Highway Capacity Analysis, Calumet Avenue and 101st Avenue

Future Conditions (Traffic Signal with right turn lane) AM

APPENDIX 12

HCS+: Signalized Intersections Release 5.4

Analyst:
Agency:
Date: 2/13/2016
Period: AM Peak
Project ID: Existing conditions with future traffic with right turn lane
E/W St: 101st

Inter.:
Area Type: All other areas
Jurisd:
Year :
N/S St:

SIGNALIZED INTERSECTION SUMMARY

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
No. Lanes	0	1	0	0	1	0	0	1	0	0	0	0
LGConfig		TR			LT			LTR				
Volume		58	235	2	306		741	0	3			
Lane Width		12.0			12.0			12.0				
RTOR Vol			0						0			

Duration 0.25 Area Type: All other areas

Signal Operations

Phase Combination	1	2	3	4			5	6	7	8
EB Left					NB	Left	A			
Thru	A					Thru	A			
Right	A					Right	A			
Peds						Peds				
WB Left	A				SB	Left				
Thru	A					Thru				
Right						Right				
Peds						Peds				
NB Right					EB	Right	A			
SB Right					WB	Right				
Green	25.0						45.0			
Yellow	4.0						4.0			
All Red	1.0						1.0			

Cycle Length: 80.0 secs

Intersection Performance Summary

Appr/ Lane Grp	Lane Group Capacity	Adj Sat Flow Rate (s)	Ratios v/c	Ratios g/C	Lane Group Delay	Lane Group LOS	Approach Delay	Approach LOS
Eastbound								
TR	519	1662	0.73	0.31	29.6	C	29.6	C
Westbound								
LT	579	1854	0.58	0.31	24.6	C	24.6	C
Northbound								
LTR	997	1772	0.77	0.56	17.4	B	17.4	B
Southbound								

Intersection Delay = 22.2 (sec/veh) Intersection LOS = C

Phone: Fax:
E-Mail:

OPERATIONAL ANALYSIS

Analyst:
Agency/Co.:
Date Performed: 2/13/2016
Analysis Time Period: AM Peak
Intersection:
Area Type: All other areas
Jurisdiction:
Analysis Year:
Project ID: Existing conditions with future traffic with right turn lane
E/W St: 101st N/S St:

VOLUME DATA

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Volume		58	235	2	306		741	0	3			
% Heavy Veh		2	2	2	2		2	2	2			
PHF		0.75	0.78	0.50	0.92		0.97	0.92	0.38			
PK 15 Vol		19	75	1	83		191	0	2			
Hi Ln Vol												
% Grade		0			0			0				
Ideal Sat		1900			1900			1900				
ParkExist												
NumPark												
No. Lanes	0	1	0	0	1	0	0	1	0	0	0	0
LGConfig		TR			LT			LTR				
Lane Width		12.0			12.0			12.0				
RTOR Vol			0						0			
Adj Flow		378			337			772				
%InSharedLn												
Prop LTs		0.000			0.012			0.990				
Prop RTs	0.796			0.000			0.010					
Peds Bikes	0						0			0		
Buses		0			0			0				
%InProtPhase												

Duration 0.25 Area Type: All other areas

OPERATING PARAMETERS

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Init Unmet		0.0			0.0			0.0				
Arriv. Type		3			3			3				
Unit Ext.		3.0			3.0			3.0				
I Factor		1.000			1.000			1.000				
Lost Time		2.0			2.0			2.0				
Ext of g		2.0			2.0			2.0				
Ped Min g		3.2						3.2			3.2	

PHASE DATA

Phase Combination		1	2	3	4	5	6	7	8
EB	Left								
	Thru	A							
	Right	A							
	Peds								
WB	Left	A							
	Thru	A							
	Right								
	Peds								
NB	Right								
SB	Right								
NB	Left					A			
	Thru					A			
	Right					A			
	Peds								
SB	Left								
	Thru								
	Right								
	Peds								
EB	Right					A			
WB	Right								
Green		25.0				45.0			
Yellow		4.0				4.0			
All Red		1.0				1.0			

Cycle Length: 80.0 secs

VOLUME ADJUSTMENT AND SATURATION FLOW WORKSHEET

Volume Adjustment

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Volume, V		58	235	2	306		741	0	3			
PHF		0.75	0.78	0.50	0.92		0.97	0.92	0.38			
Adj flow		77	301	4	333		764	0	8			
No. Lanes	0	1	0	0	1	0	0	1	0	0	0	0
Lane group		TR			LT			LTR				
Adj flow		378			337			772				
Prop LTs		0.000			0.012			0.990				
Prop RTs	0.796			0.000			0.010					

Saturation Flow Rate (see Exhibit 16-7 to determine the adjustment factors)

	Eastbound			Westbound			Northbound			Southbound		
LG	TR			LT			LTR					
So	1900			1900			1900					
Lanes 0	1	0	0	1	0	0	1	0	0	0	0	
fW	1.000			1.000			1.000					
fHV	0.980			0.980			0.980					
fG	1.000			1.000			1.000					
fP	1.000			1.000			1.000					
fBB	1.000			1.000			1.000					
fA	1.000			1.000			1.000					
fLU	1.000			1.000			1.000					
fRT	0.892			1.000			0.999					
fLT	1.000			0.995			0.953					
Sec.												
fLpb	1.000			1.000			1.000					
fRpb	1.000			1.000			1.000					
S	1662			1854			1772					
Sec.												

CAPACITY AND LOS WORKSHEET

Capacity Analysis and Lane Group Capacity

Appr/ Mvmt	Lane Group	Adj Flow Rate (v)	Adj Sat Flow Rate (s)	Flow Ratio (v/s)	Green Ratio (g/C)	--Lane Group-- Capacity (c)	v/c Ratio
Eastbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru	TR	378	1662	# 0.23	0.31	519	0.73
Right							
Westbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru	LT	337	1854	0.18	0.31	579	0.58
Right							
Northbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru	LTR	772	1772	# 0.44	0.56	997	0.77
Right							
Southbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru							
Right							

Sum of flow ratios for critical lane groups, Yc = Sum (v/s) = 0.66
Total lost time per cycle, L = 10.00 sec
Critical flow rate to capacity ratio, Xc = (Yc)(C)/(C-L) = 0.76

Control Delay and LOS Determination

Appr/ Lane Grp	Ratios v/c	Ratios g/C	Unf Del d1	Prog Adj Fact	Lane Grp Cap	Incremental Factor k	Incremental Del d2	Res Del d3	Lane Group Delay	Lane Group LOS	Approach Delay	Approach LOS
Eastbound												
TR	0.73	0.31	24.5	1.000	519	0.29	5.1	0.0	29.6	C	29.6	C
Westbound												
LT	0.58	0.31	23.1	1.000	579	0.17	1.5	0.0	24.6	C	24.6	C
Northbound												
LTR	0.77	0.56	13.6	1.000	997	0.32	3.9	0.0	17.4	B	17.4	B
Southbound												

Intersection delay = 22.2 (sec/veh) Intersection LOS = C

SUPPLEMENTAL PERMITTED LT WORKSHEET
for exclusive lefts

Input

		EB	WB	NB	SB
Opposed by Single(S) or Multiple(M) lane approach					
Cycle length, C	80.0 sec				
Total actual green time for LT lane group, G (s)					
Effective permitted green time for LT lane group, g(s)					
Opposing effective green time, go (s)					
Number of lanes in LT lane group, N					
Number of lanes in opposing approach, No					
Adjusted LT flow rate, VLT (veh/h)					
Proportion of LT in LT lane group, PLT					
Proportion of LT in opposing flow, PLTo					
Adjusted opposing flow rate, Vo (veh/h)					
Lost time for LT lane group, tL					
Computation					
LT volume per cycle, LTC=VLTC/3600					
Opposing lane util. factor, fLUo		1.000	1.000		1.000
Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)					
gf=G[exp(- a * (LTC ** b))]-tl, gf<=g					
Opposing platoon ratio, Rpo (refer Exhibit 16-11)					
Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]					
gq, (see Exhibit C16-4,5,6,7,8)					
gu=g-gq if gq>=gf, or = g-gf if gq<gf					
n=Max(gq-gf)/2,0)					
PTHo=1-PLTo					
PL*=PLT[1+(N-1)g/(gf+gu/EL1+4.24)]					
EL1 (refer to Exhibit C16-3)					
EL2=Max((1-Ptho**n)/Plto, 1.0)					
fmin=2(1+PL)/g or fmin=2(1+Pl)/g					
gdiff=max(gq-gf,0)					
fm=[gf/g]+[gu/g]/[1+PL(EL1-1)], (min=fmin;max=1.00)					
flt=fm=[gf/g]+[gu/g]/[1+PL(EL1-1)]+[gdiff/g]/[1+PL(EL2-1)],(fmin<=fm<=1.00)					
or flt=[fm+0.91(N-1)]/N**					
Left-turn adjustment, fLT					

For special case of single-lane approach opposed by multilane approach, see text.

* If Pl>=1 for shared left-turn lanes with N>1, then assume de-facto left-turn lane and redo calculations.

** For permitted left-turns with multiple exclusive left-turn lanes, flt=fm.

For special case of multilane approach opposed by single-lane approach or when gf>gq, see text.

SUPPLEMENTAL PERMITTED LT WORKSHEET
for shared lefts

Input

		EB	WB	NB	SB
Opposed by Single(S) or Multiple(M) lane approach					
Cycle length, C	80.0 sec				
Total actual green time for LT lane group, G (s)			25.0		
Effective permitted green time for LT lane group, g(s)			25.0		
Opposing effective green time, go (s)			25.0		
Number of lanes in LT lane group, N			1		

Number of lanes in opposing approach, No		1		
Adjusted LT flow rate, VLT (veh/h)		4		
Proportion of LT in LT lane group, PLT	0.000	0.012	0.990	
Proportion of LT in opposing flow, PLTo		0.00		
Adjusted opposing flow rate, Vo (veh/h)		378		
Lost time for LT lane group, tL		5.00		
Computation				
LT volume per cycle, LTC=VLTC/3600		0.09		
Opposing lane util. factor, fLUo	1.000	1.000		1.000
Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)		8.40		
gf=G[exp(- a * (LTC ** b))]-tl, gf<=g		15.7		
Opposing platoon ratio, Rpo (refer Exhibit 16-11)		1.00		
Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]		0.69		
gq, (see Exhibit C16-4,5,6,7,8)		11.81		
gu=g-gq if gq>=gf, or = g-gf if gq<gf		9.28		
n=Max(gq-gf)/2,0)		0.00		
PTHo=1-PLTo		1.00		
PL*=PLT[1+(N-1)g/(gf+gu/EL1+4.24)]		0.01		
EL1 (refer to Exhibit C16-3)		2.04		
EL2=Max((1-Ptho**n)/Plto, 1.0)				
fmin=2(1+PL)/g or fmin=2(1+Pl)/g		0.08		
gdiff=max(gq-gf,0)		0.00		
fm=[gf/g]+[gu/g]/[1+PL(EL1-1)], (min=fmin;max=1.00)		1.00		
flt=fm=[gf/g]+[gu/g]/[1+PL(EL1-1)]+[gdiff/g]/[1+PL(EL2-1)], (fmin<=fm<=1.00)				
or flt=[fm+0.91(N-1)]/N**				
Left-turn adjustment, fLT		0.995		

For special case of single-lane approach opposed by multilane approach, see text.

* If Pl>=1 for shared left-turn lanes with N>1, then assume de-facto left-turn lane and redo calculations.

** For permitted left-turns with multiple exclusive left-turn lanes, flt=fm.

For special case of multilane approach opposed by single-lane approach or when gf>gq, see text.

SUPPLEMENTAL PEDESTRIAN-BICYCLE EFFECTS WORKSHEET

Permitted Left Turns	EB	WB	NB	SB
Effective pedestrian green time, gp (s)				
Conflicting pedestrian volume, Vped (p/h)				
Pedestrian flow rate, Vpedg (p/h)				
OCCpedg				
Opposing queue clearing green, gq (s)				
Eff. ped. green consumed by opp. veh. queue, gq/gp				
OCCpedu				
Opposing flow rate, Vo (veh/h)				
OCCr				
Number of cross-street receiving lanes, Nrec				
Number of turning lanes, Nturn				
ApbT				
Proportion of left turns, PLT				
Proportion of left turns using protected phase, PLTA				
Left-turn adjustment, fLpb				
Permitted Right Turns				
Effective pedestrian green time, gp (s)				
Conflicting pedestrian volume, Vped (p/h)				
Conflicting bicycle volume, Vbic (bicycles/h)				
Vpedg				
OCCpedg				
Effective green, g (s)				
Vbicg				

OCCbicg
OCCr
Number of cross-street receiving lanes, Nrec
Number of turning lanes, Nturn
ApbT
Proportion right-turns, PRT
Proportion right-turns using protected phase, PRTA
Right turn adjustment, fRpb

SUPPLEMENTAL UNIFORM DELAY WORKSHEET

			EBLT	WBLT	NBLT	SBLT
Cycle length, C	80.0	sec				
Adj. LT vol from Vol Adjustment Worksheet, v						
v/c ratio from Capacity Worksheet, X						
Protected phase effective green interval, g (s)						
Opposing queue effective green interval, gq						
Unopposed green interval, gu						
Red time r=(C-g-gq-gu)						
Arrival rate, qa=v/(3600(max[X,1.0]))						
Protected ph. departure rate, Sp=s/3600						
Permitted ph. departure rate, Ss=s(gq+gu)/(gu*3600)						
XPerm						
XProt						
Case						
Queue at beginning of green arrow, Qa						
Queue at beginning of unsaturated green, Qu						
Residual queue, Qr						
Uniform Delay, d1						

DELAY/LOS WORKSHEET WITH INITIAL QUEUE

Appr/ Lane Group	Initial Unmet Demand Q veh	Dur. Unmet Demand t hrs.	Uniform Delay Unadj. ds	Uniform Delay Adj. d1 sec	Initial Queue Param. u	Final Unmet Demand Q veh	Initial Queue Delay d3 sec	Lane Group Delay d sec
Eastbound								
	0.0						0.0	
TR	0.0	0.00	27.5	24.5	0.00	0.0	0.0	29.6
	0.0						0.0	
Westbound								
	0.0						0.0	
LT	0.0	0.00	27.5	23.1	0.00	0.0	0.0	24.6
	0.0						0.0	
Northbound								
	0.0						0.0	
LTR	0.0	0.00	17.5	13.6	0.00	0.0	0.0	17.4
	0.0						0.0	
Southbound								
	0.0						0.0	
	0.0						0.0	
	0.0						0.0	

Intersection Delay 22.2 sec/veh Intersection LOS C

BACK OF QUEUE WORKSHEET

	Eastbound	Westbound	Northbound	Southbound
LaneGroup	TR	LT	LTR	
Init Queue	0.0	0.0	0.0	
Flow Rate	378	337	772	
So	1900	1900	1900	
No.Lanes	0 1 0	0 1 0	0 1 0	0 0 0
SL	1662	1854	1772	
LnCapacity	519	579	997	
Flow Ratio	0.2	0.2	0.4	
v/c Ratio	0.73	0.58	0.77	
Grn Ratio	0.31	0.31	0.56	
I Factor	1.000	1.000	1.000	
AT or PVG	3	3	3	
Pltn Ratio	1.00	1.00	1.00	
PF2	1.00	1.00	1.00	
Q1	7.5	6.3	13.3	
kB	0.4	0.5	0.6	
Q2	1.1	0.6	2.1	
Q Average	8.6	6.9	15.3	
Q Spacing	25.0	25.0	25.0	
Q Storage	0	0	0	
Q S Ratio				
70th Percentile Output:				
fB%	1.2	1.2	1.2	
BOQ	10.1	8.2	17.9	
QSRatio				
85th Percentile Output:				
fB%	1.5	1.5	1.5	
BOQ	13.1	10.7	22.7	
QSRatio				
90th Percentile Output:				
fB%	1.7	1.7	1.6	
BOQ	14.2	11.7	24.3	
QSRatio				
95th Percentile Output:				
fB%	1.9	1.9	1.8	
BOQ	16.1	13.2	26.9	
QSRatio				
98th Percentile Output:				
fB%	2.2	2.3	2.0	
BOQ	19.0	15.8	30.8	
QSRatio				

ERROR MESSAGES

East bound right is shared but does not move with the adjacent movement.

Highway Capacity Analysis: Calumet Avenue and 101st Avenue, Future Conditions (Traffic Signal with right turn lane) PM

APPENDIX 13

HCS+: Signalized Intersections Release 5.4

Analyst:
Agency:
Date: 2/13/2016
Period: PM Peak
Project ID: Existing conditions with future traffic with turn lane
E/W St: 101st

Inter.:
Area Type: All other areas
Jurisd:
Year :
N/S St:

SIGNALIZED INTERSECTION SUMMARY

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
No. Lanes	0	1	1	0	1	0	0	1	0	0	0	0
LGConfig		T	R		LT			LTR				
Volume		295	712	4	147		311	0	3			
Lane Width		12.0	12.0		12.0			12.0				
RTOR Vol			0						0			

Duration 0.25 Area Type: All other areas

Signal Operations

Phase Combination	1	2	3	4		5	6	7	8
EB Left					NB Left	A			
Thru	A				Thru	A			
Right	A				Right	A			
Peds					Peds				
WB Left	A				SB Left				
Thru	A				Thru				
Right					Right				
Peds					Peds				
NB Right					EB Right				
SB Right					WB Right				
Green	32.0					18.0			
Yellow	4.0					4.0			
All Red	1.0					1.0			

Cycle Length: 60.0 secs

Intersection Performance Summary

Appr/ Lane Grp	Lane Group Capacity	Adj Sat Flow Rate (s)	Ratios v/c	Ratios g/C	Lane Group Delay	Lane Group LOS	Approach Delay	Approach LOS
Eastbound								
T	994	1863	0.35	0.53	8.2	A	17.5	B
R	844	1583	0.87	0.53	21.9	C		
Westbound								
LT	981	1839	0.20	0.53	7.4	A	7.4	A
Northbound								
LTR	532	1772	0.71	0.30	23.2	C	23.2	C
Southbound								

Intersection Delay = 17.6 (sec/veh) Intersection LOS = B

Phone: Fax:
E-Mail:

OPERATIONAL ANALYSIS

Analyst:
Agency/Co.:
Date Performed: 2/13/2016
Analysis Time Period: PM Peak
Intersection:
Area Type: All other areas
Jurisdiction:
Analysis Year:
Project ID: Existing conditions with future traffic with turn lane
E/W St: 101st N/S St:

VOLUME DATA

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Volume		295	712	4	147		311	0	3			
% Heavy Veh		2	2	2	2		2	2	2			
PHF		0.86	0.97	0.50	0.76		0.83	0.92	0.75			
PK 15 Vol		86	184	2	48		94	0	1			
Hi Ln Vol												
% Grade		0			0			0				
Ideal Sat		1900	1900		1900			1900				
ParkExist												
NumPark												
No. Lanes	0	1	1	0	1	0	0	1	0	0	0	0
LGConfig		T	R		LT			LTR				
Lane Width		12.0	12.0		12.0			12.0				
RTOR Vol			0						0			
Adj Flow		343	734		201			379				
%InSharedLn												
Prop LTs		0.000			0.040			0.989				
Prop RTs	0.000		1.000	0.000			0.011					
Peds Bikes	0						0			0		
Buses		0	0		0			0				
%InProtPhase												

Duration 0.25 Area Type: All other areas

OPERATING PARAMETERS

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Init Unmet		0.0	0.0		0.0			0.0				
Arriv. Type		3	3		3			3				
Unit Ext.		3.0	3.0		3.0			3.0				
I Factor		1.000			1.000			1.000				
Lost Time		2.0	2.0		2.0			2.0				
Ext of g		2.0	2.0		2.0			2.0				
Ped Min g		3.2						3.2			3.2	

PHASE DATA

Phase Combination		1	2	3	4	5	6	7	8
EB	Left								
	Thru	A							
	Right	A							
	Peds								
WB	Left	A							
	Thru	A							
	Right								
	Peds								
NB	Right								
SB	Right								
NB	Left					A			
	Thru					A			
	Right					A			
	Peds								
SB	Left								
	Thru								
	Right								
	Peds								
EB	Right								
WB	Right								
Green		32.0				18.0			
Yellow		4.0				4.0			
All Red		1.0				1.0			

Cycle Length: 60.0 secs

VOLUME ADJUSTMENT AND SATURATION FLOW WORKSHEET

Volume Adjustment

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Volume, V		295	712	4	147		311	0	3			
PHF		0.86	0.97	0.50	0.76		0.83	0.92	0.75			
Adj flow		343	734	8	193		375	0	4			
No. Lanes	0	1	1	0	1	0	0	1	0	0	0	0
Lane group		T	R		LT			LTR				
Adj flow		343	734		201			379				
Prop LTs		0.000			0.040			0.989				
Prop RTs	0.000	1.000		0.000			0.011					

Saturation Flow Rate (see Exhibit 16-7 to determine the adjustment factors)

	Eastbound			Westbound			Northbound			Southbound		
LG	T	R		LT			LTR					
So	1900	1900		1900			1900					
Lanes 0	1	1	0	1	0	0	1	0	0	0	0	
fW	1.000	1.000		1.000			1.000					
fHV	0.980	0.980		0.980			0.980					
fG	1.000	1.000		1.000			1.000					
fP	1.000	1.000		1.000			1.000					
fBB	1.000	1.000		1.000			1.000					
fA	1.000	1.000		1.000			1.000					
fLU	1.000	1.000		1.000			1.000					
fRT	1.000	0.850		1.000			0.999					
fLT	1.000			0.987			0.953					
Sec.												
fLpb	1.000			1.000			1.000					
fRpb	1.000	1.000		1.000			1.000					
S	1863	1583		1839			1772					
Sec.												

CAPACITY AND LOS WORKSHEET

Capacity Analysis and Lane Group Capacity

Appr/ Mvmt	Lane Group	Adj Flow Rate (v)	Adj Sat Flow Rate (s)	Flow Ratio (v/s)	Green Ratio (g/C)	--Lane Group-- Capacity (c)	v/c Ratio
Eastbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru	T	343	1863	0.18	0.53	994	0.35
Right	R	734	1583	# 0.46	0.53	844	0.87
Westbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru	LT	201	1839	0.11	0.53	981	0.20
Right							
Northbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru	LTR	379	1772	# 0.21	0.30	532	0.71
Right							
Southbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru							
Right							

Sum of flow ratios for critical lane groups, Yc = Sum (v/s) = 0.68
Total lost time per cycle, L = 10.00 sec
Critical flow rate to capacity ratio, Xc = (Yc)(C)/(C-L) = 0.81

Control Delay and LOS Determination

Appr/ Lane Grp	Ratios v/c	Ratios g/C	Unf Del d1	Prog Adj Fact	Lane Grp Cap	Incremental Factor k	Incremental Del d2	Res Del d3	Lane Group Delay	Lane Group LOS	Approach Delay	Approach LOS
Eastbound												
T	0.35	0.53	8.0	1.000	994	0.11	0.2	0.0	8.2	A	17.5	B
R	0.87	0.53	12.2	1.000	844	0.40	9.7	0.0	21.9	C		
Westbound												
LT	0.20	0.53	7.3	1.000	981	0.11	0.1	0.0	7.4	A	7.4	A
Northbound												
LTR	0.71	0.30	18.7	1.000	532	0.28	4.5	0.0	23.2	C	23.2	C
Southbound												

Intersection delay = 17.6 (sec/veh) Intersection LOS = B

SUPPLEMENTAL PERMITTED LT WORKSHEET
for exclusive lefts

Input		EB	WB	NB	SB
Opposed by Single(S) or Multiple(M) lane approach					
Cycle length, C	60.0 sec				
Total actual green time for LT lane group, G (s)					
Effective permitted green time for LT lane group, g(s)					
Opposing effective green time, go (s)					
Number of lanes in LT lane group, N					
Number of lanes in opposing approach, No					
Adjusted LT flow rate, VLT (veh/h)					
Proportion of LT in LT lane group, PLT					
Proportion of LT in opposing flow, PLTo					
Adjusted opposing flow rate, Vo (veh/h)					
Lost time for LT lane group, tL					
Computation					
LT volume per cycle, LTC=VLTC/3600					
Opposing lane util. factor, fLUo		1.000	1.000		1.000
Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)					
gf=G[exp(- a * (LTC ** b))]-tl, gf<=g					
Opposing platoon ratio, Rpo (refer Exhibit 16-11)					
Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]					
gq, (see Exhibit C16-4,5,6,7,8)					
gu=g-gq if gq>=gf, or = g-gf if gq<gf					
n=Max(gq-gf)/2,0)					
PTHo=1-PLTo					
PL*=PLT[1+(N-1)g/(gf+gu/EL1+4.24)]					
EL1 (refer to Exhibit C16-3)					
EL2=Max((1-Ptho**n)/Plto, 1.0)					
fmin=2(1+PL)/g or fmin=2(1+Pl)/g					
gdiff=max(gq-gf,0)					
fm=[gf/g]+[gu/g]/[1+PL(EL1-1)], (min=fmin;max=1.00)					
flt=fm=[gf/g]+[gu/g]/[1+PL(EL1-1)]+[gdiff/g]/[1+PL(EL2-1)],(fmin<=fm<=1.00)					
or flt=[fm+0.91(N-1)]/N**					
Left-turn adjustment, fLT					

For special case of single-lane approach opposed by multilane approach, see text.
* If Pl>=1 for shared left-turn lanes with N>1, then assume de-facto left-turn lane and redo calculations.
** For permitted left-turns with multiple exclusive left-turn lanes, flt=fm.
For special case of multilane approach opposed by single-lane approach or when gf>gq, see text.

SUPPLEMENTAL PERMITTED LT WORKSHEET
for shared lefts

Input		EB	WB	NB	SB
Opposed by Single(S) or Multiple(M) lane approach					
Cycle length, C	60.0 sec				
Total actual green time for LT lane group, G (s)			32.0		
Effective permitted green time for LT lane group, g(s)			32.0		
Opposing effective green time, go (s)			32.0		
Number of lanes in LT lane group, N			1		

Number of lanes in opposing approach, No		1		
Adjusted LT flow rate, VLT (veh/h)		8		
Proportion of LT in LT lane group, PLT	0.000	0.040	0.989	
Proportion of LT in opposing flow, PLTo		0.00		
Adjusted opposing flow rate, Vo (veh/h)		343		
Lost time for LT lane group, tL		5.00		
Computation				
LT volume per cycle, LTC=VLTC/3600		0.13		
Opposing lane util. factor, fLUo	1.000	1.000		1.000
Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)		5.72		
gf=G[exp(- a * (LTC ** b))]-tl, gf<=g		21.0		
Opposing platoon ratio, Rpo (refer Exhibit 16-11)		1.00		
Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]		0.47		
gq, (see Exhibit C16-4,5,6,7,8)		3.31		
gu=g-gq if gq>=gf, or = g-gf if gq<gf		11.01		
n=Max(gq-gf)/2,0)		0.00		
PTHo=1-PLTo		1.00		
PL*=PLT[1+(N-1)g/(gf+gu/EL1+4.24)]		0.04		
EL1 (refer to Exhibit C16-3)		1.97		
EL2=Max((1-Ptho**n)/Plto, 1.0)				
fmin=2(1+PL)/g or fmin=2(1+Pl)/g		0.06		
gdiff=max(gq-gf,0)		0.00		
fm=[gf/g]+[gu/g]/[1+PL(EL1-1)], (min=fmin;max=1.00)		0.99		
flt=fm=[gf/g]+[gu/g]/[1+PL(EL1-1)]+[gdiff/g]/[1+PL(EL2-1)],(fmin<=fm<=1.00)				
or flt=[fm+0.91(N-1)]/N**				
Left-turn adjustment, fLT		0.987		

For special case of single-lane approach opposed by multilane approach, see text.

* If Pl>=1 for shared left-turn lanes with N>1, then assume de-facto left-turn lane and redo calculations.

** For permitted left-turns with multiple exclusive left-turn lanes, flt=fm.

For special case of multilane approach opposed by single-lane approach or when gf>gq, see text.

SUPPLEMENTAL PEDESTRIAN-BICYCLE EFFECTS WORKSHEET

Permitted Left Turns	EB	WB	NB	SB
Effective pedestrian green time, gp (s)				
Conflicting pedestrian volume, Vped (p/h)				
Pedestrian flow rate, Vpedg (p/h)				
OCCpedg				
Opposing queue clearing green, gq (s)				
Eff. ped. green consumed by opp. veh. queue, gq/gp				
OCCpedu				
Opposing flow rate, Vo (veh/h)				
OCCr				
Number of cross-street receiving lanes, Nrec				
Number of turning lanes, Nturn				
ApbT				
Proportion of left turns, PLT				
Proportion of left turns using protected phase, PLTA				
Left-turn adjustment, fLpb				
Permitted Right Turns				
Effective pedestrian green time, gp (s)				
Conflicting pedestrian volume, Vped (p/h)				
Conflicting bicycle volume, Vbic (bicycles/h)				
Vpedg				
OCCpedg				
Effective green, g (s)				
Vbicg				

OCCbicg
OCCr
Number of cross-street receiving lanes, Nrec
Number of turning lanes, Nturn
ApbT
Proportion right-turns, PRT
Proportion right-turns using protected phase, PRTA
Right turn adjustment, fRpb

SUPPLEMENTAL UNIFORM DELAY WORKSHEET

			EBLT	WBLT	NBLT	SBLT
Cycle length, C	60.0	sec				
Adj. LT vol from Vol Adjustment Worksheet, v						
v/c ratio from Capacity Worksheet, X						
Protected phase effective green interval, g (s)						
Opposing queue effective green interval, gq						
Unopposed green interval, gu						
Red time r=(C-g-gq-gu)						
Arrival rate, qa=v/(3600(max[X,1.0]))						
Protected ph. departure rate, Sp=s/3600						
Permitted ph. departure rate, Ss=s(gq+gu)/(gu*3600)						
XPerm						
XProt						
Case						
Queue at beginning of green arrow, Qa						
Queue at beginning of unsaturated green, Qu						
Residual queue, Qr						
Uniform Delay, d1						

DELAY/LOS WORKSHEET WITH INITIAL QUEUE

Appr/ Lane Group	Initial Unmet Demand Q veh	Dur. Unmet Demand t hrs.	Uniform Delay Unadj. ds	Uniform Delay Adj. d1 sec	Initial Queue Param. u	Final Unmet Demand Q veh	Initial Queue Delay d3 sec	Lane Group Delay d sec
Eastbound								
	0.0						0.0	
T	0.0	0.00	14.0	8.0	0.00	0.0	0.0	8.2
R	0.0	0.00	14.0	12.2	0.00	0.0	0.0	21.9
Westbound								
	0.0						0.0	
LT	0.0	0.00	14.0	7.3	0.00	0.0	0.0	7.4
	0.0						0.0	
Northbound								
	0.0						0.0	
LTR	0.0	0.00	21.0	18.7	0.00	0.0	0.0	23.2
	0.0						0.0	
Southbound								
	0.0						0.0	
	0.0						0.0	
	0.0						0.0	

Intersection Delay 17.6 sec/veh Intersection LOS B

BACK OF QUEUE WORKSHEET

	Eastbound		Westbound		Northbound		Southbound	
LaneGroup	T	R	LT		LTR			
Init Queue	0.0	0.0	0.0		0.0			
Flow Rate	343	734	201		379			
So	1900	1900	1900		1900			
No.Lanes	0 1	1	0 1	0	0 1	0	0 0	0
SL	1863	1583	1839		1772			
LnCapacity	994	844	981		532			
Flow Ratio	0.2	0.5	0.1		0.2			
v/c Ratio	0.35	0.87	0.20		0.71			
Grn Ratio	0.53	0.53	0.53		0.30			
I Factor	1.000		1.000		1.000			
AT or PVG	3	3	3		3			
Pltn Ratio	1.00	1.00	1.00		1.00			
PF2	1.00	1.00	1.00		1.00			
Q1	3.3	10.6	1.8		5.6			
kB	0.5	0.5	0.5		0.4			
Q2	0.3	2.7	0.1		0.9			
Q Average	3.6	13.4	1.9		6.5			
Q Spacing	25.0	25.0	25.0		25.0			
Q Storage	0	0	0		0			
Q S Ratio								
70th Percentile Output:								
fB%	1.2	1.2	1.2		1.2			
BOQ	4.2	15.7	2.3		7.7			
QSRatio								
85th Percentile Output:								
fB%	1.6	1.5	1.6		1.5			
BOQ	5.6	19.9	3.0		10.0			
QSRatio								
90th Percentile Output:								
fB%	1.7	1.6	1.8		1.7			
BOQ	6.2	21.5	3.3		11.0			
QSRatio								
95th Percentile Output:								
fB%	2.0	1.8	2.0		1.9			
BOQ	7.1	23.9	3.9		12.5			
QSRatio								
98th Percentile Output:								
fB%	2.5	2.1	2.6		2.3			
BOQ	8.7	27.5	4.9		15.0			
QSRatio								

ERROR MESSAGES

No errors to report.

Highway Capacity Analysis, Calumet Avenue and 101st Avenue

Future Conditions plus site(Traffic Signal with right turn lane) AM

APPENDIX 14

HCS+: Signalized Intersections Release 5.4

Analyst:
Agency:
Date: 2/13/2016
Period: AM Peak
Project ID: future conditions plus site traffic with right turn lane
E/W St: 101st

Inter.:
Area Type: All other areas
Jurisd:
Year :
N/S St:

SIGNALIZED INTERSECTION SUMMARY

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
No. Lanes	0	1	1	0	1	0	0	1	0	0	0	0
LGConfig		T	R		LT			LTR				
Volume		58	284	33	306		839	0	32			
Lane Width		12.0	12.0		12.0			12.0				
RTOR Vol			0						0			

Duration 0.25 Area Type: All other areas

Signal Operations

Phase Combination	1	2	3	4		5	6	7	8
EB Left					NB Left	A			
Thru	A				Thru	A			
Right	A				Right	A			
Peds					Peds				
WB Left	A				SB Left				
Thru	A				Thru				
Right					Right				
Peds					Peds				
NB Right					EB Right	A			
SB Right					WB Right				
Green	20.0					40.0			
Yellow	4.0					4.0			
All Red	1.0					1.0			

Cycle Length: 70.0 secs

Intersection Performance Summary

Appr/ Lane Grp	Lane Group Capacity	Adj Sat Flow Rate (s)	Ratios v/c	Ratios g/C	Lane Group Delay	Lane Group LOS	Approach Delay	Approach LOS
Eastbound								
T	532	1863	0.14	0.29	18.8	B	3.3	A
R	1583	1583	0.23	1.00	0.1	A		
Westbound								
LT	496	1736	0.80	0.29	32.6	C	32.6	C
Northbound								
LTR	1006	1760	0.94	0.57	30.4	C	30.4	C
Southbound								

Intersection Delay = 24.2 (sec/veh) Intersection LOS = C

Phone: Fax:
E-Mail:

OPERATIONAL ANALYSIS

Analyst:
Agency/Co.:
Date Performed: 2/13/2016
Analysis Time Period: AM Peak
Intersection:
Area Type: All other areas
Jurisdiction:
Analysis Year:
Project ID: future conditions plus site traffic with right turn lane
E/W St: 101st N/S St:

VOLUME DATA

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Volume		58	284	33	306		839	0	32			
% Heavy Veh		2	2	2	2		2	2	2			
PHF		0.75	0.78	0.50	0.92		0.97	0.92	0.38			
PK 15 Vol		19	91	17	83		216	0	21			
Hi Ln Vol												
% Grade		0			0			0				
Ideal Sat		1900	1900		1900			1900				
ParkExist												
NumPark												
No. Lanes	0	1	1	0	1	0	0	1	0	0	0	0
LGConfig		T	R		LT			LTR				
Lane Width		12.0	12.0		12.0			12.0				
RTOR Vol			0						0			
Adj Flow		77	364		399			949				
%InSharedLn												
Prop LTs		0.000			0.165			0.911				
Prop RTs	0.000		1.000	0.000			0.089					
Peds Bikes	0						0			0		
Buses		0	0		0			0				
%InProtPhase												

Duration 0.25 Area Type: All other areas

OPERATING PARAMETERS

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Init Unmet		0.0	0.0		0.0			0.0				
Arriv. Type		3	3		3			3				
Unit Ext.		3.0	3.0		3.0			3.0				
I Factor		1.000			1.000			1.000				
Lost Time		2.0	2.0		2.0			2.0				
Ext of g		2.0	2.0		2.0			2.0				
Ped Min g		3.2						3.2			3.2	

PHASE DATA

Phase Combination		1	2	3	4	5	6	7	8
EB	Left								
	Thru	A							
	Right	A							
	Peds								
WB	Left	A							
	Thru	A							
	Right								
	Peds								
NB	Right								
SB	Right								
NB	Left					A			
	Thru					A			
	Right					A			
	Peds								
SB	Left								
	Thru								
	Right								
	Peds								
EB	Right					A			
WB	Right								
Green		20.0				40.0			
Yellow		4.0				4.0			
All Red		1.0				1.0			

Cycle Length: 70.0 secs

VOLUME ADJUSTMENT AND SATURATION FLOW WORKSHEET

Volume Adjustment

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Volume, V		58	284	33	306		839	0	32			
PHF		0.75	0.78	0.50	0.92		0.97	0.92	0.38			
Adj flow		77	364	66	333		865	0	84			
No. Lanes	0	1	1	0	1	0	0	1	0	0	0	0
Lane group		T	R		LT			LTR				
Adj flow		77	364		399			949				
Prop LTs		0.000			0.165			0.911				
Prop RTs	0.000	1.000		0.000			0.089					

Saturation Flow Rate (see Exhibit 16-7 to determine the adjustment factors)

	Eastbound			Westbound			Northbound			Southbound		
LG	T	R		LT			LTR					
So	1900	1900		1900			1900					
Lanes 0	1	1	0	1	0	0	1	0	0	0	0	
fW	1.000	1.000		1.000			1.000					
fHV	0.980	0.980		0.980			0.980					
fG	1.000	1.000		1.000			1.000					
fP	1.000	1.000		1.000			1.000					
fBB	1.000	1.000		1.000			1.000					
fA	1.000	1.000		1.000			1.000					
fLU	1.000	1.000		1.000			1.000					
fRT	1.000	0.850		1.000			0.988					
fLT	1.000			0.932			0.956					
Sec.												
fLpb	1.000			1.000			1.000					
fRpb	1.000	1.000		1.000			1.000					
S	1863	1583		1736			1760					
Sec.												

CAPACITY AND LOS WORKSHEET

Capacity Analysis and Lane Group Capacity

Appr/ Mvmt	Lane Group	Adj Flow Rate (v)	Adj Sat Flow Rate (s)	Flow Ratio (v/s)	Green Ratio (g/C)	--Lane Group-- Capacity (c)	v/c Ratio
Eastbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru	T	77	1863	0.04	0.29	532	0.14
Right	R	364	1583	0.23	1.00	1583	0.23
Westbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru	LT	399	1736	# 0.23	0.29	496	0.80
Right							
Northbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru	LTR	949	1760	# 0.54	0.57	1006	0.94
Right							
Southbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru							
Right							

Sum of flow ratios for critical lane groups, Yc = Sum (v/s) = 0.77
Total lost time per cycle, L = 10.00 sec
Critical flow rate to capacity ratio, Xc = (Yc)(C)/(C-L) = 0.90

Control Delay and LOS Determination

Appr/ Lane Grp	Ratios v/c	Ratios g/C	Unf Del d1	Prog Adj Fact	Lane Grp Cap	Incremental Factor k	Incremental Del d2	Res Del d3	Lane Group Delay	Lane Group LOS	Approach Delay	Approach LOS
Eastbound												
T	0.14	0.29	18.6	1.000	532	0.11	0.1	0.0	18.8	B	3.3	A
R	0.23	1.00	0.0	0.950	1583	0.11	0.1	0.0	0.1	A		
Westbound												
LT	0.80	0.29	23.2	1.000	496	0.35	9.4	0.0	32.6	C	32.6	C
Northbound												
LTR	0.94	0.57	13.9	1.000	1006	0.46	16.5	0.0	30.4	C	30.4	C
Southbound												

Intersection delay = 24.2 (sec/veh) Intersection LOS = C

SUPPLEMENTAL PERMITTED LT WORKSHEET
for exclusive lefts

Input

		EB	WB	NB	SB
Opposed by Single(S) or Multiple(M) lane approach					
Cycle length, C	70.0 sec				
Total actual green time for LT lane group, G (s)					
Effective permitted green time for LT lane group, g(s)					
Opposing effective green time, go (s)					
Number of lanes in LT lane group, N					
Number of lanes in opposing approach, No					
Adjusted LT flow rate, VLT (veh/h)					
Proportion of LT in LT lane group, PLT					
Proportion of LT in opposing flow, PLTo					
Adjusted opposing flow rate, Vo (veh/h)					
Lost time for LT lane group, tL					
Computation					
LT volume per cycle, LTC=VLTC/3600					
Opposing lane util. factor, fLUo		1.000	1.000		1.000
Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)					
gf=G[exp(- a * (LTC ** b))]-tl, gf<=g					
Opposing platoon ratio, Rpo (refer Exhibit 16-11)					
Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]					
gq, (see Exhibit C16-4,5,6,7,8)					
gu=g-gq if gq>=gf, or = g-gf if gq<gf					
n=Max(gq-gf)/2,0)					
PTHo=1-PLTo					
PL*=PLT[1+(N-1)g/(gf+gu/EL1+4.24)]					
EL1 (refer to Exhibit C16-3)					
EL2=Max((1-Ptho**n)/Plto, 1.0)					
fmin=2(1+PL)/g or fmin=2(1+Pl)/g					
gdiff=max(gq-gf,0)					
fm=[gf/g]+[gu/g]/[1+PL(EL1-1)], (min=fmin;max=1.00)					
flt=fm=[gf/g]+[gu/g]/[1+PL(EL1-1)]+[gdiff/g]/[1+PL(EL2-1)],(fmin<=fm<=1.00)					
or flt=[fm+0.91(N-1)]/N**					
Left-turn adjustment, fLT					

For special case of single-lane approach opposed by multilane approach, see text.

* If Pl>=1 for shared left-turn lanes with N>1, then assume de-facto left-turn lane and redo calculations.

** For permitted left-turns with multiple exclusive left-turn lanes, flt=fm.

For special case of multilane approach opposed by single-lane approach or when gf>gq, see text.

SUPPLEMENTAL PERMITTED LT WORKSHEET
for shared lefts

Input

		EB	WB	NB	SB
Opposed by Single(S) or Multiple(M) lane approach					
Cycle length, C	70.0 sec				
Total actual green time for LT lane group, G (s)			20.0		
Effective permitted green time for LT lane group, g(s)			20.0		
Opposing effective green time, go (s)			20.0		
Number of lanes in LT lane group, N			1		

Number of lanes in opposing approach, No		1		
Adjusted LT flow rate, VLT (veh/h)		66		
Proportion of LT in LT lane group, PLT	0.000	0.165	0.911	
Proportion of LT in opposing flow, PLTo		0.00		
Adjusted opposing flow rate, Vo (veh/h)		77		
Lost time for LT lane group, tL		5.00		
Computation				
LT volume per cycle, LTC=VLTC/3600		1.28		
Opposing lane util. factor, fLUo	1.000	1.000		1.000
Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)		1.50		
gf=G[exp(- a * (LTC ** b))]-tl, gf<=g		2.0		
Opposing platoon ratio, Rpo (refer Exhibit 16-11)		1.00		
Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]		0.71		
gq, (see Exhibit C16-4,5,6,7,8)		0.00		
gu=g-gq if gq>=gf, or = g-gf if gq<gf		18.03		
n=Max(gq-gf)/2,0)		0.00		
PTHo=1-PLTo		1.00		
PL*=PLT[1+(N-1)g/(gf+gu/EL1+4.24)]		0.17		
EL1 (refer to Exhibit C16-3)		1.49		
EL2=Max((1-Ptho**n)/Plto, 1.0)				
fmin=2(1+PL)/g or fmin=2(1+Pl)/g		0.12		
gdiff=max(gq-gf,0)		0.00		
fm=[gf/g]+[gu/g]/[1+PL(EL1-1)], (min=fmin;max=1.00)		0.93		
flt=fm=[gf/g]+[gu/g]/[1+PL(EL1-1)]+[gdiff/g]/[1+PL(EL2-1)],(fmin<=fm<=1.00)				
or flt=[fm+0.91(N-1)]/N**				
Left-turn adjustment, fLT		0.932		

For special case of single-lane approach opposed by multilane approach, see text.

* If Pl>=1 for shared left-turn lanes with N>1, then assume de-facto left-turn lane and redo calculations.

** For permitted left-turns with multiple exclusive left-turn lanes, flt=fm.

For special case of multilane approach opposed by single-lane approach or when gf>gq, see text.

SUPPLEMENTAL PEDESTRIAN-BICYCLE EFFECTS WORKSHEET

Permitted Left Turns	EB	WB	NB	SB
Effective pedestrian green time, gp (s)				
Conflicting pedestrian volume, Vped (p/h)				
Pedestrian flow rate, Vpedg (p/h)				
OCCpedg				
Opposing queue clearing green, gq (s)				
Eff. ped. green consumed by opp. veh. queue, gq/gp				
OCCpedu				
Opposing flow rate, Vo (veh/h)				
OCCr				
Number of cross-street receiving lanes, Nrec				
Number of turning lanes, Nturn				
ApbT				
Proportion of left turns, PLT				
Proportion of left turns using protected phase, PLTA				
Left-turn adjustment, fLpb				
Permitted Right Turns				
Effective pedestrian green time, gp (s)				
Conflicting pedestrian volume, Vped (p/h)				
Conflicting bicycle volume, Vbic (bicycles/h)				
Vpedg				
OCCpedg				
Effective green, g (s)				
Vbicg				

OCCbicg
OCCr
Number of cross-street receiving lanes, Nrec
Number of turning lanes, Nturn
ApbT
Proportion right-turns, PRT
Proportion right-turns using protected phase, PRTA
Right turn adjustment, fRpb

SUPPLEMENTAL UNIFORM DELAY WORKSHEET

			EBLT	WBLT	NBLT	SBLT
Cycle length, C	70.0	sec				
Adj. LT vol from Vol Adjustment Worksheet, v						
v/c ratio from Capacity Worksheet, X						
Protected phase effective green interval, g (s)						
Opposing queue effective green interval, gq						
Unopposed green interval, gu						
Red time r=(C-g-gq-gu)						
Arrival rate, qa=v/(3600(max[X,1.0]))						
Protected ph. departure rate, Sp=s/3600						
Permitted ph. departure rate, Ss=s(gq+gu)/(gu*3600)						
XPerm						
XProt						
Case						
Queue at beginning of green arrow, Qa						
Queue at beginning of unsaturated green, Qu						
Residual queue, Qr						
Uniform Delay, d1						

DELAY/LOS WORKSHEET WITH INITIAL QUEUE

Appr/ Lane Group	Initial Unmet Demand Q veh	Dur. Unmet Demand t hrs.	Uniform Delay Unadj. ds	Uniform Delay Adj. d1 sec	Initial Queue Param. u	Final Unmet Demand Q veh	Initial Queue Delay d3 sec	Lane Group Delay d sec
Eastbound								
	0.0						0.0	
T	0.0	0.00	25.0	18.6	0.00	0.0	0.0	18.8
R	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.1
Westbound								
	0.0						0.0	
LT	0.0	0.00	25.0	23.2	0.00	0.0	0.0	32.6
	0.0						0.0	
Northbound								
	0.0						0.0	
LTR	0.0	0.00	15.0	13.9	0.00	0.0	0.0	30.4
	0.0						0.0	
Southbound								
	0.0						0.0	
	0.0						0.0	
	0.0						0.0	

Intersection Delay 24.2 sec/veh Intersection LOS C

BACK OF QUEUE WORKSHEET

	Eastbound		Westbound			Northbound			Southbound		
LaneGroup	T	R	LT			LTR					
Init Queue	0.0	0.0	0.0			0.0					
Flow Rate	77	364	399			949					
So	1900	1900	1900			1900					
No.Lanes	0 1	1	0 1		0	0 1		0	0	0	0
SL	1863	1583	1736			1760					
LnCapacity	532	1583	496			1006					
Flow Ratio	0.0	0.2	0.2			0.5					
v/c Ratio	0.14	0.23	0.80			0.94					
Grn Ratio	0.29	1.00	0.29			0.57					
I Factor	1.000		1.000			1.000					
AT or PVG	3	3	3			3					
Pltn Ratio	1.00	1.00	1.00			1.00					
PF2	1.00		1.00			1.00					
Q1	1.1		7.2			17.2					
kB	0.4	0.8	0.4			0.6					
Q2	0.1	0.2	1.4			5.6					
Q Average	1.2		8.6			22.7					
Q Spacing	25.0	25.0	25.0			25.0					
Q Storage	0	0	0			0					
Q S Ratio											
70th Percentile Output:											
fB%	1.2		1.2			1.2					
BOQ	1.4		10.2			26.3					
QSRatio											
85th Percentile Output:											
fB%	1.6		1.5			1.4					
BOQ	1.9		13.2			32.7					
QSRatio											
90th Percentile Output:											
fB%	1.8		1.7			1.5					
BOQ	2.1		14.3			34.7					
QSRatio											
95th Percentile Output:											
fB%	2.1		1.9			1.7					
BOQ	2.4		16.1			37.9					
QSRatio											
98th Percentile Output:											
fB%	2.6		2.2			1.9					
BOQ	3.1		19.1			42.6					
QSRatio											

ERROR MESSAGES

No errors to report.

Highway Capacity Analysis: Calumet Avenue and 101st Avenue,
Future Conditions plus site (Traffic Signal with right turn lane) PM

APPENDIX 15

HCS+: Signalized Intersections Release 5.4

Analyst:
Agency:
Date: 2/13/2016
Period: PM Peak
Project ID: Future conditions plus site with right turn lane
E/W St: 101st

Inter.:
Area Type: All other areas
Jurisd:
Year :
N/S St:

SIGNALIZED INTERSECTION SUMMARY

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
No. Lanes	0	1	1	0	1	0	0	1	0	0	0	0
LGConfig		T	R		LT			LTR				
Volume		295	820	37	147		378	0	26			
Lane Width		12.0	12.0		12.0			12.0				
RTOR Vol			0						0			

Duration 0.25 Area Type: All other areas

Signal Operations

Phase Combination	1	2	3	4			5	6	7	8
EB Left					NB	Left	A			
Thru	A					Thru	A			
Right	A					Right	A			
Peds						Peds				
WB Left	A				SB	Left				
Thru	A					Thru				
Right						Right				
Peds						Peds				
NB Right					EB	Right	A			
SB Right					WB	Right				
Green	25.0						25.0			
Yellow	4.0						4.0			
All Red	1.0						1.0			

Cycle Length: 60.0 secs

Intersection Performance Summary

Appr/ Lane Grp	Lane Group Capacity	Adj Sat Flow Rate (s)	Ratios v/c	Ratios g/C	Lane Group Delay	Lane Group LOS	Approach Delay	Approach LOS
Eastbound								
T	776	1863	0.44	0.42	12.9	B	4.0	A
R	1583	1583	0.53	1.00	0.4	A		
Westbound								
LT	600	1440	0.44	0.42	13.1	B	13.1	B
Northbound								
LTR	735	1763	0.67	0.42	16.4	B	16.4	B
Southbound								

Intersection Delay = 8.4 (sec/veh) Intersection LOS = A

Phone: Fax:
E-Mail:

OPERATIONAL ANALYSIS

Analyst:
Agency/Co.:
Date Performed: 2/13/2016
Analysis Time Period: PM Peak
Intersection:
Area Type: All other areas
Jurisdiction:
Analysis Year:
Project ID: Future conditions plus site with right turn lane
E/W St: 101st N/S St:

VOLUME DATA

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Volume		295	820	37	147		378	0	26			
% Heavy Veh		2	2	2	2		2	2	2			
PHF		0.86	0.97	0.50	0.76		0.83	0.92	0.75			
PK 15 Vol		86	211	19	48		114	0	9			
Hi Ln Vol												
% Grade		0			0			0				
Ideal Sat		1900	1900		1900			1900				
ParkExist												
NumPark												
No. Lanes	0	1	1	0	1	0	0	1	0	0	0	0
LGConfig		T	R		LT			LTR				
Lane Width		12.0	12.0		12.0			12.0				
RTOR Vol			0						0			
Adj Flow		343	845		267			490				
%InSharedLn												
Prop LTs		0.000			0.277			0.929				
Prop RTs	0.000		1.000	0.000			0.071					
Peds Bikes	0						0			0		
Buses		0	0		0			0				
%InProtPhase												

Duration 0.25 Area Type: All other areas

OPERATING PARAMETERS

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Init Unmet		0.0	0.0		0.0			0.0				
Arriv. Type		3	3		3			3				
Unit Ext.		3.0	3.0		3.0			3.0				
I Factor		1.000			1.000			1.000				
Lost Time		2.0	2.0		2.0			2.0				
Ext of g		2.0	2.0		2.0			2.0				
Ped Min g		3.2						3.2			3.2	

PHASE DATA

Phase Combination	1	2	3	4	5	6	7	8
EB Left					NB Left	A		
Thru	A				Thru	A		
Right	A				Right	A		
Peds					Peds			
WB Left	A				SB Left			
Thru	A				Thru			
Right					Right			
Peds					Peds			
NB Right					EB Right	A		
SB Right					WB Right			
Green	25.0					25.0		
Yellow	4.0					4.0		
All Red	1.0					1.0		

Cycle Length: 60.0 secs

VOLUME ADJUSTMENT AND SATURATION FLOW WORKSHEET

Volume Adjustment

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Volume, V		295	820	37	147		378	0	26			
PHF		0.86	0.97	0.50	0.76		0.83	0.92	0.75			
Adj flow		343	845	74	193		455	0	35			
No. Lanes	0	1	1	0	1	0	0	1	0	0	0	0
Lane group		T	R		LT			LTR				
Adj flow		343	845		267			490				
Prop LTs		0.000			0.277			0.929				
Prop RTs	0.000	1.000		0.000			0.071					

Saturation Flow Rate (see Exhibit 16-7 to determine the adjustment factors)

	Eastbound			Westbound			Northbound			Southbound		
LG	T	R		LT			LTR					
So	1900	1900		1900			1900					
Lanes 0	1	1	0	1	0	0	1	0	0	0	0	
fW	1.000	1.000		1.000			1.000					
fHV	0.980	0.980		0.980			0.980					
fG	1.000	1.000		1.000			1.000					
fP	1.000	1.000		1.000			1.000					
fBB	1.000	1.000		1.000			1.000					
fA	1.000	1.000		1.000			1.000					
fLU	1.000	1.000		1.000			1.000					
fRT	1.000	0.850		1.000			0.990					
fLT	1.000			0.773			0.956					
Sec.												
fLpb	1.000			1.000			1.000					
fRpb	1.000	1.000		1.000			1.000					
S	1863	1583		1440			1763					
Sec.												

CAPACITY AND LOS WORKSHEET

Capacity Analysis and Lane Group Capacity

Appr/ Mvmt	Lane Group	Adj Flow Rate (v)	Adj Sat Flow Rate (s)	Flow Ratio (v/s)	Green Ratio (g/C)	--Lane Group-- Capacity (c)	v/c Ratio
Eastbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru	T	343	1863	0.18	0.42	776	0.44
Right	R	845	1583	# 0.53	1.00	1583	0.53
Westbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru	LT	267	1440	0.19	0.42	600	0.44
Right							
Northbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru	LTR	490	1763	0.28	0.42	735	0.67
Right							
Southbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru							
Right							

Sum of flow ratios for critical lane groups, Yc = Sum (v/s) = 0.53
Total lost time per cycle, L = 0.00 sec
Critical flow rate to capacity ratio, Xc = (Yc)(C)/(C-L) = 0.53

Control Delay and LOS Determination

Appr/ Lane Grp	Ratios v/c	Ratios g/C	Unf Del d1	Prog Adj Fact	Lane Grp Cap	Incremental Factor k	Incremental Del d2	Res Del d3	Lane Group Delay	Lane Group LOS	Approach Delay	Approach LOS
Eastbound												
T	0.44	0.42	12.5	1.000	776	0.11	0.4	0.0	12.9	B	4.0	A
R	0.53	1.00	0.0	0.950	1583	0.14	0.4	0.0	0.4	A		
Westbound												
LT	0.44	0.42	12.5	1.000	600	0.11	0.5	0.0	13.1	B	13.1	B
Northbound												
LTR	0.67	0.42	14.1	1.000	735	0.24	2.3	0.0	16.4	B	16.4	B
Southbound												

Intersection delay = 8.4 (sec/veh) Intersection LOS = A

SUPPLEMENTAL PERMITTED LT WORKSHEET
for exclusive lefts

Input		EB	WB	NB	SB
Opposed by Single(S) or Multiple(M) lane approach					
Cycle length, C	60.0 sec				
Total actual green time for LT lane group, G (s)					
Effective permitted green time for LT lane group, g(s)					
Opposing effective green time, go (s)					
Number of lanes in LT lane group, N					
Number of lanes in opposing approach, No					
Adjusted LT flow rate, VLT (veh/h)					
Proportion of LT in LT lane group, PLT					
Proportion of LT in opposing flow, PLTo					
Adjusted opposing flow rate, Vo (veh/h)					
Lost time for LT lane group, tL					
Computation					
LT volume per cycle, LTC=VLTC/3600					
Opposing lane util. factor, fLUo		1.000	1.000		1.000
Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)					
gf=G[exp(- a * (LTC ** b))]-tl, gf<=g					
Opposing platoon ratio, Rpo (refer Exhibit 16-11)					
Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]					
gq, (see Exhibit C16-4,5,6,7,8)					
gu=g-gq if gq>=gf, or = g-gf if gq<gf					
n=Max(gq-gf)/2,0)					
PTHo=1-PLTo					
PL*=PLT[1+(N-1)g/(gf+gu/EL1+4.24)]					
EL1 (refer to Exhibit C16-3)					
EL2=Max((1-Ptho**n)/Plto, 1.0)					
fmin=2(1+PL)/g or fmin=2(1+Pl)/g					
gdiff=max(gq-gf,0)					
fm=[gf/g]+[gu/g]/[1+PL(EL1-1)], (min=fmin;max=1.00)					
flt=fm=[gf/g]+[gu/g]/[1+PL(EL1-1)]+[gdiff/g]/[1+PL(EL2-1)],(fmin<=fm<=1.00)					
or flt=[fm+0.91(N-1)]/N**					
Left-turn adjustment, fLT					

For special case of single-lane approach opposed by multilane approach, see text.

* If Pl>=1 for shared left-turn lanes with N>1, then assume de-facto left-turn lane and redo calculations.

** For permitted left-turns with multiple exclusive left-turn lanes, flt=fm.

For special case of multilane approach opposed by single-lane approach or when gf>gq, see text.

SUPPLEMENTAL PERMITTED LT WORKSHEET
for shared lefts

Input		EB	WB	NB	SB
Opposed by Single(S) or Multiple(M) lane approach					
Cycle length, C	60.0 sec				
Total actual green time for LT lane group, G (s)			25.0		
Effective permitted green time for LT lane group, g(s)			25.0		
Opposing effective green time, go (s)			25.0		
Number of lanes in LT lane group, N			1		

Number of lanes in opposing approach, No		1		
Adjusted LT flow rate, VLT (veh/h)		74		
Proportion of LT in LT lane group, PLT	0.000	0.277	0.929	
Proportion of LT in opposing flow, PLTo		0.00		
Adjusted opposing flow rate, Vo (veh/h)		343		
Lost time for LT lane group, tL		5.00		
Computation				
LT volume per cycle, LTC=VLTC/3600		1.23		
Opposing lane util. factor, fLUo	1.000	1.000		1.000
Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)		5.72		
gf=G[exp(- a * (LTC ** b))]-tl, gf<=g		4.0		
Opposing platoon ratio, Rpo (refer Exhibit 16-11)		1.00		
Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]		0.58		
gq, (see Exhibit C16-4,5,6,7,8)		5.53		
gu=g-gq if gq>=gf, or = g-gf if gq<gf		19.47		
n=Max(gq-gf)/2,0)		0.78		
PTHo=1-PLTo		1.00		
PL*=PLT[1+(N-1)g/(gf+gu/EL1+4.24)]		0.28		
EL1 (refer to Exhibit C16-3)		1.97		
EL2=Max((1-Ptho**n)/Plto, 1.0)				
fmin=2(1+PL)/g or fmin=2(1+Pl)/g		0.10		
gdiff=max(gq-gf,0)		0.00		
fm=[gf/g]+[gu/g]/[1+PL(EL1-1)], (min=fmin;max=1.00)		0.77		
flt=fm=[gf/g]+[gu/g]/[1+PL(EL1-1)]+[gdiff/g]/[1+PL(EL2-1)],(fmin<=fm<=1.00)				
or flt=[fm+0.91(N-1)]/N**				
Left-turn adjustment, fLT		0.773		

For special case of single-lane approach opposed by multilane approach, see text.

* If Pl>=1 for shared left-turn lanes with N>1, then assume de-facto left-turn lane and redo calculations.

** For permitted left-turns with multiple exclusive left-turn lanes, flt=fm.

For special case of multilane approach opposed by single-lane approach or when gf>gq, see text.

SUPPLEMENTAL PEDESTRIAN-BICYCLE EFFECTS WORKSHEET

Permitted Left Turns	EB	WB	NB	SB
Effective pedestrian green time, gp (s)				
Conflicting pedestrian volume, Vped (p/h)				
Pedestrian flow rate, Vpedg (p/h)				
OCCpedg				
Opposing queue clearing green, gq (s)				
Eff. ped. green consumed by opp. veh. queue, gq/gp				
OCCpedu				
Opposing flow rate, Vo (veh/h)				
OCCr				
Number of cross-street receiving lanes, Nrec				
Number of turning lanes, Nturn				
ApbT				
Proportion of left turns, PLT				
Proportion of left turns using protected phase, PLTA				
Left-turn adjustment, fLpb				
Permitted Right Turns				
Effective pedestrian green time, gp (s)				
Conflicting pedestrian volume, Vped (p/h)				
Conflicting bicycle volume, Vbic (bicycles/h)				
Vpedg				
OCCpedg				
Effective green, g (s)				
Vbicg				

OCCbicg
OCCr
Number of cross-street receiving lanes, Nrec
Number of turning lanes, Nturn
ApbT
Proportion right-turns, PRT
Proportion right-turns using protected phase, PRTA
Right turn adjustment, fRpb

SUPPLEMENTAL UNIFORM DELAY WORKSHEET

			EBLT	WBLT	NBLT	SBLT
Cycle length, C	60.0	sec				
Adj. LT vol from Vol Adjustment Worksheet, v						
v/c ratio from Capacity Worksheet, X						
Protected phase effective green interval, g (s)						
Opposing queue effective green interval, gq						
Unopposed green interval, gu						
Red time r=(C-g-gq-gu)						
Arrival rate, qa=v/(3600(max[X,1.0]))						
Protected ph. departure rate, Sp=s/3600						
Permitted ph. departure rate, Ss=s(gq+gu)/(gu*3600)						
XPerm						
XProt						
Case						
Queue at beginning of green arrow, Qa						
Queue at beginning of unsaturated green, Qu						
Residual queue, Qr						
Uniform Delay, d1						

DELAY/LOS WORKSHEET WITH INITIAL QUEUE

Appr/ Lane Group	Initial Unmet Demand Q veh	Dur. Unmet Demand t hrs.	Uniform Delay Unadj. ds	Uniform Delay Adj. d1 sec	Initial Queue Param. u	Final Unmet Demand Q veh	Initial Queue Delay d3 sec	Lane Group Delay d sec
Eastbound								
	0.0						0.0	
T	0.0	0.00	17.5	12.5	0.00	0.0	0.0	12.9
R	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.4
Westbound								
	0.0						0.0	
LT	0.0	0.00	17.5	12.5	0.00	0.0	0.0	13.1
	0.0						0.0	
Northbound								
	0.0						0.0	
LTR	0.0	0.00	17.5	14.1	0.00	0.0	0.0	16.4
	0.0						0.0	
Southbound								
	0.0						0.0	
	0.0						0.0	
	0.0						0.0	

Intersection Delay 8.4 sec/veh Intersection LOS A

BACK OF QUEUE WORKSHEET

	Eastbound		Westbound		Northbound		Southbound	
LaneGroup	T	R	LT		LTR			
Init Queue	0.0	0.0	0.0		0.0			
Flow Rate	343	845	267		490			
So	1900	1900	1900		1900			
No.Lanes	0 1	1	0 1	0	0 1	0	0 0	0
SL	1863	1583	1440		1763			
LnCapacity	776	1583	600		735			
Flow Ratio	0.2	0.5	0.2		0.3			
v/c Ratio	0.44	0.53	0.44		0.67			
Grn Ratio	0.42	1.00	0.42		0.42			
I Factor	1.000		1.000		1.000			
AT or PVG	3	3	3		3			
Pltn Ratio	1.00	1.00	1.00		1.00			
PF2	1.00		1.00		1.00			
Q1	4.1		3.2		6.6			
kB	0.5	0.7	0.4		0.4			
Q2	0.4	0.8	0.3		0.9			
Q Average	4.5		3.5		7.5			
Q Spacing	25.0	25.0	25.0		25.0			
Q Storage	0	0	0		0			
Q S Ratio								
70th Percentile Output:								
fB%	1.2		1.2		1.2			
BOQ	5.3		4.2		8.8			
QSRatio								
85th Percentile Output:								
fB%	1.6		1.6		1.5			
BOQ	6.9		5.5		11.5			
QSRatio								
90th Percentile Output:								
fB%	1.7		1.7		1.7			
BOQ	7.7		6.1		12.5			
QSRatio								
95th Percentile Output:								
fB%	2.0		2.0		1.9			
BOQ	8.8		7.0		14.2			
QSRatio								
98th Percentile Output:								
fB%	2.4		2.5		2.3			
BOQ	10.7		8.6		16.9			
QSRatio								

ERROR MESSAGES

No errors to report.

Traffic Count and Traffic Signal Warrant analysis at Calumet Avenue and Subdivision Entrance

APPENDIX 16

																580.8898	241	234	NO		
	AM subdivision	34	195	59	288	66		29	95	26	611	13	650	27		63	90	938	185	1123
	PM subdivision	68	588	76	732	92		39	131	33	258	29	320	23		51	74	1052	205	1257
		Warrant 3						No												
	AM		y=745.652-.75489x+.000217xx			y (calc)	Y Actual	X												
						228.4913	95	938	NO											
	PM	Warrant 3						NO												
			y=745.652-.75489x+.000217xx			y (calc)	Y Actual	X												
						191.6625	131	1052	NO											
	10 years in future																			
	AM subdivision	34	237.9	59	330.9	66		29	95	26	745.42	13	784.42	27		63	90	1115.32	185	1300.32
	PM subdivision	68	717.36	76	861.36	92		39	131	33	314.76	29	376.76	23		51	74	1238.12	205	1443.12
		Warrant 3						No												
	AM		y=745.652-.75489x+.000217xx			y (calc)	Y Actual	X												
						173.6428	95	1115.32	NO											
	PM	Warrant 3						NO												
			y=745.652-.75489x+.000217xx			y (calc)	Y Actual	X												
						143.6558	131	1238.12	NO											

Highway Capacity Analysis: Calumet Avenue and Subdivision Entrance (Two Way Stop) AM

APPENDIX 17

HCS+: Unsignalized Intersections Release 5.4

TWO-WAY STOP CONTROL SUMMARY

Analyst:
Agency/Co.:
Date Performed: 2/13/2016
Analysis Time Period: am peak
Intersection:
Jurisdiction:
Units: U. S. Customary
Analysis Year:
Project ID:
East/West Street: Development Drive
North/South Street: Calumet
Intersection Orientation: NS Study period (hrs): 1.00

Vehicle Volumes and Adjustments

Major Street: Approach	Northbound			Southbound		
Movement	1	2	3	4	5	6
	L	T	R	L	T	R
Volume	13	611	26	59	195	34
Peak-Hour Factor, PHF	0.97	0.97	0.38	0.97	0.97	0.97
Hourly Flow Rate, HFR	13	629	68	60	201	35
Percent Heavy Vehicles	1	--	--	0	--	--
Median Type/Storage	Undivided		/			
RT Channelized?						
Lanes	1	1	0	1	1	0
Configuration	L		TR	L		TR
Upstream Signal?		No			No	

Minor Street: Approach	Westbound			Eastbound		
Movement	7	8	9	10	11	12
	L	T	R	L	T	R
Volume	29	0	66	63	0	27
Peak Hour Factor, PHF	0.92	0.50	0.97	0.96	0.75	0.78
Hourly Flow Rate, HFR	31	0	68	65	0	34
Percent Heavy Vehicles	1	0	0	0	0	0
Percent Grade (%)		0			0	
Flared Approach: Exists?/Storage			No /			No /
Lanes	1	1	0	1	1	0
Configuration	L		TR	L		TR

Delay, Queue Length, and Level of Service

Approach	NB	SB	Westbound			Eastbound		
Movement	1	4	7	8	9	10	11	12
Lane Config	L	L	L		TR	L		TR
v (vph)	13	60	31		68	65		34
C(m) (vph)	1337	909	188		465	163		827
v/c	0.01	0.07	0.16		0.15	0.40		0.04
95% queue length	0.03	0.21	0.59		0.51	1.91		0.13
Control Delay	7.7	9.2	27.9		14.1	41.5		9.5
LOS	A	A	D		B	E		A
Approach Delay				18.4			30.6	
Approach LOS				C			D	

HCS+: Unsignalized Intersections Release 5.4

Phone: Fax:
E-Mail:

TWO-WAY STOP CONTROL(TWSC) ANALYSIS

Analyst:
Agency/Co.:
Date Performed: 2/13/2016
Analysis Time Period: am peak
Intersection:
Jurisdiction:
Units: U. S. Customary
Analysis Year:
Project ID:
East/West Street: Development Drive
North/South Street: Calumet
Intersection Orientation: NS Study period (hrs): 1.00

Vehicle Volumes and Adjustments

Major Street Movements	1	2	3	4	5	6
	L	T	R	L	T	R
Volume	13	611	26	59	195	34
Peak-Hour Factor, PHF	0.97	0.97	0.38	0.97	0.97	0.97
Peak-15 Minute Volume	3	157	17	15	50	9
Hourly Flow Rate, HFR	13	629	68	60	201	35
Percent Heavy Vehicles	1	--	--	0	--	--
Median Type/Storage	Undivided			/		
RT Channelized?						
Lanes	1	1	0	1	1	0
Configuration	L		TR	L		TR
Upstream Signal?		No			No	

Minor Street Movements	7	8	9	10	11	12
	L	T	R	L	T	R
Volume	29	0	66	63	0	27
Peak Hour Factor, PHF	0.92	0.50	0.97	0.96	0.75	0.78
Peak-15 Minute Volume	8	0	17	16	0	9
Hourly Flow Rate, HFR	31	0	68	65	0	34
Percent Heavy Vehicles	1	0	0	0	0	0
Percent Grade (%)		0			0	
Flared Approach: Exists?/Storage			No /			No /
RT Channelized?						
Lanes	1	1	0	1	1	0
Configuration	L		TR	L		TR

Pedestrian Volumes and Adjustments

Movements	13	14	15	16
Flow (ped/hr)	0	0	0	0

Lane Width (ft)	12.0	12.0	12.0	12.0
Walking Speed (ft/sec)	4.0	4.0	4.0	4.0
Percent Blockage	0	0	0	0

Upstream Signal Data

	Prog. Flow vph	Sat Flow vph	Arrival Type	Green Time sec	Cycle Length sec	Prog. Speed mph	Distance to Signal feet
S2 Left-Turn							
Through							
S5 Left-Turn							
Through							

Worksheet 3-Data for Computing Effect of Delay to Major Street Vehicles

	Movement 2	Movement 5
Shared ln volume, major th vehicles:		
Shared ln volume, major rt vehicles:		
Sat flow rate, major th vehicles:		
Sat flow rate, major rt vehicles:		
Number of major street through lanes:		

Worksheet 4-Critical Gap and Follow-up Time Calculation

Critical Gap Calculation

Movement	1 L	4 L	7 L	8 T	9 R	10 L	11 T	12 R
t(c,base)	4.1	4.1	7.1	6.5	6.2	7.1	6.5	6.2
t(c,hv)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
P(hv)	1	0	1	0	0	0	0	0
t(c,g)			0.20	0.20	0.10	0.20	0.20	0.10
Percent Grade			0.00	0.00	0.00	0.00	0.00	0.00
t(3,lt)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
t(c,T): 1-stage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2-stage	0.00	0.00	1.00	1.00	0.00	1.00	1.00	0.00
t(c) 1-stage	4.1	4.1	7.1	6.5	6.2	7.1	6.5	6.2
2-stage								

Follow-Up Time Calculations

Movement	1 L	4 L	7 L	8 T	9 R	10 L	11 T	12 R
t(f,base)	2.20	2.20	3.50	4.00	3.30	3.50	4.00	3.30
t(f,HV)	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
P(HV)	1	0	1	0	0	0	0	0
t(f)	2.2	2.2	3.5	4.0	3.3	3.5	4.0	3.3

Worksheet 5-Effect of Upstream Signals

Computation 1-Queue Clearance Time at Upstream Signal

	Movement 2		Movement 5	
	V(t)	V(l,prot)	V(t)	V(l,prot)
V prog				

Total Saturation Flow Rate, s (vph)
Arrival Type
Effective Green, g (sec)
Cycle Length, C (sec)
Rp (from Exhibit 16-11)
Proportion vehicles arriving on green P
g(q1)
g(q2)
g(q)

Computation 2-Proportion of TWSC Intersection Time blocked	Movement 2		Movement 5	
	V(t)	V(l,prot)	V(t)	V(l,prot)
alpha				
beta				
Travel time, t(a) (sec)				
Smoothing Factor, F				
Proportion of conflicting flow, f				
Max platooned flow, V(c,max)				
Min platooned flow, V(c,min)				
Duration of blocked period, t(p)				
Proportion time blocked, p	0.000		0.000	

Computation 3-Platoon Event Periods	Result
p(2)	0.000
p(5)	0.000
p(dom)	
p(subo)	
Constrained or unconstrained?	

Proportion unblocked for minor movements, p(x)	(1) Single-stage Process	(2) Two-Stage Process Stage I	(3) Two-Stage Process Stage II
p(1)			
p(4)			
p(7)			
p(8)			
p(9)			
p(10)			
p(11)			
p(12)			

Computation 4 and 5 Single-Stage Process Movement	1 L	4 L	7 L	8 T	9 R	10 L	11 T	12 R
V c,x	236	697	1045	1045	663	1061	1061	218
s								
Px								
V c,u,x								
C r,x								
C plat,x								

Two-Stage Process	7	8	10	11

	Stage1	Stage2	Stage1	Stage2	Stage1	Stage2	Stage1	Stage2
V(c,x)								
s		1500		1500		1500		1500
P(x)								
V(c,u,x)								
C(r,x)								
C(plat,x)								

Worksheet 6-Impedance and Capacity Equations

Step 1: RT from Minor St.	9	12
Conflicting Flows	663	218
Potential Capacity	465	827
Pedestrian Impedance Factor	1.00	1.00
Movement Capacity	465	827
Probability of Queue free St.	0.85	0.96
Step 2: LT from Major St.	**4**	**1**
Conflicting Flows	697	236
Potential Capacity	909	1337
Pedestrian Impedance Factor	1.00	1.00
Movement Capacity	909	1337
Probability of Queue free St.	0.93	0.99
Maj L-Shared Prob Q free St.		
Step 3: TH from Minor St.	**8**	**11**
Conflicting Flows	1045	1061
Potential Capacity	231	226
Pedestrian Impedance Factor	1.00	1.00
Cap. Adj. factor due to Impeding mvmnt	0.92	0.92
Movement Capacity	214	209
Probability of Queue free St.	1.00	1.00
Step 4: LT from Minor St.	**7**	**10**
Conflicting Flows	1045	1061
Potential Capacity	208	203
Pedestrian Impedance Factor	1.00	1.00
Maj. L, Min T Impedance factor	0.92	0.92
Maj. L, Min T Adj. Imp Factor.	0.94	0.94
Cap. Adj. factor due to Impeding mvmnt	0.90	0.80
Movement Capacity	188	163

Worksheet 7-Computation of the Effect of Two-stage Gap Acceptance

Step 3: TH from Minor St.	8	11
Part 1 - First Stage		
Conflicting Flows		
Potential Capacity		
Pedestrian Impedance Factor		
Cap. Adj. factor due to Impeding mvmnt		
Movement Capacity		
Probability of Queue free St.		

Part 2 - Second Stage		
Conflicting Flows		
Potential Capacity		
Pedestrian Impedance Factor		
Cap. Adj. factor due to Impeding mvmnt		
Movement Capacity		
Part 3 - Single Stage		
Conflicting Flows	1045	1061
Potential Capacity	231	226
Pedestrian Impedance Factor	1.00	1.00
Cap. Adj. factor due to Impeding mvmnt	0.92	0.92
Movement Capacity	214	209
Result for 2 stage process:		
a		
y		
C t	214	209
Probability of Queue free St.	1.00	1.00
Step 4: LT from Minor St.	7	10
Part 1 - First Stage		
Conflicting Flows		
Potential Capacity		
Pedestrian Impedance Factor		
Cap. Adj. factor due to Impeding mvmnt		
Movement Capacity		
Part 2 - Second Stage		
Conflicting Flows		
Potential Capacity		
Pedestrian Impedance Factor		
Cap. Adj. factor due to Impeding mvmnt		
Movement Capacity		
Part 3 - Single Stage		
Conflicting Flows	1045	1061
Potential Capacity	208	203
Pedestrian Impedance Factor	1.00	1.00
Maj. L, Min T Impedance factor	0.92	0.92
Maj. L, Min T Adj. Imp Factor.	0.94	0.94
Cap. Adj. factor due to Impeding mvmnt	0.90	0.80
Movement Capacity	188	163
Results for Two-stage process:		
a		
y		
C t	188	163

Worksheet 8-Shared Lane Calculations

Movement	7 L	8 T	9 R	10 L	11 T	12 R
Volume (vph)	31	0	68	65	0	34
Movement Capacity (vph)	188	214	465	163	209	827
Shared Lane Capacity (vph)			465			827

Worksheet 9-Computation of Effect of Flared Minor Street Approaches

Movement	7 L	8 T	9 R	10 L	11 T	12 R
C sep	188	214	465	163	209	827
Volume	31	0	68	65	0	34
Delay						
Q sep						
Q sep +1						
round (Qsep +1)						
n max						
C sh			465			827
SUM C sep						
n						
C act						

Worksheet 10-Delay, Queue Length, and Level of Service

Movement	1	4	7	8	9	10	11	12
Lane Config	L	L	L		TR	L		TR
v (vph)	13	60	31		68	65		34
C(m) (vph)	1337	909	188		465	163		827
v/c	0.01	0.07	0.16		0.15	0.40		0.04
95% queue length	0.03	0.21	0.59		0.51	1.91		0.13
Control Delay	7.7	9.2	27.9		14.1	41.5		9.5
LOS	A	A	D		B	E		A
Approach Delay				18.4			30.6	
Approach LOS				C			D	

Worksheet 11-Shared Major LT Impedance and Delay

	Movement 2	Movement 5
p(oj)	0.99	0.93
v(i1), Volume for stream 2 or 5		
v(i2), Volume for stream 3 or 6		
s(i1), Saturation flow rate for stream 2 or 5		
s(i2), Saturation flow rate for stream 3 or 6		
P*(oj)		
d(M,LT), Delay for stream 1 or 4	7.7	9.2
N, Number of major street through lanes		
d(rank,1) Delay for stream 2 or 5		

Highway Capacity Analysis: Calumet Avenue and Subdivision Entrance (Two Way Stop) PM

APPENDIX 18

HCS+: Unsignalized Intersections Release 5.4

TWO-WAY STOP CONTROL SUMMARY

Analyst:
Agency/Co.:
Date Performed: 2/13/2016
Analysis Time Period: PM peak
Intersection:
Jurisdiction:
Units: U. S. Customary
Analysis Year:
Project ID:
East/West Street: Development Drive
North/South Street: Calumet
Intersection Orientation: NS Study period (hrs): 1.00

Vehicle Volumes and Adjustments

Major Street: Approach	Northbound			Southbound		
Movement	1	2	3	4	5	6
	L	T	R	L	T	R
Volume	29	258	33	76	588	68
Peak-Hour Factor, PHF	0.97	0.97	0.38	0.97	0.97	0.97
Hourly Flow Rate, HFR	29	265	86	78	606	70
Percent Heavy Vehicles	0	--	--	0	--	--
Median Type/Storage	Undivided			/		
RT Channelized?						
Lanes	1	1	0	1	1	0
Configuration	L		TR	L		TR
Upstream Signal?		No			No	

Minor Street: Approach	Westbound			Eastbound		
Movement	7	8	9	10	11	12
	L	T	R	L	T	R
Volume	39	0	62	51	0	23
Peak Hour Factor, PHF	0.92	0.50	0.97	0.96	0.75	0.78
Hourly Flow Rate, HFR	42	0	63	53	0	29
Percent Heavy Vehicles	0	0	0	0	0	0
Percent Grade (%)		0			0	
Flared Approach: Exists?/Storage			No /			No /
Lanes	1	1	0	1	1	0
Configuration	L		TR	L		TR

Delay, Queue Length, and Level of Service

Approach	NB	SB	Westbound			Eastbound		
Movement	1	4	7	8	9	10	11	12
Lane Config	L	L	L		TR	L		TR
v (vph)	29	78	42		63	53		29
C(m) (vph)	925	1219	147		737	140		478
v/c	0.03	0.06	0.29		0.09	0.38		0.06
95% queue length	0.10	0.21	1.17		0.28	1.76		0.19
Control Delay	9.0	8.2	39.2		10.3	46.2		13.0
LOS	A	A	E		B	E		B
Approach Delay				21.9			34.4	
Approach LOS				C			D	

HCS+: Unsignalized Intersections Release 5.4

Phone: Fax:
E-Mail:

TWO-WAY STOP CONTROL(TWSC) ANALYSIS

Analyst:
Agency/Co.:
Date Performed: 2/13/2016
Analysis Time Period: PM peak
Intersection:
Jurisdiction:
Units: U. S. Customary
Analysis Year:
Project ID:
East/West Street: Development Drive
North/South Street: Calumet
Intersection Orientation: NS Study period (hrs): 1.00

Vehicle Volumes and Adjustments

Major Street Movements	1 L	2 T	3 R	4 L	5 T	6 R
Volume	29	258	33	76	588	68
Peak-Hour Factor, PHF	0.97	0.97	0.38	0.97	0.97	0.97
Peak-15 Minute Volume	7	66	22	20	152	18
Hourly Flow Rate, HFR	29	265	86	78	606	70
Percent Heavy Vehicles	0	--	--	0	--	--
Median Type/Storage	Undivided			/		
RT Channelized?						
Lanes	1	1	0	1	1	0
Configuration	L		TR	L		TR
Upstream Signal?		No			No	

Minor Street Movements	7 L	8 T	9 R	10 L	11 T	12 R
Volume	39	0	62	51	0	23
Peak Hour Factor, PHF	0.92	0.50	0.97	0.96	0.75	0.78
Peak-15 Minute Volume	11	0	16	13	0	7
Hourly Flow Rate, HFR	42	0	63	53	0	29
Percent Heavy Vehicles	0	0	0	0	0	0
Percent Grade (%)		0			0	
Flared Approach: Exists?/Storage			No	/		No /
RT Channelized?						
Lanes	1	1	0	1	1	0
Configuration	L		TR	L		TR

Pedestrian Volumes and Adjustments

Movements	13	14	15	16
Flow (ped/hr)	0	0	0	0

Lane Width (ft)	12.0	12.0	12.0	12.0
Walking Speed (ft/sec)	4.0	4.0	4.0	4.0
Percent Blockage	0	0	0	0

Upstream Signal Data

	Prog. Flow vph	Sat Flow vph	Arrival Type	Green Time sec	Cycle Length sec	Prog. Speed mph	Distance to Signal feet
S2 Left-Turn							
Through							
S5 Left-Turn							
Through							

Worksheet 3-Data for Computing Effect of Delay to Major Street Vehicles

	Movement 2	Movement 5
Shared ln volume, major th vehicles:		
Shared ln volume, major rt vehicles:		
Sat flow rate, major th vehicles:		
Sat flow rate, major rt vehicles:		
Number of major street through lanes:		

Worksheet 4-Critical Gap and Follow-up Time Calculation

Critical Gap Calculation

Movement	1 L	4 L	7 L	8 T	9 R	10 L	11 T	12 R
t(c,base)	4.1	4.1	7.1	6.5	6.2	7.1	6.5	6.2
t(c,hv)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
P(hv)	0	0	0	0	0	0	0	0
t(c,g)			0.20	0.20	0.10	0.20	0.20	0.10
Percent Grade			0.00	0.00	0.00	0.00	0.00	0.00
t(3,lt)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
t(c,T): 1-stage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2-stage	0.00	0.00	1.00	1.00	0.00	1.00	1.00	0.00
t(c) 1-stage	4.1	4.1	7.1	6.5	6.2	7.1	6.5	6.2
2-stage								

Follow-Up Time Calculations

Movement	1 L	4 L	7 L	8 T	9 R	10 L	11 T	12 R
t(f,base)	2.20	2.20	3.50	4.00	3.30	3.50	4.00	3.30
t(f,HV)	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
P(HV)	0	0	0	0	0	0	0	0
t(f)	2.2	2.2	3.5	4.0	3.3	3.5	4.0	3.3

Worksheet 5-Effect of Upstream Signals

Computation 1-Queue Clearance Time at Upstream Signal

	Movement 2		Movement 5	
	V(t)	V(l,prot)	V(t)	V(l,prot)
V prog				

Total Saturation Flow Rate, s (vph)
Arrival Type
Effective Green, g (sec)
Cycle Length, C (sec)
Rp (from Exhibit 16-11)
Proportion vehicles arriving on green P
g(q1)
g(q2)
g(q)

Computation 2-Proportion of TWSC Intersection Time blocked	Movement 2		Movement 5	
	V(t)	V(l,prot)	V(t)	V(l,prot)
alpha				
beta				
Travel time, t(a) (sec)				
Smoothing Factor, F				
Proportion of conflicting flow, f				
Max platooned flow, V(c,max)				
Min platooned flow, V(c,min)				
Duration of blocked period, t(p)				
Proportion time blocked, p		0.000		0.000

Computation 3-Platoon Event Periods	Result
p(2)	0.000
p(5)	0.000
p(dom)	
p(subo)	
Constrained or unconstrained?	

Proportion unblocked for minor movements, p(x)	(1) Single-stage Process	(2) Two-Stage Process Stage I	(3) Two-Stage Process Stage II
p(1)			
p(4)			
p(7)			
p(8)			
p(9)			
p(10)			
p(11)			
p(12)			

Computation 4 and 5
Single-Stage Process

Movement	1 L	4 L	7 L	8 T	9 R	10 L	11 T	12 R
V c,x	676	351	1178	1198	308	1195	1206	641
s								
Px								
V c,u,x								
C r,x								
C plat,x								

Two-Stage Process

7	8	10	11

	Stage1	Stage2	Stage1	Stage2	Stage1	Stage2	Stage1	Stage2
V(c,x)								
s		1500		1500		1500		1500
P(x)								
V(c,u,x)								
C(r,x)								
C(plat,x)								

Worksheet 6-Impedance and Capacity Equations

Step 1: RT from Minor St.	9	12
Conflicting Flows	308	641
Potential Capacity	737	478
Pedestrian Impedance Factor	1.00	1.00
Movement Capacity	737	478
Probability of Queue free St.	0.91	0.94
Step 2: LT from Major St.	**4**	**1**
Conflicting Flows	351	676
Potential Capacity	1219	925
Pedestrian Impedance Factor	1.00	1.00
Movement Capacity	1219	925
Probability of Queue free St.	0.94	0.97
Maj L-Shared Prob Q free St.		
Step 3: TH from Minor St.	**8**	**11**
Conflicting Flows	1198	1206
Potential Capacity	187	185
Pedestrian Impedance Factor	1.00	1.00
Cap. Adj. factor due to Impeding mvmnt	0.91	0.91
Movement Capacity	170	168
Probability of Queue free St.	1.00	1.00
Step 4: LT from Minor St.	**7**	**10**
Conflicting Flows	1178	1195
Potential Capacity	169	165
Pedestrian Impedance Factor	1.00	1.00
Maj. L, Min T Impedance factor	0.91	0.91
Maj. L, Min T Adj. Imp Factor.	0.93	0.93
Cap. Adj. factor due to Impeding mvmnt	0.87	0.85
Movement Capacity	147	140

Worksheet 7-Computation of the Effect of Two-stage Gap Acceptance

Step 3: TH from Minor St.	8	11
Part 1 - First Stage		
Conflicting Flows		
Potential Capacity		
Pedestrian Impedance Factor		
Cap. Adj. factor due to Impeding mvmnt		
Movement Capacity		
Probability of Queue free St.		

Part 2 - Second Stage		
Conflicting Flows		
Potential Capacity		
Pedestrian Impedance Factor		
Cap. Adj. factor due to Impeding mvmnt		
Movement Capacity		
Part 3 - Single Stage		
Conflicting Flows	1198	1206
Potential Capacity	187	185
Pedestrian Impedance Factor	1.00	1.00
Cap. Adj. factor due to Impeding mvmnt	0.91	0.91
Movement Capacity	170	168
Result for 2 stage process:		
a		
y		
C t	170	168
Probability of Queue free St.	1.00	1.00
Step 4: LT from Minor St.	7	10
Part 1 - First Stage		
Conflicting Flows		
Potential Capacity		
Pedestrian Impedance Factor		
Cap. Adj. factor due to Impeding mvmnt		
Movement Capacity		
Part 2 - Second Stage		
Conflicting Flows		
Potential Capacity		
Pedestrian Impedance Factor		
Cap. Adj. factor due to Impeding mvmnt		
Movement Capacity		
Part 3 - Single Stage		
Conflicting Flows	1178	1195
Potential Capacity	169	165
Pedestrian Impedance Factor	1.00	1.00
Maj. L, Min T Impedance factor	0.91	0.91
Maj. L, Min T Adj. Imp Factor.	0.93	0.93
Cap. Adj. factor due to Impeding mvmnt	0.87	0.85
Movement Capacity	147	140
Results for Two-stage process:		
a		
y		
C t	147	140

Worksheet 8-Shared Lane Calculations

Movement	7 L	8 T	9 R	10 L	11 T	12 R
Volume (vph)	42	0	63	53	0	29
Movement Capacity (vph)	147	170	737	140	168	478
Shared Lane Capacity (vph)			737			478

Worksheet 9-Computation of Effect of Flared Minor Street Approaches

Movement	7 L	8 T	9 R	10 L	11 T	12 R
C sep	147	170	737	140	168	478
Volume	42	0	63	53	0	29
Delay						
Q sep						
Q sep +1						
round (Qsep +1)						
n max			737			478
C sh						
SUM C sep						
n						
C act						

Worksheet 10-Delay, Queue Length, and Level of Service

Movement Lane Config	1 L	4 L	7 L	8	9 TR	10 L	11	12 TR
v (vph)	29	78	42		63	53		29
C(m) (vph)	925	1219	147		737	140		478
v/c	0.03	0.06	0.29		0.09	0.38		0.06
95% queue length	0.10	0.21	1.17		0.28	1.76		0.19
Control Delay	9.0	8.2	39.2		10.3	46.2		13.0
LOS	A	A	E		B	E		B
Approach Delay				21.9			34.4	
Approach LOS				C			D	

Worksheet 11-Shared Major LT Impedance and Delay

	Movement 2	Movement 5
p(oj)	0.97	0.94
v(i1), Volume for stream 2 or 5		
v(i2), Volume for stream 3 or 6		
s(i1), Saturation flow rate for stream 2 or 5		
s(i2), Saturation flow rate for stream 3 or 6		
P*(oj)		
d(M,LT), Delay for stream 1 or 4	9.0	8.2
N, Number of major street through lanes		
d(rank,1) Delay for stream 2 or 5		

Highway Capacity Analysis: Calumet Avenue and Subdivision Entrance (Traffic Signal Control) AM

APPENDIX 19

HCS+: Signalized Intersections Release 5.4

Analyst:
Agency:
Date: 2/13/2016
Period: AM Peak
Project ID: Existing conditions
E/W St: subdivision entrance

Inter.:
Area Type: All other areas
Jurisd:
Year :

N/S St: calumet Avenue

SIGNALIZED INTERSECTION SUMMARY

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
No. Lanes	0	1	0	0	1	0	1	1	0	1	1	0
LGConfig		LTR			LTR		L	TR		L	TR	
Volume	63	1	27	29	1	66	13	611	26	59	195	34
Lane Width		12.0			12.0		12.0	12.0		12.0	12.0	
RTOR Vol			0			0			0			0

Duration 1.00 Area Type: All other areas

Signal Operations

Phase Combination	1	2	3	4		5	6	7	8
EB Left	A				NB Left	A			
Thru	A				Thru	A			
Right	A				Right	A			
Peds					Peds				
WB Left	A				SB Left	A			
Thru	A				Thru	A			
Right	A				Right	A			
Peds					Peds				
NB Right					EB Right				
SB Right					WB Right				
Green	15.0					35.0			
Yellow	4.0					4.0			
All Red	1.0					1.0			

Cycle Length: 60.0 secs

Intersection Performance Summary

Appr/ Lane Grp	Lane Group Capacity	Adj Sat Flow Rate (s)	Ratios v/c	Ratios g/C	Lane Group Delay	Lane Group LOS	Approach Delay	Approach LOS
Eastbound								
LTR	333	1332	0.29	0.25	18.7	B	18.7	B
Westbound								
LTR	378	1510	0.28	0.25	18.5	B	18.5	B
Northbound								
L	657	1126	0.02	0.58	5.3	A		
TR	1080	1851	0.64	0.58	9.6	A	9.5	A
Southbound								
L	304	522	0.21	0.58	6.3	A		
TR	1062	1821	0.23	0.58	6.1	A	6.2	A

Intersection Delay = 10.2 (sec/veh) Intersection LOS = B

Phone: Fax:
E-Mail:

OPERATIONAL ANALYSIS

Analyst:
Agency/Co.:
Date Performed: 2/13/2016
Analysis Time Period: AM Peak
Intersection:
Area Type: All other areas
Jurisdiction:
Analysis Year:
Project ID: Existing conditions
E/W St: subdivision entrance N/S St: calumet Avenue

VOLUME DATA

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Volume	63	1	27	29	1	66	13	611	26	59	195	34
% Heavy Veh	2	2	2	2	2	2	2	2	2	2	2	2
PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
PK 15 Vol	17	1	7	8	1	18	4	166	7	16	53	9
Hi Ln Vol												
% Grade		0			0			0			0	
Ideal Sat		1900			1900		1900	1900		1900	1900	
ParkExist												
NumPark												
No. Lanes	0	1	0	0	1	0	1	1	0	1	1	0
LGConfig		LTR			LTR		L	TR		L	TR	
Lane Width		12.0			12.0		12.0	12.0		12.0	12.0	
RTOR Vol			0			0			0			0
Adj Flow		98			105		14	692		64	249	
%InSharedLn												
Prop LTs		0.694			0.305		1.000	0.000		1.000	0.000	
Prop RTs	0.296			0.686			0.040			0.149		
Peds Bikes	0			0			0			0		
Buses		0			0		0	0		0	0	
%InProtPhase												

Duration 1.00 Area Type: All other areas

OPERATING PARAMETERS

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Init Unmet		0.0			0.0		0.0	0.0		0.0	0.0	
Arriv. Type		3			3		3	3		3	3	
Unit Ext.		3.0			3.0		3.0	3.0		3.0	3.0	
I Factor		1.000			1.000			1.000			1.000	
Lost Time		2.0			2.0		2.0	2.0		2.0	2.0	
Ext of g		2.0			2.0		2.0	2.0		2.0	2.0	
Ped Min g		3.2			3.2			3.2			3.2	

PHASE DATA

Phase Combination		1	2	3	4	5	6	7	8
EB	Left	A				NB Left	A		
	Thru	A				Thru	A		
	Right	A				Right	A		
	Peds					Peds			
WB	Left	A				SB Left	A		
	Thru	A				Thru	A		
	Right	A				Right	A		
	Peds					Peds			
NB	Right					EB Right			
SB	Right					WB Right			
Green		15.0					35.0		
Yellow		4.0					4.0		
All Red		1.0					1.0		

Cycle Length: 60.0 secs

VOLUME ADJUSTMENT AND SATURATION FLOW WORKSHEET

Volume Adjustment

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Volume, V	63	1	27	29	1	66	13	611	26	59	195	34
PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj flow	68	1	29	32	1	72	14	664	28	64	212	37
No. Lanes	0	1	0	0	1	0	1	1	0	1	1	0
Lane group		LTR			LTR		L	TR		L	TR	
Adj flow		98			105		14	692		64	249	
Prop LTs		0.694			0.305		1.000	0.000		1.000	0.000	
Prop RTs		0.296			0.686			0.040			0.149	

Saturation Flow Rate (see Exhibit 16-7 to determine the adjustment factors)

	Eastbound			Westbound		Northbound			Southbound		
LG	LTR			LTR		L	TR		L	TR	
So	1900			1900		1900	1900		1900	1900	
Lanes 0	1	0	0	1	0	1	1	0	1	1	0
fW	1.000			1.000		1.000	1.000		1.000	1.000	
fHV	0.980			0.980		0.980	0.980		0.980	0.980	
fG	1.000			1.000		1.000	1.000		1.000	1.000	
fP	1.000			1.000		1.000	1.000		1.000	1.000	
fBB	1.000			1.000		1.000	1.000		1.000	1.000	
fA	1.000			1.000		1.000	1.000		1.000	1.000	
fLU	1.000			1.000		1.000	1.000		1.000	1.000	
fRT	0.960			0.907			0.994			0.978	
fLT	0.745			0.893		0.605	1.000		0.280	1.000	
Sec.											
fLpb	1.000			1.000		1.000	1.000		1.000	1.000	
fRpb	1.000			1.000			1.000			1.000	
S	1332			1510		1126	1851		522	1821	
Sec.											

CAPACITY AND LOS WORKSHEET

Capacity Analysis and Lane Group Capacity

Appr/ Mvmt	Lane Group	Adj Flow Rate (v)	Adj Sat Flow Rate (s)	Flow Ratio (v/s)	Green Ratio (g/C)	--Lane Group-- Capacity (c)	v/c Ratio
Eastbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru	LTR	98	1332	# 0.07	0.25	333	0.29
Right							
Westbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru	LTR	105	1510	0.07	0.25	378	0.28
Right							
Northbound							
Prot							
Perm							
Left	L	14	1126	0.01	0.58	657	0.02
Prot							
Perm							
Thru	TR	692	1851	# 0.37	0.58	1080	0.64
Right							
Southbound							
Prot							
Perm							
Left	L	64	522	0.12	0.58	304	0.21
Prot							
Perm							
Thru	TR	249	1821	0.14	0.58	1062	0.23
Right							

Sum of flow ratios for critical lane groups, Yc = Sum (v/s) = 0.45
Total lost time per cycle, L = 10.00 sec
Critical flow rate to capacity ratio, Xc = (Yc)(C)/(C-L) = 0.54

Control Delay and LOS Determination

Appr/ Lane Grp	Ratios v/c	Ratios g/C	Unf Del d1	Prog Adj Fact	Lane Grp Cap	Incremental Factor k	Incremental Del d2	Res Del d3	Lane Group Delay	Lane Group LOS	Approach Delay	Approach LOS
Eastbound												
LTR	0.29	0.25	18.2	1.000	333	0.11	0.5	0.0	18.7	B	18.7	B
Westbound												
LTR	0.28	0.25	18.1	1.000	378	0.11	0.4	0.0	18.5	B	18.5	B
Northbound												
L	0.02	0.58	5.3	1.000	657	0.11	0.0	0.0	5.3	A		
TR	0.64	0.58	8.3	1.000	1080	0.22	1.3	0.0	9.6	A	9.5	A
Southbound												
L	0.21	0.58	5.9	1.000	304	0.11	0.3	0.0	6.3	A		
TR	0.23	0.58	6.0	1.000	1062	0.11	0.1	0.0	6.1	A	6.2	A

Intersection delay = 10.2 (sec/veh) Intersection LOS = B

SUPPLEMENTAL PERMITTED LT WORKSHEET
for exclusive lefts

Input	EB	WB	NB	SB
Opposed by Single(S) or Multiple(M) lane approach				
Cycle length, C 60.0 sec				
Total actual green time for LT lane group, G (s)			35.0	35.0
Effective permitted green time for LT lane group, g(s)			35.0	35.0
Opposing effective green time, go (s)			35.0	35.0
Number of lanes in LT lane group, N			1	1
Number of lanes in opposing approach, No			1	1
Adjusted LT flow rate, VLT (veh/h)			14	64
Proportion of LT in LT lane group, PLT			1.000	1.000
Proportion of LT in opposing flow, PLTo			0.00	0.00
Adjusted opposing flow rate, Vo (veh/h)			249	692
Lost time for LT lane group, tL			5.00	5.00
Computation				
LT volume per cycle, LTC=VLTC/3600			0.23	1.07
Opposing lane util. factor, fLUo	1.000	1.000	1.000	1.000
Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)			4.15	11.53
gf=G[exp(- a * (LTC ** b))]-tl, gf<=g			0.0	0.0
Opposing platoon ratio, Rpo (refer Exhibit 16-11)			1.00	1.00
Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]			0.42	0.42
gq, (see Exhibit C16-4,5,6,7,8)			0.00	10.61
gu=g-gq if gq>=gf, or = g-gf if gq<gf			35.00	24.39
n=Max(gq-gf)/2,0)			0.00	5.31
PTHo=1-PLTo			1.00	1.00
PL*=PLT[1+(N-1)g/(gf+gu/EL1+4.24)]			1.00	1.00
EL1 (refer to Exhibit C16-3)			1.65	2.49
EL2=Max((1-Ptho**n)/Plto, 1.0)				
fmin=2(1+PL)/g or fmin=2(1+Pl)/g			0.11	0.11
gdiff=max(gq-gf,0)			0.00	0.00
fm=[gf/g]+[gu/g]/[1+PL(EL1-1)], (min=fmin;max=1.00)			0.60	0.28
flt=fm=[gf/g]+[gu/g]/[1+PL(EL1-1)]+[gdiff/g]/[1+PL(EL2-1)],(fmin<=fm<=1.00)				
or flt=[fm+0.91(N-1)]/N**				
Left-turn adjustment, fLT			0.605	0.280

For special case of single-lane approach opposed by multilane approach, see text.
* If Pl>=1 for shared left-turn lanes with N>1, then assume de-facto left-turn lane and redo calculations.
** For permitted left-turns with multiple exclusive left-turn lanes, flt=fm.
For special case of multilane approach opposed by single-lane approach or when gf>gq, see text.

SUPPLEMENTAL PERMITTED LT WORKSHEET
for shared lefts

Input	EB	WB	NB	SB
Opposed by Single(S) or Multiple(M) lane approach				
Cycle length, C 60.0 sec				
Total actual green time for LT lane group, G (s)	15.0	15.0		
Effective permitted green time for LT lane group, g(s)	15.0	15.0		
Opposing effective green time, go (s)	15.0	15.0		
Number of lanes in LT lane group, N	1	1		

Number of lanes in opposing approach, No	1	1		
Adjusted LT flow rate, VLT (veh/h)	68	32		
Proportion of LT in LT lane group, PLT	0.694	0.305	0.000	0.000
Proportion of LT in opposing flow, PLTo	0.30	0.69		
Adjusted opposing flow rate, Vo (veh/h)	105	98		
Lost time for LT lane group, tL	5.00	5.00		
Computation				
LT volume per cycle, LTC=VLTC/3600	1.13	0.53		
Opposing lane util. factor, fLUo	1.000	1.000	1.000	1.000
Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)	1.75	1.63		
gf=G[exp(- a * (LTC ** b))]-tl, gf<=g	0.9	3.4		
Opposing platoon ratio, Rpo (refer Exhibit 16-11)	1.00	1.00		
Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]	0.75	0.75		
gq, (see Exhibit C16-4,5,6,7,8)	0.58	0.29		
gu=g-gq if gq>=gf, or = g-gf if gq<gf	14.08	11.59		
n=Max(gq-gf)/2,0)	0.00	0.00		
PTHo=1-PLTo	0.70	0.31		
PL*=PLT[1+(N-1)g/(gf+gu/EL1+4.24)]	0.69	0.30		
EL1 (refer to Exhibit C16-3)	1.54	1.53		
EL2=Max((1-Ptho**n)/Plto, 1.0)	1.00	1.00		
fmin=2(1+PL)/g or fmin=2(1+Pl)/g	0.23	0.17		
gdiff=max(gq-gf,0)	0.00	0.00		
fm=[gf/g]+[gu/g]/[1+PL(EL1-1)], (min=fmin;max=1.00)	0.74	0.89		
flt=fm=[gf/g]+[gu/g]/[1+PL(EL1-1)]+[gdiff/g]/[1+PL(EL2-1)],(fmin<=fm<=1.00)				
or flt=[fm+0.91(N-1)]/N**				
Left-turn adjustment, fLT	0.745	0.893		

For special case of single-lane approach opposed by multilane approach, see text.

* If Pl>=1 for shared left-turn lanes with N>1, then assume de-facto left-turn lane and redo calculations.

** For permitted left-turns with multiple exclusive left-turn lanes, flt=fm.

For special case of multilane approach opposed by single-lane approach or when gf>gq, see text.

SUPPLEMENTAL PEDESTRIAN-BICYCLE EFFECTS WORKSHEET

Permitted Left Turns	EB	WB	NB	SB
Effective pedestrian green time, gp (s)				
Conflicting pedestrian volume, Vped (p/h)				
Pedestrian flow rate, Vpedg (p/h)				
OCCpedg				
Opposing queue clearing green, gq (s)				
Eff. ped. green consumed by opp. veh. queue, gq/gp				
OCCpedu				
Opposing flow rate, Vo (veh/h)				
OCCr				
Number of cross-street receiving lanes, Nrec				
Number of turning lanes, Nturn				
ApbT				
Proportion of left turns, PLT				
Proportion of left turns using protected phase, PLTA				
Left-turn adjustment, fLpb				
Permitted Right Turns				
Effective pedestrian green time, gp (s)				
Conflicting pedestrian volume, Vped (p/h)				
Conflicting bicycle volume, Vbic (bicycles/h)				
Vpedg				
OCCpedg				
Effective green, g (s)				
Vbicg				

OCCbicg
OCCr
Number of cross-street receiving lanes, Nrec
Number of turning lanes, Nturn
ApbT
Proportion right-turns, PRT
Proportion right-turns using protected phase, PRTA
Right turn adjustment, fRpb

SUPPLEMENTAL UNIFORM DELAY WORKSHEET

			EBLT	WBLT	NBLT	SBLT
Cycle length, C	60.0	sec				
Adj. LT vol from Vol Adjustment Worksheet, v						
v/c ratio from Capacity Worksheet, X						
Protected phase effective green interval, g (s)						
Opposing queue effective green interval, gq						
Unopposed green interval, gu						
Red time r=(C-g-gq-gu)						
Arrival rate, qa=v/(3600(max[X,1.0]))						
Protected ph. departure rate, Sp=s/3600						
Permitted ph. departure rate, Ss=s(gq+gu)/(gu*3600)						
XPerm						
XProt						
Case						
Queue at beginning of green arrow, Qa						
Queue at beginning of unsaturated green, Qu						
Residual queue, Qr						
Uniform Delay, d1						

DELAY/LOS WORKSHEET WITH INITIAL QUEUE

Appr/ Lane Group	Initial Unmet Demand Q veh	Dur. Unmet. Demand t hrs.	Uniform Delay Unadj. ds	Uniform Delay Adj. d1 sec	Initial Queue Param. u	Final Unmet Demand Q veh	Initial Queue Delay d3 sec	Lane Group Delay d sec
Eastbound								
	0.0						0.0	
LTR	0.0	0.00	22.5	18.2	0.00	0.0	0.0	18.7
	0.0						0.0	
Westbound								
	0.0						0.0	
LTR	0.0	0.00	22.5	18.1	0.00	0.0	0.0	18.5
	0.0						0.0	
Northbound								
L	0.0	0.00	12.5	5.3	0.00	0.0	0.0	5.3
TR	0.0	0.00	12.5	8.3	0.00	0.0	0.0	9.6
	0.0						0.0	
Southbound								
L	0.0	0.00	12.5	5.9	0.00	0.0	0.0	6.3
TR	0.0	0.00	12.5	6.0	0.00	0.0	0.0	6.1
	0.0						0.0	

Intersection Delay 10.2 sec/veh Intersection LOS B

BACK OF QUEUE WORKSHEET

	Eastbound	Westbound	Northbound	Southbound
LaneGroup	LTR	LTR	L TR	L TR
Init Queue	0.0	0.0	0.0 0.0	0.0 0.0
Flow Rate	98	105	14 692	64 249
So	1900	1900	1900 1900	1900 1900
No.Lanes	0 1 0	0 1 0	1 1 0	1 1 0
SL	1332	1510	1126 1851	522 1821
LnCapacity	333	378	657 1080	304 1062
Flow Ratio	0.1	0.1	0.0 0.4	0.1 0.1
v/c Ratio	0.29	0.28	0.02 0.64	0.21 0.23
Grn Ratio	0.25	0.25	0.58 0.58	0.58 0.58
I Factor	1.000	1.000	1.000	1.000
AT or PVG	3	3	3 3	3 3
Pltn Ratio	1.00	1.00	1.00 1.00	1.00 1.00
PF2	1.00	1.00	1.00 1.00	1.00 1.00
Q1	1.3	1.4	0.1 7.7	0.5 2.0
kB	0.3	0.3	0.4 0.6	0.3 0.6
Q2	0.1	0.1	0.0 1.0	0.1 0.2
Q Average	1.4	1.5	0.1 8.7	0.6 2.2
Q Spacing	25.0	25.0	25.0 25.0	25.0 25.0
Q Storage	0	0	0 0	0 0
Q S Ratio				
70th Percentile Output:				
fB%	1.2	1.2	1.2 1.2	1.2 1.2
BOQ	1.7	1.8	0.1 10.2	0.7 2.6
QSRatio				
85th Percentile Output:				
fB%	1.6	1.6	1.6 1.5	1.6 1.6
BOQ	2.3	2.4	0.2 13.2	0.9 3.4
QSRatio				
90th Percentile Output:				
fB%	1.8	1.8	1.8 1.7	1.8 1.8
BOQ	2.5	2.7	0.2 14.4	1.0 3.8
QSRatio				
95th Percentile Output:				
fB%	2.1	2.1	2.1 1.9	2.1 2.0
BOQ	3.0	3.1	0.2 16.2	1.2 4.4
QSRatio				
98th Percentile Output:				
fB%	2.6	2.6	2.7 2.2	2.7 2.5
BOQ	3.7	4.0	0.3 19.2	1.5 5.5
QSRatio				

ERROR MESSAGES

No errors to report.

Highway Capacity Analysis: Calumet Avenue and Subdivision Entrance (Traffic Signal Control) PM

APPENDIX 20

HCS+: Signalized Intersections Release 5.4

Analyst:
Agency:
Date: 2/13/2016
Period: PM Peak
Project ID: Existing conditions
E/W St: subdivision entrance

Inter.:
Area Type: All other areas
Jurisd:
Year :

N/S St: calumet Avenue

SIGNALIZED INTERSECTION SUMMARY

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
No. Lanes	0	1	0	0	1	0	1	1	0	1	1	0
LGConfig		LTR			LTR		L	TR		L	TR	
Volume	51	1	23	39	1	92	29	258	33	76	588	68
Lane Width		12.0			12.0		12.0	12.0		12.0	12.0	
RTOR Vol			0			0			0			0

Duration 1.00 Area Type: All other areas

Signal Operations

Phase Combination		1	2	3	4			5	6	7	8
EB	Left	A				NB	Left	A			
	Thru	A					Thru	A			
	Right	A					Right	A			
	Peds						Peds				
WB	Left	A				SB	Left	A			
	Thru	A					Thru	A			
	Right	A					Right	A			
	Peds						Peds				
NB	Right					EB	Right				
SB	Right					WB	Right				
Green		15.0						35.0			
Yellow		4.0						4.0			
All Red		1.0						1.0			

Cycle Length: 60.0 secs

Intersection Performance Summary

Appr/ Lane Grp	Lane Group Capacity	Adj Sat Flow Rate (s)	Ratios v/c	Ratios g/C	Lane Group Delay	Lane Group LOS	Approach Delay	Approach LOS
Eastbound								
LTR	335	1339	0.24	0.25	18.3	B	18.3	B
Westbound								
LTR	377	1508	0.38	0.25	19.3	B	19.3	B
Northbound								
L	289	495	0.11	0.58	5.7	A		
TR	1068	1831	0.30	0.58	6.5	A	6.4	A
Southbound								
L	612	1049	0.14	0.58	5.8	A		
TR	1070	1834	0.67	0.58	10.1	B	9.7	A

Intersection Delay = 10.4 (sec/veh) Intersection LOS = B

Phone: Fax:
E-Mail:

OPERATIONAL ANALYSIS

Analyst:
Agency/Co.:
Date Performed: 2/13/2016
Analysis Time Period: PM Peak
Intersection:
Area Type: All other areas
Jurisdiction:
Analysis Year:
Project ID: Existing conditions
E/W St: subdivision entrance N/S St: calumet Avenue

VOLUME DATA

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Volume	51	1	23	39	1	92	29	258	33	76	588	68
% Heavy Veh	2	2	2	2	2	2	2	2	2	2	2	2
PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
PK 15 Vol	14	1	6	11	1	25	8	70	9	21	160	18
Hi Ln Vol												
% Grade		0			0			0			0	
Ideal Sat		1900			1900		1900	1900		1900	1900	
ParkExist												
NumPark												
No. Lanes	0	1	0	0	1	0	1	1	0	1	1	0
LGConfig		LTR			LTR		L	TR		L	TR	
Lane Width		12.0			12.0		12.0	12.0		12.0	12.0	
RTOR Vol			0			0			0			0
Adj Flow		81			143		32	316		83	713	
%InSharedLn												
Prop LTs		0.679			0.294		1.000	0.000		1.000	0.000	
Prop RTs	0.309			0.699			0.114			0.104		
Peds Bikes	0			0			0			0		
Buses		0			0		0	0		0	0	
%InProtPhase												

Duration 1.00 Area Type: All other areas

OPERATING PARAMETERS

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Init Unmet		0.0			0.0		0.0	0.0		0.0	0.0	
Arriv. Type		3			3		3	3		3	3	
Unit Ext.		3.0			3.0		3.0	3.0		3.0	3.0	
I Factor		1.000			1.000			1.000			1.000	
Lost Time		2.0			2.0		2.0	2.0		2.0	2.0	
Ext of g		2.0			2.0		2.0	2.0		2.0	2.0	
Ped Min g		3.2			3.2			3.2			3.2	

PHASE DATA

Phase Combination		1	2	3	4	5	6	7	8
EB	Left	A				NB Left	A		
	Thru	A				Thru	A		
	Right	A				Right	A		
	Peds					Peds			
WB	Left	A				SB Left	A		
	Thru	A				Thru	A		
	Right	A				Right	A		
	Peds					Peds			
NB	Right					EB Right			
SB	Right					WB Right			
Green		15.0					35.0		
Yellow		4.0					4.0		
All Red		1.0					1.0		

Cycle Length: 60.0 secs

VOLUME ADJUSTMENT AND SATURATION FLOW WORKSHEET

Volume Adjustment

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Volume, V	51	1	23	39	1	92	29	258	33	76	588	68
PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj flow	55	1	25	42	1	100	32	280	36	83	639	74
No. Lanes	0	1	0	0	1	0	1	1	0	1	1	0
Lane group		LTR			LTR		L	TR		L	TR	
Adj flow		81			143		32	316		83	713	
Prop LTs		0.679			0.294		1.000	0.000		1.000	0.000	
Prop RTs		0.309			0.699			0.114			0.104	

Saturation Flow Rate (see Exhibit 16-7 to determine the adjustment factors)

	Eastbound			Westbound		Northbound			Southbound		
LG	LTR			LTR		L	TR		L	TR	
So	1900			1900		1900	1900		1900	1900	
Lanes 0	1	0	0	1	0	1	1	0	1	1	0
fW	1.000			1.000		1.000	1.000		1.000	1.000	
fHV	0.980			0.980		0.980	0.980		0.980	0.980	
fG	1.000			1.000		1.000	1.000		1.000	1.000	
fP	1.000			1.000		1.000	1.000		1.000	1.000	
fBB	1.000			1.000		1.000	1.000		1.000	1.000	
fA	1.000			1.000		1.000	1.000		1.000	1.000	
fLU	1.000			1.000		1.000	1.000		1.000	1.000	
fRT	0.958			0.906			0.983			0.984	
fLT	0.750			0.894		0.266	1.000		0.563	1.000	
Sec.											
fLpb	1.000			1.000		1.000	1.000		1.000	1.000	
fRpb	1.000			1.000			1.000			1.000	
S	1339			1508		495	1831		1049	1834	
Sec.											

CAPACITY AND LOS WORKSHEET

Capacity Analysis and Lane Group Capacity

Appr/ Mvmt	Lane Group	Adj Flow Rate (v)	Adj Sat Flow Rate (s)	Flow Ratio (v/s)	Green Ratio (g/C)	--Lane Group-- Capacity (c)	v/c Ratio
Eastbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru	LTR	81	1339	0.06	0.25	335	0.24
Right							
Westbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru	LTR	143	1508	# 0.09	0.25	377	0.38
Right							
Northbound							
Prot							
Perm							
Left	L	32	495	0.06	0.58	289	0.11
Prot							
Perm							
Thru	TR	316	1831	0.17	0.58	1068	0.30
Right							
Southbound							
Prot							
Perm							
Left	L	83	1049	0.08	0.58	612	0.14
Prot							
Perm							
Thru	TR	713	1834	# 0.39	0.58	1070	0.67
Right							

Sum of flow ratios for critical lane groups, Yc = Sum (v/s) = 0.48
Total lost time per cycle, L = 10.00 sec
Critical flow rate to capacity ratio, Xc = (Yc)(C)/(C-L) = 0.58

Control Delay and LOS Determination

Appr/ Lane Grp	Ratios v/c	Ratios g/C	Unf Del d1	Prog Adj Fact	Lane Grp Cap	Incremental Factor k	Incremental Del d2	Res Del d3	Lane Group Delay	Lane Group LOS	Approach Delay	Approach LOS
Eastbound												
LTR	0.24	0.25	18.0	1.000	335	0.11	0.4	0.0	18.3	B	18.3	B
Westbound												
LTR	0.38	0.25	18.6	1.000	377	0.11	0.6	0.0	19.3	B	19.3	B
Northbound												
L	0.11	0.58	5.6	1.000	289	0.11	0.2	0.0	5.7	A		
TR	0.30	0.58	6.3	1.000	1068	0.11	0.2	0.0	6.5	A	6.4	A
Southbound												
L	0.14	0.58	5.7	1.000	612	0.11	0.1	0.0	5.8	A		
TR	0.67	0.58	8.5	1.000	1070	0.24	1.6	0.0	10.1	B	9.7	A

Intersection delay = 10.4 (sec/veh) Intersection LOS = B

SUPPLEMENTAL PERMITTED LT WORKSHEET
for exclusive lefts

Input	EB	WB	NB	SB
Opposed by Single(S) or Multiple(M) lane approach				
Cycle length, C 60.0 sec				
Total actual green time for LT lane group, G (s)			35.0	35.0
Effective permitted green time for LT lane group, g(s)			35.0	35.0
Opposing effective green time, go (s)			35.0	35.0
Number of lanes in LT lane group, N			1	1
Number of lanes in opposing approach, No			1	1
Adjusted LT flow rate, VLT (veh/h)			32	83
Proportion of LT in LT lane group, PLT			1.000	1.000
Proportion of LT in opposing flow, PLTo			0.00	0.00
Adjusted opposing flow rate, Vo (veh/h)			713	316
Lost time for LT lane group, tL			5.00	5.00
Computation				
LT volume per cycle, LTC=VLTC/3600			0.53	1.38
Opposing lane util. factor, fLUo	1.000	1.000	1.000	1.000
Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)			11.88	5.27
gf=G[exp(- a * (LTC ** b))]-tl, gf<=g			0.0	0.0
Opposing platoon ratio, Rpo (refer Exhibit 16-11)			1.00	1.00
Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]			0.42	0.42
gq, (see Exhibit C16-4,5,6,7,8)			11.40	0.32
gu=g-gq if gq>=gf, or = g-gf if gq<gf			23.60	34.68
n=Max(gq-gf)/2,0)			5.70	0.16
PTHo=1-PLTo			1.00	1.00
PL*=PLT[1+(N-1)g/(gf+gu/EL1+4.24)]			1.00	1.00
EL1 (refer to Exhibit C16-3)			2.54	1.76
EL2=Max((1-Ptho**n)/Plto, 1.0)				
fmin=2(1+PL)/g or fmin=2(1+Pl)/g			0.11	0.11
gdiff=max(gq-gf,0)			0.00	0.00
fm=[gf/g]+[gu/g]/[1+PL(EL1-1)], (min=fmin;max=1.00)			0.27	0.56
flt=fm=[gf/g]+[gu/g]/[1+PL(EL1-1)]+[gdiff/g]/[1+PL(EL2-1)],(fmin<=fm<=1.00)				
or flt=[fm+0.91(N-1)]/N**				
Left-turn adjustment, fLT			0.266	0.563

For special case of single-lane approach opposed by multilane approach, see text.

* If Pl>=1 for shared left-turn lanes with N>1, then assume de-facto left-turn lane and redo calculations.

** For permitted left-turns with multiple exclusive left-turn lanes, flt=fm.

For special case of multilane approach opposed by single-lane approach or when gf>gq, see text.

SUPPLEMENTAL PERMITTED LT WORKSHEET
for shared lefts

Input	EB	WB	NB	SB
Opposed by Single(S) or Multiple(M) lane approach				
Cycle length, C 60.0 sec				
Total actual green time for LT lane group, G (s)	15.0	15.0		
Effective permitted green time for LT lane group, g(s)	15.0	15.0		
Opposing effective green time, go (s)	15.0	15.0		
Number of lanes in LT lane group, N	1	1		

Number of lanes in opposing approach, No	1	1		
Adjusted LT flow rate, VLT (veh/h)	55	42		
Proportion of LT in LT lane group, PLT	0.679	0.294	0.000	0.000
Proportion of LT in opposing flow, PLTo	0.29	0.68		
Adjusted opposing flow rate, Vo (veh/h)	143	81		
Lost time for LT lane group, tL	5.00	5.00		
Computation				
LT volume per cycle, LTC=VLTC/3600	0.92	0.70		
Opposing lane util. factor, fLUo	1.000	1.000	1.000	1.000
Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)	2.38	1.35		
gf=G[exp(- a * (LTC ** b))]-tl, gf<=g	1.6	2.5		
Opposing platoon ratio, Rpo (refer Exhibit 16-11)	1.00	1.00		
Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]	0.75	0.75		
gq, (see Exhibit C16-4,5,6,7,8)	2.06	0.00		
gu=g-gq if gq>=gf, or = g-gf if gq<gf	12.94	12.46		
n=Max(gq-gf)/2,0)	0.21	0.00		
PTHo=1-PLTo	0.71	0.32		
PL*=PLT[1+(N-1)g/(gf+gu/EL1+4.24)]	0.68	0.29		
EL1 (refer to Exhibit C16-3)	1.60	1.50		
EL2=Max((1-Ptho**n)/Plto, 1.0)	1.00	1.00		
fmin=2(1+PL)/g or fmin=2(1+Pl)/g	0.22	0.17		
gdiff=max(gq-gf,0)	0.42	0.00		
fm=[gf/g]+[gu/g]/[1+PL(EL1-1)], (min=fmin;max=1.00)	0.75	0.89		
flt=fm=[gf/g]+[gu/g]/[1+PL(EL1-1)]+[gdiff/g]/[1+PL(EL2-1)],(fmin<=fm<=1.00)				
or flt=[fm+0.91(N-1)]/N**				
Left-turn adjustment, fLT	0.750	0.894		

For special case of single-lane approach opposed by multilane approach, see text.

* If Pl>=1 for shared left-turn lanes with N>1, then assume de-facto left-turn lane and redo calculations.

** For permitted left-turns with multiple exclusive left-turn lanes, flt=fm.

For special case of multilane approach opposed by single-lane approach or when gf>gq, see text.

SUPPLEMENTAL PEDESTRIAN-BICYCLE EFFECTS WORKSHEET

Permitted Left Turns	EB	WB	NB	SB
Effective pedestrian green time, gp (s)				
Conflicting pedestrian volume, Vped (p/h)				
Pedestrian flow rate, Vpedg (p/h)				
OCCpedg				
Opposing queue clearing green, gq (s)				
Eff. ped. green consumed by opp. veh. queue, gq/gp				
OCCpedu				
Opposing flow rate, Vo (veh/h)				
OCCr				
Number of cross-street receiving lanes, Nrec				
Number of turning lanes, Nturn				
ApbT				
Proportion of left turns, PLT				
Proportion of left turns using protected phase, PLTA				
Left-turn adjustment, fLpb				
Permitted Right Turns				
Effective pedestrian green time, gp (s)				
Conflicting pedestrian volume, Vped (p/h)				
Conflicting bicycle volume, Vbic (bicycles/h)				
Vpedg				
OCCpedg				
Effective green, g (s)				
Vbicg				

OCCbicg
OCCr
Number of cross-street receiving lanes, Nrec
Number of turning lanes, Nturn
ApbT
Proportion right-turns, PRT
Proportion right-turns using protected phase, PRTA
Right turn adjustment, fRpb

SUPPLEMENTAL UNIFORM DELAY WORKSHEET

			EBLT	WBLT	NBLT	SBLT
Cycle length, C	60.0	sec				
Adj. LT vol from Vol Adjustment Worksheet, v						
v/c ratio from Capacity Worksheet, X						
Protected phase effective green interval, g (s)						
Opposing queue effective green interval, gq						
Unopposed green interval, gu						
Red time r=(C-g-gq-gu)						
Arrival rate, qa=v/(3600(max[X,1.0]))						
Protected ph. departure rate, Sp=s/3600						
Permitted ph. departure rate, Ss=s(gq+gu)/(gu*3600)						
XPerm						
XProt						
Case						
Queue at beginning of green arrow, Qa						
Queue at beginning of unsaturated green, Qu						
Residual queue, Qr						
Uniform Delay, d1						

DELAY/LOS WORKSHEET WITH INITIAL QUEUE

Appr/ Lane Group	Initial Unmet Demand Q veh	Dur. Unmet Demand t hrs.	Uniform Delay Unadj. ds	Uniform Delay Adj. d1 sec	Initial Queue Param. u	Final Unmet Demand Q veh	Initial Queue Delay d3 sec	Lane Group Delay d sec
Eastbound								
	0.0						0.0	
LTR	0.0	0.00	22.5	18.0	0.00	0.0	0.0	18.3
	0.0						0.0	
Westbound								
	0.0						0.0	
LTR	0.0	0.00	22.5	18.6	0.00	0.0	0.0	19.3
	0.0						0.0	
Northbound								
L	0.0	0.00	12.5	5.6	0.00	0.0	0.0	5.7
TR	0.0	0.00	12.5	6.3	0.00	0.0	0.0	6.5
	0.0						0.0	
Southbound								
L	0.0	0.00	12.5	5.7	0.00	0.0	0.0	5.8
TR	0.0	0.00	12.5	8.5	0.00	0.0	0.0	10.1
	0.0						0.0	

Intersection Delay 10.4 sec/veh Intersection LOS B

BACK OF QUEUE WORKSHEET

	Eastbound	Westbound	Northbound	Southbound
LaneGroup	LTR	LTR	L TR	L TR
Init Queue	0.0	0.0	0.0 0.0	0.0 0.0
Flow Rate	81	143	32 316	83 713
So	1900	1900	1900 1900	1900 1900
No.Lanes	0 1 0	0 1 0	1 1 0	1 1 0
SL	1339	1508	495 1831	1049 1834
LnCapacity	335	377	289 1068	612 1070
Flow Ratio	0.1	0.1	0.1 0.2	0.1 0.4
v/c Ratio	0.24	0.38	0.11 0.30	0.14 0.67
Grn Ratio	0.25	0.25	0.58 0.58	0.58 0.58
I Factor	1.000	1.000	1.000	1.000
AT or PVG	3	3	3 3	3 3
Pltn Ratio	1.00	1.00	1.00 1.00	1.00 1.00
PF2	1.00	1.00	1.00 1.00	1.00 1.00
Q1	1.1	2.0	0.2 2.7	0.6 8.1
kB	0.3	0.3	0.3 0.6	0.4 0.6
Q2	0.1	0.2	0.0 0.2	0.1 1.1
Q Average	1.2	2.2	0.3 2.9	0.7 9.2
Q Spacing	25.0	25.0	25.0 25.0	25.0 25.0
Q Storage	0	0	0 0	0 0
Q S Ratio				
70th Percentile Output:				
fB%	1.2	1.2	1.2 1.2	1.2 1.2
BOQ	1.4	2.6	0.3 3.4	0.8 10.9
QSRatio				
85th Percentile Output:				
fB%	1.6	1.6	1.6 1.6	1.6 1.5
BOQ	1.9	3.4	0.4 4.5	1.1 14.0
QSRatio				
90th Percentile Output:				
fB%	1.8	1.8	1.8 1.7	1.8 1.7
BOQ	2.1	3.8	0.5 5.0	1.2 15.2
QSRatio				
95th Percentile Output:				
fB%	2.1	2.0	2.1 2.0	2.1 1.9
BOQ	2.4	4.4	0.6 5.8	1.4 17.1
QSRatio				
98th Percentile Output:				
fB%	2.6	2.5	2.7 2.5	2.6 2.2
BOQ	3.1	5.5	0.7 7.2	1.8 20.2
QSRatio				

ERROR MESSAGES

No errors to report.

Highway Capacity Analysis: Calumet Avenue and Subdivision Entrance, (Roundabout) AM

APPENDIX 21

HCS 2010 Roundabouts 6.1

Phone: Fax:
E-Mail:

ROUNDABOUT ANALYSIS

Analyst:
Agency/Co.:
Date Performed: 2/15/2016
Analysis Time Period: AM peak
Intersection:
Jurisdiction:
Units: U. S. Customary
Analysis Year:
Project ID: existing plus site
East/West Street: subdivision entrance
North/South Street: Calumet

Volume Adjustments and Site Characteristics

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Volume	63	1	27	29	0	66	13	611	26	59	195	34
U-Turn Vol	0			0			0			0		
% Thrus Left Lane												

	Eastbound			Westbound			Northbound			Southbound		
	Left	Right	BP	Left	Right	BP	Left	Right	BP	Left	Right	BP
Lane Assn.	LTR			LTR			LTR			LTR		
RT Bypass			0			0			0			0
PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
%HV	1	1	1	1	1	1	1	1	1	1	1	1
NumPeds	0			0			0			0		
U-Turn PHF	1.00			1.00			1.00			1.00		
U-Turn %HV	1			1			1			1		
Flow Rate	69	1	30	32	0	72	14	671	29	65	214	37
No. Lanes	0	1	0	0	1	0	0	1	0	0	1	0
Cnfl. Lanes	1			1			1			1		

Duration, T 1.00 hrs.

Critical and Follow-Up Headway Adjustment

	Eastbound		Westbound		Northbound		Southbound	
Crit. Hdwy	5.1929	5.1929	5.1929		5.1929	5.1929	5.1929	
Flup. Hdwy	3.1858	3.1858	3.1858		3.1858	3.1858	3.1858	

Flow Computations

	Eastbound	Westbound	Northbound	Southbound
Circ. Flow	311	754	135	46
Exit. Flow	95	51	812	276

Capacity and Level of Service

	Eastbound			Westbound			Northbound			Southbound		
	Left	Right	BP	Left	Right	BP	Left	Right	BP	Left	Right	BP
Entry Flow		100			104			714			316	
Entry Cap.		828			532			987			1079	
Volume (vph)		99			103			707			313	
Cap. (vph)		820			527			977			1068	

v/c Ratio	0.12	0.20	0.72	0.29
Critical Lane	*	*	*	*
Lane Delay	5.6	9.5	16.8	6.2
Lane LOS	A	A	C	A
95 % Queue	0.4	0.7	7.4	1.2
Approach:				
Delay	5.60	9.47	16.77	6.23
LOS	A	A	C	A

Intersection Delay 12.55 Intersection LOS B

Highway Capacity Analysis: Calumet Avenue and Subdivision Entrance, (Roundabout) PM

APPENDIX 22

HCS 2010 Roundabouts 6.1

Phone:
Fax:
E-Mail:

ROUNDABOUT ANALYSIS

Analyst:
Agency/Co.:
Date Performed: 2/15/2016
Analysis Time Period: PM peak
Intersection:
Jurisdiction:
Units: U. S. Customary
Analysis Year:
Project ID: existing plus site
East/West Street: subdivision entrance
North/South Street: Calumet

Volume Adjustments and Site Characteristics

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Volume	51	0	23	39	0	92	29	258	33	76	588	68
U-Turn Vol	0			0			0			0		
% Thrus Left Lane												

	Eastbound			Westbound			Northbound			Southbound		
	Left	Right	BP	Left	Right	BP	Left	Right	BP	Left	Right	BP
Lane Assn.	LTR			LTR			LTR			LTR		
RT Bypass			0			0			0			0
PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
%HV	1	1	1	1	1	1	1	1	1	1	1	1
NumPeds	0			0			0			0		
U-Turn PHF	1.00			1.00			1.00			1.00		
U-Turn %HV	1			1			1			1		
Flow Rate	56	0	25	43	0	101	32	283	36	83	646	75
No. Lanes	0	1	0	0	1	0	0	1	0	0	1	0
Cnfl. Lanes	1			1			1			1		

Duration, T 1.00 hrs.

Critical and Follow-Up Headway Adjustment

	Eastbound		Westbound		Northbound		Southbound	
Crit. Hdwy	5.1929	5.1929	5.1929		5.1929	5.1929	5.1929	
Flup. Hdwy	3.1858	3.1858	3.1858		3.1858	3.1858	3.1858	

Flow Computations

	Eastbound	Westbound	Northbound	Southbound
Circ. Flow	772	371	139	75
Exit. Flow	119	107	440	714

Capacity and Level of Service

	Eastbound			Westbound			Northbound			Southbound		
	Left	Right	BP	Left	Right	BP	Left	Right	BP	Left	Right	BP
Entry Flow		81			144			351			804	
Entry Cap.		522			780			983			1048	
Volume (vph)		80			143			348			796	
Cap. (vph)		517			772			973			1038	

v/c Ratio	0.16	0.18	0.36	0.77
Critical Lane	*	*	*	*
Lane Delay	9.0	6.6	7.5	18.4
Lane LOS	A	A	A	C
95 % Queue	0.5	0.7	1.7	9.2
Approach:				
Delay	9.02	6.64	7.54	18.42
LOS	A	A	A	C

Intersection Delay 13.87 Intersection LOS B

Highway Capacity Analysis: Calumet Avenue and Subdivision Entrance, Future Conditions (Traffic Signal Control) AM

APPENDIX 23

HCS+: Signalized Intersections Release 5.4

Analyst:
Agency:
Date: 2/13/2016
Period: AM Peak
Project ID: Future traffic
E/W St: subdivision entrance

Inter.:
Area Type: All other areas
Jurisd:
Year :

N/S St: calumet Avenue

SIGNALIZED INTERSECTION SUMMARY

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
No. Lanes	0	1	0	0	1	0	1	1	0	1	1	0
LGConfig		LTR			LTR		L	TR		L	TR	
Volume	63	1	27	29	1	66	13	745	26	59	238	34
Lane Width		12.0			12.0		12.0	12.0		12.0	12.0	
RTOR Vol			0			0			0			0

Duration 1.00 Area Type: All other areas

Signal Operations

Phase Combination		1	2	3	4			5	6	7	8
EB	Left	A				NB	Left	A			
	Thru	A					Thru	A			
	Right	A					Right	A			
	Peds						Peds				
WB	Left	A				SB	Left	A			
	Thru	A					Thru	A			
	Right	A					Right	A			
	Peds						Peds				
NB	Right					EB	Right				
SB	Right					WB	Right				
Green		15.0						35.0			
Yellow		4.0						4.0			
All Red		1.0						1.0			

Cycle Length: 60.0 secs

Intersection Performance Summary

Appr/ Lane Grp	Lane Group Capacity	Adj Sat Flow Rate (s)	Ratios v/c	Ratios g/C	Lane Group Delay	Lane Group LOS	Approach Delay	Approach LOS
Eastbound								
LTR	333	1332	0.29	0.25	18.7	B	18.7	B
Westbound								
LTR	378	1510	0.28	0.25	18.5	B	18.5	B
Northbound								
L	629	1079	0.02	0.58	5.3	A		
TR	1081	1853	0.78	0.58	13.2	B	13.1	B
Southbound								
L	198	340	0.32	0.58	7.4	A		
TR	1066	1828	0.28	0.58	6.4	A	6.5	A

Intersection Delay = 12.2 (sec/veh) Intersection LOS = B

Phone: Fax:
E-Mail:

OPERATIONAL ANALYSIS

Analyst:
Agency/Co.:
Date Performed: 2/13/2016
Analysis Time Period: AM Peak
Intersection:
Area Type: All other areas
Jurisdiction:
Analysis Year:
Project ID: Future traffic
E/W St: subdivision entrance N/S St: calumet Avenue

VOLUME DATA

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Volume	63	1	27	29	1	66	13	745	26	59	238	34
% Heavy Veh	2	2	2	2	2	2	2	2	2	2	2	2
PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
PK 15 Vol	17	1	7	8	1	18	4	202	7	16	65	9
Hi Ln Vol												
% Grade		0			0			0			0	
Ideal Sat		1900			1900		1900	1900		1900	1900	
ParkExist												
NumPark												
No. Lanes	0	1	0	0	1	0	1	1	0	1	1	0
LGConfig		LTR			LTR		L	TR		L	TR	
Lane Width		12.0			12.0		12.0	12.0		12.0	12.0	
RTOR Vol			0			0			0			0
Adj Flow		98			105		14	838		64	296	
%InSharedLn												
Prop LTs		0.694			0.305		1.000	0.000		1.000	0.000	
Prop RTs	0.296			0.686			0.033			0.125		
Peds Bikes	0			0			0			0		
Buses		0			0		0	0		0	0	
%InProtPhase												

Duration 1.00 Area Type: All other areas

OPERATING PARAMETERS

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Init Unmet		0.0			0.0		0.0	0.0		0.0	0.0	
Arriv. Type		3			3		3	3		3	3	
Unit Ext.		3.0			3.0		3.0	3.0		3.0	3.0	
I Factor		1.000			1.000			1.000			1.000	
Lost Time		2.0			2.0		2.0	2.0		2.0	2.0	
Ext of g		2.0			2.0		2.0	2.0		2.0	2.0	
Ped Min g		3.2			3.2			3.2			3.2	

PHASE DATA

Phase Combination		1	2	3	4	5	6	7	8
EB	Left	A				NB Left	A		
	Thru	A				Thru	A		
	Right	A				Right	A		
	Peds					Peds			
WB	Left	A				SB Left	A		
	Thru	A				Thru	A		
	Right	A				Right	A		
	Peds					Peds			
NB	Right					EB Right			
SB	Right					WB Right			
Green		15.0					35.0		
Yellow		4.0					4.0		
All Red		1.0					1.0		

Cycle Length: 60.0 secs

VOLUME ADJUSTMENT AND SATURATION FLOW WORKSHEET

Volume Adjustment

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Volume, V	63	1	27	29	1	66	13	745	26	59	238	34
PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj flow	68	1	29	32	1	72	14	810	28	64	259	37
No. Lanes	0	1	0	0	1	0	1	1	0	1	1	0
Lane group		LTR			LTR		L	TR		L	TR	
Adj flow		98			105		14	838		64	296	
Prop LTs		0.694			0.305		1.000	0.000		1.000	0.000	
Prop RTs		0.296			0.686			0.033			0.125	

Saturation Flow Rate (see Exhibit 16-7 to determine the adjustment factors)

	Eastbound			Westbound		Northbound			Southbound		
LG	LTR			LTR		L	TR		L	TR	
So	1900			1900		1900	1900		1900	1900	
Lanes	0 1	0	0	1	0	1	1	0	1	1	0
fW	1.000			1.000		1.000	1.000		1.000	1.000	
fHV	0.980			0.980		0.980	0.980		0.980	0.980	
fG	1.000			1.000		1.000	1.000		1.000	1.000	
fP	1.000			1.000		1.000	1.000		1.000	1.000	
fBB	1.000			1.000		1.000	1.000		1.000	1.000	
fA	1.000			1.000		1.000	1.000		1.000	1.000	
fLU	1.000			1.000		1.000	1.000		1.000	1.000	
fRT	0.960			0.907			0.995			0.981	
fLT	0.745			0.893		0.579	1.000		0.183	1.000	
Sec.											
fLpb	1.000			1.000		1.000	1.000		1.000	1.000	
fRpb	1.000			1.000			1.000			1.000	
S	1332			1510		1079	1853		340	1828	
Sec.											

CAPACITY AND LOS WORKSHEET

Capacity Analysis and Lane Group Capacity

Appr/ Mvmt	Lane Group	Adj Flow Rate (v)	Adj Sat Flow Rate (s)	Flow Ratio (v/s)	Green Ratio (g/C)	--Lane Group-- Capacity (c)	v/c Ratio
Eastbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru	LTR	98	1332	# 0.07	0.25	333	0.29
Right							
Westbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru	LTR	105	1510	0.07	0.25	378	0.28
Right							
Northbound							
Prot							
Perm							
Left	L	14	1079	0.01	0.58	629	0.02
Prot							
Perm							
Thru	TR	838	1853	# 0.45	0.58	1081	0.78
Right							
Southbound							
Prot							
Perm							
Left	L	64	340	0.19	0.58	198	0.32
Prot							
Perm							
Thru	TR	296	1828	0.16	0.58	1066	0.28
Right							

Sum of flow ratios for critical lane groups, Yc = Sum (v/s) = 0.53
Total lost time per cycle, L = 10.00 sec
Critical flow rate to capacity ratio, Xc = (Yc)(C)/(C-L) = 0.63

Control Delay and LOS Determination

Appr/ Lane Grp	Ratios v/c	Ratios g/C	Unf Del d1	Prog Adj Fact	Lane Grp Cap	Incremental Factor k	Incremental Del d2	Res Del d3	Lane Group Delay	Lane Group LOS	Approach Delay	Approach LOS
Eastbound												
LTR	0.29	0.25	18.2	1.000	333	0.11	0.5	0.0	18.7	B	18.7	B
Westbound												
LTR	0.28	0.25	18.1	1.000	378	0.11	0.4	0.0	18.5	B	18.5	B
Northbound												
L	0.02	0.58	5.3	1.000	629	0.11	0.0	0.0	5.3	A		
TR	0.78	0.58	9.5	1.000	1081	0.32	3.7	0.0	13.2	B	13.1	B
Southbound												
L	0.32	0.58	6.4	1.000	198	0.11	1.0	0.0	7.4	A		
TR	0.28	0.58	6.2	1.000	1066	0.11	0.1	0.0	6.4	A	6.5	A

Intersection delay = 12.2 (sec/veh) Intersection LOS = B

SUPPLEMENTAL PERMITTED LT WORKSHEET
for exclusive lefts

Input	EB	WB	NB	SB
Opposed by Single(S) or Multiple(M) lane approach				
Cycle length, C 60.0 sec				
Total actual green time for LT lane group, G (s)			35.0	35.0
Effective permitted green time for LT lane group, g(s)			35.0	35.0
Opposing effective green time, go (s)			35.0	35.0
Number of lanes in LT lane group, N			1	1
Number of lanes in opposing approach, No			1	1
Adjusted LT flow rate, VLT (veh/h)			14	64
Proportion of LT in LT lane group, PLT			1.000	1.000
Proportion of LT in opposing flow, PLTo			0.00	0.00
Adjusted opposing flow rate, Vo (veh/h)			296	838
Lost time for LT lane group, tL			5.00	5.00
Computation				
LT volume per cycle, LTC=VLTC/3600			0.23	1.07
Opposing lane util. factor, fLUo	1.000	1.000	1.000	1.000
Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)			4.93	13.97
gf=G[exp(- a * (LTC ** b))]-tl, gf<=g			0.0	0.0
Opposing platoon ratio, Rpo (refer Exhibit 16-11)			1.00	1.00
Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]			0.42	0.42
gq, (see Exhibit C16-4,5,6,7,8)			0.00	16.78
gu=g-gq if gq>=gf, or = g-gf if gq<gf			35.00	18.22
n=Max(gq-gf)/2,0)			0.00	8.39
PTHo=1-PLTo			1.00	1.00
PL*=PLT[1+(N-1)g/(gf+gu/EL1+4.24)]			1.00	1.00
EL1 (refer to Exhibit C16-3)			1.73	2.85
EL2=Max((1-Ptho**n)/Plto, 1.0)				
fmin=2(1+PL)/g or fmin=2(1+Pl)/g			0.11	0.11
gdiff=max(gq-gf,0)			0.00	0.00
fm=[gf/g]+[gu/g]/[1+PL(EL1-1)], (min=fmin;max=1.00)			0.58	0.18
flt=fm=[gf/g]+[gu/g]/[1+PL(EL1-1)]+[gdiff/g]/[1+PL(EL2-1)],(fmin<=fm<=1.00)				
or flt=[fm+0.91(N-1)]/N**				
Left-turn adjustment, fLT			0.579	0.183

For special case of single-lane approach opposed by multilane approach, see text.

* If Pl>=1 for shared left-turn lanes with N>1, then assume de-facto left-turn lane and redo calculations.

** For permitted left-turns with multiple exclusive left-turn lanes, flt=fm.

For special case of multilane approach opposed by single-lane approach or when gf>gq, see text.

SUPPLEMENTAL PERMITTED LT WORKSHEET
for shared lefts

Input	EB	WB	NB	SB
Opposed by Single(S) or Multiple(M) lane approach				
Cycle length, C 60.0 sec				
Total actual green time for LT lane group, G (s)	15.0	15.0		
Effective permitted green time for LT lane group, g(s)	15.0	15.0		
Opposing effective green time, go (s)	15.0	15.0		
Number of lanes in LT lane group, N	1	1		

Number of lanes in opposing approach, No	1	1		
Adjusted LT flow rate, VLT (veh/h)	68	32		
Proportion of LT in LT lane group, PLT	0.694	0.305	0.000	0.000
Proportion of LT in opposing flow, PLTo	0.30	0.69		
Adjusted opposing flow rate, Vo (veh/h)	105	98		
Lost time for LT lane group, tL	5.00	5.00		
Computation				
LT volume per cycle, LTC=VLTC/3600	1.13	0.53		
Opposing lane util. factor, fLUo	1.000	1.000	1.000	1.000
Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)	1.75	1.63		
gf=G[exp(- a * (LTC ** b))]-tl, gf<=g	0.9	3.4		
Opposing platoon ratio, Rpo (refer Exhibit 16-11)	1.00	1.00		
Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]	0.75	0.75		
gq, (see Exhibit C16-4,5,6,7,8)	0.58	0.29		
gu=g-gq if gq>=gf, or = g-gf if gq<gf	14.08	11.59		
n=Max(gq-gf)/2,0)	0.00	0.00		
PTHo=1-PLTo	0.70	0.31		
PL*=PLT[1+(N-1)g/(gf+gu/EL1+4.24)]	0.69	0.30		
EL1 (refer to Exhibit C16-3)	1.54	1.53		
EL2=Max((1-Ptho**n)/Plto, 1.0)	1.00	1.00		
fmin=2(1+PL)/g or fmin=2(1+Pl)/g	0.23	0.17		
gdiff=max(gq-gf,0)	0.00	0.00		
fm=[gf/g]+[gu/g]/[1+PL(EL1-1)], (min=fmin;max=1.00)	0.74	0.89		
flt=fm=[gf/g]+[gu/g]/[1+PL(EL1-1)]+[gdiff/g]/[1+PL(EL2-1)],(fmin<=fm<=1.00)				
or flt=[fm+0.91(N-1)]/N**				
Left-turn adjustment, fLT	0.745	0.893		

For special case of single-lane approach opposed by multilane approach, see text.

* If Pl>=1 for shared left-turn lanes with N>1, then assume de-facto left-turn lane and redo calculations.

** For permitted left-turns with multiple exclusive left-turn lanes, flt=fm.

For special case of multilane approach opposed by single-lane approach or when gf>gq, see text.

SUPPLEMENTAL PEDESTRIAN-BICYCLE EFFECTS WORKSHEET

Permitted Left Turns	EB	WB	NB	SB
Effective pedestrian green time, gp (s)				
Conflicting pedestrian volume, Vped (p/h)				
Pedestrian flow rate, Vpedg (p/h)				
OCCpedg				
Opposing queue clearing green, gq (s)				
Eff. ped. green consumed by opp. veh. queue, gq/gp				
OCCpedu				
Opposing flow rate, Vo (veh/h)				
OCCr				
Number of cross-street receiving lanes, Nrec				
Number of turning lanes, Nturn				
ApbT				
Proportion of left turns, PLT				
Proportion of left turns using protected phase, PLTA				
Left-turn adjustment, fLpb				
Permitted Right Turns				
Effective pedestrian green time, gp (s)				
Conflicting pedestrian volume, Vped (p/h)				
Conflicting bicycle volume, Vbic (bicycles/h)				
Vpedg				
OCCpedg				
Effective green, g (s)				
Vbicg				

OCCbicg
OCCr
Number of cross-street receiving lanes, Nrec
Number of turning lanes, Nturn
ApbT
Proportion right-turns, PRT
Proportion right-turns using protected phase, PRTA
Right turn adjustment, fRpb

SUPPLEMENTAL UNIFORM DELAY WORKSHEET

			EBLT	WBLT	NBLT	SBLT
Cycle length, C	60.0	sec				
Adj. LT vol from Vol Adjustment Worksheet, v						
v/c ratio from Capacity Worksheet, X						
Protected phase effective green interval, g (s)						
Opposing queue effective green interval, gq						
Unopposed green interval, gu						
Red time r=(C-g-gq-gu)						
Arrival rate, qa=v/(3600(max[X,1.0]))						
Protected ph. departure rate, Sp=s/3600						
Permitted ph. departure rate, Ss=s(gq+gu)/(gu*3600)						
XPerm						
XProt						
Case						
Queue at beginning of green arrow, Qa						
Queue at beginning of unsaturated green, Qu						
Residual queue, Qr						
Uniform Delay, d1						

DELAY/LOS WORKSHEET WITH INITIAL QUEUE

Appr/ Lane Group	Initial Unmet Demand Q veh	Dur. Unmet Demand t hrs.	Uniform Delay Unadj. ds	Uniform Delay Adj. d1 sec	Initial Queue Param. u	Final Unmet Demand Q veh	Initial Queue Delay d3 sec	Lane Group Delay d sec
Eastbound								
	0.0						0.0	
LTR	0.0	0.00	22.5	18.2	0.00	0.0	0.0	18.7
	0.0						0.0	
Westbound								
	0.0						0.0	
LTR	0.0	0.00	22.5	18.1	0.00	0.0	0.0	18.5
	0.0						0.0	
Northbound								
L	0.0	0.00	12.5	5.3	0.00	0.0	0.0	5.3
TR	0.0	0.00	12.5	9.5	0.00	0.0	0.0	13.2
	0.0						0.0	
Southbound								
L	0.0	0.00	12.5	6.4	0.00	0.0	0.0	7.4
TR	0.0	0.00	12.5	6.2	0.00	0.0	0.0	6.4
	0.0						0.0	

Intersection Delay 12.2 sec/veh Intersection LOS B

BACK OF QUEUE WORKSHEET

	Eastbound	Westbound	Northbound	Southbound
LaneGroup	LTR	LTR	L TR	L TR
Init Queue	0.0	0.0	0.0 0.0	0.0 0.0
Flow Rate	98	105	14 838	64 296
So	1900	1900	1900 1900	1900 1900
No.Lanes	0 1 0	0 1 0	1 1 0	1 1 0
SL	1332	1510	1079 1853	340 1828
LnCapacity	333	378	629 1081	198 1066
Flow Ratio	0.1	0.1	0.0 0.5	0.2 0.2
v/c Ratio	0.29	0.28	0.02 0.78	0.32 0.28
Grn Ratio	0.25	0.25	0.58 0.58	0.58 0.58
I Factor	1.000	1.000	1.000	1.000
AT or PVG	3	3	3 3	3 3
Pltn Ratio	1.00	1.00	1.00 1.00	1.00 1.00
PF2	1.00	1.00	1.00 1.00	1.00 1.00
Q1	1.3	1.4	0.1 10.6	0.5 2.5
kB	0.3	0.3	0.4 0.6	0.2 0.6
Q2	0.1	0.1	0.0 1.9	0.1 0.2
Q Average	1.4	1.5	0.1 12.5	0.6 2.7
Q Spacing	25.0	25.0	25.0 25.0	25.0 25.0
Q Storage	0	0	0 0	0 0
Q S Ratio				
70th Percentile Output:				
fB%	1.2	1.2	1.2 1.2	1.2 1.2
BOQ	1.7	1.8	0.1 14.7	0.8 3.2
QSRatio				
85th Percentile Output:				
fB%	1.6	1.6	1.6 1.5	1.6 1.6
BOQ	2.3	2.4	0.2 18.8	1.0 4.2
QSRatio				
90th Percentile Output:				
fB%	1.8	1.8	1.8 1.6	1.8 1.8
BOQ	2.5	2.7	0.2 20.2	1.2 4.7
QSRatio				
95th Percentile Output:				
fB%	2.1	2.1	2.1 1.8	2.1 2.0
BOQ	3.0	3.1	0.2 22.6	1.3 5.4
QSRatio				
98th Percentile Output:				
fB%	2.6	2.6	2.7 2.1	2.7 2.5
BOQ	3.7	4.0	0.3 26.1	1.7 6.7
QSRatio				

ERROR MESSAGES

No errors to report.

Highway Capacity Analysis: Calumet Avenue and Subdivision Entrance, Future Conditions (Traffic Signal Control) PM

APPENDIX 24

HCS+: Signalized Intersections Release 5.4

Analyst:
Agency:
Date: 2/13/2016
Period: PM Peak
Project ID: Existing conditions plus future traffic
E/W St: subdivision entrance

Inter.:
Area Type: All other areas
Jurisd:
Year :
N/S St: calumet Avenue

SIGNALIZED INTERSECTION SUMMARY

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
No. Lanes	0	1	0	0	1	0	1	1	0	1	1	0
LGConfig		LTR			LTR		L	TR		L	TR	
Volume	51	1	23	39	1	92	29	315	33	76	717	68
Lane Width		12.0			12.0		12.0	12.0		12.0	12.0	
RTOR Vol			0			0			0			0

Duration 1.00 Area Type: All other areas

Signal Operations

Phase Combination		1	2	3	4			5	6	7	8
EB	Left	A				NB	Left	A			
	Thru	A					Thru	A			
	Right	A					Right	A			
	Peds						Peds				
WB	Left	A				SB	Left	A			
	Thru	A					Thru	A			
	Right	A					Right	A			
	Peds						Peds				
NB	Right					EB	Right				
SB	Right					WB	Right				
Green		15.0						35.0			
Yellow		4.0						4.0			
All Red		1.0						1.0			

Cycle Length: 60.0 secs

Intersection Performance Summary

Appr/ Lane Grp	Lane Group Capacity	Adj Sat Flow Rate (s)	Ratios v/c	Ratios g/C	Lane Group Delay	Lane Group LOS	Approach Delay	Approach LOS
Eastbound								
LTR	335	1339	0.24	0.25	18.3	B	18.3	B
Westbound								
LTR	377	1508	0.38	0.25	19.3	B	19.3	B
Northbound								
L	188	322	0.17	0.58	6.2	A		
TR	1071	1836	0.35	0.58	6.8	A	6.7	A
Southbound								
L	556	954	0.15	0.58	5.8	A		
TR	1073	1839	0.79	0.58	14.1	B	13.4	B

Intersection Delay = 12.4 (sec/veh) Intersection LOS = B

Phone: Fax:
E-Mail:

OPERATIONAL ANALYSIS

Analyst:
Agency/Co.:
Date Performed: 2/13/2016
Analysis Time Period: PM Peak
Intersection:
Area Type: All other areas
Jurisdiction:
Analysis Year:
Project ID: Existing conditions plus future traffic
E/W St: subdivision entrance N/S St: calumet Avenue

VOLUME DATA

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Volume	51	1	23	39	1	92	29	315	33	76	717	68
% Heavy Veh	2	2	2	2	2	2	2	2	2	2	2	2
PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
PK 15 Vol	14	1	6	11	1	25	8	86	9	21	195	18
Hi Ln Vol												
% Grade		0			0			0			0	
Ideal Sat		1900			1900		1900	1900		1900	1900	
ParkExist												
NumPark												
No. Lanes	0	1	0	0	1	0	1	1	0	1	1	0
LGConfig		LTR			LTR		L	TR		L	TR	
Lane Width		12.0			12.0		12.0	12.0		12.0	12.0	
RTOR Vol			0			0			0			0
Adj Flow		81			143		32	378		83	853	
%InSharedLn												
Prop LTs		0.679			0.294		1.000	0.000		1.000	0.000	
Prop RTs	0.309			0.699			0.095			0.087		
Peds Bikes	0			0			0			0		
Buses		0			0		0	0		0	0	
%InProtPhase												

Duration 1.00 Area Type: All other areas

OPERATING PARAMETERS

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Init Unmet		0.0			0.0		0.0	0.0		0.0	0.0	
Arriv. Type		3			3		3	3		3	3	
Unit Ext.		3.0			3.0		3.0	3.0		3.0	3.0	
I Factor		1.000			1.000			1.000			1.000	
Lost Time		2.0			2.0		2.0	2.0		2.0	2.0	
Ext of g		2.0			2.0		2.0	2.0		2.0	2.0	
Ped Min g		3.2			3.2			3.2			3.2	

PHASE DATA

Phase Combination		1	2	3	4	5	6	7	8
EB	Left	A				NB Left	A		
	Thru	A				Thru	A		
	Right	A				Right	A		
	Peds					Peds			
WB	Left	A				SB Left	A		
	Thru	A				Thru	A		
	Right	A				Right	A		
	Peds					Peds			
NB	Right					EB Right			
SB	Right					WB Right			
Green		15.0					35.0		
Yellow		4.0					4.0		
All Red		1.0					1.0		

Cycle Length: 60.0 secs

VOLUME ADJUSTMENT AND SATURATION FLOW WORKSHEET

Volume Adjustment

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Volume, V	51	1	23	39	1	92	29	315	33	76	717	68
PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj flow	55	1	25	42	1	100	32	342	36	83	779	74
No. Lanes	0	1	0	0	1	0	1	1	0	1	1	0
Lane group		LTR			LTR		L	TR		L	TR	
Adj flow		81			143		32	378		83	853	
Prop LTs		0.679			0.294		1.000	0.000		1.000	0.000	
Prop RTs		0.309			0.699			0.095			0.087	

Saturation Flow Rate (see Exhibit 16-7 to determine the adjustment factors)

	Eastbound			Westbound		Northbound			Southbound		
LG	LTR			LTR		L	TR		L	TR	
So	1900			1900		1900	1900		1900	1900	
Lanes 0	1	0	0	1	0	1	1	0	1	1	0
fW	1.000			1.000		1.000	1.000		1.000	1.000	
fHV	0.980			0.980		0.980	0.980		0.980	0.980	
fG	1.000			1.000		1.000	1.000		1.000	1.000	
fP	1.000			1.000		1.000	1.000		1.000	1.000	
fBB	1.000			1.000		1.000	1.000		1.000	1.000	
fA	1.000			1.000		1.000	1.000		1.000	1.000	
fLU	1.000			1.000		1.000	1.000		1.000	1.000	
fRT	0.958			0.906			0.986			0.987	
fLT	0.750			0.894		0.173	1.000		0.512	1.000	
Sec.											
fLpb	1.000			1.000		1.000	1.000		1.000	1.000	
fRpb	1.000			1.000			1.000			1.000	
S	1339			1508		322	1836		954	1839	
Sec.											

CAPACITY AND LOS WORKSHEET

Capacity Analysis and Lane Group Capacity

Appr/ Mvmt	Lane Group	Adj Flow Rate (v)	Adj Sat Flow Rate (s)	Flow Ratio (v/s)	Green Ratio (g/C)	--Lane Group-- Capacity (c)	v/c Ratio
Eastbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru	LTR	81	1339	0.06	0.25	335	0.24
Right							
Westbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru	LTR	143	1508	# 0.09	0.25	377	0.38
Right							
Northbound							
Prot							
Perm							
Left	L	32	322	0.10	0.58	188	0.17
Prot							
Perm							
Thru	TR	378	1836	0.21	0.58	1071	0.35
Right							
Southbound							
Prot							
Perm							
Left	L	83	954	0.09	0.58	556	0.15
Prot							
Perm							
Thru	TR	853	1839	# 0.46	0.58	1073	0.79
Right							

Sum of flow ratios for critical lane groups, Yc = Sum (v/s) = 0.56
Total lost time per cycle, L = 10.00 sec
Critical flow rate to capacity ratio, Xc = (Yc)(C)/(C-L) = 0.67

Control Delay and LOS Determination

Appr/ Lane Grp	Ratios v/c	Ratios g/C	Unf Del d1	Prog Adj Fact	Lane Grp Cap	Incremental Factor k	Incremental Del d2	Res Del d3	Lane Group Delay	Lane Group LOS	Approach Delay	Approach LOS
Eastbound												
LTR	0.24	0.25	18.0	1.000	335	0.11	0.4	0.0	18.3	B	18.3	B
Westbound												
LTR	0.38	0.25	18.6	1.000	377	0.11	0.6	0.0	19.3	B	19.3	B
Northbound												
L	0.17	0.58	5.8	1.000	188	0.11	0.4	0.0	6.2	A		
TR	0.35	0.58	6.6	1.000	1071	0.11	0.2	0.0	6.8	A	6.7	A
Southbound												
L	0.15	0.58	5.7	1.000	556	0.11	0.1	0.0	5.8	A		
TR	0.79	0.58	9.7	1.000	1073	0.34	4.4	0.0	14.1	B	13.4	B

Intersection delay = 12.4 (sec/veh) Intersection LOS = B

SUPPLEMENTAL PERMITTED LT WORKSHEET
for exclusive lefts

Input	EB	WB	NB	SB
Opposed by Single(S) or Multiple(M) lane approach				
Cycle length, C 60.0 sec				
Total actual green time for LT lane group, G (s)			35.0	35.0
Effective permitted green time for LT lane group, g(s)			35.0	35.0
Opposing effective green time, go (s)			35.0	35.0
Number of lanes in LT lane group, N			1	1
Number of lanes in opposing approach, No			1	1
Adjusted LT flow rate, VLT (veh/h)			32	83
Proportion of LT in LT lane group, PLT			1.000	1.000
Proportion of LT in opposing flow, PLTo			0.00	0.00
Adjusted opposing flow rate, Vo (veh/h)			853	378
Lost time for LT lane group, tL			5.00	5.00
Computation				
LT volume per cycle, LTC=VLTC/3600			0.53	1.38
Opposing lane util. factor, fLUo	1.000	1.000	1.000	1.000
Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)			14.22	6.30
gf=G[exp(- a * (LTC ** b))]-tl, gf<=g			0.0	0.0
Opposing platoon ratio, Rpo (refer Exhibit 16-11)			1.00	1.00
Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]			0.42	0.42
gq, (see Exhibit C16-4,5,6,7,8)			17.52	1.65
gu=g-gq if gq>=gf, or = g-gf if gq<gf			17.48	33.35
n=Max(gq-gf)/2,0)			8.76	0.82
PTHo=1-PLTo			1.00	1.00
PL*=PLT[1+(N-1)g/(gf+gu/EL1+4.24)]			1.00	1.00
EL1 (refer to Exhibit C16-3)			2.89	1.86
EL2=Max((1-Ptho**n)/Plto, 1.0)				
fmin=2(1+PL)/g or fmin=2(1+Pl)/g			0.11	0.11
gdiff=max(gq-gf,0)			0.00	0.00
fm=[gf/g]+[gu/g]/[1+PL(EL1-1)], (min=fmin;max=1.00)			0.17	0.51
flt=fm=[gf/g]+[gu/g]/[1+PL(EL1-1)]+[gdiff/g]/[1+PL(EL2-1)],(fmin<=fm<=1.00)				
or flt=[fm+0.91(N-1)]/N**				
Left-turn adjustment, fLT			0.173	0.512

For special case of single-lane approach opposed by multilane approach, see text.

* If Pl>=1 for shared left-turn lanes with N>1, then assume de-facto left-turn lane and redo calculations.

** For permitted left-turns with multiple exclusive left-turn lanes, flt=fm.

For special case of multilane approach opposed by single-lane approach or when gf>gq, see text.

SUPPLEMENTAL PERMITTED LT WORKSHEET
for shared lefts

Input	EB	WB	NB	SB
Opposed by Single(S) or Multiple(M) lane approach				
Cycle length, C 60.0 sec				
Total actual green time for LT lane group, G (s)	15.0	15.0		
Effective permitted green time for LT lane group, g(s)	15.0	15.0		
Opposing effective green time, go (s)	15.0	15.0		
Number of lanes in LT lane group, N	1	1		

Number of lanes in opposing approach, No	1	1		
Adjusted LT flow rate, VLT (veh/h)	55	42		
Proportion of LT in LT lane group, PLT	0.679	0.294	0.000	0.000
Proportion of LT in opposing flow, PLTo	0.29	0.68		
Adjusted opposing flow rate, Vo (veh/h)	143	81		
Lost time for LT lane group, tL	5.00	5.00		
Computation				
LT volume per cycle, LTC=VLTC/3600	0.92	0.70		
Opposing lane util. factor, fLUo	1.000	1.000	1.000	1.000
Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)	2.38	1.35		
gf=G[exp(- a * (LTC ** b))]-tl, gf<=g	1.6	2.5		
Opposing platoon ratio, Rpo (refer Exhibit 16-11)	1.00	1.00		
Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]	0.75	0.75		
gq, (see Exhibit C16-4,5,6,7,8)	2.06	0.00		
gu=g-gq if gq>=gf, or = g-gf if gq<gf	12.94	12.46		
n=Max(gq-gf)/2,0)	0.21	0.00		
PTHo=1-PLTo	0.71	0.32		
PL*=PLT[1+(N-1)g/(gf+gu/EL1+4.24)]	0.68	0.29		
EL1 (refer to Exhibit C16-3)	1.60	1.50		
EL2=Max((1-Ptho**n)/Plto, 1.0)	1.00	1.00		
fmin=2(1+PL)/g or fmin=2(1+Pl)/g	0.22	0.17		
gdiff=max(gq-gf,0)	0.42	0.00		
fm=[gf/g]+[gu/g]/[1+PL(EL1-1)], (min=fmin;max=1.00)	0.75	0.89		
flt=fm=[gf/g]+[gu/g]/[1+PL(EL1-1)]+[gdiff/g]/[1+PL(EL2-1)],(fmin<=fm<=1.00)				
or flt=[fm+0.91(N-1)]/N**				
Left-turn adjustment, fLT	0.750	0.894		

For special case of single-lane approach opposed by multilane approach, see text.

* If Pl>=1 for shared left-turn lanes with N>1, then assume de-facto left-turn lane and redo calculations.

** For permitted left-turns with multiple exclusive left-turn lanes, flt=fm.

For special case of multilane approach opposed by single-lane approach or when gf>gq, see text.

SUPPLEMENTAL PEDESTRIAN-BICYCLE EFFECTS WORKSHEET

Permitted Left Turns	EB	WB	NB	SB
Effective pedestrian green time, gp (s)				
Conflicting pedestrian volume, Vped (p/h)				
Pedestrian flow rate, Vpedg (p/h)				
OCCpedg				
Opposing queue clearing green, gq (s)				
Eff. ped. green consumed by opp. veh. queue, gq/gp				
OCCpedu				
Opposing flow rate, Vo (veh/h)				
OCCr				
Number of cross-street receiving lanes, Nrec				
Number of turning lanes, Nturn				
ApbT				
Proportion of left turns, PLT				
Proportion of left turns using protected phase, PLTA				
Left-turn adjustment, fLpb				
Permitted Right Turns				
Effective pedestrian green time, gp (s)				
Conflicting pedestrian volume, Vped (p/h)				
Conflicting bicycle volume, Vbic (bicycles/h)				
Vpedg				
OCCpedg				
Effective green, g (s)				
Vbicg				

OCCbicg
OCCr
Number of cross-street receiving lanes, Nrec
Number of turning lanes, Nturn
ApbT
Proportion right-turns, PRT
Proportion right-turns using protected phase, PRTA
Right turn adjustment, fRpb

SUPPLEMENTAL UNIFORM DELAY WORKSHEET

			EBLT	WBLT	NBLT	SBLT
Cycle length, C	60.0	sec				
Adj. LT vol from Vol Adjustment Worksheet, v						
v/c ratio from Capacity Worksheet, X						
Protected phase effective green interval, g (s)						
Opposing queue effective green interval, gq						
Unopposed green interval, gu						
Red time r=(C-g-gq-gu)						
Arrival rate, qa=v/(3600(max[X,1.0]))						
Protected ph. departure rate, Sp=s/3600						
Permitted ph. departure rate, Ss=s(gq+gu)/(gu*3600)						
XPerm						
XProt						
Case						
Queue at beginning of green arrow, Qa						
Queue at beginning of unsaturated green, Qu						
Residual queue, Qr						
Uniform Delay, d1						

DELAY/LOS WORKSHEET WITH INITIAL QUEUE

Appr/ Lane Group	Initial Unmet Demand Q veh	Dur. Unmet Demand t hrs.	Uniform Delay Unadj. ds	Uniform Delay Adj. d1 sec	Initial Queue Param. u	Final Unmet Demand Q veh	Initial Queue Delay d3 sec	Lane Group Delay d sec
Eastbound								
	0.0						0.0	
LTR	0.0	0.00	22.5	18.0	0.00	0.0	0.0	18.3
	0.0						0.0	
Westbound								
	0.0						0.0	
LTR	0.0	0.00	22.5	18.6	0.00	0.0	0.0	19.3
	0.0						0.0	
Northbound								
L	0.0	0.00	12.5	5.8	0.00	0.0	0.0	6.2
TR	0.0	0.00	12.5	6.6	0.00	0.0	0.0	6.8
	0.0						0.0	
Southbound								
L	0.0	0.00	12.5	5.7	0.00	0.0	0.0	5.8
TR	0.0	0.00	12.5	9.7	0.00	0.0	0.0	14.1
	0.0						0.0	

Intersection Delay 12.4 sec/veh Intersection LOS B

BACK OF QUEUE WORKSHEET

	Eastbound	Westbound	Northbound	Southbound
LaneGroup	LTR	LTR	L TR	L TR
Init Queue	0.0	0.0	0.0 0.0	0.0 0.0
Flow Rate	81	143	32 378	83 853
So	1900	1900	1900 1900	1900 1900
No.Lanes	0 1 0	0 1 0	1 1 0	1 1 0
SL	1339	1508	322 1836	954 1839
LnCapacity	335	377	188 1071	556 1073
Flow Ratio	0.1	0.1	0.1 0.2	0.1 0.5
v/c Ratio	0.24	0.38	0.17 0.35	0.15 0.79
Grn Ratio	0.25	0.25	0.58 0.58	0.58 0.58
I Factor	1.000	1.000	1.000	1.000
AT or PVG	3	3	3 3	3 3
Pltn Ratio	1.00	1.00	1.00 1.00	1.00 1.00
PF2	1.00	1.00	1.00 1.00	1.00 1.00
Q1	1.1	2.0	0.2 3.3	0.6 11.0
kB	0.3	0.3	0.2 0.6	0.4 0.6
Q2	0.1	0.2	0.0 0.3	0.1 2.1
Q Average	1.2	2.2	0.3 3.6	0.7 13.2
Q Spacing	25.0	25.0	25.0 25.0	25.0 25.0
Q Storage	0	0	0 0	0 0
Q S Ratio				
70th Percentile Output:				
fB%	1.2	1.2	1.2 1.2	1.2 1.2
BOQ	1.4	2.6	0.3 4.3	0.8 15.5
QSRatio				
85th Percentile Output:				
fB%	1.6	1.6	1.6 1.6	1.6 1.5
BOQ	1.9	3.4	0.5 5.7	1.1 19.7
QSRatio				
90th Percentile Output:				
fB%	1.8	1.8	1.8 1.7	1.8 1.6
BOQ	2.1	3.8	0.5 6.3	1.2 21.2
QSRatio				
95th Percentile Output:				
fB%	2.1	2.0	2.1 2.0	2.1 1.8
BOQ	2.4	4.4	0.6 7.2	1.5 23.6
QSRatio				
98th Percentile Output:				
fB%	2.6	2.5	2.7 2.5	2.6 2.1
BOQ	3.1	5.5	0.8 8.9	1.8 27.2
QSRatio				

ERROR MESSAGES

No errors to report.

Highway Capacity Analysis: Calumet Avenue and Subdivision Entrance, , Future Conditions (Roundabout) AM

APPENDIX 25

Phone:
E-Mail:

Fax:

ROUNDABOUT ANALYSIS

Analyst:
Agency/Co.:
Date Performed: 2/15/2016
Analysis Time Period:
Intersection:
Jurisdiction:
Units: U. S. Customary
Analysis Year:
Project ID: future plus site
East/West Street: subdivision entrance
North/South Street: Calumet

Volume Adjustments and Site Characteristics

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Volume	63	1	27	29	0	66	13	745	26	59	238	34
U-Turn Vol	0			0			0			0		
% Thrus Left Lane												

	Eastbound			Westbound			Northbound			Southbound		
	Left	Right	BP	Left	Right	BP	Left	Right	BP	Left	Right	BP
Lane Assn.	LTR			LTR			LTR			LTR		
RT Bypass			0			0			0			0
PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
%HV	1	1	1	1	1	1	1	1	1	1	1	1
NumPeds	0			0			0			0		
U-Turn PHF	1.00			1.00			1.00			1.00		
U-Turn %HV	1			1			1			1		
Flow Rate	69	1	30	32	0	72	14	818	29	65	261	37
No. Lanes	0	1	0	0	1	0	0	1	0	0	1	0
Cnfl. Lanes	1			1			1			1		

Duration, T 1.00 hrs.

Critical and Follow-Up Headway Adjustment

	Eastbound		Westbound		Northbound		Southbound	
Crit. Hdwy	5.1929	5.1929	5.1929		5.1929	5.1929	5.1929	
Flup. Hdwy	3.1858	3.1858	3.1858		3.1858	3.1858	3.1858	

Flow Computations

	Eastbound	Westbound	Northbound	Southbound
Circ. Flow	358	901	135	46
Exit. Flow	95	51	959	323

Capacity and Level of Service

	Eastbound			Westbound			Northbound			Southbound		
	Left	Right	BP	Left	Right	BP	Left	Right	BP	Left	Right	BP
Entry Flow		100			104			861			363	
Entry Cap.		790			459			987			1079	
Volume (vph)		99			103			852			359	
Cap. (vph)		782			454			977			1068	

v/c Ratio	0.13	0.23	0.87	0.34
Critical Lane	*	*	*	*
Lane Delay	5.9	11.4	31.0	6.8
Lane LOS	A	B	D	A
95 % Queue	0.4	0.9	16.3	1.5
Approach:				
Delay	5.90	11.39	30.98	6.76
LOS	A	B	D	A

Intersection Delay 21.64 Intersection LOS C

Highway Capacity Analysis: Calumet Avenue and Subdivision Entrance, , Future Conditions (Roundabout) PM

APPENDIX 26

Phone:
E-Mail:
Fax:

ROUNDABOUT ANALYSIS

Analyst:
Agency/Co.:
Date Performed: 2/15/2016
Analysis Time Period: PM peak
Intersection:
Jurisdiction:
Units: U. S. Customary
Analysis Year:
Project ID: future
East/West Street: subdivision entrance
North/South Street: Calumet

Volume Adjustments and Site Characteristics

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Volume	51	0	23	39	0	92	29	314	33	76	717	68
U-Turn Vol	0			0			0			0		
% Thrus Left Lane												

	Eastbound			Westbound			Northbound			Southbound		
	Left	Right	BP	Left	Right	BP	Left	Right	BP	Left	Right	BP
Lane Assn.	LTR			LTR			LTR			LTR		
RT Bypass			0			0			0			0
PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
%HV	1	1	1	1	1	1	1	1	1	1	1	1
NumPeds	0			0			0			0		
U-Turn PHF	1.00			1.00			1.00			1.00		
U-Turn %HV	1			1			1			1		
Flow Rate	56	0	25	43	0	101	32	345	36	83	787	75
No. Lanes	0	1	0	0	1	0	0	1	0	0	1	0
Cnfl. Lanes	1			1			1			1		

Duration, T 1.00 hrs.

Critical and Follow-Up Headway Adjustment

	Eastbound		Westbound		Northbound		Southbound	
Crit. Hdwy	5.1929	5.1929	5.1929		5.1929	5.1929	5.1929	
Flup. Hdwy	3.1858	3.1858	3.1858		3.1858	3.1858	3.1858	

Flow Computations

	Eastbound	Westbound	Northbound	Southbound
Circ. Flow	913	433	139	75
Exit. Flow	119	107	502	855

Capacity and Level of Service

	Eastbound			Westbound			Northbound			Southbound		
	Left	Right	BP	Left	Right	BP	Left	Right	BP	Left	Right	BP
Entry Flow		81			144			413			945	
Entry Cap.		453			733			983			1048	
Volume (vph)		80			143			409			936	
Cap. (vph)		449			726			973			1038	

v/c Ratio	0.18	0.20	0.42	0.90
Critical Lane	*	*	*	*
Lane Delay	10.7	7.2	8.5	35.4
Lane LOS	B	A	A	E
95 % Queue	0.7	0.7	2.2	19.8
Approach:				
Delay	10.65	7.15	8.48	35.43
LOS	B	A	A	E

Intersection Delay 24.56 Intersection LOS C