abelin traffic services

Iwata Subdivision
Traffic Impact Study

Billings, Montana

Prepared For:

Performance Engineering
608 North 29th Street
Billings, MT 59101

December, 2019

130 South Howie Street
Helena, Montana 59601
406-459-1443

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A. EXECUTIVE SUMMARY

The Iwata Subdivision is a 4.7 acre neighborhood commercial development project currently proposed west of Shiloh Road in Billings, MT. Upon completion, the development would include four new neighborhood commercial lots and would produce approximately 700 new daily vehicle trips in this area. The development will be accessed from an existing approach onto Shiloh Road and a new approach onto Central Avenue. The proposed subdivision will benefit considerably from the existing roundabouts on Shiloh Road. All intersections will operate at acceptable levels of service with reserve capacity for future growth. No improvements are recommended for these intersections at this time to improve capacity. The developers should work with the City of Billings as necessary to help with the future widening needs along Central Avenue. The developers should also locate the new southern approach to the development site as far to the east as possible on their frontage of Central Avenue to help maximize the intersection spacing from the existing approaches on the roadway.

B. PROJECT DESCRIPTION

This document studies the possible effects on the surrounding road system from a proposed commercial subdivision located west of Shiloh Road in Billings, MT. The site is located to the northwest of the intersection of Shiloh Road and Central Avenue. The document also identifies any traffic mitigation efforts that the developments may require. The Iwata Subdivision would be developed to include 4.7 acres of neighborhood commercial property. Based on conversations with the City of Billings planning staff, the study area selected for this project includes the intersections of Shiloh Road with Broadwater Avenue, Central Avenue, Monad Road, and the approaches to the proposed development site.

C. EXISTING CONDITIONS

The Iwata Subdivision is currently proposed on a 4.7 acre parcel of land located on the northwest corner of the intersection of Shiloh Road and Central Avenue in Billings. The existing development property currently consists of an undeveloped section of land which is bordered by existing residential subdivisions to the west and commercial properties to the north, south, and east. The Cenex gas station is located southeast of the property. See **Figure 1** for a location map of the proposed development.

Figure 1- Proposed Development Site

Adjacent Roadways

Central Avenue is an east/west principle arterial route that extends west from downtown Billings. The intersection of Central Avenue and Shiloh Road is controlled by a multi-lane roundabout. East of Shiloh Road, Central Avenue has a newly constructed four-lane urban cross-section. West of Shiloh Road, Central Avenue narrows to a 24-foot, two-lane rural cross-section. The posted speed limit along Central Avenue is 45 MPH. Traffic data collected in 2018 by MDT indicates that Central Avenue carries 4,500 Vehicles Per Day (VPD) west of Shiloh Road (40th Street) and 7,900 VPD east of Shiloh Road

Shiloh Road/ 40th Street West is a north/south urban principle arterial route that extends north from Interstate 90. Shiloh Road intersects with Central Avenue, Broadwater Avenue, and

Monad Road at roundabouts. Between Central Avenue and Grand Avenue Shiloh Road has a four-lane urban cross-section with raised medians and left-turn lanes at designated intersections. The posted speed limit in the area is 45 MPH. Traffic data collected in 2018 by MDT indicates that West Main Street carries 19,200 VPD between Central and Grand Avenue.

Traffic Counts

The traffic data used for this report was collected on the surrounding road system by ATS in May and September of 2019. The collected data includes turning movement counts at the intersections of Central Avenue (May), Broadwater Avenue (September), and Monad Road (September) with Shiloh Road. ATS also performed 24-hour volume counts on the existing approach to the site from Shiloh Road. Refer to **Figure 1** for detail of the data collection/acquisition sites. The raw traffic data is included in **Appendix A** of this report.

The raw data collected for this project was adjusted for seasonal variation in accordance with the data collected from MDT's automatic count station located in Billings on Broadwater Avenue between 22nd Street and Gay Place (Station A-051). This count station data indicated that traffic counts collected in May and September are both approximately 103% of the AADT (Average Annual Daily Traffic) volume in this area.

Historic traffic data was collected for Central Avenue and Shiloh Road from the Montana Department of Transportation. The data for this location is presented in **Table 1**. The MDT data indicates that traffic volumes along Central Avenue have increased by an average of 2% over the last ten years, while volumes on Shiloh Road have increased by an average of 6% annually.

Table 1 – Historic Average Daily Traffic Data

Location	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Central W of Shiloh #56-4A-058	4,380	4,630	4,120	4,080	4,980	5,070	5,200	5,264	5,222	4,512
Central E of Shiloh #56-4A-059	6,520	6,310	5,500	5,930	6,830	6,840	5,980	7,678	7,816	7,925
Shiloh N of Central #56-4A-128	10,290	9,960	10,890	11,000	12,390	12,400	15,120	16,446	16,183	19,200
Shiloh S of Central #56-4A-127	9,750	9,440	9,850	11,020	11,440	12,450	14,610	15,679	16,440	16,670

Level of Service

Using the data collected for this project, ATS conducted a Level of Service (LOS) analysis at area intersections. This evaluation was conducted in accordance with the procedures outlined in the Transportation Research Board's *Highway Capacity Manual (HCM) - Special Report 209* and the Highway Capacity Software (HCS) version 7.8. Intersections are graded from A to F representing the average delay that a vehicle entering an intersection can expect. Typically, a LOS of C or better is considered acceptable for peak-hour conditions.

Table 2 shows the existing 2019 LOS for the AM and PM peak hours without the generated traffic from the Iwata subdivision. The LOS calculations are included in **Appendix C**. The analysis indicates that all of the study intersection are currently operating within normal operating limits and have considerable reserve capacity for future growth. No roadway modifications are recommended at this time to improve intersection capacity. Based on future growth projections in this area, the *2018 Billings Urban Area Long Range Transportation Plan* recommends widening Central to three lane from Shiloh Road to 48th Street West (Project R-48, estimated cost $3,100,000).

Table 2 – 2019 Level of Service Summary

	AM Peak Hour		PM Peak Hour	
Intersection	**Delay (Sec.)**	**LOS**	**Delay (Sec.)**	**LOS**
Shiloh Road & Broadwater Ave.	7.6	A	7.9	A
Shiloh Road & Central Ave.	8.6	A	13.1	B
Shiloh Road & Monad Road	6.3	A	7.6	A

Area Crash Data

ATS collected crash data for the study intersections from the MDT public crash database. This system contains records and basic information for all reported crashes which occur on public roads over the past five years. Intersection crashes are typically evaluated by the rate of Crashes per Million Vehicles Entering (MVE). Intersections with higher than normal crash rates are evaluated to determine if any crash trends exists which may be contributing to the observed crash trend. The results of this analysis for the study intersections is shown in **Table 2**. The data indicates that the crash rates for these intersection is 0.7 to 1.4 per MVE, which is in line with anticipated crash rates for urban controlled intersections.

Table 3 – Intersection Crash Rates

Intersection	Crashes 2013-2018	Crash Rate
Shiloh Road & Broadwater Ave.	64	1.4 MVE
Shiloh Road & Central Ave.	26	0.7 MVE
Shiloh Road & Monad Road	23	0.7 MVE

D. PROPOSED DEVELOPMENT

The Iwata Subdivision is proposed for the northwest corner of Shiloh Road and Central Avenue adjacent to the existing Cenex gas station. The project would include 4.7 acres of neighborhood commercial property which could include gas stations, restaurants, and light commercial uses. The specific land uses for this have not yet been identified. The property would be developed into four separate lots with an internal loop road constructed to the city of Billings road standards. The site would be accessed from Shiloh Road at an existing approach 200 feet north of Central Avenue and a new approach onto Central Avenue 500 feet west of Shiloh Road. The approach onto Shiloh Road (currently 400 VPD) is restricted by the existing medians on Shiloh Road to right-in/right-out turning movements only. The visibility from these two approach locations is unrestricted. The development would also have access to the existing approach to the Cenex gas station, but this approach was discounted for the purposes of this study to concentrate the potential development traffic to only two intersections and produce a more conservative analysis. The project will be constructed over the next 3-5 years with full build-out expected by 2025. The proposed development site plan is shown in **Figure 2**.

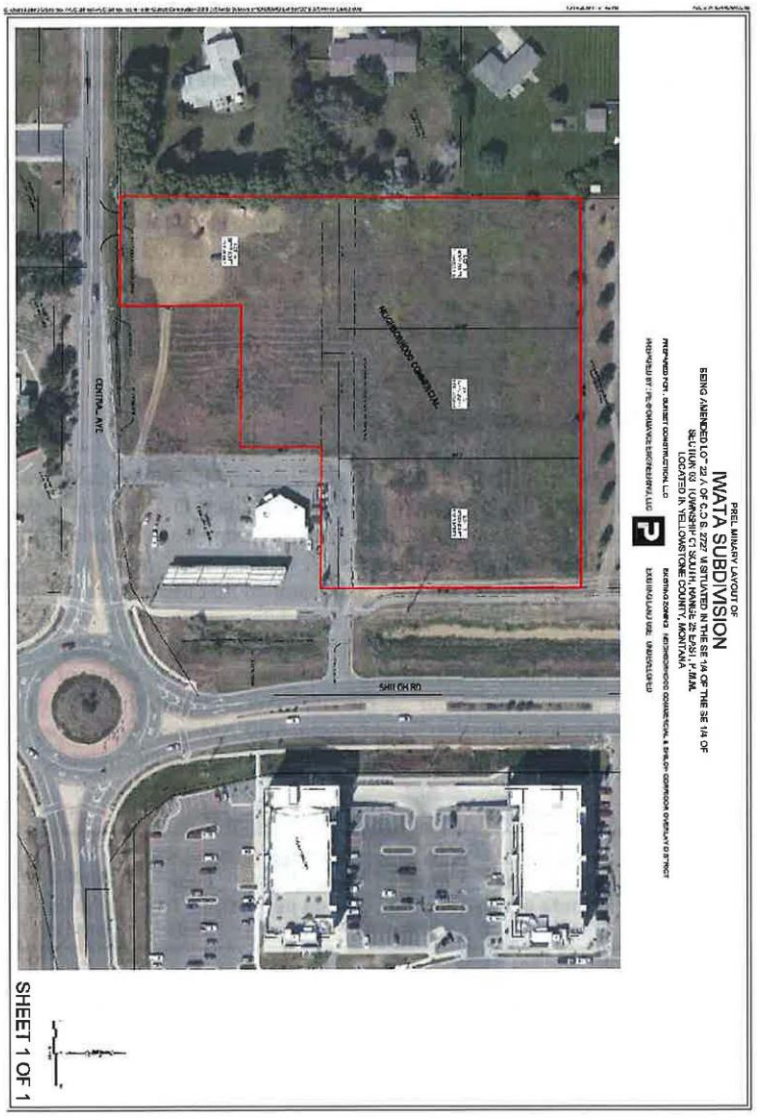
E. TRIP GENERATION AND ASSIGNMENT

ATS performed a trip generation analysis to determine the anticipated future traffic volumes from the proposed development using the trip generation rates contained in *Trip Generation* (Institute of Transportation Engineers, Tenth Edition). These rates are the national standard and are based on the most current information available to planners. A vehicle "trip" is defined as any trip that either begins or ends at the development site. ATS determined that the critical traffic impacts on the intersections and roadways would occur during the weekday morning and evening peak hours. With no specific land uses currently identified for the site, ATS selected the ITE trip generation rate for a business park (use code #770) which closely matches the types of neighborhood commercial development which could occur on the site. According to the ITE trip generation rates, at full build-out the Iwata subdivision would produce 89 AM peak hour trips, 79 PM peak hour trips, and 704 daily trips. See **Table 4** for detailed trip generation information

Table 4 - Trip Generation Rates

Land Use	Units	AM Peak Hour Trip Ends per Unit	Total AM Peak Hour Trip Ends	PM Peak Hour Trip Ends per Unit	Total PM Peak Hour Trip Ends	Weekday Trip Ends per Unit	Total Weekday Trip Ends
Business Park ITE #770	4.7	18.86	89	16.84	79	149.79	704

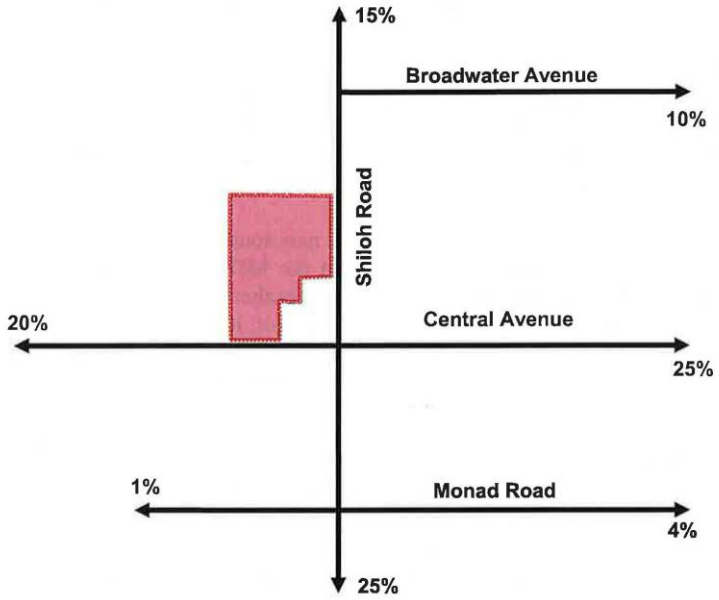
Figure 2 - Proposed Development



F. TRIP DISTRIBUTION

The traffic distribution and assignment for the proposed subdivisions was based upon the existing ADT volumes along the adjacent roadways and the peak-hour turning volumes. Traffic is expected to distribute onto the surrounding road network as shown on **Figure 3**.

Figure 3 – Trip Distribution



G. TRAFFIC IMPACTS OUTSIDE OF THE DEVELOPMENT

Using the trip generation and trip distribution numbers, ATS determined the future Level of Service for the area intersections. The anticipated intersection LOS with the Iwata Subdivision is shown in **Table 5**. The traffic volume calculations are included in **Appendix B** of this report and include a 20% background traffic volume growth rate to forecast regional traffic volume growth trends through 2025. The table indicates that the development of the Iwata Subdivision will not create any operational issues and any existing or proposed intersection with in the study area.

The development will benefit considerably from the placement of the existing roundabouts on Shiloh Road. The roundabout at Central Avenue will allow the drivers exiting the site to use the

right-out only intersection onto Shiloh Road and then use the roundabout to turn in any direction including making a U-turn to proceed to the north. All intersections will operate at acceptable levels of service with reserve capacity for future growth. The Iwata Subdivision will account for a traffic volume increase of 2% at the intersection of Central Avenue and Shiloh Road. No improvements are recommended for these intersections at this time to improve capacity.

Table 5 –Future 2025 Level of Service Summary

	AM Peak Hour		PM Peak Hour	
Intersection	**Delay (Sec.)**	**LOS**	**Delay (Sec.)**	**LOS**
Shiloh Road & Broadwater Ave.	9.9	A	10.4	B
Shiloh Road & Central Ave.	12.4	B	24.7	C
Shiloh Road & Monad Road	7.6	A	9.7	A
Shiloh Road & East Approach	12.5	B	13.2	B
Central Ave. & South Approach	15.0	C	17.6	C

*Eastbound/Southbound Side Street LOS and Delay.

ATS also reviewed the left-turn lane warrants for the new south approach to the site from Central Avenue based on the recommended practices from the MDT Road Design Manual with the projected traffic from the Iwata Subdivision. This analysis showed that there will be nearly enough traffic to warrant a left-turn lane at this approach. However, it would be difficult to install a left-turn lane for this location without impacting the adjacent intersections of Bonaventure Drive and JB Stetson Street to the west. Ultimately, this entire section of road will need to be widened to a three-lane cross section with a center left-turn lane to address the future capacity needs of Central Avenue. The *2018 Billings Urban Area Long Range Transportation Plan* recommends widening Central Avenue from Shiloh Road to 48th Street West to a three-lane cross-section (Project R-48, estimated cost $3,100,000). At this time, it is not recommended that the developers install a left-turn lane for the new south approach to the Iwata Subdivision, but the developers should work with the City of Billings as necessary to help with the future widening needs along Central Avenue. The developers should also locate the new southern approach to the development site as far to the east as possible on their frontage of Central Avenue to maximize the intersection spacing from the existing approaches on the roadway.

H. IMPACT SUMMARY & RECOMMENDATIONS

As proposed the Iwata Subdivision will have a low impact on the traffic operations at the nearby intersections. No improvements are recommended for these intersections at this time to improve capacity. The developers should work with the City of Billings as necessary to help with the future widening needs along Central Avenue. The developers should also locate the new southern approach to the development site as far to the east as possible on their frontage of Central Avenue to maximize the intersection spacing from the existing approaches on the roadway.

APPENDIX A

Traffic Data

Abelin Traffic Services
130 S. Hawie Street
Helena, MT 59601

File Name : ShilohCentraltmc
Site Code : 00000000
Start Date : 5/30/2019
Page No : 1

Groups Printed- Class 1

	Shiloh Southbound					Central Westbound					Shiloh Northbound					Central Eastbound					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
07:30 AM	18	102	35	0	155	17	21	10	0	48	30	97	17	0	144	23	71	36	0	130	477
07:45 AM	17	149	36	0	202	25	22	18	0	65	30	112	12	0	154	31	72	42	0	145	566
Total	35	251	71	0	357	42	43	28	0	113	60	209	29	0	298	54	143	78	0	275	1043
08:00 AM	19	131	34	0	184	23	27	13	0	63	25	116	25	0	166	47	61	31	0	139	552
08:15 AM	12	140	31	0	183	18	21	12	1	52	18	115	16	0	149	25	45	29	0	99	483
*** BREAK ***																					
Total	31	271	65	0	367	41	48	25	1	115	43	231	41	0	315	72	106	60	0	238	1035
*** BREAK ***																					
04:30 PM	20	150	30	0	200	49	30	23	0	102	18	130	40	0	188	18	25	25	0	68	558
04:45 PM	26	145	32	0	203	36	23	29	0	88	23	153	53	0	229	17	32	18	0	67	587
Total	46	295	62	0	403	85	53	52	0	190	41	283	93	0	417	35	57	43	0	135	1145
05:00 PM	19	151	16	0	186	30	43	30	0	103	13	160	40	0	213	17	28	17	0	62	564
05:15 PM	26	170	21	0	217	31	33	47	0	111	22	216	50	0	288	10	33	28	0	71	687
Grand Total	157	1138	235	0	1530	229	220	182	1	632	179	1099	253	0	1531	188	367	226	0	781	4474
Apprch %	10.3	74.4	15.4	0		36.2	34.8	28.8	0.2		11.7	71.8	16.5	0		24.1	47	28.9	0		
Total %	3.5	25.4	5.3	0	34.2	5.1	4.9	4.1	0	14.1	4	24.6	5.7	0	34.2	4.2	8.2	5.1	0	17.5	

Abelin Traffic Services
130 S. Howie Street
Helena, MT 59601

File Name : BroadwayTMC
Site Code : 00000000
Start Date : 9/25/2019
Page No : 1

Groups Printed- Class 1 - Class 2

	Shiloh Southbound					Broadwater Westbound					Shiloh Northbound					Broadwater Eastbound					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
07:30 AM	0	234	73	0	307	23	0	40	0	63	39	137	2	0	178	0	0	1	0	1	549
07:45 AM	0	211	36	1	248	31	0	28	1	60	38	169	7	0	214	0	0	0	0	0	522
Total	0	445	109	1	555	54	0	68	1	123	77	306	9	0	392	0	0	1	0	1	1071
08:00 AM	0	148	40	1	189	18	0	21	2	41	32	137	1	0	170	0	0	0	0	0	400
08:15 AM	0	192	27	0	219	20	0	24	1	45	16	111	3	0	130	0	0	0	0	0	394
*** BREAK ***																					
Total	0	340	67	1	408	38	0	45	3	86	48	248	4	0	300	0	0	0	0	0	794
*** BREAK ***																					
04:30 PM	0	173	17	0	190	26	0	40	0	66	32	211	0	0	243	0	0	0	0	0	499
04:45 PM	0	157	25	0	182	39	0	31	0	70	28	220	0	0	248	0	0	0	0	0	500
Total	0	330	42	0	372	65	0	71	0	136	60	431	0	0	491	0	0	0	0	0	999
05:00 PM	0	187	24	0	211	37	0	51	0	88	54	235	0	0	289	0	0	0	0	0	588
05:15 PM	0	201	21	0	222	54	0	43	0	97	38	261	0	0	299	0	0	0	0	0	618
Grand Total	0	1503	263	2	1768	248	0	278	4	530	277	1481	13	0	1771	0	0	1	0	1	4070
Apprch %	0	85	14.9	0.1		46.8	0	52.5	0.8		15.6	83.6	0.7	0		0	0	100	0		
Total %	0	36.9	6.5	0	43.4	6.1	0	6.8	0.1	13	6.8	36.4	0.3	0	43.5	0	0	0	0	0	
Class 1	0	1495										1475									
% Class 1	0	99.5	96.6	0	98.9	99.6	0	99.3	0	98.7	99.6	99.6	0	0	98.9	0	0	100	0	100	98.9
Class 2	0	8	9	2	19	1	0	2	4	7	1	6	13	0	20	0	0	0	0	0	46
% Class 2	0	0.5	3.4	100	1.1	0.4	0	0.7	100	1.3	0.4	0.4	100	0	1.1	0	0	0	0	0	1.1

Abelin Traffic Services
130 S. Howie Street
Helena, MT 59601

File Name : MonadTMC
Site Code : 00000000
Start Date : 9/25/2019
Page No : 1

Groups Printed- Class 1 - Class 2

	Shiloh Southbound					Monad Westbound					Shiloh Northbound					Monad Eastbound					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
07:30 AM	0	18	177	0	195	0	1	1	3	5	0	4	172	43	219	4	29	3	23	59	478
07:45 AM	1	24	133	0	158	0	1	0	0	1	0	6	166	32	204	2	15	0	21	38	401
Total	1	42	310	0	353	0	2	1	3	6	0	10	338	75	423	6	44	3	44	97	879
08:00 AM	1	15	131	3	150	0	0	1	4	5	0	4	127	33	164	1	11	2	29	43	362
08:15 AM	0	16	93	3	112	0	9	10	18	37	0	3	132	27	162	3	11	4	13	31	342
*** BREAK ***																					
Total	1	31	224	6	262	0	9	11	22	42	0	7	259	60	326	4	22	6	42	74	704
*** BREAK ***																					
04:30 PM	3	26	186	0	215	0	0	0	3	3	0	3	168	19	190	1	20	0	28	49	457
04:45 PM	0	19	203	0	222	0	0	1	3	4	0	4	168	24	196	1	34	1	24	60	482
Total	3	45	389	0	437	0	0	1	6	7	0	7	336	43	386	2	54	1	52	109	939
05:00 PM	0	30	247	0	277	0	0	1	1	2	0	5	214	29	248	0	45	1	34	80	607
05:15 PM	0	14	209	0	223	0	0	0	2	2	0	2	186	26	214	0	29	3	20	52	491
Grand Total	5	162	1379	6	1552	0	11	14	34	59	0	31	1333	233	1597	12	194	14	192	412	3620
Apprch %	0.3	10.4	88.9	0.4		0	18.6	23.7	57.6		0	1.9	83.5	14.6		2.9	47.1	3.4	46.6		
Total %	0.1	4.5	38.1	0.2	42.9	0	0.3	0.4	0.9	1.6	0	0.9	36.8	6.4	44.1	0.3	5.4	0.4	5.3	11.4	
Class 1	0	150	1379										1331								
% Class 1	0	92.6	100	100	98.9	0	100	92.9	100	98.3	0	41.9	99.8	100	98.7	0	100	71.4	100	96.1	98.5
Class 2	5	12	0	0	17	0	0	1	0	1	0	18	2	0	20	12	0	4	0	16	54
% Class 2	100	7.4	0	0	1.1	0	0	7.1	0	1.7	0	58.1	0.2	0	1.3	100	0	28.6	0	3.9	1.5

Basic Volume Report: GAS STATION

Station ID : GAS STATION
Info Line 1 : ATS
Info Line 2 : Unicorn #3
GPS Lat/Lon :
DB File : GAS STATION.DB

Last Connected Device Type : Unic-L
Version Number : 1.41
Serial Number :
Number of Lanes : 1
Posted Speed Limit : 0.0 mph

Lane #2 Configuration

#	Dir.	Information	Volume Mode	Volume Sensors	Divide By 2	Comment
2.		E/W	Subtract	Axle	Yes	

Lane #2 Basic Volume Data From: 10:00 - 09/25/2019 To: 08:59 - 09/26/2019

Date	DW	0000	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	Total
092519	W											33	33	17	30	19	35	30	42	15	24	9	7	4	1	299
092619	T	0	1	0	0	0	4	21	50	35																111
Month Total :		0	1	0	0	0	4	21	50	35		33	33	17	30	19	35	30	42	15	24	9	7	4	1	410
Percent :		0%	0%	0%	0%	0%	1%	5%	12%	9%		8%	8%	4%	7%	5%	9%	7%	10%	4%	6%	2%	2%	1%	0%	
ADT :		0	1	0	0	0	4	21	50	35		33	33	17	30	19	35	30	42	15	24	9	7	4	1	410

	Sun	Mon	Tue	Wed	Thu	Fri	Sat
DW Totals :	0	0	0	299	111	0	0
# Days :	0.0	0.0	0.0	0.6	0.4	0.0	0.0
ADT :	0	0	0	513	296	0	0
Percent :	0%	0%	0%	73%	27%	0%	0%

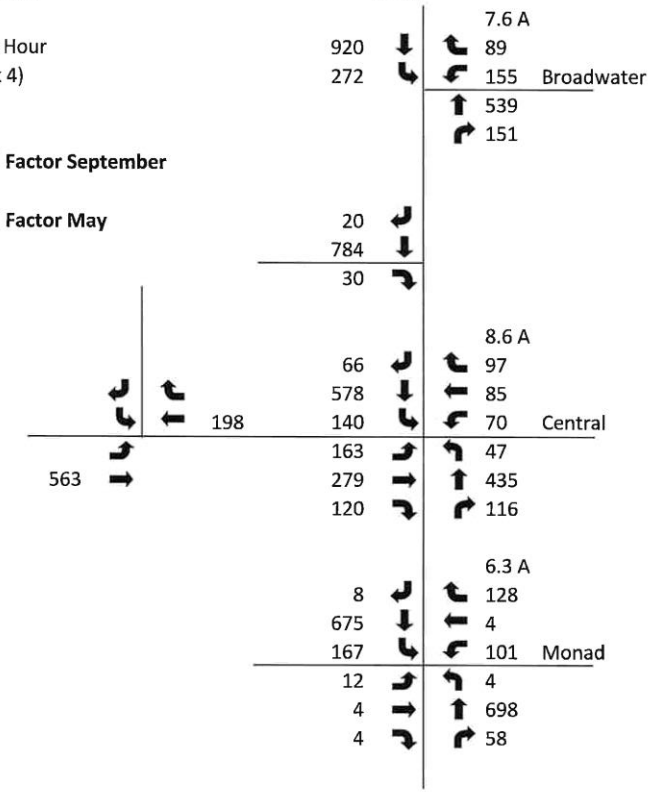
	Total	Percent
Weekday (Mon-Fri) :	410	100%
ADT :	428	
Weekend (Sat-Sun) :	0	0%
ADT :	0	

APPENDIX B

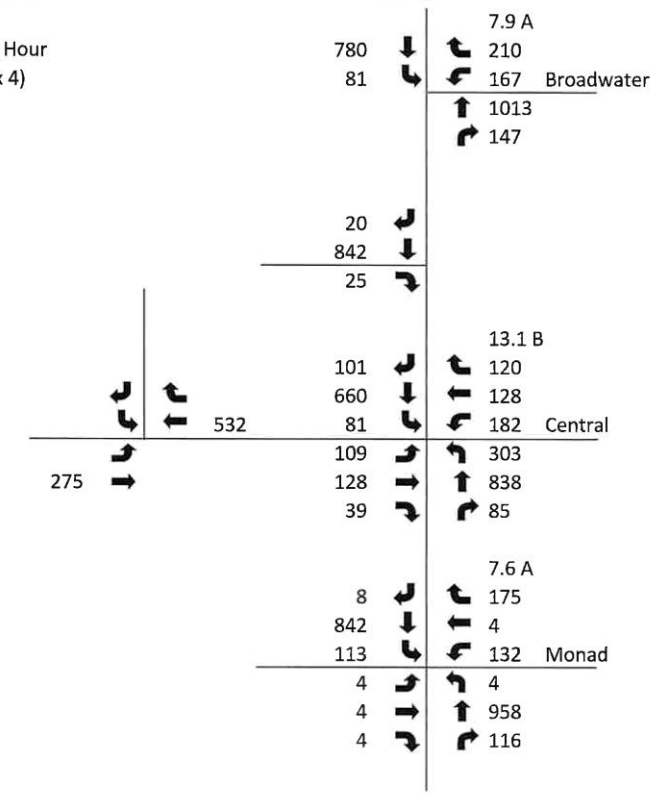
Traffic Model

Iwata Subdivision
Traffic Model
Existing
AM Peak Hour
(15 min x 4)

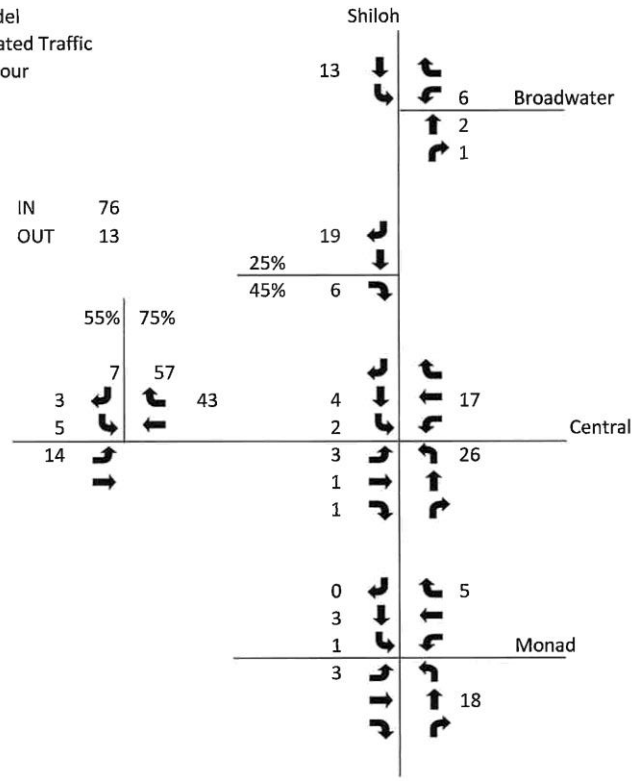
Seasonal Factor September
0.97
Seasonal Factor May
0.97



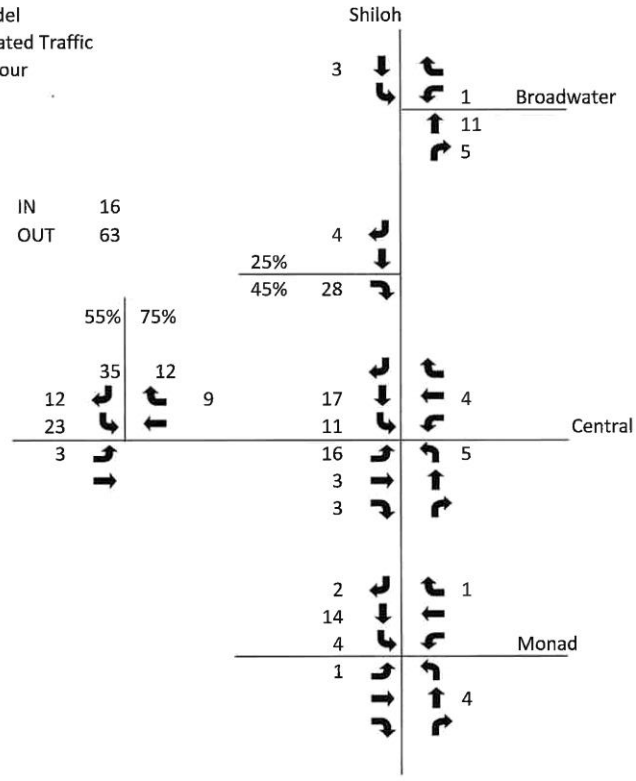
Iwata Subdivision
Traffic Model
Existing
PM Peak Hour
(15 min x 4)



Iwata Subdivision
Traffic Model
Site Generated Traffic
AM Peak Hour



Iwata Subdivision
Traffic Model
Site Generated Traffic
PM Peak Hour



Iwata Subdivision

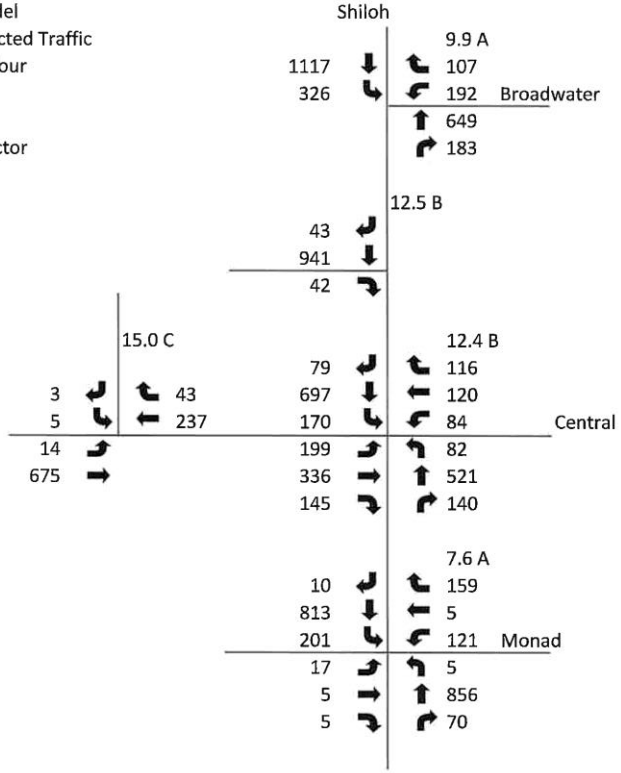
Traffic Model

Total Projected Traffic

AM Peak Hour

Growth Factor

1.2

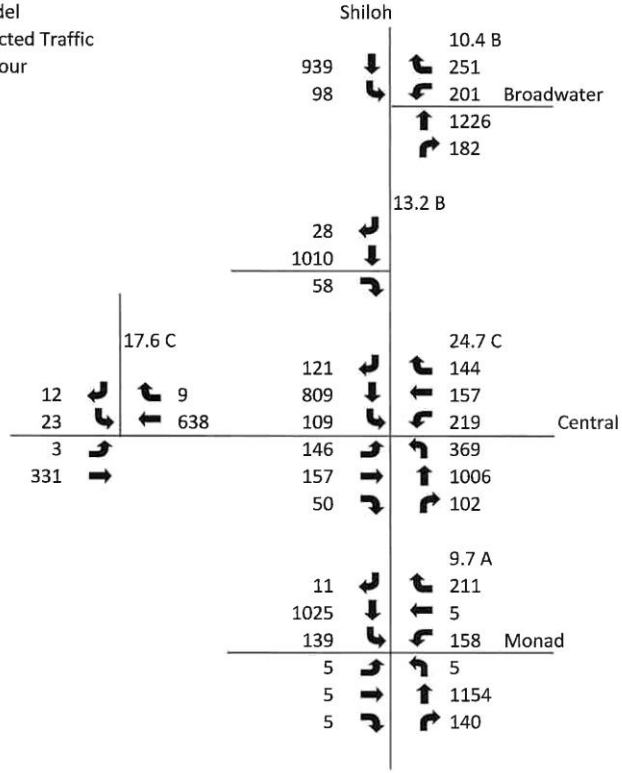


Iwata Subdivision

Traffic Model

Total Projected Traffic

PM Peak Hour



APPENDIX C

LOS Calculations

HCS7 Roundabouts Report

General Information

Analyst	RLA
Agency or Co.	ATS
Date Performed	12/1/2019
Analysis Year	2019
Time Analyzed	AM Peak Hour
Project Description	Iwata Subdivision

Site Information

Intersection	Shiloh & Broadwater
E/W Street Name	Broadwater Avenue
N/S Street Name	Shiloh Road
Analysis Time Period (hrs)	0.25
Peak Hour Factor	1.00
Jurisdiction	City of Billings

Volume Adjustments and Site Characteristics

Approach	EB				WB				NB				SB			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Number of Lanes (N)	0	0	0	0	0	1	0	1	0	0	2	0	0	0	2	0
Lane Assignment					L		R		T		TR		LT		T	
Volume (V), veh/h					0	155		89	0		539	151	0	272	920	
Percent Heavy Vehicles, %					3	3		3	3		3	3	3	3	3	
Flow Rate (v_{PCE}), pc/h					0	160		92	0		555	156	0	280	948	
Right-Turn Bypass	None				None				None				None			
Conflicting Lanes					2				1				1			
Pedestrians Crossing, p/h					0				0				0			

Critical and Follow-Up Headway Adjustment

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Critical Headway (s)				4.6453	4.3276		4.5436	4.5436		4.5436	4.5436	
Follow-Up Headway (s)				2.6667	2.5352		2.5352	2.5352		2.5352	2.5352	

Flow Computations, Capacity and v/c Ratios

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Entry Flow (v_e), pc/h				160	92		334	377		577	651	
Entry Volume, veh/h				155	89		324	366		560	632	
Circulating Flow (v_c), pc/h	1388			555			280			160		
Exiting Flow (v_{ex}), pc/h	436			0			647			1108		
Capacity (c_{pce}), pc/h				810	886		1101	1101		1228	1228	
Capacity (c), veh/h				787	860		1069	1069		1192	1192	
v/c Ratio (x)				0.20	0.10		0.30	0.34		0.47	0.53	

Delay and Level of Service

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Lane Control Delay (d), s/veh				6.7	5.2		6.3	6.8		8.0	9.0	
Lane LOS				A	A		A	A		A	A	
95% Queue, veh				0.7	0.3		1.3	1.5		2.6	3.2	
Approach Delay, s/veh				6.1			6.6			8.6		
Approach LOS				A			A			A		
Intersection Delay, s/veh | LOS	7.6						A					

HCS7 Roundabouts Report

General Information

Analyst	RLA
Agency or Co.	ATS
Date Performed	12/1/2019
Analysis Year	2019
Time Analyzed	PM Peak Hour
Project Description	Iwata Subdivision

Site Information

Intersection	Shiloh & Broadwater
E/W Street Name	Broadwater Avenue
N/S Street Name	Shiloh Road
Analysis Time Period (hrs)	0.25
Peak Hour Factor	1.00
Jurisdiction	City of Billings

Volume Adjustments and Site Characteristics

Approach	EB				WB				NB				SB			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Number of Lanes (N)	0	0	0	0	0	1	0	1	0	0	2	0	0	0	2	0
Lane Assignment					L		R		T		TR		LT		T	
Volume (V), veh/h					0	167		210	0		1013	147	0	81	780	
Percent Heavy Vehicles, %					3	3		3	3		3	3	3	3	3	
Flow Rate (v_{PCE}), pc/h					0	172		216	0		1043	151	0	83	803	
Right-Turn Bypass	None				None				None				None			
Conflicting Lanes					2				1				1			
Pedestrians Crossing, p/h					0				0				0			

Critical and Follow-Up Headway Adjustment

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Critical Headway (s)				4.6453	4.3276		4.5436	4.5436		4.5436	4.5436	
Follow-Up Headway (s)				2.6667	2.5352		2.5352	2.5352		2.5352	2.5352	

Flow Computations, Capacity and v/c Ratios

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Entry Flow (v_e), pc/h				172	216		561	633		416	470	
Entry Volume, veh/h				167	210		545	614		404	456	
Circulating Flow (v_c), pc/h	1058			1043			83			172		
Exiting Flow (v_{ex}), pc/h	234			0			1259			975		
Capacity (c_{pce}), pc/h				517	585		1317	1317		1214	1214	
Capacity (c), veh/h				502	568		1278	1278		1179	1179	
v/c Ratio (x)				0.33	0.37		0.43	0.48		0.34	0.39	

Delay and Level of Service

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Lane Control Delay (d), s/veh				12.4	11.8		7.0	7.8		6.4	6.9	
Lane LOS				B	B		A	A		A	A	
95% Queue, veh				1.4	1.7		2.2	2.7		1.5	1.9	
Approach Delay, s/veh				12.1			7.4			6.6		
Approach LOS				B			A			A		
Intersection Delay, s/veh | LOS	7.9						A					

HCS7 Roundabouts Report

General Information

Analyst	RLA
Agency or Co.	ATS
Date Performed	12/1/2019
Analysis Year	2019
Time Analyzed	AM Peak Hour
Project Description	Iwata Subdivision

Site Information

Intersection	Central & Shiloh
E/W Street Name	Central Avenue
N/S Street Name	Shiloh Road
Analysis Time Period (hrs)	0.25
Peak Hour Factor	1.00
Jurisdiction	City of Billings

Volume Adjustments and Site Characteristics

Approach	EB				WB				NB				SB			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Number of Lanes (N)	0	0	2	0	0	0	2	0	0	0	2	0	0	0	2	0
Lane Assignment	LT		TR		LT		TR		LT		TR		LT		TR	
Volume (V), veh/h	0	163	279	120	0	70	85	97	0	47	435	116	0	140	578	66
Percent Heavy Vehicles, %	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Flow Rate (v_{PCE}), pc/h	0	168	287	124	0	72	88	100	0	48	448	119	0	144	595	68
Right-Turn Bypass	None				None				None				None			
Conflicting Lanes	2				2				2				2			
Pedestrians Crossing, p/h	0				0				0				0			

Critical and Follow-Up Headway Adjustment

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Critical Headway (s)	4.6453	4.3276		4.6453	4.3276		4.6453	4.3276		4.6453	4.3276	
Follow-Up Headway (s)	2.6667	2.5352		2.6667	2.5352		2.6667	2.5352		2.6667	2.5352	

Flow Computations, Capacity and v/c Ratios

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Entry Flow (v_e), pc/h	272	307		122	138		289	326		379	428	
Entry Volume, veh/h	264	298		119	134		281	316		368	415	
Circulating Flow (v_c), pc/h	811			664			599			208		
Exiting Flow (v_{ex}), pc/h	550			204			716			791		
Capacity (c_{pce}), pc/h	640	713		733	808		778	853		1115	1190	
Capacity (c), veh/h	622	692		712	784		755	829		1082	1155	
v/c Ratio (x)	0.43	0.43		0.17	0.17		0.37	0.38		0.34	0.36	

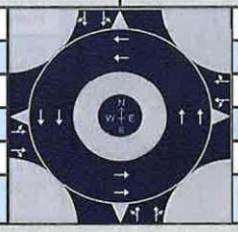
Delay and Level of Service

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Lane Control Delay (d), s/veh	12.1	11.2		6.9	6.4		9.4	8.9		6.7	6.7	
Lane LOS	B	B		A	A		A	A		A	A	
95% Queue, veh	2.1	2.2		0.6	0.6		1.7	1.8		1.5	1.7	
Approach Delay, s/veh	11.7			6.6			9.1			6.7		
Approach LOS	B			A			A			A		
Intersection Delay, s/veh | LOS	8.6						A					

HCS7 Roundabouts Report

General Information

Analyst	RLA
Agency or Co.	ATS
Date Performed	12/1/2019
Analysis Year	2019
Time Analyzed	PM Peak Hour
Project Description	Iwata Subdivision



Site Information

Intersection	Central & Shiloh
E/W Street Name	Central Avenue
N/S Street Name	Shiloh Road
Analysis Time Period (hrs)	0.25
Peak Hour Factor	1.00
Jurisdiction	City of Billings

Volume Adjustments and Site Characteristics

Approach	EB				WB				NB				SB			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Number of Lanes (N)	0	0	2	0	0	0	2	0	0	0	2	0	0	0	2	0
Lane Assignment	LT		TR		LT		TR		LT		TR		LT		TR	
Volume (V), veh/h	0	109	128	39	0	182	128	120	0	303	838	85	0	81	660	101
Percent Heavy Vehicles, %	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Flow Rate (v_{PCE}), pc/h	0	112	132	40	0	187	132	124	0	312	863	88	0	83	680	104
Right-Turn Bypass	None				None				None				None			
Conflicting Lanes	2				2				2				2			
Pedestrians Crossing, p/h	0				0				0				0			

Critical and Follow-Up Headway Adjustment

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Critical Headway (s)	4.6453	4.3276		4.6453	4.3276		4.6453	4.3276		4.6453	4.3276	
Follow-Up Headway (s)	2.6667	2.5352		2.6667	2.5352		2.6667	2.5352		2.6667	2.5352	

Flow Computations, Capacity and v/c Ratios

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Entry Flow (v_e), pc/h	133	151		208	235		594	669		407	460	
Entry Volume, veh/h	130	146		202	228		576	650		396	446	
Circulating Flow (v_c), pc/h	950			1287			327			631		
Exiting Flow (v_{ex}), pc/h	303			548			1099			907		
Capacity (c_{pce}), pc/h	563	633		413	476		999	1075		755	831	
Capacity (c), veh/h	547	615		401	462		970	1044		733	806	
v/c Ratio (x)	0.24	0.24		0.50	0.49		0.59	0.62		0.54	0.55	

Delay and Level of Service

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Lane Control Delay (d), s/veh	9.8	8.9		20.3	17.6		12.0	12.1		13.2	12.6	
Lane LOS	A	A		C	C		B	B		B	B	
95% Queue, veh	0.9	0.9		2.7	2.7		4.1	4.5		3.3	3.5	
Approach Delay, s/veh	9.3			18.9			12.0			12.9		
Approach LOS	A			C			B			B		
Intersection Delay, s/veh | LOS	13.1						B					

HCS7 Roundabouts Report

General Information

Analyst	RLA
Agency or Co.	ATS
Date Performed	12/1/2019
Analysis Year	2019
Time Analyzed	AM Peak Hour
Project Description	Iwata Subdivision

Site Information

Intersection	Shiloh & Monad
E/W Street Name	Monad Road
N/S Street Name	Shiloh Road
Analysis Time Period (hrs)	0.25
Peak Hour Factor	1.00
Jurisdiction	City of Billings

Volume Adjustments and Site Characteristics

Approach	EB				WB				NB				SB			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Number of Lanes (N)	0	0	2	0	0	0	2	0	0	0	2	0	0	0	2	0
Lane Assignment	LT		TR		LT		TR		LT		TR		LT		TR	
Volume (V), veh/h	0	12	4	4	0	101	4	128	0	4	698	58	0	167	675	8
Percent Heavy Vehicles, %	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Flow Rate (v_{PCE}), pc/h	0	12	4	4	0	104	4	132	0	4	719	60	0	172	695	8
Right-Turn Bypass	None				None				None				None			
Conflicting Lanes	2				2				1				1			
Pedestrians Crossing, p/h	0				0				0				0			

Critical and Follow-Up Headway Adjustment

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Critical Headway (s)	4.6453	4.3276		4.6453	4.3276		4.5436	4.5436		4.5436	4.5436	
Follow-Up Headway (s)	2.6667	2.5352		2.6667	2.5352		2.5352	2.5352		2.5352	2.5352	

Flow Computations, Capacity and v/c Ratios

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Entry Flow (v_e), pc/h	12	8		108	132		368	415		411	464	
Entry Volume, veh/h	12	8		105	128		357	403		399	450	
Circulating Flow (v_c), pc/h	971			735			188			112		
Exiting Flow (v_{ex}), pc/h	236			16			863			803		
Capacity (c_{pce}), pc/h	553	622		687	760		1197	1197		1282	1282	
Capacity (c), veh/h	536	604		667	738		1162	1162		1245	1245	
v/c Ratio (x)	0.02	0.01		0.16	0.17		0.31	0.35		0.32	0.36	

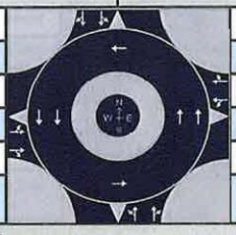
Delay and Level of Service

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Lane Control Delay (d), s/veh	7.0	6.1		7.2	6.8		6.0	6.5		5.9	6.3	
Lane LOS	A	A		A	A		A	A		A	A	
95% Queue, veh	0.1	0.0		0.6	0.6		1.3	1.6		1.4	1.7	
Approach Delay, s/veh	6.6			7.0			6.3			6.1		
Approach LOS	A			A			A			A		
Intersection Delay, s/veh | LOS	6.3						A					

HCS7 Roundabouts Report

General Information

Analyst	RLA
Agency or Co.	ATS
Date Performed	12/1/2019
Analysis Year	2019
Time Analyzed	PM Peak Hour
Project Description	Iwata Subdivision



Site Information

Intersection	Shiloh & Monad
E/W Street Name	Monad Road
N/S Street Name	Shiloh Road
Analysis Time Period (hrs)	0.25
Peak Hour Factor	1.00
Jurisdiction	City of Billings

Volume Adjustments and Site Characteristics

Approach	EB				WB				NB				SB			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Number of Lanes (N)	0	0	2	0	0	0	2	0	0	0	2	0	0	0	2	0
Lane Assignment	LT		TR		LT		TR		LT		TR		LT		TR	
Volume (V), veh/h	0	4	4	4	0	132	4	175	0	4	958	116	0	113	842	8
Percent Heavy Vehicles, %	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Flow Rate (v_{PCE}), pc/h	0	4	4	4	0	136	4	180	0	4	987	119	0	116	867	8
Right-Turn Bypass	None				None				None				None			
Conflicting Lanes	2				2				1				1			
Pedestrians Crossing, p/h	0				0				0				0			

Critical and Follow-Up Headway Adjustment

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Critical Headway (s)	4.6453	4.3276		4.6453	4.3276		4.5436	4.5436		4.5436	4.5436	
Follow-Up Headway (s)	2.6667	2.5352		2.6667	2.5352		2.5352	2.5352		2.5352	2.5352	

Flow Computations, Capacity and v/c Ratios

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Entry Flow (v_o), pc/h	6	6		140	180		522	588		466	525	
Entry Volume, veh/h	5	6		136	175		507	571		452	510	
Circulating Flow (v_c), pc/h	1119			995			124			144		
Exiting Flow (v_{ex}), pc/h	239			16			1171			1007		
Capacity (c_{pce}), pc/h	482	549		540	610		1268	1268		1246	1246	
Capacity (c), veh/h	468	533		525	592		1232	1232		1209	1209	
v/c Ratio (x)	0.01	0.01		0.26	0.30		0.41	0.46		0.37	0.42	

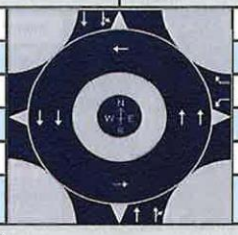
Delay and Level of Service

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Lane Control Delay (d), s/veh	7.8	6.9		10.5	10.1		7.0	7.7		6.6	7.2	
Lane LOS	A	A		B	B		A	A		A	A	
95% Queue, veh	0.0	0.0		1.0	1.2		2.0	2.5		1.8	2.1	
Approach Delay, s/veh	7.3			10.3			7.4			6.9		
Approach LOS	A			B			A			A		
Intersection Delay, s/veh | LOS	7.6						A					

HCS7 Roundabouts Report

General Information

Analyst	RLA
Agency or Co.	ATS
Date Performed	12/1/2019
Analysis Year	2025
Time Analyzed	AM Peak With Development
Project Description	Iwata Subdivision



Site Information

Intersection	Shiloh & Broadwater
E/W Street Name	Broadwater Avenue
N/S Street Name	Shiloh Road
Analysis Time Period (hrs)	0.25
Peak Hour Factor	1.00
Jurisdiction	City of Billings

Volume Adjustments and Site Characteristics

Approach	EB				WB				NB				SB			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Number of Lanes (N)	0	0	0	0	0	1	0	1	0	0	2	0	0	0	2	0
Lane Assignment					L		R		T		TR		LT		T	
Volume (V), veh/h					0	192		107	0		649	183	0	326	1117	
Percent Heavy Vehicles, %					3	3		3	3		3	3	3	3	3	
Flow Rate (v_{PCE}), pc/h					0	198		110	0		668	188	0	336	1151	
Right-Turn Bypass	None				None				None				None			
Conflicting Lanes					2				1				1			
Pedestrians Crossing, p/h					0				0				0			

Critical and Follow-Up Headway Adjustment

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Critical Headway (s)				4.6453	4.3276		4.5436	4.5436		4.5436	4.5436	
Follow-Up Headway (s)				2.6667	2.5352		2.5352	2.5352		2.5352	2.5352	

Flow Computations, Capacity and v/c Ratios

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Entry Flow (v_e), pc/h				198	110		402	454		699	788	
Entry Volume, veh/h				192	107		391	440		679	765	
Circulating Flow (v_c), pc/h	1685			668			336			198		
Exiting Flow (v_{ex}), pc/h	524			0			778			1349		
Capacity (c_{pce}), pc/h				730	805		1046	1046		1186	1186	
Capacity (c), veh/h				709	781		1015	1015		1151	1151	
v/c Ratio (x)				0.27	0.14		0.38	0.43		0.59	0.66	

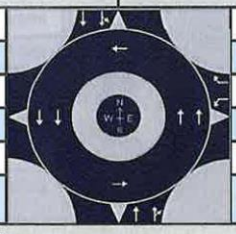
Delay and Level of Service

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Lane Control Delay (d), s/veh				8.3	6.0		7.7	8.4		10.5	12.4	
Lane LOS				A	A		A	A		B	B	
95% Queue, veh				1.1	0.5		1.8	2.2		4.0	5.4	
Approach Delay, s/veh				7.5			8.1			11.5		
Approach LOS				A			A			B		
Intersection Delay, s/veh | LOS	9.9						A					

HCS7 Roundabouts Report

General Information

Analyst	RLA
Agency or Co.	ATS
Date Performed	12/1/2019
Analysis Year	2025
Time Analyzed	PM Peak With Development
Project Description	Iwata Subdivision



Site Information

Intersection	Shiloh & Broadwater
E/W Street Name	Broadwater Avenue
N/S Street Name	Shiloh Road
Analysis Time Period (hrs)	0.25
Peak Hour Factor	1.00
Jurisdiction	City of Billings

Volume Adjustments and Site Characteristics

Approach	EB				WB				NB				SB			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Number of Lanes (N)	0	0	0	0	0	1	0	1	0	0	2	0	0	0	2	0
Lane Assignment					L		R		T		TR		LT		T	
Volume (V), veh/h					0	201		251	0		1226	182	0	98	939	
Percent Heavy Vehicles, %					3	3		3	3		3	3	3	3	3	
Flow Rate (v_{PCE}), pc/h					0	207		259	0		1263	187	0	101	967	
Right-Turn Bypass	None				None				None				None			
Conflicting Lanes					2				1				1			
Pedestrians Crossing, p/h					0				0				0			

Critical and Follow-Up Headway Adjustment

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Critical Headway (s)				4.6453	4.3276		4.5436	4.5436		4.5436	4.5436	
Follow-Up Headway (s)				2.6667	2.5352		2.5352	2.5352		2.5352	2.5352	

Flow Computations, Capacity and v/c Ratios

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Entry Flow (v_e), pc/h				207	259		682	769		502	566	
Entry Volume, veh/h				201	251		662	746		487	550	
Circulating Flow (v_c), pc/h	1275			1263			101			207		
Exiting Flow (v_{ex}), pc/h	288			0			1522			1174		
Capacity (c_{pce}), pc/h				422	485		1295	1295		1176	1176	
Capacity (c), veh/h				410	471		1258	1258		1142	1142	
v/c Ratio (x)				0.49	0.53		0.53	0.59		0.43	0.48	

Delay and Level of Service

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Lane Control Delay (d), s/veh				19.4	18.7		8.6	9.9		7.6	8.4	
Lane LOS				C	C		A	A		A	A	
95% Queue, veh				2.6	3.1		3.2	4.1		2.2	2.7	
Approach Delay, s/veh				19.0			9.3			8.1		
Approach LOS				C			A			A		
Intersection Delay, s/veh | LOS	10.4						B					

HCS7 Roundabouts Report

General Information

Analyst	RLA
Agency or Co.	ATS
Date Performed	12/1/2019
Analysis Year	2025
Time Analyzed	AM Peak With Development
Project Description	Iwata Subdivision

Site Information

Intersection	Central & Shiloh
E/W Street Name	Central Avenue
N/S Street Name	Shiloh Road
Analysis Time Period (hrs)	0.25
Peak Hour Factor	1.00
Jurisdiction	City of Billings

Volume Adjustments and Site Characteristics

Approach	EB				WB				NB				SB			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Number of Lanes (N)	0	0	2	0	0	0	2	0	0	0	2	0	0	0	2	0
Lane Assignment	LT		TR		LT		TR		LT		TR		LT		TR	
Volume (V), veh/h	0	199	336	146	0	84	120	116	0	82	521	140	0	170	697	79
Percent Heavy Vehicles, %	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Flow Rate (v_{PCE}), pc/h	0	205	346	150	0	87	124	119	0	84	537	144	0	175	718	81
Right-Turn Bypass	None				None				None				None			
Conflicting Lanes	2				2				2				2			
Pedestrians Crossing, p/h	0				0				0				0			

Critical and Follow-Up Headway Adjustment

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Critical Headway (s)	4.6453	4.3276		4.6453	4.3276		4.6453	4.3276		4.6453	4.3276	
Follow-Up Headway (s)	2.6667	2.5352		2.6667	2.5352		2.6667	2.5352		2.6667	2.5352	

Flow Computations, Capacity and v/c Ratios

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Entry Flow (v_e), pc/h	329	372		155	175		360	405		458	516	
Entry Volume, veh/h	320	361		151	170		349	394		444	501	
Circulating Flow (v_c), pc/h	980			826			726			295		
Exiting Flow (v_{ex}), pc/h	665			289			861			955		
Capacity (c_{pce}), pc/h	548	617		631	704		692	766		1029	1105	
Capacity (c), veh/h	532	599		613	683		672	744		999	1073	
v/c Ratio (x)	0.60	0.60		0.25	0.25		0.52	0.53		0.44	0.47	

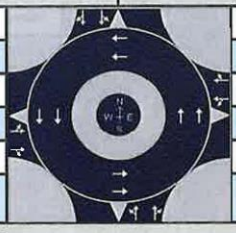
Delay and Level of Service

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Lane Control Delay (d), s/veh	19.5	17.7		9.0	8.2		13.6	12.8		8.7	8.6	
Lane LOS	C	C		A	A		B	B		A	A	
95% Queue, veh	3.9	4.0		1.0	1.0		3.0	3.1		2.3	2.5	
Approach Delay, s/veh	18.5			8.6			13.2			8.6		
Approach LOS	C			A			B			A		
Intersection Delay, s/veh | LOS	12.4						B					

HCS7 Roundabouts Report

General Information

Analyst	RLA
Agency or Co.	ATS
Date Performed	12/1/2019
Analysis Year	2025
Time Analyzed	PM Peak With Development
Project Description	Iwata Subdivision



Site Information

Intersection	Central & Shiloh
E/W Street Name	Central Avenue
N/S Street Name	Shiloh Road
Analysis Time Period (hrs)	0.25
Peak Hour Factor	1.00
Jurisdiction	City of Billings

Volume Adjustments and Site Characteristics

Approach	EB				WB				NB				SB			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Number of Lanes (N)	0	0	2	0	0	0	2	0	0	0	2	0	0	0	2	0
Lane Assignment	LT		TR		LT		TR		LT		TR		LT		TR	
Volume (V), veh/h	0	146	157	50	0	219	157	144	0	369	1006	102	0	109	809	121
Percent Heavy Vehicles, %	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Flow Rate (v_{PCE}), pc/h	0	150	162	52	0	226	162	148	0	380	1036	105	0	112	833	125
Right-Turn Bypass	None				None				None				None			
Conflicting Lanes	2				2				2				2			
Pedestrians Crossing, p/h	0				0				0				0			

Critical and Follow-Up Headway Adjustment

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Critical Headway (s)	4.6453	4.3276		4.6453	4.3276		4.6453	4.3276		4.6453	4.3276	
Follow-Up Headway (s)	2.6667	2.5352		2.6667	2.5352		2.6667	2.5352		2.6667	2.5352	

Flow Computations, Capacity and v/c Ratios

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Entry Flow (v_o), pc/h	171	193		252	284		715	806		503	567	
Entry Volume, veh/h	166	187		245	276		694	783		488	551	
Circulating Flow (v_c), pc/h	1171			1566			424			768		
Exiting Flow (v_{ex}), pc/h	379			667			1334			1111		
Capacity (c_{pce}), pc/h	460	525		320	375		914	990		666	739	
Capacity (c), veh/h	446	510		310	364		887	961		647	718	
v/c Ratio (x)	0.37	0.37		0.79	0.76		0.78	0.81		0.76	0.77	

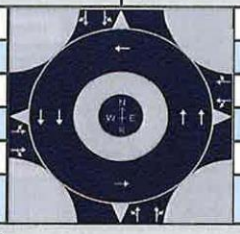
Delay and Level of Service

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Lane Control Delay (d), s/veh	14.6	13.0		47.8	38.7		20.8	21.8		24.4	23.4	
Lane LOS	B	B		E	E		C	C		C	C	
95% Queue, veh	1.7	1.7		6.3	6.0		8.1	9.3		6.9	7.3	
Approach Delay, s/veh	13.7			43.0			21.4			23.9		
Approach LOS	B			E			C			C		
Intersection Delay, s/veh | LOS	24.7						C					

HCS7 Roundabouts Report

General Information

Analyst	RLA
Agency or Co.	ATS
Date Performed	12/1/2019
Analysis Year	2025
Time Analyzed	AM Peak With Development
Project Description	Iwata Subdivision



Site Information

Intersection	Shiloh & Monad
E/W Street Name	Monad Road
N/S Street Name	Shiloh Road
Analysis Time Period (hrs)	0.25
Peak Hour Factor	1.00
Jurisdiction	City of Billings

Volume Adjustments and Site Characteristics

Approach	EB				WB				NB				SB			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Number of Lanes (N)	0	0	2	0	0	0	2	0	0	0	2	0	0	0	2	0
Lane Assignment	LT		TR		LT		TR		LT		TR		LT		TR	
Volume (V), veh/h	0	17	5	5	0	121	5	159	0	8	856	70	0	201	813	10
Percent Heavy Vehicles, %	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Flow Rate (v_{PCE}), pc/h	0	18	5	5	0	125	5	164	0	8	882	72	0	207	837	10
Right-Turn Bypass	None				None				None				None			
Conflicting Lanes	2				2				1				1			
Pedestrians Crossing, p/h	0				0				0				0			

Critical and Follow-Up Headway Adjustment

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Critical Headway (s)	4.6453	4.3276		4.6453	4.3276		4.5436	4.5436		4.5436	4.5436	
Follow-Up Headway (s)	2.6667	2.5352		2.6667	2.5352		2.5352	2.5352		2.5352	2.5352	

Flow Computations, Capacity and v/c Ratios

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Entry Flow (v_e), pc/h	18	10		130	164		452	510		495	559	
Entry Volume, veh/h	17	10		126	159		439	495		481	542	
Circulating Flow (v_c), pc/h	1169			908			230			138		
Exiting Flow (v_{ex}), pc/h	284			23			1064			967		
Capacity (c_{pce}), pc/h	461	526		586	656		1152	1152		1252	1252	
Capacity (c), veh/h	447	510		568	637		1118	1118		1216	1216	
v/c Ratio (x)	0.04	0.02		0.22	0.25		0.39	0.44		0.40	0.45	

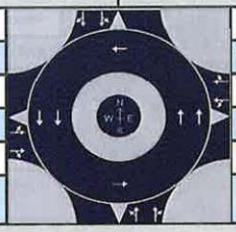
Delay and Level of Service

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Lane Control Delay (d), s/veh	8.6	7.3		9.2	8.8		7.2	8.0		6.9	7.6	
Lane LOS	A	A		A	A		A	A		A	A	
95% Queue, veh	0.1	0.1		0.8	1.0		1.9	2.3		1.9	2.3	
Approach Delay, s/veh	8.1			9.0			7.6			7.2		
Approach LOS	A			A			A			A		
Intersection Delay, s/veh | LOS	7.6						A					

HCS7 Roundabouts Report

General Information

Analyst	RLA
Agency or Co.	ATS
Date Performed	12/1/2019
Analysis Year	2025
Time Analyzed	PM Peak With Development
Project Description	Iwata Subdivision



Site Information

Intersection	Shiloh & Monad
E/W Street Name	Monad Road
N/S Street Name	Shiloh Road
Analysis Time Period (hrs)	0.25
Peak Hour Factor	1.00
Jurisdiction	City of Billings

Volume Adjustments and Site Characteristics

Approach	EB				WB				NB				SB			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Number of Lanes (N)	0	0	2	0	0	0	2	0	0	0	2	0	0	0	2	0
Lane Assignment	LT		TR		LT		TR		LT		TR		LT		TR	
Volume (V), veh/h	0	5	5	5	0	158	5	211	0	5	1154	140	0	139	1025	11
Percent Heavy Vehicles, %	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Flow Rate (v_{PCE}), pc/h	0	5	5	5	0	163	5	217	0	5	1189	144	0	143	1056	11
Right-Turn Bypass	None				None				None				None			
Conflicting Lanes	2				2				1				1			
Pedestrians Crossing, p/h	0				0				0				0			

Critical and Follow-Up Headway Adjustment

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Critical Headway (s)	4.6453	4.3276		4.6453	4.3276		4.5436	4.5436		4.5436	4.5436	
Follow-Up Headway (s)	2.6667	2.5352		2.6667	2.5352		2.5352	2.5352		2.5352	2.5352	

Flow Computations, Capacity and v/c Ratios

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Entry Flow (v_e), pc/h	7	8		168	217		629	709		569	641	
Entry Volume, veh/h	7	8		163	211		611	688		552	623	
Circulating Flow (v_c), pc/h	1362			1199			153			173		
Exiting Flow (v_{ex}), pc/h	292			21			1411			1224		
Capacity (c_{pce}), pc/h	386	446		448	512		1235	1235		1213	1213	
Capacity (c), veh/h	374	433		435	498		1199	1199		1178	1178	
v/c Ratio (x)	0.02	0.02		0.38	0.42		0.51	0.57		0.47	0.53	

Delay and Level of Service

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Lane Control Delay (d), s/veh	9.9	8.6		15.0	14.6		8.6	9.8		8.1	9.1	
Lane LOS	A	A		C	B		A	A		A	A	
95% Queue, veh	0.1	0.1		1.7	2.1		3.0	3.8		2.6	3.2	
Approach Delay, s/veh	9.2			14.8			9.3			8.6		
Approach LOS	A			B			A			A		
Intersection Delay, s/veh | LOS	9.7						A					

HCS7 Two-Way Stop-Control Report

General Information

Analyst	RLA
Agency/Co.	ATS
Date Performed	12/11/2019
Analysis Year	2025
Time Analyzed	AM Peak With Dev.
Intersection Orientation	North-South
Project Description	Iwata Subdivision

Site Information

Intersection	North Approach
Jurisdiction	City of Billings
East/West Street	North Approach
North/South Street	Shiloh Road
Peak Hour Factor	1.00
Analysis Time Period (hrs)	0.25

Lanes

Vehicle Volumes and Adjustments

Approach	Eastbound				Westbound				Northbound				Southbound			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Priority		10	11	12		7	8	9	1U	1	2	3	4U	4	5	6
Number of Lanes		0	0	1		0	0	0	0	0	0	0	0	0	2	0
Configuration				R											T	TR
Volume (veh/h)				42											941	43
Percent Heavy Vehicles (%)				3												
Proportion Time Blocked																
Percent Grade (%)		0														
Right Turn Channelized		No														
Median Type | Storage		Undivided														

Critical and Follow-up Headways

Base Critical Headway (sec)				6.9												
Critical Headway (sec)				6.96												
Base Follow-Up Headway (sec)				3.3												
Follow-Up Headway (sec)				3.33												

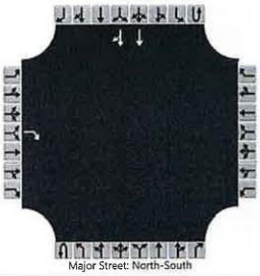
Delay, Queue Length, and Level of Service

Flow Rate, v (veh/h)				42												
Capacity, c (veh/h)				520												
v/c Ratio				0.08												
95% Queue Length, Q_{95} (veh)				0.3												
Control Delay (s/veh)				12.5												
Level of Service (LOS)				B												
Approach Delay (s/veh)		12.5														
Approach LOS		B														

HCS7 Two-Way Stop-Control Report

General Information		Site Information	
Analyst	RLA	Intersection	North Approach
Agency/Co.	ATS	Jurisdiction	City of Billings
Date Performed	12/11/2019	East/West Street	North Approach
Analysis Year	2025	North/South Street	Shiloh Road
Time Analyzed	PM Peak With Dev.	Peak Hour Factor	1.00
Intersection Orientation	North-South	Analysis Time Period (hrs)	0.25
Project Description	Iwata Subdivision		

Lanes



Vehicle Volumes and Adjustments

Approach	Eastbound				Westbound				Northbound				Southbound			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Priority		10	11	12		7	8	9	1U	1	2	3	4U	4	5	6
Number of Lanes		0	0	1		0	0	0	0	0	0	0	0	0	2	0
Configuration				R											T	TR
Volume (veh/h)				58											1010	28
Percent Heavy Vehicles (%)				3												
Proportion Time Blocked																
Percent Grade (%)		0														
Right Turn Channelized		No														
Median Type | Storage		Undivided														

Critical and Follow-up Headways

Base Critical Headway (sec)				6.9												
Critical Headway (sec)				6.96												
Base Follow-Up Headway (sec)				3.3												
Follow-Up Headway (sec)				3.33												

Delay, Queue Length, and Level of Service

Flow Rate, v (veh/h)				58												
Capacity, c (veh/h)				499												
v/c Ratio				0.12												
95% Queue Length, Q_{95} (veh)				0.4												
Control Delay (s/veh)				13.2												
Level of Service (LOS)				B												
Approach Delay (s/veh)		13.2														
Approach LOS		B														

HCS7 Two-Way Stop-Control Report

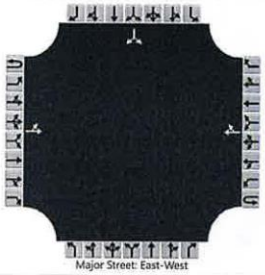
General Information

Analyst	RLA```
Agency/Co.	ATS
Date Performed	12/11/2019
Analysis Year	2025
Time Analyzed	AM Peak With Dev.
Intersection Orientation	East-West
Project Description	Iwata Subdivision

Site Information

Intersection	Central Approach
Jurisdiction	City of Billings
East/West Street	Central Avenue
North/South Street	West Approach
Peak Hour Factor	1.00
Analysis Time Period (hrs)	0.25

Lanes



Vehicle Volumes and Adjustments

Approach	Eastbound				Westbound				Northbound				Southbound			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Priority	1U	1	2	3	4U	4	5	6		7	8	9		10	11	12
Number of Lanes	0	0	1	0	0	0	1	0		0	0	0		0	1	0
Configuration		LT						TR							LR	
Volume (veh/h)		14	675				237	43						5		3
Percent Heavy Vehicles (%)		3												3		3
Proportion Time Blocked																
Percent Grade (%)														0		
Right Turn Channelized																
Median Type | Storage	Undivided															

Critical and Follow-up Headways

Base Critical Headway (sec)		4.1												7.1		6.2
Critical Headway (sec)		4.13												6.43		6.23
Base Follow-Up Headway (sec)		2.2												3.5		3.3
Follow-Up Headway (sec)		2.23												3.53		3.33

Delay, Queue Length, and Level of Service

Flow Rate, v (veh/h)		14													8	
Capacity, c (veh/h)		1277													366	
v/c Ratio		0.01													0.02	
95% Queue Length, Q_{95} (veh)		0.0													0.1	
Control Delay (s/veh)		7.9													15.0	
Level of Service (LOS)		A													C	
Approach Delay (s/veh)	0.3												15.0			
Approach LOS													C			

HCS7 Two-Way Stop-Control Report

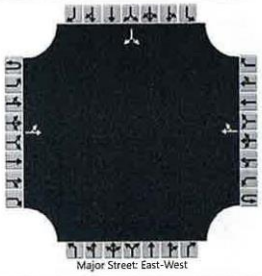
General Information

Analyst	RLA```
Agency/Co.	ATS
Date Performed	12/11/2019
Analysis Year	2025
Time Analyzed	PM Peak With Dev.
Intersection Orientation	East-West
Project Description	Iwata Subdivision

Site Information

Intersection	Central Approach
Jurisdiction	City of Billings
East/West Street	Central Avenue
North/South Street	West Approach
Peak Hour Factor	1.00
Analysis Time Period (hrs)	0.25

Lanes



Major Street: East-West

Vehicle Volumes and Adjustments

Approach	Eastbound				Westbound				Northbound				Southbound			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Priority	1U	1	2	3	4U	4	5	6		7	8	9		10	11	12
Number of Lanes	0	0	1	0	0	0	1	0		0	0	0		0	1	0
Configuration		LT						TR							LR	
Volume (veh/h)		3	331				638	9						23		12
Percent Heavy Vehicles (%)		3												3		3
Proportion Time Blocked																
Percent Grade (%)														0		
Right Turn Channelized																
Median Type | Storage	Undivided															

Critical and Follow-up Headways

Base Critical Headway (sec)		4.1												7.1		6.2
Critical Headway (sec)		4.13												6.43		6.23
Base Follow-Up Headway (sec)		2.2												3.5		3.3
Follow-Up Headway (sec)		2.23												3.53		3.33

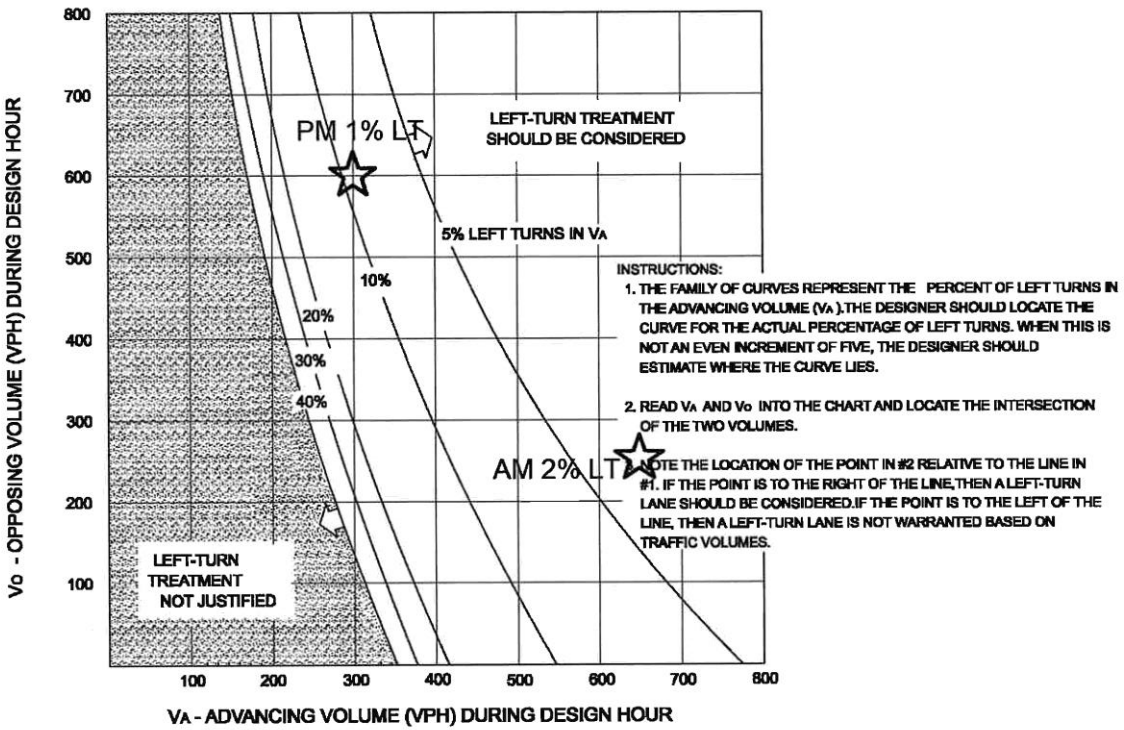
Delay, Queue Length, and Level of Service

Flow Rate, v (veh/h)		3													35	
Capacity, c (veh/h)		934													321	
v/c Ratio		0.00													0.11	
95% Queue Length, Q_{95} (veh)		0.0													0.4	
Control Delay (s/veh)		8.9													17.6	
Level of Service (LOS)		A													C	
Approach Delay (s/veh)	0.1												17.6			
Approach LOS													C			

APPENDIX D

Turn- Lane Warrants

South Approach To
Central Avenue



VOLUME GUIDELINES FOR LEFT-TURN LANES AT UNSIGNALIZED INTERSECTIONS ON 2-LANE HIGHWAYS 45 mph (70 km/h)

Figure 13.3F