**0.5**	**5.1**		

Orange at Westbound Ramps - 2030 AM Peak - Single Entry

Circulating flow across the entry, Qc (pce/hr)	725	0	187	0	0
S	#DIV/0!	0.00	0.00		
M	0.00	0.14	0.14		
X2	#DIV/0!	4.00	4.00		
F	#DIV/0!	1212.00	1212.00		
tp	1.50	1.44	1.44		
fc	#DIV/0!	0.54	0.54		
k	#DIV/0!	1.00	1.00		
Entering flow, qe (pce/hr)	0	187	725	0	0

Definitions:

pce/hr - passenger car equivalent per hour
Inscribed Diameter, D - the diameter of the largest circle that can be inscribed within the junction outline
Entry Width, e - measured at the point of maximum entry deflection, from the left hand end of give-way line along a normal to the nearside curb
Approach Width, v - measured at a point in the approach upstream from any entry flare, from the median line (or edge of travelway on dual lane roads) to the nearside curb, along a normal
Entry Angle, Q - serves as a geometric proxy for the conflict angle between entering and circulating streams.
Entry Radius, r - measured as the minimum radius of curvature of the nearside curbline at entry
Average Effective Flare Length, l' - measured along a curve offset from curbline a distance of (e-v)/2 starting from line where e is measured to intersection with a projected curve offset from median a distance v.

Entering flow, qe=V
Sharpness of Flare, S=1.6*(e-v)/l'
M=exp{(D-60)/10}
X2=v+(e-v)/(1+2*S)
F=303*X2
tp=1+.5/(1+M)
fc=.21*tp*(1+.2*X2)
k=1-.00347*(Q-30)-.978*{(1/r)-.05}
Qe=k*(F-fc*Qc) or Qe=0 when fc*Qc>F
d=3600/C+900*T*[V/C-1+sqrt{(V/C-1)^2+(3600/C)*(V/C)/450*T}] where T=analysis time period, hours (T=0.25 for a 15-minute period)
Queue length 95th percentile = 900*T*{V/C-1+sqrt[(1-V/C)^2+(3600/C)*(V/C)/150*T]}*(C/3600) where T is the same as defined for d above

References:

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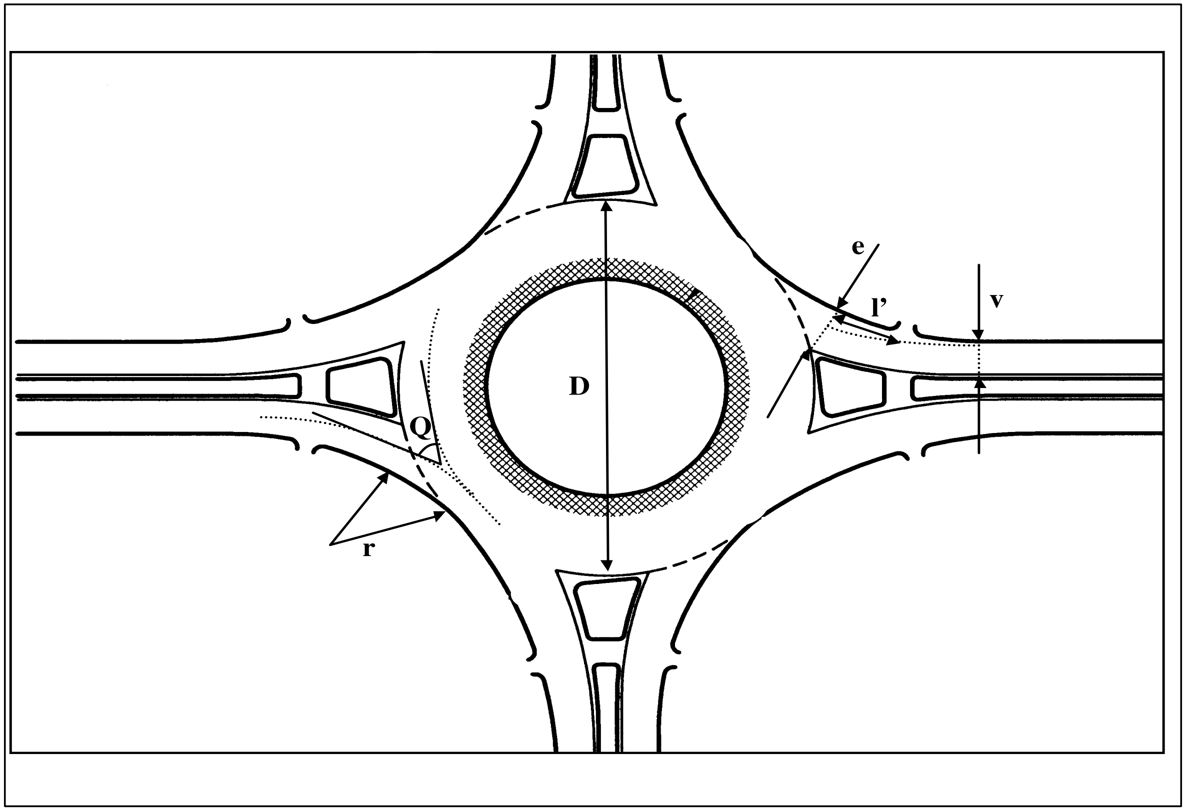
United Kingdom Department of Transport, *Geometric Design of Roundabouts,* Design Manual for Roads and Bridges, Volume 6, United Kingdom, 1993.



e
l'
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D
Q
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Assign each entry leg a number going counter-clockwise around the roundabout as illustrated by figure on the right. Enter data into shaded areas below for each entry leg roundabout has.
For each entry leg present at least one pce/hr must be shown entering or exiting roundabout for the leg. If roundabout has less than five entry legs, then enter zero in the shaded areas for the entry legs not used. (Note: Use of the tab key will toggle through all the data input shaded areas.)
To get accurate results from this spreadsheet the calculated V/C value should not exceed 0.85.

Entering (veh/hr)
(Roundabouts with 3, 4 or 5 legs)

	Exiting (veh/hr)					Entering	Circulating
	X1	**X2**	**X3**	**X4**	**X5**	**pce/hr**	**pce/hr**
E1	0	0	0	0	0	0	494
E2	520	0	0	0	0	577	0
E3	0	460	0	0	0	494	577
E4	0	0	0	0	0	0	0
E5	0	0	0	0	0	0	0

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TOTAL ENTERING ROUNDABOUT (pce/hr) ***1,071***

CAPACITY AT AN ENTRY OF A ROUNDABOUT

	E1	**E2**	**E3**	**E4**	**E5**
Inscribed diameter, D (m)		40	40		
Entry width, e (m)		4	4		
Approach width, v (m)		4	4		
Entry angle, Q (degrees)		30	30		
Entry radius, r (m)		20	20		
Average effective flare length, l' (m)		40	40		
Peak Hour Factor (PHF)	0.90	0.91	0.94	0.90	
% Single-Unit Truck or Bus	0.00%	0.00%	0.00%	0.00%	
% Truck With Trailer	0.00%	1.00%	1.00%	0.00%	
ENTRY CAPACITY (pce/hr) C=Qe	**#DIV/0!**	**1,212**	**898**		
V/C	**#DIV/0!**	**0.48**	**0.55**		
CONTROL DELAY (sec/veh) d	**#DIV/0!**	**5.6**	**8.8**		
LEVEL OF SERVICE	**#DIV/0!**	**A**	**A**		
LEVEL OF SERVICE	**#DIV/0!**	**A**	**A**		
QUEUE LENGTH 95th percentile (veh)	**#DIV/0!**	**2.6**	**3.4**		

Compared to an unsignalized intersection (first LEVEL OF SERVICE row)
Compared to a signalized intersection (second LEVEL OF SERVICE row)

Orange at Westbound Ramps - 2030 PM Peak - Single Entry

Circulating flow across the entry, Qc (pce/hr)	494	0	577	0	0
S	#DIV/0!	0.00	0.00		
M	0.00	0.14	0.14		
X2	#DIV/0!	4.00	4.00		
F	#DIV/0!	1212.00	1212.00		
tp	1.50	1.44	1.44		
fc	#DIV/0!	0.54	0.54		
k	#DIV/0!	1.00	1.00		
Entering flow, qe (pce/hr)	0	577	494	0	0

Definitions:

pce/hr - passenger car equivalent per hour
Inscribed Diameter, D - the diameter of the largest circle that can be inscribed within the junction outline
Entry Width, e - measured at the point of maximum entry deflection, from the left hand end of give-way line along a normal to the nearside curb
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Entry Angle, Q - serves as a geometric proxy for the conflict angle between entering and circulating streams.
Entry Radius, r - measured as the minimum radius of curvature of the nearside curbline at entry
Average Effective Flare Length, l' - measured along a curve offset from curbline a distance of (e-v)/2 starting from line where e is measured to intersection with a projected curve offset from median a distance v.

Entering flow, qe=V
Sharpness of Flare, S=1.6*(e-v)/l'
M=exp{(D-60)/10}
X2=v+(e-v)/(1+2*S)
F=303*X2
tp=1+.5/(1+M)
fc=.21*tp*(1+.2*X2)
k=1-.00347*(Q-30)-.978*{(1/r)-.05}
Qe=k*(F-fc*Qc) or Qe=0 when fc*Qc>F
d=3600/C+900*T*[V/C-1+sqrt{(V/C-1)^2+(3600/C)*(V/C)/450*T}] where T=analysis time period, hours (T=0.25 for a 15-minute period)
Queue length 95th percentile = 900*T*{V/C-1+sqrt[(1-V/C)^2+(3600/C)*(V/C)/150*T]}*(C/3600) where T is the same as defined for d above

References:

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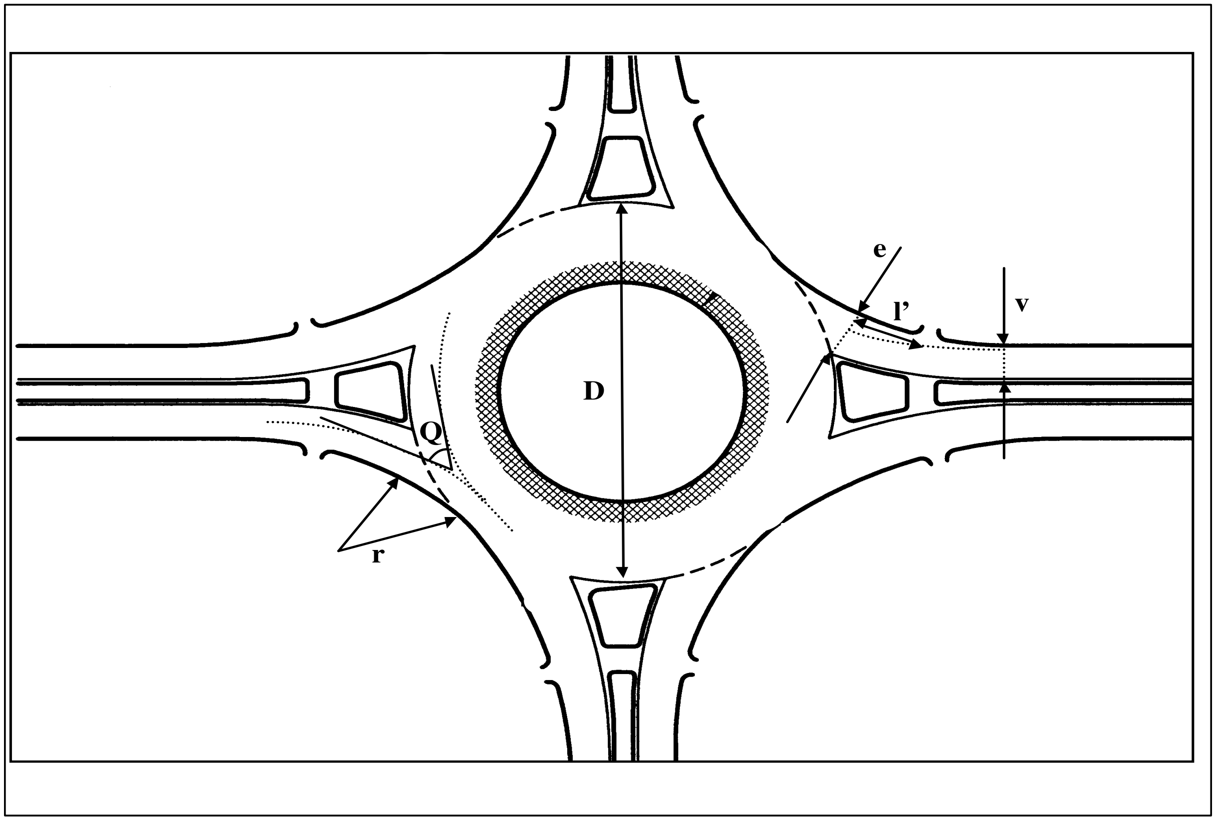

e
l'
v
D
Q
r

Assign each entry leg a number going counter-clockwise around the roundabout as illustrated by figure on the right. Enter data into shaded areas below for each entry leg roundabout has.
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To get accurate results from this spreadsheet the calculated V/C value should not exceed 0.85.

Entering (veh/hr)
(Roundabouts with 3, 4 or 5 legs)

	Exiting (veh/hr) X1	X2	X3	X4	X5	Entering pce/hr	Circulating pce/hr
E1	0	570	0	5	0	639	725
E2	1	0	120	155	0	322	6
E3	0	0	0	0	0	0	188
E4	0	640	0	0	0	725	1
E5	0	0	0	0	0	0	0

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TOTAL ENTERING ROUNDABOUT (pce/hr) ***1,686***

CAPACITY AT AN ENTRY OF A ROUNDABOUT

	E1	E2	E3	E4	E5
Inscribed diameter, D (m)	30	30	0	30	
Entry width, e (m)	4.8	4.8		4.8	
Approach width, v (m)	4.2	4.2		4.2	
Entry angle, Q (degrees)	35	25		25	
Entry radius, r (m)	35	25		25	
Average effective flare length, l' (m)	10	10		10	
Peak Hour Factor (PHF)	0.90	0.90	0.90	0.90	
% Single-Unit Truck or Bus	0.00%	0.00%	0.00%	0.00%	
% Truck With Trailer	0.00%	5.00%	2.00%	2.00%	

	E1	E2	E3	E4	E5	
ENTRY CAPACITY (pce/hr) C=Qe	992	1,460	#DIV/0!	1,463		
V/C	0.64	0.22	#DIV/0!	0.50		
CONTROL DELAY (sec/veh) d	9.9	3.2	#DIV/0!	4.9		
LEVEL OF SERVICE	A	A	#DIV/0!	A		Compared to an unsignalized intersection
LEVEL OF SERVICE	A	A	#DIV/0!	A		Compared to a signalized intersection
QUEUE LENGTH 95th percentile (veh)	4.9	0.8	#DIV/0!	2.9		

Orange at Eastbound Ramps - 2030 AM Peak - Single Entry

Circulating flow across the entry, Qc (pce/hr)	725	6	188	1	0
S	0.10	0.10	#DIV/0!	0.10	
M	0.05	0.05	0.00	0.05	
X2	4.70	4.70	#DIV/0!	4.70	
F	1425.12	1425.12	#DIV/0!	1425.12	
tp	1.48	1.48	1.50	1.48	
fc	0.60	0.60	#DIV/0!	0.60	
k	1.00	1.03	#DIV/0!	1.03	
Entering flow, qe (pce/hr)	639	322	0	725	0

Definitions:

pce/hr - passenger car equivalent per hour
Inscribed Diameter, D - the diameter of the largest circle that can be inscribed within the junction outline
Entry Width, e - measured at the point of maximum entry deflection, from the left hand end of give-way line along a normal to the nearside curb
Approach Width, v - measured at a point in the approach upstream from any entry flare, from the median line (or edge of travelway on dual lane roads) to the nearside curb, along a normal
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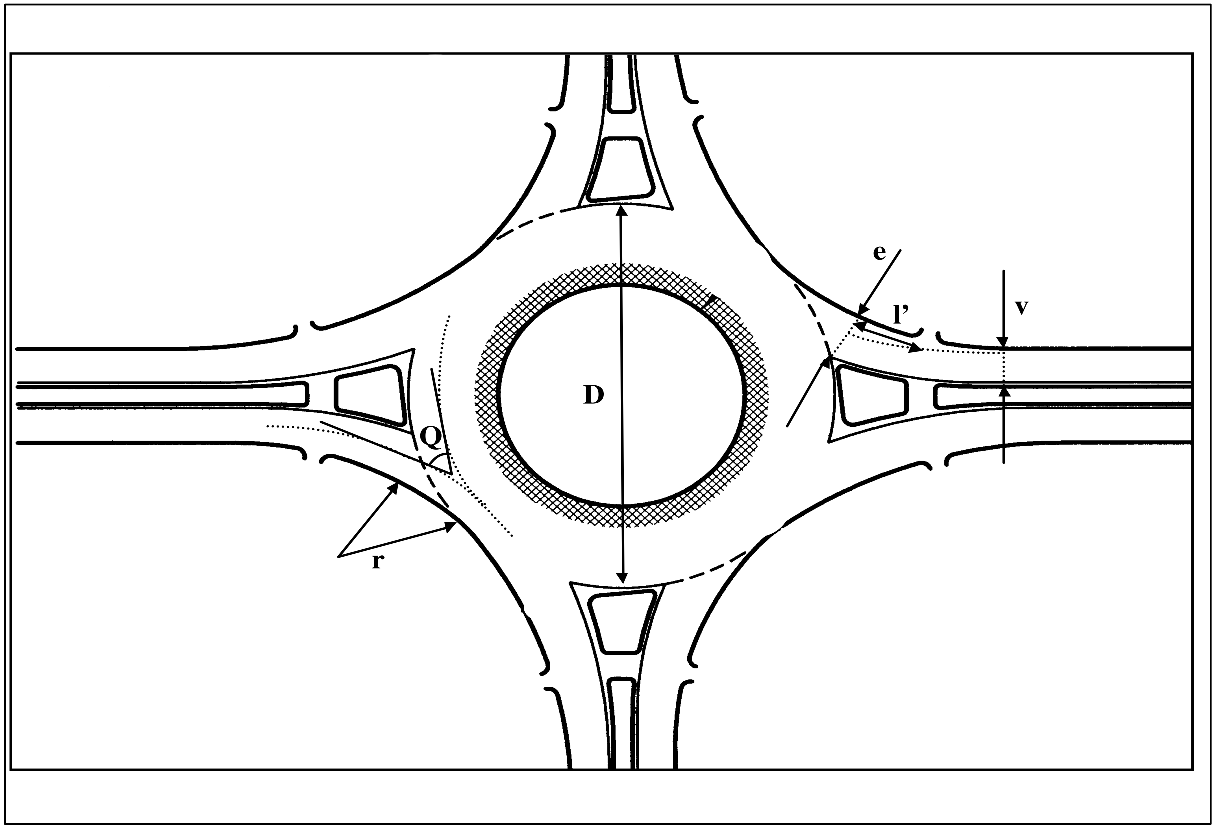
Entry Radius, r - measured as the minimum radius of curvature of the nearside curbline at entry
Average Effective Flare Length, l' - measured along a curve offset from curbline a distance of (e-v)/2 starting from line where e is measured to intersection with a projected curve offset from median a distance v.

Entering flow, qe=V
Sharpness of Flare, S=1.6*(e-v)/l'
M=exp{(D-60)/10}
X2=v+(e-v)/(1+2*S)
F=303*X2
tp=1+.5/(1+M)
fc=.21*tp*(1+.2*X2)
k=1-.00347*(Q-30)-.978*{(1/r)-.05}
Qe=k*(F-fc*Qc) or Qe=0 when fc*Qc>F
d=3600/C+900*T*[V/C-1+sqrt{(V/C-1)^2+(3600/C)*(V/C)/450*T}] where T=analysis time period, hours (T=0.25 for a 15-minute period)
Queue length 95th percentile = 900*T*{V/C-1+sqrt[(1-V/C)^2+(3600/C)*(V/C)/150*T]}*(C/3600) where T is the same as defined for d above

References:

Transportation Research Board, *Highway Capacity Manual,* National Research Council, Special Report 209, Third edition, Washington, D.C., 1998.

United Kingdom Department of Transport, *Geometric Design of Roundabouts,* Design Manual for Roads and Bridges, Volume 6, United Kingdom, 1993.



e
l'
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D
Q
r

Assign each entry leg a number going counter-clockwise around the roundabout as illustrated by figure on the right. Enter data into shaded areas below for each entry leg roundabout has.
For each entry leg present at least one pce/hr must be shown entering or exiting roundabout for the leg. If roundabout has less than five entry legs, then enter zero in the shaded areas for the entry legs not used. (Note: Use of the tab key will toggle through all the data input shaded areas.)
To get accurate results from this spreadsheet the calculated V/C value should not exceed 0.85.

Entering (veh/hr)
(Roundabouts with 3, 4 or 5 legs)

	Exiting (veh/hr)					Entering	Circulating
	X1	X2	X3	X4	X5	pce/hr	pce/hr
E1	0	460	0	10	0	527	494
E2	1	0	370	510	0	978	11
E3	0	0	0	0	0	0	578
E4	0	460	0	0	0	494	1
E5	0	0	0	0	0	0	0

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TOTAL ENTERING ROUNDABOUT (pce/hr) ***2,000***

CAPACITY AT AN ENTRY OF A ROUNDABOUT

	E1	E2	E3	E4	E5
Inscribed diameter, D (m)	30	30	0	30	
Entry width, e (m)	4.8	4.8		4.8	
Approach width, v (m)	4.2	4.2		4.2	
Entry angle, Q (degrees)	35	25		25	
Entry radius, r (m)	35	25		25	
Average effective flare length, l' (m)	10	10		10	
Peak Hour Factor (PHF)	0.90	0.91	0.90	0.94	
% Single-Unit Truck or Bus	0.00%	0.00%	0.00%	0.00%	
% Truck With Trailer	1.00%	1.00%	2.00%	1.00%	

	E1	E2	E3	E4	E5	
ENTRY CAPACITY (pce/hr) C=Qe	**1,132**	**1,457**	**#DIV/0!**	**1,463**		
V/C	**0.47**	**0.67**	**#DIV/0!**	**0.34**		
CONTROL DELAY (sec/veh) d	**5.9**	**7.4**	**#DIV/0!**	**3.7**		
LEVEL OF SERVICE	**A**	**A**	**#DIV/0!**	**A**		**Compared to an unsignalized intersection**
LEVEL OF SERVICE	**A**	**A**	**#DIV/0!**	**A**		**Compared to a signalized intersection**
QUEUE LENGTH 95th percentile (veh)	**2.5**	**5.6**	**#DIV/0!**	**1.5**		

Orange at Eastbound Ramps - 2030 PM Peak - Single Entry

Circulating flow across the entry, Qc (pce/hr)	494	11	578	1	0
S	0.10	0.10	#DIV/0!	0.10	
M	0.05	0.05	0.00	0.05	
X2	4.70	4.70	#DIV/0!	4.70	
F	1425.12	1425.12	#DIV/0!	1425.12	
tp	1.48	1.48	1.50	1.48	
fc	0.60	0.60	#DIV/0!	0.60	
k	1.00	1.03	#DIV/0!	1.03	
Entering flow, qe (pce/hr)	527	978	0	494	0

Definitions:

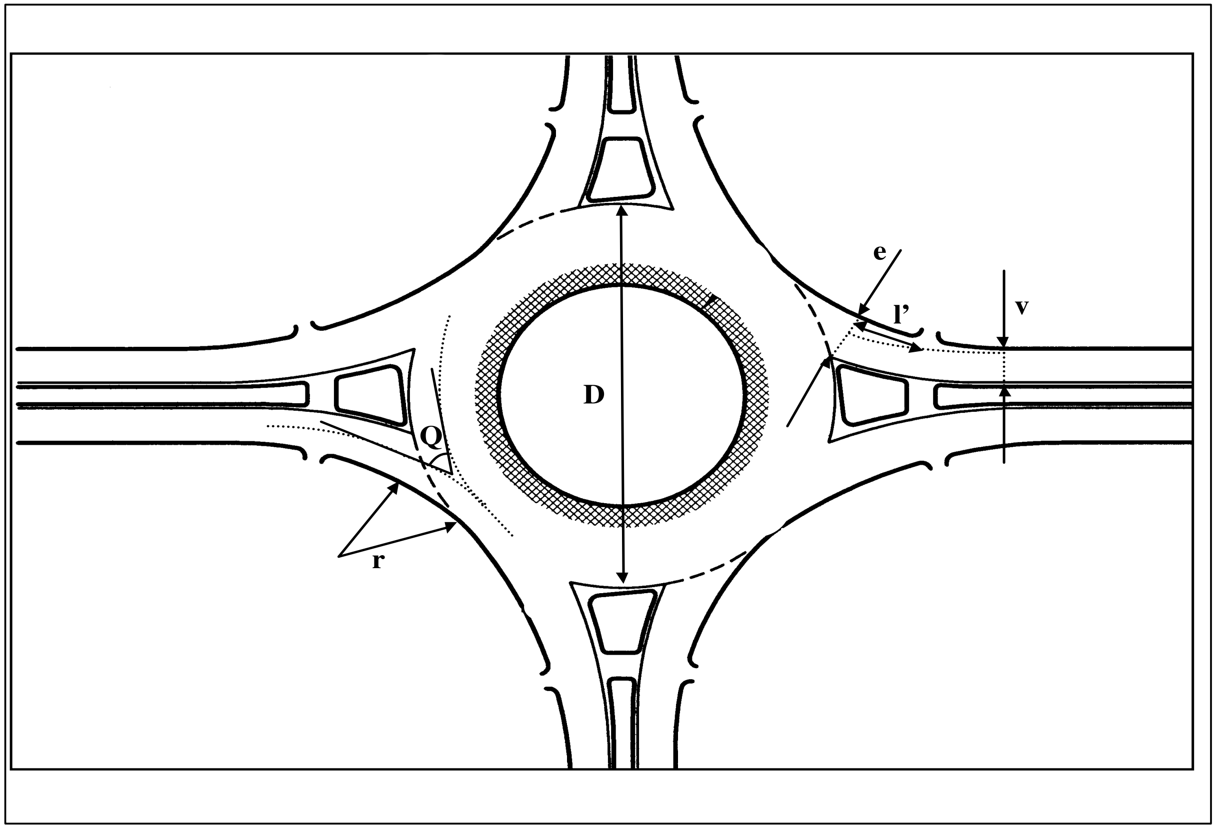
pce/hr - passenger car equivalent per hour
Inscribed Diameter, D - the diameter of the largest circle that can be inscribed within the junction outline
Entry Width, e - measured at the point of maximum entry deflection, from the left hand end of give-way line along a normal to the nearside curb
Approach Width, v - measured at a point in the approach upstream from any entry flare, from the median line (or edge of travelway on dual lane roads) to the nearside curb, along a normal
Entry Angle, Q - serves as a geometric proxy for the conflict angle between entering and circulating streams.
Entry Radius, r - measured as the minimum radius of curvature of the nearside curbline at entry
Average Effective Flare Length, l' - measured along a curve offset from curbline a distance of (e-v)/2 starting from line where e is measured to intersection with a projected curve offset from median a distance v.

Entering flow, qe=V
Sharpness of Flare, S=1.6*(e-v)/l'
M=exp{(D-60)/10}
X2=v+(e-v)/(1+2*S)
F=303*X2
tp=1+.5/(1+M)
fc=.21*tp*(1+.2*X2)
k=1-.00347*(Q-30)-.978*{(1/r)-.05}
Qe=k*(F-fc*Qc) or Qe=0 when fc*Qc>F
d=3600/C+900*T*[V/C-1+sqrt{(V/C-1)^2+(3600/C)*(V/C)/450*T}] where T=analysis time period, hours (T=0.25 for a 15-minute period)
Queue length 95th percentile = 900*T*{V/C-1+sqrt[(1-V/C)^2+(3600/C)*(V/C)/150*T]}*(C/3600) where T is the same as defined for d above

References:

Transportation Research Board, *Highway Capacity Manual,* National Research Council, Special Report 209, Third edition, Washington, D.C., 1998.

United Kingdom Department of Transport, *Geometric Design of Roundabouts,* Design Manual for Roads and Bridges, Volume 6, United Kingdom, 1993.



e
l'
v
D
Q
r

Assign each entry leg a number going counter-clockwise around the roundabout as illustrated by figure on the right. Enter data into shaded areas below for each entry leg roundabout has.
For each entry leg present at least one pce/hr must be shown entering or exiting roundabout for the leg. If roundabout has less than five entry legs, then enter zero in the shaded areas for the entry legs not used. (Note: Use of the tab key will toggle through all the data input shaded areas.)
To get accurate results from this spreadsheet the calculated V/C value should not exceed 0.85.

Entering (veh/hr)
(Roundabouts with 3, 4 or 5 legs)

	Exiting (veh/hr)					Entering	Circulating
	X1	X2	X3	X4	X5	pce/hr	pce/hr
E1	0	570	0	0	5	639	725
E2	0	0	120	0	155	321	6
E3	0	0	0	0	0	0	186
E4	0	640	0	0	0	725	186
E5	0	0	0	0	0	0	725

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TOTAL ENTERING ROUNDABOUT (pce/hr) ***1,685***

CAPACITY AT AN ENTRY OF A ROUNDABOUT

	E1	E2	E3	E4	E5
Inscribed diameter, D (m)	40	40	0	40	
Entry width, e (m)	4	4		4	
Approach width, v (m)	4	4		4	
Entry angle, Q (degrees)	30	30		30	
Entry radius, r (m)	20	20		20	
Average effective flare length, l' (m)	40	40		40	
Peak Hour Factor (PHF)	0.90	0.90	0.90	0.90	
% Single-Unit Truck or Bus	0.00%	0.00%	0.00%	0.00%	
% Truck With Trailer	0.00%	5.00%	2.00%	2.00%	

	E1	E2	E3	E4	E5	
ENTRY CAPACITY (pce/hr) C=Qe	**817**	**1,209**	**#DIV/0!**	**1,111**	**#VALUE!**	
V/C	**0.78**	**0.27**	**#DIV/0!**	**0.65**	**#VALUE!**	
CONTROL DELAY (sec/veh) d	**18.3**	**4.0**	**#DIV/0!**	**9.1**	**#VALUE!**	
LEVEL OF SERVICE	**C**	**A**	**#DIV/0!**	**A**	**#VALUE!**	**Compared to an unsignalized intersection**
LEVEL OF SERVICE	**B**	**A**	**#DIV/0!**	**A**	**#VALUE!**	**Compared to a signalized intersection**
QUEUE LENGTH 95th percentile (veh)	**7.9**	**1.1**	**#DIV/0!**	**5.1**	**#VALUE!**	

Orange 5-Leg - 2030 AM Peak - Single Entry

Circulating flow across the entry, Qc (pce/hr)	725	6	186	186	725
S	0.00	0.00	#DIV/0!	0.00	#VALUE!
M	0.14	0.14	0.00	0.14	#VALUE!
X2	4.00	4.00	#DIV/0!	4.00	#VALUE!
F	1212.00	1212.00	#DIV/0!	1212.00	#VALUE!
tp	1.44	1.44	1.50	1.44	#VALUE!
fc	0.54	0.54	#DIV/0!	0.54	#VALUE!
k	1.00	1.00	#DIV/0!	1.00	#VALUE!
Entering flow, qe (pce/hr)	639	321	0	725	0

Definitions:

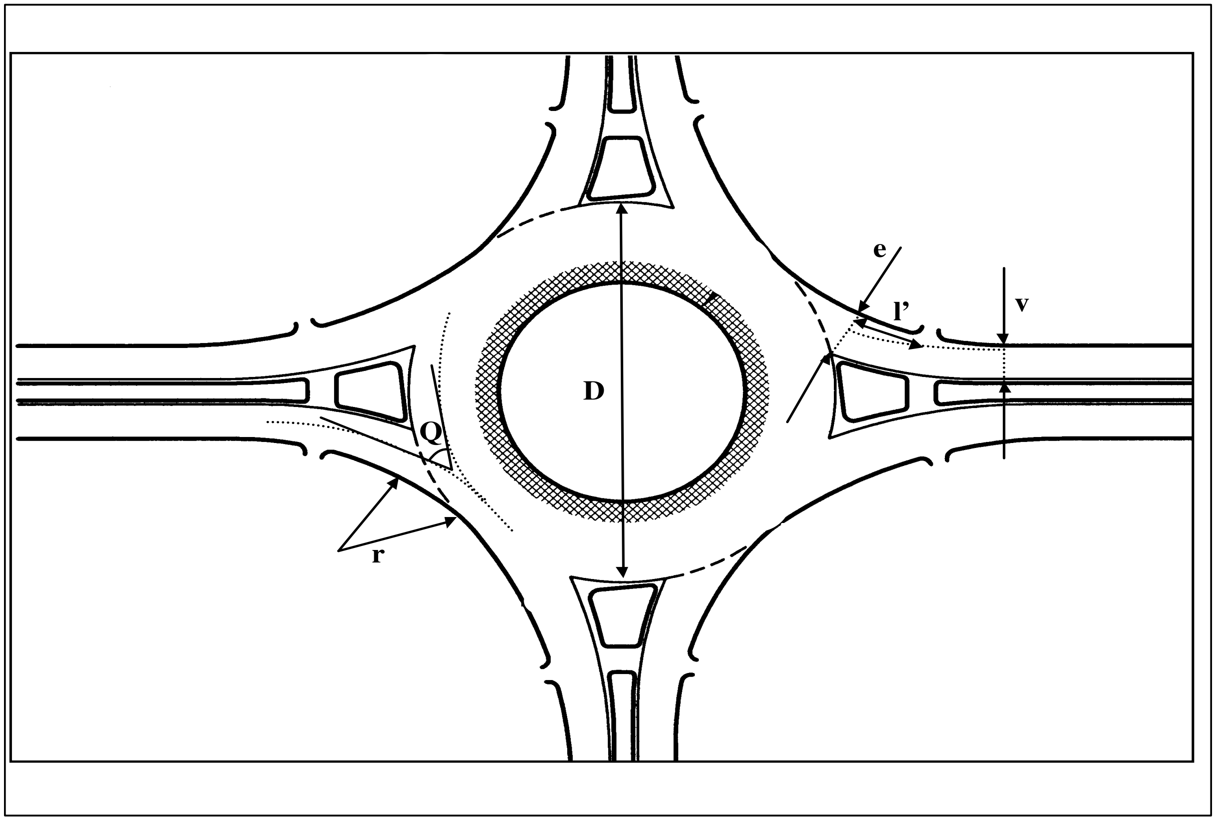
pce/hr - passenger car equivalent per hour
Inscribed Diameter, D - the diameter of the largest circle that can be inscribed within the junction outline
Entry Width, e - measured at the point of maximum entry deflection, from the left hand end of give-way line along a normal to the nearside curb
Approach Width, v - measured at a point in the approach upstream from any entry flare, from the median line (or edge of travelway on dual lane roads) to the nearside curb, along a normal
Entry Angle, Q - serves as a geometric proxy for the conflict angle between entering and circulating streams.
Entry Radius, r - measured as the minimum radius of curvature of the nearside curbline at entry
Average Effective Flare Length, l' - measured along a curve offset from curbline a distance of (e-v)/2 starting from line where e is measured to intersection with a projected curve offset from median a distance v.

Entering flow, qe=V
Sharpness of Flare, S=1.6*(e-v)/l'
M=exp{(D-60)/10}
X2=v+(e-v)/(1+2*S)
F=303*X2
tp=1+.5/(1+M)
fc=.21*tp*(1+.2*X2)
k=1-.00347*(Q-30)-.978*{(1/r)-.05}
Qe=k*(F-fc*Qc) or Qe=0 when fc*Qc>F
d=3600/C+900*T*[V/C-1+sqrt{(V/C-1)^2+(3600/C)*(V/C)/450*T}] where T=analysis time period, hours (T=0.25 for a 15-minute period)
Queue length 95th percentile = 900*T*{V/C-1+sqrt[(1-V/C)^2+(3600/C)*(V/C)/150*T]}*(C/3600) where T is the same as defined for d above

References:

Transportation Research Board, *Highway Capacity Manual,* National Research Council, Special Report 209, Third edition, Washington, D.C., 1998.

United Kingdom Department of Transport, *Geometric Design of Roundabouts,* Design Manual for Roads and Bridges, Volume 6, United Kingdom, 1993.


e
l'
v
D
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Assign each entry leg a number going counter-clockwise around the roundabout as illustrated by figure on the right. Enter data into shaded areas below for each entry leg roundabout has. **For each entry leg present at least one pce/hr must be shown entering or exiting roundabout for the leg.** If roundabout has less than five entry legs, then enter zero in the shaded areas for the entry legs not used. (Note: Use of the tab key will toggle through all the data input shaded areas.)
To get accurate results from this spreadsheet the calculated V/C value should not exceed 0.85.

Entering (veh/hr)
(Roundabouts with 3, 4 or 5 legs)

Exiting (veh/hr)	X1	X2	X3	X4	X5	Entering pce/hr	Circulating pce/hr
E1	0	460	0	0	10	538	494
E2	0	0	370	0	510	977	11
E3	0	0	0	0	0	0	577
E4	0	460	0	0	0	494	577
E5	0	0	0	0	0	0	494

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TOTAL ENTERING ROUNDABOUT (pce/hr) ***2,009***

CAPACITY AT AN ENTRY OF A ROUNDABOUT

	E1	E2	E3	E4	E5	
Inscribed diameter, D (m)	40	40	0	40		
Entry width, e (m)	4	4		4		
Approach width, v (m)	4	4		4		
Entry angle, Q (degrees)	30	30		30		
Entry radius, r (m)	20	20		20		
Average effective flare length, l' (m)	40	40		40		
Peak Hour Factor (PHF)	0.90	0.91	0.90	0.94		
% Single-Unit Truck or Bus	0.00%	0.00%	0.00%	0.00%		
% Truck With Trailer	3.00%	1.00%	2.00%	1.00%		
ENTRY CAPACITY (pce/hr) C=Qe	**943**	**1,206**	**#DIV/0!**	**898**	**#VALUE!**	
V/C	**0.57**	**0.81**	**#DIV/0!**	**0.55**	**#VALUE!**	
CONTROL DELAY (sec/veh) d	**8.8**	**14.2**	**#DIV/0!**	**8.8**	**#VALUE!**	
LEVEL OF SERVICE	**A**	**B**	**#DIV/0!**	**A**	**#VALUE!**	**Compared to an unsignalized intersection**
LEVEL OF SERVICE	**A**	**B**	**#DIV/0!**	**A**	**#VALUE!**	**Compared to a signalized intersection**
QUEUE LENGTH 95th percentile (veh)	**3.7**	**9.6**	**#DIV/0!**	**3.4**	**#VALUE!**	

Orange 5-Leg - 2030 PM Peak - Single Entry

Circulating flow across the entry, Qc (pce/hr)	494	11	577	577	494
S	0.00	0.00	#DIV/0!	0.00	#VALUE!
M	0.14	0.14	0.00	0.14	#VALUE!
X2	4.00	4.00	#DIV/0!	4.00	#VALUE!
F	1212.00	1212.00	#DIV/0!	1212.00	#VALUE!
tp	1.44	1.44	1.50	1.44	#VALUE!
fc	0.54	0.54	#DIV/0!	0.54	#VALUE!
k	1.00	1.00	#DIV/0!	1.00	#VALUE!
Entering flow, qe (pce/hr)	538	977	0	494	0

Definitions:

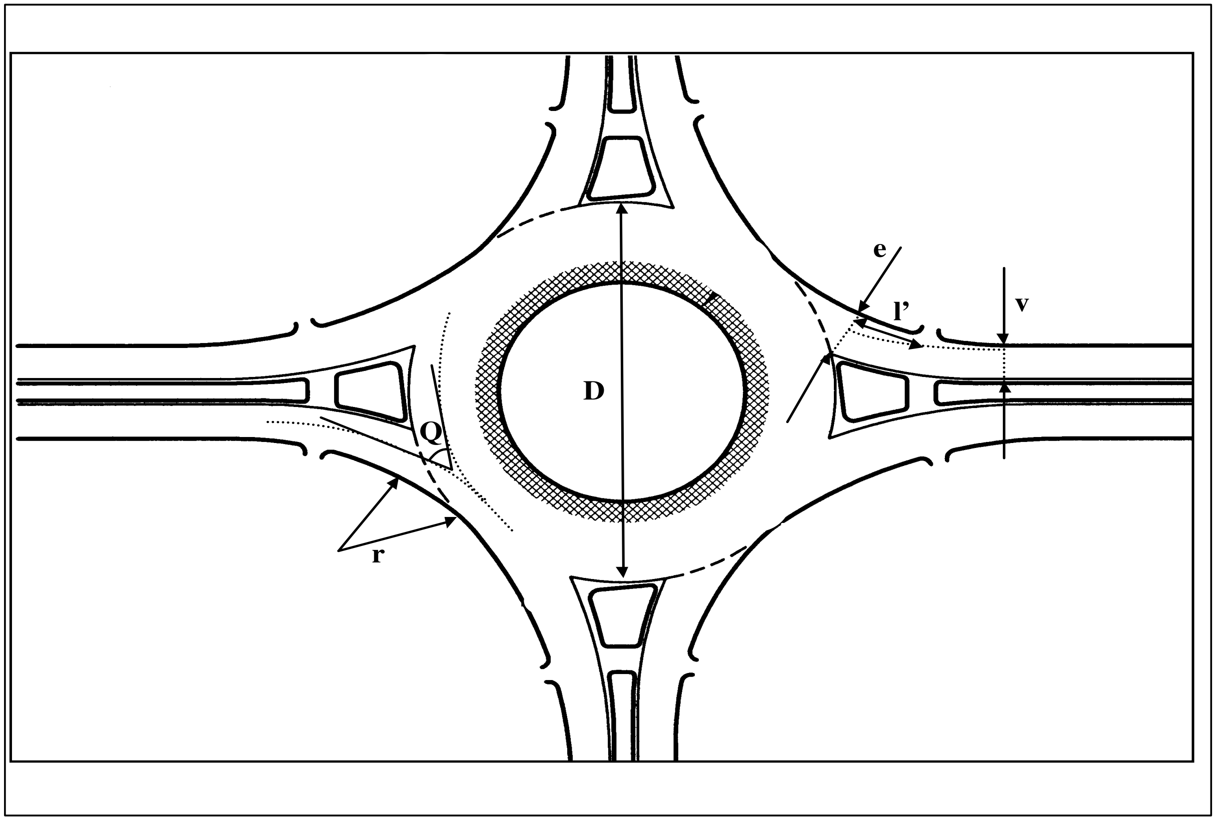
pce/hr - passenger car equivalent per hour
Inscribed Diameter, D - the diameter of the largest circle that can be inscribed within the junction outline
Entry Width, e - measured at the point of maximum entry deflection, from the left hand end of give-way line along a normal to the nearside curb
Approach Width, v - measured at a point in the approach upstream from any entry flare, from the median line (or edge of travelway on dual lane roads) to the nearside curb, along a normal
Entry Angle, Q - serves as a geometric proxy for the conflict angle between entering and circulating streams.
Entry Radius, r - measured as the minimum radius of curvature of the nearside curbline at entry
Average Effective Flare Length, l' - measured along a curve offset from curbline a distance of (e-v)/2 starting from line where e is measured to intersection with a projected curve offset from median a distance v.

Entering flow, qe=V
Sharpness of Flare, S=1.6*(e-v)/l'
M=exp{(D-60)/10}
X2=v+(e-v)/(1+2*S)
F=303*X2
tp=1+.5/(1+M)
fc=.21*tp*(1+.2*X2)
k=1-.00347*(Q-30)-.978*{(1/r)-.05}
Qe=k*(F-fc*Qc) or Qe=0 when fc*Qc>F
d=3600/C+900*T*[V/C-1+sqrt{(V/C-1)^2+(3600/C)*(V/C)/450*T}] where T=analysis time period, hours (T=0.25 for a 15-minute period)
Queue length 95th percentile = 900*T*{V/C-1+sqrt[(1-V/C)^2+(3600/C)*(V/C)/150*T]}*(C/3600) where T is the same as defined for d above

References:

Transportation Research Board, *Highway Capacity Manual,* National Research Council, Special Report 209, Third edition, Washington, D.C., 1998.

United Kingdom Department of Transport, *Geometric Design of Roundabouts,* Design Manual for Roads and Bridges, Volume 6, United Kingdom, 1993.



e
l'
v
D
Q
r

Assign each entry leg a number going counter-clockwise around the roundabout as illustrated by figure on the right. Enter data into shaded areas below for each entry leg roundabout has.
For each entry leg present at least one pce/hr must be shown entering or exiting roundabout for the leg. If roundabout has less than five entry legs, then enter zero in the shaded areas for the entry legs not used. (Note: Use of the tab key will toggle through all the data input shaded areas.)
To get accurate results from this spreadsheet the calculated V/C value should not exceed 0.85.

Entering (veh/hr)
(Roundabouts with 3, 4 or 5 legs)

	Exiting (veh/hr) X1	X2	X3	X4	X5	Entering pce/hr	Circulating pce/hr
E1	0	0	0	0	0	0	932
E2	95	0	0	190	0	329	0
E3	0	255	0	30	0	326	329
E4	180	565	0	0	0	844	402
E5	0	0	0	0	0	0	0

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TOTAL ENTERING ROUNDABOUT (pce/hr) ***1,500***

CAPACITY AT AN ENTRY OF A ROUNDABOUT

	E1	E2	E3	E4	E5
Inscribed diameter, D (m)	0	40	40	40	
Entry width, e (m)	0	4	4	4	
Approach width, v (m)	0	4	4	4	
Entry angle, Q (degrees)	0	30	30	30	
Entry radius, r (m)	0	20	20	20	
Average effective flare length, l' (m)	0	40	40	40	
Peak Hour Factor (PHF)	0.90	0.90	0.90	0.90	
% Single-Unit Truck or Bus	0.00%	0.00%	0.00%	0.00%	
% Truck With Trailer	0.00%	4.00%	3.00%	2.00%	

	E1	E2	E3	E4	E5	
ENTRY CAPACITY (pce/hr) C=Qe	**#DIV/0!**	**1,212**	**1,033**	**993**		
V/C	**#DIV/0!**	**0.27**	**0.32**	**0.85**		
CONTROL DELAY (sec/veh) d	**#DIV/0!**	**4.1**	**5.1**	**20.1**		
LEVEL OF SERVICE	**#DIV/0!**	**A**	**A**	**C**		**Compared to an unsignalized intersection**
LEVEL OF SERVICE	**#DIV/0!**	**A**	**A**	**C**		**Compared to a signalized intersection**
QUEUE LENGTH 95th percentile (veh)	**#DIV/0!**	**1.1**	**1.4**	**10.8**		

Van Buren at Westbound Ramps - 2030 AM Peak - Single Entry

Circulating flow across the entry, Qc (pce/hr)	932	0	329	402	0
S	#DIV/0!	0.00	0.00	0.00	
M	0.00	0.14	0.14	0.14	
X2	#DIV/0!	4.00	4.00	4.00	
F	#DIV/0!	1212.00	1212.00	1212.00	
tp	1.50	1.44	1.44	1.44	
fc	#DIV/0!	0.54	0.54	0.54	
k	#DIV/0!	1.00	1.00	1.00	
Entering flow, qe (pce/hr)	0	329	326	844	0

Definitions:

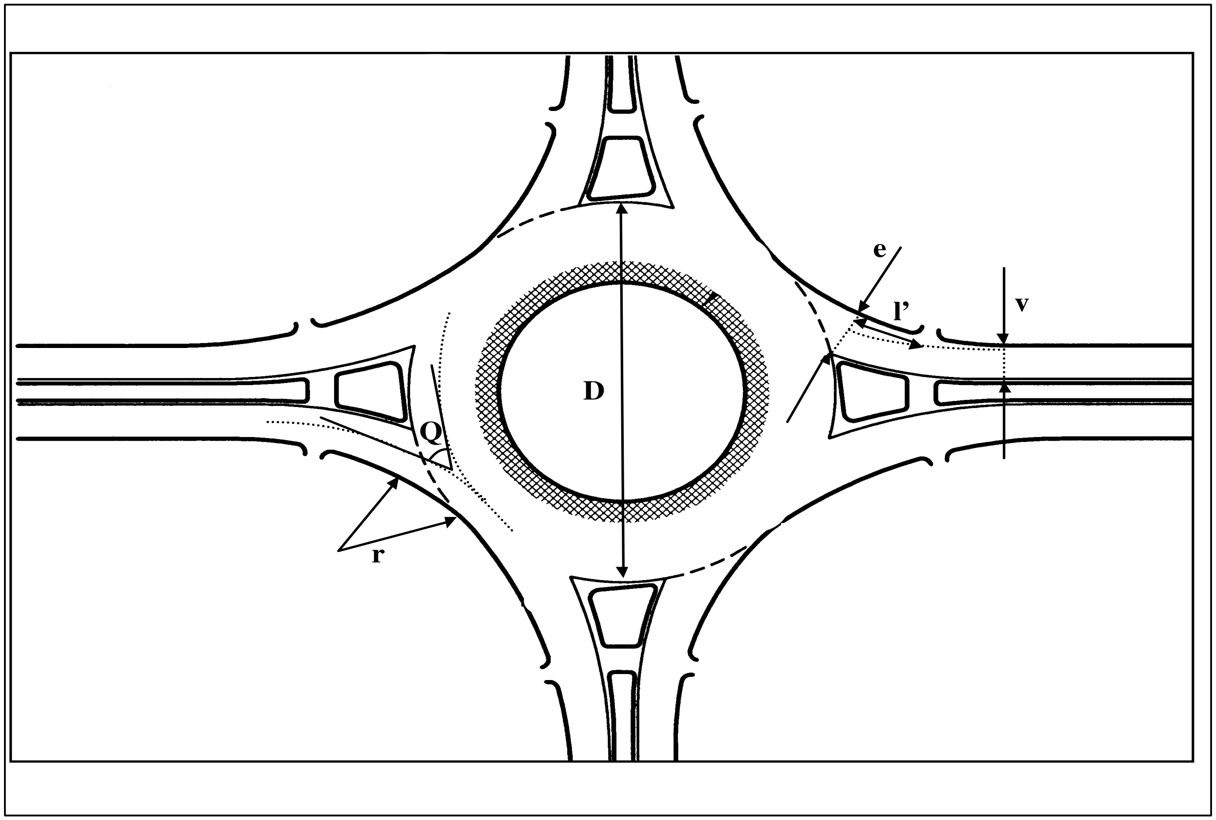
pce/hr - passenger car equivalent per hour
Inscribed Diameter, D - the diameter of the largest circle that can be inscribed within the junction outline
Entry Width, e - measured at the point of maximum entry deflection, from the left hand end of give-way line along a normal to the nearside curb
Approach Width, v - measured at a point in the approach upstream from any entry flare, from the median line (or edge of travelway on dual lane roads) to the nearside curb, along a normal
Entry Angle, Q - serves as a geometric proxy for the conflict angle between entering and circulating streams.
Entry Radius, r - measured as the minimum radius of curvature of the nearside curbline at entry
Average Effective Flare Length, l' - measured along a curve offset from curbline a distance of (e-v)/2 starting from line where e is measured to intersection with a projected curve offset from median a distance v.

Entering flow, qe=V
Sharpness of Flare, S=1.6*(e-v)/l'
M=exp{(D-60)/10}
X2=v+(e-v)/(1+2*S)
F=303*X2
tp=1+.5/(1+M)
fc=.21*tp*(1+.2*X2)
k=1-.00347*(Q-30)-.978*{(1/r)-.05}
Qe=k*(F-fc*Qc) or Qe=0 when fc*Qc>F
d=3600/C+900*T*[V/C-1+sqrt{(V/C-1)^2+(3600/C)*(V/C)/450*T}] where T=analysis time period, hours (T=0.25 for a 15-minute period)
Queue length 95th percentile = 900*T*{V/C-1+sqrt[(1-V/C)^2+(3600/C)*(V/C)/150*T]}*(C/3600) where T is the same as defined for d above

References:

Transportation Research Board, *Highway Capacity Manual,* National Research Council, Special Report 209, Third edition, Washington, D.C., 1998.

United Kingdom Department of Transport, *Geometric Design of Roundabouts,* Design Manual for Roads and Bridges, Volume 6, United Kingdom, 1993.



e
l'
v
D
Q
r

Assign each entry leg a number going counter-clockwise around the roundabout as illustrated by figure on the right. Enter data into shaded areas below for each entry leg roundabout has.
For each entry leg present at least one pce/hr must be shown entering or exiting roundabout for the leg. If roundabout has less than five entry legs, then enter zero in the shaded areas for the entry legs not used. (Note: Use of the tab key will toggle through all the data input shaded areas.)
To get accurate results from this spreadsheet the calculated V/C value should not exceed 0.85.

Entering (veh/hr)
(Roundabouts with 3, 4 or 5 legs)

	Exiting (veh/hr)					Entering	Circulating
	X1	X2	X3	X4	X5	pce/hr	pce/hr
E1	0	0	0	0	0	0	529
E2	210	0	0	730	0	1,055	0
E3	0	165	0	60	0	255	1,055
E4	90	315	0	0	0	440	423
E5	0	0	0	0	0	0	0

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TOTAL ENTERING ROUNDABOUT (pce/hr) ***1,750***

CAPACITY AT AN ENTRY OF A ROUNDABOUT

	E1	E2	E3	E4	E5
Inscribed diameter, D (m)	0	40	40	40	
Entry width, e (m)	0	4	4	4	
Approach width, v (m)	0	4	4	4	
Entry angle, Q (degrees)	0	30	30	30	
Entry radius, r (m)	0	20	20	20	
Average effective flare length, l' (m)	0	40	40	40	
Peak Hour Factor (PHF)	0.90	0.90	0.90	0.93	
% Single-Unit Truck or Bus	0.00%	0.00%	0.00%	0.00%	
% Truck With Trailer	0.00%	1.00%	2.00%	1.00%	
ENTRY CAPACITY (pce/hr) C=Qe	**#DIV/0!**	**1,212**	**638**	**982**	
V/C	**#DIV/0!**	**0.87**	**0.40**	**0.45**	
CONTROL DELAY (sec/veh) d	**#DIV/0!**	**18.7**	**9.4**	**6.6**	
LEVEL OF SERVICE	**#DIV/0!**	**C**	**A**	**A**	
LEVEL OF SERVICE	**#DIV/0!**	**B**	**A**	**A**	
QUEUE LENGTH 95th percentile (veh)	**#DIV/0!**	**12.4**	**1.9**	**2.4**	

Compared to an unsignalized intersection (first LEVEL OF SERVICE row)
Compared to a signalized intersection (second LEVEL OF SERVICE row)

Van Buren at Westbound Ramps - 2030 PM Peak - Single Entry

Circulating flow across the entry, Qc (pce/hr)	529	0	1,055	423	0
S	#DIV/0!	0.00	0.00	0.00	
M	0.00	0.14	0.14	0.14	
X2	#DIV/0!	4.00	4.00	4.00	
F	#DIV/0!	1212.00	1212.00	1212.00	
tp	1.50	1.44	1.44	1.44	
fc	#DIV/0!	0.54	0.54	0.54	
k	#DIV/0!	1.00	1.00	1.00	
Entering flow, qe (pce/hr)	0	1,055	255	440	0

Definitions:

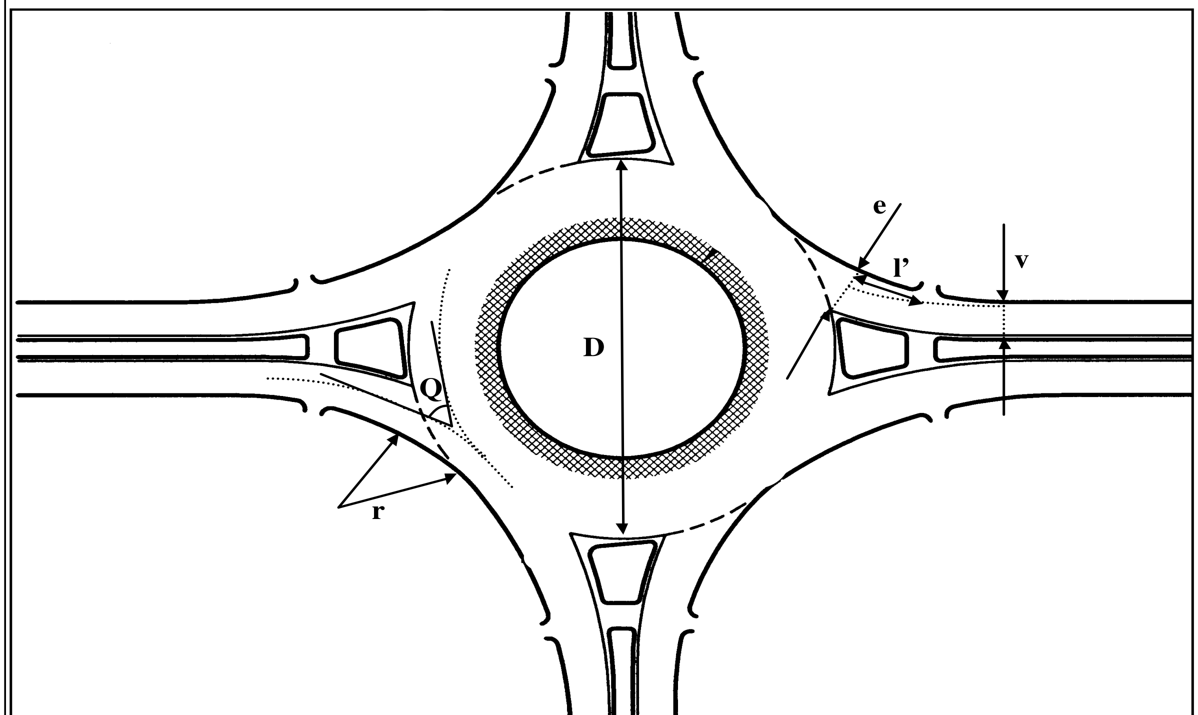
pce/hr - passenger car equivalent per hour
Inscribed Diameter, D - the diameter of the largest circle that can be inscribed within the junction outline
Entry Width, e - measured at the point of maximum entry deflection, from the left hand end of give-way line along a normal to the nearside curb
Approach Width, v - measured at a point in the approach upstream from any entry flare, from the median line (or edge of travelway on dual lane roads) to the nearside curb, along a normal
Entry Angle, Q - serves as a geometric proxy for the conflict angle between entering and circulating streams.
Entry Radius, r - measured as the minimum radius of curvature of the nearside curbline at entry
Average Effective Flare Length, l' - measured along a curve offset from curbline a distance of (e-v)/2 starting from line where e is measured to intersection with a projected curve offset from median a distance v.

Entering flow, qe=V
Sharpness of Flare, S=1.6*(e-v)/l'
M=exp{(D-60)/10}
X2=v+(e-v)/(1+2*S)
F=303*X2
tp=1+.5/(1+M)
fc=.21*tp*(1+.2*X2)
k=1-.00347*(Q-30)-.978*{(1/r)-.05}
Qe=k*(F-fc*Qc) or Qe=0 when fc*Qc>F
d=3600/C+900*T*[V/C-1+sqrt{(V/C-1)^2+(3600/C)*(V/C)/450*T}] where T=analysis time period, hours (T=0.25 for a 15-minute period)
Queue length 95th percentile = 900*T*{V/C-1+sqrt[(1-V/C)^2+(3600/C)*(V/C)/150*T]}*(C/3600) where T is the same as defined for d above

References:

Transportation Research Board, *Highway Capacity Manual,* National Research Council, Special Report 209, Third edition, Washington, D.C., 1998.

United Kingdom Department of Transport, *Geometric Design of Roundabouts,* Design Manual for Roads and Bridges, Volume 6, United Kingdom, 1993.


e
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Assign each entry leg a number going counter-clockwise around the roundabout as illustrated by figure on the right. Enter data into shaded areas below for each entry leg roundabout has. **For each entry leg present at least one pce/hr must be shown entering or exiting roundabout for the leg.** If roundabout has less than five entry legs, then enter zero in the shaded areas for the entry legs not used. (Note: Use of the tab key will toggle through all the data input shaded areas.)
To get accurate results from this spreadsheet the calculated V/C value should not exceed 0.85.

Entering (veh/hr)
(Roundabouts with 3, 4 or 5 legs)

Exiting (veh/hr)	X1	X2	X3	X4	X5	Entering pce/hr	Circulating pce/hr
E1	0	330	0	85	0	461	911
E2	1	0	165	200	0	411	133
E3	0	0	0	0	0	0	320
E4	0	785	35	0	0	911	1
E5	0	0	0	0	0	0	0

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TOTAL ENTERING ROUNDABOUT (pce/hr) ***1,783***

CAPACITY AT AN ENTRY OF A ROUNDABOUT

	E1	E2	E3	E4	E5
Inscribed diameter, D (m)	40	40	0	40	
Entry width, e (m)	4	4	0	4	
Approach width, v (m)	4	4	0	4	
Entry angle, Q (degrees)	30	30	0	30	
Entry radius, r (m)	20	20	0	20	
Average effective flare length, l' (m)	40	40	0	40	
Peak Hour Factor (PHF)	0.90	0.90	0.90	0.90	
% Single-Unit Truck or Bus	0.00%	0.00%	0.00%	0.00%	
% Truck With Trailer	0.00%	1.00%	0.00%	0.00%	

	E1	E2	E3	E4	E5	
ENTRY CAPACITY (pce/hr) C=Qe	716	1,139	#DIV/0!	1,211		
V/C	0.64	0.36	#DIV/0!	0.75		
CONTROL DELAY (sec/veh) d	13.7	4.9	#DIV/0!	11.4		
LEVEL OF SERVICE	B	A	#DIV/0!	B		Compared to an unsignalized intersection
LEVEL OF SERVICE	B	A	#DIV/0!	B		Compared to a signalized intersection
QUEUE LENGTH 95th percentile (veh)	4.7	1.7	#DIV/0!	7.6		

Van Buren at Eastbound Ramps- 2030 AM Peak - Single Entry

Circulating flow across the entry, Qc (pce/hr)	911	133	320	1	0
S	0.00	0.00	#DIV/0!	0.00	
M	0.14	0.14	0.00	0.14	
X2	4.00	4.00	#DIV/0!	4.00	
F	1212.00	1212.00	#DIV/0!	1212.00	
tp	1.44	1.44	1.50	1.44	
fc	0.54	0.54	#DIV/0!	0.54	
k	1.00	1.00	#DIV/0!	1.00	
Entering flow, qe (pce/hr)	461	411	0	911	0

Definitions:

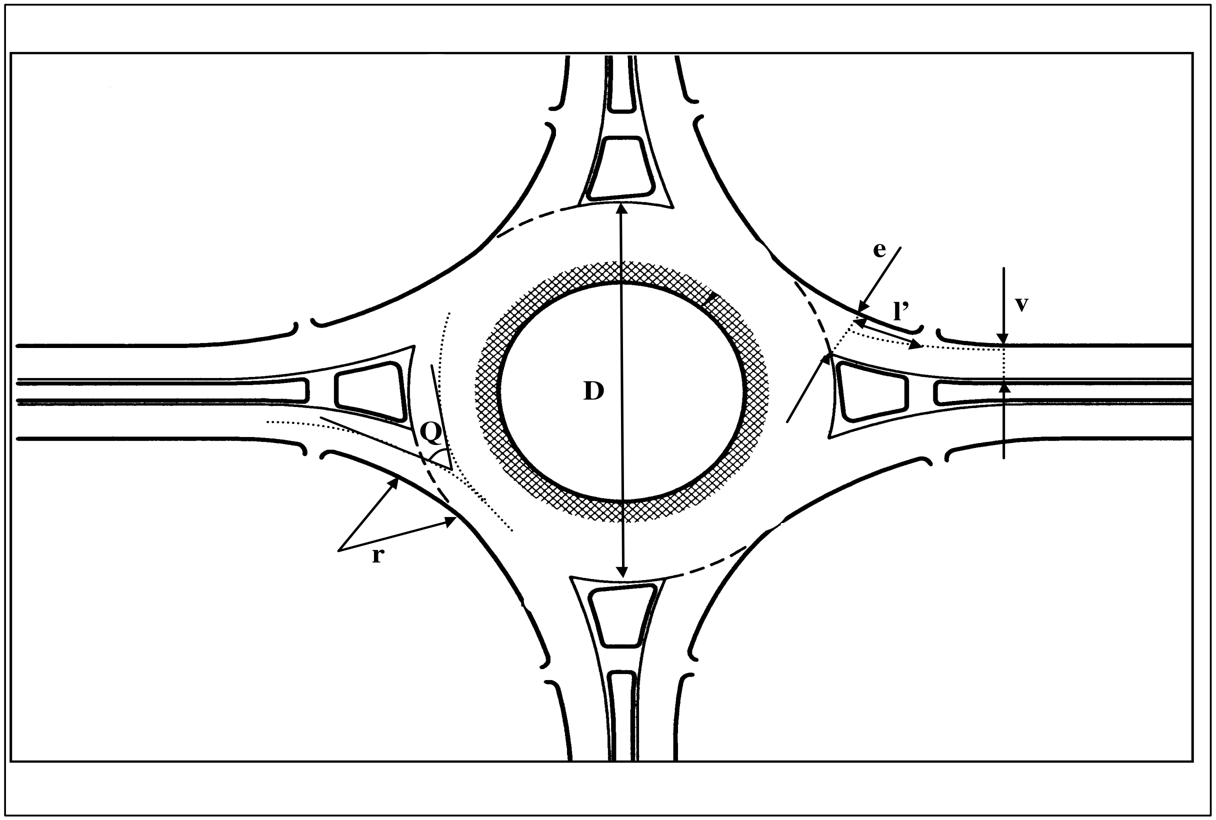
pce/hr - passenger car equivalent per hour
Inscribed Diameter, D - the diameter of the largest circle that can be inscribed within the junction outline
Entry Width, e - measured at the point of maximum entry deflection, from the left hand end of give-way line along a normal to the nearside curb
Approach Width, v - measured at a point in the approach upstream from any entry flare, from the median line (or edge of travelway on dual lane roads) to the nearside curb, along a normal
Entry Angle, Q - serves as a geometric proxy for the conflict angle between entering and circulating streams.
Entry Radius, r - measured as the minimum radius of curvature of the nearside curbline at entry
Average Effective Flare Length, l' - measured along a curve offset from curbline a distance of (e-v)/2 starting from line where e is measured to intersection with a projected curve offset from median a distance v.

Entering flow, qe=V
Sharpness of Flare, S=1.6*(e-v)/l'
M=exp{(D-60)/10}
X2=v+(e-v)/(1+2*S)
F=303*X2
tp=1+.5/(1+M)
fc=.21*tp*(1+.2*X2)
k=1-.00347*(Q-30)-.978*{(1/r)-.05}
Qe=k*(F-fc*Qc) or Qe=0 when fc*Qc>F
d=3600/C+900*T*[V/C-1+sqrt{(V/C-1)^2+(3600/C)*(V/C)/450*T}] where T=analysis time period, hours (T=0.25 for a 15-minute period)
Queue length 95th percentile = 900*T*{V/C-1+sqrt[(1-V/C)^2+(3600/C)*(V/C)/150*T]}*(C/3600) where T is the same as defined for d above

References:

Transportation Research Board, *Highway Capacity Manual,* National Research Council, Special Report 209, Third edition, Washington, D.C., 1998.

United Kingdom Department of Transport, *Geometric Design of Roundabouts,* Design Manual for Roads and Bridges, Volume 6, United Kingdom, 1993.



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Assign each entry leg a number going counter-clockwise around the roundabout as illustrated by figure on the right. Enter data into shaded areas below for each entry leg roundabout has.
For each entry leg present at least one pce/hr must be shown entering or exiting roundabout for the leg. If roundabout has less than five entry legs, then enter zero in the shaded areas for the entry legs not used. (Note: Use of the tab key will toggle through all the data input shaded areas.)
To get accurate results from this spreadsheet the calculated V/C value should not exceed 0.85.

Entering (veh/hr)
(Roundabouts with 3, 4 or 5 legs)

	Exiting (veh/hr)					Entering	Circulating
	X1	X2	X3	X4	X5	pce/hr	pce/hr
E1	0	135	0	155	0	325	505
E2	1	0	330	785	0	1,252	195
E3	0	0	0	0	0	0	1,056
E4	0	460	20	0	0	505	1
E5	0	0	0	0	0	0	0

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TOTAL ENTERING ROUNDABOUT (pce/hr) **2,083**

CAPACITY AT AN ENTRY OF A ROUNDABOUT

	E1	E2	E3	E4	E5
Inscribed diameter, D (m)	40	40	0	40	
Entry width, e (m)	4	4	0	4	
Approach width, v (m)	4	4	0	4	
Entry angle, Q (degrees)	30	30	0	30	
Entry radius, r (m)	20	20	0	20	
Average effective flare length, l' (m)	40	40	0	40	
Peak Hour Factor (PHF)	0.90	0.90	0.90	0.97	
% Single-Unit Truck or Bus	0.00%	0.00%	0.00%	0.00%	
% Truck With Trailer	1.00%	1.00%	0.00%	2.00%	
ENTRY CAPACITY (pce/hr) C=Qe	**937**	**1,106**	**#DIV/0!**	**1,211**	
V/C	**0.35**	**1.13**	**#DIV/0!**	**0.42**	
CONTROL DELAY (sec/veh) d	**5.9**	**83.6**	**#DIV/0!**	**5.1**	
LEVEL OF SERVICE	**A**	**F**	**#DIV/0!**	**A**	Compared to an unsignalized intersection
LEVEL OF SERVICE	**A**	**F**	**#DIV/0!**	**A**	Compared to a signalized intersection
QUEUE LENGTH 95th percentile (veh)	**1.6**	**32.7**	**#DIV/0!**	**2.1**	

Van Buren at Eastbound Ramps - 2030 PM Peak - Single Entry

Circulating flow across the entry, Qc (pce/hr)	505	195	1,056	1	0
S	0.00	0.00	#DIV/0!	0.00	
M	0.14	0.14	0.00	0.14	
X2	4.00	4.00	#DIV/0!	4.00	
F	1212.00	1212.00	#DIV/0!	1212.00	
tp	1.44	1.44	1.50	1.44	
fc	0.54	0.54	#DIV/0!	0.54	
k	1.00	1.00	#DIV/0!	1.00	
Entering flow, qe (pce/hr)	325	1,252	0	505	0

Definitions:

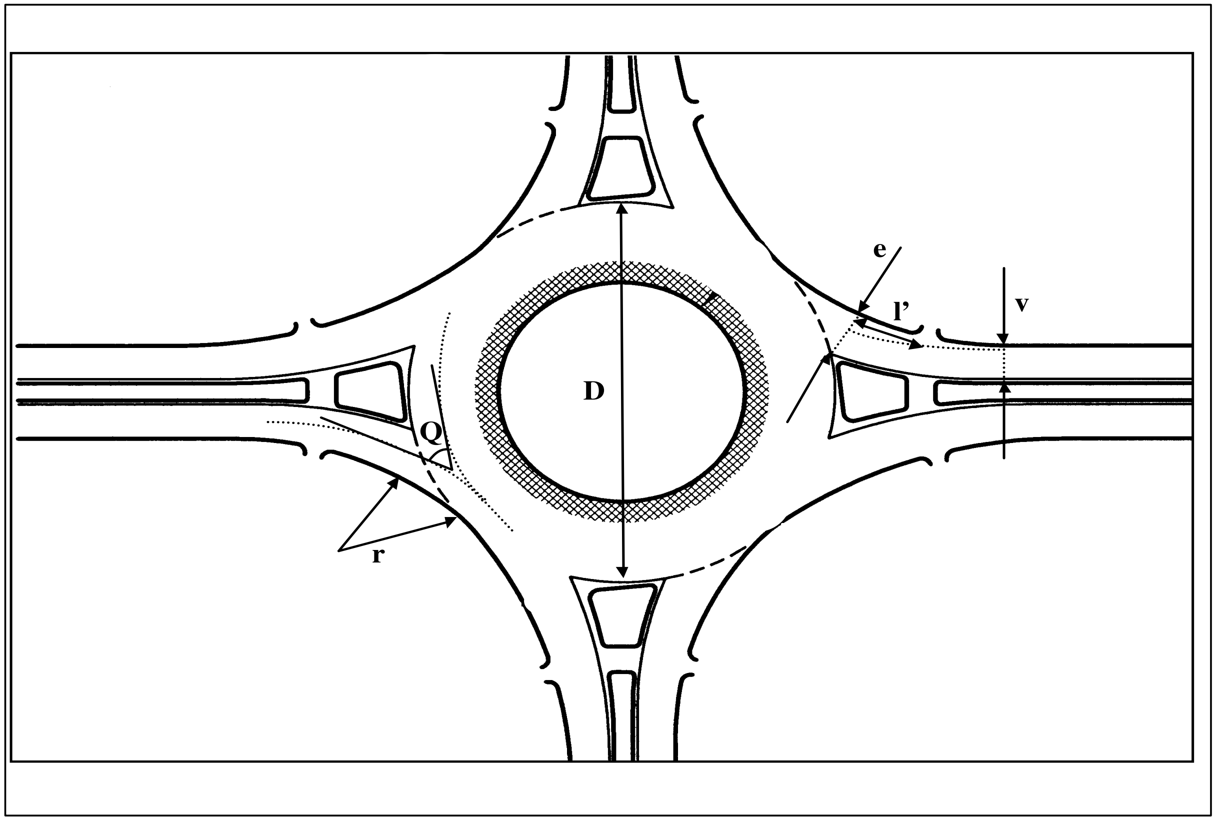
pce/hr - passenger car equivalent per hour
Inscribed Diameter, D - the diameter of the largest circle that can be inscribed within the junction outline
Entry Width, e - measured at the point of maximum entry deflection, from the left hand end of give-way line along a normal to the nearside curb
Approach Width, v - measured at a point in the approach upstream from any entry flare, from the median line (or edge of travelway on dual lane roads) to the nearside curb, along a normal
Entry Angle, Q - serves as a geometric proxy for the conflict angle between entering and circulating streams.
Entry Radius, r - measured as the minimum radius of curvature of the nearside curbline at entry
Average Effective Flare Length, l' - measured along a curve offset from curbline a distance of (e-v)/2 starting from line where e is measured to intersection with a projected curve offset from median a distance v.

Entering flow, qe=V
Sharpness of Flare, S=1.6*(e-v)/l'
M=exp{(D-60)/10}
X2=v+(e-v)/(1+2*S)
F=303*X2
tp=1+.5/(1+M)
fc=.21*tp*(1+.2*X2)
k=1-.00347*(Q-30)-.978*{(1/r)-.05}
Qe=k*(F-fc*Qc) or Qe=0 when fc*Qc>F
d=3600/C+900*T*[V/C-1+sqrt{(V/C-1)^2+(3600/C)*(V/C)/450*T}] where T=analysis time period, hours (T=0.25 for a 15-minute period)
Queue length 95th percentile = 900*T*{V/C-1+sqrt[(1-V/C)^2+(3600/C)*(V/C)/150*T]}*(C/3600) where T is the same as defined for d above

References:

Transportation Research Board, *Highway Capacity Manual,* National Research Council, Special Report 209, Third edition, Washington, D.C., 1998.

United Kingdom Department of Transport, *Geometric Design of Roundabouts,* Design Manual for Roads and Bridges, Volume 6, United Kingdom, 1993.



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Assign each entry leg a number going counter-clockwise around the roundabout as illustrated by figure on the right. Enter data into shaded areas below for each entry leg roundabout has.
For each entry leg present at least one pce/hr must be shown entering or exiting roundabout for the leg. If roundabout has less than five entry legs, then enter zero in the shaded areas for the entry legs not used. (Note: Use of the tab key will toggle through all the data input shaded areas.)
To get accurate results from this spreadsheet the calculated V/C value should not exceed 0.85.

Entering (veh/hr)
(Roundabouts with 3, 4 or 5 legs)

Exiting (veh/hr)	X1	X2	X3	X4	X5	Entering pce/hr	Circulating pce/hr
E1	0	0	0	0	0	0	932
E2	95	0	0	190	0	329	0
E3	0	255	0	30	0	326	329
E4	180	565	0	0	0	844	402
E5	0	0	0	0	0	0	0

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TOTAL ENTERING ROUNDABOUT (pce/hr) ***1,500***

CAPACITY AT AN ENTRY OF A ROUNDABOUT

	E1	E2	E3	E4	E5
Inscribed diameter, D (m)	0	55	55	55	
Entry width, e (m)	0	8	8	8	
Approach width, v (m)	0	8	8	8	
Entry angle, Q (degrees)	0	30	30	30	
Entry radius, r (m)	0	20	20	20	
Average effective flare length, l' (m)	0	40	40	40	
Peak Hour Factor (PHF)	0.90	0.90	0.90	0.90	
% Single-Unit Truck or Bus	0.00%	0.00%	0.00%	0.00%	
% Truck With Trailer	0.00%	4.00%	3.00%	2.00%	

	E1	E2	E3	E4	E5	
ENTRY CAPACITY (pce/hr) C=Qe	**#DIV/0!**	**2,424**	**2,188**	**2,136**		
V/C	**#DIV/0!**	**0.14**	**0.15**	**0.40**		
CONTROL DELAY (sec/veh) d	**#DIV/0!**	**1.7**	**1.9**	**2.8**		
LEVEL OF SERVICE	**#DIV/0!**	**A**	**A**	**A**		**Compared to an unsignalized intersection**
LEVEL OF SERVICE	**#DIV/0!**	**A**	**A**	**A**		**Compared to a signalized intersection**
QUEUE LENGTH 95th percentile (veh)	**#DIV/0!**	**0.5**	**0.5**	**1.9**		

Van Buren at Westbound Ramps - 2030 AM Peak - Dual Entry

Circulating flow across the entry, Qc (pce/hr)	932	0	329	402	0
S	#DIV/0!	0.00	0.00	0.00	
M	0.00	0.61	0.61	0.61	
X2	#DIV/0!	8.00	8.00	8.00	
F	#DIV/0!	2424.00	2424.00	2424.00	
tp	1.50	1.31	1.31	1.31	
fc	#DIV/0!	0.72	0.72	0.72	
k	#DIV/0!	1.00	1.00	1.00	
Entering flow, qe (pce/hr)	0	329	326	844	0

Definitions:

pce/hr - passenger car equivalent per hour
Inscribed Diameter, D - the diameter of the largest circle that can be inscribed within the junction outline
Entry Width, e - measured at the point of maximum entry deflection, from the left hand end of give-way line along a normal to the nearside curb
Approach Width, v - measured at a point in the approach upstream from any entry flare, from the median line (or edge of travelway on dual lane roads) to the nearside curb, along a normal
Entry Angle, Q - serves as a geometric proxy for the conflict angle between entering and circulating streams.
Entry Radius, r - measured as the minimum radius of curvature of the nearside curbline at entry
Average Effective Flare Length, l' - measured along a curve offset from curbline a distance of (e-v)/2 starting from line where e is measured to intersection with a projected curve offset from median a distance v.

Entering flow, qe=V
Sharpness of Flare, S=1.6*(e-v)/l'
M=exp{(D-60)/10}
X2=v+(e-v)/(1+2*S)
F=303*X2
tp=1+.5/(1+M)
fc=.21*tp*(1+.2*X2)
k=1-.00347*(Q-30)-.978*{(1/r)-.05}
Qe=k*(F-fc*Qc) or Qe=0 when fc*Qc>F
d=3600/C+900*T*[V/C-1+sqrt{(V/C-1)^2+(3600/C)*(V/C)/450*T}] where T=analysis time period, hours (T=0.25 for a 15-minute period)
Queue length 95th percentile = 900*T*{V/C-1+sqrt[(1-V/C)^2+(3600/C)*(V/C)/150*T]}*(C/3600) where T is the same as defined for d above

References:

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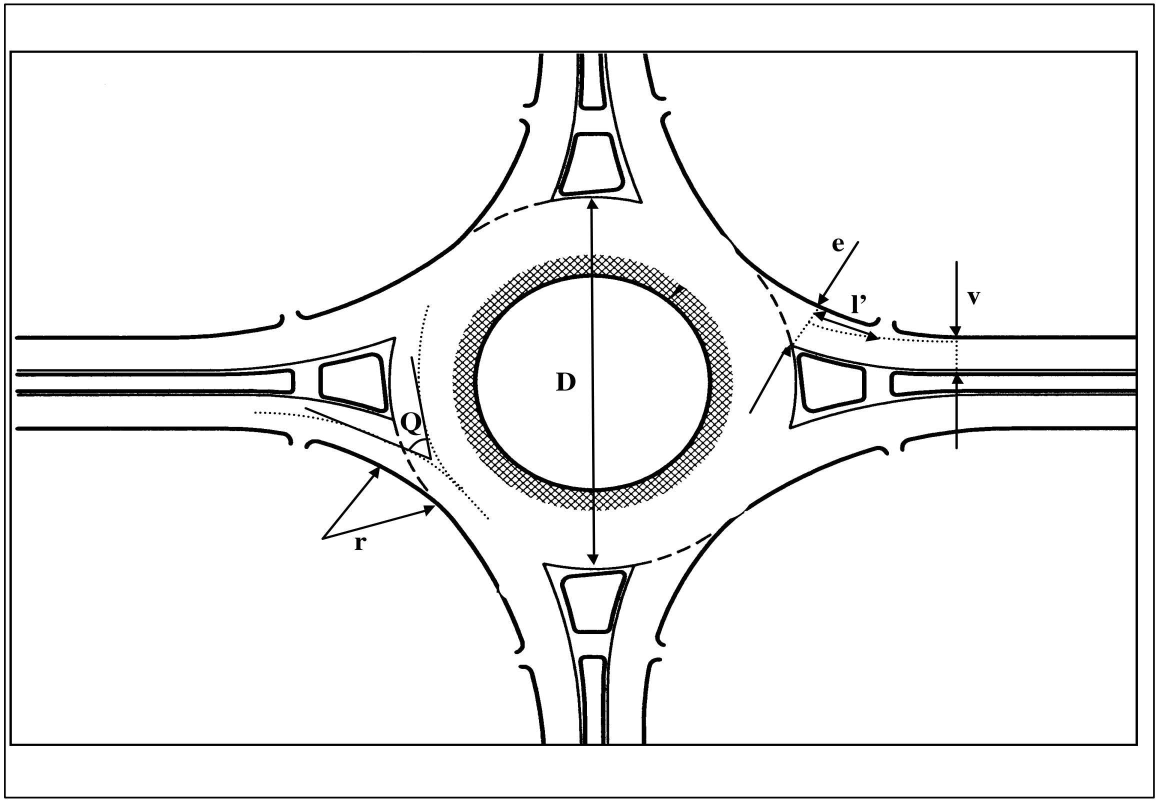

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Assign each entry leg a number going counter-clockwise around the roundabout as illustrated by figure on the right. Enter data into shaded areas below for each entry leg roundabout has.
For each entry leg present at least one pce/hr must be shown entering or exiting roundabout for the leg. If roundabout has less than five entry legs, then enter zero in the shaded areas for the entry legs not used. (Note: Use of the tab key will toggle through all the data input shaded areas.)
To get accurate results from this spreadsheet the calculated V/C value should not exceed 0.85.

Entering (veh/hr)
(Roundabouts with 3, 4 or 5 legs)

	Exiting (veh/hr) X1	X2	X3	X4	X5	Entering pce/hr	Circulating pce/hr
E1	0	0	0	0	0	0	529
E2	210	0	0	730	0	1,055	0
E3	0	165	0	60	0	255	1,055
E4	90	315	0	0	0	440	423
E5	0	0	0	0	0	0	0

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TOTAL ENTERING ROUNDABOUT (pce/hr) ***1,750***

CAPACITY AT AN ENTRY OF A ROUNDABOUT

	E1	E2	E3	E4	E5
Inscribed diameter, D (m)	0	55	55	55	
Entry width, e (m)	0	8	8	8	
Approach width, v (m)	0	8	8	8	
Entry angle, Q (degrees)	0	30	30	30	
Entry radius, r (m)	0	20	20	20	
Average effective flare length, l' (m)	0	40	40	40	
Peak Hour Factor (PHF)	0.90	0.90	0.90	0.93	
% Single-Unit Truck or Bus	0.00%	0.00%	0.00%	0.00%	
% Truck With Trailer	0.00%	1.00%	2.00%	1.00%	

	E1	E2	E3	E4	E5	
ENTRY CAPACITY (pce/hr) C=Qe	**#DIV/0!**	**2,424**	**1,669**	**2,121**		
V/C	**#DIV/0!**	**0.44**	**0.15**	**0.21**		
CONTROL DELAY (sec/veh) d	**#DIV/0!**	**2.6**	**2.5**	**2.1**		
LEVEL OF SERVICE	**#DIV/0!**	**A**	**A**	**A**		**Compared to an unsignalized intersection**
LEVEL OF SERVICE	**#DIV/0!**	**A**	**A**	**A**		**Compared to a signalized intersection**
QUEUE LENGTH 95th percentile (veh)	**#DIV/0!**	**2.3**	**0.5**	**0.8**		

Van Buren at Westbound Ramps - 2030 PM Peak - Dual Entry

Circulating flow across the entry, Qc (pce/hr)	529	0	1,055	423	0
S	#DIV/0!	0.00	0.00	0.00	
M	0.00	0.61	0.61	0.61	
X2	#DIV/0!	8.00	8.00	8.00	
F	#DIV/0!	2424.00	2424.00	2424.00	
tp	1.50	1.31	1.31	1.31	
fc	#DIV/0!	0.72	0.72	0.72	
k	#DIV/0!	1.00	1.00	1.00	
Entering flow, qe (pce/hr)	0	1,055	255	440	0

Definitions:

pce/hr - passenger car equivalent per hour
Inscribed Diameter, D - the diameter of the largest circle that can be inscribed within the junction outline
Entry Width, e - measured at the point of maximum entry deflection, from the left hand end of give-way line along a normal to the nearside curb
Approach Width, v - measured at a point in the approach upstream from any entry flare, from the median line (or edge of travelway on dual lane roads) to the nearside curb, along a normal
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Entry Radius, r - measured as the minimum radius of curvature of the nearside curbline at entry
Average Effective Flare Length, l' - measured along a curve offset from curbline a distance of (e-v)/2 starting from line where e is measured to intersection with a projected curve offset from median a distance v.

Entering flow, qe=V
Sharpness of Flare, S=1.6*(e-v)/l'
M=exp{(D-60)/10}
X2=v+(e-v)/(1+2*S)
F=303*X2
tp=1+.5/(1+M)
fc=.21*tp*(1+.2*X2)
k=1-.00347*(Q-30)-.978*{(1/r)-.05}
Qe=k*(F-fc*Qc) or Qe=0 when fc*Qc>F
d=3600/C+900*T*[V/C-1+sqrt{(V/C-1)^2+(3600/C)*(V/C)/450*T}] where T=analysis time period, hours (T=0.25 for a 15-minute period)
Queue length 95th percentile = 900*T*{V/C-1+sqrt[(1-V/C)^2+(3600/C)*(V/C)/150*T]}*(C/3600) where T is the same as defined for d above

References:

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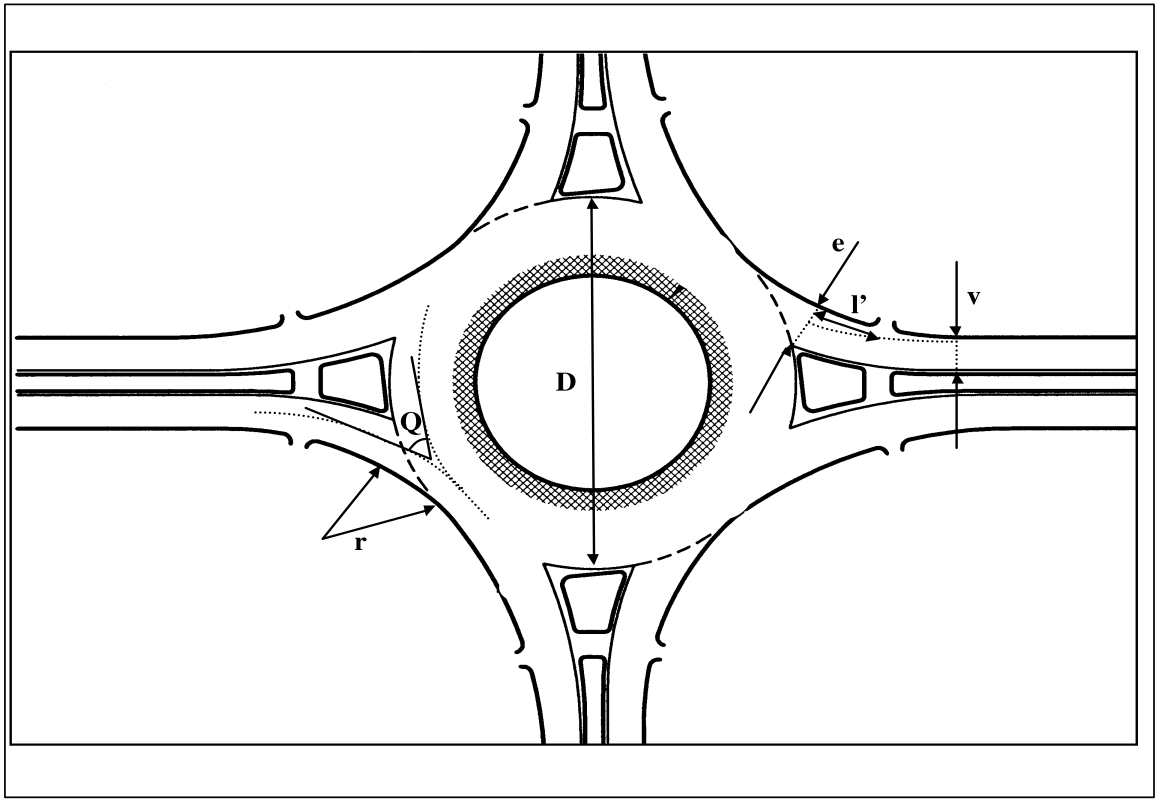

e
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Assign each entry leg a number going counter-clockwise around the roundabout as illustrated by figure on the right. Enter data into shaded areas below for each entry leg roundabout has. **For each entry leg present at least one pce/hr must be shown entering or exiting roundabout for the leg.** If roundabout has less than five entry legs, then enter zero in the shaded areas for the entry legs not used. (Note: Use of the tab key will toggle through all the data input shaded areas.)

To get accurate results from this spreadsheet the calculated V/C value should not exceed 0.85.

Entering (veh/hr)
(Roundabouts with 3, 4 or 5 legs)

Exiting (veh/hr)	X1	X2	X3	X4	X5	Entering pce/hr	Circulating pce/hr
E1	0	330	0	85	0	461	911
E2	1	0	165	200	0	411	133
E3	0	0	0	0	0	0	320
E4	0	785	35	0	0	911	1
E5	0	0	0	0	0	0	0

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TOTAL ENTERING ROUNDABOUT (pce/hr) ***1,783***

CAPACITY AT AN ENTRY OF A ROUNDABOUT

	E1	E2	E3	E4	E5
Inscribed diameter, D (m)	55	55	0	55	
Entry width, e (m)	8	8	0	8	
Approach width, v (m)	8	8	0	8	
Entry angle, Q (degrees)	30	30	0	30	
Entry radius, r (m)	20	20	0	20	
Average effective flare length, l' (m)	40	40	0	40	
Peak Hour Factor (PHF)	0.90	0.90	0.90	0.90	
% Single-Unit Truck or Bus	0.00%	0.00%	0.00%	0.00%	
% Truck With Trailer	0.00%	1.00%	0.00%	0.00%	
ENTRY CAPACITY (pce/hr) C=Qe	**1,772**	**2,329**	**#DIV/0!**	**2,423**	
V/C	**0.26**	**0.18**	**#DIV/0!**	**0.38**	
CONTROL DELAY (sec/veh) d	**2.7**	**1.9**	**#DIV/0!**	**2.4**	
LEVEL OF SERVICE	**A**	**A**	**#DIV/0!**	**A**	Compared to an unsignalized intersection
LEVEL OF SERVICE	**A**	**A**	**#DIV/0!**	**A**	Compared to a signalized intersection
QUEUE LENGTH 95th percentile (veh)	**1.0**	**0.6**	**#DIV/0!**	**1.8**	

Van Buren at Eastbound Ramps - 2030 AM Peak - Dual Entry

Circulating flow across the entry, Qc (pce/hr)	911	133	320	1	0
S	0.00	0.00	#DIV/0!	0.00	
M	0.61	0.61	0.00	0.61	
X2	8.00	8.00	#DIV/0!	8.00	
F	2424.00	2424.00	#DIV/0!	2424.00	
tp	1.31	1.31	1.50	1.31	
fc	0.72	0.72	#DIV/0!	0.72	
k	1.00	1.00	#DIV/0!	1.00	
Entering flow, qe (pce/hr)	461	411	0	911	0

Definitions:

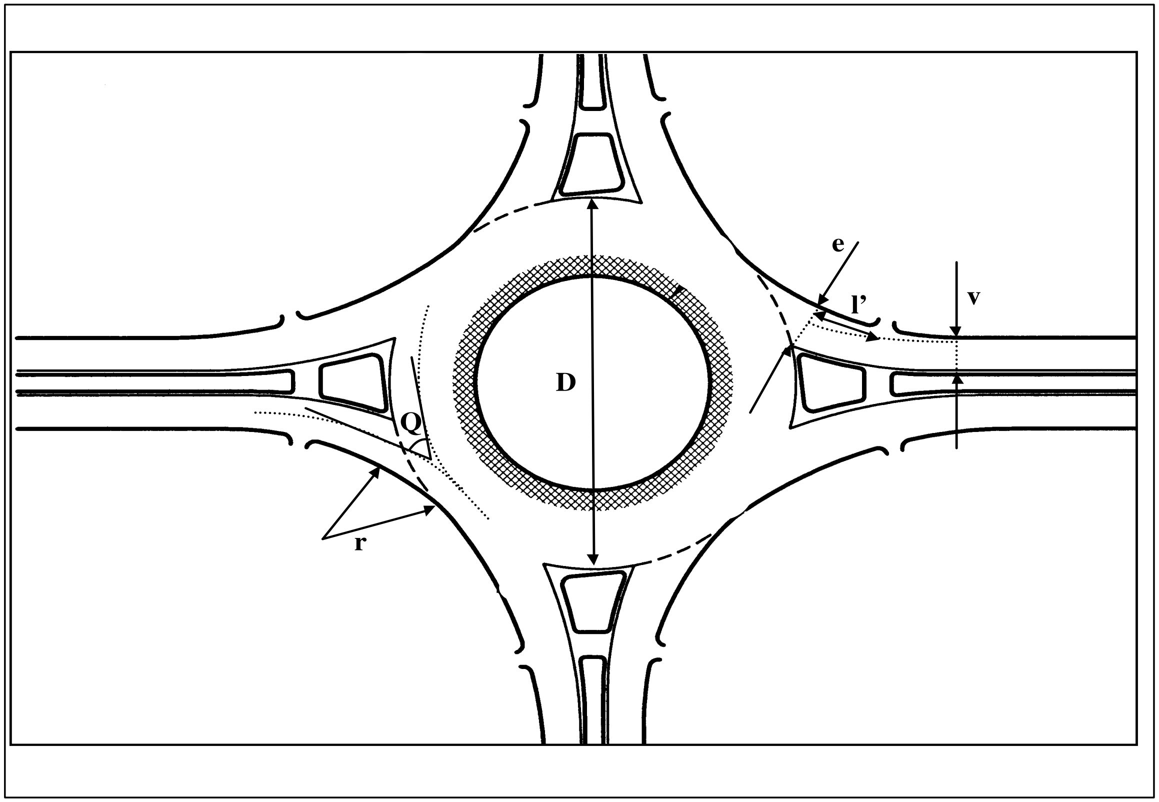
pce/hr - passenger car equivalent per hour
Inscribed Diameter, D - the diameter of the largest circle that can be inscribed within the junction outline
Entry Width, e - measured at the point of maximum entry deflection, from the left hand end of give-way line along a normal to the nearside curb
Approach Width, v - measured at a point in the approach upstream from any entry flare, from the median line (or edge of travelway on dual lane roads) to the nearside curb, along a normal
Entry Angle, Q - serves as a geometric proxy for the conflict angle between entering and circulating streams.
Entry Radius, r - measured as the minimum radius of curvature of the nearside curbline at entry
Average Effective Flare Length, l' - measured along a curve offset from curbline a distance of (e-v)/2 starting from line where e is measured to intersection with a projected curve offset from median a distance v.

Entering flow, qe=V
Sharpness of Flare, S=1.6*(e-v)/l'
M=exp{(D-60)/10}
X2=v+(e-v)/(1+2*S)
F=303*X2
tp=1+.5/(1+M)
fc=.21*tp*(1+.2*X2)
k=1-.00347*(Q-30)-.978*{(1/r)-.05}
Qe=k*(F-fc*Qc) or Qe=0 when fc*Qc>F
d=3600/C+900*T*[V/C-1+sqrt{(V/C-1)^2+(3600/C)*(V/C)/450*T}] where T=analysis time period, hours (T=0.25 for a 15-minute period)
Queue length 95th percentile = 900*T*{V/C-1+sqrt[(1-V/C)^2+(3600/C)*(V/C)/150*T]}*(C/3600) where T is the same as defined for d above

References:

Transportation Research Board, *Highway Capacity Manual,* National Research Council,
Special Report 209, Third edition, Washington, D.C., 1998.

United Kingdom Department of Transport, *Geometric Design of Roundabouts,* Design
Manual for Roads and Bridges, Volume 6, United Kingdom, 1993.


e
l'
v
D
Q
r

Assign each entry leg a number going counter-clockwise around the roundabout as illustrated by figure on the right. Enter data into shaded areas below for each entry leg roundabout has.
For each entry leg present at least one pce/hr must be shown entering or exiting roundabout for the leg. If roundabout has less than five entry legs, then enter zero in the shaded areas for the entry legs not used. (Note: Use of the tab key will toggle through all the data input shaded areas.)
To get accurate results from this spreadsheet the calculated V/C value should not exceed 0.85.

Entering (veh/hr)
(Roundabouts with 3, 4 or 5 legs)

Exiting (veh/hr)	X1	X2	X3	X4	X5	Entering pce/hr	Circulating pce/hr
E1	0	135	0	155	0	325	505
E2	1	0	330	785	0	1,252	195
E3	0	0	0	0	0	0	1,056
E4	0	460	20	0	0	505	1
E5	0	0	0	0	0	0	0

```
5 \        /   4
    \     /
     \   /
1 ---- ---- O ----- ---- 3
            |
            |
            | 2
```

TOTAL ENTERING ROUNDABOUT (pce/hr) ***2,083***

CAPACITY AT AN ENTRY OF A ROUNDABOUT

	E1	E2	E3	E4	E5
Inscribed diameter, D (m)	55	55	0	55	
Entry width, e (m)	8	8	0	8	
Approach width, v (m)	8	8	0	8	
Entry angle, Q (degrees)	30	30	0	30	
Entry radius, r (m)	20	20	0	20	
Average effective flare length, l' (m)	40	40	0	40	
Peak Hour Factor (PHF)	0.90	0.90	0.90	0.97	
% Single-Unit Truck or Bus	0.00%	0.00%	0.00%	0.00%	
% Truck With Trailer	1.00%	1.00%	0.00%	2.00%	

	E1	E2	E3	E4	E5	
ENTRY CAPACITY (pce/hr) C=Qe	**2,063**	**2,284**	**#DIV/0!**	**2,423**		
V/C	**0.16**	**0.55**	**#DIV/0!**	**0.21**		
CONTROL DELAY (sec/veh) d	**2.1**	**3.5**	**#DIV/0!**	**1.9**		
LEVEL OF SERVICE	**A**	**A**	**#DIV/0!**	**A**		**Compared to an unsignalized intersection**
LEVEL OF SERVICE	**A**	**A**	**#DIV/0!**	**A**		**Compared to a signalized intersection**
QUEUE LENGTH 95th percentile (veh)	**0.6**	**3.5**	**#DIV/0!**	**0.8**		

Van Buren at Eastbound Ramps - 2030 PM Peak - Dual Entry

Circulating flow across the entry, Qc (pce/hr)	505	195	1,056	1	0
S	0.00	0.00	#DIV/0!	0.00	
M	0.61	0.61	0.00	0.61	
X2	8.00	8.00	#DIV/0!	8.00	
F	2424.00	2424.00	#DIV/0!	2424.00	
tp	1.31	1.31	1.50	1.31	
fc	0.72	0.72	#DIV/0!	0.72	
k	1.00	1.00	#DIV/0!	1.00	
Entering flow, qe (pce/hr)	325	1,252	0	505	0

Definitions:

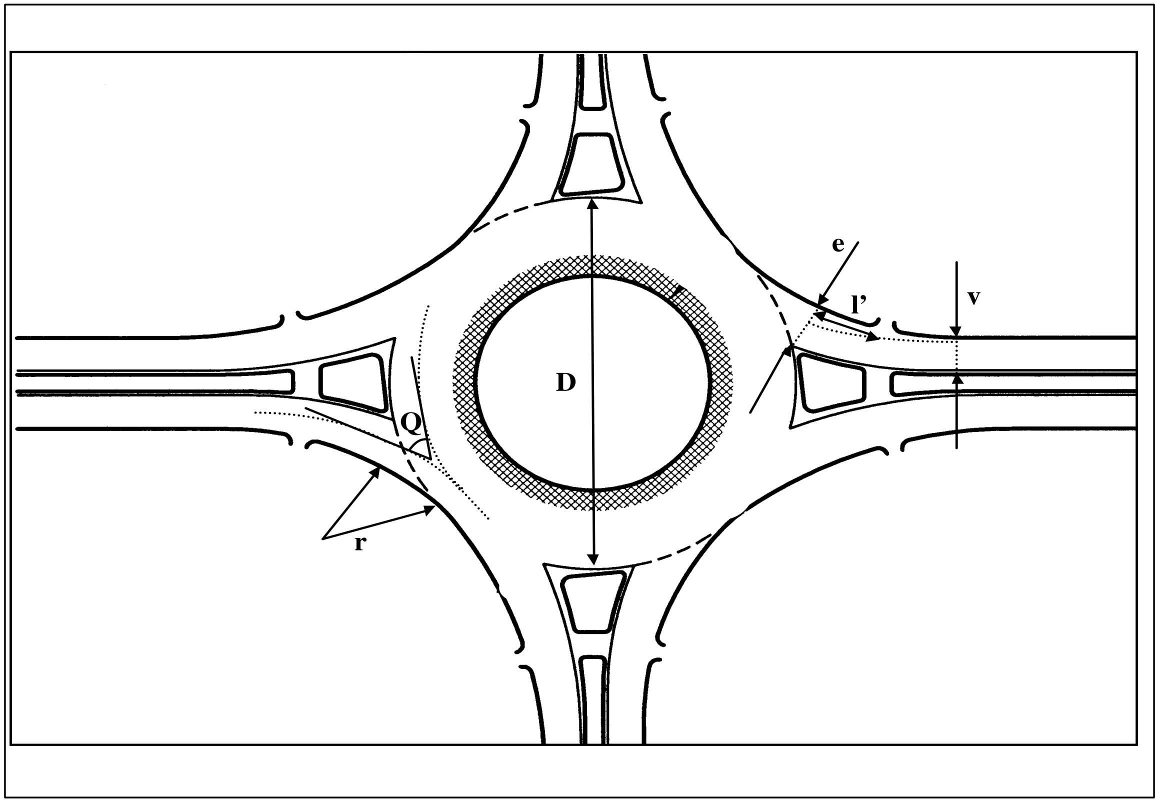
pce/hr - passenger car equivalent per hour
Inscribed Diameter, D - the diameter of the largest circle that can be inscribed within the junction outline
Entry Width, e - measured at the point of maximum entry deflection, from the left hand end of give-way line along a normal to the nearside curb
Approach Width, v - measured at a point in the approach upstream from any entry flare, from the median line (or edge of travelway on dual lane roads) to the nearside curb, along a normal
Entry Angle, Q - serves as a geometric proxy for the conflict angle between entering and circulating streams.
Entry Radius, r - measured as the minimum radius of curvature of the nearside curbline at entry
Average Effective Flare Length, l' - measured along a curve offset from curbline a distance of (e-v)/2 starting from line where e is measured to intersection with a projected curve offset from median a distance v.

Entering flow, qe=V
Sharpness of Flare, S=1.6*(e-v)/l'
M=exp{(D-60)/10}
X2=v+(e-v)/(1+2*S)
F=303*X2
tp=1+.5/(1+M)
fc=.21*tp*(1+.2*X2)
k=1-.00347*(Q-30)-.978*{(1/r)-.05}
Qe=k*(F-fc*Qc) or Qe=0 when fc*Qc>F
d=3600/C+900*T*[V/C-1+sqrt{(V/C-1)^2+(3600/C)*(V/C)/450*T}] where T=analysis time period, hours (T=0.25 for a 15-minute period)
Queue length 95th percentile = 900*T*{V/C-1+sqrt[(1-V/C)^2+(3600/C)*(V/C)/150*T]}*(C/3600) where T is the same as defined for d above

References:

Transportation Research Board, *Highway Capacity Manual,* National Research Council, Special Report 209, Third edition, Washington, D.C., 1998.

United Kingdom Department of Transport, *Geometric Design of Roundabouts,* Design Manual for Roads and Bridges, Volume 6, United Kingdom, 1993.


e
l'
v
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r

Akcelik & Associates Pty Ltd - aaSIDRA 2.1.4.357

CH2MHILL
CH2MHILL User ID: A0725
Licence Type: Single Computer

Time and Date of Analysis 10:24 AM, Jul 13,2006

Filename: C:\Documents and Settings\tnewkirk\Desktop\Projects\Montana\I-90_Phase 2\SIDRA\Orange Street\2030_AM_Orange-EB Ramps.OUT

Missoula MT I-90 Phase 2
Orange Street I-90 EB Ramps-2030 AM Peak Hour
Intersection ID:

aaTraffic SIDRA US Highway Capacity Manual (2000) Version

RUN INFORMATION

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* Basic Parameters:
  - Intersection Type: Roundabout
  - Driving on the right-hand side of the road
  - Input data specified in US units
  - Default Values File No. 11
  - Peak flow period (for performance): 15 minutes
  - Unit time (for volumes): 60 minutes (Total Flow Period)
  - Delay definition: Control delay
    Geometric delay included
  - aaSIDRA Standard Delay and Queue models used
  - Level of Service based on: Delay (HCM method)
  - Queue definition: Back of queue, 95th Percentile

Geometric delay is less than 2 seconds for some movements. The negotiation speed may be too high or the approach and exit speeds may be too low for given geometric design (e.g. for a large roundabout). Check Tables D.0, D.1 and D.4 for geometric delay data including negotiation speeds. If necessary, specify appropriate values of approach and exit speeds (RIDES Approach Data screen), and negotiation radius or negotiation speed data (RIDES Extra Data - Geometric Delay data screen).

Missoula MT I-90 Phase 2
Orange Street I-90 EB Ramps-2030 AM Peak Hour
Intersection ID:
Roundabout

Table S.0 - TRAFFIC FLOW DATA

Mov No.	Left		Through		Right		Flow Scale	Peak Flow Factor
	LV	HV	LV	HV	LV	HV		
VEHICLES	Demand flows in veh/hour as used by the program							
West: EB Off-Ramp								
12	5	0	1	0	0	0	1.00	0.95
13	0	0	0	0	600	0	1.00	0.95
South: Orange Street NB								
32	0	0	155	8	120	6	1.00	0.95

North: Orange Street SB								
42	1	0	660	13	0	0	1.00	0.95

Based on unit time = 60 minutes.
Flow Scale and Peak Hour Factor effects included in flow values.

Missoula MT I-90 Phase 2
Orange Street I-90 EB Ramps-2030 AM Peak Hour
Intersection ID:
Roundabout

Table R.0 - ROUNDABOUT BASIC PARAMETERS

Cent Island Diam (ft)	Circ Width (ft)	Insc Diam. (ft)	No.of Circ. Lanes	No.of Entry Lanes	Av.Ent Lane Width (ft)	Circulating/Exiting Stream Flow (veh/h)	%HV	Adjust. Flow (pcu/h)	%Exit Incl.	Cap. Constr. Effect	O-D Factor
West: EB Off-Ramp											
68	16	100	1	1	13.00	675	2.0	675	0	N	1.000
South: Orange Street NB											
68	16	100	1	1	13.00	7	0.0	7	0	N	0.998
North: Orange Street SB											
68	16	100	1	1	13.00	0	0.0	0	0	N	1.000

Missoula MT I-90 Phase 2
Orange Street I-90 EB Ramps-2030 AM Peak Hour
Intersection ID:
Roundabout

Table R.1 - ROUNDABOUT GAP ACCEPTANCE PARAMETERS

Turn	Lane No.	Lane Type	Circulating/Exiting Stream Flow Rate (pcu/h)	Aver Speed (mph)	Aver Dist (ft)	In-Bnch Headway (s)	Prop Bunched	Critical Gap Hdwy (s)	Critical Gap Dist (ft)	Foll-up Headway (s)
West: EB Off-Ramp										
Left	1	Dominant	675	20.0	156.4	2.00	0.569	4.22	123.8	2.40
Thru	1	Dominant	675	20.0	156.4	2.00	0.569	4.22	123.8	2.40
Right	1	Dominant	675	20.0	156.4	2.00	0.569	4.22	123.8	2.40
South: Orange Street NB										
Thru	1	Dominant	7	14.2	10136.6	2.00	0.009	4.32	89.8	2.20
Right	1	Dominant	7	14.2	10136.6	2.00	0.009	4.32	89.7	2.19
North: Orange Street SB										
Left	1	Dominant	0	0.0		2.00	0.000	4.11	0.0	2.08
Thru	1	Dominant	0	0.0		2.00	0.000	4.11	0.0	2.08

Environment Factor: 1.00
Entry/Circulating Flow Adjustment: Medium

Priority sharing is implied for some movements (Follow-up Headway plus

Intra-bunch Headway is larger than the Critical Gap). The O-D Factor (Table R.0) allows for priority sharing and priority emphasis.

Dist (Distance): Spacing, i.e. distance between the front ends of two successive vehicles across all lanes in the circulating or exiting stream

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Missoula MT I-90 Phase 2
Orange Street I-90 EB Ramps-2030 AM Peak Hour
Intersection ID:
Roundabout

Table R.5 - ROUNDABOUT CAPACITY & LEVEL OF SERVICE - aaSIDRA & HCM MODELS

Mov No.	Dem Flow (veh /h)	aaSIDRA Cap. (veh /h)	aaSIDRA Deg. Satn x	aaSIDRA Av. Delay (sec)	aaSIDRA LOS	HCM 2000 Lower Cap. (veh /h)	HCM 2000 Lower Deg. Satn x	HCM 2000 Lower Av. Delay (sec)	HCM 2000 Lower LOS	HCM 2000 Upper Cap. (veh /h)	HCM 2000 Upper Deg. Satn x	HCM 2000 Upper Av. Delay (sec)	HCM 2000 Upper LOS
West: EB Off-Ramp													
12 LT	6	8	0.750	16.5	B	6	1.000	33.5	C	8	0.750	16.1	B
13 R	600	806	0.744	19.8	B	640	0.938	36.8	D	803	0.747	19.4	B
South: Orange Street NB													
32 TR	289	1627	0.178	0.4	A	1151	0.251	0.4	A	1373	0.210	0.4	A
North: Orange Street SB													
42 LT	674	1728	0.390	0.0	A	1161	0.581	0.0	A	1384	0.487	0.0	A

Missoula MT I-90 Phase 2
Orange Street I-90 EB Ramps-2030 AM Peak Hour
Intersection ID:
Roundabout

Table R.6 - ROUNDABOUT ALTERNATIVE CAPACITY MODELS

Mov No.	Dem Flow (veh /h)	aaSIDRA Cap. (veh /h)	aaSIDRA Deg. Satn x	NAASRA 1986 Cap. (veh /h)	NAASRA 1986 % Diff from aaSIDRA	Ger. Linear Cap. (veh /h)	Ger. Linear % Diff from aaSIDRA	Ger. GapAcc Cap. (veh /h)	Ger. GapAcc % Diff from aaSIDRA
West: EB Off-Ramp									
12 LT	6	8	0.750	9	12.5	7	-12.5	7	-12.5
13 R	600	806	0.744	918	13.9	711	-11.8	673	-16.5
South: Orange Street NB									
32 TR	289	1627	0.178	1784	9.6	1209	-25.7	1240	-23.8
North: Orange Street SB									
42 LT	674	1728	0.390	1800	4.2	1218	-29.5	1250	-27.7

Missoula MT I-90 Phase 2
Orange Street I-90 EB Ramps-2030 AM Peak Hour

Intersection ID:
Roundabout

Table S.2 - MOVEMENT CAPACITY PARAMETERS

Mov No.	Demand Flow (veh/h)	HV (%)	Opposing Movement Flow (veh/h)	Opposing Movement HV (%)	Opposing Movement Adjust. Flow (pcu/h)	Total Cap. (veh /h)	Prac. Deg. Satn xp	Prac. Spare Cap. (%)	Lane Util (%)	Deg. Satn x
West: EB Off-Ramp										
12 LT	6	0.0	675	2.0	675	8	0.85	13	100	0.750*
13 R	600	0.0	675	2.0	675	806	0.85	14	100	0.744
South: Orange Street NB										
32 TR	289	4.8	7	0.0	7	1627	0.85	379	100	0.178
North: Orange Street SB										
42 LT	674	1.9	0			1728	0.85	118	100	0.390

Missoula MT I-90 Phase 2
Orange Street I-90 EB Ramps-2030 AM Peak Hour
Intersection ID:
Roundabout

Table S.3 - INTERSECTION PARAMETERS

Intersection Level of Service	=	A
Worst movement Level of Service	=	B
Average intersection delay (s)	=	7.7
Largest average movement delay (s)	=	19.8
Largest back of queue, 95% (ft)	=	287
Performance Index	=	34.70
Degree of saturation (highest)	=	0.750
Practical Spare Capacity (lowest)	=	13 %
Effective intersection capacity, (veh/h)	=	2092
Total vehicle flow (veh/h)	=	1569
Total person flow (pers/h)	=	2354
Total vehicle delay (veh-h/h)	=	3.36
Total person delay (pers-h/h)	=	5.04
Total effective vehicle stops (veh/h)	=	736
Total effective person stops (pers/h)	=	1104
Total vehicle travel (veh-mi/h)	=	565.2
Total cost ($/h)	=	660.06
Total fuel (gal/h)	=	19.1
Total CO2 (kg/h)	=	180.41

Missoula MT I-90 Phase 2
Orange Street I-90 EB Ramps-2030 AM Peak Hour
Intersection ID:
Roundabout

Table S.5 - MOVEMENT PERFORMANCE

Mov No.	Total Delay (veh-h/h)	Total Delay (pers-h/h)	Aver. Delay (sec)	Prop. Queued	Eff. Stop Rate	Longest Queue 95% Back (vehs)	Longest Queue 95% Back (ft)	Perf. Index	Aver. Speed (mph)

West: EB Off-Ramp									
12 LT	0.03	0.04	16.5	0.93	1.34	11.5	287	0.22	16.1
13 R	3.30	4.95	19.8	0.93	1.18	11.5	287	16.54	25.4
South: Orange Street NB									
32 TR	0.03	0.05	0.4	0.07	0.06	1.5	39	5.81	19.8
North: Orange Street SB									
42 LT	0.00	0.00	0.0	0.00	0.00	0.0	0	12.13	20.0

Missoula MT I-90 Phase 2
Orange Street I-90 EB Ramps-2030 AM Peak Hour
Intersection ID:
Roundabout

Table S.6 - INTERSECTION PERFORMANCE

Total Flow (veh/h)	Deg. Satn x	Total Delay (veh-h/h)	Total Delay (pers-h/h)	Aver. Delay (sec)	Prop. Queued	Eff. Stop Rate	Longest Queue (ft)	Perf. Index	Aver. Speed (mph)
West: EB Off-Ramp									
606	0.750	3.33	4.99	19.8	0.93	1.18	287	16.77	25.3
South: Orange Street NB									
289	0.178	0.03	0.05	0.4	0.07	0.06	39	5.81	19.8
North: Orange Street SB									
674	0.390	0.00	0.00	0.0	0.00	0.00	0	12.13	20.0
ALL VEHICLES:									
1569	0.750	3.36	5.04	7.7	0.37	0.47	287	34.70	21.7
INTERSECTION (persons):									
2354	0.750		5.04	7.7	0.37	0.47		34.70	21.7

Queue values in this table are 95% back of queue (feet).

Missoula MT I-90 Phase 2
Orange Street I-90 EB Ramps-2030 AM Peak Hour
Intersection ID:
Roundabout

Table S.7 - LANE PERFORMANCE

Lane No.	Mov No.	Dem Flow (veh/h)	Cap (veh/h)	Deg. Satn x	Aver. Delay (sec)	Eff. Stop Rate	Queue 95% Back (vehs)	Queue 95% Back (ft)	Short Lane (ft)
West: EB Off-Ramp									
1 LTR	12, 13	606	814	0.745	19.8	1.18	11.5	287	
South: Orange Street NB									
1 TR	32	289	1627	0.178	0.4	0.06	1.5	39	

North: Orange Street SB

1 LT	42	674	1728	0.390	0.0	0.00	0.0	0

Missoula MT I-90 Phase 2
Orange Street I-90 EB Ramps-2030 AM Peak Hour
Intersection ID:
Roundabout

Table S.8A - LANE FLOW AND CAPACITY INFORMATION

Lane No.	Mov No.	Dem Flow (veh/h) Lef	Thru	Rig	Tot	Min Cap (veh /h)	Tot Cap (veh /h)	Deg. Satn x	Lane Util %
West: EB Off-Ramp									
1 LTR	12, 13	5	1	600	606	150	814	0.745	100
South: Orange Street NB									
1 TR	32	0	163	126	289	150	1627	0.178	100
North: Orange Street SB									
1 LT	42	1	673	0	674	150	1728	0.390	100

For roundabouts, the capacity value for continuous movements is obtained as the basic saturation flow without any adjustments. Saturation flow scale applies if specified.

Missoula MT I-90 Phase 2
Orange Street I-90 EB Ramps-2030 AM Peak Hour
Intersection ID:
Roundabout

Table S.12A - FUEL CONSUMPTION, EMISSIONS AND COST - TOTAL

Mov No.	Fuel Total gal/h	Cost Total $/h	HC Total kg/h	CO Total kg/h	NOX Total kg/h	CO2 Total kg/h
West: EB Off-Ramp						
12 LT	0.1	3.55	0.001	0.03	0.001	0.8
13 R	7.2	217.94	0.109	2.14	0.114	68.2
	7.3	221.49	0.111	2.17	0.115	69.0
South: Orange Street NB						
32 TR	3.7	132.93	0.052	0.97	0.034	34.9
	3.7	132.93	0.052	0.97	0.034	34.9
North: Orange Street SB						
42 LT	8.1	305.64	0.118	2.08	0.074	76.5
	8.1	305.64	0.118	2.08	0.074	76.5
INTERSECTION:	19.1	660.06	0.280	5.23	0.223	180.4

PARAMETERS USED IN COST CALCULATIONS

Pump price of fuel ($/US gal)	=	0.900
Fuel resource cost factor	=	0.50
Ratio of running cost to fuel cost	=	3.0
Average income ($/h)	=	27.00
Time value factor	=	0.60
Average occupancy (persons/veh)	=	1.5
Light vehicle mass (1000 lb)	=	1.4
Heavy vehicle mass (1000 lb)	=	11.0
Light vehicle idle fuel rate (US gal/h)	=	0.360
Heavy vehicle idle fuel rate (US gal/h)	=	0.530

The idle fuel and vehicle mass parameters given above are the default values (data given in RIDES may override some of these parameters).

Missoula MT I-90 Phase 2
Orange Street I-90 EB Ramps-2030 AM Peak Hour
Intersection ID:
Roundabout

Table S.14 - SUMMARY OF INPUT AND OUTPUT DATA

Lane No.	Demand Flow (veh/h) L	T	R	Tot	%HV	Adj. Basic Satf.	Eff Grn (secs) 1st	2nd	Deg Sat x	Aver. Delay (sec)	Longest Queue (ft)	Shrt Lane (ft)
West: EB Off-Ramp												
1 LTR	5	1	600	606	0				0.745	19.8	287	
	5	1	600	606	0				0.745	19.8	287	
South: Orange Street NB												
1 TR		163	126	289	5				0.178	0.4	39	
	0	163	126	289	5				0.178	0.4	39	
North: Orange Street SB												
1 LT	1	673		674	2				0.390	0.0	0	
	1	673	0	674	2				0.390	0.0		

ALL VEHICLES	Total Flow	% HV	Max X	Aver. Delay	Max Queue
	1569	2	0.750	7.7	287

Total flow period = 60 minutes. Peak flow period = 15 minutes.

Queue values in this table are 95% back of queue (feet).

Note: Basic Saturation Flows are not adjusted at roundabouts or sign-controlled intersections and apply only to continuous lanes.

Missoula MT I-90 Phase 2
Orange Street I-90 EB Ramps-2030 AM Peak Hour
Intersection ID:

Roundabout

Table S.15 - CAPACITY AND LEVEL OF SERVICE

Mov No.	Mov Typ	Total Flow (veh /h)	Total Cap. (veh /h)	Deg. of Satn (v/c)	Aver. Delay (sec)	LOS	Longest Queue 95% Back (vehs)	(ft)
West: EB Off-Ramp								
12	LT	6	8	0.750*	16.5	B	11.5	287
13	R	600	806	0.744	19.8	B	11.5	287
		606		0.750	19.8	B	11.5	287
South: Orange Street NB								
32	TR	289	1627	0.178	0.4	A	1.5	39
		289		0.178	0.4	A	1.5	39
North: Orange Street SB								
42	LT	674	1728	0.390	0.0	A	0.0	0
		674		0.390	0.0	A	0.0	0
ALL VEHICLES:		1569		0.750	7.7	A	11.5	287

Level of Service calculations are based on average control delay including geometric delay (HCM criteria), independent of the current delay definition used.
For the criteria, refer to the "Level of Service" topic in the aaSIDRA Output Guide or the Output section of the on-line help.

* Maximum v/c ratio, or critical green periods

Missoula MT I-90 Phase 2
Orange Street I-90 EB Ramps-2030 AM Peak Hour
Intersection ID:
Roundabout

Table D.0 - GEOMETRIC DELAY DATA

From Approach	To Approach	Negn Radius (ft)	Negn Speed (mph)	Negn Dist. (ft)	Appr. Dist. (ft)	Downstream Distance (ft)
West: EB Off-Ramp						
	South	80.0	17.6	38.6	1800	104
	East	130.5	20.0	95.5	1800	100
	North	36.9	13.1	144.8	1800	207
South: Orange Street NB						
	East	80.0	17.6	38.6	1800	105
	North	113.2	20.0	83.1	1800	101
North: Orange Street SB						
	South	130.5	20.0	95.5	1800	100
	East	40.4	13.6	158.7	1800	218

Maximum Negotiation (Design) Speed = 50.0 mph
Downstream Distance calculated by aaSIDRA

Downstream distance is distance travelled from the stopline until exit cruise speed is reached (includes negotiation distance). Acceleration distance is weighted for light and heavy vehicles. The same distance applies for both stopped and unstopped vehicles.

Missoula MT I-90 Phase 2
Orange Street I-90 EB Ramps-2030 AM Peak Hour
Intersection ID:
Roundabout

Table D.1 - LANE DELAYS

			Delay (seconds/veh)								
		Deg.	Stop-line Delay			Acc.	Queuing		Stopd		
Lane No.	Mov No.	Satn x	1st d1	2nd d2	Total dSL	Dec. dn	Total dq	MvUp dqm	(Idle) di	Geom dig	Control dic
West: EB Off-Ramp											
1 LTR	12, 13	0.745	6.8	6.2	13.0	4.9	8.1	3.9	4.2	3.5 6.8	19.8
South: Orange Street NB											
1 TR	32	0.178	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.4	0.4
North: Orange Street SB											
1 LT	42	0.390	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

dn is average stop-start delay for all vehicles queued and unqueued

Geometric delay is less than 2 seconds for some movements. The negotiation speed may be too high or the approach and exit speeds may be too low for given geometric design (e.g. for a large roundabout). Check Tables D.0, D.1 and D.4 for geometric delay data including negotiation speeds. If necessary, specify appropriate values of approach and exit speeds (RIDES Approach Data screen), and negotiation radius or negotiation speed data (RIDES Extra Data - Geometric Delay data screen).

Missoula MT I-90 Phase 2
Orange Street I-90 EB Ramps-2030 AM Peak Hour
Intersection ID:
Roundabout

Table D.2 - LANE STOPS

		-- Effective Stop Rate --					Queue
Lane No.	Deg. Satn x	he1	he2	Geom. hig	Overall h	Prop. Queued pq	Move-up Rate hqm
West: EB Off-Ramp							
1 LTR	0.745	0.92	0.23	0.04	1.18	0.933	0.57
South: Orange Street NB							
1 TR	0.178	0.01	0.00	0.05	0.06	0.067	0.00
North: Orange Street SB							
1 LT	0.390	0.00	0.00	0.00	0.00	0.000	0.00

hig is the average value for all movements in a shared lane
hqm is average queue move-up rate for all vehicles queued and unqueued

Missoula MT I-90 Phase 2
Orange Street I-90 EB Ramps-2030 AM Peak Hour
Intersection ID:
Roundabout

Table D.3A - LANE QUEUES (veh)

Lane No.	Deg. Satn x	Ovrfl. Queue No	Average (veh) Nb1	Nb2	Nb	Percentile (veh) 70%	85%	90%	95%	98%	Queue Stor. Ratio
West: EB Off-Ramp											
1 LTR	0.745	1.1	2.4	1.5	3.9	6.4	8.0	9.1	11.5	13.5	0.16
South: Orange Street NB											
1 TR	0.178	0.0	0.5	0.0	0.5	0.9	1.1	1.2	1.5	1.7	0.02
North: Orange Street SB											
1 LT	0.390	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00

Values printed in this table are back of queue (vehicles).

Missoula MT I-90 Phase 2
Orange Street I-90 EB Ramps-2030 AM Peak Hour
Intersection ID:
Roundabout

Table D.3B - LANE QUEUES (feet)

Lane No.	Deg. Satn x	Ovrfl. Queue No	Average (feet) Nb1	Nb2	Nb	Percentile (feet) 70%	85%	90%	95%	98%	Queue Stor. Ratio
West: EB Off-Ramp											
1 LTR	0.745	28	60	38	98	160	199	229	287	337	0.16
South: Orange Street NB											
1 TR	0.178	0	12	0	12	23	28	31	39	45	0.02
North: Orange Street SB											
1 LT	0.390	0	0	0	0	0	0	0	0	0	0.00

Values printed in this table are back of queue (feet).

Missoula MT I-90 Phase 2
Orange Street I-90 EB Ramps-2030 AM Peak Hour
Intersection ID:
Roundabout

Table D.4 - MOVEMENT SPEEDS (mph)

Mov No.	App. Speeds Cruise	App. Speeds Negn	Exit Speeds Negn	Exit Speeds Cruise	Queue Move-up 1st Grn	Queue Move-up 2nd Grn	Av. Section Spd Running	Av. Section Spd Overall
West: EB Off-Ramp								
12	20.0	14.3	14.3	20.0	12.9		17.3	16.1
13	40.0	17.6	17.6	20.0	12.9		27.7	25.4
South: Orange Street NB								
32	20.0	18.9	18.9	20.0			19.8	19.8
North: Orange Street SB								
42	20.0	20.0	20.0	20.0			20.0	20.0

"Running Speed" is the average speed excluding stopped periods.

--- End of aaSIDRA Output ---

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Missoula MT I-90 Phase 2
Orange Street I-90 WB Ramps-2030 AM Peak Hour
Intersection ID:

aaTraffic SIDRA US Highway Capacity Manual (2000) Version

RUN INFORMATION
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* Basic Parameters:
  Intersection Type: Roundabout
  Driving on the right-hand side of the road
  Input data specified in US units
  Default Values File No. 11
  Peak flow period (for performance): 15 minutes
  Unit time (for volumes): 60 minutes (Total Flow Period)
  Delay definition: Control delay
                    Geometric delay included
  aaSIDRA Standard Delay and Queue models used
  Level of Service based on: Delay (HCM method)
  Queue definition: Back of queue, 95th Percentile

Missoula MT I-90 Phase 2
Orange Street I-90 WB Ramps-2030 AM Peak Hour
Intersection ID:
Roundabout

Table S.0 - TRAFFIC FLOW DATA

Mov No.	Left LV	Left HV	Through LV	Through HV	Right LV	Right HV	Flow Scale	Peak Flow Factor
VEHICLES	Demand flows in veh/hour as used by the program							
South: Orange Street NB								
32	160	8	0	0	0	0	1.00	0.95
East: WB Off-Ramp								
22	660	13	1	0	0	0	1.00	0.95

Based on unit time = 60 minutes.
Flow Scale and Peak Hour Factor effects included in flow values.

Missoula MT I-90 Phase 2
Orange Street I-90 WB Ramps-2030 AM Peak Hour
Intersection ID:
Roundabout

Table R.0 - ROUNDABOUT BASIC PARAMETERS

Cent Island Diam (ft)	Circ Width (ft)	Insc Diam. (ft)	No.of Circ. Lanes	No.of Entry Lanes	Av.Ent Lane Width (ft)	Circulating/Exiting Stream Flow (veh/h)	%HV	Adjust. Flow (pcu/h)	%Exit Incl.	Cap. Constr. Effect	O-D Factor
South: Orange Street NB											
68	16	100	1	1	13.00	0	0.0	0	0	N	1.000
East: WB Off-Ramp											
68	16	100	1	1	13.00	168	5.0	169	0	N	1.000

Missoula MT I-90 Phase 2
Orange Street I-90 WB Ramps-2030 AM Peak Hour
Intersection ID:
Roundabout

Table R.1 - ROUNDABOUT GAP ACCEPTANCE PARAMETERS

Turn	Lane No.	Lane Type	Circulating/Exiting Stream Flow Rate (pcu/h)	Aver Speed (mph)	Aver Dist (ft)	In-Bnch Headway (s)	Prop Bunched	Critical Gap Hdwy (s)	Critical Gap Dist (ft)	Foll-up Headway (s)
South: Orange Street NB										
Left	1	Dominant	0	0.0		2.00	0.000	4.12	0.0	2.09
East: WB Off-Ramp										
Left	1	Dominant	169	13.6	423.7	2.00	0.186	4.65	92.4	2.43
Thru	1	Dominant	169	13.6	423.7	2.00	0.186	4.64	92.4	2.43

Environment Factor: 1.00
Entry/Circulating Flow Adjustment: Medium

Dist (Distance): Spacing, i.e. distance between the front ends of two successive vehicles across all lanes in the circulating or exiting stream

Missoula MT I-90 Phase 2
Orange Street I-90 WB Ramps-2030 AM Peak Hour
Intersection ID:
Roundabout

Table R.5 - ROUNDABOUT CAPACITY & LEVEL OF SERVICE - aaSIDRA & HCM MODELS

Mov No.	Dem Flow (veh/h)	aaSIDRA Cap. (veh/h)	aaSIDRA Deg. Satn x	aaSIDRA Av. Delay (sec)	aaSIDRA LOS	HCM 2000 Lower Cap. (veh/h)	HCM 2000 Lower Deg. Satn x	HCM 2000 Lower Av. Delay (sec)	HCM 2000 Lower LOS	HCM 2000 Upper Cap. (veh/h)	HCM 2000 Upper Deg. Satn x	HCM 2000 Upper Av. Delay (sec)	HCM 2000 Upper LOS
South: Orange Street NB													
32 L	168	1724	0.097	4.1	A	1158	0.145	4.1	A	1381	0.122	4.1	A

East: WB Off-Ramp

22	LT	674	1262	0.534	5.6	A	1005	0.671	6.2	A	1213 0.556	5.4 A

Missoula MT I-90 Phase 2
Orange Street I-90 WB Ramps-2030 AM Peak Hour
Intersection ID:
Roundabout

Table R.6 - ROUNDABOUT ALTERNATIVE CAPACITY MODELS

Mov No.	Dem Flow (veh /h)	aaSIDRA Cap. (veh /h)	aaSIDRA Deg. Satn x	NAASRA 1986 Cap. (veh /h)	NAASRA 1986 % Diff from aaSIDRA	Ger. Linear Cap. (veh /h)	Ger. Linear % Diff from aaSIDRA	Ger. GapAcc Cap. (veh /h)	Ger. GapAcc % Diff from aaSIDRA
South: Orange Street NB									
32 L	168	1724	0.097	1796	4.2	1215	-29.5	1247	-27.7
East: WB Off-Ramp									
22 LT	674	1262	0.534	1555	23.2	1093	-13.4	1096	-13.2

Missoula MT I-90 Phase 2
Orange Street I-90 WB Ramps-2030 AM Peak Hour
Intersection ID:
Roundabout

Table S.2 - MOVEMENT CAPACITY PARAMETERS

Mov No.	Demand Flow (veh/h)	HV (%)	Opposing Movement Flow (veh/h)	Opposing Movement HV (%)	Adjust. Flow (pcu/h)	Total Cap. (veh /h)	Prac. Deg. Satn xp	Prac. Spare Cap. (%)	Lane Util (%)	Deg. Satn x
South: Orange Street NB										
32 L	168	4.8	0			1724	0.85	772	100	0.097
East: WB Off-Ramp										
22 LT	674	1.9	168	5.0	169	1262	0.85	59	100	0.534*

Missoula MT I-90 Phase 2
Orange Street I-90 WB Ramps-2030 AM Peak Hour
Intersection ID:
Roundabout

Table S.3 - INTERSECTION PARAMETERS

Intersection Level of Service	=	A
Worst movement Level of Service	=	A
Average intersection delay (s)	=	5.3
Largest average movement delay (s)	=	5.6
Largest back of queue, 95% (ft)	=	129
Performance Index	=	21.46
Degree of saturation (highest)	=	0.534

Practical Spare Capacity (lowest)	=	59 %
Effective intersection capacity, (veh/h)	=	1577
Total vehicle flow (veh/h)	=	842
Total person flow (pers/h)	=	1263
Total vehicle delay (veh-h/h)	=	1.24
Total person delay (pers-h/h)	=	1.86
Total effective vehicle stops (veh/h)	=	465
Total effective person stops (pers/h)	=	697
Total vehicle travel (veh-mi/h)	=	319.7
Total cost ($/h)	=	437.72
Total fuel (gal/h)	=	11.7
Total CO2 (kg/h)	=	110.76

Missoula MT I-90 Phase 2
Orange Street I-90 WB Ramps-2030 AM Peak Hour
Intersection ID:
Roundabout

Table S.5 - MOVEMENT PERFORMANCE

Mov No.	Total Delay (veh-h/h)	Total Delay (pers-h/h)	Aver. Delay (sec)	Prop. Queued	Eff. Stop Rate	Longest Queue 95% Back (vehs)	Longest Queue 95% Back (ft)	Perf. Index	Aver. Speed (mph)
South: Orange Street NB									
32 L	0.19	0.28	4.1	0.00	0.48	0.0	0	3.85	18.9
East: WB Off-Ramp									
22 LT	1.05	1.58	5.6	0.49	0.57	5.1	129	17.61	18.3

Missoula MT I-90 Phase 2
Orange Street I-90 WB Ramps-2030 AM Peak Hour
Intersection ID:
Roundabout

Table S.6 - INTERSECTION PERFORMANCE

Total Flow (veh/h)	Deg. Satn x	Total Delay (veh-h/h)	Total Delay (pers-h/h)	Aver. Delay (sec)	Prop. Queued	Eff. Stop Rate	Longest Queue (ft)	Perf. Index	Aver. Speed (mph)
South: Orange Street NB									
168	0.097	0.19	0.28	4.1	0.00	0.48	0	3.85	18.9
East: WB Off-Ramp									
674	0.534	1.05	1.58	5.6	0.49	0.57	129	17.61	18.3
ALL VEHICLES:									
842	0.534	1.24	1.86	5.3	0.39	0.55	129	21.46	18.4
INTERSECTION (persons):									
1263	0.534		1.86	5.3	0.39	0.55		21.46	18.4

Queue values in this table are 95% back of queue (feet).

Missoula MT I-90 Phase 2
Orange Street I-90 WB Ramps-2030 AM Peak Hour

Intersection ID:
Roundabout

Table S.7 - LANE PERFORMANCE

Lane No.	Mov No.	Dem Flow (veh /h)	Cap (veh /h)	Deg. Satn x	Aver. Delay (sec)	Eff. Stop Rate	Queue 95% Back (vehs)	Queue 95% Back (ft)	Short Lane (ft)
South: Orange Street NB									
1 L	32	168	1724	0.097	4.1	0.48	0.0	0	
East: WB Off-Ramp									
1 LT	22	674	1262	0.534	5.6	0.57	5.1	129	

Missoula MT I-90 Phase 2
Orange Street I-90 WB Ramps-2030 AM Peak Hour
Intersection ID:
Roundabout

Table S.8A - LANE FLOW AND CAPACITY INFORMATION

Lane No.	Mov No.	Dem Flow (veh/h) Lef	Thru	Rig	Tot	Min Cap (veh /h)	Tot Cap (veh /h)	Deg. Satn x	Lane Util %
South: Orange Street NB									
1 L	32	168	0	0	168	150	1724	0.097	100
East: WB Off-Ramp									
1 LT	22	673	1	0	674	150	1262	0.534	100

For roundabouts, the capacity value for continuous movements is obtained as the basic saturation flow without any adjustments. Saturation flow scale applies if specified.

Missoula MT I-90 Phase 2
Orange Street I-90 WB Ramps-2030 AM Peak Hour
Intersection ID:
Roundabout

Table S.12A - FUEL CONSUMPTION, EMISSIONS AND COST - TOTAL

Mov No.	Fuel Total gal/h	Cost Total $/h	HC Total kg/h	CO Total kg/h	NOX Total kg/h	CO2 Total kg/h
South: Orange Street NB						
32 L	2.4	85.85	0.034	0.71	0.023	22.5
	2.4	85.85	0.034	0.71	0.023	22.5
East: WB Off-Ramp						
22 LT	9.3	351.87	0.142	3.01	0.097	88.2

	9.3	351.87	0.142	3.01	0.097	88.2
INTERSECTION:	11.7	437.72	0.176	3.72	0.121	110.8

PARAMETERS USED IN COST CALCULATIONS

Pump price of fuel ($/US gal)	=	0.900
Fuel resource cost factor	=	0.50
Ratio of running cost to fuel cost	=	3.0
Average income ($/h)	=	27.00
Time value factor	=	0.60
Average occupancy (persons/veh)	=	1.5
Light vehicle mass (1000 lb)	=	1.4
Heavy vehicle mass (1000 lb)	=	11.0
Light vehicle idle fuel rate (US gal/h)	=	0.360
Heavy vehicle idle fuel rate (US gal/h)	=	0.530

The idle fuel and vehicle mass parameters given above are the default values (data given in RIDES may override some of these parameters).

Missoula MT I-90 Phase 2
Orange Street I-90 WB Ramps-2030 AM Peak Hour
Intersection ID:
Roundabout

Table S.14 - SUMMARY OF INPUT AND OUTPUT DATA

Lane No.	Demand Flow (veh/h) L	T	R	Tot	%HV	Adj. Basic Satf.	Eff Grn (secs) 1st	2nd	Deg Sat x	Aver. Delay (sec)	Longest Queue (ft)	Shrt Lane (ft)
South: Orange Street NB												
1 L	168			168	5				0.097	4.1	0	
	168	0	0	168	5				0.097	4.1		
East: WB Off-Ramp												
1 LT	673	1		674	2				0.534	5.6	129	
	673	1	0	674	2				0.534	5.6	129	

ALL VEHICLES	Total Flow	% HV	Max X	Aver. Delay	Max Queue
	842	2	0.534	5.3	129

Total flow period = 60 minutes. Peak flow period = 15 minutes.

Queue values in this table are 95% back of queue (feet).

Note: Basic Saturation Flows are not adjusted at roundabouts or sign-controlled intersections and apply only to continuous lanes.

Missoula MT I-90 Phase 2
Orange Street I-90 WB Ramps-2030 AM Peak Hour
Intersection ID:
Roundabout

Table S.15 - CAPACITY AND LEVEL OF SERVICE

Mov No.	Mov Typ	Total Flow (veh /h)	Total Cap. (veh /h)	Deg. of Satn (v/c)	Aver. Delay (sec)	LOS	Longest Queue 95% Back (vehs)	(ft)
South: Orange Street NB								
32	L	168	1724	0.097	4.1	A	0.0	0
		168		0.097	4.1	A	0.0	0
East: WB Off-Ramp								
22	LT	674	1262	0.534*	5.6	A	5.1	129
		674		0.534	5.6	A	5.1	129
ALL VEHICLES:		842		0.534	5.3	A	5.1	129

Level of Service calculations are based on
average control delay including geometric delay (HCM criteria),
independent of the current delay definition used.
For the criteria, refer to the "Level of Service" topic in the
aaSIDRA Output Guide or the Output section of the on-line help.
* Maximum v/c ratio, or critical green periods

Missoula MT I-90 Phase 2
Orange Street I-90 WB Ramps-2030 AM Peak Hour
Intersection ID:
Roundabout

Table D.0 - GEOMETRIC DELAY DATA

From Approach	To Approach	Negn Radius (ft)	Negn Speed (mph)	Negn Dist. (ft)	Appr. Dist. (ft)	Downstream Distance (ft)
South: Orange Street NB						
	West	40.4	13.6	158.7	1800	219
East: WB Off-Ramp						
	West	130.5	20.0	95.5	1800	100
	South	35.1	12.9	137.8	1800	202

Maximum Negotiation (Design) Speed = 50.0 mph
Downstream Distance calculated by aaSIDRA

Downstream distance is distance travelled from the stopline until exit cruise speed is reached (includes negotiation distance). Acceleration distance is weighted for light and heavy vehicles. The same distance applies for both stopped and unstopped vehicles.

Missoula MT I-90 Phase 2
Orange Street I-90 WB Ramps-2030 AM Peak Hour
Intersection ID:
Roundabout

Table D.1 - LANE DELAYS

Lane No.	Mov No.	Deg. Satn x	Stop-line Delay 1st d1	Stop-line Delay 2nd d2	Stop-line Delay Total dSL	Acc. Dec. dn	Queuing Total dq	Queuing MvUp dqm	Stopd (Idle) di	Geom dig	Control dic
South: Orange Street NB											
1 L	32	0.097	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.1	4.1
East: WB Off-Ramp											
1 LT	22	0.534	1.3	0.0	1.3	2.0	0.0	0.0	0.0	4.3	5.6

Delay (seconds/veh)

dn is average stop-start delay for all vehicles queued and unqueued

Missoula MT I-90 Phase 2
Orange Street I-90 WB Ramps-2030 AM Peak Hour
Intersection ID:
Roundabout

Table D.2 - LANE STOPS

Lane No.	Deg. Satn x	Effective Stop Rate he1	Effective Stop Rate he2	Effective Stop Rate Geom. hig	Effective Stop Rate Overall h	Prop. Queued pq	Queue Move-up Rate hqm
South: Orange Street NB							
1 L	0.097	0.00	0.00	0.48	0.48	0.000	0.00
East: WB Off-Ramp							
1 LT	0.534	0.31	0.00	0.26	0.57	0.488	0.00

hig is the average value for all movements in a shared lane
hqm is average queue move-up rate for all vehicles queued and unqueued

Missoula MT I-90 Phase 2
Orange Street I-90 WB Ramps-2030 AM Peak Hour
Intersection ID:
Roundabout

Table D.3A - LANE QUEUES (veh)

Lane No.	Deg. Satn x	Ovrfl. Queue No	Average (veh) Nb1	Average (veh) Nb2	Average (veh) Nb	Percentile (veh) 70%	85%	90%	95%	98%	Queue Stor. Ratio
South: Orange Street NB											
1 L	0.097	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00
East: WB Off-Ramp											
1 LT	0.534	0.0	1.7	0.0	1.7	2.9	3.6	4.1	5.1	5.9	0.07

Values printed in this table are back of queue (vehicles).

Missoula MT I-90 Phase 2

Orange Street I-90 WB Ramps-2030 AM Peak Hour
Intersection ID:
Roundabout

Table D.3B - LANE QUEUES (feet)

Lane No.	Deg. Satn x	Ovrfl. Queue No	Average (feet) Nb1	Nb2	Nb	Percentile (feet) 70%	85%	90%	95%	98%	Queue Stor. Ratio
South: Orange Street NB											
1 L	0.097	0	0	0	0	0	0	0	0	0	0.00
East: WB Off-Ramp											
1 LT	0.534	0	42	0	42	74	91	104	129	150	0.07

Values printed in this table are back of queue (feet).

Missoula MT I-90 Phase 2
Orange Street I-90 WB Ramps-2030 AM Peak Hour
Intersection ID:
Roundabout

Table D.4 - MOVEMENT SPEEDS (mph)

Mov No.	App. Speeds Cruise	Negn	Exit Speeds Negn	Cruise	Queue Move-up 1st Grn	2nd Grn	Av. Section Spd Running	Overall
South: Orange Street NB								
32	20.0	13.6	13.6	20.0			18.9	18.9
East: WB Off-Ramp								
22	20.0	12.9	12.9	20.0			18.3	18.3

"Running Speed" is the average speed excluding stopped periods.

--- End of aaSIDRA Output ---

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Time and Date of Analysis 2:29 PM, Jul 13,2006

Filename: C:\Documents and Settings\tnewkirk\Desktop\Projects\Montana\I-90_Phase 2\SIDRA\Van Buren Street\2030_AM_VanBuren-EB Ramps.OUT

Missoula MT I-90 Phase 2
Van Buren Street I-90 EB Ramps - AM Peak Hour
Intersection ID:

aaTraffic SIDRA US Highway Capacity Manual (2000) Version

RUN INFORMATION

* Basic Parameters:
  - Intersection Type: Roundabout
  - Driving on the right-hand side of the road
  - Input data specified in US units
  - Default Values File No. 11
  - Peak flow period (for performance): 15 minutes
  - Unit time (for volumes): 60 minutes (Total Flow Period)
  - Delay definition: Control delay
    Geometric delay included
  - aaSIDRA Standard Delay and Queue models used
  - Level of Service based on: Delay (HCM method)
  - Queue definition: Back of queue, 95th Percentile

Geometric delay is less than 2 seconds for some movements. The negotiation speed may be too high or the approach and exit speeds may be too low for given geometric design (e.g. for a large roundabout). Check Tables D.0, D.1 and D.4 for geometric delay data including negotiation speeds. If necessary, specify appropriate values of approach and exit speeds (RIDES Approach Data screen), and negotiation radius or negotiation speed data (RIDES Extra Data - Geometric Delay data screen).

Missoula MT I-90 Phase 2
Van Buren Street I-90 EB Ramps - AM Peak Hour
Intersection ID:
Roundabout

Table S.0 - TRAFFIC FLOW DATA

Mov No.	Left LV	Left HV	Through LV	Through HV	Right LV	Right HV	Flow Scale	Peak Flow Factor
VEHICLES	Demand flows in veh/hour as used by the program							
West: EB Off-Ramp								
12	89	0	1	0	0	0	1.00	0.95
13	0	0	0	0	347	0	1.00	0.95
South: Van Buren Street NB								
32	0	0	208	2	172	2	1.00	0.95

North: Van Burent Street SB

42	37	0	826	0	0	0	1.00	0.95

Based on unit time = 60 minutes.
Flow Scale and Peak Hour Factor effects included in flow values.

Missoula MT I-90 Phase 2
Van Buren Street I-90 EB Ramps - AM Peak Hour
Intersection ID:
Roundabout

Table R.0 - ROUNDABOUT BASIC PARAMETERS

Cent Island Diam (ft)	Circ Width (ft)	Insc Diam. (ft)	No.of Circ. Lanes	No.of Entry Lanes	Av.Ent Lane Width (ft)	Circulating/Exiting Stream Flow (veh/h)	%HV	Adjust. Flow (pcu/h)	%Exit Incl.	Cap. Constr. Effect	O-D Factor
West: EB Off-Ramp											
86	32	150	2	1	13.00	863	0.0	863	0	N	1.000
South: Van Buren Street NB											
86	32	150	2	2	13.00	127	0.0	127	0	N	0.985
North: Van Burent Street SB											
86	32	150	2	2	13.00	0	0.0	0	0	N	1.000

Missoula MT I-90 Phase 2
Van Buren Street I-90 EB Ramps - AM Peak Hour
Intersection ID:
Roundabout

Table R.1 - ROUNDABOUT GAP ACCEPTANCE PARAMETERS

Turn	Lane No.	Lane Type	Circulating/Exiting Stream Flow Rate (pcu/h)	Aver Speed (mph)	Aver Dist (ft)	In-Bnch Headway (s)	Prop Bunched	Critical Gap Hdwy (s)	Critical Gap Dist (ft)	Foll-up Headway (s)
West: EB Off-Ramp										
Left	1	Dominant	863	22.8	139.6	1.06	0.428	3.55	118.9	2.47
Thru	1	Dominant	863	22.8	139.6	1.06	0.428	3.55	118.9	2.47
Right	1	Dominant	863	22.8	139.6	1.06	0.428	3.55	118.9	2.47
South: Van Buren Street NB										
Thru	1	Subdominant	127	14.7	610.6	2.00	0.143	4.13	89.2	2.51
	2	Dominant	127	14.7	610.6	2.00	0.143	3.86	83.5	2.35
Right	2	Dominant	127	14.7	610.6	2.00	0.143	3.86	83.5	2.35
North: Van Burent Street SB										
Left	1	Subdominant	0	0.0		2.00	0.000	3.95	0.0	2.33
Thru	1	Subdominant	0	0.0		2.00	0.000	3.95	0.0	2.33
	2	Dominant	0	0.0		2.00	0.000	3.40	0.0	2.01

Environment Factor: 1.00
Entry/Circulating Flow Adjustment: Medium

Priority sharing is implied for some movements (Follow-up Headway plus Intra-bunch Headway is larger than the Critical Gap). The O-D Factor (Table R.0) allows for priority sharing and priority emphasis.

Dist (Distance): Spacing, i.e. distance between the front ends of two successive vehicles across all lanes in the circulating or exiting stream

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Missoula MT I-90 Phase 2
Van Buren Street I-90 EB Ramps - AM Peak Hour
Intersection ID:
Roundabout

Table R.5 - ROUNDABOUT CAPACITY & LEVEL OF SERVICE - aaSIDRA & HCM MODELS

Mov No.	Dem Flow (veh /h)	aaSIDRA Cap. (veh /h)	aaSIDRA Deg. Satn x	aaSIDRA Av. Delay (sec)	aaSIDRA LOS	HCM 2000 Lower Cap. (veh /h)	HCM 2000 Lower Deg. Satn x	HCM 2000 Lower Av. Delay (sec)	HCM 2000 Lower LOS	HCM 2000 Upper Cap. (veh /h)	HCM 2000 Upper Deg. Satn x	HCM 2000 Upper Av. Delay (sec)	HCM 2000 Upper LOS
West: EB Off-Ramp													
12 LT	90	174	0.517	10.8	B	- - - - NA - - - -				- - - - NA - - - -			
13 R	347	670	0.518	6.3	A	- - - - NA - - - -				- - - - NA - - - -			
South: Van Buren Street NB													
32 TR	384	2648	0.145	2.1	A	- - - - NA - - - -				- - - - NA - - - -			
North: Van Burent Street SB													
42 LT	863	3338	0.259	0.9	A	2323	0.372	0.9	A	2769	0.312	0.9	A

NA Values for this roundabout capacity model have not been calculated because the model was not applicable for the given roundabout conditions. Note that the HCM models are only applicable to single-lane roundabouts with circulating flows less than 1200 veh/h. Also note that results are not calculated for any of the models for slip lane or continuous movements. See the aaSIDRA Traffic Model Reference Guide for roundabout limits.

Missoula MT I-90 Phase 2
Van Buren Street I-90 EB Ramps - AM Peak Hour
Intersection ID:
Roundabout

Table R.6 - ROUNDABOUT ALTERNATIVE CAPACITY MODELS

Mov No.	Dem Flow (veh /h)	aaSIDRA Cap. (veh /h)	aaSIDRA Deg. Satn x	NAASRA 1986 Cap. (veh /h)	NAASRA 1986 % Diff from aaSIDRA	Ger. Linear Cap. (veh /h)	Ger. Linear % Diff from aaSIDRA	Ger. GapAcc Cap. (veh /h)	Ger. GapAcc % Diff from aaSIDRA
West: EB Off-Ramp									
12 LT	90	174	0.517	179	2.9	163	-6.3	125	-28.2
13 R	347	670	0.518	690	3.0	629	-6.1	484	-27.8

South: Van Buren Street NB									
32 TR	384	2648	0.145	3237	22.2	1316	-50.3	2270	-14.3
North: Van Burent Street SB									
42 LT	863	3338	0.259	3600	7.8	1380	-58.7	2500	-25.1

Missoula MT I-90 Phase 2
Van Buren Street I-90 EB Ramps - AM Peak Hour
Intersection ID:
Roundabout

Table S.2 - MOVEMENT CAPACITY PARAMETERS

Mov No.	Demand Flow (veh/h)	HV (%)	Opposing Movement Flow (veh/h)	Opposing Movement HV (%)	Opposing Movement Adjust. Flow (pcu/h)	Total Cap. (veh /h)	Prac. Deg. Satn xp	Prac. Spare Cap. (%)	Lane Util (%)	Deg. Satn x
West: EB Off-Ramp										
12 LT	90	0.0	863	0.0	863	174	0.85	64	100	0.517
13 R	347	0.0	863	0.0	863	670	0.85	64	100	0.518*
South: Van Buren Street NB										
32 TR	384	1.0	127	0.0	127	2648	0.85	486	100	0.145
North: Van Burent Street SB										
42 LT	863	0.0	0			3338	0.85	229	100	0.259

Missoula MT I-90 Phase 2
Van Buren Street I-90 EB Ramps - AM Peak Hour
Intersection ID:
Roundabout

Table S.3 - INTERSECTION PARAMETERS

Intersection Level of Service	=	A
Worst movement Level of Service	=	B
Average intersection delay (s)	=	2.8
Largest average movement delay (s)	=	10.8
Largest back of queue, 95% (ft)	=	89
Performance Index	=	31.38
Degree of saturation (highest)	=	0.518
Practical Spare Capacity (lowest)	=	64 %
Effective intersection capacity, (veh/h)	=	3252
Total vehicle flow (veh/h)	=	1684
Total person flow (pers/h)	=	2526
Total vehicle delay (veh-h/h)	=	1.30
Total person delay (pers-h/h)	=	1.95
Total effective vehicle stops (veh/h)	=	568
Total effective person stops (pers/h)	=	852
Total vehicle travel (veh-mi/h)	=	630.4
Total cost ($/h)	=	674.19
Total fuel (gal/h)	=	19.8
Total CO2 (kg/h)	=	187.74

Missoula MT I-90 Phase 2

Van Buren Street I-90 EB Ramps - AM Peak Hour
Intersection ID:
Roundabout

Table S.5 - MOVEMENT PERFORMANCE

Mov No.		Total Delay (veh-h/h)	Total Delay (pers-h/h)	Aver. Delay (sec)	Prop. Queued	Eff. Stop Rate	Longest Queue 95% Back (vehs)	Longest Queue 95% Back (ft)	Perf. Index	Aver. Speed (mph)
West: EB Off-Ramp										
12	LT	0.27	0.40	10.8	0.66	0.94	3.6	89	2.40	21.0
13	R	0.60	0.91	6.3	0.66	0.82	3.6	89	8.26	22.4
South: Van Buren Street NB										
32	TR	0.22	0.33	2.1	0.27	0.27	0.9	23	7.08	23.6
North: Van Burent Street SB										
42	LT	0.20	0.31	0.9	0.00	0.11	0.0	0	13.64	24.6

Missoula MT I-90 Phase 2
Van Buren Street I-90 EB Ramps - AM Peak Hour
Intersection ID:
Roundabout

Table S.6 - INTERSECTION PERFORMANCE

Total Flow (veh/h)	Deg. Satn x	Total Delay (veh-h/h)	Total Delay (pers-h/h)	Aver. Delay (sec)	Prop. Queued	Eff. Stop Rate	Longest Queue (ft)	Perf. Index	Aver. Speed (mph)
West: EB Off-Ramp									
437	0.518	0.87	1.31	7.2	0.66	0.84	89	10.66	22.1
South: Van Buren Street NB									
384	0.145	0.22	0.33	2.1	0.27	0.27	23	7.08	23.6
North: Van Burent Street SB									
863	0.259	0.20	0.31	0.9	0.00	0.11	0	13.64	24.6
ALL VEHICLES:									
1684	0.518	1.30	1.95	2.8	0.23	0.34	89	31.38	23.7
INTERSECTION (persons):									
2526	0.518		1.95	2.8	0.23	0.34		31.38	23.7

Queue values in this table are 95% back of queue (feet).

Missoula MT I-90 Phase 2
Van Buren Street I-90 EB Ramps - AM Peak Hour
Intersection ID:
Roundabout

Table S.7 - LANE PERFORMANCE

	Dem Flow	Cap	Deg.	Aver.	Eff.	Q u e u e 95% Back	Short

Lane No.	Mov No.	(veh /h)	(veh /h)	Satn x	Delay (sec)	Stop Rate	----------- (vehs)	(ft)	Lane (ft)
West: EB Off-Ramp									
1 LTR	12, 13	437	844	0.518	7.2	0.84	3.6	89	
South: Van Buren Street NB									
1 T	32	185	1276	0.145	1.8	0.24	0.9	22	
2 TR	32	199	1372	0.145	2.3	0.31	0.9	23	
North: Van Burent Street SB									
1 LT	42	399	1544	0.259	1.1	0.13	0.0	0	
2 T	42	464	1794	0.259	0.6	0.09	0.0	0	

Missoula MT I-90 Phase 2
Van Buren Street I-90 EB Ramps - AM Peak Hour
Intersection ID:
Roundabout

Table S.8A - LANE FLOW AND CAPACITY INFORMATION

Lane No.	Mov No.	Dem Flow (veh/h) Lef	Thru	Rig	Tot	Min Cap (veh /h)	Tot Cap (veh /h)	Deg. Satn x	Lane Util %
West: EB Off-Ramp									
1 LTR	12, 13	89	1	347	437	150	844	0.518	100
South: Van Buren Street NB									
1 T	32	0	185	0	185	150	1276	0.145	100
2 TR	32	0	25	174	199	150	1372	0.145	100
North: Van Burent Street SB									
1 LT	42	37	362	0	399	150	1544	0.259	100
2 T	42	0	464	0	464	150	1794	0.259	100

For roundabouts, the capacity value for continuous movements is obtained as the basic saturation flow without any adjustments. Saturation flow scale applies if specified.

Missoula MT I-90 Phase 2
Van Buren Street I-90 EB Ramps - AM Peak Hour
Intersection ID:
Roundabout

Table S.12A - FUEL CONSUMPTION, EMISSIONS AND COST - TOTAL

Mov No.	Fuel Total gal/h	Cost Total $/h	HC Total kg/h	CO Total kg/h	NOX Total kg/h	CO2 Total kg/h
West: EB Off-Ramp						
12 LT	1.2	42.93	0.019	0.44	0.015	11.6
13 R	4.3	146.12	0.065	1.55	0.054	40.7

	5.5	189.05	0.084	1.99	0.070	52.4
South: Van Buren Street NB						
32 TR	4.6	153.28	0.067	1.48	0.055	43.6
	4.6	153.28	0.067	1.48	0.055	43.6
North: Van Burent Street SB						
42 LT	9.7	331.86	0.138	2.62	0.109	91.8
	9.7	331.86	0.138	2.62	0.109	91.8
INTERSECTION:	19.8	674.19	0.289	6.09	0.233	187.7

PARAMETERS USED IN COST CALCULATIONS

Pump price of fuel ($/US gal)	=	0.900
Fuel resource cost factor	=	0.50
Ratio of running cost to fuel cost	=	3.0
Average income ($/h)	=	27.00
Time value factor	=	0.60
Average occupancy (persons/veh)	=	1.5
Light vehicle mass (1000 lb)	=	1.4
Heavy vehicle mass (1000 lb)	=	11.0
Light vehicle idle fuel rate (US gal/h)	=	0.360
Heavy vehicle idle fuel rate (US gal/h)	=	0.530

The idle fuel and vehicle mass parameters given above are the default values (data given in RIDES may override some of these parameters).

Missoula MT I-90 Phase 2
Van Buren Street I-90 EB Ramps - AM Peak Hour
Intersection ID:
Roundabout

Table S.14 - SUMMARY OF INPUT AND OUTPUT DATA

Lane No.	Demand Flow (veh/h) L	T	R	Tot	%HV	Adj. Basic Satf.	Eff Grn (secs) 1st	2nd	Deg Sat x	Aver. Delay (sec)	Longest Queue (ft)	Shrt Lane (ft)
West: EB Off-Ramp												
1 LTR	89	1	347	437	0				0.518	7.2	89	
	89	1	347	437	0				0.518	7.2	89	
South: Van Buren Street NB												
1 T		185		185	1				0.145	1.8	22	
2 TR		25	174	199	1				0.145	2.3	23	
	0	210	174	384	1				0.145	2.1	23	
North: Van Burent Street SB												
1 LT	37	362		399	0				0.259	1.1	0	
2 T		464		464	0				0.259	0.6	0	
	37	826	0	863	0				0.259	0.9		

ALL VEHICLES	Total Flow	% HV	Max X	Aver. Delay	Max Queue
	1684	0	0.518	2.8	89

Total flow period = 60 minutes. Peak flow period = 15 minutes.

Queue values in this table are 95% back of queue (feet).

Note: Basic Saturation Flows are not adjusted at roundabouts or sign-controlled intersections and apply only to continuous lanes.

Missoula MT I-90 Phase 2
Van Buren Street I-90 EB Ramps - AM Peak Hour
Intersection ID:
Roundabout

Table S.15 - CAPACITY AND LEVEL OF SERVICE

Mov No.	Mov Typ	Total Flow (veh /h)	Total Cap. (veh /h)	Deg. of Satn (v/c)	Aver. Delay (sec)	LOS	Longest Queue 95% Back (vehs)	(ft)
West: EB Off-Ramp								
12	LT	90	174	0.517	10.8	B	3.6	89
13	R	347	670	0.518*	6.3	A	3.6	89
		437		0.518	7.2	A	3.6	89
South: Van Buren Street NB								
32	TR	384	2648	0.145	2.1	A	0.9	23
		384		0.145	2.1	A	0.9	23
North: Van Burent Street SB								
42	LT	863	3338	0.259	0.9	A	0.0	0
		863		0.259	0.9	A	0.0	0
ALL VEHICLES:		1684		0.518	2.8	A	3.6	89

Level of Service calculations are based on average control delay including geometric delay (HCM criteria), independent of the current delay definition used.
For the criteria, refer to the "Level of Service" topic in the aaSIDRA Output Guide or the Output section of the on-line help.

* Maximum v/c ratio, or critical green periods

Missoula MT I-90 Phase 2
Van Buren Street I-90 EB Ramps - AM Peak Hour
Intersection ID:
Roundabout

Table D.0 - GEOMETRIC DELAY DATA

From Approach	To Approach	Negn Radius (ft)	Negn Speed (mph)	Negn Dist. (ft)	Appr. Dist. (ft)	Downstream Distance (ft)

West: EB Off-Ramp					
	South	112.7	20.0	58.0	1800	164
	East	165.3	23.1	140.8	1800	168
	North	47.1	14.4	185.1	1800	295
South: Van Buren Street NB					
	East	99.7	19.1	58.2	1800	165
	North	129.7	21.1	105.7	1800	164
North: Van Burent Street SB					
	South	165.3	23.1	140.8	1800	168
	East	55.8	15.3	219.1	1800	323

Maximum Negotiation (Design) Speed = 50.0 mph
Downstream Distance calculated by aaSIDRA

Downstream distance is distance travelled from the stopline until exit cruise speed is reached (includes negotiation distance). Acceleration distance is weighted for light and heavy vehicles. The same distance applies for both stopped and unstopped vehicles.

Missoula MT I-90 Phase 2
Van Buren Street I-90 EB Ramps - AM Peak Hour
Intersection ID:
Roundabout

Table D.1 - LANE DELAYS

			Delay (seconds/veh)								
		Deg.	Stop-line Delay			Acc.	Queuing		Stopd		
Lane	Mov	Satn	1st	2nd	Total	Dec.	Total	MvUp	(Idle)	Geom	Control
No.	No.	x	d1	d2	dSL	dn	dq	dqm	di	dig	dic
West: EB Off-Ramp											
1 LTR	12, 13	0.518	3.7	0.9	4.6	3.7	0.9	0.7	0.2	6.2 1.7	7.2
South: Van Buren Street NB											
1 T	32	0.145	0.5	0.0	0.5	1.6	0.0	0.0	0.0	1.3	1.8
2 TR	32	0.145	0.4	0.0	0.4	1.5	0.0	0.0	0.0	1.9	2.3
North: Van Burent Street SB											
1 LT	42	0.259	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	1.1
2 T	42	0.259	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.6

dn is average stop-start delay for all vehicles queued and unqueued

Geometric delay is less than 2 seconds for some movements. The negotiation speed may be too high or the approach and exit speeds may be too low for given geometric design (e.g. for a large roundabout). Check Tables D.0, D.1 and D.4 for geometric delay data including negotiation speeds. If necessary, specify appropriate values of approach and exit speeds (RIDES Approach Data screen), and negotiation radius or negotiation speed data (RIDES Extra Data - Geometric Delay data screen).

Missoula MT I-90 Phase 2
Van Buren Street I-90 EB Ramps - AM Peak Hour
Intersection ID:
Roundabout

Table D.2 - LANE STOPS

Lane No.	Deg. Satn x	-- Effective Stop Rate -- he1	he2	Geom. hig	Overall h	Prop. Queued pq	Queue Move-up Rate hqm
West: EB Off-Ramp							
1 LTR	0.518	0.66	0.08	0.10	0.84	0.661	0.16
South: Van Buren Street NB							
1 T	0.145	0.11	0.00	0.13	0.24	0.270	0.00
2 TR	0.145	0.12	0.00	0.19	0.31	0.263	0.00
North: Van Burent Street SB							
1 LT	0.259	0.00	0.00	0.13	0.13	0.000	0.00
2 T	0.259	0.00	0.00	0.09	0.09	0.000	0.00

hig is the average value for all movements in a shared lane
hqm is average queue move-up rate for all vehicles queued and unqueued

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Missoula MT I-90 Phase 2
Van Buren Street I-90 EB Ramps - AM Peak Hour
Intersection ID:
Roundabout

Table D.3A - LANE QUEUES (veh)

Lane No.	Deg. Satn x	Ovrfl. Queue No	Average (veh) Nb1	Nb2	Nb	Percentile (veh) 70%	85%	90%	95%	98%	Queue Stor. Ratio
West: EB Off-Ramp											
1 LTR	0.518	0.2	1.0	0.2	1.1	2.1	2.5	2.9	3.6	4.1	0.05
South: Van Buren Street NB											
1 T	0.145	0.0	0.3	0.0	0.3	0.5	0.6	0.7	0.9	1.0	0.01
2 TR	0.145	0.0	0.3	0.0	0.3	0.5	0.6	0.7	0.9	1.0	0.01
North: Van Burent Street SB											
1 LT	0.259	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00
2 T	0.259	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00

Values printed in this table are back of queue (vehicles).

Missoula MT I-90 Phase 2
Van Buren Street I-90 EB Ramps - AM Peak Hour
Intersection ID:
Roundabout

Table D.3B - LANE QUEUES (feet)

Lane No.	Deg. Satn x	Ovrfl. Queue No	Average (feet) Nb1	Nb2	Nb	Percentile (feet) 70%	85%	90%	95%	98%	Queue Stor. Ratio

West: EB Off-Ramp											
1 LTR	0.518	4	24	5	29	52	63	72	89	103	0.05
South: Van Buren Street NB											
1 T	0.145	0	7	0	7	13	16	18	22	26	0.01
2 TR	0.145	0	7	0	7	13	16	18	23	26	0.01
North: Van Burent Street SB											
1 LT	0.259	0	0	0	0	0	0	0	0	0	0.00
2 T	0.259	0	0	0	0	0	0	0	0	0	0.00

Values printed in this table are back of queue (feet).

Missoula MT I-90 Phase 2
Van Buren Street I-90 EB Ramps - AM Peak Hour
Intersection ID:
Roundabout

Table D.4 - MOVEMENT SPEEDS (mph)

Mov No.	App. Speeds Cruise	App. Speeds Negn	Exit Speeds Negn	Exit Speeds Cruise	Queue Move-up 1st Grn	Queue Move-up 2nd Grn	Av. Section Spd Running	Av. Section Spd Overall
West: EB Off-Ramp								
12	25.0	14.5	14.5	25.0	10.9		21.4	21.0
13	25.0	20.0	20.0	25.0	10.9		22.4	22.4
South: Van Buren Street NB								
32	25.0	20.2	20.2	25.0			23.6	23.6
North: Van Burent Street SB								
42	25.0	22.8	22.8	25.0			24.6	24.6

"Running Speed" is the average speed excluding stopped periods.

--- End of aaSIDRA Output ---

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Missoula MT I-90 Phase 2
Van Buren Street I-90 WB Ramps - AM Peak Hour
Intersection ID:

aaTraffic SIDRA US Highway Capacity Manual (2000) Version

RUN INFORMATION

* Basic Parameters:
  - Intersection Type: Roundabout
  - Driving on the right-hand side of the road
  - Input data specified in US units
  - Default Values File No. 11
  - Peak flow period (for performance): 15 minutes
  - Unit time (for volumes): 60 minutes (Total Flow Period)
  - Delay definition: Control delay
    Geometric delay included
  - aaSIDRA Standard Delay and Queue models used
  - Level of Service based on: Delay (HCM method)
  - Queue definition: Back of queue, 95th Percentile

Geometric delay is less than 2 seconds for some movements. The negotiation speed may be too high or the approach and exit speeds may be too low for given geometric design (e.g. for a large roundabout). Check Tables D.0, D.1 and D.4 for geometric delay data including negotiation speeds. If necessary, specify appropriate values of approach and exit speeds (RIDES Approach Data screen), and negotiation radius or negotiation speed data (RIDES Extra Data - Geometric Delay data screen).

Missoula MT I-90 Phase 2
Van Buren Street I-90 WB Ramps - AM Peak Hour
Intersection ID:
Roundabout

Table S.0 - TRAFFIC FLOW DATA

Mov No.	Left LV	Left HV	Through LV	Through HV	Right LV	Right HV	Flow Scale	Peak Flow Factor
VEHICLES	Demand flows in veh/hour as used by the program							
South: Van Buren Street NB								
32	96	4	192	8	0	0	1.00	0.95
East: WB Off-Ramp								
22	260	8	1	0	0	0	1.00	0.95
23	0	0	0	0	31	1	1.00	0.95

North: Van Buren Street SB								
42	1	0	583	12	186	4	1.00	0.95

Based on unit time = 60 minutes.
Flow Scale and Peak Hour Factor effects included in flow values.

Missoula MT I-90 Phase 2
Van Buren Street I-90 WB Ramps - AM Peak Hour
Intersection ID:
Roundabout

Table R.0 - ROUNDABOUT BASIC PARAMETERS

Cent Island Diam (ft)	Circ Width (ft)	Insc Diam. (ft)	No.of Circ. Lanes	No.of Entry Lanes	Av.Ent Lane Width (ft)	Circulating/Exiting Stream Flow (veh/h)	%HV	Adjust. Flow (pcu/h)	%Exit Incl.	Cap. Constr. Effect	O-D Factor
South: Van Buren Street NB											
86	32	150	2	2	13.00	1	0.0	1	0	N	1.000
East: WB Off-Ramp											
86	32	150	2	2	13.00	301	4.0	301	0	N	0.999
North: Van Buren Street SB											
86	32	150	2	1	13.00	369	3.3	370	0	N	0.977

Missoula MT I-90 Phase 2
Van Buren Street I-90 WB Ramps - AM Peak Hour
Intersection ID:
Roundabout

Table R.1 - ROUNDABOUT GAP ACCEPTANCE PARAMETERS

Turn	Lane No.	Lane Type	Circulating/Exiting Stream Flow Rate (pcu/h)	Aver Speed (mph)	Aver Dist (ft)	In-Bnch Headway (s)	Prop Bunched	Critical Gap Hdwy (s)	Critical Gap Dist (ft)	Foll-up Headway (s)
South: Van Buren Street NB										
Left	1	Subdominant	1	14.6	73311.8	2.00	0.001	4.23	90.7	2.50
Thru	2	Dominant	1	14.6	73311.8	2.00	0.001	3.42	73.4	2.02
East: WB Off-Ramp										
Left	1	Dominant	301	20.5	359.6	1.24	0.204	3.67	110.3	2.31
Thru	1	Dominant	301	20.5	359.6	1.24	0.204	3.66	110.3	2.31
Right	2	Subdominant	301	20.5	359.6	1.24	0.204	5.39	162.4	3.40
North: Van Buren Street SB										
Left	1	Dominant	370	14.7	209.5	2.00	0.362	4.03	86.6	2.57
Thru	1	Dominant	370	14.7	209.5	2.00	0.362	4.03	86.7	2.57
Right	1	Dominant	370	14.7	209.5	2.00	0.362	4.03	86.7	2.57

Environment Factor: 1.00
Entry/Circulating Flow Adjustment: Medium

Priority sharing is implied for some movements (Follow-up Headway plus Intra-bunch Headway is larger than the Critical Gap). The O-D Factor (Table R.0) allows for priority sharing and priority emphasis.

Dist (Distance): Spacing, i.e. distance between the front ends of two successive vehicles across all lanes in the circulating or exiting stream

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Missoula MT I-90 Phase 2
Van Buren Street I-90 WB Ramps - AM Peak Hour
Intersection ID:
Roundabout

Table R.5 - ROUNDABOUT CAPACITY & LEVEL OF SERVICE - aaSIDRA & HCM MODELS

Mov No.	Dem Flow (veh /h)	aaSIDRA Cap. (veh /h)	aaSIDRA Deg. Satn x	aaSIDRA Av. Delay (sec)	aaSIDRA LOS	HCM 2000 Lower Cap. (veh /h)	HCM 2000 Lower Deg. Satn x	HCM 2000 Lower Av. Delay (sec)	HCM 2000 Lower LOS	HCM 2000 Upper Cap. (veh /h)	HCM 2000 Upper Deg. Satn x	HCM 2000 Upper Av. Delay (sec)	HCM 2000 Upper LOS
South: Van Buren Street NB													
32 LT	300	2670	0.112	2.4	A	- - - - NA - - - -				- - - - NA - - - -			
East: WB Off-Ramp													
22 LT	269	1265	0.213	7.2	A	- - - - NA - - - -				- - - - NA - - - -			
23 R	32	784	0.041	3.6	A	- - - - NA - - - -				- - - - NA - - - -			
North: Van Buren Street SB													
42 LTR	786	1016	0.774	11.4	B	- - - - NA - - - -				- - - - NA - - - -			

NA Values for this roundabout capacity model have not been calculated because the model was not applicable for the given roundabout conditions. Note that the HCM models are only applicable to single-lane roundabouts with circulating flows less than 1200 veh/h. Also note that results are not calculated for any of the models for slip lane or continuous movements. See the aaSIDRA Traffic Model Reference Guide for roundabout limits.

Missoula MT I-90 Phase 2
Van Buren Street I-90 WB Ramps - AM Peak Hour
Intersection ID:
Roundabout

Table R.6 - ROUNDABOUT ALTERNATIVE CAPACITY MODELS

Mov No.	Dem Flow (veh /h)	aaSIDRA Cap. (veh /h)	aaSIDRA Deg. Satn x	NAASRA 1986 Cap. (veh /h)	NAASRA 1986 % Diff from aaSIDRA	Ger. Linear Cap. (veh /h)	Ger. Linear % Diff from aaSIDRA	Ger. GapAcc Cap. (veh /h)	Ger. GapAcc % Diff from aaSIDRA
South: Van Buren Street NB									
32 LT	300	2670	0.112	2695	0.9	1034	-61.3	1872	-29.9
East: WB Off-Ramp									
22 LT	269	1265	0.213	1398	10.5	614	-51.5	990	-21.7

23 R	32	784	0.041	1398	78.3	614	-21.7	990	26.3
North: Van Buren Street SB									
42 LTR	786	1016	0.774	1320	29.9	1054	3.7	937	-7.8

Missoula MT I-90 Phase 2
Van Buren Street I-90 WB Ramps - AM Peak Hour
Intersection ID:
Roundabout

Table S.2 - MOVEMENT CAPACITY PARAMETERS

Mov No.	Demand Flow (veh/h)	HV (%)	Opposing Movement Flow (veh/h)	Opposing Movement HV (%)	Adjust. Flow (pcu/h)	Total Cap. (veh /h)	Prac. Deg. Satn xp	Prac. Spare Cap. (%)	Lane Util (%)	Deg. Satn x
South: Van Buren Street NB										
32 LT	300	4.0	1	0.0	1	2670	0.85	657	62	0.112
East: WB Off-Ramp										
22 LT	269	3.0	301	4.0	301	1265	0.85	300	100	0.213
23 R	32	3.1	301	4.0	301	784	0.85	1983	100	0.041
North: Van Buren Street SB										
42 LTR	786	2.0	369	3.3	370	1016	0.85	10	100	0.774*

Missoula MT I-90 Phase 2
Van Buren Street I-90 WB Ramps - AM Peak Hour
Intersection ID:
Roundabout

Table S.3 - INTERSECTION PARAMETERS

Intersection Level of Service	=	A
Worst movement Level of Service	=	B
Average intersection delay (s)	=	8.5
Largest average movement delay (s)	=	11.4
Largest back of queue, 95% (ft)	=	291
Performance Index	=	30.00
Degree of saturation (highest)	=	0.774
Practical Spare Capacity (lowest)	=	10 %
Effective intersection capacity, (veh/h)	=	1793
Total vehicle flow (veh/h)	=	1387
Total person flow (pers/h)	=	2081
Total vehicle delay (veh-h/h)	=	3.26
Total person delay (pers-h/h)	=	4.89
Total effective vehicle stops (veh/h)	=	969
Total effective person stops (pers/h)	=	1453
Total vehicle travel (veh-mi/h)	=	525.8
Total cost ($/h)	=	511.46
Total fuel (gal/h)	=	17.7
Total CO2 (kg/h)	=	167.92

Missoula MT I-90 Phase 2
Van Buren Street I-90 WB Ramps - AM Peak Hour

Intersection ID:
Roundabout

Table S.5 - MOVEMENT PERFORMANCE

Mov No.	Total Delay (veh-h/h)	Total Delay (pers-h/h)	Aver. Delay (sec)	Prop. Queued	Eff. Stop Rate	Longest Queue 95% Back (vehs)	Longest Queue 95% Back (ft)	Perf. Index	Aver. Speed (mph)
South: Van Buren Street NB									
32 LT	0.20	0.30	2.4	0.02	0.24	0.8	20	5.58	23.9
East: WB Off-Ramp									
22 LT	0.54	0.81	7.2	0.36	0.62	1.1	29	6.10	22.0
23 R	0.03	0.05	3.6	0.38	0.42	0.2	5	0.64	23.2
North: Van Buren Street SB									
42 LTR	2.48	3.73	11.4	0.83	0.91	11.4	291	17.67	29.7

Missoula MT I-90 Phase 2
Van Buren Street I-90 WB Ramps - AM Peak Hour
Intersection ID:
Roundabout

Table S.6 - INTERSECTION PERFORMANCE

Total Flow (veh/h)	Deg. Satn x	Total Delay (veh-h/h)	Total Delay (pers-h/h)	Aver. Delay (sec)	Prop. Queued	Eff. Stop Rate	Longest Queue (ft)	Perf. Index	Aver. Speed (mph)
South: Van Buren Street NB									
300	0.112	0.20	0.30	2.4	0.02	0.24	20	5.58	23.9
East: WB Off-Ramp									
301	0.213	0.57	0.86	6.8	0.36	0.60	29	6.74	22.1
North: Van Buren Street SB									
786	0.774	2.48	3.73	11.4	0.83	0.91	291	17.67	29.7
ALL VEHICLES:									
1387	0.774	3.26	4.89	8.5	0.56	0.70	291	30.00	26.3
INTERSECTION (persons):									
2081	0.774		4.89	8.5	0.56	0.70		30.00	26.3

Queue values in this table are 95% back of queue (feet).

Missoula MT I-90 Phase 2
Van Buren Street I-90 WB Ramps - AM Peak Hour
Intersection ID:
Roundabout

Table S.7 - LANE PERFORMANCE

Lane	Mov	Dem Flow (veh	Cap (veh	Deg. Satn	Aver. Delay	Eff. Stop	Queue 95% Back	Short Lane

No.	No.	/h)	/h)	x	(sec)	Rate	(vehs)	(ft)	(ft)
South: Van Buren Street NB									
1 L	32	100	1440	0.069	6.1	0.55	0.4	11	
2 T	32	200	1780	0.112	0.6	0.09	0.8	20	
East: WB Off-Ramp									
1 LT	22	269	1265	0.213	7.2	0.62	1.1	29	
2 R	23	32	784	0.041	3.6	0.42	0.2	5	125
North: Van Buren Street SB									
1 LTR	42	786	1016	0.773	11.4	0.91	11.4	291	

Missoula MT I-90 Phase 2
Van Buren Street I-90 WB Ramps - AM Peak Hour
Intersection ID:
Roundabout

Table S.8A - LANE FLOW AND CAPACITY INFORMATION

Lane No.	Mov No.	Dem Flow (veh/h) Lef	Thru	Rig	Tot	Min Cap (veh /h)	Tot Cap (veh /h)	Deg. Satn x	Lane Util %
South: Van Buren Street NB									
1 L	32	100	0	0	100	100	1440	0.069	62P
2 T	32	0	200	0	200	150	1780	0.112	100
East: WB Off-Ramp									
1 LT	22	268	1	0	269	150	1265	0.213	100
2 R	23	0	0	32	32	32	784	0.041	100
North: Van Buren Street SB									
1 LTR	42	1	595	190	786	150	1016	0.773	100

P Lane under-utilisation found by the "Program"

For roundabouts, the capacity value for continuous movements is obtained as the basic saturation flow without any adjustments. Saturation flow scale applies if specified.

Missoula MT I-90 Phase 2
Van Buren Street I-90 WB Ramps - AM Peak Hour
Intersection ID:
Roundabout

Table S.12A - FUEL CONSUMPTION, EMISSIONS AND COST - TOTAL

Mov No.	Fuel Total gal/h	Cost Total $/h	HC Total kg/h	CO Total kg/h	NOX Total kg/h	CO2 Total kg/h
South: Van Buren Street NB						
32 LT	3.8	121.88	0.052	1.08	0.042	36.0
	3.8	121.88	0.052	1.08	0.042	36.0

East: WB Off-Ramp						
22 LT	3.8	123.23	0.055	1.33	0.046	35.7
23 R	0.4	13.02	0.006	0.14	0.005	3.8
	4.2	136.25	0.060	1.47	0.051	39.5
North: Van Buren Street SB						
42 LTR	9.8	253.33	0.139	3.27	0.163	92.4
	9.8	253.33	0.139	3.27	0.163	92.4
INTERSECTION:	17.7	511.46	0.251	5.82	0.255	167.9

PARAMETERS USED IN COST CALCULATIONS

Pump price of fuel ($/US gal)	=	0.900
Fuel resource cost factor	=	0.50
Ratio of running cost to fuel cost	=	3.0
Average income ($/h)	=	27.00
Time value factor	=	0.60
Average occupancy (persons/veh)	=	1.5
Light vehicle mass (1000 lb)	=	1.4
Heavy vehicle mass (1000 lb)	=	11.0
Light vehicle idle fuel rate (US gal/h)	=	0.360
Heavy vehicle idle fuel rate (US gal/h)	=	0.530

The idle fuel and vehicle mass parameters given above are the default values (data given in RIDES may override some of these parameters).

Missoula MT I-90 Phase 2
Van Buren Street I-90 WB Ramps - AM Peak Hour
Intersection ID:
Roundabout

Table S.14 - SUMMARY OF INPUT AND OUTPUT DATA

Lane No.	Demand Flow (veh/h) L	T	R	Tot	%HV	Adj. Basic Satf.	Eff Grn (secs) 1st	2nd	Deg Sat x	Aver. Delay (sec)	Longest Queue (ft)	Shrt Lane (ft)
South: Van Buren Street NB												
1 L	100			100	4				0.069	6.1	11	
2 T		200		200	4				0.112	0.6	20	
	100	200	0	300	4				0.112	2.4	20	
East: WB Off-Ramp												
1 LT	268	1		269	3				0.213	7.2	29	
2 R			32	32	3				0.041	3.6	5	125
	268	1	32	301	3				0.213	6.8	29	
North: Van Buren Street SB												
1 LTR	1	595	190	786	2				0.773	11.4	291	
	1	595	190	786	2				0.773	11.4	291	
ALL VEHICLES				Total	%				Max	Aver.	Max	

Flow	HV	X	Delay	Queue
1387	3	0.774	8.5	291

Total flow period = 60 minutes. Peak flow period = 15 minutes.

Queue values in this table are 95% back of queue (feet).

Note: Basic Saturation Flows are not adjusted at roundabouts or sign-controlled intersections and apply only to continuous lanes.

Missoula MT I-90 Phase 2
Van Buren Street I-90 WB Ramps - AM Peak Hour
Intersection ID:
Roundabout

Table S.15 - CAPACITY AND LEVEL OF SERVICE

Mov No.	Mov Typ	Total Flow (veh /h)	Total Cap. (veh /h)	Deg. of Satn (v/c)	Aver. Delay (sec)	LOS	Longest Queue 95% Back (vehs)	(ft)
South: Van Buren Street NB								
32	LT	300	2670	0.112	2.4	A	0.8	20
		300		0.112	2.4	A	0.8	20
East: WB Off-Ramp								
22	LT	269	1265	0.213	7.2	A	1.1	29
23	R	32	784	0.041	3.6	A	0.2	5
		301		0.213	6.8	A	1.1	29
North: Van Buren Street SB								
42	LTR	786	1016	0.774*	11.4	B	11.4	291
		786		0.774	11.4	B	11.4	291
ALL VEHICLES:		1387		0.774	8.5	A	11.4	291

Level of Service calculations are based on average control delay including geometric delay (HCM criteria), independent of the current delay definition used.
For the criteria, refer to the "Level of Service" topic in the aaSIDRA Output Guide or the Output section of the on-line help.
* Maximum v/c ratio, or critical green periods

Missoula MT I-90 Phase 2
Van Buren Street I-90 WB Ramps - AM Peak Hour
Intersection ID:
Roundabout

Table D.0 - GEOMETRIC DELAY DATA

From Approach	To Approach	Negn Radius (ft)	Negn Speed (mph)	Negn Dist. (ft)	Appr. Dist. (ft)	Downstream Distance (ft)
South: Van Buren Street NB						

	West	55.8	15.3	219.1	1800	324
	North	165.3	23.1	140.8	1800	170
East: WB Off-Ramp						
	West	165.3	23.1	140.8	1800	168
	South	47.1	14.4	185.1	1800	296
	North	99.7	19.1	58.2	1800	165
North: Van Buren Street SB						
	West	112.7	20.0	58.0	1800	165
	South	129.7	21.1	105.7	1800	164
	North	49.3	14.6	271.0	1800	380

Maximum Negotiation (Design) Speed = 50.0 mph
Downstream Distance calculated by aaSIDRA

Downstream distance is distance travelled from the stopline until exit cruise speed is reached (includes negotiation distance). Acceleration distance is weighted for light and heavy vehicles. The same distance applies for both stopped and unstopped vehicles.

Missoula MT I-90 Phase 2
Van Buren Street I-90 WB Ramps - AM Peak Hour
Intersection ID:
Roundabout

Table D.1 - LANE DELAYS

Lane No.	Mov No.	Deg. Satn x	Delay (seconds/veh): Stop-line Delay 1st d1	2nd d2	Total dSL	Acc. Dec. dn	Queuing Total dq	MvUp dqm	Stopd (Idle) di	Geom dig	Control dic
South: Van Buren Street NB											
1 L	32	0.069	0.0	0.0	0.0	0.1	0.0	0.0	0.0	6.1	6.1
2 T	32	0.112	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.6	0.6
East: WB Off-Ramp											
1 LT	22	0.213	0.9	0.0	0.9	1.6	0.0	0.0	0.0	6.3	7.2
2 R	23	0.041	1.6	0.0	1.6	2.1	0.0	0.0	0.0	2.0	3.6
North: Van Buren Street SB											
1 LTR	42	0.773	3.4	2.8	6.2	5.0	1.3	1.2	0.0	5.1	11.4

dn is average stop-start delay for all vehicles queued and unqueued

Geometric delay is less than 2 seconds for some movements. The negotiation speed may be too high or the approach and exit speeds may be too low for given geometric design (e.g. for a large roundabout). Check Tables D.0, D.1 and D.4 for geometric delay data including negotiation speeds. If necessary, specify appropriate values of approach and exit speeds (RIDES Approach Data screen), and negotiation radius or negotiation speed data (RIDES Extra Data - Geometric Delay data screen).

Missoula MT I-90 Phase 2
Van Buren Street I-90 WB Ramps - AM Peak Hour
Intersection ID:
Roundabout

Table D.2 - LANE STOPS

Lane No.	Deg. Satn x	-- Effective Stop Rate -- he1	he2	Geom. hig	Overall h	Prop. Queued pq	Queue Move-up Rate hqm
South: Van Buren Street NB							
1 L	0.069	0.00	0.00	0.55	0.55	0.017	0.00
2 T	0.112	0.00	0.00	0.09	0.09	0.016	0.00
East: WB Off-Ramp							
1 LT	0.213	0.25	0.00	0.37	0.62	0.361	0.00
2 R	0.041	0.26	0.00	0.16	0.42	0.379	0.00
North: Van Buren Street SB							
1 LTR	0.773	0.72	0.11	0.08	0.91	0.835	0.24

hig is the average value for all movements in a shared lane
hqm is average queue move-up rate for all vehicles queued and unqueued

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Missoula MT I-90 Phase 2
Van Buren Street I-90 WB Ramps - AM Peak Hour
Intersection ID:
Roundabout

Table D.3A - LANE QUEUES (veh)

Lane No.	Deg. Satn x	Ovrfl. Queue No	Average (veh) Nb1	Nb2	Nb	Percentile (veh) 70%	85%	90%	95%	98%	Queue Stor. Ratio
South: Van Buren Street NB											
1 L	0.069	0.0	0.1	0.0	0.1	0.3	0.3	0.4	0.4	0.5	0.01
2 T	0.112	0.0	0.2	0.0	0.2	0.5	0.6	0.6	0.8	0.9	0.01
East: WB Off-Ramp											
1 LT	0.213	0.0	0.4	0.0	0.4	0.7	0.8	0.9	1.1	1.3	0.02
2 R	0.041	0.0	0.1	0.0	0.1	0.1	0.1	0.2	0.2	0.2	0.04
North: Van Buren Street SB											
1 LTR	0.773	0.7	2.7	1.2	3.9	6.4	7.9	9.1	11.4	13.4	0.16

Values printed in this table are back of queue (vehicles).

Missoula MT I-90 Phase 2
Van Buren Street I-90 WB Ramps - AM Peak Hour
Intersection ID:
Roundabout

Table D.3B - LANE QUEUES (feet)

Lane No.	Deg. Satn x	Ovrfl. Queue No	Average (feet) Nb1	Nb2	Nb	Percentile (feet) 70%	85%	90%	95%	98%	Queue Stor. Ratio
South: Van Buren Street NB											

1 L	0.069	0	4	0	4	7	8	9	11	13	0.01
2 T	0.112	0	6	0	6	12	15	16	20	23	0.01
East: WB Off-Ramp											
1 LT	0.213	0	9	0	9	17	21	24	29	34	0.02
2 R	0.041	0	1	0	1	3	3	4	5	6	0.04
North: Van Buren Street SB											
1 LTR	0.773	17	70	30	99	162	202	231	291	341	0.16

Values printed in this table are back of queue (feet).

Missoula MT I-90 Phase 2
Van Buren Street I-90 WB Ramps - AM Peak Hour
Intersection ID:
Roundabout

Table D.4 - MOVEMENT SPEEDS (mph)

Mov No.	App. Speeds Cruise	App. Speeds Negn	Exit Speeds Negn	Exit Speeds Cruise	Queue Move-up 1st Grn	Queue Move-up 2nd Grn	Av. Section Spd Running	Av. Section Spd Overall
South: Van Buren Street NB								
32	25.0	20.5	20.5	25.0			23.9	23.9
East: WB Off-Ramp								
22	25.0	14.4	14.4	25.0			22.0	22.0
23	25.0	19.1	19.1	25.0			23.2	23.2
North: Van Buren Street SB								
42	40.0	20.8	20.8	25.0	15.3		29.8	29.7

"Running Speed" is the average speed excluding stopped periods.

--- End of aaSIDRA Output ---

C:\Documents and Settings\tnewkirk\Desktop\Projects\Montana\I-90_Phase 2\SIDRA\Van Buren Street\2030_AM_VanBuren-WB Ramps.OUT
Produced by aaSIDRA 2.1.4.357

Generated 2:37 PM, Jul 13,2006

Akcelik & Associates Pty Ltd - aaSIDRA 2.1.4.357

CH2MHILL
CH2MHILL User ID: A0725
Licence Type: Single Computer

Time and Date of Analysis 10:38 AM, Jul 12,2006

Filename: C:\Documents and Settings\tnewkirk\Desktop\Projects\Montana\I-90_Phase 2\SIDRA\2030_AM_Orange Street.OUT

Missoula MT I-90 Phase 2
Orange Street Interchange - 2030 AM Peak Hour
Intersection ID:

aaTraffic SIDRA US Highway Capacity Manual (2000) Version

RUN INFORMATION

* Basic Parameters:
  Intersection Type: Roundabout
  Driving on the right-hand side of the road
  Input data specified in US units
  Default Values File No. 11
  Peak flow period (for performance): 15 minutes
  Unit time (for volumes): 60 minutes (Total Flow Period)
  Delay definition: Control delay
  Geometric delay included
  aaSIDRA Standard Delay and Queue models used
  Level of Service based on: Delay (HCM method)
  Queue definition: Back of queue, 95th Percentile

Geometric delay is less than 2 seconds for some movements. The negotiation speed may be too high or the approach and exit speeds may be too low for given geometric design (e.g. for a large roundabout). Check Tables D.0, D.1 and D.4 for geometric delay data including negotiation speeds. If necessary, specify appropriate values of approach and exit speeds (RIDES Approach Data screen), and negotiation radius or negotiation speed data (RIDES Extra Data - Geometric Delay data screen).

Missoula MT I-90 Phase 2
Orange Street Interchange - 2030 AM Peak Hour
Intersection ID:
Roundabout

Table S.0 - TRAFFIC FLOW DATA

Mov No.	Left LV	Left HV	Through LV	Through HV	Right LV	Right HV	Flow Scale	Peak Flow Factor
VEHICLES	Demand flows in veh/hour as used by the program							
West: Orange Street								
12	0	0	155	8	120	6	1.00	0.95
SouthEast: I-5 WB Off-ramp								
72	1	0	660	13	1	0	1.00	0.95
NorthWest: I-5 EB Off-ramp								

82	5	0	0	0	601	0	1.00	0.95

Based on unit time = 60 minutes.
Flow Scale and Peak Hour Factor effects included in flow values.

Missoula MT I-90 Phase 2
Orange Street Interchange - 2030 AM Peak Hour
Intersection ID:
Roundabout

Table R.0 - ROUNDABOUT BASIC PARAMETERS

Cent Island Diam (ft)	Circ Width (ft)	Insc Diam. (ft)	No.of Circ. Lanes	No.of Entry Lanes	Av.Ent Lane Width (ft)	Circulating/Exiting Stream Flow (veh/h)	%HV	Adjust. Flow (pcu/h)	%Exit Incl.	Cap. Constr. Effect	O-D Factor
West: Orange Street											
68	16	100	1	1	13.00	7	0.0	7	0	N	0.998
SouthEast: I-5 WB Off-ramp											
68	16	100	1	1	13.00	168	4.8	169	0	N	0.997
NorthWest: I-5 EB Off-ramp											
68	16	100	1	1	13.00	675	2.0	675	0	N	0.896

Missoula MT I-90 Phase 2
Orange Street Interchange - 2030 AM Peak Hour
Intersection ID:
Roundabout

Table R.1 - ROUNDABOUT GAP ACCEPTANCE PARAMETERS

Turn	Lane No.	Lane Type	---- Circulating/Exiting Stream --- Flow Rate (pcu/h)	Aver Speed (mph)	Aver Dist (ft)	In-Bnch Headway (s)	Prop Bunched	Critical Gap Hdwy (s)	Critical Gap Dist (ft)	Foll-up Headway (s)
West: Orange Street										
Thru	1	Dominant	7	13.8	9914.5	2.00	0.009	4.32	87.8	2.20
Right	1	Dominant	7	13.8	9914.5	2.00	0.009	4.32	87.7	2.19
SouthEast: I-5 WB Off-ramp										
Left	1	Dominant	169	13.1	409.6	2.00	0.186	4.64	89.3	2.43
Thru	1	Dominant	169	13.1	409.6	2.00	0.186	4.65	89.3	2.43
Right	1	Dominant	169	13.1	409.6	2.00	0.186	4.64	89.3	2.43
NorthWest: I-5 EB Off-ramp										
Left	1	Dominant	675	13.1	102.5	2.00	0.569	4.22	81.1	2.40
Right	1	Dominant	675	13.1	102.5	2.00	0.569	4.22	81.1	2.40

Environment Factor: 1.00
Entry/Circulating Flow Adjustment: Medium

Priority sharing is implied for some movements (Follow-up Headway plus
Intra-bunch Headway is larger than the Critical Gap). The O-D Factor

(Table R.0) allows for priority sharing and priority emphasis.

Dist (Distance): Spacing, i.e. distance between the front ends of two successive vehicles across all lanes in the circulating or exiting stream

---

Missoula MT I-90 Phase 2
Orange Street Interchange - 2030 AM Peak Hour
Intersection ID:
Roundabout

Table R.5 - ROUNDABOUT CAPACITY & LEVEL OF SERVICE - aaSIDRA & HCM MODELS

Mov No.	Dem Flow (veh /h)	aaSIDRA Cap. (veh /h)	aaSIDRA Deg. Satn x	aaSIDRA Av. Delay (sec)	aaSIDRA LOS	HCM 2000 Lower Cap. (veh /h)	HCM 2000 Lower Deg. Satn x	HCM 2000 Lower Av. Delay (sec)	HCM 2000 Lower LOS	HCM 2000 Upper Cap. (veh /h)	HCM 2000 Upper Deg. Satn x	HCM 2000 Upper Av. Delay (sec)	HCM 2000 Upper LOS
West: Orange Street													
12 TR	289	1626	0.178	2.8	A	1151	0.251	2.8	A	1373	0.210	2.8	A
SouthEast: I-5 WB Off-ramp													
72 LTR	675	1259	0.536	5.0	A	1005	0.672	5.6	A	1213	0.556	4.8	A
NorthWest: I-5 EB Off-ramp													
82 LR	606	729	0.831	19.2	B	646	0.938	31.6	C	811	0.747	14.1	B

Missoula MT I-90 Phase 2
Orange Street Interchange - 2030 AM Peak Hour
Intersection ID:
Roundabout

Table R.6 - ROUNDABOUT ALTERNATIVE CAPACITY MODELS

Mov No.	Dem Flow (veh /h)	aaSIDRA Cap. (veh /h)	aaSIDRA Deg. Satn x	NAASRA 1986 Cap. (veh /h)	NAASRA 1986 % Diff from aaSIDRA	Ger. Linear Cap. (veh /h)	Ger. Linear % Diff from aaSIDRA	Ger. GapAcc Cap. (veh /h)	Ger. GapAcc % Diff from aaSIDRA
West: Orange Street									
12 TR	289	1626	0.178	1784	9.7	1209	-25.6	1240	-23.7
SouthEast: I-5 WB Off-ramp									
72 LTR	675	1259	0.536	1556	23.6	1093	-13.2	1096	-12.9
NorthWest: I-5 EB Off-ramp									
82 LR	606	729	0.831	927	27.2	718	-1.5	680	-6.7

Missoula MT I-90 Phase 2
Orange Street Interchange - 2030 AM Peak Hour
Intersection ID:
Roundabout

Table S.2 - MOVEMENT CAPACITY PARAMETERS

Mov No.	Demand Flow (veh/h)	HV (%)	Opposing Flow (veh/h)	Opposing HV (%)	Movement Adjust. Flow (pcu/h)	Total Cap. (veh /h)	Prac. Deg. Satn xp	Prac. Spare Cap. (%)	Lane Util (%)	Deg. Satn x
West: Orange Street										
12 TR	289	4.8	7	0.0	7	1626	0.85	378	100	0.178
SouthEast: I-5 WB Off-ramp										
72 LTR	675	1.9	168	4.8	169	1259	0.85	59	100	0.536
NorthWest: I-5 EB Off-ramp										
82 LR	606	0.0	675	2.0	675	729	0.85	2	100	0.831*

Missoula MT I-90 Phase 2
Orange Street Interchange - 2030 AM Peak Hour
Intersection ID:
Roundabout

Table S.3 - INTERSECTION PARAMETERS

Intersection Level of Service	=	B
Worst movement Level of Service	=	B
Average intersection delay (s)	=	10.1
Largest average movement delay (s)	=	19.2
Largest back of queue, 95% (ft)	=	384
Performance Index	=	48.67
Degree of saturation (highest)	=	0.831
Practical Spare Capacity (lowest)	=	2 %
Effective intersection capacity, (veh/h)	=	1889
Total vehicle flow (veh/h)	=	1570
Total person flow (pers/h)	=	2355
Total vehicle delay (veh-h/h)	=	4.39
Total person delay (pers-h/h)	=	6.59
Total effective vehicle stops (veh/h)	=	1409
Total effective person stops (pers/h)	=	2113
Total vehicle travel (veh-mi/h)	=	578.3
Total cost ($/h)	=	845.16
Total fuel (gal/h)	=	21.9
Total CO2 (kg/h)	=	207.40

Missoula MT I-90 Phase 2
Orange Street Interchange - 2030 AM Peak Hour
Intersection ID:
Roundabout

Table S.5 - MOVEMENT PERFORMANCE

Mov No.	Total Delay (veh-h/h)	Total Delay (pers-h/h)	Aver. Delay (sec)	Prop. Queued	Eff. Stop Rate	Longest Queue 95% Back (vehs)	Longest Queue 95% Back (ft)	Perf. Index	Aver. Speed (mph)
West: Orange Street									
12 TR	0.22	0.34	2.8	0.07	0.36	1.5	39	6.60	19.1

SouthEast: I-5 WB Off-ramp

72	LTR	0.94	1.41	5.0	0.50	0.55	5.2	131	17.34	18.4

NorthWest: I-5 EB Off-ramp

82	LR	3.22	4.84	19.2	1.00	1.54	15.4	384	24.73	15.4

Missoula MT I-90 Phase 2
Orange Street Interchange - 2030 AM Peak Hour
Intersection ID:
Roundabout

Table S.6 - INTERSECTION PERFORMANCE

	Total Flow (veh/h)	Deg. Satn x	Total Delay (veh-h/h)	Total Delay (pers-h/h)	Aver. Delay (sec)	Prop. Queued	Eff. Stop Rate	Longest Queue (ft)	Perf. Index	Aver. Speed (mph)
West: Orange Street	289	0.178	0.22	0.34	2.8	0.07	0.36	39	6.60	19.1
SouthEast: I-5 WB Off-ramp	675	0.536	0.94	1.41	5.0	0.50	0.55	131	17.34	18.4
NorthWest: I-5 EB Off-ramp	606	0.831	3.22	4.84	19.2	1.00	1.54	384	24.73	15.4
ALL VEHICLES:	1570	0.831	4.39	6.59	10.1	0.61	0.90	384	48.67	17.3
INTERSECTION (persons):	2355	0.831		6.59	10.1	0.61	0.90		48.67	17.3

Queue values in this table are 95% back of queue (feet).

Missoula MT I-90 Phase 2
Orange Street Interchange - 2030 AM Peak Hour
Intersection ID:
Roundabout

Table S.7 - LANE PERFORMANCE

Lane No.	Mov No.	Dem Flow (veh /h)	Cap (veh /h)	Deg. Satn x	Aver. Delay (sec)	Eff. Stop Rate	Q u e u e 95% Back (vehs)	Q u e u e 95% Back (ft)	Short Lane (ft)
West: Orange Street									
1 TR	12	289	1626	0.178	2.8	0.36	1.5	39	
SouthEast: I-5 WB Off-ramp									
1 LTR	72	675	1259	0.536	5.0	0.55	5.2	131	
NorthWest: I-5 EB Off-ramp									
1 LR	82	606	729	0.831	19.2	1.54	15.4	384	

Missoula MT I-90 Phase 2

Orange Street Interchange - 2030 AM Peak Hour
Intersection ID:
Roundabout

Table S.8A - LANE FLOW AND CAPACITY INFORMATION

Lane No.	Mov No.	Dem Flow (veh/h) Lef	Thru	Rig	Tot	Min Cap (veh /h)	Tot Cap (veh /h)	Deg. Satn x	Lane Util %
West: Orange Street									
1 TR	12	0	163	126	289	150	1626	0.178	100
SouthEast: I-5 WB Off-ramp									
1 LTR	72	1	673	1	675	150	1259	0.536	100
NorthWest: I-5 EB Off-ramp									
1 LR	82	5	0	601	606	150	729	0.831	100

For roundabouts, the capacity value for continuous movements is obtained as the basic saturation flow without any adjustments. Saturation flow scale applies if specified.

Missoula MT I-90 Phase 2
Orange Street Interchange - 2030 AM Peak Hour
Intersection ID:
Roundabout

Table S.12A - FUEL CONSUMPTION, EMISSIONS AND COST - TOTAL

Mov No.	Fuel Total gal/h	Cost Total $/h	HC Total kg/h	CO Total kg/h	NOX Total kg/h	CO2 Total kg/h
West: Orange Street						
12 TR	3.9	140.81	0.056	1.17	0.039	37.2
	3.9	140.81	0.056	1.17	0.039	37.2
SouthEast: I-5 WB Off-ramp						
72 LTR	9.2	346.12	0.140	2.97	0.096	87.0
	9.2	346.12	0.140	2.97	0.096	87.0
NorthWest: I-5 EB Off-ramp						
82 LR	8.8	358.24	0.145	3.08	0.096	83.2
	8.8	358.24	0.145	3.08	0.096	83.2
INTERSECTION:	21.9	845.16	0.341	7.23	0.231	207.4

PARAMETERS USED IN COST CALCULATIONS

Pump price of fuel ($/US gal) = 0.900
Fuel resource cost factor = 0.50

Ratio of running cost to fuel cost	=	3.0
Average income ($/h)	=	27.00
Time value factor	=	0.60
Average occupancy (persons/veh)	=	1.5
Light vehicle mass (1000 lb)	=	1.4
Heavy vehicle mass (1000 lb)	=	11.0
Light vehicle idle fuel rate (US gal/h)	=	0.360
Heavy vehicle idle fuel rate (US gal/h)	=	0.530

The idle fuel and vehicle mass parameters given above are the default values (data given in RIDES may override some of these parameters).

Missoula MT I-90 Phase 2
Orange Street Interchange - 2030 AM Peak Hour
Intersection ID:
Roundabout

Table S.14 - SUMMARY OF INPUT AND OUTPUT DATA

Lane No.	Demand Flow (veh/h) L	T	R	Tot	%HV	Adj. Basic Satf.	Eff Grn (secs) 1st	2nd	Deg Sat x	Aver. Delay (sec)	Longest Queue (ft)	Shrt Lane (ft)
West: Orange Street												
1 TR		163	126	289	5				0.178	2.8	39	
	0	163	126	289	5				0.178	2.8	39	
SouthEast: I-5 WB Off-ramp												
1 LTR	1	673	1	675	2				0.536	5.0	131	
	1	673	1	675	2				0.536	5.0	131	
NorthWest: I-5 EB Off-ramp												
1 LR	5		601	606	0				0.831	19.2	384	
	5	0	601	606	0				0.831	19.2	384	

ALL VEHICLES	Total Flow	% HV	Max X	Aver. Delay	Max Queue
	1570	2	0.831	10.1	384

Total flow period = 60 minutes. Peak flow period = 15 minutes.

Queue values in this table are 95% back of queue (feet).

Note: Basic Saturation Flows are not adjusted at roundabouts or sign-controlled intersections and apply only to continuous lanes.

Missoula MT I-90 Phase 2
Orange Street Interchange - 2030 AM Peak Hour
Intersection ID:
Roundabout

Table S.15 - CAPACITY AND LEVEL OF SERVICE

Mov No.	Mov Typ	Total Flow (veh	Total Cap. (veh	Deg. of Satn	Aver. Delay	LOS	Longest Queue 95% Back (vehs)	(ft)

```
                  /h)    /h)    (v/c)  (sec)
-----------------------------------------------------------------
West: Orange Street
  12 TR           289   1626   0.178     2.8    A      1.5     39
              ---------------------------------------------------
                  289          0.178     2.8    A      1.5     39
-----------------------------------------------------------------
SouthEast: I-5 WB Off-ramp
  72 LTR          675   1259   0.536     5.0    A      5.2    131
              ---------------------------------------------------
                  675          0.536     5.0    A      5.2    131
-----------------------------------------------------------------
NorthWest: I-5 EB Off-ramp
  82 LR           606    729   0.831*   19.2    B     15.4    384
              ---------------------------------------------------
                  606          0.831    19.2    B     15.4    384
-----------------------------------------------------------------
 ALL VEHICLES:   1570          0.831    10.1    B     15.4    384
-----------------------------------------------------------------
     Level of Service calculations are based on
     average control delay including geometric delay (HCM criteria),
     independent of the current delay definition used.
     For the criteria, refer to the "Level of Service" topic in the
     aaSIDRA Output Guide or the Output section of the on-line help.
  *  Maximum v/c ratio, or critical green periods
```

Missoula MT I-90 Phase 2
Orange Street Interchange - 2030 AM Peak Hour
Intersection ID:
Roundabout

Table D.0 - GEOMETRIC DELAY DATA

From Approach	To Approach	Negn Radius (ft)	Negn Speed (mph)	Negn Dist. (ft)	Appr. Dist. (ft)	Downstream Distance (ft)
West: Orange Street						
	SouthWest	57.0	15.5	32.8	1800	107
	NorthEast	36.9	13.1	115.8	1800	179
SouthEast: I-5 WB Off-ramp						
	West	36.9	13.1	115.8	1800	179
	SouthWest	37.8	13.2	148.2	1800	210
	NorthEast	80.0	17.6	38.6	1800	104
NorthWest: I-5 EB Off-ramp						
	West	57.0	15.5	32.8	1800	106
	SouthWest	80.0	17.6	38.6	1800	106
	NorthEast	37.8	13.2	148.2	1800	210

Maximum Negotiation (Design) Speed = 50.0 mph
Downstream Distance calculated by aaSIDRA

Downstream distance is distance travelled from the stopline until exit cruise speed is reached (includes negotiation distance). Acceleration distance is weighted for light and heavy vehicles. The same distance applies for both stopped and unstopped vehicles.

Orange Street Interchange - 2030 AM Peak Hour
Intersection ID:
Roundabout

Table D.1 - LANE DELAYS

Lane No.	Mov No.	Deg. Satn x	Stop-line Delay 1st d1	2nd d2	Total dSL	Acc. Dec. dn	Queuing Total dq	MvUp dqm	Stopd (Idle) di	Geom dig	Control dic
West: Orange Street											
1 TR	12	0.178	0.0	0.0	0.0	0.3	0.0	0.0	0.0	2.8	2.8
SouthEast: I-5 WB Off-ramp											
1 LTR	72	0.536	1.3	0.0	1.3	2.1	0.0	0.0	0.0	3.7	5.0
NorthWest: I-5 EB Off-ramp											
1 LR	82	0.831	6.8	10.7	17.6	4.8	12.8	4.2	8.6	1.6	19.2

Delay (seconds/veh)

dn is average stop-start delay for all vehicles queued and unqueued

Geometric delay is less than 2 seconds for some movements. The negotiation speed may be too high or the approach and exit speeds may be too low for given geometric design (e.g. for a large roundabout). Check Tables D.0, D.1 and D.4 for geometric delay data including negotiation speeds. If necessary, specify appropriate values of approach and exit speeds (RIDES Approach Data screen), and negotiation radius or negotiation speed data (RIDES Extra Data - Geometric Delay data screen).

Missoula MT I-90 Phase 2
Orange Street Interchange - 2030 AM Peak Hour
Intersection ID:
Roundabout

Table D.2 - LANE STOPS

Lane No.	Deg. Satn x	Effective Stop Rate he1	he2	Geom. hig	Overall h	Prop. Queued pq	Queue Move-up Rate hqm
West: Orange Street							
1 TR	0.178	0.01	0.00	0.34	0.36	0.068	0.00
SouthEast: I-5 WB Off-ramp							
1 LTR	0.536	0.32	0.00	0.23	0.55	0.496	0.00
NorthWest: I-5 EB Off-ramp							
1 LR	0.831	1.00	0.55	0.00	1.54	1.000	0.79

hig is the average value for all movements in a shared lane
hqm is average queue move-up rate for all vehicles queued and unqueued

---

Missoula MT I-90 Phase 2
Orange Street Interchange - 2030 AM Peak Hour
Intersection ID:
Roundabout

Table D.3A - LANE QUEUES (veh)

Lane No.	Deg. Satn x	Ovrfl. Queue No	Average (veh) Nb1	Nb2	Nb	Percentile (veh) 70%	85%	90%	95%	98%	Queue Stor. Ratio
West: Orange Street											
1 TR	0.178	0.0	0.5	0.0	0.5	0.9	1.1	1.2	1.5	1.8	0.02
SouthEast: I-5 WB Off-ramp											
1 LTR	0.536	0.0	1.7	0.0	1.7	3.0	3.7	4.2	5.2	6.0	0.07
NorthWest: I-5 EB Off-ramp											
1 LR	0.831	1.8	3.0	2.4	5.4	8.4	10.5	12.1	15.4	18.0	0.21

Values printed in this table are back of queue (vehicles).

Missoula MT I-90 Phase 2
Orange Street Interchange - 2030 AM Peak Hour
Intersection ID:
Roundabout

Table D.3B - LANE QUEUES (feet)

Lane No.	Deg. Satn x	Ovrfl. Queue No	Average (feet) Nb1	Nb2	Nb	Percentile (feet) 70%	85%	90%	95%	98%	Queue Stor. Ratio
West: Orange Street											
1 TR	0.178	0	12	0	12	23	28	32	39	46	0.02
SouthEast: I-5 WB Off-ramp											
1 LTR	0.536	0	43	0	43	76	93	106	131	153	0.07
NorthWest: I-5 EB Off-ramp											
1 LR	0.831	45	75	59	134	209	263	303	384	451	0.21

Values printed in this table are back of queue (feet).

Missoula MT I-90 Phase 2
Orange Street Interchange - 2030 AM Peak Hour
Intersection ID:
Roundabout

Table D.4 - MOVEMENT SPEEDS (mph)

Mov No.	App. Speeds Cruise	Negn	Exit Speeds Negn	Cruise	Queue Move-up 1st Grn	2nd Grn	Av. Section Spd Running	Overall
West: Orange Street								
12	20.0	14.1	14.1	20.0			19.1	19.1
SouthEast: I-5 WB Off-ramp								

```
   72    20.0  13.1   13.1  20.0                     18.4    18.4
-----------------------------------------------------------------
 NorthWest: I-5 EB Off-ramp
   82    20.0  15.4   15.4  20.0    12.9             17.2    15.4
-----------------------------------------------------------------
```

"Running Speed" is the average speed excluding stopped periods.

--- End of aaSIDRA Output ---

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Produced by aaSIDRA 2.1.4.357

Generated 10:38 AM, Jul 12,2006

Akcelik & Associates Pty Ltd - aaSIDRA 2.1.4.357

CH2MHILL
CH2MHILL User ID: A0725
Licence Type: Single Computer

Time and Date of Analysis 10:21 AM, Jul 13,2006

Filename: C:\Documents and Settings\tnewkirk\Desktop\Projects\Montana\I-90_Phase 2\SIDRA\Orange Street\2030_PM_Orange-EB Ramps.OUT

Missoula MT I-90 Phase 2
Orange Street I-90 EB Ramps-2030 PM Peak Hour
Intersection ID:

aaTraffic SIDRA US Highway Capacity Manual (2000) Version

RUN INFORMATION

* Basic Parameters:
  Intersection Type: Roundabout
  Driving on the right-hand side of the road
  Input data specified in US units
  Default Values File No. 11
  Peak flow period (for performance): 15 minutes
  Unit time (for volumes): 60 minutes (Total Flow Period)
  Delay definition: Control delay
                    Geometric delay included
  aaSIDRA Standard Delay and Queue models used
  Level of Service based on: Delay (HCM method)
  Queue definition: Back of queue, 95th Percentile

Geometric delay is less than 2 seconds for some movements. The negotiation speed may be too high or the approach and exit speeds may be too low for given geometric design (e.g. for a large roundabout). Check Tables D.0, D.1 and D.4 for geometric delay data including negotiation speeds. If necessary, specify appropriate values of approach and exit speeds (RIDES Approach Data screen), and negotiation radius or negotiation speed data (RIDES Extra Data - Geometric Delay data screen).

Missoula MT I-90 Phase 2
Orange Street I-90 EB Ramps-2030 PM Peak Hour
Intersection ID:
Roundabout

Table S.0 - TRAFFIC FLOW DATA

Mov No.	Left LV	Left HV	Through LV	Through HV	Right LV	Right HV	Flow Scale	Peak Flow Factor
VEHICLES Demand flows in veh/hour as used by the program								
West: EB Off-Ramp								
12	10	1	1	0	0	0	1.00	0.95
13	0	0	0	0	470	15	1.00	0.95
South: Orange Street NB								
32	0	0	531	5	386	4	1.00	0.95

North: Orange Street SB

42	1	0	479	5	0	0	1.00	0.95

Based on unit time = 60 minutes.
Flow Scale and Peak Hour Factor effects included in flow values.

Missoula MT I-90 Phase 2
Orange Street I-90 EB Ramps-2030 PM Peak Hour
Intersection ID:
Roundabout

Table R.0 - ROUNDABOUT BASIC PARAMETERS

Cent Island Diam (ft)	Circ Width (ft)	Insc Diam. (ft)	No.of Circ. Lanes	No.of Entry Lanes	Av.Ent Lane Width (ft)	Circulating/Exiting Stream Flow (veh/h)	%HV	Adjust. Flow (pcu/h)	%Exit Incl.	Cap. Constr. Effect	O-D Factor
West: EB Off-Ramp											
68	16	100	1	1	13.00	485	1.0	485	0	N	1.000
South: Orange Street NB											
68	16	100	1	1	13.00	13	2.5	13	0	N	0.997
North: Orange Street SB											
68	16	100	1	1	13.00	0	0.0	0	0	N	1.000

Missoula MT I-90 Phase 2
Orange Street I-90 EB Ramps-2030 PM Peak Hour
Intersection ID:
Roundabout

Table R.1 - ROUNDABOUT GAP ACCEPTANCE PARAMETERS

Turn	Lane No.	Lane Type	Circulating/Exiting Stream Flow Rate (pcu/h)	Aver Speed (mph)	Aver Dist (ft)	In-Bnch Headway (s)	Prop Bunched	Critical Gap Hdwy (s)	Critical Gap Dist (ft)	Foll-up Headway (s)
West: EB Off-Ramp										
Left	1	Dominant	485	20.0	217.4	2.00	0.448	4.66	136.5	2.57
Thru	1	Dominant	485	20.0	217.4	2.00	0.448	4.47	131.0	2.47
Right	1	Dominant	485	20.0	217.4	2.00	0.448	4.47	131.1	2.47
South: Orange Street NB										
Thru	1	Dominant	13	13.7	5729.9	2.00	0.015	4.21	84.7	2.14
Right	1	Dominant	13	13.7	5729.9	2.00	0.015	4.21	84.7	2.14
North: Orange Street SB										
Left	1	Dominant	0	0.0		2.00	0.000	4.11	0.0	2.08
Thru	1	Dominant	0	0.0		2.00	0.000	4.11	0.0	2.08

Environment Factor: 1.00
Entry/Circulating Flow Adjustment: Medium

Dist (Distance): Spacing, i.e. distance between the front ends of two successive vehicles across all lanes in the circulating or exiting stream

Missoula MT I-90 Phase 2
Orange Street I-90 EB Ramps-2030 PM Peak Hour
Intersection ID:
Roundabout

Table R.5 - ROUNDABOUT CAPACITY & LEVEL OF SERVICE - aaSIDRA & HCM MODELS

Mov No.	Dem Flow (veh /h)	aaSIDRA Cap. (veh /h)	aaSIDRA Deg. Satn x	aaSIDRA Av. Delay (sec)	aaSIDRA LOS	HCM 2000 Lower Cap. (veh /h)	HCM 2000 Lower Deg. Satn x	HCM 2000 Lower Av. Delay (sec)	HCM 2000 Lower LOS	HCM 2000 Upper Cap. (veh /h)	HCM 2000 Upper Deg. Satn x	HCM 2000 Upper Av. Delay (sec)	HCM 2000 Upper LOS
West: EB Off-Ramp													
12 LT	12	22	0.545	8.6	A	18	0.667	10.9	B	23	0.522	8.1	A
13 R	485	909	0.534	11.6	B	744	0.652	13.9	B	920	0.527	11.1	B
South: Orange Street NB													
32 TR	926	1660	0.558	0.4	A	1149	0.806	0.6	A	1371	0.675	0.5	A
North: Orange Street SB													
42 LT	485	1728	0.281	0.0	A	1161	0.418	0.0	A	1385	0.350	0.0	A

Missoula MT I-90 Phase 2
Orange Street I-90 EB Ramps-2030 PM Peak Hour
Intersection ID:
Roundabout

Table R.6 - ROUNDABOUT ALTERNATIVE CAPACITY MODELS

Mov No.	Dem Flow (veh /h)	aaSIDRA Cap. (veh /h)	aaSIDRA Deg. Satn x	NAASRA 1986 Cap. (veh /h)	NAASRA 1986 % Diff from aaSIDRA	Ger. Linear Cap. (veh /h)	Ger. Linear % Diff from aaSIDRA	Ger. GapAcc Cap. (veh /h)	Ger. GapAcc % Diff from aaSIDRA
West: EB Off-Ramp									
12 LT	12	22	0.545	28	27.3	21	-4.5	20	-9.1
13 R	485	909	0.534	1116	22.8	837	-7.9	807	-11.2
South: Orange Street NB									
32 TR	926	1660	0.558	1781	7.3	1208	-27.2	1238	-25.4
North: Orange Street SB									
42 LT	485	1728	0.281	1800	4.2	1218	-29.5	1250	-27.7

Missoula MT I-90 Phase 2
Orange Street I-90 EB Ramps-2030 PM Peak Hour
Intersection ID:
Roundabout

Table S.2 - MOVEMENT CAPACITY PARAMETERS

Mov No.	Demand Flow (veh/h)	HV (%)	Opposing Movement Flow (veh/h)	HV (%)	Adjust. Flow (pcu/h)	Total Cap. (veh /h)	Prac. Deg. Satn xp	Prac. Spare Cap. (%)	Lane Util (%)	Deg. Satn x
West: EB Off-Ramp										
12 LT	12	8.3	485	1.0	485	22	0.85	56	100	0.545
13 R	485	3.1	485	1.0	485	909	0.85	59	100	0.534
South: Orange Street NB										
32 TR	926	1.0	13	2.5	13	1660	0.85	52	100	0.558*
North: Orange Street SB										
42 LT	485	1.0	0			1728	0.85	203	100	0.281

Missoula MT I-90 Phase 2
Orange Street I-90 EB Ramps-2030 PM Peak Hour
Intersection ID:
Roundabout

Table S.3 - INTERSECTION PARAMETERS

Intersection Level of Service	=	A
Worst movement Level of Service	=	B
Average intersection delay (s)	=	3.2
Largest average movement delay (s)	=	11.6
Largest back of queue, 95% (ft)	=	182
Performance Index	=	38.48
Degree of saturation (highest)	=	0.558
Practical Spare Capacity (lowest)	=	52 %
Effective intersection capacity, (veh/h)	=	3420
Total vehicle flow (veh/h)	=	1908
Total person flow (pers/h)	=	2862
Total vehicle delay (veh-h/h)	=	1.71
Total person delay (pers-h/h)	=	2.56
Total effective vehicle stops (veh/h)	=	483
Total effective person stops (pers/h)	=	725
Total vehicle travel (veh-mi/h)	=	687.4
Total cost ($/h)	=	801.89
Total fuel (gal/h)	=	22.7
Total CO2 (kg/h)	=	215.32

Missoula MT I-90 Phase 2
Orange Street I-90 EB Ramps-2030 PM Peak Hour
Intersection ID:
Roundabout

Table S.5 - MOVEMENT PERFORMANCE

Mov No.	Total Delay (veh-h/h)	Total Delay (pers-h/h)	Aver. Delay (sec)	Prop. Queued	Eff. Stop Rate	Longest Queue 95% Back (vehs)	Longest Queue 95% Back (ft)	Perf. Index	Aver. Speed (mph)
West: EB Off-Ramp									
12 LT	0.03	0.04	8.6	0.73	0.85	5.2	134	0.35	17.8
13 R	1.56	2.35	11.6	0.73	0.84	5.2	134	9.86	30.3

South: Orange Street NB									
32	TR	0.11	0.17	0.4	0.14	0.07	7.2	182	19.54	19.7
North: Orange Street SB									
42	LT	0.00	0.00	0.0	0.00	0.00	0.0	0	8.73	20.0

Missoula MT I-90 Phase 2
Orange Street I-90 EB Ramps-2030 PM Peak Hour
Intersection ID:
Roundabout

Table S.6 - INTERSECTION PERFORMANCE

Total Flow (veh/h)	Deg. Satn x	Total Delay (veh-h/h)	Total Delay (pers-h/h)	Aver. Delay (sec)	Prop. Queued	Eff. Stop Rate	Longest Queue (ft)	Perf. Index	Aver. Speed (mph)
West: EB Off-Ramp									
497	0.545	1.59	2.39	11.5	0.73	0.84	134	10.21	29.8
South: Orange Street NB									
926	0.558	0.11	0.17	0.4	0.14	0.07	182	19.54	19.7
North: Orange Street SB									
485	0.281	0.00	0.00	0.0	0.00	0.00	0	8.73	20.0
ALL VEHICLES:									
1908	0.558	1.71	2.56	3.2	0.26	0.25	182	38.48	21.7
INTERSECTION (persons):									
2862	0.558		2.56	3.2	0.26	0.25		38.48	21.7

Queue values in this table are 95% back of queue (feet).

Missoula MT I-90 Phase 2
Orange Street I-90 EB Ramps-2030 PM Peak Hour
Intersection ID:
Roundabout

Table S.7 - LANE PERFORMANCE

Lane No.	Mov No.	Dem Flow (veh /h)	Cap (veh /h)	Deg. Satn x	Aver. Delay (sec)	Eff. Stop Rate	Queue 95% Back (vehs)	Queue 95% Back (ft)	Short Lane (ft)
West: EB Off-Ramp									
1 LTR	12, 13	497	931	0.534	11.5	0.84	5.2	134	
South: Orange Street NB									
1 TR	32	926	1660	0.558	0.4	0.07	7.2	182	
North: Orange Street SB									
1 LT	42	485	1728	0.281	0.0	0.00	0.0	0	

Missoula MT I-90 Phase 2
Orange Street I-90 EB Ramps-2030 PM Peak Hour
Intersection ID:
Roundabout

Table S.8A - LANE FLOW AND CAPACITY INFORMATION

Lane No.	Mov No.	Dem Flow (veh/h) Lef	Thru	Rig	Tot	Min Cap (veh /h)	Tot Cap (veh /h)	Deg. Satn x	Lane Util %
West: EB Off-Ramp									
1 LTR	12, 13	11	1	485	497	150	931	0.534	100
South: Orange Street NB									
1 TR	32	0	536	390	926	150	1660	0.558	100
North: Orange Street SB									
1 LT	42	1	484	0	485	150	1728	0.281	100

For roundabouts, the capacity value for continuous movements is obtained as the basic saturation flow without any adjustments. Saturation flow scale applies if specified.

Missoula MT I-90 Phase 2
Orange Street I-90 EB Ramps-2030 PM Peak Hour
Intersection ID:
Roundabout

Table S.12A - FUEL CONSUMPTION, EMISSIONS AND COST - TOTAL

Mov No.	Fuel Total gal/h	Cost Total $/h	HC Total kg/h	CO Total kg/h	NOX Total kg/h	CO2 Total kg/h
West: EB Off-Ramp						
12 LT	0.2	6.45	0.003	0.06	0.002	1.6
13 R	5.6	148.19	0.078	1.53	0.089	53.5
	5.8	154.64	0.080	1.58	0.090	55.1
South: Orange Street NB						
32 TR	11.2	427.43	0.167	3.15	0.109	106.0
	11.2	427.43	0.167	3.15	0.109	106.0
North: Orange Street SB						
42 LT	5.7	219.81	0.085	1.50	0.054	54.2
	5.7	219.81	0.085	1.50	0.054	54.2
INTERSECTION:	22.7	801.89	0.332	6.24	0.253	215.3

PARAMETERS USED IN COST CALCULATIONS

Pump price of fuel ($/US gal)	=	0.900
Fuel resource cost factor	=	0.50
Ratio of running cost to fuel cost	=	3.0
Average income ($/h)	=	27.00
Time value factor	=	0.60
Average occupancy (persons/veh)	=	1.5
Light vehicle mass (1000 lb)	=	1.4
Heavy vehicle mass (1000 lb)	=	11.0
Light vehicle idle fuel rate (US gal/h)	=	0.360
Heavy vehicle idle fuel rate (US gal/h)	=	0.530

The idle fuel and vehicle mass parameters given above are the default values (data given in RIDES may override some of these parameters).

Missoula MT I-90 Phase 2
Orange Street I-90 EB Ramps-2030 PM Peak Hour
Intersection ID:
Roundabout

Table S.14 - SUMMARY OF INPUT AND OUTPUT DATA

Lane No.	Demand Flow (veh/h) L	T	R	Tot	%HV	Adj. Basic Satf.	Eff Grn (secs) 1st	2nd	Deg Sat x	Aver. Delay (sec)	Longest Queue (ft)	Shrt Lane (ft)
West: EB Off-Ramp												
1 LTR	11	1	485	497	3				0.534	11.5	134	
	11	1	485	497	3				0.534	11.5	134	
South: Orange Street NB												
1 TR		536	390	926	1				0.558	0.4	182	
	0	536	390	926	1				0.558	0.4	182	
North: Orange Street SB												
1 LT	1	484		485	1				0.281	0.0	0	
	1	484	0	485	1				0.281	0.0		

ALL VEHICLES	Total Flow	% HV	Max X	Aver. Delay	Max Queue
	1908	2	0.558	3.2	182

Total flow period = 60 minutes. Peak flow period = 15 minutes.

Queue values in this table are 95% back of queue (feet).

Note: Basic Saturation Flows are not adjusted at roundabouts or sign-controlled intersections and apply only to continuous lanes.

Missoula MT I-90 Phase 2
Orange Street I-90 EB Ramps-2030 PM Peak Hour
Intersection ID:
Roundabout

Table S.15 - CAPACITY AND LEVEL OF SERVICE

Mov No.	Mov Typ	Total Flow (veh /h)	Total Cap. (veh /h)	Deg. of Satn (v/c)	Aver. Delay (sec)	LOS	Longest Queue 95% Back (vehs)	(ft)
West: EB Off-Ramp								
12	LT	12	22	0.545	8.6	A	5.2	134
13	R	485	909	0.534	11.6	B	5.2	134
		497		0.545	11.5	B	5.2	134
South: Orange Street NB								
32	TR	926	1660	0.558*	0.4	A	7.2	182
		926		0.558	0.4	A	7.2	182
North: Orange Street SB								
42	LT	485	1728	0.281	0.0	A	0.0	0
		485		0.281	0.0	A	0.0	0
ALL VEHICLES:		1908		0.558	3.2	A	7.2	182

Level of Service calculations are based on
average control delay including geometric delay (HCM criteria),
independent of the current delay definition used.
For the criteria, refer to the "Level of Service" topic in the
aaSIDRA Output Guide or the Output section of the on-line help.
* Maximum v/c ratio, or critical green periods

Missoula MT I-90 Phase 2
Orange Street I-90 EB Ramps-2030 PM Peak Hour
Intersection ID:
Roundabout

Table D.0 - GEOMETRIC DELAY DATA

From Approach	To Approach	Negn Radius (ft)	Negn Speed (mph)	Negn Dist. (ft)	Appr. Dist. (ft)	Downstream Distance (ft)
West: EB Off-Ramp						
	South	80.0	17.6	38.6	1800	105
	East	130.5	20.0	95.5	1800	100
	North	36.9	13.1	144.8	1800	208
South: Orange Street NB						
	East	80.0	17.6	38.6	1800	104
	North	113.2	20.0	83.1	1800	100
North: Orange Street SB						
	South	130.5	20.0	95.5	1800	100
	East	40.4	13.6	158.7	1800	218

Maximum Negotiation (Design) Speed = 50.0 mph
Downstream Distance calculated by aaSIDRA

Downstream distance is distance travelled from the stopline until exit cruise speed is reached (includes negotiation distance). Acceleration distance is weighted for light and heavy vehicles. The same distance applies for both stopped and unstopped vehicles.

Missoula MT I-90 Phase 2
Orange Street I-90 EB Ramps-2030 PM Peak Hour
Intersection ID:
Roundabout

Table D.1 - LANE DELAYS

Lane No.	Mov No.	Deg. Satn x	Stop-line Delay 1st d1	Stop-line Delay 2nd d2	Stop-line Delay Total dSL	Acc. Dec. dn	Queuing Total dq	Queuing MvUp dqm	Stopd (Idle) di	Geom dig	Control dic
West: EB Off-Ramp											
1 LTR	12, 13	0.534	3.9	0.8	4.8	3.8	0.9	0.7	0.3	3.8 6.9	11.5
South: Orange Street NB											
1 TR	32	0.558	0.1	0.0	0.1	0.8	0.0	0.0	0.0	0.3	0.4
North: Orange Street SB											
1 LT	42	0.281	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Delay (seconds/veh)

dn is average stop-start delay for all vehicles queued and unqueued

Geometric delay is less than 2 seconds for some movements. The negotiation speed may be too high or the approach and exit speeds may be too low for given geometric design (e.g. for a large roundabout). Check Tables D.0, D.1 and D.4 for geometric delay data including negotiation speeds. If necessary, specify appropriate values of approach and exit speeds (RIDES Approach Data screen), and negotiation radius or negotiation speed data (RIDES Extra Data - Geometric Delay data screen).

Missoula MT I-90 Phase 2
Orange Street I-90 EB Ramps-2030 PM Peak Hour
Intersection ID:
Roundabout

Table D.2 - LANE STOPS

Lane No.	Deg. Satn x	Effective Stop Rate he1	Effective Stop Rate he2	Effective Stop Rate Geom. hig	Effective Stop Rate Overall h	Prop. Queued pq	Queue Move-up Rate hqm
West: EB Off-Ramp							
1 LTR	0.534	0.65	0.04	0.15	0.84	0.730	0.09
South: Orange Street NB							
1 TR	0.558	0.02	0.00	0.05	0.07	0.142	0.00
North: Orange Street SB							
1 LT	0.281	0.00	0.00	0.00	0.00	0.000	0.00

hig is the average value for all movements in a shared lane
hqm is average queue move-up rate for all vehicles queued and unqueued

Missoula MT I-90 Phase 2
Orange Street I-90 EB Ramps-2030 PM Peak Hour
Intersection ID:
Roundabout

Table D.3A - LANE QUEUES (veh)

Lane No.	Deg. Satn x	Ovrfl. Queue No	Average (veh) Nb1	Nb2	Nb	Percentile (veh) 70%	85%	90%	95%	98%	Queue Stor. Ratio
West: EB Off-Ramp											
1 LTR	0.534	0.2	1.5	0.2	1.7	3.0	3.7	4.2	5.2	6.1	0.07
South: Orange Street NB											
1 TR	0.558	0.0	2.4	0.0	2.4	4.1	5.1	5.8	7.2	8.4	0.10
North: Orange Street SB											
1 LT	0.281	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00

Values printed in this table are back of queue (vehicles).

Missoula MT I-90 Phase 2
Orange Street I-90 EB Ramps-2030 PM Peak Hour
Intersection ID:
Roundabout

Table D.3B - LANE QUEUES (feet)

Lane No.	Deg. Satn x	Ovrfl. Queue No	Average (feet) Nb1	Nb2	Nb	Percentile (feet) 70%	85%	90%	95%	98%	Queue Stor. Ratio
West: EB Off-Ramp											
1 LTR	0.534	4	38	5	44	77	94	108	134	156	0.07
South: Orange Street NB											
1 TR	0.558	0	60	0	60	103	127	145	182	212	0.10
North: Orange Street SB											
1 LT	0.281	0	0	0	0	0	0	0	0	0	0.00

Values printed in this table are back of queue (feet).

Missoula MT I-90 Phase 2
Orange Street I-90 EB Ramps-2030 PM Peak Hour
Intersection ID:
Roundabout

Table D.4 - MOVEMENT SPEEDS (mph)

Mov No.	App. Speeds Cruise	Negn	Exit Speeds Negn	Cruise	Queue Move-up 1st Grn	2nd Grn	Av. Section Spd Running	Overall

West: EB Off-Ramp							
12	20.0	13.7	13.7	20.0	14.0	18.0	17.8
13	40.0	17.6	17.6	20.0	14.3	30.5	30.3
South: Orange Street NB							
32	20.0	19.0	19.0	20.0		19.7	19.7
North: Orange Street SB							
42	20.0	20.0	20.0	20.0		20.0	20.0

"Running Speed" is the average speed excluding stopped periods.

--- End of aaSIDRA Output ---

C:\Documents and Settings\tnewkirk\Desktop\Projects\Montana\I-90_Phase 2\SIDRA\Orange Street\2030_PM_Orange-EB Ramps.OUT
Produced by aaSIDRA 2.1.4.357

Generated 10:21 AM, Jul 13,2006

Akcelik & Associates Pty Ltd - aaSIDRA 2.1.4.357

CH2MHILL
CH2MHILL User ID: A0725
Licence Type: Single Computer

Time and Date of Analysis 10:18 AM, Jul 13,2006

Filename: C:\Documents and Settings\tnewkirk\Desktop\Projects\Montana\I-90_Phase 2\SIDRA\Orange Street\2030_PM_Orange-WB Ramps.OUT

Missoula MT I-90 Phase 2
Orange Street I-90 WB Ramps-2030 PM Peak Hour
Intersection ID:

aaTraffic SIDRA US Highway Capacity Manual (2000) Version

RUN INFORMATION
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* Basic Parameters:
  - Intersection Type: Roundabout
  - Driving on the right-hand side of the road
  - Input data specified in US units
  - Default Values File No. 11
  - Peak flow period (for performance): 15 minutes
  - Unit time (for volumes): 60 minutes (Total Flow Period)
  - Delay definition: Control delay
    Geometric delay included
  - aaSIDRA Standard Delay and Queue models used
  - Level of Service based on: Delay (HCM method)
  - Queue definition: Back of queue, 95th Percentile

Missoula MT I-90 Phase 2
Orange Street I-90 WB Ramps-2030 PM Peak Hour
Intersection ID:
Roundabout

Table S.0 - TRAFFIC FLOW DATA

Mov No.	Left LV	Left HV	Through LV	Through HV	Right LV	Right HV	Flow Scale	Peak Flow Factor
VEHICLES	Demand flows in veh/hour as used by the program							
South: Orange Street NB								
32	542	5	0	0	0	0	1.00	0.95
East: WB Off-Ramp								
22	479	5	1	0	0	0	1.00	0.95

Based on unit time = 60 minutes.
Flow Scale and Peak Hour Factor effects included in flow values.

Missoula MT I-90 Phase 2
Orange Street I-90 WB Ramps-2030 PM Peak Hour
Intersection ID:
Roundabout

Table R.0 - ROUNDABOUT BASIC PARAMETERS

Cent Island Diam (ft)	Circ Width (ft)	Insc Diam. (ft)	No.of Circ. Lanes	No.of Entry Lanes	Av.Ent Lane Width (ft)	Circulating/Exiting Stream: Flow (veh/h)	%HV	Adjust. Flow (pcu/h)	%Exit Incl.	Cap. Constr. Effect	O-D Factor
South: Orange Street NB											
68	16	100	1	1	13.00	0	0.0	0	0	N	1.000
East: WB Off-Ramp											
68	16	100	1	1	13.00	547	1.0	547	0	N	1.000

Missoula MT I-90 Phase 2
Orange Street I-90 WB Ramps-2030 PM Peak Hour
Intersection ID:
Roundabout

Table R.1 - ROUNDABOUT GAP ACCEPTANCE PARAMETERS

Turn	Lane No.	Lane Type	Circulating/Exiting Stream: Flow Rate (pcu/h)	Aver Speed (mph)	Aver Dist (ft)	In-Bnch Headway (s)	Prop Bunched	Critical Gap: Hdwy (s)	Critical Gap: Dist (ft)	Foll-up Headway (s)
South: Orange Street NB										
Left	1	Dominant	0	0.0		2.00	0.000	4.11	0.0	2.08
East: WB Off-Ramp										
Left	1	Dominant	547	13.6	130.8	2.00	0.490	4.39	87.3	2.44
Thru	1	Dominant	547	13.6	130.8	2.00	0.490	4.39	87.2	2.44

Environment Factor: 1.00
Entry/Circulating Flow Adjustment: Medium

Priority sharing is implied for some movements (Follow-up Headway plus Intra-bunch Headway is larger than the Critical Gap). The O-D Factor (Table R.0) allows for priority sharing and priority emphasis.

Dist (Distance): Spacing, i.e. distance between the front ends of two successive vehicles across all lanes in the circulating or exiting stream

Missoula MT I-90 Phase 2
Orange Street I-90 WB Ramps-2030 PM Peak Hour
Intersection ID:
Roundabout

Table R.5 - ROUNDABOUT CAPACITY & LEVEL OF SERVICE - aaSIDRA & HCM MODELS

Mov No.	Dem Flow (veh	aaSIDRA Cap. (veh	aaSIDRA Deg. Satn	aaSIDRA Av. Delay	aaSIDRA LOS	HCM 2000 Lower Cap. (veh	HCM 2000 Lower Deg. Satn	HCM 2000 Lower Av. Delay	HCM 2000 Lower LOS	HCM 2000 Upper Cap. (veh	HCM 2000 Upper Deg. Satn	HCM 2000 Upper Av. Delay	HCM 2000 Upper LOS

		/h)	/h)	x	(sec)		/h)	x	(sec)		/h)	x	(sec)	
South: Orange Street NB														
32	L	547	1728	0.317	4.0	A	1161	0.471	4.0	A	1385	0.395	4.0	A
East: WB Off-Ramp														
22	LT	485	893	0.543	10.0	A	724	0.670	12.9	B	899	0.539	9.5	A

Missoula MT I-90 Phase 2
Orange Street I-90 WB Ramps-2030 PM Peak Hour
Intersection ID:
Roundabout

Table R.6 - ROUNDABOUT ALTERNATIVE CAPACITY MODELS

Mov No.	Dem Flow (veh /h)	aaSIDRA Cap. (veh /h)	aaSIDRA Deg. Satn x	NAASRA 1986 Cap. (veh /h)	NAASRA 1986 % Diff from aaSIDRA	Ger. Linear Cap. (veh /h)	Ger. Linear % Diff from aaSIDRA	Ger. GapAcc Cap. (veh /h)	Ger. GapAcc % Diff from aaSIDRA
South: Orange Street NB									
32 L	547	1728	0.317	1800	4.2	1218	-29.5	1250	-27.7
East: WB Off-Ramp									
22 LT	485	893	0.543	1072	20.0	813	-9.0	779	-12.8

Missoula MT I-90 Phase 2
Orange Street I-90 WB Ramps-2030 PM Peak Hour
Intersection ID:
Roundabout

Table S.2 - MOVEMENT CAPACITY PARAMETERS

Mov No.	Demand Flow (veh/h)	HV (%)	Opposing Movement Flow (veh/h)	Opposing Movement HV (%)	Adjust. Flow (pcu/h)	Total Cap. (veh /h)	Prac. Deg. Satn xp	Prac. Spare Cap. (%)	Lane Util (%)	Deg. Satn x
South: Orange Street NB										
32 L	547	0.9	0			1728	0.85	169	100	0.317
East: WB Off-Ramp										
22 LT	485	1.0	547	1.0	547	893	0.85	57	100	0.543*

Missoula MT I-90 Phase 2
Orange Street I-90 WB Ramps-2030 PM Peak Hour
Intersection ID:
Roundabout

Table S.3 - INTERSECTION PARAMETERS

Intersection Level of Service	=	A
Worst movement Level of Service	=	A

Average intersection delay (s)	=	6.8
Largest average movement delay (s)	=	10.0
Largest back of queue, 95% (ft)	=	139
Performance Index	=	27.33
Degree of saturation (highest)	=	0.543
Practical Spare Capacity (lowest)	=	57 %
Effective intersection capacity, (veh/h)	=	1900
Total vehicle flow (veh/h)	=	1032
Total person flow (pers/h)	=	1548
Total vehicle delay (veh-h/h)	=	1.96
Total person delay (pers-h/h)	=	2.93
Total effective vehicle stops (veh/h)	=	707
Total effective person stops (pers/h)	=	1060
Total vehicle travel (veh-mi/h)	=	392.9
Total cost ($/h)	=	544.40
Total fuel (gal/h)	=	14.1
Total CO2 (kg/h)	=	133.66

Missoula MT I-90 Phase 2
Orange Street I-90 WB Ramps-2030 PM Peak Hour
Intersection ID:
Roundabout

Table S.5 - MOVEMENT PERFORMANCE

Mov No.	Total Delay (veh-h/h)	Total Delay (pers-h/h)	Aver. Delay (sec)	Prop. Queued	Eff. Stop Rate	Longest Queue 95% Back (vehs)	Longest Queue 95% Back (ft)	Perf. Index	Aver. Speed (mph)
South: Orange Street NB									
32 L	0.61	0.92	4.0	0.00	0.48	0.0	0	12.53	18.9
East: WB Off-Ramp									
22 LT	1.34	2.01	10.0	0.76	0.91	5.5	139	14.80	17.5

Missoula MT I-90 Phase 2
Orange Street I-90 WB Ramps-2030 PM Peak Hour
Intersection ID:
Roundabout

Table S.6 - INTERSECTION PERFORMANCE

Total Flow (veh/h)	Deg. Satn x	Total Delay (veh-h/h)	Total Delay (pers-h/h)	Aver. Delay (sec)	Prop. Queued	Eff. Stop Rate	Longest Queue (ft)	Perf. Index	Aver. Speed (mph)
South: Orange Street NB									
547	0.317	0.61	0.92	4.0	0.00	0.48	0	12.53	18.9
East: WB Off-Ramp									
485	0.543	1.34	2.01	10.0	0.76	0.91	139	14.80	17.5
ALL VEHICLES:									
1032	0.543	1.96	2.93	6.8	0.36	0.69	139	27.33	18.2
INTERSECTION (persons):									
1548	0.543		2.93	6.8	0.36	0.69		27.33	18.2

Queue values in this table are 95% back of queue (feet).

Missoula MT I-90 Phase 2
Orange Street I-90 WB Ramps-2030 PM Peak Hour
Intersection ID:
Roundabout

Table S.7 - LANE PERFORMANCE

Lane No.	Mov No.	Dem Flow (veh /h)	Cap (veh /h)	Deg. Satn x	Aver. Delay (sec)	Eff. Stop Rate	Queue 95% Back (vehs)	Queue 95% Back (ft)	Short Lane (ft)
South: Orange Street NB									
1 L	32	547	1728	0.316	4.0	0.48	0.0	0	
East: WB Off-Ramp									
1 LT	22	485	893	0.543	10.0	0.91	5.5	139	

Missoula MT I-90 Phase 2
Orange Street I-90 WB Ramps-2030 PM Peak Hour
Intersection ID:
Roundabout

Table S.8A - LANE FLOW AND CAPACITY INFORMATION

Lane No.	Mov No.	Dem Flow (veh/h) Lef	Thru	Rig	Tot	Min Cap (veh /h)	Tot Cap (veh /h)	Deg. Satn x	Lane Util %
South: Orange Street NB									
1 L	32	547	0	0	547	150	1728	0.316	100
East: WB Off-Ramp									
1 LT	22	484	1	0	485	150	893	0.543	100

For roundabouts, the capacity value for continuous movements is obtained as the basic saturation flow without any adjustments. Saturation flow scale applies if specified.

Missoula MT I-90 Phase 2
Orange Street I-90 WB Ramps-2030 PM Peak Hour
Intersection ID:
Roundabout

Table S.12A - FUEL CONSUMPTION, EMISSIONS AND COST - TOTAL

Mov No.	Fuel Total gal/h	Cost Total $/h	HC Total kg/h	CO Total kg/h	NOX Total kg/h	CO2 Total kg/h
South: Orange Street NB						
32 L	7.3	278.80	0.110	2.22	0.074	68.9

	7.3	278.80	0.110	2.22	0.074	68.9
East: WB Off-Ramp						
22 LT	6.8	265.60	0.107	2.28	0.073	64.8
	6.8	265.60	0.107	2.28	0.073	64.8
INTERSECTION:	14.1	544.40	0.218	4.50	0.147	133.7

PARAMETERS USED IN COST CALCULATIONS

Pump price of fuel ($/US gal)	=	0.900
Fuel resource cost factor	=	0.50
Ratio of running cost to fuel cost	=	3.0
Average income ($/h)	=	27.00
Time value factor	=	0.60
Average occupancy (persons/veh)	=	1.5
Light vehicle mass (1000 lb)	=	1.4
Heavy vehicle mass (1000 lb)	=	11.0
Light vehicle idle fuel rate (US gal/h)	=	0.360
Heavy vehicle idle fuel rate (US gal/h)	=	0.530

The idle fuel and vehicle mass parameters given above are the default values (data given in RIDES may override some of these parameters).

Missoula MT I-90 Phase 2
Orange Street I-90 WB Ramps-2030 PM Peak Hour
Intersection ID:
Roundabout

Table S.14 - SUMMARY OF INPUT AND OUTPUT DATA

Lane No.	Demand Flow (veh/h) L	T	R	Tot	%HV	Adj. Basic Satf.	Eff Grn (secs) 1st	2nd	Deg Sat x	Aver. Delay (sec)	Longest Queue (ft)	Shrt Lane (ft)
South: Orange Street NB												
1 L	547			547	1				0.316	4.0	0	
	547	0	0	547	1				0.316	4.0		
East: WB Off-Ramp												
1 LT	484	1		485	1				0.543	10.0	139	
	484	1	0	485	1				0.543	10.0	139	

ALL VEHICLES	Total Flow	% HV	Max X	Aver. Delay	Max Queue
	1032	1	0.543	6.8	139

Total flow period = 60 minutes. Peak flow period = 15 minutes.

Queue values in this table are 95% back of queue (feet).

Note: Basic Saturation Flows are not adjusted at roundabouts or sign-controlled intersections and apply only to continuous lanes.

Missoula MT I-90 Phase 2
Orange Street I-90 WB Ramps-2030 PM Peak Hour
Intersection ID:
Roundabout

Table S.15 - CAPACITY AND LEVEL OF SERVICE

Mov No.	Mov Typ	Total Flow (veh /h)	Total Cap. (veh /h)	Deg. of Satn (v/c)	Aver. Delay (sec)	LOS	Longest Queue 95% Back (vehs)	(ft)
South: Orange Street NB								
32	L	547	1728	0.317	4.0	A	0.0	0
		547		0.317	4.0	A	0.0	0
East: WB Off-Ramp								
22	LT	485	893	0.543*	10.0	A	5.5	139
		485		0.543	10.0	A	5.5	139
ALL VEHICLES:		1032		0.543	6.8	A	5.5	139

Level of Service calculations are based on
average control delay including geometric delay (HCM criteria),
independent of the current delay definition used.
For the criteria, refer to the "Level of Service" topic in the
aaSIDRA Output Guide or the Output section of the on-line help.
* Maximum v/c ratio, or critical green periods

Missoula MT I-90 Phase 2
Orange Street I-90 WB Ramps-2030 PM Peak Hour
Intersection ID:
Roundabout

Table D.0 - GEOMETRIC DELAY DATA

From Approach	To Approach	Negn Radius (ft)	Negn Speed (mph)	Negn Dist. (ft)	Appr. Dist. (ft)	Downstream Distance (ft)
South: Orange Street NB						
	West	40.4	13.6	158.7	1800	218
East: WB Off-Ramp						
	West	130.5	20.0	95.5	1800	100
	South	35.1	12.9	137.8	1800	202

Maximum Negotiation (Design) Speed = 50.0 mph
Downstream Distance calculated by aaSIDRA

Downstream distance is distance travelled from the stopline until exit cruise speed is reached (includes negotiation distance). Acceleration distance is weighted for light and heavy vehicles. The same distance applies for both stopped and unstopped vehicles.

Missoula MT I-90 Phase 2

Orange Street I-90 WB Ramps-2030 PM Peak Hour
Intersection ID:
Roundabout

Table D.1 - LANE DELAYS

Lane No.	Mov No.	Deg. Satn x	Stop-line Delay 1st d1	Stop-line Delay 2nd d2	Stop-line Delay Total dSL	Acc. Dec. dn	Queuing Total dq	Queuing MvUp dqm	Stopd (Idle) di	Geom dig	Control dic
South: Orange Street NB											
1 L	32	0.316	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	4.0
East: WB Off-Ramp											
1 LT	22	0.543	4.5	1.2	5.7	3.2	2.5	0.7	1.8	4.3	10.0

Delay (seconds/veh)

dn is average stop-start delay for all vehicles queued and unqueued

Missoula MT I-90 Phase 2
Orange Street I-90 WB Ramps-2030 PM Peak Hour
Intersection ID:
Roundabout

Table D.2 - LANE STOPS

Lane No.	Deg. Satn x	Effective Stop Rate he1	Effective Stop Rate he2	Effective Stop Rate Geom. hig	Effective Stop Rate Overall h	Prop. Queued pq	Queue Move-up Rate hqm
South: Orange Street NB							
1 L	0.316	0.00	0.00	0.48	0.48	0.000	0.00
East: WB Off-Ramp							
1 LT	0.543	0.70	0.10	0.12	0.91	0.762	0.13

hig is the average value for all movements in a shared lane
hqm is average queue move-up rate for all vehicles queued and unqueued

Missoula MT I-90 Phase 2
Orange Street I-90 WB Ramps-2030 PM Peak Hour
Intersection ID:
Roundabout

Table D.3A - LANE QUEUES (veh)

Lane No.	Deg. Satn x	Ovrfl. Queue No	Average (veh) Nb1	Average (veh) Nb2	Average (veh) Nb	Percentile (veh) 70%	85%	90%	95%	98%	Queue Stor. Ratio
South: Orange Street NB											
1 L	0.316	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00
East: WB Off-Ramp											
1 LT	0.543	0.2	1.5	0.3	1.8	3.2	3.9	4.4	5.5	6.4	0.08

Values printed in this table are back of queue (vehicles).

Missoula MT I-90 Phase 2
Orange Street I-90 WB Ramps-2030 PM Peak Hour
Intersection ID:
Roundabout

Table D.3B - LANE QUEUES (feet)

Lane No.	Deg. Satn x	Ovrfl. Queue No	Average (feet) Nb1	Nb2	Nb	Percentile (feet) 70%	85%	90%	95%	98%	Queue Stor. Ratio
South: Orange Street NB											
1 L	0.316	0	0	0	0	0	0	0	0	0	0.00
East: WB Off-Ramp											
1 LT	0.543	5	38	7	45	80	98	111	139	161	0.08

Values printed in this table are back of queue (feet).

Missoula MT I-90 Phase 2
Orange Street I-90 WB Ramps-2030 PM Peak Hour
Intersection ID:
Roundabout

Table D.4 - MOVEMENT SPEEDS (mph)

Mov No.	App. Speeds Cruise	Negn	Exit Speeds Negn	Cruise	Queue Move-up 1st Grn	2nd Grn	Av. Section Spd Running	Overall
South: Orange Street NB								
32	20.0	13.6	13.6	20.0			18.9	18.9
East: WB Off-Ramp								
22	20.0	12.9	12.9	20.0	13.7		17.9	17.5

"Running Speed" is the average speed excluding stopped periods.

--- End of aaSIDRA Output ---

C:\Documents and Settings\tnewkirk\Desktop\Projects\Montana\I-90_Phase 2\SIDRA\Orange Street\2030_PM_Orange-WB Ramps.OUT
Produced by aaSIDRA 2.1.4.357

Generated 10:18 AM, Jul 13,2006

Akcelik & Associates Pty Ltd - aaSIDRA 2.1.4.357

CH2MHILL
CH2MHILL User ID: A0725
Licence Type: Single Computer

Time and Date of Analysis 2:40 PM, Jul 13,2006

Filename: C:\Documents and Settings\tnewkirk\Desktop\Projects\Montana\I-90_Phase 2\SIDRA\Van Buren Street\2030_PM_VanBuren-EB Ramps.OUT

Missoula MT I-90 Phase 2
Van Buren Street I-90 EB Ramps - PM Peak Hour
Intersection ID:

aaTraffic SIDRA US Highway Capacity Manual (2000) Version

RUN INFORMATION
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* Basic Parameters:
  Intersection Type: Roundabout
  Driving on the right-hand side of the road
  Input data specified in US units
  Default Values File No. 11
  Peak flow period (for performance): 15 minutes
  Unit time (for volumes): 60 minutes (Total Flow Period)
  Delay definition: Control delay
                    Geometric delay included
  aaSIDRA Standard Delay and Queue models used
  Level of Service based on: Delay (HCM method)
  Queue definition: Back of queue, 95th Percentile

Geometric delay is less than 2 seconds for some movements. The negotiation speed may be too high or the approach and exit speeds may be too low for given geometric design (e.g. for a large roundabout). Check Tables D.0, D.1 and D.4 for geometric delay data including negotiation speeds. If necessary, specify appropriate values of approach and exit speeds (RIDES Approach Data screen), and negotiation radius or negotiation speed data (RIDES Extra Data - Geometric Delay data screen).

Missoula MT I-90 Phase 2
Van Buren Street I-90 EB Ramps - PM Peak Hour
Intersection ID:
Roundabout

Table S.0 - TRAFFIC FLOW DATA

Mov No.	Left LV	Left HV	Through LV	Through HV	Right LV	Right HV	Flow Scale	Peak Flow Factor
VEHICLES Demand flows in veh/hour as used by the program								
West: EB Off-Ramp								
12	162	2	1	0	0	0	1.00	0.95
13	0	0	0	0	141	1	1.00	0.95
South: Van Buren Street NB								
32	0	0	818	8	344	3	1.00	0.95

North: Van Burent Street SB

42	21	1	475	10	0	0	1.00	0.95

Based on unit time = 60 minutes.
Flow Scale and Peak Hour Factor effects included in flow values.

Missoula MT I-90 Phase 2
Van Buren Street I-90 EB Ramps - PM Peak Hour
Intersection ID:
Roundabout

Table R.0 - ROUNDABOUT BASIC PARAMETERS

Cent Island Diam (ft)	Circ Width (ft)	Insc Diam. (ft)	No.of Circ. Lanes	No.of Entry Lanes	Av.Ent Lane Width (ft)	Circulating/Exiting Stream Flow (veh/h)	%HV	Adjust. Flow (pcu/h)	%Exit Incl.	Cap. Constr. Effect	O-D Factor
West: EB Off-Ramp											
86	32	150	2	1	13.00	505	2.0	505	0	N	1.000
South: Van Buren Street NB											
86	32	150	2	2	13.00	185	1.1	185	0	N	0.981
North: Van Burent Street SB											
86	32	150	2	2	13.00	0	0.0	0	0	N	1.000

Missoula MT I-90 Phase 2
Van Buren Street I-90 EB Ramps - PM Peak Hour
Intersection ID:
Roundabout

Table R.1 - ROUNDABOUT GAP ACCEPTANCE PARAMETERS

Turn	Lane No.	Lane Type	Circulating/Exiting Stream Flow Rate (pcu/h)	Aver Speed (mph)	Aver Dist (ft)	In-Bnch Headway (s)	Prop Bunched	Critical Gap Hdwy (s)	Critical Gap Dist (ft)	Foll-up Headway (s)
West: EB Off-Ramp										
Left	1	Dominant	505	22.8	238.5	1.06	0.277	3.97	133.0	2.60
Thru	1	Dominant	505	22.8	238.5	1.06	0.277	3.97	132.9	2.60
Right	1	Dominant	505	22.8	238.5	1.06	0.277	3.97	133.0	2.60
South: Van Buren Street NB										
Thru	1	Subdominant	185	14.5	414.4	2.00	0.202	4.02	85.7	2.47
	2	Dominant	185	14.5	414.4	2.00	0.202	3.68	78.4	2.26
Right	2	Dominant	185	14.5	414.4	2.00	0.202	3.68	78.4	2.26
North: Van Burent Street SB										
Left	1	Subdominant	0	0.0		2.00	0.000	3.95	0.0	2.34
Thru	1	Subdominant	0	0.0		2.00	0.000	3.95	0.0	2.33
	2	Dominant	0	0.0		2.00	0.000	3.40	0.0	2.01

Environment Factor: 1.00
Entry/Circulating Flow Adjustment: Medium

Priority sharing is implied for some movements (Follow-up Headway plus Intra-bunch Headway is larger than the Critical Gap). The O-D Factor (Table R.0) allows for priority sharing and priority emphasis.

Dist (Distance): Spacing, i.e. distance between the front ends of two successive vehicles across all lanes in the circulating or exiting stream

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Missoula MT I-90 Phase 2
Van Buren Street I-90 EB Ramps - PM Peak Hour
Intersection ID:
Roundabout

Table R.5 - ROUNDABOUT CAPACITY & LEVEL OF SERVICE - aaSIDRA & HCM MODELS

Mov No.	Dem Flow (veh /h)	aaSIDRA Cap. (veh /h)	aaSIDRA Deg. Satn x	aaSIDRA Av. Delay (sec)	aaSIDRA LOS	HCM 2000 Lower Cap. (veh /h)	HCM 2000 Lower Deg. Satn x	HCM 2000 Lower Av. Delay (sec)	HCM 2000 Lower LOS	HCM 2000 Upper Cap. (veh /h)	HCM 2000 Upper Deg. Satn x	HCM 2000 Upper Av. Delay (sec)	HCM 2000 Upper LOS
West: EB Off-Ramp													
12 LT	165	517	0.319	8.3	A	- - - -	NA	- - - -		- - - -	NA	- - - -	
13 R	142	445	0.319	3.7	A	- - - -	NA	- - - -		- - - -	NA	- - - -	
South: Van Buren Street NB													
32 TR	1173	2599	0.451	2.4	A	- - - -	NA	- - - -		- - - -	NA	- - - -	
North: Van Burent Street SB													
42 LT	507	3337	0.152	0.9	A	2322	0.218	0.9	A	2769	0.183	0.9	A

NA Values for this roundabout capacity model have not been calculated because the model was not applicable for the given roundabout conditions. Note that the HCM models are only applicable to single-lane roundabouts with circulating flows less than 1200 veh/h. Also note that results are not calculated for any of the models for slip lane or continuous movements. See the aaSIDRA Traffic Model Reference Guide for roundabout limits.

Missoula MT I-90 Phase 2
Van Buren Street I-90 EB Ramps - PM Peak Hour
Intersection ID:
Roundabout

Table R.6 - ROUNDABOUT ALTERNATIVE CAPACITY MODELS

Mov No.	Dem Flow (veh /h)	aaSIDRA Cap. (veh /h)	aaSIDRA Deg. Satn x	NAASRA 1986 Cap. (veh /h)	NAASRA 1986 % Diff from aaSIDRA	Ger. Linear Cap. (veh /h)	Ger. Linear % Diff from aaSIDRA	Ger. GapAcc Cap. (veh /h)	Ger. GapAcc % Diff from aaSIDRA
West: EB Off-Ramp									
12 LT	165	517	0.319	633	22.4	528	2.1	450	-13.0
13 R	142	445	0.319	545	22.5	454	2.0	387	-13.0

South: Van Buren Street NB

32 TR	1173	2599	0.451	3083	18.6	1287	-50.5	2171	-16.5

North: Van Burent Street SB

42 LT	507	3337	0.152	3599	7.9	1380	-58.6	2499	-25.1

Missoula MT I-90 Phase 2
Van Buren Street I-90 EB Ramps - PM Peak Hour
Intersection ID:
Roundabout

Table S.2 - MOVEMENT CAPACITY PARAMETERS

Mov No.	Demand Flow (veh/h)	HV (%)	Opposing Movement Flow (veh/h)	Opposing Movement HV (%)	Opposing Movement Adjust. Flow (pcu/h)	Total Cap. (veh /h)	Prac. Deg. Satn xp	Prac. Spare Cap. (%)	Lane Util (%)	Deg. Satn x
West: EB Off-Ramp										
12 LT	165	1.2	505	2.0	505	517	0.85	166	100	0.319
13 R	142	0.7	505	2.0	505	445	0.85	166	100	0.319
South: Van Buren Street NB										
32 TR	1173	0.9	185	1.1	185	2599	0.85	88	100	0.451*
North: Van Burent Street SB										
42 LT	507	2.2	0			3337	0.85	459	100	0.152

Missoula MT I-90 Phase 2
Van Buren Street I-90 EB Ramps - PM Peak Hour
Intersection ID:
Roundabout

Table S.3 - INTERSECTION PARAMETERS

Intersection Level of Service	=	A
Worst movement Level of Service	=	A
Average intersection delay (s)	=	2.6
Largest average movement delay (s)	=	8.3
Largest back of queue, 95% (ft)	=	94
Performance Index	=	37.64
Degree of saturation (highest)	=	0.451
Practical Spare Capacity (lowest)	=	88 %
Effective intersection capacity, (veh/h)	=	4403
Total vehicle flow (veh/h)	=	1987
Total person flow (pers/h)	=	2981
Total vehicle delay (veh-h/h)	=	1.44
Total person delay (pers-h/h)	=	2.16
Total effective vehicle stops (veh/h)	=	633
Total effective person stops (pers/h)	=	949
Total vehicle travel (veh-mi/h)	=	744.2
Total cost ($/h)	=	804.96
Total fuel (gal/h)	=	24.2
Total CO2 (kg/h)	=	229.09

Missoula MT I-90 Phase 2

Van Buren Street I-90 EB Ramps - PM Peak Hour
Intersection ID:
Roundabout

Table S.5 - MOVEMENT PERFORMANCE

Mov No.	Total Delay (veh-h/h)	Total Delay (pers-h/h)	Aver. Delay (sec)	Prop. Queued	Eff. Stop Rate	Longest Queue 95% Back (vehs)	Longest Queue 95% Back (ft)	Perf. Index	Aver. Speed (mph)
West: EB Off-Ramp									
12 LT	0.38	0.57	8.3	0.50	0.74	1.7	43	3.97	21.8
13 R	0.15	0.22	3.7	0.50	0.50	1.7	43	2.91	23.0
South: Van Buren Street NB									
32 TR	0.79	1.19	2.4	0.43	0.33	3.7	94	22.76	23.3
North: Van Burent Street SB									
42 LT	0.12	0.18	0.9	0.00	0.11	0.0	0	8.01	24.6

Missoula MT I-90 Phase 2
Van Buren Street I-90 EB Ramps - PM Peak Hour
Intersection ID:
Roundabout

Table S.6 - INTERSECTION PERFORMANCE

Total Flow (veh/h)	Deg. Satn x	Total Delay (veh-h/h)	Total Delay (pers-h/h)	Aver. Delay (sec)	Prop. Queued	Eff. Stop Rate	Longest Queue (ft)	Perf. Index	Aver. Speed (mph)
West: EB Off-Ramp									
307	0.319	0.53	0.79	6.2	0.50	0.63	43	6.88	22.3
South: Van Buren Street NB									
1173	0.451	0.79	1.19	2.4	0.43	0.33	94	22.76	23.3
North: Van Burent Street SB									
507	0.152	0.12	0.18	0.9	0.00	0.11	0	8.01	24.6
ALL VEHICLES:									
1987	0.451	1.44	2.16	2.6	0.33	0.32	94	37.64	23.4
INTERSECTION (persons):									
2981	0.451		2.16	2.6	0.33	0.32		37.64	23.4

Queue values in this table are 95% back of queue (feet).

Missoula MT I-90 Phase 2
Van Buren Street I-90 EB Ramps - PM Peak Hour
Intersection ID:
Roundabout

Table S.7 - LANE PERFORMANCE

Dem Flow	Cap	Deg.	Aver.	Eff.	Q u e u e 95% Back	Short

Lane No.	Mov No.	(veh /h)	(veh /h)	Satn x	Delay (sec)	Stop Rate	----------- (vehs)	(ft)	Lane (ft)
West: EB Off-Ramp									
1 LTR	12, 13	307	961	0.319	6.2	0.63	1.7	43	
South: Van Buren Street NB									
1 T	32	557	1234	0.451	2.3	0.31	3.7	92	
2 TR	32	616	1364	0.451	2.5	0.34	3.7	94	
North: Van Burent Street SB									
1 LT	42	235	1544	0.152	1.1	0.13	0.0	0	
2 T	42	272	1793	0.152	0.6	0.09	0.0	0	

Missoula MT I-90 Phase 2
Van Buren Street I-90 EB Ramps - PM Peak Hour
Intersection ID:
Roundabout

Table S.8A - LANE FLOW AND CAPACITY INFORMATION

Lane No.	Mov No.	Dem Flow (veh/h) Lef	Thru	Rig	Tot	Min Cap (veh /h)	Tot Cap (veh /h)	Deg. Satn x	Lane Util %
West: EB Off-Ramp									
1 LTR	12, 13	164	1	142	307	150	961	0.319	100
South: Van Buren Street NB									
1 T	32	0	557	0	557	150	1234	0.451	100
2 TR	32	0	269	347	616	150	1364	0.451	100
North: Van Burent Street SB									
1 LT	42	22	213	0	235	150	1544	0.152	100
2 T	42	0	272	0	272	150	1793	0.152	100

For roundabouts, the capacity value for continuous movements is obtained as the basic saturation flow without any adjustments. Saturation flow scale applies if specified.

Missoula MT I-90 Phase 2
Van Buren Street I-90 EB Ramps - PM Peak Hour
Intersection ID:
Roundabout

Table S.12A - FUEL CONSUMPTION, EMISSIONS AND COST - TOTAL

Mov No.	Fuel Total gal/h	Cost Total $/h	HC Total kg/h	CO Total kg/h	NOX Total kg/h	CO2 Total kg/h
West: EB Off-Ramp						
12 LT	2.2	76.15	0.034	0.80	0.028	21.3
13 R	1.7	58.10	0.026	0.60	0.022	16.6

	4.0	134.25	0.059	1.40	0.049	37.8
South: Van Buren Street NB						
32 TR	14.3	475.45	0.209	4.78	0.174	135.4
	14.3	475.45	0.209	4.78	0.174	135.4
North: Van Burent Street SB						
42 LT	5.9	195.26	0.082	1.56	0.064	55.9
	5.9	195.26	0.082	1.56	0.064	55.9
INTERSECTION:	24.2	804.96	0.350	7.75	0.288	229.1

PARAMETERS USED IN COST CALCULATIONS

Pump price of fuel ($/US gal)	=	0.900
Fuel resource cost factor	=	0.50
Ratio of running cost to fuel cost	=	3.0
Average income ($/h)	=	27.00
Time value factor	=	0.60
Average occupancy (persons/veh)	=	1.5
Light vehicle mass (1000 lb)	=	1.4
Heavy vehicle mass (1000 lb)	=	11.0
Light vehicle idle fuel rate (US gal/h)	=	0.360
Heavy vehicle idle fuel rate (US gal/h)	=	0.530

The idle fuel and vehicle mass parameters given above are the default values (data given in RIDES may override some of these parameters).

Missoula MT I-90 Phase 2
Van Buren Street I-90 EB Ramps - PM Peak Hour
Intersection ID:
Roundabout

Table S.14 - SUMMARY OF INPUT AND OUTPUT DATA

Lane No.	Demand Flow (veh/h) L	T	R	Tot	%HV	Adj. Basic Satf.	Eff Grn (secs) 1st	2nd	Deg Sat x	Aver. Delay (sec)	Longest Queue (ft)	Shrt Lane (ft)
West: EB Off-Ramp												
1 LTR	164	1	142	307	1				0.319	6.2	43	
	164	1	142	307	1				0.319	6.2	43	
South: Van Buren Street NB												
1 T		557		557	1				0.451	2.3	92	
2 TR		269	347	616	1				0.451	2.5	94	
	0	826	347	1173	1				0.451	2.4	94	
North: Van Burent Street SB												
1 LT	22	213		235	2				0.152	1.1	0	
2 T		272		272	2				0.152	0.6	0	
	22	485	0	507	2				0.152	0.9		

ALL VEHICLES	Total Flow	% HV	Max X	Aver. Delay	Max Queue
	1987	1	0.451	2.6	94

Total flow period = 60 minutes. Peak flow period = 15 minutes.

Queue values in this table are 95% back of queue (feet).

Note: Basic Saturation Flows are not adjusted at roundabouts or sign-controlled intersections and apply only to continuous lanes.

Missoula MT I-90 Phase 2
Van Buren Street I-90 EB Ramps - PM Peak Hour
Intersection ID:
Roundabout

Table S.15 - CAPACITY AND LEVEL OF SERVICE

Mov No.	Mov Typ	Total Flow (veh /h)	Total Cap. (veh /h)	Deg. of Satn (v/c)	Aver. Delay (sec)	LOS	Longest Queue 95% Back (vehs)	(ft)
West: EB Off-Ramp								
12	LT	165	517	0.319	8.3	A	1.7	43
13	R	142	445	0.319	3.7	A	1.7	43
		307		0.319	6.2	A	1.7	43
South: Van Buren Street NB								
32	TR	1173	2599	0.451*	2.4	A	3.7	94
		1173		0.451	2.4	A	3.7	94
North: Van Burent Street SB								
42	LT	507	3337	0.152	0.9	A	0.0	0
		507		0.152	0.9	A	0.0	0
ALL VEHICLES:		1987		0.451	2.6	A	3.7	94

Level of Service calculations are based on
average control delay including geometric delay (HCM criteria),
independent of the current delay definition used.
For the criteria, refer to the "Level of Service" topic in the
aaSIDRA Output Guide or the Output section of the on-line help.
* Maximum v/c ratio, or critical green periods

Missoula MT I-90 Phase 2
Van Buren Street I-90 EB Ramps - PM Peak Hour
Intersection ID:
Roundabout

Table D.0 - GEOMETRIC DELAY DATA

From Approach	To Approach	Negn Radius (ft)	Negn Speed (mph)	Negn Dist. (ft)	Appr. Dist. (ft)	Downstream Distance (ft)

West: EB Off-Ramp					
	South	112.7	20.0	58.0	1800	165
	East	165.3	23.1	140.8	1800	168
	North	47.1	14.4	185.1	1800	295
South: Van Buren Street NB					
	East	99.7	19.1	58.2	1800	165
	North	129.7	21.1	105.7	1800	164
North: Van Burent Street SB					
	South	165.3	23.1	140.8	1800	169
	East	55.8	15.3	219.1	1800	324

Maximum Negotiation (Design) Speed = 50.0 mph
Downstream Distance calculated by aaSIDRA

Downstream distance is distance travelled from the stopline until exit cruise speed is reached (includes negotiation distance). Acceleration distance is weighted for light and heavy vehicles. The same distance applies for both stopped and unstopped vehicles.

Missoula MT I-90 Phase 2
Van Buren Street I-90 EB Ramps - PM Peak Hour
Intersection ID:
Roundabout

Table D.1 - LANE DELAYS

			Delay (seconds/veh)								
		Deg.	Stop-line Delay			Acc.	Queuing		Stopd		
Lane	Mov	Satn	1st	2nd	Total	Dec.	Total	MvUp	(Idle)	Geom	Control
No.	No.	x	d1	d2	dSL	dn	dq	dqm	di	dig	dic
West: EB Off-Ramp											
1 LTR	12, 13	0.319	2.1	0.0	2.1	2.6	0.0	0.0	0.0	6.2 1.7	6.2
South: Van Buren Street NB											
1 T	32	0.451	1.0	0.0	1.0	2.6	0.0	0.0	0.0	1.3	2.3
2 TR	32	0.451	0.9	0.0	0.9	2.4	0.0	0.0	0.0	1.7	2.5
North: Van Burent Street SB											
1 LT	42	0.152	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	1.1
2 T	42	0.152	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.6

dn is average stop-start delay for all vehicles queued and unqueued

Geometric delay is less than 2 seconds for some movements. The negotiation speed may be too high or the approach and exit speeds may be too low for given geometric design (e.g. for a large roundabout). Check Tables D.0, D.1 and D.4 for geometric delay data including negotiation speeds. If necessary, specify appropriate values of approach and exit speeds (RIDES Approach Data screen), and negotiation radius or negotiation speed data (RIDES Extra Data - Geometric Delay data screen).

Missoula MT I-90 Phase 2
Van Buren Street I-90 EB Ramps - PM Peak Hour
Intersection ID:
Roundabout

Table D.2 - LANE STOPS

Lane No.	Deg. Satn x	-- Effective Stop Rate -- he1	he2	Geom. hig	Overall h	Prop. Queued pq	Queue Move-up Rate hqm
West: EB Off-Ramp							
1 LTR	0.319	0.42	0.00	0.21	0.63	0.499	0.00
South: Van Buren Street NB							
1 T	0.451	0.21	0.00	0.10	0.31	0.437	0.00
2 TR	0.451	0.21	0.00	0.13	0.34	0.423	0.00
North: Van Burent Street SB							
1 LT	0.152	0.00	0.00	0.13	0.13	0.000	0.00
2 T	0.152	0.00	0.00	0.09	0.09	0.000	0.00

hig is the average value for all movements in a shared lane
hqm is average queue move-up rate for all vehicles queued and unqueued

---

Missoula MT I-90 Phase 2
Van Buren Street I-90 EB Ramps - PM Peak Hour
Intersection ID:
Roundabout

Table D.3A - LANE QUEUES (veh)

Lane No.	Deg. Satn x	Ovrfl. Queue No	Average (veh) Nb1	Nb2	Nb	Percentile (veh) 70%	85%	90%	95%	98%	Queue Stor. Ratio
West: EB Off-Ramp											
1 LTR	0.319	0.0	0.5	0.0	0.5	1.0	1.2	1.4	1.7	2.0	0.02
South: Van Buren Street NB											
1 T	0.451	0.0	1.2	0.0	1.2	2.1	2.6	2.9	3.7	4.2	0.05
2 TR	0.451	0.0	1.2	0.0	1.2	2.2	2.6	3.0	3.7	4.3	0.05
North: Van Burent Street SB											
1 LT	0.152	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00
2 T	0.152	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00

Values printed in this table are back of queue (vehicles).

Missoula MT I-90 Phase 2
Van Buren Street I-90 EB Ramps - PM Peak Hour
Intersection ID:
Roundabout

Table D.3B - LANE QUEUES (feet)

Lane No.	Deg. Satn x	Ovrfl. Queue No	Average (feet) Nb1	Nb2	Nb	Percentile (feet) 70%	85%	90%	95%	98%	Queue Stor. Ratio

West: EB Off-Ramp										
1 LTR	0.319	0	14	0	14	25	31	35	43	50	0.02
South: Van Buren Street NB										
1 T	0.451	0	30	0	30	54	65	74	92	107	0.05
2 TR	0.451	0	30	0	30	54	67	76	94	109	0.05
North: Van Burent Street SB										
1 LT	0.152	0	0	0	0	0	0	0	0	0	0.00
2 T	0.152	0	0	0	0	0	0	0	0	0	0.00

Values printed in this table are back of queue (feet).

Missoula MT I-90 Phase 2
Van Buren Street I-90 EB Ramps - PM Peak Hour
Intersection ID:
Roundabout

Table D.4 - MOVEMENT SPEEDS (mph)

Mov	App. Speeds		Exit Speeds		Queue Move-up		Av. Section Spd	
No.	Cruise	Negn	Negn	Cruise	1st Grn	2nd Grn	Running	Overall
West: EB Off-Ramp								
12	25.0	14.4	14.4	25.0			21.8	21.8
13	25.0	20.0	20.0	25.0			23.0	23.0
South: Van Buren Street NB								
32	25.0	20.5	20.5	25.0			23.3	23.3
North: Van Burent Street SB								
42	25.0	22.8	22.8	25.0			24.6	24.6

"Running Speed" is the average speed excluding stopped periods.

--- End of aaSIDRA Output ---

C:\Documents and Settings\tnewkirk\Desktop\Projects\Montana\I-90_Phase 2\SIDRA\Van Buren Street\2030_PM_VanBuren-EB Ramps.OUT
Produced by aaSIDRA 2.1.4.357

Generated 2:40 PM, Jul 13,2006

Akcelik & Associates Pty Ltd - aaSIDRA 2.1.4.357

CH2MHILL
CH2MHILL User ID: A0725
Licence Type: Single Computer

Time and Date of Analysis 2:45 PM, Jul 13,2006

Filename: C:\Documents and Settings\tnewkirk\Desktop\Projects\Montana\I-90_Phase 2\SIDRA\Van Buren Street\2030_PM_VanBuren-WB Ramps.OUT

Missoula MT I-90 Phase 2
Van Buren Street I-90 WB Ramps - PM Peak Hour
Intersection ID:

aaTraffic SIDRA US Highway Capacity Manual (2000) Version

RUN INFORMATION

* Basic Parameters:
  Intersection Type: Roundabout
  Driving on the right-hand side of the road
  Input data specified in US units
  Default Values File No. 11
  Peak flow period (for performance): 15 minutes
  Unit time (for volumes): 60 minutes (Total Flow Period)
  Delay definition: Control delay
  Geometric delay included
  aaSIDRA Standard Delay and Queue models used
  Level of Service based on: Delay (HCM method)
  Queue definition: Back of queue, 95th Percentile

  Geometric delay is less than 2 seconds for some movements. The negotiation speed may be too high or the approach and exit speeds may be too low for given geometric design (e.g. for a large roundabout). Check Tables D.0, D.1 and D.4 for geometric delay data including negotiation speeds. If necessary, specify appropriate values of approach and exit speeds (RIDES Approach Data screen), and negotiation radius or negotiation speed data (RIDES Extra Data - Geometric Delay data screen).

Missoula MT I-90 Phase 2
Van Buren Street I-90 WB Ramps - PM Peak Hour
Intersection ID:
Roundabout

Table S.0 - TRAFFIC FLOW DATA

Mov No.	Left LV	Left HV	Through LV	Through HV	Right LV	Right HV	Flow Scale	Peak Flow Factor
VEHICLES	Demand flows in veh/hour as used by the program							
South: Van Buren Street NB								
32	219	2	761	8	0	0	1.00	0.95
East: WB Off-Ramp								
22	170	3	1	0	0	0	1.00	0.95
23	0	0	0	0	62	1	1.00	0.95

North: Van Buren Street SB

42	1	0	328	3	94	1	1.00	0.95

Based on unit time = 60 minutes.
Flow Scale and Peak Hour Factor effects included in flow values.

Missoula MT I-90 Phase 2
Van Buren Street I-90 WB Ramps - PM Peak Hour
Intersection ID:
Roundabout

Table R.0 - ROUNDABOUT BASIC PARAMETERS

						Circulating/Exiting Stream					
Cent Island Diam (ft)	Circ Width (ft)	Insc Diam. (ft)	No.of Circ. Lanes	No.of Entry Lanes	Av.Ent Lane Width (ft)	Flow (veh/h)	%HV	Adjust. Flow (pcu/h)	%Exit Incl.	Cap. Constr. Effect	O-D Factor
South: Van Buren Street NB											
86	32	150	2	2	13.00	1	0.0	1	0	N	1.000
East: WB Off-Ramp											
86	32	150	2	2	13.00	991	1.0	991	0	N	0.995
North: Van Buren Street SB											
86	32	150	2	1	13.00	396	1.4	396	0	N	0.975

Missoula MT I-90 Phase 2
Van Buren Street I-90 WB Ramps - PM Peak Hour
Intersection ID:
Roundabout

Table R.1 - ROUNDABOUT GAP ACCEPTANCE PARAMETERS

Turn	Lane No.	Lane Type	---- Circulating/Exiting Stream --- Flow Rate (pcu/h)	Aver Speed (mph)	Aver Dist (ft)	In-Bnch Headway (s)	Prop Bunched	Critical Gap Hdwy (s)	Critical Gap Dist (ft)	Foll-up Headway (s)
South: Van Buren Street NB										
Left	1	Subdominant	1	14.6	73311.8	2.00	0.001	4.59	98.5	2.71
Thru	2	Dominant	1	14.6	73311.8	2.00	0.001	3.40	72.9	2.01
East: WB Off-Ramp										
Left	1	Dominant	991	21.4	114.0	1.39	0.578	2.90	91.0	2.05
Thru	1	Dominant	991	21.4	114.0	1.39	0.578	2.90	91.0	2.05
Right	2	Subdominant	991	21.4	114.0	1.39	0.578	3.74	117.4	2.65
North: Van Buren Street SB										
Left	1	Dominant	396	14.9	199.3	2.00	0.383	4.12	90.2	2.64
Thru	1	Dominant	396	14.9	199.3	2.00	0.383	4.12	90.2	2.64
Right	1	Dominant	396	14.9	199.3	2.00	0.383	4.12	90.2	2.64

Environment Factor: 1.00
Entry/Circulating Flow Adjustment: Medium

Priority sharing is implied for some movements (Follow-up Headway plus Intra-bunch Headway is larger than the Critical Gap). The O-D Factor (Table R.0) allows for priority sharing and priority emphasis.

Dist (Distance): Spacing, i.e. distance between the front ends of two successive vehicles across all lanes in the circulating or exiting stream

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Missoula MT I-90 Phase 2
Van Buren Street I-90 WB Ramps - PM Peak Hour
Intersection ID:
Roundabout

Table R.5 - ROUNDABOUT CAPACITY & LEVEL OF SERVICE - aaSIDRA & HCM MODELS

Mov No.	Dem Flow (veh /h)	aaSIDRA Cap. (veh /h)	aaSIDRA Deg. Satn x	aaSIDRA Av. Delay (sec)	aaSIDRA LOS	HCM 2000 Lower Cap. (veh /h)	HCM 2000 Lower Deg. Satn x	HCM 2000 Lower Av. Delay (sec)	HCM 2000 Lower LOS	HCM 2000 Upper Cap. (veh /h)	HCM 2000 Upper Deg. Satn x	HCM 2000 Upper Av. Delay (sec)	HCM 2000 Upper LOS
South: Van Buren Street NB													
32 LT	990	2306	0.429	1.8	A	- - - - NA - - - -				- - - - NA - - - -			
East: WB Off-Ramp													
22 LT	174	967	0.180	9.3	A	- - - - NA - - - -				- - - - NA - - - -			
23 R	63	670	0.094	6.2	A	- - - - NA - - - -				- - - - NA - - - -			
North: Van Buren Street SB													
42 LTR	427	960	0.445	3.8	A	- - - - NA - - - -				- - - - NA - - - -			

NA Values for this roundabout capacity model have not been calculated because the model was not applicable for the given roundabout conditions. Note that the HCM models are only applicable to single-lane roundabouts with circulating flows less than 1200 veh/h. Also note that results are not calculated for any of the models for slip lane or continuous movements. See the aaSIDRA Traffic Model Reference Guide for roundabout limits.

Missoula MT I-90 Phase 2
Van Buren Street I-90 WB Ramps - PM Peak Hour
Intersection ID:
Roundabout

Table R.6 - ROUNDABOUT ALTERNATIVE CAPACITY MODELS

Mov No.	Dem Flow (veh /h)	aaSIDRA Cap. (veh /h)	aaSIDRA Deg. Satn x	NAASRA 1986 Cap. (veh /h)	NAASRA 1986 % Diff from aaSIDRA	Ger. Linear Cap. (veh /h)	Ger. Linear % Diff from aaSIDRA	Ger. GapAcc Cap. (veh /h)	Ger. GapAcc % Diff from aaSIDRA
South: Van Buren Street NB									
32 LT	990	2306	0.429	2315	0.4	888	-61.5	1608	-30.3
East: WB Off-Ramp									
22 LT	174	967	0.180	778	-19.5	462	-52.2	539	-44.3

23 R	63	670	0.094	778	16.1	462	-31.0	539	-19.6
North: Van Buren Street SB									
42 LTR	427	960	0.445	1292	34.6	1040	8.3	918	-4.4

Missoula MT I-90 Phase 2
Van Buren Street I-90 WB Ramps - PM Peak Hour
Intersection ID:
Roundabout

Table S.2 - MOVEMENT CAPACITY PARAMETERS

Mov No.	Demand Flow (veh/h)	HV (%)	Opposing Movement Flow (veh/h)	Opposing Movement HV (%)	Adjust. Flow (pcu/h)	Total Cap. (veh /h)	Prac. Deg. Satn xp	Prac. Spare Cap. (%)	Lane Util (%)	Deg. Satn x
South: Van Buren Street NB										
32 LT	990	1.0	1	0.0	1	2306	0.85	98	39	0.429
East: WB Off-Ramp										
22 LT	174	1.7	991	1.0	991	967	0.85	372	100	0.180
23 R	63	1.6	991	1.0	991	670	0.85	804	100	0.094
North: Van Buren Street SB										
42 LTR	427	0.9	396	1.4	396	960	0.85	91	100	0.445*

Missoula MT I-90 Phase 2
Van Buren Street I-90 WB Ramps - PM Peak Hour
Intersection ID:
Roundabout

Table S.3 - INTERSECTION PARAMETERS

Intersection Level of Service	=	A
Worst movement Level of Service	=	A
Average intersection delay (s)	=	3.3
Largest average movement delay (s)	=	9.3
Largest back of queue, 95% (ft)	=	98
Performance Index	=	33.01
Degree of saturation (highest)	=	0.445
Practical Spare Capacity (lowest)	=	91 %
Effective intersection capacity, (veh/h)	=	3719
Total vehicle flow (veh/h)	=	1654
Total person flow (pers/h)	=	2481
Total vehicle delay (veh-h/h)	=	1.52
Total person delay (pers-h/h)	=	2.28
Total effective vehicle stops (veh/h)	=	591
Total effective person stops (pers/h)	=	886
Total vehicle travel (veh-mi/h)	=	626.9
Total cost ($/h)	=	677.75
Total fuel (gal/h)	=	20.2
Total CO2 (kg/h)	=	191.61

Missoula MT I-90 Phase 2
Van Buren Street I-90 WB Ramps - PM Peak Hour

Intersection ID:
Roundabout

Table S.5 - MOVEMENT PERFORMANCE

Mov No.		Total Delay (veh-h/h)	Total Delay (pers-h/h)	Aver. Delay (sec)	Prop. Queued	Eff. Stop Rate	Longest Queue 95% Back (vehs)	Longest Queue 95% Back (ft)	Perf. Index	Aver. Speed (mph)
South: Van Buren Street NB										
32	LT	0.51	0.76	1.8	0.02	0.19	3.9	98	18.18	24.1
East: WB Off-Ramp										
22	LT	0.45	0.68	9.3	0.60	0.78	1.0	26	4.30	21.5
23	R	0.11	0.16	6.2	0.60	0.67	0.5	12	1.43	22.4
North: Van Buren Street SB										
42	LTR	0.46	0.68	3.8	0.60	0.52	3.3	84	9.11	22.9

Missoula MT I-90 Phase 2
Van Buren Street I-90 WB Ramps - PM Peak Hour
Intersection ID:
Roundabout

Table S.6 - INTERSECTION PERFORMANCE

Total Flow (veh/h)	Deg. Satn x	Total Delay (veh-h/h)	Total Delay (pers-h/h)	Aver. Delay (sec)	Prop. Queued	Eff. Stop Rate	Longest Queue (ft)	Perf. Index	Aver. Speed (mph)
South: Van Buren Street NB									
990	0.429	0.51	0.76	1.8	0.02	0.19	98	18.18	24.1
East: WB Off-Ramp									
237	0.180	0.56	0.84	8.5	0.60	0.75	26	5.72	21.7
North: Van Buren Street SB									
427	0.445	0.46	0.68	3.8	0.60	0.52	84	9.11	22.9
ALL VEHICLES:									
1654	0.445	1.52	2.28	3.3	0.25	0.36	98	33.01	23.4
INTERSECTION (persons):									
2481	0.445		2.28	3.3	0.25	0.36		33.01	23.4

Queue values in this table are 95% back of queue (feet).

Missoula MT I-90 Phase 2
Van Buren Street I-90 WB Ramps - PM Peak Hour
Intersection ID:
Roundabout

Table S.7 - LANE PERFORMANCE

Lane	Mov	Dem Flow (veh	Cap (veh	Deg. Satn	Aver. Delay	Eff. Stop	Queue 95% Back	Short Lane

No.	No.	/h)	/h)	x	(sec)	Rate	(vehs)	(ft)	(ft)
South: Van Buren Street NB									
1 L	32	221	1325	0.167	6.0	0.55	1.1	27	
2 T	32	769	1791	0.429	0.6	0.09	3.9	98	
East: WB Off-Ramp									
1 LT	22	174	967	0.180	9.3	0.78	1.0	26	
2 R	23	63	670	0.094	6.2	0.67	0.5	12	125
North: Van Buren Street SB									
1 LTR	42	427	960	0.445	3.8	0.52	3.3	84	

Missoula MT I-90 Phase 2
Van Buren Street I-90 WB Ramps - PM Peak Hour
Intersection ID:
Roundabout

Table S.8A - LANE FLOW AND CAPACITY INFORMATION

Lane No.	Mov No.	Dem Flow (veh/h) Lef	Thru	Rig	Tot	Min Cap (veh /h)	Tot Cap (veh /h)	Deg. Satn x	Lane Util %
South: Van Buren Street NB									
1 L	32	221	0	0	221	150	1325	0.167	39P
2 T	32	0	769	0	769	150	1791	0.429	100
East: WB Off-Ramp									
1 LT	22	173	1	0	174	150	967	0.180	100
2 R	23	0	0	63	63	63	670	0.094	100
North: Van Buren Street SB									
1 LTR	42	1	331	95	427	150	960	0.445	100

P Lane under-utilisation found by the "Program"

For roundabouts, the capacity value for continuous movements is obtained as the basic saturation flow without any adjustments. Saturation flow scale applies if specified.

Missoula MT I-90 Phase 2
Van Buren Street I-90 WB Ramps - PM Peak Hour
Intersection ID:
Roundabout

Table S.12A - FUEL CONSUMPTION, EMISSIONS AND COST - TOTAL

Mov No.	Fuel Total gal/h	Cost Total $/h	HC Total kg/h	CO Total kg/h	NOX Total kg/h	CO2 Total kg/h
South: Van Buren Street NB						
32 LT	11.7	393.98	0.166	3.32	0.132	110.8
	11.7	393.98	0.166	3.32	0.132	110.8

East: WB Off-Ramp						
22 LT	2.4	81.35	0.036	0.88	0.030	23.0
23 R	0.8	26.52	0.012	0.28	0.010	7.6
	3.2	107.87	0.048	1.16	0.040	30.7
North: Van Buren Street SB						
42 LTR	5.3	175.91	0.078	1.85	0.066	50.2
	5.3	175.91	0.078	1.85	0.066	50.2
INTERSECTION:	20.2	677.75	0.292	6.33	0.238	191.6

PARAMETERS USED IN COST CALCULATIONS

Pump price of fuel ($/US gal)	=	0.900
Fuel resource cost factor	=	0.50
Ratio of running cost to fuel cost	=	3.0
Average income ($/h)	=	27.00
Time value factor	=	0.60
Average occupancy (persons/veh)	=	1.5
Light vehicle mass (1000 lb)	=	1.4
Heavy vehicle mass (1000 lb)	=	11.0
Light vehicle idle fuel rate (US gal/h)	=	0.360
Heavy vehicle idle fuel rate (US gal/h)	=	0.530

The idle fuel and vehicle mass parameters given above are the default values (data given in RIDES may override some of these parameters).

Missoula MT I-90 Phase 2
Van Buren Street I-90 WB Ramps - PM Peak Hour
Intersection ID:
Roundabout

Table S.14 - SUMMARY OF INPUT AND OUTPUT DATA

Lane No.	Demand Flow (veh/h) L	T	R	Tot	%HV	Adj. Basic Satf.	Eff Grn (secs) 1st	2nd	Deg Sat x	Aver. Delay (sec)	Longest Queue (ft)	Shrt Lane (ft)
South: Van Buren Street NB												
1 L	221			221	1				0.167	6.0	27	
2 T		769		769	1				0.429	0.6	98	
	221	769	0	990	1				0.429	1.8	98	
East: WB Off-Ramp												
1 LT	173	1		174	2				0.180	9.3	26	
2 R			63	63	2				0.094	6.2	12	125
	173	1	63	237	2				0.180	8.5	26	
North: Van Buren Street SB												
1 LTR	1	331	95	427	1				0.445	3.8	84	
	1	331	95	427	1				0.445	3.8	84	

ALL VEHICLES Total % Max Aver. Max

Flow	HV	X	Delay	Queue
1654	1	0.445	3.3	98

Total flow period = 60 minutes. Peak flow period = 15 minutes.

Queue values in this table are 95% back of queue (feet).

Note: Basic Saturation Flows are not adjusted at roundabouts or sign-controlled intersections and apply only to continuous lanes.

Missoula MT I-90 Phase 2
Van Buren Street I-90 WB Ramps - PM Peak Hour
Intersection ID:
Roundabout

Table S.15 - CAPACITY AND LEVEL OF SERVICE

Mov No.	Mov Typ	Total Flow (veh /h)	Total Cap. (veh /h)	Deg. of Satn (v/c)	Aver. Delay (sec)	LOS	Longest Queue 95% Back (vehs)	(ft)
South: Van Buren Street NB								
32	LT	990	2306	0.429	1.8	A	3.9	98
		990		0.429	1.8	A	3.9	98
East: WB Off-Ramp								
22	LT	174	967	0.180	9.3	A	1.0	26
23	R	63	670	0.094	6.2	A	0.5	12
		237		0.180	8.5	A	1.0	26
North: Van Buren Street SB								
42	LTR	427	960	0.445*	3.8	A	3.3	84
		427		0.445	3.8	A	3.3	84
ALL VEHICLES:		1654		0.445	3.3	A	3.9	98

Level of Service calculations are based on average control delay including geometric delay (HCM criteria), independent of the current delay definition used.
For the criteria, refer to the "Level of Service" topic in the aaSIDRA Output Guide or the Output section of the on-line help.
* Maximum v/c ratio, or critical green periods

Missoula MT I-90 Phase 2
Van Buren Street I-90 WB Ramps - PM Peak Hour
Intersection ID:
Roundabout

Table D.0 - GEOMETRIC DELAY DATA

From Approach	To Approach	Negn Radius (ft)	Negn Speed (mph)	Negn Dist. (ft)	Appr. Dist. (ft)	Downstream Distance (ft)
South: Van Buren Street NB						

	West	55.8	15.3	219.1	1800	323
	North	165.3	23.1	140.8	1800	169
East: WB Off-Ramp						
	West	165.3	23.1	140.8	1800	168
	South	47.1	14.4	185.1	1800	296
	North	99.7	19.1	58.2	1800	165
North: Van Buren Street SB						
	West	112.7	20.0	58.0	1800	165
	South	129.7	21.1	105.7	1800	164
	North	49.3	14.6	271.0	1800	380

Maximum Negotiation (Design) Speed = 50.0 mph
Downstream Distance calculated by aaSIDRA

Downstream distance is distance travelled from the stopline until exit cruise speed is reached (includes negotiation distance). Acceleration distance is weighted for light and heavy vehicles. The same distance applies for both stopped and unstopped vehicles.

Missoula MT I-90 Phase 2
Van Buren Street I-90 WB Ramps - PM Peak Hour
Intersection ID:
Roundabout

Table D.1 - LANE DELAYS

Lane No.	Mov No.	Deg. Satn x	Delay (seconds/veh) Stop-line Delay 1st d1	2nd d2	Total dSL	Acc. Dec. dn	Queuing Total dq	MvUp dqm	Stopd (Idle) di	Geom dig	Control dic
South: Van Buren Street NB											
1 L	32	0.167	0.0	0.0	0.0	0.1	0.0	0.0	0.0	6.0	6.0
2 T	32	0.429	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.6	0.6
East: WB Off-Ramp											
1 LT	22	0.180	3.1	0.0	3.1	2.7	0.3	0.0	0.3	6.3	9.3
2 R	23	0.094	4.2	0.0	4.2	3.3	0.9	0.0	0.9	2.0	6.2
North: Van Buren Street SB											
1 LTR	42	0.445	2.4	0.0	2.4	3.6	0.0	0.0	0.0	1.4	3.8

dn is average stop-start delay for all vehicles queued and unqueued

Geometric delay is less than 2 seconds for some movements. The negotiation speed may be too high or the approach and exit speeds may be too low for given geometric design (e.g. for a large roundabout). Check Tables D.0, D.1 and D.4 for geometric delay data including negotiation speeds. If necessary, specify appropriate values of approach and exit speeds (RIDES Approach Data screen), and negotiation radius or negotiation speed data (RIDES Extra Data - Geometric Delay data screen).

Missoula MT I-90 Phase 2
Van Buren Street I-90 WB Ramps - PM Peak Hour
Intersection ID:
Roundabout

Table D.2 - LANE STOPS

Lane No.	Deg. Satn x	Effective Stop Rate he1	he2	Geom. hig	Overall h	Prop. Queued pq	Queue Move-up Rate hqm
South: Van Buren Street NB							
1 L	0.167	0.00	0.00	0.55	0.55	0.018	0.00
2 T	0.429	0.00	0.00	0.09	0.09	0.021	0.00
East: WB Off-Ramp							
1 LT	0.180	0.55	0.00	0.23	0.78	0.599	0.00
2 R	0.094	0.56	0.00	0.11	0.67	0.596	0.00
North: Van Buren Street SB							
1 LTR	0.445	0.45	0.00	0.08	0.52	0.598	0.00

hig is the average value for all movements in a shared lane
hqm is average queue move-up rate for all vehicles queued and unqueued

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Missoula MT I-90 Phase 2
Van Buren Street I-90 WB Ramps - PM Peak Hour
Intersection ID:
Roundabout

Table D.3A - LANE QUEUES (veh)

Lane No.	Deg. Satn x	Ovrfl. Queue No	Average (veh) Nb1	Nb2	Nb	Percentile (veh) 70%	85%	90%	95%	98%	Queue Stor. Ratio
South: Van Buren Street NB											
1 L	0.167	0.0	0.3	0.0	0.3	0.6	0.8	0.9	1.1	1.2	0.02
2 T	0.429	0.0	1.3	0.0	1.3	2.3	2.8	3.1	3.9	4.5	0.05
East: WB Off-Ramp											
1 LT	0.180	0.0	0.3	0.0	0.3	0.6	0.7	0.8	1.0	1.2	0.01
2 R	0.094	0.0	0.1	0.0	0.1	0.3	0.3	0.4	0.5	0.6	0.10
North: Van Buren Street SB											
1 LTR	0.445	0.0	1.1	0.0	1.1	1.9	2.4	2.7	3.3	3.9	0.05

Values printed in this table are back of queue (vehicles).

Missoula MT I-90 Phase 2
Van Buren Street I-90 WB Ramps - PM Peak Hour
Intersection ID:
Roundabout

Table D.3B - LANE QUEUES (feet)

Lane No.	Deg. Satn x	Ovrfl. Queue No	Average (feet) Nb1	Nb2	Nb	Percentile (feet) 70%	85%	90%	95%	98%	Queue Stor. Ratio
South: Van Buren Street NB											

1 L	0.167	0	9	0	9	16	19	22	27	31	0.02
2 T	0.429	0	32	0	32	57	70	79	98	114	0.05
East: WB Off-Ramp											
1 LT	0.180	0	8	0	8	16	19	21	26	30	0.01
2 R	0.094	0	4	0	4	7	9	10	12	14	0.10
North: Van Buren Street SB											
1 LTR	0.445	0	27	0	27	49	59	67	84	97	0.05

Values printed in this table are back of queue (feet).

Missoula MT I-90 Phase 2
Van Buren Street I-90 WB Ramps - PM Peak Hour
Intersection ID:
Roundabout

Table D.4 - MOVEMENT SPEEDS (mph)

Mov No.	App. Speeds Cruise	App. Speeds Negn	Exit Speeds Negn	Exit Speeds Cruise	Queue Move-up 1st Grn	Queue Move-up 2nd Grn	Av. Section Spd Running	Av. Section Spd Overall
South: Van Buren Street NB								
32	25.0	21.4	21.4	25.0			24.1	24.1
East: WB Off-Ramp								
22	25.0	14.4	14.4	25.0			21.6	21.5
23	25.0	19.1	19.1	25.0			22.7	22.4
North: Van Buren Street SB								
42	25.0	20.9	20.9	25.0			22.9	22.9

"Running Speed" is the average speed excluding stopped periods.

--- End of aaSIDRA Output ---

C:\Documents and Settings\tnewkirk\Desktop\Projects\Montana\I-90_Phase 2\SIDRA\Van Buren Street\2030_PM_VanBuren-WB Ramps.OUT
Produced by aaSIDRA 2.1.4.357

Generated 2:45 PM, Jul 13,2006

Akcelik & Associates Pty Ltd - aaSIDRA 2.1.4.357

CH2MHILL
CH2MHILL User ID: A0725
Licence Type: Single Computer

Time and Date of Analysis 9:57 AM, Jul 13,2006

Filename: C:\Documents and Settings\tnewkirk\Desktop\Projects\Montana\I-90_Phase 2\SIDRA\2030_PM_Orange Street_5-leg.OUT

Missoula MT I-90 Phase 2
Orange Street Interchange - 2030 PM Peak Hour
Intersection ID:

aaTraffic SIDRA US Highway Capacity Manual (2000) Version

RUN INFORMATION

* Basic Parameters:
  - Intersection Type: Roundabout
  - Driving on the right-hand side of the road
  - Input data specified in US units
  - Default Values File No. 11
  - Peak flow period (for performance): 15 minutes
  - Unit time (for volumes): 60 minutes (Total Flow Period)
  - Delay definition: Control delay
    Geometric delay included
  - aaSIDRA Standard Delay and Queue models used
  - Level of Service based on: Delay (HCM method)
  - Queue definition: Back of queue, 95th Percentile

Geometric delay is less than 2 seconds for some movements. The negotiation speed may be too high or the approach and exit speeds may be too low for given geometric design (e.g. for a large roundabout). Check Tables D.0, D.1 and D.4 for geometric delay data including negotiation speeds. If necessary, specify appropriate values of approach and exit speeds (RIDES Approach Data screen), and negotiation radius or negotiation speed data (RIDES Extra Data - Geometric Delay data screen).

Missoula MT I-90 Phase 2
Orange Street Interchange - 2030 PM Peak Hour
Intersection ID:
Roundabout

Table S.0 - TRAFFIC FLOW DATA

Mov No.	Left LV	Left HV	Through LV	Through HV	Right LV	Right HV	Flow Scale	Peak Flow Factor
VEHICLES	Demand flows in veh/hour as used by the program							
West: Orange Street								
12	0	0	531	5	386	4	1.00	0.95
SouthEast: I-5 WB Off-ramp								
72	1	0	479	5	1	0	1.00	0.95
NorthWest: I-5 EB Off-ramp								

82	10	1	0	0	471	15	1.00	0.95

Based on unit time = 60 minutes.
Flow Scale and Peak Hour Factor effects included in flow values.

Missoula MT I-90 Phase 2
Orange Street Interchange - 2030 PM Peak Hour
Intersection ID:
Roundabout

Table R.0 - ROUNDABOUT BASIC PARAMETERS

Cent Island Diam (ft)	Circ Width (ft)	Insc Diam. (ft)	No.of Circ. Lanes	No.of Entry Lanes	Av.Ent Lane Width (ft)	Circulating/Exiting Stream Flow (veh/h)	%HV	Adjust. Flow (pcu/h)	%Exit Incl.	Cap. Constr. Effect	O-D Factor
West: Orange Street											
68	16	100	1	1	13.00	13	2.5	13	0	N	0.997
SouthEast: I-5 WB Off-ramp											
68	16	100	1	1	13.00	547	1.0	547	0	N	0.978
NorthWest: I-5 EB Off-ramp											
68	16	100	1	1	13.00	485	1.0	485	0	N	0.900

Missoula MT I-90 Phase 2
Orange Street Interchange - 2030 PM Peak Hour
Intersection ID:
Roundabout

Table R.1 - ROUNDABOUT GAP ACCEPTANCE PARAMETERS

Turn	Lane No.	Lane Type	Circulating/Exiting Stream Flow Rate (pcu/h)	Aver Speed (mph)	Aver Dist (ft)	In-Bnch Headway (s)	Prop Bunched	Critical Gap Hdwy (s)	Critical Gap Dist (ft)	Foll-up Headway (s)
West: Orange Street										
Thru	1	Dominant	13	13.6	5674.9	2.00	0.015	4.21	83.9	2.14
Right	1	Dominant	13	13.6	5674.9	2.00	0.015	4.21	83.9	2.14
SouthEast: I-5 WB Off-ramp										
Left	1	Dominant	547	13.1	126.4	2.00	0.490	4.39	84.3	2.44
Thru	1	Dominant	547	13.1	126.4	2.00	0.490	4.39	84.3	2.44
Right	1	Dominant	547	13.1	126.4	2.00	0.490	4.39	84.3	2.44
NorthWest: I-5 EB Off-ramp										
Left	1	Dominant	485	13.1	142.5	2.00	0.448	4.66	89.4	2.57
Right	1	Dominant	485	13.1	142.5	2.00	0.448	4.47	85.9	2.47

Environment Factor: 1.00
Entry/Circulating Flow Adjustment: Medium

Priority sharing is implied for some movements (Follow-up Headway plus Intra-bunch Headway is larger than the Critical Gap). The O-D Factor

(Table R.0) allows for priority sharing and priority emphasis.

Dist (Distance): Spacing, i.e. distance between the front ends of two successive vehicles across all lanes in the circulating or exiting stream

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Missoula MT I-90 Phase 2
Orange Street Interchange - 2030 PM Peak Hour
Intersection ID:
Roundabout

Table R.5 - ROUNDABOUT CAPACITY & LEVEL OF SERVICE - aaSIDRA & HCM MODELS

Mov No.	Dem Flow (veh /h)	aaSIDRA Cap. (veh /h)	aaSIDRA Deg. Satn x	aaSIDRA Av. Delay (sec)	aaSIDRA LOS	HCM 2000 Lower Cap. (veh /h)	HCM 2000 Lower Deg. Satn x	HCM 2000 Lower Av. Delay (sec)	HCM 2000 Lower LOS	HCM 2000 Upper Cap. (veh /h)	HCM 2000 Upper Deg. Satn x	HCM 2000 Upper Av. Delay (sec)	HCM 2000 Upper LOS
West: Orange Street													
12 TR	926	1659	0.558	2.9	A	1149	0.806	3.0	A	1371	0.675	2.9	A
SouthEast: I-5 WB Off-ramp													
72 LTR	486	873	0.557	9.5	A	724	0.671	12.4	B	899	0.541	8.9	A
NorthWest: I-5 EB Off-ramp													
82 LR	497	839	0.592	7.1	A	763	0.651	8.7	A	943	0.527	5.8	A

Missoula MT I-90 Phase 2
Orange Street Interchange - 2030 PM Peak Hour
Intersection ID:
Roundabout

Table R.6 - ROUNDABOUT ALTERNATIVE CAPACITY MODELS

Mov No.	Dem Flow (veh /h)	aaSIDRA Cap. (veh /h)	aaSIDRA Deg. Satn x	NAASRA 1986 Cap. (veh /h)	NAASRA 1986 % Diff from aaSIDRA	Ger. Linear Cap. (veh /h)	Ger. Linear % Diff from aaSIDRA	Ger. GapAcc Cap. (veh /h)	Ger. GapAcc % Diff from aaSIDRA
West: Orange Street									
12 TR	926	1659	0.558	1781	7.4	1208	-27.2	1238	-25.4
SouthEast: I-5 WB Off-ramp									
72 LTR	486	873	0.557	1072	22.8	813	-6.9	779	-10.8
NorthWest: I-5 EB Off-ramp									
82 LR	497	839	0.592	1143	36.2	858	2.3	827	-1.4

Missoula MT I-90 Phase 2
Orange Street Interchange - 2030 PM Peak Hour
Intersection ID:
Roundabout

Table S.2 - MOVEMENT CAPACITY PARAMETERS

Mov No.	Demand Flow (veh/h)	HV (%)	Opposing Movement Flow (veh/h)	HV (%)	Adjust. Flow (pcu/h)	Total Cap. (veh /h)	Prac. Deg. Satn xp	Prac. Spare Cap. (%)	Lane Util (%)	Deg. Satn x
West: Orange Street										
12 TR	926	1.0	13	2.5	13	1659	0.85	52	100	0.558
SouthEast: I-5 WB Off-ramp										
72 LTR	486	1.0	547	1.0	547	873	0.85	53	100	0.557
NorthWest: I-5 EB Off-ramp										
82 LR	497	3.2	485	1.0	485	839	0.85	43	100	0.592*

Missoula MT I-90 Phase 2
Orange Street Interchange - 2030 PM Peak Hour
Intersection ID:
Roundabout

Table S.3 - INTERSECTION PARAMETERS

Intersection Level of Service	=	A
Worst movement Level of Service	=	A
Average intersection delay (s)	=	5.7
Largest average movement delay (s)	=	9.5
Largest back of queue, 95% (ft)	=	187
Performance Index	=	51.69
Degree of saturation (highest)	=	0.592
Practical Spare Capacity (lowest)	=	43 %
Effective intersection capacity, (veh/h)	=	3223
Total vehicle flow (veh/h)	=	1909
Total person flow (pers/h)	=	2864
Total vehicle delay (veh-h/h)	=	3.01
Total person delay (pers-h/h)	=	4.51
Total effective vehicle stops (veh/h)	=	1229
Total effective person stops (pers/h)	=	1844
Total vehicle travel (veh-mi/h)	=	703.3
Total cost ($/h)	=	966.48
Total fuel (gal/h)	=	25.5
Total CO2 (kg/h)	=	241.06

Missoula MT I-90 Phase 2
Orange Street Interchange - 2030 PM Peak Hour
Intersection ID:
Roundabout

Table S.5 - MOVEMENT PERFORMANCE

Mov No.	Total Delay (veh-h/h)	Total Delay (pers-h/h)	Aver. Delay (sec)	Prop. Queued	Eff. Stop Rate	Longest Queue 95% Back (vehs)	Longest Queue 95% Back (ft)	Perf. Index	Aver. Speed (mph)
West: Orange Street									
12 TR	0.74	1.11	2.9	0.15	0.35	7.4	187	22.10	19.0

SouthEast: I-5 WB Off-ramp

72	LTR	1.29	1.93	9.5	0.79	0.93	5.9	148	14.82	17.5

NorthWest: I-5 EB Off-ramp

82	LR	0.98	1.47	7.1	0.86	0.91	7.0	179	14.78	18.0

Missoula MT I-90 Phase 2
Orange Street Interchange - 2030 PM Peak Hour
Intersection ID:
Roundabout

Table S.6 - INTERSECTION PERFORMANCE

	Total Flow (veh/h)	Deg. Satn x	Total Delay (veh-h/h)	Total Delay (pers-h/h)	Aver. Delay (sec)	Prop. Queued	Eff. Stop Rate	Longest Queue (ft)	Perf. Index	Aver. Speed (mph)
West: Orange Street	926	0.558	0.74	1.11	2.9	0.15	0.35	187	22.10	19.0
SouthEast: I-5 WB Off-ramp	486	0.557	1.29	1.93	9.5	0.79	0.93	148	14.82	17.5
NorthWest: I-5 EB Off-ramp	497	0.592	0.98	1.47	7.1	0.86	0.91	179	14.78	18.0
ALL VEHICLES:	1909	0.592	3.01	4.51	5.7	0.50	0.64	187	51.69	18.4
INTERSECTION (persons):	2864	0.592		4.51	5.7	0.50	0.64		51.69	18.4

Queue values in this table are 95% back of queue (feet).

Missoula MT I-90 Phase 2
Orange Street Interchange - 2030 PM Peak Hour
Intersection ID:
Roundabout

Table S.7 - LANE PERFORMANCE

Lane No.	Mov No.	Dem Flow (veh /h)	Cap (veh /h)	Deg. Satn x	Aver. Delay (sec)	Eff. Stop Rate	Queue 95% Back (vehs)	Queue 95% Back (ft)	Short Lane (ft)
West: Orange Street									
1 TR	12	926	1659	0.558	2.9	0.35	7.4	187	
SouthEast: I-5 WB Off-ramp									
1 LTR	72	486	873	0.557	9.5	0.93	5.9	148	
NorthWest: I-5 EB Off-ramp									
1 LR	82	497	839	0.593	7.1	0.91	7.0	179	

Missoula MT I-90 Phase 2

Orange Street Interchange - 2030 PM Peak Hour
Intersection ID:
Roundabout

Table S.8A - LANE FLOW AND CAPACITY INFORMATION

Lane No.	Mov No.	Dem Flow (veh/h) Lef	Thru	Rig	Tot	Min Cap (veh /h)	Tot Cap (veh /h)	Deg. Satn x	Lane Util %
West: Orange Street									
1 TR	12	0	536	390	926	150	1659	0.558	100
SouthEast: I-5 WB Off-ramp									
1 LTR	72	1	484	1	486	150	873	0.557	100
NorthWest: I-5 EB Off-ramp									
1 LR	82	11	0	486	497	150	839	0.593	100

For roundabouts, the capacity value for continuous movements is obtained as the basic saturation flow without any adjustments. Saturation flow scale applies if specified.

Missoula MT I-90 Phase 2
Orange Street Interchange - 2030 PM Peak Hour
Intersection ID:
Roundabout

Table S.12A - FUEL CONSUMPTION, EMISSIONS AND COST - TOTAL

Mov No.	Fuel Total gal/h	Cost Total $/h	HC Total kg/h	CO Total kg/h	NOX Total kg/h	CO2 Total kg/h
West: Orange Street						
12 TR	11.9	452.68	0.180	3.67	0.122	112.5
	11.9	452.68	0.180	3.67	0.122	112.5
SouthEast: I-5 WB Off-ramp						
72 LTR	6.8	262.05	0.106	2.27	0.072	64.1
	6.8	262.05	0.106	2.27	0.072	64.1
NorthWest: I-5 EB Off-ramp						
82 LR	6.8	251.75	0.104	2.32	0.073	64.5
	6.8	251.75	0.104	2.32	0.073	64.5
INTERSECTION:	25.5	966.48	0.390	8.26	0.268	241.1

PARAMETERS USED IN COST CALCULATIONS

Pump price of fuel ($/US gal)	=	0.900
Fuel resource cost factor	=	0.50

Ratio of running cost to fuel cost	=	3.0
Average income ($/h)	=	27.00
Time value factor	=	0.60
Average occupancy (persons/veh)	=	1.5
Light vehicle mass (1000 lb)	=	1.4
Heavy vehicle mass (1000 lb)	=	11.0
Light vehicle idle fuel rate (US gal/h)	=	0.360
Heavy vehicle idle fuel rate (US gal/h)	=	0.530

The idle fuel and vehicle mass parameters given above are the default values (data given in RIDES may override some of these parameters).

Missoula MT I-90 Phase 2
Orange Street Interchange - 2030 PM Peak Hour
Intersection ID:
Roundabout

Table S.14 - SUMMARY OF INPUT AND OUTPUT DATA

Lane No.	Demand Flow (veh/h) L	T	R	Tot	%HV	Adj. Basic Satf.	Eff Grn (secs) 1st	2nd	Deg Sat x	Aver. Delay (sec)	Longest Queue (ft)	Shrt Lane (ft)
West: Orange Street												
1 TR		536	390	926	1				0.558	2.9	187	
	0	536	390	926	1				0.558	2.9	187	
SouthEast: I-5 WB Off-ramp												
1 LTR	1	484	1	486	1				0.557	9.5	148	
	1	484	1	486	1				0.557	9.5	148	
NorthWest: I-5 EB Off-ramp												
1 LR	11		486	497	3				0.593	7.1	179	
	11	0	486	497	3				0.593	7.1	179	

ALL VEHICLES	Total Flow	% HV	Max X	Aver. Delay	Max Queue
	1909	2	0.592	5.7	187

Total flow period = 60 minutes. Peak flow period = 15 minutes.

Queue values in this table are 95% back of queue (feet).

Note: Basic Saturation Flows are not adjusted at roundabouts or sign-controlled intersections and apply only to continuous lanes.

Missoula MT I-90 Phase 2
Orange Street Interchange - 2030 PM Peak Hour
Intersection ID:
Roundabout

Table S.15 - CAPACITY AND LEVEL OF SERVICE

Mov No.	Mov Typ	Total Flow (veh	Total Cap. (veh	Deg. of Satn	Aver. Delay	LOS	Longest Queue 95% Back (vehs)	(ft)

	/h)	/h)	(v/c)	(sec)			
West: Orange Street							
12 TR	926	1659	0.558	2.9	A	7.4	187
	926		0.558	2.9	A	7.4	187
SouthEast: I-5 WB Off-ramp							
72 LTR	486	873	0.557	9.5	A	5.9	148
	486		0.557	9.5	A	5.9	148
NorthWest: I-5 EB Off-ramp							
82 LR	497	839	0.592*	7.1	A	7.0	179
	497		0.592	7.1	A	7.0	179
ALL VEHICLES:	1909		0.592	5.7	A	7.4	187

Level of Service calculations are based on
average control delay including geometric delay (HCM criteria),
independent of the current delay definition used.
For the criteria, refer to the "Level of Service" topic in the
aaSIDRA Output Guide or the Output section of the on-line help.

* Maximum v/c ratio, or critical green periods

Missoula MT I-90 Phase 2
Orange Street Interchange - 2030 PM Peak Hour
Intersection ID:
Roundabout

Table D.0 - GEOMETRIC DELAY DATA

From Approach	To Approach	Negn Radius (ft)	Negn Speed (mph)	Negn Dist. (ft)	Appr. Dist. (ft)	Downstream Distance (ft)
West: Orange Street						
	SouthWest	57.0	15.5	32.8	1800	106
	NorthEast	36.9	13.1	115.8	1800	178
SouthEast: I-5 WB Off-ramp						
	West	36.9	13.1	115.8	1800	178
	SouthWest	37.8	13.2	148.2	1800	210
	NorthEast	80.0	17.6	38.6	1800	104
NorthWest: I-5 EB Off-ramp						
	West	57.0	15.5	32.8	1800	106
	SouthWest	80.0	17.6	38.6	1800	106
	NorthEast	37.8	13.2	148.2	1800	210

Maximum Negotiation (Design) Speed = 50.0 mph
Downstream Distance calculated by aaSIDRA

Downstream distance is distance travelled from the stopline until exit cruise speed is reached (includes negotiation distance). Acceleration distance is weighted for light and heavy vehicles. The same distance applies for both stopped and unstopped vehicles.

Orange Street Interchange - 2030 PM Peak Hour
Intersection ID:
Roundabout

Table D.1 - LANE DELAYS

Lane No.	Mov No.	Deg. Satn x	Stop-line Delay 1st d1	2nd d2	Total dSL	Acc. Dec. dn	Queuing Total dq	MvUp dqm	Stopd (Idle) di	Geom dig	Control dic
West: Orange Street											
1 TR	12	0.558	0.1	0.0	0.1	0.7	0.0	0.0	0.0	2.8	2.9
SouthEast: I-5 WB Off-ramp											
1 LTR	72	0.557	4.5	1.4	5.9	3.3	2.5	0.8	1.7	3.7	9.5
NorthWest: I-5 EB Off-ramp											
1 LR	82	0.593	3.9	1.5	5.5	4.1	1.4	0.7	0.6	1.6	7.1

Delay (seconds/veh)

dn is average stop-start delay for all vehicles queued and unqueued

Geometric delay is less than 2 seconds for some movements. The negotiation speed may be too high or the approach and exit speeds may be too low for given geometric design (e.g. for a large roundabout). Check Tables D.0, D.1 and D.4 for geometric delay data including negotiation speeds. If necessary, specify appropriate values of approach and exit speeds (RIDES Approach Data screen), and negotiation radius or negotiation speed data (RIDES Extra Data - Geometric Delay data screen).

Missoula MT I-90 Phase 2
Orange Street Interchange - 2030 PM Peak Hour
Intersection ID:
Roundabout

Table D.2 - LANE STOPS

Lane No.	Deg. Satn x	-- Effective Stop Rate -- he1	he2	Geom. hig	Overall h	Prop. Queued pq	Queue Move-up Rate hqm
West: Orange Street							
1 TR	0.558	0.03	0.00	0.32	0.35	0.147	0.00
SouthEast: I-5 WB Off-ramp							
1 LTR	0.557	0.72	0.11	0.10	0.93	0.789	0.15
NorthWest: I-5 EB Off-ramp							
1 LR	0.593	0.77	0.11	0.04	0.91	0.858	0.14

hig is the average value for all movements in a shared lane
hqm is average queue move-up rate for all vehicles queued and unqueued

---

Missoula MT I-90 Phase 2
Orange Street Interchange - 2030 PM Peak Hour
Intersection ID:
Roundabout

Table D.3A - LANE QUEUES (veh)

Lane No.	Deg. Satn x	Ovrfl. Queue No	Average (veh) Nb1	Nb2	Nb	Percentile (veh) 70%	85%	90%	95%	98%	Queue Stor. Ratio
West: Orange Street											
1 TR	0.558	0.0	2.5	0.0	2.5	4.2	5.2	6.0	7.4	8.7	0.10
SouthEast: I-5 WB Off-ramp											
1 LTR	0.557	0.2	1.6	0.3	1.9	3.4	4.1	4.7	5.9	6.8	0.08
NorthWest: I-5 EB Off-ramp											
1 LR	0.593	0.3	1.9	0.4	2.3	4.0	4.9	5.6	7.0	8.1	0.10

Values printed in this table are back of queue (vehicles).

Missoula MT I-90 Phase 2
Orange Street Interchange - 2030 PM Peak Hour
Intersection ID:
Roundabout

Table D.3B - LANE QUEUES (feet)

Lane No.	Deg. Satn x	Ovrfl. Queue No	Average (feet) Nb1	Nb2	Nb	Percentile (feet) 70%	85%	90%	95%	98%	Queue Stor. Ratio
West: Orange Street											
1 TR	0.558	0	62	0	62	107	131	150	187	218	0.10
SouthEast: I-5 WB Off-ramp											
1 LTR	0.557	6	41	8	48	85	104	119	148	172	0.08
NorthWest: I-5 EB Off-ramp											
1 LR	0.593	7	50	9	59	102	125	143	179	208	0.10

Values printed in this table are back of queue (feet).

Missoula MT I-90 Phase 2
Orange Street Interchange - 2030 PM Peak Hour
Intersection ID:
Roundabout

Table D.4 - MOVEMENT SPEEDS (mph)

Mov No.	App. Speeds Cruise	Negn	Exit Speeds Negn	Cruise	Queue Move-up 1st Grn	2nd Grn	Av. Section Spd Running	Overall
West: Orange Street								
12	20.0	14.1	14.1	20.0			19.0	19.0
SouthEast: I-5 WB Off-ramp								

```
   72    20.0  13.1   13.1  20.0    13.7            17.9    17.5
-----------------------------------------------------------------
 NorthWest: I-5 EB Off-ramp
   82    20.0  15.4   15.4  20.0    14.3            18.2    18.0
-----------------------------------------------------------------
```

"Running Speed" is the average speed excluding stopped periods.

--- End of aaSIDRA Output ---

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Produced by aaSIDRA 2.1.4.357

Generated 9:57 AM, Jul 13,2006

Appendix D

Ramp Acceleration and Deceleration Computations

Missoula E/W Ramp Length Design Date: 5-8-07 By: Tsee
Roundabout Alternative Checked By: RBeckman

Cross Road to I-90	Orange St								VanBuren St							
Ramp Name	**Ramp H1**		**Ramp H2**		**Ramp H3**		**Ramp H4**		**Ramp J1**		**Ramp J2**		**Ramp J3**		**Ramp J4**	
Ramp Direc.	WB		WB		EB		EB		WB		WB		EB		EB	
Ramp Op.	on		off		on		off		on		off		on		off	
Accel/Decel	Accel		Decel		Accel		Decel		Accel		Decel		Accel		Decel	
Entering Limiting Curve																
Limiting Curve Radius (ft)	766.8		1910		2158.2		2865		764		1273		1951		2865	
Limiting Curve Superelevation (%	8.00%		5.00%		3.60%		3.00%		7.00%		7.00%		4.40%		2.60%	
Limiting Curve Speed (mph, at entrance of curve, Exhibit 3-26	50		50		45		45		40		50		50		40	
Initial speed before limiting curve (mph	0		70		0		70		0		70		0		70	
Grade < 3% / length of grade < 3% Measured from existing survey info	2.2%	650	1.8%	340	2.0%	220	0.5%	130	1.0%	200	1.0%	150	2.0%	380	1.5%	600
Grade 3-4% / Length of Grade 3-4% Measured from existing survey info	0.0%	0	3.0%	40	4.5%	80	0.0%	0	4.5%	200	0.0%	0	4.5%	360	0.0%	0
Grade 5-6% / Length of Grade 5-6% Measured from existing survey info	0.0%	0	0.0%	0	5.0%	360	0.0%	0	6.0%	200	0.0%	0	0.0%	0	5.0%	120
Average Grade before entering limiting curve	2.20%		1.93%		3.94%		0.50%		3.83%		1.00%		3.22%		2.08%	
Upgrade / DownGrade	Ugrade		Downgrade		Ugrade		Downgrade		Ugrade		Downgrade		Ugrade		Downgrade	
Adjustment Factor (from EXHIBIT 10-71)	1		1		1.3		1		1.3		1		1.3		1	
Required length before entering limiting curve (EXHIBIT 10-70, 10-73), (ft)	720		340		560		390		360		340		720		390	
Ramp Length before entering Limiting Curve Adjusted for Grade (ft)	720		340		730		390		470		340		936		390	
Existing length PRECEEDING limiting curve	783		280		816		60		633		170		732		651	
Difference	63		-60		86		-330		163		-170		-204		261	
Exiting Limiting Curve																
Initial Speed (mph)	50		50		45		45		40		50		50		40	
Speed Reached (mph)	70		0		70		0		70		0		70		0	
Grade < 3% / length of grade < 3% Measured from existing survey info	2.5%	720	2.6%	150	1.0%	500	1.8%	520	1.0%	700	1.5%	600	0.5%	300	2.5%	280
Grade 3-4% / Length of Grade 3-4% Measured from existing survey info	0.0%	0	4.2%	450	0.0%	0	4.0%	300	0.0%	0	0.0%	0	0.0%	0	0.0%	0
Grade 5-6% / Length of Grade 5-6% Measured from existing survey info	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	5.7%	360
Average Grade after exiting limiting curve	2.45%		3.80%		1.00%		2.60%		1.00%		1.50%		0.50%		4.30%	
Adjustment Factor (from EXHIBIT 10-71)	1		1.2		1		1		1		1		1		1.2	
Vehicle Queue at intersection (roundabout)	0		140		0		290		0		30		0		90	
Required Ramp length upon Exiting limiting curve, (Exhibit 10-70, 10-73)	580		435		820		385		1000		435		580		320	
Required Ramp length upon Exiting limiting curve + queue + grade adjustment	580		662		820		675		1000		465		580		474	
Existing ramp length upon Exiting limiting curve	160		857		398		1028		295		741		300		804	
Difference	-420		195		-422		353		-705		276		-280		330	
Assessment	Consider extending ramp 360' (420'-63')		Decel is adequate		Consider extending ramp 340' (422'-86')		Decel is adequate		Consider extending ramp 550' (705'-163')		Decel is adequate		Consider extending ramp 480' (204'+280')		Decel is adequate	
Taper Length (12' width, 50:1 acc or 300' parallel, 15:1 decel.)	300'		180'		300'		180'		300'		180'		300'		180'	

Missoula E/W Ramp Length Design Date: 5-8-07 By: Tsee
Traffic Signal Alternative Checked By: RBeckman

Cross Road to I-90	Orange St								VanBuren St							
Ramp Name	**Ramp H1**		**Ramp H2**		**Ramp H3**		**Ramp H4**		**Ramp J1**		**Ramp J2**		**Ramp J3**		**Ramp J4**	
Ramp Direc.	WB		WB		EB		EB		WB		WB		EB		EB	
Ramp Op.	on		off		on		off		on		off		on		off	
Accel/Decel	Accel		Decel		Accel		Decel		Accel		Decel		Accel		Decel	
Entering Limiting Curve																
Limiting Curve Radius (ft)	766.8		1910		2158.2		2865		764		1273		1951		2865	
Limiting Curve Superelevation (%)	8.00%		5.00%		3.60%		3.00%		7.00%		7.00%		4.40%		2.60%	
Limiting Curve Speed (mph, at entrance of curve, Exhibit 3-26)	50		50		45		45		40		50		50		40	
Initial speed before limiting curve (mph)	0		70		0		70		0		70		0		70	
Grade < 3% / length of grade < 3% Measured from existing survey info	2.2%	650	1.8%	340	2.0%	220	0.5%	130	1.0%	200	1.0%	150	2.0%	380	1.5%	600
Grade 3-4% / Length of Grade 3-4% Measured from existing survey info	0.0%	0	3.0%	40	4.5%	80	0.0%	0	4.5%	200	0.0%	0	4.5%	360	0.0%	0
Grade 5-6% / Length of Grade 5-6% Measured from existing survey info	0.0%	0	0.0%	0	5.0%	360	0.0%	0	6.0%	200	0.0%	0	0.0%	0	5.0%	120
Average Grade before entering limiting curve	2.20%		1.93%		3.94%		0.50%		3.83%		1.00%		3.22%		2.08%	
Upgrade / DownGrade	Ugrade		Downgrade		Ugrade		Downgrade		Ugrade		Downgrade		Ugrade		Downgrade	
Adjustment Factor (from EXHIBIT 10-71)	1		1		1.3		1		1.3		1		1.3		1	
Required length before entering limiting curve (EXHIBIT 10-70, 10-73), (ft)	720		340		560		390		360		340		720		390	
Ramp Length before entering Limiting Curve Adjusted for Grade (ft)	720		340		730		390		470		340		936		390	
Existing length PRECEEDING limiting curve	783		280		816		60		633		170		732		651	
Difference	63		-60		86		-330		163		-170		-204		261	
Exiting Limiting Curve																
Initial Speed (mph)	50		50		45		45		40		50		50		40	
Speed Reached (mph)	70		0		70		0		70		0		70		0	
Grade < 3% / length of grade < 3% Measured from existing survey info	2.5%	720	2.6%	150	1.0%	500	1.8%	520	1.0%	700	1.5%	600	0.5%	300	2.5%	280
Grade 3-4% / Length of Grade 3-4% Measured from existing survey info	0.0%	0	4.2%	450	0.0%	0	4.0%	300	0.0%	0	0.0%	0	0.0%	0	0.0%	0
Grade 5-6% / Length of Grade 5-6% Measured from existing survey info	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	5.7%	360
Average Grade after exiting limiting curve	2.45%		3.80%		1.00%		2.60%		1.00%		1.50%		0.50%		4.30%	
Adjustment Factor (from EXHIBIT 10-71)	1		1.2		1		1		1		1		1		1.2	
Vehicle Queue at intersection (traffic signal/AWSC)	0		535		0		420		0		240		0		310	
Required Ramp length upon Exiting limiting curve, (Exhibit 10-70, 10-73)	580		435		820		385		1000		435		580		320	
Required Ramp length upon Exiting limiting curve + queue + grade adjustment	580		1057		820		805		1000		675		580		694	
Existing ramp length upon Exiting limiting curve	160		857		398		1028		295		741		300		804	
Difference	-420		-200		-422		223		-705		66		-280		110	
Assessment	Consider extending ramp 360' (420'-63')		Decel is inadequate		Consider extending ramp 340' (422'-86')		Decel is inadequate		Consider extending ramp 550' (705'-163')		Decel is inadequate		Consider extending ramp 480' (204'+280')		Decel is adequate	
Taper Length (12' width, 50:1 acc or 300' parallel, 15:1 decel.)	300'		180'		300'		180'		300'		180'		300'		180'	

Appendix E

Origin-Destination Field Data Summary

License Plate Matching Origin-Destination Summary

AM Sightings

	Second Location				
First Location	Orange AM Off	Orange AM On	Van Buren AM Off	Van Buren AM On	**Total**
Orange AM Off	1	14	1	50	**66**
Orange AM On	15	1	23	1	**40**
Van Buren AM Off	1	0	0	11	**12**
Van Buren AM On	20	1	12	0	**33**
Total	**37**	**16**	**36**	**62**	**151**

PM Sightings

	Second Location				
First Location	Orange PM Off	Orange PM On	Van Buren PM Off	Van Buren PM On	**Total**
Orange PM Off	1	32	0	59	**92**
Orange PM On	28	0	68	1	**97**
Van Buren PM Off	3	0	0	30	**33**
Van Buren PM On	11	0	21	1	**33**
Total	**43**	**32**	**89**	**91**	**255**

AM - PM Sightings (Commuter traffic)

	Second Location				
First Location	Orange PM Off	Orange PM On	Van Buren PM Off	Van Buren PM On	**Total**
Orange AM Off	19	196	4	1	**220**
Orange AM On	35	7	1	1	**44**
Van Buren AM Off	5	1	15	83	**104**
Van Buren AM On	4	7	57	5	**73**
Total	**63**	**211**	**77**	**90**	**441**

*Entering EB Orange Street On-Ramp volume (6:30a-9:30a, 3:30p-6:30p) = 1300
*Entering WB Van Buren Street On-Ramp (6:30a-9:30a, 3:30p-6:30p) = 1170

*Based on 24-hour volume counts recorded during L2 collection of speed data in April 2007