HDR | ONE COMPANY *Many Solutions*℠

Technical Memo

To:	Steve Gramm, SDDOT		
From:	Steve Hoff, HDR Engineering, Inc.	Project:	I-190/Silver Street Study
CC:			
Date:	6/22/2010	Job No:	DOT Contract 410445, Order PD-02-09

RE: Phase 1, Task 100: Baseline Analysis

This Technical Memo has been prepared to document the data, analysis and findings as outlined in the Task 100 section of the subject work order. The Technical Memo is organized by subtask and the data, analysis and findings related to each subtask are presented in the subtask discussions.

Subtask 101 – determine extent of study area. HDR prepared a graphic showing the proposed study area and presented the concept to the Study Team at the kick-off meeting in Rapid City on March 22. The Study Team had no comments and the study area was determined to include the portions of the Interstate and arterial street systems as shown in Figure 1.

The study area includes the following roadways:

- Interstate 190 (entire length)
- Interstate 90, west of I-190 to east of Haines Avenue
- West Boulevard, south of Omaha Street to south of I-90
- Omaha Street, west of West Boulevard to east of 5th Street
- Silver Street, west of Boegel Street to West Boulevard
- North Street, West Boulevard to east of Haines Avenue
- Mt. Rushmore Road, south of Omaha Street to North Street
- 5th Street, south of Omaha Street to North Street
- Haines Avenue, North Street to north of Disk Drive
- Anamosa Street, west of West Boulevard to east of Haines Avenue
- Disk Drive, Howard Street to east of Haines Avenue

Interstate interchanges include:

- I-90/I-190
- I-90/Haines Ave.
- I-190/Silver St. and adjacent ramps
- Adjacent I-90 interchange ramps necessary to analyze study area ramps operations

Arterial intersections include:

- Disk Dr./Haines Ave.
- I-90/Haines Ave.
- Anamosa St./Haines Ave.
- North St./Haines Ave.
- 5th St./Omaha St.
- Mt. Rushmore Rd./North St.
- Mt. Rushmore Rd./Omaha St.
- West Blvd. (W)/Anamosa St.
- West Blvd. (E)/Anamosa St.
- Boegel St./Silver St.
- I-190/Silver St./North St.
- West Blvd./Omaha St.

6300 So Old Village Place
Suite 100
Sioux Falls, South Dakota 57108
Phone (605) 977-7740
Fax (605) 977-7747
www.hdrinc.com

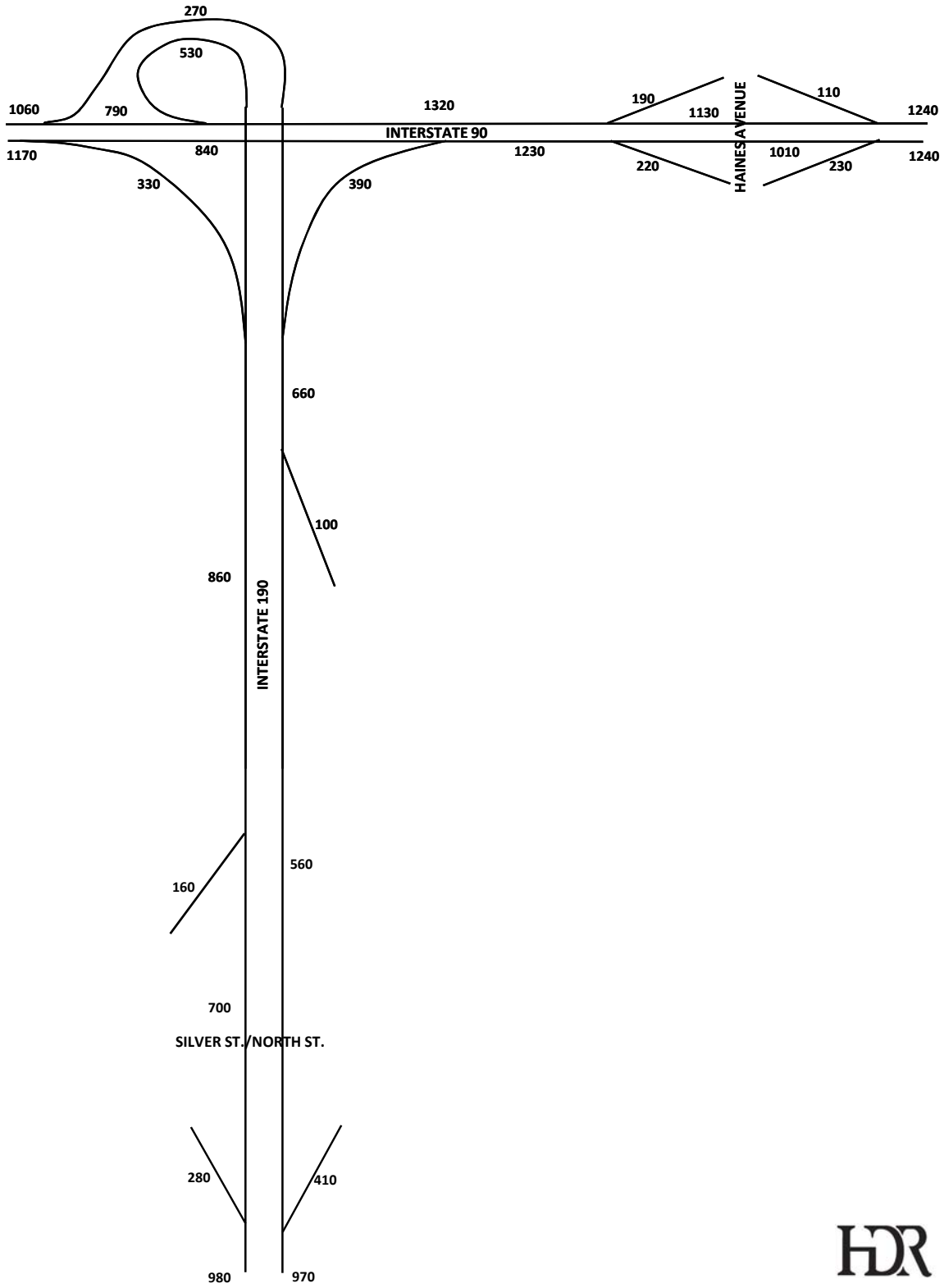
Figure 1 – Study Area

Subtask 102 – Gather existing air-photo and GIS coverage. Airphoto bases were received in March and are being used for development of concepts and other work items. GIS coverage with database was received from SDDOT in April. Other GIS coverage, such as utilities, from the City may be needed for preliminary design.

Subtask 103 – Gather available traffic data from SDDOT and City. Traffic data was obtained from SDDOT and the City and supplemented by turning movement counts performed by HDR staff. The peak hour Interstate counts are shown in Figures 2 and 3. The peak hour arterial intersection turning movements are shown in Figures 4 and 5.

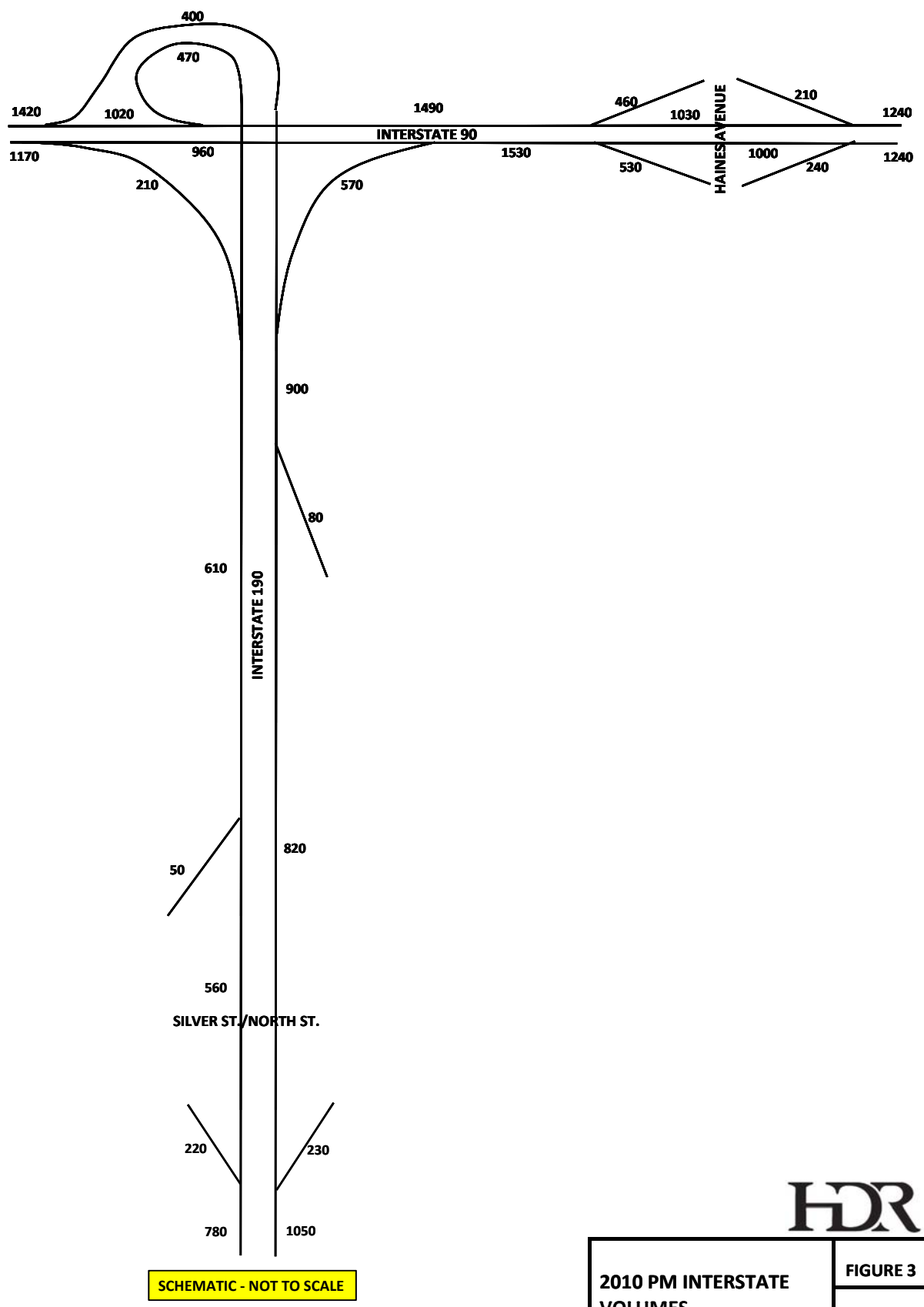
Subtask 104 – Produce peak hour movement forecasts. Traffic forecasting information was obtained from the regional traffic forecasting model maintained by the City and used to produce peak hour movement forecasts. The peak hour Interstate forecasts are shown in Figures 6 and 7. The peak hour arterial intersection turning movements are shown in Figures 8 and 9.

6300 So Old Village Place
Suite 100
Sioux Falls, South Dakota 57108
Phone (605) 977-7740
Fax (605) 977-7747
www.hdrinc.com



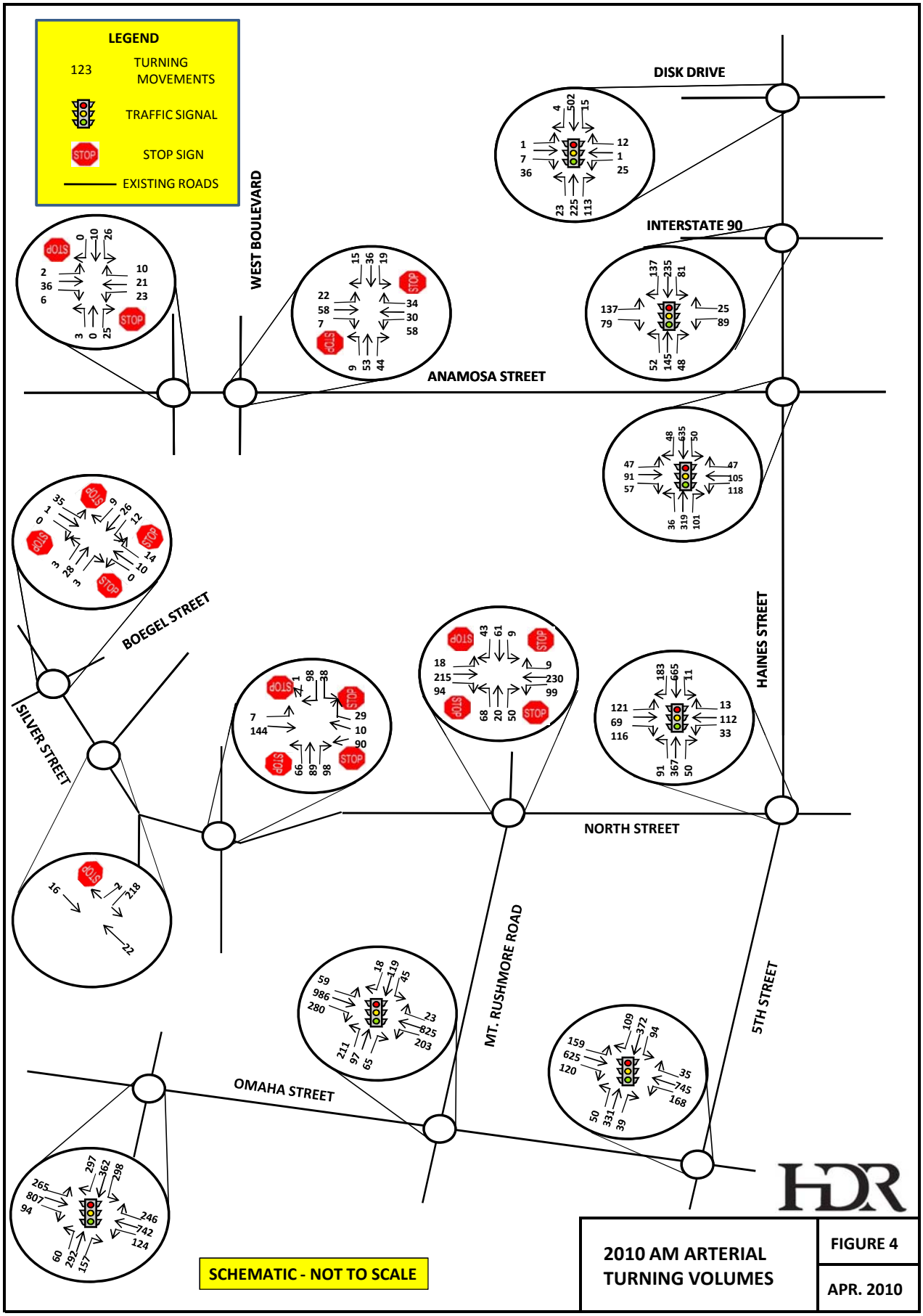
SCHEMATIC - NOT TO SCALE

2010 AM INTERSTATE VOLUMES	FIGURE 2
	APR. 2010



HDR

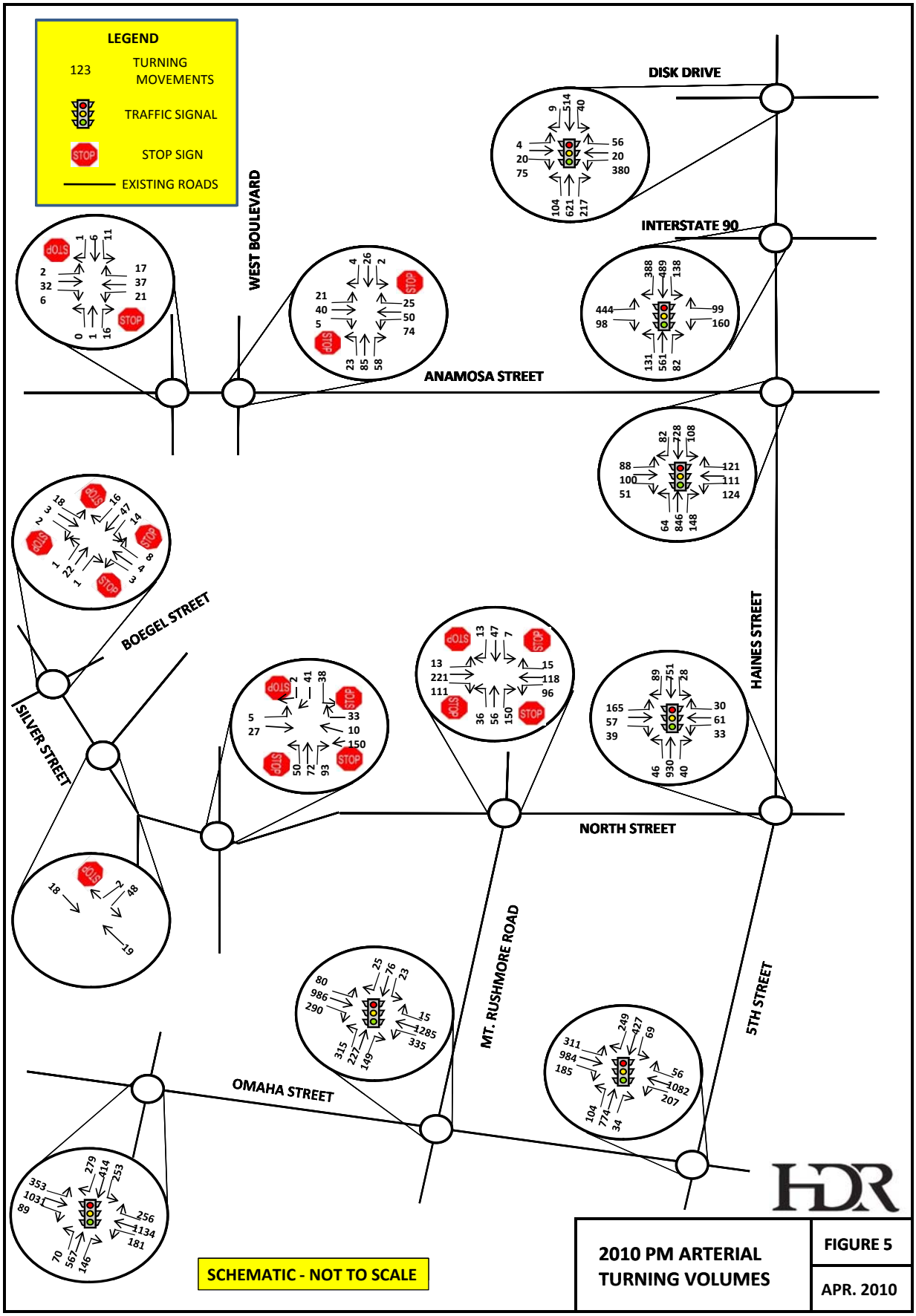
2010 PM INTERSTATE VOLUMES	FIGURE 3
	APR. 2010



2010 AM ARTERIAL TURNING VOLUMES

FIGURE 4

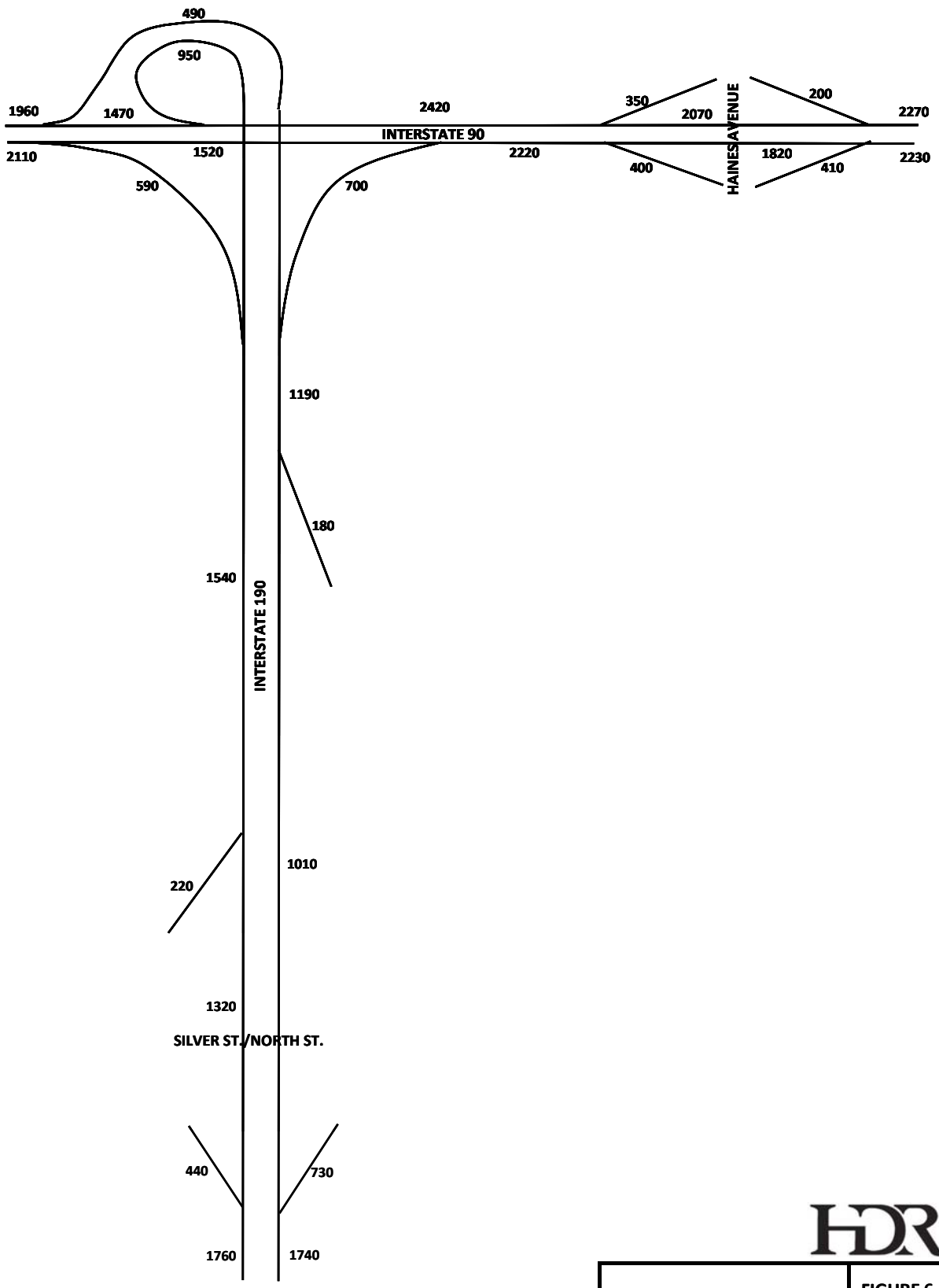
APR. 2010



2010 PM ARTERIAL TURNING VOLUMES

FIGURE 5

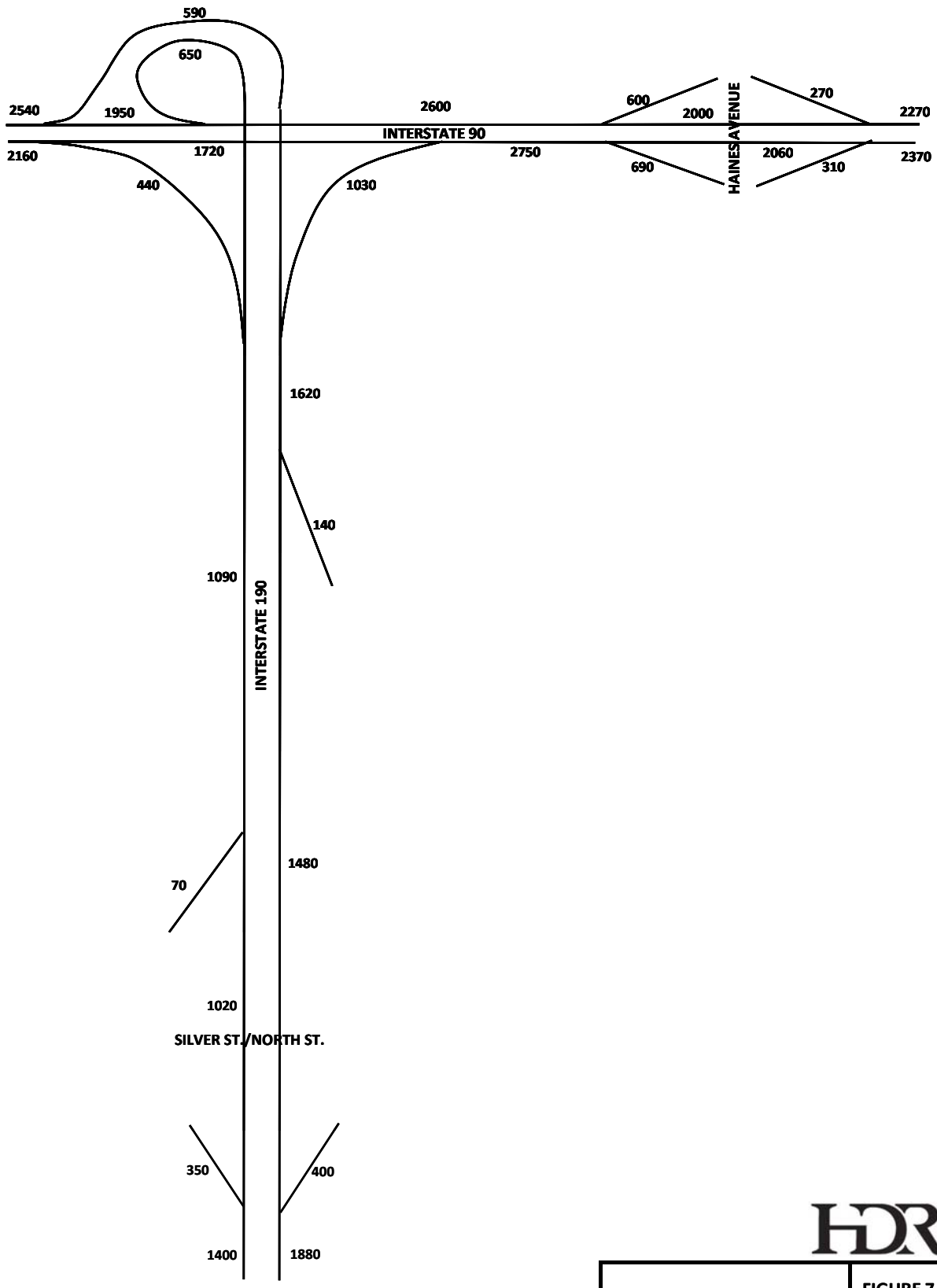
APR. 2010



SCHEMATIC - NOT TO SCALE

HDR

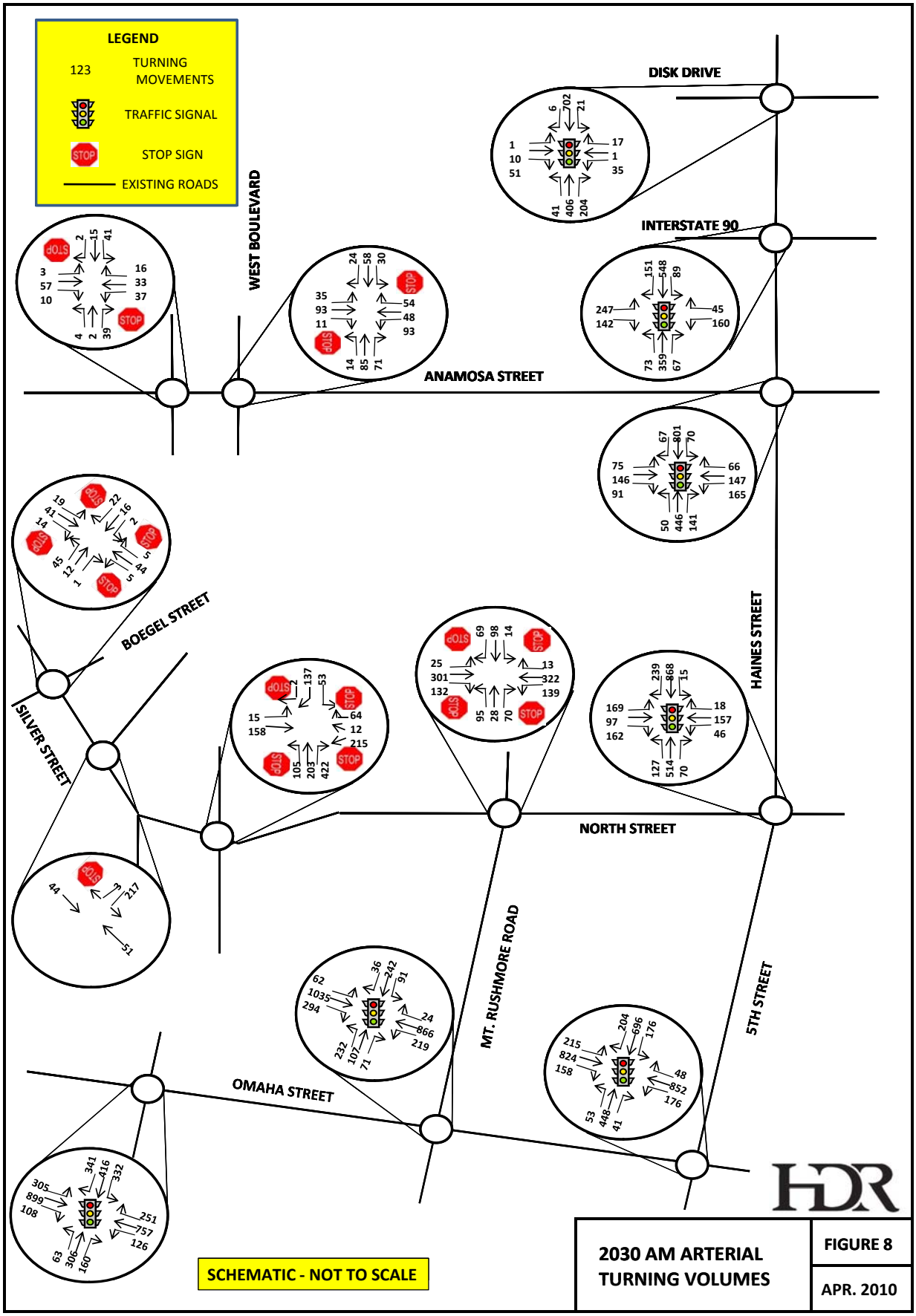
2030 AM INTERSTATE VOLUMES	FIGURE 6
	APR. 2010



SCHEMATIC - NOT TO SCALE

HDR

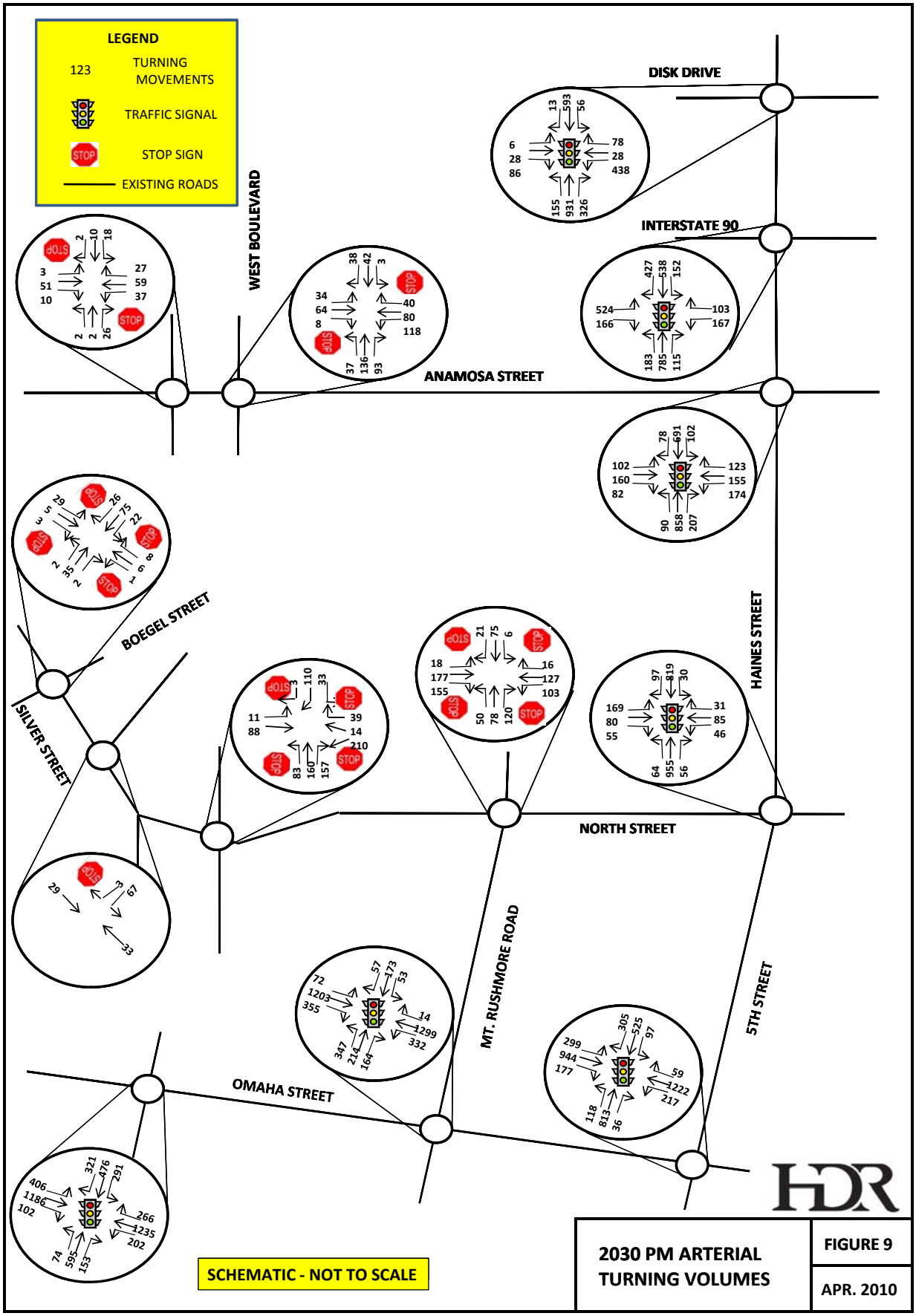
2030 PM INTERSTATE VOLUMES	FIGURE 7
	APR. 2010



2030 AM ARTERIAL TURNING VOLUMES

FIGURE 8

APR. 2010



2030 PM ARTERIAL TURNING VOLUMES

FIGURE 9

APR. 2010

Subtask 105 – Review peak hour movement forecasts with SDDOT and City. Graphics showing the movement forecasts were delivered to SDDOT on 4/23/10 for distribution and review.

Subtask 106 – Create study area operations models and analyze existing conditions. Operations models were created and Interstate and arterial operations were analyzed. Summaries of the operations analysis results are shown in Tables 1-4. The analyses indicate acceptable Interstate mainline levels of service, with all segments operating at LOS A or B under 2010 conditions. Likewise, the Interstate ramps and weave locations operate at LOS A or B under 2010 traffic conditions. The 2010 arterial intersection levels of service for the study area intersections are also acceptable, ranging from LOS A to C. Analysis outputs are provided in the Appendix.

Subtask 107 – Update models for future year No Action conditions and repeat analysis. The operations models were updated with the future year traffic forecasts and the operations analysis was repeated, with results shown in Tables 1-5. A number of Interstate mainline segments were seen to fall to LOS C by 2030, but all segments remained within the acceptable range. All the Interstate ramps remained within acceptable levels of service in 2030, except the eastbound I-90 off ramp at Haines Avenue, which operates at LOS F. Interstate weave sections continue to operate at acceptable level of service through 2030. Arterial intersection levels of service are acceptable through 2030, except the intersection of Disk Dr./Haines Ave., which operates at LOS D in the 2030 PM peak hour. Analysis outputs are provided in the Appendix.

TABLE 1 - INTERSTATE MAINLINE LEVEL OF SERVICE

			2010		2030	
ROUTE	FROM	TO	AM	PM	AM	PM
I-190 NB	OMAHA ST.	SILVER ST.	A	A	B	C
	SILVER ST.	ANAMOSA ST.	A	A	B	B
	ANAMOSA ST.	I-90	A	A	B	B
I-190 SB	I-90	SILVER OFF	A	A	B	B
	SILVER OFF	SILVER ON	A	A	B	A
	SILVER ON	OMAHA ST.	A	A	B	B
I-90 EB	DEADWOOD ST.	I-190 OFF	A	A	C	C
	I-190 OFF	I-190 ON	A	A	B	B
	I-190 ON	HAINES OFF	A	A	B	B
	HAINES OFF	HAINES ON	A	A	B	B
	HAINES ON	LACROSSE OFF	A	A	C	C
I-90 WB	LACROSSE ON	HAINES OFF	A	A	C	C
	HAINES OFF	HAINES ON	A	A	B	B
	HAINES ON	I-190 OFF	A	A	B	B
	I-190 OFF	I-190 ON	A	A	B	B
	I-190 ON	DEADWOOD ST.	A	B	B	C

6300 So Old Village Place
Suite 100
Sioux Falls, South Dakota 57108
Phone (605) 977-7740
Fax (605) 977-7747
www.hdrinc.com

TABLE 2 - INTERSTATE RAMP LEVEL OF SERVICE

ROUTE	RAMP	2010		2030	
		AM	PM	AM	PM
I-190 NB	SILVER OFF	A	B	B	B
	ANAMOSA ON	A	B	B	B
	I-90 OFF	A	A	A	A
I-190 SB	I-90 ON	A	A	B	B
	SILVER OFF	A	A	B	A
	SILVER ON	A	A	B	A
I-90 EB	I-190 OFF	A	A	B	B
	I-190 ON	A	A	B	C
	HAINES OFF	A	B	C	F
	HAINES ON	A	A	B	B
I-90 WB	HAINES OFF	A	A	B	B
	HAINES ON	A	B	B	C
	I-190 OFF	A	A	A	A
	I-190 ON	A	A	A	A

TABLE 3 - INTERSTATE WEAVE LEVEL OF SERVICE

ROUTE	FROM	TO	2010		2030	
			AM	PM	AM	PM
I-190 NB	ANAMOSA	I-90	A	A	B	B
I-90 EB	I-190	HAINES	A	B	C	C

6300 So Old Village Place
Suite 100
Sioux Falls, South Dakota 57108
Phone (605) 977-7740
Fax (605) 977-7747
www.hdrinc.com

TABLE 4 - LEVEL OF SERVICE SUMMARY

STREET INTERSECTIONS

EXISTING CONDITIONS

	LEVEL OF SERVICE		V/C RATIO	
INTERSECTION	**AM**	**PM**	**AM**	**PM**
HAINES/DISK	A	C	0.31	0.63
HAINES/I-90	A	B	0.26	0.56
HAINES/ANAMOSA	C	B	0.59	0.63
HAINES/NORTH	B	A	0.61	0.54
5TH/OMAHA	C	C	0.51	0.67
MT. RUSHMORE/NORTH	A	A	0.42	0.38
MT. RUSHMORE/OMAHA	C	C	0.57	0.62
WEST/ANAMOSA (W)	A	A	0.27	0.36
WEST/ANAMOSA (E)	A	A	0.25	0.25
BOEGEL/SILVER	A	A	0.21	0.24
WEST/NORTH	B	A	0.34	0.33
WEST/OMAHA	C	C	0.57	0.73

TABLE 5 - LEVEL OF SERVICE SUMMARY

STREET INTERSECTIONS

2030 CONDITIONS, EXISTING NETWORK

	LEVEL OF SERVICE		V/C RATIO	
INTERSECTION	**AM**	**PM**	**AM**	**PM**
HAINES/DISK	A	D	0.37	0.79
HAINES/I-90	A	B	0.45	0.65
HAINES/ANAMOSA	C	C	0.65	0.68
HAINES/NORTH	B	B	0.70	0.65
5TH/OMAHA	C	C	0.70	0.82
MT. RUSHMORE/NORTH	C	B	0.57	0.41
MT. RUSHMORE/OMAHA	C	C	0.66	0.66
WEST/ANAMOSA (W)	A	A	0.28	0.28
WEST/ANAMOSA (E)	A	A	0.35	0.46
BOEGEL/SILVER	A	A	0.25	0.29
WEST/NORTH	C	B	0.58	0.50
WEST/OMAHA	C	C	0.62	0.92

6300 So Old Village Place
Suite 100
Sioux Falls, South Dakota 57108
Phone (605) 977-7740
Fax (605) 977-7747
www.hdrinc.com

Subtask 108 – Crash analysis. Crash data for the study area was provided in a geo-referenced database, displayed in ArcGIS format. The GIS allowed display of crash locations on top of a study area map and easy identification of crash clusters and potential crash problems needing improvements.

Overall, the Interstate system showed randomly scattered crashes, with two exceptions – the I-90/I-190 interchange area and the weave area on eastbound I-90, between I-190 and Haines Avenue.

Figure 10 – Crash display I-90/I-190 interchange area

The I-90/I-190 interchange area (Figure 10), showed a slight concentration of crashes, but analysis of the crash records showed no trend toward any particular type of crash. Rather, crashes appear to be related to operating on hills and curves during winter driving conditions, as well as a number of animal-related crashes. No particular road-related remedy is suggested, although continued attention to winter maintenance may help control crash rates.

The crash rate for the eastbound I-90 segment between I-190 and Haines Avenue (Figure 11) appears fairly high, although the rate may be skewed by the short length of the segment. Review of the crash details shows that 83% of the crashes occurred in inclement driving conditions. Again, continued attention to winter maintenance may help control crash rates.

Interstate segment crash rates are shown in Table 6.

Figure 11 – Crash display I-90 between I-190 and Haines Avenue

TABLE 6 - INTERSTATE AREA CRASH RATES

AREA	CRASHES	MILEAGE	AADT	CRASH RATE (CRASHES PER MILLION VEHICLE MILES)
I-90/I-190 INTERCHANGE	31	2.9	8300	1.18
I-90 EASTBOUND WEAVE, I-190 TO HAINES	12	0.14	16190	4.83

Intersection crash rates for the arterial street intersections are shown in Table 7. The critical crash rate that triggers improvement can vary from community to community and year to year, depending on the statistical analysis of crash rates from a large population of intersections. While the small number of intersections in this study do not permit calculation of a critical crash rate, arterial intersection critical rates in South Dakota usually range in the vicinity of 0.80 – 1.20 crashes per million entering vehicles. This would point toward the following intersections as potential candidates for improvement:

- Omaha St./West Blvd./I-190
- Omaha St./5th St.

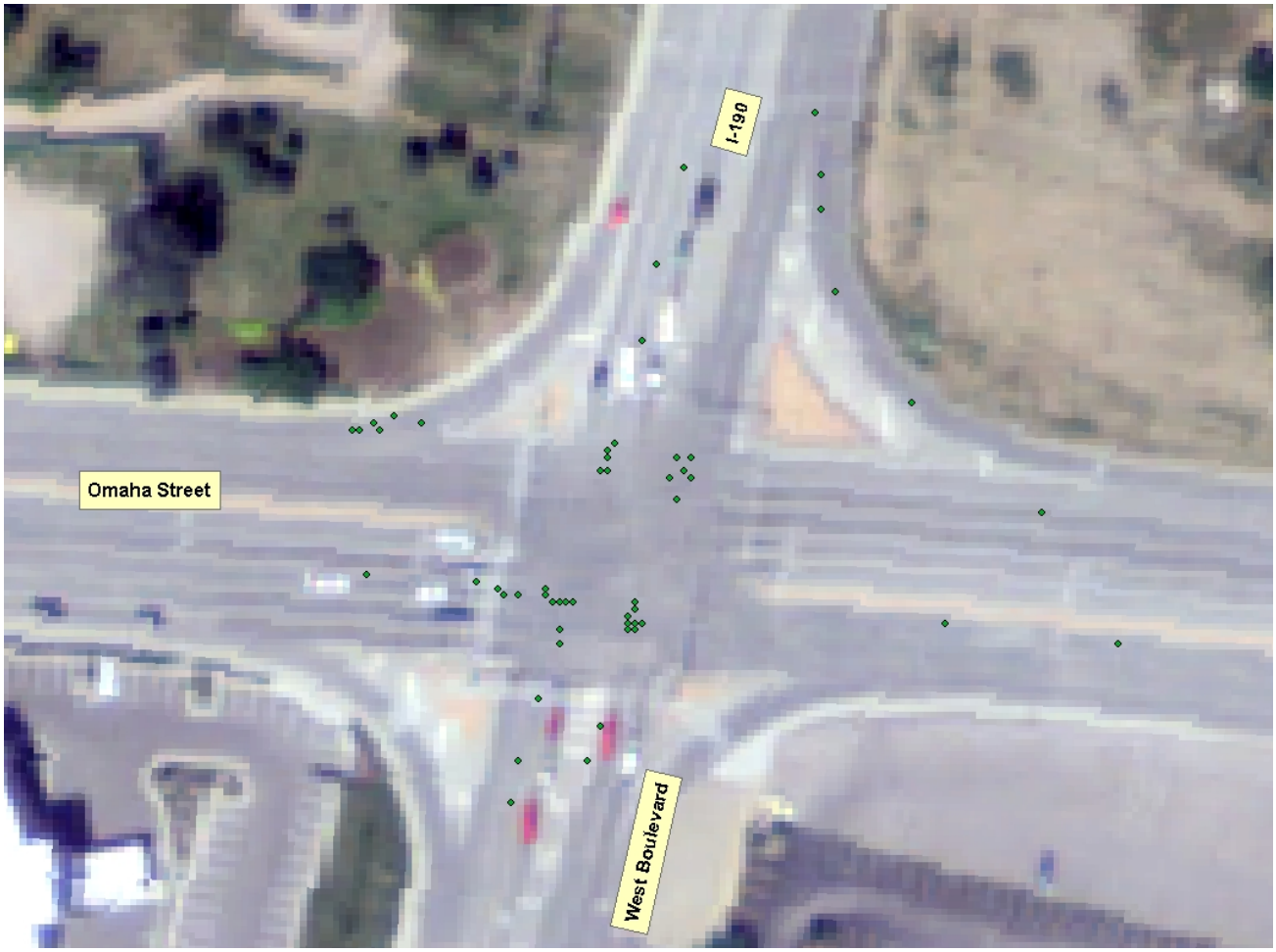
- North St./Mt. Rushmore Rd.
- Haines St./I-90
- Haines St./Disk Dr.

Since this study is limited to a small number of arterial intersections, it was possible to review the crash records for each intersection to look for trends and indications of potential problems. The crash location display for each intersection is shown starting on the following page, along with a short summary of the findings.

TABLE 7 - INTERSECTION CRASH RATES

INTERSECTION	NUMBER OF CRASHES	DAILY VEHICLES	CRASH RATE (CRASHES PER MILLION ENTERING VEHICLES)
OMAHA/WEST/I-190	72	59,700	1.10
OMAHA/MT. RUSHMORE	28	32,600	0.78
OMAHA/5TH	57	49,900	1.04
NORTH/WEST/SILVER	7	8,000	0.80
NORTH/MT. RUSHMORE	10	8,000	1.14
HAINES/5TH/NORTH	15	24,000	0.57
HAINES/ANAMOSA	16	25,100	0.58
WEST/ANAMOSA	3	6,000	0.46
HAINES/I-90	40	25,900	1.41
HAINES/DISK	31	27,800	1.02

6300 So Old Village Place
Suite 100
Sioux Falls, South Dakota 57108
Phone (605) 977-7740
Fax (605) 977-7747
www.hdrinc.com



Omaha St./West Blvd./I-190

A total of 72 crashes were reported in three years (2007, 2008, 2009). Over 72% of the crashes were rear-end, while over 18% were angle crashes. The crash display indicates that many of the crashes are occurring after vehicles have crossed the stop-bar and entered the intersection. This suggests that rear-end crashes may be occurring due to downstream congestion and downstream merging. Some potential countermeasures may include:

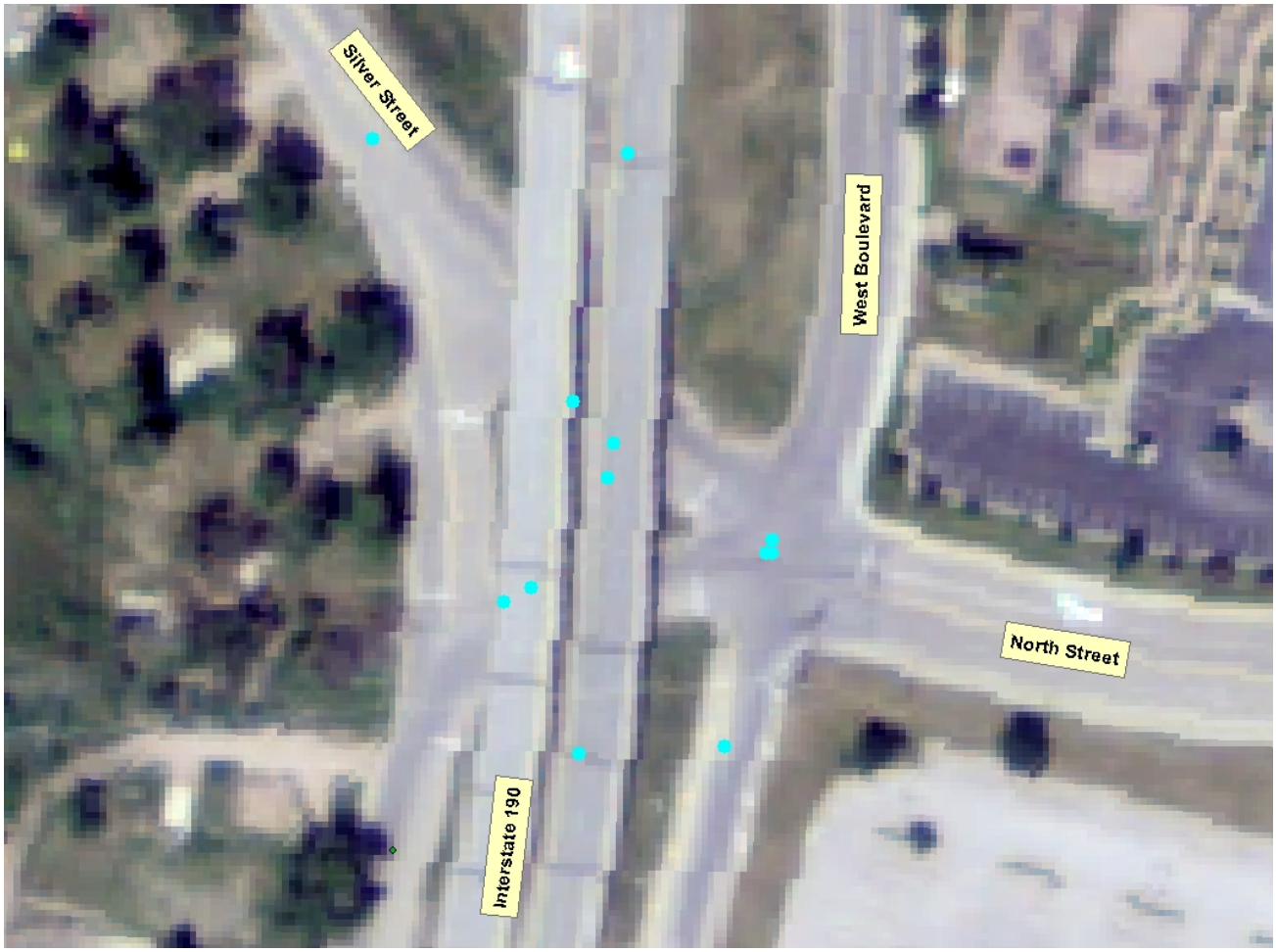
- Downstream acceleration lane for southbound to westbound right turn.
- Check peak hour queues on southbound West Boulevard.
- Check lane marking for double left turn lanes to reduce vehicles drifting into others' paths.

Omaha St./Mt. Rushmore Rd.

A total of 28 crashes were reported in three years (2007 – 2009), split primarily between rear-end (50%) and angle (32%) crashes. Crash locations are scattered around the intersection, although a concentration may be developing related to the westbound to southbound left turn. No other trends were noted or improvements suggested.

Omaha St./5th St.

A total of 57 crashes were reported in three years (2007 – 2009), split primarily between rear-end (72%) and angle (21%) crashes. The majority of the crashes appear to be occurring in the center of the intersection in line with left turn lanes. It is possible that some of the rear-end accidents are occurring due to downstream congestion, perhaps related to railroad operations in the vicinity.



I-190/West Blvd./Silver St./North St.

A total of 13 crashes were reported at this location, but 6 of the 13 were single-vehicle crashes actually on I-190 in inclement weather conditions. Seven of the 13 were listed as intersection-related. There were an insufficient number of crashes to establish trends or suggest crash-related improvements.

Mt. Rushmore Rd./North St./Allen St.

A total of 10 crashes were reported in three years (2007 – 2009), split primarily between rear-end (30%) and angle (60%) crashes. The intersection is currently operating with all-way stop control. Intersections of this type typically have a slightly higher critical crash rate than larger signal-controlled arterial intersections. It appears that the crash rate at this intersection may not be critical and that the majority of the crashes are related to driver difficulties in determining right-of-way. The location does not currently meet the number of crashes necessary to warrant conversion to a traffic signal, but conditions should continue to be monitored in the future.

6300 So Old Village Place
Suite 100
Sioux Falls, South Dakota 57108
Phone (605) 977-7740
Fax (605) 977-7747
www.hdrinc.com

Haines Ave./5th St./North St.

A total of 15 crashes were reported in three years (2007 – 2009), split primarily between rear-end (27%) and angle (67%) crashes. Most of the crashes were related to drivers failing to yield or not obeying the traffic signals. No other trends were noted and the crash rate does not appear to be critical. No crash-related improvements were suggested.

6300 So Old Village Place
Suite 100
Sioux Falls, South Dakota 57108
Phone (605) 977-7740
Fax (605) 977-7747
www.hdrinc.com

Haines Ave./Anamosa St.

A total of 16 crashes were reported in three years (2007 – 2009), split primarily between rear-end (31%) and angle (50%) crashes. Most of the crashes were related to drivers failing to yield or not obeying the traffic signals. No other trends were noted and the crash rate does not appear to be critical. No crash-related improvements were suggested.

Anamosa St./West Blvd.

A total of 3 crashes were reported in three years (2007 – 2009). No trends were noted and the crash rate does not appear to be critical. No crash-related improvements were suggested.

6300 So Old Village Place
Suite 100
Sioux Falls, South Dakota 57108
Phone (605) 977-7740
Fax (605) 977-7747
www.hdrinc.com

I-90/Haines Ave.

A total of 40 crashes were reported in the interchange area in a three year period (2007-2009). A large portion of the crashes (43%) occurred during inclement driving conditions and it appears that a significant number involved single-vehicle incidents on I-90. A cluster of rear-end crashes appears to be developing in the southbound lanes of Haines Ave., south of the interchange. One potential cause for this cluster may be the interaction of vehicles trying to turn left onto Knollwood Dr. The intersection influence areas of these two intersections appear to overlap, making it difficult for drivers to react in time to avoid collisions. While Knollwood Drive serves businesses and residences fronting I-90, safety concerns may require rerouting Knollwood traffic in the future.

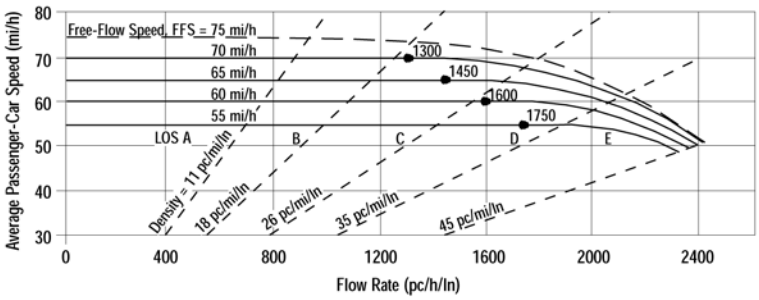
Haines Ave./Disk Drive

A total of 31 crashes were reported in the three reporting years (2007-2009). They were comprised primarily of rear-end (45%) and angle (48%) crashes. Failure to yield citations were prevalent in the crash records, indicating that some drivers may be using the yellow, all-red and red portions of the turning phases to continue to turn under congested conditions. The intersection crash rate may not reach the critical threshold in a city-wide statistical analysis, but operations at the intersection should be reviewed as development continues and volumes rise.

APPENDIX

6300 So Old Village Place
Suite 100
Sioux Falls, South Dakota 57108
Phone (605) 977-7740
Fax (605) 977-7747
www.hdrinc.com

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: AM 2010
Comment: eastbound

Site Information

Jurisdiction/Date: Jurisdiction 3/25/2010
Highway/Direction of Travel: I-90
From/To: Deadwood on/I-190 off

☑ Oper. (LOS) ☐ Des. (N) ☐ Des. (v_p) ☐ Plan. (LOS) ☐ Plan. (N) ☐ Plan. (v_p)

Flow Inputs

Volume, V: 1170 veh/h
Annual avg. daily traffic, AADT: ____ veh/day
Peak-hour proportion of AADT, K: ____
Peak-hour direction proportion, D: ____
DDHV = AADT x K x D: ____ veh/h
Driver type: ☑ Commuter/Weekday ☐ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ☐ Level ☑ Rolling ☐ Mountainous
Grade Length ____ mi Up/Down ____ %

Calculate Flow Adjustments

f_p (☐ Field data?): 1.00
E_T (☐ Field data?): 2.5
E_R (☐ Field data?): 2.0
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.913

Speed Inputs

Lane width: ____ ft
Rt-shoulder lat. clearance: ____ ft
Interchange density: ____ I/mi
Number of lanes, N: 2
FFS (measured): 65.0 mi/h
Base free-flow speed, BFFS: ____ mi/h

Calculate Speed Adjustments and FFS

f_{LW} (☐ Field data?): ____ mi/h
f_{LC} (☐ Field data?): ____ mi/h
f_{ID} (☐ Field data?): ____ mi/h
f_N (☐ Field data?): ____ mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: ____ mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 696 pc/h/ln
S: 65.0 mi/h
$D = v_p/S$: 10.7 pc/i/ln
LOS: A

Design (v_p) or Planning (v_p)

LOS: ____
v_p: ____ pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: ____ veh/h
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
LOS: ____

Design (N) or Planning (N) 2nd Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln
LOS: ____

Glossary

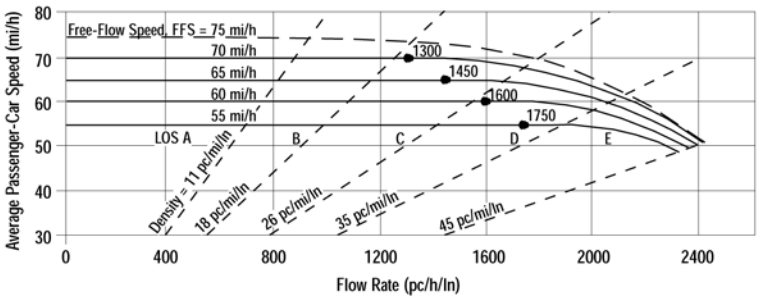
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: AM 2010
Comment: eastbound

Site Information

Jurisdiction/Date: Jurisdiction 3/25/2010
Highway/Direction of Travel: I-90
From/To: I-190 off/I-190 on

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 840 veh/h
Annual avg. daily traffic, AADT: veh/day
Peak-hour proportion of AADT, K:
Peak-hour direction proportion, D:
DDHV = AADT x K x D: veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.4 mi Up/Down: -2.0 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 1.5

E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.972

Speed Inputs

Lane width: ft
Rt-shoulder lat. clearance: ft
Interchange density: l/mi
Number of lanes, N: 2
FFS (measured): 65.0 mi/h
Base free-flow speed, BFFS: mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): mi/h
f_{LC} (❑ Field data?): mi/h
f_{ID} (❑ Field data?): mi/h
f_N (❑ Field data?): mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 470 pc/h/ln
S: 65.0 mi/h
$D = v_p/S$: 7.2 pc/i/ln
LOS: A

Design (v_p) or Planning (v_p)

LOS:
v_p: pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: veh/h
S: mi/h
$D = v_p/S$: pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
LOS:

Design (N) or Planning (N) 2nd Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
S: mi/h
$D = v_p/S$: pc/mi/ln
LOS:

Glossary

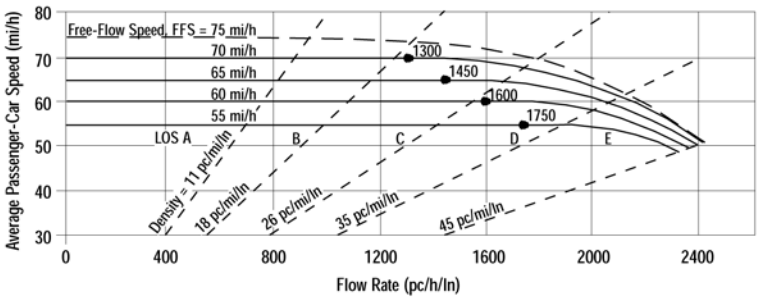
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: AM 2010
Comment: eastbound

Site Information

Jurisdiction/Date: Jurisdiction 3/25/2010
Highway/Direction of Travel: I-90
From/To: I-190 on/Haines off

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 1230 veh/h
Annual avg. daily traffic, AADT: veh/day
Peak-hour proportion of AADT, K:
Peak-hour direction proportion, D:
DDHV = AADT x K x D: veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.1 mi Up/Down: -2.0 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 1.5

E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.972

Speed Inputs

Lane width: ft
Rt-shoulder lat. clearance: ft
Interchange density: l/mi
Number of lanes, N: 3
FFS (measured): 65.0 mi/h
Base free-flow speed, BFFS: mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): mi/h
f_{LC} (❑ Field data?): mi/h
f_{ID} (❑ Field data?): mi/h
f_N (❑ Field data?): mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 459 pc/h/ln
S: 65.0 mi/h
$D = v_p/S$: 7.1 pc/i/ln
LOS: A

Design (v_p) or Planning (v_p)

LOS:
v_p: pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: veh/h
S: mi/h
$D = v_p/S$: pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
LOS:

Design (N) or Planning (N) 2nd Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
S: mi/h
$D = v_p/S$: pc/mi/ln
LOS:

Glossary

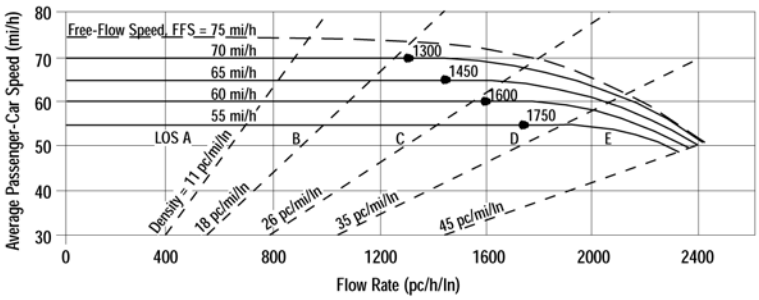
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: AM 2010
Comment: eastbound

Site Information

Jurisdiction/Date: Jurisdiction 3/25/2010
Highway/Direction of Travel: I-90
From/To: Haines off/Haines on

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 1010 veh/h
Annual avg. daily traffic, AADT: veh/day
Peak-hour proportion of AADT, K:
Peak-hour direction proportion, D:
DDHV = AADT x K x D: veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.4 mi Up/Down: 1.0 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 1.5

E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.972

Speed Inputs

Lane width: ft
Rt-shoulder lat. clearance: ft
Interchange density: l/mi
Number of lanes, N: 2
FFS (measured): 65.0 mi/h
Base free-flow speed, BFFS: mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): mi/h
f_{LC} (❑ Field data?): mi/h
f_{ID} (❑ Field data?): mi/h
f_N (❑ Field data?): mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 565 pc/h/ln
S: 65.0 mi/h
$D = v_p/S$: 8.7 pc/i/ln
LOS: A

Design (v_p) or Planning (v_p)

LOS:
v_p: pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: veh/h
S: mi/h
$D = v_p/S$: pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
LOS:

Design (N) or Planning (N) 2nd Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
S: mi/h
$D = v_p/S$: pc/mi/ln
LOS:

Glossary

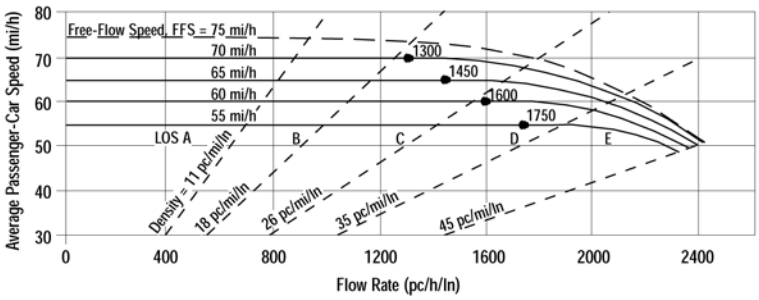
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: AM 2010
Comment: eastbound

Site Information

Jurisdiction/Date: Jurisdiction 3/25/2010
Highway/Direction of Travel: I-90
From/To: Haines on/Lacrosse off

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 1240 veh/h
Annual avg. daily traffic, AADT: ____ veh/day
Peak-hour proportion of AADT, K: ____
Peak-hour direction proportion, D: ____
DDHV = AADT x K x D: ____ veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.6 mi Up/Down: 1.0 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 1.5
E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.972

Speed Inputs

Lane width: ____ ft
Rt-shoulder lat. clearance: ____ ft
Interchange density: ____ I/mi
Number of lanes, N: 2
FFS (measured): 65.0 mi/h
Base free-flow speed, BFFS: ____ mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): ____ mi/h
f_{LC} (❑ Field data?): ____ mi/h
f_{ID} (❑ Field data?): ____ mi/h
f_N (❑ Field data?): ____ mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: ____ mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 693 pc/h/ln
S: 65.0 mi/h
$D = v_p/S$: 10.7 pc/i/ln
LOS: A

Design (v_p) or Planning (v_p)

LOS: ____
v_p: ____ pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: ____ veh/h
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
LOS: ____

Design (N) or Planning (N) 2nd Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln
LOS: ____

Glossary

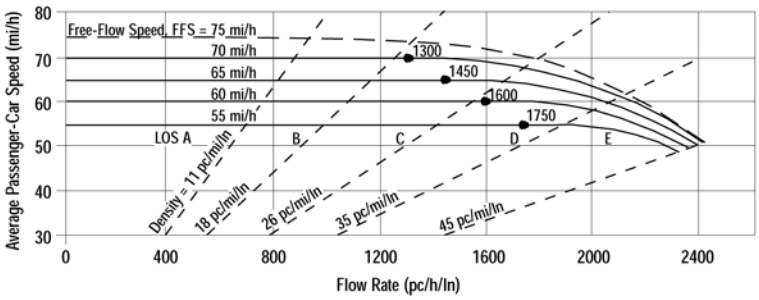
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: AM 2010
Comment: westbound

Site Information

Jurisdiction/Date: Jurisdiction 3/25/2010
Highway/Direction of Travel: I-90
From/To: Lacrosse on/Haines off

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V	1240 veh/h	Peak-hour factor, PHF	0.92
Annual avg. daily traffic, AADT	veh/day	% Trucks and buses, P_T	5
Peak-hour proportion of AADT, K		% RVs, P_R	2
Peak-hour direction proportion, D		General terrain	
DDHV = AADT x K x D	veh/h	❑ Level ❑ Rolling ❑ Mountainous	
Driver type	☑ Commuter/Weekday ❑ Recreational/Weekend	Grade Length 0.5 mi	Up/Down 0.1 %

Calculate Flow Adjustments

f_p (❑ Field data?)	1.00	E_R (❑ Field data?)	1.2
E_T (❑ Field data?)	1.5	$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$	0.972

Speed Inputs

Lane width	ft
Rt-shoulder lat. clearance	ft
Interchange density	l/mi
Number of lanes, N	2
FFS (measured)	65.0 mi/h
Base free-flow speed, BFFS	mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?)	mi/h
f_{LC} (❑ Field data?)	mi/h
f_{ID} (❑ Field data?)	mi/h
f_N (❑ Field data?)	mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N	mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$	693 pc/h/ln
S	65.0 mi/h
$D = v_p/S$	10.7 pc/i/ln
LOS	A

Design (v_p) or Planning (v_p)

LOS	
v_p	pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$	veh/h
S	mi/h
$D = v_p/S$	pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N	assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$	pc/h/ln
LOS	

Design (N) or Planning (N) 2nd Iteration

N	assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$	pc/h/ln
S	mi/h
$D = v_p/S$	pc/mi/ln
LOS	

Glossary

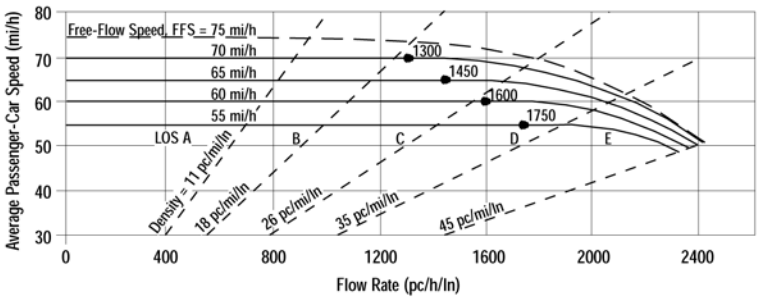
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: AM 2010
Comment: westbound

Site Information

Jurisdiction/Date: Jurisdiction 3/25/2010
Highway/Direction of Travel: I-90
From/To: Haines off/Haines on

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 1130 veh/h
Annual avg. daily traffic, AADT: veh/day
Peak-hour proportion of AADT, K:
Peak-hour direction proportion, D:
DDHV = AADT x K x D: veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.5 mi Up/Down: 0.1 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 1.5

E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.972

Speed Inputs

Lane width: ft
Rt-shoulder lat. clearance: ft
Interchange density: I/mi
Number of lanes, N: 2
FFS (measured): 65.0 mi/h
Base free-flow speed, BFFS: mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): mi/h
f_{LC} (❑ Field data?): mi/h
f_{ID} (❑ Field data?): mi/h
f_N (❑ Field data?): mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 632 pc/h/ln
S: 65.0 mi/h
$D = v_p/S$: 9.7 pc/i/ln
LOS: A

Design (v_p) or Planning (v_p)

LOS:
v_p: pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: veh/h
S: mi/h
$D = v_p/S$: pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
LOS:

Design (N) or Planning (N) 2nd Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
S: mi/h
$D = v_p/S$: pc/mi/ln
LOS:

Glossary

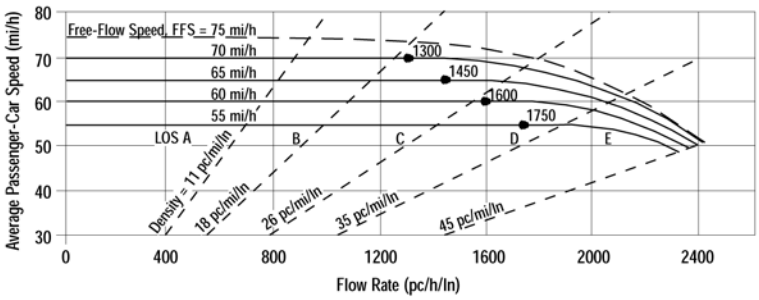
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: AM 2010
Comment: westbound

Site Information

Jurisdiction/Date: Jurisdiction 3/25/2010
Highway/Direction of Travel: I-90
From/To: Haines on/I-190 off

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 1320 veh/h
Annual avg. daily traffic, AADT: ____ veh/day
Peak-hour proportion of AADT, K: ____
Peak-hour direction proportion, D: ____
DDHV = AADT x K x D: ____ veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.4 mi Up/Down: 2.0 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 1.5
E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.972

Speed Inputs

Lane width: ____ ft
Rt-shoulder lat. clearance: ____ ft
Interchange density: ____ I/mi
Number of lanes, N: 3
FFS (measured): 65.0 mi/h
Base free-flow speed, BFFS: ____ mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): ____ mi/h
f_{LC} (❑ Field data?): ____ mi/h
f_{ID} (❑ Field data?): ____ mi/h
f_N (❑ Field data?): ____ mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: ____ mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 492 pc/h/ln
S: 65.0 mi/h
$D = v_p/S$: 7.6 pc/i/ln
LOS: A

Design (v_p) or Planning (v_p)

LOS: ____
v_p: ____ pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: ____ veh/h
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
LOS: ____

Design (N) or Planning (N) 2nd Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln
LOS: ____

Glossary

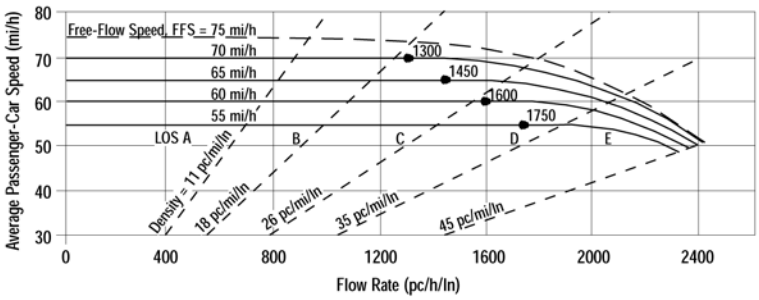
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: AM 2010
Comment: westbound

Site Information

Jurisdiction/Date: Jurisdiction 3/25/2010
Highway/Direction of Travel: I-90
From/To: I-190 off/I-190 on

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 790 veh/h
Annual avg. daily traffic, AADT: veh/day
Peak-hour proportion of AADT, K:
Peak-hour direction proportion, D:
DDHV = AADT x K x D: veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.4 mi Up/Down: 2.0 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 1.5

E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.972

Speed Inputs

Lane width: ft
Rt-shoulder lat. clearance: ft
Interchange density: l/mi
Number of lanes, N: 2
FFS (measured): 65.0 mi/h
Base free-flow speed, BFFS: mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): mi/h
f_{LC} (❑ Field data?): mi/h
f_{ID} (❑ Field data?): mi/h
f_N (❑ Field data?): mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 442 pc/h/ln
S: 65.0 mi/h
$D = v_p/S$: 6.8 pc/i/ln
LOS: A

Design (v_p) or Planning (v_p)

LOS:
v_p: pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: veh/h
S: mi/h
$D = v_p/S$: pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
LOS:

Design (N) or Planning (N) 2nd Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
S: mi/h
$D = v_p/S$: pc/mi/ln
LOS:

Glossary

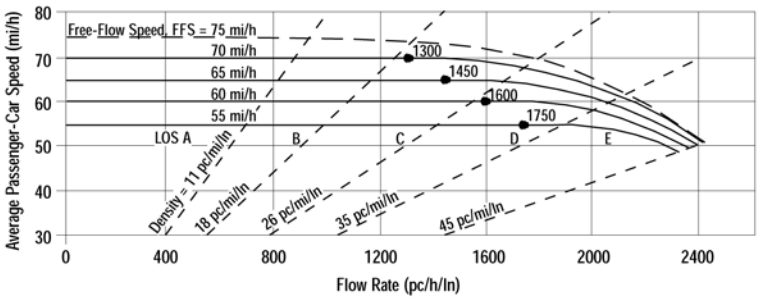
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: AM 2010
Comment: westbound

Site Information

Jurisdiction/Date: Jurisdiction 3/25/2010
Highway/Direction of Travel: I-90
From/To: I-190 on/Deadwood off

☑ Oper. (LOS) ☐ Des. (N) ☐ Des. (v_p) ☐ Plan. (LOS) ☐ Plan. (N) ☐ Plan. (v_p)

Flow Inputs

Volume, V: 1060 veh/h
Annual avg. daily traffic, AADT: ____ veh/day
Peak-hour proportion of AADT, K: ____
Peak-hour direction proportion, D: ____
DDHV = AADT x K x D: ____ veh/h
Driver type: ☑ Commuter/Weekday ☐ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ☐ Level ☑ Rolling ☐ Mountainous
Grade Length ____ mi Up/Down ____ %

Calculate Flow Adjustments

f_p (☐ Field data?): 1.00
E_T (☐ Field data?): 2.5
E_R (☐ Field data?): 2.0
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.913

Speed Inputs

Lane width: ____ ft
Rt-shoulder lat. clearance: ____ ft
Interchange density: ____ I/mi
Number of lanes, N: 2
FFS (measured): 65.0 mi/h
Base free-flow speed, BFFS: ____ mi/h

Calculate Speed Adjustments and FFS

f_{LW} (☐ Field data?): ____ mi/h
f_{LC} (☐ Field data?): ____ mi/h
f_{ID} (☐ Field data?): ____ mi/h
f_N (☐ Field data?): ____ mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: ____ mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 631 pc/h/ln
S: 65.0 mi/h
$D = v_p/S$: 9.7 pc/i/ln
LOS: A

Design (v_p) or Planning (v_p)

LOS: ____
v_p: ____ pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: ____ veh/h
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
LOS: ____

Design (N) or Planning (N) 2nd Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln
LOS: ____

Glossary

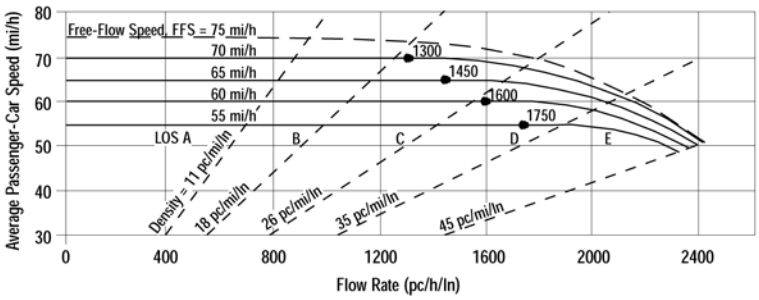
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: AM 2010
Comment: northbound

Site Information

Jurisdiction/Date: Jurisdiction 3/25/2010
Highway/Direction of Travel: I-190
From/To: Omaha St./Silver St. off

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 970 veh/h
Annual avg. daily traffic, AADT: ____ veh/day
Peak-hour proportion of AADT, K: ____
Peak-hour direction proportion, D: ____
DDHV = AADT x K x D: ____ veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.1 mi Up/Down: 0.2 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 1.5

E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.972

Speed Inputs

Lane width: ____ ft
Rt-shoulder lat. clearance: ____ ft
Interchange density: ____ I/mi
Number of lanes, N: 2
FFS (measured): 55.0 mi/h
Base free-flow speed, BFFS: ____ mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): ____ mi/h
f_{LC} (❑ Field data?): ____ mi/h
f_{ID} (❑ Field data?): ____ mi/h
f_N (❑ Field data?): ____ mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: ____ mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 542 pc/h/ln
S: 55.0 mi/h
$D = v_p/S$: 9.9 pc/i/ln
LOS: A

Design (v_p) or Planning (v_p)

LOS: ____
v_p: ____ pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: ____ veh/h
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
LOS: ____

Design (N) or Planning (N) 2nd Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln
LOS: ____

Glossary

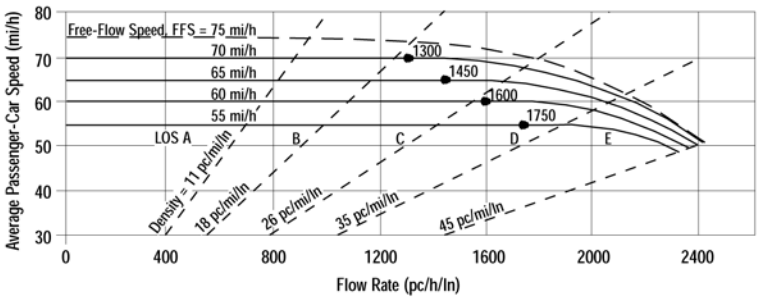
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: AM 2010
Comment: northbound

Site Information

Jurisdiction/Date: Jurisdiction 3/25/2010
Highway/Direction of Travel: I-190
From/To: Silver St. off/Anamosa on

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 560 veh/h
Annual avg. daily traffic, AADT: ____ veh/day
Peak-hour proportion of AADT, K: ____
Peak-hour direction proportion, D: ____
DDHV = AADT x K x D: ____ veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.9 mi Up/Down: 2.0 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 2.0

E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.949

Speed Inputs

Lane width: ____ ft
Rt-shoulder lat. clearance: ____ ft
Interchange density: ____ I/mi
Number of lanes, N: 2
FFS (measured): 55.0 mi/h
Base free-flow speed, BFFS: ____ mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): ____ mi/h
f_{LC} (❑ Field data?): ____ mi/h
f_{ID} (❑ Field data?): ____ mi/h
f_N (❑ Field data?): ____ mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: ____ mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 321 pc/h/ln
S: 55.0 mi/h
$D = v_p/S$: 5.8 pc/i/ln
LOS: A

Design (v_p) or Planning (v_p)

LOS: ____
v_p: ____ pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: ____ veh/h
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
LOS: ____

Design (N) or Planning (N) 2nd Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln
LOS: ____

Glossary

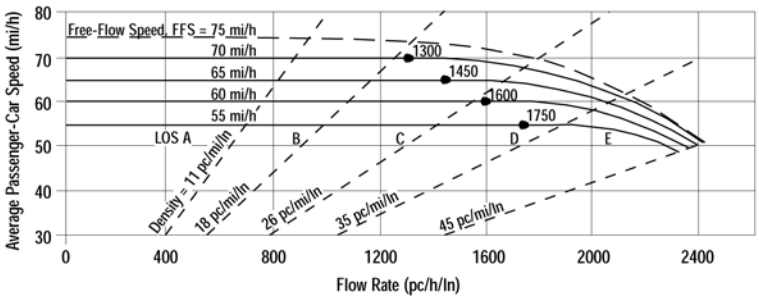
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: AM 2010
Comment: northbound

Site Information

Jurisdiction/Date: Jurisdiction 3/25/2010
Highway/Direction of Travel: I-190
From/To: Anamosa on/I-90 off

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 660 veh/h
Annual avg. daily traffic, AADT: veh/day
Peak-hour proportion of AADT, K:
Peak-hour direction proportion, D:
DDHV = AADT x K x D: veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.2 mi Up/Down: 2.0 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 1.5

E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.972

Speed Inputs

Lane width: ft
Rt-shoulder lat. clearance: ft
Interchange density: l/mi
Number of lanes, N: 2
FFS (measured): 55.0 mi/h
Base free-flow speed, BFFS: mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): mi/h
f_{LC} (❑ Field data?): mi/h
f_{ID} (❑ Field data?): mi/h
f_N (❑ Field data?): mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 369 pc/h/ln
S: 55.0 mi/h
$D = v_p/S$: 6.7 pc/i/ln
LOS: A

Design (v_p) or Planning (v_p)

LOS:
v_p: pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: veh/h
S: mi/h
$D = v_p/S$: pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
LOS:

Design (N) or Planning (N) 2nd Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
S: mi/h
$D = v_p/S$: pc/mi/ln
LOS:

Glossary

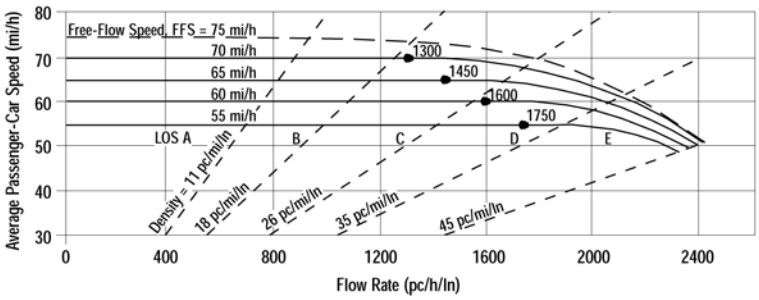
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: AM 2010
Comment: southbound

Site Information

Jurisdiction/Date: Jurisdiction 3/25/2010
Highway/Direction of Travel: I-190
From/To: Silver on/Omaha

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 980 veh/h
Annual avg. daily traffic, AADT: ____ veh/day
Peak-hour proportion of AADT, K: ____
Peak-hour direction proportion, D: ____
DDHV = AADT x K x D: ____ veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain
❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.1 mi Up/Down: -0.2 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 1.5

E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.972

Speed Inputs

Lane width: ____ ft
Rt-shoulder lat. clearance: ____ ft
Interchange density: ____ I/mi
Number of lanes, N: 2
FFS (measured): 55.0 mi/h
Base free-flow speed, BFFS: ____ mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): ____ mi/h
f_{LC} (❑ Field data?): ____ mi/h
f_{ID} (❑ Field data?): ____ mi/h
f_N (❑ Field data?): ____ mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: ____ mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 548 pc/h/ln
S: 55.0 mi/h
$D = v_p/S$: 10.0 pc/i/ln
LOS: A

Design (v_p) or Planning (v_p)

LOS: ____
v_p: ____ pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: ____ veh/h
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
LOS: ____

Design (N) or Planning (N) 2nd Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln
LOS: ____

Glossary

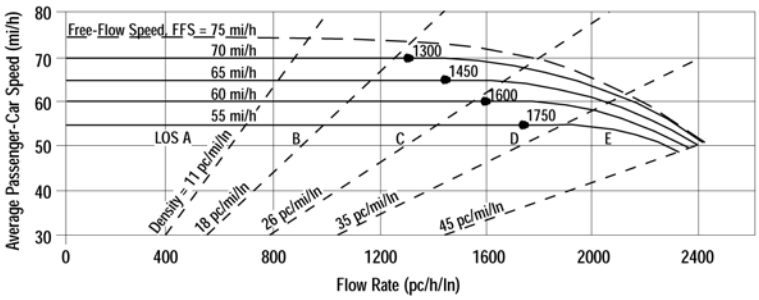
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: AM 2010
Comment: southbound

Site Information

Jurisdiction/Date: Jurisdiction 3/25/2010
Highway/Direction of Travel: I-190
From/To: Silver off/Silver on

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 700 veh/h
Annual avg. daily traffic, AADT: ____ veh/day
Peak-hour proportion of AADT, K: ____
Peak-hour direction proportion, D: ____
DDHV = AADT x K x D: ____ veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.5 mi Up/Down: -2.0 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 1.5

E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.972

Speed Inputs

Lane width: ____ ft
Rt-shoulder lat. clearance: ____ ft
Interchange density: ____ I/mi
Number of lanes, N: 2
FFS (measured): 55.0 mi/h
Base free-flow speed, BFFS: ____ mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): ____ mi/h
f_{LC} (❑ Field data?): ____ mi/h
f_{ID} (❑ Field data?): ____ mi/h
f_N (❑ Field data?): ____ mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: ____ mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 391 pc/h/ln
S: 55.0 mi/h
$D = v_p/S$: 7.1 pc/i/ln
LOS: A

Design (v_p) or Planning (v_p)

LOS: ____
v_p: ____ pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: ____ veh/h
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
LOS: ____

Design (N) or Planning (N) 2nd Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln
LOS: ____

Glossary

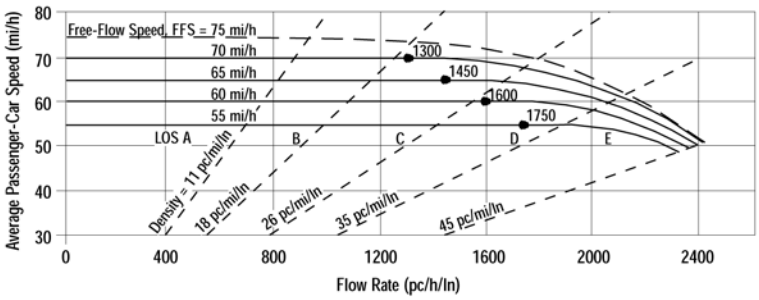
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: AM 2010
Comment: southbound

Site Information

Jurisdiction/Date: Jurisdiction 3/25/2010
Highway/Direction of Travel: I-190
From/To: I-90 on/Silver St. off

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 860 veh/h
Annual avg. daily traffic, AADT: ____ veh/day
Peak-hour proportion of AADT, K: ____
Peak-hour direction proportion, D: ____
DDHV = AADT x K x D: ____ veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.7 mi Up/Down: -2.0 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 1.5

E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.972

Speed Inputs

Lane width: ____ ft
Rt-shoulder lat. clearance: ____ ft
Interchange density: ____ I/mi
Number of lanes, N: 2
FFS (measured): 55.0 mi/h
Base free-flow speed, BFFS: ____ mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): ____ mi/h
f_{LC} (❑ Field data?): ____ mi/h
f_{ID} (❑ Field data?): ____ mi/h
f_N (❑ Field data?): ____ mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: ____ mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 481 pc/h/ln
S: 55.0 mi/h
$D = v_p/S$: 8.7 pc/i/ln
LOS: A

Design (v_p) or Planning (v_p)

LOS: ____
v_p: ____ pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: ____ veh/h
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
LOS: ____

Design (N) or Planning (N) 2nd Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln
LOS: ____

Glossary

N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: AM 2010
Comment: Comments

Site Information

Jurisdiction/Date: Jurisdiction 3/25/2010
Freeway/Direction of Travel: I-90
Junction: EB I-190 off

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☐ Yes ☐ On
☑ No ☐ Off
L_{up} = _____ ft
V_u = _____ veh/h

Freeway terrain: Rolling
Ramp terrain: Rolling

Ramp Type
☐ Merge ☑ Diverge
☑ Right side ☐ Left side
Number of freeway lanes: 2
Number of ramp lanes: 1
Length of ramp roadway: 1340 ft

S_{FF} = 65.0 mi/h S_{FR} = 50.0 mi/h

Downstream Adjacent Ramp

☑ Yes ☑ On
☐ No ☐ Off
L_{down} = 1850 ft
V_D = 390 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				1170	0.92	5	☐ 0.930	☐ 1.00	1367
v_R				330	0.92	5	☐ 0.930	☐ 1.00	386
v_U							☐ 0.976	☐ 1.00	
v_D				390	0.92	5	☐ 0.930	☐ 1.00	456

Merge Areas

Estimation of v_{12}

$$v_{12} = v_F * P_{FM}$$

L_{EQ} = _____ (Equation 25-2 or 25-3)
P_{FM} = _____ using Equation _____ (Exhibit 25-5)
v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}		See Exhibit 25-7	
v_{R12}		4600: All	

Level-of-Service Determination (if not F)

$$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$$

D_R = _____ pc/mi/ln
LOS = _____ (Exhibit 25-4)

Speed Estimation

M_s = _____ (Exhibit 25-19)
S_R = _____ mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = _____ mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$$v_{12} = v_R + (v_F - v_R)P_{FD}$$

L_{EQ} = _____ (Equation 25-8 or 25-9)
P_{FD} = 1.000 using Equation _____ (Exhibit 25-12)
v_{12} = 1367 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$	1367	See Exhibit 25-14	
v_{12}	1367	4400: All	
$v_{FO} = v_F - v_R$	982	See Exhibit 25-14	
v_R	330	See Exhibit 25-3	

Level-of-Service Determination (if not F)

$$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$$

D_R = 3.9 pc/mi/ln
LOS = A (Exhibit 25-4)

Speed Estimation

D_s = 0.268 (Exhibit 25-19)
S_R = 58.8 mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = 58.8 mi/h (Equation 25-15)

©Catalina Engineering, Inc.

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	3/25/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-90	
Analysis Period/Year	AM 2010	Junction	EB I-190 on	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Freeway terrain: Rolling
Ramp terrain: Rolling

Upstream Adjacent Ramp
☑ Yes ☐ On
☐ No ☑ Off
L_{up} = 1850 ft
V_u = 330 veh/h

Ramp Type
☑ Merge ☐ Diverge
☑ Right side ☐ Left side
Number of freeway lanes: 2
Number of ramp lanes: 1
Length of ramp roadway: 1570 ft

S_{FF} = 65.0 mi/h
S_{FR} = 50.0 mi/h

Downstream Adjacent Ramp
☑ Yes ☐ On
☐ No ☑ Off
L_{down} = 730 ft
V_D = 220 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				840	0.92	5	☐ 0.930	☐ 1.00	982
v_R				390	0.92	5	☐ 0.930	☐ 1.00	456
v_U				330	0.92	5	☐ 0.930	☐ 1.00	386
v_D				220	0.92	5	☐ 0.930	☐ 1.00	257

Merge Areas

Estimation of v_{12}

$$v_{12} = v_F * P_{FM}$$

L_{EQ} = _____ (Equation 25-2 or 25-3)
P_{FM} = 1.000 using Equation _____ (Exhibit 25-5)
v_{12} = 982 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	1437	See Exhibit 25-7	
v_{R12}	1437	4600: All	

Level-of-Service Determination (if not F)

$$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$$

D_R = 6.6 pc/mi/ln
LOS = A (Exhibit 25-4)

Speed Estimation

M_s = 0.180 (Exhibit 25-19)
S_R = 60.9 mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = 60.9 mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$$v_{12} = v_R + (v_F - v_R)P_{FD}$$

L_{EQ} = _____ (Equation 25-8 or 25-9)
P_{FD} = _____ using Equation _____ (Exhibit 25-12)
v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$		See Exhibit 25-14	
v_{12}		4400: All	
$v_{FO} = v_F - v_R$		See Exhibit 25-14	
v_R		See Exhibit 25-3	

Level-of-Service Determination (if not F)

$$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$$

D_R = _____ pc/mi/ln
LOS = _____ (Exhibit 25-4)

Speed Estimation

D_s = _____ (Exhibit 25-19)
S_R = _____ mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = _____ mi/h (Equation 25-15)

©Catalina Engineering, Inc.

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	3/25/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-90	
Analysis Period/Year	AM 2010	Junction	EB 90 Haines off	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☑ Yes ☑ On

☐ No ☐ Off

L_{up} = 730 ft

V_u = 390 veh/h

Freeway terrain: Rolling

Ramp terrain: Rolling

Ramp Type

☐ Merge ☑ Diverge

☑ Right side ☐ Left side

Number of freeway lanes: 3

Number of ramp lanes: 1

Length of ramp roadway: 1130 ft

S_{FF} = 65.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☑ Yes ☑ On

☐ No ☐ Off

L_{down} = 2330 ft

V_D = 230 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				1230	0.92	5	☐ 0.930	☐ 1.00	1437
v_R				220	0.92	5	☐ 0.930	☐ 1.00	257
v_U				390	0.92	5	☐ 0.930	☐ 1.00	456
v_D				230	0.92	5	☐ 0.930	☐ 1.00	269

Merge Areas

Estimation of v_{12}

$$v_{12} = v_F * P_{FM}$$

L_{EQ} = _____ (Equation 25-2 or 25-3)

P_{FM} = _____ using Equation _____ (Exhibit 25-5)

v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}		See Exhibit 25-7	
v_{R12}		4600: All	

Level-of-Service Determination (if not F)

$$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$$

D_R = _____ pc/mi/ln

LOS = _____ (Exhibit 25-4)

Speed Estimation

M_s = _____ (Exhibit 25-19)

S_R = _____ mi/h (Exhibit 25-19)

S_O = _____ mi/h (Exhibit 25-19)

S = _____ mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$$v_{12} = v_R + (v_F - v_R)P_{FD}$$

L_{EQ} = 5392 (Equation 25-8 or 25-9)

P_{FD} = 1.038 using Equation 6 (Exhibit 25-12)

v_{12} = 1482 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$	1437	See Exhibit 25-14	
v_{12}	1482	4400: All	
$v_{FO} = v_F - v_R$	1180	See Exhibit 25-14	
v_R	220	See Exhibit 25-3	

Level-of-Service Determination (if not F)

$$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$$

D_R = 6.8 pc/mi/ln

LOS = A (Exhibit 25-4)

Speed Estimation

D_s = 0.321 (Exhibit 25-19)

S_R = 57.6 mi/h (Exhibit 25-19)

S_O = 71.3 mi/h (Exhibit 25-19)

S = 57.3 mi/h (Equation 25-15)

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	3/25/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-90	
Analysis Period/Year	AM 2010	Junction	EB 90 Haines on	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☑ Yes ☐ On
☐ No ☑ Off
L_{up} = 2330 ft
V_u = 220 veh/h

Freeway terrain: Rolling
Ramp terrain: Rolling

Ramp Type
☑ Merge ☐ Diverge
☑ Right side ☐ Left side
Number of freeway lanes: 2
Number of ramp lanes: 1
Length of ramp roadway: 1270 ft

S_{FF} = 65.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☑ Yes ☐ On
☐ No ☑ Off
L_{down} = 2910 ft
V_D = 230 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				1010	0.92	5	☐ 0.930	☐ 1.00	1180
v_R				230	0.92	5	☐ 0.930	☐ 1.00	269
v_U				220	0.92	5	☐ 0.930	☐ 1.00	257
v_D				230	0.92	5	☐ 0.930	☐ 1.00	269

Merge Areas

Estimation of v_{12}

$v_{12} = v_F * P_{FM}$

L_{EQ} = _____ (Equation 25-2 or 25-3)
P_{FM} = 1.000 using Equation _____ (Exhibit 25-5)
v_{12} = 1180 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	1449	See Exhibit 25-7	
v_{R12}	1449	4600: All	

Level-of-Service Determination (if not F)

$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$

D_R = 8.7 pc/mi/ln
LOS = A (Exhibit 25-4)

Speed Estimation

M_s = 0.223 (Exhibit 25-19)
S_R = 59.9 mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = 59.9 mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$v_{12} = v_R + (v_F - v_R)P_{FD}$

L_{EQ} = _____ (Equation 25-8 or 25-9)
P_{FD} = _____ using Equation _____ (Exhibit 25-12)
v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$		See Exhibit 25-14	
v_{12}		4400: All	
$v_{FO} = v_F - v_R$		See Exhibit 25-14	
v_R		See Exhibit 25-3	

Level-of-Service Determination (if not F)

$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$

D_R = _____ pc/mi/ln
LOS = _____ (Exhibit 25-4)

Speed Estimation

D_s = _____ (Exhibit 25-19)
S_R = _____ mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = _____ mi/h (Equation 25-15)

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	3/25/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-90	
Analysis Period/Year	AM 2010	Junction	WB Haines off	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☑ Yes ☑ On
☐ No ☐ Off
L_{up} = 2400 ft
V_u = 220 veh/h

Freeway terrain: Rolling
Ramp terrain: Rolling

Ramp Type
☐ Merge ☑ Diverge
☑ Right side ☐ Left side

Number of freeway lanes: 2
Number of ramp lanes: 1
Length of ramp roadway: 1390 ft

S_{FF} = 65.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☑ Yes ☑ On
☐ No ☐ Off
L_{down} = 2500 ft
V_D = 190 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				1240	0.92	5	☐ 0.930	☐ 1.00	1449
v_R				110	0.92	5	☐ 0.930	☐ 1.00	129
v_U				220	0.92	5	☐ 0.930	☐ 1.00	257
v_D				190	0.92	5	☐ 0.930	☐ 1.00	222

Merge Areas

Estimation of v_{12}

$$v_{12} = v_F * P_{FM}$$

L_{EQ} = _____ (Equation 25-2 or 25-3)
P_{FM} = _____ using Equation _____ (Exhibit 25-5)
v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}		See Exhibit 25-7	
v_{R12}		4600: All	

Level-of-Service Determination (if not F)

$$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$$

D_R = _____ pc/mi/ln
LOS = _____ (Exhibit 25-4)

Speed Estimation

M_s = _____ (Exhibit 25-19)
S_R = _____ mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = _____ mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$$v_{12} = v_R + (v_F - v_R)P_{FD}$$

L_{EQ} = _____ (Equation 25-8 or 25-9)
P_{FD} = 1.000 using Equation _____ (Exhibit 25-12)
v_{12} = 1449 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$	1449	See Exhibit 25-14	
v_{12}	1449	4400: All	
$v_{FO} = v_F - v_R$	1320	See Exhibit 25-14	
v_R	110	See Exhibit 25-3	

Level-of-Service Determination (if not F)

$$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$$

D_R = 4.2 pc/mi/ln
LOS = A (Exhibit 25-4)

Speed Estimation

D_s = 0.310 (Exhibit 25-19)
S_R = 57.9 mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = 57.9 mi/h (Equation 25-15)

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	3/25/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-90	
Analysis Period/Year	AM 2010	Junction	WB Haines on	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☑ Yes ☐ On

☐ No ☑ Off

L_{up} = 2500 ft

V_u = 110 veh/h

Freeway terrain: Rolling

Ramp terrain: Rolling

Ramp Type

☑ Merge ☐ Diverge

☑ Right side ☐ Left side

Number of freeway lanes: 2

Number of ramp lanes: 1

Length of ramp roadway: 1170 ft

S_{FF} = 65.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☑ Yes ☐ On

☐ No ☑ Off

L_{down} = 2220 ft

V_D = 530 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				1130	0.92	5	☐ 0.930	☐ 1.00	1320
v_R				100	0.92	5	☐ 0.930	☐ 1.00	117
v_U				110	0.92	5	☐ 0.930	☐ 1.00	129
v_D				530	0.92	5	☐ 0.930	☐ 1.00	619

Merge Areas

Estimation of v_{12}

$$v_{12} = v_F * P_{FM}$$

L_{EQ} = _____ (Equation 25-2 or 25-3)

P_{FM} = 1.000 using Equation _____ (Exhibit 25-5)

v_{12} = 1320 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	1437	See Exhibit 25-7	
v_{R12}	1437	4600: All	

Level-of-Service Determination (if not F)

$$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$$

D_R = 9.3 pc/mi/ln

LOS = A (Exhibit 25-4)

Speed Estimation

M_s = 0.232 (Exhibit 25-19)

S_R = 59.7 mi/h (Exhibit 25-19)

S_O = _____ mi/h (Exhibit 25-19)

S = 59.7 mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$$v_{12} = v_R + (v_F - v_R)P_{FD}$$

L_{EQ} = _____ (Equation 25-8 or 25-9)

P_{FD} = _____ using Equation _____ (Exhibit 25-12)

v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$		See Exhibit 25-14	
v_{12}		4400: All	
$v_{FO} = v_F - v_R$		See Exhibit 25-14	
v_R		See Exhibit 25-3	

Level-of-Service Determination (if not F)

$$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$$

D_R = _____ pc/mi/ln

LOS = _____ (Exhibit 25-4)

Speed Estimation

D_s = _____ (Exhibit 25-19)

S_R = _____ mi/h (Exhibit 25-19)

S_O = _____ mi/h (Exhibit 25-19)

S = _____ mi/h (Equation 25-15)

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	3/25/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-90	
Analysis Period/Year	AM 2010	Junction	WB 190 off	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☑ Yes ☑ On
☐ No ☐ Off
L_{up} = 2220 ft
V_u = 190 veh/h

Freeway terrain: Rolling
Ramp terrain: Rolling

Ramp Type
☐ Merge ☑ Diverge
☑ Right side ☐ Left side

Number of freeway lanes: 3
Number of ramp lanes: 1
Length of ramp roadway: 2690 ft

S_{FF} = 65.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☑ Yes ☑ On
☐ No ☐ Off
L_{down} = 2070 ft
V_D = 270 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				1320	0.92	5	☐ 0.930	☐ 1.00	1542
v_R				530	0.92	5	☐ 0.930	☐ 1.00	619
v_U				190	0.92	5	☐ 0.930	☐ 1.00	222
v_D				270	0.92	5	☐ 0.930	☐ 1.00	315

Merge Areas

Estimation of v_{12}

$$v_{12} = v_F * P_{FM}$$

L_{EQ} = _____ (Equation 25-2 or 25-3)
P_{FM} = _____ using Equation _____ (Exhibit 25-5)
v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}		See Exhibit 25-7	
v_{R12}		4600: All	

Level-of-Service Determination (if not F)

$$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$$

D_R = _____ pc/mi/ln
LOS = _____ (Exhibit 25-4)

Speed Estimation

M_s = _____ (Exhibit 25-19)
S_R = _____ mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = _____ mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$$v_{12} = v_R + (v_F - v_R)P_{FD}$$

L_{EQ} = 3737 (Equation 25-8 or 25-9)
P_{FD} = 0.717 using Equation 6 (Exhibit 25-12)
v_{12} = 1281 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$	1542	See Exhibit 25-14	
v_{12}	1281	4400: All	
$v_{FO} = v_F - v_R$	923	See Exhibit 25-14	
v_R	530	See Exhibit 25-3	

Level-of-Service Determination (if not F)

$$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$$

D_R = -8.9 pc/mi/ln
LOS = A (Exhibit 25-4)

Speed Estimation

D_s = 0.354 (Exhibit 25-19)
S_R = 56.9 mi/h (Exhibit 25-19)
S_O = 71.3 mi/h (Exhibit 25-19)
S = 58.9 mi/h (Equation 25-15)

©Catalina Engineering, Inc.

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	3/25/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-90	
Analysis Period/Year	AM 2010	Junction	WB 190 on	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☑ Yes ☐ On
☐ No ☑ Off
L_{up} = 2070 ft
V_u = 530 veh/h

Freeway terrain: Rolling
Ramp terrain: Rolling

Ramp Type
☑ Merge ☐ Diverge
☑ Right side ☐ Left side
Number of freeway lanes: 2
Number of ramp lanes: 1
Length of ramp roadway: 4410 ft

S_{FF} = 65.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☐ Yes ☐ On
☑ No ☐ Off
L_{down} = _____ ft
V_D = _____ veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				790	0.92	5	☐ 0.930	☐ 1.00	923
v_R				270	0.92	5	☐ 0.930	☐ 1.00	315
v_U				530	0.92	5	☐ 0.930	☐ 1.00	619
v_D							☐ 0.976	☐ 1.00	

Merge Areas

Estimation of v_{12}

$v_{12} = v_F * P_{FM}$

L_{EQ} = _____ (Equation 25-2 or 25-3)
P_{FM} = 1.000 using Equation _____ (Exhibit 25-5)
v_{12} = 923 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	1239	See Exhibit 25-7	
v_{R12}	1239	4600: All	

Level-of-Service Determination (if not F)

$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$

D_R = -12.7 pc/mi/ln
LOS = A (Exhibit 25-4)

Speed Estimation

M_s = -0.062 (Exhibit 25-19)
S_R = 66.4 mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = 66.4 mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$v_{12} = v_R + (v_F - v_R)P_{FD}$

L_{EQ} = _____ (Equation 25-8 or 25-9)
P_{FD} = _____ using Equation _____ (Exhibit 25-12)
v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$		See Exhibit 25-14	
v_{12}		4400: All	
$v_{FO} = v_F - v_R$		See Exhibit 25-14	
v_R		See Exhibit 25-3	

Level-of-Service Determination (if not F)

$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$

D_R = _____ pc/mi/ln
LOS = _____ (Exhibit 25-4)

Speed Estimation

D_s = _____ (Exhibit 25-19)
S_R = _____ mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = _____ mi/h (Equation 25-15)

©Catalina Engineering, Inc.

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	3/25/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-190	
Analysis Period/Year	AM 2010	Junction	NB Silver off	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☐ Yes ☐ On
☑ No ☐ Off
L_{up} = _____ ft
V_u = _____ veh/h

Freeway terrain: Specific grade
Ramp terrain: Specific grade

Ramp Type
☐ Merge ☑ Diverge
☑ Right side ☐ Left side
Number of freeway lanes: 2
Number of ramp lanes: 1
Length of ramp roadway: 410 ft

S_{FF} = 55.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☑ Yes ☑ On
☐ No ☐ Off
L_{down} = 4470 ft
V_D = 100 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				970	0.92	5	☐ 0.976	☐ 1.00	1081
v_R				410	0.92	5	☐ 0.976	☐ 1.00	457
v_U							☐ 0.976	☐ 1.00	
v_D				100	0.92	5	☐ 0.930	☐ 1.00	117

Merge Areas

Estimation of v_{12}

$$v_{12} = v_F * P_{FM}$$

L_{EQ} = _____ (Equation 25-2 or 25-3)
P_{FM} = _____ using Equation _____ (Exhibit 25-5)
v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}		See Exhibit 25-7	
v_{R12}		4600: All	

Level-of-Service Determination (if not F)

$$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$$

D_R = _____ pc/mi/ln
LOS = _____ (Exhibit 25-4)

Speed Estimation

M_s = _____ (Exhibit 25-19)
S_R = _____ mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = _____ mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$$v_{12} = v_R + (v_F - v_R)P_{FD}$$

L_{EQ} = _____ (Equation 25-8 or 25-9)
P_{FD} = 1.000 using Equation _____ (Exhibit 25-12)
v_{12} = 1081 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$	1081	See Exhibit 25-14	
v_{12}	1081	4400: All	
$v_{FO} = v_F - v_R$	624	See Exhibit 25-14	
v_R	410	See Exhibit 25-3	

Level-of-Service Determination (if not F)

$$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$$

D_R = 9.9 pc/mi/ln
LOS = A (Exhibit 25-4)

Speed Estimation

D_s = 0.339 (Exhibit 25-19)
S_R = 50.6 mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = 50.6 mi/h (Equation 25-15)

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	3/25/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-190	
Analysis Period/Year	AM 2010	Junction	NB Anamosa on	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☑ Yes ☐ On
☐ No ☑ Off
L_{up} = 4470 ft
V_u = 410 veh/h

Freeway terrain: Rolling
Ramp terrain: Rolling

Ramp Type
☑ Merge ☐ Diverge
☑ Right side ☐ Left side
Number of freeway lanes: 2
Number of ramp lanes: 1
Length of ramp roadway: 470 ft

S_{FF} = 55.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☑ Yes ☐ On
☐ No ☑ Off
L_{down} = 1200 ft
V_D = 390 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				560	0.92	5	☐ 0.930	☐ 1.00	654
v_R				100	0.92	5	☐ 0.930	☐ 1.00	117
v_U				410	0.92	5	☐ 0.930	☐ 1.00	479
v_D				390	0.92	5	☐ 0.930	☐ 1.00	456

Merge Areas

Estimation of v_{12}

$v_{12} = v_F * P_{FM}$

L_{EQ} = _____ (Equation 25-2 or 25-3)
P_{FM} = 1.000 using Equation _____ (Exhibit 25-5)
v_{12} = 654 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	771	See Exhibit 25-7	
v_{R12}	771	4600: All	

Level-of-Service Determination (if not F)

$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$

D_R = 8.5 pc/mi/ln
LOS = A (Exhibit 25-4)

Speed Estimation

M_s = 0.287 (Exhibit 25-19)
S_R = 51.3 mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = 51.3 mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$v_{12} = v_R + (v_F - v_R)P_{FD}$

L_{EQ} = _____ (Equation 25-8 or 25-9)
P_{FD} = _____ using Equation _____ (Exhibit 25-12)
v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$		See Exhibit 25-14	
v_{12}		4400: All	
$v_{FO} = v_F - v_R$		See Exhibit 25-14	
v_R		See Exhibit 25-3	

Level-of-Service Determination (if not F)

$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$

D_R = _____ pc/mi/ln
LOS = _____ (Exhibit 25-4)

Speed Estimation

D_s = _____ (Exhibit 25-19)
S_R = _____ mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = _____ mi/h (Equation 25-15)

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	3/25/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-190	
Analysis Period/Year	AM 2010	Junction	NB 90 off	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☑ Yes ☑ On

☐ No ☐ Off

L_{up} = 1200 ft

V_u = 100 veh/h

Freeway terrain: Rolling

Ramp terrain: Rolling

Ramp Type

☐ Merge ☑ Diverge

☑ Right side ☐ Left side

Number of freeway lanes: 2

Number of ramp lanes: 1

Length of ramp roadway: 1570 ft

S_{FF} = 55.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☐ Yes ☐ On

☑ No ☐ Off

L_{down} = _____ ft

V_D = _____ veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				660	0.92	5	☐ 0.930	☐ 1.00	771
v_R				390	0.92	5	☐ 0.930	☐ 1.00	456
v_U				100	0.92	5	☐ 0.930	☐ 1.00	117
v_D							☐ 0.976	☐ 1.00	

Merge Areas

Estimation of v_{12}

$$v_{12} = v_F * P_{FM}$$

L_{EQ} = _____ (Equation 25-2 or 25-3)

P_{FM} = _____ using Equation _____ (Exhibit 25-5)

v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}		See Exhibit 25-7	
v_{R12}		4600: All	

Level-of-Service Determination (if not F)

$$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$$

D_R = _____ pc/mi/ln

LOS = _____ (Exhibit 25-4)

Speed Estimation

M_s = _____ (Exhibit 25-19)

S_R = _____ mi/h (Exhibit 25-19)

S_O = _____ mi/h (Exhibit 25-19)

S = _____ mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$$v_{12} = v_R + (v_F - v_R)P_{FD}$$

L_{EQ} = _____ (Equation 25-8 or 25-9)

P_{FD} = 1.000 using Equation _____ (Exhibit 25-12)

v_{12} = 771 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$	771	See Exhibit 25-14	
v_{12}	771	4400: All	
$v_{FO} = v_F - v_R$	315	See Exhibit 25-14	
v_R	390	See Exhibit 25-3	

Level-of-Service Determination (if not F)

$$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$$

D_R = -3.2 pc/mi/ln

LOS = A (Exhibit 25-4)

Speed Estimation

D_s = 0.339 (Exhibit 25-19)

S_R = 50.6 mi/h (Exhibit 25-19)

S_O = _____ mi/h (Exhibit 25-19)

S = 50.6 mi/h (Equation 25-15)

©Catalina Engineering, Inc.

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	3/25/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-190	
Analysis Period/Year	AM 2010	Junction	SB 90 on	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☐ Yes ☐ On

☑ No ☐ Off

L_{up} = _____ ft

V_u = _____ veh/h

Freeway terrain: Rolling

Ramp terrain: Rolling

Ramp Type

☑ Merge ☐ Diverge

☑ Right side ☐ Left side

Number of freeway lanes: 2

Number of ramp lanes: 1

Length of ramp roadway: 1340 ft

S_{FF} = 55.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☑ Yes ☐ On

☐ No ☑ Off

L_{down} = 3920 ft

V_D = 160 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				530	0.92	5	☐ 0.930	☐ 1.00	619
v_R				330	0.92	5	☐ 0.930	☐ 1.00	386
v_U							☐ 0.976	☐ 1.00	
v_D				160	0.92	5	☐ 0.930	☐ 1.00	187

Merge Areas

Estimation of v_{12}

$$v_{12} = v_F * P_{FM}$$

L_{EQ} = _____ (Equation 25-2 or 25-3)

P_{FM} = 1.000 using Equation _____ (Exhibit 25-5)

v_{12} = 619 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	1005	See Exhibit 25-7	
v_{R12}	1005	4600: All	

Level-of-Service Determination (if not F)

$$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$$

D_R = 4.7 pc/mi/ln

LOS = A (Exhibit 25-4)

Speed Estimation

M_s = 0.211 (Exhibit 25-19)

S_R = 52.3 mi/h (Exhibit 25-19)

S_O = _____ mi/h (Exhibit 25-19)

S = 52.3 mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$$v_{12} = v_R + (v_F - v_R)P_{FD}$$

L_{EQ} = _____ (Equation 25-8 or 25-9)

P_{FD} = _____ using Equation _____ (Exhibit 25-12)

v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$		See Exhibit 25-14	
v_{12}		4400: All	
$v_{FO} = v_F - v_R$		See Exhibit 25-14	
v_R		See Exhibit 25-3	

Level-of-Service Determination (if not F)

$$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$$

D_R = _____ pc/mi/ln

LOS = _____ (Exhibit 25-4)

Speed Estimation

D_s = _____ (Exhibit 25-19)

S_R = _____ mi/h (Exhibit 25-19)

S_O = _____ mi/h (Exhibit 25-19)

S = _____ mi/h (Equation 25-15)

©Catalina Engineering, Inc.

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	3/25/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-190	
Analysis Period/Year	AM 2010	Junction	SB Silver off	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☑ Yes ☑ On
☐ No ☐ Off
L_{up} = 3920 ft
V_u = 330 veh/h

Freeway terrain: Rolling
Ramp terrain: Rolling

Ramp Type
☐ Merge ☑ Diverge
☑ Right side ☐ Left side

Number of freeway lanes: 2
Number of ramp lanes: 1
Length of ramp roadway: 1340 ft

S_{FF} = 55.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☑ Yes ☑ On
☐ No ☐ Off
L_{down} = 2580 ft
V_D = 280 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				860	0.92	5	☐ 0.930	☐ 1.00	1005
v_R				160	0.92	5	☐ 0.930	☐ 1.00	187
v_U				330	0.92	5	☐ 0.930	☐ 1.00	386
v_D				280	0.92	5	☐ 0.930	☐ 1.00	327

Merge Areas

Estimation of v_{12}

$$v_{12} = v_F * P_{FM}$$

L_{EQ} = _____ (Equation 25-2 or 25-3)
P_{FM} = _____ using Equation _____ (Exhibit 25-5)
v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}		See Exhibit 25-7	
v_{R12}		4600: All	

Level-of-Service Determination (if not F)

$$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$$

D_R = _____ pc/mi/ln
LOS = _____ (Exhibit 25-4)

Speed Estimation

M_s = _____ (Exhibit 25-19)
S_R = _____ mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = _____ mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$$v_{12} = v_R + (v_F - v_R)P_{FD}$$

L_{EQ} = _____ (Equation 25-8 or 25-9)
P_{FD} = 1.000 using Equation _____ (Exhibit 25-12)
v_{12} = 1005 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$	1005	See Exhibit 25-14	
v_{12}	1005	4400: All	
$v_{FO} = v_F - v_R$	818	See Exhibit 25-14	
v_R	160	See Exhibit 25-3	

Level-of-Service Determination (if not F)

$$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$$

D_R = 0.8 pc/mi/ln
LOS = A (Exhibit 25-4)

Speed Estimation

D_s = 0.315 (Exhibit 25-19)
S_R = 50.9 mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = 50.9 mi/h (Equation 25-15)

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	3/25/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-190	
Analysis Period/Year	AM 2010	Junction	SB Silver on	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☑ Yes ☐ On
☐ No ☑ Off
L_{up} = 2580 ft
V_u = 160 veh/h

Freeway terrain: Rolling
Ramp terrain: Rolling

Ramp Type
☑ Merge ☐ Diverge
☑ Right side ☐ Left side
Number of freeway lanes: 2
Number of ramp lanes: 1
Length of ramp roadway: 1340 ft

S_{FF} = 55.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☐ Yes ☐ On
☑ No ☐ Off
L_{down} = _____ ft
V_D = _____ veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				700	0.92	5	☐ 0.930	☐ 1.00	818
v_R				280	0.92	5	☐ 0.930	☐ 1.00	327
v_U				160	0.92	5	☐ 0.930	☐ 1.00	187
v_D							☐ 0.976	☐ 1.00	

Merge Areas

Estimation of v_{12}

$v_{12} = v_F * P_{FM}$

L_{EQ} = _____ (Equation 25-2 or 25-3)
P_{FM} = 1.000 using Equation _____ (Exhibit 25-5)
v_{12} = 818 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	1145	See Exhibit 25-7	
v_{R12}	1145	4600: All	

Level-of-Service Determination (if not F)

$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$

D_R = 5.9 pc/mi/ln
LOS = A (Exhibit 25-4)

Speed Estimation

M_s = 0.213 (Exhibit 25-19)
S_R = 52.2 mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = 52.2 mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$v_{12} = v_R + (v_F - v_R)P_{FD}$

L_{EQ} = _____ (Equation 25-8 or 25-9)
P_{FD} = _____ using Equation _____ (Exhibit 25-12)
v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$		See Exhibit 25-14	
v_{12}		4400: All	
$v_{FO} = v_F - v_R$		See Exhibit 25-14	
v_R		See Exhibit 25-3	

Level-of-Service Determination (if not F)

$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$

D_R = _____ pc/mi/ln
LOS = _____ (Exhibit 25-4)

Speed Estimation

D_s = _____ (Exhibit 25-19)
S_R = _____ mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = _____ mi/h (Equation 25-15)

©Catalina Engineering, Inc.

CHAPTER 24 - FREEWAY WEAVING WORKSHEET

General Information

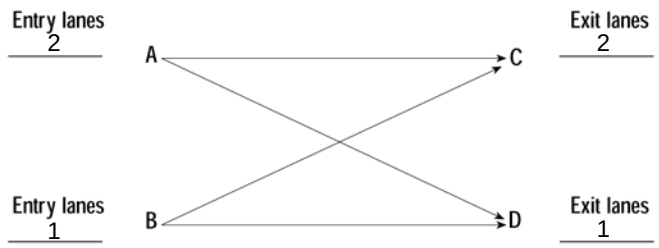
Analyst	Laughlin
Agency or Company	HDR
Analysis Period/Year	AM 2010
Comment	Comments

Site Information

Jurisdiction/Date	Jurisdiction 3/25/2010
Freeway/Direction of Travel	I-190
Weaving Segment Location	Anamosa NB

☑ Operational (LOS) ❑ Design (N, L, Type) ❑ Planning (LOS) ❑ Planning (N, L, Type)

Inputs



Driver type from A ☑ Commuter/weekday ❑ Recreational/weekend

Driver type from B ☑ Commuter/weekday ❑ Recreational/weekend

Freeway free-flow speed, S_{FF} =	55	mi/h
Weaving number of lanes, N =	3	
Weaving segment length, L	1200	ft
Freeway terrain	❑ Level	☑ Rolling
Ramp terrain	❑ Level	☑ Rolling
Weaving type	☑ Type A	❑ Type B ❑ Type C
Volume ratio, $VR = \frac{v_w}{v}$	0.566	
Weaving ratio, $R = \frac{v_{w2}}{v_w}$	0.093	

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D	V (veh/h)	PHF	% HV	f_{HV} Field data if checked	f_p Field data if checked	$v = \frac{V}{PHF * f_{HV} * f_p}$
v_{AC}				270	0.92	5	❑ 0.930	❑ 1.00	315
v_{BD}				60	0.92	5	❑ 0.930	❑ 1.00	70
v_{AD}				390	0.92	5	❑ 0.930	❑ 1.00	456
v_{BC}				40	0.92	5	❑ 0.930	❑ 1.00	47
v_w									502
v_{nw}									386
v									888

Weaving and Nonweaving Speeds

	Unconstrained		Constrained	
	Weaving (i = w)	Nonweaving (i = nw)	Weaving (i = w)	Nonweaving (i = nw)
a (Exhibit 24-6)	0.15	48.4	0.35	39.9
b (Exhibit 24-6)	2.2	4.0	2.2	4.0
c (Exhibit 24-6)	0.97	1.3	0.97	1.3
d (Exhibit 24-6)	0.80	0.75	0.80	0.75
Weaving intensity factor, W_i $W_i = \frac{a(1 + VR)^b (v/N)^c}{(L)^d}$	0.345	0.168	0.806	0.096
Weaving and nonweaving speeds, S_i (mi/h) $S_i = 15 + \frac{S_{FF} - 10}{1 + W_i}$	48.4	53.51	39.9	56.05

Number of lanes required for unconstrained operation, N_w (Exhibit 24-7) 1.54

Maximum number of lanes, N_w(max) (Exhibit 24-7) 1.40

❑ If $N_w < N_w$(max) unconstrained operation ☑ If $N_w \geq N_w$(max) constrained operation

Weaving Segment Speed, Density, Level of Service, and Capacity

Weaving segment speed, S (mi/h) $S = \frac{v}{\left(\frac{v_w}{S_w}\right) + \left(\frac{v_{nw}}{S_{nw}}\right)}$	45.6
Weaving segment density, D (pc/mi/ln) $D = \frac{v/N}{S}$	6.5
Level of service, LOS (Exhibit 24-2)	A
Capacity for base condition, c_b (pc/h) (Exhibit 24-8)	3934
Capacity as a 15-min flow rate, c (veh/h) $c = c_b * f_{HV} * f_p$	3660
Capacity as a full-hour volume, c_h (veh/h) $c_h = c(PHF)$	3367

©Catalina Engineering, Inc.

CHAPTER 24 - FREEWAY WEAVING WORKSHEET

General Information

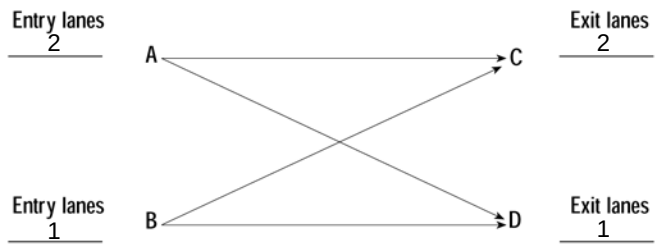
Analyst	Laughlin
Agency or Company	HDR
Analysis Period/Year	AM 2010
Comment	Comments

Site Information

Jurisdiction/Date	Jurisdiction 3/25/2010
Freeway/Direction of Travel	I-90
Weaving Segment Location	I-190 to Haines EB

☑ Operational (LOS) ❑ Design (N, L, Type) ❑ Planning (LOS) ❑ Planning (N, L, Type)

Inputs



Driver type from A ☑ Commuter/weekday ❑ Recreational/weekend

Driver type from B ☑ Commuter/weekday ❑ Recreational/weekend

Freeway free-flow speed, S_{FF} =	65	mi/h
Weaving number of lanes, N =	3	
Weaving segment length, L	730	ft
Freeway terrain	❑ Level	☑ Rolling
Ramp terrain	❑ Level	☑ Rolling
Weaving type	☑ Type A	❑ Type B ❑ Type C
Volume ratio, VR = $\frac{v_w}{v}$	0.743	
Weaving ratio, R = $\frac{v_{w2}}{v_w}$	0.423	

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D	V (veh/h)	PHF	% HV	f_{HV}	f_p	$v = \frac{V}{PHF * f_{HV} * f_p}$
							Field data if checked		
v_{AC}				90	0.92	5	❑ 0.930	❑ 1.00	105
v_{BD}				90	0.92	5	❑ 0.930	❑ 1.00	105
v_{AD}				300	0.92	5	❑ 0.930	❑ 1.00	351
v_{BC}				220	0.92	5	❑ 0.930	❑ 1.00	257
v_w									608
v_{nw}									210
v									818

Weaving and Nonweaving Speeds

	Unconstrained		Constrained	
	Weaving (i = w)	Nonweaving (i = nw)	Weaving (i = w)	Nonweaving (i = nw)
a (Exhibit 24-6)	0.15	49.4	0.35	37.9
b (Exhibit 24-6)	2.2	4.0	2.2	4.0
c (Exhibit 24-6)	0.97	1.3	0.97	1.3
d (Exhibit 24-6)	0.80	0.75	0.80	0.75
Weaving intensity factor, W_i $W_i = \frac{a(1 + VR)^b (v/N)^c}{(L)^d}$	0.601	0.337	1.402	0.193
Weaving and nonweaving speeds, S_i (mi/h) $S_i = 15 + \frac{S_{FF} - 10}{1 + W_i}$	49.4	56.13	37.9	61.11

Number of lanes required for unconstrained operation, N_w (Exhibit 24-7) 1.59

Maximum number of lanes, N_w(max) (Exhibit 24-7) 1.40

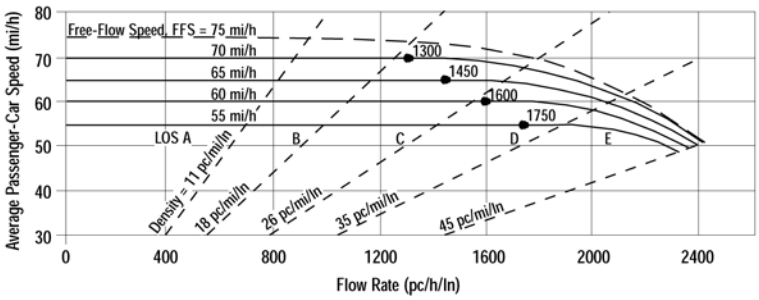
❑ If $N_w < N_w$(max) unconstrained operation ☑ If $N_w \geq N_w$(max) constrained operation

Weaving Segment Speed, Density, Level of Service, and Capacity

Weaving segment speed, S (mi/h) $S = \frac{v}{\left(\frac{v_w}{S_w}\right) + \left(\frac{v_{nw}}{S_{nw}}\right)}$	42.0
Weaving segment density, D (pc/mi/ln) $D = \frac{v/N}{S}$	6.5
Level of service, LOS (Exhibit 24-2)	A
Capacity for base condition, c_b (pc/h) (Exhibit 24-8)	3376
Capacity as a 15-min flow rate, c (veh/h) $c = c_b * f_{HV} * f_p$	3140
Capacity as a full-hour volume, c_h (veh/h) $c_h = c(PHF)$	2889

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: PM 2010
Comment: eastbound

Site Information

Jurisdiction/Date: Jurisdiction 3/25/2010
Highway/Direction of Travel: I-90
From/To: Deadwood on/I-190 off

☑ Oper. (LOS) ☐ Des. (N) ☐ Des. (v_p) ☐ Plan. (LOS) ☐ Plan. (N) ☐ Plan. (v_p)

Flow Inputs

Volume, V: 1170 veh/h
Annual avg. daily traffic, AADT: veh/day
Peak-hour proportion of AADT, K:
Peak-hour direction proportion, D:
DDHV = AADT x K x D: veh/h
Driver type: ☑ Commuter/Weekday ☐ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ☐ Level ☑ Rolling ☐ Mountainous
Grade Length: mi Up/Down: %

Calculate Flow Adjustments

f_p (☐ Field data?): 1.00
E_T (☐ Field data?): 2.5
E_R (☐ Field data?): 2.0
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.913

Speed Inputs

Lane width: ft
Rt-shoulder lat. clearance: ft
Interchange density: l/mi
Number of lanes, N: 2
FFS (measured): 65.0 mi/h
Base free-flow speed, BFFS: mi/h

Calculate Speed Adjustments and FFS

f_{LW} (☐ Field data?): mi/h
f_{LC} (☐ Field data?): mi/h
f_{ID} (☐ Field data?): mi/h
f_N (☐ Field data?): mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 696 pc/h/ln
S: 65.0 mi/h
$D = v_p/S$: 10.7 pc/i/ln
LOS: A

Design (v_p) or Planning (v_p)

LOS:
v_p: pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: veh/h
S: mi/h
$D = v_p/S$: pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
LOS:

Design (N) or Planning (N) 2nd Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
S: mi/h
$D = v_p/S$: pc/mi/ln
LOS:

Glossary

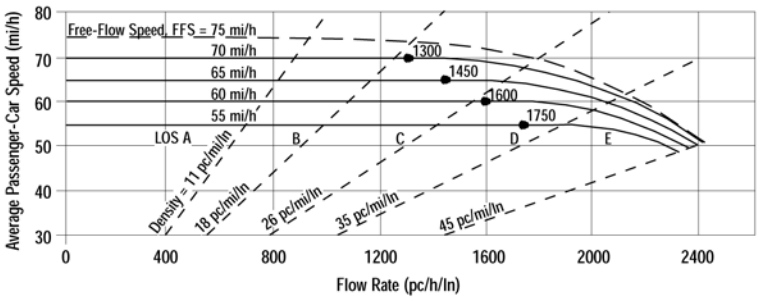
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: PM 2010
Comment: eastbound

Site Information

Jurisdiction/Date: Jurisdiction 3/25/2010
Highway/Direction of Travel: I-90
From/To: I-190 off/I-190 on

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 960 veh/h
Annual avg. daily traffic, AADT: ____ veh/day
Peak-hour proportion of AADT, K: ____
Peak-hour direction proportion, D: ____
DDHV = AADT x K x D: ____ veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.4 mi Up/Down: -2.0 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 1.5

E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.972

Speed Inputs

Lane width: ____ ft
Rt-shoulder lat. clearance: ____ ft
Interchange density: ____ I/mi
Number of lanes, N: 2
FFS (measured): 65.0 mi/h
Base free-flow speed, BFFS: ____ mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): ____ mi/h
f_{LC} (❑ Field data?): ____ mi/h
f_{ID} (❑ Field data?): ____ mi/h
f_N (❑ Field data?): ____ mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: ____ mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 537 pc/h/ln
S: 65.0 mi/h
$D = v_p/S$: 8.3 pc/i/ln
LOS: A

Design (v_p) or Planning (v_p)

LOS: ____
v_p: ____ pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: ____ veh/h
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
LOS: ____

Design (N) or Planning (N) 2nd Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln
LOS: ____

Glossary

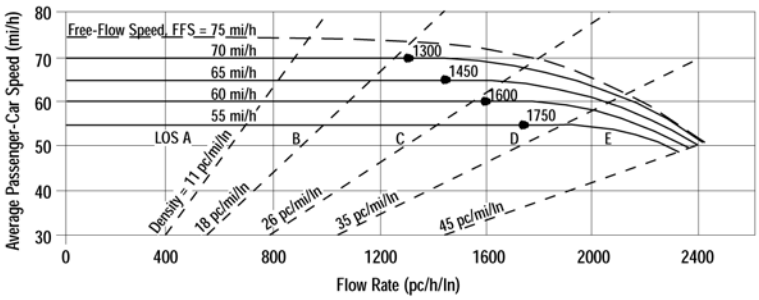
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: PM 2010
Comment: eastbound

Site Information

Jurisdiction/Date: Jurisdiction 3/25/2010
Highway/Direction of Travel: I-90
From/To: I-190 on/Haines off

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 1530 veh/h
Annual avg. daily traffic, AADT: veh/day
Peak-hour proportion of AADT, K:
Peak-hour direction proportion, D:
DDHV = AADT x K x D: veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.1 mi Up/Down: -2.0 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 1.5

E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.972

Speed Inputs

Lane width: ft
Rt-shoulder lat. clearance: ft
Interchange density: l/mi
Number of lanes, N: 3
FFS (measured): 65.0 mi/h
Base free-flow speed, BFFS: mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): mi/h
f_{LC} (❑ Field data?): mi/h
f_{ID} (❑ Field data?): mi/h
f_N (❑ Field data?): mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 570 pc/h/ln
S: 65.0 mi/h
$D = v_p/S$: 8.8 pc/i/ln
LOS: A

Design (v_p) or Planning (v_p)

LOS:
v_p: pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: veh/h
S: mi/h
$D = v_p/S$: pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
LOS:

Design (N) or Planning (N) 2nd Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
S: mi/h
$D = v_p/S$: pc/mi/ln
LOS:

Glossary

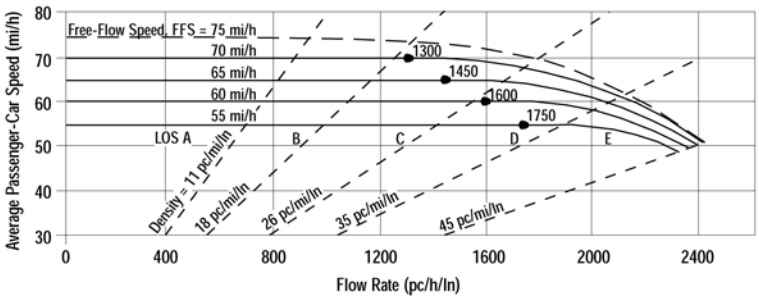
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: PM 2010
Comment: eastbound

Site Information

Jurisdiction/Date: Jurisdiction 3/25/2010
Highway/Direction of Travel: I-90
From/To: Haines off/Haines on

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 1000 veh/h
Annual avg. daily traffic, AADT: veh/day
Peak-hour proportion of AADT, K:
Peak-hour direction proportion, D:
DDHV = AADT x K x D: veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.4 mi Up/Down: 1.0 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 1.5

E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.972

Speed Inputs

Lane width: ft
Rt-shoulder lat. clearance: ft
Interchange density: l/mi
Number of lanes, N: 2
FFS (measured): 65.0 mi/h
Base free-flow speed, BFFS: mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): mi/h
f_{LC} (❑ Field data?): mi/h
f_{ID} (❑ Field data?): mi/h
f_N (❑ Field data?): mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 559 pc/h/ln
S: 65.0 mi/h
$D = v_p/S$: 8.6 pc/i/ln
LOS: A

Design (v_p) or Planning (v_p)

LOS:
v_p: pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: veh/h
S: mi/h
$D = v_p/S$: pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
LOS:

Design (N) or Planning (N) 2nd Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
S: mi/h
$D = v_p/S$: pc/mi/ln
LOS:

Glossary

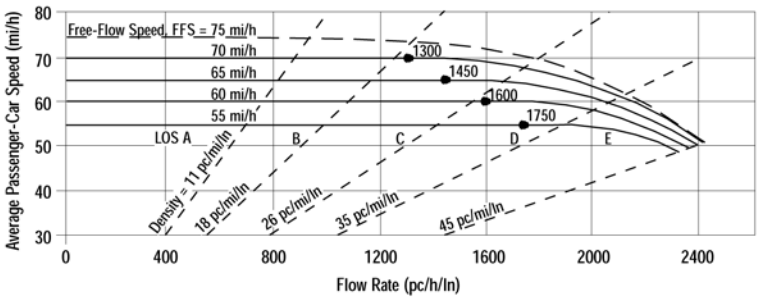
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: PM 2010
Comment: eastbound

Site Information

Jurisdiction/Date: Jurisdiction 3/25/2010
Highway/Direction of Travel: I-90
From/To: Haines on/Lacrosse off

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 1240 veh/h
Annual avg. daily traffic, AADT: ____ veh/day
Peak-hour proportion of AADT, K: ____
Peak-hour direction proportion, D: ____
DDHV = AADT x K x D: ____ veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain
❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.6 mi Up/Down: 1.0 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 1.5
E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.972

Speed Inputs

Lane width: ____ ft
Rt-shoulder lat. clearance: ____ ft
Interchange density: ____ I/mi
Number of lanes, N: 2
FFS (measured): 65.0 mi/h
Base free-flow speed, BFFS: ____ mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): ____ mi/h
f_{LC} (❑ Field data?): ____ mi/h
f_{ID} (❑ Field data?): ____ mi/h
f_N (❑ Field data?): ____ mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: ____ mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 693 pc/h/ln
S: 65.0 mi/h
$D = v_p/S$: 10.7 pc/i/ln
LOS: A

Design (v_p) or Planning (v_p)

LOS: ____
v_p: ____ pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: ____ veh/h
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
LOS: ____

Design (N) or Planning (N) 2nd Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln
LOS: ____

Glossary

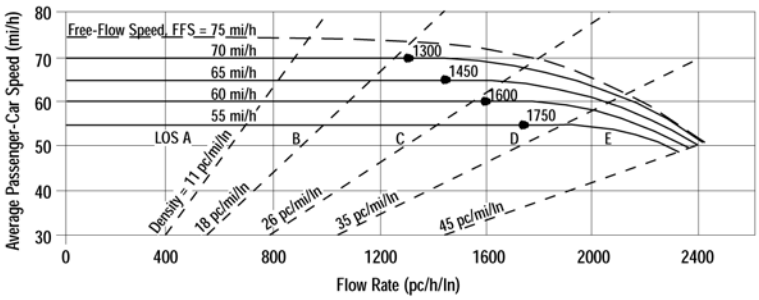
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: PM 2010
Comment: westbound

Site Information

Jurisdiction/Date: Jurisdiction 3/25/2010
Highway/Direction of Travel: I-90
From/To: Lacrosse on/Haines off

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V	1240 veh/h	Peak-hour factor, PHF	0.92
Annual avg. daily traffic, AADT	veh/day	% Trucks and buses, P_T	5
Peak-hour proportion of AADT, K		% RVs, P_R	2
Peak-hour direction proportion, D		General terrain	
DDHV = AADT x K x D	veh/h	❑ Level ❑ Rolling ❑ Mountainous	
Driver type	☑ Commuter/Weekday ❑ Recreational/Weekend	Grade Length	0.5 mi Up/Down 0.1 %

Calculate Flow Adjustments

f_p (❑ Field data?)	1.00	E_R (❑ Field data?)	1.2
E_T (❑ Field data?)	1.5	$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$	0.972

Speed Inputs

Lane width	ft
Rt-shoulder lat. clearance	ft
Interchange density	l/mi
Number of lanes, N	2
FFS (measured)	65.0 mi/h
Base free-flow speed, BFFS	mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?)	mi/h
f_{LC} (❑ Field data?)	mi/h
f_{ID} (❑ Field data?)	mi/h
f_N (❑ Field data?)	mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N	mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$	693 pc/h/ln
S	65.0 mi/h
$D = v_p/S$	10.7 pc/i/ln
LOS	A

Design (v_p) or Planning (v_p)

LOS	
v_p	pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$	veh/h
S	mi/h
$D = v_p/S$	pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N	assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$	pc/h/ln
LOS	

Design (N) or Planning (N) 2nd Iteration

N	assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$	pc/h/ln
S	mi/h
$D = v_p/S$	pc/mi/ln
LOS	

Glossary

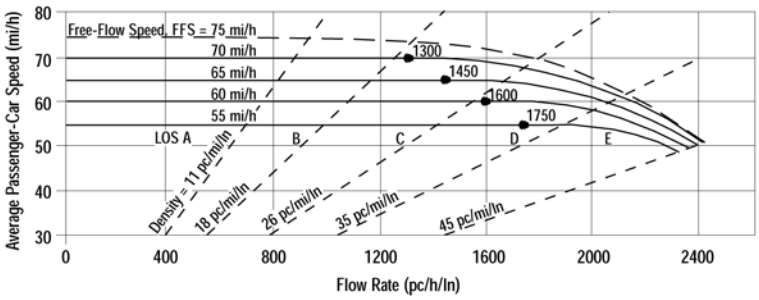
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: PM 2010
Comment: westbound

Site Information

Jurisdiction/Date: Jurisdiction 3/25/2010
Highway/Direction of Travel: I-90
From/To: Haines off/Haines on

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 1030 veh/h
Annual avg. daily traffic, AADT: ____ veh/day
Peak-hour proportion of AADT, K: ____
Peak-hour direction proportion, D: ____
DDHV = AADT x K x D: ____ veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.5 mi Up/Down: 0.1 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 1.5

E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.972

Speed Inputs

Lane width: ____ ft
Rt-shoulder lat. clearance: ____ ft
Interchange density: ____ I/mi
Number of lanes, N: 2
FFS (measured): 65.0 mi/h
Base free-flow speed, BFFS: ____ mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): ____ mi/h
f_{LC} (❑ Field data?): ____ mi/h
f_{ID} (❑ Field data?): ____ mi/h
f_N (❑ Field data?): ____ mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: ____ mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 576 pc/h/ln
S: 65.0 mi/h
$D = v_p/S$: 8.9 pc/i/ln
LOS: A

Design (v_p) or Planning (v_p)

LOS: ____
v_p: ____ pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: ____ veh/h
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
LOS: ____

Design (N) or Planning (N) 2nd Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln
LOS: ____

Glossary

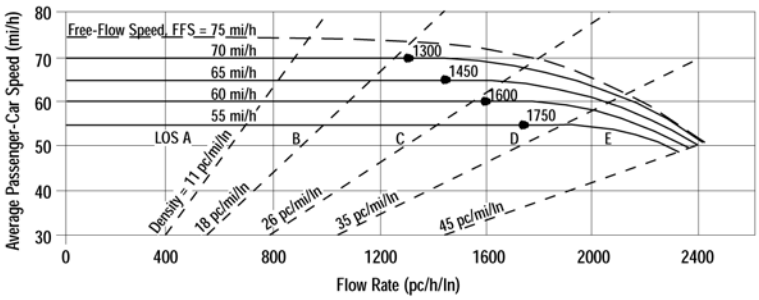
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: PM 2010
Comment: westbound

Site Information

Jurisdiction/Date: Jurisdiction 3/25/2010
Highway/Direction of Travel: I-90
From/To: Haines on/I-190 off

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 1490 veh/h
Annual avg. daily traffic, AADT: veh/day
Peak-hour proportion of AADT, K:
Peak-hour direction proportion, D:
DDHV = AADT x K x D: veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.4 mi Up/Down: 2.0 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 1.5

E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.972

Speed Inputs

Lane width: ft
Rt-shoulder lat. clearance: ft
Interchange density: l/mi
Number of lanes, N: 3
FFS (measured): 65.0 mi/h
Base free-flow speed, BFFS: mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): mi/h
f_{LC} (❑ Field data?): mi/h
f_{ID} (❑ Field data?): mi/h
f_N (❑ Field data?): mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 556 pc/h/ln
S: 65.0 mi/h
$D = v_p/S$: 8.5 pc/i/ln
LOS: A

Design (v_p) or Planning (v_p)

LOS:
v_p: pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: veh/h
S: mi/h
$D = v_p/S$: pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
LOS:

Design (N) or Planning (N) 2nd Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
S: mi/h
$D = v_p/S$: pc/mi/ln
LOS:

Glossary

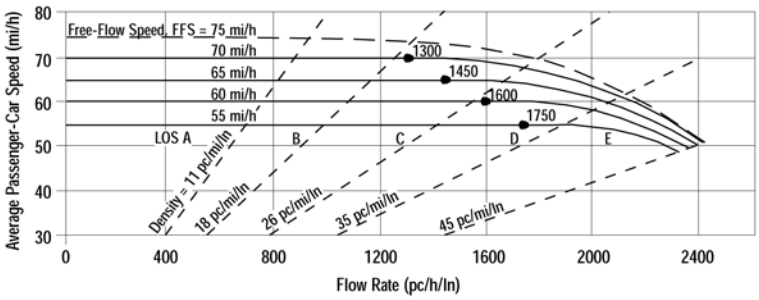
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: PM 2010
Comment: westbound

Site Information

Jurisdiction/Date: Jurisdiction 3/25/2010
Highway/Direction of Travel: I-90
From/To: I-190 off/I-190 on

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 1020 veh/h
Annual avg. daily traffic, AADT: ____ veh/day
Peak-hour proportion of AADT, K: ____
Peak-hour direction proportion, D: ____
DDHV = AADT x K x D: ____ veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.4 mi Up/Down: 2.0 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 1.5
E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.972

Speed Inputs

Lane width: ____ ft
Rt-shoulder lat. clearance: ____ ft
Interchange density: ____ I/mi
Number of lanes, N: 2
FFS (measured): 65.0 mi/h
Base free-flow speed, BFFS: ____ mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): ____ mi/h
f_{LC} (❑ Field data?): ____ mi/h
f_{ID} (❑ Field data?): ____ mi/h
f_N (❑ Field data?): ____ mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: ____ mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 570 pc/h/ln
S: 65.0 mi/h
$D = v_p/S$: 8.8 pc/i/ln
LOS: A

Design (v_p) or Planning (v_p)

LOS: ____
v_p: ____ pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: ____ veh/h
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
LOS: ____

Design (N) or Planning (N) 2nd Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln
LOS: ____

Glossary

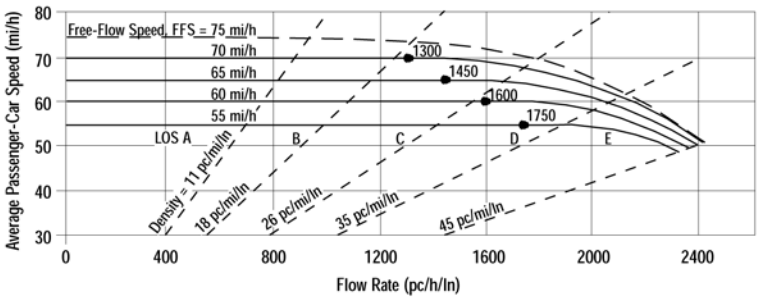
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: PM 2010
Comment: westbound

Site Information

Jurisdiction/Date: Jurisdiction 3/25/2010
Highway/Direction of Travel: I-90
From/To: I-190 on/Deadwood off

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V	1420 veh/h	Peak-hour factor, PHF	0.92
Annual avg. daily traffic, AADT	veh/day	% Trucks and buses, P_T	5
Peak-hour proportion of AADT, K		% RVs, P_R	2
Peak-hour direction proportion, D		General terrain	
DDHV = AADT x K x D	veh/h	❑ Level ☑ Rolling ❑ Mountainous	
Driver type	☑ Commuter/Weekday ❑ Recreational/Weekend	Grade Length	mi Up/Down %

Calculate Flow Adjustments

f_p (❑ Field data?)	1.00	E_R (❑ Field data?)	2.0
E_T (❑ Field data?)	2.5	$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$	0.913

Speed Inputs

Lane width	ft
Rt-shoulder lat. clearance	ft
Interchange density	l/mi
Number of lanes, N	2
FFS (measured)	65.0 mi/h
Base free-flow speed, BFFS	mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?)	mi/h
f_{LC} (❑ Field data?)	mi/h
f_{ID} (❑ Field data?)	mi/h
f_N (❑ Field data?)	mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N	mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$	845 pc/h/ln
S	65.0 mi/h
$D = v_p/S$	13.0 pc/i/ln
LOS	B

Design (v_p) or Planning (v_p)

LOS	
v_p	pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$	veh/h
S	mi/h
$D = v_p/S$	pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N	assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$	pc/h/ln
LOS	

Design (N) or Planning (N) 2nd Iteration

N	assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$	pc/h/ln
S	mi/h
$D = v_p/S$	pc/mi/ln
LOS	

Glossary

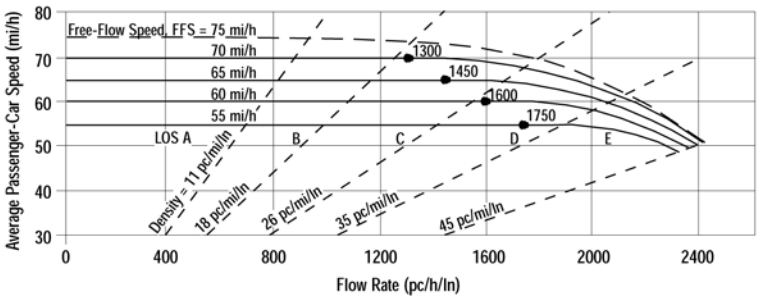
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: PM 2010
Comment: northbound

Site Information

Jurisdiction/Date: Jurisdiction 3/25/2010
Highway/Direction of Travel: I-190
From/To: Omaha St./Silver St. off

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 1050 veh/h
Annual avg. daily traffic, AADT: veh/day
Peak-hour proportion of AADT, K:
Peak-hour direction proportion, D:
DDHV = AADT x K x D: veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.1 mi Up/Down: 0.2 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 1.5
E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.972

Speed Inputs

Lane width: ft
Rt-shoulder lat. clearance: ft
Interchange density: l/mi
Number of lanes, N: 2
FFS (measured): 55.0 mi/h
Base free-flow speed, BFFS: mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): mi/h
f_{LC} (❑ Field data?): mi/h
f_{ID} (❑ Field data?): mi/h
f_N (❑ Field data?): mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 587 pc/h/ln
S: 55.0 mi/h
$D = v_p/S$: 10.7 pc/i/ln
LOS: A

Design (v_p) or Planning (v_p)

LOS:
v_p: pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: veh/h
S: mi/h
$D = v_p/S$: pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
LOS:

Design (N) or Planning (N) 2nd Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
S: mi/h
$D = v_p/S$: pc/mi/ln
LOS:

Glossary

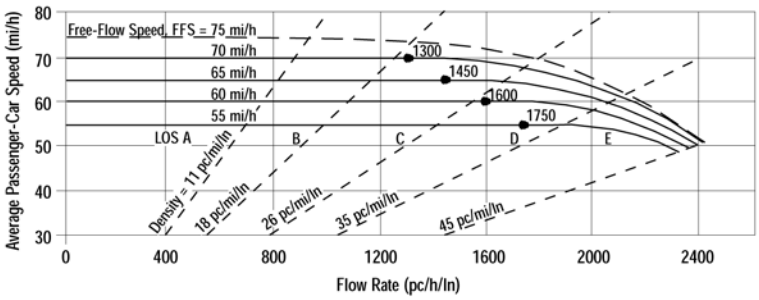
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: PM 2010
Comment: northbound

Site Information

Jurisdiction/Date: Jurisdiction 3/25/2010
Highway/Direction of Travel: I-190
From/To: Silver St. off/Anamosa on

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 820 veh/h
Annual avg. daily traffic, AADT: ____ veh/day
Peak-hour proportion of AADT, K: ____
Peak-hour direction proportion, D: ____
DDHV = AADT x K x D: ____ veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.9 mi Up/Down: 2.0 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 2.0

E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.949

Speed Inputs

Lane width: ____ ft
Rt-shoulder lat. clearance: ____ ft
Interchange density: ____ I/mi
Number of lanes, N: 2
FFS (measured): 55.0 mi/h
Base free-flow speed, BFFS: ____ mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): ____ mi/h
f_{LC} (❑ Field data?): ____ mi/h
f_{ID} (❑ Field data?): ____ mi/h
f_N (❑ Field data?): ____ mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: ____ mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 470 pc/h/ln
S: 55.0 mi/h
$D = v_p/S$: 8.5 pc/i/ln
LOS: A

Design (v_p) or Planning (v_p)

LOS: ____
v_p: ____ pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: ____ veh/h
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
LOS: ____

Design (N) or Planning (N) 2nd Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln
LOS: ____

Glossary

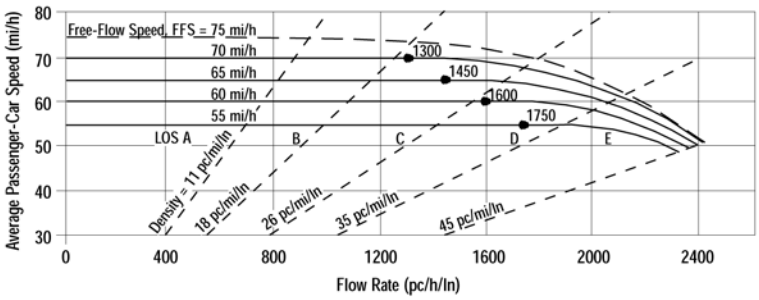
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: PM 2010
Comment: northbound

Site Information

Jurisdiction/Date: Jurisdiction 3/25/2010
Highway/Direction of Travel: I-190
From/To: Anamosa on/I-90 off

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 900 veh/h
Annual avg. daily traffic, AADT: ____ veh/day
Peak-hour proportion of AADT, K: ____
Peak-hour direction proportion, D: ____
DDHV = AADT x K x D: ____ veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.2 mi Up/Down: 2.0 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 1.5

E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.972

Speed Inputs

Lane width: ____ ft
Rt-shoulder lat. clearance: ____ ft
Interchange density: ____ I/mi
Number of lanes, N: 2
FFS (measured): 55.0 mi/h
Base free-flow speed, BFFS: ____ mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): ____ mi/h
f_{LC} (❑ Field data?): ____ mi/h
f_{ID} (❑ Field data?): ____ mi/h
f_N (❑ Field data?): ____ mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: ____ mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 503 pc/h/ln
S: 55.0 mi/h
$D = v_p/S$: 9.2 pc/i/ln
LOS: A

Design (v_p) or Planning (v_p)

LOS: ____
v_p: ____ pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: ____ veh/h
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
LOS: ____

Design (N) or Planning (N) 2nd Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln
LOS: ____

Glossary

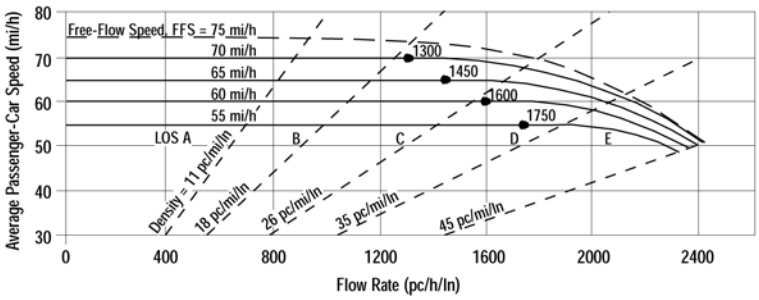
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: PM 2010
Comment: southbound

Site Information

Jurisdiction/Date: Jurisdiction 3/25/2010
Highway/Direction of Travel: I-190
From/To: Silver on/Omaha

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 780 veh/h
Annual avg. daily traffic, AADT: ____ veh/day
Peak-hour proportion of AADT, K: ____
Peak-hour direction proportion, D: ____
DDHV = AADT x K x D: ____ veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.1 mi Up/Down: -0.2 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 1.5

E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.972

Speed Inputs

Lane width: ____ ft
Rt-shoulder lat. clearance: ____ ft
Interchange density: ____ I/mi
Number of lanes, N: 2
FFS (measured): 55.0 mi/h
Base free-flow speed, BFFS: ____ mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): ____ mi/h
f_{LC} (❑ Field data?): ____ mi/h
f_{ID} (❑ Field data?): ____ mi/h
f_N (❑ Field data?): ____ mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: ____ mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 436 pc/h/ln
S: 55.0 mi/h
$D = v_p/S$: 7.9 pc/i/ln
LOS: A

Design (v_p) or Planning (v_p)

LOS: ____
v_p: ____ pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: ____ veh/h
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
LOS: ____

Design (N) or Planning (N) 2nd Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln
LOS: ____

Glossary

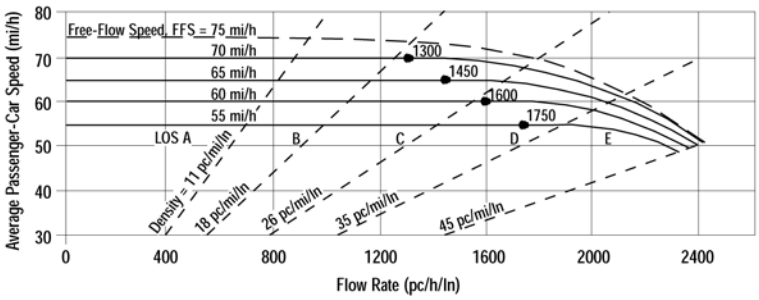
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: PM 2010
Comment: southbound

Site Information

Jurisdiction/Date: Jurisdiction 3/25/2010
Highway/Direction of Travel: I-190
From/To: Silver off/Silver on

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 560 veh/h
Annual avg. daily traffic, AADT: ____ veh/day
Peak-hour proportion of AADT, K: ____
Peak-hour direction proportion, D: ____
DDHV = AADT x K x D: ____ veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain
❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.5 mi Up/Down: -2.0 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 1.5

E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.972

Speed Inputs

Lane width: ____ ft
Rt-shoulder lat. clearance: ____ ft
Interchange density: ____ I/mi
Number of lanes, N: 2
FFS (measured): 55.0 mi/h
Base free-flow speed, BFFS: ____ mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): ____ mi/h
f_{LC} (❑ Field data?): ____ mi/h
f_{ID} (❑ Field data?): ____ mi/h
f_N (❑ Field data?): ____ mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: ____ mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 313 pc/h/ln
S: 55.0 mi/h
$D = v_p/S$: 5.7 pc/i/ln
LOS: A

Design (v_p) or Planning (v_p)

LOS: ____
v_p: ____ pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: ____ veh/h
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
LOS: ____

Design (N) or Planning (N) 2nd Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln
LOS: ____

Glossary

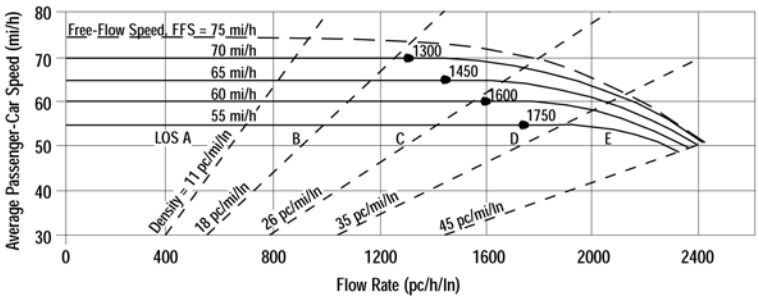
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: PM 2010
Comment: southbound

Site Information

Jurisdiction/Date: Jurisdiction 3/25/2010
Highway/Direction of Travel: I-190
From/To: I-90 on/Silver St. off

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 610 veh/h
Annual avg. daily traffic, AADT: ____ veh/day
Peak-hour proportion of AADT, K: ____
Peak-hour direction proportion, D: ____
DDHV = AADT x K x D: ____ veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.7 mi Up/Down: -2.0 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 1.5

E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.972

Speed Inputs

Lane width: ____ ft
Rt-shoulder lat. clearance: ____ ft
Interchange density: ____ I/mi
Number of lanes, N: 2
FFS (measured): 55.0 mi/h
Base free-flow speed, BFFS: ____ mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): ____ mi/h
f_{LC} (❑ Field data?): ____ mi/h
f_{ID} (❑ Field data?): ____ mi/h
f_N (❑ Field data?): ____ mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: ____ mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 341 pc/h/ln
S: 55.0 mi/h
$D = v_p/S$: 6.2 pc/i/ln
LOS: A

Design (v_p) or Planning (v_p)

LOS: ____
v_p: ____ pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: ____ veh/h
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
LOS: ____

Design (N) or Planning (N) 2nd Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln
LOS: ____

Glossary

N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: PM 2010
Comment: Comments

Site Information

Jurisdiction/Date: Jurisdiction 3/25/2010
Freeway/Direction of Travel: I-90
Junction: EB I-190 off

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☐ Yes ☐ On
☑ No ☐ Off
L_{up} = _____ ft
V_u = _____ veh/h

Freeway terrain: Rolling
Ramp terrain: Rolling

Ramp Type
☐ Merge ☑ Diverge
☑ Right side ☐ Left side
Number of freeway lanes: 2
Number of ramp lanes: 1
Length of ramp roadway: 1340 ft

S_{FF} = 65.0 mi/h S_{FR} = 50.0 mi/h

Downstream Adjacent Ramp

☑ Yes ☑ On
☐ No ☐ Off
L_{down} = 1850 ft
V_D = 570 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV}	f_p	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
							Field data if checked		
v_F				1170	0.92	5	☐ 0.930	☐ 1.00	1367
v_R				210	0.92	5	☐ 0.930	☐ 1.00	245
v_U							☐ 0.976	☐ 1.00	
v_D				570	0.92	5	☐ 0.930	☐ 1.00	666

Merge Areas

Estimation of v_{12}

$$v_{12} = v_F * P_{FM}$$

L_{EQ} = _____ (Equation 25-2 or 25-3)
P_{FM} = _____ using Equation _____ (Exhibit 25-5)
v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}		See Exhibit 25-7	
v_{R12}		4600: All	

Level-of-Service Determination (if not F)

$$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$$

D_R = _____ pc/mi/ln
LOS = _____ (Exhibit 25-4)

Speed Estimation

M_s = _____ (Exhibit 25-19)
S_R = _____ mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = _____ mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$$v_{12} = v_R + (v_F - v_R)P_{FD}$$

L_{EQ} = _____ (Equation 25-8 or 25-9)
P_{FD} = 1.000 using Equation _____ (Exhibit 25-12)
v_{12} = 1367 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$	1367	See Exhibit 25-14	
v_{12}	1367	4400: All	
$v_{FO} = v_F - v_R$	1122	See Exhibit 25-14	
v_R	210	See Exhibit 25-3	

Level-of-Service Determination (if not F)

$$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$$

D_R = 3.9 pc/mi/ln
LOS = A (Exhibit 25-4)

Speed Estimation

D_s = 0.255 (Exhibit 25-19)
S_R = 59.1 mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = 59.1 mi/h (Equation 25-15)

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	3/25/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-90	
Analysis Period/Year	PM 2010	Junction	EB I-190 on	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☑ Yes ☐ On
☐ No ☑ Off
L_{up} = 1850 ft
V_u = 210 veh/h

Freeway terrain: Rolling
Ramp terrain: Rolling

Ramp Type
☑ Merge ☐ Diverge
☑ Right side ☐ Left side
Number of freeway lanes: 2
Number of ramp lanes: 1
Length of ramp roadway: 1570 ft

S_{FF} = 65.0 mi/h S_{FR} = 50.0 mi/h

Downstream Adjacent Ramp

☑ Yes ☐ On
☐ No ☑ Off
L_{down} = 730 ft
V_D = 530 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				960	0.92	5	☐ 0.930	☐ 1.00	1122
v_R				570	0.92	5	☐ 0.930	☐ 1.00	666
v_U				210	0.92	5	☐ 0.930	☐ 1.00	245
v_D				530	0.92	5	☐ 0.930	☐ 1.00	619

Merge Areas

Estimation of v_{12}

$$v_{12} = v_F * P_{FM}$$

L_{EQ} = _____ (Equation 25-2 or 25-3)
P_{FM} = 1.000 using Equation _____ (Exhibit 25-5)
v_{12} = 1122 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	1788	See Exhibit 25-7	
v_{R12}	1788	4600: All	

Level-of-Service Determination (if not F)

$$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$$

D_R = 9.3 pc/mi/ln
LOS = A (Exhibit 25-4)

Speed Estimation

M_s = 0.187 (Exhibit 25-19)
S_R = 60.7 mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = 60.7 mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$$v_{12} = v_R + (v_F - v_R)P_{FD}$$

L_{EQ} = _____ (Equation 25-8 or 25-9)
P_{FD} = _____ using Equation _____ (Exhibit 25-12)
v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$		See Exhibit 25-14	
v_{12}		4400: All	
$v_{FO} = v_F - v_R$		See Exhibit 25-14	
v_R		See Exhibit 25-3	

Level-of-Service Determination (if not F)

$$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$$

D_R = _____ pc/mi/ln
LOS = _____ (Exhibit 25-4)

Speed Estimation

D_s = _____ (Exhibit 25-19)
S_R = _____ mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = _____ mi/h (Equation 25-15)

©Catalina Engineering, Inc.

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	3/25/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-90	
Analysis Period/Year	PM 2010	Junction	EB 90 Haines off	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☑ Yes ☑ On
☐ No ☐ Off
L_{up} = 730 ft
V_u = 570 veh/h

Freeway terrain: Rolling
Ramp terrain: Rolling

Ramp Type
☐ Merge ☑ Diverge
☑ Right side ☐ Left side

Number of freeway lanes: 3
Number of ramp lanes: 1
Length of ramp roadway: 1130 ft

S_{FF} = 65.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☑ Yes ☑ On
☐ No ☐ Off
L_{down} = 2330 ft
V_D = 240 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				1530	0.92	5	☐ 0.930	☐ 1.00	1788
v_R				530	0.92	5	☐ 0.930	☐ 1.00	619
v_U				570	0.92	5	☐ 0.930	☐ 1.00	666
v_D				240	0.92	5	☐ 0.930	☐ 1.00	280

Merge Areas

Estimation of v_{12}

$$v_{12} = v_F * P_{FM}$$

L_{EQ} = _____ (Equation 25-2 or 25-3)
P_{FM} = _____ using Equation _____ (Exhibit 25-5)
v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}		See Exhibit 25-7	
v_{R12}		4600: All	

Level-of-Service Determination (if not F)

$$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$$

D_R = _____ pc/mi/ln
LOS = _____ (Exhibit 25-4)

Speed Estimation

M_s = _____ (Exhibit 25-19)
S_R = _____ mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = _____ mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$$v_{12} = v_R + (v_F - v_R)P_{FD}$$

L_{EQ} = 10238 (Equation 25-8 or 25-9)
P_{FD} = 1.198 using Equation 6 (Exhibit 25-12)
v_{12} = 2020 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$	1788	See Exhibit 25-14	
v_{12}	2020	4400: All	
$v_{FO} = v_F - v_R$	1168	See Exhibit 25-14	
v_R	530	See Exhibit 25-3	

Level-of-Service Determination (if not F)

$$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$$

D_R = 11.5 pc/mi/ln
LOS = B (Exhibit 25-4)

Speed Estimation

D_s = 0.354 (Exhibit 25-19)
S_R = 56.9 mi/h (Exhibit 25-19)
S_O = 71.3 mi/h (Exhibit 25-19)
S = 55.4 mi/h (Equation 25-15)

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	3/25/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-90	
Analysis Period/Year	PM 2010	Junction	EB 90 Haines on	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☑ Yes ☐ On

☐ No ☑ Off

L_{up} = 2330 ft

V_u = 530 veh/h

Freeway terrain: Rolling

Ramp terrain: Rolling

Ramp Type

☑ Merge ☐ Diverge

☑ Right side ☐ Left side

Number of freeway lanes: 2

Number of ramp lanes: 1

Length of ramp roadway: 1270 ft

S_{FF} = 65.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☑ Yes ☐ On

☐ No ☑ Off

L_{down} = 2910 ft

V_D = 230 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				1000	0.92	5	☐ 0.930	☐ 1.00	1168
v_R				240	0.92	5	☐ 0.930	☐ 1.00	280
v_U				530	0.92	5	☐ 0.930	☐ 1.00	619
v_D				230	0.92	5	☐ 0.930	☐ 1.00	269

Merge Areas

Estimation of v_{12}

$$v_{12} = v_F * P_{FM}$$

L_{EQ} = _____ (Equation 25-2 or 25-3)

P_{FM} = 1.000 using Equation _____ (Exhibit 25-5)

v_{12} = 1168 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	1449	See Exhibit 25-7	
v_{R12}	1449	4600: All	

Level-of-Service Determination (if not F)

$$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$$

D_R = 8.7 pc/mi/ln

LOS = A (Exhibit 25-4)

Speed Estimation

M_s = 0.223 (Exhibit 25-19)

S_R = 59.9 mi/h (Exhibit 25-19)

S_O = _____ mi/h (Exhibit 25-19)

S = 59.9 mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$$v_{12} = v_R + (v_F - v_R)P_{FD}$$

L_{EQ} = _____ (Equation 25-8 or 25-9)

P_{FD} = _____ using Equation _____ (Exhibit 25-12)

v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$		See Exhibit 25-14	
v_{12}		4400: All	
$v_{FO} = v_F - v_R$		See Exhibit 25-14	
v_R		See Exhibit 25-3	

Level-of-Service Determination (if not F)

$$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$$

D_R = _____ pc/mi/ln

LOS = _____ (Exhibit 25-4)

Speed Estimation

D_s = _____ (Exhibit 25-19)

S_R = _____ mi/h (Exhibit 25-19)

S_O = _____ mi/h (Exhibit 25-19)

S = _____ mi/h (Equation 25-15)

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	3/25/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-90	
Analysis Period/Year	PM 2010	Junction	WB Haines off	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☑ Yes ☑ On
☐ No ☐ Off
L_{up} = 2400 ft
V_u = 220 veh/h

Freeway terrain: Rolling
Ramp terrain: Rolling

Ramp Type
☐ Merge ☑ Diverge
☑ Right side ☐ Left side

Number of freeway lanes: 2
Number of ramp lanes: 1
Length of ramp roadway: 1390 ft

S_{FF} = 65.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☑ Yes ☑ On
☐ No ☐ Off
L_{down} = 2500 ft
V_D = 460 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				1240	0.92	5	☐ 0.930	☐ 1.00	1449
v_R				210	0.92	5	☐ 0.930	☐ 1.00	245
v_U				220	0.92	5	☐ 0.930	☐ 1.00	257
v_D				460	0.92	5	☐ 0.930	☐ 1.00	538

Merge Areas

Estimation of v_{12}

$$v_{12} = v_F * P_{FM}$$

L_{EQ} = _____ (Equation 25-2 or 25-3)
P_{FM} = _____ using Equation _____ (Exhibit 25-5)
v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}		See Exhibit 25-7	
v_{R12}		4600: All	

Level-of-Service Determination (if not F)

$$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$$

D_R = _____ pc/mi/ln
LOS = _____ (Exhibit 25-4)

Speed Estimation

M_s = _____ (Exhibit 25-19)
S_R = _____ mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = _____ mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$$v_{12} = v_R + (v_F - v_R)P_{FD}$$

L_{EQ} = _____ (Equation 25-8 or 25-9)
P_{FD} = 1.000 using Equation _____ (Exhibit 25-12)
v_{12} = 1449 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$	1449	See Exhibit 25-14	
v_{12}	1449	4400: All	
$v_{FO} = v_F - v_R$	1204	See Exhibit 25-14	
v_R	210	See Exhibit 25-3	

Level-of-Service Determination (if not F)

$$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$$

D_R = 4.2 pc/mi/ln
LOS = A (Exhibit 25-4)

Speed Estimation

D_s = 0.320 (Exhibit 25-19)
S_R = 57.6 mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = 57.6 mi/h (Equation 25-15)

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	3/25/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-90	
Analysis Period/Year	PM 2010	Junction	WB Haines on	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☑ Yes ☐ On
☐ No ☑ Off
L_{up} = 2500 ft
V_u = 210 veh/h

Freeway terrain: Rolling
Ramp terrain: Rolling

Ramp Type
☑ Merge ☐ Diverge
☑ Right side ☐ Left side
Number of freeway lanes: 2
Number of ramp lanes: 1
Length of ramp roadway: 1170 ft

S_{FF} = 65.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☑ Yes ☐ On
☐ No ☑ Off
L_{down} = 2220 ft
V_D = 470 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				1030	0.92	5	☐ 0.930	☐ 1.00	1204
v_R				460	0.92	5	☐ 0.930	☐ 1.00	538
v_U				210	0.92	5	☐ 0.930	☐ 1.00	245
v_D				470	0.92	5	☐ 0.930	☐ 1.00	549

Merge Areas

Estimation of v_{12}

$$v_{12} = v_F * P_{FM}$$

L_{EQ} = _____ (Equation 25-2 or 25-3)
P_{FM} = 1.000 using Equation _____ (Exhibit 25-5)
v_{12} = 1204 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	1741	See Exhibit 25-7	
v_{R12}	1741	4600: All	

Level-of-Service Determination (if not F)

$$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$$

D_R = 11.5 pc/mi/ln
LOS = B (Exhibit 25-4)

Speed Estimation

M_s = 0.238 (Exhibit 25-19)
S_R = 59.5 mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = 59.5 mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$$v_{12} = v_R + (v_F - v_R)P_{FD}$$

L_{EQ} = _____ (Equation 25-8 or 25-9)
P_{FD} = _____ using Equation _____ (Exhibit 25-12)
v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$		See Exhibit 25-14	
v_{12}		4400: All	
$v_{FO} = v_F - v_R$		See Exhibit 25-14	
v_R		See Exhibit 25-3	

Level-of-Service Determination (if not F)

$$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$$

D_R = _____ pc/mi/ln
LOS = _____ (Exhibit 25-4)

Speed Estimation

D_s = _____ (Exhibit 25-19)
S_R = _____ mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = _____ mi/h (Equation 25-15)

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	3/25/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-90	
Analysis Period/Year	PM 2010	Junction	WB 190 off	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☑ Yes ☑ On
☐ No ☐ Off
L_{up} = 2220 ft
V_u = 460 veh/h

Freeway terrain: Rolling
Ramp terrain: Rolling

Ramp Type
☐ Merge ☑ Diverge
☑ Right side ☐ Left side

Number of freeway lanes: 3
Number of ramp lanes: 1
Length of ramp roadway: 2690 ft

S_{FF} = 65.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☑ Yes ☑ On
☐ No ☐ Off
L_{down} = 2070 ft
V_D = 400 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				1490	0.92	5	☐ 0.930	☐ 1.00	1741
v_R				470	0.92	5	☐ 0.930	☐ 1.00	549
v_U				460	0.92	5	☐ 0.930	☐ 1.00	538
v_D				400	0.92	5	☐ 0.930	☐ 1.00	467

Merge Areas

Estimation of v_{12}

$$v_{12} = v_F * P_{FM}$$

L_{EQ} = _____ (Equation 25-2 or 25-3)
P_{FM} = _____ using Equation _____ (Exhibit 25-5)
v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}		See Exhibit 25-7	
v_{R12}		4600: All	

Level-of-Service Determination (if not F)

$$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$$

D_R = _____ pc/mi/ln
LOS = _____ (Exhibit 25-4)

Speed Estimation

M_s = _____ (Exhibit 25-19)
S_R = _____ mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = _____ mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$$v_{12} = v_R + (v_F - v_R)P_{FD}$$

L_{EQ} = 7755 (Equation 25-8 or 25-9)
P_{FD} = 0.795 using Equation 6 (Exhibit 25-12)
v_{12} = 1497 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$	1741	See Exhibit 25-14	
v_{12}	1497	4400: All	
$v_{FO} = v_F - v_R$	1192	See Exhibit 25-14	
v_R	470	See Exhibit 25-3	

Level-of-Service Determination (if not F)

$$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$$

D_R = -7.1 pc/mi/ln
LOS = A (Exhibit 25-4)

Speed Estimation

D_s = 0.347 (Exhibit 25-19)
S_R = 57.0 mi/h (Exhibit 25-19)
S_O = 71.3 mi/h (Exhibit 25-19)
S = 58.7 mi/h (Equation 25-15)

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	3/25/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-90	
Analysis Period/Year	PM 2010	Junction	WB 190 on	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☑ Yes ☐ On
☐ No ☑ Off
L_{up} = 2070 ft
V_u = 470 veh/h

Freeway terrain: Rolling
Ramp terrain: Rolling

Ramp Type
☑ Merge ☐ Diverge
☑ Right side ☐ Left side
Number of freeway lanes: 2
Number of ramp lanes: 1
Length of ramp roadway: 4410 ft

S_{FF} = 65.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☐ Yes ☐ On
☑ No ☐ Off
L_{down} = _____ ft
V_D = _____ veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				1020	0.92	5	☐ 0.930	☐ 1.00	1192
v_R				400	0.92	5	☐ 0.930	☐ 1.00	467
v_U				470	0.92	5	☐ 0.930	☐ 1.00	549
v_D							☐ 0.976	☐ 1.00	

Merge Areas

Estimation of v_{12}

$$v_{12} = v_F * P_{FM}$$

L_{EQ} = _____ (Equation 25-2 or 25-3)
P_{FM} = 1.000 using Equation _____ (Exhibit 25-5)
v_{12} = 1192 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	1659	See Exhibit 25-7	
v_{R12}	1659	4600: All	

Level-of-Service Determination (if not F)

$$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$$

D_R = -9.4 pc/mi/ln
LOS = A (Exhibit 25-4)

Speed Estimation

M_s = -0.055 (Exhibit 25-19)
S_R = 66.3 mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = 66.3 mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$$v_{12} = v_R + (v_F - v_R)P_{FD}$$

L_{EQ} = _____ (Equation 25-8 or 25-9)
P_{FD} = _____ using Equation _____ (Exhibit 25-12)
v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$		See Exhibit 25-14	
v_{12}		4400: All	
$v_{FO} = v_F - v_R$		See Exhibit 25-14	
v_R		See Exhibit 25-3	

Level-of-Service Determination (if not F)

$$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$$

D_R = _____ pc/mi/ln
LOS = _____ (Exhibit 25-4)

Speed Estimation

D_s = _____ (Exhibit 25-19)
S_R = _____ mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = _____ mi/h (Equation 25-15)

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	3/25/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-190	
Analysis Period/Year	PM 2010	Junction	NB Silver off	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☐ Yes ☐ On

☑ No ☐ Off

L_{up} = _____ ft

V_u = _____ veh/h

Freeway terrain: Specific grade

Ramp terrain: Specific grade

Ramp Type

☐ Merge ☑ Diverge

☑ Right side ☐ Left side

Number of freeway lanes: 2

Number of ramp lanes: 1

Length of ramp roadway: 410 ft

S_{FF} = 55.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☑ Yes ☑ On

☐ No ☐ Off

L_{down} = 4470 ft

V_D = 80 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				1050	0.92	5	☐ 0.976	☐ 1.00	1170
v_R				230	0.92	5	☐ 0.976	☐ 1.00	256
v_U							☐ 0.976	☐ 1.00	
v_D				80	0.92	5	☐ 0.930	☐ 1.00	93

Merge Areas

Estimation of v_{12}

$$v_{12} = v_F * P_{FM}$$

L_{EQ} = _____ (Equation 25-2 or 25-3)

P_{FM} = _____ using Equation _____ (Exhibit 25-5)

v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}		See Exhibit 25-7	
v_{R12}		4600: All	

Level-of-Service Determination (if not F)

$$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$$

D_R = _____ pc/mi/ln

LOS = _____ (Exhibit 25-4)

Speed Estimation

M_s = _____ (Exhibit 25-19)

S_R = _____ mi/h (Exhibit 25-19)

S_O = _____ mi/h (Exhibit 25-19)

S = _____ mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$$v_{12} = v_R + (v_F - v_R)P_{FD}$$

L_{EQ} = _____ (Equation 25-8 or 25-9)

P_{FD} = 1.000 using Equation _____ (Exhibit 25-12)

v_{12} = 1170 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$	1170	See Exhibit 25-14	
v_{12}	1170	4400: All	
$v_{FO} = v_F - v_R$	914	See Exhibit 25-14	
v_R	230	See Exhibit 25-3	

Level-of-Service Determination (if not F)

$$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$$

D_R = 10.6 pc/mi/ln

LOS = B (Exhibit 25-4)

Speed Estimation

D_s = 0.321 (Exhibit 25-19)

S_R = 50.8 mi/h (Exhibit 25-19)

S_O = _____ mi/h (Exhibit 25-19)

S = 50.8 mi/h (Equation 25-15)

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	3/25/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-190	
Analysis Period/Year	PM 2010	Junction	NB Anamosa on	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☑ Yes ☐ On
☐ No ☑ Off
L_{up} = 4470 ft
V_u = 230 veh/h

Freeway terrain: Rolling
Ramp terrain: Rolling

Ramp Type
☑ Merge ☐ Diverge
☑ Right side ☐ Left side
Number of freeway lanes: 2
Number of ramp lanes: 1
Length of ramp roadway: 470 ft

S_{FF} = 55.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☑ Yes ☐ On
☐ No ☑ Off
L_{down} = 1200 ft
V_D = 570 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				820	0.92	5	☐ 0.930	☐ 1.00	958
v_R				80	0.92	5	☐ 0.930	☐ 1.00	93
v_U				230	0.92	5	☐ 0.930	☐ 1.00	269
v_D				570	0.92	5	☐ 0.930	☐ 1.00	666

Merge Areas

Estimation of v_{12}

$$v_{12} = v_F * P_{FM}$$

L_{EQ} = _____ (Equation 25-2 or 25-3)
P_{FM} = 1.000 using Equation _____ (Exhibit 25-5)
v_{12} = 958 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	1052	See Exhibit 25-7	
v_{R12}	1052	4600: All	

Level-of-Service Determination (if not F)

$$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$$

D_R = 10.7 pc/mi/ln
LOS = B (Exhibit 25-4)

Speed Estimation

M_s = 0.290 (Exhibit 25-19)
S_R = 51.2 mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = 51.2 mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$$v_{12} = v_R + (v_F - v_R)P_{FD}$$

L_{EQ} = _____ (Equation 25-8 or 25-9)
P_{FD} = _____ using Equation _____ (Exhibit 25-12)
v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$		See Exhibit 25-14	
v_{12}		4400: All	
$v_{FO} = v_F - v_R$		See Exhibit 25-14	
v_R		See Exhibit 25-3	

Level-of-Service Determination (if not F)

$$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$$

D_R = _____ pc/mi/ln
LOS = _____ (Exhibit 25-4)

Speed Estimation

D_s = _____ (Exhibit 25-19)
S_R = _____ mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = _____ mi/h (Equation 25-15)

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	3/25/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-190	
Analysis Period/Year	PM 2010	Junction	NB 90 off	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☑ Yes ☑ On

☐ No ☐ Off

L_{up} = 1200 ft

V_u = 80 veh/h

Freeway terrain: Rolling

Ramp terrain: Rolling

Ramp Type

☐ Merge ☑ Diverge

☑ Right side ☐ Left side

Number of freeway lanes: 2

Number of ramp lanes: 1

Length of ramp roadway: 1570 ft

S_{FF} = 55.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☐ Yes ☐ On

☑ No ☐ Off

L_{down} = _____ ft

V_D = _____ veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				900	0.92	5	☐ 0.930	☐ 1.00	1052
v_R				570	0.92	5	☐ 0.930	☐ 1.00	666
v_U				80	0.92	5	☐ 0.930	☐ 1.00	93
v_D							☐ 0.976	☐ 1.00	

Merge Areas

Estimation of v_{12}

$$v_{12} = v_F * P_{FM}$$

L_{EQ} = _____ (Equation 25-2 or 25-3)

P_{FM} = _____ using Equation _____ (Exhibit 25-5)

v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}		See Exhibit 25-7	
v_{R12}		4600: All	

Level-of-Service Determination (if not F)

$$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$$

D_R = _____ pc/mi/ln

LOS = _____ (Exhibit 25-4)

Speed Estimation

M_s = _____ (Exhibit 25-19)

S_R = _____ mi/h (Exhibit 25-19)

S_O = _____ mi/h (Exhibit 25-19)

S = _____ mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$$v_{12} = v_R + (v_F - v_R)P_{FD}$$

L_{EQ} = _____ (Equation 25-8 or 25-9)

P_{FD} = 1.000 using Equation _____ (Exhibit 25-12)

v_{12} = 1052 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$	1052	See Exhibit 25-14	
v_{12}	1052	4400: All	
$v_{FO} = v_F - v_R$	386	See Exhibit 25-14	
v_R	570	See Exhibit 25-3	

Level-of-Service Determination (if not F)

$$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$$

D_R = -0.8 pc/mi/ln

LOS = A (Exhibit 25-4)

Speed Estimation

D_s = 0.358 (Exhibit 25-19)

S_R = 50.3 mi/h (Exhibit 25-19)

S_O = _____ mi/h (Exhibit 25-19)

S = 50.3 mi/h (Equation 25-15)

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: PM 2010
Comment: Comments

Site Information

Jurisdiction/Date: Jurisdiction 3/25/2010
Freeway/Direction of Travel: I-190
Junction: SB 90 on

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☐ Yes ☐ On
☑ No ☐ Off
L_{up} = _____ ft
V_u = _____ veh/h

Freeway terrain: Rolling
Ramp terrain: Rolling

Ramp Type
☑ Merge ☐ Diverge
☑ Right side ☐ Left side
Number of freeway lanes: 2
Number of ramp lanes: 1
Length of ramp roadway: 1340 ft

S_{FF} = 55.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☑ Yes ☐ On
☐ No ☑ Off
L_{down} = 3920 ft
V_D = 50 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				470	0.92	5	☐ 0.930	☐ 1.00	549
v_R				210	0.92	5	☐ 0.930	☐ 1.00	245
v_U							☐ 0.976	☐ 1.00	
v_D				50	0.92	5	☐ 0.930	☐ 1.00	58

Merge Areas

Estimation of v_{12}

$$v_{12} = v_F * P_{FM}$$

L_{EQ} = _____ (Equation 25-2 or 25-3)
P_{FM} = 1.000 using Equation _____ (Exhibit 25-5)
v_{12} = 549 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	795	See Exhibit 25-7	
v_{R12}	795	4600: All	

Level-of-Service Determination (if not F)

$$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$$

D_R = 3.2 pc/mi/ln
LOS = A (Exhibit 25-4)

Speed Estimation

M_s = 0.209 (Exhibit 25-19)
S_R = 52.3 mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = 52.3 mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$$v_{12} = v_R + (v_F - v_R)P_{FD}$$

L_{EQ} = _____ (Equation 25-8 or 25-9)
P_{FD} = _____ using Equation _____ (Exhibit 25-12)
v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$		See Exhibit 25-14	
v_{12}		4400: All	
$v_{FO} = v_F - v_R$		See Exhibit 25-14	
v_R		See Exhibit 25-3	

Level-of-Service Determination (if not F)

$$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$$

D_R = _____ pc/mi/ln
LOS = _____ (Exhibit 25-4)

Speed Estimation

D_s = _____ (Exhibit 25-19)
S_R = _____ mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = _____ mi/h (Equation 25-15)

©Catalina Engineering, Inc.

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	3/25/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-190	
Analysis Period/Year	PM 2010	Junction	SB Silver off	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☑ Yes ☑ On
☐ No ☐ Off
L_{up} = 3920 ft
V_u = 210 veh/h

Freeway terrain: Rolling
Ramp terrain: Rolling

Ramp Type
☐ Merge ☑ Diverge
☑ Right side ☐ Left side

Number of freeway lanes: 2
Number of ramp lanes: 1
Length of ramp roadway: 1340 ft

S_{FF} = 55.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☑ Yes ☑ On
☐ No ☐ Off
L_{down} = 2580 ft
V_D = 220 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				610	0.92	5	☐ 0.930	☐ 1.00	713
v_R				50	0.92	5	☐ 0.930	☐ 1.00	58
v_U				210	0.92	5	☐ 0.930	☐ 1.00	245
v_D				220	0.92	5	☐ 0.930	☐ 1.00	257

Merge Areas

Estimation of v_{12}

$$v_{12} = v_F * P_{FM}$$

L_{EQ} = _____ (Equation 25-2 or 25-3)
P_{FM} = _____ using Equation _____ (Exhibit 25-5)
v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}		See Exhibit 25-7	
v_{R12}		4600: All	

Level-of-Service Determination (if not F)

$$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$$

D_R = _____ pc/mi/ln
LOS = _____ (Exhibit 25-4)

Speed Estimation

M_s = _____ (Exhibit 25-19)
S_R = _____ mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = _____ mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$$v_{12} = v_R + (v_F - v_R)P_{FD}$$

L_{EQ} = _____ (Equation 25-8 or 25-9)
P_{FD} = 1.000 using Equation _____ (Exhibit 25-12)
v_{12} = 713 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$	713	See Exhibit 25-14	
v_{12}	713	4400: All	
$v_{FO} = v_F - v_R$	654	See Exhibit 25-14	
v_R	50	See Exhibit 25-3	

Level-of-Service Determination (if not F)

$$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$$

D_R = -1.7 pc/mi/ln
LOS = A (Exhibit 25-4)

Speed Estimation

D_s = 0.303 (Exhibit 25-19)
S_R = 51.1 mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = 51.1 mi/h (Equation 25-15)

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	3/25/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-190	
Analysis Period/Year	PM 2010	Junction	SB Silver on	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☑ Yes ☐ On
☐ No ☑ Off
L_{up} = 2580 ft
V_u = 50 veh/h

Freeway terrain: Rolling
Ramp terrain: Rolling

Ramp Type
☑ Merge ☐ Diverge
☑ Right side ☐ Left side
Number of freeway lanes: 2
Number of ramp lanes: 1
Length of ramp roadway: 1340 ft

S_{FF} = 55.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☐ Yes ☐ On
☑ No ☐ Off
L_{down} = _____ ft
V_D = _____ veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				560	0.92	5	☐ 0.930	☐ 1.00	654
v_R				220	0.92	5	☐ 0.930	☐ 1.00	257
v_U				50	0.92	5	☐ 0.930	☐ 1.00	58
v_D							☐ 0.976	☐ 1.00	

Merge Areas

Estimation of v_{12}

$v_{12} = v_F * P_{FM}$

L_{EQ} = _____ (Equation 25-2 or 25-3)
P_{FM} = 1.000 using Equation _____ (Exhibit 25-5)
v_{12} = 654 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	911	See Exhibit 25-7	
v_{R12}	911	4600: All	

Level-of-Service Determination (if not F)

$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$

D_R = 4.1 pc/mi/ln
LOS = A (Exhibit 25-4)

Speed Estimation

M_s = 0.210 (Exhibit 25-19)
S_R = 52.3 mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = 52.3 mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$v_{12} = v_R + (v_F - v_R)P_{FD}$

L_{EQ} = _____ (Equation 25-8 or 25-9)
P_{FD} = _____ using Equation _____ (Exhibit 25-12)
v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$		See Exhibit 25-14	
v_{12}		4400: All	
$v_{FO} = v_F - v_R$		See Exhibit 25-14	
v_R		See Exhibit 25-3	

Level-of-Service Determination (if not F)

$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$

D_R = _____ pc/mi/ln
LOS = _____ (Exhibit 25-4)

Speed Estimation

D_s = _____ (Exhibit 25-19)
S_R = _____ mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = _____ mi/h (Equation 25-15)

©Catalina Engineering, Inc.

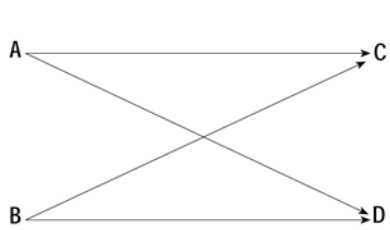
CHAPTER 24 - FREEWAY WEAVING WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	3/25/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-190	
Analysis Period/Year	PM 2010	Weaving Segment Location	Anamosa NB	
Comment	Comments			

☑ Operational (LOS) ❑ Design (N, L, Type) ❑ Planning (LOS) ❑ Planning (N, L, Type)

Inputs

Entry lanes 2 — Exit lanes 2



Entry lanes 1 — Exit lanes 1

Driver type from A ☑ Commuter/weekday ❑ Recreational/weekend

Driver type from B ☑ Commuter/weekday ❑ Recreational/weekend

Freeway free-flow speed, S_{FF} =	55	mi/h
Weaving number of lanes, N =	3	
Weaving segment length, L	1200	ft
Freeway terrain	❑ Level	☑ Rolling
Ramp terrain	❑ Level	☑ Rolling
Weaving type	☑ Type A	❑ Type B ❑ Type C
Volume ratio, VR = $\frac{v_w}{v}$	0.571	
Weaving ratio, R = $\frac{v_{w2}}{v_w}$	0.050	

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D	V (veh/h)	PHF	% HV	f_{HV} Field data if checked	f_p Field data if checked	$v = \frac{V}{PHF * f_{HV} * f_p}$
v_{AC}				400	0.92	5	❑ 0.930	❑ 1.00	467
v_{BD}				50	0.92	5	❑ 0.930	❑ 1.00	58
v_{AD}				570	0.92	5	❑ 0.930	❑ 1.00	666
v_{BC}				30	0.92	5	❑ 0.930	❑ 1.00	35
v_w									701
v_{nw}									526
v									1227

Weaving and Nonweaving Speeds

	Unconstrained		Constrained	
	Weaving (i = w)	Nonweaving (i = nw)	Weaving (i = w)	Nonweaving (i = nw)
a (Exhibit 24-6)	0.15	45.5	0.35	36.3
b (Exhibit 24-6)	2.2	4.0	2.2	4.0
c (Exhibit 24-6)	0.97	1.3	0.97	1.3
d (Exhibit 24-6)	0.80	0.75	0.80	0.75
Weaving intensity factor, W_i $W_i = \frac{a(1 + VR)^b (v/N)^c}{(L)^d}$	0.476	0.260	1.111	0.149
Weaving and nonweaving speeds, S_i (mi/h) $S_i = 15 + \frac{S_{FF} - 10}{1 + W_i}$	45.5	50.71	36.3	54.18

Number of lanes required for unconstrained operation, N_w (Exhibit 24-7) 1.59

Maximum number of lanes, N_w(max) (Exhibit 24-7) 1.40

❑ If $N_w < N_w$(max) unconstrained operation ☑ If $N_w \geq N_w$(max) constrained operation

Weaving Segment Speed, Density, Level of Service, and Capacity

Weaving segment speed, S (mi/h) $S = \frac{v}{\left(\frac{v_w}{S_w}\right) + \left(\frac{v_{nw}}{S_{nw}}\right)}$	42.3
Weaving segment density, D (pc/mi/ln) $D = \frac{v/N}{S}$	9.7
Level of service, LOS (Exhibit 24-2)	A
Capacity for base condition, c_b (pc/h) (Exhibit 24-8)	3917
Capacity as a 15-min flow rate, c (veh/h) $c = c_b * f_{HV} * f_p$	3644
Capacity as a full-hour volume, c_h (veh/h) $c_h = c(PHF)$	3352

©Catalina Engineering, Inc.

CHAPTER 24 - FREEWAY WEAVING WORKSHEET

General Information

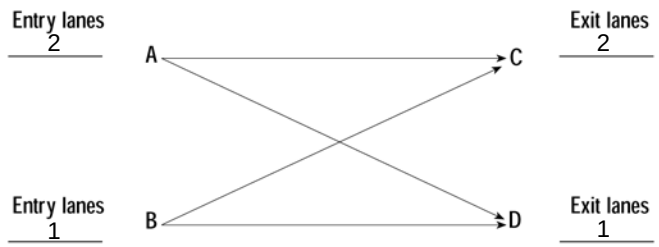
Analyst	Laughlin
Agency or Company	HDR
Analysis Period/Year	PM 2010
Comment	Comments

Site Information

Jurisdiction/Date	Jurisdiction 3/25/2010
Freeway/Direction of Travel	I-90
Weaving Segment Location	I-190 to Haines EB

☑ Operational (LOS) ❑ Design (N, L, Type) ❑ Planning (LOS) ❑ Planning (N, L, Type)

Inputs



Driver type from A ☑ Commuter/weekday ❑ Recreational/weekend

Driver type from B ☑ Commuter/weekday ❑ Recreational/weekend

Freeway free-flow speed, S_{FF} =	65	mi/h
Weaving number of lanes, N =	3	
Weaving segment length, L	730	ft
Freeway terrain	❑ Level	☑ Rolling
Ramp terrain	❑ Level	☑ Rolling
Weaving type	☑ Type A	❑ Type B ❑ Type C
Volume ratio, VR = $\frac{v_w}{v}$	0.355	
Weaving ratio, R = $\frac{v_{w2}}{v_w}$	0.500	

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D	V (veh/h)	PHF	% HV	f_{HV} Field data if checked	f_p Field data if checked	$v = \frac{V}{PHF * f_{HV} * f_p}$
v_{AC}				1000	0.92	5	❑ 0.930	❑ 1.00	1168
v_{BD}				200	0.92	5	❑ 0.930	❑ 1.00	234
v_{AD}				330	0.92	5	❑ 0.930	❑ 1.00	386
v_{BC}				330	0.92	5	❑ 0.930	❑ 1.00	386
v_w									771
v_{nw}									1402
v									2173

Weaving and Nonweaving Speeds

	Unconstrained		Constrained	
	Weaving (i = w)	Nonweaving (i = nw)	Weaving (i = w)	Nonweaving (i = nw)
a (Exhibit 24-6)	0.15	44.1		
b (Exhibit 24-6)	2.2	4.0		
c (Exhibit 24-6)	0.97	1.3		
d (Exhibit 24-6)	0.80	0.75		
Weaving intensity factor, W_i $W_i = \frac{a(1 + VR)^b (v/N)^c}{(L)^d}$	0.891	0.439		
Weaving and nonweaving speeds, S_i (mi/h) $S_i = 15 + \frac{S_{FF} - 10}{1 + W_i}$	44.1	53.23		

Number of lanes required for unconstrained operation, N_w (Exhibit 24-7) 1.09

Maximum number of lanes, N_w(max) (Exhibit 24-7) 1.40

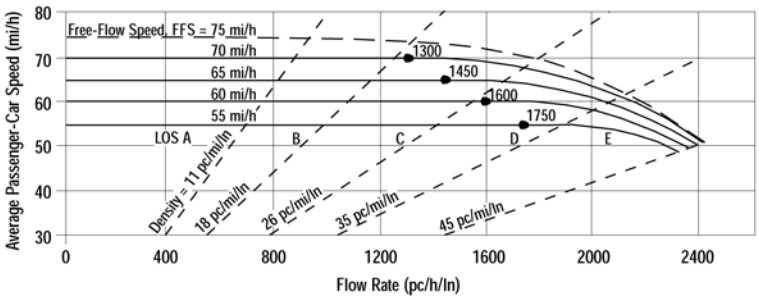
☑ If $N_w < N_w$(max) unconstrained operation ❑ If $N_w \geq N_w$(max) constrained operation

Weaving Segment Speed, Density, Level of Service, and Capacity

Weaving segment speed, S (mi/h) $S = \frac{v}{\left(\frac{v_w}{S_w}\right) + \left(\frac{v_{nw}}{S_{nw}}\right)}$	49.6
Weaving segment density, D (pc/mi/ln) $D = \frac{v/N}{S}$	14.6
Level of service, LOS (Exhibit 24-2)	B
Capacity for base condition, c_b (pc/h) (Exhibit 24-8)	4816
Capacity as a 15-min flow rate, c (veh/h) $c = c_b * f_{HV} * f_p$	4480
Capacity as a full-hour volume, c_h (veh/h) $c_h = c(PHF)$	4122

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: AM 2030
Comment: eastbound

Site Information

Jurisdiction/Date: Jurisdiction 4/5/2010
Highway/Direction of Travel: I-90
From/To: Deadwood on/I-190 off

☑ Oper. (LOS) ☐ Des. (N) ☐ Des. (v_p) ☐ Plan. (LOS) ☐ Plan. (N) ☐ Plan. (v_p)

Flow Inputs

Volume, V: 2110 veh/h
Annual avg. daily traffic, AADT: ____ veh/day
Peak-hour proportion of AADT, K: ____
Peak-hour direction proportion, D: ____
DDHV = AADT x K x D: ____ veh/h
Driver type: ☑ Commuter/Weekday ☐ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ☐ Level ☑ Rolling ☐ Mountainous
Grade Length ____ mi Up/Down ____ %

Calculate Flow Adjustments

f_p (☐ Field data?): 1.00
E_T (☐ Field data?): 2.5
E_R (☐ Field data?): 2.0
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.913

Speed Inputs

Lane width: ____ ft
Rt-shoulder lat. clearance: ____ ft
Interchange density: ____ I/mi
Number of lanes, N: 2
FFS (measured): 65.0 mi/h
Base free-flow speed, BFFS: ____ mi/h

Calculate Speed Adjustments and FFS

f_{LW} (☐ Field data?): ____ mi/h
f_{LC} (☐ Field data?): ____ mi/h
f_{ID} (☐ Field data?): ____ mi/h
f_N (☐ Field data?): ____ mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: ____ mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 1256 pc/h/ln
S: 65.0 mi/h
$D = v_p/S$: 19.3 pc/i/ln
LOS: C

Design (v_p) or Planning (v_p)

LOS: ____
v_p: ____ pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: ____ veh/h
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
LOS: ____

Design (N) or Planning (N) 2nd Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln
LOS: ____

Glossary

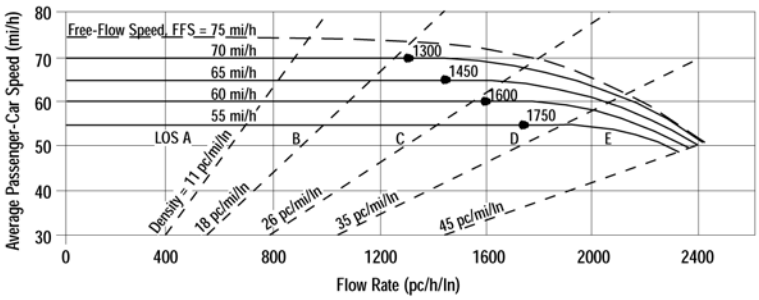
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: AM 2030
Comment: eastbound

Site Information

Jurisdiction/Date: Jurisdiction 4/5/2010
Highway/Direction of Travel: I-90
From/To: I-190 off/I-190 on

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 1520 veh/h
Annual avg. daily traffic, AADT: veh/day
Peak-hour proportion of AADT, K:
Peak-hour direction proportion, D:
DDHV = AADT x K x D: veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.4 mi Up/Down: -2.0 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 1.5
E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.972

Speed Inputs

Lane width: ft
Rt-shoulder lat. clearance: ft
Interchange density: l/mi
Number of lanes, N: 2
FFS (measured): 65.0 mi/h
Base free-flow speed, BFFS: mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): mi/h
f_{LC} (❑ Field data?): mi/h
f_{ID} (❑ Field data?): mi/h
f_N (❑ Field data?): mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 850 pc/h/ln
S: 65.0 mi/h
$D = v_p/S$: 13.1 pc/i/ln
LOS: B

Design (v_p) or Planning (v_p)

LOS:
v_p: pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: veh/h
S: mi/h
$D = v_p/S$: pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
LOS:

Design (N) or Planning (N) 2nd Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
S: mi/h
$D = v_p/S$: pc/mi/ln
LOS:

Glossary

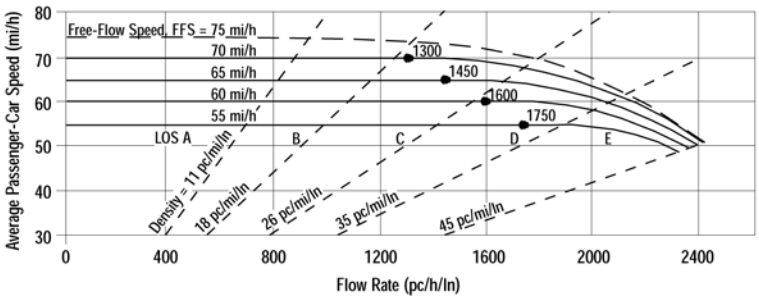
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: AM 2030
Comment: eastbound

Site Information

Jurisdiction/Date: Jurisdiction 4/5/2010
Highway/Direction of Travel: I-90
From/To: I-190 on/Haines off

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 2220 veh/h
Annual avg. daily traffic, AADT: veh/day
Peak-hour proportion of AADT, K:
Peak-hour direction proportion, D:
DDHV = AADT x K x D: veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.1 mi Up/Down: -2.0 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 1.5
E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.972

Speed Inputs

Lane width: ft
Rt-shoulder lat. clearance: ft
Interchange density: l/mi
Number of lanes, N: 3
FFS (measured): 65.0 mi/h
Base free-flow speed, BFFS: mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): mi/h
f_{LC} (❑ Field data?): mi/h
f_{ID} (❑ Field data?): mi/h
f_N (❑ Field data?): mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 828 pc/h/ln
S: 65.0 mi/h
$D = v_p/S$: 12.7 pc/i/ln
LOS: B

Design (v_p) or Planning (v_p)

LOS:
v_p: pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: veh/h
S: mi/h
$D = v_p/S$: pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
LOS:

Design (N) or Planning (N) 2nd Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
S: mi/h
$D = v_p/S$: pc/mi/ln
LOS:

Glossary

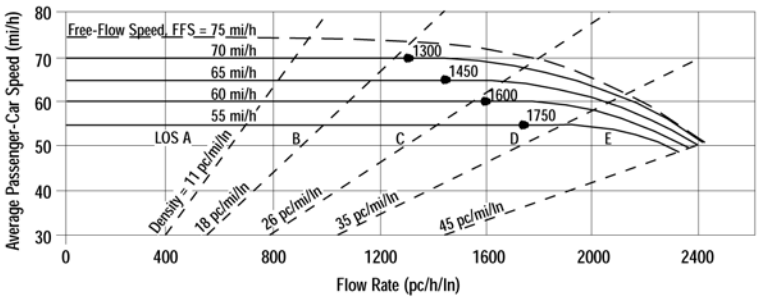
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: AM 2030
Comment: eastbound

Site Information

Jurisdiction/Date: Jurisdiction 4/5/2010
Highway/Direction of Travel: I-90
From/To: Haines off/Haines on

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 1820 veh/h
Annual avg. daily traffic, AADT: veh/day
Peak-hour proportion of AADT, K:
Peak-hour direction proportion, D:
DDHV = AADT x K x D: veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.4 mi Up/Down: 1.0 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 1.5

E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.972

Speed Inputs

Lane width: ft
Rt-shoulder lat. clearance: ft
Interchange density: I/mi
Number of lanes, N: 2
FFS (measured): 65.0 mi/h
Base free-flow speed, BFFS: mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): mi/h
f_{LC} (❑ Field data?): mi/h
f_{ID} (❑ Field data?): mi/h
f_N (❑ Field data?): mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 1018 pc/h/ln
S: 65.0 mi/h
$D = v_p/S$: 15.7 pc/i/ln
LOS: B

Design (v_p) or Planning (v_p)

LOS:
v_p: pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: veh/h
S: mi/h
$D = v_p/S$: pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
LOS:

Design (N) or Planning (N) 2nd Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
S: mi/h
$D = v_p/S$: pc/mi/ln
LOS:

Glossary

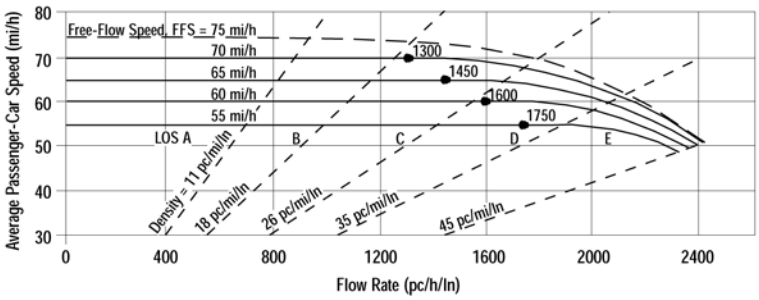
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: AM 2030
Comment: eastbound

Site Information

Jurisdiction/Date: Jurisdiction 4/5/2010
Highway/Direction of Travel: I-90
From/To: Haines on/Lacrosse off

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 2230 veh/h
Annual avg. daily traffic, AADT: veh/day
Peak-hour proportion of AADT, K:
Peak-hour direction proportion, D:
DDHV = AADT x K x D: veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.6 mi Up/Down: 1.0 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 1.5

E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.972

Speed Inputs

Lane width: ft
Rt-shoulder lat. clearance: ft
Interchange density: l/mi
Number of lanes, N: 2
FFS (measured): 65.0 mi/h
Base free-flow speed, BFFS: mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): mi/h
f_{LC} (❑ Field data?): mi/h
f_{ID} (❑ Field data?): mi/h
f_N (❑ Field data?): mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 1247 pc/h/ln
S: 65.0 mi/h
$D = v_p/S$: 19.2 pc/i/ln
LOS: C

Design (v_p) or Planning (v_p)

LOS:
v_p: pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: veh/h
S: mi/h
$D = v_p/S$: pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
LOS:

Design (N) or Planning (N) 2nd Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
S: mi/h
$D = v_p/S$: pc/mi/ln
LOS:

Glossary

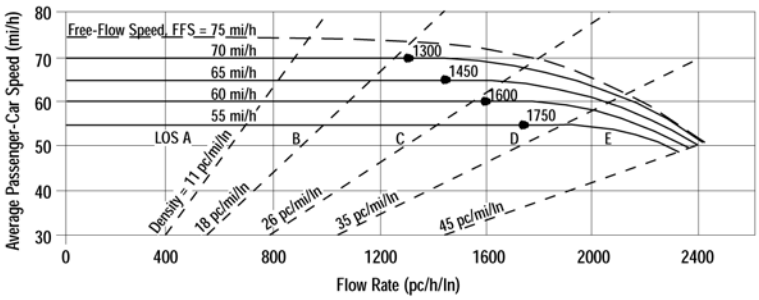
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: AM 2030
Comment: westbound

Site Information

Jurisdiction/Date: Jurisdiction 4/5/2010
Highway/Direction of Travel: I-90
From/To: Lacrosse on/Haines off

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 2270 veh/h
Annual avg. daily traffic, AADT: ____ veh/day
Peak-hour proportion of AADT, K: ____
Peak-hour direction proportion, D: ____
DDHV = AADT x K x D: ____ veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.5 mi Up/Down: -1.0 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 1.5

E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.972

Speed Inputs

Lane width: ____ ft
Rt-shoulder lat. clearance: ____ ft
Interchange density: ____ I/mi
Number of lanes, N: 2
FFS (measured): 65.0 mi/h
Base free-flow speed, BFFS: ____ mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): ____ mi/h
f_{LC} (❑ Field data?): ____ mi/h
f_{ID} (❑ Field data?): ____ mi/h
f_N (❑ Field data?): ____ mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: ____ mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 1269 pc/h/ln
S: 65.0 mi/h
$D = v_p/S$: 19.5 pc/i/ln
LOS: C

Design (v_p) or Planning (v_p)

LOS: ____
v_p: ____ pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: ____ veh/h
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
LOS: ____

Design (N) or Planning (N) 2nd Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln
LOS: ____

Glossary

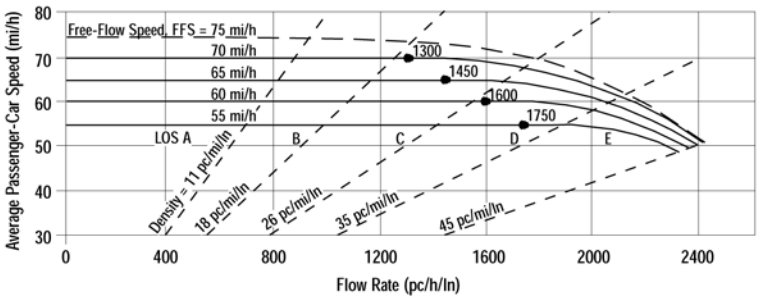
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: AM 2030
Comment: westbound

Site Information

Jurisdiction/Date: Jurisdiction 4/5/2010
Highway/Direction of Travel: I-90
From/To: Haines off/Haines on

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 2070 veh/h
Annual avg. daily traffic, AADT: veh/day
Peak-hour proportion of AADT, K:
Peak-hour direction proportion, D:
DDHV = AADT x K x D: veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.5 mi Up/Down: -1.0 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 1.5

E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.972

Speed Inputs

Lane width: ft
Rt-shoulder lat. clearance: ft
Interchange density: l/mi
Number of lanes, N: 2
FFS (measured): 65.0 mi/h
Base free-flow speed, BFFS: mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): mi/h
f_{LC} (❑ Field data?): mi/h
f_{ID} (❑ Field data?): mi/h
f_N (❑ Field data?): mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 1158 pc/h/ln
S: 65.0 mi/h
$D = v_p/S$: 17.8 pc/i/ln
LOS: B

Design (v_p) or Planning (v_p)

LOS:
v_p: pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: veh/h
S: mi/h
$D = v_p/S$: pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
LOS:

Design (N) or Planning (N) 2nd Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
S: mi/h
$D = v_p/S$: pc/mi/ln
LOS:

Glossary

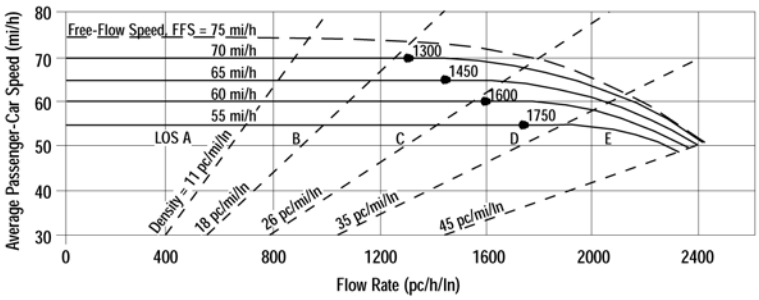
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: AM 2030
Comment: westbound

Site Information

Jurisdiction/Date: Jurisdiction 4/5/2010
Highway/Direction of Travel: I-90
From/To: Haines on/I-190 off

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 2420 veh/h
Annual avg. daily traffic, AADT: veh/day
Peak-hour proportion of AADT, K:
Peak-hour direction proportion, D:
DDHV = AADT x K x D: veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.4 mi Up/Down: 2.0 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 1.5

E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.972

Speed Inputs

Lane width: ft
Rt-shoulder lat. clearance: ft
Interchange density: l/mi
Number of lanes, N: 3
FFS (measured): 65.0 mi/h
Base free-flow speed, BFFS: mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): mi/h
f_{LC} (❑ Field data?): mi/h
f_{ID} (❑ Field data?): mi/h
f_N (❑ Field data?): mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 902 pc/h/ln
S: 65.0 mi/h
$D = v_p/S$: 13.9 pc/i/ln
LOS: B

Design (v_p) or Planning (v_p)

LOS:
v_p: pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: veh/h
S: mi/h
$D = v_p/S$: pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
LOS:

Design (N) or Planning (N) 2nd Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
S: mi/h
$D = v_p/S$: pc/mi/ln
LOS:

Glossary

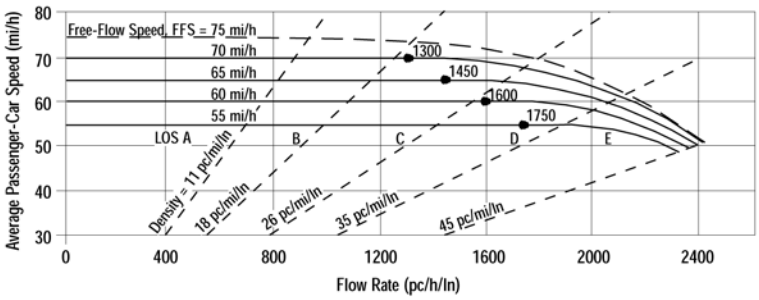
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: AM 2030
Comment: westbound

Site Information

Jurisdiction/Date: Jurisdiction 4/5/2010
Highway/Direction of Travel: I-90
From/To: I-190 off/I-190 on

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 1470 veh/h
Annual avg. daily traffic, AADT: ____ veh/day
Peak-hour proportion of AADT, K: ____
Peak-hour direction proportion, D: ____
DDHV = AADT x K x D: ____ veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.4 mi Up/Down: 2.0 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 1.5

E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.972

Speed Inputs

Lane width: ____ ft
Rt-shoulder lat. clearance: ____ ft
Interchange density: ____ I/mi
Number of lanes, N: 2
FFS (measured): 65.0 mi/h
Base free-flow speed, BFFS: ____ mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): ____ mi/h
f_{LC} (❑ Field data?): ____ mi/h
f_{ID} (❑ Field data?): ____ mi/h
f_N (❑ Field data?): ____ mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: ____ mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 822 pc/h/ln
S: 65.0 mi/h
$D = v_p/S$: 12.6 pc/i/ln
LOS: B

Design (v_p) or Planning (v_p)

LOS: ____
v_p: ____ pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: ____ veh/h
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
LOS: ____

Design (N) or Planning (N) 2nd Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln
LOS: ____

Glossary

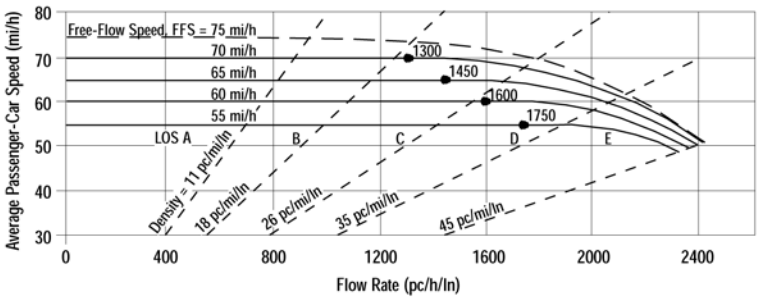
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: AM 2030
Comment: westbound

Site Information

Jurisdiction/Date: Jurisdiction 4/5/2010
Highway/Direction of Travel: I-90
From/To: I-190 on/Deadwood off

☑ Oper. (LOS) ☐ Des. (N) ☐ Des. (v_p) ☐ Plan. (LOS) ☐ Plan. (N) ☐ Plan. (v_p)

Flow Inputs

Volume, V	1960 veh/h	Peak-hour factor, PHF	0.92
Annual avg. daily traffic, AADT	veh/day	% Trucks and buses, P_T	5
Peak-hour proportion of AADT, K		% RVs, P_R	2
Peak-hour direction proportion, D		General terrain	
DDHV = AADT x K x D	veh/h	☐ Level ☑ Rolling ☐ Mountainous	
Driver type	☑ Commuter/Weekday ☐ Recreational/Weekend	Grade Length	mi Up/Down %

Calculate Flow Adjustments

f_p (☐ Field data?)	1.00	E_R (☐ Field data?)	2.0
E_T (☐ Field data?)	2.5	$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$	0.913

Speed Inputs

Lane width	ft
Rt-shoulder lat. clearance	ft
Interchange density	l/mi
Number of lanes, N	2
FFS (measured)	65.0 mi/h
Base free-flow speed, BFFS	mi/h

Calculate Speed Adjustments and FFS

f_{LW} (☐ Field data?)	mi/h
f_{LC} (☐ Field data?)	mi/h
f_{ID} (☐ Field data?)	mi/h
f_N (☐ Field data?)	mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N	mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$	1166 pc/h/ln
S	65.0 mi/h
$D = v_p/S$	17.9 pc/i/ln
LOS	B

Design (v_p) or Planning (v_p)

LOS	
v_p	pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$	veh/h
S	mi/h
$D = v_p/S$	pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N	assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$	pc/h/ln
LOS	

Design (N) or Planning (N) 2nd Iteration

N	assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$	pc/h/ln
S	mi/h
$D = v_p/S$	pc/mi/ln
LOS	

Glossary

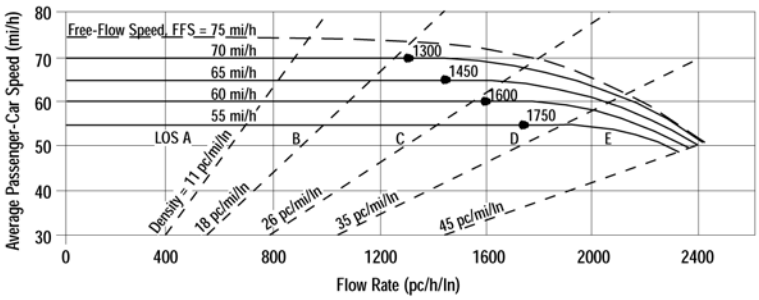
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: AM 2030
Comment: Comments

Site Information

Jurisdiction/Date: Jurisdiction 4/5/2010
Highway/Direction of Travel: I-190
From/To: Omaha/Silver

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 1740 veh/h
Annual avg. daily traffic, AADT: veh/day
Peak-hour proportion of AADT, K:
Peak-hour direction proportion, D:
DDHV = AADT x K x D: veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.1 mi Up/Down: 0.2 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 1.5

E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.972

Speed Inputs

Lane width: ft
Rt-shoulder lat. clearance: ft
Interchange density: l/mi
Number of lanes, N: 2
FFS (measured): 55.0 mi/h
Base free-flow speed, BFFS: mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): mi/h
f_{LC} (❑ Field data?): mi/h
f_{ID} (❑ Field data?): mi/h
f_N (❑ Field data?): mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 973 pc/h/ln
S: 55.0 mi/h
$D = v_p/S$: 17.7 pc/i/ln
LOS: B

Design (v_p) or Planning (v_p)

LOS:
v_p: pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: veh/h
S: mi/h
$D = v_p/S$: pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
LOS:

Design (N) or Planning (N) 2nd Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
S: mi/h
$D = v_p/S$: pc/mi/ln
LOS:

Glossary

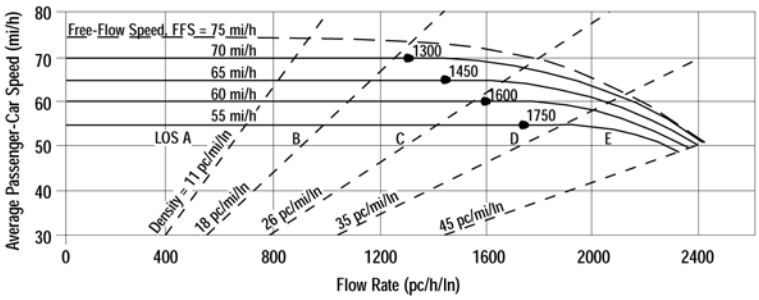
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: AM 2030
Comment: Comments

Site Information

Jurisdiction/Date: Jurisdiction 4/5/2010
Highway/Direction of Travel: I-190
From/To: Silver/Anamosa

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 1320 veh/h
Annual avg. daily traffic, AADT: veh/day
Peak-hour proportion of AADT, K:
Peak-hour direction proportion, D:
DDHV = AADT x K x D: veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.9 mi Up/Down: 2.0 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 2.0

E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.949

Speed Inputs

Lane width: ft
Rt-shoulder lat. clearance: ft
Interchange density: I/mi
Number of lanes, N: 2
FFS (measured): 55.0 mi/h
Base free-flow speed, BFFS: mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): mi/h
f_{LC} (❑ Field data?): mi/h
f_{ID} (❑ Field data?): mi/h
f_N (❑ Field data?): mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 756 pc/h/ln
S: 55.0 mi/h
$D = v_p/S$: 13.7 pc/i/ln
LOS: B

Design (v_p) or Planning (v_p)

LOS:
v_p: pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: veh/h
S: mi/h
$D = v_p/S$: pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
LOS:

Design (N) or Planning (N) 2nd Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
S: mi/h
$D = v_p/S$: pc/mi/ln
LOS:

Glossary

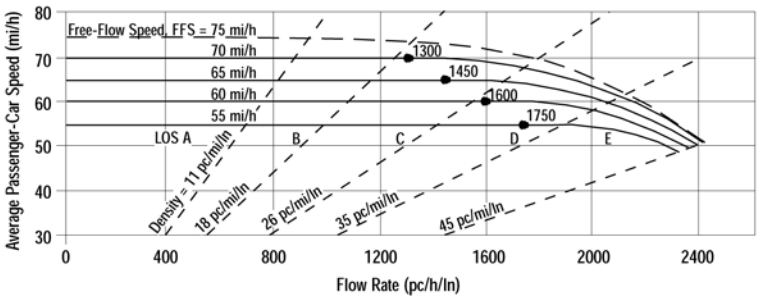
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: AM 2030
Comment: Comments

Site Information

Jurisdiction/Date: Jurisdiction 4/5/2010
Highway/Direction of Travel: I-190
From/To: Anamosa on/i-90 off

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 1190 veh/h
Annual avg. daily traffic, AADT: veh/day
Peak-hour proportion of AADT, K:
Peak-hour direction proportion, D:
DDHV = AADT x K x D: veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.2 mi Up/Down: 2.0 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 1.5
E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.972

Speed Inputs

Lane width: ft
Rt-shoulder lat. clearance: ft
Interchange density: l/mi
Number of lanes, N: 2
FFS (measured): 55.0 mi/h
Base free-flow speed, BFFS: mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): mi/h
f_{LC} (❑ Field data?): mi/h
f_{ID} (❑ Field data?): mi/h
f_N (❑ Field data?): mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 665 pc/h/ln
S: 55.0 mi/h
$D = v_p/S$: 12.1 pc/i/ln
LOS: B

Design (v_p) or Planning (v_p)

LOS:
v_p: pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: veh/h
S: mi/h
$D = v_p/S$: pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
LOS:

Design (N) or Planning (N) 2nd Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
S: mi/h
$D = v_p/S$: pc/mi/ln
LOS:

Glossary

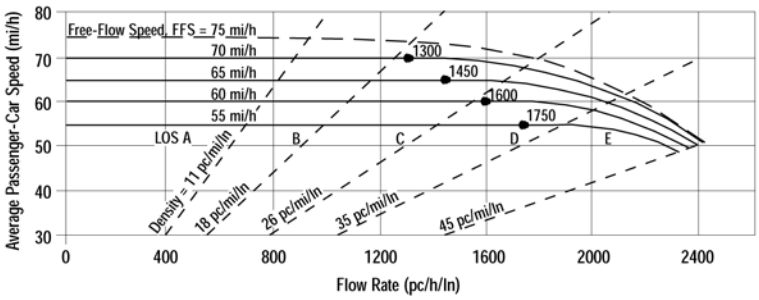
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: AM 2030
Comment: Comments

Site Information

Jurisdiction/Date: Jurisdiction 4/5/2010
Highway/Direction of Travel: I-190
From/To: Silver on/Omaha

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 1760 veh/h
Annual avg. daily traffic, AADT: veh/day
Peak-hour proportion of AADT, K:
Peak-hour direction proportion, D:
DDHV = AADT x K x D: veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.1 mi Up/Down: -0.2 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 1.5

E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.972

Speed Inputs

Lane width: ft
Rt-shoulder lat. clearance: ft
Interchange density: l/mi
Number of lanes, N: 2
FFS (measured): 55.0 mi/h
Base free-flow speed, BFFS: mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): mi/h
f_{LC} (❑ Field data?): mi/h
f_{ID} (❑ Field data?): mi/h
f_N (❑ Field data?): mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 984 pc/h/ln
S: 55.0 mi/h
$D = v_p/S$: 17.9 pc/i/ln
LOS: B

Design (v_p) or Planning (v_p)

LOS:
v_p: pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: veh/h
S: mi/h
$D = v_p/S$: pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
LOS:

Design (N) or Planning (N) 2nd Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
S: mi/h
$D = v_p/S$: pc/mi/ln
LOS:

Glossary

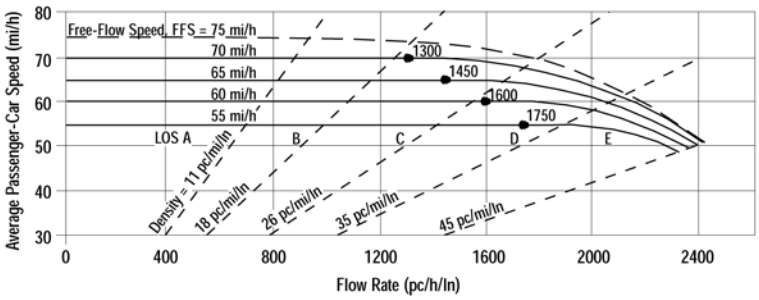
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: AM 2030
Comment: Comments

Site Information

Jurisdiction/Date: Jurisdiction 4/5/2010
Highway/Direction of Travel: I-190
From/To: Silver off/Silver on

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 1320 veh/h
Annual avg. daily traffic, AADT: ____ veh/day
Peak-hour proportion of AADT, K: ____
Peak-hour direction proportion, D: ____
DDHV = AADT x K x D: ____ veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.5 mi Up/Down: -2.0 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 1.5

E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.972

Speed Inputs

Lane width: ____ ft
Rt-shoulder lat. clearance: ____ ft
Interchange density: ____ I/mi
Number of lanes, N: 2
FFS (measured): 55.0 mi/h
Base free-flow speed, BFFS: ____ mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): ____ mi/h
f_{LC} (❑ Field data?): ____ mi/h
f_{ID} (❑ Field data?): ____ mi/h
f_N (❑ Field data?): ____ mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: ____ mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 738 pc/h/ln
S: 55.0 mi/h
$D = v_p/S$: 13.4 pc/i/ln
LOS: B

Design (v_p) or Planning (v_p)

LOS: ____
v_p: ____ pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: ____ veh/h
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
LOS: ____

Design (N) or Planning (N) 2nd Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln
LOS: ____

Glossary

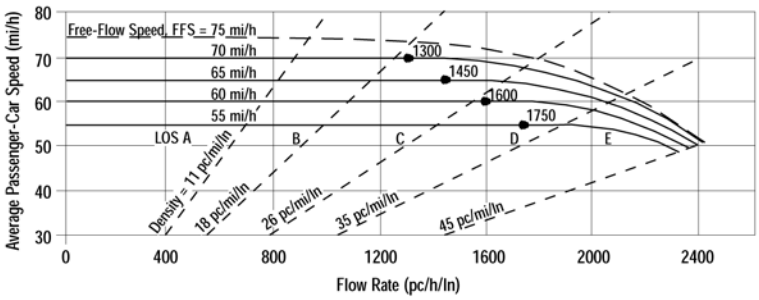
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: AM 2030
Comment: Comments

Site Information

Jurisdiction/Date: Jurisdiction 4/5/2010
Highway/Direction of Travel: I-190
From/To: I-90 on/Silver off

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 1540 veh/h
Annual avg. daily traffic, AADT: veh/day
Peak-hour proportion of AADT, K:
Peak-hour direction proportion, D:
DDHV = AADT x K x D: veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.7 mi Up/Down: -2.0 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 1.5

E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.972

Speed Inputs

Lane width: ft
Rt-shoulder lat. clearance: ft
Interchange density: l/mi
Number of lanes, N: 2
FFS (measured): 55.0 mi/h
Base free-flow speed, BFFS: mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): mi/h
f_{LC} (❑ Field data?): mi/h
f_{ID} (❑ Field data?): mi/h
f_N (❑ Field data?): mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 861 pc/h/ln
S: 55.0 mi/h
$D = v_p/S$: 15.7 pc/i/ln
LOS: B

Design (v_p) or Planning (v_p)

LOS:
v_p: pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: veh/h
S: mi/h
$D = v_p/S$: pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
LOS:

Design (N) or Planning (N) 2nd Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
S: mi/h
$D = v_p/S$: pc/mi/ln
LOS:

Glossary

N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	4/5/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-90	
Analysis Period/Year	AM 2030	Junction	EB I-190 off	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☐ Yes ☐ On
☑ No ☐ Off
L_{up} = _____ ft
V_u = _____ veh/h

Freeway terrain: Rolling
Ramp terrain: Rolling

Ramp Type
☐ Merge ☑ Diverge
☑ Right side ☐ Left side

Number of freeway lanes: 2
Number of ramp lanes: 1
Length of ramp roadway: 1340 ft

S_{FF} = 65.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☑ Yes ☑ On
☐ No ☐ Off
L_{down} = 1850 ft
V_D = 700 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				2110	0.92	5	☐ 0.930	☐ 1.00	2465
v_R				590	0.92	5	☐ 0.930	☐ 1.00	689
v_U							☐ 0.976	☐ 1.00	
v_D				700	0.92	5	☐ 0.930	☐ 1.00	818

Merge Areas

Estimation of v_{12}

$$v_{12} = v_F * P_{FM}$$

L_{EQ} = _____ (Equation 25-2 or 25-3)
P_{FM} = _____ using Equation _____ (Exhibit 25-5)
v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}		See Exhibit 25-7	
v_{R12}		4600: All	

Level-of-Service Determination (if not F)

$$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$$

D_R = _____ pc/mi/ln
LOS = _____ (Exhibit 25-4)

Speed Estimation

M_s = _____ (Exhibit 25-19)
S_R = _____ mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = _____ mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$$v_{12} = v_R + (v_F - v_R)P_{FD}$$

L_{EQ} = _____ (Equation 25-8 or 25-9)
P_{FD} = 1.000 using Equation _____ (Exhibit 25-12)
v_{12} = 2465 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$	2465	See Exhibit 25-14	
v_{12}	2465	4400: All	
$v_{FO} = v_F - v_R$	1776	See Exhibit 25-14	
v_R	590	See Exhibit 25-3	

Level-of-Service Determination (if not F)

$$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$$

D_R = 13.4 pc/mi/ln
LOS = B (Exhibit 25-4)

Speed Estimation

D_s = 0.360 (Exhibit 25-19)
S_R = 56.7 mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = 56.7 mi/h (Equation 25-15)

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	4/5/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-90	
Analysis Period/Year	AM 2030	Junction	EB I-190 on	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Freeway terrain: Rolling
Ramp terrain: Rolling

Upstream Adjacent Ramp
☑ Yes ☐ On
☐ No ☑ Off
L_{up} = 1850 ft
V_u = 590 veh/h

Ramp Type
☑ Merge ☐ Diverge
☑ Right side ☐ Left side
Number of freeway lanes: 2
Number of ramp lanes: 1
Length of ramp roadway: 1570 ft

S_{FF} = 65.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp
☑ Yes ☐ On
☐ No ☑ Off
L_{down} = 730 ft
V_D = 400 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				1520	0.92	5	☐ 0.930	☐ 1.00	1776
v_R				700	0.92	5	☐ 0.930	☐ 1.00	818
v_U				590	0.92	5	☐ 0.930	☐ 1.00	689
v_D				400	0.92	5	☐ 0.930	☐ 1.00	467

Merge Areas

Estimation of v_{12}

$$v_{12} = v_F * P_{FM}$$

L_{EQ} = _____ (Equation 25-2 or 25-3)
P_{FM} = 1.000 using Equation _____ (Exhibit 25-5)
v_{12} = 1776 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	2594	See Exhibit 25-7	
v_{R12}	2594	4600: All	

Level-of-Service Determination (if not F)

$$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$$

D_R = 15.5 pc/mi/ln
LOS = B (Exhibit 25-4)

Speed Estimation

M_s = 0.232 (Exhibit 25-19)
S_R = 59.7 mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = 59.7 mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$$v_{12} = v_R + (v_F - v_R)P_{FD}$$

L_{EQ} = _____ (Equation 25-8 or 25-9)
P_{FD} = _____ using Equation _____ (Exhibit 25-12)
v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$		See Exhibit 25-14	
v_{12}		4400: All	
$v_{FO} = v_F - v_R$		See Exhibit 25-14	
v_R		See Exhibit 25-3	

Level-of-Service Determination (if not F)

$$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$$

D_R = _____ pc/mi/ln
LOS = _____ (Exhibit 25-4)

Speed Estimation

D_s = _____ (Exhibit 25-19)
S_R = _____ mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = _____ mi/h (Equation 25-15)

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	4/5/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-90	
Analysis Period/Year	AM 2030	Junction	EB 90 Haines off	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☑ Yes ☑ On
☐ No ☐ Off
L_{up} = 730 ft
V_u = 700 veh/h

Freeway terrain: Rolling
Ramp terrain: Rolling

Ramp Type
☐ Merge ☑ Diverge
☑ Right side ☐ Left side

Number of freeway lanes: 3
Number of ramp lanes: 1
Length of ramp roadway: 1130 ft

S_{FF} = 65.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☑ Yes ☑ On
☐ No ☐ Off
L_{down} = 2330 ft
V_D = 410 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				2220	0.92	5	☐ 0.930	☐ 1.00	2594
v_R				400	0.92	5	☐ 0.930	☐ 1.00	467
v_U				700	0.92	5	☐ 0.930	☐ 1.00	818
v_D				410	0.92	5	☐ 0.930	☐ 1.00	479

Merge Areas

Estimation of v_{12}

$$v_{12} = v_F * P_{FM}$$

L_{EQ} = _____ (Equation 25-2 or 25-3)
P_{FM} = _____ using Equation _____ (Exhibit 25-5)
v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}		See Exhibit 25-7	
v_{R12}		4600: All	

Level-of-Service Determination (if not F)

$$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$$

D_R = _____ pc/mi/ln
LOS = _____ (Exhibit 25-4)

Speed Estimation

M_s = _____ (Exhibit 25-19)
S_R = _____ mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = _____ mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$$v_{12} = v_R + (v_F - v_R)P_{FD}$$

L_{EQ} = 8597 (Equation 25-8 or 25-9)
P_{FD} = 1.293 using Equation 6 (Exhibit 25-12)
v_{12} = 3216 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$	2594	See Exhibit 25-14	
v_{12}	3216	4400: All	
$v_{FO} = v_F - v_R$	2127	See Exhibit 25-14	
v_R	400	See Exhibit 25-3	

Level-of-Service Determination (if not F)

$$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$$

D_R = 21.7 pc/mi/ln
LOS = C (Exhibit 25-4)

Speed Estimation

D_s = 0.340 (Exhibit 25-19)
S_R = 57.2 mi/h (Exhibit 25-19)
S_O = 71.3 mi/h (Exhibit 25-19)
S = 54.6 mi/h (Equation 25-15)

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	4/5/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-90	
Analysis Period/Year	AM 2030	Junction	EB 90 Haines on	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☑ Yes ☐ On

☐ No ☑ Off

L_{up} = 2330 ft

V_u = 400 veh/h

Freeway terrain: Rolling

Ramp terrain: Rolling

Ramp Type

☑ Merge ☐ Diverge

☑ Right side ☐ Left side

Number of freeway lanes: 2

Number of ramp lanes: 1

Length of ramp roadway: 1270 ft

S_{FF} = 65.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☑ Yes ☐ On

☐ No ☑ Off

L_{down} = 2910 ft

V_D = 410 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				1820	0.92	5	☐ 0.930	☐ 1.00	2127
v_R				410	0.92	5	☐ 0.930	☐ 1.00	479
v_U				400	0.92	5	☐ 0.930	☐ 1.00	467
v_D				410	0.92	5	☐ 0.930	☐ 1.00	479

Merge Areas

Estimation of v_{12}

$$v_{12} = v_F * P_{FM}$$

L_{EQ} = _____ (Equation 25-2 or 25-3)

P_{FM} = 1.000 using Equation _____ (Exhibit 25-5)

v_{12} = 2127 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	2606	See Exhibit 25-7	
v_{R12}	2606	4600: All	

Level-of-Service Determination (if not F)

$$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$$

D_R = 17.6 pc/mi/ln

LOS = B (Exhibit 25-4)

Speed Estimation

M_s = 0.260 (Exhibit 25-19)

S_R = 59.0 mi/h (Exhibit 25-19)

S_O = _____ mi/h (Exhibit 25-19)

S = 59.0 mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$$v_{12} = v_R + (v_F - v_R)P_{FD}$$

L_{EQ} = _____ (Equation 25-8 or 25-9)

P_{FD} = _____ using Equation _____ (Exhibit 25-12)

v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$		See Exhibit 25-14	
v_{12}		4400: All	
$v_{FO} = v_F - v_R$		See Exhibit 25-14	
v_R		See Exhibit 25-3	

Level-of-Service Determination (if not F)

$$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$$

D_R = _____ pc/mi/ln

LOS = _____ (Exhibit 25-4)

Speed Estimation

D_s = _____ (Exhibit 25-19)

S_R = _____ mi/h (Exhibit 25-19)

S_O = _____ mi/h (Exhibit 25-19)

S = _____ mi/h (Equation 25-15)

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	4/5/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-90	
Analysis Period/Year	AM 2030	Junction	WB Haines off	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☑ Yes ☑ On

☐ No ☐ Off

L_{up} = 2400 ft

V_u = 400 veh/h

Freeway terrain: Rolling

Ramp terrain: Rolling

Ramp Type

☐ Merge ☑ Diverge

☑ Right side ☐ Left side

Number of freeway lanes: 2

Number of ramp lanes: 1

Length of ramp roadway: 1390 ft

S_{FF} = 65.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☑ Yes ☑ On

☐ No ☐ Off

L_{down} = 2500 ft

V_D = 350 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				2270	0.92	5	☐ 0.930	☐ 1.00	2652
v_R				200	0.92	5	☐ 0.930	☐ 1.00	234
v_U				400	0.92	5	☐ 0.930	☐ 1.00	467
v_D				350	0.92	5	☐ 0.930	☐ 1.00	409

Merge Areas

Estimation of v_{12}

$$v_{12} = v_F * P_{FM}$$

L_{EQ} = _____ (Equation 25-2 or 25-3)

P_{FM} = _____ using Equation _____ (Exhibit 25-5)

v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}		See Exhibit 25-7	
v_{R12}		4600: All	

Level-of-Service Determination (if not F)

$$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$$

D_R = _____ pc/mi/ln

LOS = _____ (Exhibit 25-4)

Speed Estimation

M_s = _____ (Exhibit 25-19)

S_R = _____ mi/h (Exhibit 25-19)

S_O = _____ mi/h (Exhibit 25-19)

S = _____ mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$$v_{12} = v_R + (v_F - v_R)P_{FD}$$

L_{EQ} = _____ (Equation 25-8 or 25-9)

P_{FD} = 1.000 using Equation _____ (Exhibit 25-12)

v_{12} = 2652 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$	2652	See Exhibit 25-14	
v_{12}	2652	4400: All	
$v_{FO} = v_F - v_R$	2419	See Exhibit 25-14	
v_R	200	See Exhibit 25-3	

Level-of-Service Determination (if not F)

$$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$$

D_R = 14.6 pc/mi/ln

LOS = B (Exhibit 25-4)

Speed Estimation

D_s = 0.319 (Exhibit 25-19)

S_R = 57.7 mi/h (Exhibit 25-19)

S_O = _____ mi/h (Exhibit 25-19)

S = 57.7 mi/h (Equation 25-15)

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	4/5/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-90	
Analysis Period/Year	AM 2030	Junction	WB Haines on	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☑ Yes ☐ On
☐ No ☑ Off
L_{up} = 2500 ft
V_u = 200 veh/h

Freeway terrain: Rolling
Ramp terrain: Rolling

Ramp Type
☑ Merge ☐ Diverge
☑ Right side ☐ Left side
Number of freeway lanes: 2
Number of ramp lanes: 1
Length of ramp roadway: 1170 ft

S_{FF} = 65.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☑ Yes ☐ On
☐ No ☑ Off
L_{down} = 2220 ft
V_D = 950 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				2070	0.92	5	☐ 0.930	☐ 1.00	2419
v_R				350	0.92	5	☐ 0.930	☐ 1.00	409
v_U				200	0.92	5	☐ 0.930	☐ 1.00	234
v_D				950	0.92	5	☐ 0.930	☐ 1.00	1110

Merge Areas

Estimation of v_{12}

$$v_{12} = v_F * P_{FM}$$

L_{EQ} = _____ (Equation 25-2 or 25-3)
P_{FM} = 1.000 using Equation _____ (Exhibit 25-5)
v_{12} = 2419 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	2828	See Exhibit 25-7	
v_{R12}	2828	4600: All	

Level-of-Service Determination (if not F)

$$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$$

D_R = 20.0 pc/mi/ln
LOS = B (Exhibit 25-4)

Speed Estimation

M_s = 0.282 (Exhibit 25-19)
S_R = 58.5 mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = 58.5 mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$$v_{12} = v_R + (v_F - v_R)P_{FD}$$

L_{EQ} = _____ (Equation 25-8 or 25-9)
P_{FD} = _____ using Equation _____ (Exhibit 25-12)
v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$		See Exhibit 25-14	
v_{12}		4400: All	
$v_{FO} = v_F - v_R$		See Exhibit 25-14	
v_R		See Exhibit 25-3	

Level-of-Service Determination (if not F)

$$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$$

D_R = _____ pc/mi/ln
LOS = _____ (Exhibit 25-4)

Speed Estimation

D_s = _____ (Exhibit 25-19)
S_R = _____ mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = _____ mi/h (Equation 25-15)

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	4/5/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-90	
Analysis Period/Year	AM 2030	Junction	WB 190 off	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☑ Yes ☑ On

☐ No ☐ Off

L_{up} = 2220 ft

V_u = 350 veh/h

Freeway terrain: Rolling

Ramp terrain: Rolling

Ramp Type

☐ Merge ☑ Diverge

☑ Right side ☐ Left side

Number of freeway lanes: 2

Number of ramp lanes: 1

Length of ramp roadway: 2640 ft

S_{FF} = 65.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☑ Yes ☑ On

☐ No ☐ Off

L_{down} = 2070 ft

V_D = 490 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				2420	0.92	5	☐ 0.930	☐ 1.00	2828
v_R				950	0.92	5	☐ 0.930	☐ 1.00	1110
v_U				350	0.92	5	☐ 0.930	☐ 1.00	409
v_D				490	0.92	5	☐ 0.930	☐ 1.00	573

Merge Areas

Estimation of v_{12}

$$v_{12} = v_F * P_{FM}$$

L_{EQ} = _____ (Equation 25-2 or 25-3)

P_{FM} = _____ using Equation _____ (Exhibit 25-5)

v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}		See Exhibit 25-7	
v_{R12}		4600: All	

Level-of-Service Determination (if not F)

$$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$$

D_R = _____ pc/mi/ln

LOS = _____ (Exhibit 25-4)

Speed Estimation

M_s = _____ (Exhibit 25-19)

S_R = _____ mi/h (Exhibit 25-19)

S_O = _____ mi/h (Exhibit 25-19)

S = _____ mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$$v_{12} = v_R + (v_F - v_R)P_{FD}$$

L_{EQ} = _____ (Equation 25-8 or 25-9)

P_{FD} = 1.000 using Equation _____ (Exhibit 25-12)

v_{12} = 2828 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$	2828	See Exhibit 25-14	
v_{12}	2828	4400: All	
$v_{FO} = v_F - v_R$	1718	See Exhibit 25-14	
v_R	950	See Exhibit 25-3	

Level-of-Service Determination (if not F)

$$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$$

D_R = 4.8 pc/mi/ln

LOS = A (Exhibit 25-4)

Speed Estimation

D_s = 0.398 (Exhibit 25-19)

S_R = 55.8 mi/h (Exhibit 25-19)

S_O = _____ mi/h (Exhibit 25-19)

S = 55.8 mi/h (Equation 25-15)

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	4/5/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-90	
Analysis Period/Year	AM 2030	Junction	WB 190 on	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☑ Yes ☐ On
☐ No ☑ Off
L_{up} = 2070 ft
V_u = 950 veh/h

Freeway terrain: Rolling
Ramp terrain: Rolling

Ramp Type
☑ Merge ☐ Diverge
☑ Right side ☐ Left side
Number of freeway lanes: 2
Number of ramp lanes: 1
Length of ramp roadway: 4410 ft

S_{FF} = 65.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☐ Yes ☐ On
☑ No ☐ Off
L_{down} = ____ ft
V_D = ____ veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				1470	0.92	5	☐ 0.930	☐ 1.00	1718
v_R				490	0.92	5	☐ 0.930	☐ 1.00	573
v_U				950	0.92	5	☐ 0.930	☐ 1.00	1110
v_D							☐ 0.976	☐ 1.00	

Merge Areas

Estimation of v_{12}

$v_{12} = v_F * P_{FM}$

L_{EQ} = ____ (Equation 25-2 or 25-3)
P_{FM} = 1.000 using Equation ____ (Exhibit 25-5)
v_{12} = 1718 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	2290	See Exhibit 25-7	
v_{R12}	2290	4600: All	

Level-of-Service Determination (if not F)

$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$

D_R = -4.6 pc/mi/ln
LOS = A (Exhibit 25-4)

Speed Estimation

M_s = -0.037 (Exhibit 25-19)
S_R = 65.9 mi/h (Exhibit 25-19)
S_O = ____ mi/h (Exhibit 25-19)
S = 65.9 mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$v_{12} = v_R + (v_F - v_R)P_{FD}$

L_{EQ} = ____ (Equation 25-8 or 25-9)
P_{FD} = ____ using Equation ____ (Exhibit 25-12)
v_{12} = ____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$		See Exhibit 25-14	
v_{12}		4400: All	
$v_{FO} = v_F - v_R$		See Exhibit 25-14	
v_R		See Exhibit 25-3	

Level-of-Service Determination (if not F)

$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$

D_R = ____ pc/mi/ln
LOS = ____ (Exhibit 25-4)

Speed Estimation

D_s = ____ (Exhibit 25-19)
S_R = ____ mi/h (Exhibit 25-19)
S_O = ____ mi/h (Exhibit 25-19)
S = ____ mi/h (Equation 25-15)

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	4/5/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-190	
Analysis Period/Year	AM 2030	Junction	NB Silver off	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☐ Yes ☐ On
☑ No ☐ Off
L_{up} = _____ ft
V_u = _____ veh/h

Freeway terrain: Level
Ramp terrain: Level

Ramp Type
☐ Merge ☑ Diverge
☑ Right side ☐ Left side

Number of freeway lanes: 2
Number of ramp lanes: 1
Length of ramp roadway: 410 ft

S_{FF} = 55.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☑ Yes ☑ On
☐ No ☐ Off
L_{down} = 4740 ft
V_D = 180 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				1740	0.92	5	☐ 0.976	☐ 1.00	1939
v_R				730	0.92	5	☐ 0.976	☐ 1.00	813
v_U							☐ 0.976	☐ 1.00	
v_D				180	0.92	5	☐ 0.930	☐ 1.00	210

Merge Areas

Estimation of v_{12}

$$v_{12} = v_F * P_{FM}$$

L_{EQ} = _____ (Equation 25-2 or 25-3)
P_{FM} = _____ using Equation _____ (Exhibit 25-5)
v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}		See Exhibit 25-7	
v_{R12}		4600: All	

Level-of-Service Determination (if not F)

$$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$$

D_R = _____ pc/mi/ln
LOS = _____ (Exhibit 25-4)

Speed Estimation

M_s = _____ (Exhibit 25-19)
S_R = _____ mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = _____ mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$$v_{12} = v_R + (v_F - v_R)P_{FD}$$

L_{EQ} = _____ (Equation 25-8 or 25-9)
P_{FD} = 1.000 using Equation _____ (Exhibit 25-12)
v_{12} = 1939 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$	1939	See Exhibit 25-14	
v_{12}	1939	4400: All	
$v_{FO} = v_F - v_R$	1125	See Exhibit 25-14	
v_R	730	See Exhibit 25-3	

Level-of-Service Determination (if not F)

$$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$$

D_R = 17.2 pc/mi/ln
LOS = B (Exhibit 25-4)

Speed Estimation

D_s = 0.371 (Exhibit 25-19)
S_R = 50.2 mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = 50.2 mi/h (Equation 25-15)

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	4/5/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-190	
Analysis Period/Year	AM 2030	Junction	NB Anamosa on	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☑ Yes ☐ On
☐ No ☑ Off
L_{up} = 4740 ft
V_u = 730 veh/h

Freeway terrain: Rolling
Ramp terrain: Rolling

Ramp Type
☑ Merge ☐ Diverge
☑ Right side ☐ Left side
Number of freeway lanes: 2
Number of ramp lanes: 1
Length of ramp roadway: 470 ft

S_{FF} = 55.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☑ Yes ☐ On
☐ No ☑ Off
L_{down} = 1200 ft
V_D = 700 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				1010	0.92	5	☐ 0.930	☐ 1.00	1180
v_R				180	0.92	5	☐ 0.930	☐ 1.00	210
v_U				730	0.92	5	☐ 0.930	☐ 1.00	853
v_D				700	0.92	5	☐ 0.930	☐ 1.00	818

Merge Areas

Estimation of v_{12}

$$v_{12} = v_F * P_{FM}$$

L_{EQ} = _____ (Equation 25-2 or 25-3)
P_{FM} = 1.000 using Equation _____ (Exhibit 25-5)
v_{12} = 1180 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	1390	See Exhibit 25-7	
v_{R12}	1390	4600: All	

Level-of-Service Determination (if not F)

$$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$$

D_R = 13.3 pc/mi/ln
LOS = B (Exhibit 25-4)

Speed Estimation

M_s = 0.294 (Exhibit 25-19)
S_R = 51.2 mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = 51.2 mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$$v_{12} = v_R + (v_F - v_R)P_{FD}$$

L_{EQ} = _____ (Equation 25-8 or 25-9)
P_{FD} = _____ using Equation _____ (Exhibit 25-12)
v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$		See Exhibit 25-14	
v_{12}		4400: All	
$v_{FO} = v_F - v_R$		See Exhibit 25-14	
v_R		See Exhibit 25-3	

Level-of-Service Determination (if not F)

$$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$$

D_R = _____ pc/mi/ln
LOS = _____ (Exhibit 25-4)

Speed Estimation

D_s = _____ (Exhibit 25-19)
S_R = _____ mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = _____ mi/h (Equation 25-15)

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	4/5/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-190	
Analysis Period/Year	AM 2030	Junction	NB 90 off	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☑ Yes ☑ On

☐ No ☐ Off

L_{up} = 1200 ft

V_u = 180 veh/h

Freeway terrain: Rolling

Ramp terrain: Rolling

Ramp Type

☐ Merge ☑ Diverge

☑ Right side ☐ Left side

Number of freeway lanes: 2

Number of ramp lanes: 1

Length of ramp roadway: 1570 ft

S_{FF} = 55.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☐ Yes ☐ On

☑ No ☐ Off

L_{down} = _____ ft

V_D = _____ veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				1190	0.92	5	☐ 0.930	☐ 1.00	1390
v_R				700	0.92	5	☐ 0.930	☐ 1.00	818
v_U				180	0.92	5	☐ 0.930	☐ 1.00	210
v_D							☐ 0.976	☐ 1.00	

Merge Areas

Estimation of v_{12}

$$v_{12} = v_F * P_{FM}$$

L_{EQ} = _____ (Equation 25-2 or 25-3)

P_{FM} = _____ using Equation _____ (Exhibit 25-5)

v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}		See Exhibit 25-7	
v_{R12}		4600: All	

Level-of-Service Determination (if not F)

$$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$$

D_R = _____ pc/mi/ln

LOS = _____ (Exhibit 25-4)

Speed Estimation

M_s = _____ (Exhibit 25-19)

S_R = _____ mi/h (Exhibit 25-19)

S_O = _____ mi/h (Exhibit 25-19)

S = _____ mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$$v_{12} = v_R + (v_F - v_R)P_{FD}$$

L_{EQ} = _____ (Equation 25-8 or 25-9)

P_{FD} = 1.000 using Equation _____ (Exhibit 25-12)

v_{12} = 1390 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$	1390	See Exhibit 25-14	
v_{12}	1390	4400: All	
$v_{FO} = v_F - v_R$	573	See Exhibit 25-14	
v_R	700	See Exhibit 25-3	

Level-of-Service Determination (if not F)

$$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$$

D_R = 2.1 pc/mi/ln

LOS = A (Exhibit 25-4)

Speed Estimation

D_s = 0.372 (Exhibit 25-19)

S_R = 50.2 mi/h (Exhibit 25-19)

S_O = _____ mi/h (Exhibit 25-19)

S = 50.2 mi/h (Equation 25-15)

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	4/5/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-190	
Analysis Period/Year	AM 2030	Junction	SB 90 on	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☐ Yes ☐ On

☑ No ☐ Off

L_{up} = _____ ft

V_u = _____ veh/h

Freeway terrain: Rolling

Ramp terrain: Rolling

Ramp Type

☑ Merge ☐ Diverge

☑ Right side ☐ Left side

Number of freeway lanes: 2

Number of ramp lanes: 1

Length of ramp roadway: 1340 ft

S_{FF} = 55.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☑ Yes ☐ On

☐ No ☑ Off

L_{down} = 3920 ft

V_D = 220 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				950	0.92	5	☐ 0.930	☐ 1.00	1110
v_R				590	0.92	5	☐ 0.930	☐ 1.00	689
v_U							☐ 0.976	☐ 1.00	
v_D				220	0.92	5	☐ 0.930	☐ 1.00	257

Merge Areas

Estimation of v_{12}

$$v_{12} = v_F * P_{FM}$$

L_{EQ} = _____ (Equation 25-2 or 25-3)

P_{FM} = 1.000 using Equation _____ (Exhibit 25-5)

v_{12} = 1110 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	1799	See Exhibit 25-7	
v_{R12}	1799	4600: All	

Level-of-Service Determination (if not F)

$$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$$

D_R = 10.8 pc/mi/ln

LOS = B (Exhibit 25-4)

Speed Estimation

M_s = 0.224 (Exhibit 25-19)

S_R = 52.1 mi/h (Exhibit 25-19)

S_O = _____ mi/h (Exhibit 25-19)

S = 52.1 mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$$v_{12} = v_R + (v_F - v_R)P_{FD}$$

L_{EQ} = _____ (Equation 25-8 or 25-9)

P_{FD} = _____ using Equation _____ (Exhibit 25-12)

v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$		See Exhibit 25-14	
v_{12}		4400: All	
$v_{FO} = v_F - v_R$		See Exhibit 25-14	
v_R		See Exhibit 25-3	

Level-of-Service Determination (if not F)

$$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$$

D_R = _____ pc/mi/ln

LOS = _____ (Exhibit 25-4)

Speed Estimation

D_s = _____ (Exhibit 25-19)

S_R = _____ mi/h (Exhibit 25-19)

S_O = _____ mi/h (Exhibit 25-19)

S = _____ mi/h (Equation 25-15)

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	4/5/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-190	
Analysis Period/Year	AM 2030	Junction	SB Silve off	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☑ Yes ☑ On

☐ No ☐ Off

L_{up} = 3920 ft

V_u = 590 veh/h

Freeway terrain: Rolling

Ramp terrain: Rolling

Ramp Type

☐ Merge ☑ Diverge

☑ Right side ☐ Left side

Number of freeway lanes: 2

Number of ramp lanes: 1

Length of ramp roadway: 810 ft

S_{FF} = 55.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☑ Yes ☑ On

☐ No ☐ Off

L_{down} = 2580 ft

V_D = 440 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				1540	0.92	5	☐ 0.930	☐ 1.00	1799
v_R				220	0.92	5	☐ 0.930	☐ 1.00	257
v_U				590	0.92	5	☐ 0.930	☐ 1.00	689
v_D				440	0.92	5	☐ 0.930	☐ 1.00	514

Merge Areas

Estimation of v_{12}

$$v_{12} = v_F * P_{FM}$$

L_{EQ} = _____ (Equation 25-2 or 25-3)

P_{FM} = _____ using Equation _____ (Exhibit 25-5)

v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}		See Exhibit 25-7	
v_{R12}		4600: All	

Level-of-Service Determination (if not F)

$$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$$

D_R = _____ pc/mi/ln

LOS = _____ (Exhibit 25-4)

Speed Estimation

M_s = _____ (Exhibit 25-19)

S_R = _____ mi/h (Exhibit 25-19)

S_O = _____ mi/h (Exhibit 25-19)

S = _____ mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$$v_{12} = v_R + (v_F - v_R)P_{FD}$$

L_{EQ} = _____ (Equation 25-8 or 25-9)

P_{FD} = 1.000 using Equation _____ (Exhibit 25-12)

v_{12} = 1799 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$	1799	See Exhibit 25-14	
v_{12}	1799	4400: All	
$v_{FO} = v_F - v_R$	1542	See Exhibit 25-14	
v_R	220	See Exhibit 25-3	

Level-of-Service Determination (if not F)

$$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$$

D_R = 12.4 pc/mi/ln

LOS = B (Exhibit 25-4)

Speed Estimation

D_s = 0.321 (Exhibit 25-19)

S_R = 50.8 mi/h (Exhibit 25-19)

S_O = _____ mi/h (Exhibit 25-19)

S = 50.8 mi/h (Equation 25-15)

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	4/5/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-190	
Analysis Period/Year	AM 2030	Junction	SB Silver on	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☑ Yes ☐ On
☐ No ☑ Off
L_{up} = 2580 ft
V_u = 220 veh/h

Freeway terrain: Rolling
Ramp terrain: Rolling

Ramp Type
☑ Merge ☐ Diverge
☑ Right side ☐ Left side
Number of freeway lanes: 2
Number of ramp lanes: 1
Length of ramp roadway: 870 ft

S_{FF} = 55.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☐ Yes ☐ On
☑ No ☐ Off
L_{down} = _____ ft
V_D = _____ veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				1320	0.92	5	☐ 0.930	☐ 1.00	1542
v_R				440	0.92	5	☐ 0.930	☐ 1.00	514
v_U				220	0.92	5	☐ 0.930	☐ 1.00	257
v_D							☐ 0.976	☐ 1.00	

Merge Areas

Estimation of v_{12}

$v_{12} = v_F * P_{FM}$

L_{EQ} = _____ (Equation 25-2 or 25-3)
P_{FM} = 1.000 using Equation _____ (Exhibit 25-5)
v_{12} = 1542 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	2057	See Exhibit 25-7	
v_{R12}	2057	4600: All	

Level-of-Service Determination (if not F)

$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$

D_R = 15.8 pc/mi/ln
LOS = B (Exhibit 25-4)

Speed Estimation

M_s = 0.273 (Exhibit 25-19)
S_R = 51.4 mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = 51.4 mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$v_{12} = v_R + (v_F - v_R)P_{FD}$

L_{EQ} = _____ (Equation 25-8 or 25-9)
P_{FD} = _____ using Equation _____ (Exhibit 25-12)
v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$		See Exhibit 25-14	
v_{12}		4400: All	
$v_{FO} = v_F - v_R$		See Exhibit 25-14	
v_R		See Exhibit 25-3	

Level-of-Service Determination (if not F)

$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$

D_R = _____ pc/mi/ln
LOS = _____ (Exhibit 25-4)

Speed Estimation

D_s = _____ (Exhibit 25-19)
S_R = _____ mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = _____ mi/h (Equation 25-15)

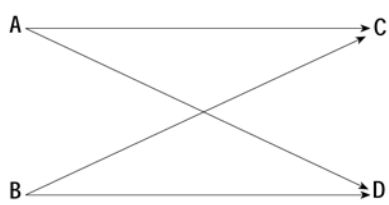
CHAPTER 24 - FREEWAY WEAVING WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	4/5/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-190	
Analysis Period/Year	AM 2030	Weaving Segment Location	Anamosa NB	
Comment	Comments			

☑ Operational (LOS) ❑ Design (N, L, Type) ❑ Planning (LOS) ❑ Planning (N, L, Type)

Inputs

Entry lanes 2 — Exit lanes 2



Entry lanes 1 — Exit lanes 1

Driver type from A ☑ Commuter/weekday ❑ Recreational/weekend

Driver type from B ☑ Commuter/weekday ❑ Recreational/weekend

Freeway free-flow speed, S_{FF} =	55	mi/h
Weaving number of lanes, N =	3	
Weaving segment length, L	1200	ft
Freeway terrain	❑ Level	☑ Rolling
Ramp terrain	❑ Level	☑ Rolling
Weaving type	☑ Type A	❑ Type B ❑ Type C
Volume ratio, VR = $\frac{v_w}{v}$	0.577	
Weaving ratio, R = $\frac{v_{w2}}{v_w}$	0.114	

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D	V (veh/h)	PHF	% HV	f_{HV} Field data if checked	f_p Field data if checked	$v = \frac{V}{PHF * f_{HV} * f_p}$
v_{AC}				490	0.92	5	❑ 0.930	❑ 1.00	573
v_{BD}				90	0.92	5	❑ 0.930	❑ 1.00	105
v_{AD}				700	0.92	5	❑ 0.930	❑ 1.00	818
v_{BC}				90	0.92	5	❑ 0.930	❑ 1.00	105
v_w									923
v_{nw}									678
v									1601

Weaving and Nonweaving Speeds

	Unconstrained		Constrained	
	Weaving (i = w)	Nonweaving (i = nw)	Weaving (i = w)	Nonweaving (i = nw)
a (Exhibit 24-6)	0.15	42.8	0.35	33.4
b (Exhibit 24-6)	2.2	4.0	2.2	4.0
c (Exhibit 24-6)	0.97	1.3	0.97	1.3
d (Exhibit 24-6)	0.80	0.75	0.80	0.75
Weaving intensity factor, W_i $W_i = \frac{a(1 + VR)^b (v/N)^c}{(L)^d}$	0.621	0.372	1.449	0.213
Weaving and nonweaving speeds, S_i (mi/h) $S_i = 15 + \frac{S_{FF} - 10}{1 + W_i}$	42.8	47.79	33.4	52.10

Number of lanes required for unconstrained operation, N_w (Exhibit 24-7) 1.64

Maximum number of lanes, N_w(max) (Exhibit 24-7) 1.40

❑ If $N_w < N_w$(max) unconstrained operation ☑ If $N_w \geq N_w$(max) constrained operation

Weaving Segment Speed, Density, Level of Service, and Capacity

Weaving segment speed, S (mi/h) $S = \frac{v}{\left(\frac{v_w}{S_w}\right) + \left(\frac{v_{nw}}{S_{nw}}\right)}$	39.4
Weaving segment density, D (pc/mi/ln) $D = \frac{v/N}{S}$	13.6
Level of service, LOS (Exhibit 24-2)	B
Capacity for base condition, c_b (pc/h) (Exhibit 24-8)	3902
Capacity as a 15-min flow rate, c (veh/h) $c = c_b * f_{HV} * f_p$	3630
Capacity as a full-hour volume, c_h (veh/h) $c_h = c(PHF)$	3339

©Catalina Engineering, Inc.

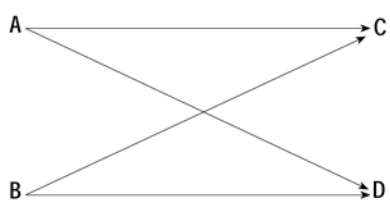
CHAPTER 24 - FREEWAY WEAVING WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	4/5/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-90	
Analysis Period/Year	AM 2030	Weaving Segment Location	I-190 to Haines EB	
Comment	Comments			

☑ Operational (LOS) ❑ Design (N, L, Type) ❑ Planning (LOS) ❑ Planning (N, L, Type)

Inputs

Entry lanes 2 — Exit lanes 2



Entry lanes 1 — Exit lanes 1

Driver type from A ☑ Commuter/weekday ❑ Recreational/weekend

Driver type from B ☑ Commuter/weekday ❑ Recreational/weekend

Freeway free-flow speed, S_{FF} = 65 mi/h

Weaving number of lanes, N = 3

Weaving segment length, L 730 ft

Freeway terrain ❑ Level ☑ Rolling

Ramp terrain ❑ Level ☑ Rolling

Weaving type ☑ Type A ❑ Type B ❑ Type C

Volume ratio, $VR = \frac{v_w}{v}$ 0.240

Weaving ratio, $R = \frac{v_{w2}}{v_w}$ 0.286

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D	V (veh/h)	PHF	% HV	f_{HV} Field data if checked	f_p Field data if checked	$v = \frac{V}{PHF * f_{HV} * f_p}$
v_{AC}				2020	0.92	5	❑ 0.930	❑ 1.00	2360
v_{BD}				200	0.92	5	❑ 0.930	❑ 1.00	234
v_{AD}				200	0.92	5	❑ 0.930	❑ 1.00	234
v_{BC}				500	0.92	5	❑ 0.930	❑ 1.00	584
v_w									818
v_{nw}									2594
v									3412

Weaving and Nonweaving Speeds

	Unconstrained		Constrained	
	Weaving (i = w)	Nonweaving (i = nw)	Weaving (i = w)	Nonweaving (i = nw)
a (Exhibit 24-6)	0.15	40.8		
b (Exhibit 24-6)	2.2	4.0		
c (Exhibit 24-6)	0.97	1.3		
d (Exhibit 24-6)	0.80	0.75		
Weaving intensity factor, W_i $W_i = \frac{a(1 + VR)^b (v/N)^c}{(L)^d}$	1.135	0.553		
Weaving and nonweaving speeds, S_i (mi/h) $S_i = 15 + \frac{S_{FF} - 10}{1 + W_i}$	40.8	50.42		

Number of lanes required for unconstrained operation, N_w (Exhibit 24-7) 0.91

Maximum number of lanes, N_w(max) (Exhibit 24-7) 1.40

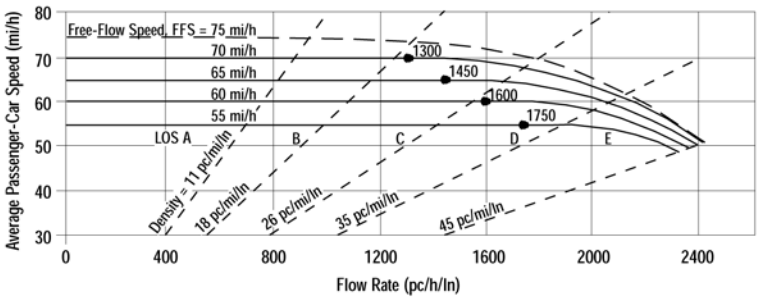
☑ If $N_w < N_w$(max) unconstrained operation ❑ If $N_w \geq N_w$(max) constrained operation

Weaving Segment Speed, Density, Level of Service, and Capacity

Weaving segment speed, S (mi/h) $S = \frac{v}{\left(\frac{v_w}{S_w}\right) + \left(\frac{v_{nw}}{S_{nw}}\right)}$	47.7
Weaving segment density, D (pc/mi/ln) $D = \frac{v/N}{S}$	23.8
Level of service, LOS (Exhibit 24-2)	C
Capacity for base condition, c_b (pc/h) (Exhibit 24-8)	5259
Capacity as a 15-min flow rate, c (veh/h) $c = c_b * f_{HV} * f_p$	4892
Capacity as a full-hour volume, c_h (veh/h) $c_h = c(PHF)$	4501

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: PM 2030
Comment: eastbound

Site Information

Jurisdiction/Date: Jurisdiction 4/6/2010
Highway/Direction of Travel: I-90
From/To: Deadwood/I-190

☑ Oper. (LOS) ☐ Des. (N) ☐ Des. (v_p) ☐ Plan. (LOS) ☐ Plan. (N) ☐ Plan. (v_p)

Flow Inputs

Volume, V: 2160 veh/h
Annual avg. daily traffic, AADT: ____ veh/day
Peak-hour proportion of AADT, K: ____
Peak-hour direction proportion, D: ____
DDHV = AADT x K x D: ____ veh/h
Driver type: ☑ Commuter/Weekday ☐ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ☐ Level ☑ Rolling ☐ Mountainous
Grade Length ____ mi Up/Down ____ %

Calculate Flow Adjustments

f_p (☐ Field data?): 1.00
E_T (☐ Field data?): 2.5
E_R (☐ Field data?): 2.0
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.913

Speed Inputs

Lane width: ____ ft
Rt-shoulder lat. clearance: ____ ft
Interchange density: ____ I/mi
Number of lanes, N: 2
FFS (measured): 65.0 mi/h
Base free-flow speed, BFFS: ____ mi/h

Calculate Speed Adjustments and FFS

f_{LW} (☐ Field data?): ____ mi/h
f_{LC} (☐ Field data?): ____ mi/h
f_{ID} (☐ Field data?): ____ mi/h
f_N (☐ Field data?): ____ mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: ____ mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 1285 pc/h/ln
S: 65.0 mi/h
$D = v_p/S$: 19.8 pc/i/ln
LOS: C

Design (v_p) or Planning (v_p)

LOS: ____
v_p: ____ pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: ____ veh/h
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
LOS: ____

Design (N) or Planning (N) 2nd Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln
LOS: ____

Glossary

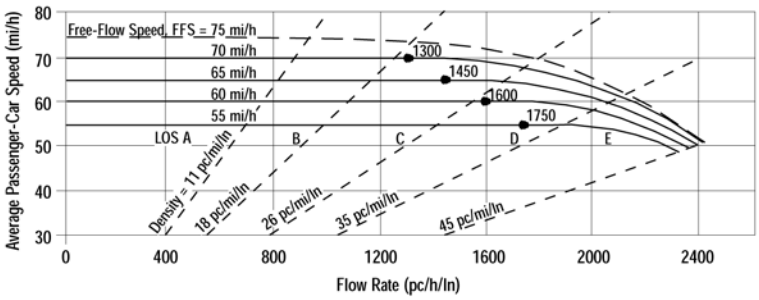
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: PM 2030
Comment: eastbound

Site Information

Jurisdiction/Date: Jurisdiction 4/6/2010
Highway/Direction of Travel: I-90
From/To: I-190 off/I-190 on

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 1720 veh/h
Annual avg. daily traffic, AADT: veh/day
Peak-hour proportion of AADT, K:
Peak-hour direction proportion, D:
DDHV = AADT x K x D: veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.4 mi Up/Down: -2.0 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 1.5

E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.972

Speed Inputs

Lane width: ft
Rt-shoulder lat. clearance: ft
Interchange density: l/mi
Number of lanes, N: 2
FFS (measured): 65.0 mi/h
Base free-flow speed, BFFS: mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): mi/h
f_{LC} (❑ Field data?): mi/h
f_{ID} (❑ Field data?): mi/h
f_N (❑ Field data?): mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 962 pc/h/ln
S: 65.0 mi/h
$D = v_p/S$: 14.8 pc/i/ln
LOS: B

Design (v_p) or Planning (v_p)

LOS:
v_p: pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: veh/h
S: mi/h
$D = v_p/S$: pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
LOS:

Design (N) or Planning (N) 2nd Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
S: mi/h
$D = v_p/S$: pc/mi/ln
LOS:

Glossary

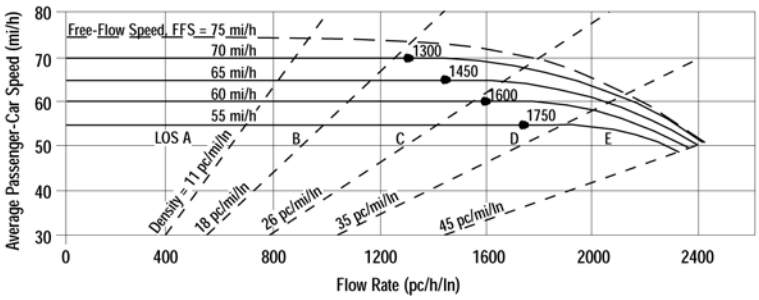
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: PM 2030
Comment: eastbound

Site Information

Jurisdiction/Date: Jurisdiction 4/6/2010
Highway/Direction of Travel: I-90
From/To: I-190/Haines

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 2750 veh/h
Annual avg. daily traffic, AADT: ____ veh/day
Peak-hour proportion of AADT, K: ____
Peak-hour direction proportion, D: ____
DDHV = AADT x K x D: ____ veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.1 mi Up/Down: -2.0 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 1.5

E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.972

Speed Inputs

Lane width: ____ ft
Rt-shoulder lat. clearance: ____ ft
Interchange density: ____ I/mi
Number of lanes, N: 3
FFS (measured): 65.0 mi/h
Base free-flow speed, BFFS: ____ mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): ____ mi/h
f_{LC} (❑ Field data?): ____ mi/h
f_{ID} (❑ Field data?): ____ mi/h
f_N (❑ Field data?): ____ mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: ____ mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 1025 pc/h/ln
S: 65.0 mi/h
$D = v_p/S$: 15.8 pc/i/ln
LOS: B

Design (v_p) or Planning (v_p)

LOS: ____
v_p: ____ pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: ____ veh/h
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
LOS: ____

Design (N) or Planning (N) 2nd Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln
LOS: ____

Glossary

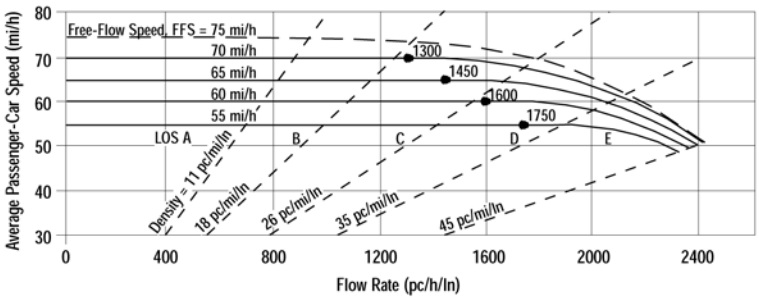
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: PM 2030
Comment: eastbound

Site Information

Jurisdiction/Date: Jurisdiction 4/6/2010
Highway/Direction of Travel: I-90
From/To: Haines off/Haines on

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 2060 veh/h
Annual avg. daily traffic, AADT: ____ veh/day
Peak-hour proportion of AADT, K: ____
Peak-hour direction proportion, D: ____
DDHV = AADT x K x D: ____ veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.4 mi Up/Down: 1.0 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 1.5

E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.972

Speed Inputs

Lane width: ____ ft
Rt-shoulder lat. clearance: ____ ft
Interchange density: ____ I/mi
Number of lanes, N: 2
FFS (measured): 65.0 mi/h
Base free-flow speed, BFFS: ____ mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): ____ mi/h
f_{LC} (❑ Field data?): ____ mi/h
f_{ID} (❑ Field data?): ____ mi/h
f_N (❑ Field data?): ____ mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: ____ mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 1152 pc/h/ln
S: 65.0 mi/h
$D = v_p/S$: 17.7 pc/i/ln
LOS: B

Design (v_p) or Planning (v_p)

LOS: ____
v_p: ____ pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: ____ veh/h
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
LOS: ____

Design (N) or Planning (N) 2nd Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln
LOS: ____

Glossary

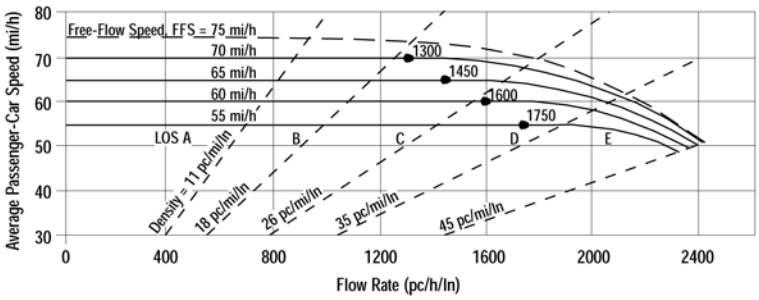
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: PM 2030
Comment: eastbound

Site Information

Jurisdiction/Date: Jurisdiction 4/6/2010
Highway/Direction of Travel: I-90
From/To: Haines/Lacrosse

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 2370 veh/h
Annual avg. daily traffic, AADT: ____ veh/day
Peak-hour proportion of AADT, K: ____
Peak-hour direction proportion, D: ____
DDHV = AADT x K x D: ____ veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.6 mi Up/Down: 1.0 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 1.5

E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.972

Speed Inputs

Lane width: ____ ft
Rt-shoulder lat. clearance: ____ ft
Interchange density: ____ I/mi
Number of lanes, N: 2
FFS (measured): 65.0 mi/h
Base free-flow speed, BFFS: ____ mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): ____ mi/h
f_{LC} (❑ Field data?): ____ mi/h
f_{ID} (❑ Field data?): ____ mi/h
f_N (❑ Field data?): ____ mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: ____ mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 1325 pc/h/ln
S: 65.0 mi/h
$D = v_p/S$: 20.4 pc/i/ln
LOS: C

Design (v_p) or Planning (v_p)

LOS: ____
v_p: ____ pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: ____ veh/h
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
LOS: ____

Design (N) or Planning (N) 2nd Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln
LOS: ____

Glossary

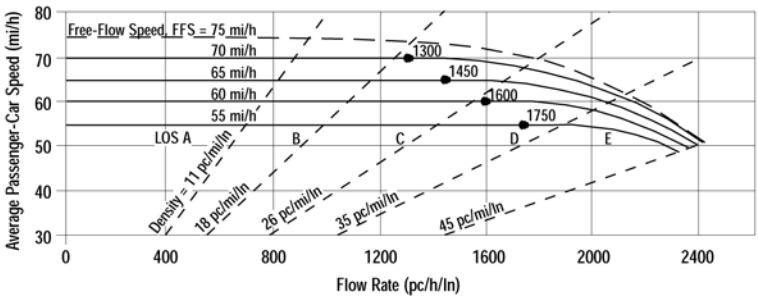
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: PM 2030
Comment: westbound

Site Information

Jurisdiction/Date: Jurisdiction 4/6/2010
Highway/Direction of Travel: I-90
From/To: Lacrosse/Haines

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 2270 veh/h
Annual avg. daily traffic, AADT: ____ veh/day
Peak-hour proportion of AADT, K: ____
Peak-hour direction proportion, D: ____
DDHV = AADT x K x D: ____ veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain
❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.5 mi Up/Down: -1.0 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 1.5

E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.972

Speed Inputs

Lane width: ____ ft
Rt-shoulder lat. clearance: ____ ft
Interchange density: ____ I/mi
Number of lanes, N: 2
FFS (measured): 65.0 mi/h
Base free-flow speed, BFFS: ____ mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): ____ mi/h
f_{LC} (❑ Field data?): ____ mi/h
f_{ID} (❑ Field data?): ____ mi/h
f_N (❑ Field data?): ____ mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: ____ mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 1269 pc/h/ln
S: 65.0 mi/h
$D = v_p/S$: 19.5 pc/i/ln
LOS: C

Design (v_p) or Planning (v_p)

LOS: ____
v_p: ____ pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: ____ veh/h
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
LOS: ____

Design (N) or Planning (N) 2nd Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln
LOS: ____

Glossary

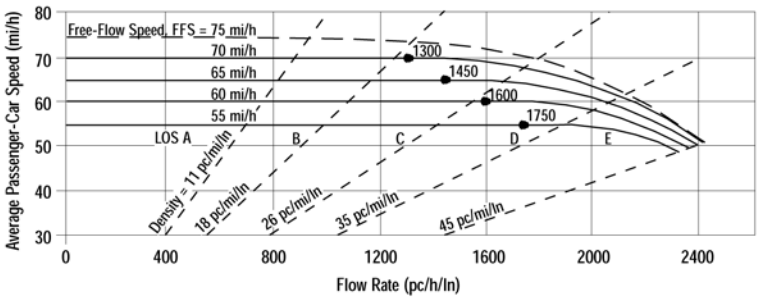
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: PM 2030
Comment: westbound

Site Information

Jurisdiction/Date: Jurisdiction 4/6/2010
Highway/Direction of Travel: I-90
From/To: Haines off/Haines on

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 2000 veh/h
Annual avg. daily traffic, AADT: ____ veh/day
Peak-hour proportion of AADT, K: ____
Peak-hour direction proportion, D: ____
DDHV = AADT x K x D: ____ veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain
❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.5 mi Up/Down: -1.0 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 1.5

E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.972

Speed Inputs

Lane width: ____ ft
Rt-shoulder lat. clearance: ____ ft
Interchange density: ____ I/mi
Number of lanes, N: 2
FFS (measured): 65.0 mi/h
Base free-flow speed, BFFS: ____ mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): ____ mi/h
f_{LC} (❑ Field data?): ____ mi/h
f_{ID} (❑ Field data?): ____ mi/h
f_N (❑ Field data?): ____ mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: ____ mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 1118 pc/h/ln
S: 65.0 mi/h
$D = v_p/S$: 17.2 pc/i/ln
LOS: B

Design (v_p) or Planning (v_p)

LOS: ____
v_p: ____ pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: ____ veh/h
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
LOS: ____

Design (N) or Planning (N) 2nd Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln
LOS: ____

Glossary

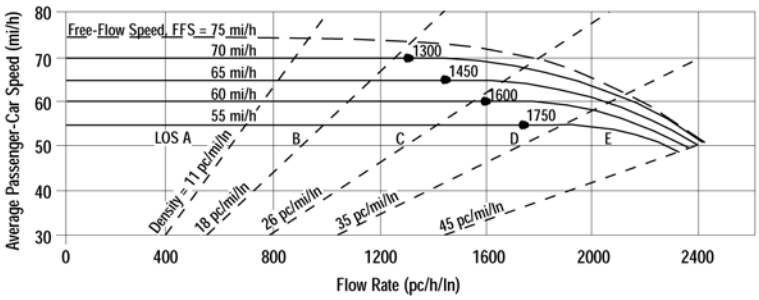
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: PM 2030
Comment: westbound

Site Information

Jurisdiction/Date: Jurisdiction 4/6/2010
Highway/Direction of Travel: I-90
From/To: Haines/I-190

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 2600 veh/h
Annual avg. daily traffic, AADT: ____ veh/day
Peak-hour proportion of AADT, K: ____
Peak-hour direction proportion, D: ____
DDHV = AADT x K x D: ____ veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain
❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.4 mi Up/Down: 2.0 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 1.5

E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.972

Speed Inputs

Lane width: ____ ft
Rt-shoulder lat. clearance: ____ ft
Interchange density: ____ I/mi
Number of lanes, N: 3
FFS (measured): 65.0 mi/h
Base free-flow speed, BFFS: ____ mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): ____ mi/h
f_{LC} (❑ Field data?): ____ mi/h
f_{ID} (❑ Field data?): ____ mi/h
f_N (❑ Field data?): ____ mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: ____ mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 969 pc/h/ln
S: 65.0 mi/h
$D = v_p/S$: 14.9 pc/i/ln
LOS: B

Design (v_p) or Planning (v_p)

LOS: ____
v_p: ____ pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: ____ veh/h
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
LOS: ____

Design (N) or Planning (N) 2nd Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln
LOS: ____

Glossary

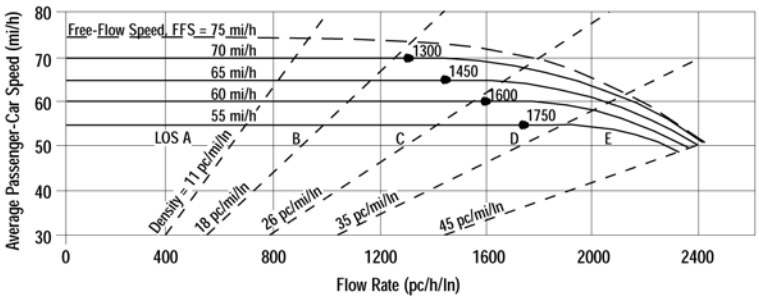
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: PM 2030
Comment: westbound

Site Information

Jurisdiction/Date: Jurisdiction 4/6/2010
Highway/Direction of Travel: I-90
From/To: I-190 off/I-190 on

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 1950 veh/h
Annual avg. daily traffic, AADT: ____ veh/day
Peak-hour proportion of AADT, K: ____
Peak-hour direction proportion, D: ____
DDHV = AADT x K x D: ____ veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.4 mi Up/Down: 2.0 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 1.5

E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.972

Speed Inputs

Lane width: ____ ft
Rt-shoulder lat. clearance: ____ ft
Interchange density: ____ I/mi
Number of lanes, N: 2
FFS (measured): 65.0 mi/h
Base free-flow speed, BFFS: ____ mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): ____ mi/h
f_{LC} (❑ Field data?): ____ mi/h
f_{ID} (❑ Field data?): ____ mi/h
f_N (❑ Field data?): ____ mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: ____ mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 1091 pc/h/ln
S: 65.0 mi/h
$D = v_p/S$: 16.8 pc/i/ln
LOS: B

Design (v_p) or Planning (v_p)

LOS: ____
v_p: ____ pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: ____ veh/h
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
LOS: ____

Design (N) or Planning (N) 2nd Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln
LOS: ____

Glossary

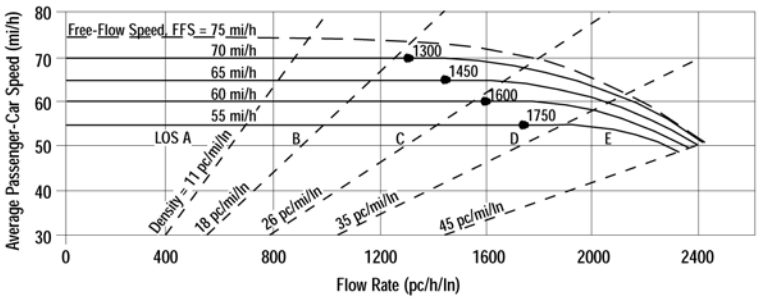
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: PM 2030
Comment: westbound

Site Information

Jurisdiction/Date: Jurisdiction 4/6/2010
Highway/Direction of Travel: I-90
From/To: I-190/Deadwood

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 2540 veh/h
Annual avg. daily traffic, AADT: ____ veh/day
Peak-hour proportion of AADT, K: ____
Peak-hour direction proportion, D: ____
DDHV = AADT x K x D: ____ veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ❑ Level ☑ Rolling ❑ Mountainous
Grade Length ____ mi Up/Down ____ %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 2.5
E_R (❑ Field data?): 2.0
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.913

Speed Inputs

Lane width: ____ ft
Rt-shoulder lat. clearance: ____ ft
Interchange density: ____ I/mi
Number of lanes, N: 2
FFS (measured): 65.0 mi/h
Base free-flow speed, BFFS: ____ mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): ____ mi/h
f_{LC} (❑ Field data?): ____ mi/h
f_{ID} (❑ Field data?): ____ mi/h
f_N (❑ Field data?): ____ mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: ____ mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 1512 pc/h/ln
S: 65.0 mi/h
$D = v_p/S$: 23.3 pc/i/ln
LOS: C

Design (v_p) or Planning (v_p)

LOS: ____
v_p: ____ pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: ____ veh/h
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
LOS: ____

Design (N) or Planning (N) 2nd Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln
LOS: ____

Glossary

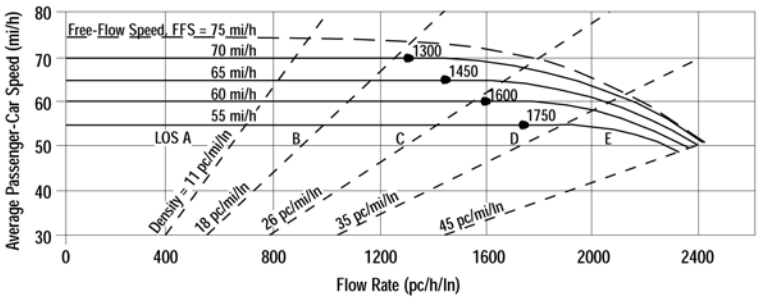
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: PM 2030
Comment: northbound

Site Information

Jurisdiction/Date: Jurisdiction 4/6/2010
Highway/Direction of Travel: I-190
From/To: Omaha/Silver

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 1880 veh/h
Annual avg. daily traffic, AADT: ____ veh/day
Peak-hour proportion of AADT, K: ____
Peak-hour direction proportion, D: ____
DDHV = AADT x K x D: ____ veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.1 mi Up/Down: 0.2 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 1.5

E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.972

Speed Inputs

Lane width: ____ ft
Rt-shoulder lat. clearance: ____ ft
Interchange density: ____ I/mi
Number of lanes, N: 2
FFS (measured): 55.0 mi/h
Base free-flow speed, BFFS: ____ mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): ____ mi/h
f_{LC} (❑ Field data?): ____ mi/h
f_{ID} (❑ Field data?): ____ mi/h
f_N (❑ Field data?): ____ mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: ____ mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 1051 pc/h/ln
S: 55.0 mi/h
$D = v_p/S$: 19.1 pc/i/ln
LOS: C

Design (v_p) or Planning (v_p)

LOS: ____
v_p: ____ pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: ____ veh/h
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
LOS: ____

Design (N) or Planning (N) 2nd Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln
LOS: ____

Glossary

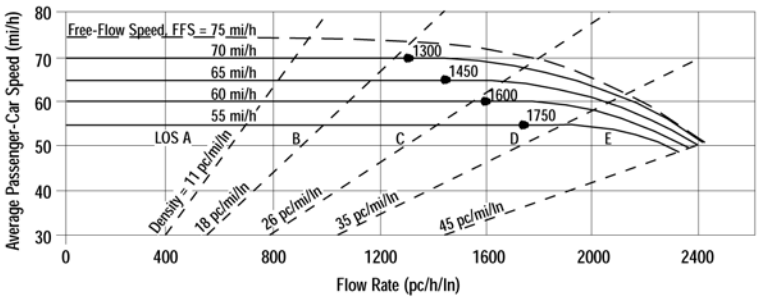
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: PM 2030
Comment: northbound

Site Information

Jurisdiction/Date: Jurisdiction 4/6/2010
Highway/Direction of Travel: I-190
From/To: Silver/Anamosa

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 1480 veh/h
Annual avg. daily traffic, AADT: veh/day
Peak-hour proportion of AADT, K:
Peak-hour direction proportion, D:
DDHV = AADT x K x D: veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.9 mi Up/Down: 2.0 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 2.0

E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.949

Speed Inputs

Lane width: ft
Rt-shoulder lat. clearance: ft
Interchange density: l/mi
Number of lanes, N: 2
FFS (measured): 55.0 mi/h
Base free-flow speed, BFFS: mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): mi/h
f_{LC} (❑ Field data?): mi/h
f_{ID} (❑ Field data?): mi/h
f_N (❑ Field data?): mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 848 pc/h/ln
S: 55.0 mi/h
$D = v_p/S$: 15.4 pc/i/ln
LOS: B

Design (v_p) or Planning (v_p)

LOS:
v_p: pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: veh/h
S: mi/h
$D = v_p/S$: pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
LOS:

Design (N) or Planning (N) 2nd Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
S: mi/h
$D = v_p/S$: pc/mi/ln
LOS:

Glossary

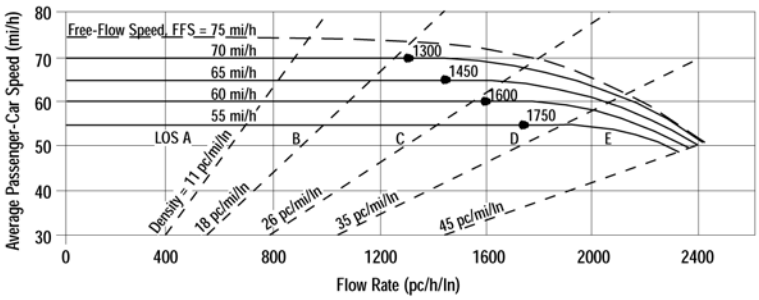
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: PM 2030
Comment: northbound

Site Information

Jurisdiction/Date: Jurisdiction 4/6/2010
Highway/Direction of Travel: I-190
From/To: Anamosa/I-90

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 1620 veh/h
Annual avg. daily traffic, AADT: veh/day
Peak-hour proportion of AADT, K:
Peak-hour direction proportion, D:
DDHV = AADT x K x D: veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.2 mi Up/Down: 2.0 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 1.5

E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.972

Speed Inputs

Lane width: ft
Rt-shoulder lat. clearance: ft
Interchange density: l/mi
Number of lanes, N: 2
FFS (measured): 55.0 mi/h
Base free-flow speed, BFFS: mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): mi/h
f_{LC} (❑ Field data?): mi/h
f_{ID} (❑ Field data?): mi/h
f_N (❑ Field data?): mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 906 pc/h/ln
S: 55.0 mi/h
$D = v_p/S$: 16.5 pc/i/ln
LOS: B

Design (v_p) or Planning (v_p)

LOS:
v_p: pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: veh/h
S: mi/h
$D = v_p/S$: pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
LOS:

Design (N) or Planning (N) 2nd Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
S: mi/h
$D = v_p/S$: pc/mi/ln
LOS:

Glossary

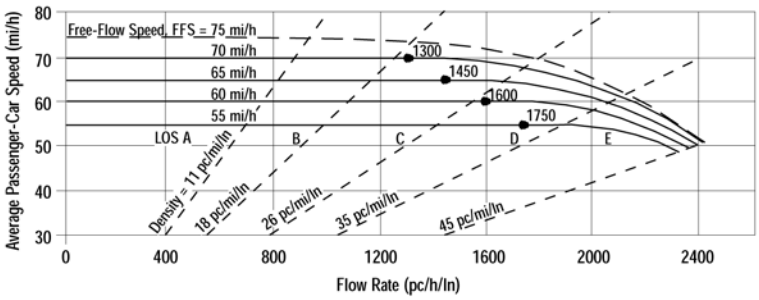
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: PM 2030
Comment: southbound

Site Information

Jurisdiction/Date: Jurisdiction 4/6/2010
Highway/Direction of Travel: I-190
From/To: Silver/Omaha

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 1400 veh/h
Annual avg. daily traffic, AADT: ____ veh/day
Peak-hour proportion of AADT, K: ____
Peak-hour direction proportion, D: ____
DDHV = AADT x K x D: ____ veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain
❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.1 mi Up/Down: -0.2 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 1.5

E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.972

Speed Inputs

Lane width: ____ ft
Rt-shoulder lat. clearance: ____ ft
Interchange density: ____ I/mi
Number of lanes, N: 2
FFS (measured): 55.0 mi/h
Base free-flow speed, BFFS: ____ mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): ____ mi/h
f_{LC} (❑ Field data?): ____ mi/h
f_{ID} (❑ Field data?): ____ mi/h
f_N (❑ Field data?): ____ mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: ____ mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 783 pc/h/ln
S: 55.0 mi/h
D = v_p/S: 14.2 pc/i/ln
LOS: B

Design (v_p) or Planning (v_p)

LOS: ____
v_p: ____ pc/h/ln
V = v_p x PHF x N x f_{HV} x f_p: ____ veh/h
S: ____ mi/h
D = v_p/S: ____ pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
LOS: ____

Design (N) or Planning (N) 2nd Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
S: ____ mi/h
D = v_p/S: ____ pc/mi/ln
LOS: ____

Glossary

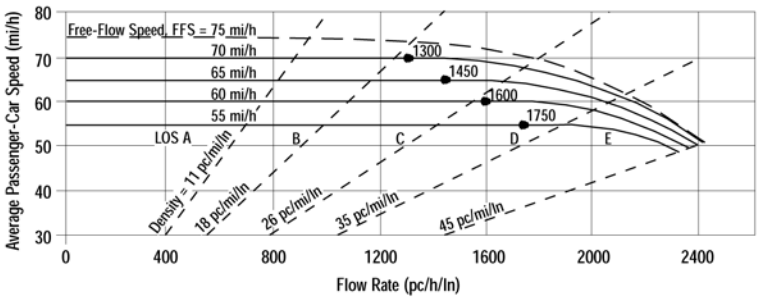
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: PM 2030
Comment: southbound

Site Information

Jurisdiction/Date: Jurisdiction 4/6/2010
Highway/Direction of Travel: I-190
From/To: Silver off/Silver on

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 1020 veh/h
Annual avg. daily traffic, AADT: veh/day
Peak-hour proportion of AADT, K:
Peak-hour direction proportion, D:
DDHV = AADT x K x D: veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain: ❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.5 mi Up/Down: -2.0 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 1.5

E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.972

Speed Inputs

Lane width: ft
Rt-shoulder lat. clearance: ft
Interchange density: l/mi
Number of lanes, N: 2
FFS (measured): 55.0 mi/h
Base free-flow speed, BFFS: mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): mi/h
f_{LC} (❑ Field data?): mi/h
f_{ID} (❑ Field data?): mi/h
f_N (❑ Field data?): mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 570 pc/h/ln
S: 55.0 mi/h
$D = v_p/S$: 10.4 pc/i/ln
LOS: A

Design (v_p) or Planning (v_p)

LOS:
v_p: pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: veh/h
S: mi/h
$D = v_p/S$: pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
LOS:

Design (N) or Planning (N) 2nd Iteration

N: assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: pc/h/ln
S: mi/h
$D = v_p/S$: pc/mi/ln
LOS:

Glossary

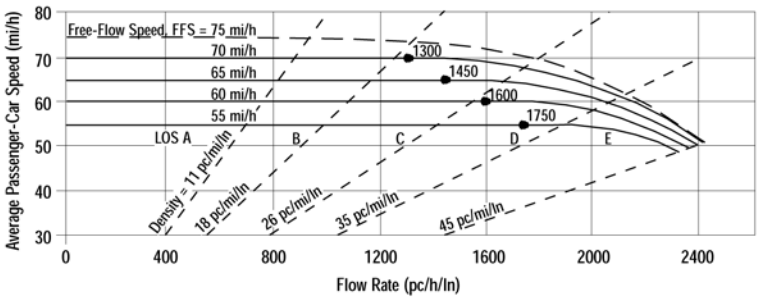
N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 23 - BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Oper. (LOS)	FFS, N, v_p	LOS, S, D
Des. (N)	FFS, LOS, v_p	N, S, D
Des. (v_p)	FFS, LOS, N	v_p, S, D
Plan. (LOS)	FFS, N, AADT	LOS, S, D
Plan. (N)	FFS, LOS, AADT	N, S, D
Plan. (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst: Laughlin
Agency or Company: HDR
Analysis Period/Year: PM 2030
Comment: southbound

Site Information

Jurisdiction/Date: Jurisdiction 4/6/2010
Highway/Direction of Travel: I-190
From/To: I-90/Silver

☑ Oper. (LOS) ❑ Des. (N) ❑ Des. (v_p) ❑ Plan. (LOS) ❑ Plan. (N) ❑ Plan. (v_p)

Flow Inputs

Volume, V: 1090 veh/h
Annual avg. daily traffic, AADT: ____ veh/day
Peak-hour proportion of AADT, K: ____
Peak-hour direction proportion, D: ____
DDHV = AADT x K x D: ____ veh/h
Driver type: ☑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF: 0.92
% Trucks and buses, P_T: 5
% RVs, P_R: 2
General terrain
❑ Level ❑ Rolling ❑ Mountainous
Grade Length: 0.7 mi Up/Down: -2.0 %

Calculate Flow Adjustments

f_p (❑ Field data?): 1.00
E_T (❑ Field data?): 1.5

E_R (❑ Field data?): 1.2
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$: 0.972

Speed Inputs

Lane width: ____ ft
Rt-shoulder lat. clearance: ____ ft
Interchange density: ____ I/mi
Number of lanes, N: 2
FFS (measured): 55.0 mi/h
Base free-flow speed, BFFS: ____ mi/h

Calculate Speed Adjustments and FFS

f_{LW} (❑ Field data?): ____ mi/h
f_{LC} (❑ Field data?): ____ mi/h
f_{ID} (❑ Field data?): ____ mi/h
f_N (❑ Field data?): ____ mi/h
FFS = BFFS - f_{LW} - f_{LC} - f_{ID} - f_N: ____ mi/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: 610 pc/h/ln
S: 55.0 mi/h
$D = v_p/S$: 11.1 pc/i/ln
LOS: B

Design (v_p) or Planning (v_p)

LOS: ____
v_p: ____ pc/h/ln
$V = v_p \times PHF \times N \times f_{HV} \times f_p$: ____ veh/h
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln

Design (N) or Planning (N) 1st Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
LOS: ____

Design (N) or Planning (N) 2nd Iteration

N: ____ assumed
$v_p = \frac{V \text{ or } DDHV}{(PHF \times N \times f_{HV} \times f_p)}$: ____ pc/h/ln
S: ____ mi/h
$D = v_p/S$: ____ pc/mi/ln
LOS: ____

Glossary

N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7

©Catalina Engineering, Inc.

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	4/6/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-90	
Analysis Period/Year	PM 2030	Junction	EB I-190 off	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☐ Yes ☐ On
☑ No ☐ Off
L_{up} = _____ ft
V_u = _____ veh/h

Freeway terrain: Rolling
Ramp terrain: Rolling

Ramp Type
☐ Merge ☑ Diverge
☑ Right side ☐ Left side

Number of freeway lanes: 2
Number of ramp lanes: 1
Length of ramp roadway: 1340 ft

S_{FF} = 65.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☑ Yes ☑ On
☐ No ☐ Off
L_{down} = 1850 ft
V_D = 1030 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				2160	0.92	5	☐ 0.930	☐ 1.00	2524
v_R				440	0.92	5	☐ 0.930	☐ 1.00	514
v_U							☐ 0.976	☐ 1.00	
v_D				1030	0.92	5	☐ 0.930	☐ 1.00	1204

Merge Areas

Estimation of v_{12}

$v_{12} = v_F * P_{FM}$

L_{EQ} = _____ (Equation 25-2 or 25-3)
P_{FM} = _____ using Equation _____ (Exhibit 25-5)
v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}		See Exhibit 25-7	
v_{R12}		4600: All	

Level-of-Service Determination (if not F)

$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$

D_R = _____ pc/mi/ln
LOS = _____ (Exhibit 25-4)

Speed Estimation

M_s = _____ (Exhibit 25-19)
S_R = _____ mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = _____ mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$v_{12} = v_R + (v_F - v_R)P_{FD}$

L_{EQ} = _____ (Equation 25-8 or 25-9)
P_{FD} = 1.000 using Equation _____ (Exhibit 25-12)
v_{12} = 2524 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$	2524	See Exhibit 25-14	
v_{12}	2524	4400: All	
$v_{FO} = v_F - v_R$	2010	See Exhibit 25-14	
v_R	440	See Exhibit 25-3	

Level-of-Service Determination (if not F)

$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$

D_R = 13.9 pc/mi/ln
LOS = B (Exhibit 25-4)

Speed Estimation

D_s = 0.344 (Exhibit 25-19)
S_R = 57.1 mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = 57.1 mi/h (Equation 25-15)

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	4/6/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-90	
Analysis Period/Year	PM 2030	Junction	EB I-190 on	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☑ Yes ☐ On

☐ No ☑ Off

L_{up} = 1850 ft

V_u = 440 veh/h

Freeway terrain: Rolling

Ramp terrain: Rolling

Ramp Type

☑ Merge ☐ Diverge

☑ Right side ☐ Left side

Number of freeway lanes: 2

Number of ramp lanes: 1

Length of ramp roadway: 1570 ft

S_{FF} = 65.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☑ Yes ☐ On

☐ No ☑ Off

L_{down} = 730 ft

V_D = 690 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				1720	0.92	5	☐ 0.930	☐ 1.00	2010
v_R				1030	0.92	5	☐ 0.930	☐ 1.00	1204
v_U				440	0.92	5	☐ 0.930	☐ 1.00	514
v_D				690	0.92	5	☐ 0.930	☐ 1.00	806

Merge Areas

Estimation of v_{12}

$$v_{12} = v_F * P_{FM}$$

L_{EQ} = _____ (Equation 25-2 or 25-3)

P_{FM} = 1.000 using Equation _____ (Exhibit 25-5)

v_{12} = 2010 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	3213	See Exhibit 25-7	
v_{R12}	3213	4600: All	

Level-of-Service Determination (if not F)

$$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$$

D_R = 20.1 pc/mi/ln

LOS = C (Exhibit 25-4)

Speed Estimation

M_s = 0.277 (Exhibit 25-19)

S_R = 58.6 mi/h (Exhibit 25-19)

S_O = _____ mi/h (Exhibit 25-19)

S = 58.6 mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$$v_{12} = v_R + (v_F - v_R)P_{FD}$$

L_{EQ} = _____ (Equation 25-8 or 25-9)

P_{FD} = _____ using Equation _____ (Exhibit 25-12)

v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$		See Exhibit 25-14	
v_{12}		4400: All	
$v_{FO} = v_F - v_R$		See Exhibit 25-14	
v_R		See Exhibit 25-3	

Level-of-Service Determination (if not F)

$$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$$

D_R = _____ pc/mi/ln

LOS = _____ (Exhibit 25-4)

Speed Estimation

D_s = _____ (Exhibit 25-19)

S_R = _____ mi/h (Exhibit 25-19)

S_O = _____ mi/h (Exhibit 25-19)

S = _____ mi/h (Equation 25-15)

©Catalina Engineering, Inc.

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	4/6/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-90	
Analysis Period/Year	PM 2030	Junction	EB Haines off	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☑ Yes ☑ On
☐ No ☐ Off
L_{up} = 730 ft
V_u = 1030 veh/h

Freeway terrain: Rolling
Ramp terrain: Rolling

Ramp Type
☐ Merge ☑ Diverge
☑ Right side ☐ Left side

Number of freeway lanes: 3
Number of ramp lanes: 1
Length of ramp roadway: 1130 ft

S_{FF} = 65.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☑ Yes ☑ On
☐ No ☐ Off
L_{down} = 2330 ft
V_D = 310 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				2750	0.92	5	☐ 0.930	☐ 1.00	3213
v_R				690	0.92	5	☐ 0.930	☐ 1.00	806
v_U				1030	0.92	5	☐ 0.930	☐ 1.00	1204
v_D				310	0.92	5	☐ 0.930	☐ 1.00	362

Merge Areas

Estimation of v_{12}

$$v_{12} = v_F * P_{FM}$$

L_{EQ} = _____ (Equation 25-2 or 25-3)
P_{FM} = _____ using Equation _____ (Exhibit 25-5)
v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}		See Exhibit 25-7	
v_{R12}		4600: All	

Level-of-Service Determination (if not F)

$$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$$

D_R = _____ pc/mi/ln
LOS = _____ (Exhibit 25-4)

Speed Estimation

M_s = _____ (Exhibit 25-19)
S_R = _____ mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = _____ mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$$v_{12} = v_R + (v_F - v_R)P_{FD}$$

L_{EQ} = 14391 (Equation 25-8 or 25-9)
P_{FD} = 1.587 using Equation 6 (Exhibit 25-12)
v_{12} = 4627 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$	3213	See Exhibit 25-14	
v_{12}	4627	4400: All	✓
$v_{FO} = v_F - v_R$	2407	See Exhibit 25-14	
v_R	690	See Exhibit 25-3	

Level-of-Service Determination (if not F)

$$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$$

D_R = _____ pc/mi/ln
LOS = F (Exhibit 25-4)

Speed Estimation

D_s = _____ (Exhibit 25-19)
S_R = _____ mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = _____ mi/h (Equation 25-15)

©Catalina Engineering, Inc.

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	4/6/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-90	
Analysis Period/Year	PM 2030	Junction	EB Haines on	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☑ Yes ☐ On
☐ No ☑ Off
L_{up} = 2330 ft
V_u = 690 veh/h

Freeway terrain: Rolling
Ramp terrain: Rolling

Ramp Type
☑ Merge ☐ Diverge
☑ Right side ☐ Left side
Number of freeway lanes: 2
Number of ramp lanes: 1
Length of ramp roadway: 1270 ft

S_{FF} = 65.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☑ Yes ☐ On
☐ No ☑ Off
L_{down} = 2910 ft
V_D = 430 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				2060	0.92	5	☐ 0.930	☐ 1.00	2407
v_R				310	0.92	5	☐ 0.930	☐ 1.00	362
v_U				690	0.92	5	☐ 0.930	☐ 1.00	806
v_D				430	0.92	5	☐ 0.930	☐ 1.00	502

Merge Areas

Estimation of v_{12}

$$v_{12} = v_F * P_{FM}$$

L_{EQ} = _____ (Equation 25-2 or 25-3)
P_{FM} = 1.000 using Equation _____ (Exhibit 25-5)
v_{12} = 2407 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	2769	See Exhibit 25-7	
v_{R12}	2769	4600: All	

Level-of-Service Determination (if not F)

$$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$$

D_R = 18.9 pc/mi/ln
LOS = B (Exhibit 25-4)

Speed Estimation

M_s = 0.269 (Exhibit 25-19)
S_R = 58.8 mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = 58.8 mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$$v_{12} = v_R + (v_F - v_R)P_{FD}$$

L_{EQ} = _____ (Equation 25-8 or 25-9)
P_{FD} = _____ using Equation _____ (Exhibit 25-12)
v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$		See Exhibit 25-14	
v_{12}		4400: All	
$v_{FO} = v_F - v_R$		See Exhibit 25-14	
v_R		See Exhibit 25-3	

Level-of-Service Determination (if not F)

$$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$$

D_R = _____ pc/mi/ln
LOS = _____ (Exhibit 25-4)

Speed Estimation

D_s = _____ (Exhibit 25-19)
S_R = _____ mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = _____ mi/h (Equation 25-15)

©Catalina Engineering, Inc.

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	4/6/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-90	
Analysis Period/Year	PM 2030	Junction	WB Haines off	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☑ Yes ☑ On
☐ No ☐ Off
L_{up} = 2400 ft
V_u = 450 veh/h

Freeway terrain: Rolling
Ramp terrain: Rolling

Ramp Type
☐ Merge ☑ Diverge
☑ Right side ☐ Left side

Number of freeway lanes: 2
Number of ramp lanes: 1
Length of ramp roadway: 1390 ft

S_{FF} = 65.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☑ Yes ☑ On
☐ No ☐ Off
L_{down} = 2500 ft
V_D = 600 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				2270	0.92	5	☐ 0.930	☐ 1.00	2652
v_R				270	0.92	5	☐ 0.930	☐ 1.00	315
v_U				450	0.92	5	☐ 0.930	☐ 1.00	526
v_D				600	0.92	5	☐ 0.930	☐ 1.00	701

Merge Areas

Estimation of v_{12}

$$v_{12} = v_F * P_{FM}$$

L_{EQ} = _____ (Equation 25-2 or 25-3)
P_{FM} = _____ using Equation _____ (Exhibit 25-5)
v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}		See Exhibit 25-7	
v_{R12}		4600: All	

Level-of-Service Determination (if not F)

$$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$$

D_R = _____ pc/mi/ln
LOS = _____ (Exhibit 25-4)

Speed Estimation

M_s = _____ (Exhibit 25-19)
S_R = _____ mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = _____ mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$$v_{12} = v_R + (v_F - v_R)P_{FD}$$

L_{EQ} = _____ (Equation 25-8 or 25-9)
P_{FD} = 1.000 using Equation _____ (Exhibit 25-12)
v_{12} = 2652 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$	2652	See Exhibit 25-14	
v_{12}	2652	4400: All	
$v_{FO} = v_F - v_R$	2337	See Exhibit 25-14	
v_R	270	See Exhibit 25-3	

Level-of-Service Determination (if not F)

$$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$$

D_R = 14.6 pc/mi/ln
LOS = B (Exhibit 25-4)

Speed Estimation

D_s = 0.326 (Exhibit 25-19)
S_R = 57.5 mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = 57.5 mi/h (Equation 25-15)

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	4/6/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-90	
Analysis Period/Year	PM 2030	Junction	WB Haines on	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☑ Yes ☐ On
☐ No ☑ Off
L_{up} = 2500 ft
V_u = 270 veh/h

Freeway terrain: Rolling
Ramp terrain: Rolling

Ramp Type
☑ Merge ☐ Diverge
☑ Right side ☐ Left side
Number of freeway lanes: 2
Number of ramp lanes: 1
Length of ramp roadway: 1170 ft

S_{FF} = 65.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☑ Yes ☐ On
☐ No ☑ Off
L_{down} = 2220 ft
V_D = 650 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				2000	0.92	5	☐ 0.930	☐ 1.00	2337
v_R				600	0.92	5	☐ 0.930	☐ 1.00	701
v_U				270	0.92	5	☐ 0.930	☐ 1.00	315
v_D				650	0.92	5	☐ 0.930	☐ 1.00	760

Merge Areas

Estimation of v_{12}

$$v_{12} = v_F * P_{FM}$$

L_{EQ} = _____ (Equation 25-2 or 25-3)
P_{FM} = 1.000 using Equation _____ (Exhibit 25-5)
v_{12} = 2337 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	3038	See Exhibit 25-7	
v_{R12}	3038	4600: All	

Level-of-Service Determination (if not F)

$$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$$

D_R = 21.5 pc/mi/ln
LOS = C (Exhibit 25-4)

Speed Estimation

M_s = 0.297 (Exhibit 25-19)
S_R = 58.2 mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = 58.2 mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$$v_{12} = v_R + (v_F - v_R)P_{FD}$$

L_{EQ} = _____ (Equation 25-8 or 25-9)
P_{FD} = _____ using Equation _____ (Exhibit 25-12)
v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$		See Exhibit 25-14	
v_{12}		4400: All	
$v_{FO} = v_F - v_R$		See Exhibit 25-14	
v_R		See Exhibit 25-3	

Level-of-Service Determination (if not F)

$$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$$

D_R = _____ pc/mi/ln
LOS = _____ (Exhibit 25-4)

Speed Estimation

D_s = _____ (Exhibit 25-19)
S_R = _____ mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = _____ mi/h (Equation 25-15)

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	4/6/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-90	
Analysis Period/Year	PM 2030	Junction	WB 190 off	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☑ Yes ☑ On

☐ No ☐ Off

L_{up} = 2220 ft

V_u = 600 veh/h

Freeway terrain: Rolling

Ramp terrain: Rolling

Ramp Type

☐ Merge ☑ Diverge

☑ Right side ☐ Left side

Number of freeway lanes: 3

Number of ramp lanes: 1

Length of ramp roadway: 2640 ft

S_{FF} = 65.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☑ Yes ☑ On

☐ No ☐ Off

L_{down} = 2070 ft

V_D = 590 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				2600	0.92	5	☐ 0.930	☐ 1.00	3038
v_R				650	0.92	5	☐ 0.930	☐ 1.00	760
v_U				600	0.92	5	☐ 0.930	☐ 1.00	701
v_D				590	0.92	5	☐ 0.930	☐ 1.00	689

Merge Areas

Estimation of v_{12}

$$v_{12} = v_F * P_{FM}$$

L_{EQ} = _____ (Equation 25-2 or 25-3)

P_{FM} = _____ using Equation _____ (Exhibit 25-5)

v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}		See Exhibit 25-7	
v_{R12}		4600: All	

Level-of-Service Determination (if not F)

$$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$$

D_R = _____ pc/mi/ln

LOS = _____ (Exhibit 25-4)

Speed Estimation

M_s = _____ (Exhibit 25-19)

S_R = _____ mi/h (Exhibit 25-19)

S_O = _____ mi/h (Exhibit 25-19)

S = _____ mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$$v_{12} = v_R + (v_F - v_R)P_{FD}$$

L_{EQ} = 8431 (Equation 25-8 or 25-9)

P_{FD} = 0.789 using Equation 6 (Exhibit 25-12)

v_{12} = 2558 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$	3038	See Exhibit 25-14	
v_{12}	2558	4400: All	
$v_{FO} = v_F - v_R$	2279	See Exhibit 25-14	
v_R	650	See Exhibit 25-3	

Level-of-Service Determination (if not F)

$$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$$

D_R = 2.5 pc/mi/ln

LOS = A (Exhibit 25-4)

Speed Estimation

D_s = 0.366 (Exhibit 25-19)

S_R = 56.6 mi/h (Exhibit 25-19)

S_O = 71.3 mi/h (Exhibit 25-19)

S = 58.5 mi/h (Equation 25-15)

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	4/6/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-90	
Analysis Period/Year	PM 2030	Junction	WB 190 on	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☑ Yes ☑ On
☐ No ☐ Off
L_{up} = 2070 ft
V_u = 650 veh/h

Freeway terrain: Rolling
Ramp terrain: Rolling

Ramp Type
☑ Merge ☐ Diverge
☑ Right side ☐ Left side
Number of freeway lanes: 2
Number of ramp lanes: 1
Length of ramp roadway: 4410 ft

S_{FF} = 65.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☐ Yes ☐ On
☑ No ☐ Off
L_{down} = _____ ft
V_D = _____ veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				1950	0.92	5	☐ 0.930	☐ 1.00	2279
v_R				590	0.92	5	☐ 0.930	☐ 1.00	689
v_U				650	0.92	5	☐ 0.930	☐ 1.00	760
v_D							☐ 0.976	☐ 1.00	

Merge Areas

Estimation of v_{12}

$$v_{12} = v_F * P_{FM}$$

L_{EQ} = _____ (Equation 25-2 or 25-3)
P_{FM} = 1.000 using Equation _____ (Exhibit 25-5)
v_{12} = 2279 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	2968	See Exhibit 25-7	
v_{R12}	2968	4600: All	

Level-of-Service Determination (if not F)

$$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$$

D_R = 0.7 pc/mi/ln
LOS = A (Exhibit 25-4)

Speed Estimation

M_s = 0.000 (Exhibit 25-19)
S_R = 65.0 mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = 65.0 mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$$v_{12} = v_R + (v_F - v_R)P_{FD}$$

L_{EQ} = _____ (Equation 25-8 or 25-9)
P_{FD} = _____ using Equation _____ (Exhibit 25-12)
v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$		See Exhibit 25-14	
v_{12}		4400: All	
$v_{FO} = v_F - v_R$		See Exhibit 25-14	
v_R		See Exhibit 25-3	

Level-of-Service Determination (if not F)

$$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$$

D_R = _____ pc/mi/ln
LOS = _____ (Exhibit 25-4)

Speed Estimation

D_s = _____ (Exhibit 25-19)
S_R = _____ mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = _____ mi/h (Equation 25-15)

©Catalina Engineering, Inc.

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	4/6/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-190	
Analysis Period/Year	PM 2030	Junction	NB Silver off	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☐ Yes ☐ On
☑ No ☐ Off
L_{up} = _____ ft
V_u = _____ veh/h

Freeway terrain: Level
Ramp terrain: Level

Ramp Type
☐ Merge ☑ Diverge
☑ Right side ☐ Left side

Number of freeway lanes: 2
Number of ramp lanes: 1
Length of ramp roadway: 410 ft

S_{FF} = 55.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☑ Yes ☑ On
☐ No ☐ Off
L_{down} = 4740 ft
V_D = 140 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				1880	0.92	5	☐ 0.976	☐ 1.00	2095
v_R				400	0.92	5	☐ 0.976	☐ 1.00	446
v_U							☐ 0.976	☐ 1.00	
v_D				140	0.92	5	☐ 0.930	☐ 1.00	164

Merge Areas

Estimation of v_{12}

$$v_{12} = v_F * P_{FM}$$

L_{EQ} = _____ (Equation 25-2 or 25-3)
P_{FM} = _____ using Equation _____ (Exhibit 25-5)
v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}		See Exhibit 25-7	
v_{R12}		4600: All	

Level-of-Service Determination (if not F)

$$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$$

D_R = _____ pc/mi/ln
LOS = _____ (Exhibit 25-4)

Speed Estimation

M_s = _____ (Exhibit 25-19)
S_R = _____ mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = _____ mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$$v_{12} = v_R + (v_F - v_R)P_{FD}$$

L_{EQ} = _____ (Equation 25-8 or 25-9)
P_{FD} = 1.000 using Equation _____ (Exhibit 25-12)
v_{12} = 2095 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$	2095	See Exhibit 25-14	
v_{12}	2095	4400: All	
$v_{FO} = v_F - v_R$	1649	See Exhibit 25-14	
v_R	400	See Exhibit 25-3	

Level-of-Service Determination (if not F)

$$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$$

D_R = 18.6 pc/mi/ln
LOS = B (Exhibit 25-4)

Speed Estimation

D_s = 0.338 (Exhibit 25-19)
S_R = 50.6 mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = 50.6 mi/h (Equation 25-15)

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	4/6/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-190	
Analysis Period/Year	PM 2030	Junction	NB Anamosa on	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☑ Yes ☐ On

☐ No ☑ Off

L_{up} = 4740 ft

V_u = 400 veh/h

Freeway terrain: Rolling

Ramp terrain: Rolling

Ramp Type

☑ Merge ☐ Diverge

☑ Right side ☐ Left side

Number of freeway lanes: 2

Number of ramp lanes: 1

Length of ramp roadway: 470 ft

S_{FF} = 55.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☑ Yes ☐ On

☐ No ☑ Off

L_{down} = 1200 ft

V_D = 1030 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				1480	0.92	5	☐ 0.930	☐ 1.00	1729
v_R				140	0.92	5	☐ 0.930	☐ 1.00	164
v_U				400	0.92	5	☐ 0.976	☐ 1.00	446
v_D				1030	0.92	5	☐ 0.930	☐ 1.00	1204

Merge Areas

Estimation of v_{12}

$$v_{12} = v_F * P_{FM}$$

L_{EQ} = _____ (Equation 25-2 or 25-3)

P_{FM} = 1.000 using Equation _____ (Exhibit 25-5)

v_{12} = 1729 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	1893	See Exhibit 25-7	
v_{R12}	1893	4600: All	

Level-of-Service Determination (if not F)

$$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$$

D_R = 17.2 pc/mi/ln

LOS = B (Exhibit 25-4)

Speed Estimation

M_s = 0.305 (Exhibit 25-19)

S_R = 51.0 mi/h (Exhibit 25-19)

S_O = _____ mi/h (Exhibit 25-19)

S = 51.0 mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$$v_{12} = v_R + (v_F - v_R)P_{FD}$$

L_{EQ} = _____ (Equation 25-8 or 25-9)

P_{FD} = _____ using Equation _____ (Exhibit 25-12)

v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$		See Exhibit 25-14	
v_{12}		4400: All	
$v_{FO} = v_F - v_R$		See Exhibit 25-14	
v_R		See Exhibit 25-3	

Level-of-Service Determination (if not F)

$$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$$

D_R = _____ pc/mi/ln

LOS = _____ (Exhibit 25-4)

Speed Estimation

D_s = _____ (Exhibit 25-19)

S_R = _____ mi/h (Exhibit 25-19)

S_O = _____ mi/h (Exhibit 25-19)

S = _____ mi/h (Equation 25-15)

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	4/6/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-190	
Analysis Period/Year	PM 2030	Junction	NB 90 off	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☑ Yes ☑ On

☐ No ☐ Off

L_{up} = 1200 ft

V_u = 140 veh/h

Freeway terrain: Rolling

Ramp terrain: Rolling

Ramp Type

☐ Merge ☑ Diverge

☑ Right side ☐ Left side

Number of freeway lanes: 2

Number of ramp lanes: 1

Length of ramp roadway: 1570 ft

S_{FF} = 55.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☐ Yes ☐ On

☑ No ☐ Off

L_{down} = _____ ft

V_D = _____ veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				1620	0.92	5	☐ 0.930	☐ 1.00	1893
v_R				1030	0.92	5	☐ 0.930	☐ 1.00	1204
v_U				140	0.92	5	☐ 0.930	☐ 1.00	164
v_D							☐ 0.976	☐ 1.00	

Merge Areas

Estimation of v_{12}

$$v_{12} = v_F * P_{FM}$$

L_{EQ} = _____ (Equation 25-2 or 25-3)

P_{FM} = _____ using Equation _____ (Exhibit 25-5)

v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}		See Exhibit 25-7	
v_{R12}		4600: All	

Level-of-Service Determination (if not F)

$$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$$

D_R = _____ pc/mi/ln

LOS = _____ (Exhibit 25-4)

Speed Estimation

M_s = _____ (Exhibit 25-19)

S_R = _____ mi/h (Exhibit 25-19)

S_O = _____ mi/h (Exhibit 25-19)

S = _____ mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$$v_{12} = v_R + (v_F - v_R)P_{FD}$$

L_{EQ} = _____ (Equation 25-8 or 25-9)

P_{FD} = 1.000 using Equation _____ (Exhibit 25-12)

v_{12} = 1893 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$	1893	See Exhibit 25-14	
v_{12}	1893	4400: All	
$v_{FO} = v_F - v_R$	689	See Exhibit 25-14	
v_R	1030	See Exhibit 25-3	

Level-of-Service Determination (if not F)

$$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$$

D_R = 6.4 pc/mi/ln

LOS = A (Exhibit 25-4)

Speed Estimation

D_s = 0.406 (Exhibit 25-19)

S_R = 49.7 mi/h (Exhibit 25-19)

S_O = _____ mi/h (Exhibit 25-19)

S = 49.7 mi/h (Equation 25-15)

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	4/6/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-190	
Analysis Period/Year	PM 2030	Junction	SB 90 on	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☐ Yes ☐ On

☑ No ☐ Off

L_{up} = _____ ft

V_u = _____ veh/h

Freeway terrain: Rolling

Ramp terrain: Rolling

Ramp Type

☑ Merge ☐ Diverge

☑ Right side ☐ Left side

Number of freeway lanes: 2

Number of ramp lanes: 1

Length of ramp roadway: 1340 ft

S_{FF} = 55.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☑ Yes ☐ On

☐ No ☑ Off

L_{down} = 3920 ft

V_D = 70 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				650	0.92	5	☐ 0.930	☐ 1.00	760
v_R				440	0.92	5	☐ 0.930	☐ 1.00	514
v_U							☐ 0.976	☐ 1.00	
v_D				70	0.92	5	☐ 0.930	☐ 1.00	82

Merge Areas

Estimation of v_{12}

$$v_{12} = v_F * P_{FM}$$

L_{EQ} = _____ (Equation 25-2 or 25-3)

P_{FM} = 1.000 using Equation _____ (Exhibit 25-5)

v_{12} = 760 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	1274	See Exhibit 25-7	
v_{R12}	1274	4600: All	

Level-of-Service Determination (if not F)

$$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$$

D_R = 6.8 pc/mi/ln

LOS = A (Exhibit 25-4)

Speed Estimation

M_s = 0.214 (Exhibit 25-19)

S_R = 52.2 mi/h (Exhibit 25-19)

S_O = _____ mi/h (Exhibit 25-19)

S = 52.2 mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$$v_{12} = v_R + (v_F - v_R)P_{FD}$$

L_{EQ} = _____ (Equation 25-8 or 25-9)

P_{FD} = _____ using Equation _____ (Exhibit 25-12)

v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$		See Exhibit 25-14	
v_{12}		4400: All	
$v_{FO} = v_F - v_R$		See Exhibit 25-14	
v_R		See Exhibit 25-3	

Level-of-Service Determination (if not F)

$$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$$

D_R = _____ pc/mi/ln

LOS = _____ (Exhibit 25-4)

Speed Estimation

D_s = _____ (Exhibit 25-19)

S_R = _____ mi/h (Exhibit 25-19)

S_O = _____ mi/h (Exhibit 25-19)

S = _____ mi/h (Equation 25-15)

©Catalina Engineering, Inc.

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	4/6/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-190	
Analysis Period/Year	PM 2030	Junction	SB Silver off	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☑ Yes ☑ On
☐ No ☐ Off
L_{up} = 3920 ft
V_u = 440 veh/h

Freeway terrain: Rolling
Ramp terrain: Rolling

Ramp Type
☐ Merge ☑ Diverge
☑ Right side ☐ Left side

Number of freeway lanes: 2
Number of ramp lanes: 1
Length of ramp roadway: 810 ft

S_{FF} = 55.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☑ Yes ☑ On
☐ No ☐ Off
L_{down} = 2580 ft
V_D = 350 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				1090	0.92	5	☐ 0.930	☐ 1.00	1274
v_R				70	0.92	5	☐ 0.930	☐ 1.00	82
v_U				440	0.92	5	☐ 0.930	☐ 1.00	514
v_D				350	0.92	5	☐ 0.976	☐ 1.00	390

Merge Areas

Estimation of v_{12}

$$v_{12} = v_F * P_{FM}$$

L_{EQ} = _____ (Equation 25-2 or 25-3)
P_{FM} = _____ using Equation _____ (Exhibit 25-5)
v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}		See Exhibit 25-7	
v_{R12}		4600: All	

Level-of-Service Determination (if not F)

$$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$$

D_R = _____ pc/mi/ln
LOS = _____ (Exhibit 25-4)

Speed Estimation

M_s = _____ (Exhibit 25-19)
S_R = _____ mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = _____ mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$$v_{12} = v_R + (v_F - v_R)P_{FD}$$

L_{EQ} = _____ (Equation 25-8 or 25-9)
P_{FD} = 1.000 using Equation _____ (Exhibit 25-12)
v_{12} = 1274 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$	1274	See Exhibit 25-14	
v_{12}	1274	4400: All	
$v_{FO} = v_F - v_R$	1192	See Exhibit 25-14	
v_R	70	See Exhibit 25-3	

Level-of-Service Determination (if not F)

$$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$$

D_R = 7.9 pc/mi/ln
LOS = A (Exhibit 25-4)

Speed Estimation

D_s = 0.305 (Exhibit 25-19)
S_R = 51.0 mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = 51.0 mi/h (Equation 25-15)

©Catalina Engineering, Inc.

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	4/6/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-190	
Analysis Period/Year	PM 2030	Junction	SB Silver on	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☑ Yes ☐ On
☐ No ☑ Off
L_{up} = 2580 ft
V_u = 70 veh/h

Freeway terrain: Level
Ramp terrain: Level

Ramp Type
☑ Merge ☐ Diverge
☑ Right side ☐ Left side
Number of freeway lanes: 2
Number of ramp lanes: 1
Length of ramp roadway: 810 ft

S_{FF} = 55.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☐ Yes ☐ On
☑ No ☐ Off
L_{down} = _____ ft
V_D = _____ veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				1020	0.92	5	☐ 0.976	☐ 1.00	1136
v_R				350	0.92	5	☐ 0.976	☐ 1.00	390
v_U				70	0.92	5	☐ 0.930	☐ 1.00	82
v_D							☐ 0.976	☐ 1.00	

Merge Areas

Estimation of v_{12}

$v_{12} = v_F * P_{FM}$

L_{EQ} = _____ (Equation 25-2 or 25-3)
P_{FM} = 1.000 using Equation _____ (Exhibit 25-5)
v_{12} = 1136 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	1526	See Exhibit 25-7	
v_{R12}	1526	4600: All	

Level-of-Service Determination (if not F)

$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$

D_R = 12.1 pc/mi/ln
LOS = B (Exhibit 25-4)

Speed Estimation

M_s = 0.266 (Exhibit 25-19)
S_R = 51.5 mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = 51.5 mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$v_{12} = v_R + (v_F - v_R)P_{FD}$

L_{EQ} = _____ (Equation 25-8 or 25-9)
P_{FD} = _____ using Equation _____ (Exhibit 25-12)
v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$		See Exhibit 25-14	
v_{12}		4400: All	
$v_{FO} = v_F - v_R$		See Exhibit 25-14	
v_R		See Exhibit 25-3	

Level-of-Service Determination (if not F)

$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$

D_R = _____ pc/mi/ln
LOS = _____ (Exhibit 25-4)

Speed Estimation

D_s = _____ (Exhibit 25-19)
S_R = _____ mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = _____ mi/h (Equation 25-15)

©Catalina Engineering, Inc.

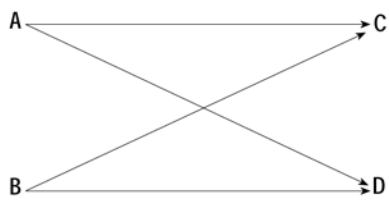
CHAPTER 24 - FREEWAY WEAVING WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	4/6/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-190	
Analysis Period/Year	PM 2030	Weaving Segment Location	Anamosa NB	
Comment	Comments			

☑ Operational (LOS) ❑ Design (N, L, Type) ❑ Planning (LOS) ❑ Planning (N, L, Type)

Inputs

Entry lanes 2 — Exit lanes 2



Entry lanes 1 — Exit lanes 1

Driver type from A ☑ Commuter/weekday ❑ Recreational/weekend

Driver type from B ☑ Commuter/weekday ❑ Recreational/weekend

Freeway free-flow speed, S_{FF} = 55 mi/h

Weaving number of lanes, N = 3

Weaving segment length, L 1200 ft

Freeway terrain ❑ Level ☑ Rolling

Ramp terrain ❑ Level ☑ Rolling

Weaving type ☑ Type A ❑ Type B ❑ Type C

Volume ratio, $VR = \frac{v_w}{v}$ 0.574

Weaving ratio, $R = \frac{v_{w2}}{v_w}$ 0.059

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D	V (veh/h)	PHF	% HV	f_{HV} Field data if checked	f_p Field data if checked	$v = \frac{V}{PHF * f_{HV} * f_p}$
v_{AC}				670	0.92	5	❑ 0.930	❑ 1.00	783
v_{BD}				80	0.92	5	❑ 0.930	❑ 1.00	93
v_{AD}				950	0.92	5	❑ 0.930	❑ 1.00	1110
v_{BC}				60	0.92	5	❑ 0.930	❑ 1.00	70
v_w									1180
v_{nw}									876
v									2057

Weaving and Nonweaving Speeds

	Unconstrained		Constrained	
	Weaving (i = w)	Nonweaving (i = nw)	Weaving (i = w)	Nonweaving (i = nw)
a (Exhibit 24-6)	0.15	40.2	0.35	30.8
b (Exhibit 24-6)	2.2	4.0	2.2	4.0
c (Exhibit 24-6)	0.97	1.3	0.97	1.3
d (Exhibit 24-6)	0.80	0.75	0.80	0.75
Weaving intensity factor, W_i $W_i = \frac{a(1 + VR)^b (v/N)^c}{(L)^d}$	0.789	0.512	1.841	0.293
Weaving and nonweaving speeds, S_i (mi/h) $S_i = 15 + \frac{S_{FF} - 10}{1 + W_i}$	40.2	44.76	30.8	49.81

Number of lanes required for unconstrained operation, N_w (Exhibit 24-7) 1.69

Maximum number of lanes, N_w(max) (Exhibit 24-7) 1.40

❑ If $N_w < N_w$(max) unconstrained operation ☑ If $N_w \geq N_w$(max) constrained operation

Weaving Segment Speed, Density, Level of Service, and Capacity

Weaving segment speed, S (mi/h) $S = \frac{v}{\left(\frac{v_w}{S_w}\right) + \left(\frac{v_{nw}}{S_{nw}}\right)}$	36.8
Weaving segment density, D (pc/mi/ln) $D = \frac{v/N}{S}$	18.6
Level of service, LOS (Exhibit 24-2)	B
Capacity for base condition, c_b (pc/h) (Exhibit 24-8)	3910
Capacity as a 15-min flow rate, c (veh/h) $c = c_b * f_{HV} * f_p$	3637
Capacity as a full-hour volume, c_h (veh/h) $c_h = c(PHF)$	3346

©Catalina Engineering, Inc.

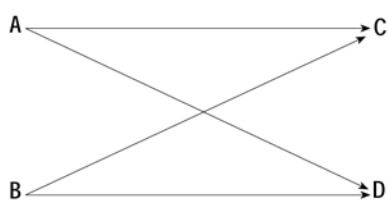
CHAPTER 24 - FREEWAY WEAVING WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	4/6/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-90	
Analysis Period/Year	PM 2030	Weaving Segment Location	190-Haines	
Comment	Comments			

☑ Operational (LOS) ❑ Design (N, L, Type) ❑ Planning (LOS) ❑ Planning (N, L, Type)

Inputs

Entry lanes 2 — Exit lanes 2



Entry lanes 1 — Exit lanes 1

Driver type from A ☑ Commuter/weekday ❑ Recreational/weekend

Driver type from B ☑ Commuter/weekday ❑ Recreational/weekend

Freeway free-flow speed, S_{FF} = 65 mi/h

Weaving number of lanes, N = 3

Weaving segment length, L 730 ft

Freeway terrain ❑ Level ☑ Rolling

Ramp terrain ❑ Level ☑ Rolling

Weaving type ☑ Type A ❑ Type B ❑ Type C

Volume ratio, $VR = \frac{v_w}{v}$ 0.378

Weaving ratio, $R = \frac{v_{w2}}{v_w}$ 0.337

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D	V (veh/h)	PHF	% HV	f_{HV} Field data if checked	f_p Field data if checked	$v = \frac{V}{PHF * f_{HV} * f_p}$
v_{AC}				1370	0.92	5	❑ 0.930	❑ 1.00	1601
v_{BD}				340	0.92	5	❑ 0.930	❑ 1.00	397
v_{AD}				350	0.92	5	❑ 0.930	❑ 1.00	409
v_{BC}				690	0.92	5	❑ 0.930	❑ 1.00	806
v_w									1215
v_{nw}									1998
v									3213

Weaving and Nonweaving Speeds

	Unconstrained		Constrained	
	Weaving (i = w)	Nonweaving (i = nw)	Weaving (i = w)	Nonweaving (i = nw)
a (Exhibit 24-6)	0.15	38.4		
b (Exhibit 24-6)	2.2	4.0		
c (Exhibit 24-6)	0.97	1.3		
d (Exhibit 24-6)	0.80	0.75		
Weaving intensity factor, W_i $W_i = \frac{a(1 + VR)^b (v/N)^c}{(L)^d}$	1.352	0.781		
Weaving and nonweaving speeds, S_i (mi/h) $S_i = 15 + \frac{S_{FF} - 10}{1 + W_i}$	38.4	45.88		

Number of lanes required for unconstrained operation, N_w (Exhibit 24-7) 1.21

Maximum number of lanes, N_w(max) (Exhibit 24-7) 1.40

☑ If $N_w < N_w$(max) unconstrained operation ❑ If $N_w \geq N_w$(max) constrained operation

Weaving Segment Speed, Density, Level of Service, and Capacity

Weaving segment speed, S (mi/h) $S = \frac{v}{\left(\frac{v_w}{S_w}\right) + \left(\frac{v_{nw}}{S_{nw}}\right)}$	42.7
Weaving segment density, D (pc/mi/ln) $D = \frac{v/N}{S}$	25.1
Level of service, LOS (Exhibit 24-2)	C
Capacity for base condition, c_b (pc/h) (Exhibit 24-8)	4737
Capacity as a 15-min flow rate, c (veh/h) $c = c_b * f_{HV} * f_p$	4407
Capacity as a full-hour volume, c_h (veh/h) $c_h = c(PHF)$	4054

©Catalina Engineering, Inc.

CHAPTER 25 - RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information		Site Information		
Analyst	Laughlin	Jurisdiction/Date	Jurisdiction	4/6/2010
Agency or Company	HDR	Freeway/Direction of Travel	I-90	
Analysis Period/Year	PM 2030	Junction	EB Haines off	
Comment	Comments			

☑ Operational (LOS) ☐ Design (L_A, L_D, or N) ☐ Planning (LOS) ☐ Planning (L_A, L_D, or N)

Inputs

Upstream Adjacent Ramp

☑ Yes ☑ On
☐ No ☐ Off
L_{up} = 730 ft
V_u = 1030 veh/h

Freeway terrain: Rolling
Ramp terrain: Rolling

Ramp Type
☐ Merge ☑ Diverge
☑ Right side ☐ Left side

Number of freeway lanes: 3
Number of ramp lanes: 2
Length of ramp roadway: 2360 ft

S_{FF} = 65.0 mi/h S_{FR} = 45.0 mi/h

Downstream Adjacent Ramp

☑ Yes ☑ On
☐ No ☐ Off
L_{down} = 2330 ft
V_D = 310 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	AADT (veh/day)	K	D (veh/h)	V	PHF	% HV	f_{HV} (Field data if checked)	f_p (Field data if checked)	$v = \frac{V}{PHF\ f_{HV}\ f_p}$
v_F				2750	0.92	5	☐ 0.930	☐ 1.00	3213
v_R				690	0.92	5	☐ 0.930	☐ 1.00	806
v_U				1030	0.92	5	☐ 0.930	☐ 1.00	1204
v_D				310	0.92	5	☐ 0.930	☐ 1.00	362

Merge Areas

Estimation of v_{12}

$$v_{12} = v_F * P_{FM}$$

L_{EQ} = _____ (Equation 25-2 or 25-3)
P_{FM} = _____ using Equation _____ (Exhibit 25-5)
v_{12} = _____ pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}		See Exhibit 25-7	
v_{R12}		4600: All	

Level-of-Service Determination (if not F)

$$D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$$

D_R = _____ pc/mi/ln
LOS = _____ (Exhibit 25-4)

Speed Estimation

M_s = _____ (Exhibit 25-19)
S_R = _____ mi/h (Exhibit 25-19)
S_O = _____ mi/h (Exhibit 25-19)
S = _____ mi/h (Equation 25-14)

Diverge Areas

Estimation of v_{12}

$$v_{12} = v_R + (v_F - v_R)P_{FD}$$

L_{EQ} = 14391 (Equation 25-8 or 25-9)
P_{FD} = 0.450 using Equation 6 (Exhibit 25-12)
v_{12} = 1889 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{FI} = v_F$	3213	See Exhibit 25-14	
v_{12}	1889	4400: All	
$v_{FO} = v_F - v_R$	2407	See Exhibit 25-14	
v_R	690	See Exhibit 25-3	

Level-of-Service Determination (if not F)

$$D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$$

D_R = 11.7 pc/mi/ln
LOS = B (Exhibit 25-4)

Speed Estimation

D_s = 0.371 (Exhibit 25-19)
S_R = 56.5 mi/h (Exhibit 25-19)
S_O = 70.0 mi/h (Exhibit 25-19)
S = 61.4 mi/h (Equation 25-15)

HCM Signalized Intersection Capacity Analysis
3: Disk Drive & Haines St.

4/27/2010

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	1	7	36	25	1	12	23	225	113	15	502	4
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0	4.0	4.0	4.0	
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00		1.00	0.95	1.00	1.00	0.95	
Frt	1.00	1.00	0.85	1.00	0.86		1.00	1.00	0.85	1.00	1.00	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1770	1863	1583	1770	1600		1770	3539	1583	1770	3535	
Flt Permitted	1.00	1.00	1.00	0.50	1.00		0.34	1.00	1.00	0.60	1.00	
Satd. Flow (perm)	1863	1863	1583	931	1600		635	3539	1583	1117	3535	
Peak-hour factor, PHF	0.79	0.79	0.79	0.73	0.73	0.73	0.92	0.92	0.92	0.67	0.67	0.67
Adj. Flow (vph)	1	9	46	34	1	16	25	245	123	22	749	6
RTOR Reduction (vph)	0	0	43	0	13	0	0	0	47	0	0	0
Lane Group Flow (vph)	1	9	3	34	4	0	25	245	76	22	755	0
Turn Type	Perm		Perm	pm+pt			pm+pt		Perm	pm+pt		
Protected Phases		4		3	8		5	2		1	6	
Permitted Phases	4		4	8			2		2	6		
Actuated Green, G (s)	4.0	4.0	4.0	9.6	9.6		38.4	37.1	37.1	38.4	37.1	
Effective Green, g (s)	4.0	4.0	4.0	9.6	9.6		38.4	37.1	37.1	38.4	37.1	
Actuated g/C Ratio	0.07	0.07	0.07	0.16	0.16		0.64	0.62	0.62	0.64	0.62	
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0	4.0	4.0	4.0	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	124	124	106	171	256		431	2188	979	729	2186	
v/s Ratio Prot		0.00		c0.01	0.00		c0.00	0.07		0.00	c0.21	
v/s Ratio Perm	0.00		0.00	c0.03			0.04		0.05	0.02		
v/c Ratio	0.01	0.07	0.03	0.20	0.01		0.06	0.11	0.08	0.03	0.35	
Uniform Delay, d1	26.1	26.3	26.2	21.7	21.2		4.0	4.7	4.6	3.9	5.6	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	
Incremental Delay, d2	0.0	0.2	0.1	0.6	0.0		0.1	0.1	0.2	0.0	0.4	
Delay (s)	26.2	26.5	26.3	22.3	21.2		4.1	4.8	4.7	4.0	6.0	
Level of Service	C	C	C	C	C		A	A	A	A	A	
Approach Delay (s)		26.3			21.9			4.7			5.9	
Approach LOS		C			C			A			A	

Intersection Summary			
HCM Average Control Delay	7.1	HCM Level of Service	A
HCM Volume to Capacity ratio	0.31		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	33.8%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

HCM Signalized Intersection Capacity Analysis
37: I-90 & Haines St.

4/27/2010

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	137	0	79	89	0	25	52	145	48	81	235	137
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0		4.0	4.0		4.0	4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	0.97		1.00	0.97		1.00	1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00		0.85	1.00		0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95		1.00	0.95		1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	3433		1583	3433		1583	1770	3539	1583	1770	3539	1583
Flt Permitted	0.95		1.00	0.95		1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)	3433		1583	3433		1583	1770	3539	1583	1770	3539	1583
Peak-hour factor, PHF	0.76	0.76	0.76	0.80	0.80	0.80	0.84	0.84	0.84	0.75	0.75	0.75
Adj. Flow (vph)	180	0	104	111	0	31	62	173	57	108	313	183
RTOR Reduction (vph)	0	0	0	0	0	0	0	0	0	0	0	0
Lane Group Flow (vph)	180	0	104	111	0	31	62	173	57	108	313	183
Turn Type	Prot		Free	Prot		Free	Prot		Free	Prot		Free
Protected Phases	7			3			5	2		1	6	
Permitted Phases			Free			Free			Free			Free
Actuated Green, G (s)	4.0		40.0	4.0		40.0	2.0	20.4	40.0	3.6	22.0	40.0
Effective Green, g (s)	4.0		40.0	4.0		40.0	2.0	20.4	40.0	3.6	22.0	40.0
Actuated g/C Ratio	0.10		1.00	0.10		1.00	0.05	0.51	1.00	0.09	0.55	1.00
Clearance Time (s)	4.0			4.0			4.0	4.0		4.0	4.0	
Vehicle Extension (s)	3.0			3.0			3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	343		1583	343		1583	89	1805	1583	159	1946	1583
v/s Ratio Prot	c0.05			0.03			0.04	0.05		c0.06	c0.09	
v/s Ratio Perm			0.07			0.02			0.04			c0.12
v/c Ratio	0.52		0.07	0.32		0.02	0.70	0.10	0.04	0.68	0.16	0.12
Uniform Delay, d1	17.1		0.0	16.7		0.0	18.7	5.0	0.0	17.6	4.4	0.0
Progression Factor	1.00		1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	1.5		0.1	0.6		0.0	21.1	0.1	0.0	11.0	0.2	0.1
Delay (s)	18.5		0.1	17.3		0.0	39.8	5.2	0.0	28.6	4.6	0.1
Level of Service	B		A	B		A	D	A	A	C	A	A
Approach Delay (s)		11.8			13.5			11.5			7.6	
Approach LOS		B			B			B			A	

Intersection Summary			
HCM Average Control Delay	10.0	HCM Level of Service	A
HCM Volume to Capacity ratio	0.26		
Actuated Cycle Length (s)	40.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	23.7%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

HCM Signalized Intersection Capacity Analysis
8: Anamosa St. & Haines St.

4/27/2010

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	47	91	57	118	105	47	36	319	101	50	635	48
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor	1.00	1.00		1.00	1.00		1.00	0.95		1.00	0.95	
Frt	1.00	0.94		1.00	0.95		1.00	0.96		1.00	0.99	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1770	1755		1770	1776		1770	3412		1770	3502	
Flt Permitted	0.54	1.00		0.57	1.00		0.20	1.00		0.37	1.00	
Satd. Flow (perm)	1003	1755		1067	1776		373	3412		686	3502	
Peak-hour factor, PHF	0.74	0.74	0.74	0.69	0.69	0.69	0.77	0.77	0.77	0.69	0.69	0.69
Adj. Flow (vph)	64	123	77	171	152	68	47	414	131	72	920	70
RTOR Reduction (vph)	0	37	0	0	27	0	0	51	0	0	9	0
Lane Group Flow (vph)	64	163	0	171	193	0	47	494	0	72	981	0
Turn Type	pm+pt			pm+pt			pm+pt			pm+pt		
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases	4			8			2			6		
Actuated Green, G (s)	20.0	16.0		20.0	16.0		24.0	20.0		24.0	20.0	
Effective Green, g (s)	20.0	16.0		20.0	16.0		24.0	20.0		24.0	20.0	
Actuated g/C Ratio	0.33	0.27		0.33	0.27		0.40	0.33		0.40	0.33	
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	4.0		4.0	4.0	
Lane Grp Cap (vph)	385	468		403	474		242	1137		347	1167	
v/s Ratio Prot	0.01	0.09		c0.03	0.11		0.01	0.14		c0.01	c0.28	
v/s Ratio Perm	0.04			c0.11			0.06			0.07		
v/c Ratio	0.17	0.35		0.42	0.41		0.19	0.43		0.21	0.84	
Uniform Delay, d1	13.9	17.8		14.9	18.1		12.4	15.6		11.4	18.5	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	0.9	2.0		3.3	2.6		1.8	1.2		1.4	7.4	
Delay (s)	14.8	19.8		18.1	20.7		14.2	16.8		12.7	25.9	
Level of Service	B	B		B	C		B	B		B	C	
Approach Delay (s)		18.6			19.6			16.6			25.0	
Approach LOS		B			B			B			C	

Intersection Summary			
HCM Average Control Delay	21.2	HCM Level of Service	C
HCM Volume to Capacity ratio	0.59		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	16.0
Intersection Capacity Utilization	50.6%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

HCM Signalized Intersection Capacity Analysis
15: North Street & Haines St.

4/27/2010

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	121	69	116	33	112	13	91	367	50	11	665	183
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor	1.00	1.00	1.00	1.00	0.95		1.00	0.95		1.00	0.95	
Frt	1.00	1.00	0.85	1.00	0.98		1.00	0.98		1.00	0.97	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1770	1863	1583	1770	3483		1770	3475		1770	3425	
Flt Permitted	0.63	1.00	1.00	0.69	1.00		0.16	1.00		0.46	1.00	
Satd. Flow (perm)	1178	1863	1583	1283	3483		300	3475		860	3425	
Peak-hour factor, PHF	0.65	0.65	0.65	0.66	0.66	0.66	0.81	0.81	0.81	0.82	0.82	0.82
Adj. Flow (vph)	186	106	178	50	170	20	112	453	62	13	811	223
RTOR Reduction (vph)	0	0	136	0	15	0	0	17	0	0	41	0
Lane Group Flow (vph)	186	106	42	50	175	0	112	498	0	13	993	0
Turn Type	Perm		Perm	Perm			pm+pt			Perm		
Protected Phases		4			8		5	2			6	
Permitted Phases	4		4	8			2			6		
Actuated Green, G (s)	13.1	13.1	13.1	13.1	13.1		33.9	33.9		26.0	26.0	
Effective Green, g (s)	13.1	13.1	13.1	13.1	13.1		33.9	33.9		26.0	26.0	
Actuated g/C Ratio	0.24	0.24	0.24	0.24	0.24		0.62	0.62		0.47	0.47	
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	281	444	377	306	830		289	2142		407	1619	
v/s Ratio Prot		0.06			0.05		c0.03	0.14			c0.29	
v/s Ratio Perm	c0.16		0.03	0.04			0.21			0.02		
v/c Ratio	0.66	0.24	0.11	0.16	0.21		0.39	0.23		0.03	0.61	
Uniform Delay, d1	18.9	16.9	16.4	16.6	16.8		6.2	4.7		7.8	10.8	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	5.8	0.3	0.1	0.3	0.1		0.9	0.3		0.1	1.7	
Delay (s)	24.7	17.2	16.5	16.9	16.9		7.0	5.0		7.9	12.5	
Level of Service	C	B	B	B	B		A	A		A	B	
Approach Delay (s)		19.9			16.9			5.3			12.5	
Approach LOS		B			B			A			B	

Intersection Summary			
HCM Average Control Delay	12.5	HCM Level of Service	B
HCM Volume to Capacity ratio	0.61		
Actuated Cycle Length (s)	55.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	52.8%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

HCM Signalized Intersection Capacity Analysis
19: Omaha St. & 5th St.

4/27/2010

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	159	625	120	168	745	35	50	331	39	94	372	109
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	0.97	0.91		0.97	0.91		1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00	0.98		1.00	0.99		1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	3433	4962		3433	5051		1770	3539	1583	1770	3539	1583
Flt Permitted	0.95	1.00		0.95	1.00		0.53	1.00	1.00	0.42	1.00	1.00
Satd. Flow (perm)	3433	4962		3433	5051		981	3539	1583	781	3539	1583
Peak-hour factor, PHF	0.84	0.84	0.84	0.86	0.86	0.86	0.80	0.80	0.80	0.98	0.98	0.98
Adj. Flow (vph)	189	744	143	195	866	41	62	414	49	96	380	111
RTOR Reduction (vph)	0	48	0	0	9	0	0	0	35	0	0	0
Lane Group Flow (vph)	189	839	0	195	898	0	62	414	14	96	380	111
Turn Type	Prot			Prot			pm+pt		Perm	pm+pt		Free
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases							2		2	6		Free
Actuated Green, G (s)	6.9	15.4		6.9	15.4		20.1	17.7	17.7	23.3	19.3	60.0
Effective Green, g (s)	6.9	15.4		6.9	15.4		20.1	17.7	17.7	23.3	19.3	60.0
Actuated g/C Ratio	0.12	0.26		0.12	0.26		0.34	0.29	0.29	0.39	0.32	1.00
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	4.0	4.0	4.0	4.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	395	1274		395	1296		360	1044	467	369	1138	1583
v/s Ratio Prot	0.06	0.17		c0.06	c0.18		0.01	c0.12		c0.02	0.11	
v/s Ratio Perm							0.05		0.01	0.08		c0.07
v/c Ratio	0.48	0.66		0.49	0.69		0.17	0.40	0.03	0.26	0.33	0.07
Uniform Delay, d1	24.9	20.0		24.9	20.2		13.7	16.9	15.0	12.0	15.5	0.0
Progression Factor	0.70	1.52		1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.6	0.9		1.0	1.6		0.2	1.1	0.1	0.4	0.8	0.1
Delay (s)	18.0	31.2		25.9	21.8		14.0	18.0	15.2	12.4	16.3	0.1
Level of Service	B	C		C	C		B	B	B	B	B	A
Approach Delay (s)		28.9			22.5			17.3			12.6	
Approach LOS		C			C			B			B	

Intersection Summary			
HCM Average Control Delay	22.0	HCM Level of Service	C
HCM Volume to Capacity ratio	0.51		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	16.0
Intersection Capacity Utilization	47.4%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

HCM Unsignalized Intersection Capacity Analysis
21: North Street & Allen Ave.

4/27/2010

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	18	215	94	99	230	9	68	20	50	9	61	43
Peak Hour Factor	0.63	0.63	0.63	0.67	0.67	0.67	0.68	0.68	0.68	0.64	0.64	0.64
Hourly flow rate (vph)	29	341	149	148	343	13	100	29	74	14	95	67

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	NB 2	SB 1
Volume Total (vph)	199	320	319	185	129	74	177
Volume Left (vph)	29	0	148	0	100	0	14
Volume Right (vph)	0	149	0	13	0	74	67
Hadj (s)	0.11	-0.29	0.27	-0.02	0.42	-0.67	-0.18
Departure Headway (s)	6.9	6.5	7.0	6.7	8.1	7.0	7.3
Degree Utilization, x	0.38	0.58	0.62	0.35	0.29	0.14	0.36
Capacity (veh/h)	502	530	489	515	406	471	456
Control Delay (s)	12.8	16.7	19.8	12.1	13.1	9.9	14.4
Approach Delay (s)	15.2		16.9		12.0		14.4
Approach LOS	C		C		B		B

Intersection Summary			
Delay	15.3		
HCM Level of Service	C		
Intersection Capacity Utilization	42.0%	ICU Level of Service	A
Analysis Period (min)	15		

HCM Signalized Intersection Capacity Analysis
22: Omaha St. & Mt. Rushmore Rd.

4/27/2010

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	59	986	280	209	825	23	211	97	65	45	119	18
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	0.97	0.91	1.00	0.97	0.91		0.97	0.95	1.00	1.00	0.95	1.00
Frt	1.00	1.00	0.85	1.00	1.00		1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	3433	5085	1583	3433	5065		3433	3539	1583	1770	3539	1583
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.69	1.00	1.00
Satd. Flow (perm)	3433	5085	1583	3433	5065		3433	3539	1583	1282	3539	1583
Peak-hour factor, PHF	0.94	0.94	0.94	0.92	0.92	0.92	0.96	0.96	0.96	0.84	0.84	0.84
Adj. Flow (vph)	63	1049	298	227	897	25	220	101	68	54	142	21
RTOR Reduction (vph)	0	0	211	0	5	0	0	0	48	0	0	16
Lane Group Flow (vph)	63	1049	87	227	917	0	220	101	20	54	142	5
Turn Type	Prot		Perm	Prot			Prot		Perm	pm+pt		Perm
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases			4						2	6		6
Actuated Green, G (s)	2.4	17.6	17.6	6.0	21.2		6.0	18.0	18.0	16.8	14.4	14.4
Effective Green, g (s)	2.4	17.6	17.6	6.0	21.2		6.0	18.0	18.0	16.8	14.4	14.4
Actuated g/C Ratio	0.04	0.29	0.29	0.10	0.35		0.10	0.30	0.30	0.28	0.24	0.24
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0	4.0	4.0	4.0	4.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	137	1492	464	343	1790		343	1062	475	378	849	380
v/s Ratio Prot	0.02	c0.21		c0.07	c0.18		c0.06	c0.03		0.01	c0.04	
v/s Ratio Perm			0.06						0.01	0.03		0.00
v/c Ratio	0.46	0.70	0.19	0.66	0.51		0.64	0.10	0.04	0.14	0.17	0.01
Uniform Delay, d1	28.2	18.9	15.9	26.0	15.3		26.0	15.1	14.9	16.0	18.1	17.4
Progression Factor	0.80	1.56	5.32	0.72	1.42		1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	1.9	1.2	0.2	4.1	0.2		4.1	0.2	0.2	0.2	0.4	0.1
Delay (s)	24.5	30.6	84.4	22.9	22.0		30.0	15.3	15.1	16.2	18.5	17.4
Level of Service	C	C	F	C	C		C	B	B	B	B	B
Approach Delay (s)		41.7			22.2			23.6			17.8	
Approach LOS		D			C			C			B	

Intersection Summary			
HCM Average Control Delay	30.7	HCM Level of Service	C
HCM Volume to Capacity ratio	0.57		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	24.0
Intersection Capacity Utilization	47.7%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

HCM Unsignalized Intersection Capacity Analysis
29: Anamosa St. & West Blvd. W

4/27/2010

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	2	36	6	23	21	10	3	0	25	26	10	0
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.73	0.73	0.73	0.52	0.52	0.52	0.70	0.70	0.70	0.64	0.64	0.64
Hourly flow rate (vph)	3	49	8	44	40	19	4	0	36	41	16	0
Pedestrians												
Lane Width (ft)												
Walking Speed (ft/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (ft)												
pX, platoon unblocked												
vC, conflicting volume	60			58			205	207	53	233	201	50
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	60			58			205	207	53	233	201	50
tC, single (s)	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	100			97			99	100	96	94	98	100
cM capacity (veh/h)	1544			1547			722	669	1014	680	674	1018

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	60	104	40	56
Volume Left	3	44	4	41
Volume Right	8	19	36	0
cSH	1544	1547	972	678
Volume to Capacity	0.00	0.03	0.04	0.08
Queue Length 95th (ft)	0	2	3	7
Control Delay (s)	0.3	3.3	8.9	10.8
Lane LOS	A	A	A	B
Approach Delay (s)	0.3	3.3	8.9	10.8
Approach LOS			A	B

Intersection Summary			
Average Delay	5.1		
Intersection Capacity Utilization	24.8%	ICU Level of Service	A
Analysis Period (min)	15		

HCM Unsignalized Intersection Capacity Analysis
27: Anamosa St. & West Blvd E

4/27/2010

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	22	58	7	58	30	34	9	53	44	19	36	15
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.59	0.59	0.59	0.62	0.62	0.62	0.83	0.83	0.83	0.63	0.63	0.63
Hourly flow rate (vph)	37	98	12	94	48	55	11	64	53	30	57	24
Pedestrians												
Lane Width (ft)												
Walking Speed (ft/s)												
Percent Blockage												
Right turn flare (veh)			2			16						
Median type								None			None	
Median storage veh)												
Upstream signal (ft)												
pX, platoon unblocked												
vC, conflicting volume	293	268	69	296	253	90	81			117		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	293	268	69	296	253	90	81			117		
tC, single (s)	7.1	6.5	6.2	7.1	6.5	6.2	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	93	84	99	83	92	94	99			98		
cM capacity (veh/h)	573	621	994	557	632	967	1517			1472		

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	147	197	128	111
Volume Left	37	94	11	30
Volume Right	12	55	53	24
cSH	661	808	1517	1472
Volume to Capacity	0.22	0.24	0.01	0.02
Queue Length 95th (ft)	21	24	1	2
Control Delay (s)	12.3	12.0	0.7	2.2
Lane LOS	B	B	A	A
Approach Delay (s)	12.3	12.0	0.7	2.2
Approach LOS	B	B		

Intersection Summary			
Average Delay	7.7		
Intersection Capacity Utilization	26.7%	ICU Level of Service	A
Analysis Period (min)	15		

HCM Unsignalized Intersection Capacity Analysis
32: Boegel St. & Silver St.

4/27/2010

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	3	28	3	12	26	9	0	10	14	35	1	0
Peak Hour Factor	0.53	0.53	0.53	0.69	0.69	0.69	0.75	0.75	0.75	0.64	0.64	0.64
Hourly flow rate (vph)	6	53	6	17	38	13	0	13	19	55	2	0

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total (vph)	64	68	32	56
Volume Left (vph)	6	17	0	55
Volume Right (vph)	6	13	19	0
Hadj (s)	0.00	-0.03	-0.32	0.23
Departure Headway (s)	4.2	4.1	3.9	4.4
Degree Utilization, x	0.07	0.08	0.03	0.07
Capacity (veh/h)	839	847	872	782
Control Delay (s)	7.5	7.5	7.1	7.8
Approach Delay (s)	7.5	7.5	7.1	7.8
Approach LOS	A	A	A	A

Intersection Summary			
Delay	7.5		
HCM Level of Service	A		
Intersection Capacity Utilization	20.7%	ICU Level of Service	A
Analysis Period (min)	15		

HCM Unsignalized Intersection Capacity Analysis
24: North Street & West Blvd E

6/21/2010

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	7	144	0	90	10	29	66	89	98	38	0	99
Peak Hour Factor	0.66	0.66	0.66	0.78	0.78	0.78	0.67	0.67	0.67	0.68	0.68	0.68
Hourly flow rate (vph)	11	218	0	115	13	37	99	133	146	56	0	146

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	NB 2	SB 1
Volume Total (vph)	83	145	115	50	231	146	201
Volume Left (vph)	11	0	115	0	99	0	56
Volume Right (vph)	0	0	0	37	0	146	146
Hadj (s)	0.10	0.03	0.53	-0.49	0.25	-0.67	-0.34
Departure Headway (s)	6.5	6.4	7.0	6.0	6.2	5.3	5.9
Degree Utilization, x	0.15	0.26	0.23	0.08	0.40	0.22	0.33
Capacity (veh/h)	514	523	474	549	543	640	577
Control Delay (s)	9.4	10.5	10.9	8.3	12.2	8.6	11.7
Approach Delay (s)	10.1		10.1		10.8		11.7
Approach LOS	B		B		B		B

Intersection Summary			
Delay	10.7		
HCM Level of Service	B		
Intersection Capacity Utilization	34.0%	ICU Level of Service	A
Analysis Period (min)	15		

HCM Signalized Intersection Capacity Analysis
18: Omaha St. & West Blvd.

4/27/2010

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	265	807	94	124	742	246	60	292	157	298	362	297
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	0.97	0.91	1.00	0.97	0.91	1.00	1.00	0.95	1.00	0.97	0.95	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	3433	5085	1583	3433	5085	1583	1770	3539	1583	3433	3539	1583
Flt Permitted	0.95	1.00	1.00	0.95	1.00	1.00	0.51	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)	3433	5085	1583	3433	5085	1583	952	3539	1583	3433	3539	1583
Peak-hour factor, PHF	0.81	0.81	0.81	0.86	0.86	0.86	0.83	0.83	0.83	0.88	0.88	0.88
Adj. Flow (vph)	327	996	116	144	863	286	72	352	189	339	411	338
RTOR Reduction (vph)	0	0	0	0	0	0	0	0	0	0	0	0
Lane Group Flow (vph)	327	996	116	144	863	286	72	352	189	339	411	338
Turn Type	Prot		Free	Prot		Free	pm+pt		Free	Prot		Free
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases			Free			Free	2		Free			Free
Actuated Green, G (s)	6.0	18.2	60.0	4.0	16.2	60.0	17.6	15.2	60.0	6.6	19.4	60.0
Effective Green, g (s)	6.0	18.2	60.0	4.0	16.2	60.0	17.6	15.2	60.0	6.6	19.4	60.0
Actuated g/C Ratio	0.10	0.30	1.00	0.07	0.27	1.00	0.29	0.25	1.00	0.11	0.32	1.00
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	4.0		4.0	4.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	343	1542	1583	229	1373	1583	312	897	1583	378	1144	1583
v/s Ratio Prot	c0.10	c0.20		0.04	0.17		0.01	0.10		c0.10	c0.12	
v/s Ratio Perm			0.07			0.18	0.06		0.12			c0.21
v/c Ratio	0.95	0.65	0.07	0.63	0.63	0.18	0.23	0.39	0.12	0.90	0.36	0.21
Uniform Delay, d1	26.9	18.1	0.0	27.3	19.3	0.0	15.6	18.6	0.0	26.4	15.5	0.0
Progression Factor	1.00	1.00	1.00	0.94	1.54	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	36.2	0.9	0.1	4.8	0.8	0.2	0.4	1.3	0.2	22.9	0.9	0.3
Delay (s)	63.1	19.0	0.1	30.6	30.5	0.2	16.0	19.9	0.2	49.2	16.4	0.3
Level of Service	E	B	A	C	C	A	B	B	A	D	B	A
Approach Delay (s)		27.5			23.8			13.3			21.6	
Approach LOS		C			C			B			C	

Intersection Summary			
HCM Average Control Delay	23.0	HCM Level of Service	C
HCM Volume to Capacity ratio	0.57		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	51.8%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

HCM Signalized Intersection Capacity Analysis
3: Disk Drive & Haines St.

4/27/2010

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	4	20	75	380	20	56	104	621	217	40	514	9
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0	4.0	4.0	4.0	
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00		1.00	0.95	1.00	1.00	0.95	
Frt	1.00	1.00	0.85	1.00	0.89		1.00	1.00	0.85	1.00	1.00	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1770	1863	1583	1770	1658		1770	3539	1583	1770	3530	
Flt Permitted	0.73	1.00	1.00	0.43	1.00		0.31	1.00	1.00	0.38	1.00	
Satd. Flow (perm)	1355	1863	1583	801	1658		581	3539	1583	710	3530	
Peak-hour factor, PHF	0.88	0.88	0.88	0.97	0.97	0.97	0.97	0.97	0.97	0.82	0.82	0.82
Adj. Flow (vph)	5	23	85	392	21	58	107	640	224	49	627	11
RTOR Reduction (vph)	0	0	77	0	41	0	0	0	125	0	2	0
Lane Group Flow (vph)	5	23	8	392	38	0	107	640	99	49	636	0
Turn Type	Perm		Perm	pm+pt			pm+pt		Perm	pm+pt		
Protected Phases		4		3	8		5	2		1	6	
Permitted Phases	4		4	8			2		2	6		
Actuated Green, G (s)	5.5	5.5	5.5	17.5	17.5		32.6	26.4	26.4	28.4	24.3	
Effective Green, g (s)	5.5	5.5	5.5	17.5	17.5		32.6	26.4	26.4	28.4	24.3	
Actuated g/C Ratio	0.09	0.09	0.09	0.29	0.29		0.54	0.44	0.44	0.47	0.41	
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0	4.0	4.0	4.0	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	124	171	145	363	484		439	1557	697	409	1430	
v/s Ratio Prot		0.01		c0.14	0.02		c0.03	c0.18		0.01	0.18	
v/s Ratio Perm	0.00		0.00	c0.17			0.11		0.06	0.05		
v/c Ratio	0.04	0.13	0.05	1.08	0.08		0.24	0.41	0.14	0.12	0.44	
Uniform Delay, d1	24.8	25.1	24.9	20.3	15.4		7.0	11.5	10.0	8.6	13.0	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	
Incremental Delay, d2	0.1	0.4	0.2	70.3	0.1		0.3	0.8	0.4	0.1	1.0	
Delay (s)	25.0	25.4	25.0	90.5	15.5		7.3	12.3	10.5	8.7	14.0	
Level of Service	C	C	C	F	B		A	B	B	A	B	
Approach Delay (s)		25.1			77.9			11.3			13.6	
Approach LOS		C			E			B			B	

Intersection Summary			
HCM Average Control Delay	26.7	HCM Level of Service	C
HCM Volume to Capacity ratio	0.63		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	58.2%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	444	0	98	160	0	99	131	561	82	138	489	388
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0		4.0	4.0		4.0	4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	0.97		1.00	0.97		1.00	1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00		0.85	1.00		0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95		1.00	0.95		1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	3433		1583	3433		1583	1770	3539	1583	1770	3539	1583
Flt Permitted	0.95		1.00	0.95		1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)	3433		1583	3433		1583	1770	3539	1583	1770	3539	1583
Peak-hour factor, PHF	0.86	0.86	0.86	0.79	0.79	0.79	0.92	0.92	0.92	0.90	0.90	0.90
Adj. Flow (vph)	516	0	114	203	0	125	142	610	89	153	543	431
RTOR Reduction (vph)	0	0	0	0	0	0	0	0	0	0	0	0
Lane Group Flow (vph)	516	0	114	203	0	125	142	610	89	153	543	431
Turn Type	Prot		Free	Prot		Free	Prot		Free	Prot		Free
Protected Phases	7			3			5	2		1	6	
Permitted Phases			Free			Free			Free			Free
Actuated Green, G (s)	9.0		45.0	9.0		45.0	5.6	18.4	45.0	5.6	18.4	45.0
Effective Green, g (s)	9.0		45.0	9.0		45.0	5.6	18.4	45.0	5.6	18.4	45.0
Actuated g/C Ratio	0.20		1.00	0.20		1.00	0.12	0.41	1.00	0.12	0.41	1.00
Clearance Time (s)	4.0			4.0			4.0	4.0		4.0	4.0	
Vehicle Extension (s)	3.0			3.0			3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	687		1583	687		1583	220	1447	1583	220	1447	1583
v/s Ratio Prot	c0.15			0.06			0.08	c0.17		c0.09	0.15	
v/s Ratio Perm			0.07			0.08			0.06			0.27
v/c Ratio	0.75		0.07	0.30		0.08	0.65	0.42	0.06	0.70	0.38	0.27
Uniform Delay, d1	16.9		0.0	15.3		0.0	18.8	9.5	0.0	18.9	9.3	0.0
Progression Factor	1.00		1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	4.6		0.1	0.2		0.1	6.4	0.9	0.1	9.2	0.7	0.4
Delay (s)	21.6		0.1	15.5		0.1	25.1	10.4	0.1	28.1	10.0	0.4
Level of Service	C		A	B		A	C	B	A	C	B	A
Approach Delay (s)		17.7			9.7			11.8			8.8	
Approach LOS		B			A			B			A	

Intersection Summary			
HCM Average Control Delay	11.7	HCM Level of Service	B
HCM Volume to Capacity ratio	0.56		
Actuated Cycle Length (s)	45.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	45.8%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

HCM Signalized Intersection Capacity Analysis
8: Anamosa St. & Haines St.

4/27/2010

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	88	100	51	124	111	121	64	846	148	108	728	82
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor	1.00	1.00		1.00	1.00		1.00	0.95		1.00	0.95	
Frt	1.00	0.95		1.00	0.92		1.00	0.98		1.00	0.98	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1770	1768		1770	1717		1770	3460		1770	3486	
Flt Permitted	0.39	1.00		0.59	1.00		0.26	1.00		0.15	1.00	
Satd. Flow (perm)	734	1768		1105	1717		488	3460		281	3486	
Peak-hour factor, PHF	0.91	0.91	0.91	0.94	0.94	0.94	0.94	0.94	0.94	0.96	0.96	0.96
Adj. Flow (vph)	97	110	56	132	118	129	68	900	157	112	758	85
RTOR Reduction (vph)	0	34	0	0	73	0	0	20	0	0	12	0
Lane Group Flow (vph)	97	132	0	132	174	0	68	1037	0	112	831	0
Turn Type	pm+pt			pm+pt			pm+pt			pm+pt		
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases	4			8			2			6		
Actuated Green, G (s)	14.1	10.9		14.1	10.9		28.4	25.0		31.4	26.5	
Effective Green, g (s)	14.1	10.9		14.1	10.9		28.4	25.0		31.4	26.5	
Actuated g/C Ratio	0.23	0.18		0.23	0.18		0.47	0.42		0.52	0.44	
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	4.0		4.0	4.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	228	321		295	312		304	1442		269	1540	
v/s Ratio Prot	0.02	0.07		c0.02	c0.10		0.01	c0.30		c0.03	0.24	
v/s Ratio Perm	0.08			0.08			0.09			0.18		
v/c Ratio	0.43	0.41		0.45	0.56		0.22	0.72		0.42	0.54	
Uniform Delay, d1	18.7	21.7		19.1	22.4		8.9	14.6		9.1	12.3	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	1.3	0.9		1.1	2.2		0.4	3.1		1.0	1.4	
Delay (s)	20.0	22.6		20.2	24.5		9.3	17.7		10.1	13.6	
Level of Service	B	C		C	C		A	B		B	B	
Approach Delay (s)		21.6			23.0			17.2			13.2	
Approach LOS		C			C			B			B	

Intersection Summary			
HCM Average Control Delay	17.0	HCM Level of Service	B
HCM Volume to Capacity ratio	0.63		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	16.0
Intersection Capacity Utilization	65.5%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

HCM Signalized Intersection Capacity Analysis
15: North Street & Haines St.

4/27/2010

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	165	57	39	33	61	30	46	930	40	28	751	89
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor	1.00	1.00	1.00	1.00	0.95		1.00	0.95		1.00	0.95	
Frt	1.00	1.00	0.85	1.00	0.95		1.00	0.99		1.00	0.98	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1770	1863	1583	1770	3364		1770	3518		1770	3483	
Flt Permitted	0.67	1.00	1.00	0.71	1.00		0.23	1.00		0.27	1.00	
Satd. Flow (perm)	1251	1863	1583	1330	3364		430	3518		506	3483	
Peak-hour factor, PHF	0.87	0.87	0.87	0.72	0.72	0.72	0.92	0.92	0.92	0.96	0.96	0.96
Adj. Flow (vph)	190	66	45	46	85	42	50	1011	43	29	782	93
RTOR Reduction (vph)	0	0	35	0	33	0	0	5	0	0	14	0
Lane Group Flow (vph)	190	66	10	46	94	0	50	1049	0	29	861	0
Turn Type	Perm		Perm	Perm			pm+pt			Perm		
Protected Phases		4			8		5	2			6	
Permitted Phases	4		4	8			2			6		
Actuated Green, G (s)	10.8	10.8	10.8	10.8	10.8		31.2	31.2		25.4	25.4	
Effective Green, g (s)	10.8	10.8	10.8	10.8	10.8		31.2	31.2		25.4	25.4	
Actuated g/C Ratio	0.22	0.22	0.22	0.22	0.22		0.62	0.62		0.51	0.51	
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	270	402	342	287	727		317	2195		257	1769	
v/s Ratio Prot		0.04			0.03		0.01	c0.30			0.25	
v/s Ratio Perm	c0.15		0.01	0.03			0.09			0.06		
v/c Ratio	0.70	0.16	0.03	0.16	0.13		0.16	0.48		0.11	0.49	
Uniform Delay, d1	18.1	15.9	15.5	15.9	15.8		4.4	5.0		6.4	8.0	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	8.1	0.2	0.0	0.3	0.1		0.2	0.7		0.9	1.0	
Delay (s)	26.2	16.1	15.5	16.2	15.9		4.7	5.8		7.3	9.0	
Level of Service	C	B	B	B	B		A	A		A	A	
Approach Delay (s)		22.4			16.0			5.7			8.9	
Approach LOS		C			B			A			A	

Intersection Summary			
HCM Average Control Delay	9.6	HCM Level of Service	A
HCM Volume to Capacity ratio	0.54		
Actuated Cycle Length (s)	50.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	56.1%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

HCM Signalized Intersection Capacity Analysis
19: Omaha St. & 5th St.

4/27/2010

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	311	984	185	207	1082	56	104	774	34	69	427	249
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	0.97	0.91		0.97	0.91		1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00	0.98		1.00	0.99		1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	3433	4964		3433	5048		1770	3539	1583	1770	3539	1583
Flt Permitted	0.95	1.00		0.95	1.00		0.41	1.00	1.00	0.24	1.00	1.00
Satd. Flow (perm)	3433	4964		3433	5048		765	3539	1583	444	3539	1583
Peak-hour factor, PHF	0.96	0.96	0.96	0.98	0.98	0.98	0.96	0.96	0.96	0.98	0.98	0.98
Adj. Flow (vph)	324	1025	193	211	1104	57	108	806	35	70	436	254
RTOR Reduction (vph)	0	46	0	0	10	0	0	0	25	0	0	0
Lane Group Flow (vph)	324	1173	0	211	1151	0	108	806	10	70	436	254
Turn Type	Prot			Prot			pm+pt		Perm	pm+pt		Free
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases							2		2	6		Free
Actuated Green, G (s)	8.0	18.0		6.0	16.0		20.8	17.6	17.6	19.2	16.8	60.0
Effective Green, g (s)	8.0	18.0		6.0	16.0		20.8	17.6	17.6	19.2	16.8	60.0
Actuated g/C Ratio	0.13	0.30		0.10	0.27		0.35	0.29	0.29	0.32	0.28	1.00
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	4.0	4.0	4.0	4.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	458	1489		343	1346		319	1038	464	195	991	1583
v/s Ratio Prot	c0.09	c0.24		0.06	0.23		c0.02	c0.23		0.01	0.12	
v/s Ratio Perm							0.10		0.01	0.10		c0.16
v/c Ratio	0.71	0.79		0.62	0.86		0.34	0.78	0.02	0.36	0.44	0.16
Uniform Delay, d1	24.9	19.2		25.9	20.9		13.7	19.4	15.1	15.1	17.7	0.0
Progression Factor	0.82	1.46		1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	4.3	2.4		3.3	5.5		0.6	5.7	0.1	1.1	1.4	0.2
Delay (s)	24.7	30.5		29.2	26.4		14.4	25.1	15.2	16.2	19.2	0.2
Level of Service	C	C		C	C		B	C	B	B	B	A
Approach Delay (s)		29.3			26.9			23.5			12.6	
Approach LOS		C			C			C			B	

Intersection Summary			
HCM Average Control Delay	24.6	HCM Level of Service	C
HCM Volume to Capacity ratio	0.67		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	69.6%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

HCM Unsignalized Intersection Capacity Analysis
21: North Street & Allen Ave.

4/27/2010

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	13	221	111	96	118	15	36	56	150	7	47	13
Peak Hour Factor	0.59	0.59	0.59	0.75	0.75	0.75	0.79	0.79	0.79	0.88	0.88	0.88
Hourly flow rate (vph)	22	375	188	128	157	20	46	71	190	8	53	15

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	NB 2	SB 1
Volume Total (vph)	209	375	207	99	116	190	76
Volume Left (vph)	22	0	128	0	46	0	8
Volume Right (vph)	0	188	0	20	0	190	15
Hadj (s)	0.09	-0.32	0.34	-0.11	0.23	-0.67	-0.06
Departure Headway (s)	6.3	5.9	6.9	6.4	7.1	6.2	7.2
Degree Utilization, x	0.37	0.62	0.40	0.18	0.23	0.33	0.15
Capacity (veh/h)	548	584	497	527	473	538	452
Control Delay (s)	11.7	16.7	13.2	9.6	11.1	11.1	11.5
Approach Delay (s)	14.9		12.0		11.1		11.5
Approach LOS	B		B		B		B

Intersection Summary			
Delay	13.1		
HCM Level of Service	B		
Intersection Capacity Utilization	38.2%	ICU Level of Service	A
Analysis Period (min)	15		

HCM Signalized Intersection Capacity Analysis
22: Omaha St. & Mt. Rushmore Rd.

4/27/2010

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	80	986	290	335	1285	15	315	227	149	23	76	25
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	0.97	0.91	1.00	0.97	0.91		0.97	0.95	1.00	1.00	0.95	1.00
Frt	1.00	1.00	0.85	1.00	1.00		1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	3433	5085	1583	3433	5077		3433	3539	1583	1770	3539	1583
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.60	1.00	1.00
Satd. Flow (perm)	3433	5085	1583	3433	5077		3433	3539	1583	1121	3539	1583
Peak-hour factor, PHF	0.96	0.96	0.96	0.98	0.98	0.98	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	83	1027	302	342	1311	15	335	241	159	24	81	27
RTOR Reduction (vph)	0	0	218	0	2	0	0	0	107	0	0	20
Lane Group Flow (vph)	83	1027	84	342	1324	0	335	241	52	24	81	7
Turn Type	Prot		Perm	Prot			Prot		Perm	pm+pt		Perm
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases			4						2	6		6
Actuated Green, G (s)	3.2	16.6	16.6	6.0	19.4		6.2	19.8	19.8	16.8	15.2	15.2
Effective Green, g (s)	3.2	16.6	16.6	6.0	19.4		6.2	19.8	19.8	16.8	15.2	15.2
Actuated g/C Ratio	0.05	0.28	0.28	0.10	0.32		0.10	0.33	0.33	0.28	0.25	0.25
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0	4.0	4.0	4.0	4.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	183	1407	438	343	1642		355	1168	522	331	897	401
v/s Ratio Prot	0.02	0.20		c0.10	c0.26		c0.10	c0.07		0.00	0.02	
v/s Ratio Perm			0.05						0.03	0.02		0.00
v/c Ratio	0.45	0.73	0.19	1.00	0.81		0.94	0.21	0.10	0.07	0.09	0.02
Uniform Delay, d1	27.6	19.7	16.6	27.0	18.6		26.7	14.5	13.9	15.8	17.1	16.8
Progression Factor	0.80	1.72	5.62	0.70	1.25		1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	1.2	1.3	0.1	42.2	2.4		33.2	0.4	0.4	0.1	0.2	0.1
Delay (s)	23.3	35.1	93.3	61.1	25.6		60.0	14.9	14.3	15.9	17.3	16.9
Level of Service	C	D	F	E	C		E	B	B	B	B	B
Approach Delay (s)		46.8			32.9			35.3			17.0	
Approach LOS		D			C			D			B	

Intersection Summary			
HCM Average Control Delay	37.8	HCM Level of Service	D
HCM Volume to Capacity ratio	0.62		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	54.3%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

HCM Unsignalized Intersection Capacity Analysis
29: Anamosa St. & West Blvd. (W)

4/27/2010

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	2	32	6	21	37	17	0	1	16	11	6	1
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.77	0.77	0.77	0.67	0.67	0.67	0.71	0.71	0.71	0.75	0.75	0.75
Hourly flow rate (vph)	3	42	8	31	55	25	0	1	23	15	8	1
Pedestrians												
Lane Width (ft)												
Walking Speed (ft/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (ft)												
pX, platoon unblocked												
vC, conflicting volume	81			49			187	194	45	204	185	68
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	81			49			187	194	45	204	185	68
tC, single (s)	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	100			98			100	100	98	98	99	100
cM capacity (veh/h)	1517			1557			753	686	1024	723	694	995

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	52	112	24	24
Volume Left	3	31	0	15
Volume Right	8	25	23	1
cSH	1517	1557	995	724
Volume to Capacity	0.00	0.02	0.02	0.03
Queue Length 95th (ft)	0	2	2	3
Control Delay (s)	0.4	2.2	8.7	10.1
Lane LOS	A	A	A	B
Approach Delay (s)	0.4	2.2	8.7	10.1
Approach LOS			A	B

Intersection Summary			
Average Delay	3.4		
Intersection Capacity Utilization	25.1%	ICU Level of Service	A
Analysis Period (min)	15		

HCM Unsignalized Intersection Capacity Analysis
27: Anamosa St. & West Blvd. (E)

4/27/2010

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	21	40	5	74	50	25	23	85	58	2	26	4
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.87	0.87	0.87	0.79	0.79	0.79	0.78	0.78	0.78	0.80	0.80	0.80
Hourly flow rate (vph)	24	46	6	94	63	32	29	109	74	2	32	5
Pedestrians												
Lane Width (ft)												
Walking Speed (ft/s)												
Percent Blockage												
Right turn flare (veh)			2			16						
Median type								None			None	
Median storage veh)												
Upstream signal (ft)												
pX, platoon unblocked												
vC, conflicting volume	293	282	35	271	248	146	38			183		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	293	282	35	271	248	146	38			183		
tC, single (s)	7.1	6.5	6.2	7.1	6.5	6.2	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	96	93	99	85	90	96	98			100		
cM capacity (veh/h)	579	614	1038	629	641	901	1573			1392		

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	76	189	213	40
Volume Left	24	94	29	2
Volume Right	6	32	74	5
cSH	651	762	1573	1392
Volume to Capacity	0.12	0.25	0.02	0.00
Queue Length 95th (ft)	10	24	1	0
Control Delay (s)	11.5	12.0	1.1	0.5
Lane LOS	B	B	A	A
Approach Delay (s)	11.5	12.0	1.1	0.5
Approach LOS	B	B		

Intersection Summary			
Average Delay	6.6		
Intersection Capacity Utilization	35.8%	ICU Level of Service	A
Analysis Period (min)	15		

HCM Unsignalized Intersection Capacity Analysis
32: Boegel St. & Silver St.

4/27/2010

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	1	22	1	14	47	16	0	4	5	18	3	2
Peak Hour Factor	0.67	0.67	0.67	0.84	0.84	0.84	0.56	0.56	0.56	0.72	0.72	0.72
Hourly flow rate (vph)	1	33	1	17	56	19	0	7	9	25	4	3

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total (vph)	36	92	16	32
Volume Left (vph)	1	17	0	25
Volume Right (vph)	1	19	9	3
Hadj (s)	0.02	-0.05	-0.30	0.14
Departure Headway (s)	4.1	4.0	3.9	4.3
Degree Utilization, x	0.04	0.10	0.02	0.04
Capacity (veh/h)	856	887	881	805
Control Delay (s)	7.3	7.4	7.0	7.5
Approach Delay (s)	7.3	7.4	7.0	7.5
Approach LOS	A	A	A	A

Intersection Summary			
Delay	7.4		
HCM Level of Service	A		
Intersection Capacity Utilization	24.1%	ICU Level of Service	A
Analysis Period (min)	15		

HCM Unsignalized Intersection Capacity Analysis
24: North Street & West Blvd.

6/21/2010

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	5	27	0	150	10	33	50	72	93	38	0	41
Peak Hour Factor	0.66	0.66	0.66	0.78	0.78	0.78	0.67	0.67	0.67	0.68	0.68	0.68
Hourly flow rate (vph)	8	41	0	192	13	42	75	107	139	56	0	60

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	NB 2	SB 1
Volume Total (vph)	21	27	192	55	182	139	116
Volume Left (vph)	8	0	192	0	75	0	56
Volume Right (vph)	0	0	0	42	0	139	60
Hadj (s)	0.21	0.03	0.53	-0.50	0.24	-0.67	-0.18
Departure Headway (s)	6.2	6.0	6.2	5.2	5.7	4.8	5.6
Degree Utilization, x	0.04	0.05	0.33	0.08	0.29	0.19	0.18
Capacity (veh/h)	531	549	549	652	603	709	610
Control Delay (s)	8.3	8.1	11.1	7.5	9.9	7.7	9.8
Approach Delay (s)	8.2		10.3		8.9		9.8
Approach LOS	A		B		A		A

Intersection Summary			
Delay	9.5		
HCM Level of Service	A		
Intersection Capacity Utilization	32.9%	ICU Level of Service	A
Analysis Period (min)	15		

HCM Signalized Intersection Capacity Analysis
18: Omaha St. & West Blvd.

4/27/2010

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	353	1031	89	181	1134	256	70	567	146	253	414	279
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	0.97	0.91	1.00	0.97	0.91	1.00	1.00	0.95	1.00	0.97	0.95	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	3433	5085	1583	3433	5085	1583	1770	3539	1583	3433	3539	1583
Flt Permitted	0.95	1.00	1.00	0.95	1.00	1.00	0.50	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)	3433	5085	1583	3433	5085	1583	925	3539	1583	3433	3539	1583
Peak-hour factor, PHF	0.87	0.87	0.87	0.96	0.96	0.96	0.97	0.97	0.97	0.94	0.94	0.94
Adj. Flow (vph)	406	1185	102	189	1181	267	72	585	151	269	440	297
RTOR Reduction (vph)	0	0	0	0	0	0	0	0	0	0	0	0
Lane Group Flow (vph)	406	1185	102	189	1181	267	72	585	151	269	440	297
Turn Type	Prot		Free	Prot		Free	pm+pt		Free	Prot		Free
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases			Free			Free	2		Free			Free
Actuated Green, G (s)	7.0	18.0	60.0	5.0	16.0	60.0	18.4	16.0	60.0	5.0	18.6	60.0
Effective Green, g (s)	7.0	18.0	60.0	5.0	16.0	60.0	18.4	16.0	60.0	5.0	18.6	60.0
Actuated g/C Ratio	0.12	0.30	1.00	0.08	0.27	1.00	0.31	0.27	1.00	0.08	0.31	1.00
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	4.0		4.0	4.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	401	1526	1583	286	1356	1583	317	944	1583	286	1097	1583
v/s Ratio Prot	c0.12	c0.23		0.06	0.23		0.01	c0.17		c0.08	0.12	
v/s Ratio Perm			0.06			0.17	0.06		0.10			c0.19
v/c Ratio	1.01	0.78	0.06	0.66	0.87	0.17	0.23	0.62	0.10	0.94	0.40	0.19
Uniform Delay, d1	26.5	19.2	0.0	26.7	21.0	0.0	15.0	19.3	0.0	27.4	16.3	0.0
Progression Factor	1.00	1.00	1.00	0.85	1.68	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	48.1	2.6	0.1	3.1	3.6	0.1	0.4	3.1	0.1	37.5	1.1	0.3
Delay (s)	74.6	21.7	0.1	25.7	39.0	0.1	15.4	22.4	0.1	64.8	17.4	0.3
Level of Service	E	C	A	C	D	A	B	C	A	E	B	A
Approach Delay (s)		33.1			31.1			17.6			25.0	
Approach LOS		C			C			B			C	

Intersection Summary			
HCM Average Control Delay	28.5	HCM Level of Service	C
HCM Volume to Capacity ratio	0.73		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	68.2%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

HCM Signalized Intersection Capacity Analysis
3: Disk Drive & Haines St.

4/27/2010

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	1	10	51	35	1	17	41	406	204	21	702	6
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0	4.0	4.0	4.0	
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00		1.00	0.95	1.00	1.00	0.95	
Frt	1.00	1.00	0.85	1.00	0.86		1.00	1.00	0.85	1.00	1.00	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1770	1863	1583	1770	1597		1770	3539	1583	1770	3535	
Flt Permitted	0.98	1.00	1.00	0.49	1.00		0.29	1.00	1.00	0.49	1.00	
Satd. Flow (perm)	1817	1863	1583	920	1597		534	3539	1583	907	3535	
Peak-hour factor, PHF	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Adj. Flow (vph)	1	11	58	40	1	19	47	461	232	24	798	7
RTOR Reduction (vph)	0	0	54	0	16	0	0	0	89	0	1	0
Lane Group Flow (vph)	1	11	4	40	4	0	47	461	143	24	804	0
Turn Type	Perm		Perm	pm+pt			pm+pt		Perm	pm+pt		
Protected Phases		4		3	8		5	2		1	6	
Permitted Phases	4		4	8			2		2	6		
Actuated Green, G (s)	4.1	4.1	4.1	9.7	9.7		40.9	37.0	37.0	35.7	34.4	
Effective Green, g (s)	4.1	4.1	4.1	9.7	9.7		40.9	37.0	37.0	35.7	34.4	
Actuated g/C Ratio	0.07	0.07	0.07	0.16	0.16		0.68	0.62	0.62	0.60	0.57	
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0	4.0	4.0	4.0	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	124	127	108	171	258		444	2182	976	558	2027	
v/s Ratio Prot		0.01		c0.01	0.00		c0.01	0.13		0.00	c0.23	
v/s Ratio Perm	0.00		0.00	c0.03			0.07		0.09	0.02		
v/c Ratio	0.01	0.09	0.04	0.23	0.02		0.11	0.21	0.15	0.04	0.40	
Uniform Delay, d1	26.1	26.2	26.1	21.7	21.1		3.5	5.1	4.8	5.0	7.1	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	
Incremental Delay, d2	0.0	0.3	0.1	0.7	0.0		0.1	0.2	0.3	0.0	0.6	
Delay (s)	26.1	26.5	26.2	22.4	21.2		3.6	5.3	5.2	5.0	7.7	
Level of Service	C	C	C	C	C		A	A	A	A	A	
Approach Delay (s)		26.3			22.0			5.1			7.6	
Approach LOS		C			C			A			A	

Intersection Summary			
HCM Average Control Delay	7.8	HCM Level of Service	A
HCM Volume to Capacity ratio	0.37		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	16.0
Intersection Capacity Utilization	41.5%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

HCM Signalized Intersection Capacity Analysis
37: I-90 & Haines St.

4/27/2010

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	247	0	142	160	0	45	73	359	67	89	548	151
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0		4.0	4.0		4.0	4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	0.97		1.00	0.97		1.00	1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00		0.85	1.00		0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95		1.00	0.95		1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	3433		1583	3433		1583	1770	3539	1583	1770	3539	1583
Flt Permitted	0.95		1.00	0.95		1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)	3433		1583	3433		1583	1770	3539	1583	1770	3539	1583
Peak-hour factor, PHF	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Adj. Flow (vph)	281	0	161	182	0	51	83	408	76	101	623	172
RTOR Reduction (vph)	0	0	0	0	0	0	0	0	0	0	0	0
Lane Group Flow (vph)	281	0	161	182	0	51	83	408	76	101	623	172
Turn Type	Prot		Free	Prot		Free	Prot		Free	Prot		Free
Protected Phases	7			3			5	2		1	6	
Permitted Phases			Free			Free			Free			Free
Actuated Green, G (s)	6.0		40.0	6.0		40.0	3.0	19.0	40.0	3.0	19.0	40.0
Effective Green, g (s)	6.0		40.0	6.0		40.0	3.0	19.0	40.0	3.0	19.0	40.0
Actuated g/C Ratio	0.15		1.00	0.15		1.00	0.08	0.48	1.00	0.08	0.48	1.00
Clearance Time (s)	4.0			4.0			4.0	4.0		4.0	4.0	
Vehicle Extension (s)	3.0			3.0			3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	515		1583	515		1583	133	1681	1583	133	1681	1583
v/s Ratio Prot	c0.08			0.05			0.05	0.12		c0.06	c0.18	
v/s Ratio Perm			0.10			0.03			0.05			0.11
v/c Ratio	0.55		0.10	0.35		0.03	0.62	0.24	0.05	0.76	0.37	0.11
Uniform Delay, d1	15.7		0.0	15.3		0.0	18.0	6.2	0.0	18.1	6.7	0.0
Progression Factor	1.00		1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	1.2		0.1	0.4		0.0	8.8	0.3	0.1	21.7	0.6	0.1
Delay (s)	16.9		0.1	15.7		0.0	26.8	6.6	0.1	39.9	7.3	0.1
Level of Service	B		A	B		A	C	A	A	D	A	A
Approach Delay (s)		10.8			12.3			8.7			9.6	
Approach LOS		B			B			A			A	

Intersection Summary			
HCM Average Control Delay	9.9	HCM Level of Service	A
HCM Volume to Capacity ratio	0.45		
Actuated Cycle Length (s)	40.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	36.2%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

HCM Signalized Intersection Capacity Analysis
8: Anamosa St. & Haines St.

4/27/2010

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	75	146	91	165	147	66	50	446	141	70	801	67
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor	1.00	1.00		1.00	1.00		1.00	0.95		1.00	0.95	
Frt	1.00	0.94		1.00	0.95		1.00	0.96		1.00	0.99	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1770	1756		1770	1776		1770	3412		1770	3498	
Flt Permitted	0.50	1.00		0.46	1.00		0.20	1.00		0.28	1.00	
Satd. Flow (perm)	933	1756		848	1776		373	3412		531	3498	
Peak-hour factor, PHF	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Adj. Flow (vph)	85	166	103	188	167	75	57	507	160	80	910	76
RTOR Reduction (vph)	0	37	0	0	27	0	0	50	0	0	10	0
Lane Group Flow (vph)	85	232	0	188	215	0	57	617	0	80	976	0
Turn Type	pm+pt			pm+pt			pm+pt			pm+pt		
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases	4			8			2			6		
Actuated Green, G (s)	20.0	16.0		20.0	16.0		24.0	20.0		24.0	20.0	
Effective Green, g (s)	20.0	16.0		20.0	16.0		24.0	20.0		24.0	20.0	
Actuated g/C Ratio	0.33	0.27		0.33	0.27		0.40	0.33		0.40	0.33	
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	4.0		4.0	4.0	
Lane Grp Cap (vph)	367	468		344	474		242	1137		295	1166	
v/s Ratio Prot	0.02	0.13		c0.04	0.12		0.02	0.18		c0.02	c0.28	
v/s Ratio Perm	0.06			c0.15			0.08			0.09		
v/c Ratio	0.23	0.49		0.55	0.45		0.24	0.54		0.27	0.84	
Uniform Delay, d1	14.1	18.6		15.6	18.4		12.5	16.3		11.6	18.5	
Progression Factor	1.00	1.00		1.00	1.00		0.59	0.63		1.00	1.00	
Incremental Delay, d2	1.5	3.7		6.1	3.1		2.2	1.8		2.3	7.2	
Delay (s)	15.6	22.3		21.7	21.5		9.5	12.0		13.9	25.7	
Level of Service	B	C		C	C		A	B		B	C	
Approach Delay (s)		20.7			21.6			11.8			24.8	
Approach LOS		C			C			B			C	

Intersection Summary			
HCM Average Control Delay	20.1	HCM Level of Service	C
HCM Volume to Capacity ratio	0.65		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	16.0
Intersection Capacity Utilization	63.3%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group

HCM Signalized Intersection Capacity Analysis
15: North Street & Haines St.

4/27/2010

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	169	97	162	46	157	18	127	514	70	15	868	239
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor	1.00	1.00	1.00	1.00	0.95		1.00	0.95		1.00	0.95	
Frt	1.00	1.00	0.85	1.00	0.98		1.00	0.98		1.00	0.97	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1770	1863	1583	1770	3486		1770	3475		1770	3424	
Flt Permitted	0.63	1.00	1.00	0.69	1.00		0.12	1.00		0.40	1.00	
Satd. Flow (perm)	1169	1863	1583	1278	3486		219	3475		744	3424	
Peak-hour factor, PHF	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Adj. Flow (vph)	192	110	184	52	178	20	144	584	80	17	986	272
RTOR Reduction (vph)	0	0	142	0	15	0	0	16	0	0	38	0
Lane Group Flow (vph)	192	110	42	52	183	0	144	648	0	17	1220	0
Turn Type	Perm		Perm	Perm			pm+pt			Perm		
Protected Phases		4			8		5	2			6	
Permitted Phases	4		4	8			2			6		
Actuated Green, G (s)	13.7	13.7	13.7	13.7	13.7		38.3	38.3		30.0	30.0	
Effective Green, g (s)	13.7	13.7	13.7	13.7	13.7		38.3	38.3		30.0	30.0	
Actuated g/C Ratio	0.23	0.23	0.23	0.23	0.23		0.64	0.64		0.50	0.50	
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	267	425	361	292	796		251	2218		372	1712	
v/s Ratio Prot		0.06			0.05		c0.04	0.19			c0.36	
v/s Ratio Perm	c0.16		0.03	0.04			0.32			0.02		
v/c Ratio	0.72	0.26	0.12	0.18	0.23		0.57	0.29		0.05	0.71	
Uniform Delay, d1	21.4	19.0	18.4	18.6	18.9		8.0	4.8		7.7	11.7	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.84	0.11		0.53	0.49	
Incremental Delay, d2	8.9	0.3	0.1	0.3	0.1		2.5	0.3		0.2	1.7	
Delay (s)	30.3	19.3	18.5	18.9	19.0		17.3	0.8		4.2	7.5	
Level of Service	C	B	B	B	B		B	A		A	A	
Approach Delay (s)		23.3			19.0			3.8			7.4	
Approach LOS		C			B			A			A	

Intersection Summary			
HCM Average Control Delay	10.1	HCM Level of Service	B
HCM Volume to Capacity ratio	0.70		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	66.3%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

HCM Signalized Intersection Capacity Analysis
19: Omaha St. & 5th St.

4/27/2010

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	215	824	158	176	852	48	53	448	41	176	696	204
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	0.97	0.91		0.97	0.91		1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00	0.98		1.00	0.99		1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	3433	4962		3433	5044		1770	3539	1583	1770	3539	1583
Flt Permitted	0.95	1.00		0.95	1.00		0.26	1.00	1.00	0.29	1.00	1.00
Satd. Flow (perm)	3433	4962		3433	5044		477	3539	1583	543	3539	1583
Peak-hour factor, PHF	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Adj. Flow (vph)	244	936	180	200	968	55	60	509	47	200	791	232
RTOR Reduction (vph)	0	48	0	0	10	0	0	0	34	0	0	0
Lane Group Flow (vph)	244	1068	0	200	1013	0	60	509	13	200	791	232
Turn Type	Prot			Prot			pm+pt		Perm	pm+pt		Free
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases							2		2	6		Free
Actuated Green, G (s)	6.0	16.8		5.0	15.8		18.5	16.1	16.1	25.9	19.8	60.0
Effective Green, g (s)	6.0	16.8		5.0	15.8		18.5	16.1	16.1	25.9	19.8	60.0
Actuated g/C Ratio	0.10	0.28		0.08	0.26		0.31	0.27	0.27	0.43	0.33	1.00
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	4.0	4.0	4.0	4.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	343	1389		286	1328		199	950	425	359	1168	1583
v/s Ratio Prot	c0.07	c0.22		0.06	0.20		0.01	0.14		c0.06	c0.22	
v/s Ratio Perm							0.08		0.01	0.18		c0.15
v/c Ratio	0.71	0.77		0.70	0.76		0.30	0.54	0.03	0.56	0.68	0.15
Uniform Delay, d1	26.2	19.8		26.8	20.4		15.0	18.8	16.2	11.5	17.3	0.0
Progression Factor	0.68	1.42		1.00	1.00		1.00	1.00	1.00	0.77	0.52	1.00
Incremental Delay, d2	4.2	1.6		7.3	2.7		0.9	2.2	0.1	1.5	2.5	0.2
Delay (s)	21.9	29.8		34.0	23.0		15.9	20.9	16.3	10.3	11.5	0.2
Level of Service	C	C		C	C		B	C	B	B	B	A
Approach Delay (s)		28.4			24.8			20.1			9.1	
Approach LOS		C			C			C			A	

Intersection Summary			
HCM Average Control Delay	20.9	HCM Level of Service	C
HCM Volume to Capacity ratio	0.70		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	60.4%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

HCM Unsignalized Intersection Capacity Analysis
21: North Street & Allen Ave.

4/27/2010

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	25	301	132	139	322	13	95	28	70	14	98	69
Peak Hour Factor	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Hourly flow rate (vph)	28	342	150	158	366	15	108	32	80	16	111	78

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	NB 2	SB 1
Volume Total (vph)	199	321	341	198	140	80	206
Volume Left (vph)	28	0	158	0	108	0	16
Volume Right (vph)	0	150	0	15	0	80	78
Hadj (s)	0.11	-0.29	0.27	-0.02	0.42	-0.67	-0.18
Departure Headway (s)	7.2	6.8	7.3	7.0	8.4	7.2	7.5
Degree Utilization, x	0.40	0.61	0.69	0.39	0.32	0.16	0.43
Capacity (veh/h)	480	506	474	497	394	455	447
Control Delay (s)	13.7	18.5	23.9	13.1	14.1	10.4	16.1
Approach Delay (s)	16.7		20.0		12.8		16.1
Approach LOS	C		C		B		C

Intersection Summary			
Delay	17.2		
HCM Level of Service	C		
Intersection Capacity Utilization	56.8%	ICU Level of Service	B
Analysis Period (min)	15		

HCM Signalized Intersection Capacity Analysis
22: Omaha St. & Mt. Rushmore Rd.

4/27/2010

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	62	1035	294	219	866	24	232	107	71	91	242	36
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	0.97	0.91	1.00	0.97	0.91		0.97	0.95	1.00	1.00	0.95	1.00
Frt	1.00	1.00	0.85	1.00	1.00		1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	3433	5085	1583	3433	5065		3433	3539	1583	1770	3539	1583
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.67	1.00	1.00
Satd. Flow (perm)	3433	5085	1583	3433	5065		3433	3539	1583	1257	3539	1583
Peak-hour factor, PHF	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Adj. Flow (vph)	70	1176	334	249	984	27	264	122	81	103	275	41
RTOR Reduction (vph)	0	0	236	0	5	0	0	0	59	0	0	31
Lane Group Flow (vph)	70	1176	98	249	1006	0	264	122	22	103	275	10
Turn Type	Prot		Perm	Prot			Prot		Perm	pm+pt		Perm
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases			4						2	6		6
Actuated Green, G (s)	2.4	17.6	17.6	6.0	21.2		6.0	16.4	16.4	18.4	14.4	14.4
Effective Green, g (s)	2.4	17.6	17.6	6.0	21.2		6.0	16.4	16.4	18.4	14.4	14.4
Actuated g/C Ratio	0.04	0.29	0.29	0.10	0.35		0.10	0.27	0.27	0.31	0.24	0.24
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0	4.0	4.0	4.0	4.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	137	1492	464	343	1790		343	967	433	420	849	380
v/s Ratio Prot	0.02	c0.23		c0.07	c0.20		c0.08	0.03		0.02	c0.08	
v/s Ratio Perm			0.06						0.01	0.06		0.01
v/c Ratio	0.51	0.79	0.21	0.73	0.56		0.77	0.13	0.05	0.25	0.32	0.03
Uniform Delay, d1	28.2	19.5	16.0	26.2	15.7		26.3	16.4	16.1	15.3	18.8	17.4
Progression Factor	0.79	1.53	5.48	0.78	1.35		1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	2.3	2.1	0.2	5.9	0.3		10.0	0.3	0.2	0.3	1.0	0.1
Delay (s)	24.6	32.0	87.6	26.5	21.5		36.3	16.7	16.3	15.6	19.8	17.6
Level of Service	C	C	F	C	C		D	B	B	B	B	B
Approach Delay (s)		43.4			22.5			27.7			18.6	
Approach LOS		D			C			C			B	

Intersection Summary			
HCM Average Control Delay	31.6	HCM Level of Service	C
HCM Volume to Capacity ratio	0.66		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	20.0
Intersection Capacity Utilization	52.9%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

HCM Unsignalized Intersection Capacity Analysis
29: Anamosa St. & West Blvd. W

4/27/2010

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	3	57	10	37	33	16	4	2	39	41	15	2
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Hourly flow rate (vph)	3	65	11	42	38	18	5	2	44	47	17	2
Pedestrians												
Lane Width (ft)												
Walking Speed (ft/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (ft)												
pX, platoon unblocked												
vC, conflicting volume	56			76			219	217	70	253	214	47
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	56			76			219	217	70	253	214	47
tC, single (s)	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	100			97			99	100	96	93	97	100
cM capacity (veh/h)	1549			1523			705	661	992	652	664	1023

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	80	98	51	66
Volume Left	3	42	5	47
Volume Right	11	18	44	2
cSH	1549	1523	937	663
Volume to Capacity	0.00	0.03	0.05	0.10
Queue Length 95th (ft)	0	2	4	8
Control Delay (s)	0.3	3.3	9.1	11.0
Lane LOS	A	A	A	B
Approach Delay (s)	0.3	3.3	9.1	11.0
Approach LOS			A	B

Intersection Summary			
Average Delay	5.2		
Intersection Capacity Utilization	27.9%	ICU Level of Service	A
Analysis Period (min)	15		

HCM Unsignalized Intersection Capacity Analysis
27: Anamosa St. & West Blvd E

4/27/2010

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	35	93	11	93	48	54	14	85	71	30	58	24
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Hourly flow rate (vph)	40	106	12	106	55	61	16	97	81	34	66	27
Pedestrians												
Lane Width (ft)												
Walking Speed (ft/s)												
Percent Blockage												
Right turn flare (veh)			2			16						
Median type								None			None	
Median storage veh)												
Upstream signal (ft)												
pX, platoon unblocked												
vC, conflicting volume	374	357	80	376	330	137	93			177		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	374	357	80	376	330	137	93			177		
tC, single (s)	7.1	6.5	6.2	7.1	6.5	6.2	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	92	81	99	78	90	93	99			98		
cM capacity (veh/h)	490	549	981	477	569	912	1501			1399		

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	158	222	193	127
Volume Left	40	106	16	34
Volume Right	12	61	81	27
cSH	579	703	1501	1399
Volume to Capacity	0.27	0.32	0.01	0.02
Queue Length 95th (ft)	28	34	1	2
Control Delay (s)	13.8	13.6	0.7	2.2
Lane LOS	B	B	A	A
Approach Delay (s)	13.8	13.6	0.7	2.2
Approach LOS	B	B		

Intersection Summary			
Average Delay	8.0		
Intersection Capacity Utilization	34.7%	ICU Level of Service	A
Analysis Period (min)	15		

HCM Unsignalized Intersection Capacity Analysis
32: Boegel St. & Silver St.

4/27/2010

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	45	12	1	2	16	22	5	44	5	19	41	14
Peak Hour Factor	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Hourly flow rate (vph)	51	14	1	2	18	25	6	50	6	22	47	16

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total (vph)	66	45	61	84
Volume Left (vph)	51	2	6	22
Volume Right (vph)	1	25	6	16
Hadj (s)	0.18	-0.29	0.00	-0.03
Departure Headway (s)	4.4	4.0	4.2	4.2
Degree Utilization, x	0.08	0.05	0.07	0.10
Capacity (veh/h)	779	859	817	833
Control Delay (s)	7.8	7.2	7.6	7.6
Approach Delay (s)	7.8	7.2	7.6	7.6
Approach LOS	A	A	A	A

Intersection Summary			
Delay	7.6		
HCM Level of Service	A		
Intersection Capacity Utilization	24.9%	ICU Level of Service	A
Analysis Period (min)	15		

HCM Unsignalized Intersection Capacity Analysis
24: North Street & West Blvd E

6/21/2010

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	15	158	0	215	12	64	105	203	422	53	0	137
Peak Hour Factor	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Hourly flow rate (vph)	17	180	0	244	14	73	119	231	480	60	0	156

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	NB 2	SB 1
Volume Total (vph)	77	120	244	86	350	480	216
Volume Left (vph)	17	0	244	0	119	0	60
Volume Right (vph)	0	0	0	73	0	480	156
Hadj (s)	0.14	0.03	0.53	-0.56	0.20	-0.67	-0.34
Departure Headway (s)	8.2	8.1	8.2	7.1	7.0	6.2	7.1
Degree Utilization, x	0.18	0.27	0.56	0.17	0.69	0.82	0.43
Capacity (veh/h)	421	418	420	480	498	573	474
Control Delay (s)	11.7	12.8	20.0	10.4	22.8	30.2	15.3
Approach Delay (s)	12.4		17.5		27.1		15.3
Approach LOS	B		C		D		C

Intersection Summary			
Delay	21.6		
HCM Level of Service	C		
Intersection Capacity Utilization	57.9%	ICU Level of Service	B
Analysis Period (min)	15		

HCM Signalized Intersection Capacity Analysis
18: Omaha St. & West Blvd.

4/27/2010

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	305	899	108	126	757	251	63	306	160	332	416	341
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	0.97	0.91	1.00	0.97	0.91	1.00	1.00	0.95	1.00	0.97	0.95	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	3433	5085	1583	3433	5085	1583	1770	3539	1583	3433	3539	1583
Flt Permitted	0.95	1.00	1.00	0.95	1.00	1.00	0.48	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)	3433	5085	1583	3433	5085	1583	896	3539	1583	3433	3539	1583
Peak-hour factor, PHF	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Adj. Flow (vph)	347	1022	123	143	860	285	72	348	182	377	473	388
RTOR Reduction (vph)	0	0	0	0	0	0	0	0	0	0	0	0
Lane Group Flow (vph)	347	1022	123	143	860	285	72	348	182	377	473	388
Turn Type	Prot		Free	Prot		Free	pm+pt		Free	Prot		Free
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases			Free			Free	2		Free			Free
Actuated Green, G (s)	6.0	18.2	60.0	4.0	16.2	60.0	17.6	15.2	60.0	6.6	19.4	60.0
Effective Green, g (s)	6.0	18.2	60.0	4.0	16.2	60.0	17.6	15.2	60.0	6.6	19.4	60.0
Actuated g/C Ratio	0.10	0.30	1.00	0.07	0.27	1.00	0.29	0.25	1.00	0.11	0.32	1.00
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	4.0		4.0	4.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	343	1542	1583	229	1373	1583	298	897	1583	378	1144	1583
v/s Ratio Prot	c0.10	c0.20		0.04	0.17		0.01	0.10		c0.11	c0.13	
v/s Ratio Perm			0.08			0.18	0.06		0.11			c0.25
v/c Ratio	1.01	0.66	0.08	0.62	0.63	0.18	0.24	0.39	0.11	1.00	0.41	0.25
Uniform Delay, d1	27.0	18.2	0.0	27.3	19.2	0.0	15.6	18.5	0.0	26.7	15.9	0.0
Progression Factor	1.00	1.00	1.00	0.91	1.61	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	51.6	1.1	0.1	4.3	0.7	0.2	0.4	1.3	0.1	45.3	1.1	0.4
Delay (s)	78.6	19.3	0.1	29.0	31.7	0.2	16.0	19.8	0.1	72.0	17.0	0.4
Level of Service	E	B	A	C	C	A	B	B	A	E	B	A
Approach Delay (s)		31.5			24.4			13.4			28.5	
Approach LOS		C			C			B			C	

Intersection Summary			
HCM Average Control Delay	26.4	HCM Level of Service	C
HCM Volume to Capacity ratio	0.62		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	54.6%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

HCM Signalized Intersection Capacity Analysis
3: Disk Drive & Haines St.

4/27/2010

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	6	28	86	438	28	78	155	931	326	56	593	13
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0	4.0	4.0	4.0	
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00		1.00	0.95	1.00	1.00	0.95	
Frt	1.00	1.00	0.85	1.00	0.89		1.00	1.00	0.85	1.00	1.00	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1770	1863	1583	1770	1657		1770	3539	1583	1770	3528	
Flt Permitted	0.68	1.00	1.00	0.44	1.00		0.26	1.00	1.00	0.19	1.00	
Satd. Flow (perm)	1265	1863	1583	817	1657		488	3539	1583	357	3528	
Peak-hour factor, PHF	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Adj. Flow (vph)	7	32	98	498	32	89	176	1058	370	64	674	15
RTOR Reduction (vph)	0	0	90	0	62	0	0	0	197	0	2	0
Lane Group Flow (vph)	7	32	8	498	59	0	176	1058	173	64	687	0
Turn Type	Perm		Perm	pm+pt			pm+pt		Perm	pm+pt		
Protected Phases		4		3	8		5	2		1	6	
Permitted Phases	4		4	8			2		2	6		
Actuated Green, G (s)	5.9	5.9	5.9	20.9	20.9		41.1	32.7	32.7	32.6	28.2	
Effective Green, g (s)	5.9	5.9	5.9	20.9	20.9		41.1	32.7	32.7	32.6	28.2	
Actuated g/C Ratio	0.08	0.08	0.08	0.30	0.30		0.59	0.47	0.47	0.47	0.40	
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0	4.0	4.0	4.0	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	107	157	133	394	495		450	1653	739	255	1421	
v/s Ratio Prot		0.02		c0.20	0.04		c0.05	c0.30		0.02	0.19	
v/s Ratio Perm	0.01		0.01	c0.18			0.18		0.11	0.10		
v/c Ratio	0.07	0.20	0.06	1.26	0.12		0.39	0.64	0.23	0.25	0.48	
Uniform Delay, d1	29.5	29.9	29.5	23.3	17.9		7.7	14.2	11.2	10.9	15.5	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	
Incremental Delay, d2	0.3	0.6	0.2	137.7	0.1		0.6	1.9	0.7	0.5	1.2	
Delay (s)	29.8	30.5	29.7	160.9	18.0		8.2	16.1	11.9	11.4	16.7	
Level of Service	C	C	C	F	B		A	B	B	B	B	
Approach Delay (s)		29.9			133.0			14.3			16.2	
Approach LOS		C			F			B			B	

Intersection Summary			
HCM Average Control Delay	39.0	HCM Level of Service	D
HCM Volume to Capacity ratio	0.79		
Actuated Cycle Length (s)	70.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	70.0%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

HCM Signalized Intersection Capacity Analysis
37: I-90 & Haines St.

4/27/2010

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	524	0	166	167	0	103	183	785	115	152	538	427
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0		4.0	4.0		4.0	4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	0.97		1.00	0.97		1.00	1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00		0.85	1.00		0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95		1.00	0.95		1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	3433		1583	3433		1583	1770	3539	1583	1770	3539	1583
Flt Permitted	0.95		1.00	0.95		1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)	3433		1583	3433		1583	1770	3539	1583	1770	3539	1583
Peak-hour factor, PHF	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Adj. Flow (vph)	595	0	189	190	0	117	208	892	131	173	611	485
RTOR Reduction (vph)	0	0	0	0	0	0	0	0	0	0	0	0
Lane Group Flow (vph)	595	0	189	190	0	117	208	892	131	173	611	485
Turn Type	Prot		Free	Prot		Free	Prot		Free	Prot		Free
Protected Phases	7			3			5	2		1	6	
Permitted Phases			Free			Free			Free			Free
Actuated Green, G (s)	11.6		50.0	11.6		50.0	8.6	20.0	50.0	6.4	17.8	50.0
Effective Green, g (s)	11.6		50.0	11.6		50.0	8.6	20.0	50.0	6.4	17.8	50.0
Actuated g/C Ratio	0.23		1.00	0.23		1.00	0.17	0.40	1.00	0.13	0.36	1.00
Clearance Time (s)	4.0			4.0			4.0	4.0		4.0	4.0	
Vehicle Extension (s)	3.0			3.0			3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	796		1583	796		1583	304	1416	1583	227	1260	1583
v/s Ratio Prot	c0.17			0.06			c0.12	c0.25		0.10	0.17	
v/s Ratio Perm			0.12			0.07			0.08			c0.31
v/c Ratio	0.75		0.12	0.24		0.07	0.68	0.63	0.08	0.76	0.48	0.31
Uniform Delay, d1	17.8		0.0	15.6		0.0	19.4	12.0	0.0	21.1	12.5	0.0
Progression Factor	1.00		1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	3.9		0.2	0.2		0.1	6.2	2.1	0.1	14.0	1.3	0.5
Delay (s)	21.7		0.2	15.8		0.1	25.7	14.2	0.1	35.1	13.9	0.5
Level of Service	C		A	B		A	C	B	A	D	B	A
Approach Delay (s)		16.5			9.8			14.6			11.7	
Approach LOS		B			A			B			B	

Intersection Summary			
HCM Average Control Delay	13.6	HCM Level of Service	B
HCM Volume to Capacity ratio	0.65		
Actuated Cycle Length (s)	50.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	55.1%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

HCM Signalized Intersection Capacity Analysis
8: Anamosa St. & Haines St.

4/27/2010

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	102	160	82	174	155	123	90	858	207	102	691	78
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor	1.00	1.00		1.00	1.00		1.00	0.95		1.00	0.95	
Frt	1.00	0.95		1.00	0.93		1.00	0.97		1.00	0.98	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1770	1768		1770	1739		1770	3436		1770	3485	
Flt Permitted	0.34	1.00		0.36	1.00		0.20	1.00		0.15	1.00	
Satd. Flow (perm)	632	1768		671	1739		379	3436		285	3485	
Peak-hour factor, PHF	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Adj. Flow (vph)	116	182	93	198	176	140	102	975	235	116	785	89
RTOR Reduction (vph)	0	30	0	0	44	0	0	31	0	0	13	0
Lane Group Flow (vph)	116	245	0	198	272	0	102	1179	0	116	861	0
Turn Type	pm+pt			pm+pt			pm+pt			pm+pt		
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases	4			8			2			6		
Actuated Green, G (s)	17.6	14.4		19.2	15.2		31.2	26.7		30.0	26.1	
Effective Green, g (s)	17.6	14.4		19.2	15.2		31.2	26.7		30.0	26.1	
Actuated g/C Ratio	0.27	0.22		0.30	0.23		0.48	0.41		0.46	0.40	
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	4.0		4.0	4.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	227	392		266	407		278	1411		221	1399	
v/s Ratio Prot	0.03	0.14		c0.05	0.16		0.03	c0.34		c0.03	0.25	
v/s Ratio Perm	0.11			c0.17			0.15			0.21		
v/c Ratio	0.51	0.63		0.74	0.67		0.37	0.84		0.52	0.62	
Uniform Delay, d1	19.0	22.9		20.2	22.6		10.2	17.2		12.5	15.5	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	1.9	3.1		10.7	4.1		0.8	6.0		2.2	2.0	
Delay (s)	20.9	26.0		30.9	26.7		11.1	23.2		14.8	17.5	
Level of Service	C	C		C	C		B	C		B	B	
Approach Delay (s)		24.5			28.3			22.2			17.2	
Approach LOS		C			C			C			B	

Intersection Summary			
HCM Average Control Delay	21.9	HCM Level of Service	C
HCM Volume to Capacity ratio	0.68		
Actuated Cycle Length (s)	65.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	72.4%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

HCM Signalized Intersection Capacity Analysis
15: North Street & Haines St.

4/27/2010

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	169	80	55	46	85	31	64	955	56	30	819	97
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor	1.00	1.00	1.00	1.00	0.95		1.00	0.95		1.00	0.95	
Frt	1.00	1.00	0.85	1.00	0.96		1.00	0.99		1.00	0.98	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1770	1863	1583	1770	3398		1770	3510		1770	3483	
Flt Permitted	0.67	1.00	1.00	0.70	1.00		0.16	1.00		0.25	1.00	
Satd. Flow (perm)	1245	1863	1583	1300	3398		306	3510		460	3483	
Peak-hour factor, PHF	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Adj. Flow (vph)	192	91	62	52	97	35	73	1085	64	34	931	110
RTOR Reduction (vph)	0	0	48	0	27	0	0	7	0	0	15	0
Lane Group Flow (vph)	192	91	14	52	105	0	73	1142	0	34	1026	0
Turn Type	Perm		Perm	Perm			pm+pt			Perm		
Protected Phases		4			8		5	2			6	
Permitted Phases	4		4	8			2			6		
Actuated Green, G (s)	11.0	11.0	11.0	11.0	11.0		31.0	31.0		24.1	24.1	
Effective Green, g (s)	11.0	11.0	11.0	11.0	11.0		31.0	31.0		24.1	24.1	
Actuated g/C Ratio	0.22	0.22	0.22	0.22	0.22		0.62	0.62		0.48	0.48	
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	274	410	348	286	748		275	2176		222	1679	
v/s Ratio Prot		0.05			0.03		0.02	c0.33			c0.29	
v/s Ratio Perm	c0.15		0.01	0.04			0.15			0.07		
v/c Ratio	0.70	0.22	0.04	0.18	0.14		0.27	0.52		0.15	0.61	
Uniform Delay, d1	18.0	16.0	15.3	15.8	15.7		5.3	5.4		7.2	9.5	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	7.8	0.3	0.0	0.3	0.1		0.5	0.9		1.5	1.7	
Delay (s)	25.8	16.3	15.4	16.2	15.8		5.8	6.3		8.7	11.2	
Level of Service	C	B	B	B	B		A	A		A	B	
Approach Delay (s)		21.4			15.9			6.2			11.1	
Approach LOS		C			B			A			B	

Intersection Summary			
HCM Average Control Delay	10.6	HCM Level of Service	B
HCM Volume to Capacity ratio	0.65		
Actuated Cycle Length (s)	50.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	57.5%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

HCM Signalized Intersection Capacity Analysis
19: Omaha St. & 5th St.

4/27/2010

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	299	944	177	217	1222	59	118	813	36	97	525	305
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	0.97	0.91		0.97	0.91		1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00	0.98		1.00	0.99		1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	3433	4965		3433	5050		1770	3539	1583	1770	3539	1583
Flt Permitted	0.95	1.00		0.95	1.00		0.29	1.00	1.00	0.19	1.00	1.00
Satd. Flow (perm)	3433	4965		3433	5050		533	3539	1583	355	3539	1583
Peak-hour factor, PHF	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Adj. Flow (vph)	340	1073	201	247	1389	67	134	924	41	110	597	347
RTOR Reduction (vph)	0	39	0	0	8	0	0	0	28	0	0	0
Lane Group Flow (vph)	340	1235	0	247	1448	0	134	924	13	110	597	347
Turn Type	Prot			Prot			pm+pt		Perm	pm+pt		Free
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases							2		2	6		Free
Actuated Green, G (s)	8.0	22.0		7.0	21.0		25.8	21.8	21.8	24.2	21.0	70.0
Effective Green, g (s)	8.0	22.0		7.0	21.0		25.8	21.8	21.8	24.2	21.0	70.0
Actuated g/C Ratio	0.11	0.31		0.10	0.30		0.37	0.31	0.31	0.35	0.30	1.00
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	4.0	4.0	4.0	4.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	392	1560		343	1515		267	1102	493	187	1062	1583
v/s Ratio Prot	c0.10	0.25		0.07	c0.29		c0.03	c0.26		0.03	0.17	
v/s Ratio Perm							0.16		0.01	0.18		c0.22
v/c Ratio	0.87	0.79		0.72	0.96		0.50	0.84	0.03	0.59	0.56	0.22
Uniform Delay, d1	30.5	21.9		30.5	24.0		15.5	22.5	16.7	17.4	20.6	0.0
Progression Factor	0.87	1.84		1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	10.4	1.5		7.3	13.9		1.5	7.7	0.1	4.7	2.2	0.3
Delay (s)	37.0	41.9		37.8	38.0		17.0	30.1	16.8	22.0	22.8	0.3
Level of Service	D	D		D	D		B	C	B	C	C	A
Approach Delay (s)		40.8			38.0			28.0			15.3	
Approach LOS		D			D			C			B	

Intersection Summary			
HCM Average Control Delay	32.4	HCM Level of Service	C
HCM Volume to Capacity ratio	0.82		
Actuated Cycle Length (s)	70.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	74.6%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

HCM Unsignalized Intersection Capacity Analysis
21: North Street & Allen Ave.

4/27/2010

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	18	177	155	103	127	16	50	78	120	6	75	21
Peak Hour Factor	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Hourly flow rate (vph)	20	201	176	117	144	18	57	89	136	7	85	24

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	NB 2	SB 1
Volume Total (vph)	121	277	189	90	145	136	116
Volume Left (vph)	20	0	117	0	57	0	7
Volume Right (vph)	0	176	0	18	0	136	24
Hadj (s)	0.12	-0.41	0.34	-0.11	0.23	-0.67	-0.08
Departure Headway (s)	6.3	5.8	6.6	6.2	6.8	5.9	6.7
Degree Utilization, x	0.21	0.44	0.35	0.16	0.27	0.22	0.21
Capacity (veh/h)	541	598	513	547	500	570	495
Control Delay (s)	9.8	12.0	12.0	9.1	11.1	9.3	11.5
Approach Delay (s)	11.3		11.0		10.2		11.5
Approach LOS	B		B		B		B

Intersection Summary			
Delay	11.0		
HCM Level of Service	B		
Intersection Capacity Utilization	40.9%	ICU Level of Service	A
Analysis Period (min)	15		

HCM Signalized Intersection Capacity Analysis
22: Omaha St. & Mt. Rushmore Rd.

4/27/2010

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	72	1203	355	332	1299	14	347	214	164	53	173	57
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	0.97	0.91	1.00	0.97	0.91		0.97	0.95	1.00	1.00	0.95	1.00
Frt	1.00	1.00	0.85	1.00	1.00		1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	3433	5085	1583	3433	5077		3433	3539	1583	1770	3539	1583
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.60	1.00	1.00
Satd. Flow (perm)	3433	5085	1583	3433	5077		3433	3539	1583	1119	3539	1583
Peak-hour factor, PHF	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Adj. Flow (vph)	82	1367	403	377	1476	16	394	243	186	60	197	65
RTOR Reduction (vph)	0	0	283	0	1	0	0	0	125	0	0	50
Lane Group Flow (vph)	82	1367	120	377	1491	0	394	243	61	60	197	15
Turn Type	Prot		Perm	Prot			Prot		Perm	pm+pt		Perm
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases			4						2	6		6
Actuated Green, G (s)	3.2	20.8	20.8	8.0	25.6		9.0	22.8	22.8	18.6	16.2	16.2
Effective Green, g (s)	3.2	20.8	20.8	8.0	25.6		9.0	22.8	22.8	18.6	16.2	16.2
Actuated g/C Ratio	0.05	0.30	0.30	0.11	0.37		0.13	0.33	0.33	0.27	0.23	0.23
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0	4.0	4.0	4.0	4.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	157	1511	470	392	1857		441	1153	516	320	819	366
v/s Ratio Prot	0.02	c0.27		c0.11	0.29		c0.11	c0.07		0.01	0.06	
v/s Ratio Perm			0.08						0.04	0.04		0.01
v/c Ratio	0.52	0.90	0.25	0.96	0.80		0.89	0.21	0.12	0.19	0.24	0.04
Uniform Delay, d1	32.7	23.6	18.7	30.8	19.9		30.0	17.1	16.5	19.5	21.9	20.9
Progression Factor	1.00	1.00	1.00	0.73	1.45		1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	3.1	8.0	0.3	25.8	1.6		19.9	0.4	0.5	0.3	0.7	0.2
Delay (s)	35.8	31.7	19.0	48.3	30.5		49.9	17.5	17.0	19.8	22.6	21.1
Level of Service	D	C	B	D	C		D	B	B	B	C	C
Approach Delay (s)		29.1			34.1			32.9			21.8	
Approach LOS		C			C			C			C	

Intersection Summary			
HCM Average Control Delay	31.2	HCM Level of Service	C
HCM Volume to Capacity ratio	0.66		
Actuated Cycle Length (s)	70.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	60.7%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

HCM Unsignalized Intersection Capacity Analysis
29: Anamosa St. & West Blvd. (W)

4/27/2010

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	3	51	10	34	59	27	2	2	26	18	10	2
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Hourly flow rate (vph)	3	58	11	39	67	31	2	2	30	20	11	2
Pedestrians												
Lane Width (ft)												
Walking Speed (ft/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (ft)												
pX, platoon unblocked												
vC, conflicting volume	98			69			238	245	64	261	236	82
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	98			69			238	245	64	261	236	82
tC, single (s)	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	100			97			100	100	97	97	98	100
cM capacity (veh/h)	1495			1532			690	639	1001	656	647	977

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	73	136	34	34
Volume Left	3	39	2	20
Volume Right	11	31	30	2
cSH	1495	1532	937	667
Volume to Capacity	0.00	0.03	0.04	0.05
Queue Length 95th (ft)	0	2	3	4
Control Delay (s)	0.4	2.2	9.0	10.7
Lane LOS	A	A	A	B
Approach Delay (s)	0.4	2.2	9.0	10.7
Approach LOS			A	B

Intersection Summary			
Average Delay	3.6		
Intersection Capacity Utilization	27.8%	ICU Level of Service	A
Analysis Period (min)	15		

HCM Unsignalized Intersection Capacity Analysis
27: Anamosa St. & West Blvd. (E)

4/27/2010

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	34	64	8	118	80	40	37	136	93	3	42	38
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Hourly flow rate (vph)	39	73	9	134	91	45	42	155	106	3	48	43
Pedestrians												
Lane Width (ft)												
Walking Speed (ft/s)												
Percent Blockage												
Right turn flare (veh)			2			16						
Median type								None			None	
Median storage veh)												
Upstream signal (ft)												
pX, platoon unblocked												
vC, conflicting volume	436	420	69	409	389	207	91			260		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	436	420	69	409	389	207	91			260		
tC, single (s)	7.1	6.5	6.2	7.1	6.5	6.2	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	91	86	99	72	83	95	97			100		
cM capacity (veh/h)	426	508	994	477	529	833	1504			1304		

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	120	270	302	94
Volume Left	39	134	42	3
Volume Right	9	45	106	43
cSH	519	599	1504	1304
Volume to Capacity	0.23	0.45	0.03	0.00
Queue Length 95th (ft)	22	58	2	0
Control Delay (s)	14.3	16.6	1.3	0.3
Lane LOS	B	C	A	A
Approach Delay (s)	14.3	16.6	1.3	0.3
Approach LOS	B	C		

Intersection Summary			
Average Delay	8.4		
Intersection Capacity Utilization	45.6%	ICU Level of Service	A
Analysis Period (min)	15		

HCM Unsignalized Intersection Capacity Analysis
32: Boegel St. & Silver St.

4/27/2010

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	2	35	2	22	75	26	1	6	8	29	5	3
Peak Hour Factor	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Hourly flow rate (vph)	2	40	2	25	85	30	1	7	9	33	6	3

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total (vph)	44	140	17	42
Volume Left (vph)	2	25	1	33
Volume Right (vph)	2	30	9	3
Hadj (s)	0.01	-0.06	-0.27	0.14
Departure Headway (s)	4.2	4.0	4.1	4.5
Degree Utilization, x	0.05	0.16	0.02	0.05
Capacity (veh/h)	838	878	835	772
Control Delay (s)	7.4	7.8	7.1	7.7
Approach Delay (s)	7.4	7.8	7.1	7.7
Approach LOS	A	A	A	A

Intersection Summary			
Delay	7.6		
HCM Level of Service	A		
Intersection Capacity Utilization	28.8%	ICU Level of Service	A
Analysis Period (min)	15		

HCM Unsignalized Intersection Capacity Analysis
24: North Street & West Blvd.

6/21/2010

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	11	88	0	210	14	39	83	160	157	33	0	110
Peak Hour Factor	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Hourly flow rate (vph)	12	100	0	239	16	44	94	182	178	38	0	125

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	NB 2	SB 1
Volume Total (vph)	46	67	239	60	276	178	163
Volume Left (vph)	13	0	239	0	94	0	38
Volume Right (vph)	0	0	0	44	0	178	125
Hadj (s)	0.17	0.03	0.53	-0.48	0.20	-0.67	-0.38
Departure Headway (s)	6.9	6.8	6.9	5.9	6.3	5.4	6.0
Degree Utilization, x	0.09	0.13	0.46	0.10	0.48	0.27	0.27
Capacity (veh/h)	474	485	494	571	546	639	558
Control Delay (s)	9.4	9.6	14.5	8.3	13.7	9.1	11.3
Approach Delay (s)	9.5		13.2		11.9		11.3
Approach LOS	A		B		B		B

Intersection Summary			
Delay	11.9		
HCM Level of Service	B		
Intersection Capacity Utilization	49.9%	ICU Level of Service	A
Analysis Period (min)	15		

HCM Signalized Intersection Capacity Analysis
18: Omaha St. & West Blvd.

4/27/2010

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	406	1186	102	202	1235	266	74	595	153	291	476	321
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	0.97	0.91	1.00	0.97	0.91	1.00	1.00	0.95	1.00	0.97	0.95	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	3433	5085	1583	3433	5085	1583	1770	3539	1583	3433	3539	1583
Flt Permitted	0.95	1.00	1.00	0.95	1.00	1.00	0.38	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)	3433	5085	1583	3433	5085	1583	703	3539	1583	3433	3539	1583
Peak-hour factor, PHF	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Adj. Flow (vph)	461	1348	116	230	1403	302	84	676	174	331	541	365
RTOR Reduction (vph)	0	0	0	0	0	0	0	0	0	0	0	0
Lane Group Flow (vph)	461	1348	116	230	1403	302	84	676	174	331	541	365
Turn Type	Prot		Free	Prot		Free	pm+pt		Free	Prot		Free
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases			Free			Free	2		Free			Free
Actuated Green, G (s)	11.0	26.0	75.0	7.0	22.0	75.0	22.8	18.0	75.0	8.0	21.2	75.0
Effective Green, g (s)	11.0	26.0	75.0	7.0	22.0	75.0	22.8	18.0	75.0	8.0	21.2	75.0
Actuated g/C Ratio	0.15	0.35	1.00	0.09	0.29	1.00	0.30	0.24	1.00	0.11	0.28	1.00
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	4.0		4.0	4.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	504	1763	1583	320	1492	1583	282	849	1583	366	1000	1583
v/s Ratio Prot	c0.13	c0.27		0.07	c0.28		0.02	c0.19		c0.10	0.15	
v/s Ratio Perm			0.07			0.19	0.07		0.11			c0.23
v/c Ratio	0.91	0.76	0.07	0.72	0.94	0.19	0.30	0.80	0.11	0.90	0.54	0.23
Uniform Delay, d1	31.5	21.8	0.0	33.0	25.9	0.0	19.1	26.8	0.0	33.1	22.8	0.0
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	21.1	2.0	0.1	7.5	11.9	0.3	0.6	7.6	0.1	24.8	2.1	0.3
Delay (s)	52.7	23.8	0.1	40.6	37.8	0.3	19.7	34.4	0.1	57.9	24.9	0.3
Level of Service	D	C	A	D	D	A	B	C	A	E	C	A
Approach Delay (s)		29.3			32.2			26.7			26.5	
Approach LOS		C			C			C			C	

Intersection Summary			
HCM Average Control Delay	29.3	HCM Level of Service	C
HCM Volume to Capacity ratio	0.92		
Actuated Cycle Length (s)	75.0	Sum of lost time (s)	20.0
Intersection Capacity Utilization	73.5%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

HCM Signalized Intersection Capacity Analysis
3: Disk Drive & Haines St.

4/27/2010

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	1	10	51	35	1	17	41	406	204	21	702	6
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0	4.0	4.0	4.0	
Lane Util. Factor	1.00	1.00	1.00	0.97	1.00		1.00	0.95	1.00	1.00	0.95	
Frt	1.00	1.00	0.85	1.00	0.86		1.00	1.00	0.85	1.00	1.00	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1770	1863	1583	3433	1597		1770	3539	1583	1770	3535	
Flt Permitted	0.98	1.00	1.00	0.49	1.00		0.29	1.00	1.00	0.49	1.00	
Satd. Flow (perm)	1817	1863	1583	1785	1597		534	3539	1583	907	3535	
Peak-hour factor, PHF	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Adj. Flow (vph)	1	11	58	40	1	19	47	461	232	24	798	7
RTOR Reduction (vph)	0	0	54	0	16	0	0	0	89	0	1	0
Lane Group Flow (vph)	1	11	4	40	4	0	47	461	143	24	804	0
Turn Type	Perm		Perm	pm+pt			pm+pt		Perm	pm+pt		
Protected Phases		4		3	8		5	2		1	6	
Permitted Phases	4		4	8			2		2	6		
Actuated Green, G (s)	4.1	4.1	4.1	9.7	9.7		40.9	37.0	37.0	35.7	34.4	
Effective Green, g (s)	4.1	4.1	4.1	9.7	9.7		40.9	37.0	37.0	35.7	34.4	
Actuated g/C Ratio	0.07	0.07	0.07	0.16	0.16		0.68	0.62	0.62	0.60	0.57	
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0	4.0	4.0	4.0	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	124	127	108	333	258		444	2182	976	558	2027	
v/s Ratio Prot		0.01		c0.00	0.00		c0.01	0.13		0.00	c0.23	
v/s Ratio Perm	0.00		0.00	c0.02			0.07		0.09	0.02		
v/c Ratio	0.01	0.09	0.04	0.12	0.02		0.11	0.21	0.15	0.04	0.40	
Uniform Delay, d1	26.1	26.2	26.1	21.5	21.1		3.5	5.1	4.8	5.0	7.1	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	
Incremental Delay, d2	0.0	0.3	0.1	0.2	0.0		0.1	0.2	0.3	0.0	0.6	
Delay (s)	26.1	26.5	26.2	21.6	21.2		3.6	5.3	5.2	5.0	7.7	
Level of Service	C	C	C	C	C		A	A	A	A	A	
Approach Delay (s)		26.3			21.5			5.1			7.6	
Approach LOS		C			C			A			A	

Intersection Summary			
HCM Average Control Delay	7.8	HCM Level of Service	A
HCM Volume to Capacity ratio	0.34		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	16.0
Intersection Capacity Utilization	40.6%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

HCM Signalized Intersection Capacity Analysis
3: Disk Drive & Haines St.

4/27/2010

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	6	28	86	438	28	78	155	931	326	56	593	13
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0	4.0	4.0	4.0	
Lane Util. Factor	1.00	1.00	1.00	0.97	1.00		1.00	0.95	1.00	1.00	0.95	
Frt	1.00	1.00	0.85	1.00	0.89		1.00	1.00	0.85	1.00	1.00	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1770	1863	1583	3433	1657		1770	3539	1583	1770	3528	
Flt Permitted	0.70	1.00	1.00	0.43	1.00		0.30	1.00	1.00	0.20	1.00	
Satd. Flow (perm)	1307	1863	1583	1564	1657		555	3539	1583	377	3528	
Peak-hour factor, PHF	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Adj. Flow (vph)	7	32	98	498	32	89	176	1058	370	64	674	15
RTOR Reduction (vph)	0	0	89	0	68	0	0	0	186	0	2	0
Lane Group Flow (vph)	7	32	9	498	53	0	176	1058	184	64	687	0
Turn Type	Perm		Perm	pm+pt			pm+pt		Perm	pm+pt		
Protected Phases		4		3	8		5	2		1	6	
Permitted Phases	4		4	8			2		2	6		
Actuated Green, G (s)	5.7	5.7	5.7	14.0	14.0		36.7	29.8	29.8	31.3	27.1	
Effective Green, g (s)	5.7	5.7	5.7	14.0	14.0		36.7	29.8	29.8	31.3	27.1	
Actuated g/C Ratio	0.10	0.10	0.10	0.23	0.23		0.61	0.50	0.50	0.52	0.45	
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0	4.0	4.0	4.0	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	124	177	150	499	387		479	1758	786	294	1593	
v/s Ratio Prot		0.02		c0.07	0.03		c0.04	c0.30		0.02	0.19	
v/s Ratio Perm	0.01		0.01	c0.16			0.18		0.12	0.10		
v/c Ratio	0.06	0.18	0.06	1.00	0.14		0.37	0.60	0.23	0.22	0.43	
Uniform Delay, d1	24.7	25.0	24.7	22.7	18.2		5.6	10.8	8.6	7.6	11.2	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	
Incremental Delay, d2	0.2	0.5	0.2	39.5	0.2		0.5	1.5	0.7	0.4	0.9	
Delay (s)	24.9	25.5	24.9	62.2	18.4		6.0	12.4	9.3	7.9	12.1	
Level of Service	C	C	C	E	B		A	B	A	A	B	
Approach Delay (s)		25.0			53.6			11.0			11.7	
Approach LOS		C			D			B			B	

Intersection Summary			
HCM Average Control Delay	20.2	HCM Level of Service	C
HCM Volume to Capacity ratio	0.70		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	58.2%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			