MDM TRANSPORTATION CONSULTANTS, INC.
Planners & Engineers

PRINCIPALS
Robert J. Michaud, P.E.
Daniel J. Mills, P.E., PTOE

MEMORANDUM

DATE: June 2, 2020

TO: Beth Suedmeyer
Environmental Planning – Planning & Community Development
Town of Sudbury
278 Old Sudbury Road
Sudbury, MA 01776

FROM: Robert J. Michaud, P.E. – Managing Principal
Daniel A. Dumais, P.E. – Senior Project Manager

RE: **Response to Comments Issued by McMahon Associates**
Proposed Cold Brook Crossing Residential Development
North Road, Sudbury, Massachusetts

MDM Transportation Consultants, Inc. (MDM) has prepared the following response to transportation-related comments as issued in a letter by McMahon Associates dated May 5, 2020. To facilitate review, comments on the site plans and the January 2020 traffic impact and access study (TIAS) are paraphrased with corresponding responses.

Existing Conditions/Study Area

Comment 1. "We agree that these intersections reflect key intersections within the vicinity of the site. However, as a majority of the site traffic is expected to come from the east via North Road (Route 117), we suggest that the Applicant consider including the intersection of Fitchburg Turnpike (Route 117) at Sudbury Road in the study area. This signalized intersection is located less than a mile east of the proposed site driveway, just over the Town Line in Concord, MA.

In addition, the ENF identified the following additional study area intersections within the Towns of Sudbury and Concord where transportation improvements may be implemented:

- *North Road (Route 117) at Cummings Office Park (142-150 North Road), Sudbury*
- *Fitchburg Turnpike (Route 117) at Plainfield Road, Concord*

Comments from the Town of Concord also note that the following intersections should be considered when implementing traffic signal synchronization;

- *Fitchburg Turnpike (Route 117) at Sudbury Road, Concord*
- *South Great Road (Route 117) at Concord Road (Route 126), Lincoln"*

Response: An expanded analysis to include the Route 117 at Sudbury Road intersection in Concord that augments the submitted TIAS is included in the **Attachments**.

In summary, the incremental traffic associated with the proposed development is not expected to materially impact operating conditions at the signalized study intersection of Route 117 at Sudbury Road compared to No-Build conditions. The intersection will continue to operate below capacity at LOS C or better during the peak hours with a nominal increase in vehicle queues. The study intersection exhibited below-average crash rates based on historic crash data and is not listed as an HSIP location. The analysis indicates that neither capacity nor safety countermeasures are warranted to mitigate project impacts – a finding that is consistent with analysis of other locations along North Road including that indicates leading to the submitted February 2020 TIAS which includes the intersections of Pantry Road/Dakin Road and Powder Mill Road/Mossman Road.

While project impacts at the study location are immaterial and operations are deemed acceptable based on standard transportation engineering analysis practices, MDM notes that the executed Development Agreement between the Developer and the Town of Sudbury includes a $1-million funding obligation for off-site traffic or other mitigation improvements, or improvements not related to costs to the applicant for turning lanes or other safety improvements at the entrance of the Melone Property Development site. This funding provides the Town the means of implementing off-site transportation initiatives at its discretion, including maintenance-related improvements at the Route 117 study intersections (including the expanded Concord location). Detailed inventory of existing signal equipment along North Road including the Concord location indicates such improvements could include repair/replacement or upgrading of signal equipment including associated signal detection equipment. Such upgrades if implemented would allow optimized operations during peak traffic periods, reducing delays and queuing relative to existing conditions. The Traffic Signal Evaluation dated November 21, 2018 prepared for the Town by Ocean State Signal[1] provides specific recommendations for potential improvements, which MDM opines are not warranted by or necessary to support the limited project impacts.

Traffic Data

Comment 2. "Based on a review of the ATR data, daily traffic patterns on North Road (Route 117) coincide with the TMC time periods. We agree that the weekday morning peak hour occurs between 7:30 AM and 8:30 AM and the weekday afternoon peak hour occurs between 5:00 PM and 6:00 PM, as presented in the TIAS."

[1] Technical Memorandum entitled "*Traffic Signal Evaluation at Eight Locations Associated with the Quarry North at Melone Development*", prepared by Ocean State Signal dated November 21, 2018.

Response: No further response required.

Comment 3. "We agree that the 0.5% annual growth rate is appropriate to apply to the 2018 data to generate 2020 baseline volumes."

Response: No further response required.

Comment 4. "We agree that traffic volumes collected in this area in the month of September generally reflect an average month, and no seasonally adjustment is necessary."

Response: No further response required.

Safety

Comment 5. "We suggest that the Applicant review the most recent five years of competed crash data available through MassDOT, which would include data for 2013 to 2017. We also suggest that crash data along North Road (Route 117) in the vicinity of the proposed site driveway is reviewed. Crash rates should be compared to both the District and Statewide averages to assess potential safety concerns."

Response: Crash data was obtained from MassDOT for the Town of Sudbury for the five-year period 2015 through 2019 (the most recent full year of data currently available from MassDOT) for the study intersections and the roadway segment along North Road in the vicinity of Site (Sudbury Town Line and Northwood Road). The crash data is summarized in **Table R1** with detailed data provided in the **Attachments.**

Response: An expanded analysis to include the Route 117 at Sudbury Road intersection in Concord that augments the submitted TIAS is included in the **Attachments**.

In summary, the incremental traffic associated with the proposed development is not expected to materially impact operating conditions at the signalized study intersection of Route 117 at Sudbury Road compared to No-Build conditions. The intersection will continue to operate below capacity at LOS C or better during the peak hours with a nominal increase in vehicle queues. The study intersection exhibited below-average crash rates based on historic crash data and is not listed as an HSIP location. The analysis indicates that neither capacity nor safety countermeasures are warranted to mitigate project impacts – a finding that is consistent with analysis of other locations along North Road including that indicates leading to the submitted February 2020 TIAS which includes the intersections of Pantry Road/Dakin Road and Powder Mill Road/Mossman Road.

While project impacts at the study location are immaterial and operations are deemed acceptable based on standard transportation engineering analysis practices, MDM notes that the executed Development Agreement between the Developer and the Town of Sudbury includes a $1-million funding obligation for off-site traffic or other mitigation improvements, or improvements not related to costs to the applicant for turning lanes or other safety improvements at the entrance of the Melone Property Development site. This funding provides the Town the means of implementing off-site transportation initiatives at its discretion, including maintenance-related improvements at the Route 117 study intersections (including the expanded Concord location). Detailed inventory of existing signal equipment along North Road including the Concord location indicates such improvements could include repair/replacement or upgrading of signal equipment including associated signal detection equipment. Such upgrades if implemented would allow optimized operations during peak traffic periods, reducing delays and queuing relative to existing conditions. The Traffic Signal Evaluation dated November 21, 2018 prepared for the Town by Ocean State Signal[1] provides specific recommendations for potential improvements, which MDM opines are not warranted by or necessary to support the limited project impacts.

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Response: Crash data was obtained from MassDOT for the Town of Sudbury for the five-year period 2015 through 2019 (the most recent full year of data currently available from MassDOT) for the study intersections and the roadway segment along North Road in the vicinity of Site (Sudbury Town Line and Northwood Road). The crash data is summarized in **Table R1** with detailed data provided in the **Attachments.**

TABLE R1
INTERSECTION CRASH SUMMARY
2015 THROUGH 2019[1]

Data Category	STUDY LOCATIONS		
	North Rd at Dakin Rd/Pantry Rd	North Rd at Powder Mill Rd/Mossman Rd	North Road Between Sudbury Town Line and Northwood Road
Traffic Control	Signalized	Unsignalized	Roadway Segment
Crash Rate[2]	**0.31**	**0.26**	**0.27**
MassDOT Avg. Rate[3]	0.89	0.66	3.80
Year:			
2015	2	1	1
2016	2	1	1
2017	5	2	0
2018	0	2	1
2019	1	2	0
Total	**10**	**8**	**3**
Type:			
Angle	7	3	0
Rear-End	1	2	3
Head-On	0	0	0
Sideswipe	1	1	0
Single Vehicle	1	2	0
Other/Unknown	0	0	0
Severity:			
P. Damage Only	8	5	2
Personal Injury	2	3	1
Fatality	0	0	0
Conditions:			
Dry	7	6	2
Wet	0	2	1
Snow	3	0	0
Time:			
7:00 to 9:00 AM	1	1	0
4:00 to 6:00 PM	2	2	1
Rest of Day	7	5	2

[1] Source: MassDOT Crash Database
[2] Crashes per million entering vehicles
[3] District 3 Average Crash Rate

As summarized in **Table R1**, the study intersections and the roadway segment in the vicinity of the proposed driveway experienced crash rates that are below the MassDOT District 3 averages; therefore, no immediate safety countermeasures are warranted based on the crash history at the study locations. Furthermore, none of the study intersection nor the roadway segment are listed as 2015-2017 HSIP locations.

Sight Distance

Comment 6. "Based on sight distance measurements taken in the field, we agree that the proposed driveway location meets the AASHTO minimum sight distance requirements. It is recommended that all proposed landscaping and signage remain under a height of two-feet, and are placed as to not obstruct sight lines."

Response: MDM concurs, no further response required.

Background Growth

Comment 7. "We agree that the 1% annual growth rate applied is expected to present a conservative analysis based on the historical traffic data available."

Response: No further response required.

Trip Generation

Comment 8. "We agree that the trip generation estimates and distributions for the Maynard Crossing development are applied to the study area appropriately. Due to the Cold Brook Crossing site's close proximity to the Town of Concord, we suggest that the Applicant contact the Town of Concord Planning Department to confirm that there are no additional developments that should be included in the traffic volume projections."

Response: The Town of Concord Planning Department noted the creation of two residential building lots on Route 117 adjacent to Nashawtuc Country Club. These developments are accounted for in the background growth rate. The TIAS findings remain valid, no further response necessary.

Comment 9. "Although LUC 251 (Senior Adult Housing—Detached) and LUC 252 (Senior Adult Housing—Attached) would also be applicable to the proposed age-restricted units, we agree with the trip generation calculations provided as they present a conservative analysis."

Response: No further response required.

Comment 10. "We recommend that the Applicant confirm what the intent is with the remaining developable land. If there is a possibility of additional development being proposed, we suggest that the TIAS be revised to include a scenario which represents a full build out of the site to include these units."

Response: The remaining developable land is intended to consist of 6 additional townhome units. **Table R2** provides sensitivity trip generation analysis including the additional units in addition to the age-restricted units compared to the trip generation presented in the January TIAS.

TABLE R2
TRIP-GENERATION COMPARISON

Peak Hour/Direction	TIAS (274 Units)[1]	Townhomes (98 Units)[2]	Apartments (101 Units)[3]	Age Restricted (81 Units)[4]	Difference (Δ)
Weekday Morning Peak Hour:					
Entering	27	10	9	6	-2
Exiting	84	35	27	10	-12
Total	111	45	36	16	-14
Weekday Evening Peak Hour:					
Entering	83	15	27	12	-29
Exiting	52	40	17	9	+14
Total	135	55	44	21	-15
Weekday Daily (24 hours)	1,722	718	550	300	-154

Source: ITE *Trip Generation*, 10th Edition; 2017.
[1]ITE LUC 220 – Multifamily – Low Rise applied to 123 units and ITE LUC 221 – Multifamily – Mid Rise applied to 151 units.
[2]ITE LUC 220 – Multifamily – Low Rise applied to 98 units
[3]ITE LUC 221 – Multifamily – Mid Rise applied to 101 units.
[4]ITE LUC 252 – Senior Adult Housing – Attached applied to 81 units.

As shown in **Table R2**, the sensitivity trip generation analysis indicates lower trip activity than the highly conservative estimates presented in the January 2020 TIAS. Therefore, the finding of the TIAS remain valid and no further analysis is required.

Trip Distribution

Comment 11. "We agree that this methodology is appropriate for the respective land uses."

Response: No further response required.

Comment 12. "Although it is not expected to have a notable impact on the capacity analysis results, it is suggested that the capacity analysis be revised to show all new trips accessing the site through the study area intersections."

Response: The trip distribution patterns based on US Census Journey-to-work data and existing area travel patterns indicate that 10% of the new site trips will utilize local roadways between the study intersections of North Road at Dakin Road/Pantry Road and North Road at Powder Mill Road/Mossman Road. The trips that would travel through the study intersection were appropriately applied in the TIAS, therefore, no further analysis is required.

Parking Generation

Comment 13. "The proposed 766 parking spaces are expected to be adequate for the proposed site based on the Town's Zoning Bylaw."

Response: No further response required.

Traffic Analysis

Comment 14. "We recommend that the Applicant confirm the signal timings with the latest traffic signal plan for North Road (Route 117) at Dakin Road/Pantry Road and update the capacity analysis appropriately."

Response: The signal timings used in the analysis of the North Road (Route 117) intersection with Dakin Road/Pantry Road reflect the existing signal controller settings as documented in the traffic signal inventory conducted for the Town of Sudbury by Ocean State signal in a technical memorandum of November 21, 2018 (see **Attachments**). These represent the latest known traffic signal timings for the intersection. Field review of the signal operations appear to be consistent with the inventory, noting that the signal is actuated and as such subject to varying green time allocation based on time of day and volume conditions. Update of capacity analysis as presented in the TIAS is not warranted; no further response required.

While project impacts at the study location are immaterial and operations are deemed acceptable based on standard transportation engineering analysis practices, MDM notes that the executed Development Agreement between the Developer and the Town of Sudbury includes a $1-million funding obligation for off-site traffic or other mitigation improvements, or improvements not related to costs to the applicant for turning lanes or other safety improvements at the entrance of the Melone Property Development site. This funding provides the Town the means of implementing off-site transportation initiatives at its discretion, including maintenance-related improvements at the Route 117 study intersections (including the expanded Concord location). Detailed inventory of existing signal equipment along North Road including the Concord location indicates such improvements could include repair/replacement or upgrading of signal equipment including associated signal detection equipment. Such upgrades if implemented would allow optimized operations during peak traffic periods, reducing delays and queuing relative to existing conditions. The Traffic Signal Evaluation dated November 21, 2018 prepared for the Town by Ocean State Signal[2] provides specific recommendations for potential improvements, which MDM opines are not warranted by or necessary to support the limited project impacts.

Comment 15. "The capacity analysis indicates that the proposed development is not expected to have a significant impact on the traffic operations at the existing study area intersections. We suggest that additional mitigation measures be considered for potential impacts to additional study area intersections and the proposed site driveway based on recommendations from this review."

Response: The project impacts are immaterial to area intersections including the supplemental location in Concord (Route 1117 at Sudbury Road) and as such do not warrant additional mitigative actions. While project impacts at study location are immaterial and operations at area intersections impacted by the project are deemed acceptable based on standard transportation engineering analysis practices, MDM notes that the executed Development Agreement between the Developer and the Town of Sudbury includes a $1-million funding obligation for off-site traffic or other mitigation improvements, or improvements not related to costs to the applicant for turning lanes or other safety improvements at the entrance of the Melone Property Development site. Implementation of improvements at off-site locations if deemed appropriate by the Town may be achieved by means of funding provided by the Developer as part of the executed Development Agreement.

[2] Technical Memorandum entitled "*Traffic Signal Evaluation at Eight Locations Associated with the Quarry North at Melone Development*", prepared by Ocean State Signal dated November 21, 2018.

Conclusions and Recommendations

Comment 16. "We suggest that the Applicant include any proposed mitigation in their capacity analysis. Analyzing the proposed mitigation alternative should also confirm the storage length requirements for the eastbound left-turn lane. Additional mitigation alternatives that we suggest the Applicant consider include:

- *Providing a two-lane exit at the site driveway to include separate left-turn and right-turn lanes.*
- *Completing a signal warrant analysis at the site driveway to verify the appropriate traffic control. If a traffic signal is warranted, the project team should explore the feasibility of constructing a new traffic signal."*

Response: Proposed mitigation is limited to access improvements along Route 117 at the Site Driveway that conform to the executed Development Agreement between the Developer and the Town which includes an exclusive left-turn lane. A capacity analysis of site driveway with left-turn lane along Route 117 is provided in the **Attachments,** indicating LOS C or better operations during peak hours. The design of the storage lane allows for queue storage of more than 4 vehicles (notwithstanding that average left-turn queues are only one vehicle) which allows for proper lane tapering and deceleration requirements based on the regulatory travel speeds along North Road. The engineering design submittals to be provided to the Town for approval of the improvements will include applicable taper and lane storage calculations.

The Site Driveway has been designed to provide a single wide egress lane; separate turn lanes are not justified based on the limited project volumes and are not preferred due to potential sight line blockages that could occur if such a design were provided.

A review of a 4-hour traffic signal warrants (see **Attachments**) indicates that traffic signals are not warranted at Site Driveway intersection along North Street.

ATTACHMENTS

- Expanded Traffic Analysis Memorandum
- Crash Data
- Trip Generation
- Signal Warrant Analysis
- Left Turn Lane Analysis
- Traffic Signal Inventory

□ Expanded Traffic Analysis Memorandum

MDM TRANSPORTATION CONSULTANTS, INC.
Planners & Engineers

PRINCIPALS
Robert J. Michaud, P.E.
Daniel J. Mills, P.E., PTOE

MEMORANDUM

DATE: June 2, 2019

TO: Chris Claussen
Quarry North LLC
379 Concord Road
Sudbury, MA 01776

FROM: Robert J. Michaud, P.E. – Managing Principal
Daniel A. Dumais, P.E. – Senior Project Manager

RE: **Cold Brook Crossing – Expanded Analysis (Route 117 at Sudbury Road)**
North Road, Sudbury, MA

MDM Transportation Consultants, Inc. (MDM) has prepared an expanded analysis of traffic impacts to augment the *Traffic Impact and Access Study* prepared for the Cold Brook Crossing[1] development to examine the impact of the development on the signalized intersection of Fitchburg Turnpike (Route 117) and Sudbury Road in the Town of Concord, MA. The location of the Site relative to the expanded study area is shown in **Figure 1** for reference. This expanded analysis documents existing operational and safety-related characteristics of the intersection, estimates future year operating characteristics independent of the development, and identifies incremental impacts of Site-related traffic.

The expanded traffic assessment indicates that intersections along North Road from Nine Acres Corners in Concord to Powder Mill Road in Sudbury will not be materially impacted as the result of the development. Key findings of the expanded analysis are as follows:

- *Below Average Crash Rates.* The supplemental study intersection of Route 117 at Sudbury Road exhibits a crash rate that is below state average and is not listed by MassDOT as Highway Safety Improvement Project (HSIP) high crash locations; therefore, no immediate safety countermeasures are warranted based on the crash history at study intersections.

[1] *TIAS, Cold Brook Crossing – North Road, Sudbury, MA,* prepared by MDM Transportation Consultants, Inc. (February 2020).

Figure 1

Site Location

MDM TRANSPORTATION CONSULTANTS, INC.
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Date: May 2020
Dwg No. 1073 Sensitivity.dwg

- *Adequate Roadway Capacity & Operations*. Operations at the signalized intersection of Route 117 at Sudbury Road are below capacity at level-of-service (LOS) C or better under Baseline and future-year analysis scenarios. Incremental traffic associated with the proposed development results in no material impact to operating conditions at the signalized study intersection compared to No-Build conditions.

In summary, the incremental traffic associated with the proposed development is not expected to materially impact operating conditions at the signalized study intersection of Route 117 at Sudbury Road compared to No-Build conditions. The intersection will continue to operate below capacity at LOS C or better during the peak hours with a nominal increase in vehicle queues. The study intersection exhibited below-average crash rates based on historic crash data and is not listed as an HSIP location. The analysis indicates that neither capacity nor safety countermeasures are warranted to mitigate project impacts – a finding that is consistent with analysis of other locations along North Road including that indicates leading to the submitted February 2020 TIAS which includes the intersections of Pantry Road/Dakin Road and Powder Mill Road/Mossman Road. Applicant-sponsored access/egress improvements, and a robust TDM plan as outlined in the *Conclusions and Recommendations* section of the submitted February 2020 TIAS will enhance site access/egress, enhance pedestrian and bicycle accommodations on-site, and to reduce dependency on single-occupant auto use.

While project impacts at the study location are immaterial and operations are deemed acceptable based on standard transportation engineering analysis practices, MDM notes that the executed Development Agreement between the Developer and the Town of Sudbury includes a $1-million funding obligation for off-site traffic or other mitigation improvements, or improvements not related to costs to the applicant for turning lanes or other safety improvements at the entrance of the Melone Property Development site. This funding provides the Town the means of implementing off-site transportation initiatives at its discretion, including maintenance-related improvements at the Route 117 study intersections (including the expanded Concord location). Detailed inventory of existing signal equipment along North Road including the Concord location indicates such improvements could include repair/replacement or upgrading of signal equipment including associated signal detection equipment. Such upgrades if implemented would allow optimized operations during peak traffic periods, reducing delays and queuing relative to existing conditions. The Traffic Signal Evaluation dated November 21, 2018 prepared for the Town by Ocean State Signal[2] provides specific recommendations for potential improvements, which MDM opines are not warranted by or necessary to support the limited project impacts.

EXISTING CONDITIONS

An overview of existing (Baseline) roadway conditions, traffic volumes and safety characteristics is provided below.

[2] Technical Memorandum entitled "*Traffic Signal Evaluation at Eight Locations Associated with the Quarry North at Melone Development*", prepared by Ocean State Signal dated November 21, 2018.

Fitchburg Turnpike (Route 117) at Sudbury Road

Route 117 meets Sudbury Road to form a four-way, signalized intersection. The Route 117 eastbound and westbound approaches provide an exclusive left turn lane, an exclusive through lane, and an exclusive channelized right-turn lane. The Sudbury Road northbound approach provides a single shared left/through/right lane while the southbound approach provides two travel lanes: one exclusive left turn lane and a shared through/right-turn lane. Land use at the intersection consists of a convenience store, a pizzeria, a liquor store and an auto repair service.

Baseline Traffic Data

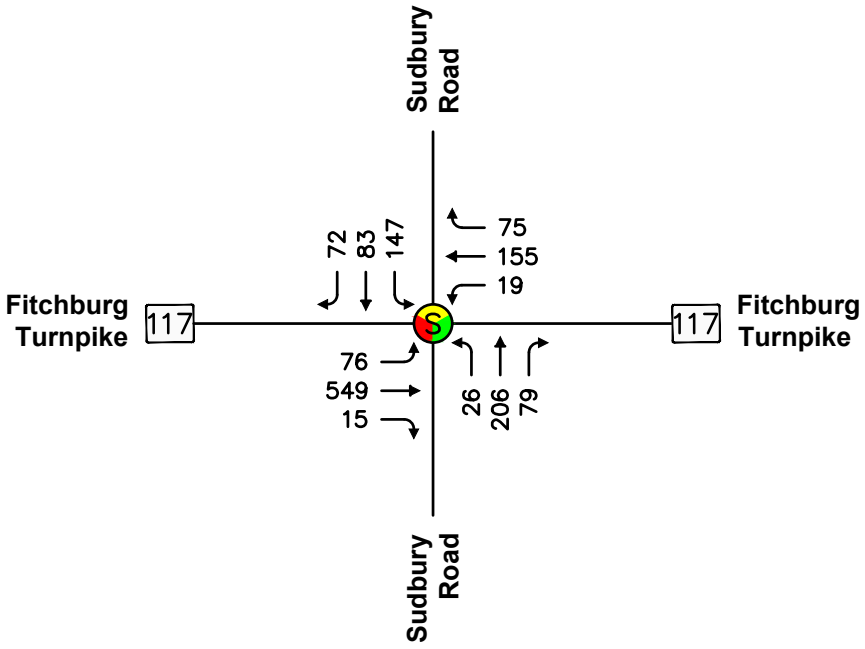
Traffic volume data was obtained for study area intersections from the Melone Residential Development Traffic Impact Study prepared by McMahon Associates, Inc.[3] the for the weekday morning (7:00 AM – 9:00 AM) and the weekday evening (4:00 PM - 6:00 PM) peak traffic periods. Traffic data used in this evaluation were collected in September 2018, which is a period which represents average traffic conditions based on review of MassDOT permanent count station data for the area; therefore, no seasonal adjustment was required. To remain consistent with the TIAS[4], the counts we adjusted by 0.5% to represent 2020 Baseline conditions. Turning movement counts and permanent count station data are provided in the **Attachments**. The Baseline weekday morning and weekday evening peak hour traffic volumes are shown in **Figure 2**.

Safety

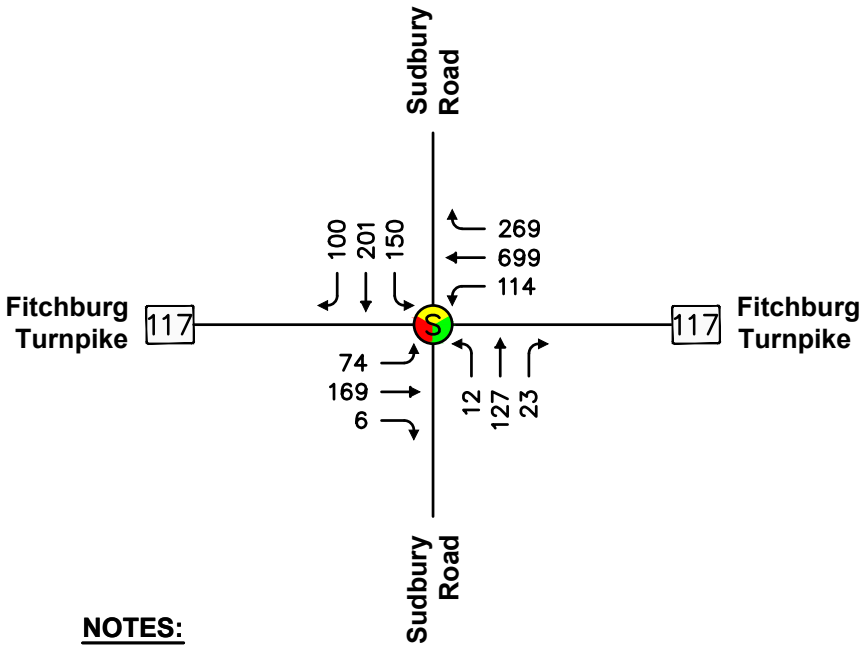
In order to identify crash trends and safety characteristics for study intersection, crash data was obtained from MassDOT for the Town of Concord for the five-year period 2015 through 2019 (the most recent full year of data currently available from MassDOT). Crash data for the study intersections is summarized in **Table 1** with detailed data provided in the **Attachments.**

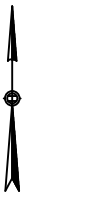
Crash rates were calculated for the study intersection as reported in **Table 1**. This rate quantifies the number of crashes per million entering vehicles. MassDOT has determined the official District 4 (which includes the Town of Concord) crash rate to be 0.89 for signalized intersections. This rate represents MassDOT's "average" crash experience for District 3 communities and serves as a basis for comparing reported crash rates for the study intersections. Where calculated crash rates notably exceed the district average, some form of safety countermeasures may be warranted. In addition, review of the MassDOT high crash cluster mapping was conducted to determine locations listed as eligible for Highway Safety Improvement Program (HSIP) evaluation and funding.

[3] *TIS, Melone Residential Development – North Road, Sudbury, MA,* prepared by McMahon Associates, Inc. (October 2018).
[4] *TIAS, Cold Brook Crossing – North Road, Sudbury, MA,* prepared by MDM Transportation Consultants, Inc. (February 2020).



Weekday Morning Peak Hour





North
Scale: Not to Scale

NOTES:
NEGL.= Negligible
S = Signalized Intersection

Weekday Evening Peak Hour

Figure 2

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2020 Baseline Conditions
Weekday Peak Hour Volumes

Date: May 2020
Dwg No. 1073 Sensitivity.dwg

As summarized in **Table 1**, a total of twenty-seven (27) crashes were reported for the signalized intersection of Route 117 and Sudbury Road. The resulting crash rate of 0.70 is lower than the District 4 average. The reported crashes included fifteen (15) angle/ sideswipe type collisions, six (6) rear-end type collisions, three (3) head-on type collision, one (1) single vehicle collision and two (2) unknown or unreported type collisions. Eighty-one percent (81%) of the crashes resulted in property-damage only, generally indicative of low-speed crashes. No fatalities or pedestrian-related incidents were reported during the study period. In summary, the crash rates at the study intersection is lower than the District 4 average crash rate and are not listed as an HSIP location. No immediate safety countermeasures are warranted based on the crash history at the study location.

TABLE 1
INTERSECTION CRASH SUMMARY — 2015 THROUGH 2019[1]

Data Category	Route 117 at Sudbury Road
Traffic Control	Signalized
Crash Rate[2] [3]	**0.70**
MHD District 4 Avg.[3]	0.73
Year:	
2015	8
2016	5
2017	2
2018	3
2019	9
Total	27
Type:	
Angle	14
Rear-End	6
Head-On	3
Sideswipe	1
Single Vehicle	1
Other/Unknown	2
Severity:	
P. Damage Only	22
Personal Injury	5
Fatality	0
Other/Unknown	0
Conditions:	
Dry	22
Wet	3
Snow	1
Other	1
Time:	
7:00 to 9:00 AM	4
4:00 to 6:00 PM	6
Rest of Day	17

[1]Source: MassDOT Crash Database
[2]Crashes per million entering vehicles
[3]District 4 average = 0.73 for signalized intersections

FUTURE CONDITIONS

The future (No-Build and Build) roadway conditions were developed following the procedure laid out in the February TIAS and the analysis includes the following assumptions expanded to the signalized Route 117 at Sudbury Road intersection:

- A 1-percent annual growth rate was applied to Baseline traffic volumes over a seven-year period.

- Traffic associated with the build-out of Maynard Crossing were added to the future networks. Background trip tracings are provided in the **Attachments**. Future 2027 No-Build traffic volumes are displayed in **Figure 3**.

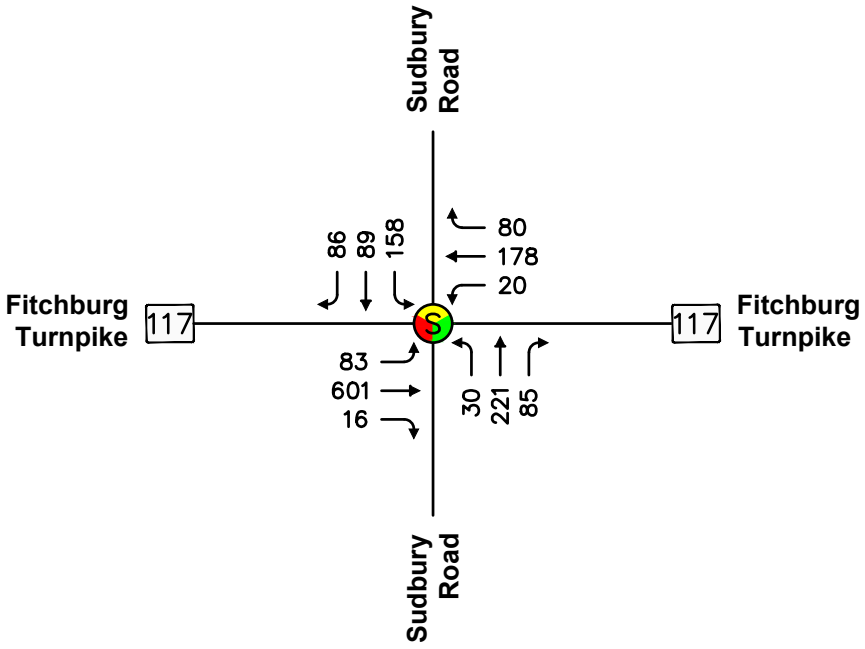
- The distribution for projected traffic for the proposed development is based primarily on Journey to Work Census data for persons living within the Town of Sudbury. The resulting trip distribution for new trips is presented in **Figure 4**.

- Development-related trips for the proposed development are assigned to the roadway network using the ITE trip-generation estimates presented in the February TIAS and the distribution patterns presented in **Figure 4**. Development-related trips at each intersection approach for the weekday morning and weekday evening peak hours are quantified in **Figure 5**.

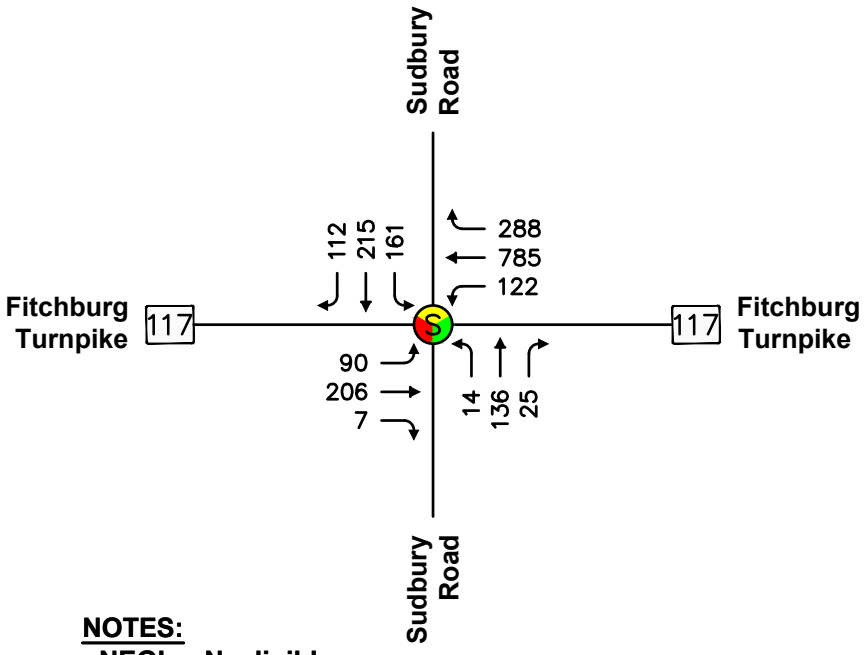
- 2027 Build condition traffic volumes are derived by adding the incremental traffic increases for development to the 2027 No-Build conditions. **Figure 6** presents the 2027 Build condition traffic-volume networks for the weekday morning and weekday evening peak hours.

Intersection Capacity Analysis Results

Level-of-Service (LOS) analyses were conducted for the Baseline, 2027 No-Build, and 2027 Build conditions for the signalized study intersection. The results of the intersection capacity are summarized below in **Table 2**. Detailed analysis results are presented in the **Attachments**.



Weekday Morning Peak Hour



North
Scale: Not to Scale

NOTES:
NEGL.= Negligible
S = Signalized Intersection

Weekday Evening Peak Hour

Figure 3

MDM TRANSPORTATION CONSULTANTS, INC.
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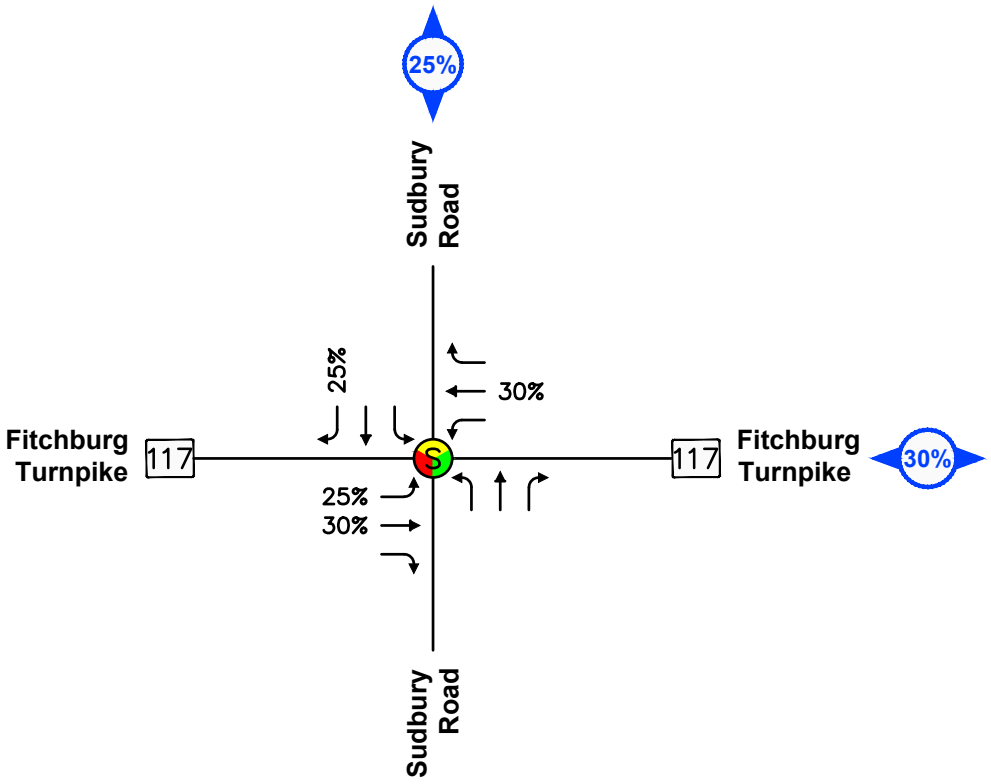
2027 No-Build Conditions
Weekday Peak Hour Volumes

Date: May 2020
Dwg No. 1073 Sensitivity.dwg



North
Scale: Not to Scale

NOTES:

S = Signalized Intersection

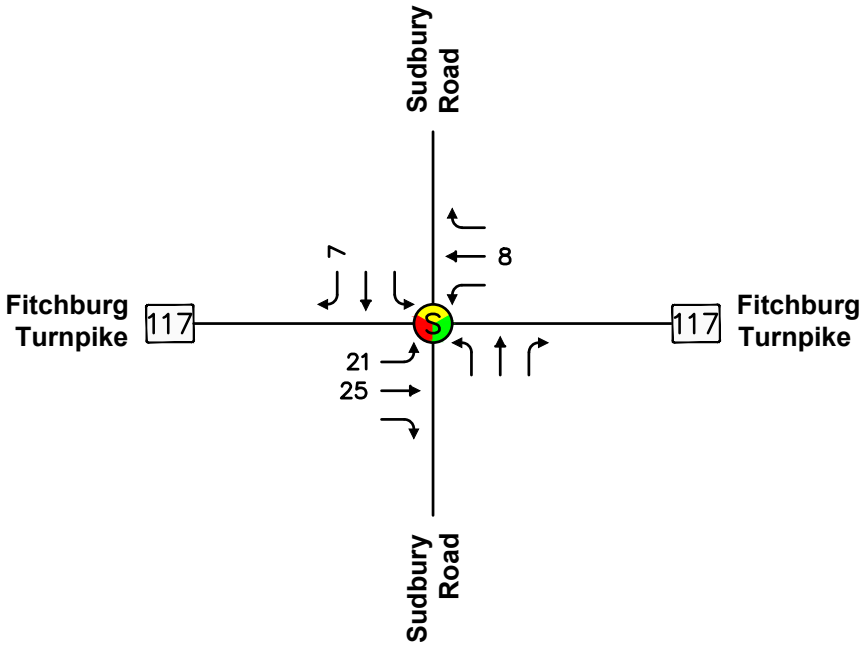
Figure 4

Trip Distribution

MDM TRANSPORTATION CONSULTANTS, INC.
Planners & Engineers

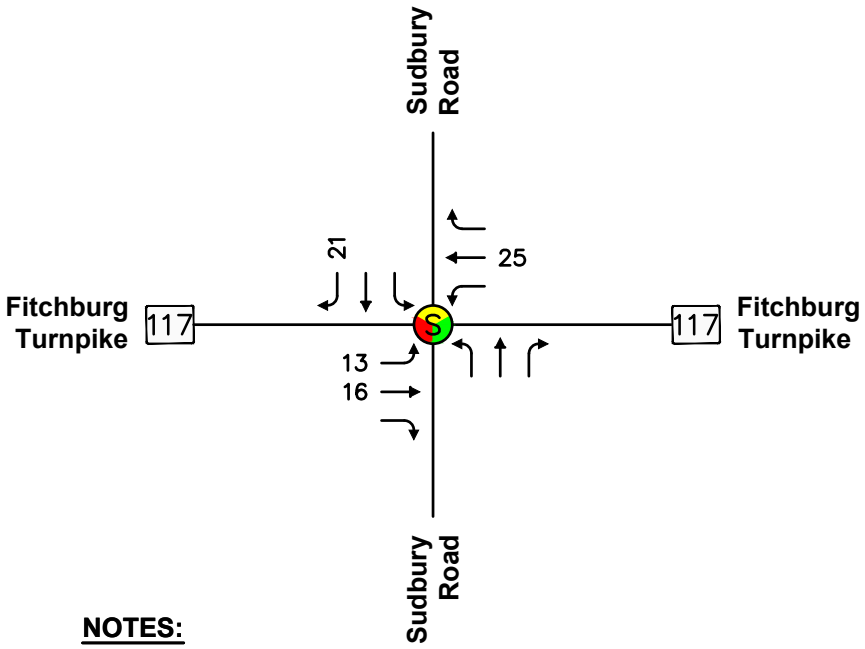
Date: May 2020
Dwg No. 1073 Sensitivity.dwg

SITE TRIPS	
Enter	27
Exit	84
Total	111



Weekday Morning Peak Hour

SITE TRIPS	
Enter	83
Exit	52
Total	135



North
Scale: Not to Scale

NOTES:
NEGL.= Negligible
S = Signalized Intersection

Weekday Evening Peak Hour

Figure 5

MDM TRANSPORTATION CONSULTANTS, INC.
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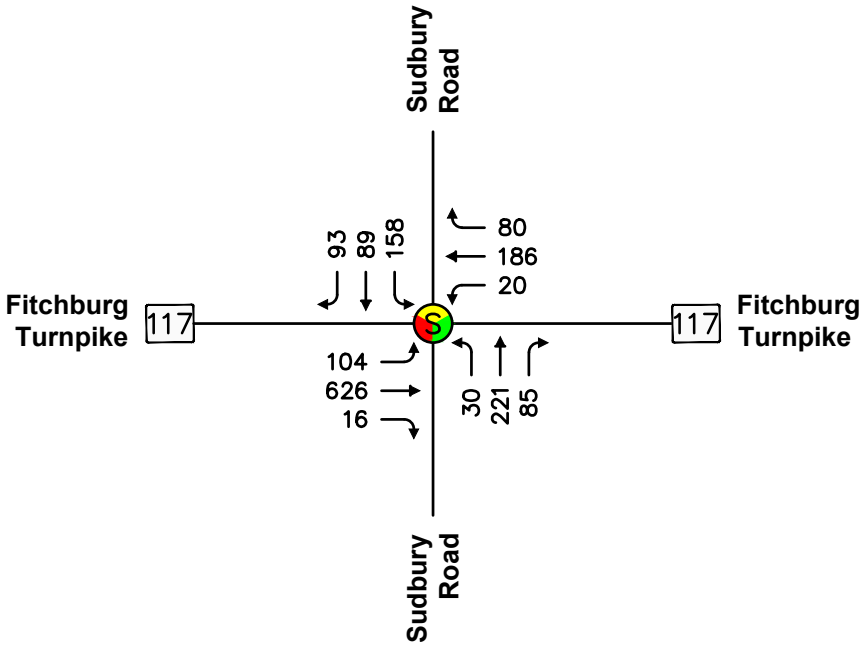
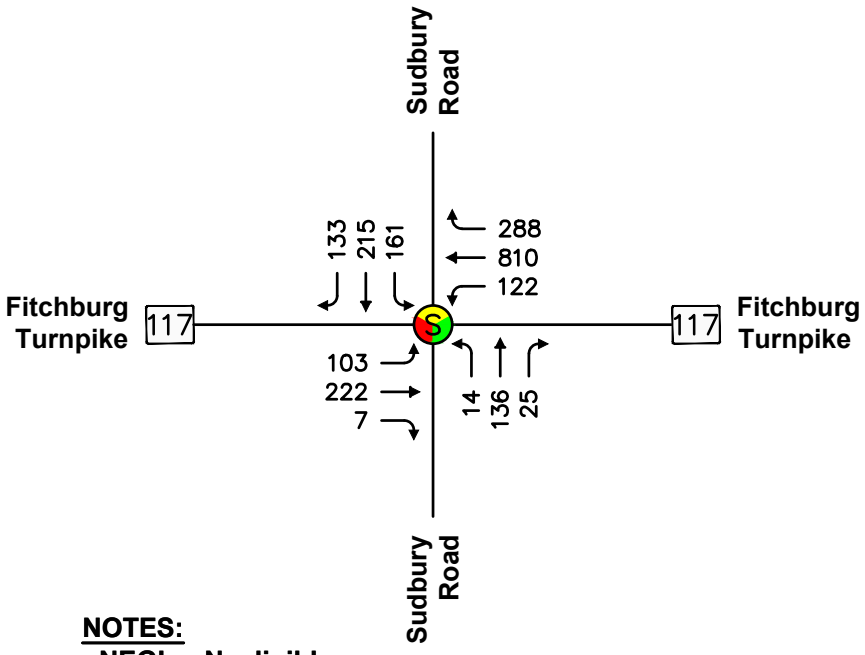
Site Generated Trips
Weekday Peak Hour Volumes

Date: May 2020
Dwg No. 1073 Sensitivity.dwg



Weekday Morning Peak Hour



North
Scale: Not to Scale

NOTES:
NEGL.= Negligible
= Signalized Intersection

Weekday Evening Peak Hour

Figure 6

MDM TRANSPORTATION CONSULTANTS, INC.
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2027 Build Conditions
Weekday Peak Hour Volumes

Date: May 2020
Dwg No. 1073 Sensitivity.dwg

TABLE 2
INTERSECTION CAPACITY ANALYSIS RESULTS
FITCHBURG TURNPIKE (ROUTE 117) AT SUDBURY ROAD

		Baseline			2027 No-Build			2027 Build		
Period	Approach	v/c[1]	Delay[2]	LOS[3]	v/c	Delay	LOS	v/c	Delay	LOS
Weekday Morning	Eastbound	0.70	15	B	0.76	17	B	0.76	17	B
Peak hour	Westbound	0.20	7	A	0.22	7	A	0.23	7	A
	Northbound	0.58	19	B	0.60	21	C	0.61	22	C
	Southbound	0.54	18	B	0.58	20	B	0.61	21	C
	Overall	**0.70**	**15**	**B**	**0.76**	**17**	**B**	**0.76**	**17**	**B**
Weekday Evening	Eastbound	0.29	8	A	0.46	11	B	0.56	13	B
Peak Hour	Westbound	0.72	12	B	0.78	14	B	0.80	14	B
	Northbound	0.34	19	B	0.35	20	B	0.36	20	B
	Southbound	0.62	23	C	0.67	29	C	0.69	30	C
	Overall	**0.72**	**14**	**B**	**0.78**	**17**	**B**	**0.80**	**18**	**B**

[1]Volume-to-capacity ratio
[2]Average control delay per vehicle (in seconds)
[3]Level of service

As shown in **Table 2**, the proposed development is expected to have no material change in delays at signalized study intersection of Route 117 at Sudbury Road. Operations at the signalized Main Street at Salisbury Street intersection are projected to remain at an overall LOS B during peak hours. The proposed development is expected to have minimal impact on the signalized study intersection and will not result in any material changes in traffic operations in the study area relative to No-Build conditions with each approach to the intersection continuing to operate at LOS C or better during the peak hours.

Independent Traffic Signal Inventory

The signal timings used in the analysis of the Route 117 at Sudbury Road intersection were obtained from an independent third-party traffic signal inventory prepared by Ocean State signal on November 21, 2018[5] (see **Attachments**). These represent the latest known traffic signal timings for the intersection and provide an inventory of the traffic signal equipment. The signal inventory identified that the Sudbury Road northbound approach had malfunctioning vehicle loop detection and the intersection was observed to gap out for the mainline Route 117 approaches due to vehicle platooning during the peak hours.

Signal Queue Impacts

Vehicle queue results are presented for the signalized study intersection. These vehicle queues are compared to available storage lengths, which are defined as lengths of exclusive turn lanes or the distance to the nearest major intersection for through lanes. Vehicle queue results from the capacity analysis are summarized in **Table 3**. The estimated queue lengths are based on the

[5] Ibid.

capacity analysis results provided using Synchro computer software. Detailed worksheets of the queuing analysis are provided in the **Attachments**.

TABLE 3
VEHICLE QUEUE ANALYSIS SUMMARY
FITCHBURG TURNPIKE (ROUTE 117) AT SUDBURY ROAD

		2027 No-Build		2027 Build	
Approach	Storage Length (feet)	Average Queue Length[1]	95th Percentile Queue Length[1]	Average Queue Length	95th Percentile Queue Length
Weekday Morning Peak Hour					
Eastbound L	225±	<25	35	<25	43
Eastbound T	>1000	163	259	174	277
Eastbound R	50±	<25	<25	<25	<25
Westbound L	100±	<25	<25	<25	<25
Westbound T	>1000	35	64	37	66
Westbound R	60±	<25	<25	<25	16
Northbound L/T/R	>1000	83	243	89	244
Southbound L	170±	42	155	45	158
Southbound T/R	>1000	25	88	28	90
Weekday Evening Peak Hour					
Eastbound L	225±	<25	61	25	87
Eastbound T	>1000	38	69	42	75
Eastbound R	50±	<25	<25	<25	<25
Westbound L	100±	<25	48	<25	48
Westbound T	>1000	221	367	237	388
Westbound R	60±	39	80	41	80
Northbound L/T/R	>1000	50	105	52	105
Southbound L	170±	56	144	58	145
Southbound T/R	>1000	99	190	109	201

[1]Average and 95th percentile queue lengths are reported in feet per lane.

As summarized in **Table 3**, under Build conditions the average and 95th percentile queue lengths will generally remain within the available storage lengths. The project will result in a change in queue lengths of 1 vehicle or less during peak hours.

In summary, project trips represent less than a 4 percent change in No Build peak hour traffic volumes, do not result any material increases in intersection delays or vehicle queues relative to No Build conditions. Mitigative actions are therefore not warranted or necessary to support the proposed development.

CONCLUSIONS

In summary, the incremental traffic associated with the proposed development is not expected to materially impact operating conditions at the signalized study intersection of Route 117 at Sudbury Road compared to No-Build conditions. The intersection will continue to operate below capacity at LOS C or better during the peak hours with a nominal increase in vehicle queues. The study intersection exhibited below-average crash rates based on historic crash data and is not listed as an HSIP location. The analysis indicates that neither capacity nor safety countermeasures are warranted to mitigate project impacts – a finding that is consistent with analysis of other locations along North Road including that indicates leading to the submitted February 2020 TIAS which includes the intersections of Pantry Road/Dakin Road and Powder Mill Road/Mossman Road. Applicant-sponsored access/egress improvements, and a robust TDM plan as outlined in the *Conclusions and Recommendations* section of the submitted February 2020 TIAS will enhance site access/egress, enhance pedestrian and bicycle accommodations on-site, and to reduce dependency on single-occupant auto use.

While project impacts at the study location are immaterial and operations are deemed acceptable based on standard transportation engineering analysis practices, MDM notes that the executed Development Agreement between the Developer and the Town of Sudbury includes a $1-million funding obligation for off-site traffic or other mitigation improvements, or improvements not related to costs to the applicant for turning lanes or other safety improvements at the entrance of the Melone Property Development site. This funding provides the Town the means of implementing off-site transportation initiatives at its discretion, including maintenance-related improvements at the Route 117 study intersections (including the expanded Concord location). Detailed inventory of existing signal equipment along North Road including the Concord location indicates such improvements could include repair/replacement or upgrading of signal equipment including associated signal detection equipment. Such upgrades if implemented would allow optimized operations during peak traffic periods, reducing delays and queuing relative to existing conditions. The Traffic Signal Evaluation dated November 21, 2018 prepared for the Town by Ocean State Signal[6] provides specific recommendations for potential improvements, which MDM opines are not warranted by or necessary to support the limited project impacts.

[6] Technical Memorandum entitled "*Traffic Signal Evaluation at Eight Locations Associated with the Quarry North at Melone Development*", prepared by Ocean State Signal dated November 21, 2018.

ATTACHMENTS

- Traffic Volume Data
- Seasonal/ Yearly Growth Data
- Crash Data
- Background Projects
- Capacity Analysis
- Traffic Signal Inventory

□ Traffic Volume Data

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120 Water Street, 4th Floor
Boston, MA 02109
617-556-0020

N/S: Sudbury Road
E/W: Fitchburg Turnpike (Route 117)
Sudbury, MA
Weekday AM

File Name : AM_Fitchburg Tpk at Sudbury Rd
Site Code : 09201801
Start Date : 9/20/2018
Page No : 1

Groups Printed- Cars & Peds - Heavy Vehicles

	Sudbury Road From North					Fitchburg Turnpike (Route 117) From East					Sudbury Road From South					Fitchburg Turnpike (Route 117) From West					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
07:00 AM	7	16	42	0	65	11	22	3	0	36	31	54	0	0	85	1	143	19	0	163	349
07:15 AM	17	22	35	0	74	17	17	5	0	39	33	52	0	0	85	0	145	18	0	163	361
07:30 AM	14	20	53	0	87	19	28	4	0	51	20	38	7	0	65	0	126	19	0	145	348
07:45 AM	15	17	37	0	69	10	47	8	0	65	17	58	23	0	98	6	126	15	0	147	379
Total	53	75	167	0	295	57	114	20	0	191	101	202	30	0	333	7	540	71	0	618	1437
08:00 AM	22	14	33	0	69	18	32	4	0	54	12	37	3	0	52	7	128	19	0	154	329
08:15 AM	14	25	37	0	76	18	38	3	0	59	15	53	0	0	68	2	160	18	0	180	383
08:30 AM	20	26	39	1	86	28	36	4	0	68	34	56	0	0	90	0	130	23	0	153	397
08:45 AM	22	25	38	0	85	23	34	7	0	64	26	27	1	0	54	3	126	46	0	175	378
Total	78	90	147	1	316	87	140	18	0	245	87	173	4	0	264	12	544	106	0	662	1487
Grand Total	131	165	314	1	611	144	254	38	0	436	188	375	34	0	597	19	1084	177	0	1280	2924
Apprch %	21.4	27	51.4	0.2		33	58.3	8.7	0		31.5	62.8	5.7	0		1.5	84.7	13.8	0		
Total %	4.5	5.6	10.7	0	20.9	4.9	8.7	1.3	0	14.9	6.4	12.8	1.2	0	20.4	0.6	37.1	6.1	0	43.8	
Cars & Peds	120	150	301	0	571	138	244	34	0	416	182	357	31	0	570	16	1053	172	0	1241	2798
% Cars & Peds	91.6	90.9	95.9	0	93.5	95.8	96.1	89.5	0	95.4	96.8	95.2	91.2	0	95.5	84.2	97.1	97.2	0	97	95.7
Heavy Vehicles	11	15	13	1	40	6	10	4	0	20	6	18	3	0	27	3	31	5	0	39	126
% Heavy Vehicles	8.4	9.1	4.1	100	6.5	4.2	3.9	10.5	0	4.6	3.2	4.8	8.8	0	4.5	15.8	2.9	2.8	0	3	4.3

	Sudbury Road From North					Fitchburg Turnpike (Route 117) From East					Sudbury Road From South					Fitchburg Turnpike (Route 117) From West					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
Peak Hour Analysis From 07:00 AM to 08:45 AM - Peak 1 of 1																					
Peak Hour for Entire Intersection Begins at 07:45 AM																					
07:45 AM	15	17	37	0	69	10	**47**	**8**	0	65	17	**58**	**23**	0	**98**	6	126	15	0	147	379
08:00 AM	**22**	14	33	0	69	18	32	4	0	54	12	37	3	0	52	**7**	128	19	0	154	329
08:15 AM	14	25	37	0	76	18	38	3	0	59	15	53	0	0	68	2	**160**	18	0	**180**	383
08:30 AM	20	**26**	**39**	**1**	**86**	**28**	36	4	0	**68**	**34**	56	0	0	90	0	130	**23**	0	153	**397**
Total Volume	71	82	146	1	300	74	153	19	0	246	78	204	26	0	308	15	544	75	0	634	1488
% App. Total	23.7	27.3	48.7	0.3		30.1	62.2	7.7	0		25.3	66.2	8.4	0		2.4	85.8	11.8	0		
PHF	.807	.788	.936	.250	.872	.661	.814	.594	.000	.904	.574	.879	.283	.000	.786	.536	.850	.815	.000	.881	.937

120 Water Street, 4th Floor
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617-556-0020

N/S: Sudbury Road
E/W: Fitchburg Turnpike (Route 117)
Sudbury, MA
Weekday AM

File Name : AM_Fitchburg Tpk at Sudbury Rd
Site Code : 09201801
Start Date : 9/20/2018
Page No : 1

Groups Printed- Heavy Vehicles

	Sudbury Road From North					Fitchburg Turnpike (Route 117) From East					Sudbury Road From South					Fitchburg Turnpike (Route 117) From West					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
07:00 AM	2	1	3	0	6	0	2	2	0	4	1	1	0	0	2	0	3	0	0	3	15
07:15 AM	0	0	2	0	2	1	0	0	0	1	2	4	0	0	6	0	6	1	0	7	16
07:30 AM	2	2	1	0	5	0	1	0	0	1	0	3	0	0	3	0	2	0	0	2	11
07:45 AM	0	2	1	0	3	2	1	0	0	3	0	4	3	0	7	0	3	1	0	4	17
Total	4	5	7	0	16	3	4	2	0	9	3	12	3	0	18	0	14	2	0	16	59
08:00 AM	3	2	2	0	7	1	1	1	0	3	1	1	0	0	2	1	6	1	0	8	20
08:15 AM	1	2	1	0	4	0	1	0	0	1	1	3	0	0	4	1	4	0	0	5	14
08:30 AM	1	1	2	1	5	1	1	1	0	3	1	2	0	0	3	0	4	1	0	5	16
08:45 AM	2	5	1	0	8	1	3	0	0	4	0	0	0	0	0	1	3	1	0	5	17
Total	7	10	6	1	24	3	6	2	0	11	3	6	0	0	9	3	17	3	0	23	67
Grand Total	11	15	13	1	40	6	10	4	0	20	6	18	3	0	27	3	31	5	0	39	126
Apprch %	27.5	37.5	32.5	2.5		30	50	20	0		22.2	66.7	11.1	0		7.7	79.5	12.8	0		
Total %	8.7	11.9	10.3	0.8	31.7	4.8	7.9	3.2	0	15.9	4.8	14.3	2.4	0	21.4	2.4	24.6	4	0	31	

	Sudbury Road From North					Fitchburg Turnpike (Route 117) From East					Sudbury Road From South					Fitchburg Turnpike (Route 117) From West					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
Peak Hour Analysis From 07:00 AM to 08:45 AM - Peak 1 of 1																					
Peak Hour for Entire Intersection Begins at 07:45 AM																					
07:45 AM	0	**2**	1	0	3	**2**	**1**	0	0	**3**	0	**4**	**3**	0	**7**	0	3	**1**	0	4	17
08:00 AM	**3**	2	**2**	0	**7**	1	1	**1**	0	3	**1**	1	0	0	2	**1**	**6**	1	0	**8**	**20**
08:15 AM	1	2	1	0	4	0	1	0	0	1	1	3	0	0	4	1	4	0	0	5	14
08:30 AM	1	1	2	**1**	5	1	1	1	0	3	1	2	0	0	3	0	4	1	0	5	16
Total Volume	5	7	6	1	19	4	4	2	0	10	3	10	3	0	16	2	17	3	0	22	67
% App. Total	26.3	36.8	31.6	5.3		40	40	20	0		18.8	62.5	18.8	0		9.1	77.3	13.6	0		
PHF	.417	.875	.750	.250	.679	.500	1.000														

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N/S: Sudbury Road
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Sudbury, MA
Weekday AM

File Name : AM_Fitchburg Tpk at Sudbury Rd
Site Code : 09201801
Start Date : 9/20/2018
Page No : 1

Groups Printed- Bikes by Direction

	Sudbury Road From North					Fitchburg Turnpike (Route 117) From East					Sudbury Road From South					Fitchburg Turnpike (Route 117) From West					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
07:00 AM	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1
07:15 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
07:30 AM	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
07:45 AM	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1
Total	0	1	0	0	1	0	0	0	0	0	0	2	0	0	2	0	0	0	0	0	3
08:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1
08:15 AM	0	0	0	0	0	0	1	0	0	1	1	0	0	0	1	0	0	0	0	0	2
08:30 AM	0	2	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
08:45 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	2	0	0	2	0	1	0	0	1	1	0	0	0	1	0	1	0	0	1	5
Grand Total	0	3	0	0	3	0	1	0	0	1	1	2	0	0	3	0	1	0	0	1	8
Apprch %	0	100	0	0		0	100	0	0		33.3	66.7	0	0		0	100	0	0		
Total %	0	37.5	0	0	37.5	0	12.5	0	0	12.5	12.5	25	0	0	37.5	0	12.5	0	0	12.5	

	Sudbury Road From North					Fitchburg Turnpike (Route 117) From East					Sudbury Road From South					Fitchburg Turnpike (Route 117) From West					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
Peak Hour Analysis From 07:00 AM to 08:45 AM - Peak 1 of 1																					
Peak Hour for Entire Intersection Begins at 07:45 AM																					
07:45 AM	0	0	0	0	0	0	0	0	0	0	0	**1**	0	0	**1**	0	0	0	0	0	1
08:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**	0	0	**1**	1
08:15 AM	0	0	0	0	0	0	**1**	0	0	**1**	**1**	0	0	0	1	0	0	0	0	0	**2**
08:30 AM	0	**2**	0	0	**2**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Total Volume	0	2	0	0	2	0	1	0	0	1	1	1	0	0	2	0	1	0	0	1	6
% App. Total	0	100	0	0		0	100	0	0		50	50	0	0		0	100	0	0		
PHF	.000	.250	.000	.000	.250	.000	.250	.000	.000	.250	.250	.250	.000	.000	.500	.000	.250	.000	.000	.250	.750

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N/S: Sudbury Road
E/W: Fitchburg Turnpike (Route 117)
Sudbury, MA
Weekday PM

File Name : PM_Fitchburg Tpk at Sudbury Rd
Site Code : 09281803
Start Date : 9/27/2018
Page No : 1

Groups Printed- Cars & Peds - Heavy Vehicles

	Sudbury Road From North					Fitchburg Turnpike (Route 117) From East					Sudbury Road From South					Fitchburg Turnpike (Route 117) From West					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
04:00 PM	31	38	22	0	91	71	167	20	0	258	5	37	1	0	43	1	41	18	0	60	452
04:15 PM	29	52	32	0	113	61	171	23	0	255	4	27	4	0	35	0	35	22	0	57	460
04:30 PM	27	57	37	0	121	56	169	41	0	266	5	23	4	0	32	1	30	20	0	51	470
04:45 PM	22	56	20	1	99	54	174	35	0	263	6	17	3	0	26	1	40	12	0	53	441
Total	109	203	111	1	424	242	681	119	0	1042	20	104	12	0	136	3	146	72	0	221	1823
05:00 PM	19	39	39	0	97	66	177	31	0	274	1	30	5	0	36	1	47	22	0	70	477
05:15 PM	27	43	30	1	101	74	182	30	0	286	1	36	3	0	40	1	36	17	0	54	481
05:30 PM	30	63	38	0	131	60	163	28	0	251	9	33	1	1	44	3	38	19	0	60	486
05:45 PM	23	54	42	0	119	66	170	24	0	260	12	27	3	0	42	1	46	15	0	62	483
Total	99	199	149	1	448	266	692	113	0	1071	23	126	12	1	162	6	167	73	0	246	1927
Grand Total	208	402	260	2	872	508	1373	232	0	2113	43	230	24	1	298	9	313	145	0	467	3750
Apprch %	23.9	46.1	29.8	0.2		24	65	11	0		14.4	77.2	8.1	0.3		1.9	67	31	0		
Total %	5.5	10.7	6.9	0.1	23.3	13.5	36.6	6.2	0	56.3	1.1	6.1	0.6	0	7.9	0.2	8.3	3.9	0	12.5	
Cars & Peds	203	394	259	2	858	504	1357	230	0	2091	42	227	24	1	294	9	310	143	0	462	3705
% Cars & Peds	97.6	98	99.6	100	98.4	99.2	98.8	99.1	0	99	97.7	98.7	100	100	98.7	100	99	98.6	0	98.9	98.8
Heavy Vehicles	5	8	1	0	14	4	16	2	0	22	1	3	0	0	4	0	3	2	0	5	45
% Heavy Vehicles	2.4	2	0.4	0	1.6	0.8	1.2	0.9	0	1	2.3	1.3	0	0	1.3	0	1	1.4	0	1.1	1.2

	Sudbury Road From North					Fitchburg Turnpike (Route 117) From East					Sudbury Road From South					Fitchburg Turnpike (Route 117) From West					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
Peak Hour Analysis From 04:00 PM to 05:45 PM - Peak 1 of 1																					
Peak Hour for Entire Intersection Begins at 05:00 PM																					
05:00 PM	19	39	39	0	97	66	177	**31**	0	274	1	30	**5**	0	36	1	**47**	**22**	0	**70**	477
05:15 PM	27	43	30	**1**	101	**74**	**182**	30	0	**286**	1	**36**	3	0	40	1	36	17	0	54	481
05:30 PM	**30**	**63**	38	0	**131**	60	163	28	0	251	9	33	1	**1**	**44**	**3**	38	19	0	60	**486**
05:45 PM	23	54	**42**	0	119	66	170	24	0	260	**12**	27	3	0	42	1	46	15	0	62	483
Total Volume	99	199	149	1	448	266	692	113	0	1071	23	126	12	1	162	6	167	73	0	246	1927
% App. Total	22.1	44.4	33.3	0.2		24.8	64.6	10.6	0		14.2	77.8	7.4	0.6		2.4	67.9	29.7	0		
PHF	.825	.790	.887	.250	.855	.899	.951	.911	.000	.936	.479	.875	.600	.250	.920	.500	.888	.830	.000	.879	.991
Cars & Peds																					
% Cars & Peds	98.0	98.5	100	100	98.9	98.5	99.0	99.1	0	98.9	95.7	98.4	100	100	98.1	100	99.4	98.6	0	99.2	98.9
Heavy Vehicles	2	3	0	0	5	4	7	1	0	12	1	2	0	0	3	0	1	1	0	2	22
% Heavy Vehicles	2.0	1.5	0	0	1.1	1.5	1.0	0.9	0	1.1	4.3	1.6	0	0	1.9	0	0.6	1.4	0	0.8	1.1

McMAHON
TRANSPORTATION ENGINEERS & PLANNERS

120 Water Street, 4th Floor
Boston, MA 02109
617-556-0020

N/S: Sudbury Road
E/W: Fitchburg Turnpike (Route 117)
Sudbury, MA
Weekday PM

File Name : PM_Fitchburg Tpk at Sudbury Rd
Site Code : 09281803
Start Date : 9/27/2018
Page No : 1

Groups Printed- Heavy Vehicles

	Sudbury Road From North					Fitchburg Turnpike (Route 117) From East					Sudbury Road From South					Fitchburg Turnpike (Route 117) From West					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
04:00 PM	1	1	0	0	2	0	3	0	0	3	0	0	0	0	0	0	1	0	0	1	6
04:15 PM	1	1	0	0	2	0	4	0	0	4	0	1	0	0	1	0	1	0	0	1	8
04:30 PM	0	1	1	0	2	0	1	0	0	1	0	0	0	0	0	0	0	1	0	1	4
04:45 PM	1	2	0	0	3	0	1	1	0	2	0	0	0	0	0	0	0	0	0	0	5
Total	3	5	1	0	9	0	9	1	0	10	0	1	0	0	1	0	2	1	0	3	23
05:00 PM	0	0	0	0	0	3	3	0	0	6	0	0	0	0	0	0	1	1	0	2	8
05:15 PM	1	0	0	0	1	1	1	0	0	2	0	0	0	0	0	0	0	0	0	0	3
05:30 PM	1	1	0	0	2	0	1	1	0	2	0	1	0	0	1	0	0	0	0	0	5
05:45 PM	0	2	0	0	2	0	2	0	0	2	1	1	0	0	2	0	0	0	0	0	6
Total	2	3	0	0	5	4	7	1	0	12	1	2	0	0	3	0	1	1	0	2	22
Grand Total	5	8	1	0	14	4	16	2	0	22	1	3	0	0	4	0	3	2	0	5	45
Apprch %	35.7	57.1	7.1	0		18.2	72.7	9.1	0		25	75	0	0		0	60	40	0		
Total %	11.1	17.8	2.2	0	31.1	8.9	35.6	4.4	0	48.9	2.2	6.7	0	0	8.9	0	6.7	4.4	0	11.1	

	Sudbury Road From North					Fitchburg Turnpike (Route 117) From East					Sudbury Road From South					Fitchburg Turnpike (Route 117) From West					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
Peak Hour Analysis From 04:00 PM to 05:45 PM - Peak 1 of 1																					
Peak Hour for Entire Intersection Begins at 04:15 PM																					
04:15 PM	**1**	1	0	0	2	0	**4**	0	0	4	0	**1**	0	0	**1**	0	**1**	0	0	1	**8**
04:30 PM	0	1	**1**	0	2	0	1	0	0	1	0	0	0	0	0	0	0	**1**	0	1	4
04:45 PM	1	**2**	0	0	**3**	0	1	**1**	0	2	0	0	0	0	0	0	0	0	0	0	5
05:00 PM	0	0	0	0	0	**3**	3	0	0	**6**	0	0	0	0	0	0	1	1	0	**2**	8
Total Volume	2	4	1	0	7	3	9	1	0	13	0	1	0	0	1	0	2	2	0	4	25
% App. Total	28.6	57.1	14.3	0		23.1	69.2	7.7	0		0	100	0	0		0	50	50	0		
PHF	.500	.500	.250	.000	.583	.250	.563	.250	.000	.542	.000	.250	.000	.000	.250	.000	.500	.500	.000	.500	.781

McMAHON
TRANSPORTATION ENGINEERS & PLANNERS

120 Water Street, 4th Floor
Boston, MA 02109
617-556-0020

N/S: Sudbury Road
E/W: Fitchburg Turnpike (Route 117)
Sudbury, MA
Weekday PM

File Name : PM_Fitchburg Tpk at Sudbury Rd
Site Code : 09281803
Start Date : 9/27/2018

Groups Printed- Bikes by Direction

	Sudbury Road From North					Fitchburg Turnpike (Route 117) From East					Sudbury Road From South					Fitchburg Turnpike (Route 117) From West					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
04:00 PM	1	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
04:15 PM	0	0	0	0	0	1	0	0	0	1	2	1	0	0	3	0	0	0	0	0	4
04:30 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
04:45 PM	0	1	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	2
Total	1	2	0	0	3	1	1	0	0	2	2	1	0	0	3	0	0	0	0	0	8
05:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
05:15 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
05:30 PM	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1
05:45 PM	0	1	0	0	1	0	1	0	0	1	1	0	0	0	1	0	0	0	0	0	3
Total	0	1	0	0	1	0	1	0	0	1	1	1	0	0	2	0	0	0	0	0	4
Grand Total	1	3	0	0	4	1	2	0	0	3	3	2	0	0	5	0	0	0	0	0	12
Apprch %	25	75	0	0		33.3	66.7	0	0		60	40	0	0		0	0	0	0		
Total %	8.3	25	0	0	33.3	8.3	16.7	0	0	25	25	16.7	0	0	41.7	0	0	0	0	0	

	Sudbury Road From North					Fitchburg Turnpike (Route 117) From East					Sudbury Road From South					Fitchburg Turnpike (Route 117) From West					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
Peak Hour Analysis From 04:00 PM to 05:45 PM - Peak 1 of 1																					
Peak Hour for Entire Intersection Begins at 04:00 PM																					
04:00 PM	**1**	**1**	0	0	**2**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
04:15 PM	0	0	0	0	0	**1**	0	0	0	**1**	**2**	**1**	0	0	**3**	0	0	0	0	0	**4**
04:30 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
04:45 PM	0	1	0	0	1	0	**1**	0	0	1	0	0	0	0	0	0	0	0	0	0	2
Total Volume	1	2	0	0	3	1	1	0	0	2	2	1	0	0	3	0	0	0	0	0	8
% App. Total	33.3	66.7	0	0		50	50	0	0		66.7	33.3	0	0		0	0	0	0		
PHF	.250	.500	.000	.000	.375	.250	.250	.000	.000	.500	.250	.250	.000	.000	.250	.000	.000	.000	.000	.000	.500

□ Seasonal Data/ Yearly Growth

STATION 403 - CONCORD - RTE.2 - 0.2 km EAST OF CONCORD ROTARY

YR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
10	41,546	41,883	46,472	50,492	45,910	46,524	43,534	39,595	40,709	46,285	43,576	44,350	44,240
	-6%	-4%	-6%	-12%	0%	-1%	0%	9%	10%	-2%	-1%	-5%	-2%
11	39,037	40,138	43,732	44,191	45,777	46,145	43,496	43,117	44,740	45,508	43,282	42,043	43,434
	6%	5%	-2%	0%	0%	-1%	-7%	4%	0%	-1%	-1%	-1%	0%
12	41,311	42,111	43,069	44,294	45,759	45,640	40,408	44,775	44,720	44,904	42,980	41,701	43,473
	1%	-7%	-2%	-3%	-3%	-1%	4%	-3%	-1%	0%	-1%	3%	-1%
13	41,792	39,095	42,007	42,993	44,222	44,984	41,995	43,310	44,422	45,062	42,684	42,773	42,945
	-3%	-3%	1%	1%	1%	1%	2%	0%	0%	1%	1%	5%	1%
15	39,457	36,908	42,703	44,051	45,401	45,790	43,572	43,700	43,992	46,043	43,701	47,474	43,566
	6%	15%	4%	1%	3%	4%	3%	6%	3%	2%	4%	-9%	3%
16	41,896	42,396	44,580	44,670	46,737	47,669	45,004	46,441	45,499	47,080	45,357	43,312	45,053
	3%	1%	1%	1%	2%	2%	1%	1%	4%	4%	3%	-2%	2%
17	43,250	43,008	45,196	45,139	47,491	48,619	45,489	46,860	47,255	48,955	46,715	42,282	45,855
	0%	3%	0%	4%	1%	1%	-2%	-2%	-5%	-1%	-9%	7%	0%
18	43,289	44,164	45,201	46,965	48,147	49,054	44,492	45,928	44,882	48,454	42,446	45,171	45,683
Seasonal Adjustment Factor (to average month)	*1.07*	*1.08*	*1.00*	*0.98*	*0.96*	*0.95*	*1.02*	*1.00*	*1.00*	*0.95*	*1.01*	*1.02*	
												Growth	**0.4%**

□ Crash Data

INTERSECTION CRASH RATE WORKSHEET

CITY/TOWN : Concord, MA COUNT DATE : May-20

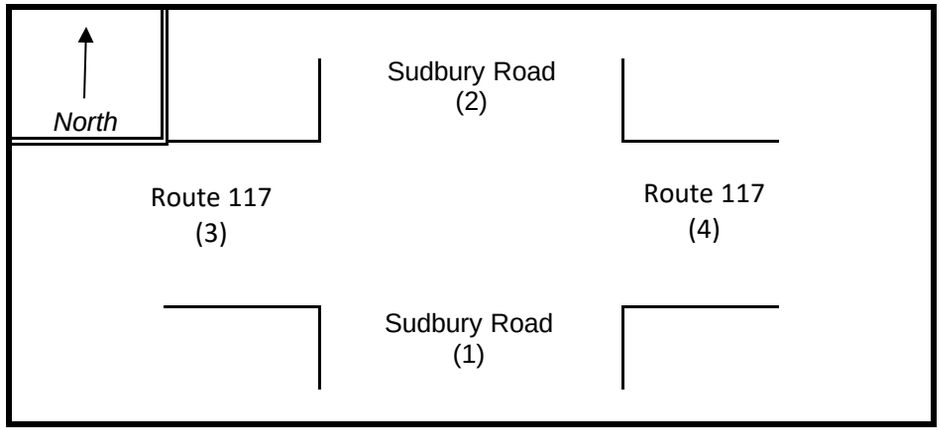
DISTRICT : 4 UNSIGNALIZED : SIGNALIZED : X

~ INTERSECTION DATA ~

MAJOR STREET : Fitchburg Turnpike (Route 117)

MINOR STREET(S) : Sudbury Road

INTERSECTION DIAGRAM (Label Approaches)



PEAK HOUR VOLUMES

APPROACH :	1	2	3	4	5	Total Peak Hourly Approach Volume
DIRECTION :	NB	SB	EB	WB		
PEAK HOURLY VOLUMES (PM) :	162	451	249	1,082		**1,944**

" K " FACTOR : **0.092** INTERSECTION ADT (**V**) = TOTAL DAILY APPROACH VOLUME : **21,130**

TOTAL # OF CRASHES : 27 # OF YEARS : 5 AVERAGE # OF CRASHES PER YEAR (**A**) : **5.40**

CRASH RATE CALCULATION : **0.70** RATE = $\frac{(A * 1{,}000{,}000)}{(V * 365)}$

Comments : MassDOT District 3 Avg: Signalized = 0.89; Unsignalized = 0.61

Project Title & Date: 1073 - Sudbury

Crash Date	Crash Severity	Crash Time	Crash Year	Number of Vehicles	Light Conditions	Manner of Collision	Road Surface Condition	Roadway Junction Type	Total Fatalities	Total Non-Fatal Injuries	Vehicle Actions Prior to Crash (All Vehicles)	Vehicle Configuration (All Vehicles)	Vehicle Travel Directions (All Vehicles)	Weather Conditions	Most Harmful Event (All Vehicles)	X	Y	Roadway
01/12/2016	Property damage only (none injured)	6:44 AM	2016	2	Daylight	Angle	Dry	T-intersection	0	0	V1: Turning left / V2: Travelling straight ahead	V1:(Single-unit truck (3-or-more axles)) / V2:(Passenger car)	V1: N / V2: W	Clear	V1:(Collision with motor vehicle in traffic) / V2:(Collision with motor vehicle in traffic)	210572.3998	907875.877	FITCHBURG TURNPIKE
04/16/2019	Property damage only (none injured)	7:59 AM	2019	2	Daylight	Angle	Dry	T-intersection	0	0	V1: Travelling straight ahead / V2: Turning left	V1:(Passenger car) / V2:(Passenger car)	V1: N / V2: S	Clear	V1:(Collision with motor vehicle in traffic) / V2:(Collision with motor vehicle in traffic)	210521.4982	908013.38	SUDBURY RD
11/29/2017	Property damage only (none injured)	8:03 AM	2017	2	Daylight	Angle	Wet	Four-way intersection	0	0	V1: Travelling straight ahead / V2: Turning left	V1:(Passenger car) / V2:(Passenger car)	V1: N / V2: E	Cloudy	V1:(Collision with motor vehicle in traffic) / V2:(Collision with motor vehicle in traffic)	210558.3907	907875.063	FITCHBURG TPKE / SUDBURY RD
08/31/2016	Property damage only (none injured)	8:35 AM	2016	2	Daylight	Angle	Dry	Four-way intersection	0	0	V1: Turning left / V2: Travelling straight ahead	V1:(Passenger car) / V2:(Passenger car)	V1: W / V2: S	Cloudy	V1:(Collision with motor vehicle in traffic) / V2:(Collision with motor vehicle in traffic)	210558.3907	907875.063	FITCHBURG TPKE Rte 117 / SUDBURY RD
06/02/2015	Non-fatal injury	9:46 AM	2015	2	Daylight	Angle	Wet	Four-way intersection	0	2	V1: Travelling straight ahead / V2: Travelling straight ahead	V1:(Passenger car) / V2:(Passenger car)	V1: W / V2: N	Rain	V1:(Collision with motor vehicle in traffic) / V2:(Collision with motor vehicle in traffic)	210558.3907	907875.063	SUDBURY RD / FITCHBURG TPKE
02/11/2015	Property damage only (none injured)	1:06 PM	2015	2	Daylight	Angle	Wet	T-intersection	0	0	V1: Travelling straight ahead / V2: Travelling straight ahead	V1:(Passenger car) / V2:(Passenger car)	V1: S / V2: E	Cloudy	V1:(Collision with motor vehicle in traffic) / V2:(Collision with motor vehicle in traffic)	210558.3907	907875.063	FITCHBURG TPKE / SUDBURY RD
04/16/2019	Property damage only (none injured)	2:06 PM	2019	2	Daylight	Angle	Dry	Four-way intersection	0	0	V1: Changing lanes / V2: Turning left	V1:(Passenger car) / V2:(Passenger car)	V1: W / V2: S	Clear	V1:(Collision with motor vehicle in traffic) / V2:(Collision with motor vehicle in traffic)	210558.3907	907875.063	SUDBURY RD / FITCHBURG TPKE
02/11/2015	Property damage only (none injured)	3:40 PM	2015	2	Daylight	Angle	Dry	T-intersection	0	0	V1: Travelling straight ahead / V2: Entering traffic lane	V1:(Passenger car) / V2:(Passenger car)	V1: S / V2: E	Cloudy	V1:(Collision with motor vehicle in traffic) / V2:(Collision with motor vehicle in traffic)	210530.6348	907982.99	SUDBURY RD
07/18/2019	Property damage only (none injured)	3:44 PM	2019	2	Daylight	Angle		Not at junction	0	0	V1: Entering traffic lane / V2: Travelling straight ahead	V1:(Passenger car) / V2:(Passenger car)	V1: W / V2: N	Cloudy	V1:(Collision with motor vehicle in traffic) / V2:(Collision with motor vehicle in traffic)	210542.857	907949.707	SUDBURY RD
01/28/2019	Property damage only (none injured)	4:32 PM	2019	2	Dawn	Angle	Dry	Four-way intersection	0	0	V1: Slowing or stopped in traffic / V2: Travelling straight ahead	V1:(Passenger car) / V2:(Passenger car)	V1: E / V2: W	Clear	V1:(Collision with motor vehicle in traffic) / V2:(Collision with motor vehicle in traffic)	210575.8216	907876.076	FITCHBURG TPKE
11/18/2015	Non-fatal injury	4:53 PM	2015	2	Dark - lighted roadway	Angle	Dry	Not at junction	0	2	V1: Travelling straight ahead / V2: Making U-turn	V1:(Passenger car) / V2:(Passenger car)	V1: E / V2: W	Clear	V1:(Collision with motor vehicle in traffic) / V2:(Collision with motor vehicle in traffic)	210496.0788	907861.24	FITCHBURG TURNPIKE Rte 117 E
05/21/2018	Property damage only (none injured)	4:54 PM	2018	2	Daylight	Angle	Dry	Four-way intersection	0	0	V1: Turning right / V2: Travelling straight ahead	V1:(Passenger car) / V2:(Passenger car)	V1: E / V2: E	Clear	V1:(Collision with motor vehicle in traffic) / V2:(Collision with motor vehicle in traffic)	210558.3907	907875.063	SUDBURY RD / FITCHBURG TPKE
06/07/2019	Property damage only (none injured)	6:43 PM	2019	2	Daylight	Angle	Dry	Not at junction	0	0	V1: Turning left / V2: Travelling straight ahead	V1:(Passenger car) / V2:(Passenger car)	V1: S / V2: S	Clear	V1:(Collision with motor vehicle in traffic) / V2:(Collision with motor vehicle in traffic)	210533.2968	907870.116	FITCHBURG TPKE
07/12/2015	Property damage only (none injured)	7:43 PM	2015	2	Daylight	Angle	Dry	Four-way intersection	0	0	V1: Travelling straight ahead / V2: Travelling straight ahead	V1:(Passenger car) / V2:(Passenger car)	V1: E / V2: N	Clear	V1:(Collision with motor vehicle in traffic) / V2:(Collision with motor vehicle in traffic)	210558.3907	907875.063	FITCHBURG TPKE / SUDBURY RD
09/20/2019	Property damage only (none injured)	3:07 PM	2019	2	Daylight	Head-on	Dry	Four-way intersection	0	0	V1: Turning left / V2: Travelling straight ahead	V1:(Passenger car) / V2:(Passenger car)	V1: E / V2: W	Clear	V1:(Collision with motor vehicle in traffic) / V2:(Collision with motor vehicle in traffic)	210558.3904	907875.062	SUDBURY RD / FITCHBURG TPKE
06/14/2019	Property damage only (none injured)	7:35 PM	2019	2	Daylight	Head-on	Dry	Four-way intersection	0	0	V1: Travelling straight ahead / V2: Turning left	V1:(Passenger car) / V2:(Passenger car)	V1: W / V2: E	Clear	V1:(Collision with motor vehicle in traffic) / V2:(Collision with motor vehicle in traffic)	210558.3907	907875.063	FITCHBURG TPKE / SUDBURY RD
06/12/2017	Non-fatal injury	11:40 PM	2017	2	Dark - lighted roadway	Head-on	Dry	Four-way intersection	0	2	V1: Travelling straight ahead / V2: Slowing or stopped in traffic	V1:(Passenger car) / V2:(Passenger car)	V1: W / V2: E	Clear	V1:(Collision with motor vehicle in traffic) / V2:(Collision with motor vehicle in traffic)	210558.3907	907875.063	FITCHBURG TPKE / SUDBURY RD
12/04/2019	Property damage only (none injured)	6:42 AM	2019	2	Dawn	Rear-end	Ice	Not at junction	0	0	V1: Travelling straight ahead / V2: Slowing or stopped in traffic	V1:(Passenger car) / V2:(Passenger car)	V1: E / V2: E	Clear	V1:(Collision with motor vehicle in traffic) / V2:(Collision with motor vehicle in traffic)	210528.5429	907869.179	FITCHBURG TPKE
06/13/2018	Property damage only (none injured)	8:36 AM	2018	2	Daylight	Rear-end	Dry	Not at junction	0	0	V1: Slowing or stopped in traffic / V2: Travelling straight ahead	V1:(Passenger car) / V2:(Passenger car)	V1: E / V2: E	Cloudy	V1:(Collision with motor vehicle in traffic) / V2:(Collision with motor vehicle in traffic)	210572.3998	907875.877	FITCHBURG TPKE
08/16/2018	Property damage only (none injured)	12:28 PM	2018	2	Daylight	Rear-end	Dry	Not at junction	0	0	V1: Slowing or stopped in traffic / V2: Travelling straight ahead	V1:(Passenger car) / V2:(Passenger car)	V1: E / V2: E	Clear	V1:(Collision with motor vehicle in traffic) / V2:(Collision with motor vehicle in traffic)	210543.4382	907872.115	FITCHBURG TPKE
12/09/2016	Property damage only (none injured)	4:30 PM	2016	2	Dark - lighted roadway	Rear-end	Dry	Four-way intersection	0	0	V1: Travelling straight ahead / V2: Travelling straight ahead	V1:(Passenger car) / V2:(Passenger car)	V1: E / V2: E	Clear	V1:(Collision with motor vehicle in traffic) / V2:(Collision with motor vehicle in traffic)	210558.3907	907875.063	SUDBURY RD / FITCHBURG TPKE
08/13/2015	Property damage only (none injured)	6:53 PM	2015	2	Daylight	Rear-end	Dry	Four-way intersection	0	0	V1: Travelling straight ahead / V2: Travelling straight ahead	V1:(Passenger car) / V2:(Passenger car)	V1: W / V2: W	Clear	V1:(Collision with motor vehicle in traffic) / V2:(Collision with motor vehicle in traffic)	210558.3907	907875.063	SUDBURY RD / FITCHBURG TPKE
11/14/2016	Non-fatal injury	8:43 PM	2016	2	Dark - unknown roadway lighting	Rear-end	Dry	Four-way intersection	0	1	V1: Slowing or stopped in traffic / V2: Travelling straight ahead	V1:(Passenger car) / V2:(Passenger car)	V1: W / V2: W	Clear	V1:(Collision with motor vehicle in traffic) / V2:(Collision with motor vehicle in traffic)	210558.3907	907875.063	FITCHBURG TPKE Rte 117 W / SUDBURY RD
02/26/2016	Property damage only (none injured)	5:32 PM	2016	2	Dusk	Sideswipe, same direction	Dry	Not at junction	0	0	V1: Travelling straight ahead / V2: Turning left	V1:(Passenger car) / V2:(Passenger car)	V1: W / V2: W	Cloudy	V1:(Collision with motor vehicle in traffic) / V2:(Collision with motor vehicle in traffic)	210542.5877	907829.021	SUDBURY RD
10/01/2015	Non-fatal injury	8:18 PM	2015	1	Dark - lighted roadway	Single vehicle crash	Dry	T-intersection	0	1	V1: Travelling straight ahead	V1:(Passenger car)	V1: W	Clear	V1:(Collision with tree)	210542.5877	907829.021	SUDBURY RD
10/13/2015	Property damage only (none injured)	9:27 AM	2015	1	Daylight	Unknown	Dry	Not at junction	0	0	V1: Parked	V1:(Passenger car)	V1: N	Clear	V1:(Collision with motor vehicle in traffic)	210521.7446	908012.559	SUDBURY RD
03/20/2019	Property damage only (none injured)	5:32 PM	2019	2	Daylight	Unknown	Dry	Y-intersection	0	0	V1: Travelling straight ahead / V2: Entering traffic lane	V1:(Passenger car) / V2:(Passenger car)	V1: N / V2: W	Clear	V1:(Collision with motor vehicle in traffic) / V2:(Collision with motor vehicle in traffic)	210558.3907	907875.063	FITCHBURG TPKE / SUDBURY RD

□ Capacity Analysis

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	76	549	15	19	155	75	26	206	79	147	83	72
Future Volume (vph)	76	549	15	19	155	75	26	206	79	147	83	72
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (ft)	175		50	120		20	0		0	160		0
Storage Lanes	1		1	1		1	0		0	1		0
Taper Length (ft)	25			25			25			25		
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Frt			0.850			0.850		0.966			0.930	
Flt Protected	0.950			0.950				0.996		0.950		
Satd. Flow (prot)	1736	1845	1429	1626	1845	1538	0	1735	0	1736	1635	0
Flt Permitted	0.653			0.314				0.968		0.486		
Satd. Flow (perm)	1193	1845	1429	537	1845	1538	0	1687	0	888	1635	0
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)			16			80		24			63	
Link Speed (mph)		30			30			30			30	
Link Distance (ft)		1000			1000			1000			1000	
Travel Time (s)		22.7			22.7			22.7			22.7	
Peak Hour Factor	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Heavy Vehicles (%)	4%	3%	13%	11%	3%	5%	12%	5%	4%	4%	9%	7%
Adj. Flow (vph)	81	584	16	20	165	80	28	219	84	156	88	77
Shared Lane Traffic (%)												
Lane Group Flow (vph)	81	584	16	20	165	80	0	331	0	156	165	0
Enter Blocked Intersection	No	No	No	No	No	No	No	No	No	No	No	No
Lane Alignment	Left	Left	Right	Left	Left	Right	Left	Left	Right	Left	Left	Right
Median Width(ft)		12			12			12			12	
Link Offset(ft)		0			0			0			0	
Crosswalk Width(ft)		16			16			16			16	
Two way Left Turn Lane												
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Turning Speed (mph)	15		9	15		9	15		9	15		9
Number of Detectors	1	2	1	1	2	1	1	2		1	2	
Detector Template	Left	Thru	Right	Left	Thru	Right	Left	Thru		Left	Thru	
Leading Detector (ft)	20	100	20	20	100	20	20	100		20	100	
Trailing Detector (ft)	0	0	0	0	0	0	0	0		0	0	
Detector 1 Position(ft)	0	0	0	0	0	0	0	0		0	0	
Detector 1 Size(ft)	20	6	20	20	6	20	20	6		20	6	
Detector 1 Type	Cl+Ex	Cl+Ex	Cl+Ex	Cl+Ex	Cl+Ex	Cl+Ex	Cl+Ex	Cl+Ex		Cl+Ex	Cl+Ex	
Detector 1 Channel												
Detector 1 Extend (s)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	
Detector 1 Queue (s)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	
Detector 1 Delay (s)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	
Detector 2 Position(ft)		94			94			94			94	
Detector 2 Size(ft)		6			6			6			6	
Detector 2 Type		Cl+Ex			Cl+Ex			Cl+Ex			Cl+Ex	
Detector 2 Channel												
Detector 2 Extend (s)		0.0			0.0			0.0			0.0	
Turn Type	Perm	NA	Perm	Perm	NA	Perm	Perm	NA		Perm	NA	
Protected Phases		2			6			8			4	

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Permitted Phases	2		2	6		6	8			4		
Detector Phase	2	2	2	6	6	6	8	8		4	4	
Switch Phase												
Minimum Initial (s)	12.0	12.0	12.0	12.0	12.0	12.0	7.0	7.0		7.0	7.0	
Minimum Split (s)	18.0	18.0	18.0	18.0	18.0	18.0	11.0	11.0		11.0	11.0	
Total Split (s)	46.0	46.0	46.0	46.0	46.0	46.0	24.0	24.0		24.0	24.0	
Total Split (%)	65.7%	65.7%	65.7%	65.7%	65.7%	65.7%	34.3%	34.3%		34.3%	34.3%	
Maximum Green (s)	40.0	40.0	40.0	40.0	40.0	40.0	20.0	20.0		20.0	20.0	
Yellow Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	3.0	3.0		3.0	3.0	
All-Red Time (s)	2.0	2.0	2.0	2.0	2.0	2.0	1.0	1.0		1.0	1.0	
Lost Time Adjust (s)	0.0	0.0	0.0	0.0	0.0	0.0		0.0		0.0	0.0	
Total Lost Time (s)	6.0	6.0	6.0	6.0	6.0	6.0		4.0		4.0	4.0	
Lead/Lag												
Lead-Lag Optimize?												
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0		3.0	3.0	
Recall Mode	Min	Min	Min	Min	Min	Min	None	None		None	None	
Act Effct Green (s)	22.3	22.3	22.3	22.3	22.3	22.3		16.1		16.1	16.1	
Actuated g/C Ratio	0.45	0.45	0.45	0.45	0.45	0.45		0.33		0.33	0.33	
v/c Ratio	0.15	0.70	0.02	0.08	0.20	0.11		0.58		0.54	0.29	
Control Delay	8.7	15.8	4.0	8.7	8.8	2.6		19.2		24.2	11.1	
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0		0.0		0.0	0.0	
Total Delay	8.7	15.8	4.0	8.7	8.8	2.6		19.2		24.2	11.1	
LOS	A	B	A	A	A	A		B		C	B	
Approach Delay		14.7			6.9			19.2			17.5	
Approach LOS		B			A			B			B	
90th %ile Green (s)	35.7	35.7	35.7	35.7	35.7	35.7	20.0	20.0		20.0	20.0	
90th %ile Term Code	Gap	Gap	Gap	Hold	Hold	Hold	Max	Max		Max	Max	
70th %ile Green (s)	27.2	27.2	27.2	27.2	27.2	27.2	20.0	20.0		20.0	20.0	
70th %ile Term Code	Gap	Gap	Gap	Hold	Hold	Hold	Hold	Hold		Max	Max	
50th %ile Green (s)	22.5	22.5	22.5	22.5	22.5	22.5	18.0	18.0		18.0	18.0	
50th %ile Term Code	Gap	Gap	Gap	Hold	Hold	Hold	Hold	Hold		Gap	Gap	
30th %ile Green (s)	17.4	17.4	17.4	17.4	17.4	17.4	13.5	13.5		13.5	13.5	
30th %ile Term Code	Gap	Gap	Gap	Hold	Hold	Hold	Hold	Hold		Gap	Gap	
10th %ile Green (s)	12.0	12.0	12.0	12.0	12.0	12.0	9.3	9.3		9.3	9.3	
10th %ile Term Code	Min	Min	Min	Min	Min	Min	Hold	Hold		Gap	Gap	
Queue Length 50th (ft)	13	130	0	3	28	0		69		35	20	
Queue Length 95th (ft)	34	231	7	13	57	16		184		#115	72	
Internal Link Dist (ft)		920			920			920			920	
Turn Bay Length (ft)	175		50	120		20				160		
Base Capacity (vph)	973	1505	1168	438	1505	1269		748		386	747	
Starvation Cap Reductn	0	0	0	0	0	0		0		0	0	
Spillback Cap Reductn	0	0	0	0	0	0		0		0	0	
Storage Cap Reductn	0	0	0	0	0	0		0		0	0	
Reduced v/c Ratio	0.08	0.39	0.01	0.05	0.11	0.06		0.44		0.40	0.22	

Intersection Summary

Area Type: Other
Cycle Length: 70
Actuated Cycle Length: 49.1

Natural Cycle: 45
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.70
Intersection Signal Delay: 14.9 Intersection LOS: B
Intersection Capacity Utilization 81.4% ICU Level of Service D
Analysis Period (min) 15
90th %ile Actuated Cycle: 65.7
70th %ile Actuated Cycle: 57.2
50th %ile Actuated Cycle: 50.5
30th %ile Actuated Cycle: 40.9
10th %ile Actuated Cycle: 31.3
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 1: Sudbury Road & Fitchburg Turnpike

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	74	169	6	114	699	269	12	127	23	150	201	100
Future Volume (vph)	74	169	6	114	699	269	12	127	23	150	201	100
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (ft)	175		50	120		20	0		0	160		0
Storage Lanes	1		1	1		1	0		0	1		0
Taper Length (ft)	25			25			25			25		
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Frt			0.850			0.850		0.981			0.950	
Flt Protected	0.950			0.950				0.996		0.950		
Satd. Flow (prot)	1787	1881	1615	1770	1881	1583	0	1842	0	1805	1764	0
Flt Permitted	0.261			0.649				0.967		0.674		
Satd. Flow (perm)	491	1881	1615	1209	1881	1583	0	1788	0	1281	1764	0
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)			16			83		12			36	
Link Speed (mph)		30			30			30			30	
Link Distance (ft)		1000			1000			1000			1000	
Travel Time (s)		22.7			22.7			22.7			22.7	
Peak Hour Factor	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
Heavy Vehicles (%)	1%	1%	0%	2%	1%	2%	0%	1%	0%	0%	2%	3%
Adj. Flow (vph)	75	171	6	115	706	272	12	128	23	152	203	101
Shared Lane Traffic (%)												
Lane Group Flow (vph)	75	171	6	115	706	272	0	163	0	152	304	0
Enter Blocked Intersection	No	No	No	No	No	No	No	No	No	No	No	No
Lane Alignment	Left	Left	Right	Left	Left	Right	Left	Left	Right	Left	Left	Right
Median Width(ft)		12			12			12			12	
Link Offset(ft)		0			0			0			0	
Crosswalk Width(ft)		16			16			16			16	
Two way Left Turn Lane												
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Turning Speed (mph)	15		9	15		9	15		9	15		9
Number of Detectors	1	2	1	1	2	1	1	2		1	2	
Detector Template	Left	Thru	Right	Left	Thru	Right	Left	Thru		Left	Thru	
Leading Detector (ft)	20	100	20	20	100	20	20	100		20	100	
Trailing Detector (ft)	0	0	0	0	0	0	0	0		0	0	
Detector 1 Position(ft)	0	0	0	0	0	0	0	0		0	0	
Detector 1 Size(ft)	20	6	20	20	6	20	20	6		20	6	
Detector 1 Type	Cl+Ex	Cl+Ex	Cl+Ex	Cl+Ex	Cl+Ex	Cl+Ex	Cl+Ex	Cl+Ex		Cl+Ex	Cl+Ex	
Detector 1 Channel												
Detector 1 Extend (s)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	
Detector 1 Queue (s)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	
Detector 1 Delay (s)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	
Detector 2 Position(ft)		94			94			94			94	
Detector 2 Size(ft)		6			6			6			6	
Detector 2 Type		Cl+Ex			Cl+Ex			Cl+Ex			Cl+Ex	
Detector 2 Channel												
Detector 2 Extend (s)		0.0			0.0			0.0			0.0	
Turn Type	Perm	NA	Perm	Perm	NA	Perm	Perm	NA		Perm	NA	
Protected Phases		2			6			8			4	

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Permitted Phases	2		2	6		6	8			4		
Detector Phase	2	2	2	6	6	6	8	8		4	4	
Switch Phase												
Minimum Initial (s)	12.0	12.0	12.0	12.0	12.0	12.0	7.0	7.0		7.0	7.0	
Minimum Split (s)	18.0	18.0	18.0	18.0	18.0	18.0	11.0	11.0		11.0	11.0	
Total Split (s)	46.0	46.0	46.0	46.0	46.0	46.0	24.0	24.0		24.0	24.0	
Total Split (%)	65.7%	65.7%	65.7%	65.7%	65.7%	65.7%	34.3%	34.3%		34.3%	34.3%	
Maximum Green (s)	40.0	40.0	40.0	40.0	40.0	40.0	20.0	20.0		20.0	20.0	
Yellow Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	3.0	3.0		3.0	3.0	
All-Red Time (s)	2.0	2.0	2.0	2.0	2.0	2.0	1.0	1.0		1.0	1.0	
Lost Time Adjust (s)	0.0	0.0	0.0	0.0	0.0	0.0		0.0		0.0	0.0	
Total Lost Time (s)	6.0	6.0	6.0	6.0	6.0	6.0		4.0		4.0	4.0	
Lead/Lag												
Lead-Lag Optimize?												
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0		3.0	3.0	
Recall Mode	Min	Min	Min	Min	Min	Min	None	None		None	None	
Act Effct Green (s)	27.1	27.1	27.1	27.1	27.1	27.1		13.7		13.7	13.7	
Actuated g/C Ratio	0.52	0.52	0.52	0.52	0.52	0.52		0.26		0.26	0.26	
v/c Ratio	0.29	0.17	0.01	0.18	0.72	0.31		0.34		0.45	0.62	
Control Delay	10.9	7.1	1.7	7.5	14.3	5.9		18.7		23.3	22.6	
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0		0.0		0.0	0.0	
Total Delay	10.9	7.1	1.7	7.5	14.3	5.9		18.7		23.3	22.6	
LOS	B	A	A	A	B	A		B		C	C	
Approach Delay		8.1			11.5			18.7			22.8	
Approach LOS		A			B			B			C	
90th %ile Green (s)	40.0	40.0	40.0	40.0	40.0	40.0	20.0	20.0		20.0	20.0	
90th %ile Term Code	Hold	Hold	Hold	Max	Max	Max	Hold	Hold		Max	Max	
70th %ile Green (s)	37.1	37.1	37.1	37.1	37.1	37.1	18.5	18.5		18.5	18.5	
70th %ile Term Code	Hold	Hold	Hold	Gap	Gap	Gap	Hold	Hold		Gap	Gap	
50th %ile Green (s)	28.0	28.0	28.0	28.0	28.0	28.0	13.4	13.4		13.4	13.4	
50th %ile Term Code	Hold	Hold	Hold	Gap	Gap	Gap	Hold	Hold		Gap	Gap	
30th %ile Green (s)	20.3	20.3	20.3	20.3	20.3	20.3	10.3	10.3		10.3	10.3	
30th %ile Term Code	Hold	Hold	Hold	Gap	Gap	Gap	Hold	Hold		Gap	Gap	
10th %ile Green (s)	13.5	13.5	13.5	13.5	13.5	13.5	7.4	7.4		7.4	7.4	
10th %ile Term Code	Hold	Hold	Hold	Gap	Gap	Gap	Hold	Hold		Gap	Gap	
Queue Length 50th (ft)	11	23	0	15	137	26		37		38	70	
Queue Length 95th (ft)	39	58	3	44	299	72		98		103	173	
Internal Link Dist (ft)		920			920			920			920	
Turn Bay Length (ft)	175		50	120		20				160		
Base Capacity (vph)	387	1483	1277	953	1483	1266		764		543	768	
Starvation Cap Reductn	0	0	0	0	0	0		0		0	0	
Spillback Cap Reductn	0	0	0	0	0	0		0		0	0	
Storage Cap Reductn	0	0	0	0	0	0		0		0	0	
Reduced v/c Ratio	0.19	0.12	0.00	0.12	0.48	0.21		0.21		0.28	0.40	

Intersection Summary

Area Type: Other
Cycle Length: 70
Actuated Cycle Length: 51.7

Natural Cycle: 45
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.72
Intersection Signal Delay: 14.3
Intersection LOS: B
Intersection Capacity Utilization 88.9%
ICU Level of Service E
Analysis Period (min) 15
90th %ile Actuated Cycle: 70
70th %ile Actuated Cycle: 65.6
50th %ile Actuated Cycle: 51.4
30th %ile Actuated Cycle: 40.6
10th %ile Actuated Cycle: 30.9

Splits and Phases: 1: Sudbury Road & Fitchburg Turnpike

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	83	601	16	20	178	80	30	221	85	158	89	86
Future Volume (vph)	83	601	16	20	178	80	30	221	85	158	89	86
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (ft)	175		50	120		20	0		0	160		0
Storage Lanes	1		1	1		1	0		0	1		0
Taper Length (ft)	25			25			25			25		
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Frt			0.850			0.850		0.966			0.927	
Flt Protected	0.950			0.950				0.996		0.950		
Satd. Flow (prot)	1736	1845	1429	1626	1845	1538	0	1735	0	1736	1631	0
Flt Permitted	0.639			0.254				0.964		0.459		
Satd. Flow (perm)	1167	1845	1429	435	1845	1538	0	1679	0	839	1631	0
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)			16			85		24			69	
Link Speed (mph)		30			30			30			30	
Link Distance (ft)		1000			1000			1000			1000	
Travel Time (s)		22.7			22.7			22.7			22.7	
Peak Hour Factor	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Heavy Vehicles (%)	4%	3%	13%	11%	3%	5%	12%	5%	4%	4%	9%	7%
Adj. Flow (vph)	88	639	17	21	189	85	32	235	90	168	95	91
Shared Lane Traffic (%)												
Lane Group Flow (vph)	88	639	17	21	189	85	0	357	0	168	186	0
Enter Blocked Intersection	No	No	No	No	No	No	No	No	No	No	No	No
Lane Alignment	Left	Left	Right	Left	Left	Right	Left	Left	Right	Left	Left	Right
Median Width(ft)		12			12			12			12	
Link Offset(ft)		0			0			0			0	
Crosswalk Width(ft)		16			16			16			16	
Two way Left Turn Lane												
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Turning Speed (mph)	15		9	15		9	15		9	15		9
Number of Detectors	1	2	1	1	2	1	1	2		1	2	
Detector Template	Left	Thru	Right	Left	Thru	Right	Left	Thru		Left	Thru	
Leading Detector (ft)	20	100	20	20	100	20	20	100		20	100	
Trailing Detector (ft)	0	0	0	0	0	0	0	0		0	0	
Detector 1 Position(ft)	0	0	0	0	0	0	0	0		0	0	
Detector 1 Size(ft)	20	6	20	20	6	20	20	6		20	6	
Detector 1 Type	Cl+Ex	Cl+Ex	Cl+Ex	Cl+Ex	Cl+Ex	Cl+Ex	Cl+Ex	Cl+Ex		Cl+Ex	Cl+Ex	
Detector 1 Channel												
Detector 1 Extend (s)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	
Detector 1 Queue (s)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	
Detector 1 Delay (s)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	
Detector 2 Position(ft)		94			94			94			94	
Detector 2 Size(ft)		6			6			6			6	
Detector 2 Type		Cl+Ex			Cl+Ex			Cl+Ex			Cl+Ex	
Detector 2 Channel												
Detector 2 Extend (s)		0.0			0.0			0.0			0.0	
Turn Type	Perm	NA	Perm	Perm	NA	Perm	Perm	NA		Perm	NA	
Protected Phases		2			6			8			4	

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Permitted Phases	2		2	6		6	8			4		
Detector Phase	2	2	2	6	6	6	8	8		4	4	
Switch Phase												
Minimum Initial (s)	12.0	12.0	12.0	12.0	12.0	12.0	7.0	7.0		7.0	7.0	
Minimum Split (s)	18.0	18.0	18.0	18.0	18.0	18.0	11.0	11.0		11.0	11.0	
Total Split (s)	46.0	46.0	46.0	46.0	46.0	46.0	24.0	24.0		24.0	24.0	
Total Split (%)	65.7%	65.7%	65.7%	65.7%	65.7%	65.7%	34.3%	34.3%		34.3%	34.3%	
Maximum Green (s)	40.0	40.0	40.0	40.0	40.0	40.0	20.0	20.0		20.0	20.0	
Yellow Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	3.0	3.0		3.0	3.0	
All-Red Time (s)	2.0	2.0	2.0	2.0	2.0	2.0	1.0	1.0		1.0	1.0	
Lost Time Adjust (s)	0.0	0.0	0.0	0.0	0.0	0.0		0.0		0.0	0.0	
Total Lost Time (s)	6.0	6.0	6.0	6.0	6.0	6.0		4.0		4.0	4.0	
Lead/Lag												
Lead-Lag Optimize?												
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0		3.0	3.0	
Recall Mode	Min	Min	Min	Min	Min	Min	None	None		None	None	
Act Effct Green (s)	24.8	24.8	24.8	24.8	24.8	24.8		18.8		18.8	18.8	
Actuated g/C Ratio	0.46	0.46	0.46	0.46	0.46	0.46		0.35		0.35	0.35	
v/c Ratio	0.16	0.76	0.03	0.11	0.22	0.11		0.60		0.58	0.30	
Control Delay	8.9	18.2	3.9	9.0	9.1	2.4		21.3		28.7	12.2	
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0		0.0		0.0	0.0	
Total Delay	8.9	18.2	3.9	9.0	9.1	2.4		21.3		28.7	12.2	
LOS	A	B	A	A	A	A		C		C	B	
Approach Delay		16.8			7.2			21.3			20.0	
Approach LOS		B			A			C			B	
90th %ile Green (s)	40.0	40.0	40.0	40.0	40.0	40.0	20.0	20.0		20.0	20.0	
90th %ile Term Code	Max	Max	Max	Hold	Hold	Hold	Max	Max		Max	Max	
70th %ile Green (s)	29.9	29.9	29.9	29.9	29.9	29.9	20.0	20.0		20.0	20.0	
70th %ile Term Code	Gap	Gap	Gap	Hold	Hold	Hold	Hold	Hold		Max	Max	
50th %ile Green (s)	24.7	24.7	24.7	24.7	24.7	24.7	20.0	20.0		20.0	20.0	
50th %ile Term Code	Gap	Gap	Gap	Hold	Hold	Hold	Hold	Hold		Max	Max	
30th %ile Green (s)	20.0	20.0	20.0	20.0	20.0	20.0	19.0	19.0		19.0	19.0	
30th %ile Term Code	Gap	Gap	Gap	Hold	Hold	Hold	Hold	Hold		Gap	Gap	
10th %ile Green (s)	13.3	13.3	13.3	13.3	13.3	13.3	13.4	13.4		13.4	13.4	
10th %ile Term Code	Gap	Gap	Gap	Hold	Hold	Hold	Hold	Hold		Gap	Gap	
Queue Length 50th (ft)	16	163	0	4	35	0		83		42	25	
Queue Length 95th (ft)	35	259	7	14	64	16		#243		#155	88	
Internal Link Dist (ft)		920			920			920			920	
Turn Bay Length (ft)	175		50	120		20				160		
Base Capacity (vph)	883	1397	1086	329	1397	1185		665		325	674	
Starvation Cap Reductn	0	0	0	0	0	0		0		0	0	
Spillback Cap Reductn	0	0	0	0	0	0		0		0	0	
Storage Cap Reductn	0	0	0	0	0	0		0		0	0	
Reduced v/c Ratio	0.10	0.46	0.02	0.06	0.14	0.07		0.54		0.52	0.28	

Intersection Summary

Area Type: Other
Cycle Length: 70
Actuated Cycle Length: 54.1

Natural Cycle: 50
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.76
Intersection Signal Delay: 16.7 Intersection LOS: B
Intersection Capacity Utilization 86.7% ICU Level of Service E
Analysis Period (min) 15
90th %ile Actuated Cycle: 70
70th %ile Actuated Cycle: 59.9
50th %ile Actuated Cycle: 54.7
30th %ile Actuated Cycle: 49
10th %ile Actuated Cycle: 36.7
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 1: Sudbury Road & Fitchburg Turnpike

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	90	206	7	122	785	288	14	136	25	161	215	112
Future Volume (vph)	90	206	7	122	785	288	14	136	25	161	215	112
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (ft)	175		50	120		20	0		0	160		0
Storage Lanes	1		1	1		1	0		0	1		0
Taper Length (ft)	25			25			25			25		
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Ped Bike Factor										0.74		
Frt			0.850			0.850		0.981			0.949	
Flt Protected	0.950			0.950				0.996		0.950		
Satd. Flow (prot)	1787	1881	1615	1770	1881	1583	0	1842	0	1805	1762	0
Flt Permitted	0.197			0.628				0.963		0.629		
Satd. Flow (perm)	371	1881	1615	1170	1881	1583	0	1781	0	886	1762	0
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)			16			79		12			37	
Link Speed (mph)		30			30			30			30	
Link Distance (ft)		1000			1000			1000			1000	
Travel Time (s)		22.7			22.7			22.7			22.7	
Confl. Peds. (#/hr)										215		
Peak Hour Factor	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
Heavy Vehicles (%)	1%	1%	0%	2%	1%	2%	0%	1%	0%	0%	2%	3%
Adj. Flow (vph)	91	208	7	123	793	291	14	137	25	163	217	113
Shared Lane Traffic (%)												
Lane Group Flow (vph)	91	208	7	123	793	291	0	176	0	163	330	0
Enter Blocked Intersection	No	No	No	No	No	No	No	No	No	No	No	No
Lane Alignment	Left	Left	Right	Left	Left	Right	Left	Left	Right	Left	Left	Right
Median Width(ft)		12			12			12			12	
Link Offset(ft)		0			0			0			0	
Crosswalk Width(ft)		16			16			16			16	
Two way Left Turn Lane												
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Turning Speed (mph)	15		9	15		9	15		9	15		9
Number of Detectors	1	2	1	1	2	1	1	2		1	2	
Detector Template	Left	Thru	Right	Left	Thru	Right	Left	Thru		Left	Thru	
Leading Detector (ft)	20	100	20	20	100	20	20	100		20	100	
Trailing Detector (ft)	0	0	0	0	0	0	0	0		0	0	
Detector 1 Position(ft)	0	0	0	0	0	0	0	0		0	0	
Detector 1 Size(ft)	20	6	20	20	6	20	20	6		20	6	
Detector 1 Type	Cl+Ex	Cl+Ex	Cl+Ex	Cl+Ex	Cl+Ex	Cl+Ex	Cl+Ex	Cl+Ex		Cl+Ex	Cl+Ex	
Detector 1 Channel												
Detector 1 Extend (s)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	
Detector 1 Queue (s)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	
Detector 1 Delay (s)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	
Detector 2 Position(ft)		94			94			94			94	
Detector 2 Size(ft)		6			6			6			6	
Detector 2 Type		Cl+Ex			Cl+Ex			Cl+Ex			Cl+Ex	
Detector 2 Channel												
Detector 2 Extend (s)		0.0			0.0			0.0			0.0	

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Turn Type	Perm	NA	Perm	Perm	NA	Perm	Perm	NA		Perm	NA	
Protected Phases		2			6			8			4	
Permitted Phases	2		2	6		6	8			4		
Detector Phase	2	2	2	6	6	6	8	8		4	4	
Switch Phase												
Minimum Initial (s)	12.0	12.0	12.0	12.0	12.0	12.0	7.0	7.0		7.0	7.0	
Minimum Split (s)	18.0	18.0	18.0	18.0	18.0	18.0	11.0	11.0		11.0	11.0	
Total Split (s)	46.0	46.0	46.0	46.0	46.0	46.0	24.0	24.0		24.0	24.0	
Total Split (%)	65.7%	65.7%	65.7%	65.7%	65.7%	65.7%	34.3%	34.3%		34.3%	34.3%	
Maximum Green (s)	40.0	40.0	40.0	40.0	40.0	40.0	20.0	20.0		20.0	20.0	
Yellow Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	3.0	3.0		3.0	3.0	
All-Red Time (s)	2.0	2.0	2.0	2.0	2.0	2.0	1.0	1.0		1.0	1.0	
Lost Time Adjust (s)	0.0	0.0	0.0	0.0	0.0	0.0		0.0		0.0	0.0	
Total Lost Time (s)	6.0	6.0	6.0	6.0	6.0	6.0		4.0		4.0	4.0	
Lead/Lag												
Lead-Lag Optimize?												
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0		3.0	3.0	
Recall Mode	Min	Min	Min	Min	Min	Min	None	None		None	None	
Act Effct Green (s)	31.0	31.0	31.0	31.0	31.0	31.0		15.8		15.8	15.8	
Actuated g/C Ratio	0.54	0.54	0.54	0.54	0.54	0.54		0.27		0.27	0.27	
v/c Ratio	0.46	0.21	0.01	0.20	0.78	0.33		0.35		0.67	0.65	
Control Delay	17.6	7.7	1.9	8.1	17.4	6.6		19.8		36.9	24.5	
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0		0.0		0.0	0.0	
Total Delay	17.6	7.7	1.9	8.1	17.4	6.6		19.8		36.9	24.5	
LOS	B	A	A	A	B	A		B		D	C	
Approach Delay		10.5			13.9			19.8			28.6	
Approach LOS		B			B			B			C	
90th %ile Green (s)	40.0	40.0	40.0	40.0	40.0	40.0	20.0	20.0		20.0	20.0	
90th %ile Term Code	Hold	Hold	Hold	Max	Max	Max	Hold	Hold		Max	Max	
70th %ile Green (s)	40.0	40.0	40.0	40.0	40.0	40.0	20.0	20.0		20.0	20.0	
70th %ile Term Code	Hold	Hold	Hold	Max	Max	Max	Hold	Hold		Max	Max	
50th %ile Green (s)	36.1	36.1	36.1	36.1	36.1	36.1	19.2	19.2		19.2	19.2	
50th %ile Term Code	Hold	Hold	Hold	Gap	Gap	Gap	Hold	Hold		Gap	Gap	
30th %ile Green (s)	25.2	25.2	25.2	25.2	25.2	25.2	12.9	12.9		12.9	12.9	
30th %ile Term Code	Hold	Hold	Hold	Gap	Gap	Gap	Hold	Hold		Gap	Gap	
10th %ile Green (s)	16.2	16.2	16.2	16.2	16.2	16.2	8.3	8.3		8.3	8.3	
10th %ile Term Code	Hold	Hold	Hold	Gap	Gap	Gap	Hold	Hold		Gap	Gap	
Queue Length 50th (ft)	19	38	0	22	221	39		50		56	99	
Queue Length 95th (ft)	61	69	3	48	367	80		105		#144	190	
Internal Link Dist (ft)		920			920			920			920	
Turn Bay Length (ft)	175		50	120		20				160		
Base Capacity (vph)	266	1349	1163	839	1349	1158		674		332	683	
Starvation Cap Reductn	0	0	0	0	0	0		0		0	0	
Spillback Cap Reductn	0	0	0	0	0	0		0		0	0	
Storage Cap Reductn	0	0	0	0	0	0		0		0	0	
Reduced v/c Ratio	0.34	0.15	0.01	0.15	0.59	0.25		0.26		0.49	0.48	

Intersection Summary

Area Type: Other

Cycle Length: 70
Actuated Cycle Length: 57.6
Natural Cycle: 50
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.78
Intersection Signal Delay: 17.2 — Intersection LOS: B
Intersection Capacity Utilization 95.6% — ICU Level of Service F
Analysis Period (min) 15
90th %ile Actuated Cycle: 70
70th %ile Actuated Cycle: 70
50th %ile Actuated Cycle: 65.3
30th %ile Actuated Cycle: 48.1
10th %ile Actuated Cycle: 34.5
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 1: Sudbury Road & Fitchburg Turnpike

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	104	626	16	20	186	80	30	221	85	158	89	93
Future Volume (vph)	104	626	16	20	186	80	30	221	85	158	89	93
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (ft)	175		50	120		20	0		0	160		0
Storage Lanes	1		1	1		1	0		0	1		0
Taper Length (ft)	25			25			25			25		
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Frt			0.850			0.850		0.966			0.923	
Flt Protected	0.950			0.950				0.996		0.950		
Satd. Flow (prot)	1736	1845	1429	1626	1845	1538	0	1735	0	1736	1624	0
Flt Permitted	0.633			0.240				0.963		0.448		
Satd. Flow (perm)	1156	1845	1429	411	1845	1538	0	1677	0	818	1624	0
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)			16			85		24			75	
Link Speed (mph)		30			30			30			30	
Link Distance (ft)		1000			1000			1000			1000	
Travel Time (s)		22.7			22.7			22.7			22.7	
Peak Hour Factor	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Heavy Vehicles (%)	4%	3%	13%	11%	3%	5%	12%	5%	4%	4%	9%	7%
Adj. Flow (vph)	111	666	17	21	198	85	32	235	90	168	95	99
Shared Lane Traffic (%)												
Lane Group Flow (vph)	111	666	17	21	198	85	0	357	0	168	194	0
Enter Blocked Intersection	No	No	No	No	No	No	No	No	No	No	No	No
Lane Alignment	Left	Left	Right	Left	Left	Right	Left	Left	Right	Left	Left	Right
Median Width(ft)		12			12			12			12	
Link Offset(ft)		0			0			0			0	
Crosswalk Width(ft)		16			16			16			16	
Two way Left Turn Lane												
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Turning Speed (mph)	15		9	15		9	15		9	15		9
Number of Detectors	1	2	1	1	2	1	1	2		1	2	
Detector Template	Left	Thru	Right	Left	Thru	Right	Left	Thru		Left	Thru	
Leading Detector (ft)	20	100	20	20	100	20	20	100		20	100	
Trailing Detector (ft)	0	0	0	0	0	0	0	0		0	0	
Detector 1 Position(ft)	0	0	0	0	0	0	0	0		0	0	
Detector 1 Size(ft)	20	6	20	20	6	20	20	6		20	6	
Detector 1 Type	Cl+Ex	Cl+Ex	Cl+Ex	Cl+Ex	Cl+Ex	Cl+Ex	Cl+Ex	Cl+Ex		Cl+Ex	Cl+Ex	
Detector 1 Channel												
Detector 1 Extend (s)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	
Detector 1 Queue (s)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	
Detector 1 Delay (s)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	
Detector 2 Position(ft)		94			94			94			94	
Detector 2 Size(ft)		6			6			6			6	
Detector 2 Type		Cl+Ex			Cl+Ex			Cl+Ex			Cl+Ex	
Detector 2 Channel												
Detector 2 Extend (s)		0.0			0.0			0.0			0.0	
Turn Type	Perm	NA	Perm	Perm	NA	Perm	Perm	NA		Perm	NA	
Protected Phases		2			6			8			4	

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Permitted Phases	2		2	6		6	8			4		
Detector Phase	2	2	2	6	6	6	8	8		4	4	
Switch Phase												
Minimum Initial (s)	12.0	12.0	12.0	12.0	12.0	12.0	7.0	7.0		7.0	7.0	
Minimum Split (s)	18.0	18.0	18.0	18.0	18.0	18.0	11.0	11.0		11.0	11.0	
Total Split (s)	46.0	46.0	46.0	46.0	46.0	46.0	24.0	24.0		24.0	24.0	
Total Split (%)	65.7%	65.7%	65.7%	65.7%	65.7%	65.7%	34.3%	34.3%		34.3%	34.3%	
Maximum Green (s)	40.0	40.0	40.0	40.0	40.0	40.0	20.0	20.0		20.0	20.0	
Yellow Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	3.0	3.0		3.0	3.0	
All-Red Time (s)	2.0	2.0	2.0	2.0	2.0	2.0	1.0	1.0		1.0	1.0	
Lost Time Adjust (s)	0.0	0.0	0.0	0.0	0.0	0.0		0.0		0.0	0.0	
Total Lost Time (s)	6.0	6.0	6.0	6.0	6.0	6.0		4.0		4.0	4.0	
Lead/Lag												
Lead-Lag Optimize?												
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0		3.0	3.0	
Recall Mode	Min	Min	Min	Min	Min	Min	None	None		None	None	
Act Effct Green (s)	26.3	26.3	26.3	26.3	26.3	26.3		18.9		18.9	18.9	
Actuated g/C Ratio	0.47	0.47	0.47	0.47	0.47	0.47		0.34		0.34	0.34	
v/c Ratio	0.20	0.76	0.02	0.11	0.23	0.11		0.61		0.61	0.32	
Control Delay	9.1	18.3	3.8	8.9	9.0	2.3		22.4		31.2	12.5	
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0		0.0		0.0	0.0	
Total Delay	9.1	18.3	3.8	8.9	9.0	2.3		22.4		31.2	12.5	
LOS	A	B	A	A	A	A		C		C	B	
Approach Delay		16.7			7.1			22.4			21.2	
Approach LOS		B			A			C			C	
90th %ile Green (s)	40.0	40.0	40.0	40.0	40.0	40.0	20.0	20.0		20.0	20.0	
90th %ile Term Code	Max	Max	Max	Hold	Hold	Hold	Max	Max		Max	Max	
70th %ile Green (s)	32.4	32.4	32.4	32.4	32.4	32.4	20.0	20.0		20.0	20.0	
70th %ile Term Code	Gap	Gap	Gap	Hold	Hold	Hold	Max	Max		Max	Max	
50th %ile Green (s)	26.8	26.8	26.8	26.8	26.8	26.8	20.0	20.0		20.0	20.0	
50th %ile Term Code	Gap	Gap	Gap	Hold	Hold	Hold	Hold	Hold		Max	Max	
30th %ile Green (s)	21.9	21.9	21.9	21.9	21.9	21.9	19.4	19.4		19.4	19.4	
30th %ile Term Code	Gap	Gap	Gap	Hold	Hold	Hold	Hold	Hold		Gap	Gap	
10th %ile Green (s)	13.9	13.9	13.9	13.9	13.9	13.9	13.4	13.4		13.4	13.4	
10th %ile Term Code	Gap	Gap	Gap	Hold	Hold	Hold	Hold	Hold		Gap	Gap	
Queue Length 50th (ft)	21	174	0	4	37	0		89		45	28	
Queue Length 95th (ft)	43	277	7	14	66	16		#244		#158	90	
Internal Link Dist (ft)		920			920			920			920	
Turn Bay Length (ft)	175		50	120		20				160		
Base Capacity (vph)	854	1364	1060	303	1364	1159		647		308	658	
Starvation Cap Reductn	0	0	0	0	0	0		0		0	0	
Spillback Cap Reductn	0	0	0	0	0	0		0		0	0	
Storage Cap Reductn	0	0	0	0	0	0		0		0	0	
Reduced v/c Ratio	0.13	0.49	0.02	0.07	0.15	0.07		0.55		0.55	0.29	

Intersection Summary

Area Type: Other
Cycle Length: 70
Actuated Cycle Length: 55.6

Natural Cycle: 50
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.76
Intersection Signal Delay: 17.1 Intersection LOS: B
Intersection Capacity Utilization 88.5% ICU Level of Service E
Analysis Period (min) 15
90th %ile Actuated Cycle: 70
70th %ile Actuated Cycle: 62.4
50th %ile Actuated Cycle: 56.8
30th %ile Actuated Cycle: 51.3
10th %ile Actuated Cycle: 37.3
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 1: Sudbury Road & Fitchburg Turnpike

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	103	222	7	122	810	288	14	136	25	161	215	133
Future Volume (vph)	103	222	7	122	810	288	14	136	25	161	215	133
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (ft)	175		50	120		20	0		0	160		0
Storage Lanes	1		1	1		1	0		0	1		0
Taper Length (ft)	25			25			25			25		
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Ped Bike Factor										0.74		
Frt			0.850			0.850		0.981			0.943	
Flt Protected	0.950			0.950				0.996		0.950		
Satd. Flow (prot)	1787	1881	1615	1770	1881	1583	0	1842	0	1805	1750	0
Flt Permitted	0.183			0.619				0.961		0.624		
Satd. Flow (perm)	344	1881	1615	1153	1881	1583	0	1777	0	878	1750	0
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)			16			77		12			44	
Link Speed (mph)		30			30			30			30	
Link Distance (ft)		1000			1000			1000			1000	
Travel Time (s)		22.7			22.7			22.7			22.7	
Confl. Peds. (#/hr)										215		
Peak Hour Factor	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
Heavy Vehicles (%)	1%	1%	0%	2%	1%	2%	0%	1%	0%	0%	2%	3%
Adj. Flow (vph)	104	224	7	123	818	291	14	137	25	163	217	134
Shared Lane Traffic (%)												
Lane Group Flow (vph)	104	224	7	123	818	291	0	176	0	163	351	0
Enter Blocked Intersection	No	No	No	No	No	No	No	No	No	No	No	No
Lane Alignment	Left	Left	Right	Left	Left	Right	Left	Left	Right	Left	Left	Right
Median Width(ft)		12			12			12			12	
Link Offset(ft)		0			0			0			0	
Crosswalk Width(ft)		16			16			16			16	
Two way Left Turn Lane												
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Turning Speed (mph)	15		9	15		9	15		9	15		9
Number of Detectors	1	2	1	1	2	1	1	2		1	2	
Detector Template	Left	Thru	Right	Left	Thru	Right	Left	Thru		Left	Thru	
Leading Detector (ft)	20	100	20	20	100	20	20	100		20	100	
Trailing Detector (ft)	0	0	0	0	0	0	0	0		0	0	
Detector 1 Position(ft)	0	0	0	0	0	0	0	0		0	0	
Detector 1 Size(ft)	20	6	20	20	6	20	20	6		20	6	
Detector 1 Type	Cl+Ex	Cl+Ex	Cl+Ex	Cl+Ex	Cl+Ex	Cl+Ex	Cl+Ex	Cl+Ex		Cl+Ex	Cl+Ex	
Detector 1 Channel												
Detector 1 Extend (s)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	
Detector 1 Queue (s)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	
Detector 1 Delay (s)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	
Detector 2 Position(ft)		94			94			94			94	
Detector 2 Size(ft)		6			6			6			6	
Detector 2 Type		Cl+Ex			Cl+Ex			Cl+Ex			Cl+Ex	
Detector 2 Channel												
Detector 2 Extend (s)		0.0			0.0			0.0			0.0	

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Turn Type	Perm	NA	Perm	Perm	NA	Perm	Perm	NA		Perm	NA	
Protected Phases		2			6			8			4	
Permitted Phases	2		2	6		6	8			4		
Detector Phase	2	2	2	6	6	6	8	8		4	4	
Switch Phase												
Minimum Initial (s)	12.0	12.0	12.0	12.0	12.0	12.0	7.0	7.0		7.0	7.0	
Minimum Split (s)	18.0	18.0	18.0	18.0	18.0	18.0	11.0	11.0		11.0	11.0	
Total Split (s)	46.0	46.0	46.0	46.0	46.0	46.0	24.0	24.0		24.0	24.0	
Total Split (%)	65.7%	65.7%	65.7%	65.7%	65.7%	65.7%	34.3%	34.3%		34.3%	34.3%	
Maximum Green (s)	40.0	40.0	40.0	40.0	40.0	40.0	20.0	20.0		20.0	20.0	
Yellow Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	3.0	3.0		3.0	3.0	
All-Red Time (s)	2.0	2.0	2.0	2.0	2.0	2.0	1.0	1.0		1.0	1.0	
Lost Time Adjust (s)	0.0	0.0	0.0	0.0	0.0	0.0		0.0		0.0	0.0	
Total Lost Time (s)	6.0	6.0	6.0	6.0	6.0	6.0		4.0		4.0	4.0	
Lead/Lag												
Lead-Lag Optimize?												
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0		3.0	3.0	
Recall Mode	Min	Min	Min	Min	Min	Min	None	None		None	None	
Act Effct Green (s)	31.9	31.9	31.9	31.9	31.9	31.9		15.9		15.9	15.9	
Actuated g/C Ratio	0.54	0.54	0.54	0.54	0.54	0.54		0.27		0.27	0.27	
v/c Ratio	0.56	0.22	0.01	0.20	0.80	0.32		0.36		0.68	0.69	
Control Delay	23.3	7.8	1.9	8.1	18.2	6.6		20.1		38.4	26.0	
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0		0.0		0.0	0.0	
Total Delay	23.3	7.8	1.9	8.1	18.2	6.6		20.1		38.4	26.0	
LOS	C	A	A	A	B	A		C		D	C	
Approach Delay		12.5			14.4			20.1			30.0	
Approach LOS		B			B			C			C	
90th %ile Green (s)	40.0	40.0	40.0	40.0	40.0	40.0	20.0	20.0		20.0	20.0	
90th %ile Term Code	Max	Max	Max	Max	Max	Max	Hold	Hold		Max	Max	
70th %ile Green (s)	40.0	40.0	40.0	40.0	40.0	40.0	20.0	20.0		20.0	20.0	
70th %ile Term Code	Hold	Hold	Hold	Max	Max	Max	Hold	Hold		Max	Max	
50th %ile Green (s)	37.6	37.6	37.6	37.6	37.6	37.6	19.6	19.6		19.6	19.6	
50th %ile Term Code	Hold	Hold	Hold	Gap	Gap	Gap	Hold	Hold		Gap	Gap	
30th %ile Green (s)	27.1	27.1	27.1	27.1	27.1	27.1	13.2	13.2		13.2	13.2	
30th %ile Term Code	Hold	Hold	Hold	Gap	Gap	Gap	Hold	Hold		Gap	Gap	
10th %ile Green (s)	17.0	17.0	17.0	17.0	17.0	17.0	8.3	8.3		8.3	8.3	
10th %ile Term Code	Hold	Hold	Hold	Gap	Gap	Gap	Hold	Hold		Gap	Gap	
Queue Length 50th (ft)	25	42	0	23	237	41		52		58	109	
Queue Length 95th (ft)	#87	75	3	48	388	80		105		#145	201	
Internal Link Dist (ft)		920			920			920			920	
Turn Bay Length (ft)	175		50	120		20				160		
Base Capacity (vph)	243	1329	1145	814	1329	1141		659		321	669	
Starvation Cap Reductn	0	0	0	0	0	0		0		0	0	
Spillback Cap Reductn	0	0	0	0	0	0		0		0	0	
Storage Cap Reductn	0	0	0	0	0	0		0		0	0	
Reduced v/c Ratio	0.43	0.17	0.01	0.15	0.62	0.26		0.27		0.51	0.52	

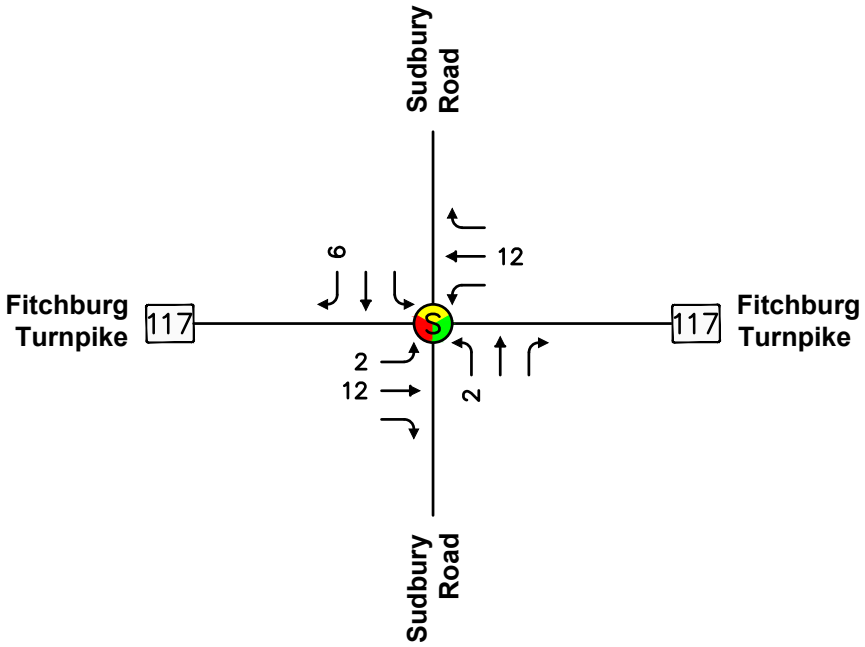
Intersection Summary

Area Type: Other

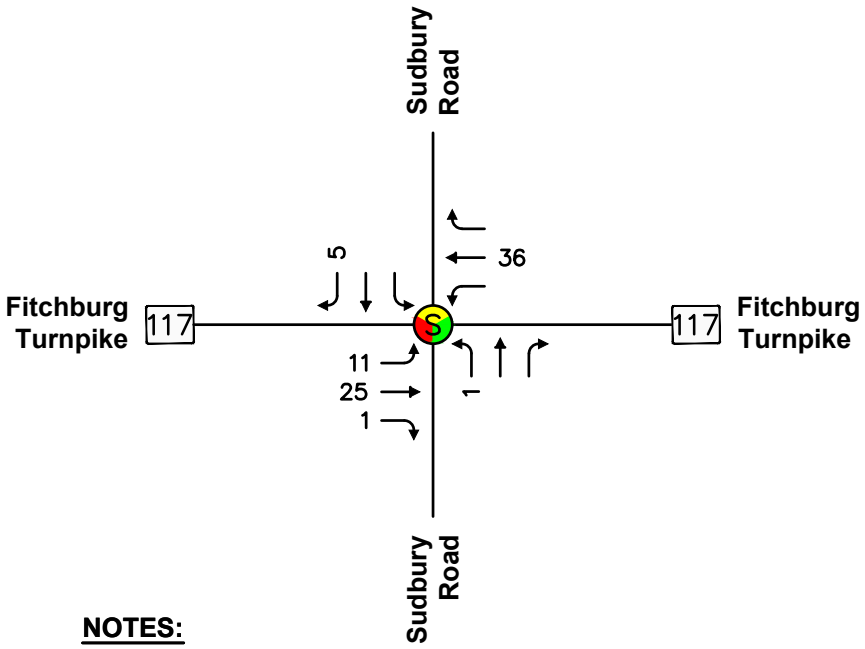
Cycle Length: 70
Actuated Cycle Length: 58.6
Natural Cycle: 55
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.80
Intersection Signal Delay: 18.1
Intersection LOS: B
Intersection Capacity Utilization 98.2%
ICU Level of Service F
Analysis Period (min) 15
90th %ile Actuated Cycle: 70
70th %ile Actuated Cycle: 70
50th %ile Actuated Cycle: 67.2
30th %ile Actuated Cycle: 50.3
10th %ile Actuated Cycle: 35.3
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 1: Sudbury Road & Fitchburg Turnpike

□ Background Projects



Weekday Morning Peak Hour



North
Scale: Not to Scale

NOTES:
NEGL.= Negligible
S = Signalized Intersection

Weekday Evening Peak Hour

Attachments

MDM TRANSPORTATION CONSULTANTS, INC.
Planners & Engineers

129 Parker Street
Mixed Use Development
Site Generated Trips

Date: May 2020
Dwg No. 1073 Sensitivity.dwg

□ Traffic Signal Inventory

2. *Route 117 at Sudbury Road*

Jurisdiction:	Town of Concord
Controller Make:	Naztec
Controller Model:	980
Software Version:	unknown
Cabinet Architecture:	TS-2
Cabinet Size:	NEMA Size 6 (44” W x 25.5” D x 56” H)
Cabinet Assembly Date:	March-2013
Signal Phases:	2-Phase (E/W, N/S)
Vehicle Detection Type:	Video
Vehicle Detection Make:	Traficon
Vehicle Detection Model:	T1 x-stream edge
Number of Channels of Vehicle Detection:	4 (1 - Eastbound, 2 - Southbound, 3 - Westbound, 4 - Northbound)
Malfunctioning Vehicle Detection Channels:	Channel 4 – Sudbury Road Northbound
Operating Mode:	Fully Actuated
Maximum Green 1 Hours:	All Times
Maximum Green 1 Duration:	Route 117 E/W: 40 Seconds Sudbury Road N/S: 20 Seconds
Maximum Green 2 Hours:	None
Maximum Green 2 Duration:	Route 117 E/W: 40 Seconds Sudbury Road N/S: 20 Seconds
Number of Mast Arms:	3

2. *Fitchburg Turnpike (Route 117) at Sudbury Road*

This intersection operates with two vehicle phases (E/W and N/S). The signal provides up to 40 seconds of green time for Route 117 traffic at all times of the day. This duration is much shorter than the 60-70 seconds provided at the Pantry/Dakin Road intersection. The signal cabinet is in new condition. The controller is an a Naztec 980 which is also in new condition. The intersection has video vehicle detectors installed on all four approach roadways. Three of the four video cameras were observed to be functioning properly. The Sudbury Road northbound approach is not functioning and places a constant call for the north/south vehicle signal phase. The intersection has three traffic signal mast arms.

As with the Pantry Road/Dakin Road intersection, a number of vehicles traveling eastbound along Route 117 during the morning peak period were observed to allow a large gap to open between their vehicle and the vehicle in front of them. This gap was similarly interpreted as if all demand had been served on the east/west approaches and ended the green interval before reaching the maximum green duration in order to serve demand on the north/south approaches. Meanwhile a large queue of eastbound vehicles was present behind the lead vehicle. The traffic volume was observed to be mostly eastbound vehicles during the morning peak period. It is expected that the afternoon volume would mostly be westbound vehicles. It is also expected that the same queuing behavior can be observed during the afternoon peak period.

- Crash Data

INTERSECTION CRASH RATE WORKSHEET

CITY/TOWN : Sudbury, MA COUNT DATE : Jan-20

DISTRICT : 3 UNSIGNALIZED : X SIGNALIZED :

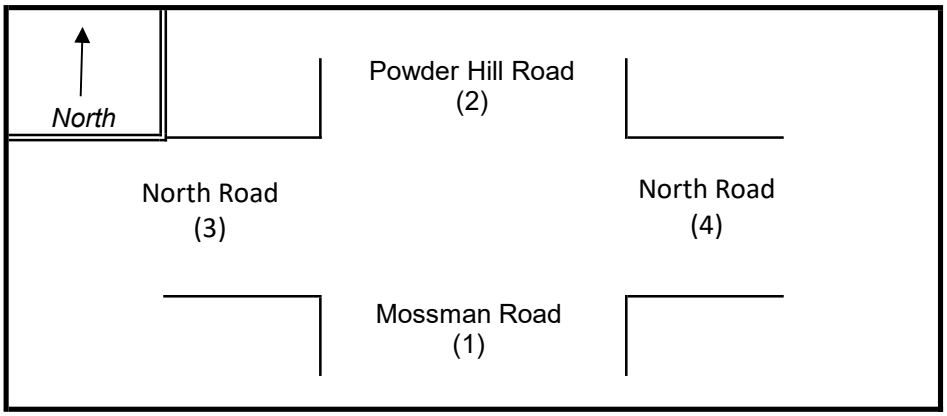
~ INTERSECTION DATA ~

MAJOR STREET : North Road

MINOR STREET(S) : Powder Hill Road

Mossman Road

INTERSECTION DIAGRAM (Label Approaches)



PEAK HOUR VOLUMES

APPROACH :	1	2	3	4	5	Total Peak Hourly Approach Volume
DIRECTION :	NB	SB	EB	WB		
PEAK HOURLY VOLUMES (PM) :	58	122	276	1,093		**1,549**

" K " FACTOR : **0.092** INTERSECTION ADT (**V**) = TOTAL DAILY APPROACH VOLUME : **16,837**

TOTAL # OF CRASHES : 8 # OF YEARS : 5 AVERAGE # OF CRASHES PER YEAR (**A**) : **1.60**

CRASH RATE CALCULATION : **0.26** RATE = $\frac{(A * 1{,}000{,}000)}{(V * 365)}$

Comments : MassDOT District 3 Avg: Signalized = 0.89; Unsignalized = 0.66

Project Title & Date: 1073 - Sudbury

INTERSECTION CRASH RATE WORKSHEET

CITY/TOWN : Sudbury, MA COUNT DATE : Jan-20

DISTRICT : 3 UNSIGNALIZED : SIGNALIZED : X

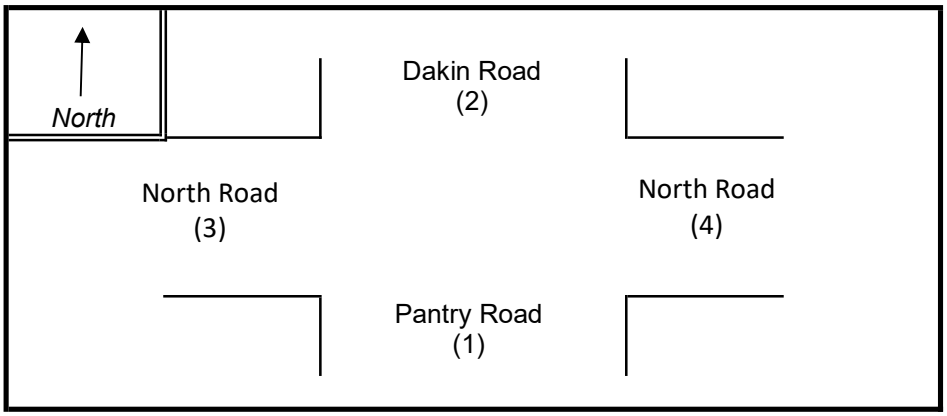
~ INTERSECTION DATA ~

MAJOR STREET : North Road

MINOR STREET(S) : Dakin Road

Pantry Road

INTERSECTION DIAGRAM (Label Approaches)



PEAK HOUR VOLUMES

APPROACH :	1	2	3	4	5	Total Peak Hourly Approach Volume
DIRECTION :	NB	SB	EB	WB		
PEAK HOURLY VOLUMES (PM) :	233	165	313	904		1,615

" K " FACTOR : 0.092

INTERSECTION ADT (**V**) = TOTAL DAILY APPROACH VOLUME : 17,554

TOTAL # OF CRASHES : 10

OF YEARS : 5

AVERAGE # OF CRASHES PER YEAR (**A**) : 2.00

CRASH RATE CALCULATION : 0.31

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

Comments : MassDOT District 3 Avg: Signalized = 0.89; Unsignalized = 0.66

Project Title & Date: 1073 - Sudbury

SEGMENT CRASH RATE WORKSHEET

CITY/TOWN : Sudbury, MA COUNT DATE : Jan-20

DISTRICT : 3

~ SEGMENT DATA ~

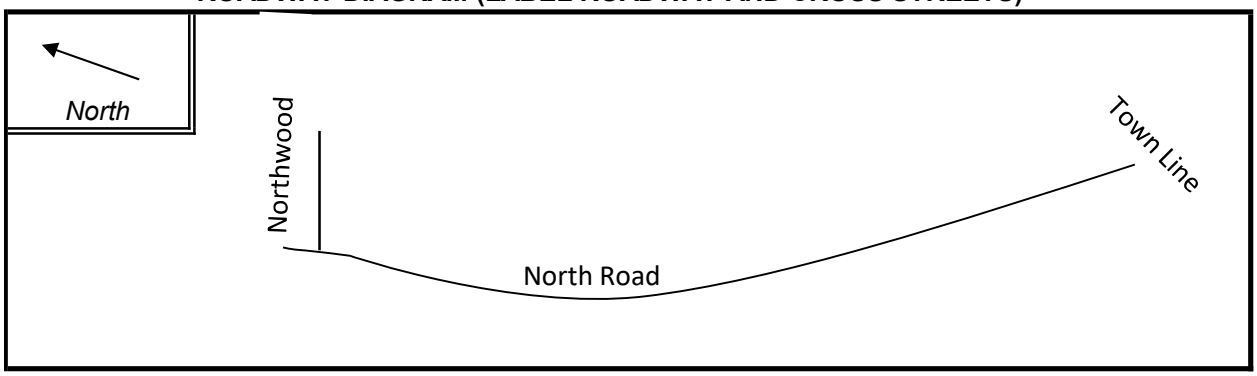
ROADWAY NAME: North Road

START POINT: Sudbury Town Line

END POINT: Northwood Road

FUNCTIONAL CLASSIFICATION OF ROADWAY: Urban Minor Arterial

ROADWAY DIAGRAM (LABEL ROADWAY AND CROSS STREETS)



AVERAGE DAILY TRAFFIC

SEGMENT LENGTH IN MILES (**L**):	**0.5**
AVERAGE DAILY TRAFFIC VOLUME (**V**):	12,390

TOTAL # OF CRASHES:	3	# OF YEARS :	5	AVERAGE # OF CRASHES PER YEAR (**A**) :	**0.60**

CRASH RATE CALCULATION : **0.27**

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

Comments : MassDOT District 3 Avg: Signalized = 0.89; Unsignalized = 0.66

Project Title & Date: 1073 - Sudbury

Crash Date	Crash Severity	Crash Status	Crash Time	Number of Vehicles	Light Conditions	Manner of Collision	Road Surface Condition	Total Fatalities	Total Non-Fatal Injuries	Vehicle Actions Prior to Crash (All Vehicles)	Vehicle Configuration (All Vehicles)	Vehicle Travel Directions (All Vehicles)	Weather Conditions	Most Harmful Event (All Vehicles)	X	Y	Roadway
03/23/2015	Non-fatal injury	Closed	12:57 PM	3	Daylight	Angle	Dry	0	2	V1: Travelling straight ahead / V2: Travelling straight ahead / V3: Travelling straight ahead	V1:(Light truck(van, mini-van, pickup, sport utility)) / V2:(Passenger car) / V3:(Passenger car)	V1: W / V2: N / V3: S	Clear	V1:(Collision with motor vehicle in traffic) / V2:(Collision with motor vehicle in traffic) / V3:(Collision with motor vehicle in traffic)	207671.6	907490.4	NORTH ROAD Rte 117 W / DAKIN ROAD / PANTRY ROAD
09/27/2015	Property damage only (none injured)	Closed	2:15 PM	2	Daylight	Angle	Dry	0	0	V1: Travelling straight ahead / V2: Turning left	V1:(Light truck(van, mini-van, pickup, sport utility)) / V2:(Passenger car)	V1: S / V2: E	Clear	V1:(Collision with motor vehicle in traffic) / V2:(Collision with motor vehicle in traffic)	207671.6	907490.4	NORTH ROAD Rte 117 / PANTRY ROAD
01/07/2016	Property damage only (none injured)	Closed	5:00 PM	2	Dark - lighted roadway	Rear-end	Dry	0	0	V1: Slowing or stopped in traffic / V2: Travelling straight ahead	V1:(Passenger car) / V2:(Passenger car)	V1: W / V2: W	Clear	V1:(Collision with motor vehicle in traffic) / V2:(Collision with motor vehicle in traffic)	207671.6	907490.4	NORTH ROAD / PANTRY ROAD
10/09/2016	Property damage only (none injured)	Closed	10:23 AM	2	Daylight	Angle	Wet	0	0	V1: Travelling straight ahead / V2: Travelling straight ahead	V1:(Passenger car) / V2:(Passenger car)	V1: S / V2: W	Cloudy/Rain	V1:(Collision with motor vehicle in traffic) / V2:(Collision with motor vehicle in traffic)	207671.6	907490.4	DAKIN ROAD / NORTH ROAD Rte 117 W
02/07/2017	Property damage only (none injured)	Closed	10:12 AM	1	Daylight	Single vehicle crash	Snow	0	0	V1: Travelling straight ahead	V1:(Light truck(van, mini-van, pickup, sport utility))	V1: W	Snow	V1:(Collision with highway traffic sign post)	207698.8	907486.4	NORTH ROAD Rte 117 W
02/09/2017	Property damage only (none injured)	Closed	9:12 AM	2	Daylight	Angle	Snow	0	0	V1: Turning left / V2: Travelling straight ahead	V1:(Passenger car) / V2:(Passenger car)	V1: E / V2: W	Snow	V1:(Collision with motor vehicle in traffic) / V2:(Collision with motor vehicle in traffic)	207671.6	907490.4	NORTH ROAD Rte 117 / DAKIN ROAD
07/27/2017	Property damage only (none injured)	Closed	12:39 PM	2	Daylight	Angle	Dry	0	0	V1: Travelling straight ahead / V2: Turning left	V1:(Passenger car) / V2:(Passenger car)	V1: S / V2: W	Cloudy/Rain	V1:(Collision with motor vehicle in traffic) / V2:(Collision with motor vehicle in traffic)	207671.6	907490.4	NORTH ROAD Rte 117 / PANTRY ROAD
08/11/2017	Property damage only (none injured)	Closed	2:50 PM	2	Daylight	Sideswipe, same direction	Dry	0	0	V1: Travelling straight ahead / V2: Travelling straight ahead	V1:(Passenger car) / V2:(Passenger car)	V1: N / V2: W	Clear	V1:(Collision with motor vehicle in traffic) / V2:(Collision with motor vehicle in traffic)	207671.6	907490.4	NORTH ROAD / PANTRY ROAD / DAKIN ROAD
09/14/2017	Property damage only (none injured)	Closed	8:59 AM	2	Daylight	Angle	Dry	0	0	V1: Travelling straight ahead / V2: Turning left	V1:(Passenger car) / V2:(Passenger car)	V1: W / V2: N	Cloudy	V1:(Collision with motor vehicle in traffic) / V2:(Collision with motor vehicle in traffic)	207671.6	907490.4	NORTH ROAD / DAKIN ROAD
06/06/2019	Non-fatal injury	Open	5:08 PM	2	Daylight	Angle	Dry	0	0	V2: Travelling straight ahead / V1: Travelling straight ahead	V2:(Passenger car) / V1:(Light truck(van, mini-van, pickup, sport utility))	V2: S / V1: W	Clear	V2:(Collision with motor vehicle in traffic) / V1:(Collision with motor vehicle in traffic)	207671.6	907490.4	NORTH RD / DAKIN RD

Crash Date	Crash Severity	Crash Time	Crash Year	Number of Vehicles	Light Conditions	Manner of Collision	Road Surface Condition	Total Fatalities	Total Non-Fatal Injuries	Vehicle Configuration (All Vehicles)	Vehicle Travel Directions (All Vehicles)	Weather Conditions	Most Harmful Event (All Vehicles)	X	Y	Roadway
01/06/2015	Property damage only (none injured)	5:24 PM	2015	2	Dark - lighted roadway	Angle	Wet	0	0	V1:(Light truck(van, mini-van, pickup, sport utility)) / V2:(Passenger car)	V1: N / V2: E	Snow	V1:(Collision with motor vehicle in traffic) / V2:(Collision with motor vehicle in traffic)	206285.5	908203.6	NORTH ROAD Rte 117 E / MOSSMAN ROAD
05/07/2016	Non-fatal injury	12:26 AM	2016	1	Dark - lighted roadway	Single vehicle crash	Dry	0	1	V1:(Light truck(van, mini-van, pickup, sport utility))	V1: E	Clear	V1:(Collision with utility pole)	206249.1	908222.3	NORTH ROAD
01/16/2017	Property damage only (none injured)	11:14 AM	2017	2	Daylight	Angle	Dry	0	0	V1:(Light truck(van, mini-van, pickup, sport utility)) / V2:(Passenger car)	V1: E / V2: W	Clear	V1:(Collision with motor vehicle in traffic) / V2:(Collision with motor vehicle in traffic)	206285.5	908203.6	NORTH ROAD Rte 117 E / MOSSMAN ROAD / POWDER MILL ROAD
04/13/2017	Non-fatal injury	7:28 AM	2017	3	Daylight	Angle	Dry	0	1	V1:(Passenger car) / V2:(Passenger car) / V3:(Light truck(van, mini-van, pickup, sport utility))	V1: W / V2: S / V3: E	Clear	V1:(Collision with motor vehicle in traffic) / V2:(Collision with motor vehicle in traffic) / V3:(Collision with motor vehicle in traffic)	206285.5	908203.6	NORTH ROAD / MOSSMAN ROAD
04/19/2018	Property damage only (none injured)	12:41 PM	2018	1	Daylight	Rear-end	Dry	0	0	V1:(Passenger car)	V1: E	Clear	V1:(Collision with motor vehicle in traffic)	206282.9	908198.8	MOSSMAN RD
10/18/2018	Property damage only (none injured)	4:43 PM	2018	2	Daylight	Sideswipe, same direction	Dry	0	0	V1:(Passenger car) / V2:(Passenger car)	V1: S / V2: S	Clear/Cloudy	V1:(Collision with motor vehicle in traffic) / V2:(Collision with motor vehicle in traffic)	206285.5	908203.6	NORTH ROAD Rte 117 / POWDER MILL ROAD / MOSSMAN ROAD
03/11/2019	Property damage only (none injured)	1:23 PM	2019	2	Daylight	Rear-end	Wet	0	0	V1:(Passenger car) / V2:(Passenger car)	V1: E / V2: E	Clear	V1:(Collision with motor vehicle in traffic) / V2:(Collision with motor vehicle in traffic)	206285.5	908203.6	NORTH RD / POWDERMILL RD / MOSSMAN RD
05/11/2019	Non-fatal injury	8:25 PM	2019	1	Dark - lighted roadway	Single vehicle crash	Dry	0	0	V1:(Motorcycle)	V1: W	Clear	V1:(Overturn/rollover)	206285.5	908203.6	NORTH RD / MOSSMAN RD / POWDERMILL RD

Crash Date	Crash Severity	Crash Time	Crash Year	Number of Vehicles	Light Conditions	Manner of Collision	Road Surface Condition	Total Fatalities	Total Non-Fatal Injuries	Vehicle Actions Prior to Crash (All Vehicles)	Vehicle Configuration (All Vehicles)	Vehicle Travel Directions (All Vehicles)	Weather Conditions	Most Harmful Event (All Vehicles)	X	Y	Roadway
06/11/2015	Property damage only (none injured)	4:48 PM	2015	1	Dawn	Single vehicle crash	Dry	0	0	V1: Travelling straight ahead	V1:(Light truck(van, mini-van, pickup, sport utility))	V1: E	Clear	V1:(Collision with animal - deer)	209409.3	907507.3	NORTH ROAD Rte 117 E
03/10/2016	Property damage only (none injured)	3:30 PM	2016	2	Daylight	Single vehicle crash	Wet	0	0	V1: Travelling straight ahead / V2: Travelling straight ahead	V1:(Passenger car) / V2:(Light truck(van, mini-van, pickup, sport utility))	V1: E / V2: W	Rain	V1:(Collision with guardrail) / V2:(Other)	209409.3	907507.3	NORTH ROAD Rte 117 E
05/13/2018	Non-fatal injury	7:48 PM	2018	1	Dusk	Single vehicle crash	Dry	0	1	V1: Travelling straight ahead	V1:(Passenger car)	V1: W	Clear	V1:(Collision with ditch)	209409.3	907507.3	NORTH ROAD

- Trip Generation

Institute of Transportation Engineers (ITE) 10th Edition
Land Use Code (LUC) 220 - Multifamily Housing (Low-Rise)

Average Vehicle Trips Ends vs: Dwelling Units
Independent Variable (X): 98

AVERAGE WEEKDAY DAILY

T = 7.32 * X
T = 7.32 * 98
T = 717.36
T = 718 vehicle trips
with 50% (**359** vpd) entering and 50% (**359** vpd) exiting.

WEEKDAY MORNING PEAK HOUR OF ADJACENT STREET TRAFFIC

T = 0.46 * X
T = 0.46 * 98
T = 45.08
T = 45 vehicle trips
with 23% (**10** vph) entering and 77% (**35** vph) exiting.

WEEKDAY MORNING PEAK HOUR OF GENERATOR

T = 0.56 * X
T = 0.56 * 0
T = 54.88
T = 55 vehicle trips
with 28% (**15** vph) entering and 72% (**40** vph) exiting.

WEEKDAY EVENING PEAK HOUR OF ADJACENT STREET TRAFFIC

T = 0.56 * X
T = 0.56 * 98
T = 54.88
T = 55 vehicle trips
with 63% (**35** vph) entering and 37% (**20** vph) exiting.

WEEKDAY EVENING PEAK HOUR OF GENERATOR

T = 0.67 * X
T = 0.67 * 0
T = 65.66
T = 66 vehicle trips
with 59% (**39** vph) entering and 41% (**27** vph) exiting.

SATURDAY DAILY

T = 8.14 * X
T = 8.14 * 98
T = 797.72
T = 798 vehicle trips
with 50% (**399** vpd) entering and 50% (**399** vpd) exiting.

SATURDAY MIDDAY PEAK HOUR OF GENERATOR

T = 0.70 * X
T = 0.70 * 98
T = 68.60
T = 69 vehicle trips
with 49% (**34** vph) entering and 51% (**35** vph) exiting.

Institute of Transportation Engineers (ITE) 10th Edition
Land Use Code (LUC) 221 - Multifamily Housing (Mid-Rise)

Average Vehicle Trips Ends vs: Dwelling Units
Independent Variable (X): 101

AVERAGE WEEKDAY DAILY

T = 5.44 * X
T = 5.44 * 101
T = 549.44
T = 550 vehicle trips
with 50% (**275** vpd) entering and 50% (**275** vpd) exiting.

WEEKDAY MORNING PEAK HOUR OF ADJACENT STREET TRAFFIC

T = 0.36 * X
T = 0.36 * 101
T = 36.36
T = 36 vehicle trips
with 26% (**9** vph) entering and 74% (**27** vph) exiting.

WEEKDAY EVENING PEAK HOUR OF ADJACENT STREET TRAFFIC

T = 0.44 * X
T = 0.44 * 101
T = 44.44
T = 44 vehicle trips
with 61% (**27** vph) entering and 39% (**17** vph) exiting.

SATURDAY DAILY

T = 4.91 * X
T = 4.91 * 101
T = 495.91
T = 496 vehicle trips
with 50% (**248** vpd) entering and 50% (**248** vpd) exiting.

SATURDAY MIDDAY PEAK HOUR OF GENERATOR

T = 0.44 * X
T = 0.44 * 101
T = 44.44
T = 44 vehicle trips
with 49% (**22** vph) entering and 51% (**22** vph) exiting.

Institute of Transportation Engineers (ITE) 10th Edition
Land Use Code (LUC) 252 - Senior Adult Housing - Attached

Average Vehicle Trips Ends vs: Dwelling Units
Independent Variable (X): 81

AVERAGE WEEKDAY DAILY

T = 3.70*(X) (Small Sample Size - Use with Caution)
T = 3.70* 81
T = 299.70 vehicle trips
T= 300
with 50% (150 vpd) entering and 50% (150 vpd) exiting.

WEEKDAY MORNING PEAK HOUR OF ADJACENT STREET TRAFFIC

T = 0.2*(X)
T = 0.20* 81
T = 16.00 vehicle trips
T = 16
with 35% (6 vph) entering and 65%(10 vph) exiting.

WEEKDAY EVENING PEAK HOUR OF ADJACENT STREET TRAFFIC

T = 0.26*(X)
T = 0.26* 81
T = 21.00
T = 21
with 55% (12 vph) entering and 45%(9 vph) exiting.

SATURDAY DAILY

T = 3.23 * (X) (Small Sample Size - Use with Caution)
T = 3.23 * 81
T = 261.63
T = 262 vehicle trips
with 50% (131 vpd) entering and 50% (131 vpd) exiting.

SATURDAY MIDDAY PEAK HOUR OF GENERATOR

T = 0.33 * (X)
T = 0.33 * 81
T = 26.73
T = 27 vehicle trips
with 62% (17 vph) entering and 38%(10 vph) exiting.

□ Signal Warrant Analysis

MUTCD Traffic Signal Warrant #2 Analysis

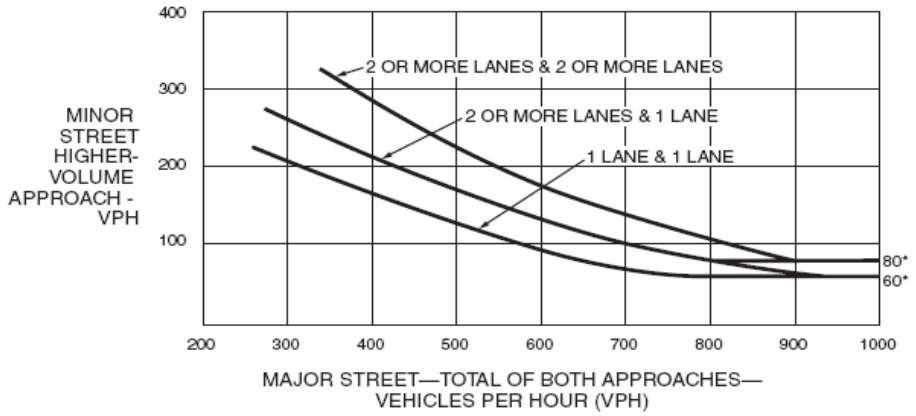
Project Name 1073 - Sudbury
Date Baseline Volumes
100% Exiting Vehicles Included for Site Drive Approach

	Street Name	Direction
Major 1	North Road	EB
Major 2	North Road	WB
Minor 1	Site Driveway	SB
Minor 2	N/A	0

Node	Time Period	Major St. 1 Approach Volume	Major St. 2 Approach Volume	Total Major St. Volume	Minor St. 1 Approach Volume	Minor St. 2 Approach Volume	Higher Minor St. Volume	Warrant 2 Threshold Met
1	6:00-7:00 AM	893	74	967	0	0	0	NO
2	7:00-8:00 AM	900	162	1062	84	0	84	YES
3	8:00-9:00 AM	765	269	1034	84	0	84	YES
4	9:00-10:00 AM	556	208	764	0	0	0	NO
5	10:00-11:00 AM	228	129	357	0	0	0	NO
6	11:00 AM-12:00 PM	198	162	360	0	0	0	NO
7	12:00-1:00 PM	179	218	397	0	0	0	NO
8	1:00 PM - 2:00 PM	175	249	424	0	0	0	NO
9	2:00 PM - 3:00 PM	154	333	487	0	0	0	NO
10	3:00 PM - 4:00 PM	215	718	933	0	0	0	NO
11	4:00 PM - 5:00 PM	177	856	1033	0	0	0	NO
12	5:00 PM - 6:00 PM	184	801	985	52	0	52	NO
13	6:00 PM - 7:00 PM	148	686	834	52	0	52	NO
14	7:00 PM - 8:00 PM	67	321	388	0	0	0	NO
15	8:00 PM - 9:00 PM	59	191	250	0	0	0	NO
16	9:00 PM - 10:00 PM	51	149	200	0	0	0	NO
							Hours Met	2

Figure 4C-2. Warrant 2, Four-Hour Vehicular Volume (70% Factor)

(COMMUNITY LESS THAN 10,000 POPULATION OR ABOVE 40 MPH ON MAJOR STREET)



*Note: 80 vph applies as the lower threshold volume for a minor-street approach with two or more lanes and 60 vph applies as the lower threshold volume for a minor-street approach with one lane.

□ Left Turn Lane Analysis

Intersection	
Int Delay, s/veh	1.8

Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Traffic Vol, veh/h	12	874	334	15	46	38
Future Vol, veh/h	12	874	334	15	46	38
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	150	-	-	-	0	-
Veh in Median Storage, #	-	0	0	-	0	-
Grade, %	-	0	0	-	0	-
Peak Hour Factor	92	92	92	92	92	92
Heavy Vehicles, %	0	2	5	0	0	0
Mvmt Flow	13	950	363	16	50	41

Major/Minor	Major1		Major2		Minor2	
Conflicting Flow All	379	0	-	0	1347	371
Stage 1	-	-	-	-	371	-
Stage 2	-	-	-	-	976	-
Critical Hdwy	4.1	-	-	-	6.4	6.2
Critical Hdwy Stg 1	-	-	-	-	5.4	-
Critical Hdwy Stg 2	-	-	-	-	5.4	-
Follow-up Hdwy	2.2	-	-	-	3.5	3.3
Pot Cap-1 Maneuver	1191	-	-	-	168	679
Stage 1	-	-	-	-	702	-
Stage 2	-	-	-	-	368	-
Platoon blocked, %			-	-	-	
Mov Cap-1 Maneuver	1191	-	-	-	166	679
Mov Cap-2 Maneuver	-	-	-	-	166	-
Stage 1	-	-	-	-	694	-
Stage 2	-	-	-	-	368	-

Approach	EB	WB	SB
HCM Control Delay, s	0.1	0	27.2
HCM LOS			D

Minor Lane/Major Mvmt	EBL	EBT	WBT	WBR	SBLn1
Capacity (veh/h)	1191	-	-	-	252
HCM Lane V/C Ratio	0.011	-	-	-	0.362
HCM Control Delay (s)	8.1	-	-	-	27.2
HCM Lane LOS	A	-	-	-	D
HCM 95th %tile Q(veh)	0	-	-	-	1.6

Intersection	
Int Delay, s/veh	0.9

Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Traffic Vol, veh/h	37	328	46	1011	29	23
Future Vol, veh/h	37	328	46	1011	29	23
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	150	-	-	-	0	-
Veh in Median Storage, #	-	0	0	-	0	-
Grade, %	-	0	0	-	0	-
Peak Hour Factor	92	92	92	92	92	92
Heavy Vehicles, %	0	1	2	0	0	0
Mvmt Flow	40	357	50	1099	32	25

Major/Minor	Major1		Major2		Minor2	
Conflicting Flow All	1149	0	-	0	1037	600
Stage 1	-	-	-	-	600	-
Stage 2	-	-	-	-	437	-
Critical Hdwy	4.1	-	-	-	6.4	6.2
Critical Hdwy Stg 1	-	-	-	-	5.4	-
Critical Hdwy Stg 2	-	-	-	-	5.4	-
Follow-up Hdwy	2.2	-	-	-	3.5	3.3
Pot Cap-1 Maneuver	615	-	-	-	258	505
Stage 1	-	-	-	-	552	-
Stage 2	-	-	-	-	655	-
Platoon blocked, %			-	-	-	
Mov Cap-1 Maneuver	615	-	-	-	241	505
Mov Cap-2 Maneuver	-	-	-	-	241	-
Stage 1	-	-	-	-	516	-
Stage 2	-	-	-	-	655	-

Approach	EB	WB	SB
HCM Control Delay, s	1.1	0	19
HCM LOS			C

Minor Lane/Major Mvmt	EBL	EBT	WBT	WBR	SBLn1
Capacity (veh/h)	615	-	-	-	313
HCM Lane V/C Ratio	0.065	-	-	-	0.181
HCM Control Delay (s)	11.3	-	-	-	19
HCM Lane LOS	B	-	-	-	C
HCM 95th %tile Q(veh)	0.2	-	-	-	0.6

Traffic Signal Inventory

Technical Memorandum

To: Dan Nason, P.E., Director of Public Works

From: Mike Wasielewski, P.E., PTOE

cc: Bill O'Rourke, P.E., Deputy Director of Public Works

Date: November 21, 2018

Re: Traffic signal evaluation at eight locations associated with the Quarry North at Melone Redevelopment

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At the request of the Town of Sudbury, Ocean State Signal performed an evaluation of existing traffic signal equipment at the following three locations along Route 117 located in the Towns of Sudbury, Concord and Lincoln:

1. North Road (Route 117) at Pantry Road and Dakin Road [Town of Sudbury]
2. Fitchburg Turnpike (Route 117) at Sudbury Road [Town of Concord]
3. South Great Road (Route 117) at Concord Road (Route 126) [Town of Lincoln]

Additionally, the following five intersections were reviewed in the center of Sudbury and along Boston Post Road (Route 20):

4. Hudson Road/Old Sudbury Road (Route 27) at Concord Road [Town of Sudbury]
5. Boston Post Road (Route 20) at Bay Drive/Highland Avenue/Shopping Plaza Driveway [MassDOT]
6. Boston Post Road (Route 20) at Nobscot Road [MassDOT]
7. Boston Post Road (Route 20) at Union Avenue & Shopping Plaza Driveway [MassDOT]
8. Boston Post Road (Route 20) at Concord Road [MassDOT]

The equipment evaluations at locations 1-4 were performed on the morning of Monday, November 19, 2018. A visual only evaluation (the signal cabinet was not opened) was performed at location 5-8 on the morning of Wednesday, November 21, 2018. The purpose of the evaluations was to document the following:

- Determination of traffic signal cabinet architecture (NEMA TS-1 [older standard] or NEMA TS-2 [latest standard])
- Make, model and software revision of the existing traffic signal controller
- Type, make, model and operating condition of existing vehicle detection equipment

- Size and location of existing traffic signal mast arms and signal posts

The results of this evaluation will be used to generate recommendations that could improve traffic flow along the Route 117 corridor, within the center of Sudbury (Route 27) and along the Route 20 corridor.

This Technical Memorandum will present the findings of the evaluation, suggest improvements that could be implemented to improve vehicle flow, and present budgetary cost estimates to implement the suggested improvements.

Summary of Evaluation Data

1. North Road (Route 117) at Pantry Road and Dakin Road

Jurisdiction:	Town of Sudbury
Controller Make:	Eagle/Siemens
Controller Model:	M42
Software Version:	3.32f
Cabinet Architecture:	TS-2
Cabinet Size:	NEMA Size 6 (44” W x 25.5” D x 56” H)
Cabinet Assembly Date:	May-2002
Signal Phases:	3-Phase (E/W, N/S, Exclusive Pedestrian)
Vehicle Detection Type:	Wire Loop
Vehicle Detection Make:	Eberly Design Inc. (EDI)
Vehicle Detection Model:	LM 622t
Number of Channels of Vehicle Detection:	4 (1 - Eastbound, 2 - Northbound, 3 - Westbound, 4 - Southbound)
Malfunctioning Vehicle Detection Channels:	None
Operating Mode:	Fully Actuated
Maximum Green 1 Hours:	0:00 - 15:00 (Monday - Friday) 19:00 - 0:00 (Monday - Friday) All Times (Saturday - Sunday)
Maximum Green 1 Duration:	North Road (Route 117) E/W: 60 Seconds Pantry & Dakin Roads N/S: 20 Seconds
Maximum Green 2 Hours:	15:00 – 19:00 (Monday – Friday)
Maximum Green 2 Duration:	North Road (Route 117) E/W: 70 Seconds Pantry & Dakin Roads N/S: 20 Seconds
Number of Mast Arms:	2

2. *North Road (Route 117) at Pantry Road and Dakin Road*

Jurisdiction:	Town of Concord
Controller Make:	Naztec
Controller Model:	980
Software Version:	unknown
Cabinet Architecture:	TS-2
Cabinet Size:	NEMA Size 6 (44” W x 25.5” D x 56” H)
Cabinet Assembly Date:	March-2013
Signal Phases:	2-Phase (E/W, N/S)
Vehicle Detection Type:	Video
Vehicle Detection Make:	Traficon
Vehicle Detection Model:	T1 x-stream edge
Number of Channels of Vehicle Detection:	4 (1 - Eastbound, 2 - Southbound, 3 - Westbound, 4 - Northbound)
Malfunctioning Vehicle Detection Channels:	Channel 4 – Sudbury Road Northbound
Operating Mode:	Fully Actuated
Maximum Green 1 Hours:	All Times
Maximum Green 1 Duration:	North Road (Route 117) E/W: 40 Seconds Pantry & Dakin Roads N/S: 20 Seconds
Maximum Green 2 Hours:	None
Maximum Green 2 Duration:	North Road (Route 117) E/W: 40 Seconds Pantry & Dakin Roads N/S: 20 Seconds
Number of Mast Arms:	3

3. *South Great Road (Route 117) at Concord Road (Route 126)*

Jurisdiction:	Town of Lincoln
Controller Make:	Eagle/Siemens
Controller Model:	M52
Software Version:	3.53a
Cabinet Architecture:	TS-2
Cabinet Size:	NEMA Size 6 (44” W x 25.5” D x 56” H)
Cabinet Assembly Date:	January-2000 Controller replaced in 2014
Signal Phases:	4-Phase (Westbound Left Turn, E/W, Exclusive Pedestrian, N/S)
Vehicle Detection Type:	Wire Loop
Vehicle Detection Make:	Eberly Design Inc. (EDI)
Vehicle Detection Model:	LM 622t
Number of Channels of Vehicle Detection:	5 (1 - Westbound Left Turn, 2 - Eastbound, 3 - Westbound, 4 – Southbound, 5 - Northbound)
Malfunctioning Vehicle Detection Channels:	None
Operating Mode:	Fully Actuated
Maximum Green 1 Hours:	All Times
Maximum Green 1 Duration:	S. Great Road (Route 117) Westbound Left-turn: 10 Seconds S. Great Road (Route 117) E/W: 45 Seconds Pantry & Dakin Roads N/S: 20 Seconds
Maximum Green 2 Hours:	15:00 – 19:00 (Monday – Friday)
Maximum Green 2 Duration:	North Road (Route 117) E/W: 70 Seconds Pantry & Dakin Roads N/S: 20 Seconds
Number of Mast Arms:	2

4. *Hudson Road (Route 27) and Old Sudbury Road (Route 27) at Concord Road*

Jurisdiction:	Town of Concord
Controller Make:	Siemens
Controller Model:	M52
Software Version:	3.55a
Cabinet Architecture:	TS-2
Cabinet Size:	NEMA Size 5 (30” W x 17” D x 55” H)
Cabinet Assembly Date:	October-2015
Signal Phases:	5-Phase (E/W left-turns, E/W, northbound left-turn, N/S, exclusive pedestrian)
Vehicle Detection Type:	Wire loops
Vehicle Detection Make:	Eberly Design, Inc. (EDI)
Vehicle Detection Model:	Oracle2
Number of Channels of Vehicle Detection:	8 (one channel unused)
Malfunctioning Vehicle Detection Channels:	None
Operating Mode:	Fully Actuated
Number of Mast Arms:	1

5. *Boston Post Road (Route 20) at Bay Drive/Highland Avenue/Shopping Plaza Driveway*

Jurisdiction:	MassDOT
Controller Make:	Peek (Assumed from cabinet exterior)
Controller Model:	Unknown
Software Version:	Unknown
Cabinet Architecture:	TS-2
Cabinet Size:	NEMA Size 6 (44” W x 25.5” D x 56” H)
Cabinet Assembly Date:	Unknown
Signal Phases:	Unknown
Vehicle Detection Type:	Wire loops & 1 camera for Highland Ave
Vehicle Detection Make:	Unknown
Vehicle Detection Model:	Unknown
Number of Channels of Vehicle Detection:	Unknown
Malfunctioning Vehicle Detection Channels:	Unknown
Operating Mode:	Fully Actuated with Time-of-Day coordination using GPS time clock synchronization
Signal Interconnect Communication	None
Number of Mast Arms:	4

6. *Boston Post Road (Route 20) at Nobscot Road*

Jurisdiction:	MassDOT
Controller Make:	Peek (Assumed from cabinet exterior)
Controller Model:	Unknown
Software Version:	Unknown
Cabinet Architecture:	TS-2
Cabinet Size:	NEMA Size 6 (44” W x 25.5” D x 56” H)
Cabinet Assembly Date:	Unknown
Signal Phases:	3 Phase (E/W, N/S, Exclusive Pedestrian)
Vehicle Detection Type:	Wire loops
Vehicle Detection Make:	Unknown
Vehicle Detection Model:	Unknown
Number of Channels of Vehicle Detection:	Unknown
Malfunctioning Vehicle Detection Channels:	Unknown
Operating Mode:	Fully Actuated with Time-of-Day coordination using GPS time clock synchronization
Signal Interconnect Communication	None
Number of Mast Arms:	4

7. *Boston Post Road (Route 20) at Union Avenue & Shopping Plaza Driveway*

Jurisdiction:	MassDOT
Controller Make:	Peek (Assumed from cabinet exterior)
Controller Model:	Unknown
Software Version:	Unknown
Cabinet Architecture:	TS-2
Cabinet Size:	NEMA Size 6 (44” W x 25.5” D x 56” H)
Cabinet Assembly Date:	Unknown
Signal Phases:	2 Phases (E/W, N/S)
Vehicle Detection Type:	Wire loops
Vehicle Detection Make:	Unknown
Vehicle Detection Model:	Unknown
Number of Channels of Vehicle Detection:	Unknown
Malfunctioning Vehicle Detection Channels:	Unknown
Operating Mode:	Fully Actuated with Time-of-Day coordination using GPS time clock synchronization
Signal Interconnect Communication	None
Number of Mast Arms:	0 (Span wire mounted signals)

8. *Boston Post Road (Route 20) at Concord Road*

Jurisdiction:	MassDOT
Controller Make:	Eagle/Siemens (From OSS records)
Controller Model:	M34
Software Version:	Unknown
Cabinet Architecture:	TS-2
Cabinet Size:	NEMA Size 6 (44" W x 25.5" D x 56" H)
Cabinet Assembly Date:	July-1999
Signal Phases:	3 Phases (E/W, Southbound, Pedestrian)
Vehicle Detection Type:	Wire loops
Vehicle Detection Make:	Eberly Design, Inc. (EDI)
Vehicle Detection Model:	Unknown
Number of Channels of Vehicle Detection:	Unknown
Malfunctioning Vehicle Detection Channels:	Unknown
Operating Mode:	Fully Actuated
Signal Interconnect Communication	None
Number of Mast Arms:	1 (Northwest Corner)

Discussion of Evaluation Data

1. *North Road (Route 117) at Pantry Road and Dakin Road*

This intersection operates with two vehicle phases (E/W and N/S) and an exclusive pedestrian phase. The signal provides up to 70 seconds of green time for Route 117 traffic during the afternoon peak period (3 PM to 7PM) and up to 60 seconds at all other times of the day. The signal cabinet is in good condition. The controller is an older Eagle M42 which is in good condition. The intersection has wire loop detectors installed on all four approach roadways, and all loop detectors were observed to be operating properly. The signal has two traffic signal mast arms at the primary intersection and a third mast arm east of the fire station driveway to prevent vehicles from blocking the fire station driveway during the special preemption phase for the fire station.

A number of vehicles traveling eastbound along Route 117 during the morning peak period were observed to allow a large gap to open between their vehicle and the vehicle in front of them. This gap was so large, that the traffic signal controller interpreted the gap as if all demand had been served on the east/west approaches and ended the green interval long before reaching the maximum green duration in order to serve demand on the north/south approaches. Meanwhile a large queue of eastbound vehicles was present behind the lead vehicle. The traffic volume was observed to be mostly eastbound vehicles during the morning peak period (traveling to work). It is expected

that the afternoon volume would mostly be westbound vehicles (traveling home). It is expected that the same queuing behavior could be observed during the afternoon peak period.

2. *Fitchburg Turnpike (Route 117) at Sudbury Road*

This intersection operates with two vehicle phases (E/W and N/S). The signal provides up to 40 seconds of green time for Route 117 traffic at all times of the day. This duration is much shorter than the 60-70 seconds provided at the Pantry/Dakin Road intersection. The signal cabinet is in new condition. The controller is an a Naztec 980 which is also in new condition. The intersection has video vehicle detectors installed on all four approach roadways. Three of the four video cameras were observed to be functioning properly. The Sudbury Road northbound approach is not functioning and places a constant call for the north/south vehicle signal phase. The intersection has three traffic signal mast arms.

As with the Pantry Road/Dakin Road intersection, a number of vehicles traveling eastbound along Route 117 during the morning peak period were observed to allow a large gap to open between their vehicle and the vehicle in front of them. This gap was similarly interpreted as if all demand had been served on the east/west approaches and ended the green interval before reaching the maximum green duration in order to serve demand on the north/south approaches. Meanwhile a large queue of eastbound vehicles was present behind the lead vehicle. The traffic volume was observed to be mostly eastbound vehicles during the morning peak period. It is expected that the afternoon volume would mostly be westbound vehicles. It is also expected that the same queuing behavior can be observed during the afternoon peak period.

3. *South Great Road (Route 117) at Concord Road (Route 126)*

This intersection operates with three vehicle phases (westbound left-turn, E/W and N/S) and an exclusive pedestrian phase. The signal provides up to 45 seconds of green time for Route 117 traffic during all times of the day. This duration is slightly longer than the 40 seconds provided at the Sudbury Road intersection, but much shorter than the 60-70 seconds provided at the Pantry/Dakin Road intersection. The signal cabinet is in good condition. The controller is a newer Eagle/Siemens M52 which is in good condition. The existing controller is a replacement for the Eagle M42 controller that was originally installed with the cabinet. The intersection has wire loop detectors installed on all four approach roadways, and all loop detectors were observed to be operating properly. The signal has no traffic signal mast arms at the intersection. All signal heads are mounted at the edge of the roadway on traffic signal posts.

As with the other two locations, a number of vehicles traveling eastbound along Route 117 during the morning peak period were observed to allow a large gap to open between their vehicle and the vehicle in front of them. This gap was so large, that the traffic signal controller interpreted the gap as if all demand had been served on the east/west approaches and ended the green interval before reaching the maximum green duration in order to serve demand on the north/south approaches. Meanwhile a large queue of eastbound vehicles was present behind the lead vehicle. The traffic volume was observed to be mostly eastbound vehicles during the morning peak period (traveling to work). It is expected that the afternoon volume would be mostly westbound vehicles

(traveling home). It is expected that the same queuing behavior could be observed during the afternoon peak period.

4. *Hudson Road/Old Sudbury Road (Route 27) at Concord Road*

This intersection operates with four vehicle phases (E/W left-turns, E/W, northbound left-run and N/S) and an exclusive pedestrian phase. The signal cabinet is in new condition, but is a NEMA size 5 cabinet. The existing equipment is tightly packed in the cabinet and there is no room for additional equipment. The controller is a newer Eagle/Siemens M52 which is in new condition. The intersection has wire loop detectors installed on all four approach roadways, and all loop detectors were observed to be operating properly. The signal has one traffic signal mast arms located on the northwest corner of the intersection.

Locations 5-8 along the Route 20 Corridor

Locations 5-8, located on Route 20, are under MassDOT jurisdiction; therefore, the cabinets could not be opened to evaluate the equipment inside. Observations were made related to existing vehicle detection, signal operation and mast arm location.

All cabinets appear to be TS-2 cabinets. Three of the four locations (Bay Drive, Nobscot Road and Union Avenue) have GPS time synchronization receivers installed, which indicates that the intersections do not have the ability to communicate with each other. These three intersections operate with fixed cycle lengths to provide coordinated operation between them. Coordination is likely programed only during the morning and afternoon peak periods (6AM - 9AM and 3PM - 7 PM) and possibly during the mid-day on weekends. Two intersections (Bay Drive and Nobscot Road) have four mast arms, which are good for mounting video/radar vehicle detection equipment to support adaptive operation. The Union Avenue intersection has span wire mounted signal equipment. The Concord Road intersection has a single mast arm located on the northwest corner of the intersection. A single-point camera system with additional single approach cameras could be installed at the Union Avenue and Concord Road intersections to fully support adaptive operation.

Conclusions

Route 117

The existing wire loop detectors at the Pantry Road/Dakin Road and Concord Road intersections were found to be operating properly. Replacement of the existing loops at this point in time, would not improve intersection operation. Should the loops begin to fail in the future, video detection is a viable option (multi-camera and single-point camera systems) at the Pantry Road/Dakin Road intersection. However, the lack of mast arms at the Concord Road intersection makes a multi-camera video detection system a less feasible solution because cameras could not be placed in locations that would promote reliable operation. A single-point camera detection system could be considered at this intersection. The signal-point camera system would require a new 20-foot tall signal post to replace an existing 10-foot post and an additional 10-foot camera extension post would be needed to reach the camera height (30 feet) required by the system. Existing trees and shrubs, likely located on private property, would also

need to be trimmed back on the westbound approach to ensure visibility of approaching vehicles.

Three of the four existing video cameras at the Sudbury Road intersection are operational. The signal receives a constant vehicle call from the malfunctioning camera on the Sudbury Road northbound approach. The fourth camera should be repaired or replaced.

The maximum green time duration for traffic traveling along Route 117 varies between intersections. 60 to 70 seconds is provided at the Pantry Road/Dakin Road intersection, 40 seconds is provided at the Sudbury Road intersection and 45 seconds is provided at the Concord Road intersection. During the morning peak period, maximum green durations would be expected to increase when moving from west to east as the predominant vehicle volume increases. During the afternoon peak hour, the green durations would be expected to increase from east to west with the predominant vehicle flow.

To prevent the signals from terminating the green interval prematurely due to excessive gaps in traffic the following measures could be employed:

- Control the Route 117 vehicle movements with a maximum recall during the morning and afternoon peak periods. The max recall will ignore the Route 117 wire loop detector inputs and serve the programmed maximum green time every cycle during the hours so programmed. This will prevent the signal from moving away from Route 117 prematurely.

- Operate all three intersections with a fixed cycle length and programmed offset times. The side streets would remain actuated (green would end when demand was served or maximum green was reached), but any unused time in the remainder of the cycle would be allocated to the Route 117 movements. With the installation of GPS receivers, the clocks in the signal controllers could be synchronized. Offset times could be programmed to promote progression of traffic along Route 117 eastbound during the morning peak period and westbound during the evening peak period. The intersection could operate in fully actuated mode (as they do today) during the mid-day and overnight hours. Because of the great distance between intersections, some vehicles may arrive at the next intersection early (before the green) and some vehicles at the end of the platoon may not make it through the green interval at the next intersection, but fewer vehicles would be required to stop compared to today.

Sudbury Center

The Town of Sudbury is considering adding additional wire loop vehicle detectors along the Hudson Road eastbound and Concord Road southbound approaches to improve intersection operation. The added loops would require additional excavation, conduit and pull boxes. Ocean State Signal was asked to evaluate the potential of video or radar detection on these approaches in place of additional wire loops. Initially video detection did not look feasible, but upon further examination a combination video and radar detector unit could be deployed on the Hudson Road eastbound and Concord Road southbound approaches to provide advance vehicle detection. The low branches on the existing trees located in the northwest corner of the intersection and along Concord Road southbound could interfere with the radar signal and would need to be trimmed up. The existing mast arm would be used to mount the two units, the existing conduit system could be used for the new cable to provide power and communication to

the units, and the existing card rack in the cabinet has the capacity to accommodate new communication card for the units.

The skewed geometry, existing mast arm location, cabinet space to accommodate additional detection equipment and the topography surrounding the intersection would limit the feasibility and effectiveness of a single-point camera system in addressing the advance vehicle detection requirements.

Route 20

A major obstacle to implementing Adaptive Signal Control at the Route 20 intersections is providing communication between the intersections. The adaptive system operates by measuring vehicle volume at each individual intersection. The adaptive processor at each intersection sends volume data to and receives volume data from its neighboring intersection. Most of the intersections (three out of four) do not have line of sight visibility between intersections, therefore wireless broadband communication between the intersections is not feasible. There are overhead utilities along the corridor. It may be possible to install a new fiber optic communication cable on the existing utility poles. At this point, the challenges we see with this approach would be:

1. Acquiring the rights from the pole owner to install the cable,
2. Connecting the cable from the poles to the existing traffic signal cabinets.

An additional communication link would be needed out to the internet (typically through a cable modem installed in one of the existing cabinets). This link is vital to provide the ability to configure and monitor the system remotely.

Recommendations

1. Consider installation of a single-point video detection system at the Pantry Road/Dakin Road intersection to replace the existing in-pavement wire loop detectors. The new video system would not likely provide significant operational improvements at the intersection, but it would provide a more reliable and flexible detection platform over the existing aging in-pavement wire loop detectors.

2. The existing vehicle detection video camera for Sudbury Road northbound should be repaired or replaced. This video detection camera is not distributed by Ocean State Signal, and therefore, cannot be repaired or replaced by Ocean State Signal.

3. Consider installation of a single-point video detection system at the Concord Road intersection. The new video system would not likely provide significant operational improvements at the intersection, but it would provide a more reliable and flexible detection platform over the aging in-pavement wire loop detectors. Operation of the single-point system at this intersection is dependent on the ability to have trees cleared on the northeast corner of the intersection (likely on private property) to provide visibility of approaching westbound vehicles.

4. A study should be conducted by a traffic engineering to develop uniform green durations for the Route 117 movements at all three reviewed intersections. Maximum green durations for the morning peak, mid-day and afternoon peak periods should be

considered. Implementation would require coordination with the Towns of Sudbury, Concord and Lincoln.

5. Max Recall for the Route 117 movements or a fixed cycle length should be considered for all three intersections to maximize traffic flow along Route 117 and prevent the signals from prematurely terminating the green interval. Implementation would require coordination with the staffs from the Towns of Sudbury, Concord and Lincoln.

6. Consider installation of combination video/radar units on the existing mast arm for advance vehicle detection on the Hudson Road eastbound (Route 27) and Concord Road southbound approaches.

7. Consider installing Adaptive Signal Control Technology along the Route 20 corridor. Installation of adaptive control would require the following:

    a. Install adaptive control processor
    b. Upgrade existing wire loop vehicle detection systems at each intersection to single-point and/or combination video/radar equipment to provide the needed input data to the adaptive algorithm
    c. Upgrade traffic signal controller to communicate with the adaptive processor
    d. Install communication equipment (including fiber optic cable) to facilitate communication between intersections.
    e. Installation of a high-speed internet connection to support remote configuration and monitoring of the system (includes monthly service fee).

    Route 20 is a MassDOT controlled corridor. Implementation of an adaptive system will require coordination with MassDOT. An Engineering study of the corridor will likely be required by MassDOT. MassDOT will also likely require the development of a Systems Engineering Analysis.

Estimated Costs for Budgeting

The following estimated costs include materials and estimated installation costs and are provided for budgeting purposes only and are not formal quotes.

Recommendation	Description	Estimated Budgetary Cost
1	Installation of a video/radar detection system using the existing mast arms at the Pantry Road/Dakin Road intersection	$40,000
2	Repair malfunctioning video detection camera on Sudbury Road northbound	$5,000

Recommendation	Description	Estimated Budgetary Cost
3	Installation of a single-point video detection system including a new 20' traffic signal post, signal head mounting hardware, camera extension bracket, cable and tree trimming at the Concord Road intersection	$57,000
4	Engineering study to develop timing changes	$30,000
5 Part A	Implement Max Recalls during peak periods (uses features present in the existing controllers. Requires field technician time only)	$1,800
5 Part B	Implement fixed cycle lengths with GPS time clock synchronization. Requires new signal controllers, GPS units, installation.	$6,000 per intersection
6	Install combination video/radar units on Hudson Road and Concord Road southbound.	$19,000
7 Part A	Engineering study of Adaptive Signal Control Technology	$60,000
7 Part B	Install Adaptive Signal Control Technology (fiber optic cable, cabinet equipment, signal controller, adaptive processor, video detection equipment, installation)	$70,000 per intersection
7 Part C	Internet connection (cable modem). One connection serves the entire 4 intersection system	$75 per month

- Size and location of existing traffic signal mast arms and signal posts

The results of this evaluation will be used to generate recommendations that could improve traffic flow along the Route 117 corridor, within the center of Sudbury (Route 27) and along the Route 20 corridor.

This Technical Memorandum will present the findings of the evaluation, suggest improvements that could be implemented to improve vehicle flow, and present budgetary cost estimates to implement the suggested improvements.

Summary of Evaluation Data

1. North Road (Route 117) at Pantry Road and Dakin Road

Jurisdiction:	Town of Sudbury
Controller Make:	Eagle/Siemens
Controller Model:	M42
Software Version:	3.32f
Cabinet Architecture:	TS-2
Cabinet Size:	NEMA Size 6 (44” W x 25.5” D x 56” H)
Cabinet Assembly Date:	May-2002
Signal Phases:	3-Phase (E/W, N/S, Exclusive Pedestrian)
Vehicle Detection Type:	Wire Loop
Vehicle Detection Make:	Eberly Design Inc. (EDI)
Vehicle Detection Model:	LM 622t
Number of Channels of Vehicle Detection:	4 (1 - Eastbound, 2 - Northbound, 3 - Westbound, 4 - Southbound)
Malfunctioning Vehicle Detection Channels:	None
Operating Mode:	Fully Actuated
Maximum Green 1 Hours:	0:00 - 15:00 (Monday - Friday) 19:00 - 0:00 (Monday - Friday) All Times (Saturday - Sunday)
Maximum Green 1 Duration:	North Road (Route 117) E/W: 60 Seconds Pantry & Dakin Roads N/S: 20 Seconds
Maximum Green 2 Hours:	15:00 – 19:00 (Monday – Friday)
Maximum Green 2 Duration:	North Road (Route 117) E/W: 70 Seconds Pantry & Dakin Roads N/S: 20 Seconds
Number of Mast Arms:	2