MEMORANDUM

To: **Martha White, Natick Town Administrator** **February 17, 2011**
Eric Nascimento, MassDOT Highway Division District 3

From: **Chen-Yuan Wang and Efi Pagitsas**

Re: **Safety and Operations Analyses at Selected Boston Region MPO Intersections: West Central Street (Route 135) at Speen Street in Natick**

This memorandum summarizes safety and operations analyses and proposes improvement strategies for the intersection of West Central Street (Route 135) at Speen Street in Natick. It contains the following sections:

- Intersection Layout and Traffic Control
- Issues and Concerns
- Crash Data Analysis
- Intersection Capacity Analysis
- Analyses of Improvement Alternatives
- Improvement Recommendations and Discussion

The memorandum also includes a collection of technical appendices that contain methods and data applied in the study and detailed reports of the intersection capacity analysis.

INTERSECTION LAYOUT AND TRAFFIC CONTROL

This is a signalized intersection where two major regional roadways meet. It is located in the central-western section of Natick about a mile west of the town center. West Central Street, a two-lane roadway running in the east-west direction, is the major street of the intersection. It is a part of State Route 135, a principal arterial in eastern Massachusetts that runs from Route 128/Interstate 95 (I-95) in Dedham to the town center of Northborough west of Interstate 495 through several communities between the two major highways.

Speen Street, a two-lane roadway running in the north-south direction, is classified as an urban minor arterial north of the intersection and as an urban collector south of the intersection. It runs from Old Connecticut Path in Framingham, intersecting Route 30, Route 9, and Route 135 (at this intersection), to Coolidge Street in South Natick, where further south it connects to Route 16/Route 27 in Sherborn. It serves Natick Mall, Home Depot, and several other commercial developments between Route 9 and Route 30. Speen Street is also a major access road to the MassTurnpike (Interstate 90), as I-90 Exit 13 (Natick/Framingham Exit) is located just west of its intersection with Route 30.

Figure 1 shows the intersection layout and the area nearby. Approaching the intersection, both approaches of West Central Street widen to include an exclusive left-turn lane that has a storage space about 100 feet long. Speen Street widens to include a continuous left-turn lane, starting from its railroad bridge section about 400 feet north of the intersection. The northbound approach of Speen Street remains a single lane shared by all movements.

Crosswalks are installed across the eastbound and the southbound approaches. Sidewalks exist on all corners of the intersection. They continue on both sides of Speen Street north of the intersection. There are no sidewalks south of the intersection. They exist only on the north side of West Central Street east of the intersection and only on the south side west of the intersection.

The intersection traffic signal appears to be new and is fully actuated by approaching traffic. Overhead signal heads are appropriately placed and supported by a cable system. The signal cycles also include an on-call exclusive pedestrian phase that lasts about 26 seconds. Pedestrian signal heads with push buttons and audible indications are placed at both ends of the existing crosswalks. Right turns on red are allowed on all approaches except the northbound approach.

The land uses in the intersection vicinity are mainly single-family residential mixed with commercial developments, office parks, public transportation, and public waters and lands. The Massachusetts Bay Transportation Authority (MBTA) Framingham/Worcester Commuter Rail Line runs parallel to Route 135 north of the intersection. West Natick Station, on the line, is located on Route 135 about half a mile west of this intersection. Lake Cochituate, a popular state park, occupies a large area west of Speen Street. Fiske Pond, a reservoir owned by the Massachusetts Department of Conservation and Recreation (DCR), is located immediately south of Route 135 near the intersection. The land use on both sides of Speen Street is mainly single-family houses until the area north of Route 9. At the intersection, the northeast quadrant is occupied by a retail store (CVS), and the other three quadrants are conservation lands with open waters (portions of Fiske Pond).

West Central Street (Route 135) in the intersection vicinity has a speed limit of 40 miles per hour (MPH). Speen Street has a speed limit of 35 MPH in the northern section and 25 MPH south of the intersection. The southern section of Speen Street is narrow, as both of sides have adjacent wet lands and Fiske Pond.

ISSUES AND CONCERNS

A review of the recent crash data from 2006 to 2008 indicates that the intersection has a high number of crashes and a crash rate much higher than other signalized intersections in the area (see the next section for further analysis).

The intersection is congested during peak periods on almost all approaches, depending on the peak direction. As a principal arterial in the region, traffic on West Central Street is heavy in both directions during peak periods, especially the eastbound direction in the AM peak periods. As a major north-south arterial leading to many commercial developments and transportation facilities in the area, Speen Street north of the intersection carries even more traffic than either side of West Central Street at the intersection. This section of Speen Street is especially congested during the PM peak hour.

CTPS

FIGURE 1
West Central Street (Route 135) at Speen Street, Natick

Safety and Operations Improvements at Selected Intersections

The issues and concerns for this intersection can be summarized as follows:

- High number of crashes and high crash rate at the intersection
- Traffic congestion during peak hours
- Limited space for geometry modifications due to the adjacent conservation lands
- No pedestrian sidewalks on Speen Street south of the intersection

CRASH DATA ANALYSIS

Based on the 2006–2008 MassDOT Registry of Motor Vehicles Division crash data, Table 1 shows that on average about 30 crashes occurred at the intersection each year. About 15% of the total crashes resulted in personal injuries. The crash types consist of about 45% rear-end collisions, nearly 40% angle collisions, and about 15% other types. No crashes involved pedestrians or bicyclists. One-third (33%) of the total crashes occurred during weekday peak periods. A quarter (25%) of the total crashes occurred in wet or icy conditions. About 20% of the total crashes occurred in dark conditions. The relatively high percentage of crashes occurring during peak periods was possibly caused by the congested conditions at the intersection.

TABLE 1
Summary of Crash Data (2006–2008)

Statistics Period		2006	2007	2008	2006–08	Average
Total number of crashes		34	33	26	93	31
Severity	Property damage only	25	31	20	76	25
	Personal injury	7	1	6	14	5
	Fatality	0	0	0	0	0
	Not reported	2	1	0	3	1
Collision Type	Angle	14	14	7	35	12
	Rear-end	14	15	13	42	14
	Sideswipe	3	2	1	6	2
	Head-on	1	0	2	3	1
	Single vehicle	0	2	2	4	1
	Not reported	2	0	1	3	1
Crashes involving pedestrian(s)		0	0	0	0	0
Crashes involving cyclist(s)		0	0	0	0	0
Occurred during weekday peak periods*		14	10	7	31	10
Wet or icy pavement conditions		6	10	7	23	8
Dark/lighted conditions		6	9	3	18	6

* Peak periods are defined as 7:00–10:00 AM and 3:30–6:30 PM.

Crash rate[1] is another effective tool for examining the relative safety of a particular location. Based on the above data and the recently collected traffic volume data, the crash rate for this intersection is calculated as 2.90 (see Appendix A for the calculation sheet). The rate is much

[1] Crash rates normalize crash frequency (crashes per year) by vehicle exposure (traffic volumes or miles traveled). Crash rates are expressed as “crashes per million entering vehicles” for intersection locations and as “crashes per million miles traveled” for roadway segments.

higher than the average rate for the signalized locations in MassDOT Highway Division's District 3, which is estimated to be 0.93.[2]

INTERSECTION CAPACITY ANALYSIS

Boston Region MPO staff collected pedestrian, bicyclist, and vehicular turning movement counts at the intersection on June 8, 2010. The data were recorded in 15-minute intervals for the peak traffic periods in the morning, from 7:00 to 9:00, and in the evening, from 4:00 to 6:00. It should be noted that during that time the southbound section of Speen Street south of the intersection was closed.[3] After consultation with the town officers, we decided to proceed with this study using adjustments of the counts at this intersection based on available turning movement counts from traffic studies in recent years.

Table 2 shows the adjusted turning movements on all approaches in both the AM and PM peak hours. The AM peak hour is identified as 7:15 to 8:15, and the PM peak hour is from 5:00 to 6:00, based on the 2010 counts. The intersection is estimated to carry about 2,400 vehicles in the AM peak hour and about 2,650 vehicles in the PM peak hour. Six and 22 pedestrians were observed in the AM and the PM peak hour, respectively. Nine and 13 bicyclists were observed in the AM and PM peak hour, respectively (not shown in Table 2). They all appeared to be commuters and most of them traveled on Route 135 and Speen Street north of the intersection.

TABLE 2
AM and PM Peak-Hour Traffic Volumes and Pedestrian Crossings

Street name		**West Central Street**						**Speen Street**						**Total**
Direction		**Eastbound**			**Westbound**			**Northbound**			**Southbound**			
Turning movement		LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT	
AM peak hour	Turning volume	339	426	15	50	266	145	5	477	53	175	250	149	2410
	Approach volume	840			461			535			574			
	Pedestrian crossings	3			0			0			3			6
PM peak hour	Turning volume	290	340	20	90	327	120	11	317	47	250	605	221	2638
	Approach volume	650			537			375			1076			
	Pedestrian crossings	10			10			0			2			22

Based on the adjusted turning-movement counts and the signal timings measured at the site, the intersection capacity was analyzed using an intersection capacity analysis program, Synchro.[4] The program indicated that the intersection operates at an overall level of service (LOS) E with an average delay of over one minute per vehicle in the AM peak hour and at LOS F with an average delay of over two minutes per vehicle in the PM peak hour (see Table 3). The level-of-

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[2] The average crash rates estimated by the MassDOT Highway Division are based upon a database that contains intersection crash rates submitted to the Highway Division as part of a review process for an environmental impact report or functional design report. The most recent average crash rates, which are updated on a nearly yearly basis, are based on all entries in the database, not just those entries made within the past year.

[3] A Fiske Pond culvert underneath Speen Street just south of the intersection was damaged during a rain storm in March 2010. The southbound section was closed to avoid further damage and for drivers' safety.

[4] Synchro is developed and distributed by Trafficware, Ltd. It can perform capacity analysis and traffic simulation (when combined with SimTraffic) for an individual intersection or a series of intersections.

service criteria are based on the Highway Capacity Manual 2000.[5] Detailed analysis settings and results for both the AM and PM peak hour are included in Appendix B.

TABLE 3
Intersection Capacity Analysis, Existing Conditions

Street name		**West Central Street**						**Speen Street**						**Overall**
Direction		**Eastbound**			**Westbound**			**Northbound**			**Southbound**			
Turning movement		LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT	
AM peak hour	LOS	**F**	**D**		**C**	**E**		**E**			**D**	**C**		**E**
	Delay (sec/veh)	199	39		29	69		58			47	29		74
PM peak hour	LOS	**F**	**C**		**C**	**D**		**F**			**E**	**F**		**F**
	Delay (sec/veh)	86	29		23	51		400			58	153		133

As the analysis shows, traffic on the eastbound (EB) left turns endures extensive delays in both the AM and PM peak hours due to the insufficient capacity of the single turning lane. All the movements in the northbound (NB) approach endure extensive delays in the PM peak hour, when its opposite approach carries an extremely high traffic volume. Apparently, the existing intersection layout and signal timing plan do not provide sufficient capacity to meet traffic demand at the intersection.

ANALYSES OF IMPROVEMENT ALTERNATIVES

The intersection locates in a limited space because it is surrounded by conservation lands. It appears that the current layout and signal sequence are appropriate for the high traffic demand in the limited space. The crash data analysis indicates that a high proportion (one-third) of crashes occurred during peak periods. Mitigating traffic congestion during peak periods would be an effective way to enhance the intersection safety.

Currently the actuated traffic signal at the intersection operates in four traffic phases: (1) southbound (SB) left-turn and through phase, (2) northbound/southbound (NB/SB) all movements (left turns permitted), (3) leading eastbound/westbound (EB/WB) left-turn protected phase, and (4) eastbound/westbound (EB/WB) all movements (left turns permitted). The phasing plan also includes a 26-second on-call exclusive pedestrian phase.[6] Stopwatch measurements at the site indicate a somewhat different maximum cycle length (including the pedestrian phase) in the AM and PM peak hour, ranging from 140 seconds to 154 seconds.[7]

As there is limited space for expansion, we basically tested two simple alternatives for improving traffic operations at the intersection:

1) Retime the signals with the current phasing sequence and intersection layout
2) Add an exclusive WB right-turn lane with the current phasing sequence

[5] Transportation Research Board, *Highway Capacity Manual 2000*, National Research Council, Washington D.C., 2000

[6] The pedestrian phase time is sufficient. Based on a 4-second start-up time and a 3.5-feet-per-second walking speed, the time required to cross the longer southbound approach (about 60 feet) is calculated as 22 seconds.

[7] It should be noted that the measurements were taken when SB Speen Street south of the intersection was closed. The may not represent the usual setting of the signal.

Synchro tests of signal timing optimization indicate that a maximum cycle length of 150 seconds (including a 26-second exclusive pedestrian phase) would be appropriate for the intersection phasing plan. Alternative 1 represents the results of the optimization tests based on the adjusted turning movement counts.

The only area available for expansion for increasing the intersection capacity is the northeast quadrant where the CVS parking lot is currently located. Alternative 2 was developed in an attempt to utilize the open space to accommodate the relatively high volume of WB right turns and consequently to increase the overall capacity. It was tested under the same maximum cycle length and phasing sequence as Alternative 1.

Table 4 summarizes the intersection capacity analyses for the two alternatives. Detailed analysis settings and results for both the AM and PM peak hours for the alternatives are included in Appendices C and D separately. As Table 4 shows, retiming the traffic signal and rebalancing the phase times based on the approaching traffic (Alternative 1) would somewhat improve traffic operations at the intersection. Adding a right-turn exclusive lane (Alternative 2) would significantly improve traffic operations in both the AM and PM peak hours, with reduced overall intersection delays. It would operate at LOS D in the AM peak hour and LOS E in the PM peak hour, considered acceptable for an urbanized intersection.

TABLE 4
Intersection Capacity Analyses of Improvement Alternatives

Street name		**West Central Street**		**Speen Street**		**Overall**
Approach		**Eastbound**	**Westbound**	**Northbound**	**Southbound**	
AM peak hour	Existing	F/115	E/65	E/58	C/35	E/74
	Alternative 1	E/66	F/88	E/63	D/44	E/64
	Alternative 2	D/55	D/54	D/51	C/30	D/48
PM peak hour	Existing	D/55	D/47	F/>180	F/131	F/133
	Alternative 1	F/101	F/96	E/66	E/58	E/78
	Alternative 2	E/78	E/73	C/32	D/42	E/56

Note Performance measures: Level of Service (A to F)/Average Delay (seconds per vehicle)
Alternative 1: Retime the signals with the current phasing sequence and intersection layout
Alternative 2: Add an exclusive WB right-turn lane with the current phasing sequence

In addition, a future-year scenario of 10% growth over a 20-year planning horizon was tested for the two alternatives.[8] Synchro tests show that under the 2030 projected traffic conditions Alternative 1 would deteriorate to LOS F with an average delay of about one and half minutes in the AM peak hour and nearly two minutes in the PM peak hour. Alternative 2 would still operate at LOS E, with an average delay of nearly one minute in the AM peak hour and one and a quarter minutes in the PM peak hour under the projected traffic conditions.

The above analyses indicate that adding a WB right-turn lane would significantly improve traffic operations at the intersection. A brief review of the intersection aerial photograph indicates that

[8] The growth assumption is based on a review of the traffic projections at the intersection from the Boston Region MPO transportation-planning model.

Alternative 2 is potentially feasible by acquiring a strip of the lawn area along the north side of West Central Street. The exclusive right-turn lane should be channelized with a refuge island for pedestrians and bicyclists. The distance for pedestrians to cross the southbound approach would potentially be reduced with the installation of the refuge island. Meanwhile, bicyclists would have a place to stay while waiting for the signal change. The island should be designed with curb cuts or ramps for easy access by pedestrians and bicyclists.

IMPROVEMENT RECOMMENDATIONS AND DISCUSSION

The intersection is the junction of two major regional roadways. It is very congested during the AM and PM peak hours and has a high number of crashes and a crash rate much higher than other signalized intersections in the area. The crash data analysis indicates that a high proportion (one-third) of crashes occurred during peak periods. Mitigating traffic congestion during peak periods would be an effective way to enhance the intersection's safety.

As the intersection is situated in a limited space surrounded by conservation lands, there are few options for increasing its capacity. This study basically examined two improvement alternatives:

1) Retime the signals with the current phasing sequence and intersection layout
2) Add an exclusive WB right-turn lane with the current phasing sequence

The Synchro operations analyses show that Alternative 1 would somewhat improve traffic operations at the intersection, with reduced overall intersection delays in both the AM and PM peak hours. Alternative 2 would significantly improve traffic operations, with much reduced overall intersection delays, and the intersection would operate at an acceptable LOS D in the AM peak hour and LOS E in the PM peak hour.

Currently Speen Street south of the intersection is completely closed (in both directions) and the culvert replacement and roadway reconstruction work is underway. According to Town staff, a sidewalk along the west side of Speen Street will be installed as part of the roadway reconstruction. The sidewalk will be very beneficial to the area's residents as it provides a connection to the adjacent sidewalks at the intersection. It would also enhance the pedestrian safety on Speen Street.

Alternative 1 shows that the intersection's signal timing appears to have room for adjustments to enhance traffic operations. The Speen Street culvert/roadway reconstruction is expected to be completed in the spring of 2012. We recommend that once the traffic is back to normal after completion of the project, the intersection signal should be retimed with updated turning movements.

In the long run, we recommend Alternative 2. It would improve traffic operations significantly at the intersection. The alternative should include the following major features:

- Channelize the exclusive right-turn lane to provide a refuge island (with curb cuts or ramps) for pedestrians and bicyclists
- Provide a minimum of 4-foot shoulders for bicycle accommodation
- Upgrade the existing sidewalks

The distance for pedestrians to cross the southbound approach would potentially be reduced with the installation of the refuge island. Meanwhile, bicyclists would have a place to stay while waiting for the signal change.

At this preliminary planning stage, it appears that the improvement alternative can only be feasible if a major portion of the lawn area along the north side of West Central Street is obtainable.[9] Assuming no cost for land takings, the total cost of the installation of an exclusive right-turn exclusive lane with a refuge island[10] and the construction of adjacent shoulders and sidewalks is roughly estimated as $150,000 to $200,000. Currently West Central Street (Route 135) is under the jurisdiction of MassDOT, and Speen Street is administered by the Town of Natick. The implementation would require the Town to work closely with MassDOT through the project implantation process (see Appendix E).

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[9] Town staff indicated that the land acquisition may be feasible in light of a previous agreement with the CVS developer. However, it would require at least 16 feet in width of the lawn area, as MassDOT now mandates a 4-foot shoulder for bicycle accommodation and upgraded sidewalks for any new projects.

[10] The lane is assumed to be 150 feet long (including the taper) and 12 feet wide. The refuge island is assumed to be about 100 to 150 square feet. The more precise size of the installation should be identified in the functional design stage.

Appendix A

Intersection Crash Rate Calculation
West Central Street at Speen Street, Natick

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INTERSECTION CRASH RATE WORKSHEET

CITY/TOWN : Natick

COUNT DATE : 6/8/10

DISTRICT : 3

UNSIGNALIZED :

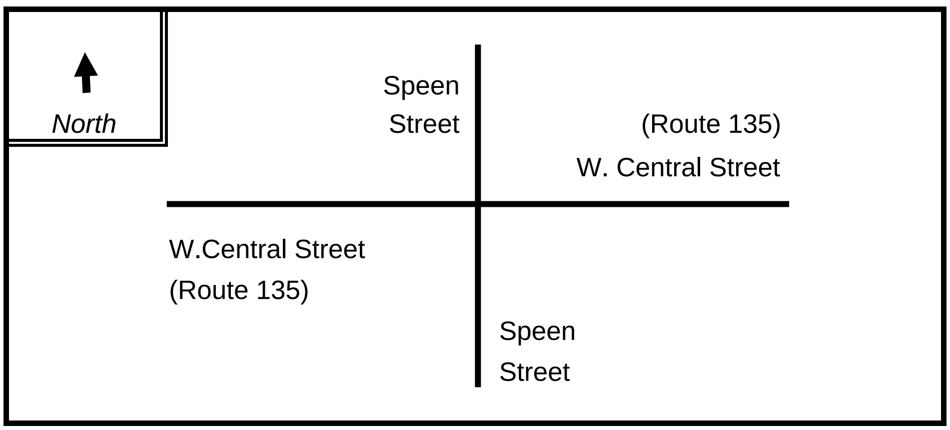
SIGNALIZED : X

~ INTERSECTION DATA ~

MAJOR STREET : West Central Street (Route 135)

MINOR STREET(S) : Speen Street

INTERSECTION DIAGRAM
(Label Approaches)



PEAK HOUR VOLUMES

APPROACH :	1	2	3	4	5	Total Peak Hourly Approach Volume
DIRECTION :	EB	WB	NB	SB		
PEAK HOURLY VOLUMES (AM/PM) :	650	537	375	1,076		2,638

" K " FACTOR : **0.090**

INTERSECTION ADT (**V**) = TOTAL DAILY APPROACH VOLUME : **29,311**

TOTAL # OF CRASHES : 93

OF YEARS : 3

AVERAGE # OF CRASHES PER YEAR (**A**) : **31.00**

CRASH RATE CALCULATION : **2.90**

RATE = $\frac{(A * 1{,}000{,}000)}{(V * 365)}$

Comments : MassDOT Highway District 3 Average Rate = 0.93

Project Title & Date: Safety and Operations Analyses at Selceted Intersections

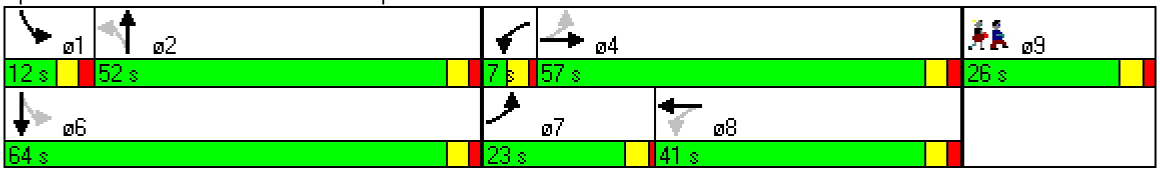
Appendix B

AM/PM Peak Hour Intersection Capacity Analysis
Existing Traffic Conditions
West Central Street at Speen Street, Natick

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	399	426	15	50	266	145	5	477	53	175	250	149
Confl. Peds. (#/hr)	3					3	3					3
Confl. Bikes (#/hr)			3			3			1			
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Growth Factor	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Heavy Vehicles (%)	5%	5%	5%	5%	5%	5%	6%	6%	6%	5%	5%	5%
Bus Blockages (#/hr)	0	0	0	0	0	0	0	0	0	0	0	0
Parking (#/hr)												
Mid-Block Traffic (%)		0%			0%			0%			0%	
Shared Lane Traffic (%)												
Turn Type	pm+pt			pm+pt			Perm			pm+pt		
Protected Phases	7	4		3	8			2		1	6	
Permitted Phases	4			8			2			6		
Detector Phase	7	4		3	8		2	2		1	6	
Switch Phase												
Minimum Initial (s)	4.0	4.0		3.0	4.0		4.0	4.0		4.0	4.0	
Minimum Split (s)	9.0	21.0		7.0	21.0		21.0	21.0		9.0	21.0	
Total Split (s)	23.0	57.0	0.0	7.0	41.0	0.0	52.0	52.0	0.0	12.0	64.0	0.0
Total Split (%)	14.9%	37.0%	0.0%	4.5%	26.6%	0.0%	33.8%	33.8%	0.0%	7.8%	41.6%	0.0%
Yellow Time (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	
All-Red Time (s)	1.0	2.0		1.0	2.0		2.0	2.0		2.0	2.0	
Lost Time Adjust (s)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Lost Time (s)	4.0	5.0	4.0	4.0	5.0	4.0	5.0	5.0	4.0	5.0	5.0	4.0
Lead/Lag	Lead	Lag		Lead	Lag		Lag	Lag		Lead		
Lead-Lag Optimize?	Yes	Yes		Yes	Yes		Yes	Yes		Yes		
Recall Mode	Max	Min		Max	Min		None	None		None	None	
Act Effct Green (s)	60.2	52.2		40.1	36.1			47.2		59.2	59.2	
Actuated g/C Ratio	0.46	0.39		0.30	0.27			0.36		0.45	0.45	
v/c Ratio	1.33	0.65		0.23	0.91			0.89		0.76	0.54	
Control Delay	199.4	39.0		28.7	69.3			58.3		47.2	29.4	
Queue Delay	0.0	0.0		0.0	0.0			0.0		0.0	0.0	
Total Delay	199.4	39.0		28.7	69.3			58.3		47.2	29.4	
LOS	F	D		C	E			E		D	C	
Approach Delay		115.2			64.9			58.3			34.8	
Approach LOS		F			E			E			C	

Intersection Summary	
Cycle Length: 154	
Actuated Cycle Length: 132.2	
Natural Cycle: 150	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 1.33	
Intersection Signal Delay: 73.8	Intersection LOS: E
Intersection Capacity Utilization 111.9%	ICU Level of Service H
Analysis Period (min) 15	

Splits and Phases: 3: Route 135 & Speen Street



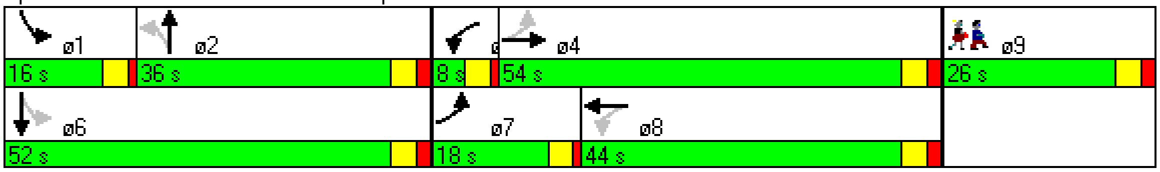
Lane Group	ø9
Lane Configurations	
Volume (vph)	
Confl. Peds. (#/hr)	
Confl. Bikes (#/hr)	
Peak Hour Factor	
Growth Factor	
Heavy Vehicles (%)	
Bus Blockages (#/hr)	
Parking (#/hr)	
Mid-Block Traffic (%)	
Shared Lane Traffic (%)	
Turn Type	
Protected Phases	9
Permitted Phases	
Detector Phase	
Switch Phase	
Minimum Initial (s)	4.0
Minimum Split (s)	26.0
Total Split (s)	26.0
Total Split (%)	17%
Yellow Time (s)	3.0
All-Red Time (s)	2.0
Lost Time Adjust (s)	
Total Lost Time (s)	
Lead/Lag	
Lead-Lag Optimize?	
Recall Mode	None
Act Effct Green (s)	
Actuated g/C Ratio	
v/c Ratio	
Control Delay	
Queue Delay	
Total Delay	
LOS	
Approach Delay	
Approach LOS	

Intersection Summary

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	290	340	20	90	327	120	11	317	47	250	605	221
Confl. Peds. (#/hr)	10		2	2		10	10					10
Confl. Bikes (#/hr)			4			6						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
Growth Factor	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Heavy Vehicles (%)	2%	2%	2%	2%	2%	2%	2%	2%	2%	3%	3%	3%
Bus Blockages (#/hr)	0	0	0	0	0	0	0	0	0	0	0	0
Parking (#/hr)												
Mid-Block Traffic (%)		0%			0%			0%			0%	
Shared Lane Traffic (%)												
Turn Type	pm+pt			pm+pt			Perm			pm+pt		
Protected Phases	7	4		3	8			2		1	6	
Permitted Phases	4			8			2			6		
Detector Phase	7	4		3	8		2	2		1	6	
Switch Phase												
Minimum Initial (s)	4.0	4.0		3.0	4.0		4.0	4.0		4.0	4.0	
Minimum Split (s)	9.0	21.0		7.0	21.0		21.0	21.0		9.0	21.0	
Total Split (s)	18.0	54.0	0.0	8.0	44.0	0.0	36.0	36.0	0.0	16.0	52.0	0.0
Total Split (%)	12.9%	38.6%	0.0%	5.7%	31.4%	0.0%	25.7%	25.7%	0.0%	11.4%	37.1%	0.0%
Yellow Time (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	
All-Red Time (s)	1.0	2.0		1.0	2.0		2.0	2.0		1.0	2.0	
Lost Time Adjust (s)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Lost Time (s)	4.0	5.0	4.0	4.0	5.0	4.0	5.0	5.0	4.0	4.0	5.0	4.0
Lead/Lag	Lead	Lag		Lead	Lag		Lag	Lag		Lead		
Lead-Lag Optimize?	Yes	Yes		Yes	Yes		Yes	Yes		Yes		
Recall Mode	Max	Min		Max	Min		None	None		None	None	
Act Effct Green (s)	56.3	47.3		42.2	37.2			31.2		48.3	47.3	
Actuated g/C Ratio	0.48	0.41		0.36	0.32			0.27		0.42	0.41	
v/c Ratio	1.03	0.52		0.29	0.84			1.79		0.89	1.25	
Control Delay	85.9	29.9		23.1	51.3			400.0		58.4	153.1	
Queue Delay	0.0	0.0		0.0	0.0			0.0		0.0	0.0	
Total Delay	85.9	29.9		23.1	51.3			400.0		58.4	153.1	
LOS	F	C		C	D			F		E	F	
Approach Delay		54.9			46.6			400.0			131.1	
Approach LOS		D			D			F			F	

Intersection Summary	
Cycle Length: 140	
Actuated Cycle Length: 116.3	
Natural Cycle: 150	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 1.79	
Intersection Signal Delay: 133.4	Intersection LOS: F
Intersection Capacity Utilization 122.4%	ICU Level of Service H
Analysis Period (min) 15	

Splits and Phases: 3: Route 135 & Speen Street



Lane Group	ø9
Lane Configurations	
Volume (vph)	
Confl. Peds. (#/hr)	
Confl. Bikes (#/hr)	
Peak Hour Factor	
Growth Factor	
Heavy Vehicles (%)	
Bus Blockages (#/hr)	
Parking (#/hr)	
Mid-Block Traffic (%)	
Shared Lane Traffic (%)	
Turn Type	
Protected Phases	9
Permitted Phases	
Detector Phase	
Switch Phase	
Minimum Initial (s)	4.0
Minimum Split (s)	26.0
Total Split (s)	26.0
Total Split (%)	19%
Yellow Time (s)	3.0
All-Red Time (s)	2.0
Lost Time Adjust (s)	
Total Lost Time (s)	
Lead/Lag	
Lead-Lag Optimize?	
Recall Mode	None
Act Effct Green (s)	
Actuated g/C Ratio	
v/c Ratio	
Control Delay	
Queue Delay	
Total Delay	
LOS	
Approach Delay	
Approach LOS	

Intersection Summary

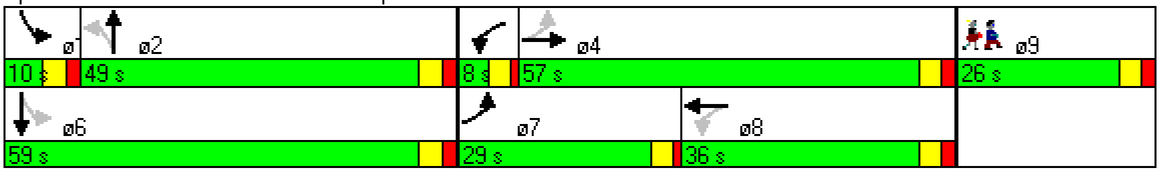
Appendix C

AM/PM Peak Hour Intersection Capacity Analysis
Alternative 1
Retime the Signal with Existing Layout and Phasing Sequence
West Central Street at Speen Street, Natick

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	399	426	15	50	266	145	5	477	53	175	250	149
Confl. Peds. (#/hr)	3					3	3					3
Confl. Bikes (#/hr)			3			3			1			
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Growth Factor	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Heavy Vehicles (%)	5%	5%	5%	5%	5%	5%	6%	6%	6%	5%	5%	5%
Bus Blockages (#/hr)	0	0	0	0	0	0	0	0	0	0	0	0
Parking (#/hr)												
Mid-Block Traffic (%)		0%			0%			0%			0%	
Shared Lane Traffic (%)												
Turn Type	pm+pt			pm+pt			Perm			pm+pt		
Protected Phases	7	4		3	8			2		1	6	
Permitted Phases	4			8			2			6		
Detector Phase	7	4		3	8		2	2		1	6	
Switch Phase												
Minimum Initial (s)	4.0	4.0		3.0	4.0		4.0	4.0		4.0	4.0	
Minimum Split (s)	9.0	21.0		7.0	21.0		21.0	21.0		9.0	21.0	
Total Split (s)	29.0	57.0	0.0	8.0	36.0	0.0	49.0	49.0	0.0	10.0	59.0	0.0
Total Split (%)	19.3%	38.0%	0.0%	5.3%	24.0%	0.0%	32.7%	32.7%	0.0%	6.7%	39.3%	0.0%
Yellow Time (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	
All-Red Time (s)	1.0	2.0		1.0	2.0		2.0	2.0		2.0	2.0	
Lost Time Adjust (s)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Lost Time (s)	4.0	5.0	4.0	4.0	5.0	4.0	5.0	5.0	4.0	5.0	5.0	4.0
Lead/Lag	Lead	Lag		Lead	Lag		Lag	Lag		Lead		
Lead-Lag Optimize?	Yes	Yes		Yes	Yes		Yes	Yes		Yes		
Recall Mode	Max	Min		Max	Min		None	None		None	None	
Act Effct Green (s)	61.2	52.2		36.1	31.1			44.2		54.2	54.2	
Actuated g/C Ratio	0.48	0.41		0.28	0.24			0.34		0.42	0.42	
v/c Ratio	1.07	0.63		0.20	1.02			0.93		0.89	0.58	
Control Delay	99.8	36.2		25.8	95.2			63.1		71.8	31.6	
Queue Delay	0.0	0.0		0.0	0.0			0.0		0.0	0.0	
Total Delay	99.8	36.2		25.8	95.2			63.1		71.8	31.6	
LOS	F	D		C	F			E		E	C	
Approach Delay		66.4			87.6			63.1			43.9	
Approach LOS		E			F			E			D	

Intersection Summary	
Cycle Length: 150	
Actuated Cycle Length: 128.2	
Natural Cycle: 150	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 1.07	
Intersection Signal Delay: 64.4	Intersection LOS: E
Intersection Capacity Utilization 111.9%	ICU Level of Service H
Analysis Period (min) 15	

Splits and Phases: 3: Route 135 & Speen Street



Lane Group	ø9
Lane Configurations	
Volume (vph)	
Confl. Peds. (#/hr)	
Confl. Bikes (#/hr)	
Peak Hour Factor	
Growth Factor	
Heavy Vehicles (%)	
Bus Blockages (#/hr)	
Parking (#/hr)	
Mid-Block Traffic (%)	
Shared Lane Traffic (%)	
Turn Type	
Protected Phases	9
Permitted Phases	
Detector Phase	
Switch Phase	
Minimum Initial (s)	4.0
Minimum Split (s)	26.0
Total Split (s)	26.0
Total Split (%)	17%
Yellow Time (s)	3.0
All-Red Time (s)	2.0
Lost Time Adjust (s)	
Total Lost Time (s)	
Lead/Lag	
Lead-Lag Optimize?	
Recall Mode	None
Act Effct Green (s)	
Actuated g/C Ratio	
v/c Ratio	
Control Delay	
Queue Delay	
Total Delay	
LOS	
Approach Delay	
Approach LOS	

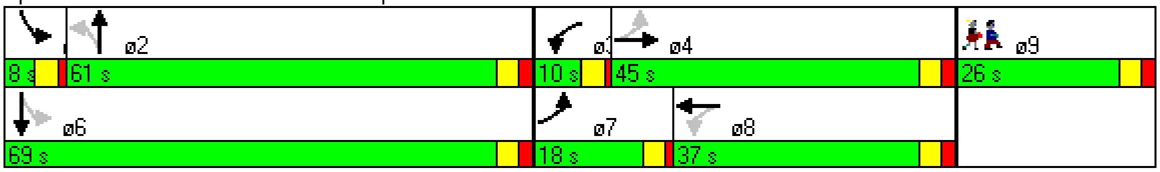
Intersection Summary

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	290	340	20	90	327	120	11	317	47	250	605	221
Confl. Peds. (#/hr)	10		2	2		10	10					10
Confl. Bikes (#/hr)			4			6						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
Growth Factor	100%	100%	110%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Heavy Vehicles (%)	2%	2%	2%	2%	2%	2%	2%	2%	2%	3%	3%	3%
Bus Blockages (#/hr)	0	0	0	0	0	0	0	0	0	0	0	0
Parking (#/hr)												
Mid-Block Traffic (%)		0%			0%			0%			0%	
Shared Lane Traffic (%)												
Turn Type	pm+pt			pm+pt			Perm			pm+pt		
Protected Phases	7	4		3	8			2		1	6	
Permitted Phases	4			8			2			6		
Detector Phase	7	4		3	8		2	2		1	6	
Switch Phase												
Minimum Initial (s)	3.0	4.0		3.0	4.0		4.0	4.0		3.0	4.0	
Minimum Split (s)	7.0	21.0		7.0	21.0		21.0	21.0		7.0	21.0	
Total Split (s)	18.0	45.0	0.0	10.0	37.0	0.0	61.0	61.0	0.0	8.0	69.0	0.0
Total Split (%)	12.0%	30.0%	0.0%	6.7%	24.7%	0.0%	40.7%	40.7%	0.0%	5.3%	46.0%	0.0%
Yellow Time (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	
All-Red Time (s)	1.0	2.0		1.0	2.0		2.0	2.0		1.0	2.0	
Lost Time Adjust (s)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Lost Time (s)	4.0	5.0	4.0	4.0	5.0	4.0	5.0	5.0	4.0	4.0	5.0	4.0
Lead/Lag	Lead	Lag		Lead	Lag		Lag	Lag		Lead		
Lead-Lag Optimize?	Yes	Yes		Yes	Yes		Yes	Yes		Yes		
Recall Mode	Max	Min		Max	Min		None	None		None	None	
Act Effct Green (s)	51.2	40.2		39.2	32.1			56.2		65.3	64.3	
Actuated g/C Ratio	0.40	0.31		0.31	0.25			0.44		0.51	0.50	
v/c Ratio	1.25	0.68		0.41	1.08			0.94		0.70	1.01	
Control Delay	168.9	46.4		33.9	109.2			66.2		34.4	65.1	
Queue Delay	0.0	0.0		0.0	0.0			0.0		0.0	0.0	
Total Delay	168.9	46.4		33.9	109.2			66.2		34.4	65.1	
LOS	F	D		C	F			E		C	E	
Approach Delay		100.8			96.5			66.2			58.0	
Approach LOS		F			F			E			E	

Intersection Summary

Cycle Length: 150
Actuated Cycle Length: 128.2
Natural Cycle: 145
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 1.25
Intersection Signal Delay: 77.6 — Intersection LOS: E
Intersection Capacity Utilization 122.4% — ICU Level of Service H
Analysis Period (min) 15

Splits and Phases: 3: Route 135 & Speen Street



Lane Group	ø9
Lane Configurations	
Volume (vph)	
Confl. Peds. (#/hr)	
Confl. Bikes (#/hr)	
Peak Hour Factor	
Growth Factor	
Heavy Vehicles (%)	
Bus Blockages (#/hr)	
Parking (#/hr)	
Mid-Block Traffic (%)	
Shared Lane Traffic (%)	
Turn Type	
Protected Phases	9
Permitted Phases	
Detector Phase	
Switch Phase	
Minimum Initial (s)	4.0
Minimum Split (s)	26.0
Total Split (s)	26.0
Total Split (%)	17%
Yellow Time (s)	3.0
All-Red Time (s)	2.0
Lost Time Adjust (s)	
Total Lost Time (s)	
Lead/Lag	
Lead-Lag Optimize?	
Recall Mode	None
Act Effct Green (s)	
Actuated g/C Ratio	
v/c Ratio	
Control Delay	
Queue Delay	
Total Delay	
LOS	
Approach Delay	
Approach LOS	

Intersection Summary

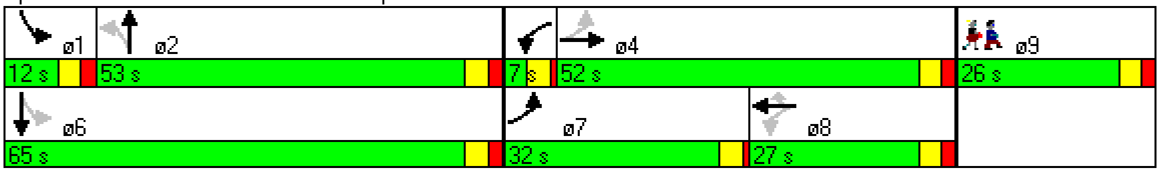
Appendix D

AM/PM Peak Hour Intersection Capacity Analysis
Alternative 2
Add a WB Right-Turn Exclusive Lane with Existing Phasing Sequence
West Central Street at Speen Street, Natick

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	399	426	15	50	266	145	5	477	53	175	250	149
Confl. Peds. (#/hr)	3					3	3					3
Confl. Bikes (#/hr)			3			3			1			
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Growth Factor	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Heavy Vehicles (%)	5%	5%	5%	5%	5%	5%	6%	6%	6%	5%	5%	5%
Bus Blockages (#/hr)	0	0	0	0	0	0	0	0	0	0	0	0
Parking (#/hr)												
Mid-Block Traffic (%)		0%			0%			0%			0%	
Shared Lane Traffic (%)												
Turn Type	pm+pt			pm+pt		Perm	Perm			pm+pt		
Protected Phases	7	4		3	8			2		1	6	
Permitted Phases	4			8		8	2			6		
Detector Phase	7	4		3	8	8	2	2		1	6	
Switch Phase												
Minimum Initial (s)	4.0	4.0		3.0	4.0	4.0	4.0	4.0		4.0	4.0	
Minimum Split (s)	9.0	21.0		7.0	21.0	21.0	21.0	21.0		9.0	21.0	
Total Split (s)	32.0	52.0	0.0	7.0	27.0	27.0	53.0	53.0	0.0	12.0	65.0	0.0
Total Split (%)	21.3%	34.7%	0.0%	4.7%	18.0%	18.0%	35.3%	35.3%	0.0%	8.0%	43.3%	0.0%
Yellow Time (s)	3.0	3.0		3.0	3.0	3.0	3.0	3.0		3.0	3.0	
All-Red Time (s)	1.0	2.0		1.0	2.0	2.0	2.0	2.0		2.0	2.0	
Lost Time Adjust (s)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Lost Time (s)	4.0	5.0	4.0	4.0	5.0	5.0	5.0	5.0	4.0	5.0	5.0	4.0
Lead/Lag	Lead	Lag		Lead	Lag	Lag	Lag	Lag		Lead		
Lead-Lag Optimize?	Yes	Yes		Yes	Yes	Yes	Yes	Yes		Yes		
Recall Mode	Max	Min		Max	Min	Min	None	None		None	None	
Act Effct Green (s)	55.2	47.2		26.1	22.1	22.1		47.6		59.6	59.6	
Actuated g/C Ratio	0.43	0.37		0.20	0.17	0.17		0.37		0.47	0.47	
v/c Ratio	0.96	0.70		0.26	0.89	0.40		0.86		0.69	0.52	
Control Delay	68.9	42.0		34.1	82.0	10.9		51.2		38.7	26.4	
Queue Delay	0.0	0.0		0.0	0.0	0.0		0.0		0.0	0.0	
Total Delay	68.9	42.0		34.1	82.0	10.9		51.2		38.7	26.4	
LOS	E	D		C	F	B		D		D	C	
Approach Delay		54.8			54.4			51.2			30.2	
Approach LOS		D			D			D			C	

Intersection Summary	
Cycle Length: 150	
Actuated Cycle Length: 127.6	
Natural Cycle: 150	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 0.96	
Intersection Signal Delay: 48.0	Intersection LOS: D
Intersection Capacity Utilization 102.9%	ICU Level of Service G
Analysis Period (min) 15	

Splits and Phases: 3: Route 135 & Speen Street



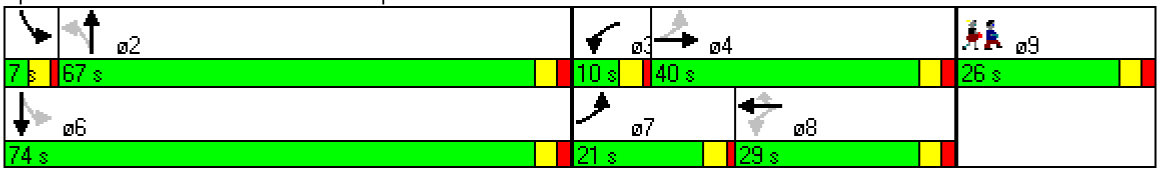
Lane Group	ø9
Lane Configurations	
Volume (vph)	
Confl. Peds. (#/hr)	
Confl. Bikes (#/hr)	
Peak Hour Factor	
Growth Factor	
Heavy Vehicles (%)	
Bus Blockages (#/hr)	
Parking (#/hr)	
Mid-Block Traffic (%)	
Shared Lane Traffic (%)	
Turn Type	
Protected Phases	9
Permitted Phases	
Detector Phase	
Switch Phase	
Minimum Initial (s)	4.0
Minimum Split (s)	26.0
Total Split (s)	26.0
Total Split (%)	17%
Yellow Time (s)	3.0
All-Red Time (s)	2.0
Lost Time Adjust (s)	
Total Lost Time (s)	
Lead/Lag	
Lead-Lag Optimize?	
Recall Mode	None
Act Effct Green (s)	
Actuated g/C Ratio	
v/c Ratio	
Control Delay	
Queue Delay	
Total Delay	
LOS	
Approach Delay	
Approach LOS	

Intersection Summary

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	290	340	20	90	327	120	11	317	47	250	605	221
Confl. Peds. (#/hr)	10		2	2		10	10					10
Confl. Bikes (#/hr)			4			6						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
Growth Factor	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Heavy Vehicles (%)	2%	2%	2%	2%	2%	2%	2%	2%	2%	3%	3%	3%
Bus Blockages (#/hr)	0	0	0	0	0	0	0	0	0	0	0	0
Parking (#/hr)												
Mid-Block Traffic (%)		0%			0%			0%			0%	
Shared Lane Traffic (%)												
Turn Type	pm+pt			pm+pt		Perm	Perm			pm+pt		
Protected Phases	7	4		3	8			2		1	6	
Permitted Phases	4			8		8	2			6		
Detector Phase	7	4		3	8	8	2	2		1	6	
Switch Phase												
Minimum Initial (s)	3.0	4.0		3.0	4.0	4.0	4.0	4.0		3.0	4.0	
Minimum Split (s)	7.0	21.0		7.0	21.0	21.0	21.0	21.0		7.0	21.0	
Total Split (s)	21.0	40.0	0.0	10.0	29.0	29.0	67.0	67.0	0.0	7.0	74.0	0.0
Total Split (%)	14.0%	26.7%	0.0%	6.7%	19.3%	19.3%	44.7%	44.7%	0.0%	4.7%	49.3%	0.0%
Yellow Time (s)	3.0	3.0		3.0	3.0	3.0	3.0	3.0		3.0	3.0	
All-Red Time (s)	1.0	2.0		1.0	2.0	2.0	2.0	2.0		1.0	2.0	
Lost Time Adjust (s)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Lost Time (s)	4.0	5.0	4.0	4.0	5.0	5.0	5.0	5.0	4.0	4.0	5.0	4.0
Lead/Lag	Lead	Lag		Lead	Lag	Lag	Lag	Lag		Lead		
Lead-Lag Optimize?	Yes	Yes		Yes	Yes	Yes	Yes	Yes		Yes		
Recall Mode	Max	Min		Max	Min	Min	None	None		None	None	
Act Effct Green (s)	46.2	35.1		31.1	24.1	24.1		62.2		70.3	69.3	
Actuated g/C Ratio	0.36	0.27		0.24	0.19	0.19		0.49		0.55	0.54	
v/c Ratio	1.07	0.77		0.52	1.01	0.35		0.66		0.62	0.94	
Control Delay	105.9	54.9		43.2	102.9	13.9		32.3		27.8	45.8	
Queue Delay	0.0	0.0		0.0	0.0	0.0		0.0		0.0	0.0	
Total Delay	105.9	54.9		43.2	102.9	13.9		32.3		27.8	45.8	
LOS	F	D		D	F	B		C		C	D	
Approach Delay		77.6			73.0			32.3			41.6	
Approach LOS		E			E			C			D	

Intersection Summary	
Cycle Length: 150	
Actuated Cycle Length: 128.2	
Natural Cycle: 145	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 1.07	
Intersection Signal Delay: 55.6	Intersection LOS: E
Intersection Capacity Utilization 114.8%	ICU Level of Service H
Analysis Period (min) 15	

Splits and Phases: 3: Route 135 & Speen Street



Lane Group	ø9
Lane Configurations	
Volume (vph)	
Confl. Peds. (#/hr)	
Confl. Bikes (#/hr)	
Peak Hour Factor	
Growth Factor	
Heavy Vehicles (%)	
Bus Blockages (#/hr)	
Parking (#/hr)	
Mid-Block Traffic (%)	
Shared Lane Traffic (%)	
Turn Type	
Protected Phases	9
Permitted Phases	
Detector Phase	
Switch Phase	
Minimum Initial (s)	4.0
Minimum Split (s)	26.0
Total Split (s)	26.0
Total Split (%)	17%
Yellow Time (s)	3.0
All-Red Time (s)	2.0
Lost Time Adjust (s)	
Total Lost Time (s)	
Lead/Lag	
Lead-Lag Optimize?	
Recall Mode	None
Act Effct Green (s)	
Actuated g/C Ratio	
v/c Ratio	
Control Delay	
Queue Delay	
Total Delay	
LOS	
Approach Delay	
Approach LOS	

Intersection Summary

Appendix E

MassDOT Project Implementation Process

The following description of the implementation process is based on Chapter 2 of the *MassDOT Highway Division's Project Development and Design Guide (2005)*. The text below borrows heavily from that document.

1 NEEDS IDENTIFICATION

For each of the locations at which an improvement is to be implemented, MassDOT Highway Division leads an effort to define the problem, establishes project goals and objectives, and defines the scope of the planning needed for implementation. To that end, it has to complete a Project Need Form (PNF), which states in general terms the deficiencies or needs related to the transportation facility or location. The PNF documents the problems and explains why corrective action is needed. For this study, the information defining the need for the project will be drawn primarily, perhaps exclusively, from the present report. Also, at this point in the process, MassDOT Highway Division meets with potential participants, such as the Boston Region Metropolitan Planning Organization (MPO) and community members, to allow for an informal review of the project.

The PNF is reviewed by the MassDOT Highway Division district office whose jurisdiction includes the location of the proposed project. MassDOT Highway Division also sends the PNF to the MPO, for informational purposes. The outcome of this step determines whether the project requires further planning, whether it is already well supported by prior planning studies, and, therefore, whether it is ready to move forward into the design phase, or whether it should be dismissed from further consideration.

2 PLANNING

This phase will likely not be required for the implementation of the improvements proposed in this planning study, as this planning report should constitute the outcome of this step. However, in general, the purpose of this implementation step is for the project proponent to identify issues, impacts, and approvals that may need to be obtained, so that the subsequent design and permitting processes are understood.

The level of planning needed will vary widely, based on the complexity of the project. Typical tasks include: define the existing context, confirm project need, establish goals and objectives, initiate public outreach, define the project, collect data, develop and analyze alternatives, make recommendations, and provide documentation. Likely outcomes include consensus on the project definition to enable it to move forward into environmental documentation (if needed) and design, or a recommendation to delay the project or dismiss it from further consideration.

3 PROJECT INITIATION

At this point in the process, the proponent, MassDOT Highway Division, fills out, for each improvement, a Project Initiation Form (PIF), which is reviewed by its Project Review Committee (PRC) and the MPO. The PRC is composed of the Chief

Engineer, each District Highway Director, and representatives of the Project Management, Environmental, Planning, Right-of-Way, Traffic, and Bridge departments, and the Capital Expenditure Program Office (CEPO). The PIF documents the project type and description, summarizes the project planning process, identifies likely funding and project management responsibility, and defines a plan for interagency and public participation. First the PRC reviews and evaluates the proposed project based on the Executive Office of Transportation and Public Works's statewide priorities and criteria. If the result is positive, MassDOT Highway Division moves the project forward to the design phase, and to programming review by the MPO. The PRC may provide a Project Management Plan to define roles and responsibilities for subsequent steps. The MPO review includes project evaluation based on the MPO's regional priorities and criteria. The MPO may assign project evaluation criteria score, a Transportation Improvement Program (TIP) year, a tentative project category, and a tentative funding category.

4 ENVIRONMENTAL, DESIGN, AND RIGHT-OF-WAY PROCESS

This step has four distinct but closely integrated elements: public outreach, environmental documentation and permitting (if required), design, and right-of-way acquisition (if required). The outcome of this step is a fully designed and permitted project ready for construction. However, a project does not have to be fully designed in order for the MPO to program it in the TIP.

5 PROGRAMMING

Programming, which typically begins during the design phase, can actually occur at any time during the process, from planning to design. In this step, which is distinct from project initiation, where the MPO receives preliminary information on the proposed project, the proponent requests that the MPO place the project in the region's TIP. The MPO considers the project in terms of regional needs, evaluation criteria, and compliance with the regional Transportation Plan and decides whether to place it in the draft TIP for public review and then in the final TIP.

6 PROCUREMENT

Following project design and programming, MassDOT Highway Division publishes a request for proposals. It then reviews the bids and awards the contract to the qualified bidder with the lowest bid.

7 CONSTRUCTION

After a construction contract is awarded, MassDOT Highway Division and the contractor develop a public participation plan and a management plan for the construction process.

8 PROJECT ASSESSMENT

The purpose of this step is to receive constituents' comments on the project development process and the project's design elements. MassDOT Highway Division can apply what is learned in this process to future projects.