



Swampscott Road at First Street Salem, MA

An evaluation of traffic control options

Prepared for the City of Salem, Massachusetts

by Stantec Consulting, Inc.

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Swampscott Road at First Street Salem, Massachusetts

An evaluation of traffic control options

Introduction and Purpose

As requested by the City of Salem, Stantec Consulting, Inc. has identified and evaluated three potential options for improving traffic operations and safety at the “T” intersection of Swampscott Road at First Street. Figure 1 shows the existing intersection location on a USGS map with an aerial of the existing intersection configuration.



Swampscott Road looking south to busy commercial area

Westbound traffic on First Street is controlled by a stop sign, while north/south Swampscott Road traffic is uncontrolled. The northbound segment of Swampscott Road approaches First Street as a single lane that flares out to a 50-foot radius at the intersection to allow free flow of right turn movements onto First Street. In the southbound direction, as can be seen in Figure 1 and the photo above, Swampscott Road approaches First Street in two lanes.

A non-ADA compliant crosswalk is provided on Swampscott Road just south of First Street connecting the channelization island with a utility pole to the sidewalk on the east side of Swampscott Road.



Base Map & Aerial Source: Executive Office of Environmental Affairs MassGIS



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Swampscott Road at First Street
 Salem, Massachusetts

Project Vicinity Map

Figure 1

A single through/left lane is provided plus an unmarked right turn lane to commercial businesses on the west side – Salem Fitness Center, North Shore Physical Therapy, and North Shore Self Storage/U-haul rental. The right lane joins a single driveway offset just south of the T intersection.

Both Swampscott Road and First Street are under the jurisdiction of the City of Salem.

Swampscott Road and is approximately 1.5 miles in length. Classified as an Urban Collector, it is generally on a north/south alignment running between Loring Avenue to the south and Highland Avenue to the north. Swampscott Road carries heavy truck volumes and serves primarily industrial and commercial uses that generate very little pedestrian and bicycle use demands. Its classification as an Urban Collector would suggest its through traffic volumes range from 20-80% of its total traffic volume.

MassDOT classifies First Street as a Local Road. It runs east-west at Swampscott Road. A posted *truck exclusion* roadway, First Street intersects Traders Way in a four way signalized intersection approximately 2,000 feet to the east, eventually turning northerly on a dog-leg alignment and intersecting Highland Avenue. First Street is approximately 0.83 miles in length. Following six hours of direct observations, it appears as though the truck size vehicles on First Street are primarily buses and local service trucks. Its classification as a Local Road suggests its primary function should be to serve adjacent land uses, not through traffic, which should be less than 20% of its total traffic volume.

To summarize, functionally classified Local Roads like First Street by definition are intended to serve as access to adjacent land uses, while Urban Collectors like Swampscott Road are intended to serve a mixture of through traffic plus access to adjacent land uses. First Street carries high traffic volumes because it services a multi-family residential area and retail shopping areas with driveways along Traders Way.

First Street is abutted by a large multi-family development on the south side and Home Depot on the north side. Neither of these uses has direct access onto First Street, which has large tree buffers on both sides of the street. These buffers give

First Street the appearance of being in the middle of a forest. Both developments have access onto Traders Way, which intersects First Street in a perpendicular intersection that is controlled by a traffic signal.

The intersection of Swampscott Road has both traffic operations and safety problems.

A review of the historical crash record for this intersection based on MassDOT data found that it exceeds the crash rate of similar unsignalized locations both in District 4 and statewide. Details of this are discussed further on.

Additionally, based on six hours of counts and observations during a 7-9 AM weekday (Friday, September 30th), a 4-6 PM weekday (Thursday, September 22nd), and Saturday mid-day (October 1st), the intersection has traffic operations difficulties, particularly during the Saturday and PM peak hours, when the queue on First Street approaching Swampscott Road became very long.

The left turn movements from the First Street stop sign are difficult for a couple of reasons. First of all, traffic on Swampscott Road is traveling a relatively high rate of speed. The posted speed limit on Swampscott Road is 40 miles per hour, and vehicles use it accordingly, especially since there are no stop signs or signals on Swampscott Road on its entire length between Highland Avenue (State Route 107) and Loring Avenue.

Data Collection

Counts at the intersection of Swampscott Road and First Street were performed on three different days:

- ❖ Thursday, September 22, 2016 from 4-6 PM
- ❖ Friday, September 30, 2016 from 7-9 AM; and
- ❖ Saturday, October 1, 2016 from 11 AM-1 PM.

These hours are considered to be representative of typical peak hour conditions at the intersection.

Count Results and Observations

Summaries for the observed AM, PM, and Saturday peak hour counts are provided on Figure 2.

During the six hours of counts at the First Street/Swampscott Road intersection, almost no pedestrian and bicycle activity was observed.

While this does not mean pedestrians and bicyclists should not be encouraged to use the intersection, it does mean that the issues observed did not pertain to pedestrian and bicycle flows, but were primarily related to motor vehicle traffic conflicts.

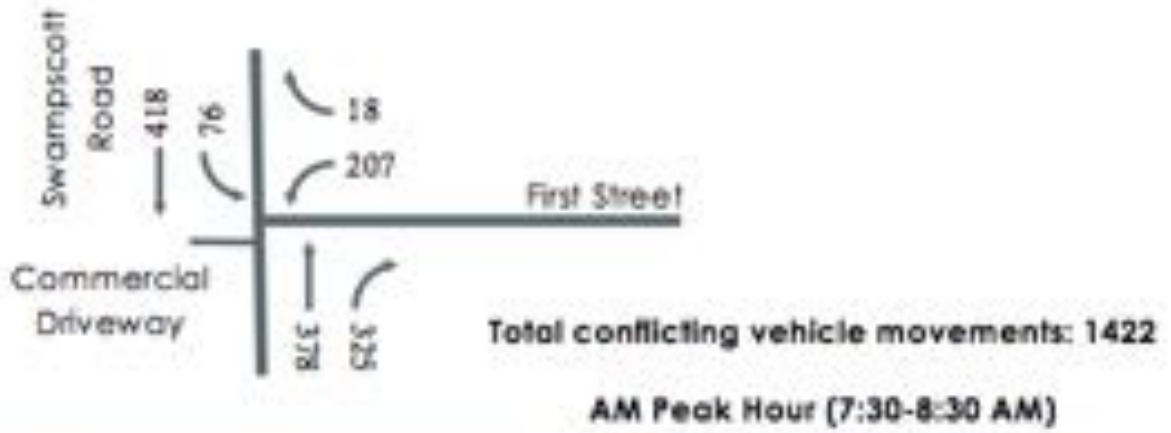
Swampscott Road carried approximately 8% trucks during the morning peak period, but low truck volumes during the PM and Saturday peak periods.

Except for the Saturday count that had intermittent rain, the weather during the counts was reasonably good. During all three of the count periods, traffic approaching from First Street was observed as significantly delayed in accessing Swampscott Road.

Over the course of the six hours of counts, the morning peak period had the best traffic operating operations. Operations during the Saturday peak hour were observed as being more congested than during the afternoon peak period.

Approximately 95% of the motorists exiting First Street turned left onto Swampscott Road, while 80% of the motorists entering First Street were oriented to or from the south on Swampscott Road.

Westbound queues on First Street exceeded 10 vehicles for extended periods during the Saturday and evening peak periods. Horns were occasionally heard from frustrated motorists. Intersection traffic, during a few minutes or so, was stopped in all directions. Access from the commercial driveway just south of the intersection was congested, especially left turns onto Swampscott Road and crossing movements to First Street.



Schematic Diagram:
Not to Scale

*Swampscott Road at First Street
Salem, Massachusetts*

Year 2016 Manual Count Summary

Based on the count observations, access to the private driveway must be addressed in whatever strategy is appropriate for the intersection.

Crash History

Crash data for the most recent 5-year period available from MassDOT's crash data portal for mapped crashes was evaluated for the First Street at Swampscott Road intersection.

During the 5-year period between 2010 and 2014, a total of 30 crashes were reported at this intersection. Of these reported crashes, 7 involved non-fatal injuries, while 22 involved property damage only, and 1 had unidentified severity. Applying MassDOT's crash rate analysis to the 2010-2014 reported crashes only (MassDOT cautions that mapped crashes on average are 20% lower than actual reported crashes), we find that the intersection is a higher than average crash location with a mapped 5-year crash rate of **0.89 crashes per million entering vehicles**. This intersection exceeds the average MassDOT statewide and District 4 crash rates (0.60 and 0.58, respectively) by approximately 50%. Refer to the Technical Appendix for additional crash details and the crash rate sheet.

Future Traffic Projections

MassDOT recently submitted a draft planning study report on the Highland Avenue (Route 107) corridor within the Cities of Lynn and Salem. Pertaining to the segment of Highland Avenue between Swampscott Road and Traders Way/Marlborough Road, the study estimated that AM, PM, and Saturday peak hour traffic growth by the year 2035 will range from 3-9% over 2015 baseline volumes.

To be conservative with analysis of the Swampscott Road at First Street intersection, we compared results assuming existing (2016) conditions, future plus 9% traffic growth (approximately 2035 MassDOT projection), and the future *reserve capacity* of options at assuming 35% traffic growth, to determine which optional approach would provide the best long term operating conditions.

Table 1 - 2010-2014 Swampscott Road at First Street Crash History Summary

<u>Year</u>	<u>Reported Mapped Crashes¹</u>	<u>Fatal Non-injury Crashes</u>	<u>Property Damage Only Crashes</u>	<u>Not Reported Crash Types</u>
2010	6	3	3	0
2011	5	0	4	1
2012	7	2	5	0
2013	5	0	5	0
2014	<u>9</u>	<u>2</u>	<u>7</u>	<u>0</u>
Totals	30	7	22	1
Average Crashes Per Year	6	Significant Crash Rate?²		
Average Crash Rate	0.89	Yes		

¹ **Reported Mapped Crashes** (note: MassDOT has mapped crashes over a 12-year period. The latest 5 years of data are reported above. MassDOT indicates approximately 80% of all reported crashes statewide can be mapped.)

² **Significant Crash Rate** means that the **0.89 average crash rate** exceeds the statewide *and* MassDOT District 4 number of crashes per million entering vehicles, **0.60** and **0.58**, respectively.

Options Evaluated

In addition to the “Do-Nothing”, three potential improvement options were developed for analysis.

- 0) “Do-Nothing” Option 0 retains the intersection as currently configured with stop-sign control on First Street and Swampscott Road uncontrolled, as it is today.
- 1) “Revise T Intersection” Option 1 re-orientes the T intersection in a manner that fosters the major traffic movements between Swampscott Road to the south and First Street, rather than the north/south Swampscott Road movements.³
- 2) “Mini-roundabout” Option 2 involves creation of a three-legged unsignalized mini-roundabout. As envisioned, it would include three raised splitter islands on all three approaches and be designed to accommodate approach speeds of 20 miles per hour. The center island would be mountable to accommodate the large trucks observed on Swampscott Road. This would create a permanent slow point on Swampscott Road. ADA/MAAB compliant crosswalks and sidewalks would be provided on all approaches.
- 3) “Signalize” Option 3 retains the same orientation as currently, but signalizes the intersection, providing designated shared through/left lanes and a right turn lane on all three approaches as well as a separate exclusive pedestrian phase. With signalization, two options are possible for the commercial driveway on the west side of Swampscott Road. For analysis purposes, we have assumed the site driveway will continue to operate unsignalized. Alternatively, it could be signalized and/or relocated to the intersection to allow traffic to exit the site more safely without blockage from northbound traffic queues.

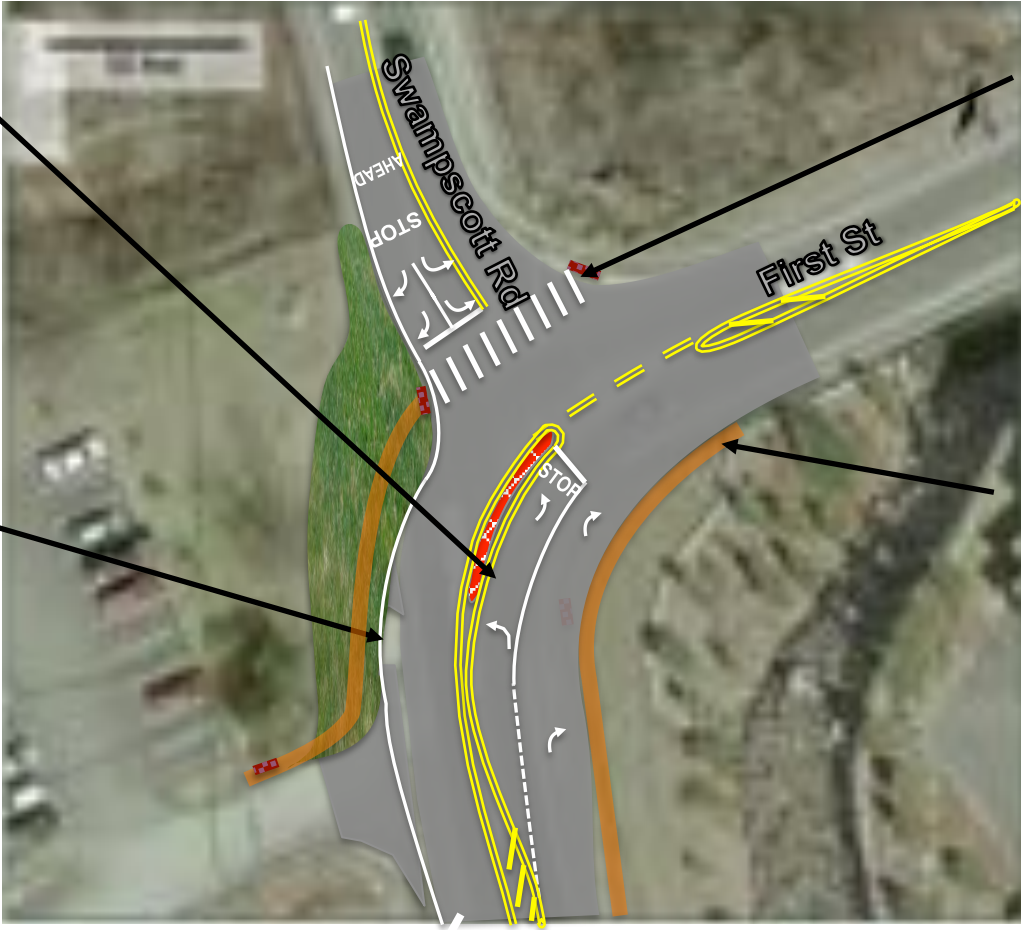
Options 1-3 are illustrated on Figures 3-5.

³ Signalizing and re-orienting this intersection was an option considered in the MassDOT Highland Avenue Corridor Study. For this study, we evaluated a slightly different re-orientation without signalization. Signalization of this option is possible, but we did not consider the reorientation to be consistent with the continuity of Swampscott Road as a functionally classified Urban Collector.

All markings/signs must be compliant with latest adopted MUTCD.

Add raised or semi-mountable channelizing island. Provide up to 135' long left NB lane and add left turn yield to on-coming traffic

Install ADA compliant crosswalks and sign to allow *bikes to share sidewalk*, as they do today. Very low pedestrian and bike activity observed. Bikes must yield to pedestrians on the narrow sidewalks.



Relocate utility pole behind sidewalk & remove cross walk

Retain Truck Exclusion on First Street



Schematic Diagram:
Not to Scale

Swampscott Road at First Street
Salem, Massachusetts

Option 1 – Revise T Intersection

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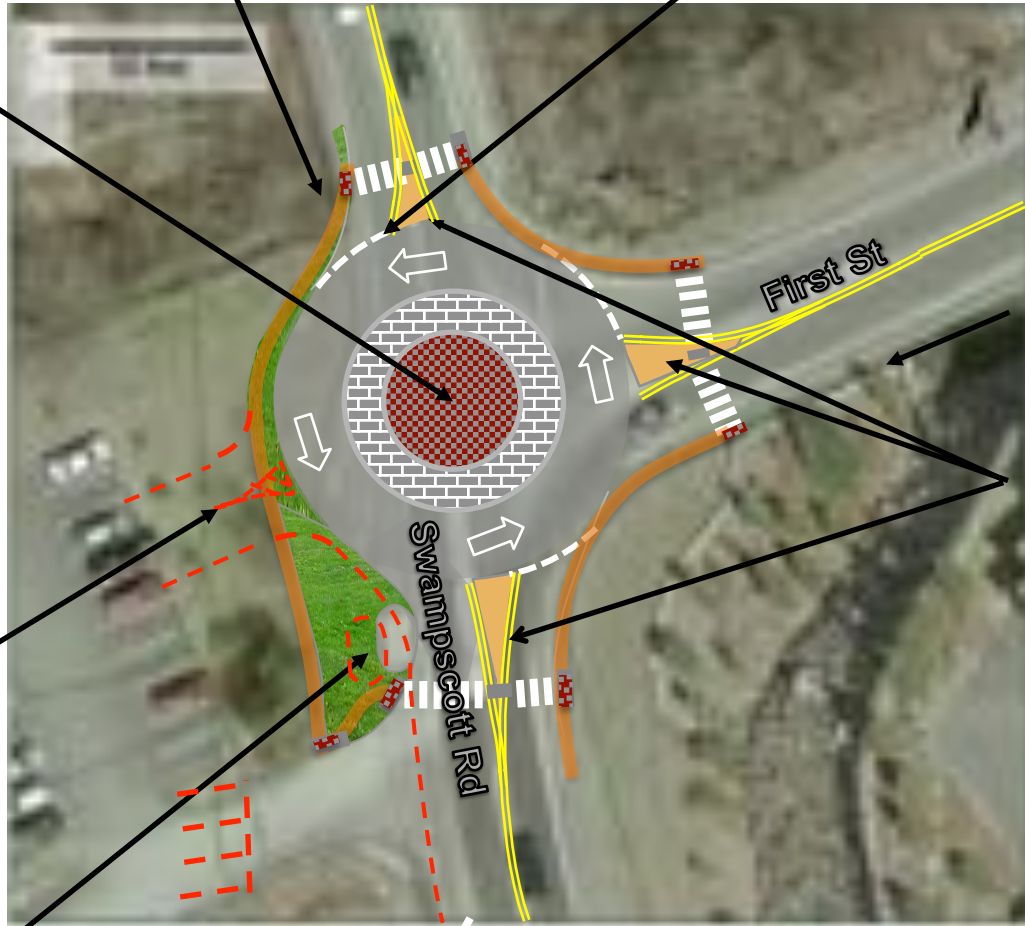
Figure 3

Mountable center island design for truck movements. Employ two colors for center island. Truck Apron and 25-foot diameter mountable center island (NO TRUCK U-TURNS PERMITTED) with ADA sidewalks and crosswalks

Optional crosswalk if there is a demand; requires new short sidewalk

All approaches have yield lines and yield signs

Design in accordance with FHWA mini-roundabout guidelines. All roundabout markings/signs must be compliant with latest adopted MUTCD



Retain Truck Exclusion on First Street

All splitter islands mountable and slightly raised

Design option - to provide direct roundabout access, retain or relocate main driveway & retain total parking.

Design option - retain or relocate bollard-protected utility pole approximately 10 feet to improve geometry



Schematic Diagram:
Not to Scale

Swampscott Road at First Street
Salem, Massachusetts

Option 2 – Mini-roundabout

All markings/signs must be compliant with latest adopted MUTCD.

Signalize with four actuated phases, and modify T to provide relatively short 50-60 foot long turn lanes except NB right lane that should be about 150 feet long to avoid blockage + a taper

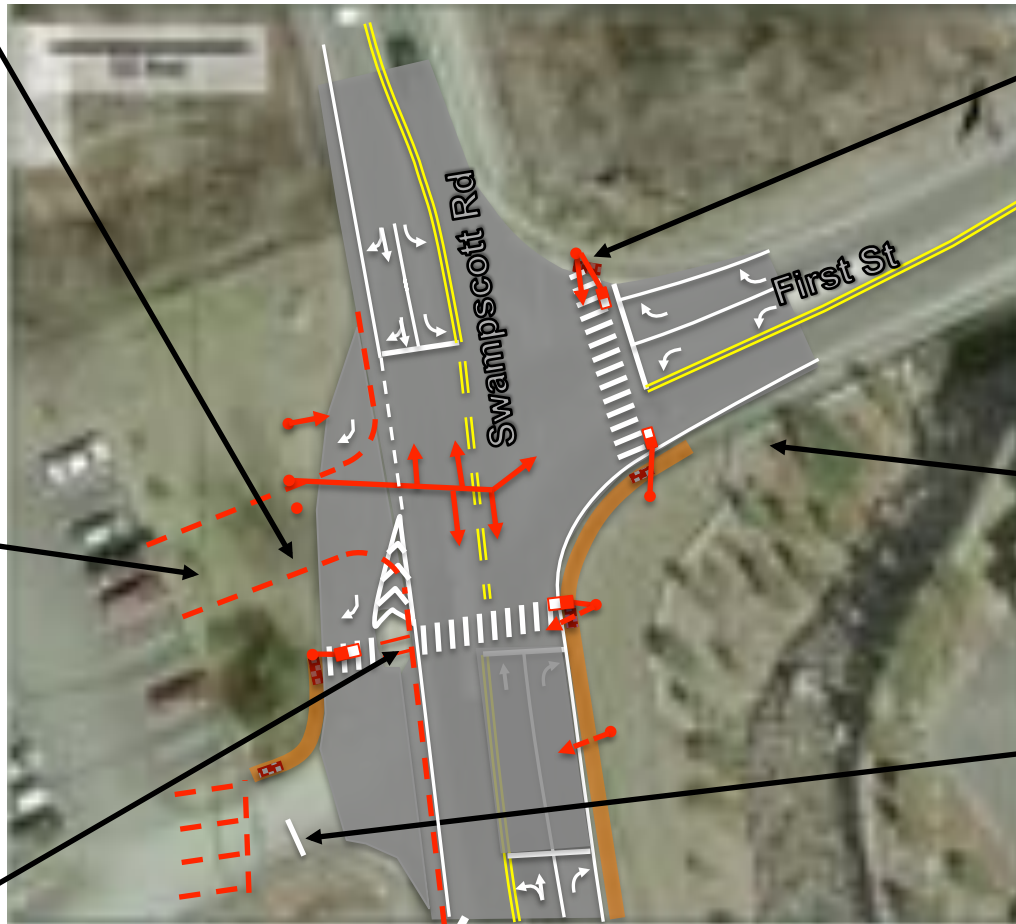
Install ADA compliant crosswalks and sign to allow *bikes to share sidewalk*, as they do today. Very low pedestrian and bike activity observed. Bikes must yield to pedestrians on the narrow sidewalks.

Design option – retain and signalize existing driveway or relocate and signalize retaining total parking supply

Retain Truck Exclusion on First Street

Retain bollards protected utility pole & access driveway & provide crosswalk median break at least 36" wide.

Three design options - leave unsignalized, signalize in place or relocate/ signalize driveway & 3 spaces



Schematic Diagram:
Not to Scale

Swampscott Road at First Street
Salem, Massachusetts

Option 3 – Signalize

Stantec Consulting Services Inc.



Figure 5

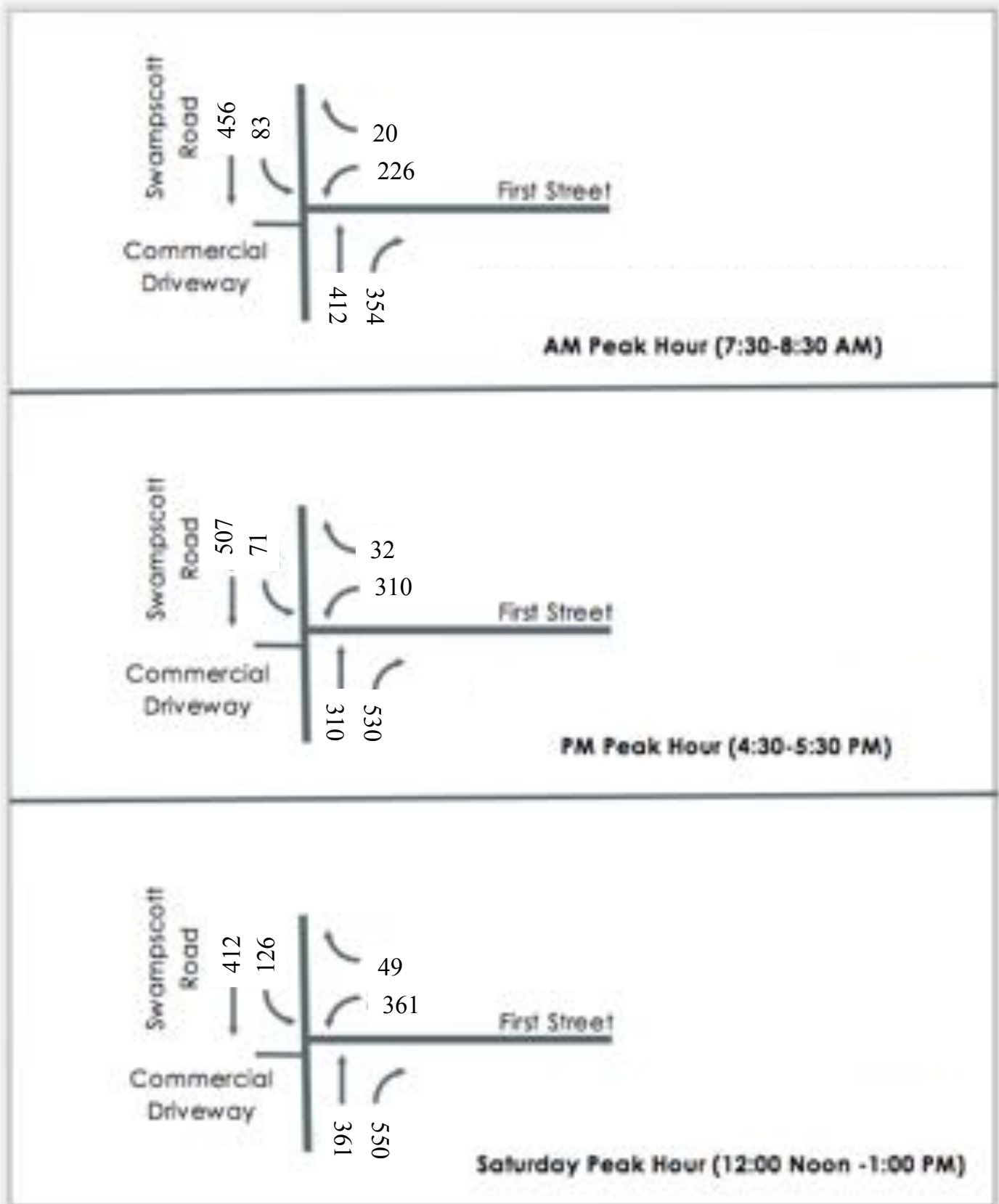
Traffic Analysis/Potential for Future Crashes for Options Considered

Figure 6 illustrates projected turning movement volumes for the AM, PM, and Saturday mid-day peak hours by applying a 9% growth factor, similar to the maximum peak hour growth illustrated in the DRAFT MassDOT Route 107 Lynn Salem Corridor Study. Unsignalized traffic operations were performed in accordance with the 2010 Highway Capacity Manual consistent with MassDOT Traffic Analysis Guidelines. For the signal option, analysis was performed using the HCM 2000 methodology due to analysis issues with the HCM 2010 signal module. The GDOT roundabout analysis tool, accepted by MassDOT for preliminary evaluation, was also used. Traffic operations analysis results are summarized on Table 2.

From Table 2, the best overall traffic operating conditions are expected from Options 2 (Mini-roundabout) and 3 (Signal). Because Options 0 (Do-Nothing) and 1 (Revise T Intersection) *have poor operating conditions with existing traffic volumes and potential crash related issues*. They are both considered to be unacceptable to be carried forward.

From a traffic back up or queuing perspective, Option 2, overall, would perform better than Option 3 particularly on the westbound approach from First Street. Levels of service on the intersection approaches with the roundabout would typically be from LOS A-C, while they would be LOS A and B with traffic signal control. During the AM and PM peak hours, the roundabout would generally operate with less delays, while during the Saturday peak hour, the signal control would produce less overall delay.

The Federal Highway Administration recognizes roundabouts as one of their top ten high priority crash reduction measures. We anticipate in this case that the roundabout option would have future crash benefits superior to those traffic signal control which tends to increase the frequency of rear-end collisions while reducing angle type collisions. Based on the crash history of the Swampscott Road/First Street intersection, a signal would likely provide some safety benefits compared to existing conditions, but the roundabout option is expected to be superior from a crash reduction perspective.



* Volumes assume maximum 9% traffic growth from DRAFT MassDOT Route 107 Lynn Salem Corridor Study



Schematic Diagram:
Not to Scale

Swampscott Road at First Street
Salem, Massachusetts

Year 2035 Peak Hour Traffic Projections*

Stantec Consulting Services Inc.



Figure 6

Table 2 - Swampscott Road at First Street Traffic Operations Comparisons

7:30-8:30 AM Peak Hour																								
Intersection	2016 Existing 7:30-8:30 AM				Option 1 - 2016 Re-oriented "T" with SB/NB left stops 7:30-8:30 AM				Option 2 - 2016 Mini-roundabout 7:30-8:30 AM				Option 3 - 2016 Signal with Ped Phase 7:30-8:30 AM				Option 2 Roundabout - 2035 MassDOT Highland Ave Projected 9% Traffic Growth 7:30-8:30 AM				Option 3 Signal - 2035 MassDOT Highland Ave Projected 9% Traffic Growth 7:30-8:30 AM			
	LOS	V/C	Q	Del	LOS	V/C	Q	Del	LOS	V/C	Q	Del	LOS	V/C	Q	Del	LOS	V/C	Q	Del	LOS	V/C	Q	Del
Swampscott Road at First Street	E	0.88	NA	57	A	0.43	NA	13	NA	NA	NA	NA	B	0.63	NA	12	NA	NA	NA	NA	B	0.64	NA	13
First Street WB	F	1.58	455	300+	NA	NA	0	0	A	0.34	40	8	B	0.56	160	16	A	0.38	45	13	B	0.63	175	18
Swampscott Road NB	NA	NA	0	0	A	0.29	30	9	B	0.63	120	11	B	0.65	245	10	B	0.69	155	24	B	0.69	295	11
Swampscott Road SB	A	0.10	8	2	D/F	0.79	110	32	B	0.54	85	10	B	0.61	270	12	B	0.60	105	21	B	0.65	305	12
4:30-5:30 PM Peak Hour																								
Intersection	2016 Existing 4:30-5:30 PM				Option 1 - 2016 Re-oriented "T" with SB/NB left stops 4:30-5:30 PM				Option 2 - 2016 Mini-roundabout 4:30-5:30 PM				Option 3 - 2016 Signal 4:30-5:30 PM				Option 2 Roundabout - 2035 MassDOT Highland Ave Projected 9% Traffic Growth 4:30-5:30 PM				Option 3 Signal - 2035 MassDOT Highland Ave Projected 9% Traffic Growth 4:30-5:30 PM			
	LOS	V/C	Q	Del	LOS	V/C	Q	Del	LOS	V/C	Q	Del	LOS	V/C	Q	Del	LOS	V/C	Q	Del	LOS	V/C	Q	Del
Swampscott Road at First Street	F	1.00	NA	53	A	0.54	NA	11	NA	NA	NA	NA	B	0.67	NA	12	NA	NA	NA	NA	B	0.69	NA	13
First Street WB	F	1.82	430	170	NA	NA	0	0	A	0.39	50	8	B	0.64	265	17	A	0.43	55	12	B	0.70	300	17
Swampscott Road NB	N/C	N/C	0	0	A	0.25	25	9	B	0.65	130	11	A	0.57	220	9	B	0.71	165	13	A	0.61	250	9
Swampscott Road SB	A	0.05	5	1	D/F	0.72	85	31	B	0.59	100	12	B	0.63	220	13	B	0.66	130	15	B	0.69	365	13
12:00 Noon to 1 PM Saturday Peak Hour																								
Intersection	2016 Existing 12:00 Noon-1:00 PM				Option 1 - 2016 Re-oriented "T" with SB/NB left stops 12:00 Noon -1:00 PM				Option 2 - 2016 Mini-roundabout 12:00 Noon-1:00 PM				Option 3 - 2016 Signal 12:00 Noon -1:00 PM				Option 2 Roundabout - 2035 MassDOT Highland Ave Projected 9% Traffic Growth 12:00 Noon-1:00 PM				Option 3 Signal - 2035 MassDOT Highland Ave Projected 9% Traffic Growth 12:00 Noon -1:00 PM			
	LOS	V/C	Q	Del	LOS	V/C	Q	Del	LOS	V/C	Q	Del	LOS	V/C	Q	Del	LOS	V/C	Q	Del	LOS	V/C	Q	Del
Swampscott Road at First Street	F	1.02	NA	121	D	0.52	NA	29	NA	NA	NA	NA	B	0.54	NA	8	NA	NA	NA	NA	B	0.58	NA	9
First Street WB	F	2.28	703	300+	NA	NA	0	0	A	0.41	50	8	B	0.59	150	13	A	0.46	60	10	B	0.65	165	15
Swampscott Road NB	NA	NA	0	0	A	0.29	30	9	C	0.76	195	15	A	0.58	145	7	C	0.83	265	20	A	0.63	160	8
Swampscott Road SB	B	0.16	15	3	C/F	1.47	240	96	B	0.54	85	11	A	0.44	115	7	B	0.61	110	13	A	0.47	125	8

NA - Not Available

LOS - Level of Service from A-F; A is best, F is worst. LOS from HCM 2010, except Roundabout LOS, V/C, and Delay from GDOT Roundabout Analysis Tool.

V/C - Proportion of volume to available capacity during analysis hour.

Q - 95th percentile vehicle queue measured in feet from the intersection.

Del - Average motorist delay expressed in seconds during peak 15 minute period of the peak hour.

 Movement or intersection at capacity or over-capacity (LOS E/F) conditions.

Option Evaluation Pro/Con Findings

Option 0 - "Do-Nothing"

Based on the traffic operations observations, and evaluation of crash history we *do not recommend* retaining the existing intersection controls at the Swampscott Road/First Street intersection.

Pros:

- ❖ Lowest implementation cost.

Cons:

- ❖ High crash location will continue and likely worsen as traffic volumes on First and Swampscott Road grow in the future.
- ❖ Long delays for westbound traffic approaching Swampscott Road will continue.
- ❖ Long delays will continue for motorists exiting the commercial area (Salem Fitness Center, North Shore Physical Therapy, and North Shore Self Storage/U-haul rental) opposite First Street on the west side of Swampscott Road.

Option 1 – "Unsignalized Re-oriented T Intersection"

Pros:

- ❖ Lower implementation cost than Options 2 or 3.
- ❖ Provides better level of service than existing conditions, reducing delays to westbound traffic approaching Swampscott Road.

Cons:

- ❖ Heavy left turn movement requires a stop sign, as it could create a new hazard with a limited view of on-coming traffic for northbound Swampscott Road and westbound First Street traffic.

- ❖ New delays will be created for traffic heading northbound and southbound on Swampscott Road. The queuing associated with the new northbound left turn lane will regularly block driveway access to the commercial area (Salem Fitness Center, North Shore Physical Therapy, and North Shore Self Storage/U-haul rental).
- ❖ Long delays will continue for motorists exiting the commercial area.
- ❖ Its design is inconsistent with the existing functional classification of First Street as a Local Road and Swampscott Road as an Urban Collector Street, as it makes Swampscott Road discontinuous.
- ❖ The realignment of First Street to Swampscott Road would likely send more traffic down First Street, which already absorbs the majority of traffic to and from Swampscott Road to the south.
- ❖ Requires costly relocation of a utility pole.
- ❖ May induce more traffic on First Street than the existing configuration, which was opposed by neighbors during a September 2016 meeting to discuss findings of the Route 107 Lynn Salem Corridor Study.
- ❖ Pedestrian crossing of northbound Swampscott Road approaching First Street is lost.

Option 2 “Mini-roundabout”

Creation of a mini-roundabout *would be an acceptable option for this intersection*, as it will allow traffic to traverse the intersection with overall lower delays than with existing conditions in an orderly manner without installation of traffic signal control equipment.

Pros:

- ❖ AM, PM and Saturday relatively good peak hour traffic operations, comparable to signalization, will improve compared to existing conditions for traffic approaching on First Street.
- ❖ Balanced conflicting volumes at the intersection are conducive to the creation of a mini-roundabout to accommodate existing and future traffic flows in an orderly manner, particularly during peak hours.
- ❖ Should reduce the potential for crashes, particularly those involving personal injuries, as traffic would be slow but generally moving.

- ❖ Queues created will be shorter and will dissipate far quicker than under existing conditions and compared to Option 3 signalization.
- ❖ Motorists exiting the commercial area (Salem Fitness Center, North Shore Physical Therapy, and North Shore Self Storage/U-haul rental) will be able to exit at the roundabout better than under existing conditions, even if the driveway is retained in its existing location. The concept assumes removal of the exclusive right turn inbound lane but leaving the driveway in its existing layout. Alternatively, the driveway could be relocated northerly directly intersecting the roundabout. This would involve a higher cost, but would, with a minor reconfiguration, retain the existing parking supply, while improving access to and from the commercial driveway.
- ❖ Pedestrian crossings would be available on all the intersection legs and would be easier than today.
- ❖ Implementation and long-term maintenance costs should be lower than Option 3 – Signalize with Pedestrian Phases, as the continuing maintenance costs involve signal equipment with power and equipment replacement costs.

Cons:

- ❖ Traffic delays on the two Swampscott Road approaches will increase compared to Options 0 and 1 that would have one or two uncontrolled Swampscott Road approaches.
- ❖ Truck traffic would be adversely affected on Swampscott Road – a designated truck route. Trucks approaching at all times would at minimum need to slow down to yield to vehicles and pedestrians traversing the mini-roundabout. This may increase noise from acceleration/deceleration of trucks.
- ❖ The exclusive right turn lane southbound on Swampscott Road accessing the commercial area would be eliminated.
- ❖ Traffic changes will require a “learning curve”, as mini-roundabouts are not common in the City of Salem.
- ❖ The safety of the roundabout would benefit from the costly relocation of a bollard-protected utility pole and the commercial driveway to improve

the geometry of the roundabout exit for trucks using Swampscott Road and the limited number of buses and service trucks on First Street.

- ❖ Traversing a 15-20 miles per hour mini-roundabout will require advance warning for motorists used to flying through this intersection at a 35-40 miles per hour speed.
- ❖ Implementation costs are higher than with Options 0 and 1.

Option 3 "Signal"

Signalizing with a pedestrian phase *would be acceptable option for this intersection*, as it will allow traffic to traverse the intersection in an orderly manner, with lower overall delays lower than found under existing conditions.

Pros:

- ❖ AM, PM and Saturday peak hour traffic operations will improve compared to existing conditions for traffic approaching on First Street.
- ❖ Providing right turn lanes on all approaches will be beneficial for capacity reasons.
- ❖ Should reduce the potential for angle/conflict-related crashes.
- ❖ Queues created will dissipate far quicker than under existing conditions.
- ❖ Motorists exiting the commercial area (Salem Fitness Center, North Shore Physical Therapy, and North Shore Self Storage/U-haul rental) will be able to exit more safely than under existing conditions. The concept assumes retention of the exclusive right turn inbound lane to the commercial driveway. This would involve a higher cost and would affect parking, although a slight reconfiguration would retain the existing parking supply.
- ❖ Implementation does not require the costly relocation of a bollard-protected utility pole.
- ❖ Pedestrian crossings would be easier and less hazardous than today.

Cons:

- ❖ While improving the overall level of service, traffic delays on the Swampscott Road approaches will increase compared to the Options 0, 1 and 2.

- ❖ Truck traffic on Swampscott Road – a designated truck route -- is significant and will often need to slow down and stop. This may increase noise from acceleration/deceleration of trucks.
- ❖ Queuing on Swampscott Road, which does not occur that often today, will be more common due to signalization.
- ❖ Rear end crashes could generally increase at the intersection following signalization.
- ❖ Implementation and long-term maintenance costs are higher than those associated with the “Mini-roundabout” Option.
- ❖ There are three options for the commercial driveway. All have some drawbacks. Keeping the driveway where it is and not signalizing it could increase some of its delays during peak hours, though off-peak hours should be minimally affected. Without signal control, traffic on the commercial driveway will have better/safer access to all directions. Leaving it where it exists would add an extra signal phase to the intersection and would increase the clearance intervals for the signal phases. Relocating the driveway to the intersection would be more efficient from a traffic operations perspective, but requires work on private property for temporary easements and construction and may not be desired by the property owner.

Recommendations

Both Option 2- Mini-roundabout and Option 3 – Signal should produce modest safety benefits. Roundabouts have been found to reduce the most severe crashes and queuing compared to signalization. Short and long term costs of Option 3 will be higher than those associated with Option 2.

Implementation of *either* Options 2 or 3 should provide acceptable traffic operations during the foreseeable future compared to Options 0 or 1. However, Options 0 or 1 are not recommended, as both options have significant drawbacks and do not address the access issue of the commercial driveway located a short distance from the intersection.

We recommend the City of Salem and neighbors discuss and compare the pros and cons of Options 2 and 3, either of which represents an improvement over existing conditions. Should the City select Option 3, we recommend retaining the continuity of Swampscott Road, as illustrated, while integrating access to the Swampscott Road commercial businesses into the solution.

Upon selecting a Preferred Alternative, the City should pursue funding of the choice that best fits into the long-term goals for the City and the nearby neighborhood residents and businesses.

Intersection: Swampscott Road at First Street

Date: 9/22/16 Weather: Sunny/warm

Counted by: GLH

Interval	Southbound		Westbound		Northbound			
	Left	Through	Left	Right	Through	Right		
4:00 -4:15 PM	16	82	87	9	53	112	359	
4:15-4:30 PM	11	114	81	3	76	118	403	
4:30-4:45 PM	12	114	90	7	77	122	422	
4:45-5:00 PM	16	112	78	7	62	121	396	1580
5:00-5:15 PM	20	118	79	8	77	109	411	1632
5:15-5:30 PM	17	121	80	7	68	134	427	1656
5:30-5:45 PM	21	101	78	8	58	121	387	1621
5:45-6:00 PM	14	118	76	4	59	107	378	1603
Two-hour total	127	880	649	53	530	944	3183	
Peak Hour								
4:30-5:30 PM	65	465	327	29	284	486	1656	
Peak Hour Factor		0.96		0.92		0.95		

17355.5556

Say 17,400 vpd - Swampscott Rd. S of First St.

10077.7778

Say 10,100 vpd - First St E of Swampscott Rd.

9366.66667

Say 9,400 vpd - Swampscott Rd, N of First St

	Southbound		Westbound		Northbound	
	Left	thru/right	Left/thru	right	thru	right
Peak Hour Trucks	1	5	2	0	8	3
Peak Hour Total	65	465	327	29	284	486
Truck %	2%	1%	1%	0%	3%	1%

Swampscott Road S to
Swampscott Rd N and First Street
2 hr. Volumes

To Swampscott	To First
1463	1720

Intersection: Swampscott Road at First Street

Date: 9/22/16 Weather: Sunny/warm

Counted by: GLH

Interval	Southbound		Westbound		Northbound			
	Left	Through	Left	Right	Through	Right		
4:00 -4:15 PM	16	82	87	9	53	112	359	
4:15-4:30 PM	11	114	81	3	76	118	403	
4:30-4:45 PM	12	114	90	7	77	122	422	
4:45-5:00 PM	16	112	78	7	62	121	396	1580
5:00-5:15 PM	20	118	79	8	77	109	411	1632
5:15-5:30 PM	17	121	80	7	68	134	427	1656
5:30-5:45 PM	21	101	78	8	58	121	387	1621
5:45-6:00 PM	14	118	76	4	59	107	378	1603
Two-hour total	127	880	649	53	530	944	3183	
Peak Hour								
4:30-5:30 PM	65	465	327	29	284	486	1656	
Peak Hour Factor		0.96		0.92		0.95		

17355.5556

Say 17,400 vpd - Swampscott Rd. S of First St.

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Say 10,100 vpd - First St E of Swampscott Rd.

9366.66667

Say 9,400 vpd - Swampscott Rd, N of First St

	Southbound		Westbound		Northbound	
	Left	thru/right	Left/thru	right	thru	right
Peak Hour Trucks	1	5	2	0	8	3
Peak Hour Total	65	465	327	29	284	486
Truck %	2%	1%	1%	0%	3%	1%

Swampscott Road S to
Swampscott Rd N and First Street
2 hr. Volumes

To Swampscott	To First
1463	1720

Intersection: Swampscott Road at First Street

Date: 9/22/16

Counted by: GLH

Interval	Southbound		Westbound		Northbound			
	Left	Through	Left	Right	Through	Right		
11:00 -11:15AM	20	93	76	8	75	114	386	
11:15-11:30 AM	49	96	77	5	80	107	414	
11:30-11:45 AM	45	95	94	9	63	89	395	
11:45-12:00 Noon	38	94	81	13	77	99	402	1597
12:00-12:15 PM	37	95	79	14	96	130	451	1662
12:15-12:30 PM	21	87	86	10	77	129	410	1658
12:30-12:45 PM	26	101	75	11	81	116	410	1673
12:45-1:00 PM	32	95	79	10	77	130	423	1694
Two-hour total	268	756	647	80	626	914	3291	
Peak Hour								
12:00 Noon - 1 PM	116	378	319	45	331	505	1694	
Peak Hour Factor	0.94		0.95		0.92			

17033.3333

Say 17,000 vpd - Swampscott Rd. S of First St.

10944.4444

Say 10,950 vpd - First St E of Swampscott Rd.

9666.66667

Say 9,650 vpd - Swampscott Rd, N of First St

	Southbound		Westbound		Northbound	
	Left	thru/right	Left/thru	right	thru	right
Peak Hour Trucks	1	2	3	0	2	3
Peak Hour Total	116	378	319	45	331	505
Truck %	1%	1%	1%	0%	1%	1%

Swampscott Road S to
Swampscott Rd N and First
Street 2 hr. Volumes

	To Swampscott	To First
11AM - 1PM	1462	1829
4-6 PM	1463	1720
7-9 AM	1450	1219
Sub-total	4375	4768
Total		9143
Percentage by Route	48%	52%

More towards First Street than Swampscott Road north

CRASH RATE WORKSHEET

CITY/TOWN : Salem, MA COUNT DATE : 9/22/16

DISTRICT : 4 UNSIGNALIZED : SIGNALIZED :

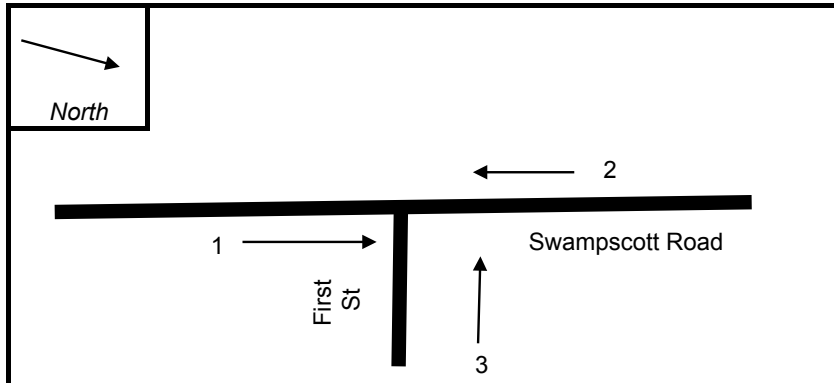
~ INTERSECTION DATA ~

MAJOR STREET : Swampscott Road at

MINOR STREET(S) : First Street

Mapable crashes from 2012-2014 five year period

**INTERSECTION
 DIAGRAM**
 (Label Approaches)



Peak Hour Volumes

APPROACH :	1	2	3	4	5	6
DIRECTION :	NB	SB	WB			
VOLUMES (AM/PM) :	770	530	356			

" K " FACTOR : APPROACH ADT : ADT = TOTAL VOL/"K" FACT.

TOTAL # OF ACCIDENTS : # OF YEARS : AVERAGE # OF ACCIDENTS (A) :

CRASH RATE CALCULATION : RATE = $\frac{(A * 1,000,000)}{(ADT * 365)}$











Comments : Higher than the District 4 average unsignalized intersection crash rate of 0.56 and the statewide unsignalized intersection crash rate of 0.62. Therefore is a high crash location.

Crash Number	Crash Date	Crash Time	City/Town	Crash Severity	Roadway	Near Intersection Roadway	Landmark	Police Agency
2586834	3/22/10	12:00 PM	SALEM	Non-fatal injury	SWAMPSCOTT ROAD / FIRST STREET			Local police
2758441	10/21/10	3:15 PM	SALEM	Non-fatal injury	SWAMPSCOTT ROAD / FIRST STREET			
2660645	10/28/10	8:00 AM	SALEM	Non-fatal injury	SWAMPSCOTT ROAD / FIRST STREET			Local police
3224247	6/6/12	3:29 PM	SALEM	Non-fatal injury	SWAMPSCOTT ROAD			Local police
3357039	12/16/12	2:45 PM	SALEM	Non-fatal injury	SWAMPSCOTT ROAD / FIRST STREET			Local police
3803922	4/8/14	9:30 AM	SALEM	Non-fatal injury	SWAMPSCOTT ROAD / FIRST STREET			Local police
3965623	9/20/14	7:46 PM	SALEM	Non-fatal injury	SWAMPSCOTT RD / FIRST ST			Local police
2957034	11/20/11	1:51 PM	SALEM	Not Reported	SWAMPSCOTT ROAD	FIRST STREET		Local police
2615848	6/1/10	12:27 PM	SALEM	Property damage only (none injured)	SWAMPSCOTT ROAD / FIRST STREET			Local police
2639412	8/24/10	4:24 PM	SALEM	Property damage only (none injured)	SWAMPSCOTT ROAD			Local police
2691176	1/18/11	11:10 AM	SALEM	Property damage only (none injured)	SWAMPSCOTT ROAD	FIRST STREET		Local police
2714282	2/5/11	4:49 PM	SALEM	Property damage only (none injured)	SWAMPSCOTT ROAD / FIRST STREET			Local police
2737877	6/1/11	9:30 AM	SALEM	Property damage only (none injured)	SWAMPSCOTT ROAD / FIRST STREET			Local police
2957030	11/25/11	1:12 PM	SALEM	Property damage only (none injured)	SWAMPSCOTT ROAD / FIRST STREET			Local police
3089930	3/1/12	6:06 PM	SALEM	Property damage only (none injured)	SWAMPSCOTT ROAD / FIRST STREET			Local police
3246574	5/10/12	11:26 AM	SALEM	Property damage only (none injured)	SWAMPSCOTT ROAD			Local police
3289674	9/14/12	9:20 AM	SALEM	Property damage only (none injured)	SWAMPSCOTT ROAD	FIRST STREET		Local police
3293444	10/3/12	3:03 PM	SALEM	Property damage only (none injured)	FIRST STREET	SWAMPSCOTT ROAD		Local police
3346741	12/2/12	11:41 PM	SALEM	Property damage only (none injured)	SWAMPSCOTT ROAD			Local police
3459431	4/15/13	1:20 PM	SALEM	Property damage only (none injured)	SWAMPSCOTT ROAD / FIRST STREET			Local police
3450565	4/22/13	4:13 PM	SALEM	Property damage only (none injured)	FIRST STREET / SWAMPSCOTT ROAD			Local police
3489431	6/11/13	10:10 AM	SALEM	Property damage only (none injured)	SWAMPSCOTT ROAD / FIRST STREET			Local police
3603294	8/30/13	12:00 AM	SALEM	Property damage only (none injured)	SWAMPSCOTT RD			Local police
3660379	11/12/13	7:28 AM	SALEM	Property damage only (none injured)	SWAMPSCOTT ROAD / FIRST STREET			Local police
3743303	2/7/14	10:55 AM	SALEM	Property damage only (none injured)	SWAMPSCOTT RD / FIRST STREET			Local police
3803501	2/15/14	4:20 PM	SALEM	Property damage only (none injured)	FIRST STREET / SWAMPSCOTT ROAD			Local police
3803633	5/8/14	7:43 PM	SALEM	Property damage only (none injured)	SWAMPSCOTT RD / FIRST ST			Local police
3865261	6/13/14	11:27 AM	SALEM	Property damage only (none injured)	SWAMPSCOTT ROAD / FIRST STREET			Local police
3943787	8/26/14	3:59 PM	SALEM	Property damage only (none injured)	FIRST ST / SWAMPSCOTT RD			Local police
3965734	9/26/14	3:49 PM	SALEM	Property damage only (none injured)	FIRST STREET	SWAMPSCOTT ROAD		Local police
This data was manually selected from the map.								

HCM Unsignalized Intersection Capacity Analysis

1: Swampcott Road & First Street

Baseline

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (veh/h)	207	18	325	378	76	418
Future Volume (Veh/h)	207	18	325	378	76	418
Sign Control	Stop		Free			Free
Grade	0%		0%			0%
Peak Hour Factor	0.76	0.76	0.90	0.90	0.89	0.89
Hourly flow rate (vph)	272	24	361	420	85	470
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)		4				
Median type			None			None
Median storage (veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume	1211	571			781	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1211	571			781	
tC, single (s)	6.4	6.2			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	0	95			90	
cM capacity (veh/h)	179	524			841	
Direction, Lane #	WB 1	NB 1	SB 1			
Volume Total	296	781	555			
Volume Left	272	0	85			
Volume Right	24	420	0			
cSH	190	1700	841			
Volume to Capacity	1.55	0.46	0.10			
Queue Length 95th (ft)	476	0	8			
Control Delay (s)	318.4	0.0	2.6			
Lane LOS	F		A			
Approach Delay (s)	318.4	0.0	2.6			
Approach LOS	F					
Intersection Summary						
Average Delay			58.7			
Intersection Capacity Utilization			87.9%	ICU Level of Service		E
Analysis Period (min)			15			

HCM 2010 TWSC
1: Swampcott Road & First Street

Baseline

Intersection

Int Delay, s/veh 56.8

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Traffic Vol, veh/h	207	18	325	378	76	418
Future Vol, veh/h	207	18	325	378	76	418
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	-	None	-	None	-	None
Storage Length	0	100	-	-	0	-
Veh in Median Storage, #	0	-	0	-	-	0
Grade, %	0	-	0	-	-	0
Peak Hour Factor	76	76	90	90	89	89
Heavy Vehicles, %	4	0	8	2	1	8
Mvmt Flow	272	24	361	420	85	470

Major/Minor	Minor1	Major1	Major2
Conflicting Flow All	1211	571	0 0 781 0
Stage 1	571	-	- - - -
Stage 2	640	-	- - - -
Critical Hdwy	6.44	6.2	- - 4.11 -
Critical Hdwy Stg 1	5.44	-	- - - -
Critical Hdwy Stg 2	5.44	-	- - - -
Follow-up Hdwy	3.536	3.3	- - 2.209 -
Pot Cap-1 Maneuver	~ 199	524	- - 841 -
Stage 1	561	-	- - - -
Stage 2	521	-	- - - -
Platoon blocked, %			- - - -
Mov Cap-1 Maneuver	~ 172	524	- - 841 -
Mov Cap-2 Maneuver	~ 172	-	- - - -
Stage 1	561	-	- - - -
Stage 2	450	-	- - - -

Approach	WB	NB	SB
HCM Control Delay, s	\$ 310.6	0	1.5
HCM LOS	F		

Minor Lane/Major Mvmt	NBT	NBR	WBLn1	WBLn2	SBL	SBT
Capacity (veh/h)	-	-	172	524	841	-
HCM Lane V/C Ratio	-	-	1.584	0.045	0.102	-
HCM Control Delay (s)	-	-	\$ 336.5	12.2	9.8	0
HCM Lane LOS	-	-	F	B	A	A
HCM 95th %tile Q(veh)	-	-	18.2	0.1	0.3	-











Notes

~: Volume exceeds capacity \$: Delay exceeds 300s +: Computation Not Defined *: All major volume in platoon

HCM Unsignalized Intersection Capacity Analysis

1: Swampcott Road & First Street

Baseline

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (veh/h)	327	29	284	486	65	465
Future Volume (Veh/h)	327	29	284	486	65	465
Sign Control	Stop		Free			Free
Grade	0%		0%			0%
Peak Hour Factor	0.92	0.92	0.95	0.95	0.96	0.96
Hourly flow rate (vph)	355	32	299	512	68	484
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)		4				
Median type			None			None
Median storage (veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume	1175	555			299	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1175	555			299	
tC, single (s)	6.4	6.2			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	0	94			95	
cM capacity (veh/h)	201	535			1262	
Direction, Lane #						
	WB 1	NB 1	SB 1			
Volume Total	387	811	552			
Volume Left	355	0	68			
Volume Right	32	512	0			
cSH	213	1700	1262			
Volume to Capacity	1.82	0.48	0.05			
Queue Length 95th (ft)	678	0	4			
Control Delay (s)	424.4	0.0	1.5			
Lane LOS	F		A			
Approach Delay (s)	424.4	0.0	1.5			
Approach LOS	F					
Intersection Summary						
Average Delay			94.3			
Intersection Capacity Utilization			100.9%	ICU Level of Service		G
Analysis Period (min)			15			

HCM 2010 TWSC
1: Swampcott Road & First Street

Baseline

Intersection

Int Delay, s/veh 53.4

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Traffic Vol, veh/h	327	29	284	486	65	465
Future Vol, veh/h	327	29	284	486	65	465
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	-	None	-	Free	-	None
Storage Length	0	100	-	-	0	-
Veh in Median Storage, #	0	-	0	-	-	0
Grade, %	0	-	0	-	-	0
Peak Hour Factor	92	92	95	95	96	96
Heavy Vehicles, %	1	0	3	1	2	1
Mvmt Flow	355	32	299	512	68	484

Major/Minor	Minor1	Major1	Major2
Conflicting Flow All	919	299	0
Stage 1	299	-	-
Stage 2	620	-	-
Critical Hdwy	6.41	6.2	4.12
Critical Hdwy Stg 1	5.41	-	-
Critical Hdwy Stg 2	5.41	-	-
Follow-up Hdwy	3.509	3.3	2.218
Pot Cap-1 Maneuver	~ 302	745	0
Stage 1	755	-	0
Stage 2	538	-	0
Platoon blocked, %			
Mov Cap-1 Maneuver	~ 280	745	1262
Mov Cap-2 Maneuver	~ 280	-	-
Stage 1	755	-	-
Stage 2	498	-	-

Approach	WB	NB	SB
HCM Control Delay, s	169.3	0	1
HCM LOS	F		

Minor Lane/Major Mvmt	NBTWBLn1	WBLn2	SBL	SBT
Capacity (veh/h)	- 280	745	1262	-
HCM Lane V/C Ratio	- 1.269	0.042	0.054	-
HCM Control Delay (s)	- 183.4	10	8	0
HCM Lane LOS	- F	B	A	A
HCM 95th %tile Q(veh)	- 17.2	0.1	0.2	-











Notes

~: Volume exceeds capacity \$: Delay exceeds 300s +: Computation Not Defined *: All major volume in platoon

HCM Unsignalized Intersection Capacity Analysis

1: Swampcott Road & First Street

Baseline

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (veh/h)	319	45	331	505	116	378
Future Volume (Veh/h)	319	45	331	505	116	378
Sign Control	Stop		Free			Free
Grade	0%		0%			0%
Peak Hour Factor	0.95	0.95	0.92	0.92	0.95	0.95
Hourly flow rate (vph)	336	47	360	549	122	398
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)		4				
Median type			None			None
Median storage (veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume	1276	634			909	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1276	634			909	
tC, single (s)	6.4	6.2			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	0	90			84	
cM capacity (veh/h)	155	482			753	
Direction, Lane #						
	WB 1	NB 1	SB 1			
Volume Total	383	909	520			
Volume Left	336	0	122			
Volume Right	47	549	0			
cSH	169	1700	753			
Volume to Capacity	2.26	0.53	0.16			
Queue Length 95th (ft)	782	0	14			
Control Delay (s)	629.4	0.0	4.2			
Lane LOS	F		A			
Approach Delay (s)	629.4	0.0	4.2			
Approach LOS	F					
Intersection Summary						
Average Delay			134.3			
Intersection Capacity Utilization			102.4%	ICU Level of Service		G
Analysis Period (min)			15			

HCM 2010 TWSC
1: Swampcott Road & First Street

Baseline

Intersection

Int Delay, s/veh 121.2

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Traffic Vol, veh/h	319	45	331	505	116	378
Future Vol, veh/h	319	45	331	505	116	378
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	-	None	-	None	-	None
Storage Length	0	100	-	-	0	-
Veh in Median Storage, #	0	-	0	-	-	0
Grade, %	0	-	0	-	-	0
Peak Hour Factor	95	95	92	92	95	95
Heavy Vehicles, %	1	0	1	1	1	1
Mvmt Flow	336	47	360	549	122	398

Major/Minor	Minor1		Major1		Major2	
Conflicting Flow All	1276	634	0	0	909	0
Stage 1	634	-	-	-	-	-
Stage 2	642	-	-	-	-	-
Critical Hdwy	6.41	6.2	-	-	4.11	-
Critical Hdwy Stg 1	5.41	-	-	-	-	-
Critical Hdwy Stg 2	5.41	-	-	-	-	-
Follow-up Hdwy	3.509	3.3	-	-	2.209	-
Pot Cap-1 Maneuver	~ 185	483	-	-	753	-
Stage 1	530	-	-	-	-	-
Stage 2	526	-	-	-	-	-
Platoon blocked, %			-	-		-
Mov Cap-1 Maneuver	~ 147	483	-	-	753	-
Mov Cap-2 Maneuver	~ 147	-	-	-	-	-
Stage 1	530	-	-	-	-	-
Stage 2	417	-	-	-	-	-

Approach	WB	NB	SB
HCM Control Delay, s	\$ 569.6	0	2.5
HCM LOS	F		

Minor Lane/Major Mvmt	NBT	NBR	WBLn1	WBLn2	SBL	SBT
Capacity (veh/h)	-	-	147	483	753	-
HCM Lane V/C Ratio	-	-	2.284	0.098	0.162	-
HCM Control Delay (s)	-	-	\$ 648.1	13.3	10.7	0
HCM Lane LOS	-	-	F	B	B	A
HCM 95th %tile Q(veh)	-	-	28.1	0.3	0.6	-

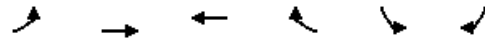
Notes

~: Volume exceeds capacity \$: Delay exceeds 300s +: Computation Not Defined *: All major volume in platoon

HCM Unsignalized Intersection Capacity Analysis

1: Swampcott Road & First Street

Baseline



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations	↵	↑	↑	↵	↵	↵
Traffic Volume (veh/h)	325	378	207	18	76	418
Future Volume (Veh/h)	325	378	207	18	76	418
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.90	0.90	0.76	0.76	0.89	0.89
Hourly flow rate (vph)	361	420	272	24	85	470
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						4
Median type		None	None			
Median storage (veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume	296				1414	272
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	296				1414	272
tC, single (s)	4.2				6.4	6.3
tC, 2 stage (s)						
tF (s)	2.3				3.5	3.4
p0 queue free %	71				21	38
cM capacity (veh/h)	1232				108	752
Direction, Lane #	EB 1	EB 2	WB 1	WB 2	SB 1	
Volume Total	361	420	272	24	555	
Volume Left	361	0	0	0	85	
Volume Right	0	0	0	24	470	
cSH	1232	1700	1700	1700	704	
Volume to Capacity	0.29	0.25	0.16	0.01	0.79	
Queue Length 95th (ft)	31	0	0	0	197	
Control Delay (s)	9.1	0.0	0.0	0.0	31.5	
Lane LOS	A				D	
Approach Delay (s)	4.2		0.0		31.5	
Approach LOS					D	
Intersection Summary						
Average Delay			12.7			
Intersection Capacity Utilization			43.4%		ICU Level of Service	A
Analysis Period (min)			15			

HCM 2010 TWSC
1: Swampcott Road & First Street

Baseline

Intersection

Int Delay, s/veh 12.8

Movement	EBL	EBT	WBT	WBR	SBL	SBR
Traffic Vol, veh/h	325	378	207	18	76	418
Future Vol, veh/h	325	378	207	18	76	418
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	Free	-	None	-	None
Storage Length	75	-	-	100	0	100
Veh in Median Storage, #	-	0	0	-	0	-
Grade, %	-	0	0	-	0	-
Peak Hour Factor	90	90	76	76	89	89
Heavy Vehicles, %	8	2	4	0	1	8
Mvmt Flow	361	420	272	24	85	470

Major/Minor	Major1	Major2	Minor2
Conflicting Flow All	272	0	1414
Stage 1	-	-	272
Stage 2	-	-	1142
Critical Hdwy	4.18	-	6.41
Critical Hdwy Stg 1	-	-	5.41
Critical Hdwy Stg 2	-	-	5.41
Follow-up Hdwy	2.272	-	3.509
Pot Cap-1 Maneuver	1257	-	752
Stage 1	-	-	776
Stage 2	-	-	306
Platoon blocked, %	-	-	-
Mov Cap-1 Maneuver	1257	-	752
Mov Cap-2 Maneuver	-	-	108
Stage 1	-	-	776
Stage 2	-	-	218

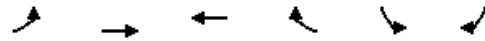
Approach	EB	WB	SB
HCM Control Delay, s	4.2	0	31.6
HCM LOS			D

Minor Lane/Major Mvmt	EBL	EBT	WBT	WBR	SBLn1	SBLn2
Capacity (veh/h)	1257	-	-	-	108	752
HCM Lane V/C Ratio	0.287	-	-	-	0.791	0.625
HCM Control Delay (s)	9	-	-	-	109.9	17.4
HCM Lane LOS	A	-	-	-	F	C
HCM 95th %tile Q(veh)	1.2	-	-	-	4.4	4.4

HCM Unsignalized Intersection Capacity Analysis

1: Swampcott Road & First Street

Baseline



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Traffic Volume (veh/h)	284	486	327	29	65	465
Future Volume (Veh/h)	284	486	327	29	65	465
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.95	0.95	0.92	0.92	0.96	0.96
Hourly flow rate (vph)	299	512	355	32	68	484
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						4
Median type		None	None			
Median storage (veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume	387				1481	371
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	387				1481	371
tC, single (s)	4.1				6.4	6.2
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	75				34	29
cM capacity (veh/h)	1177				103	677
Direction, Lane #	EB 1	EB 2	WB 1	SB 1		
Volume Total	299	512	387	552		
Volume Left	299	0	0	68		
Volume Right	0	0	32	484		
cSH	1177	1700	1700	772		
Volume to Capacity	0.25	0.30	0.23	0.71		
Queue Length 95th (ft)	25	0	0	154		
Control Delay (s)	9.1	0.0	0.0	30.9		
Lane LOS	A			D		
Approach Delay (s)	3.4		0.0	30.9		
Approach LOS				D		
Intersection Summary						
Average Delay			11.3			
Intersection Capacity Utilization			54.4%		ICU Level of Service	A
Analysis Period (min)			15			

HCM 2010 TWSC
 1: Swampcott Road & First Street

Baseline

Intersection

Int Delay, s/veh 11.3

Movement	EBL	EBT	WBT	WBR	SBL	SBR
Traffic Vol, veh/h	284	486	327	29	65	465
Future Vol, veh/h	284	486	327	29	65	465
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	75	-	-	-	-	100
Veh in Median Storage, #	-	0	0	-	0	-
Grade, %	-	0	0	-	0	-
Peak Hour Factor	95	95	92	92	96	96
Heavy Vehicles, %	1	0	3	1	2	1
Mvmt Flow	299	512	355	32	68	484

Major/Minor	Major1	Major2	Minor2
Conflicting Flow All	387	0	1480
Stage 1	-	-	371
Stage 2	-	-	1109
Critical Hdwy	4.11	-	6.42
Critical Hdwy Stg 1	-	-	5.42
Critical Hdwy Stg 2	-	-	5.42
Follow-up Hdwy	2.209	-	3.518
Pot Cap-1 Maneuver	1177	-	138
Stage 1	-	-	698
Stage 2	-	-	316
Platoon blocked, %	-	-	-
Mov Cap-1 Maneuver	1177	-	103
Mov Cap-2 Maneuver	-	-	103
Stage 1	-	-	698
Stage 2	-	-	236













Approach	EB	WB	SB
HCM Control Delay, s	3.4	0	30.8
HCM LOS			D

Minor Lane/Major Mvmt	EBL	EBT	WBT	WBR	SBLn1	SBLn2
Capacity (veh/h)	1177	-	-	-	103	677
HCM Lane V/C Ratio	0.254	-	-	-	0.657	0.715
HCM Control Delay (s)	9.1	-	-	-	90.5	22.5
HCM Lane LOS	A	-	-	-	F	C
HCM 95th %tile Q(veh)	1	-	-	-	3.3	6

HCM Unsignalized Intersection Capacity Analysis

1: Swampcott Road & First Street

Baseline

						
Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Traffic Volume (veh/h)	331	505	319	45	116	378
Future Volume (Veh/h)	331	505	319	45	116	378
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.92	0.92	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	360	549	336	47	122	398
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						4
Median type		None	None			
Median storage (veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume	383				1605	336
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	383				1605	336
tC, single (s)	4.1				6.4	6.2
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	70				0	44
cM capacity (veh/h)	1181				81	708
Direction, Lane #	EB 1	EB 2	WB 1	WB 2	SB 1	
Volume Total	360	549	336	47	520	
Volume Left	360	0	0	0	122	
Volume Right	0	0	0	47	398	
cSH	1181	1700	1700	1700	278	
Volume to Capacity	0.30	0.32	0.20	0.03	1.87	
Queue Length 95th (ft)	32	0	0	0	892	
Control Delay (s)	9.4	0.0	0.0	0.0	435.2	
Lane LOS	A				F	
Approach Delay (s)	3.7		0.0		435.2	
Approach LOS					F	
Intersection Summary						
Average Delay			126.8			
Intersection Capacity Utilization			51.6%		ICU Level of Service	A
Analysis Period (min)			15			

HCM 2010 TWSC
1: Swampcott Road & First Street

Baseline

Intersection

Int Delay, s/veh 29.3

Movement	EBL	EBT	WBT	WBR	SBL	SBR
Traffic Vol, veh/h	331	505	319	45	116	378
Future Vol, veh/h	331	505	319	45	116	378
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	Free	-	None	-	None
Storage Length	80	-	-	100	0	100
Veh in Median Storage, #	-	0	0	-	0	-
Grade, %	-	0	0	-	0	-
Peak Hour Factor	92	92	95	95	95	95
Heavy Vehicles, %	1	1	1	0	1	1
Mvmt Flow	360	549	336	47	122	398

Major/Minor	Major1	Major2	Minor2
Conflicting Flow All	336	0	336
Stage 1	-	-	336
Stage 2	-	-	1268
Critical Hdwy	4.11	-	6.21
Critical Hdwy Stg 1	-	-	5.41
Critical Hdwy Stg 2	-	-	5.41
Follow-up Hdwy	2.209	-	3.309
Pot Cap-1 Maneuver	1229	-	708
Stage 1	-	-	726
Stage 2	-	-	266
Platoon blocked, %	-	-	-
Mov Cap-1 Maneuver	1229	-	708
Mov Cap-2 Maneuver	-	-	-
Stage 1	-	-	726
Stage 2	-	-	188

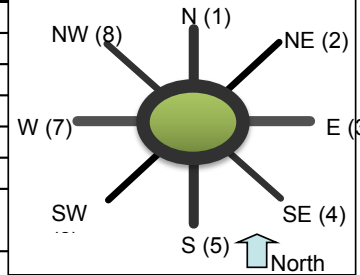
Approach	EB	WB	SB
HCM Control Delay, s	3.6	0	95.7
HCM LOS			F

Minor Lane/Major Mvmt	EBL	EBT	WBT	WBR	SBLn1	SBLn2
Capacity (veh/h)	1229	-	-	-	83	708
HCM Lane V/C Ratio	0.293	-	-	-	1.471	0.562
HCM Control Delay (s)	9.1	-	-	-	354.3	16.4
HCM Lane LOS	A	-	-	-	F	C
HCM 95th %tile Q(veh)	1.2	-	-	-	9.6	3.5

Notes

~: Volume exceeds capacity \$: Delay exceeds 300s +: Computation Not Defined *: All major volume in platoon

General & Site Information		v3.
Analyst:	GLH	
Agency/Co:	Stantec	
Date:	10/19/16	
Project or PI#:	Swampscott Road /First Street Options Review	
Year, Peak Hour:	AM Peak Period - 2016 Volumes	
County/District:	MassDOT District 4	
Intersection Name:	Swampscott Road and First Street Intersection	



Volumes		Entry Legs (FROM)							
		N (1)	NE (2)	E (3)	SE (4)	S (5)	SW (6)	W (7)	NW (8)
Exit Legs (TO)	N (1), vph			18		378			
	NE (2), vph								
	E (3), vph	76				325			
	SE (4), vph								
	S (5), vph	418		207					
	SW (6), vph								
	W (7), vph								
	NW (8), vph								
Output	Total Vehicles	494	0	225	0	703	0	0	0

Volume Characteristics	N	NE	E	SE	S	SW	W	NW
% Cars	99.0%	100.0%	99.0%	100.0%	98.0%	100.0%	100.0%	100.0%
% Heavy Vehicles	1.0%	0.0%	1.0%	0.0%	2.0%	0.0%	0.0%	0.0%
% Bicycle	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
# of Pedestrians (ped/hr)	0	0	0	0	0	0	0	0
PHF	0.89	0.95	0.76	0.95	0.90	0.95	0.95	0.95
F _{HV}	0.990	1.000	0.990	1.000	0.980	1.000	1.000	1.000
F _{ped}	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

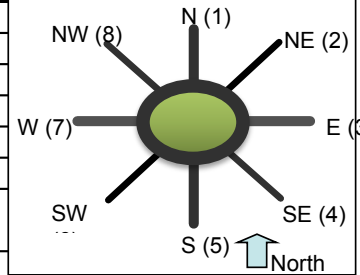
Entry/Conflicting Flows	N	NE	E	SE	S	SW	W	NW
Flow to Leg # N (1), pcu/h	0	0	24	0	428	0	0	0
NE (2), pcu/h	0	0	0	0	0	0	0	0
E (3), pcu/h	86	0	0	0	368	0	0	0
SE (4), pcu/h	0	0	0	0	0	0	0	0
S (5), pcu/h	474	0	275	0	0	0	0	0
SW (6), pcu/h	0	0	0	0	0	0	0	0
W (7), pcu/h	0	0	0	0	0	0	0	0
NW (8), pcu/h	0	0	0	0	0	0	0	0
Entry flow, pcu/h	561	0	299	0	797	0	0	0
Conflicting flow, pcu/h	275	0	428	0	86	0	0	0

Results: Approach Measures of Effectiveness								
HCM 6th Edition	N	NE	E	SE	S	SW	W	NW
Entry Capacity, vph	1032	NA	883	NA	1239	NA	NA	NA
Entry Flow Rates, vph	555	NA	296	NA	781	NA	NA	NA
V/C ratio	0.54		0.34		0.63			
Control Delay, sec/pcu	10		8		11			
LOS	B		A		B			
95th % Queue (ft)	84		37		121			

Notes: v3.1

Unit Legend:
vph = vehicles per hour
PHF = peak hour factor
F_{HV} = heavy vehicle factor
pcu = passenger car unit

General & Site Information		v3.
Analyst:	GLH	
Agency/Co:	Stantec	
Date:	10/19/16	
Project or PI#:	Swampscott Road /First Street Options Review	
Year, Peak Hour:	PM Peak Period - 2016 Volumes	
County/District:	MassDOT District 4	
Intersection Name:	Swampscott Road and First Street Intersection	



Volumes		Entry Legs (FROM)							
		N (1)	NE (2)	E (3)	SE (4)	S (5)	SW (6)	W (7)	NW (8)
Exit Legs (TO)	N (1), vph			29		284			
	NE (2), vph								
	E (3), vph	65				486			
	SE (4), vph								
	S (5), vph	465		327					
	SW (6), vph								
	W (7), vph								
	NW (8), vph								
Output	Total Vehicles	530	0	356	0	770	0	0	0

Volume Characteristics	N	NE	E	SE	S	SW	W	NW
% Cars	98.0%	100.0%	99.0%	100.0%	97.0%	100.0%	100.0%	100.0%
% Heavy Vehicles	2.0%	0.0%	1.0%	0.0%	3.0%	0.0%	0.0%	0.0%
% Bicycle	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
# of Pedestrians (ped/hr)	0	0	0	0	0	0	0	0
PHF	0.96	0.95	0.92	0.95	0.95	0.95	0.95	0.95
F _{HV}	0.980	1.000	0.990	1.000	0.971	1.000	1.000	1.000
F _{ped}	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

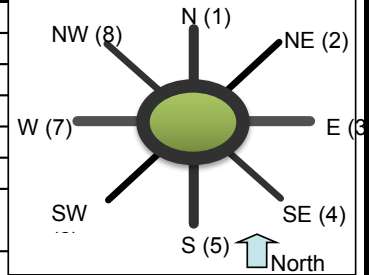
Entry/Conflicting Flows	N	NE	E	SE	S	SW	W	NW
Flow to Leg # N (1), pcu/h	0	0	32	0	308	0	0	0
NE (2), pcu/h	0	0	0	0	0	0	0	0
E (3), pcu/h	69	0	0	0	527	0	0	0
SE (4), pcu/h	0	0	0	0	0	0	0	0
S (5), pcu/h	494	0	359	0	0	0	0	0
SW (6), pcu/h	0	0	0	0	0	0	0	0
W (7), pcu/h	0	0	0	0	0	0	0	0
NW (8), pcu/h	0	0	0	0	0	0	0	0
Entry flow, pcu/h	563	0	391	0	835	0	0	0
Conflicting flow, pcu/h	359	0	308	0	69	0	0	0

Results: Approach Measures of Effectiveness								
HCM 6th Edition	N	NE	E	SE	S	SW	W	NW
Entry Capacity, vph	938	NA	998	NA	1249	NA	NA	NA
Entry Flow Rates, vph	552	NA	387	NA	811	NA	NA	NA
V/C ratio	0.59		0.39		0.65			
Control Delay, sec/pcu	12		8		11			
LOS	B		A		B			
95th % Queue (ft)	101		47		131			

Notes: v3.1

Unit Legend:
vph = vehicles per hour
PHF = peak hour factor
F_{HV} = heavy vehicle factor
pcu = passenger car unit

General & Site Information		v3.
Analyst:	GLH	
Agency/Co:	Stantec	
Date:	10/19/16	
Project or PI#:	Swampscott Road /First Street Options Review	
Year, Peak Hour:	Saturday Peak Period Noon to 1 PM Existing	
County/District:	MassDOT District 4	
Intersection Name:	Swampscott Road and First Street Intersection	



Volumes		Entry Legs (FROM)							
		N (1)	NE (2)	E (3)	SE (4)	S (5)	SW (6)	W (7)	NW (8)
Exit Legs (TO)	N (1), vph			45		331			
	NE (2), vph								
	E (3), vph	116				505			
	SE (4), vph								
	S (5), vph	378		319					
	SW (6), vph								
	W (7), vph								
	NW (8), vph								
Output	Total Vehicles	494	0	364	0	836	0	0	0

Volume Characteristics	N	NE	E	SE	S	SW	W	NW
% Cars	99.0%	100.0%	99.0%	100.0%	99.0%	100.0%	100.0%	100.0%
% Heavy Vehicles	1.0%	0.0%	1.0%	0.0%	1.0%	0.0%	0.0%	0.0%
% Bicycle	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
# of Pedestrians (ped/hr)	0	0	0	0	0	0	0	0
PHF	0.94	0.95	0.95	0.95	0.92	0.95	0.95	0.95
F _{HV}	0.990	1.000	0.990	1.000	0.990	1.000	1.000	1.000
F _{ped}	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

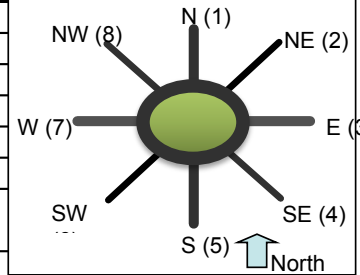
Entry/Conflicting Flows	N	NE	E	SE	S	SW	W	NW
Flow to Leg # N (1), pcu/h	0	0	48	0	363	0	0	0
NE (2), pcu/h	0	0	0	0	0	0	0	0
E (3), pcu/h	125	0	0	0	554	0	0	0
SE (4), pcu/h	0	0	0	0	0	0	0	0
S (5), pcu/h	406	0	339	0	0	0	0	0
SW (6), pcu/h	0	0	0	0	0	0	0	0
W (7), pcu/h	0	0	0	0	0	0	0	0
NW (8), pcu/h	0	0	0	0	0	0	0	0
Entry flow, pcu/h	531	0	387	0	918	0	0	0
Conflicting flow, pcu/h	339	0	363	0	125	0	0	0

Results: Approach Measures of Effectiveness								
HCM 6th Edition	N	NE	E	SE	S	SW	W	NW
Entry Capacity, vph	967	NA	943	NA	1203	NA	NA	NA
Entry Flow Rates, vph	526	NA	383	NA	909	NA	NA	NA
V/C ratio	0.54		0.41		0.76			
Control Delay, sec/pcu	11		8		15			
LOS	B		A		C			
95th % Queue (ft)	85		50		193			

Notes: v3.1

Unit Legend:
vph = vehicles per hour
PHF = peak hour factor
F_{HV} = heavy vehicle factor
pcu = passenger car unit

General & Site Information		v3.
Analyst:	GLH	
Agency/Co:	Stantec	
Date:	10/19/16	
Project or PI#:	Swampscott Road /First Street Options Review	
Year, Peak Hour:	AM Peak Period - MassDOT 2035 9% Growth Assumed	
County/District:	MassDOT District 4	
Intersection Name:	Swampscott Road and First Street Intersection	



Volumes		Entry Legs (FROM)							
		N (1)	NE (2)	E (3)	SE (4)	S (5)	SW (6)	W (7)	NW (8)
Exit Legs (TO)	N (1), vph			20		412			
	NE (2), vph								
	E (3), vph	83				354			
	SE (4), vph								
	S (5), vph	456		226					
	SW (6), vph								
	W (7), vph								
	NW (8), vph								
Output	Total Vehicles	539	0	246	0	766	0	0	0

Volume Characteristics	N	NE	E	SE	S	SW	W	NW
% Cars	99.0%	100.0%	99.0%	100.0%	98.0%	100.0%	100.0%	100.0%
% Heavy Vehicles	1.0%	0.0%	1.0%	0.0%	2.0%	0.0%	0.0%	0.0%
% Bicycle	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
# of Pedestrians (ped/hr)	0	0	0	0	0	0	0	0
PHF	0.89	0.95	0.76	0.95	0.90	0.95	0.95	0.95
F _{HV}	0.990	1.000	0.990	1.000	0.980	1.000	1.000	1.000
F _{ped}	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

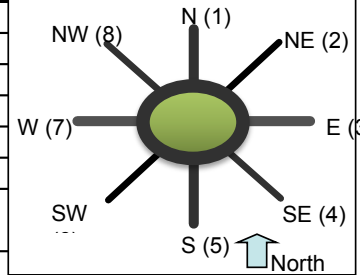
Entry/Conflicting Flows	N	NE	E	SE	S	SW	W	NW
Flow to Leg # N (1), pcu/h	0	0	27	0	467	0	0	0
NE (2), pcu/h	0	0	0	0	0	0	0	0
E (3), pcu/h	94	0	0	0	401	0	0	0
SE (4), pcu/h	0	0	0	0	0	0	0	0
S (5), pcu/h	517	0	300	0	0	0	0	0
SW (6), pcu/h	0	0	0	0	0	0	0	0
W (7), pcu/h	0	0	0	0	0	0	0	0
NW (8), pcu/h	0	0	0	0	0	0	0	0
Entry flow, pcu/h	612	0	327	0	868	0	0	0
Conflicting flow, pcu/h	300	0	467	0	94	0	0	0

Results: Approach Measures of Effectiveness								
HCM 6th Edition	N	NE	E	SE	S	SW	W	NW
Entry Capacity, vph	1006	NA	849	NA	1229	NA	NA	NA
Entry Flow Rates, vph	606	NA	324	NA	851	NA	NA	NA
V/C ratio	0.60		0.38		0.69			
Control Delay, sec/pcu	12		9		13			
LOS	B		A		B			
95th % Queue (ft)	106		45		153			

Notes: v3.1

Unit Legend:
vph = vehicles per hour
PHF = peak hour factor
F_{HV} = heavy vehicle factor
pcu = passenger car unit

General & Site Information		v3.
Analyst:	GLH	
Agency/Co:	Stantec	
Date:	10/19/16	
Project or PI#:	Swampscott Road /First Street Options Review	
Year, Peak Hour:	PM Peak Period -MassDOT 2035 Max 9% Growth Assumed	
County/District:	MassDOT District 4	
Intersection Name:	Swampscott Road and First Street Intersection	



Volumes		Entry Legs (FROM)							
		N (1)	NE (2)	E (3)	SE (4)	S (5)	SW (6)	W (7)	NW (8)
Exit Legs (TO)	N (1), vph			32		310			
	NE (2), vph								
	E (3), vph	71				530			
	SE (4), vph								
	S (5), vph	507		356					
	SW (6), vph								
	W (7), vph								
	NW (8), vph								
Output	Total Vehicles	578	0	388	0	840	0	0	0

Volume Characteristics	N	NE	E	SE	S	SW	W	NW
% Cars	98.0%	100.0%	99.0%	100.0%	97.0%	100.0%	100.0%	100.0%
% Heavy Vehicles	2.0%	0.0%	1.0%	0.0%	3.0%	0.0%	0.0%	0.0%
% Bicycle	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
# of Pedestrians (ped/hr)	0	0	0	0	0	0	0	0
PHF	0.96	0.95	0.92	0.95	0.95	0.95	0.95	0.95
F _{HV}	0.980	1.000	0.990	1.000	0.971	1.000	1.000	1.000
F _{ped}	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

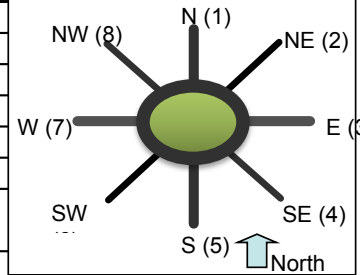
Entry/Conflicting Flows	N	NE	E	SE	S	SW	W	NW
Flow to Leg # N (1), pcu/h	0	0	35	0	336	0	0	0
NE (2), pcu/h	0	0	0	0	0	0	0	0
E (3), pcu/h	75	0	0	0	575	0	0	0
SE (4), pcu/h	0	0	0	0	0	0	0	0
S (5), pcu/h	539	0	391	0	0	0	0	0
SW (6), pcu/h	0	0	0	0	0	0	0	0
W (7), pcu/h	0	0	0	0	0	0	0	0
NW (8), pcu/h	0	0	0	0	0	0	0	0
Entry flow, pcu/h	614	0	426	0	911	0	0	0
Conflicting flow, pcu/h	391	0	336	0	75	0	0	0

Results: Approach Measures of Effectiveness								
HCM 6th Edition	N	NE	E	SE	S	SW	W	NW
Entry Capacity, vph	908	NA	970	NA	1241	NA	NA	NA
Entry Flow Rates, vph	602	NA	422	NA	884	NA	NA	NA
V/C ratio	0.66		0.43		0.71			
Control Delay, sec/pcu	15		9		13			
LOS	B		A		B			
95th % Queue (ft)	132		56		167			

Notes: v3.1

Unit Legend:
vph = vehicles per hour
PHF = peak hour factor
F_{HV} = heavy vehicle factor
pcu = passenger car unit

General & Site Information		v3.
Analyst:	GLH	
Agency/Co:	Stantec	
Date:	10/19/16	
Project or PI#:	Swampscott Road /First Street Options Review	
Year, Peak Hour:	Saturday Peak Period Noon to 1 PM + 9% Traffic Growth	
County/District:	MassDOT District 4	
Intersection Name:	Swampscott Road and First Street Intersection	



Volumes		Entry Legs (FROM)							
		N (1)	NE (2)	E (3)	SE (4)	S (5)	SW (6)	W (7)	NW (8)
Exit Legs (TO)	N (1), vph			49		361			
	NE (2), vph								
	E (3), vph	126				550			
	SE (4), vph								
	S (5), vph	412		348					
	SW (6), vph								
	W (7), vph								
	NW (8), vph								
Output	Total Vehicles	538	0	397	0	911	0	0	0

Volume Characteristics	N	NE	E	SE	S	SW	W	NW
% Cars	99.0%	100.0%	99.0%	100.0%	99.0%	100.0%	100.0%	100.0%
% Heavy Vehicles	1.0%	0.0%	1.0%	0.0%	1.0%	0.0%	0.0%	0.0%
% Bicycle	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
# of Pedestrians (ped/hr)	0	0	0	0	0	0	0	0
PHF	0.94	0.95	0.95	0.95	0.92	0.95	0.95	0.95
F _{HV}	0.990	1.000	0.990	1.000	0.990	1.000	1.000	1.000
F _{ped}	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Entry/Conflicting Flows	N	NE	E	SE	S	SW	W	NW
Flow to Leg # N (1), pcu/h	0	0	52	0	396	0	0	0
NE (2), pcu/h	0	0	0	0	0	0	0	0
E (3), pcu/h	135	0	0	0	604	0	0	0
SE (4), pcu/h	0	0	0	0	0	0	0	0
S (5), pcu/h	443	0	370	0	0	0	0	0
SW (6), pcu/h	0	0	0	0	0	0	0	0
W (7), pcu/h	0	0	0	0	0	0	0	0
NW (8), pcu/h	0	0	0	0	0	0	0	0
Entry flow, pcu/h	578	0	422	0	1000	0	0	0
Conflicting flow, pcu/h	370	0	396	0	135	0	0	0

Results: Approach Measures of Effectiveness								
HCM 6th Edition	N	NE	E	SE	S	SW	W	NW
Entry Capacity, vph	937	NA	912	NA	1190	NA	NA	NA
Entry Flow Rates, vph	572	NA	418	NA	990	NA	NA	NA
V/C ratio	0.61		0.46		0.83			
Control Delay, sec/pcu	13		10		20			
LOS	B		A		C			
95th % Queue (ft)	109		62		264			













Notes: v3.1

Unit Legend:
vph = vehicles per hour
PHF = peak hour factor
F_{HV} = heavy vehicle factor
pcu = passenger car unit

HCM Signalized Intersection Capacity Analysis

1: Swampcott Road & First Street







Baseline

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	207	18	325	378	76	418
Future Volume (vph)	207	18	325	378	76	418
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1736	1615	1759	1583	1787	1759
Flt Permitted	0.95	1.00	1.00	1.00	0.31	1.00
Satd. Flow (perm)	1736	1615	1759	1583	586	1759
Peak-hour factor, PHF	0.76	0.76	0.90	0.90	0.89	0.89
Adj. Flow (vph)	272	24	361	420	85	470
RTOR Reduction (vph)	0	17	0	169	0	0
Lane Group Flow (vph)	272	7	361	251	85	470
Heavy Vehicles (%)	4%	0%	8%	2%	1%	8%
Turn Type	Prot	Perm	NA	pm+ov	pm+pt	NA
Protected Phases	8		2	8	1	6
Permitted Phases		8		2	6	
Actuated Green, G (s)	13.8	13.8	15.7	29.5	21.7	21.7
Effective Green, g (s)	13.8	13.8	15.7	29.5	21.7	21.7
Actuated g/C Ratio	0.28	0.28	0.32	0.60	0.44	0.44
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	484	451	559	1073	306	772
v/s Ratio Prot	c0.16		0.21	0.07	0.01	c0.27
v/s Ratio Perm		0.00		0.09	0.11	
v/c Ratio	0.56	0.01	0.65	0.23	0.28	0.61
Uniform Delay, d1	15.2	12.9	14.5	4.7	8.9	10.6
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	1.5	0.0	2.6	0.1	0.5	1.4
Delay (s)	16.7	12.9	17.0	4.8	9.4	12.0
Level of Service	B	B	B	A	A	B
Approach Delay (s)	16.4		10.4			11.6
Approach LOS	B		B			B
Intersection Summary						
HCM 2000 Control Delay			11.9		HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio			0.63			
Actuated Cycle Length (s)			49.4		Sum of lost time (s)	16.0
Intersection Capacity Utilization			42.8%		ICU Level of Service	A
Analysis Period (min)			15			
c Critical Lane Group						

Queues

1: Swampcott Road & First Street

Baseline

						
Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	272	24	361	420	85	470
v/c Ratio	0.51	0.05	0.59	0.31	0.22	0.61
Control Delay	21.2	9.3	20.3	1.4	11.1	15.4
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	21.2	9.3	20.3	1.4	11.1	15.4
Queue Length 50th (ft)	56	0	76	0	10	71
Queue Length 95th (ft)	158	14	#244	34	51	271
Internal Link Dist (ft)	3568		3158			2564
Turn Bay Length (ft)		100			50	
Base Capacity (vph)	752	713	987	1381	378	1277
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.36	0.03	0.37	0.30	0.22	0.37













Intersection Summary

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

HCM Signalized Intersection Capacity Analysis

1: Swampcott Road & First Street

Baseline







						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	327	29	284	486	65	465
Future Volume (vph)	327	29	284	486	65	465
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1787	1615	1845	1599	1770	1881
Flt Permitted	0.95	1.00	1.00	1.00	0.36	1.00
Satd. Flow (perm)	1787	1615	1845	1599	669	1881
Peak-hour factor, PHF	0.92	0.92	0.95	0.95	0.96	0.96
Growth Factor (vph)	135%	135%	135%	135%	135%	135%
Adj. Flow (vph)	480	43	404	691	91	654
RTOR Reduction (vph)	0	24	0	220	0	0
Lane Group Flow (vph)	480	19	404	471	91	654
Heavy Vehicles (%)	1%	0%	3%	1%	2%	1%
Turn Type	Prot	Perm	NA	pm+ov	Perm	NA
Protected Phases	8		2	8		6
Permitted Phases		8		2	6	
Actuated Green, G (s)	15.4	15.4	15.4	30.8	15.4	15.4
Effective Green, g (s)	16.4	16.4	16.4	32.8	16.4	16.4
Actuated g/C Ratio	0.34	0.34	0.34	0.68	0.34	0.34
Clearance Time (s)	5.0	5.0	5.0	5.0	5.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	609	550	629	1223	228	641
v/s Ratio Prot	c0.27		0.22	0.13		c0.35
v/s Ratio Perm		0.01		0.16	0.14	
v/c Ratio	0.79	0.04	0.64	0.39	0.40	1.02
Uniform Delay, d1	14.3	10.6	13.4	3.3	12.1	15.9
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	6.7	0.0	2.2	0.2	1.1	40.8
Delay (s)	21.0	10.6	15.6	3.5	13.2	56.6
Level of Service	C	B	B	A	B	E
Approach Delay (s)	20.1		8.0			51.3
Approach LOS	C		A			D
Intersection Summary						
HCM 2000 Control Delay			24.3		HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio			0.84			
Actuated Cycle Length (s)			48.1		Sum of lost time (s)	13.0
Intersection Capacity Utilization			64.2%		ICU Level of Service	C
Analysis Period (min)			15			

c Critical Lane Group

Queues

1: Swampcott Road & First Street

Baseline













						
Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	480	43	404	691	91	654
v/c Ratio	0.72	0.07	0.59	0.45	0.37	0.93
Control Delay	23.8	7.0	19.2	1.5	19.1	40.6
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	23.8	7.0	19.2	1.5	19.1	40.6
Queue Length 50th (ft)	82	1	65	0	13	126
Queue Length 95th (ft)	#354	22	#277	36	#82	#501
Internal Link Dist (ft)	3568		3158			2564
Turn Bay Length (ft)		100			50	
Base Capacity (vph)	665	624	687	1524	249	700
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.72	0.07	0.59	0.45	0.37	0.93

Intersection Summary

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

HCM 2010 Signalized Intersection Summary
 1: Swampcott Road & First Street







Baseline

								
Movement	WBL	WBR	NBT	NBR	SBL	SBT		
Lane Configurations								
Traffic Volume (veh/h)	319	45	331	505	116	378		
Future Volume (veh/h)	319	45	331	505	116	378		
Number	3	18	2	12	1	6		
Initial Q (Qb), veh	0	0	0	0	0	0		
Ped-Bike Adj(A_pbT)	1.00	1.00		1.00	1.00			
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00		
Adj Sat Flow, veh/h/ln	1881	1900	1881	1881	1881	1881		
Adj Flow Rate, veh/h	336	47	360	549	122	398		
Adj No. of Lanes	1	1	1	1	1	1		
Peak Hour Factor	0.95	0.95	0.92	0.92	0.95	0.95		
Percent Heavy Veh, %	1	0	1	1	1	1		
Cap, veh/h	445	401	664	940	413	1010		
Arrive On Green	0.25	0.25	0.35	0.34	0.08	0.54		
Sat Flow, veh/h	1792	1615	1881	1599	1792	1881		
Grp Volume(v), veh/h	336	47	360	549	122	398		
Grp Sat Flow(s),veh/h/ln	1792	1615	1881	1599	1792	1881		
Q Serve(g_s), s	6.5	0.8	5.7	8.0	0.0	4.6		
Cycle Q Clear(g_c), s	6.5	0.8	5.7	8.0	0.0	4.6		
Prop In Lane	1.00	1.00		1.00	1.00			
Lane Grp Cap(c), veh/h	445	401	664	940	413	1010		
V/C Ratio(X)	0.75	0.12	0.54	0.58	0.30	0.39		
Avail Cap(c_a), veh/h	768	692	907	1147	467	1311		
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00		
Upstream Filter(I)	1.00	1.00	1.00	1.00	1.00	1.00		
Uniform Delay (d), s/veh	13.0	10.9	9.7	4.8	14.2	5.1		
Incr Delay (d2), s/veh	2.6	0.1	0.7	0.6	0.4	0.2		
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0		
%ile BackOfQ(50%),veh/ln	3.5	0.4	3.0	5.6	1.2	2.4		
LnGrp Delay(d),s/veh	15.6	11.0	10.4	5.4	14.6	5.3		
LnGrp LOS	B	B	B	A	B	A		
Approach Vol, veh/h	383		909			520		
Approach Delay, s/veh	15.0		7.4			7.5		
Approach LOS	B		A			A		
Timer	1	2	3	4	5	6	7	8
Assigned Phs	1	2				6		8
Phs Duration (G+Y+Rc), s	6.9	17.2				24.0		13.3
Change Period (Y+Rc), s	4.0	4.5				4.0		4.0
Max Green Setting (Gmax), s	4.0	17.5				26.0		16.0
Max Q Clear Time (g_c+I1), s	2.0	10.0				6.6		8.5
Green Ext Time (p_c), s	0.5	2.6				2.0		1.0
Intersection Summary								
HCM 2010 Ctrl Delay			9.0					
HCM 2010 LOS			A					

Queues

1: Swampcott Road & First Street













Baseline

						
Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	336	47	360	549	122	398
v/c Ratio	0.59	0.09	0.58	0.40	0.23	0.45
Control Delay	18.1	5.2	16.9	1.1	8.3	9.2
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	18.1	5.2	16.9	1.1	8.3	9.2
Queue Length 50th (ft)	69	0	77	0	15	60
Queue Length 95th (ft)	148	17	145	12	36	113
Internal Link Dist (ft)	3568		3158			2564
Turn Bay Length (ft)		100		80	50	
Base Capacity (vph)	756	710	895	1362	530	1240
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.44	0.07	0.40	0.40	0.23	0.32
Intersection Summary						

HCM Signalized Intersection Capacity Analysis

1: Swampcott Road & First Street

Baseline

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	207	18	325	378	76	418
Future Volume (vph)	207	18	325	378	76	418
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1736	1615	1759	1583	1787	1759
Flt Permitted	0.95	1.00	1.00	1.00	0.21	1.00
Satd. Flow (perm)	1736	1615	1759	1583	404	1759
Peak-hour factor, PHF	0.76	0.76	0.90	0.90	0.89	0.89
Growth Factor (vph)	135%	135%	135%	135%	135%	135%
Adj. Flow (vph)	368	32	488	567	115	634
RTOR Reduction (vph)	0	19	0	197	0	0
Lane Group Flow (vph)	368	13	488	370	115	634
Heavy Vehicles (%)	4%	0%	8%	2%	1%	8%
Turn Type	Prot	Perm	NA	pm+ov	pm+pt	NA
Protected Phases	8		2	8	1	6
Permitted Phases		8		2	6	
Actuated Green, G (s)	16.8	16.8	21.5	38.3	28.5	28.5
Effective Green, g (s)	16.8	16.8	21.5	38.3	28.5	28.5
Actuated g/C Ratio	0.28	0.28	0.36	0.64	0.48	0.48
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	488	454	633	1121	262	839
v/s Ratio Prot	c0.21		0.28	0.09	0.02	c0.36
v/s Ratio Perm		0.01		0.14	0.19	
v/c Ratio	0.75	0.03	0.77	0.33	0.44	0.76
Uniform Delay, d1	19.6	15.5	16.9	4.9	10.6	12.8
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	6.5	0.0	5.8	0.2	1.2	3.9
Delay (s)	26.1	15.6	22.7	5.0	11.8	16.7
Level of Service	C	B	C	A	B	B
Approach Delay (s)	25.2		13.2			15.9
Approach LOS	C		B			B

Intersection Summary







HCM 2000 Control Delay	16.3	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.78		
Actuated Cycle Length (s)	59.7	Sum of lost time (s)	16.0
Intersection Capacity Utilization	54.3%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

Queues

1: Swampcott Road & First Street

Baseline

						
Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	368	32	488	567	115	634
v/c Ratio	0.70	0.06	0.72	0.42	0.38	0.73
Control Delay	30.1	10.0	25.8	1.7	13.7	19.8
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	30.1	10.0	25.8	1.7	13.7	19.8
Queue Length 50th (ft)	104	1	127	1	16	131
Queue Length 95th (ft)	#246	17	#403	43	65	#462
Internal Link Dist (ft)	3568		3158			2564
Turn Bay Length (ft)		100		80	50	
Base Capacity (vph)	553	532	725	1354	303	989
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.67	0.06	0.67	0.42	0.38	0.64













Intersection Summary

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

HCM Signalized Intersection Capacity Analysis

1: Swampcott Road & First Street

Baseline







						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	327	29	284	486	65	465
Future Volume (vph)	327	29	284	486	65	465
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1787	1615	1845	1599	1770	1881
Flt Permitted	0.95	1.00	1.00	1.00	0.36	1.00
Satd. Flow (perm)	1787	1615	1845	1599	669	1881
Peak-hour factor, PHF	0.92	0.92	0.95	0.95	0.96	0.96
Growth Factor (vph)	135%	135%	135%	135%	135%	135%
Adj. Flow (vph)	480	43	404	691	91	654
RTOR Reduction (vph)	0	24	0	220	0	0
Lane Group Flow (vph)	480	19	404	471	91	654
Heavy Vehicles (%)	1%	0%	3%	1%	2%	1%
Turn Type	Prot	Perm	NA	pm+ov	Perm	NA
Protected Phases	8		2	8		6
Permitted Phases		8		2	6	
Actuated Green, G (s)	15.4	15.4	15.4	30.8	15.4	15.4
Effective Green, g (s)	16.4	16.4	16.4	32.8	16.4	16.4
Actuated g/C Ratio	0.34	0.34	0.34	0.68	0.34	0.34
Clearance Time (s)	5.0	5.0	5.0	5.0	5.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	609	550	629	1223	228	641
v/s Ratio Prot	c0.27		0.22	0.13		c0.35
v/s Ratio Perm		0.01		0.16	0.14	
v/c Ratio	0.79	0.04	0.64	0.39	0.40	1.02
Uniform Delay, d1	14.3	10.6	13.4	3.3	12.1	15.9
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	6.7	0.0	2.2	0.2	1.1	40.8
Delay (s)	21.0	10.6	15.6	3.5	13.2	56.6
Level of Service	C	B	B	A	B	E
Approach Delay (s)	20.1		8.0			51.3
Approach LOS	C		A			D
Intersection Summary						
HCM 2000 Control Delay			24.3		HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio			0.84			
Actuated Cycle Length (s)			48.1		Sum of lost time (s)	13.0
Intersection Capacity Utilization			64.2%		ICU Level of Service	C
Analysis Period (min)			15			

c Critical Lane Group

Queues

1: Swampcott Road & First Street

Baseline

						
Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	480	43	404	691	91	654
v/c Ratio	0.72	0.07	0.59	0.45	0.37	0.93
Control Delay	23.8	7.0	19.2	1.5	19.1	40.6
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	23.8	7.0	19.2	1.5	19.1	40.6
Queue Length 50th (ft)	82	1	65	0	13	126
Queue Length 95th (ft)	#354	22	#277	36	#82	#501
Internal Link Dist (ft)	3568		3158			2564
Turn Bay Length (ft)		100			50	
Base Capacity (vph)	665	624	687	1524	249	700
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.72	0.07	0.59	0.45	0.37	0.93













Intersection Summary

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

HCM Signalized Intersection Capacity Analysis

1: Swampcott Road & First Street

Baseline







						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	319	45	331	505	116	378
Future Volume (vph)	319	45	331	505	116	378
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1787	1615	1881	1599	1787	1881
Flt Permitted	0.95	1.00	1.00	1.00	0.31	1.00
Satd. Flow (perm)	1787	1615	1881	1599	587	1881
Peak-hour factor, PHF	0.95	0.95	0.92	0.92	0.95	0.95
Growth Factor (vph)	135%	135%	135%	135%	135%	135%
Adj. Flow (vph)	453	64	486	741	165	537
RTOR Reduction (vph)	0	43	0	142	0	0
Lane Group Flow (vph)	453	21	486	599	165	537
Heavy Vehicles (%)	1%	0%	1%	1%	1%	1%
Turn Type	Prot	Perm	NA	pm+ov	pm+pt	NA
Protected Phases	8		2	8	1	6
Permitted Phases		8		2	6	
Actuated Green, G (s)	15.1	15.1	15.3	30.4	22.7	22.7
Effective Green, g (s)	15.1	15.1	15.8	30.4	22.7	22.7
Actuated g/C Ratio	0.33	0.33	0.34	0.66	0.50	0.50
Clearance Time (s)	4.0	4.0	4.5	4.0	4.0	4.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	589	532	648	1200	366	932
v/s Ratio Prot	c0.25		c0.26	0.16	0.03	c0.29
v/s Ratio Perm		0.01		0.21	0.19	
v/c Ratio	0.77	0.04	0.75	0.50	0.45	0.58
Uniform Delay, d1	13.8	10.4	13.3	3.9	12.1	8.2
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	6.0	0.0	4.9	0.3	0.9	0.9
Delay (s)	19.8	10.5	18.1	4.2	13.0	9.0
Level of Service	B	B	B	A	B	A
Approach Delay (s)	18.6		9.7			10.0
Approach LOS	B		A			A
Intersection Summary						
HCM 2000 Control Delay			11.7		HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio			0.79			
Actuated Cycle Length (s)			45.8		Sum of lost time (s)	12.0
Intersection Capacity Utilization			66.1%		ICU Level of Service	C
Analysis Period (min)			15			

c Critical Lane Group

Queues

1: Swampcott Road & First Street

Baseline

						
Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	453	64	486	741	165	537
v/c Ratio	0.76	0.11	0.74	0.54	0.40	0.59
Control Delay	26.2	4.7	22.1	2.6	12.6	11.5
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	26.2	4.7	22.1	2.6	12.6	11.5
Queue Length 50th (ft)	118	0	118	17	23	94
Queue Length 95th (ft)	#249	19	#241	39	47	165
Internal Link Dist (ft)	3568		3158			2564
Turn Bay Length (ft)		100		80	50	
Base Capacity (vph)	664	641	787	1370	410	1137
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.68	0.10	0.62	0.54	0.40	0.47

Intersection Summary

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