vhb

Memorandum

To:	Kent Gonzales Northland Development	Date:	February 14, 2019
		Project #:	12239.00
From:	Randall C. Hart Principal Matthew Duranleau, E.I.T.	Re:	Revised Building Program and Traffic Generation Memorandum The Northland Newton Development Needham Street Newton, Massachusetts

Vanasse Hangen Brustlin, Inc. has conducted a supplemental evaluation of potential traffic generation and impacts associated with The Northland Newton Development ("The Project"). The Transportation Impact and Assessment (TIA) dated October 2018[1] and submitted to the city cites a redevelopment program of 1.9 million gross square feet (sf) of development (approximately 400 ksf of which consists of parking structures) and will retain the historic Saco Pettee mill building that was previously converted to office space. The project then included 180,000 sf of leasable office space (in the historic Saco Pettee mill building), 822 residential housing units, 237,000 sf of retail/restaurant/active use space, and approximately 1,953 parking spaces, as well as substantial public amenities such as plazas and greens, enhanced pedestrian and bicycle connections and amenities, passive open space enhancements, and a series of robust traffic demand management initiatives.

Since the project was filed, there have been significant public outreach meetings and several presentations to the City Land Use Committee in Council Chambers. Informed by these meetings, the Proponent has listened closely to comments and concerns and has been evaluating potential changes (reductions) to the proposal to better meet city expectation and desires. With that in mind, this supplemental assessment has been prepared to provide a preliminarily assessment of traffic projections associated with the project based on a revised, smaller, redevelopment plan. The modified redevelopment plan includes: 180,000 sf of leasable office space (in the historic Saco Pettee mill building; no change from existing), 800 residential housing units, 115,000 sf of retail/restaurant/active use space, and approximately 1,550 parking spaces. It should be noted that the Site under existing conditions contains 180,000 sf of office space in the existing mill building, 62,600 sf of retail space, and 257,000 sf of former manufacturing space that has been vacant for over four years. Table 1 summarizes the proposed changes in the building program.

1 Transportation Impact and Access Study; The Northland Newton Development; Newton, MA; October 2018; Prepared by VHB.

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Table 1 Changes in Building Program

Land Use	Existing Site	TIAS Building Program [a]	February 2019 Building Program	Change in Building Program
Manufacturing	257,000 sf [b]	0 sf	0 sf	**n/a**
Office	180,000 sf	180,000 sf	180,000 sf	**n/a**
Residential	0 units	822 units	800 units	**- 22 units**
Retail/Restaurant/Active Space	62,600 sf	237,000 sf	115,000 sf	**- 122,000 sf**
Community Center Space	0 sf	4,000 sf	4,000 sf	**n/a**
Parking Spaces	> 500 spaces	1,953 spaces	1,550 spaces	**- 358 spaces**

a Building Program as outlined in October 2018 TIA for the Northland Newton Development.
b The existing manufacturing space on Site has been vacant for more than four years and therefore is not included in any existing trip generation analyses.

The revised building program results in 122,000 less square feet of total proposed retail space on-Site, 22 less proposed residential units on-Site, and 403 fewer parking spaces on-Site than previously proposed. The revised building program will result in an additional 52,400 square feet of retail space on-Site as compared to the existing conditions, while the previous building program resulted in an additional 174,400 square feet of retail space on-Site as compared to the existing conditions.

An analysis of the revised program is presented below:

Traffic Generation

A comparison has been conducted between number of vehicle trips expected to be generated by the revised building program and the number of vehicle trips expected to be generated by the previous building program. A full summary of the Site-generated trips expected to be generated by the previous building program is included in the TIA and includes two sets of trip-generation estimates; one assuming a future condition with the existing mode share in the City of Newton and one assuming a robust shuttle service. To provide a conservative comparison, the trip generation rates for the revised building program have been developed assuming the existing mode shares in the City of Newton. It should be noted that the existing mode shares for the City of Newton have been updated for the revised building program from the 2010 census data to the 2015 census data, as requested in BETA Group's peer review of the TIA.

To estimate the traffic generation for the various components of the proposed site with the revised building program, data provided in the Institute of Transportation Engineers (ITE) *Trip Generation Manual* was used[2]. Specifically, the following Land Use Codes (LUC) were utilized:

- ITE LUC 710 – Office, based on 180,000 sf of floor area (existing space on site to remain)
- ITE LUC 820 – Shopping Center, based on 115,000 sf of floor area (represents 52,400 sf of additional space from that which exists today)
- ITE LUC 221 – (Mid-Rise Residential) 800 units

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2 Trip Generation Manual, 10th Edition, Institute of Transportation Engineers, Washington DC, 2017

The ITE land use codes above were used to determine the unadjusted total vehicle trips that will be generated on Site with the revised building program and ITE trip generation worksheets are included in the Attachments. Similar to the trip generation analysis summarized in the TIA, the unadjusted total peak hour vehicle trips were adjusted based on existing mode shares, pass-by rates, internal capture between the proposed uses on-Site, and the existing Site-generated trips in order to determine the net new vehicle trips that are expected to be generated by the Site.

Table 2 summarizes the net new peak hour vehicle trips by land use on Site based on the revised building program and compares them to the net new vehicle trips presented in the TIA for the previous building program.

Table 2 Net New Vehicle Trip Generation Comparison

		Existing [a]	Previous Building Program [b]				Revised Building Program				Net New Difference	
Time Period	Direction	Total	Office 180 ksf	Residential 822 units	Retail 237 ksf	Net New Total [b]	Office [c] 180 ksf	Residential [d] 800 units	Retail [e] 115 ksf	Net New Total [b]	Volume Diff.	Percent Diff.
Weekday Morning	Enter	*221*	139	56	116	**90**	140	53	89	**61**	-29	-32%
Peak Hour	Exit	*56*	17	159	58	**178**	17	151	45	**157**	-21	-12%
	Total	*277*	156	215	174	**268**	157	204	134	**218**	-50	-19%
Weekday Evening	Enter	*120*	15	88	255	**238**	15	83	140	**118**	-120	-50%
Peak Hour	Exit	*248*	116	58	283	**209**	116	61	149	**78**	-131	-63%
	Total	*368*	131	146	538	**447**	131	144	289	**196**	-251	-56%
Saturday Midday	Enter	*186*	25	75	395	**309**	30	72	216	**132**	-177	-57%
Peak Hour	Exit	*163*	31	80	344	**292**	31	89	179	**136**	-156	-53%
	Total	*349*	56	155	739	**601**	61	161	395	**268**	-333	-55%

a Trip generation estimate including credits for existing mode share, internal capture, and pass-by; from Table 10 in the Northland Newton Development TIA.
b Net new total trips includes sum of office, residential, and retail trips with existing site trips subtracted out.
c Based on ITE LUC 710 (General Office Building) for 180,000 sf, including credits for existing mode share and internal capture.
d Based on ITE LUC 221 (Mid-Rise Residential) for 800 units, including credits for existing mode share and internal capture.
e Based on ITE LUC 820 (Shopping Center) for 115,000 sf, including credits for existing mode share, internal capture, and pass-by.

As shown in Table 2, the proposed Site with the revised building program is expected to generate approximately 218, 196, and 268 net new vehicle trips during the weekday morning, weekday evening, and Saturday midday peak hours, respectively. Compared to the previous building program outlined in the TIA, the revised building program is expected to generate less traffic during all peak hours, with significantly less traffic being generated during the weekday evening and Saturday midday peak hours. Compared with the previous building program, the revised building program is expected to generate approximately 50, 251, and 333 **fewer** vehicle trips during the weekday morning, weekday evening, and Saturday midday peak hours, respectively, which corresponds to a reduction in peak hour generated trips of 19%, 56%, and 55% for the weekday morning, weekday evening, and Saturday midday peak hours.

The greatest reductions in Site-generated vehicle trips between the two building programs is during the weekday evening and Saturday midday peak hours, which correspond to the highest trip-generating time periods for a retail land use. This is due to the reduction in retail space between the previous building program and the revised building program. It should also be noted that due to the reduction in retail space, the internal capture rates between the retail, office, and residential uses on Site differs between the two building programs, which results in fewer internal capture trips for the office and residential land uses under the revised building program.

Traffic Operations Analysis

To assess the change in operations due to the revised building program, several "sample" intersection capacity analyses were conducted at study area intersections with respect to the 2025 Build Conditions. In the TIA, intersection capacity analyses were conducted at 27 intersections in Newton and Needham. However, to provide a "snapshot" of the change in operations within the study area due to the revised building program, capacity analyses were conducted at the following five intersections:

- Chestnut Street at Route 9 Westbound Service Road
- Chestnut Street at Route 9 Eastbound Service Road
- Needham Street at Oak Street / Christina Street
- Needham Street at Charlemont Street / North Site Driveway
- Winchester Street at Needham Street / Dedham Street

Capacity analyses provide an indication of how well the roadway facilities serve the traffic demands placed upon them. Roadway operating conditions are classified by calculated levels-of-service.

Level of Service Criteria

Level–of-service (LOS) is the term used to denote the different operating conditions that occur on a given roadway segment under various traffic volume loads. It is a qualitative measure that considers a number of factors including roadway geometry, speed, travel delay, freedom to maneuver, and safety. Level-of-service provides an index to operational qualities of a roadway segment or an intersection. Level-of-service designations range from A to F, with LOS A representing the best operating conditions and LOS F representing the worst operating conditions.

For this study, capacity analyses were completed for the signalized and unsignalized intersections within the study area using Synchro traffic analysis software. Level-of-service designation is reported differently for signalized and unsignalized intersections. For signalized intersections, the analysis considers the operation of each lane or lane group entering the intersection and the LOS designation is for overall conditions at the intersection. For unsignalized intersections, the analysis assumes that traffic on the mainline is not affected by traffic on the side streets. The LOS is only determined for left-turns from the main street and all movements from the minor street.

The evaluation criteria used to analyze the signalized study area intersection in this traffic study is based on the percentile-delay method (SYNCHRO results). The evaluation criteria used to analyze the unsignalized study area intersections is based on the *2010 Highway Capacity Manual* (HCM)[3].

Intersection Capacity Analysis

Levels-of-service analyses were conducted for the 2025 Build conditions with the revised building program for several study area intersections and have been compared against the 2025 No Build conditions and the 2025 Build conditions presented in the Traffic Impact Assessment. The intersection capacity analyses presented are for the Build conditions with existing mode share. Tables 3 and 4 summarize the capacity analyses for the signalized and unsignalized intersections, respectively. The capacity analyses worksheets are included in the Attachments to this memorandum.

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[3] Highway Capacity Manual, Transportation Research Board, Washington D.C., 2010.

Table 3 Signalized Intersection Capacity Analysis (With Existing Mode Share)

Location / Movement	2025 No-Build Conditions					2025 Build Conditions - TIAS Building Program					2025 Build Conditions - February 2019 Building Program				
	v/c [a]	Del [b]	LOS [c]	50 Q [d]	95 Q [e]	v/c	Del	LOS	50 Q	95 Q	v/c	Del	LOS	50 Q	95 Q
6: Needham Street at Oak Street / Christina Street															
Weekday Morning															
EB L/T	>1.20	>120	F	~289	#480	>1.20	>120	F	~295	#488	>1.20	>120	F	~286	#478
EB R	0.24	8	A	19	67	0.27	8	A	22	75	0.26	8	A	21	73
WB L	0.73	65	E	99	#224	0.73	66	E	99	#224	0.73	65	E	99	#224
WB T/R	0.52	44	D	158	267	0.55	45	D	168	281	0.52	44	D	158	267
NB L	0.95	81	F	114	#294	0.83	58	E	90	#238	0.81	55	E	85	#225
NB T/R	0.76	21	C	431	754	0.82	24	C	502	#895	0.81	24	C	497	877
SB L	0.18	21	C	13	41	0.24	25	C	14	45	0.24	24	C	14	45
SB T/R	0.96	59	E	608	#1025	0.99	67	E	645	#1070	0.97	63	E	629	#1053
Total		**60**	**E**				**62**	**E**				**58**	**E**		
Weekday Evening															
EB L/T	>1.20	>120	F	~332	#545	1.19	>120	F	~293	#500	1.12	>120	F	~270	#475
EB R	0.37	12	B	47	114	0.34	22	B	38	99	0.33	11	B	34	93
WB L	1.08	>120	F	~110	#249	0.92	102	F	97	#232	0.86	89	F	96	#225
WB T/R	0.41	38	D	113	193	0.45	39	D	125	210	0.42	39	D	118	200
NB L	0.78	50	D	80	#204	0.89	67	E	103	#258	0.82	55	E	89	#226
NB T/R	0.74	21	C	411	725	0.80	24	C	480	#876	0.78	22	C	453	800
SB L	0.23	22	C	18	48	0.35	28	C	22	63	0.31	25	C	21	59
SB T/R	1.04	86	F	~791	#1113	1.14	104	F	~931	#1263	1.11	93	F	~887	#1217
Total		**68**	**E**				**70**	**E**				**62**	**E**		
Saturday Midday															
EB L/T	>1.20	>120	F	~318	#490	>1.20	>120	F	~334	#510	>1.20	>120	F	~311	#483
EB R	0.26	8	A	23	67	0.29	8	A	28	75	0.27	8	A	24	69
WB L	0.95	103	F	92	#229	0.99	114	F	93	#232	0.92	96	F	91	#225
WB T/R	0.35	29	C	71	139	0.40	31	C	86	160	0.37	30	C	76	145
NB L	0.64	31	C	42	#119	0.73	39	D	61	#173	0.66	32	C	46	#133
NB T/R	0.69	18	B	304	563	0.77	21	C	376	#710	0.73	19	B	338	628
SB L	0.16	19	B	14	39	0.26	22	C	16	48	0.19	20	B	14	40
SB T/R	1.14	102	F	~775	#1095	>1.20	>120	F	~881	#1209	1.18	119	F	~827	#1153
Total		**76**	**E**				**93**	**F**				**81**	**F**		
Weekday Midday															
EB L/T	>1.20	>120	F	~332	#543	>1.20	>120	F	~309	#515	>1.20	>120	F	~288	#491
EB R	0.37	11	B	38	100	0.35	10	A	32	90	0.33	9	A	28	82
WB L	>1.20	>120	F	~133	#273	>1.20	>120	F	~122	#262	1.17	>120	F	~116	#255
WB T/R	0.45	35	C	107	188	0.49	36	D	118	204	0.46	35	D	111	194
NB L	0.77	44	D	69	#193	0.90	63	E	93	#248	0.83	52	D	81	#222
NB T/R	0.83	24	C	436	#883	0.90	30	C	520	#1006	0.88	28	C	491	#965
SB L	0.43	33	C	20	67	0.79	92	F	29	#113	0.70	70	E	27	#107
SB T/R	1.17	116	F	~817	#1140	>1.20	>120	F	~917	#1248	>1.20	>120	F	~879	#1207
Total		**91**	**F**				**99**	**F**				**89**	**F**		

a Volume to capacity ratio.
b Average total delay, in seconds per vehicle.
c Level-of-service.
d 50th percentile queue, in feet.
e 95th percentile queue, in feet.
~ Volume exceeds capacity, queue is theoretically infinite.
# 95th percentile volume exceeds capacity, queue may be longer.

Table 3 Signalized Intersection Capacity Analysis (With Existing Mode Share) – Cont.

Location / Movement	2025 No-Build Conditions					2025 Build Conditions - TIAS Building Program					2025 Build Conditions - February 2019 Building Program				
	v/c [a]	Del [b]	LOS [c]	50 Q [d]	95 Q [e]	v/c	Del	LOS	50 Q	95 Q	v/c	Del	LOS	50 Q	95 Q
9: Needham Street at North Site Driveway/Charlemont Street															
Weekday Morning															
EB L	0.04	30	C	3	12	0.40	39	D	33	59	0.34	37	D	26	49
EB T/R	0.01	0	A	0	0	0.12	1	A	0	0	0.10	0	A	0	0
WB L	0.19	34	C	13	36	0.19	36	D	14	38	0.20	36	D	14	37
WB T/R	0.04	0	A	0	0	0.04	0	A	0	0	0.04	0	A	0	0
NB L	0.03	7	A	1	14	0.22	11	B	10	51	0.19	10	A	8	46
NB T/R	0.59	11	B	139	#733	0.63	13	B	164	#726	0.63	13	B	154	#727
SB L	0.04	7	A	1	13	0.06	9	A	3	14	0.06	9	A	3	14
SB T/R	0.57	11	B	131	#692	0.71	19	B	281	#731	0.70	18	B	267	#708
Total		**11**	**B**				**16**	**B**				**16**	**B**		
Weekday Evening															
EB L	0.50	43	D	35	92	0.81	61	E	112	#228	0.68	52	D	73	141
EB T/R	0.07	0	A	0	0	0.18	1	A	0	0	0.14	1	A	0	0
WB L	0.22	35	C	15	48	0.16	34	C	19	50	0.19	35	C	18	48
WB T/R	0.18	20	B	6	37	0.13	18	B	8	37	0.15	19	B	8	37
NB L	0.06	7	A	1	18	0.58	35	D	24	92	0.26	14	B	11	45
NB T/R	0.66	13	B	194	712	0.69	16	B	268	#641	0.68	14	B	214	#719
SB L	0.02	7	A	1	6	0.02	11	B	1	7	0.02	10	A	1	7
SB T/R	0.67	14	B	179	#668	0.95	41	D	501	#901	0.82	24	C	371	#808
Total		**15**	**B**				**31**	**C**				**21**	**C**		
Saturday Midday															
EB L	0.49	44	D	31	82	0.78	59	E	105	#210	0.64	51	D	64	127
EB T/R	0.09	0	A	0	0	0.20	1	A	0	0	0.15	1	A	0	0
WB L	0.42	42	D	27	73	0.29	37	D	33	75	0.35	39	D	32	74
WB T/R	0.19	14	B	1	29	0.13	13	B	1	29	0.15	13	B	1	29
NB L	0.06	7	A	1	18	0.65	41	D	26	107	0.30	15	B	11	47
NB T/R	0.69	13	B	204	#766	0.77	20	C	303	#817	0.73	16	B	238	#824
SB L	0.06	7	A	2	12	0.09	12	B	4	15	0.08	10	A	3	14
SB T/R	0.68	14	B	184	#705	1.00	51	D	~552	#980	0.84	25	C	383	#857
Total		**15**	**B**				**36**	**D**				**21**	**C**		
Weekday Midday															
EB L	0.57	48	D	49	100	0.79	60	E	108	#220	0.67	52	D	70	138
EB T/R	0.07	0	A	0	0	0.16	1	A	0	0	0.13	1	A	0	0
WB L	0.25	37	D	21	52	0.18	35	C	21	54	0.22	35	D	21	53
WB T/R	0.19	20	B	7	37	0.13	18	B	8	37	0.16	19	B	7	37
NB L	0.10	8	A	4	22	0.62	3	D	25	98	0.37	20	B	12	49
NB T/R	0.71	14	B	237	#822	0.75	18	B	313	#814	0.74	16	B	248	#829
SB L	0.02	8	A	1	6	0.03	12	B	1	7	0.02	10	A	1	7
SB T/R	0.73	18	B	358	#769	1.01	55	D	~606	#1009	0.88	29	C	428	#929
Total		**17**	**B**				**37**	**D**				**24**	**C**		

a Volume to capacity ratio.
b Average total delay, in seconds per vehicle.
c Level-of-service.
d 50th percentile queue, in feet.
e 95th percentile queue, in feet.
~ Volume exceeds capacity, queue is theoretically infinite.
# 95th percentile volume exceeds capacity, queue may be longer.

Table 3 Signalized Intersection Capacity Analysis (With Existing Mode Share) – Cont.

Location /	2025 No-Build Conditions					2025 Build Conditions - TIAS Building Program					2025 Build Conditions - February 2019 Building Program				
Movement	v/c [a]	Del [b]	LOS [c]	50 Q [d]	95 Q [e]	v/c	Del	LOS	50 Q	95 Q	v/c	Del	LOS	50 Q	95 Q
14: Winchester Street at Needham Street/Dedham Street															
Weekday Morning															
EB L	0.75	36	D	206	305	0.79	38	D	227	334	0.79	37	D	225	331
EB T/R	0.27	24	C	56	116	0.29	24	C	60	124	0.28	23	C	57	119
WB L/T/R	1.02	93	F	~177	#390	1.05	100	F	~191	#399	1.03	95	F	~177	#390
NB L	0.19	29	C	14	44	0.22	30	C	17	49	0.19	29	C	14	44
NB T/R	0.55	32	C	159	276	0.55	32	C	159	276	0.55	32	C	159	276
SB L/T	0.87	51	D	244	#452	0.88	53	D	245	#454	0.88	53	D	245	#454
SB R	0.72	8	A	114	263	0.74	9	A	136	305	0.73	9	A	125	286
Total [f]		**35**	**C**				**37**	**D**				**36**	**D**		
Weekday Evening															
EB L	0.78	35	D	226	311	0.83	38	D	256	#351	0.79	36	D	238	323
EB T/R	0.32	24	C	72	133	0.35	25	C	82	148	0.32	24	C	75	138
WB L/T/R	0.77	52	D	104	#207	0.80	55	E	113	#229	0.78	53	D	108	#217
NB L	0.10	24	C	9	28	0.16	26	C	14	38	0.13	25	C	12	33
NB T/R	0.62	32	C	201	301	0.63	33	C	202	301	0.62	32	C	202	301
SB L/T	1.03	86	F	~270	#471	1.09	105	F	~280	#479	1.05	95	F	~276	#475
SB R	0.48	2	A	9	45	0.54	3	A	30	84	0.51	3	A	19	59
Total [g]		**35**	**D**				**38**	**D**				**37**	**D**		
Saturday Midday															
EB L	0.76	33	C	204	#352	0.81	35	D	243	#443	0.78	34	C	224	#403
EB T/R	0.40	24	C	84	185	0.44	25	C	100	212	0.41	24	C	90	193
WB L/T/R	0.82	55	D	134	#337	0.89	66	E	147	#365	0.85	59	E	140	#347
NB L	0.20	29	C	19	51	0.29	31	C	27	68	0.23	30	C	21	57
NB T/R	0.53	33	C	118	212	0.53	33	C	118	212	0.53	33	C	118	212
SB L/T	0.78	46	D	147	265	0.78	47	D	147	266	0.78	46	D	147	265
SB R	0.56	5	A	50	137	0.65	7	A	91	230	0.60	6	A	63	171
Total		**29**	**C**				**31**	**C**				**30**	**C**		
Saturday Midday															
EB L	0.70	31	C	176	258	0.73	33	C	198	286	0.71	32	C	182	265
EB T/R	0.28	23	C	55	113	0.31	23	C	65	127	0.29	23	C	58	117
WB L/T/R	0.67	44	D	75	150	0.70	47	D	86	160	0.68	45	D	79	155
NB L	0.08	23	C	8	27	0.12	24	C	13	37	0.09	23	C	10	32
NB T/R	0.52	27	C	146	250	0.53	28	C	157	250	0.52	28	C	149	250
SB L/T	0.67	34	C	156	#295	0.69	37	D	168	#313	0.67	35	C	159	#299
SB R	0.40	2	A	0	29	0.47	2	A	4	37	0.43	2	A	0	30
Total		**25**	**C**				**25**	**C**				**25**	**C**		

a Volume to capacity ratio.
b Average total delay, in seconds per vehicle.
c Level-of-service.
d 50th percentile queue, in feet.
e 95th percentile queue, in feet.
f Threshold between LOS C and D is 35 seconds. Overall delay under 2025 No Build Conditions is 34.9 seconds (LOS C).
g Threshold between LOS C and D is 35 seconds. Overall delay under 2025 No Build Conditions is 35.1 seconds (LOS D).
~ Volume exceeds capacity, queue is theoretically infinite.
# 95th percentile volume exceeds capacity, queue may be longer.

Table 4 Unsignalized Intersection Capacity Analysis (With Existing Mode Share)

Location / Movement	2025 No-Build Conditions					2025 Build Conditions - TIAS Building Program					2025 Build Conditions - February 2019 Building Program				
	D [a]	v/c [b]	Del [c]	LOS [d]	95 Q [e]	D	v/c	Del	LOS	95 Q	D	v/c	Del	LOS	95 Q
1: Chestnut Street at Route 9 Westbound Service Road [f]															
Weekday Morning															
EB L/T/R	40	0.11	13	B	8	40	0.11	13	B	8	40	0.11	13	B	8
WB L/T/R	190	0.44	16	C	50	190	0.44	16	C	50	190	0.44	16	C	50
SB L/T/R	615	1.09	72	F	428	625	1.11	77	F	445	620	1.10	74	F	433
Weekday Evening															
EB L/T/R	150	0.41	17	C	43	150	0.42	18	C	43	150	0.41	17	C	43
WB L/T/R	180	0.47	18	C	53	185	0.50	19	C	55	185	0.49	19	C	55
SB L/T/R	655	>1.20	>120	F	665	680	>1.20	>120	F	733	665	>1.20	>120	F	698
Saturday Midday															
EB L/T/R	5	0.01	10	A	0	5	0.01	10	B	0	5	0.01	10	B	0
WB L/T/R	125	0.24	12	B	23	130	0.26	12	B	25	125	0.25	12	B	25
SB L/T/R	545	0.80	25	C	110	585	0.88	34	D	278	565	0.83	28	D	238
2: Chestnut Street at Route 9 Eastbound Service Road [f]															
Weekday Morning															
EB L/T/R	325	0.67	23	C	125	325	0.68	24	C	130	325	0.68	24	C	130
WB L/T/R	45	0.10	11	B	8	45	0.11	12	B	8	45	0.10	12	B	8
NB L/T/R	430	0.81	31	D	200	455	0.87	38	E	243	455	0.86	37	E	240
Weekday Evening															
EB L/T/R	345	0.74	26	D	143	350	0.77	28	D	150	350	0.76	27	D	148
WB L/T/R	20	0.06	12	B	5	20	0.06	12	B	5	20	0.06	12	B	5
NB L/T/R	385	0.77	26	D	160	420	0.86	33	D	203	395	0.80	29	D	173
Saturday Midday															
EB L/T/R	260	0.51	16	C	70	270	0.55	18	C	83	260	0.52	17	C	75
WB L/T/R	20	0.05	10	B	3	20	0.05	11	B	5	20	0.05	10	B	3
NB L/T/R	385	0.66	19	C	120	435	0.78	27	D	185	410	0.72	23	C	153

Note: Weekday Midday analyses not performed for intersections #1 and #2.
a Demand.
b Volume to capacity ratio.
c Average total delay, in seconds per vehicle.
d Level-of-service.
e 95th percentile queue, in feet.
f Analyzed as all-way STOP controlled.
~ Volume exceeds capacity, queue is theoretically infinite.
# 95th percentile volume exceeds capacity, queue may be longer.

As shown in Tables 3 and 4, overall operations under the 2025 Build conditions are expected to improve with the revised building program as compared to the building program outlined in the TIA, especially at the intersection of Needham Street and Oak Street / Christina Street. The revised building program results in less Site-generated trips than the building program outlined in the TIA, which in turn has a smaller effect on delays and queues at the study area intersections.

At the intersection of Needham Street at Oak Street / Christina Street, overall operations under the 2025 Build conditions with the revised building program are expected to improve over the 2025 No Build conditions during three of the four peak periods. This is due to the smaller building program and due to the creation of internal connections on Site that allows Site-generated traffic to access all portions of the Site from all directions without traveling through the intersection of Needham Street at Oak Street / Christina Street.

At the intersection of Needham Street at Charlemont Street / North Site Driveway, overall operations of LOS B or C are expected during all peak periods with the revised building program. This is an improvement from the Build condition with the previous building program, where the intersection was expected to operate at overall LOS D during the Saturday midday and weekday midday peak periods. At the other three intersections analyzed, minimal changes are expected between the 2025 No Build conditions and the 2025 Build conditions with the revised building program. The increase in delays and queues at each intersection between the No Build and Build conditions are less with the revised building program than with the building program outlined in the TIA.

Project Consistency with State/Local Initiatives

The proposed redevelopment Project has been carefully developed to contain a "mix" of uses that will result in significant shared activity on-Site and sharing of activity with commercial and residential neighbors in the immediate area. The project design and its mitigative initiatives have been well thought out and are mindful of the goals outlined in the Needham Street Area Vision Plan 2018 and in State initiatives. Some of the goals outlined in the Vision Plan include providing numerous public benefits, such as affordable and market rate housing in an accessible, desirable location, creating vibrant and safe walkable environments with new open spaces, and improving transportation access and connectivity. Another major focus of the Vision Plan is to accommodate alternative modes of transportation along the corridor. The project is very strong in putting these goals to work as part of the Project. While there are numerous public amenities and pedestrian/bicycle environment enhancements proposed throughout the Project, the most impactful improvement to the transportation system proposed is the addition of local and regional shuttle bus connections to key transportation hubs.

MassDOT and the City of Newton have a major reconstruction project proposed along the Needham Street corridor. That project is expected to start construction in Fall of this year. The MassDOT roadway project will improve the operations and safety along the corridor to the extent practical and feasible. There will be substantial pedestrian and bicycle enhancements as part of the project that the Proponent will tie into and bolster in many areas of the Site and surroundings. Since the State is proposing a substantial infrastructure enhancement within the right of way that exists in the vicinity of the site, the Proponent has focused mitigation dollars on non-traditional (non-infrastructure) initiatives geared to addressing the demand side of the transportation equation.

The project initiatives are consistent with the Needham Street Vision Plan 2018, as described above, and are also consistent with many of the mitigative directives outlined in the Transportation Impact Assessment (TIA) Guidelines presented by MassDOT (copy provided in the Attachments). As outlined in the document, "*MassDOT seeks to ensure that the transportation impact review process reflects and advances the Commonwealth of Massachusetts's policy goals, in particular those that promote MassDOT's Project Development and Design Guide standards on Complete Streets, the Global Warming Solutions Act, the Massachusetts GreenDOT Policy Initiative, the Mode Shift Initiative, the Healthy Transportation Compact, the Healthy Transportation Policy Directive, and the Massachusetts Ridesharing Regulation. These goals work together to mutually reinforce one another and strengthen the Commonwealth's efforts to reduce its dependence on driving*". The Proponent's mitigative approach is non-traditional in nature and not like any other project that has been developed in the region. At the same time, it is highly consistent with the MassDOT guidelines and mitigation directives, yet the City's Peer Consultant didn't acknowledge this in their January 2019 report to the City.

To demonstrate some of the consistencies between the Project and the mitigation directives outlines in the TIA guidelines, several of the key areas of the TIA guidelines are outlined below:

Section IV Performance:

B. Vehicular operations

Impacts to elements of the transportation system (e.g intersections, ramps terminals) are generally determined by the technical analysis described above (e.g. vehicular operations at intersections, safety assessment of crashes). The analysis typically indicates when impacts result from the proposed development, but the location and mode of the impacts does not necessarily dictate the optimal location or mode for mitigation. The Proponent is encouraged to work closely with MassDOT to determine the best locations and <u>modes</u> to target for mitigation

C. Bicycle, Pedestrian, and Transit Modes

1. The TIA should include an assessment of the mode split assumptions, as well as the Proponent's plan to <u>maximize travel choice, promote non-single occupancy vehicle modes, and achieve the assumed mode shares</u>.

2. If a facility is impacted by the Proponent's trips and the facility has an access or accommodation deficiency in the mode under review (bicycle, pedestrian, transit), the Proponent must assess options to facility safe, convenient, and attractive access via these modes.

3. In location where transit facilities are not available, the Proponent shall evaluate and document needs, origins and destinations, and opportunities to provide transit service or connections.

Section 4 Mitigation

This section provides an overview of the mitigation analysis process and typical mitigation measures that may be considered. The Proponent is required to propose and justify recommended project mitigation based on the context of the project, the location, existing conditions, and other relevant considerations.

I Mitigation Analysis

Attract trips to a site that fails to provide adequate pedestrian, bicycle, or public transit access, the Proponent is required to commit to a mitigation program that demonstrates the following:

1. *The Proponent has identified and evaluated a set of potential mitigation alternatives, including improvements to pedestrian, bicycle, and public transit access, as well as a range of geometric and operational improvements for traffic.*
2. *The commitment program mitigates impacts of the proposed development in a manner that <u>enhances walking, bicycling, and public transit access to the project site</u> and avoids further degradation to the traffic performance of the transportation system by the time of development in a manner that meets the following conditions:*
    a. *The transportation impacts of the proposal are mitigated to the most practical degree possible through transportation improvements or measures that directly address the transportation impacts of the development and/or the inadequacy of walking, bicycling, or public transit access.*
    b. *An effective transportation demand management (TDM) program is prepared and fully funded.*
    c. *The overall benefits of the development outweigh it unresolved impacts.*

Conclusion

VHB has conducted a supplemental evaluation of potential traffic generation and impacts associated with The Northland Newton Development. The Traffic Impact Assessment (TIA) dated October 2018 and submitted to the city cites a redevelopment program of 1.9 million gross square feet (sf) of development, consisting of 180,000 sf of leasable office space (in the historic Saco Petee mill building), 822 residential housing units, 237,000 sf of retail/restaurant/active use space, and approximately 1,953 parking spaces. Since the project was filed, there has been significant public outreach meetings and presentations with the City. Informed by these meetings, a revised, smaller, building program has been prepared consisting of 180,000 sf of leasable office space (in the historic Saco Petee mill building), 800 residential housing units, and 115,000 sf of retail/restaurant/active use space.

As outlined in this memorandum, the revised building program is expected to generate significantly less Site-generated trips than the building program outlined in the TIA. Specifically, the revised building program is expected to generate approximately 19%, 56%, and 55% fewer vehicle trips than the previous building program during the weekday morning, weekday evening, and Saturday midday peak hours. An analysis of select study area intersections during all peak hours, including in particular the intersection of Needham Street at Oak Street / Christina Street, show that overall operations are expected to be better under the 2025 Build conditions with the revised building plan than under the 2025 Build conditions with the building program as outlined in the TIA.

In addition, the proposed building program is consistent with many local and state initiatives, including the Needham Street Area Vision Plan 2018 and MassDOT's Transportation Impact Assessment Guidelines. Specifically, the proposed bicycle/pedestrian improvements and the proposed shuttle service are consistent with the local and regional initiatives to increase walking, bicycling, and public transit access and to reduce dependence on automobile travel.

Attachments

- ITE Trip Generation Worksheets
- Capacity Analysis Worksheets
- MassDOT TIA Guidelines

ITE Trip Generation Worksheets

ITE TRIP GENERATION WORKSHEET **PROPOSED**

(10th Edition, Updated 2017)

LANDUSE: Mid-Rise Residential
LANDUSE CODE: 221
SETTING/LOCATION: General Urban/Suburban
JOB NAME:
JOB NUMBER:

Independent Variable --- Number of Units

800 units

WEEKDAY

RATES:

	# Studies	R^2	Total Trip Ends Average	Total Trip Ends Low	Total Trip Ends High	Independent Variable Range Average	Independent Variable Range Low	Independent Variable Range High	Directional Distribution Enter	Directional Distribution Exit
DAILY	27	0.77	5.44	1.27	12.50	205	21	494	50%	50%
AM PEAK OF GENERATOR	48	0.69	0.32	0.06	0.77	225	21	1,168	27%	73%
PM PEAK OF GENERATOR	47	0.66	0.41	0.09	1.26	211	21	1,168	60%	40%
AM PEAK (ADJACENT ST)	53	0.67	0.36	0.06	1.61	207	26	703	26%	74%
PM PEAK (ADJACENT ST)	60	0.72	0.44	0.15	1.11	208	26	703	61%	39%

TRIPS:

	BY AVERAGE Total	BY AVERAGE Enter	BY AVERAGE Exit	BY REGRESSION Total	BY REGRESSION Enter	BY REGRESSION Exit
DAILY	4,352	2,176	2,176	4,358	2,179	2,179
AM PEAK (ADJACENT ST)	288	75	213	263	68	194
PM PEAK (ADJACENT ST)	352	215	137	326	199	127

SATURDAY

RATES:

	# Studies	R^2	Total Trip Ends Average	Total Trip Ends Low	Total Trip Ends High	Independent Variable Range Average	Independent Variable Range Low	Independent Variable Range High	Directional Distribution Enter	Directional Distribution Exit
DAILY	6	0.73	4.91	4.03	8.51	224	111	336	50%	50%
PEAK OF GENERATOR	8	0.89	0.44	0.34	0.73	264	111	462	49%	51%

TRIPS:

	BY AVERAGE Total	BY AVERAGE Enter	BY AVERAGE Exit	BY REGRESSION Total	BY REGRESSION Enter	BY REGRESSION Exit
DAILY	3,928	1,964	1,964	2,849	1,425	1,425
PEAK OF GENERATOR	352	172	180	343	168	175

SUNDAY

RATES:

	# Studies	R^2	Total Trip Ends Average	Total Trip Ends Low	Total Trip Ends High	Independent Variable Range Average	Independent Variable Range Low	Independent Variable Range High	Directional Distribution Enter	Directional Distribution Exit
DAILY	6	--	4.09	3.06	8.41	224	111	336	50%	50%
PEAK OF GENERATOR	6	--	0.39	0.26	1.07	224	111	336	62%	38%

TRIPS:

	BY AVERAGE Total	BY AVERAGE Enter	BY AVERAGE Exit	BY REGRESSION Total	BY REGRESSION Enter	BY REGRESSION Exit
DAILY	3,272	1,636	1,636	N/A	N/A	N/A
PEAK OF GENERATOR	312	193	119	NA	NA	NA

ITE TRIP GENERATION WORKSHEET **PROPOSED**

(10th Edition, Updated 2017)

LANDUSE: Shopping Center
LANDUSE CODE: 820
SETTING/LOCATION: General Urban/Suburban
JOB NAME:
JOB NUMBER:

Independent Variable ---

FLOOR AREA (KSF): 115.0

WEEKDAY

RATES:

	# Studies	R^2	Total Trip Ends Average	Total Trip Ends Low	Total Trip Ends High	Independent Variable Range Average	Independent Variable Range Low	Independent Variable Range High	Directional Distribution Enter	Directional Distribution Exit
DAILY	147	0.76	37.75	7.42	207.98	453	9	1,510	50%	50%
AM PEAK OF GENERATOR	47	0.71	3.00	0.70	23.74	323	8	1,320	54%	46%
PM PEAK OF GENERATOR	53	0.76	4.21	0.78	27.27	298	7	1,320	50%	50%
AM PEAK (ADJACENT ST)	84	0.90	0.94	0.18	23.74	351	9	1,510	62%	38%
PM PEAK (ADJACENT ST)	261	0.82	3.81	0.74	18.69	327	2	2,200	48%	52%

TRIPS:

	BY AVERAGE Total	BY AVERAGE Enter	BY AVERAGE Exit	BY REGRESSION Total	BY REGRESSION Enter	BY REGRESSION Exit
DAILY	4,341	2,171	2,171	6,611	3,306	3,306
AM PEAK (ADJACENT ST)	108	67	41	209	130	80
PM PEAK (ADJACENT ST)	438	210	228	603	289	313

SATURDAY

RATES:

	# Studies	R^2	Total Trip Ends Average	Total Trip Ends Low	Total Trip Ends High	Independent Variable Range Average	Independent Variable Range Low	Independent Variable Range High	Directional Distribution Enter	Directional Distribution Exit
DAILY	58	0.71	46.12	13.07	167.89	602	56	1,510	50%	50%
PEAK OF GENERATOR	119	0.87	4.50	1.42	15.10	416	4	1,510	52%	48%

TRIPS:

	BY AVERAGE Total	BY AVERAGE Enter	BY AVERAGE Exit	BY REGRESSION Total	BY REGRESSION Enter	BY REGRESSION Exit
DAILY	5,304	2,652	2,652	9,719	4,860	4,860
PEAK OF GENERATOR	518	269	248	691	359	332

SUNDAY

RATES:

	# Studies	R^2	Total Trip Ends Average	Total Trip Ends Low	Total Trip Ends High	Independent Variable Range Average	Independent Variable Range Low	Independent Variable Range High	Directional Distribution Enter	Directional Distribution Exit
DAILY	30	–	21.10	4.15	148.15	509	47	1,510	50%	50%
PEAK OF GENERATOR	24	–	2.79	0.39	12.40	382	47	1,268	49%	51%

TRIPS:

	BY AVERAGE Total	BY AVERAGE Enter	BY AVERAGE Exit	BY REGRESSION Total	BY REGRESSION Enter	BY REGRESSION Exit
DAILY	2,427	1,213	1,213	N/A	N/A	N/A
PEAK OF GENERATOR	321	157	164	N/A	N/A	N/A

ITE TRIP GENERATION WORKSHEET **PROPOSED**

(10th Edition, Updated 2017)

LANDUSE: General Office Building
LANDUSE CODE: 710
SETTING/LOCATION: General Urban/Suburban
JOB NAME:
JOB NUMBER:

Independent Variable ---

FLOOR AREA (KSF): 180

WEEKDAY

RATES:

	# Studies	R^2	Total Trip Ends Average	Total Trip Ends Low	Total Trip Ends High	Independent Variable Range Average	Independent Variable Range Low	Independent Variable Range High	Directional Distribution Enter	Directional Distribution Exit
DAILY	66	0.83	9.74	2.71	27.56	171	6	1,300	50%	50%
AM PEAK OF GENERATOR	228	0.84	1.47	0.57	4.93	209	6	2,408	88%	12%
PM PEAK OF GENERATOR	243	0.82	1.42	0.49	6.20	205	6	2,408	18%	82%
AM PEAK (ADJACENT ST)	35	0.85	1.16	0.37	4.23	117	5	511	86%	14%
PM PEAK (ADJACENT ST)	32	0.88	1.15	0.47	3.23	114	6	511	16%	84%

TRIPS:

	BY AVERAGE Total	BY AVERAGE Enter	BY AVERAGE Exit	BY REGRESSION Total	BY REGRESSION Enter	BY REGRESSION Exit
DAILY	1,753	877	877	1,877	938	938
AM PEAK (ADJACENT ST)	209	180	29	196	168	27
PM PEAK (ADJACENT ST)	207	33	174	199	32	167

SATURDAY

RATES:

	# Studies	R^2	Total Trip Ends Average	Total Trip Ends Low	Total Trip Ends High	Independent Variable Range Average	Independent Variable Range Low	Independent Variable Range High	Directional Distribution Enter	Directional Distribution Exit
DAILY	5	--	2.21	1.24	7.46	94	28	183	50%	50%
PEAK OF GENERATOR	3	--	0.53	0.30	1.57	82	28	183	54%	46%

TRIPS:

	BY AVERAGE Total	BY AVERAGE Enter	BY AVERAGE Exit	BY REGRESSION Total	BY REGRESSION Enter	BY REGRESSION Exit
DAILY	398	199	199	N/A	N/A	N/A
PEAK OF GENERATOR	95	52	44	N/A	N/A	N/A

SUNDAY

RATES:

	# Studies	R^2	Total Trip Ends Average	Total Trip Ends Low	Total Trip Ends High	Independent Variable Range Average	Independent Variable Range Low	Independent Variable Range High	Directional Distribution Enter	Directional Distribution Exit
DAILY	5	--	0.70	0.19	3.05	94	28	183	50%	50%
PEAK OF GENERATOR	3	--	0.21	0.11	0.68	82	28	183	58%	42%

TRIPS:

	BY AVERAGE Total	BY AVERAGE Enter	BY AVERAGE Exit	BY REGRESSION Total	BY REGRESSION Enter	BY REGRESSION Exit
DAILY	126	63	63	N/A	N/A	N/A
PEAK OF GENERATOR	38	22	16	N/A	N/A	N/A

PROPOSED SHARED PERSON TRIPS - WEEKDAY

RETAIL - OFFICE

WEEKDAY DAILY

RETAIL	%	#	BALANCED	#	%	OFFICE
EXIT ->	3%	5,884	**159**	1,060	15%	-> ENTER
ENTER <-	4%	5,884	**233**	1,060	22%	<- EXIT

WEEKDAY MORNING

RETAIL	%	#	BALANCED	#	%	OFFICE
EXIT ->	29%	142	**8**	190	4%	-> ENTER
ENTER <-	32%	231	**9**	31	28%	<- EXIT

WEEKDAY EVENING

RETAIL	%	#	BALANCED	#	%	OFFICE
EXIT ->	2%	558	**11**	36	31%	-> ENTER
ENTER <-	8%	515	**38**	189	20%	<- EXIT

RETAIL - RESIDENTIAL

WEEKDAY DAILY

RETAIL	%	#	BALANCED	#	%	RESIDENTIAL
EXIT ->	26%	5,884	**1,133**	2,462	46%	-> ENTER
ENTER <-	10%	5,884	**588**	2,462	42%	<- EXIT

WEEKDAY MORNING

RETAIL	%	#	BALANCED	#	%	RESIDENTIAL
EXIT ->	14%	142	**2**	77	2%	-> ENTER
ENTER <-	17%	231	**2**	220	1%	<- EXIT

WEEKDAY EVENING

RETAIL	%	#	BALANCED	#	%	RESIDENTIAL
EXIT ->	26%	558	**104**	225	46%	-> ENTER
ENTER <-	10%	515	**52**	144	42%	<- EXIT

OFFICE - RESIDENTIAL

WEEKDAY DAILY

OFFICE	%	#	BALANCED	#	%	RESIDENTIAL
EXIT ->	2%	1,060	**21**	2,462	3%	-> ENTER
ENTER <-	0%	1,060	**0**	2,462	0%	<- EXIT

WEEKDAY MORNING

OFFICE	%	#	BALANCED	#	%	RESIDENTIAL
EXIT ->	1%	31	**0**	77	0%	-> ENTER
ENTER <-	3%	190	**4**	220	2%	<- EXIT

WEEKDAY EVENING

OFFICE	%	#	BALANCED	#	%	RESIDENTIAL
EXIT ->	2%	189	**4**	225	4%	-> ENTER
ENTER <-	57%	36	**6**	144	4%	<- EXIT

TOTAL SHARED TRIPS - WEEKDAY DAILY

	ENTER	EXIT	TOTAL
RETAIL	821	1,292	2113
OFFICE	159	254	413
RES	1,154	588	1742

TOTAL SHARED TRIPS - WEEKDAY MORNING

	ENTER	EXIT	TOTAL
RETAIL	11	10	21
OFFICE	12	9	21
RES	2	6	8

TOTAL SHARED TRIPS - WEEKDAY EVENING

	ENTER	EXIT	TOTAL
RETAIL	90	115	205
OFFICE	17	42	59
RES	108	58	166

1 Weekday AM and PM Internal capture rates based on NCHRP Report 684, Saturday midday rates assumed to be the same was weekday evening rate
2 Daily Internal capture rates based on Trip Generation Handbook, 1st Edition, 2001

PROPOSED SHARED PERSON TRIPS - SATURDAY

RETAIL - OFFICE

SATURDAY DAILY						
RETAIL	%	#	BALANCED	#	%	OFFICE
EXIT ->	3%	8,650	**34**	225	15%	-> ENTER
ENTER <-	4%	8,650	**50**	225	22%	<- EXIT

SATURDAY MIDDAY						
RETAIL	%	#	BALANCED	#	%	OFFICE
EXIT ->	2%	591	**12**	58	31%	-> ENTER
ENTER <-	8%	640	**10**	50	20%	<- EXIT

RETAIL - RESIDENTIAL

SATURDAY DAILY						
RETAIL	%	#	BALANCED	#	%	RESIDENTIAL
EXIT ->	26%	8,650	**741**	1,610	46%	-> ENTER
ENTER <-	10%	8,650	**676**	1,610	42%	<- EXIT

SATURDAY MIDDAY						
RETAIL	%	#	BALANCED	#	%	RESIDENTIAL
EXIT ->	26%	591	**87**	190	46%	-> ENTER
ENTER <-	10%	640	**64**	198	42%	<- EXIT

OFFICE - RESIDENTIAL

SATURDAY DAILY						
OFFICE	%	#	BALANCED	#	%	RESIDENTIAL
EXIT ->	2%	225	**5**	1,610	3%	-> ENTER
ENTER <-	0%	225	**0**	1,610	0%	<- EXIT

SATURDAY MIDDAY						
OFFICE	%	#	BALANCED	#	%	RESIDENTIAL
EXIT ->	2%	50	**1**	190	4%	-> ENTER
ENTER <-	57%	58	**8**	198	4%	<- EXIT

TOTAL SHARED TRIPS - SATURDAY DAILY			
	ENTER	EXIT	TOTAL
RETAIL	726	775	1501
OFFICE	34	55	89
RES	746	676	1422

TOTAL SHARED TRIPS - SATURDAY MIDDAY			
	ENTER	EXIT	TOTAL
RETAIL	74	99	173
OFFICE	20	11	31
RES	88	72	160

1 Weekday AM and PM Internal capture rates based on NCHRP Report 684, Saturday midday rates assumed to be the same was weekday evening rate
2 Daily Internal capture rates based on Trip Generation Handbook, 1st Edition, 2001

Capacity Analysis Worksheets

Intersection	
Intersection Delay, s/veh	93.1
Intersection LOS	F

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Vol, veh/h	30	1	10	50	105	35	70	620	1	0	355	265
Future Vol, veh/h	30	1	10	50	105	35	70	620	1	0	355	265
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Heavy Vehicles, %	0	0	0	0	0	0	0	0	0	0	0	0
Mvmt Flow	33	1	11	54	114	38	76	674	1	0	386	288
Number of Lanes	0	1	0	0	1	0	0	1	0	0	1	0

Approach	EB	WB	NB	SB
Opposing Approach	WB	EB	SB	NB
Opposing Lanes	1	1	1	1
Conflicting Approach Left	SB	NB	EB	WB
Conflicting Lanes Left	1	1	1	1
Conflicting Approach Right	NB	SB	WB	EB
Conflicting Lanes Right	1	1	1	1
HCM Control Delay	12.7	16	136.4	73.8
HCM LOS	B	C	F	F

Lane	NBLn1	EBLn1	WBLn1	SBLn1
Vol Left, %	10%	73%	26%	0%
Vol Thru, %	90%	2%	55%	57%
Vol Right, %	0%	24%	18%	43%
Sign Control	Stop	Stop	Stop	Stop
Traffic Vol by Lane	691	41	190	620
LT Vol	70	30	50	0
Through Vol	620	1	105	355
RT Vol	1	10	35	265
Lane Flow Rate	751	45	207	674
Geometry Grp	1	1	1	1
Degree of Util (X)	1.225	0.1	0.412	1.048
Departure Headway (Hd)	6.043	8.727	7.714	5.955
Convergence, Y/N	Yes	Yes	Yes	Yes
Cap	608	413	469	613
Service Time	4.043	6.727	5.714	3.955
HCM Lane V/C Ratio	1.235	0.109	0.441	1.1
HCM Control Delay	136.4	12.7	16	73.8
HCM Lane LOS	F	B	C	F
HCM 95th-tile Q	26.9	0.3	2	17.3

Intersection	
Intersection Delay, s/veh	30.9
Intersection LOS	D

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		✥			✥			✥			✥	
Traffic Vol, veh/h	255	50	20	0	5	40	2	395	60	70	345	2
Future Vol, veh/h	255	50	20	0	5	40	2	395	60	70	345	2
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Heavy Vehicles, %	0	0	0	0	0	0	1	1	1	0	0	0
Mvmt Flow	277	54	22	0	5	43	2	429	65	76	375	2
Number of Lanes	0	1	0	0	1	0	0	1	0	0	1	0

Approach	EB	WB	NB	SB
Opposing Approach	WB	EB	SB	NB
Opposing Lanes	1	1	1	1
Conflicting Approach Left	SB	NB	EB	WB
Conflicting Lanes Left	1	1	1	1
Conflicting Approach Right	NB	SB	WB	EB
Conflicting Lanes Right	1	1	1	1
HCM Control Delay	24	11.6	37.2	31.5
HCM LOS	C	B	E	D

Lane	NBLn1	EBLn1	WBLn1	SBLn1
Vol Left, %	0%	78%	0%	17%
Vol Thru, %	86%	15%	11%	83%
Vol Right, %	13%	6%	89%	0%
Sign Control	Stop	Stop	Stop	Stop
Traffic Vol by Lane	457	325	45	417
LT Vol	2	255	0	70
Through Vol	395	50	5	345
RT Vol	60	20	40	2
Lane Flow Rate	497	353	49	453
Geometry Grp	1	1	1	1
Degree of Util (X)	0.865	0.685	0.104	0.809
Departure Headway (Hd)	6.269	6.979	7.674	6.429
Convergence, Y/N	Yes	Yes	Yes	Yes
Cap	576	516	470	562
Service Time	4.343	5.054	5.674	4.506
HCM Lane V/C Ratio	0.863	0.684	0.104	0.806
HCM Control Delay	37.2	24	11.6	31.5
HCM Lane LOS	E	C	B	D
HCM 95th-tile Q	9.6	5.2	0.3	7.9

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Ø1	Ø3	Ø7	Ø9
Lane Configurations																
Traffic Volume (vph)	140	125	175	130	200	25	165	815	70	30	715	100				
Future Volume (vph)	140	125	175	130	200	25	165	815	70	30	715	100				
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900				
Storage Length (ft)	0		100	200		50	0		0	220		0				
Storage Lanes	0		1	1		0	1		0	1		0				
Taper Length (ft)	25			25			25			25						
Satd. Flow (prot)	0	1832	1599	1805	1858	0	1787	1854	0	1770	1823	0				
Flt Permitted		0.462		0.412			0.058			0.149						
Satd. Flow (perm)	0	863	1599	783	1858	0	109	1854	0	278	1823	0				
Right Turn on Red			Yes			Yes			Yes			Yes				
Satd. Flow (RTOR)			145		5			6			7					
Link Speed (mph)		30			30			30			30					
Link Distance (ft)		1238			516			754			366					
Travel Time (s)		28.1			11.7			17.1			8.3					
Confl. Peds. (#/hr)	6					6	2		2	2		2				
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92				
Heavy Vehicles (%)	1%	1%	1%	0%	0%	0%	1%	1%	1%	2%	2%	2%				
Shared Lane Traffic (%)																
Lane Group Flow (vph)	0	288	190	141	244	0	179	962	0	33	886	0				
Turn Type	Perm	NA	pm+ov	Perm	NA		pm+pt	NA		Perm	NA					
Protected Phases		4	5		8		5	2			6		1	3	7	9
Permitted Phases	4		4	8			2			6						
Detector Phase	4	4	5	8	8		5	2		6	6					
Switch Phase																
Minimum Initial (s)	6.0	6.0	6.0	6.0	6.0		6.0	15.0		15.0	15.0		3.0	3.0	3.0	3.0
Minimum Split (s)	22.0	22.0	13.0	26.0	26.0		13.0	29.0		28.0	28.0		5.0	5.0	5.0	5.0
Total Split (s)	36.0	36.0	17.0	36.0	36.0		17.0	66.0		66.0	66.0		5.0	5.0	5.0	5.0
Total Split (%)	27.9%	27.9%	13.2%	27.9%	27.9%		13.2%	51.2%		51.2%	51.2%		4%	4%	4%	4%
Yellow Time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0		2.0	2.0	2.0	2.0
All-Red Time (s)	2.0	2.0	2.0	2.0	2.0		2.0	2.0		2.0	2.0		0.0	0.0	0.0	0.0
Lost Time Adjust (s)		0.0	0.0	0.0	0.0		0.0	0.0		0.0	0.0					
Total Lost Time (s)		6.0	6.0	6.0	6.0		6.0	6.0		6.0	6.0					
Lead/Lag	Lag	Lag	Lead	Lag	Lag		Lead	Lag					Lead	Lead	Lead	Lag
Lead-Lag Optimize?																
Recall Mode	None	None	None	None	None		None	None		None	None		None	None	None	None
Act Effct Green (s)		31.0	47.8	30.0	30.0		77.8	76.9		60.0	60.0					
Actuated g/C Ratio		0.26	0.40	0.25	0.25		0.64	0.64		0.50	0.50					
v/c Ratio		1.30	0.26	0.73	0.52		0.81	0.81		0.24	0.97					
Control Delay		203.0	7.9	64.8	43.8		55.2	24.2		24.4	54.6					
Queue Delay		0.0	0.0	0.0	0.0		0.0	0.0		0.0	8.1					
Total Delay		203.0	7.9	64.8	43.8		55.2	24.2		24.4	62.7					
LOS		F	A	E	D		E	C		C	E					
Approach Delay		125.5			51.5			29.0			61.3					
Approach LOS		F			D			C			E					
Queue Length 50th (ft)		~286	21	99	158		85	497		14	629					
Queue Length 95th (ft)		#478	73	#224	267		#225	877		45	#1053					
Internal Link Dist (ft)		1158			436			674			286					
Turn Bay Length (ft)			100	200						220						
Base Capacity (vph)		221	722	194	465		223	1184		138	909					
Starvation Cap Reductn		0	0	0	0		0	0		0	33					
Spillback Cap Reductn		0	0	0	0		0	0		0	0					
Storage Cap Reductn		0	0	0	0		0	0		0	0					
Reduced v/c Ratio		1.30	0.26	0.73	0.52		0.80	0.81		0.24	1.01					

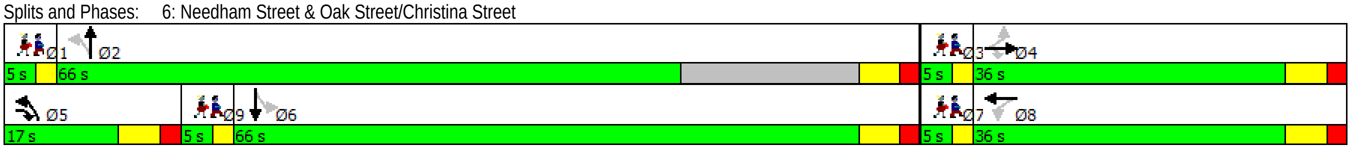
Intersection Summary

Area Type: Other
Cycle Length: 129
Actuated Cycle Length: 120.8
Natural Cycle: 150
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 1.30
Intersection Signal Delay: 57.9 — Intersection LOS: E
Intersection Capacity Utilization 106.1% — ICU Level of Service G
Analysis Period (min) 15

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.

\# 95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 6: Needham Street & Oak Street/Christina Street



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Ø3	Ø7	Ø9	Ø10
Lane Configurations																
Traffic Volume (vph)	40	0	35	25	0	15	75	785	50	15	770	40				
Future Volume (vph)	40	0	35	25	0	15	75	785	50	15	770	40				
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900				
Storage Length (ft)	125		0	125		0	100		0	100		0				
Storage Lanes	1		0	1		0	1		0	1		0				
Taper Length (ft)	25			25			25			25						
Satd. Flow (prot)	1805	1615	0	1805	1578	0	1770	1842	0	1770	1847	0				
Flt Permitted	0.744			0.723			0.221			0.155						
Satd. Flow (perm)	1409	1615	0	1374	1578	0	412	1842	0	289	1847	0				
Right Turn on Red			Yes			Yes			Yes			Yes				
Satd. Flow (RTOR)		335			295			4			3					
Link Speed (mph)		30			30			30			30					
Link Distance (ft)		491			563			244			497					
Travel Time (s)		11.2			12.8			5.5			11.3					
Confl. Peds. (#/hr)	1					1	2		6	6		2				
Confl. Bikes (#/hr)									1							
Peak Hour Factor	0.67	0.67	0.67	0.75	0.75	0.75	0.97	0.97	0.97	0.96	0.96	0.96				
Heavy Vehicles (%)	0%	0%	0%	0%	0%	0%	2%	2%	2%	2%	2%	2%				
Shared Lane Traffic (%)																
Lane Group Flow (vph)	60	52	0	33	20	0	77	861	0	16	844	0				
Turn Type	Perm	NA		Perm	NA		pm+pt	NA		pm+pt	NA					
Protected Phases		4			8		5	2		1	6		3	7	9	10
Permitted Phases	4			8			2			6						
Detector Phase	4	4		8	8		5	2		1	6					
Switch Phase																
Minimum Initial (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0		1.0	1.0	1.0	1.0
Minimum Split (s)	23.0	23.0		23.0	23.0		9.0	22.0		9.0	22.0		3.0	3.0	3.0	3.0
Total Split (s)	26.0	26.0		26.0	26.0		16.0	56.0		16.0	56.0		3.0	3.0	3.0	3.0
Total Split (%)	25.0%	25.0%		25.0%	25.0%		15.4%	53.8%		15.4%	53.8%		3%	3%	3%	3%
Yellow Time (s)	4.0	4.0		4.0	4.0		3.0	4.0		3.0	4.0		2.0	2.0	2.0	2.0
All-Red Time (s)	2.0	2.0		2.0	2.0		3.0	2.0		3.0	2.0		0.0	0.0	0.0	0.0
Lost Time Adjust (s)	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0					
Total Lost Time (s)	6.0	6.0		6.0	6.0		6.0	6.0		6.0	6.0					
Lead/Lag	Lag	Lag		Lag	Lag					Lead	Lag		Lead	Lead	Lag	Lead
Lead-Lag Optimize?																
Recall Mode	None	None		None	None		None	Min		None	Min		None	None	None	None
Act Effct Green (s)	9.1	9.1		8.7	8.7		52.3	53.3		45.3	46.9					
Actuated g/C Ratio	0.13	0.13		0.12	0.12		0.73	0.74		0.63	0.65					
v/c Ratio	0.34	0.10		0.20	0.04		0.19	0.63		0.06	0.70					
Control Delay	37.3	0.4		35.5	0.2		9.9	12.6		8.8	18.0					
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0					
Total Delay	37.3	0.4		35.5	0.2		9.9	12.6		8.8	18.0					
LOS	D	A		D	A		A	B		A	B					
Approach Delay		20.2			22.2			12.4			17.8					
Approach LOS		C			C			B			B					
Queue Length 50th (ft)	26	0		14	0		8	154		3	267					
Queue Length 95th (ft)	49	0		37	0		46	#727		14	#708					
Internal Link Dist (ft)		411			483			164			417					
Turn Bay Length (ft)	125			125			100			100						
Base Capacity (vph)	424	720		413	681		524	1369		404	1317					
Starvation Cap Reductn	0	0		0	0		0	0		0	0					
Spillback Cap Reductn	0	0		0	0		0	0		0	0					
Storage Cap Reductn	0	0		0	0		0	0		0	0					
Reduced v/c Ratio	0.14	0.07		0.08	0.03		0.15	0.63		0.04	0.64					

Intersection Summary

Area Type: Other
Cycle Length: 104
Actuated Cycle Length: 71.9
Natural Cycle: 90
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.70
Intersection Signal Delay: 15.5 | Intersection LOS: B
Intersection Capacity Utilization 71.6% | ICU Level of Service C
Analysis Period (min) 15
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

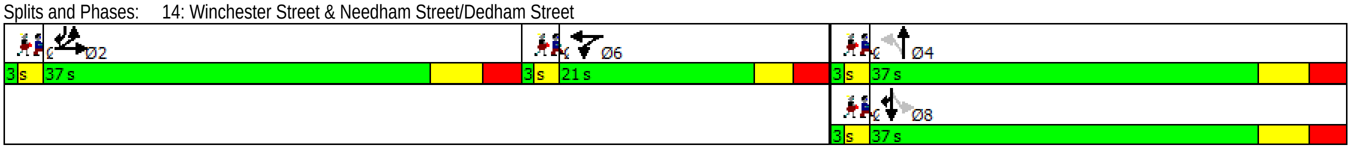
Splits and Phases: 9: Needham Street & North Site Driveway/Charlemont Street

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Ø1	Ø3	Ø5	Ø7
Lane Configurations	↰↰	↱			✢		↰	↱			↰	↱				
Traffic Volume (vph)	750	95	45	15	125	155	30	290	5	50	345	825				
Future Volume (vph)	750	95	45	15	125	155	30	290	5	50	345	825				
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900				
Storage Length (ft)	340		75	0		0	100		0	0		0				
Storage Lanes	1		1	0		0	1		0	0		1				
Taper Length (ft)	25			25			25			25						
Satd. Flow (prot)	3433	1758	0	0	1740	0	1770	1858	0	0	1870	1599				
Flt Permitted	0.950				0.998		0.295				0.810					
Satd. Flow (perm)	3389	1758	0	0	1739	0	550	1858	0	0	1524	1599				
Right Turn on Red			Yes			Yes			No			Yes				
Satd. Flow (RTOR)		23			45							424				
Link Speed (mph)		30			30			30			30					
Link Distance (ft)		1135			451			634			722					
Travel Time (s)		25.8			10.3			14.4			16.4					
Confl. Peds. (#/hr)	5		1	1		5										
Confl. Bikes (#/hr)									1							
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92				
Heavy Vehicles (%)	2%	2%	2%	0%	0%	0%	2%	2%	2%	1%	1%	1%				
Shared Lane Traffic (%)																
Lane Group Flow (vph)	815	152	0	0	320	0	33	320	0	0	429	897				
Turn Type	Split	NA		Split	NA		Perm	NA		Perm	NA	pt+ov				
Protected Phases	2	2		6	6			4			8	2 8	1	3	5	7
Permitted Phases							4			8						
Detector Phase	2	2		6	6		4	4		8	8	2 8				
Switch Phase																
Minimum Initial (s)	10.0	10.0		6.0	6.0		6.0	6.0		6.0	6.0		1.0	1.0	1.0	1.0
Minimum Split (s)	17.0	17.0		19.0	19.0		20.0	20.0		36.0	36.0		3.0	3.0	3.0	3.0
Total Split (s)	37.0	37.0		21.0	21.0		37.0	37.0		37.0	37.0		3.0	3.0	3.0	3.0
Total Split (%)	35.6%	35.6%		20.2%	20.2%		35.6%	35.6%		35.6%	35.6%		3%	3%	3%	3%
Yellow Time (s)	4.0	4.0		3.0	3.0		4.0	4.0		4.0	4.0		2.0	2.0	2.0	2.0
All-Red Time (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0		0.0	0.0	0.0	0.0
Lost Time Adjust (s)	0.0	0.0			0.0		0.0	0.0			0.0					
Total Lost Time (s)	7.0	7.0			6.0		7.0	7.0			7.0					
Lead/Lag	Lag	Lag		Lag	Lag		Lag	Lag		Lag	Lag		Lead	Lead	Lead	Lead
Lead-Lag Optimize?																
Recall Mode	None	None		None	None		None	None		None	None		None	None	None	None
Act Effct Green (s)	28.8	28.8			15.0		29.9	29.9			30.5	65.0				
Actuated g/C Ratio	0.30	0.30			0.16		0.31	0.31			0.32	0.68				
v/c Ratio	0.79	0.28			1.03		0.19	0.55			0.88	0.73				
Control Delay	37.3	23.4			94.5		29.4	32.4			52.9	8.8				
Queue Delay	0.0	0.0			0.0		0.0	0.0			0.0	0.0				
Total Delay	37.3	23.4			94.5		29.4	32.4			52.9	8.8				
LOS	D	C			F		C	C			D	A				
Approach Delay		35.1			94.5			32.1			23.0					
Approach LOS		D			F			C			C					
Queue Length 50th (ft)	225	57			~177		14	159			245	125				
Queue Length 95th (ft)	331	119			#390		44	276			#454	286				
Internal Link Dist (ft)		1055			371			554			642					
Turn Bay Length (ft)	340						100									
Base Capacity (vph)	1081	569			311		173	584			486	1239				
Starvation Cap Reductn	0	0			0		0	0			0	0				
Spillback Cap Reductn	0	0			0		0	0			0	0				
Storage Cap Reductn	0	0			0		0	0			0	0				
Reduced v/c Ratio	0.75	0.27			1.03		0.19	0.55			0.88	0.72				

Intersection Summary

Area Type: Other
Cycle Length: 104
Actuated Cycle Length: 95.5
Natural Cycle: 85
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 1.03
Intersection Signal Delay: 35.8 — Intersection LOS: D
Intersection Capacity Utilization 100.5% — ICU Level of Service G
Analysis Period (min) 15
~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 14: Winchester Street & Needham Street/Dedham Street

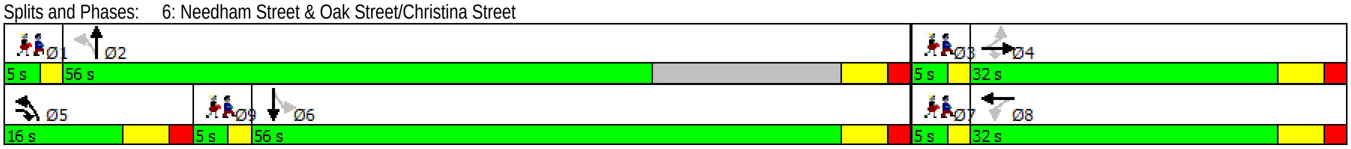


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Ø1	Ø3	Ø7	Ø9
Lane Configurations																
Traffic Volume (vph)	180	135	190	135	145	50	185	850	85	50	840	150				
Future Volume (vph)	180	135	190	135	145	50	185	850	85	50	840	150				
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900				
Storage Length (ft)	0		100	200		50	0		0	220		0				
Storage Lanes	0		1	1		0	1		0	1		0				
Taper Length (ft)	25			25			25			25						
Satd. Flow (prot)	0	1847	1615	1805	1814	0	1805	1869	0	1787	1838	0				
Flt Permitted		0.573		0.269			0.069			0.087						
Satd. Flow (perm)	0	1086	1575	511	1814	0	131	1869	0	164	1838	0				
Right Turn on Red			Yes			Yes			Yes			Yes				
Satd. Flow (RTOR)			139		14			7			10					
Link Speed (mph)		30			30			30			30					
Link Distance (ft)		1238			516			754			275					
Travel Time (s)		28.1			11.7			17.1			6.3					
Confl. Peds. (#/hr)	2		1	1		2			1	1						
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92				
Heavy Vehicles (%)	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	1%	1%				
Shared Lane Traffic (%)																
Lane Group Flow (vph)	0	343	207	147	212	0	201	1016	0	54	1076	0				
Turn Type	Perm	NA	pm+ov	Perm	NA		pm+pt	NA		Perm	NA					
Protected Phases		4	5		8		5	2			6		1	3	7	9
Permitted Phases	4		4	8			2			6						
Detector Phase	4	4	5	8	8		5	2		6	6					
Switch Phase																
Minimum Initial (s)	6.0	6.0	6.0	6.0	6.0		6.0	15.0		15.0	15.0		3.0	3.0	3.0	3.0
Minimum Split (s)	22.0	22.0	13.0	26.0	26.0		13.0	29.0		28.0	28.0		5.0	5.0	5.0	5.0
Total Split (s)	32.0	32.0	16.0	32.0	32.0		16.0	56.0		56.0	56.0		5.0	5.0	5.0	5.0
Total Split (%)	28.1%	28.1%	14.0%	28.1%	28.1%		14.0%	49.1%		49.1%	49.1%		4%	4%	4%	4%
Yellow Time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0		2.0	2.0	2.0	2.0
All-Red Time (s)	2.0	2.0	2.0	2.0	2.0		2.0	2.0		2.0	2.0		0.0	0.0	0.0	0.0
Lost Time Adjust (s)		0.0	0.0	0.0	0.0		0.0	0.0		0.0	0.0					
Total Lost Time (s)		6.0	6.0	6.0	6.0		6.0	6.0		6.0	6.0					
Lead/Lag	Lag	Lag	Lead	Lag	Lag		Lead	Lag					Lead	Lead	Lead	Lag
Lead-Lag Optimize?																
Recall Mode	None	None	None	None	None		None	None		None	None		None	None	None	None
Act Effct Green (s)		26.0	36.0	26.0	26.0		66.0	65.1		50.0	50.0					
Actuated g/C Ratio		0.25	0.34	0.25	0.25		0.63	0.62		0.48	0.48					
v/c Ratio		1.28	0.33	1.17	0.46		0.83	0.88		0.70	1.22					
Control Delay		185.0	9.3	170.3	35.4		51.5	27.7		70.4	137.6					
Queue Delay		0.0	0.0	0.0	0.0		0.0	0.0		0.0	0.0					
Total Delay		185.0	9.3	170.3	35.4		51.5	27.7		70.4	137.6					
LOS		F	A	F	D		D	C		E	F					
Approach Delay		118.9			90.6			31.6			134.4					
Approach LOS		F			F			C			F					
Queue Length 50th (ft)		~288	28	~116	111		81	491		27	~879					
Queue Length 95th (ft)		#491	82	#255	194		#222	#965		#107	#1207					
Internal Link Dist (ft)		1158			436			674			195					
Turn Bay Length (ft)			100	200						220						
Base Capacity (vph)		269	634	126	460		242	1177		77	880					
Starvation Cap Reductn		0	0	0	0		0	0		0	0					
Spillback Cap Reductn		0	0	0	0		0	0		0	0					
Storage Cap Reductn		0	0	0	0		0	0		0	0					
Reduced v/c Ratio		1.28	0.33	1.17	0.46		0.83	0.86		0.70	1.22					

Intersection Summary

Area Type: Other
Cycle Length: 114
Actuated Cycle Length: 105
Natural Cycle: 150
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 1.28
Intersection Signal Delay: 88.5 Intersection LOS: F
Intersection Capacity Utilization 111.4% ICU Level of Service H
Analysis Period (min) 15
~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 6: Needham Street & Oak Street/Christina Street



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Ø3	Ø7	Ø9	Ø10
Lane Configurations	↰	↱		↰	↱		↰	↱		↰	↱					
Traffic Volume (vph)	125	0	60	40	15	25	80	840	30	5	810	95				
Future Volume (vph)	125	0	60	40	15	25	80	840	30	5	810	95				
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900				
Storage Length (ft)	125		0	125		0	100		0	100		0				
Storage Lanes	1		0	1		0	1		0	1		0				
Taper Length (ft)	25			25			25			25						
Satd. Flow (prot)	1805	1615	0	1805	1721	0	1787	1870	0	1787	1843	0				
Flt Permitted	0.729			0.715			0.107			0.104						
Satd. Flow (perm)	1385	1615	0	1358	1721	0	201	1870	0	196	1843	0				
Right Turn on Red			Yes			Yes			Yes			Yes				
Satd. Flow (RTOR)		314			27			2			8					
Link Speed (mph)		30			30			30			30					
Link Distance (ft)		491			696			244			497					
Travel Time (s)		11.2			15.8			5.5			11.3					
Confl. Peds. (#/hr)							7		3	3		7				
Confl. Bikes (#/hr)									2							
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92				
Heavy Vehicles (%)	0%	0%	0%	0%	0%	0%	1%	1%	1%	1%	1%	1%				
Shared Lane Traffic (%)																
Lane Group Flow (vph)	136	65	0	43	43	0	87	946	0	5	983	0				
Turn Type	Perm	NA		Perm	NA		pm+pt	NA		pm+pt	NA					
Protected Phases		4			8		5	2		1	6		3	7	9	10
Permitted Phases	4			8			2			6						
Detector Phase	4	4		8	8		5	2		1	6					
Switch Phase																
Minimum Initial (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0		1.0	1.0	1.0	1.0
Minimum Split (s)	23.0	23.0		23.0	23.0		9.0	22.0		9.0	22.0		3.0	3.0	3.0	3.0
Total Split (s)	26.0	26.0		26.0	26.0		16.0	56.0		16.0	56.0		3.0	3.0	3.0	3.0
Total Split (%)	25.0%	25.0%		25.0%	25.0%		15.4%	53.8%		15.4%	53.8%		3%	3%	3%	3%
Yellow Time (s)	4.0	4.0		4.0	4.0		3.0	4.0		3.0	4.0		2.0	2.0	2.0	2.0
All-Red Time (s)	2.0	2.0		2.0	2.0		3.0	2.0		3.0	2.0		0.0	0.0	0.0	0.0
Lost Time Adjust (s)	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0					
Total Lost Time (s)	6.0	6.0		6.0	6.0		6.0	6.0		6.0	6.0					
Lead/Lag	Lag	Lag		Lag	Lag					Lead	Lag		Lead	Lead	Lag	Lead
Lead-Lag Optimize?																
Recall Mode	None	None		None	None		None	Min		None	Min		None	None	None	None
Act Effct Green (s)	13.0	13.0		13.0	13.0		61.6	60.6		53.9	53.4					
Actuated g/C Ratio	0.15	0.15		0.15	0.15		0.70	0.69		0.61	0.61					
v/c Ratio	0.67	0.13		0.22	0.16		0.37	0.74		0.02	0.88					
Control Delay	51.9	0.5		35.2	18.7		19.9	16.0		9.8	28.5					
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0					
Total Delay	51.9	0.5		35.2	18.7		19.9	16.0		9.8	28.5					
LOS	D	A		D	B		B	B		A	C					
Approach Delay		35.3			26.9			16.3			28.4					
Approach LOS		D			C			B			C					
Queue Length 50th (ft)	70	0		21	7		12	248		1	428					
Queue Length 95th (ft)	138	0		53	37		49	#829		7	#929					
Internal Link Dist (ft)		411			616			164			417					
Turn Bay Length (ft)	125			125			100			100						
Base Capacity (vph)	315	610		309	413		331	1287		301	1119					
Starvation Cap Reductn	0	0		0	0		0	0		0	0					
Spillback Cap Reductn	0	0		0	0		0	0		0	0					
Storage Cap Reductn	0	0		0	0		0	0		0	0					
Reduced v/c Ratio	0.43	0.11		0.14	0.10		0.26	0.74		0.02	0.88					

Intersection Summary

Area Type: Other
Cycle Length: 104
Actuated Cycle Length: 88.1
Natural Cycle: 90
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.88
Intersection Signal Delay: 23.6 Intersection LOS: C
Intersection Capacity Utilization 81.5% ICU Level of Service D
Analysis Period (min) 15
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

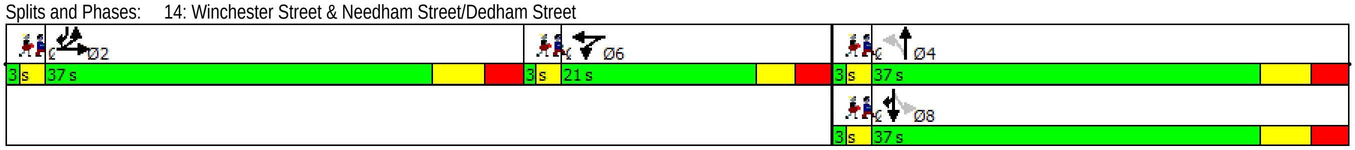
Splits and Phases: 9: Needham Street & North Site Driveway/Charlemont Street

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Ø1	Ø3	Ø5	Ø7
Lane Configurations																
Traffic Volume (vph)	665	105	40	15	80	65	25	290	15	55	250	515				
Future Volume (vph)	665	105	40	15	80	65	25	290	15	55	250	515				
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900				
Storage Length (ft)	340		75	0		0	100		0	0		0				
Storage Lanes	1		1	0		0	1		0	0		1				
Taper Length (ft)	25			25			25			25						
Satd. Flow (prot)	3502	1822	0	0	1787	0	1805	1885	0	0	1864	1599				
Flt Permitted	0.950				0.995		0.450				0.788					
Satd. Flow (perm)	3502	1822	0	0	1787	0	849	1885	0	0	1482	1599				
Right Turn on Red			Yes			Yes			No			Yes				
Satd. Flow (RTOR)		18			28							560				
Link Speed (mph)		30			30			30			30					
Link Distance (ft)		1135			451			634			722					
Travel Time (s)		25.8			10.3			14.4			16.4					
Confl. Peds. (#/hr)							8					8				
Confl. Bikes (#/hr)									1							
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92				
Heavy Vehicles (%)	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	1%	1%				
Shared Lane Traffic (%)																
Lane Group Flow (vph)	723	157	0	0	174	0	27	331	0	0	332	560				
Turn Type	Split	NA		Split	NA		Perm	NA		Perm	NA	pt+ov				
Protected Phases	2	2		6	6			4			8	2 8	1	3	5	7
Permitted Phases							4			8						
Detector Phase	2	2		6	6		4	4		8	8	2 8				
Switch Phase																
Minimum Initial (s)	10.0	10.0		6.0	6.0		6.0	6.0		6.0	6.0		1.0	1.0	1.0	1.0
Minimum Split (s)	17.0	17.0		19.0	19.0		20.0	20.0		36.0	36.0		3.0	3.0	3.0	3.0
Total Split (s)	37.0	37.0		21.0	21.0		37.0	37.0		37.0	37.0		3.0	3.0	3.0	3.0
Total Split (%)	35.6%	35.6%		20.2%	20.2%		35.6%	35.6%		35.6%	35.6%		3%	3%	3%	3%
Yellow Time (s)	4.0	4.0		3.0	3.0		4.0	4.0		4.0	4.0		2.0	2.0	2.0	2.0
All-Red Time (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0		0.0	0.0	0.0	0.0
Lost Time Adjust (s)	0.0	0.0			0.0		0.0	0.0			0.0					
Total Lost Time (s)	7.0	7.0			6.0		7.0	7.0			7.0					
Lead/Lag	Lag	Lag		Lag	Lag		Lag	Lag		Lag	Lag		Lead	Lead	Lead	Lead
Lead-Lag Optimize?																
Recall Mode	None	None		None	None		None	None		None	None		None	None	None	None
Act Effct Green (s)	25.0	25.0			11.1		28.9	28.9			28.4	60.5				
Actuated g/C Ratio	0.29	0.29			0.13		0.34	0.34			0.33	0.71				
v/c Ratio	0.71	0.29			0.68		0.09	0.52			0.67	0.43				
Control Delay	31.8	23.1			45.1		23.0	27.6			34.7	1.6				
Queue Delay	0.0	0.0			0.0		0.0	0.0			0.0	0.0				
Total Delay	31.8	23.1			45.1		23.0	27.6			34.7	1.6				
LOS	C	C			D		C	C			C	A				
Approach Delay		30.3			45.1			27.3			13.9					
Approach LOS		C			D			C			B					
Queue Length 50th (ft)	182	58			79		10	149			159	0				
Queue Length 95th (ft)	265	117			155		32	250			#299	30				
Internal Link Dist (ft)		1055			371			554			642					
Turn Bay Length (ft)	340						100									
Base Capacity (vph)	1257	665			343		309	688			531	1365				
Starvation Cap Reductn	0	0			0		0	0			0	0				
Spillback Cap Reductn	0	0			0		0	0			0	0				
Storage Cap Reductn	0	0			0		0	0			0	0				
Reduced v/c Ratio	0.58	0.24			0.51		0.09	0.48			0.63	0.41				

Intersection Summary

Area Type: Other
Cycle Length: 104
Actuated Cycle Length: 85.5
Natural Cycle: 85
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.71
Intersection Signal Delay: 24.6 Intersection LOS: C
Intersection Capacity Utilization 84.7% ICU Level of Service E
Analysis Period (min) 15
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 14: Winchester Street & Needham Street/Dedham Street



Intersection	
Intersection Delay, s/veh	109.7
Intersection LOS	F

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Vol, veh/h	120	1	30	125	30	30	60	505	1	1	435	230
Future Vol, veh/h	120	1	30	125	30	30	60	505	1	1	435	230
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Heavy Vehicles, %	0	0	0	0	0	0	0	0	0	0	0	0
Mvmt Flow	130	1	33	136	33	33	65	549	1	1	473	250
Number of Lanes	0	1	0	0	1	0	0	1	0	0	1	0

Approach	EB	WB	NB	SB
Opposing Approach	WB	EB	SB	NB
Opposing Lanes	1	1	1	1
Conflicting Approach Left	SB	NB	EB	WB
Conflicting Lanes Left	1	1	1	1
Conflicting Approach Right	NB	SB	WB	EB
Conflicting Lanes Right	1	1	1	1
HCM Control Delay	17.4	18.8	104.6	160.3
HCM LOS	C	C	F	F

Lane	NBLn1	EBLn1	WBLn1	SBLn1
Vol Left, %	11%	79%	68%	0%
Vol Thru, %	89%	1%	16%	65%
Vol Right, %	0%	20%	16%	35%
Sign Control	Stop	Stop	Stop	Stop
Traffic Vol by Lane	566	151	185	666
LT Vol	60	120	125	1
Through Vol	505	1	30	435
RT Vol	1	30	30	230
Lane Flow Rate	615	164	201	724
Geometry Grp	1	1	1	1
Degree of Util (X)	1.125	0.372	0.445	1.278
Departure Headway (Hd)	7.13	9.108	8.868	6.691
Convergence, Y/N	Yes	Yes	Yes	Yes
Cap	517	397	408	550
Service Time	5.13	7.108	6.868	4.691
HCM Lane V/C Ratio	1.19	0.413	0.493	1.316
HCM Control Delay	104.6	17.4	18.8	160.3
HCM Lane LOS	F	C	C	F
HCM 95th-tile Q	19.1	1.7	2.2	27.9

Intersection	
Intersection Delay, s/veh	61.1
Intersection LOS	F

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Vol, veh/h	180	155	15	1	2	20	2	365	30	100	490	2
Future Vol, veh/h	180	155	15	1	2	20	2	365	30	100	490	2
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Heavy Vehicles, %	0	0	0	0	0	0	0	0	0	0	0	0
Mvmt Flow	196	168	16	1	2	22	2	397	33	109	533	2
Number of Lanes	0	1	0	0	1	0	0	1	0	0	1	0

Approach	EB	WB	NB	SB
Opposing Approach	WB	EB	SB	NB
Opposing Lanes	1	1	1	1
Conflicting Approach Left	SB	NB	EB	WB
Conflicting Lanes Left	1	1	1	1
Conflicting Approach Right	NB	SB	WB	EB
Conflicting Lanes Right	1	1	1	1
HCM Control Delay	27.1	11.8	28.5	105
HCM LOS	D	B	D	F

Lane	NBLn1	EBLn1	WBLn1	SBLn1
Vol Left, %	1%	51%	4%	17%
Vol Thru, %	92%	44%	9%	83%
Vol Right, %	8%	4%	87%	0%
Sign Control	Stop	Stop	Stop	Stop
Traffic Vol by Lane	397	350	23	592
LT Vol	2	180	1	100
Through Vol	365	155	2	490
RT Vol	30	15	20	2
Lane Flow Rate	432	380	25	643
Geometry Grp	1	1	1	1
Degree of Util (X)	0.767	0.725	0.055	1.137
Departure Headway (Hd)	6.734	7.247	8.306	6.361
Convergence, Y/N	Yes	Yes	Yes	Yes
Cap	539	502	434	573
Service Time	4.734	5.247	6.306	4.363
HCM Lane V/C Ratio	0.801	0.757	0.058	1.122
HCM Control Delay	28.5	27.1	11.8	105
HCM Lane LOS	D	D	B	F
HCM 95th-tile Q	6.9	5.9	0.2	21.1

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Ø1	Ø3	Ø7	Ø9
Lane Configurations																
Traffic Volume (vph)	165	120	190	120	135	45	170	780	70	45	800	140				
Future Volume (vph)	165	120	190	120	135	45	170	780	70	45	800	140				
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900				
Storage Length (ft)	0		100	200		50	0		0	220		0				
Storage Lanes	0		1	1		0	1		0	1		0				
Taper Length (ft)	25			25			25			25						
Satd. Flow (prot)	0	1847	1615	1805	1814	0	1805	1873	0	1787	1840	0				
Flt Permitted		0.586		0.318			0.059			0.169						
Satd. Flow (perm)	0	1110	1574	604	1814	0	112	1873	0	318	1840	0				
Right Turn on Red			Yes			Yes			Yes			Yes				
Satd. Flow (RTOR)			137		12			6			9					
Link Speed (mph)		30			30			30			30					
Link Distance (ft)		1238			516			754			354					
Travel Time (s)		28.1			11.7			17.1			8.0					
Confl. Peds. (#/hr)	2		1	1		2			1	1						
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92				
Heavy Vehicles (%)	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	1%	1%				
Shared Lane Traffic (%)																
Lane Group Flow (vph)	0	309	207	130	196	0	185	924	0	49	1022	0				
Turn Type	Perm	NA	pm+ov	Perm	NA		pm+pt	NA		Perm	NA					
Protected Phases		4	5		8		5	2			6		1	3	7	9
Permitted Phases	4		4	8			2			6						
Detector Phase	4	4	5	8	8		5	2		6	6					
Switch Phase																
Minimum Initial (s)	6.0	6.0	6.0	6.0	6.0		6.0	15.0		15.0	15.0		3.0	3.0	3.0	3.0
Minimum Split (s)	22.0	22.0	13.0	26.0	26.0		13.0	29.0		28.0	28.0		5.0	5.0	5.0	5.0
Total Split (s)	36.0	36.0	17.0	36.0	36.0		17.0	66.0		66.0	66.0		5.0	5.0	5.0	5.0
Total Split (%)	27.9%	27.9%	13.2%	27.9%	27.9%		13.2%	51.2%		51.2%	51.2%		4%	4%	4%	4%
Yellow Time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0		2.0	2.0	2.0	2.0
All-Red Time (s)	2.0	2.0	2.0	2.0	2.0		2.0	2.0		2.0	2.0		0.0	0.0	0.0	0.0
Lost Time Adjust (s)		0.0	0.0	0.0	0.0		0.0	0.0		0.0	0.0					
Total Lost Time (s)		6.0	6.0	6.0	6.0		6.0	6.0		6.0	6.0					
Lead/Lag	Lag	Lag	Lead	Lag	Lag		Lead	Lag					Lead	Lead	Lead	Lag
Lead-Lag Optimize?																
Recall Mode	None	None	None	None	None		None	None		None	None		None	None	None	None
Act Effct Green (s)		30.0	41.0	30.0	30.0		77.0	76.0		60.0	60.0					
Actuated g/C Ratio		0.25	0.34	0.25	0.25		0.64	0.63		0.50	0.50					
v/c Ratio		1.12	0.33	0.86	0.42		0.82	0.78		0.31	1.11					
Control Delay		130.8	10.6	88.8	39.0		55.3	22.3		25.1	92.5					
Queue Delay		0.0	0.0	0.0	0.0		0.0	0.0		0.0	0.2					
Total Delay		130.8	10.6	88.8	39.0		55.3	22.3		25.1	92.7					
LOS		F	B	F	D		E	C		C	F					
Approach Delay		82.6			58.8			27.8			89.6					
Approach LOS		F			E			C			F					
Queue Length 50th (ft)		~270	34	96	118		89	453		21	~887					
Queue Length 95th (ft)		#475	93	#225	200		#226	800		59	#1217					
Internal Link Dist (ft)		1158			436			674			274					
Turn Bay Length (ft)			100	200						220						
Base Capacity (vph)		277	631	151	462		226	1204		159	924					
Starvation Cap Reductn		0	0	0	0		0	0		0	31					
Spillback Cap Reductn		0	0	0	0		0	0		0	0					
Storage Cap Reductn		0	0	0	0		0	0		0	0					
Reduced v/c Ratio		1.12	0.33	0.86	0.42		0.82	0.77		0.31	1.14					

Intersection Summary

Area Type: Other

Cycle Length: 129

Actuated Cycle Length: 120

Natural Cycle: 140

Control Type: Actuated-Uncoordinated

Maximum v/c Ratio: 1.12

Intersection Signal Delay: 62.4 Intersection LOS: E

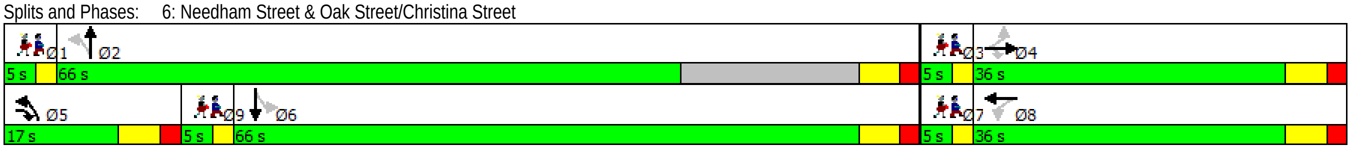
Intersection Capacity Utilization 105.4% ICU Level of Service G

Analysis Period (min) 15

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 6: Needham Street & Oak Street/Christina Street



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Ø3	Ø7	Ø9	Ø10
Lane Configurations																
Traffic Volume (vph)	130	0	65	35	15	25	70	775	25	5	750	85				
Future Volume (vph)	130	0	65	35	15	25	70	775	25	5	750	85				
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900				
Storage Length (ft)	125		0	125		0	100		0	100		0				
Storage Lanes	1		0	1		0	1		0	1		0				
Taper Length (ft)	25			25			25			25						
Satd. Flow (prot)	1805	1615	0	1805	1721	0	1787	1870	0	1787	1845	0				
Flt Permitted	0.729			0.711			0.157			0.143						
Satd. Flow (perm)	1385	1615	0	1351	1721	0	295	1870	0	269	1845	0				
Right Turn on Red			Yes			Yes			Yes			Yes				
Satd. Flow (RTOR)		329			27			2			8					
Link Speed (mph)		30			30			30			30					
Link Distance (ft)		491			696			244			497					
Travel Time (s)		11.2			15.8			5.5			11.3					
Confl. Peds. (#/hr)							7		3	3		7				
Confl. Bikes (#/hr)									2							
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92				
Heavy Vehicles (%)	0%	0%	0%	0%	0%	0%	1%	1%	1%	1%	1%	1%				
Shared Lane Traffic (%)																
Lane Group Flow (vph)	141	71	0	38	43	0	76	869	0	5	907	0				
Turn Type	Perm	NA		Perm	NA		pm+pt	NA		pm+pt	NA					
Protected Phases		4			8		5	2		1	6		3	7	9	10
Permitted Phases	4			8			2			6						
Detector Phase	4	4		8	8		5	2		1	6					
Switch Phase																
Minimum Initial (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0		1.0	1.0	1.0	1.0
Minimum Split (s)	23.0	23.0		23.0	23.0		9.0	22.0		9.0	22.0		3.0	3.0	3.0	3.0
Total Split (s)	26.0	26.0		26.0	26.0		16.0	56.0		16.0	56.0		3.0	3.0	3.0	3.0
Total Split (%)	25.0%	25.0%		25.0%	25.0%		15.4%	53.8%		15.4%	53.8%		3%	3%	3%	3%
Yellow Time (s)	4.0	4.0		4.0	4.0		3.0	4.0		3.0	4.0		2.0	2.0	2.0	2.0
All-Red Time (s)	2.0	2.0		2.0	2.0		3.0	2.0		3.0	2.0		0.0	0.0	0.0	0.0
Lost Time Adjust (s)	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0					
Total Lost Time (s)	6.0	6.0		6.0	6.0		6.0	6.0		6.0	6.0					
Lead/Lag	Lag	Lag		Lag	Lag					Lead	Lag		Lead	Lead	Lag	Lead
Lead-Lag Optimize?																
Recall Mode	None	None		None	None		None	Min		None	Min		None	None	None	None
Act Effct Green (s)	13.1	13.1		13.1	13.1		60.6	59.5		52.9	52.4					
Actuated g/C Ratio	0.15	0.15		0.15	0.15		0.69	0.68		0.61	0.60					
v/c Ratio	0.68	0.14		0.19	0.15		0.26	0.68		0.02	0.82					
Control Delay	52.0	0.5		34.5	18.5		13.5	14.4		9.8	24.1					
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0					
Total Delay	52.0	0.5		34.5	18.5		13.5	14.4		9.8	24.1					
LOS	D	A		C	B		B	B		A	C					
Approach Delay		34.8			26.0			14.4			24.0					
Approach LOS		C			C			B			C					
Queue Length 50th (ft)	73	0		18	8		11	214		1	371					
Queue Length 95th (ft)	141	0		48	37		45	#719		7	#808					
Internal Link Dist (ft)		411			616			164			417					
Turn Bay Length (ft)	125			125			100			100						
Base Capacity (vph)	319	625		311	417		392	1277		338	1110					
Starvation Cap Reductn	0	0		0	0		0	0		0	0					
Spillback Cap Reductn	0	0		0	0		0	0		0	0					
Storage Cap Reductn	0	0		0	0		0	0		0	0					
Reduced v/c Ratio	0.44	0.11		0.12	0.10		0.19	0.68		0.01	0.82					

Intersection Summary

Area Type: Other

Cycle Length: 104

Actuated Cycle Length: 87.2

Natural Cycle: 90

Control Type: Actuated-Uncoordinated

Maximum v/c Ratio: 0.82

Intersection Signal Delay: 20.9 Intersection LOS: C

Intersection Capacity Utilization 77.5% ICU Level of Service D

Analysis Period (min) 15

\# 95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 9: Needham Street & North Site Driveway/Charlemont Street

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Ø1	Ø3	Ø5	Ø7
Lane Configurations																
Traffic Volume (vph)	785	125	45	20	95	85	25	345	15	65	305	605				
Future Volume (vph)	785	125	45	20	95	85	25	345	15	65	305	605				
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900				
Storage Length (ft)	340		75	0		0	100		0	0		0				
Storage Lanes	1		1	0		0	1		0	0		1				
Taper Length (ft)	25			25			25			25						
Satd. Flow (prot)	3502	1824	0	0	1783	0	1805	1887	0	0	1864	1599				
Flt Permitted	0.950				0.995		0.341				0.623					
Satd. Flow (perm)	3502	1824	0	0	1783	0	644	1887	0	0	1172	1599				
Right Turn on Red			Yes			Yes			No			Yes				
Satd. Flow (RTOR)		18			30							544				
Link Speed (mph)		30			30			30			30					
Link Distance (ft)		1135			451			634			722					
Travel Time (s)		25.8			10.3			14.4			16.4					
Confl. Peds. (#/hr)							8					8				
Confl. Bikes (#/hr)									1							
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92				
Heavy Vehicles (%)	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	1%	1%				
Shared Lane Traffic (%)																
Lane Group Flow (vph)	853	185	0	0	217	0	27	391	0	0	403	658				
Turn Type	Split	NA		Split	NA		Perm	NA		Perm	NA	pt+ov				
Protected Phases	2	2		6	6			4			8	2 8	1	3	5	7
Permitted Phases							4			8						
Detector Phase	2	2		6	6		4	4		8	8	2 8				
Switch Phase																
Minimum Initial (s)	10.0	10.0		6.0	6.0		6.0	6.0		6.0	6.0		1.0	1.0	1.0	1.0
Minimum Split (s)	17.0	17.0		19.0	19.0		20.0	20.0		36.0	36.0		3.0	3.0	3.0	3.0
Total Split (s)	37.0	37.0		21.0	21.0		37.0	37.0		37.0	37.0		3.0	3.0	3.0	3.0
Total Split (%)	35.6%	35.6%		20.2%	20.2%		35.6%	35.6%		35.6%	35.6%		3%	3%	3%	3%
Yellow Time (s)	4.0	4.0		3.0	3.0		4.0	4.0		4.0	4.0		2.0	2.0	2.0	2.0
All-Red Time (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0		0.0	0.0	0.0	0.0
Lost Time Adjust (s)	0.0	0.0			0.0		0.0	0.0			0.0					
Total Lost Time (s)	7.0	7.0			6.0		7.0	7.0			7.0					
Lead/Lag	Lag	Lag		Lag	Lag		Lag	Lag		Lag	Lag		Lead	Lead	Lead	Lead
Lead-Lag Optimize?																
Recall Mode	None	None		None	None		None	None		None	None		None	None	None	None
Act Effct Green (s)	28.5	28.5			13.1		30.7	30.7			30.1	65.7				
Actuated g/C Ratio	0.31	0.31			0.14		0.33	0.33			0.33	0.71				
v/c Ratio	0.79	0.32			0.78		0.13	0.62			1.05	0.51				
Control Delay	35.8	24.3			53.2		24.9	32.1			95.0	2.6				
Queue Delay	0.0	0.0			0.0		0.0	0.0			0.0	0.0				
Total Delay	35.8	24.3			53.2		24.9	32.1			95.0	2.6				
LOS	D	C			D		C	C			F	A				
Approach Delay		33.7			53.2			31.6			37.7					
Approach LOS		C			D			C			D					
Queue Length 50th (ft)	238	75			108		12	202			~276	19				
Queue Length 95th (ft)	323	138			#217		33	301			#475	59				
Internal Link Dist (ft)		1055			371			554			642					
Turn Bay Length (ft)	340						100									
Base Capacity (vph)	1142	607			315		214	626			382	1312				
Starvation Cap Reductn	0	0			0		0	0			0	0				
Spillback Cap Reductn	0	0			0		0	0			0	0				
Storage Cap Reductn	0	0			0		0	0			0	0				
Reduced v/c Ratio	0.75	0.30			0.69		0.13	0.62			1.05	0.50				

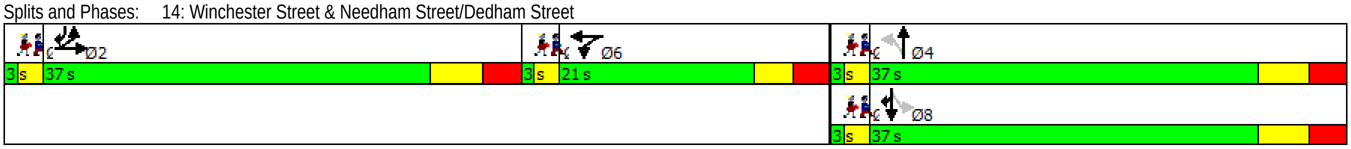
Intersection Summary

Area Type: Other
Cycle Length: 104
Actuated Cycle Length: 92.4
Natural Cycle: 95
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 1.05
Intersection Signal Delay: 36.5 — Intersection LOS: D
Intersection Capacity Utilization 96.0% — ICU Level of Service F
Analysis Period (min) 15

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 14: Winchester Street & Needham Street/Dedham Street



Intersection	
Intersection Delay, s/veh	24.3
Intersection LOS	C

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Vol, veh/h	2	0	1	65	25	35	65	425	1	1	410	155
Future Vol, veh/h	2	0	1	65	25	35	65	425	1	1	410	155
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Heavy Vehicles, %	0	0	0	0	0	0	0	0	0	0	0	0
Mvmt Flow	2	0	1	71	27	38	71	462	1	1	446	168
Number of Lanes	0	1	0	0	1	0	0	1	0	0	1	0

Approach	EB	WB	NB	SB
Opposing Approach	WB	EB	SB	NB
Opposing Lanes	1	1	1	1
Conflicting Approach Left	SB	NB	EB	WB
Conflicting Lanes Left	1	1	1	1
Conflicting Approach Right	NB	SB	WB	EB
Conflicting Lanes Right	1	1	1	1
HCM Control Delay	10.1	11.7	23.2	28.2
HCM LOS	B	B	C	D

Lane	NBLn1	EBLn1	WBLn1	SBLn1
Vol Left, %	13%	67%	52%	0%
Vol Thru, %	87%	0%	20%	72%
Vol Right, %	0%	33%	28%	27%
Sign Control	Stop	Stop	Stop	Stop
Traffic Vol by Lane	491	3	125	566
LT Vol	65	2	65	1
Through Vol	425	0	25	410
RT Vol	1	1	35	155
Lane Flow Rate	534	3	136	615
Geometry Grp	1	1	1	1
Degree of Util (X)	0.767	0.006	0.245	0.84
Departure Headway (Hd)	5.175	6.986	6.5	4.916
Convergence, Y/N	Yes	Yes	Yes	Yes
Cap	699	510	552	738
Service Time	3.209	5.063	4.552	2.949
HCM Lane V/C Ratio	0.764	0.006	0.246	0.833
HCM Control Delay	23.2	10.1	11.7	28.2
HCM Lane LOS	C	B	B	D
HCM 95th-tile Q	7.3	0	1	9.5

Intersection	
Intersection Delay, s/veh	24.7
Intersection LOS	C

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		✣			✣			✣			✣	
Traffic Vol, veh/h	110	125	25	0	2	20	0	360	50	105	370	2
Future Vol, veh/h	110	125	25	0	2	20	0	360	50	105	370	2
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Heavy Vehicles, %	0	0	0	0	0	0	0	0	0	0	0	0
Mvmt Flow	120	136	27	0	2	22	0	391	54	114	402	2
Number of Lanes	0	1	0	0	1	0	0	1	0	0	1	0

Approach	EB	WB	NB	SB
Opposing Approach	WB	EB	SB	NB
Opposing Lanes	1	1	1	1
Conflicting Approach Left	SB	NB	EB	WB
Conflicting Lanes Left	1	1	1	1
Conflicting Approach Right	NB	SB	WB	EB
Conflicting Lanes Right	1	1	1	1
HCM Control Delay	16.6	10.4	22.5	31.7
HCM LOS	C	B	C	D

Lane	NBLn1	EBLn1	WBLn1	SBLn1
Vol Left, %	0%	42%	0%	22%
Vol Thru, %	88%	48%	9%	78%
Vol Right, %	12%	10%	91%	0%
Sign Control	Stop	Stop	Stop	Stop
Traffic Vol by Lane	410	260	22	477
LT Vol	0	110	0	105
Through Vol	360	125	2	370
RT Vol	50	25	20	2
Lane Flow Rate	446	283	24	518
Geometry Grp	1	1	1	1
Degree of Util (X)	0.721	0.519	0.046	0.837
Departure Headway (Hd)	5.822	6.616	6.983	5.813
Convergence, Y/N	Yes	Yes	Yes	Yes
Cap	624	545	510	627
Service Time	3.839	4.661	5.058	3.828
HCM Lane V/C Ratio	0.715	0.519	0.047	0.826
HCM Control Delay	22.5	16.6	10.4	31.7
HCM Lane LOS	C	C	B	D
HCM 95th-tile Q	6.1	3	0.1	9

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Ø1	Ø3	Ø7	Ø9
Lane Configurations																
Traffic Volume (vph)	255	70	185	130	90	65	140	720	55	35	800	155				
Future Volume (vph)	255	70	185	130	90	65	140	720	55	35	800	155				
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900				
Storage Length (ft)	0		100	200		50	0		0	220		0				
Storage Lanes	0		1	1		0	1		0	1		0				
Taper Length (ft)	25			25			25			25						
Satd. Flow (prot)	0	1828	1615	1805	1756	0	1805	1874	0	1787	1830	0				
Flt Permitted		0.547		0.324			0.069			0.219						
Satd. Flow (perm)	0	1032	1615	616	1756	0	131	1874	0	412	1830	0				
Right Turn on Red			Yes			Yes			Yes			Yes				
Satd. Flow (RTOR)			142		30			6			11					
Link Speed (mph)		30			30			30			30					
Link Distance (ft)		1238			516			754			361					
Travel Time (s)		28.1			11.7			17.1			8.2					
Confl. Peds. (#/hr)	3					3			3	3						
Confl. Bikes (#/hr)									1			1				
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92				
Heavy Vehicles (%)	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	1%	1%				
Shared Lane Traffic (%)																
Lane Group Flow (vph)	0	353	201	141	169	0	152	843	0	38	1038	0				
Turn Type	Perm	NA	pm+ov	Perm	NA		pm+pt	NA		Perm	NA					
Protected Phases		4	5		8		5	2			6		1	3	7	9
Permitted Phases	4		4	8			2			6						
Detector Phase	4	4	5	8	8		5	2		6	6					
Switch Phase																
Minimum Initial (s)	6.0	6.0	6.0	6.0	6.0		6.0	15.0		15.0	15.0		3.0	3.0	3.0	3.0
Minimum Split (s)	22.0	22.0	13.0	26.0	26.0		13.0	29.0		28.0	28.0		5.0	5.0	5.0	5.0
Total Split (s)	32.0	32.0	16.0	32.0	32.0		16.0	56.0		56.0	56.0		5.0	5.0	5.0	5.0
Total Split (%)	28.1%	28.1%	14.0%	28.1%	28.1%		14.0%	49.1%		49.1%	49.1%		4%	4%	4%	4%
Yellow Time (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0		2.0	2.0	2.0	2.0
All-Red Time (s)	2.0	2.0	2.0	2.0	2.0		2.0	2.0		2.0	2.0		0.0	0.0	0.0	0.0
Lost Time Adjust (s)		0.0	0.0	0.0	0.0		0.0	0.0		0.0	0.0					
Total Lost Time (s)		6.0	6.0	6.0	6.0		6.0	6.0		6.0	6.0					
Lead/Lag	Lag	Lag	Lead	Lag	Lag		Lead	Lag					Lead	Lead	Lead	Lag
Lead-Lag Optimize?																
Recall Mode	None	None	None	None	None		None	None		None	None		None	None	None	None
Act Effct Green (s)		27.0	42.4	26.0	26.0		65.4	64.5		50.0	50.0					
Actuated g/C Ratio		0.26	0.41	0.25	0.25		0.63	0.62		0.48	0.48					
v/c Ratio		1.33	0.27	0.92	0.37		0.66	0.73		0.19	1.18					
Control Delay		203.4	7.6	95.6	29.6		32.0	19.2		19.7	118.6					
Queue Delay		0.0	0.0	0.0	0.0		0.0	0.0		0.0	0.0					
Total Delay		203.4	7.6	95.6	29.6		32.0	19.2		19.7	118.6					
LOS		F	A	F	C		C	B		B	F					
Approach Delay		132.3			59.6			21.2			115.1					
Approach LOS		F			E			C			F					
Queue Length 50th (ft)		~311	24	91	76		46	338		14	~827					
Queue Length 95th (ft)		#483	69	#225	145		#133	628		40	#1153					
Internal Link Dist (ft)		1158			436			674			281					
Turn Bay Length (ft)			100	200						220						
Base Capacity (vph)		266	748	153	460		242	1187		197	882					
Starvation Cap Reductn		0	0	0	0		0	0		0	0					
Spillback Cap Reductn		0	0	0	0		0	0		0	0					
Storage Cap Reductn		0	0	0	0		0	0		0	0					
Reduced v/c Ratio		1.33	0.27	0.92	0.37		0.63	0.71		0.19	1.18					

Intersection Summary

Area Type: Other

Cycle Length: 114

Actuated Cycle Length: 104.4

Natural Cycle: 150

Control Type: Actuated-Uncoordinated

Maximum v/c Ratio: 1.33

Intersection Signal Delay: 80.6 Intersection LOS: F

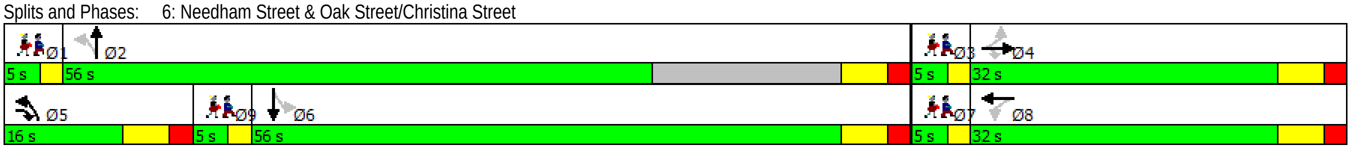
Intersection Capacity Utilization 106.1% ICU Level of Service G

Analysis Period (min) 15

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 6: Needham Street & Oak Street/Christina Street



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Ø3	Ø7	Ø9	Ø10
Lane Configurations	↰	↱		↰	↱		↰	↱		↰	↱					
Traffic Volume (vph)	115	0	70	60	2	35	75	845	30	15	765	105				
Future Volume (vph)	115	0	70	60	2	35	75	845	30	15	765	105				
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900				
Storage Length (ft)	125		0	125		0	100		0	100		0				
Storage Lanes	1		0	1		0	1		0	1		0				
Taper Length (ft)	25			25			25			25						
Satd. Flow (prot)	1805	1615	0	1805	1628	0	1805	1887	0	1787	1838	0				
Flt Permitted	0.731			0.708			0.139			0.105						
Satd. Flow (perm)	1389	1615	0	1345	1628	0	264	1887	0	198	1838	0				
Right Turn on Red			Yes			Yes			Yes			Yes				
Satd. Flow (RTOR)		325			38			2			9					
Link Speed (mph)		30			30			30			30					
Link Distance (ft)		491			556			244			497					
Travel Time (s)		11.2			12.6			5.5			11.3					
Confl. Peds. (#/hr)							7		8	8		7				
Confl. Bikes (#/hr)									2			1				
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92				
Heavy Vehicles (%)	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	1%	1%				
Shared Lane Traffic (%)																
Lane Group Flow (vph)	125	76	0	65	40	0	82	951	0	16	946	0				
Turn Type	Perm	NA		Perm	NA		pm+pt	NA		pm+pt	NA					
Protected Phases		4			8		5	2		1	6		3	7	9	10
Permitted Phases	4			8			2			6						
Detector Phase	4	4		8	8		5	2		1	6					
Switch Phase																
Minimum Initial (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0		1.0	1.0	1.0	1.0
Minimum Split (s)	23.0	23.0		23.0	23.0		9.0	22.0		9.0	22.0		3.0	3.0	3.0	3.0
Total Split (s)	26.0	26.0		26.0	26.0		16.0	56.0		16.0	56.0		3.0	3.0	3.0	3.0
Total Split (%)	25.0%	25.0%		25.0%	25.0%		15.4%	53.8%		15.4%	53.8%		3%	3%	3%	3%
Yellow Time (s)	4.0	4.0		4.0	4.0		3.0	4.0		3.0	4.0		2.0	2.0	2.0	2.0
All-Red Time (s)	2.0	2.0		2.0	2.0		3.0	2.0		3.0	2.0		0.0	0.0	0.0	0.0
Lost Time Adjust (s)	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0					
Total Lost Time (s)	6.0	6.0		6.0	6.0		6.0	6.0		6.0	6.0					
Lead/Lag	Lag	Lag		Lag	Lag					Lead	Lag		Lead	Lead	Lag	Lead
Lead-Lag Optimize?																
Recall Mode	None	None		None	None		None	Min		None	Min		None	None	None	None
Act Effct Green (s)	12.2	12.2		12.2	12.2		61.2	60.3		53.8	53.3					
Actuated g/C Ratio	0.14	0.14		0.14	0.14		0.70	0.69		0.62	0.61					
v/c Ratio	0.64	0.15		0.35	0.15		0.30	0.73		0.08	0.84					
Control Delay	50.9	0.6		38.6	13.0		15.1	15.6		9.8	24.8					
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0					
Total Delay	50.9	0.6		38.6	13.0		15.1	15.6		9.8	24.8					
LOS	D	A		D	B		B	B		A	C					
Approach Delay		31.9			28.9			15.5			24.6					
Approach LOS		C			C			B			C					
Queue Length 50th (ft)	64	0		32	1		11	238		3	383					
Queue Length 95th (ft)	127	0		74	29		47	#824		14	#857					
Internal Link Dist (ft)		411			476			164			417					
Turn Bay Length (ft)	125			125			100			100						
Base Capacity (vph)	320	621		309	404		377	1306		305	1127					
Starvation Cap Reductn	0	0		0	0		0	0		0	0					
Spillback Cap Reductn	0	0		0	0		0	0		0	0					
Storage Cap Reductn	0	0		0	0		0	0		0	0					
Reduced v/c Ratio	0.39	0.12		0.21	0.10		0.22	0.73		0.05	0.84					

Intersection Summary	
Area Type: Other	
Cycle Length: 104	
Actuated Cycle Length: 87.1	
Natural Cycle: 90	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 0.84	
Intersection Signal Delay: 21.3	Intersection LOS: C
Intersection Capacity Utilization 78.9%	ICU Level of Service D
Analysis Period (min) 15	

\# 95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

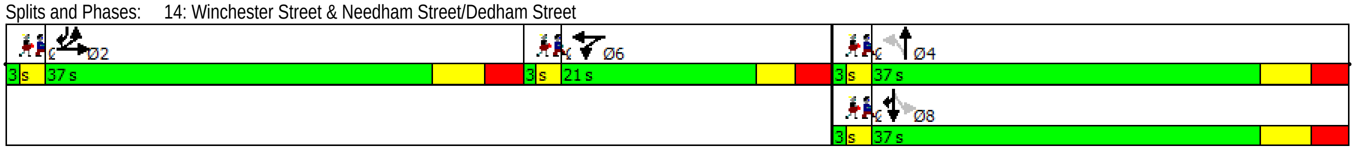
Splits and Phases: 9: Needham Street & North Site Driveway/Charlemont Street

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Ø1	Ø3	Ø5	Ø7
Lane Configurations																
Traffic Volume (vph)	825	145	80	20	145	90	45	220	10	50	215	640				
Future Volume (vph)	825	145	80	20	145	90	45	220	10	50	215	640				
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900				
Storage Length (ft)	340		75	0		0	100		0	0		0				
Storage Lanes	1		1	0		0	1		0	0		1				
Taper Length (ft)	25			25			25			25						
Satd. Flow (prot)	3502	1770	0	0	1782	0	1805	1883	0	0	1864	1599				
Flt Permitted	0.950				0.996		0.446				0.787					
Satd. Flow (perm)	3426	1770	0	0	1779	0	844	1883	0	0	1477	1599				
Right Turn on Red			Yes			Yes			No			Yes				
Satd. Flow (RTOR)		27			22							370				
Link Speed (mph)		30			30			30			30					
Link Distance (ft)		1135			451			634			722					
Travel Time (s)		25.8			10.3			14.4			16.4					
Confl. Peds. (#/hr)	8		4	4		8	4		5	5		4				
Confl. Bikes (#/hr)									1			1				
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92				
Heavy Vehicles (%)	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	1%	1%				
Shared Lane Traffic (%)																
Lane Group Flow (vph)	897	245	0	0	278	0	49	250	0	0	288	696				
Turn Type	Split	NA		Split	NA		Perm	NA		Perm	NA	pt+ov				
Protected Phases	2	2		6	6			4			8	2 8	1	3	5	7
Permitted Phases							4			8						
Detector Phase	2	2		6	6		4	4		8	8	2 8				
Switch Phase																
Minimum Initial (s)	10.0	10.0		6.0	6.0		6.0	6.0		6.0	6.0		1.0	1.0	1.0	1.0
Minimum Split (s)	17.0	17.0		19.0	19.0		20.0	20.0		36.0	36.0		3.0	3.0	3.0	3.0
Total Split (s)	37.0	37.0		21.0	21.0		37.0	37.0		37.0	37.0		3.0	3.0	3.0	3.0
Total Split (%)	35.6%	35.6%		20.2%	20.2%		35.6%	35.6%		35.6%	35.6%		3%	3%	3%	3%
Yellow Time (s)	4.0	4.0		3.0	3.0		4.0	4.0		4.0	4.0		2.0	2.0	2.0	2.0
All-Red Time (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0		0.0	0.0	0.0	0.0
Lost Time Adjust (s)	0.0	0.0			0.0		0.0	0.0			0.0					
Total Lost Time (s)	7.0	7.0			6.0		7.0	7.0			7.0					
Lead/Lag	Lag	Lag		Lag	Lag		Lag	Lag		Lag	Lag		Lead	Lead	Lead	Lead
Lead-Lag Optimize?																
Recall Mode	None	None		None	None		None	None		None	None		None	None	None	None
Act Effct Green (s)	28.7	28.7			15.2		22.0	22.0			22.0	56.6				
Actuated g/C Ratio	0.33	0.33			0.17		0.25	0.25			0.25	0.65				
v/c Ratio	0.78	0.41			0.85		0.23	0.53			0.78	0.60				
Control Delay	33.8	24.4			59.4		29.8	33.2			46.4	5.8				
Queue Delay	0.0	0.0			0.0		0.0	0.0			0.0	0.0				
Total Delay	33.8	24.4			59.4		29.8	33.2			46.4	5.8				
LOS	C	C			E		C	C			D	A				
Approach Delay		31.8			59.4			32.7			17.7					
Approach LOS		C			E			C			B					
Queue Length 50th (ft)	224	90			140		21	118			147	63				
Queue Length 95th (ft)	#403	193			#347		57	212			265	171				
Internal Link Dist (ft)		1055			371			554			642					
Turn Bay Length (ft)	340						100									
Base Capacity (vph)	1215	632			327		293	654			512	1177				
Starvation Cap Reductn	0	0			0		0	0			0	0				
Spillback Cap Reductn	0	0			0		0	0			0	0				
Storage Cap Reductn	0	0			0		0	0			0	0				
Reduced v/c Ratio	0.74	0.39			0.85		0.17	0.38			0.56	0.59				

Intersection Summary

Area Type: Other
Cycle Length: 104
Actuated Cycle Length: 87.7
Natural Cycle: 85
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.85
Intersection Signal Delay: 29.6 Intersection LOS: C
Intersection Capacity Utilization 88.1% ICU Level of Service E
Analysis Period (min) 15
\# 95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 14: Winchester Street & Needham Street/Dedham Street



TRANSPORTATION IMPACT ASSESSMENT (TIA) GUIDELINES

Section 1 – Introduction

MassDOT's mission is to deliver excellent customer service to people who travel in the Commonwealth, and to provide our nation's safest and most reliable transportation system in a way that strengthens our economy and quality of life. MassDOT operates in partnership with local and regional agencies to accomplish this mission, in close coordination with Massachusetts Environmental Policy Act (MEPA) procedures and other land use planning processes.

The Commonwealth of Massachusetts reviews development proposals and may require mitigation in accordance with Code of Massachusetts Regulations (301 CMR 11.00: MEPA Regulations and 720 CMR 11.00: Approval of Access to State Highways). MassDOT transportation impact review can be triggered as a function of the MEPA process or MassDOT permitting process.

I. TIA GUIDELINES PURPOSE & POLICY CONTEXT

The primary purpose of the TIA Guidelines is to provide the planning and the preliminary level of engineering analysis to ensure consistency, adequacy, and comprehensiveness in the basic information included in the transportation analysis sections of environmental documents submitted to Commonwealth agencies for review. These guidelines generally apply to all projects subject to MEPA that trigger transportation thresholds. Specific and unique requirements may be noted in the Certificate of the Secretary of the Executive Office of Energy and Environmental Affairs (EOEEA) on an Environmental Notification Form (ENF), Expanded ENF for a project, or a Notice of Project Change (NPC).

A well-prepared TIA will provide the proponent, MassDOT, its partner agencies, and the general public with information needed to properly assess the adequacy of existing and planned transportation infrastructure to accommodate the proposed project, as well as proponent project impacts and proposed mitigation measures. Completing the TIA in a careful and collaborative manner will produce reliable information to support effective and efficient decision-making consistent with the Commonwealth's policies. TIA information will also be used as a basis for the monitoring program that ensures the proponent provides recommended mitigations on an on-going basis (where applicable).

MassDOT seeks to ensure that the transportation impact review process reflects and advances the Commonwealth of Massachusetts' policy goals, in particular those that promote MassDOT's *Project Development and Design Guide* standards on Complete Streets, the Global Warming Solutions Act, the Massachusetts GreenDOT Policy Initiative, the Mode Shift Initiative, the Healthy Transportation Compact, the Healthy Transportation Policy Directive, and the Massachusetts Ridesharing Regulation, Safe Routes to School, as summarized below. These goals work together to mutually reinforce one another and strengthen the Commonwealth's efforts to reduce its dependence on driving.

A. *Design Guide standards on Complete Streets.* Complete Streets is the comprehensive multi-modal design approach in MassDOT's *Project Development and Design Guide* that requires safe and appropriate accommodation for all roadway users. The document offers guiding principles that include the need "to ensure that the safety and mobility of all users of the transportation system (pedestrians, bicyclists, motorists, and transit users) are considered equally through all phases of a project so that even the most vulnerable (e.g., children and the elderly) can feel and be safe within the public right of way."

B. *Global Warming Solutions Act (GWSA).* As required by the GWSA, the Executive Office of Energy and Environmental Affairs (EOEEA) developed the Clean Energy and Climate Plan for 2020. The GWSA has set a statutory obligation to reduce greenhouse gas emissions (GHG) by 25 percent below 1990 levels by 2020, and by 80 percent below 1990 levels by 2050. The Plan also describes a targeted portfolio of existing and proposed federal and state policies that will enable Massachusetts to reach the GHG reduction target. Based on the Plan, transportation sector is targeted to provide 7.6 percent of the total 25 percent GHG reduction goal for the year 2020.

C. *Massachusetts GreenDOT Policy Initiative.* GreenDOT is MassDOT's comprehensive environmental responsibility and sustainability initiative. GreenDOT calls for MassDOT to incorporate sustainability into all of its activities, from strategic planning to project design and construction to system operation, in order to promote sustainable economic development, protect the natural environment, and enhance the quality of life for all of the Commonwealth's residents and visitors. GreenDOT's three primary goals are to 1) Reduce greenhouse gas (GHG) emissions; 2) Promote the healthy transportation options of walking, bicycling, and public transit; and 3) Support smart growth development.

D. *Mode Shift Initiative.* MassDOT's has established a statewide mode shift goal of tripling the share of travel in Massachusetts by bicycling, transit and walking. The initiative seeks to reduce the number of cars on the road and advance the Commonwealth's greenhouse gas (GHG) emission reduction target of 25 percent from 1990 levels by 2020 and an 80 percent reduction from 1990 levels by 2050.

E. *Healthy Transportation Compact.* The Compact is an inter-agency initiative designed to facilitate transportation decisions that balance the needs of all transportation users, enhance transportation choice and mobility in all modes, improve public health, support a cleaner environment, and create stronger communities. MassDOT views the Healthy Transportation Compact as an exciting opportunity to strengthen the commitment to public health and improve access for pedestrians, bicyclists, and public transit riders.

F. *Healthy Transportation Policy Directive*. This policy directive builds upon MassDOT's Complete Streets guidelines, GreenDOT Policy, and Healthy Transportation Compact by requiring that all MassDOT projects not only accommodate, but actively promote healthy transportation modes.

G. *Massachusetts Ridesharing Regulation*. Massachusetts ridesharing law requires employers with certain numbers of employees to establish drive-alone trip reduction incentives and to subsequently document employee commuting patterns. While compliance with the 25 percent drive-alone commute trip reduction goal depends on voluntary efforts of employees and is not enforceable, completion of the annual reporting requirements and implementation of specific trip reduction incentives by affected employers is enforceable.

H. *Safe Routes to School*. MassDOT's Safe Routes to School program provides education and encouragement services at 625 elementary and middle schools, which are attended by nearly 300,000 students in 171 municipalities statewide. The program promotes walking and bicycling to school and provides students, parents, and community members with information on the many benefits of walking and bicycling and how to do it safely. Any development projects near schools, in particular residential developments that may house schoolchildren, should consider provision of safe and convenient connections to the schools.

Each of the above policy initiatives must be supported through implementation of the TIA Guidelines, which provide for a multi-modal transportation development review and mitigation process. The TIA Guidelines are intended to emphasize transportation-efficient development and enhancement of transit, bicycle, and pedestrian facilities, as well as foster implementation of on-going, effective Transportation Demand Management programs. TIA preparation should reflect the most up-to-date versions of these policies, as well as any other Commonwealth of Massachusetts policies or regulations that are relevant to evaluation of transportation impacts and development of mitigation, management and monitoring programs.

GUIDELINE ORGANIZATION

The TIA Guideline is subdivided into six sections by topic. The sections are:

- Section 1 – Introduction
- Section 2 – Standard Operating Procedures
- Section 3 – Analytical Procedures
- Section 4 – Mitigation
- Section 5 – TIA Report
- Section 6 – Monitoring

Section 2 – Standard Operating Procedures

This section provides an introductory overview of basic procedural matters including common abbreviations, how to determine the type of study required, preparer qualifications, and the MassDOT TIA Scoping Meeting process.

I. ABBREVIATIONS

Several abbreviations are used throughout this document. Key abbreviations are listed below for reference purposes.

- AAB = Massachusetts Architectural Access Board
- AASHTO = American Association of State Highway and Transportation Officials
- ADT = Average Daily Trips
- CMR = Code of Massachusetts Regulation
- DEP = Department of Environmental Protection
- DOT = Department of Transportation
- EENF = Expanded Environmental Notification Form
- EIR = Environmental Impact Report
- ENF = Environmental Notification Form
- FHWA = Federal Highway Administration
- GHG = Greenhouse Gas
- HSIP = Highway Safety Improvement Program
- ITE = Institute of Transportation Engineers
- LOS = Level of Service
- MEPA = Massachusetts Environmental Policy Act
- MMLOS = Multi-modal Level of Service
- MPO = Metropolitan Planning Organization
- NCHRP = National Cooperative Highway Research Program
- NPC = Notice of Project Change
- RPA = Regional Planning Agency
- RTA = Regional Transit Authority
- TSL = Transportation Scoping Letter
- TDM = Transportation Demand Management
- TIA = Transportation Impact Assessment
- TMA = Transportation Management Association
- v/c = Volume-to-Capacity Ratio

II. TIA PREPARER QUALIFICATIONS

Each TIA should be prepared by or under the direct supervision of a licensed Professional Engineer or Professional Traffic Operations Engineer registered in the Commonwealth of Massachusetts. The preparer must have significant background and experience in the methods and concepts associated with transportation impact studies.

III. THRESHOLDS FOR REQUIRING A TRANSPORTATION IMPACT ASSESSMENT

Preparation of a TIA is generally triggered as a function of the Massachusetts Environmental Policy Act (MEPA) process and/or the MassDOT State Highway Access Regulations. There are a number of transportation-related thresholds, and each project proponent should thoroughly review them, but the following are the thresholds that are most commonly triggered for projects that would require a MassDOT permit.

A. MEPA Thresholds (Code of Massachusetts Regulations (CMR) number 301)

1. Section 11.03.06.a (Transportation) indicates that an Environmental Notification Form (ENF) and Mandatory Environmental Impact Report (EIR) are required for a site with:

   Subsection 6) a trip generation of 3,000 or more new Average Daily Trips (ADT) by motor vehicles on roadways providing access to a single location (site), regardless of number of proposed driveways or

   Subsection 7) construction of 1,000 or more new motor vehicle parking spaces at a single location

2. Section 11.03.06.b, "ENF and Other MEPA Review if the Secretary so Requires" identifies the following lower thresholds that require only an ENF (although the Secretary of Energy and Environmental Affairs may require additional review at his/her discretion):

   Subsection 13) Generation of 2,000 or more new ADT by motor vehicles on roadways providing access to a single location or

   Subsection 14) Generation of 1,000 or more new ADT by motor vehicles on roadways providing access to a single location and construction of 150 or more new motor vehicle parking spaces at a single location

Note: The calculation of "new ADT" for the purpose of determining MEPA thresholds and jurisdiction must be done in a manner consistent with MEPA guidelines. Trip adjustments (e.g. for mode split, pass-by, or internal capture) may be made for the purpose of evaluating transportation impacts and mitigation requirements, as discussed below in Sections 3 and 4.

At MassDOT discretion, a TIA may be required for a project with lesser trip generation if it can be demonstrated that the project may have an impact on safety and traffic operations.

IV. TRANSPORTATION SCOPING LETTER (TSL)

MassDOT requires preparation of a Transportation Scoping Letter (TSL) for TIA scoping purposes. The TSL is intended to enable the proponent and MassDOT to concur on the basic analytical approach, technical assumptions, and key transportation issues to be addressed in the TIA. The TSL must be submitted by the proponent and approved by MassDOT prior to development of the TIA; it may be included with the ENF, or, if the proponent wants to file an EENF or include a TIA along with the ENF, then the TSL must be submitted prior to preparation of the ENF/EENF. The process for initiation of the TSL and follow-on work relative to its preparation will be as outlined in MassDOT Standard Operating Procedure.

A TSL shall include the following elements, to the degree that the proponent is able to develop the information prior to executing the in-depth TIA analysis. In situations where the information specified below would require extensive analysis that cannot be completed prior to the execution of the TIA itself, the proponent may describe the data sources to be used and the anticipated analytical approach.

A. *Trip generation* – Identify the expected use or uses, the amount of space or number of employees (or other suitable indicator of trip generation), and the resulting person-trip generation of the proposed development, including the weekday morning peak hour, the evening peak hour, daily traffic, and other peak periods as may be appropriate (weekday mid-day peak, weekend mid-day peak, etc.), together with appropriate documentation and references. Both trip rates and trip types should be documented.

B. *Mode Split* – Identify the proposed project's anticipated/assumed split among major transportation modes – walking, bicycling, public transit, motor vehicle, and other modes (e.g. vanpooling, ridesharing) OR describe the basic approach that will be used to develop the mode split. Identify the source and justification for the mode split assumptions. Proponents should note that MassDOT expects them to maximize project-generated travel by non-single-occupancy vehicle (non-SOV) modes by maximizing transportation choice, providing robust connectivity for non-SOV modes, and promoting Transportation Demand Management.

C. *Transportation Demand Management* – Identify the existing Transportation Demand Management (TDM) options, relevant programs and providers, and potential solutions in the study area. Contact or review available resources of the following stakeholders to identify existing TDM offerings, local conditions, and potential future options:

- MassRIDES, the Commonwealth's travel options program, and/or the local transportation management association (TMA)
- Nearby employers that participate in TDM programs

D. *Study Area and Transportation Network* (The following general parameters are offered to aid identification of the study area) – MassDOT approval of the final study area scope is required. Identify the proposed study area and the multi-modal transportation system that serves the study area and provides access to the project site. Include major highways and roadways, intersections and interchanges, pedestrian facilities, bicycle facilities and access, and public transit network. The TIA study area should, in large part, be based on ambient and potential future project area conditions, and should take special care to include transportation system features with existing or potential issues that would be exacerbated by project-generated trips. Example of this include an intersection approach or particular lane group/movement that queues back into an upstream intersection, or a "short-lane" queuing situation with resultant upstream lane blockage on adjoining lanes of its own approach, or generation of pedestrian trips in a location that has substandard pedestrian accommodation. The TSL should demonstrate that adequate field reconnaissance, including photographs and/or videography, was conducted to identify any such issues. For MassDOT's analytical needs, the study area should focus on roadway intersections and segments within the study area, with a particular focus on roadways under MassDOT jurisdiction. Contact or review available resources of the following stakeholders regarding the existing system, transportation system issues, and planned future conditions:

- MassDOT Highway Division district staff (including Pedestrian/Bicycle Coordinator and/or Complete Streets Coordinator)
- Regional Planning Agency (RPA) staff
- Regional Transit Authority (RTA)
- Municipal planning, transportation, and/or public works staff

E. *Trip distribution pattern* – Identify the anticipated trip distribution pattern by mode, with graphical representation on a map illustrating the site influence area. The trip distribution pattern should be based on a reasonable set of assumptions and calculations (e.g. a gravity model based on existing travel patterns) that are clearly explained and justified. The graphical representation should present the distribution pattern in percentages.

F. *Analysis periods* – Based on the site trip generation and the proponent's knowledge of the study area, the TSL should identify recommended study periods.

G. *Site plan* – Indicate the proposed "footprint" of the project relative to existing site conditions, the boundaries of land owned by the proponent, the abutting land uses, transportation facilities (including private and access roadways, sidewalks, public right-of-way, public transit stations/stops/routes, and bicycle facilities) adjacent to the site. Discussion of the site plan should identify existing bicycle and pedestrian infrastructure, existing and future desire lines, and a preliminary connectivity assessment.

H. *Access spacing and circulation assessment* – Provide preliminary documentation as to whether site driveways will satisfy MassDOT access spacing standards. Include a preliminary circulation layout and connection plan that accounts for future development build out of the vicinity (document motor vehicle, transit, pedestrian, and bicycle connectivity as well as anticipated truck delivery routing). Consider opportunities for shared access and/or driveway consolidation within the site and/or with adjacent properties.

I. *Safety* – Provide a preliminary assessment as to whether there are locations within the site influence area that are Highway Safety Improvement Program (HSIP)-eligible. An HSIP-eligible location is a location that is within the top 5 percent of crash locations for each Metropolitan Planning Organization (MPO) region (based on number and severity of crashes using the equivalent property damage only – EPDO). The HSIP-eligible clusters are highlighted on the maps contained in the following website link: http://services.massdot.state.ma.us/maptemplate/TopCrashLocations and identified as the latest year HSIP cluster (including bicycle, pedestrian, etc.). The TSL should also identify any locations where design or operations could pose a safety issue, based on the preparer's best engineering judgment, irrespective of HSIP status or eligibility.

J. *Parking* - Identify the anticipated number and type of parking spaces (to include automobile parking, bicycle parking, and preferential parking) and parking ratio, including a comparison to required minimum and maximum parking ratios for the site (if ratios are required) for both ITE and local municipality ratios (if available). Identify potential shared parking, on-street parking, and off-site parking opportunities.

The assumptions and plans presented in the TSL are understood to be preliminary and are likely to evolve during the development process. Minor changes made between the time a TSL has been reviewed and the TIA is submitted are acceptable as long as the changes do not alter the basic methodology presented in the TSL; the changes represent an improved understanding of conditions and needs; and the changes from the TSL are highlighted and justified. If there is information or feedback from stakeholders that is pending but not available for preparation of the TSL, the proponent should indicate in the TSL what is pending and how that information will be used in preparation of the TIA.

V. TIA SCOPING MEETING

At MassDOT's discretion, a scoping meeting with MassDOT may be held prior to preparation of a TIA. The scoping meeting is intended to allow MassDOT and the project proponent to obtain consensus to the study assumptions, data requirements, analysis periods, analysis methodology, and other key aspects prior to the project proponent preparing the TIA. This process ensures a common understanding and reduces the potential time and cost of preparing revisions to the TIA. As such, MassDOT strongly encourages proponents to request a scoping meeting. To provide the most benefit, the scoping meeting should be scheduled early in the process, well in advance of MEPA submissions for which the proponent is responsible.

Upon request, MassDOT will arrange and schedule a scoping meeting with the project proponent to discuss anticipated traffic impacts and the required TIA scope of work. MassDOT may invite representatives of MEPA, MassRides, the RTA, the RPA, the local agency(ies), the project proponent, affected municipalities, and other parties as appropriate. The purpose of this meeting is to:

- help the project proponent understand the MEPA and MassDOT access permitting processes;
- identify the modes of transportation to be evaluated;
- identify the analytical methodologies to be applied to the operations analysis of each mode;
- help the project proponent review their approach to maximizing the share of walking, transit, and bicycle trips and minimizing single-occupant vehicle trips;
- identify particular issues that the study will need to address (such as known safety, capacity, and/or connectivity considerations for each mode);
- identify required analysis periods (e.g. times of day, weekday, weekend, etc.);
- identify the design year and project phasing (if applicable);
- identify available transportation demand management programs, tools, and resources;
- define appropriate trip generation rate(s) and trip type(s);
- define trip distribution;
- define the study area;
- review MassDOT's requirements as they relate to the study methodology and assumptions; and,
- exchange other information and address the proponent's questions as needed.

After completing a scoping meeting, the proponent should submit an updated TSL to confirm the scoping meeting outcomes. MassDOT will review the proponent's final TSL and provide feedback in the form of a MEPA comment letter (if appropriate) or a memorandum that provides concurrence and/or comments on required changes to the scope of the TIA.

Section 3 – Analytical Procedures

This section describes the essential elements of a TIA beginning with definition of the study area limits and providing a summary of the analytical process and requirements.

Note that the Multi-Modal Level of Service Analysis (MMLOS) procedures highlighted in this document are relatively new and are expected to improve over time, allowing for more detailed analysis. MassDOT seeks to embrace the MMLOS concept and will incorporate MMLOS tools, procedures, and performance measures as they are successfully demonstrated and proven. Accordingly, future changes to the MMLOS analytical procedures and performance measures should be expected.

I. STUDY AREA

The TIA should describe the project study area and the multi-modal transportation system that serves the study area and provides access to the project site. The study area discussion should describe the major highways and roadways, intersections and interchanges, pedestrian facilities, bicycle facilities and access, and public transit network, as well as existing conditions of the systems, key issues, and any proposed projects or changes to the transportation network in the study area.

A. Walking, bicycling, and public transit network, with specific attention to connectivity, desire lines, and gap analysis in order to maximize travel choices and promote these modes. Consideration should be given to the appropriate level of analysis for transit, walking and bicycling study areas.

B. Driveways and public street intersections located along the proponent's project site development frontage should be included in the study.

C. Intersections (to be assessed by approach) or roadway segments where site-generated trips increase the peak hour traffic volume by a) five (5) percent or more or b) by more than 100 vehicles per hour should be included in the study.

1. Intersections or road segments meeting the five percent threshold may be exempted from study if:

    a) In MassDOT's judgment, the intersection or segment operates acceptably today and site development impact will not cause a capacity or safety mitigation need; or

    b) A mitigation for the intersection or segment has been previously identified and no further analysis is warranted (note that site-generated trip assignment may still be required for tracking or mitigation assessment purposes); or

    c) Other reasons deemed appropriate by MassDOT.

2. Intersections or road segments that do not meet the five percent threshold may be included in the study area if:

   a) In MassDOT's judgment the intersection is highly congested/near or over capacity and prone to significant operational deterioration from even a small increment in traffic; or

   b) The location is expected to have a significant impact to the state highway system; or

   c) There are local municipality requirements that call for inclusion; or

   d) There are special circumstances related to that location that merit review.

II. GENERAL TRAFFIC VOLUME DATA REQUIREMENTS

The TIA will be predicated on volume data obtained and/or collected by the proponent to reflect study conditions. Note that, to be deemed current, traffic volume data must be collected within two-years of TIA initial submittal.

A. *Turning movement count data:* The proponent shall conduct turning movement counts (TMCs) for all study intersections. In general:

1. One traffic count is required for each analysis period, unless otherwise specified.

   Traffic volume counts should include motor vehicle, pedestrian, and bicycle movements. The counts should note whether pedestrian or bicycle movements are completed diagonally at intersections, instances of bicyclists riding on sidewalks, and midblock pedestrian crossings at location(s) where the number of crossings exceeds 15 pedestrians per hour.

2. Weekday traffic counts should be conducted on a "typical" Tuesday, Wednesday, or Thursday when school is in session (when possible) during weeks not containing a holiday. Data must not be collected during unusual weather events or other atypical circumstances, unless otherwise directed.

3. A weekend traffic count(s) may be required, when deemed appropriate (for example, religious institutions, sports or special event facilities, large commercial developments, tourist attractions, and other land uses may warrant a weekend analysis).

4. Upon approval, the timeframe for conducting traffic counts may be altered based on land use or seasonal variations.

B. *Automated traffic recorder (ATR) counts* – The proponent shall conduct ATR counts at locations and time periods as needed.

1. All ATR counts conducted at the request of MassDOT shall conform to the MassDOT Highway Performance Monitoring System (HPMS) data collection format. This format calls for adherence to the guidelines and procedures mandated by the Federal Highway Administration's (FHWA) Traffic Monitoring Guide, the FHWA's HPMS Field Manual, and the AASHTO Guidelines for Traffic Data Programs.

C. *Use of historical volume data* – Data taken from other sources should be no more than two years old (on the submittal date of the subject EENF or EIR/EIS) unless approved by MassDOT.

D. *Analysis periods* – In general, the TIA should include weekday evening (typically one hour between 4:00-6:00 p.m.) peak hour analyses. Other peak hours (such as weekday morning from 7:00-9:00 a.m., midday from 11:00 a.m.-1:00 p.m., afternoon school dismissal peak hour, unique shift change periods, etc.) also may need to be studied based on the peak trip generation periods(s) associated with the proposed land use(s). In general, most retail studies include the weekday p.m. and Saturday midday peak (11:00 a.m.-1:00 p.m.), while most office / industrial / residential studies include the weekday a.m. and p.m. peak hours.

E. *Volume data for signal warrant analysis* – MassDOT expects that any proposed traffic signal installation on State Highway will meet the eight-hour vehicular volume warrant (MUTCD Warrant 1). Accordingly, a minimum of eight-hour turning movement count data is required for justification of warrant analysis for proposed signal installation.

F. *Heavy vehicle percentage* – The traffic volume data used in the analysis shall include the percentage of heavy vehicles reflected in the actual turn movement count data. The percentage may be applied on an approach-by-approach basis or by lane group, as necessary. For traffic counting and analysis purposes, heavy vehicles shall be defined as trucks having more than two axles or buses of any type, independent of axle configuration.

G. *Adjustments* – All seasonal or other adjustments must be cited and their use fully justified.

1. When using historical counts, existing conditions volumes must be adjusted by a seasonal/growth rate and increased by any new traffic from developments that have been completed and/or approved since the time of the original count as necessary.

2. Existing conditions counts may also need to be adjusted if the project is located in a region that experiences a notable seasonal variation or is primarily retail. The basis for a seasonal factor should be addressed considering the direction of the MassDOT Traffic and Safety Engineering 25% Design Submission Guidelines available via the following link: http://www.mhd.state.ma.us/downloads/trafficMgmt/FunctionalDesignReportGuidelines.pdf.

H. *Speed data* – Speed data may be required for purposes including, but not limited to, sight distance assessments, safety reviews, assessing community impacts, etc.

I. *Transit service frequency* – Transit routes, stops, passenger loads (when available), frequency of service, and service operating hours shall be documented. If transit-based mitigation is proposed, then additional data may be required as documented in Section 3.VII, Quantifying Impacts Of Transit-Based Mitigation.

J. *Planned Projects* – In addition to regional background, traffic associated with other projects under construction or in the planning process needs to be included in the No-Build condition projections. The planned projects need to be outlined in the TIA.

III. GENERAL ANALYSIS METHODOLOGY REQUIREMENTS

Unless directed otherwise during the MassDOT TIA scoping meeting, the following analysis methodologies shall be used for TIA preparation:

A. *Signalized intersection capacity analysis* – Signalized intersection capacity analysis shall be conducted using an approved software package as noted on MassDOT's most recent list of analysis tools (A Guide on Traffic Analysis Tools, available at http://www.mhd.state.ma.us/downloads/trafficMgmt/TrafficAnalysisToolsGuide.pdf) and per the requirements of the MassDOT Traffic and Safety Engineering 25% Design Submission Guidelines. Motor vehicle level-of-service, average delay, and volume-to-capacity ratios shall be calculated using procedures from the most recent edition of the Highway Capacity Manual (HCM), published by the Transportation Research Board. In addition, Multi-modal Level of Service Analyses (MMLOS) shall be prepared for pedestrians and bicycles using the most recent Highway Capacity Manual methodology. Proponents should note that use of traffic capacity analysis software evaluating traffic volumes passing through the intersection from each approach may not always be the appropriate analytical approach. For example, at signalized locations experiencing severe congestion and possible over-saturation (i.e., with demand exceeding capacity and approach queues unable to be processed in their entirety during a signal cycle), the proponent should employ an alternative approach that may include counting of intersection approach volumes and floating car (or equivalent) delay calculations. At unsignalized high volume locations, gap acceptance surveys could be used as a checkpoint for operational values obtained using the HCM methodology. In these cases, MassDOT would recommend the appropriate assumptions, methodology, and software package to be used in conducting the analysis. It is the responsibility of the proponent, however, to identify when these conditions exist, and to work with MassDOT to develop alternatives.

1. *Traffic signal timing assumptions* – Optimized signal timings may be allowed for future operational analysis purposes, but only at MassDOT's discretion. When approved for use, optimized signal timing assumptions should be clearly identified on the analysis worksheets for clarity.

B. *Stop- and yield-controlled intersection capacity analysis* – Capacity analysis for stop and yield-controlled intersections shall be conducted using an approved software package as noted on MassDOT's most recent list of approved traffic analysis tools (A Guide on Traffic Analysis Tools, available at http://www.mhd.state.ma.us/downloads/trafficMgmt/TrafficAnalysisToolsGuide.pdf) and per the requirements of the MassDOT Traffic and Safety Engineering 25% Design Submission Guidelines. Motor vehicle level-of-service, average delay, and volume-to-capacity ratios shall be calculated using procedures from the most recent edition of the Highway Capacity Manual, published by the Transportation Research Board.

C. *Roundabout analysis* – Capacity analysis of roundabouts shall be conducted using an approved software package as noted on MassDOT's most recent list of approved traffic analysis tools (A Guide on Traffic Analysis Tools, available at http://www.mhd.state.ma.us/downloads/trafficMgmt/TrafficAnalysisToolsGuide.pdf) and per the requirements of the MassDOT Traffic and Safety Engineering 25% Design Submission Guidelines. Motor vehicle level-of-service, average delay, and volume-to-capacity ratios shall be calculated using procedures from the most recent edition of the Highway Capacity Manual, published by the Transportation Research Board. Roundabouts should be evaluated where feasible (based on right-of-way availability and abutting land uses) as an alternative to the installation of a traffic signal.

D. *Freeway facility analysis* – Capacity analysis of freeway facilities (including elements such as basic freeway segments, ramp segments, and weaving segments where required) shall be conducted using HCM methodology or the latest approved software package as noted on MassDOT's most recent list of approved traffic analysis tools (A Guide on Traffic Analysis Tools, available at http://www.mhd.state.ma.us/downloads/trafficMgmt/TrafficAnalysisToolsGuide.pdf) and per the requirements of the MassDOT Traffic and Safety Engineering 25% Design Submission Guidelines.

E. *Urban street facility and segment analysis* – Pending MassDOT scoping direction, MMLOS analyses should be prepared for motor vehicles, pedestrians, bicycles, and transit using the most recent edition of the Highway Capacity Manual analysis, published by the Transportation Research Board.

F. *Safety analysis* – Safety analysis shall be prepared per the requirements of the MassDOT Traffic and Safety Engineering 25% Design Submission Guidelines. Collection and analysis of crash records for all corridors and intersections within the study area is required. The crash data should be based on the latest 5 years of data available (preferred) or the latest 3 years of data available (minimum). MassDOT crash data should be buttressed with local records, to the extent possible based on the availability of local data. Calculation of the study area intersection(s) and segment(s) crash rates, as applicable, are required and shall be compared to the MassDOT District and State-wide average crash rates. Collision diagrams shall be based on actual crash reports with crash diagrams and narratives and shall be completed for all study area intersections with more than 3 crashes per year unless otherwise directed by MassDOT. Intersection safety narratives shall discuss potential crash causes and potential remedies.

1. Consideration shall be given to (but not limited to) the items listed in the Safety Review Prompt List (http://www.mhd.state.ma.us/downloads/trafficMgmt/SafetyReviewPromptList.pdf) during a site visit. Discussion shall be included in the TIA regarding the safety evaluation.

2. If all or a portion of the project area is considered HSIP-eligible, the Safety Review shall be replaced with a Road Safety Audit (RSA) for the specific area. The Road Safety Audit shall be conducted in accordance with MassDOT Road Safety Audit Guidelines and shall be conducted prior to developing the 25% Design Plans. Completion of the RSA at the earliest project stages will help identify the most appropriate improvements and ideally would be performed prior to the TIA but is not required prior to TIA submittal. RSAs shall be completed prior to the Section 61 finding.

G. *Traffic signal warrant analysis* – This analysis must be performed whenever new traffic signals are proposed, using the most recent edition of the Manual on Uniform Traffic Control Devices Handbook, including the Massachusetts Amendments.

1. *Traffic data*: Per the MassDOT Traffic and Safety Engineering 25% Design Submission Guidelines, the traffic count data for the major-street and the minor-street approaches shall be collected and analyzed for a minimum of the highest-volume 8 hours of the day.

The minor-street volume shall be conducted by manual turning movement count method. The volume data should be shown in tabular form for review.

H. *Queue length analysis* – Both 50th (average) and 95th Percentile Back of Queue calculation results shall be summarized per the requirements of the MassDOT Traffic and Safety Engineering 25% Design Submission Guidelines. A standard vehicle length of 25 feet should be used, unless data can be provided to support an alternate length. The TIA should include graphical representation of 50^{th} and 95^{th} percentile queue lengths at select study intersections if required during the scoping process.

I. *General Criteria for Turn lanes*– Where required by MassDOT, the need for left-turn lanes and/or right-turn deceleration lanes must be assessed based the criteria of the MassDOT Project Development and Design Guidebook.

IV. PERFORMANCE MEASURES & GOALS

Transportation system performance presented in TIAs will be reviewed considering safety and operations analysis methodologies for each mode of travel within the study area based on the following criteria:

A. Safety

1. If a proponent's trips impact an intersection or segment that has a crash rate higher than the statewide average crash rate for comparable intersections or segments, the proponent must assess options to mitigate the safety condition. The proponent should determine if all or a portion of the study area is identified as HSIP-eligible. If the location is HSIP-eligible, a road safety audit (RSA) must be conducted prior to the issuance of the Section 61 Finding to ensure that any resulting mitigation is identified before 25% design plans are submitted to MassDOT.
2. The TIA should also identify any locations where design or operations could pose a safety issue, based on the preparer's best engineering judgment, irrespective of HSIP status or eligibility, and identify potential remedies.

B. Vehicular Operations

1. If a proponent's trips result in a level of service (LOS) degradation, a development will be considered to have had an impact and the proponent must assess options to mitigate the impact.
    a) Even if LOS doesn't drop, MassDOT may still find a development has a significant impact (for example, pre-development might be LOS D and post-development might be LOS D but with another 10 seconds of delay).

b) Impacts to elements of the transportation system (e.g. intersections, ramp terminals) are generally determined by the technical analysis described above (e.g. vehicular operations at intersections, safety assessment of crashes). This analysis typically indicates when impacts result from the proposed development, but the location and mode of the impact does not necessarily dictate the optimal location or mode for mitigation. The proponent is encouraged to work closely with MassDOT to determine the best locations and modes to target for mitigation.

2. The proponent should highlight signalized intersections that operate at LOS E or F in suburban and rural areas (considered to be isolated areas with populations less than approximately 30,000). The proponent should ensure that a range of mitigation opportunities are reviewed for these locations and is encouraged to meet with and discuss options with MassDOT staff at the appropriate time prior to finalizing the TIA.

3. The proponent should highlight signalized intersections that operate at LOS F in urban areas. The proponent should ensure that a range of mitigation opportunities are reviewed for these locations and is encouraged to meet with and discuss options with MassDOT staff at the appropriate time prior to finalizing the TIA.

C. Bicycle, Pedestrian, and Transit Modes

1. The TIA should include an assessment of the mode split assumptions, as well as the proponent's plan to maximize travel choice, promote non-SOV modes, and achieve the assumed mode shares.

   If a facility is impacted by a proponent's trips and the facility has an access or accommodation deficiency in the mode under review (bicycle, pedestrian, transit), the proponent must assess options to facilitate safe, convenient, and attractive access via these modes.

2. In locations where pedestrian facilities are not available, the proponent shall evaluate and document pedestrian needs, desire lines, and opportunities to provide pedestrian infrastructure.

3. In locations where bicycle facilities are not available, the proponent shall evaluate and document bicycle needs, desire lines, and opportunities to provide bicycle infrastructure.

   In locations where transit facilities are not available, the proponent shall evaluate and document needs, origins and destinations, and opportunities to provide transit service.

4. When required, the MMLOS applications for signalized/unsignalized intersection analyses, urban arterials facilities, and roadway segments should be used for informational purposes to aid MassDOT and the proponent in understanding relative impacts to the modes assessed.

    a) Where required, Transit MMLOS shall be assessed by stop. For MMLOS reporting purposes, if there is no existing fixed-route transit service in the study area, the transit MMLOS should be reported as “no service” to distinguish it from a situation where service exists but is poor (e.g. LOS F).

    b) Where required, bicycle and pedestrian MMLOS shall be assessed by both segment and intersection for each direction of travel. For MMLOS reporting purposes, if there are no existing bicycle or pedestrian facilities in the study area, the respective MMLOS should be reported as “no facilities” to distinguish it from a situation where facilities exist but operate at poor LOS.

V. TRIP GENERATION

Trip generation involves the estimation of the number and type of trips associated with the land use(s) proposed by the proponent. In preparing trip estimates for a proposed development, the proponent should be guided by the following principles:

1. Trip rate and trip type should be selected to best reflect the anticipated trip generation of the proposed land use(s) and the available/proposed multi-modal transportation system in the study area.

2. *MassDOT’s Mode Shift Initiative* has established a statewide mode shift goal of tripling the share of travel in Massachusetts by bicycling, transit and walking.

3. All elements of the analysis and the project proposal – trip generation, mode split, trip distribution, adjustment factors, parking, siting, availability of non-auto modes, mitigation, TDM, etc. – must be consistent with each other. The assumptions and calculations for the trip generation analysis must be delineated so that this is readily and clearly understood.

A. *ITE rates* – A trip generation analysis must be presented that uses <u>unadjusted</u> (no reductions for trip type or internal trips) Institute of Traffic Engineers (ITE) rates for the appropriate land use code, from the most recent edition of <u>Trip Generation</u>. Rates should be developed from the “fitted curve” equations when available and appropriate, and used according to the methods outlined in <u>Trip Generation Handbook</u>, latest edition. Rates derived from the most applicable independent variable (e.g. square feet, number of employees, acres, etc.) should be used.

The trip generation section of the TIA should include a brief discussion of the data and rates available in the Trip Generation Handbook, the rate used for the unadjusted trip generation, and the rationale for its use.

B. *Alternative rates* – An analysis using alternative rates may be presented under the following conditions or for the reasons listed below. In all cases, the use of alternative rates must be thoroughly justified, their appropriateness fully explained, and their source(s) cited.

1. If there are no applicable ITE Trip Generation rates.
2. If the sample size on which the ITE Trip Generation rates are based is prohibitively small.
3. If the description of the ITE Trip Generation Land Use Code does not resemble the description of the proposed project, despite being similar in name.
4. If the description of the studies used to derive ITE Trip Generation rates does not resemble the characteristics of the proposed project, including its surrounding land use context.

A sample size of at least three similar sites is desirable when introducing alternative data, unless the empirical trip rate measured is the actual existing use of the site.

C. *Vehicular trip rate reductions* – Reductions to vehicular trip generation estimates associated with Trip Type shall be calculated in accordance to the ITE Trip Generation and the Trip Generation Handbook as well as Section VI below. Each reduction must be explained in full and accounted for in a table that summarizes the trip generation approach. Shared trips between mixed uses should be estimated following industry best practices.

D. *Multi-modal trip generation estimates* – The trip generation section should include estimates of trips by mode. These estimates should be informed by the availability of public transit, walking, and bicycling infrastructure and/or services, and should be based where possible on recognized data sources such as US Census data, regional travel data, transportation survey data, etc.

Requirements to estimate the number of net new trips generated as pedestrian, bicycle, and/or transit, and appropriate data sources, should be proposed in the TSL and approved by MassDOT prior to submittal of the TIA for MassDOT review (in the case of rail facilities, data sources should include the MBTA).

VI. TRIP TYPE AND DISTRIBUTION

A. *Site-generated trips* – All vehicle-trips to or from the site through all access points must be documented and trip type must be considered, according to the applicable land uses, as outlined in the latest editions of Trip Generation and the Trip Generation Handbook. Analytic bases for reducing the site-generated motor vehicle volumes because of trip type must be documented.

B. *Trip type* – The following types of trips are documented in the ITE Trip Generation Handbook and should be considered for all projects:

1. *Primary trips* are made for the specific purpose of visiting the site. This type of trip typically travels from the origin to the generator and then returns to the origin.

2. *Internal trips* occur among multi-use developments and are trips "not made on the major street system." Internal trips, if present, must be subtracted out before pass-by trip reductions are applied.

3. *Pass-by trips* are made as intermediate trips on the way from an origin to a primary trip destination and do not require a route diversion from another roadway. Pass-by trips are new at the site driveway but are not new on the adjacent roadway. The number of pass-by trips is calculated after accounting for internal trips (Total Site Trip Generation – Internal Trips = External Trips; then apply pass-by reduction to External Trips).

4. *Diverted linked trips* require a route diversion from one roadway to another to reach the site. Diverted linked trips are new to both the site driveways as well as the roadway(s) on which they divert.

Trip Type Notes:

Internal trip rates will vary based on the proposed land use type and size, as well as the context of the surrounding area. For example, transit-oriented developments in an urban area would generally be expected to have a higher internal trip rate than a mixed use development proposed in a rural area.

Data on internal trip rates is evolving and the most recent resources available should be used to document potential internal trip impacts. In addition to locally collected empirical data, two potential resources to consult include: 1) the ITE Trip Generation Handbook, which provides general guidance for estimating internal trip capture between land uses, and 2) the National Cooperative Highway Research Program (NCHRP) Research Report 684 (Enhancing Internal Trip Capture Estimation for Mixed-Use Developments).

Pass-by trip rates should be based on the average pass-by rate obtained from the most recent edition of the ITE Trip Generation Handbook.

The number of pass-by trips must not exceed 15 percent (15%) of the adjacent street traffic volume (street volume prior to site development) during the peak hour per ITE's Transportation Impact Analyses for Site Development.

Diverted linked trip reductions will only be allowed in situations where the project proponent and MassDOT agree that the use of diverted trips can be adequately documented and accounted for.

C. *Trip distribution* should be based on the following three methods:

- Existing traffic patterns
- Gravity model
- US Census Data

1. The TIA must include a description and diagram of the anticipated trip distribution pattern and trip assignment to the study intersections, including assumptions made. Information regarding the gravity model methodology and assumptions must be documented in the TIA.

VII. QUANTIFYING IMPACTS OF TRANSIT-BASED MITIGATION

A. The following procedures may be followed to quantify the impacts of transit-based mitigation in situations where buses, trains, or boats are well-utilized and/or the development would generate larger numbers of transit trips. Note that the list of procedures is not meant to be limiting – other acceptable methods may be determined in coordination with the local RTA and MassDOT.

1. Estimate the site's inbound and outbound transit ridership for the study hours and assign by direction and route (method to be determined in coordination with the local RTA and MassDOT).

2. Estimate the resulting change in average dwell time using the most recent edition of the Transit Capacity and Quality of Service Manual (TCQSM) and knowledge of the transit agency's current fare collection method(s).

3. Estimate current ridership (from transit agency data or by doing a through-the-window check (e.g., lots of open seats, seats mostly filled, a few standees, etc.)).

4. Calculate bus speeds pre- and post-development based on changes in average intersection delay and the additional dwell time already calculated. Calculate transit MMLOS based on the calculated bus speeds and crowding levels.

5. Calculate transit MMLOS incorporating the effects of mitigation strategies.

Section 4 – Mitigation

This section provides an overview of the mitigation analysis process and typical mitigation measures that may be considered. The proponent is required to propose and justify recommended project mitigation based on the context of the project, the location, existing conditions, and other relevant considerations. MassDOT will review and consider the recommended mitigation and will then determine the mitigation required of the project.

I. MITIGATION ANALYSIS

A. If a proposed development (1) may cause the operations and efficiency of a transportation facility to measurably degrade (as determined through consultation with MassDOT), (2) adds vehicle trips to a facility that is already performing with poor operating characteristics (e.g., having at least one lane group and/or turning movement at or below LOS D in rural areas and LOS E in urban areas),or (3) attracts trips to a site that fails to provide adequate pedestrian, bicycle, or public transit access, the proponent is required to commit to a mitigation program that demonstrates the following:

1. The proponent has identified and evaluated a set of potential mitigation alternatives, including improvements to pedestrian, bicycle, and public transit access, as well as a range of geometric and operational improvements for traffic. The TIAS should include a discussion of these alternatives that have been considered for each applicable element of the transportation system.

2. The committed program mitigates the impacts of the proposed development in a manner that enhances walking, bicycling, and public transit access to the project site and avoids further degradation to the traffic performance of the transportation system by the time of development in a manner that meets the following conditions:

    a) The transportation impacts of the proposal are mitigated to the most practical degree possible through transportation improvements or measures that directly address the transportation impacts of the development and/or the inadequacy of walking, bicycling, or public transit access,

    b) An effective transportation demand management (TDM) program is prepared and fully funded, and

    c) The overall benefits of the development outweigh its unresolved impacts.

B. *Primary analysis* – For all mitigation measures, capacity analyses must be performed as previously outlined in these guidelines and the results shown in tabular form. Any future year performance degradation under the Build scenario must be fully mitigated to the extent feasible. The effects of all mitigation measures, including such measures as transportation demand management activities, should be quantified, and the analytical bases documented.

C. *Additional analyses* – All mitigation measures must be analyzed at a preliminary screening level for impacts on wetlands, archeology, abutting landowners, storm water, impaired water bodies, etc., to determine the feasibility of their implementation. The need for additional highway right-of-way to implement the proposed improvements must be documented and anticipated design exceptions must be noted and explored in the TIA to assess feasibility.

D. *Implementation commitment* – For each mitigation measure, the manner in which responsibility for implementation will be established and documented must be described (including clear identification of responsible parties), and the duration of responsibility specified, where applicable. The individual costs of the proposed mitigation measures must also be given. A schedule of when, in relation to any project phasing, particular measures are proposed to be implemented must be outlined. Any agreements or permits that would be needed to implement proposed measures must be documented. Interim mitigation should be proposed when appropriate.

A monitoring program completed by the proponent must be established in close coordination with MassDOT and provided on an on-going basis as appropriate for the mitigation measure. Section 6 of this document addresses monitoring requirements.

E. *Conceptual design plans* – Any conceptual mitigation design plans included in the TIA must meet the following criteria:

1. a standard engineering scale must be used;

2. proposed geometric changes and widening (driveways, storage lanes, acceleration/deceleration lanes, bicycle lanes, sidewalks, etc.) must be clearly depicted over existing conditions;

3. existing and proposed layout lines, building footprint(s) and uses, property lines, parking lot areas, driveways, and the relation of the proposed site to existing rights-of-way and adjacent land uses must be clearly depicted;

4. the conceptual design plans must show the location of any impacted wetlands and any proposed changes in traffic control (such as signalization, roundabouts, etc.);
5. dimensions and geometry of travel lanes, shoulders, bike lanes, and sidewalks must be provided;
6. a construction baseline must also be included;
7. discussion of adherence to MassDOT's Complete Streets principles must be provided; and,
8. discussion of how the site plan has been designed to encourage mode shift and to maximize convenience of walking, biking and transit trips must be provided.

II. STRATEGIES & OPTIONS

This section identifies a range of potential mitigation measures. The measures listed in this section could be proposed individually or in combination. Other alternative measures may be considered.

A. *Pedestrian/Bicycle* – In addition to accommodating pedestrians and bicycles as part of roadway improvement mitigation, pedestrian and bicycle improvements may be considered as potential mitigation measures, particularly higher levels of design and accommodation that could reduce the number of study area-generated vehicle-trips. Pedestrian facilities shall include sidewalks, traffic control devices, curb cut ramps, and other elements. Bicycle improvements may include separated shared-use paths, widened roadway surfaces (either reserved bicycle lanes or wide outside lanes with "sharrows" for bicycle use), traffic control devices, and other elements. Secondary negative impacts of roadway mitigation measures on pedestrian or bicycle infrastructure, such as crosswalks and roadway shoulders, must be avoided, minimized, and/or mitigated themselves. The appropriate MassDOT District should be consulted to ensure feasibility of proposed improvements and/or mitigation (in some Districts, this discussion will be facilitated by the District Pedestrian/Bicycle Coordinator and District Complete Streets Coordinator).

B. *Transit service* – Transit service improvements must also be considered to reduce the number of study area-generated vehicle-trips. If a proponent proposes transit service mitigations, they must coordinate on ridership projections (vehicle trip reductions) with the local regional transit authority (RTA) or other transit service provider (e.g. transportation management association, local shuttle provider, local council on aging, etc.). Transit service improvements may include, but are not limited to:

1. providing facility enhancements including, but not limited to, shelters, bus turnouts, exclusive bus lanes, real-time travel information, etc.; and/or
2. enhancing existing or proposed service (documentation will be required demonstrating the transit route, travel time, frequency, service periods, etc.).

Refer to Section 3.VII. Quantifying Impacts Of Transit-Based Mitigation, for additional details.

C. *Parking* – Proponents who reduce parking below locally-required minimum parking standards (or parking guidance included in ITE Parking Generation, through TDM techniques or other means, may be eligible for a corresponding reduction in assumed vehicle trip generation.[1]

D. *Development Options/Sustainable Development Goals* – The Commonwealth has identified 10 Sustainable Development Goals – desirable smart growth/smart energy strategies that, in part, include concentrating development and mix of uses as well as providing transportation choices. Projects may achieve mitigation in part by embracing the concepts in the Commonwealth's Smart Growth/Smart Energy toolkit. For example, modifying the size or density of the project, altering land uses, incorporating transit-oriented-design features, providing bicycle and pedestrian infrastructure, and other related options may be incorporated into a proponent's traffic mitigation package

E. *Fee-in-Lieu/Mitigation Bank* – MassDOT, at its discretion, may accept financial payment in lieu of direct investment in facility and/or service improvements. To exercise this option, the proponent and MassDOT will first need to reach agreement as to the financial value of the appropriate mitigation required. The proponent would then make a financial contribution to an established MassDOT mitigation bank that will fund an improvement in the future. Where appropriate, potential uses of the mitigation bank might include, but are not limited to:

- Proportional funding of a larger system improvement (e.g. new interchange, future roadway widening, etc.)
- Transit system enhancements
- Traffic signal system enhancements (e.g. signal coordination, transit signal priority, etc.)
- Intelligent Transportation System projects (e.g. provision of changeable message signs, traffic cameras, real-time information systems, traffic management center, etc.)

[1] The potential for achieving capacity mitigation through parking reductions presumes that the proponent has secured local approval to reduce parking below locally-required parking minimums. This mitigation option does not imply that MassDOT has regulatory authority over locally adopted parking requirements.

- Roadway connectivity improvements that shift demand off of critical roadways
- Pedestrian or bicycle system improvements that close gaps, provide direct connections to transit service, and/or shift demand off of critical roadways
- Development and implementation of an access management plan for the study area.

F. *Transportation Demand Management (TDM) Program* - Developments that require a MassDOT permit are required to implement a TDM program. Detailed TDM program information is presented in Section 4.III below.

G. *Roadway improvement* – Roadway improvements may improve transportation capacity, circulation connectivity, and/or safety. Potential roadway improvements should consider all users. Pedestrian and bicycle accommodation must be considered as part of any roadway improvement mitigation. If bicycle lanes, shoulders of adequate width for bicycling, or wide outside lanes with “sharrows” are not provided, the proponent may be required to prepare a Design Exception Report or documentation for the MassDOT Complete Streets Engineer, which must identify the reasons for not providing this accommodation. A design exception is granted at MassDOT’s discretion.

III. TRANSPORTATION DEMAND MANAGEMENT PROGRAMS

Transportation Demand Management (TDM) is a broad-based approach to improving transportation access and mobility that, as the name suggests, focuses on reducing or managing the demand for scarce transportation system resources, rather than on increasing the capacity (or “supply”) of a scarce transportation resource. In most instances, the scarce transportation resource is mobility and system capacity for motor vehicles, in particular during peak commuting periods. Therefore, TDM programs are designed to reduce motor vehicle travel demand (especially during peak periods) and enable the transportation system to function more effectively and efficiently through measures that shift passengers to travel modes other motor vehicles; increase the number of passengers in motor vehicles; change the time of travel to periods of lower system demand; and eliminate the need for some trips altogether.

In addition to reducing traffic congestion and potentially delaying or eliminating the need for costly roadway system expansion, TDM programs have a number of corollary benefits. These benefits include reducing greenhouse gas (GHG) emissions that contribute to climate change, providing travelers with active transportation options can promote improved health, and reducing transportation-related costs for travelers.

A. The project proponent is expected to implement a TDM program that includes measures, extent of commitment, and degree of aggressiveness that are compatible with the proposed land use and the geographic context, and that are commensurate with the proponent’s assumptions about mode split and internal trip capture. The proponent should conduct discussions with the affected municipalities, MassRIDES, the area TMA and/or other applicable parties prior to the preparation of a TIA, and should include specific TDM measures to reduce site-generated traffic. The TIA should include specific, measurable TDM commitments, which will be tracked and monitored through the project Transportation Monitoring Program.

B. The proponent should implement a TDM plan that includes the following measures. If the proponent feels that one or more of these measures is not applicable based on land use type or geographic location, then the proponent's filings should address this and explain why such measures are not included.

1. Infrastructure Improvements

a) Complete Streets

- Any proposed mitigation measures within the state highway layout must be consistent with a Complete Streets design approach that provides adequate and safe accommodation for all roadway users, including pedestrians, bicyclists, and public transit riders. Guidance on Complete Streets design guidelines is included in the *MassDOT Project Development and Design Guide*. Where these criteria cannot be met, the proponent should provide the justification as to the reason why, and should work closely with the MassDOT Highway Division to obtain a design waiver.
- Sidewalks and bicycle accommodations on internal roadways, with connections to adjacent pedestrian and bicycle networks.
- Site design that facilitates connectivity and permeability of the site to adjacent areas, at a minimum for pedestrians and bicyclists.

b) Transit

- Provision of a bus stop, bus pullout, and/or bus shelter on site, as requested by the local transit provider.

c) Bicycle

- Provision of secure, weather-protected bicycle parking for residents and employees.
- Provision of publicly-accessible, highly-visible bicycle parking near building entrances for retail customers and visitors.
- Sponsorship of a bike share service to facilitate installation of a new or expanded bike share station.

d) Parking Accommodation

- Reduction of parking supply to reduce single-occupancy vehicle (SOV) trips; this should include reduction of the parking supply through consideration of "shared parking," in which different land uses with complementary parking demand profiles (e.g. office and residential) enable a reduction of overall parking supply. The parking supply should also reflect the internal capture rate included in the trip generation analysis; the proponent must show calculations of parking reduction based on the internal capture rate.
- Provision of preferential parking spaces for carpools and vanpools.
- Provision of preferential parking spaces for low-emission vehicles.
- Provision of parking space(s) for a car-sharing service to facilitate reduced vehicle ownership.
- Provision of electric vehicle (EV) charging stations with parking reserved for EVs, and provision of infrastructure that would allow for expansion of EV charging stations as demand grows.

e) Internal Building Accommodations

- Provision of showers, changing rooms, and locker facilities for on-site employees.
- Provision of on-site amenities including food service, kitchen facilities, mail drop center, and other amenities that can reduce the need for employees to make midday convenience trips by automobile.

2. Incentive, Information, and Encouragement-Based Measures

a) General TDM Support

- Designation of a full-time, on-site employee as Transportation Coordinator who will be responsible for implementation of the TDM program and for the TDM monitoring.
- Membership in the local Transportation Management Association (TMA) if the development is within that TMA's service area, or if a nearby TMA could be expanded to include the development.

- If the development is not within a TMA service area, participate in MassRides, the Commonwealth's travel options service.
- Coordination with MassRides or the local TMA in order to support TDM program development prior to the submission of a TIA.
- Through the TMA or MassRides, provision of the following TDM services, as applicable:
- Provision of a guaranteed ride home program.
- Dissemination of information about the TDM program to employees through web-based information, print materials, and promotional events.
- Subsidy, promotion, and participation in any shuttle services.
- Support for ride-matching, carpooling, and other greener modes of transportation through the active promotion of NuRide, the Commonwealth's web-based trip planning and ride-matching system that allows users to earn rewards for taking greener trips.

b) Travel Information

- Provision of comprehensive information (through print materials, an orientation packet, and/or a development website, as appropriate to the proposed development) with information on multimodal transportation options for residents, retail and office tenants, and retail and office employees.
- Provision of maps and information about public transit, walking and bicycling options in a visible and permanent location.

c) Employee Benefits

- Provision of subsidized transit passes to employees.
- Provision of pre-tax payroll deduction for transit passes to employees.
- Provision of vanpool subsidies to employees and/or tenants.
- Allow employees to pay for vanpool fares through pre-tax payroll deductions.
- Accommodation of alternative work schedules and arrangements, including support for flexible/staggered work hours, compressed work weeks, and telecommuting.
- Management of work shifts to coordinate with the availability of public transportation.
- Provision of direct deposit for employees.

d) Parking Management

- Market-rate parking fees to reduce SOV trips.
- "Unbundling" of parking costs from other charges (e.g. rental charges or home purchase price), requiring that parking spaces be leased or sold separately.
- Management of SOV travel through the implementation of a parking pass program.
- Provision of parking "cash out" for employees who do not use on-site parking.

e) Public Transit Service

- Coordination with the local public transit provider on opportunities to enhance transit service to the project prior to the submission of a TIA.
- Financial support to enable bus route extension or service frequency enhancement for the project site.

Section 5 - TIA Report Requirements

This section documents information that should typically be provided in the TIA report and appendix materials. The TIA must include documentation of key information as may be adjusted or amended per the Office of Energy and Environmental Affairs ENF Certificate, MassDOT TIA Scoping Meeting, or other communication from MassDOT or the MEPA Office.

I. TIA CONTENTS

A. Introduction

1. *Project description* – Provide a description of the proposed project and the study area. The boundaries of the study area must be as defined and documented in the Certificate of the Secretary of Energy and Environmental Affairs on the ENF for the project. The total anticipated build-out of the project, how it will be phased (as appropriate), and a detailed description of the proposed land use(s) (including specific tenants, if known) must be clearly stated.

2. *Locus maps* – Show the regional and local context of the project with the following maps.

    a) Site plotted centrally on the USGS map.

    b) *Site plotted in accordance to the MassDOT Road Inventory Maps on the MassDOT Regional Series map, with the study area boundary shown. Note: Similar maps from other providers will be accepted.*

3. *Site plan* – Indicate the proposed "footprint" of the project relative to existing site conditions, the boundaries of all land owned by the proponent, the abutting land uses and their owners, and all transportation facilities (including private and access roadways, sidewalks, public transit stations/stops/routes, and bicycle facilities) adjacent to the site. Topographic features that may impact the overall development potential of the site should be depicted. A standard engineering scale must be used and noted on all maps.

4. *Zoning map* – Indicate the current zoning of the site and the adjacent parcels. Any proposed changes in zoning must be described relative to the potential full development of the site. A brief summary of the applicable zoning regulations and requirements must be included.

B. Existing Conditions Assessment

1. *Roadway network* – Provide a map indicating the jurisdictional responsibility for each roadway link and intersection within the study area. For each study intersection, identify current lane configurations and traffic control devices.

2. *Multi-modal network* – Provide a map illustrating the site in relation to the study area pedestrian, bicycle, transit, and freight network. Also identify major attractors such as schools, neighborhood or regional commercial facilities, regional employment, etc.

3. *Pedestrian facilities review* – Identify existing pedestrian facilities, including a qualitative assessment of sidewalk condition, sidewalk width, the presence of sidewalk ramps, marked and signalized pedestrian crossings, and the presence of lighting.

    a) *Pedestrian volumes* - Provide a pedestrian traffic flow map illustrating pedestrian volume data for the study area.

    b) *Bicycle facilities review* – Identify existing bicycle facilities including documentation of marked existing bike lane(s), separated bikeways (multi-use path, cycle track, etc.), pavement markings (sharrow/other), shoulders, signage, and other relevant bicycle accommodations (e.g. width of shoulders and whether they are usable for bicycling, width of outside lane and whether it can serve as a shared lane), as well as general pavement condition/challenges and the presence of lighting.

        (1) *Bicycle volumes* - Provide a bicycle traffic flow map illustrating the bicycle volume data for the study area.

        (2) *Bicycle Parking* – Provide a map of existing bicycle parking within ¼-mile of the project site.

4. *Transit facilities review* – Identify bus routes within ½ mile, park-and-ride facilities within one (1) mile, and commuter rail stations within five (5) miles of the development, including the route and stop location(s). Note transit facility infrastructure, signage, connectivity to sidewalks/other facilities, and the presence of lighting at stops.

    a) *Transit service information* – Provide a summary of the overall service route, service hours (start and end times by day for weekdays and weekends) and service frequency. Note transit priority treatments as applicable. Include RTA-provided ridership by route and time of day, if required.

1. *Freight network* – Identify designated freight facilities, freight destinations and/or documented truck routes within the study area.

2. *"Transportation Options" services review* – Provide a summary of available transportation option services such as (but not limited to) Transportation Management Association(s), MassRides, trip reduction services through employers, commuter trip reduction programs, car sharing programs, etc.

3. *Multimodal connectivity analysis* – Qualitatively identify connectivity gaps for the motor vehicle, pedestrian, bicycle, and transit modes in the site vicinity. Summarize the findings with maps, tables, and/or text, identifying the location and extent of gaps for each mode.

4. *Motor vehicle volumes* – Provide a traffic flow map illustrating the required daily and/or peak hour motor vehicle traffic volume data.

5. *Safety analysis* – Provide a summary of the safety analysis documenting crash analysis, collision diagrams, and collision mapping per Section 3.III.F, General Analysis Methodology Requirements.

6. *Operational analysis* – Provide a summary of existing conditions operational analysis results documenting intersection motor vehicle capacity and MMLOS analysis for pedestrian, bicycle, and transit modes per Sections 3.III.A through E, General Analysis Methodology Requirements. Where required by MassDOT, weave, merge, diverge, ramp, and road segment analyses shall be included.

7. *Queue length analysis* –Provide a summary (tabular and graphic) of the 50th (average) and 95th Percentile existing Back of Queue calculation results (including a summary of available queuing capacity) per Section 3.III.H, General Analysis Methodology Requirements.

C. Future Conditions Assessment

1. Future conditions in the TIA shall cover at least a seven-year time horizon from the filing date of the subject project EENF or EIR. Other time horizons may be required, depending on the nature, location, and/or scheduling of the project, the magnitude of proposed mitigation measures, and the responsibility and schedule for their implementation. The seven-year period replaces the previous five-year time horizon. It is intended to incorporate a "built-in" time allowance for projects completing the MEPA process before applying for a Vehicular Access Permit and/or designing mitigation. In that regard and with due consideration to the typical length of the MEPA process, a project could then proceed to preparation of a Functional Design Report (FDR) without any requirement for updated traffic volumes or analysis.

It should be noted that FHWA review is mandated when a project involves potential impacts to interstate highway interchanges and ramps. A time horizon of 20 years is required by FHWA in such cases. Time horizon(s), growth rates, accounting for in-process developments, and planned transportation improvements shall be determined based on consultation with the appropriate Regional Planning Agencies, RTAs, MassDOT District Offices, and the local communities.

a) *No-build condition* – Traffic volumes and turning movement counts at study area intersections must be shown graphically for the No-Build scenario. These volumes must account for:

(1) General background growth associated with overall population and employment trends in the study area and surrounding region, based on consultation with the appropriate Regional Planning Agency, the Central Planning Transportation Staff, and municipality.

(2) In-process development – Estimated vehicular trips for all other developments within the study area that are not yet complete and generating trips, but that have received:

(a) local approval(s), where state approvals are not required, within two years from the filing date of the subject Expanded ENF and/or EIR/EIS;

(b) a certificate from the Secretary of EOEEA on an ENF, where no additional MEPA review was required, within two years before the filing date of the subject Expanded ENF and/or EIR/EIS; OR,

(c) a certificate from the Secretary of EOEEA finding an SEIR, a DEIR or FEIR to be adequate, within two years before the filing date of the subject documents.

Traffic volumes associated with these study area projects must be taken directly from the relevant environmental documents, or in the absence of such data, must be estimated using the methodology as outlined in Section 3.V, Trip Generation**.**

b) *Build without mitigation condition* – Trips for the proposed project must be added to the No-build volumes to generate Build Without Mitigation volumes, and the results shown graphically. This analysis must include documentation of all modes.

(1) If alternative trip generation rates are to be considered, operational analyses of future conditions may be required using both ITE *Trip Generation* rates and the proposed alternative rates.

c) *Build with mitigation condition* – Trips for the proposed project must be added to the No-build volumes to generate Build With Mitigation volumes, and the results shown graphically. This analysis must include documentation of all modes.

2. *Planned and funded transportation improvements* – The effects of planned and funded transportation improvements at locations within the study area must be documented and considered in the No-build, Build Without Mitigation, and Build With Mitigation future conditions, when such improvements are funded and scheduled to be constructed within the analysis time horizon.

3. *Operational analysis* – Provide a summary of No-build, Build Without Mitigation, and Build With Mitigation operational analysis results documenting performance measures for vehicle, pedestrian, bicycle, and transit modes per Section 3.IV.B and 3.IV.C, Performance Measures.

4. *Signal* w*arrant* a*nalysis* – Provide a summary of traffic signal warrant analysis performed per the requirements of Section 3.III.G, General Analysis Methodology Requirements:

   a) whenever new traffic signals are proposed, OR
   b) whenever an unsignalized intersection operates at LOS F and there is a reason to believe a traffic signal might be warranted, OR
   c) when required by MassDOT.

5. *Queue length analysis* – Provide a summary (tabular and graphic) of 50^{th} (average) and 95^{th} Percentile existing Back of Queue calculation results (including a summary of available queuing capacity) per Section 3.III.H, General Analysis Methodology Requirements.

6. *Turn lane warrant analysis* – Provide a summary of left-turn lane and/or right-turn deceleration lane warrant analyses prepared per Section 3.III.I, General Analysis Methodology Requirements.

D. Access Management and Circulation Analysis

1. TIAs must provide an overview of the proposed access location(s), key features, and an assessment of conformance with applicable Access Spacing standards.

a) Identify proposed locations of all access points for all modes of the public transportation network.

b) Show proposed internal circulation for all modes, including motor vehicle, transit, pedestrian, and bicycle connectivity as well as truck delivery route(s). Document points of interaction with pedestrian facilities and the methods used to ensure pedestrian safety. Internal circulation should be designed in accordance with MassDOT Complete Streets design guidelines that call for safe and convenient accommodation of all users. Consider opportunities for shared access and/or driveway consolidation with adjacent properties.

c) Document proposed distances between new motor vehicle access points and existing adjacent driveways and intersections, as well as their conformance with applicable minimum access spacing standards, including preference for access to lower hierarchy streets, where possible.

d) Document situations where the minimum access spacing standard is not met and for proposed situations where access points on opposite sides of a roadway do not align. Note: Minimum access spacing standards must be met whenever possible, and proposed motor vehicle access must be aligned with existing roads and driveways whenever possible.

e) If required by MassDOT, provide a circulation layout and connection plan that shows any future development build out of the vicinity and any associated changes to access or circulation. The plan must document all modes as discussed in (b) above.

E. Parking

1. TIAs must provide an overview of proposed parking supply and layout. Items to be addressed include:

a) Identify number of vehicular parking spaces and parking ratio, including a comparison to required local minimum and maximum parking ratios for the site, as well as comparison to industry standard ratios such as those presented in ITE Parking Generation and/or the Urban Land Institute's Shared Parking.

b) Identify location and number of carpool, vanpool, and/or car-sharing spaces, as well as spaces for low-emissions vehicles. Electric vehicle charging stations should also be identified.

c) Identify number of bicycle parking spaces and proximity of parking to entrances. Identify the number of bicycle parking spaces provided as long-term bicycle storage (e.g. lockers, weather-protected garage storage, etc.) versus the number of visible and publicly-accessible bicycle parking spaces. Indicate intended use for bicycle storage (i.e. for employees, residents, customers, etc.).

d) Identify on-site pedestrian circulation routes and their relationship to parking. Note the proximity and connectivity of on-site pedestrian facilities to adjacent street facilities and street crossings.

e) Identify parking management strategies, including pricing and/or time restrictions as appropriate.

f) Identify potential shared parking opportunities.

g) Identify potential off-site parking opportunities (as well as on-street parking facilities, where applicable). This information will be presented as a map depicting existing parking within ¼-mile of the project site along with a written description.

h) Identify parking banks (landscape area reserves), where applicable. Parking banks are areas that are landscaped and may be used to accommodate future parking. Typically considered in a phased development, parking banks would remain as green spaces during the initial stages of a development and, subject to a demonstrated need and subsequent approval process, could be converted to parking as needed.

F. "Transportation Options"

1. Provide an assessment of transportation options available to project residents, employees, customers, visitors, and/or other users of the proponent's project. Items to be addressed include transportation demand management program(s), participation in a transportation management association, transit options, non-motorized transportation modes, etc.

G. Intersection Sight Distance Documentation

1. Document the available intersection sight distance at proposed site driveway(s). Sight distance measurements must be in conformance with the latest edition of the AASHTO manual, A Policy on Geometric Design of Highways and Streets.

H. Mitigation Measures

1. The TIA shall document mitigation measures proposed to ensure the proponent's project meets applicable operating standards. A statement of implementation commitment shall be provided consistent with Section 4.I.D.

2. MassDOT should be consulted to ensure feasibility of proposed improvements and/or mitigation. Pending local District arrangements, this effort may include consultation with the MassDOT District Pedestrian/Bicycle Coordinator and/or District Complete Streets Coordinator.

3. Proponents are strongly encouraged to propose effective TDM-based mitigation measures, in a variety of forms, to reduce motor vehicle trip generation, to influence the time of day when the motor vehicle trips occur, and/or to promote the healthy transportation modes of walking, bicycling, and public transit. In addition to reducing peak hour congestion and improving health, TDM techniques offer potential reductions in energy consumption and greenhouse gas emissions, consistent with the GreenDOT Policy Directive. Project proponents must coordinate with MassRIDES or the local Transportation Management Agency (TMA) to obtain the necessary information to estimate the effect of potential TDM strategies. MassRIDES will work with proponents to understand the following:

   a) how development occurring in areas with an active Transportation Management Association (TMA) could achieve trip reductions through participation in the TMA; and/or

   b) how development in areas without a TMA could propose and commit to developing and maintaining a range of TDM measures appropriate for the development location, type, and context. Such measures should be coordinated with MassRides and may include: enhanced transit service, ridesharing (carpooling or vanpools), shuttle services, transit subsidies, parking pricing, flexible schedules, telecommuting, biking and walking, and other related measures that reduce single occupant vehicle trips.

4. Refer to Section 5, Mitigation, for additional details.

I. Conclusion

1. The Conclusion must outline the TIA findings and recommendations.

2. The TIA must also acknowledge the MassDOT Highway Division Access Permit process and anticipated next steps.

II. TIA APPENDIX DATA

The purpose of the Technical Appendix is to provide documentation of the data collection and analytical procedures used in the TIA preparation. The following is a listing of the typical elements for a Technical Appendix.

A. Traffic volumes

1. Automatic Traffic Recorder summaries

2. Summary of "raw" turning movement, pedestrian, and bicycle counts at intersections

    a) calculation of peak hour factors by approach
    b) calculation of percent heavy vehicles by movement

3. Adjustment factors and sources

    a) seasonal adjustments
    b) no-build growth factors

B. Sketches, signal layout plans, and related field data

C. Transit service existing conditions data

D. Operational analysis worksheets from approved traffic operations software

E. ITE *Trip Generation* land use code sheets

F. Calculations for alternative trip generation rates

G. RTA-provided transit data documenting service capacity, ridership, etc., as appropriate

H. Plotted sight distance analyses

I. Collision diagrams (if required)

J. Traffic signal warrant worksheets (if required)

K. Speed data (if required)

III. RECOMMENDED REFERENCES FOR USE IN TIA PREPARATION

The following publications are recommended for use in TIA preparation.

A. American Association of State Highway and Transportation Officials (AASHTO). *AASHTO Guidelines for Traffic Data Programs*. Most recent edition.

B. American Association of State Highway and Transportation Officials. *A Policy on Geometric Design of Highways and Streets*. Most recent edition.

C. Federal Highway Administration. *Access Management for Streets and Highways (Implementation Package FHWA-IP-82-3)*. June 1982.

D. American Association of State Highway and Transportation Officials. *Guide for the Development of Bicycle Facilities*. Most recent edition.

E. Federal Highway Administration. *Highway Performance Monitoring System Field Manual.* Available on-line at: http://www.fhwa.dot.gov/policyinformation/hpms/fieldmanual/

F. Federal Highway Administration. *Manual on Uniform Traffic Control Devices Handbook* (including the Massachusetts Amendments). Most recent edition.

G. Federal Highway Administration. *Traffic Monitoring Guide*. Available on-line at: http://www.fhwa.dot.gov/ohim/tmguide/

H. Institute of Transportation Engineers. *Parking Generation.* Most recent edition.

I. Institute of Transportation Engineers. *Transportation Impact Analyses for Site Development.* Most recent edition.

J. Institute of Transportation Engineers. *Trip Generation.* Most recent edition.

K. Institute of Transportation Engineers. *Trip Generation Handbook*. Most recent edition.

L. Massachusetts Department of Transportation. *Massachusetts Highway Department Project Development and Design Guidebook*. Most recent edition.

M. Massachusetts Executive Office of Energy and Environmental Affairs. *Smart Growth/Smart Energy Toolkit.* Most recent edition.

N. Massachusetts Department of Transportation. *Traffic and Safety Engineering 25% Design Submission Guidelines*. Most recent edition.

O. National Association of City Transportation Officials. *NACTO Urban Bikeway Design Guide*. Most recent edition.

P. National Cooperative Highway Research Program. *Improving Pedestrian Safety at Unsignalized Crossings*. NCHRP Research Report 562. 2006.

Q. Transportation Research Board. *Access Management Manual*. Most recent edition

R. Transportation Research Board. *Highway Capacity Manual*. Most recent edition.

S. Transportation Research Board. *Transit Capacity and Quality of Service Manual*. Most recent edition.

T. Urban Land Institute. *Shared Parking*. Most recent edition.

U. *301 CMR 11.00: MEPA Regulations, Section 11.03: Review Thresholds*

Section 6 - Monitoring

A monitoring program completed by the proponent must be established in close coordination with MassDOT and provided on an on-going basis as appropriate for the mitigation measure. The intent of the transportation monitoring program is to confirm that post-development impacts are consistent with forecast changes and that mitigation measures are properly completed and/or maintained. With a monitoring program, the actual impacts of a project can be determined and additional mitigation measures identified in the event that shortfalls arise in meeting mode share or other targets. The need and schedule for the implementation of additional mitigation measures will depend on the results of the transportation monitoring program.

This section presents monitoring program issues, findings and implications, and annual reporting requirements.

I. Transportation Monitoring Program

As part of the project mitigation program, the proponent should commit to implementing a transportation monitoring program to be conducted upon the occupancy of the project. The goals of the transportation monitoring program will be to evaluate the accuracy of the assumptions made in the TIA and the adequacy of the transportation mitigation, including the effectiveness of the TDM program. The monitoring program will include, but will not be limited to, the following issues:

1. Monitoring of trip-making and mode share relative to the mode share assumptions and goals in the TIA.
2. Verification of infrastructure elements, including transportation system improvements, parking accommodations, and on-site amenities, as well as measures of infrastructure utilization.
3. Status of MassRides/TMA participation.
4. Incentive- and education-based measures, including measures provided, uptake/participation by on-site residents/employees/visitors, and outcomes of measures implemented.

II. Monitoring Program Findings & Implications

If the transportation monitoring program indicates that the proposed mitigation is not effective in accommodating the future traffic volumes at key area intersections impacting the state highway system, the proponent will be responsible for identifying and implementing operational improvements at these constrained locations. These improvements could entail traffic signal timing and phasing modifications, and/or further refinement of the TDM program to reduce site trip generation.

III. Annual Reporting Requirements

The proponent and/or project tenant(s) will submit to MassDOT an annual Transportation Monitoring Program Report on the implementation of the TDM program for the first five years of operation. MassDOT will review the annual report for operational effectiveness, and if necessary, provide suggestions for adjustments or improvements to the program.

Additional information and any updates to these guidelines, including links to sample monitoring reports and traffic analysis tools, will be posted as it becomes available at:

http://www.massdot.state.ma.us/planning/Main/PlanningProcess/DevelopmentReview.aspx