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Concord Cut-Through Traffic Study

Town of Concord

Concord Cut-Through Traffic Study

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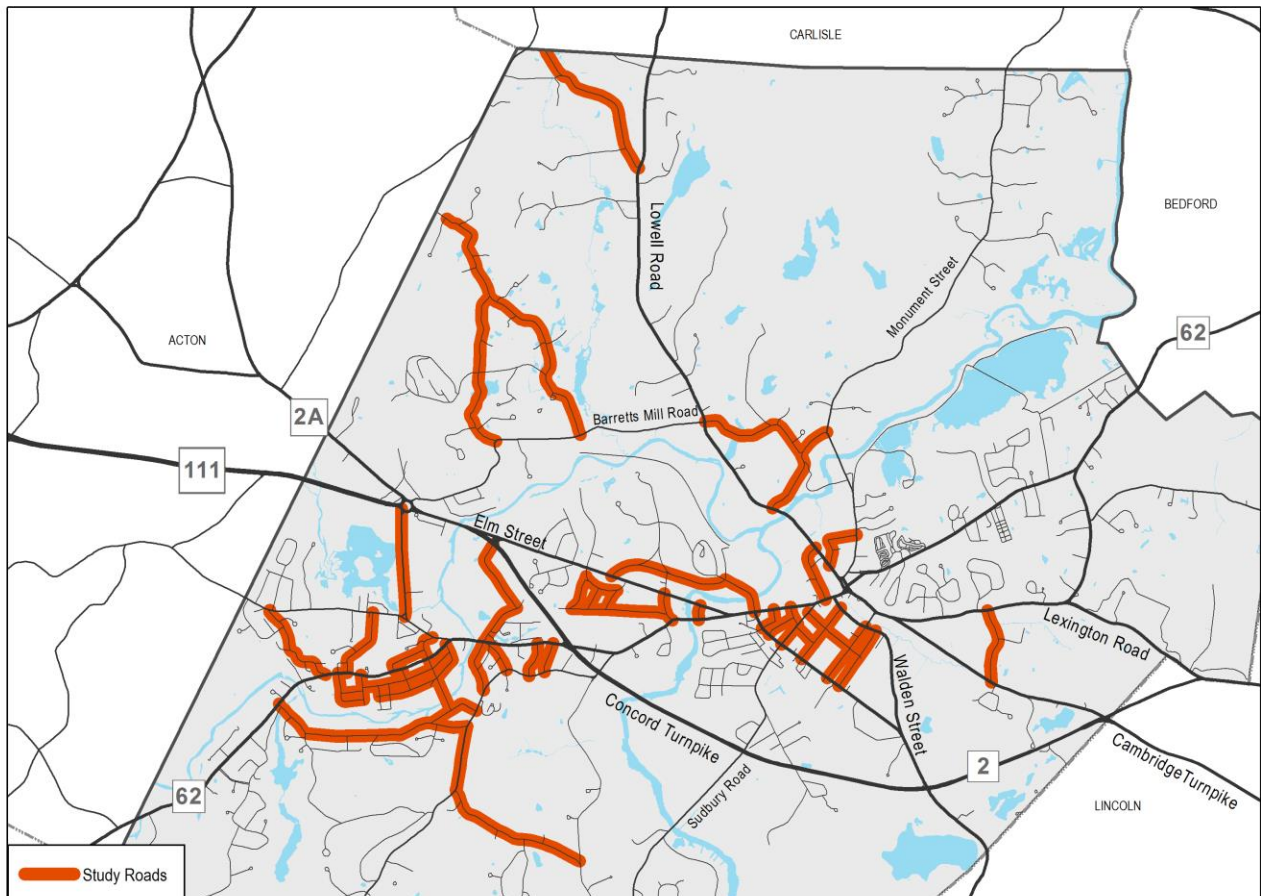
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Executive Summary

In recent years, the residents of the Town of Concord have noticed a change in the way their local streets are being utilized. Residents have commented that there are more vehicles driving through their residential neighborhoods and at higher speeds. The Town of Concord has initiated this study to examine cut-through traffic patterns along several residential roadways (see figure and table below). This study does not include arterial and collector roads that are designed for larger volumes of traffic. The goal of this study is to examine existing traffic patterns through data collection and analysis, and to recommend possible actions that would discourage or eliminate cut-through traffic within the study area. Concord is not alone in this struggle, as neighborhoods around the world are experiencing an increase in cut-through traffic due to the use of wayfinding and traffic apps. Mitigation of cut-through traffic involves significant trade-offs that communities need to weigh carefully.

This technical memorandum begins by identifying regional and local traffic patterns (Section 2), and then describes how public input was solicited and incorporated into the study (Section 3). Section 4 details the methodology used to identify cut-through streets and the results of the analysis. Section 5 suggests some of the various strategies that can be used to mitigate cut-through traffic. Section 6 provides an analysis of two signalized intersections which were reviewed for potential improvements to timing and sequencing. Section 7 recommends approaches for mitigating cut-through traffic on the streets confirmed to be experiencing cut-through traffic, as well as a process for working on future streets of concern.



Study Streets

Over the years, the Town of Concord has compiled a list of 48 “streets of concern” based on residents contacting the Department of Public Works with concerns about traffic on particular streets. At the outset of this study, staff developed a map showing the potential cut-throughs that they were aware of and circulated it to the public (via an online post) and Traffic Management Group for input.

Study Streets

Downtown Concord		West Concord	
1	Sudbury Rd	26	Commonwealth Ave
2	Laurel St	27	Baker Ave
3	Everett St	28	Cottage St
4	Hubbard St	29	Old Bridge Rd
5	Middle St	30	MacArthur Rd
6	Academy Ln	31	Orchard Rd
7	Belknap St	32	Conant St
8	Devens St	33	Hillside Ave/Old Stow Rd
9	Stow St	34	Derby St
10	Nashawtuc Rd/Musketaquid Rd	35	Church St
11	Wilson Rd	36	Pine St
12	Hosmer Rd	37	West St
13	Garland Rd	38	Chase Rd
14	Wood St	39	Frances St
15	River St	40	Brown St
16	Nashoba Rd	41	Prairie St
17	Crescent Rd	42	Prairie St/Pleasant St/Riverside Ave
18	Keyes Rd	43	Westvale Dr
19	Lang St/Bow St	44	Central St
20	Hawthorne Lane	45	Highland St
North Concord		46	Harrington Ave
21	Westford Rd	47	Upland Rd
22	Strawberry Hill Rd	48	Old Marlboro/Williams Rd
23	College Rd		
24	Liberty St		
25	Barnes Hill Rd/Estabrook Rd		

Existing Traffic Patterns

The primary cause of the overall congestion and the resulting cut-through traffic issues stem from regional traffic patterns. Cut-through traffic is an issue with which many communities in Massachusetts must grapple. Most traffic is regional as it travels to major employment, commercial, and activity centers. As a suburban town through which Route 2 and other major arterials traverse, Concord is no exception. Commuters and people traveling for non-work purposes are destined for the major employment and activity centers in Boston, Burlington, Woburn, and other nearby communities.

Public Input

The 48 Streets listed above was developed from public input. As such, additional public input was solicited through an online interactive map and through public meetings to make this process more inclusive.

The online interactive map, known as a Wikimap, gathered over 300 user comments on cut-through issues. A summary of the wikimap findings indicates that not only were high volumes of concern to residents, but also high speeds and pedestrian safety. The Wikimap comments were mapped to show which locations were commented on the most to show the areas of greatest concern to the greatest number of people. The areas with the highest frequency of comments were Downtown Concord, the Musketaquid/Elm/Simon Willard Neighborhood, the MacArthur/Orchard Neighborhood, the Fairhaven Neighborhood, and the Upland/Pine Neighborhood.

The first public meeting was held on May 1, 2019 at the Town House in Concord to introduce the study and solicit input from Concord residents on their concerns about cut-through traffic. After data gathering and preliminary analysis, a one-day workshop was held on August 22, 2019 in which one-hour time slots were dedicated to individual neighborhoods.

Analysis

The analysis evaluates the study streets to determine whether they are experiencing such an increase in traffic as to warrant mitigation.

The methodology considered:

1. Context
 - a. Land use: is it a residential area that is being disturbed by traffic?
 - b. Functional classification: is it a street that is designed to only carry low volumes of traffic?
2. Volumes
 - a. Develop trip generation estimates: given the density of the neighborhood and the destinations in the vicinity, how much traffic should reasonably be expected on the street?
 - b. Gather count data: how much traffic is actually using the street?
 - c. Review actual versus estimated volumes: how do the count data compare to the trip generation estimates?

The results of the analysis indicated that 17 streets that appear to be experiencing cut-through traffic and require additional analysis and cut-through treatment solutions (see table below).

Confirmed Cut-Through Streets

Downtown Concord	
1	Everett St
2	Middle St
3	Academy Ln
4	Devens St
5	Nashawtuc Rd/ Musketaquid Rd
6	Wood St
7	River St
8	Hawthorne Lane
North Concord	
9	Westford Rd
10	Liberty St
11	Barnes Hill Rd/ Estabrook Rd
West Concord	
12	Old Bridge Rd
13	Orchard Rd
14	Hillside Ave/Old Stow Rd
15	Pine St
16	West St
17	Upland Rd

Intersection Analysis

As part of this study, the Town of Concord scoped Jacobs to collect turning movement counts and analyze existing AM and PM peak hour capacity analysis at the intersections of Thoreau Street at Main Street and Thoreau Street at Sudbury Road. The intersections' performance was analyzed under 2019 and 2026 traffic volumes to develop an understanding of how to optimize signal timing at these intersections.

Recommendations

Recommendations were made for the streets confirmed by the analysis to be experiencing cut-through traffic and presented in Section 7. **Conditions on all street segments should be monitored to determine whether these recommendations are effective or additional mitigation is necessary.**

For future streets of concern, the analysis methodology described in this study can be used to verify whether a street is experiencing cut-through traffic. If it is, a neighborhood can circulate a petition (the process for which is described at the end of the report) to advance mitigation and to verify that there is a widespread concern of cut-through traffic.

1. Introduction

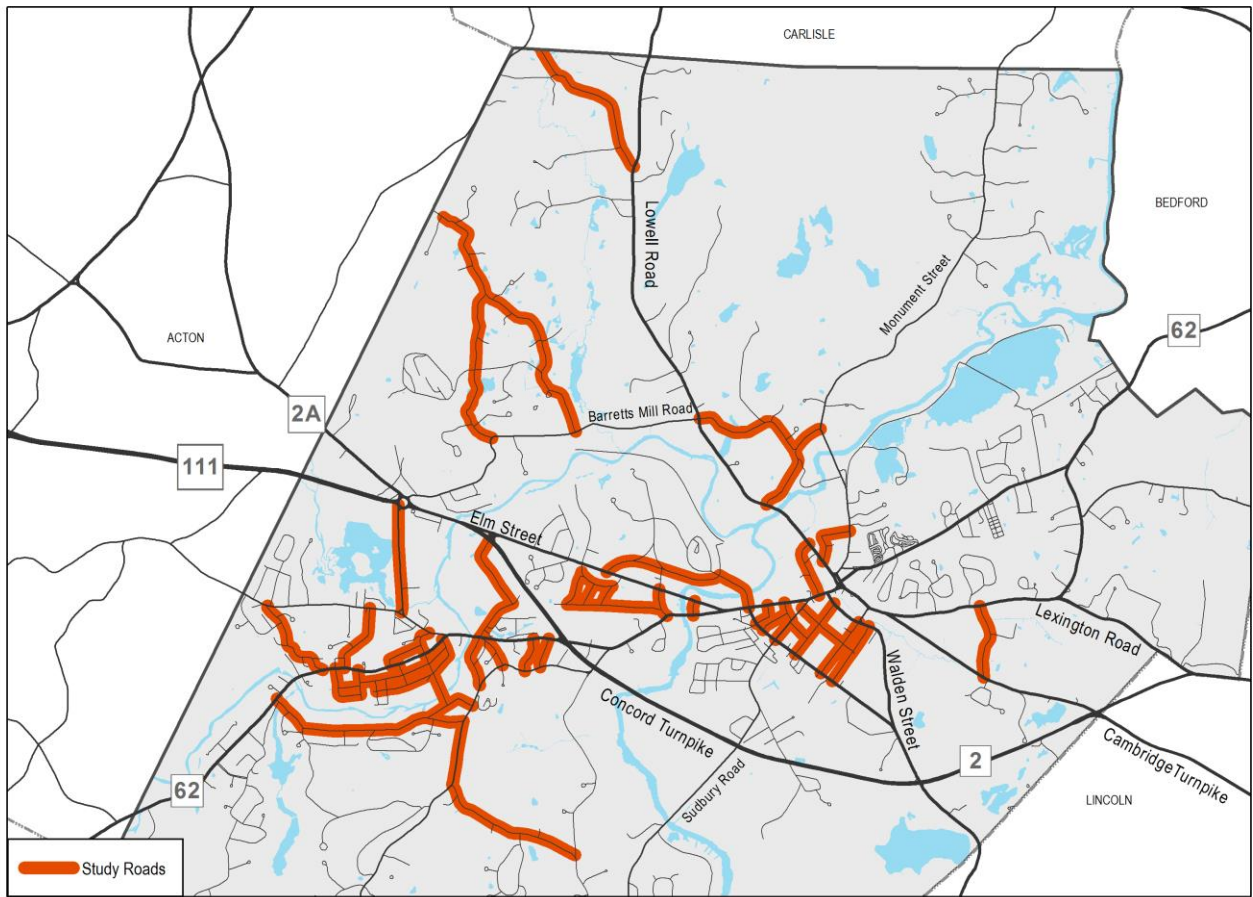
In recent years, the residents of the Town of Concord have noticed a change in the way their local streets are being utilized. Residents have commented that there are more vehicles driving through their residential neighborhoods and at higher speeds. The Town of Concord has initiated this study to examine cut-through traffic patterns along several residential roadways (Figure 1 and Table 1). This study does not include arterial and collector roads that are designed for larger volumes of traffic. The goal of this study is to examine existing traffic patterns through data collection and analysis, and to recommend possible actions that would discourage or eliminate cut-through traffic within the study area. Concord is not alone in this struggle, as neighborhoods around the world are experiencing an increase in cut-through traffic due to the use of wayfinding and traffic apps. Mitigation of cut-through traffic involves significant trade-offs that communities need to weigh carefully.

This technical memorandum begins by identifying regional and local traffic patterns (Section 2), and then describes how public input was solicited and incorporated into the study (Section 3). Section 4 details the methodology used to identify cut-through streets and the results of the analysis. Section 5 suggests some of the various strategies that can be used to mitigate cut-through traffic. Section 6 provides an analysis of two signalized intersections which were reviewed for potential improvements to timing and sequencing. Section 7 recommends approaches for mitigating cut-through traffic on the streets confirmed to be experiencing cut-through traffic, as well as a process for working on future streets of concern.

1.1 Study Area Definition

Over the years, the Town of Concord has compiled a list of 48 “streets of concern” based on residents contacting the Department of Public Works with concerns about traffic on particular streets. At the outset of this study, staff developed a map showing the potential cut-throughs that they were aware of and circulated it to the public (via an online post) and Traffic Management Group for input.

Jacobs then reviewed the content of the comments submitted by Concord residents to establish patterns for cut-through movements, desired paths, and concentrated locations to pinpoint the core of the impacts. Over 100 Concord residents submitted comments to the Town and over 300 comments were reviewed. The comments revealed that three neighborhoods were experiencing significant traffic changes. Jacobs identified these neighborhoods as study areas or stations that would be holistically analyzed as part of a cut-through study; North Concord, Downtown Concord, and West Concord (both North and South of Route 62/Main Street). These stations would define the perimeter for the cut-through analysis.



JACOBS Concord Cut-Through Traffic Study



Figure 1: Study Area

Table 1: Study Streets

Downtown Concord		West Concord	
1	Sudbury Rd	26	Commonwealth Ave
2	Laurel St	27	Baker Ave
3	Everett St	28	Cottage St
4	Hubbard St	29	Old Bridge Rd
5	Middle St	30	MacArthur Rd
6	Academy Ln	31	Orchard Rd
7	Belknap St	32	Conant St
8	Devens St	33	Hillside Ave/Old Stow Rd
9	Stow St	34	Derby St
10	Nashawtuc Rd/Musketaquid Rd	35	Church St
11	Wilson Rd	36	Pine St
12	Hosmer Rd	37	West St
13	Garland Rd	38	Chase Rd
14	Wood St	39	Frances St
15	River St	40	Brown St
16	Nashoba Rd	41	Prairie St
17	Crescent Rd	42	Prairie St/Pleasant St/Riverside Ave
18	Keyes Rd	43	Westvale Dr
19	Lang St/Bow St	44	Central St
20	Hawthorne Lane	45	Highland St
North Concord		46	Harrington Ave
21	Westford Rd	47	Upland Rd
22	Strawberry Hill Rd	48	Old Marlboro/Williams Rd
23	College Rd		
24	Liberty St		
25	Barnes Hill Rd/Estabrook Rd		

1.2 State of the Practice

A literature review was conducted to assess how other places around the U.S. and the world are dealing with cut-through traffic. Most of the available literature focuses on traffic calming rather than cut-through traffic. Most recommended methodologies for studying cut-through traffic involve license plate surveys, or a combination of license plate surveys and other techniques such as traffic counts. There are traffic calming toolboxes available that include the suitability of different devices for a set of given roadway characteristics. Despite not using a license plate survey, the methodology proposed for identifying and analyzing roadways in the Concord Cut-Through Traffic Study is consistent with other approaches.

The literature review suggests that few communities have confronted the challenge of cut-through traffic head on and have instead grouped it into an overarching traffic calming program. The studies completed for Lexington and Belmont indicate that other Massachusetts communities are challenged by regional traffic cutting through local residential streets as well.

UC Berkeley researchers have confirmed that the use of wayfinding apps has greatly exacerbated the problem of cut-through traffic. Researchers suggest that new, collaborative approaches focusing on technology and policy are needed to address the issue. The approach of constructing or installing new infrastructure, which is often the only tool available to municipalities, is inadequate.

- Cut-through traffic is a regional issue with which many communities in Massachusetts and the world have to grapple. Yet few appear to have tackled it.
- Most of the available literature focuses on traffic calming rather than cut-through traffic.
- Research confirms that wayfinding apps are increasing cut-through traffic in local neighborhoods, and infrastructure updates are currently the only available tool that municipalities have to respond.

- The methodology proposed for identifying and analyzing roadways in the Concord Cut-Through Traffic Study appears to be logical given the state of the practice.

The full literature review is included in Appendix A.

2. Existing Traffic Patterns

The primary cause of the overall congestion and the resulting cut-through traffic issues stem from regional traffic patterns. This section establishes the larger context of the study and Concord's place in the region.

2.1 Regional Traffic Patterns

Concord lies along several regionally significant roadways that connect residential areas to employment centers within the metropolitan area. Thousands of vehicles use these regional roadways to pass through Concord daily. For this reason, when considering cut-through traffic in Concord, regional connectivity and traffic patterns should be considered.

The Boston Region Metropolitan Planning Organization/Central Transportation Planning Staff monitors the regional transportation network of Expressways Highways and Arterial Roadways. Performance measures are published using data from 2015. In addition, data from Google Traffic was reviewed for the peak hours to identify commuting patterns in and through Concord. These data sources indicate that regional traffic in the morning is heading east and south. It is slowest along Routes 111, 2A, 2, 62, 117 and Lowell Street heading east/south; it is slow in both directions on portions of the Concord Turnpike and Sudbury Road. In the evening, traffic is generally heading north and west (except for Route 2A, which slows down heading south/east at the Concord/Acton town line). It is slowest on Routes 2, 62, 111, Lexington Road, and Commonwealth Avenue heading north out of West Concord. Segments of Routes 62 and 2 are also slow in the eastbound direction. Sudbury Road south of downtown Concord is slow in both directions. Additional details are provided in Appendix B.

2.2 Town of Concord Traffic Patterns

There are approximately 17,400 private vehicles owned by residents on Concord¹. Figure 2 indicates that on an average day, there are approximately 212,500 trips both into and out of Concord on the main arterials. Figure 3 shows that 88% of these trips (188,000 vehicles per day) enter and exit using the main regional roadways of Route 2, Route 2A, and Route 62. If every Concord resident drove their vehicle in and out of Concord on one day, this would total about 35,000 trips, which is a fraction of all the trips entering and exiting Concord on an average day. The majority of traffic in Concord are regional through trips, not originating in or destined for Concord.

¹ As indicated by 2017 vehicle excise tax records noted in the 2018 Envision Concord-Bridge to 2030 Comprehensive Long Range Plan.

Estimate of all vehicle trips into and out of Concord on average day = 212,500

Total vehicles owned by Concord residents = 17,400

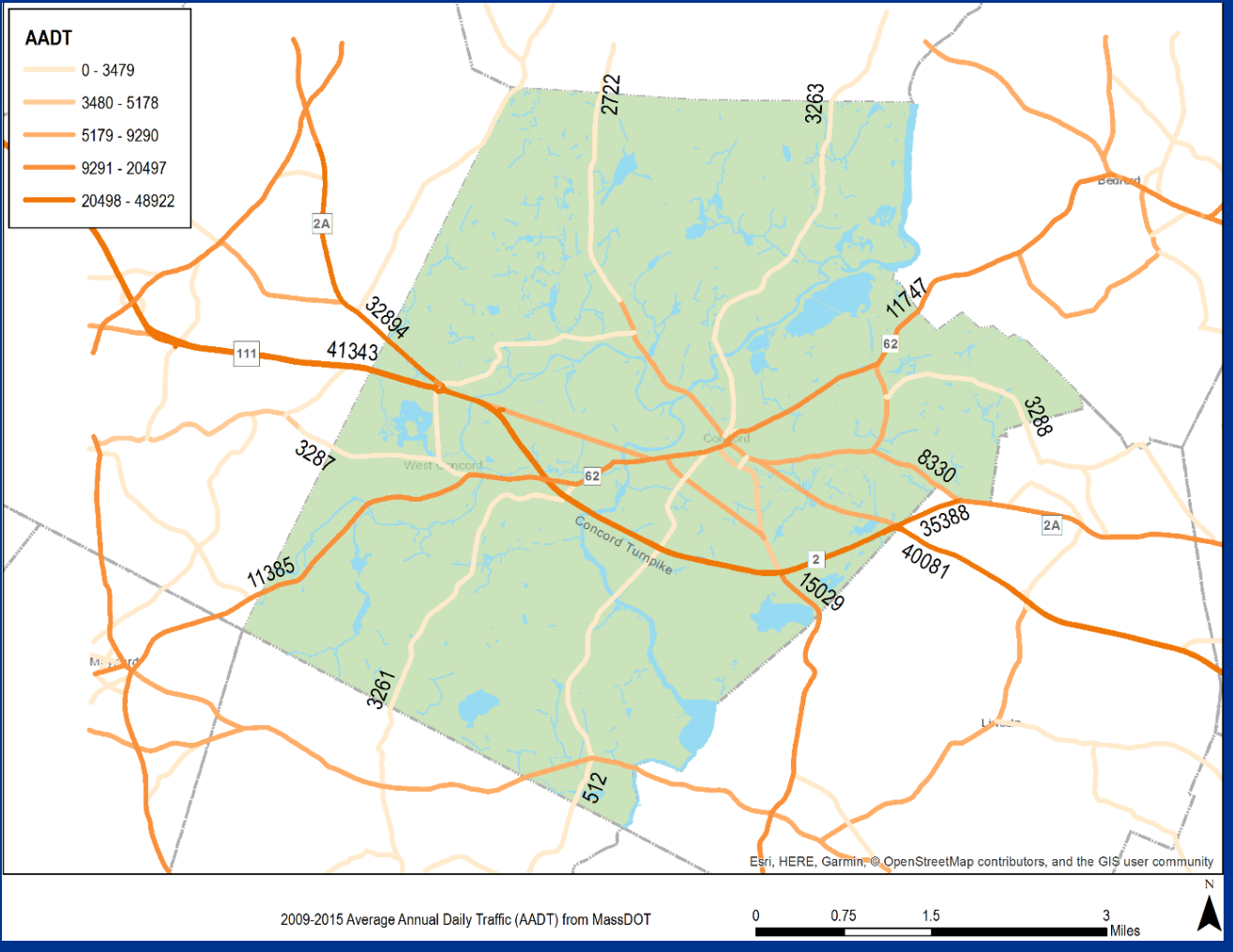


Figure 2: Average Annual Daily Traffic (2009-2015), including the AADT on Gateways in/out of Concord

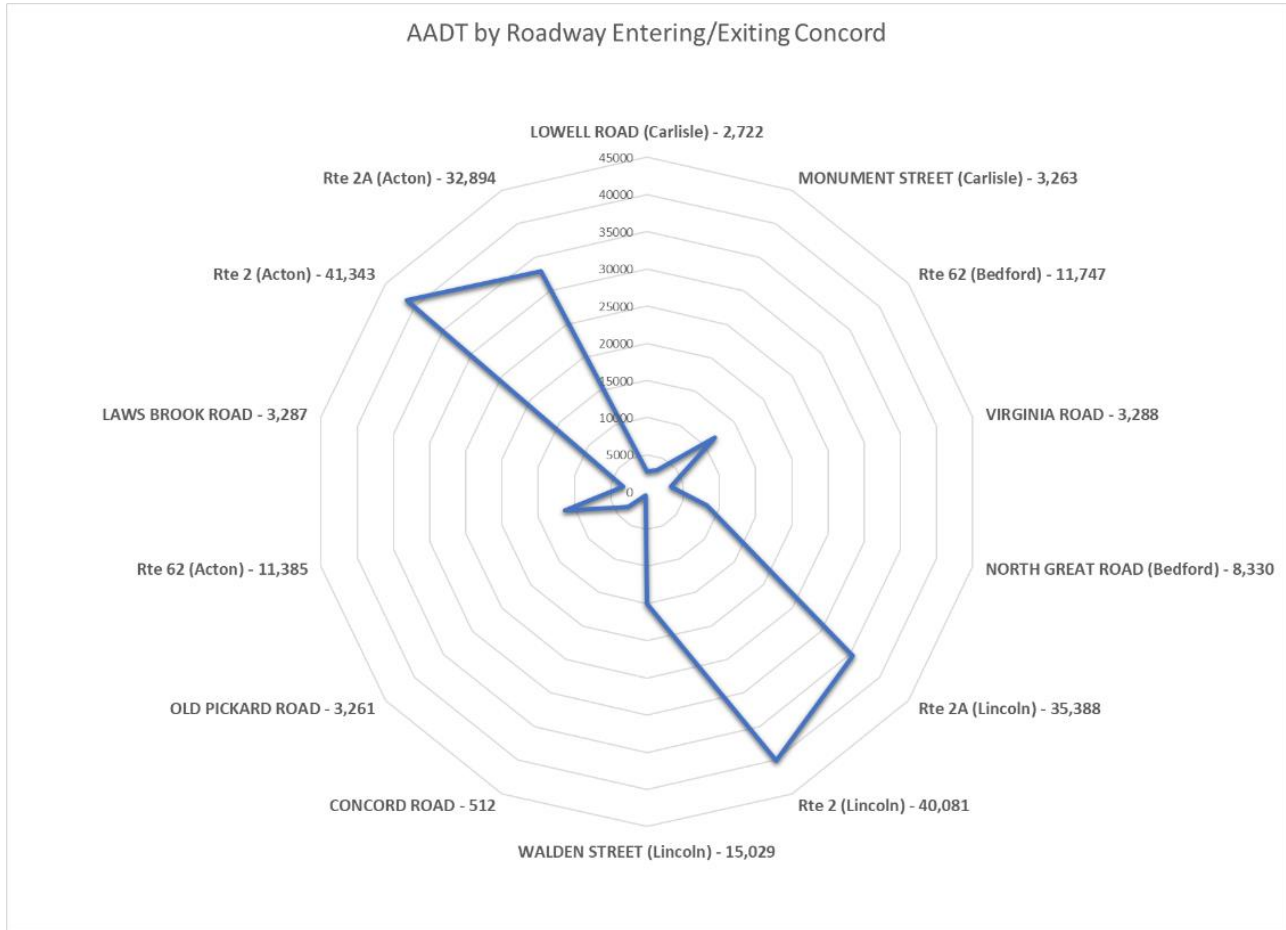


Figure 3: Daily Traffic by Roadway Entering/Exiting Concord

In addition, a review of crash data was undertaken to indicate any existing safety issues to be considered. This review found that there are no HSIP Crash Clusters in Concord. Crash data (from MassDOT and local police) indicate that of the 1,130 crashes that occurred in Concord between 2014 and 2016, 232 of them occurred within 50' of one of the 49 cut-through segments identified by the Town (Figure 31). Seven of these involved bicyclists and three of them involved pedestrians. In addition to the major routes, Commonwealth Avenue, Baker Avenue Extension, Marlboro Road and Stow Street appear to have higher numbers of crashes. Additional detail from the crash analysis is provided in Appendix C.

2.3 Summary of Findings

Cut-through traffic is an issue with which many communities in Massachusetts must grapple. Most traffic is regional as it travels to major employment, commercial, and activity centers. As a suburban town through which Route 2 and other major arterials traverse, Concord is no exception. Commuters and people traveling for non-work purposes are destined for the major employment and activity centers in Boston, Burlington, Woburn, and other nearby communities.

3. Public Input

Public input was solicited through an online interactive map and through public meetings. The online interactive map, known as a Wikimap, was developed to allow residents to review the initial list of study streets and to identify additional streets that they had concerns about. A screenshot of the wikimap is shown in Figure 4. Understanding that some people may not have the opportunity to comment through the Wikimap, the Town extended an open invitation to contact staff by phone or email to provide their comments or feedback.

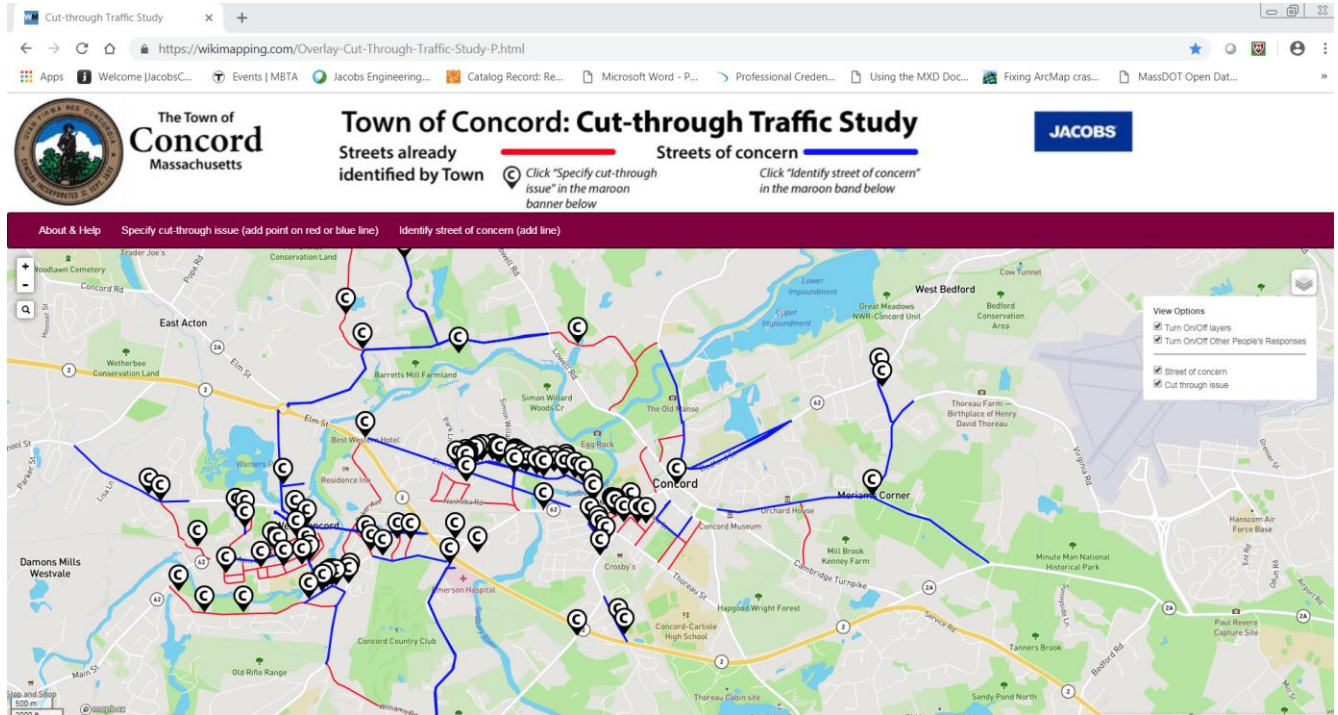


Figure 4: Wikimap used for the Cut-Through Study

The Wikimap gathered over 300 user comments on cut-through issues. Users could comment on entire street segments (“lines”) or on specific, individual locations (“points”). A summary of the wikimap findings is provided in Appendix D and indicates that not only were high volumes of concern to residents, but also high speeds and pedestrian safety.

The Wikimap comments were mapped to show which locations were commented on the most to show the areas of greatest concern to the greatest number of people. The resulting heat maps are shown in Figure 5 and Figure 6. The areas with the highest frequency of comments were Downtown Concord, the Musketaquid/Elm/Simon Willard Neighborhood, the MacArthur/Orchard Neighborhood, the Fairhaven Neighborhood, and the Upland/Pine Neighborhood. These areas were included on the Town’s list of study streets and are analyzed in Section 4, with the exception of the Fairhaven Neighborhood; this neighborhood was not originally on the Town’s list of study streets, but neighbors can pursue the process described in Section 7.4 to analyze and mitigate cut-through traffic.

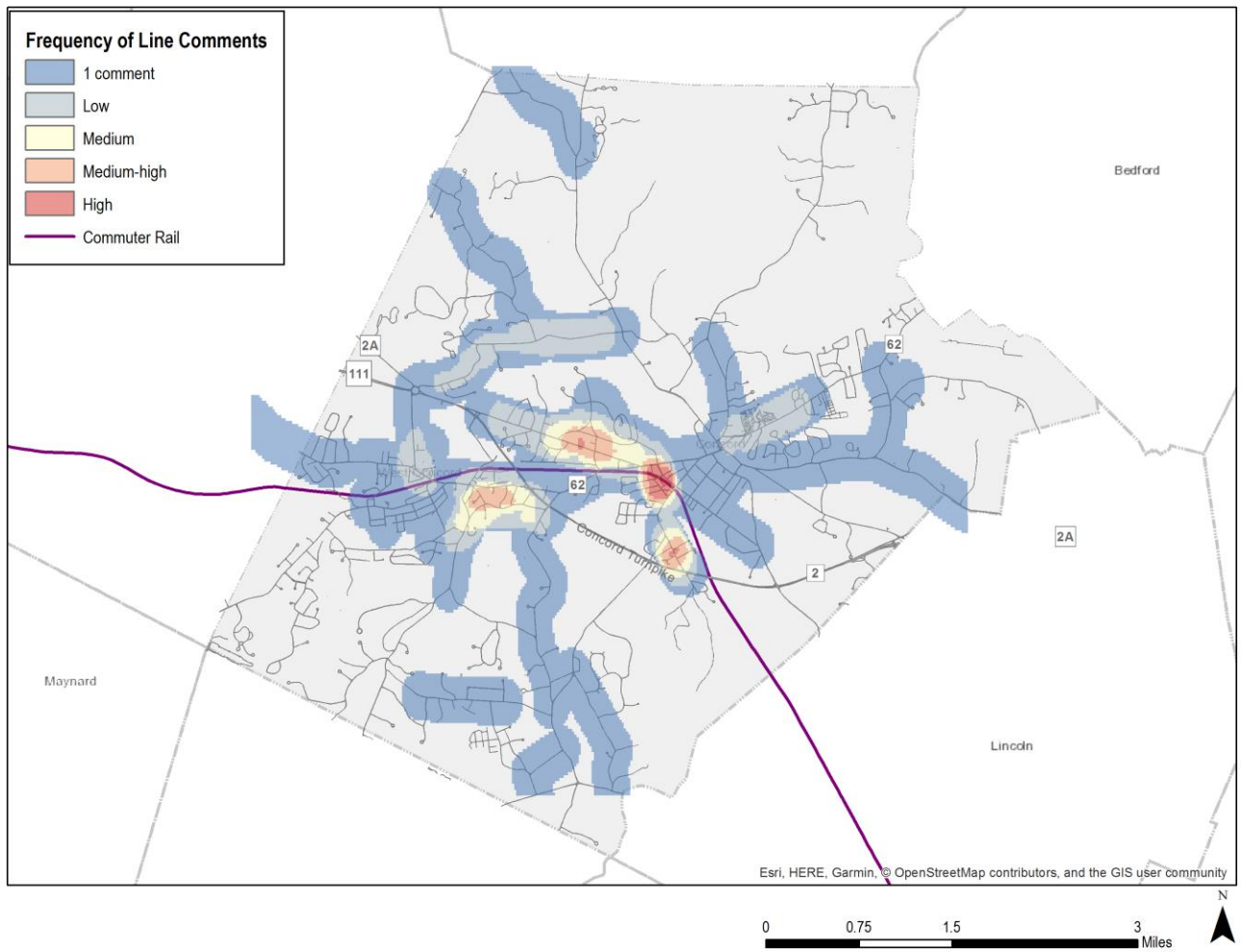


Figure 5: Frequency of Line Comments

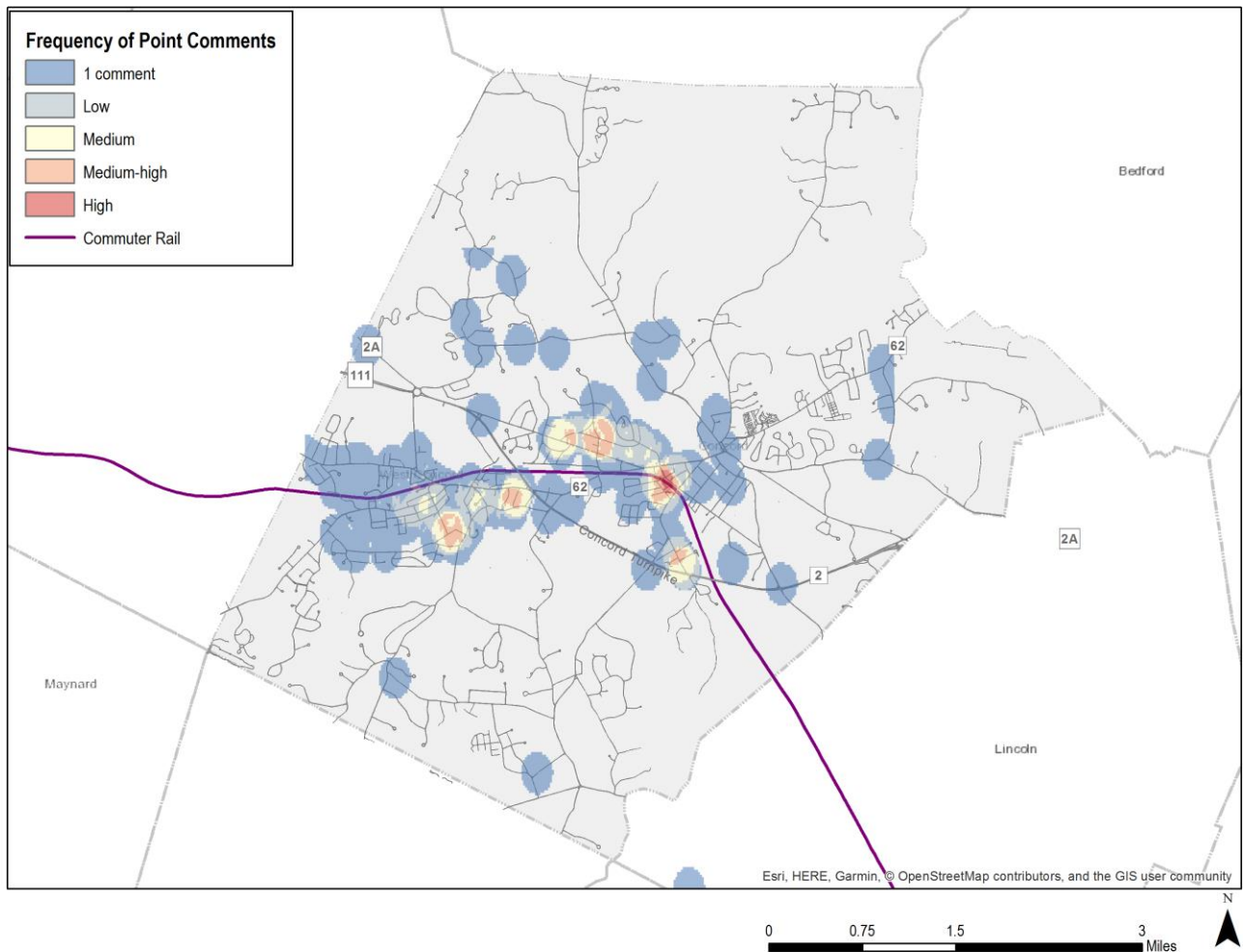


Figure 6: Frequency of Point Comments

Public meetings were also held to gather input (sign-in sheets are included in Appendix E). The first meeting was held on May 1, 2019 at the Town House in Concord to introduce the study and solicit input from Concord residents on their concerns about cut-through traffic. Figure 8 shows one of the maps used to gather comments during the meeting.

After data gathering and preliminary analysis, a one-day workshop was held on August 22, 2019 in which one-hour time slots were dedicated to individual neighborhoods. The study methodology was presented, followed by preliminary analysis results and recommendations. The recommendations were discussed in depth with neighborhood representatives, and next steps were presented. A point person from each neighborhood was identified to move the recommendations forward through the petition process described in Section 7.



Figure 7: One of the Public Meetings for the Study



Figure 8: Example Map used at a Public Meeting

4. Analysis

This section describes the methodology used to verify which of the study streets are experiencing cut-through traffic and the results of that analysis.

4.1 Methodology

Over the years, the Town of Concord has compiled a list of 48 “streets of concern” based on residents contacting the Department of Public Works with concerns about traffic on particular streets. This preliminary list has served as the basis for this study, and the methodology described in this section evaluates this list to determine whether the streets are experiencing such an increase in traffic as to warrant mitigation.

The methodology considered:

3. Context

- a. Land use: is it a residential area that is being disturbed by traffic?
- b. Functional classification: is it a street that is designed to only carry low volumes of traffic?

4. Volumes

- a. Develop trip generation estimates: given the density of the neighborhood and the destinations in the vicinity, how much traffic should reasonably be expected on the street?
- b. Gather count data: how much traffic is actually using the street?
- c. Review actual versus estimated volumes: how do the count data compare to the trip generation estimates?

4.1.1 Context

First, Town staff and Jacobs reviewed the list to verify which streets were local², residential streets. Table 2 shows that 41 of the initial 48 streets of concern met these criteria.

² For a detailed description of roadway functional classification, see Appendix D.

Table 2: Streets of Concern Revised for Context

Downtown Concord			West Concord		
1	Sudbury Rd	Collector	26	Commonwealth Ave	Collector
2	Laurel St	Local Residential	27	Baker Ave	Local Commercial
3	Everett St	Local Residential	28	Cottage St	Local Residential
4	Hubbard St	Local Residential	29	Old Bridge Rd	Local Residential
5	Middle St	Local Residential	30	MacArthur Rd	Local Residential
6	Academy Ln	Local Residential	31	Orchard Rd	Local Residential
7	Belknap St	Local Residential	32	Conant St	Local Commercial
8	Devens St	Local Residential	33	Hillside Ave/Old Stow Rd	Local Residential
9	Stow St	Local Residential	34	Derby St	Local Residential
10	Nashawtuc Rd/ Musketaquid Rd	Local Residential	35	Church St	Local Commercial
11	Wilson Rd	Local Residential	36	Pine St	Local Residential
12	Hosmer Rd	Local Residential	37	West St	Local Residential
13	Garland Rd	Local Residential	38	Chase Rd	Local Residential
14	Wood St	Local Residential	39	Frances St	Local Residential
15	River St	Local Residential	40	Brown St	Local Residential
16	Nashoba Rd	Local Residential	41	Prairie St	Local Residential
17	Crescent Rd	Local Residential	42	Prairie St/ Pleasant St/Riverside Ave	Local Residential
18	Keyes Rd	Local Commercial	43	Westvale Dr	Local Residential
19	Lang St/Bow St	Local Residential	44	Central St	Local Residential
20	Hawthorne Lane	Local Residential	45	Highland St	Local Residential
North Concord			46	Harrington Ave	Local Residential
21	Westford Rd	Local Residential	47	Upland Rd	Local Residential
22	Strawberry Hill Rd	Local Residential	48	Old Marlboro/Williams Rd	Collector
23	College Rd	Local Residential			
24	Liberty St	Local Residential			
25	Barnes Hill Rd/ Estabrook Rd	Local Residential			

4.1.2 Volumes

Next, Jacobs estimated the traffic volumes that might reasonably be expected on each of the study streets given the neighborhood’s density and the street’s length. Actual traffic volumes were then gathered using tube counters, and then the estimated and actual volumes were compared.

4.1.2.1 Estimated Traffic Volumes

The Institute of Transportation Engineer’s (ITE) *Trip Generation Manual* reports rates derived from field-collected data for different land use categories (e.g., single-family residential or commercial retail) as a function of trips per unit of land use (e.g., square feet or population). The data collected from this manual are used for forecasting travel demands for various land uses so that transportation planners and engineers can design and build for the anticipated capacity and transportation needs.

Jacobs used the *ITE Trip Generation Manual* to estimate the potential weekday, AM peak hour, and PM peak hour volumes for each study street.

4.1.2.2 Actual Traffic Volumes

Actual traffic volumes were gathered using pneumatic tube counters laid across each of the study streets. Counters were installed in April/May 2019 on each of the study streets for a period of 48 hours to gather weekday, AM Peak Hour, and PM Peak Hour volumes, as well as the direction of the traffic. Counter locations and the recorded volumes are shown on the maps in Section 7: Recommendations.

The actual volumes were then compared to the estimated volumes to identify significant differences.

4.1.2.3 Comparison of Estimated versus Actual Volumes

For this study, three thresholds were established for a street to be considered a cut-through:

1. Actual weekday volumes need to be at least 1,000 vehicles per day.
2. Actual volumes need to be at least five times greater than estimated volumes (weekday, AM Peak Hour, or PM Peak Hour).
3. Actual peak hour volumes need to be at least 20% of the total daily traffic (that is, the actual weekday volumes). The high percentage of commuter traffic volumes would suggest significant vehicular movements outside of standard neighborhood trips.

4.2 Traffic Speed Counts

A common complaint amongst Concord residents was the increased speed at which vehicles are driving through their residential neighborhoods. Though high speeds are not explicitly indicative of cut-through traffic, high speeds can sometimes result from drivers attempting to find a faster commuting route.

Recent studies performed by the Federal Highway Administration (FHWA) have stated that pedestrians involved in crashes with motor vehicles are more likely to be severely or fatally injured when vehicle speeds are higher. Though this concept has been widely understood for some time, there is now research and data confirming the percentage likelihood of fatality or severe injury at different speeds in miles per hour (MPH). At 20 miles per hour, there is an 18% chance of fatality or severe injury and that percentage increases to 50% at 30 miles per hour. With that statistic in mind, and the understanding that a residential neighborhood encourages pedestrian safety on its local roadways, Jacobs determined a threshold of 30 miles per hour to be the maximum speed acceptable for the local roadways in question.

Speed data was gathered at the time of the traffic volume counts and is provided in Appendix F. The results show that speeds are within the accepted range.

4.3 Results

Jacobs applied the methodology described above to each street initially identified by Concord residents as a possible cut-through. The analysis identified 17 streets that appear to be experiencing cut-through traffic and require additional analysis and cut-through treatment solutions (Table 3). The following sections discuss the analysis results in detail.

Table 3: Confirmed Cut-Through Streets

Downtown Concord	
1	Everett St
2	Middle St
3	Academy Ln
4	Devens St
5	Nashawtuc Rd/ Musketaquid Rd
6	Wood St
7	River St
8	Hawthorne Lane
North Concord	
9	Westford Rd
10	Liberty St
11	Barnes Hill Rd/ Estabrook Rd
West Concord	
12	Old Bridge Rd
13	Orchard Rd
14	Hillside Ave/Old Stow Rd
15	Pine St
16	West St
17	Upland Rd

4.3.1 Downtown Concord

Twenty streets were specifically identified by Concord residents as experiencing cut-through traffic behavior such as high volumes, speeding, and failure to stop or yield. The analysis shown in Figure 9 confirmed that seven of the twenty streets met or surpassed the thresholds for cut-through traffic concerns: Everett Street, Middle Street, Academy Lane, Devens Street, Nashawtuc Road and Musketaquid Road, Wood Street, and River Street.

The combination of Nashawtuc Road and Musketaquid Road provide commuters with a residential shortcut north of Elm Street, avoiding the intersection of Elm Street and Nashoba Road, and access to Thoreau Street as a connection to Route 2 and Interstate 95. Volume estimates suggested 23 and 238 trips for AM and PM peak hour volumes along Nashawtuc and Musketaquid Roads. However, actual volume data recorded that AM peak hour counts were 8 times greater than the estimated volumes for Musketaquid Road, with 208 AM peak hour trips. The Town of Concord recognized this route as a cut-through and attempted to mitigate the cut-through traffic to the residential neighborhood by restricting left turning movements during the eastbound peak volume hour. This strategy did decrease the volumes in the affected neighborhood; however, this strategy also redistributed the cut-through volumes to another neighborhood encompassing Wood Street and River Street. Wood Street and River Street are used as alternative routes to get to Main Street and Route 2 while avoiding the merge from Elm Street. Volume counts for Wood Street recorded that AM and PM peak hour counts were 6 to 8 times greater than the estimated AM and PM peak hour volumes. Meanwhile, River Street count data indicates that AM peak hour traffic comprises over 25% of total weekday volume.

South of Main Street and east of Thoreau Street, commuter traffic from the west side of downtown Concord uses Academy Lane, Middle Street, Devens Street and Everett Street to get to Thoreau Street and connect to Route 2 and Interstate 95. It is also possible that cut-through traffic on Academy Lane, Middle Street and Devens Street is the result of parents dropping their kids off at the elementary school on Laurel Street. AM and

PM peak hour counts were 29 and 10 times greater than the estimated volumes for Academy Lane, respectively. Middle Street and Devens Street also experience higher than predicted AM peak hour traffic volumes. Estimated AM peak hour volumes for Middle Street and Devens Street were considerably lower than the actual volumes. The high volumes and directions recorded on Academy Lane, Middle Street and Devens Street do not coincide with commuter traffic movements; however, the high volumes and low speeds do suggest morning school drop-off traffic.

Everett Street is a direct connection between Thoreau Street/Walnut Street and Cambridge Turnpike. Both Thoreau Street/Walnut street and Cambridge Turnpike connect to Route 2 and Interstate 95.

Roadway	Context	Estimated Volumes			Actual Volumes (Count Data)			Estimated vs. Actual Difference			Factor Increase in Volume			Peak Hour %		Cut-Through?	Comments	
		Weekday	AM Peak	PM Peak	Weekday	AM Peak	PM Peak	Weekday	AM Peak	PM Peak	Weekday	AM Peak	PM Peak	% of AM Peak vs. Weekday	% of PM Peak vs. Weekday			
Downtown Concord																		
1	Sudbury Rd	Collector	590	61	132	5758	427	495	5167	366	363	8.76	6.06	2.76	7.42	8.60	No	Collector Street
2	Laurel St	Local Res	2344	755	1952	539	118	45	-1805	-637	-1907	-0.77	-0.84	-0.98	21.89	8.35	No	High % of AM Peak Volume but low total volume when accounting for school. Peak traffic is bidirectional in the AM and PM. Everett has higher volumes than Laurel despite school.
3	Everett St	Local Res	301	23	28	2818	247	318	2517	224	290	8.36	9.62	10.41	8.77	11.28	Yes	High volume AM NB, PM SB - likely cut through for EB Route 2 to Cambridge Turnpike
4	Hubbard St	Local Res	925	125	124	1400	115	144	475	-10	20	0.51	-0.08	0.16	8.21	10.29	No	Volume consistent with land use given rec center and post office.
5	Middle St	Local Res	309	29	33	764	236	48	454	207	15	1.47	7.27	0.44	30.91	6.29	Yes	High % of AM Peak hour trips going EB in the AM peak, but low total volume and negligible difference between estimated and actual volumes
6	Academy Ln	Local Res	113	11	10	1309	331	112	1196	320	102	10.54	28.58	10.12	25.29	8.56	Yes	High % of AM Peak Volume, large difference between estimated and actual volumes. SB in the AM direction is heaviest volume
7	Belknap St	Local Res	1873	354	260	328	39	52	-1545	-315	-208	-0.82	-0.89	-0.80	11.89	15.85	No	Volume consistent with land use - this counts funeral home and businesses on Thoreau so estimated volumes might be on the high side
8	Devens St	Local Res	148	13	13	707	135	63	559	122	50	3.78	9.14	3.75	19.11	8.92	Yes	High % of AM Peak volume in the EB direction and large difference between estimated and actual volumes. However, operates as a collector from Hubbard. Under 1000 weekday volume.
9	Stow St	Local Res	1825	226	260	1530	210	168	-296	-16	-92	-0.16	-0.07	-0.35	13.73	10.98	No	Volume consistent with land use - collects traffic from other streets, serves library and downtown, and school.
10	Nashawtuc Rd/ Musketaquid Rd	Local Res	301	23	28	722	208	34	421	185	6	1.40	7.94	0.22	28.81	4.71	Yes	High % of AM Peak in the EB. Increase of 400 per day from estimated volumes. Under 1000ADT
11	Wilson Rd	Local Res	159	14	14	133	15	22	-27	1	8	-0.17	0.07	0.54	11.32	16.60	No	Volume consistent with land use
12	Hosmer Rd	Local Res	78	9	7	59	9	8	-19	0	1	-0.24	-0.01	0.17	15.25	13.56	No	Volume consistent with land use
13	Garland Rd	Local Res	66	8	6	61	8	11	-6	0	5	-0.08	-0.04	0.92	13.22	18.18	No	Volume consistent with land use
14	Wood St	Local Res	113	11	10	741	84	88	627	73	78	5.53	6.51	7.74	11.34	11.88	Yes	High actual volume compared to estimated. AM Peak in the SB direction
15	River St	Local Res	154	41	29	288	73	21	133	32	-8	0.86	0.79	-0.27	25.39	7.30	Yes	High actual volume compared to estimated. AM Peak in the SB direction
16	Nashoba Rd	Local Res	437	32	41	304	24	30	-133	-8	-11	-0.30	-0.26	-0.27	7.89	9.87	No	Volume consistent with land use
17	Crescent Rd	Local Res	113	11	10	66	13	9	-47	2	-1	-0.42	0.16	-0.11	19.70	13.64	No	Volume consistent with land use
18	Keyes Rd	Local Comm	4082	110	220	4180	438	342	98	328	122	0.02	2.97	0.55	10.48	8.18	No	Not Residential
19	Lang St/Bow St	Local Res	322	25	30	320	52	34	-3	27	4	-0.01	1.11	0.14	16.28	10.64	No	Volume consistent with land use
20	Hawthorne Lane	Local Res	237	19	22	529	35	51	292	16	29	1.24	0.84	1.35	6.62	9.64	Yes	Moderate difference between actual and estimated volumes, under 1000 ADT - counts conducted during road closure
						red > 1000 green < 1000						red > 5 yellow >1 and <5 green < 1			red > 20% green < 20%			NB Northbound SB Southbound EB Eastbound WB Westbound

Figure 9: Cut-Through Analysis for Downtown Concord

4.3.2 North Concord

Concord residents indicated that five streets in the North Concord area were possibly experiencing cut-through traffic and speeding and failure to stop or yield. Figure 10 provides the results of the analysis and confirms that three of the five streets meet the criteria for cut-through traffic: Westford Road, Liberty Street and Barnes Hill Road/Estabrook Road.

Westford Road provides a direct route from downtown Concord, by way of Lowell Road, to Route 225 and Route 27 which connect to Interstate 495. This connection would be an ideal route for someone who commutes along Interstate 495 and wanted to avoid collector and arterial roadway traffic on Concord Street and Route 225. Actual AM and PM peak hour volumes were 11 to 14 times greater than the estimated volumes Westford Road. High traffic volumes, in addition to above average speeds on this residential roadway, suggest that Westford Road is subject to cut-through traffic.

Liberty Street and Estabrook Street appear to make a convenient commuter connection from the collector streets of Monument Street and Lowell Road, without having to drive through downtown or wait at a traffic signal. Both Liberty Street and Estabrook Street experienced higher actual volumes than estimated, as well as higher vehicle speeds than expected in a residential neighborhood. Actual AM peak hour counts were 6 times greater than the estimated volumes for Liberty Street. Actual AM and PM peak hour volumes were 18 and 21 times greater than the estimated volumes for Estabrook Road. The speed study also recorded high vehicular speeds among a high percentage of users along Liberty Street, suggesting collector roadway traffic behavior as opposed to residential.

Roadway	Context	Estimated Volumes			Actual Volumes (Count Data)			Estimated vs. Actual Difference			Factor Increase in Volume			Peak Hour %		Cut-Through?	Comments	
		Weekday	AM Peak	PM Peak	Weekday	AM Peak	PM Peak	Weekday	AM Peak	PM Peak	Weekday	AM Peak	PM Peak	% of AM Peak vs. Weekday	% of PM Peak vs. Weekday			
North Concord																		
21	Westford Rd	Local Res	364	28	34	3613	412	426	3249	384	392	8.91	13.97	11.52	11.40	11.79	Yes	High volume AM EB, PM WB. Connectivity to Route 225, also serves as a collector route to and from I-495.
22	Strawberry Hill Rd	Local Res	3771	654	501	2944	369	337	-827	-285	-164	-0.22	-0.44	-0.33	12.53	11.45	No	Volume consistent with land use
23	College Rd	Local Res	905	66	88	549	75	51	-356	9	-37	-0.39	0.14	-0.42	13.66	9.29	No	Volume consistent with land use
24	Liberty St	Local Res	980	44	108	1452	304	264	472	260	156	0.48	5.90	1.44	20.94	18.18	Yes	High % AM and PM volume, increase from estimated volumes to actual, WB in the AM and PM
25	Barnes Hill Rd/ Estabrook Rd	Local Res	322	25	30	3192	482	662	2869	457	632	8.90	18.53	21.12	15.10	20.74	Yes	High volumes. EB in the AM, WB in the PM.
						red > 1000						red > 5			red > 20%			NB Northbound
						green < 1000						yellow >1 and <5			green < 20%			SB Southbound
												green < 1						EB Eastbound
																		WB Westbound

Figure 10: Cut-Through Analysis for North Concord

4.3.3 West Concord

Concord residents indicated that 23 streets in the West Concord area were possibly experiencing cut-through traffic. Figure 11 provides the results of the analysis and confirms that five of the streets meet the criteria for cut-through traffic: Old Bridge Road, Orchard Road, Hillside Avenue/Old Stow Road, Pine Street, and West Street.

The actual AM Peak hour volumes on Old Bridge Road are nearly ten times greater than what would normally be expected with the estimated volumes. Orchard Road and Hillside Ave/Old Stow Road also have high actual AM Peak hour volumes when compared to the estimated volumes, and the AM peak hours comprise more than 20% of the overall weekday volume. The actual AM and PM Peak hour volumes for Pine street were much greater than the estimated volumes for peak hours. For West Street, the actual weekday, AM Peak hour, and PM Peak hour volumes were much greater than the corresponding estimated volumes, and the actual AM Peak hour comprised more than 20% of the total weekday volume.

The traffic counter for Upland Road was accidentally located incorrectly, but the using the data from the incorrect location and the data from the Pine Street location confirms that Upland Road is a cut-through: the actual weekday, AM Peak hour, and PM Peak hour volumes were much greater than the corresponding estimated volumes.

Roadway	Context	Estimated Volumes			Actual Volumes (Count Data)			Estimated vs. Actual Difference			Factor Increase in Volume			Peak Hour %		Cut-Through?	Comments	
		Weekday	AM Peak	PM Peak	Weekday	AM Peak	PM Peak	Weekday	AM Peak	PM Peak	Weekday	AM Peak	PM Peak	% of AM Peak vs. Weekday	% of PM Peak vs. Weekday			
West Concord																		
26	Commonwealth Ave	Collector	828	113	132	8610	617	781	7782	504	649	9.40	4.48	4.90	7.17	9.07	No	Not residential
27	Baker Ave	Local Comm	9971	1283	1480	3097	326	285	-6874	-957	-1195	-0.69	-0.75	-0.81	10.53	9.20	No	Not residential
28	Cottage St	Local Res	934	152	166	2872	247	297	1938	95	131	2.07	0.63	0.79	8.60	10.34	No	To be monitored. Connects to businesses on Main St. Links Baker and Old Marlboro.
29	Old Bridge Rd	Local Res	237	19	22	1405	206	126	1168	187	104	4.94	9.84	4.81	14.66	8.97	Yes	High AM peak hour volume.
30	MacArthur Rd	Local Res	182	15	16	179	21	20	-3	6	4	-0.01	0.36	0.22	11.73	11.17	No	Volume consistent with land use
31	Orchard Rd	Local Res	170	15	15	522	116	54	352	101	39	2.06	6.87	2.51	22.22	10.34	Yes	High AM peak hour volume.
32	Conant St	Local Comm	769	64	80	3570	318	305	2801	254	225	3.64	3.97	2.81	8.91	8.54	No	Not residential
33	Hillside Ave/ Old Stow Rd	Local Res	620	45	59	1872	391	182	1252	346	123	2.02	7.64	2.07	20.89	9.72	Yes	High AM peak hour volume.
34	Derby St	Local Res	487	57	177	355	37	30	-132	-20	-147	-0.27	-0.36	-0.83	10.42	8.45	No	Volume consistent with land use
35	Church St	Local Comm	228	34	102	3413	279	358	3185	245	256	13.97	7.11	2.50	8.17	10.49	No	Not residential
36	Pine St	Local Res	634	43	53	3585	446	417	2951	403	364	4.65	9.46	6.93	12.44	11.63	Yes	High SB AM peak hour and high NB PM peak hour
37	West St	Local Res	102	10	9	891	193	95	789	183	86	7.75	17.42	9.57	21.66	10.66	Yes	School traffic and collector from nearby streets
38	Chase Rd	Local Res	41	7	4	158	23	26	116	16	22	2.81	2.32	6.41	14.60	16.51	No	School traffic and collector from nearby streets
39	Frances St	Local Res	54	8	5	184	29	25	130	21	20	2.41	2.80	4.41	15.80	13.62	No	Volume consistent with land use
40	Brown St	Local Res	102	10	9	429	57	53	327	47	44	3.21	4.44	4.89	13.30	12.37	No	Estimated volumes don't take into account access to park and school
41	Prairie St	Local Res	301	23	28	192	15	16	-109	-8	-12	-0.36	-0.36	-0.43	7.81	8.33	No	Volume consistent with land use
42	Prairie St/Pleasant St/ Riverside Ave	Local Res	2083	562	307	712	129	90	-1371	-433	-217	-0.66	-0.77	-0.71	18.12	12.64	No	Volume consistent with land use
43	Westvale Dr	Local Res	136	13	12	228	10	16	92	-3	4	0.67	-0.21	0.31	4.39	7.02	No	Volume consistent with land use
44	Central St	Local Res	630	46	60	628	99	80	-2	53	20	0.00	1.15	0.33	15.78	12.75	No	Volume consistent with land use
45	Highland St	Local Res	290	23	27	161	11	23	-130	-12	-4	-0.45	-0.51	-0.14	6.85	14.33	No	Volume consistent with land use
46	Harrington Ave	Local Res	1648	122	164	2415	265	266	766	143	102	0.46	1.17	0.62	10.98	11.02	No	Operates more like a collector. To be monitored.
47	Upland Rd	Local Res	290	23	27	2980	389	346	2690	366	319	9.26	16.25	11.89	13.05	11.61	Yes	Count was conducted west of Pine; data shown here are derived by subtracting Upland count from the Pine Street data to show the volumes using Upland Road east of Pine.
48	Old Marlboro/ Williams Rd	Collector	6455	996	640	2210	267	257	-4245	-729	-383	-0.66	-0.73	-0.60	12.08	11.63	No	Count was taken on Williams west of Mattison Drive. Williams is not a Collector, but Old Marlboro is.
						red > 1000 green < 1000						red > 5 yellow >1 and <5 green < 1			red > 20% green < 20%			NB Northbound SB Southbound EB Eastbound WB Westbound

Figure 11: Cut-Through Analysis for West Concord

5. Managing Cut-through Traffic

Methods for managing cut-through traffic on residential streets are described below. The most effective method for managing cut-through traffic is to address the problem at the source, usually congestion on a highway or arterial street. Although many of the arterials in Concord are congested, there is little that can be done to address this in the near term.

Strategy	Benefits	Trade-Off/Challenges
Turn restrictions; one-way restrictions; road closures (partial or full)	Effectiveness	Residents (and related service vehicles/deliveries) are subject to measures as well
Close road to "local traffic only"	Potentially effective	Not enforceable Legality is vague Need to coordinate with app developers
Traffic calming measures	Discourage cut-through traffic by slowing it down	Residents (and related service vehicles/deliveries) are subject to measures as well. Even slowed traffic is sometimes faster than congested highway

Figure 12: Potential Cut-Through Traffic Strategies

5.1 Restrictions/Diverters/Closures

Installation of traffic diverters or partial closures are designed to prevent traffic from making specific movements at an intersection. Possible measures include forced turn islands, barriers, channelization, diagonal diverters, half-closures, and one-way chokers. They could also include one-way streets, "Do Not Enter" restrictions, and peak hour turn restrictions.



Figure 13: Partial Closure (source: nyc.streetsblog.org)

5.1.1 Benefits

The benefit of these measures is that they actively prevent traffic from certain movements. They are effective at reducing cut-through traffic.

5.1.2 Trade-Offs/Challenges

These measures could push the issue to neighboring streets. Residents (and related service vehicles/deliveries) are also subject to these restrictions.

5.2 Road Closures to “Local Traffic Only”

Some jurisdictions have attempted to reduce cut-through traffic by restricting a street to “local traffic only.”

5.2.1 Benefits

This measure is only potentially effective at reducing cut-through traffic due to the fact that it is not enforceable and the legality of such restrictions is vague.

5.2.2 Trade-Offs/Challenges

These measures could push the issue to neighboring streets. Residents (and related service vehicles/deliveries) are also subject to these restrictions.

5.3 Traffic Calming Measures

Installation of traffic calming measures can have the effect of slowing traffic down and therefore making the street less attractive as a cut-through. Possible measures include curb extensions, chokers, chicanes, neck downs, speed humps, speed tables, traffic circles, and medians. The Town has a Traffic Calming Policy³ in place delineating a process for responding to and addressing resident concerns.

³ <https://www.concordma.gov/DocumentCenter/View/245/Traffic-Calming-Policy-PDF>



Figure 14: Traffic Calming (source: City of Toronto; nyc.streetsblog.org)

5.3.1 Benefits

Traffic calming measures help to slow traffic which could discourage cut-through movements. These types of measures generally don't impact roadway access, so residents are not inconvenienced by new traffic patterns or traffic restrictions.

5.3.2 Trade-Offs/Challenges

These measures rely on passive controls; therefore, they may not effectively reduce cut-through traffic, as calmed traffic could still be faster than the congested highway.

6. Intersection Analysis

As part of this study, the Town of Concord scoped Jacobs to collect turning movement counts (TMC) and analyze existing AM and PM peak hour capacity analysis at the intersections of Thoreau Street at Main Street and Thoreau Street at Sudbury Road. This section describes the analysis methodology and the results.

6.1 Traffic Volumes

The TMC's were conducted on April 30, 2019 between the hours of 7:00 AM to 9:00 AM and 4:00 PM to 6:00 PM as shown in Figure 15. The AM peak hour at Thoreau Street at Sudbury Road occurred between 7:15 AM to 8:25 AM and at Thoreau Street at Main Street between 7:30 AM to 8:30 AM. The PM peak hour at both intersections occurred between 5:00 PM and 6:00 PM. Traffic volumes are typically seasonally adjusted to the average month, but since the counts were done in April, the MassDOT seasonal factor would have reduced the traffic volumes by 5%. As a conservative analysis, no seasonal factor was applied.

Traffic volume growth was evaluated by researching MassDOT count stations within the vicinity of the intersections. MassDOT count station #4890 had traffic volumes from years 2010 to 2018. The growth rate during between 2010 and 2018 has been calculated to be 1.6% per year. The turning movement counts for the two study intersections were projected by 1.6% per year for 7 years to develop the 2026 future year traffic volumes shown in Figure 16. Figure 17 shows how the 2026 traffic volumes would flow in a Build condition where cut-through mitigation is applied and traffic is redirected back to the main line and out of the neighborhoods.

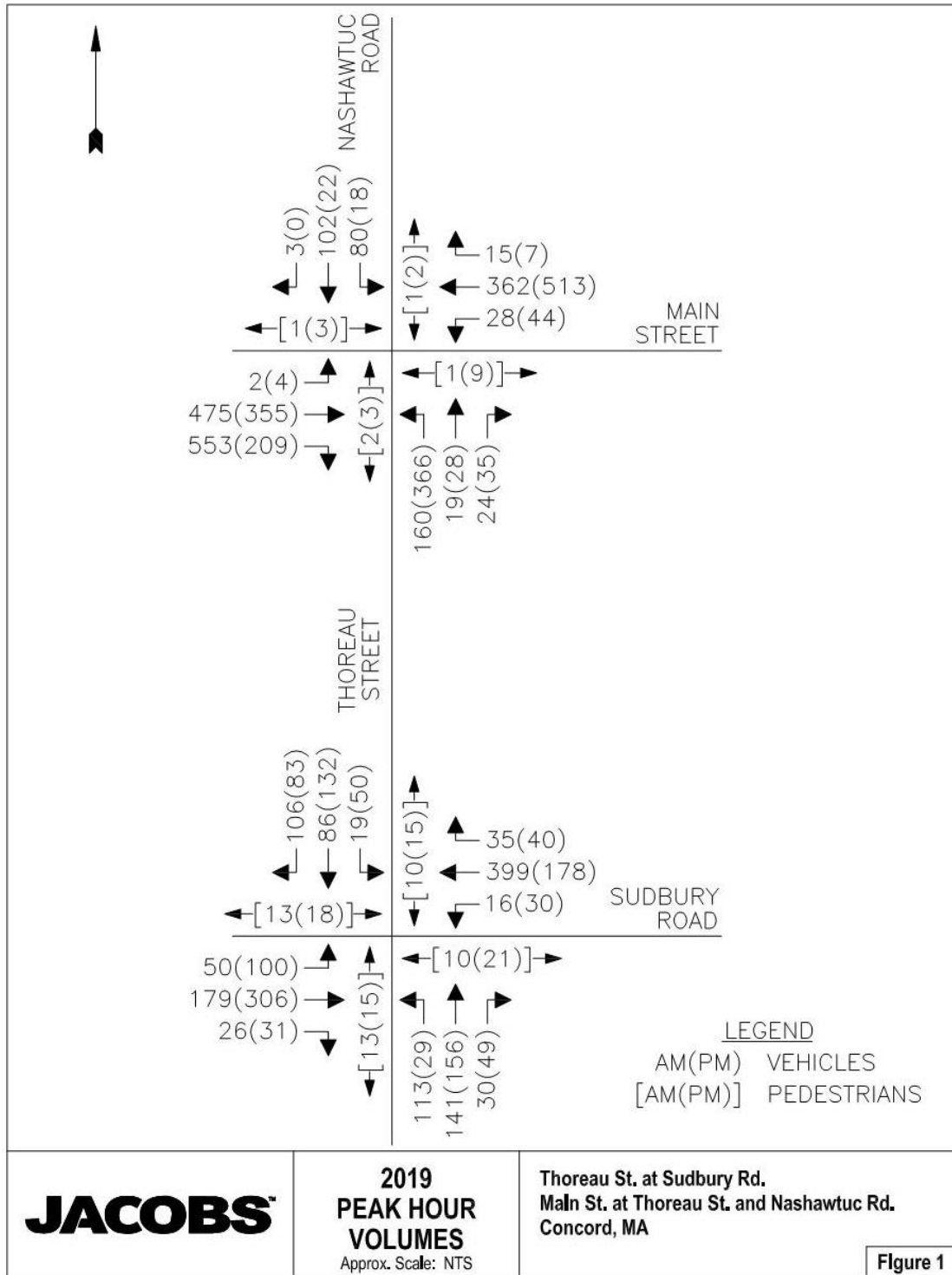


Figure 15: 2019 Peak Hour Volumes

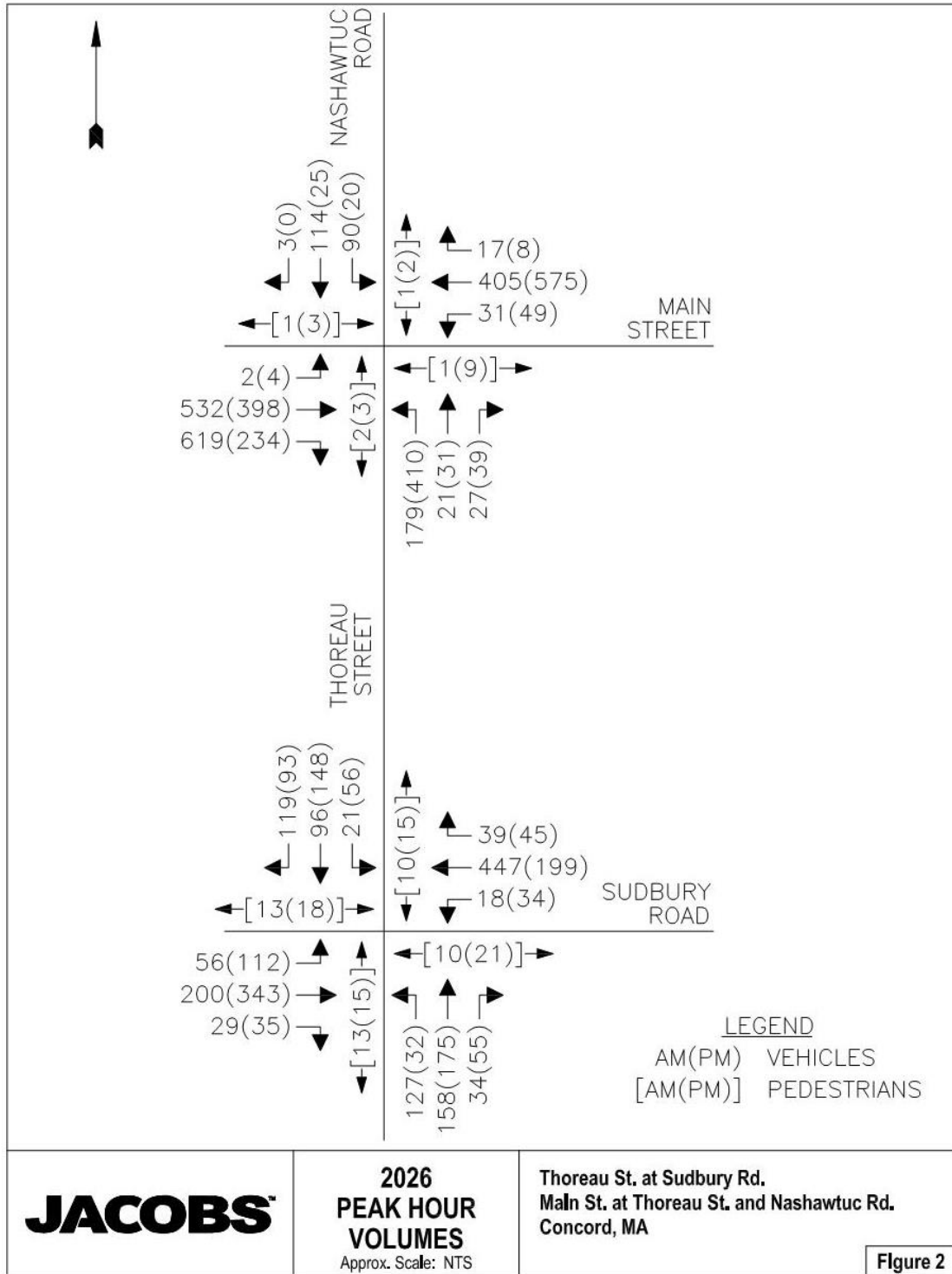


Figure 16: 2026 Peak Hour Volumes

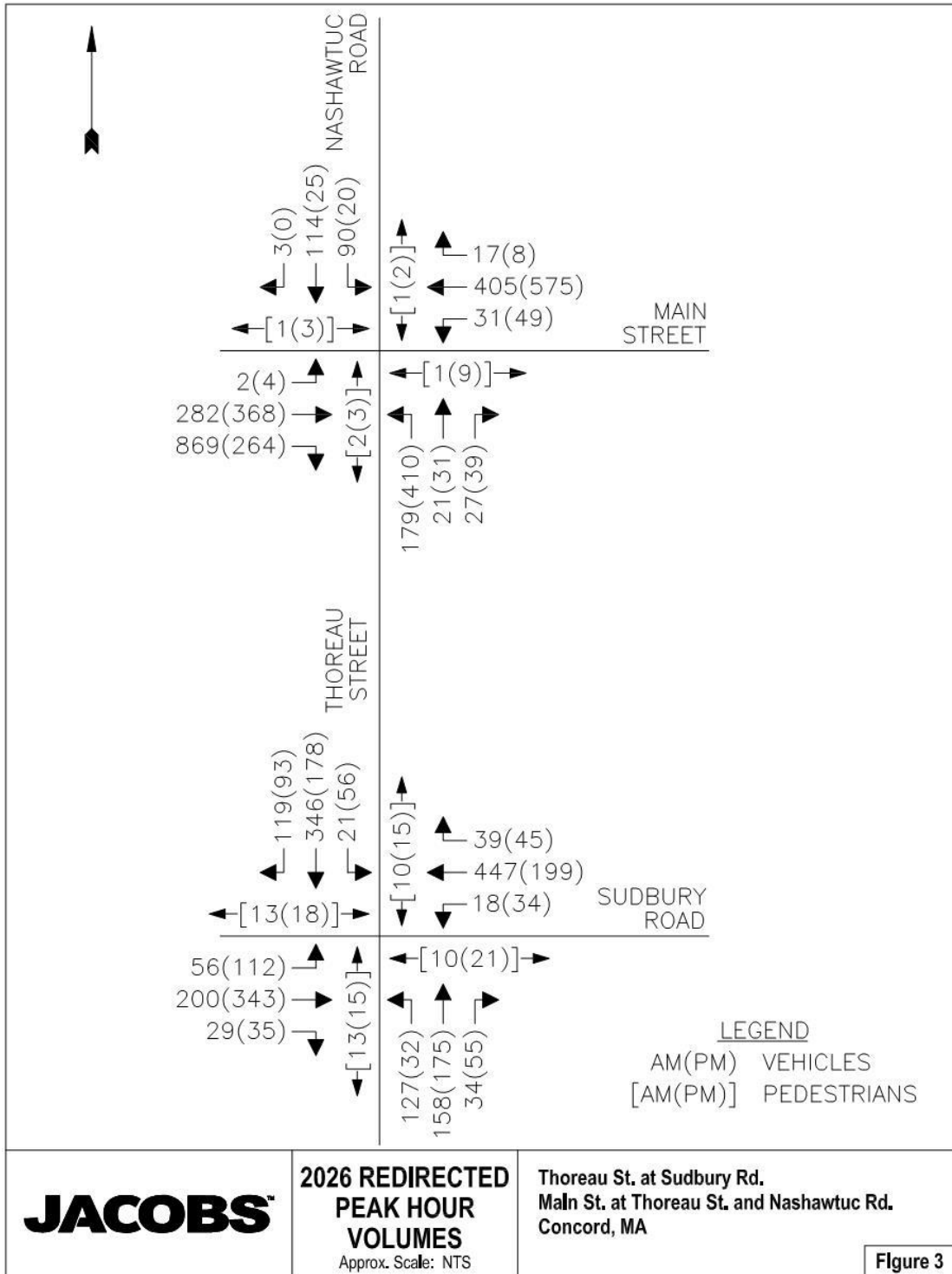


Figure 17: 2026 Redirected Peak Hour Volumes

6.2 Intersection Analysis Methodology

The Highway Capacity Manual (HCM) from the Federal Highway Administration (FHWA) provides guidance and analysis methodologies that are used to calculate performance levels for freeway sections, ramp junctions, weave sections and intersections (signalized and unsignalized).

Intersection performance measures can be calculated in the form of volume to capacity (v/c) ratio, average vehicular delay, average and 95th percentile queue lengths, and level-of-service. Synchro 9.0 was the primary software used to perform the intersection analysis. This software program (Synchro 9.0) is preferred/recommended by MassDOT.

The volume-to-capacity ratio, a measure of the amount of traffic compared to the available capacity, is a basic measure of congestion along the approach. As with delay, this measure can be utilized for either the individual approach or the intersection as a whole. As opposed to delay, there is no standard gauge to provide a specific point of reference for a certain volume-to-capacity ratio; however, a lower volume-to-capacity ratio indicates that backups are less likely. As the ratio approaches and exceeds 1.00, backups and poor service have a greater potential to occur. Generally speaking, a ratio under 1.00 is considered acceptable.

Level-of-Service (LOS) is a term used to denote different operating conditions that occur under various traffic volume loads. It is a *qualitative measure* of the effect of a number of factors including geometrics, speed, travel delay, freedom to maneuver, and safety. The LOS is divided into a range of six letter grades, ranging from A to F, with A being the best and F the worst. LOS E or F is generally considered inadequate traffic operations in suburban and urban areas.

- LOS A describes conditions with little to no delay to motorists.
- LOS B represents conditions with relatively low delay to motorists.
- LOS C describes conditions with average delay to motorists.
- LOS D describes operations where the influence of congestion becomes more noticeable. Delays are still within an acceptable range.
- LOS E represents operating conditions with high delay. This level is considered by many agencies to be the limit of acceptable delay.
- LOS F is considered unacceptable to most drivers with high delay values that often occur when arrivals exceed the capacity of the intersection.

LOS designation is reported differently for signalized and unsignalized intersections. For signalized intersections, it is defined in terms of delay, which is a measure of driver discomfort and frustration, fuel consumption, and lost travel time. Specifically, LOS criteria are quantified in terms of average control delay per vehicle for the peak hour, which is reported for the entire intersection and by lane or lane group approach.

The delay ranges differ slightly between unsignalized and signalized intersections due to driver expectations and behavior for each LOS. Table 4 summarizes the LOS criteria.

Table 4: Intersection LOS Thresholds

LOS	Signalized	Unsignalized
	Control Delay (sec/veh)	Control Delay (sec/veh)
A	0-10	0-10
B	>10-20	> 10-15
C	>20-35	>15-25
D	>35-55	>25-35
E	>55-80	>35-50
F	>80	>50

Source: 2000 Highway Capacity Manual

In addition to LOS, the 95th percentile queue lengths are examined. While an intersection may show acceptable LOS, extensive queue lengths may exist that impede operations elsewhere by extending into adjacent intersections or other conflict areas.

6.3 2019 Existing and 2026 No Build Intersection Capacity Analysis

Jacobs obtained the latest signal phasing and timing information and observed traffic operations at the two study intersections on June 6, 2019.

Intersection peak-hour traffic operations were analyzed using the existing peak hour volumes shown in Figure 15. Existing intersection peak hour factors (PHF) and truck percentages were included in the analysis.

The results of the 2019 existing and 2026 No Build intersection analyses are shown in Table 5 through Table 8. The intersection analysis worksheets and detailed results can be found in Appendix H.

Table 5: Thoreau Street at Sudbury Road 2019 and 2026 AM No Build

Intersection	Movement	2019 Existing Conditions AM Peak				2026 No Build Conditions AM Peak			
		Delay (sec)	95% Queue (ft)	v/c ¹	LOS ²	Delay (sec)	95% Queue (ft)	v/c ¹	LOS ²
Thoreau St at Sudbury Rd	SE LT	28	116	0.5	C	28.9	131	0.47	C
	SE R	24.9	2	0.1	C	26	16	0.09	C
	NW L	17.2	102	0.34	B	18.2	113	0.36	B
	NW TR	17.3	140	0.31	B	18.4	157	0.33	B
	NE LTR	31.9	314	0.8	C	24.2	376	0.66	C
	SW L	13.6	22	0.05	B	12.9	25	0.05	B
	SW TR	16.5	368	0.57	B	18	481	0.66	B
Total		22.5		0.66	C	20.9		0.63	C

Sudbury Rd NE/SW, Thoreau St NW/SE, ¹Volume to Capacity Ratio, ² Level of Service

Table 6: Thoreau Street at Main Street 2019 and 2026 AM No Build

Intersection	Movement	2019 Existing Conditions AM Peak				2026 No Build Conditions AM Peak			
		Delay (sec)	95% Queue (ft)	v/c ¹	LOS ²	Delay (sec)	95% Queue (ft)	v/c ¹	LOS ²
Thoreau St at Main St	EB TL	20.4	362	0.71	C	18.2	453	0.7	B
	EB R	21.3	353	0.71	C	20.6	433	0.75	C
	WB L	11.2	20	0.12	B	9.5	22	0.11	A
	WB TR	12	204	0.47	B	9.6	228	0.45	A
	NB LTR	24.1	152	0.69	C	30.6	178	0.74	C
	SB LTR	17.9	126	0.5	B	21.4	146	0.51	C
	TOTAL	19		0.73	B	18.7		0.76	B

Table 5 and Table 6 show the AM peak hour with an acceptable LOS for all approaches for both intersections.

Table 7: Thoreau Street at Sudbury Road 2019 and 2026 PM No Build

Intersection	Movement	2019 Existing Conditions PM Peak				2026 No Build Conditions PM Peak			
		Delay (sec)	95% Queue (ft)	v/c ¹	LOS ²	Delay (sec)	95% Queue (ft)	v/c ¹	LOS ²
Thoreau St at Sudbury Rd	SE LT	28.4	188	0.67	C	29.3	233	0.69	C
	SE R	20.6	0	0.08	C	20.5	0	0.09	C
	NW L	15.7	34	0.12	B	14.8	37	0.12	B
	NW TR	17.3	162	0.37	B	16.4	183	0.37	B
	NE LTR	193.9	623	1.35	F	343.9	715	1.68	F
	SW L	15.6	33	0.12	B	17.8	37	0.16	B
	SW TR	13.3	163	0.29	B	16	183	0.35	B
	Total	91.3		0.97	F	153.4		1.07	F

Sudbury Rd NE/SW, Thoreau St NW/SE, ¹ Volume to Capacity Ratio, ² Level of Service

Table 8: Thoreau Street at Main Street 2019 and 2026 PM No Build

Intersection	Movement	2019 Existing Conditions PM Peak				2026 No Build Conditions PM Peak			
		Delay (sec)	95% Queue (ft)	v/c ¹	LOS ²	Delay (sec)	95% Queue (ft)	v/c ¹	LOS ²
Thoreau St at Main St	EB TL	23	248	0.64	C	24.1	284	0.67	C
	EB R	18.3	81	0.26	B	18.7	97	0.3	B
	WB L	13.4	28	0.18	B	13.2	30	0.19	B
	WB TR	22.4	302	0.78	C	23.4	356	0.81	C
	NB LTR	26.9	406	0.81	C	54.2	478	0.97	D
	SB LTR	12.9	33	0.11	B	14.9	36	0.13	B
	TOTAL	22.5		0.87	C	30		0.97	C

Main St EB/WB, Thoreau St NB/SB, ¹ Volume to Capacity Ratio, ² Level of Service

Table 7 and Table 8 show the PM peak hour with an acceptable LOS for all approaches on the Thoreau Street at Main Street intersection during the PM Peak hour. The intersection of Thoreau Street at Sudbury Road has excessive delays on the Sudbury Road northeast bound approach, which operates at LOS F and has queue lengths up to 715 feet in the future year.

6.4 Build Conditions

Table 9 through Table 12 show the results for the Build conditions in 2026 in which the traffic signals are optimized. The first Build scenario uses the 2026 traffic volumes under current conditions, while the second Build scenario uses the 2026 Redirected/Diverted traffic volumes in which cut-through mitigation has been applied.

Table 9: Thoreau Street at Sudbury Road 2026 AM Build

Intersection	Movement	2026 Optimized Conditions AM Peak				2026 Optimized W/Diverted Traffic AM Peak			
		Delay (sec)	95% Queue (ft)	v/c ¹	LOS ²	Delay (sec)	95% Queue (ft)	v/c ¹	LOS ²
Thoreau St at Sudbury Rd	SE LT	28.9	131	0.47	C	45.9	471	0.86	D
	SE R	26	16	0.09	C	25.1	21	0.09	C
	NW L	18.2	113	0.36	B	19.9	109	0.49	B
	NW TR	18.4	157	0.33	B	17	151	0.27	B
	NE LTR	24.2	376	0.66	C	114.9	451	1.1	F
	SW L	12.9	25	0.05	B	19.7	26	0.07	B
	SW TR	18	481	0.66	B	31	509	0.79	C
	Total	20.9		0.63	C	46.3		0.86	D

Sudbury Rd NE/SW, Thoreau St NW/SE, ¹ Volume to Capacity Ratio, ² Level of Service

Table 10: Thoreau Street at Main Street 2026 AM Build

Intersection	Movement	2026 Optimized Conditions AM Peak				2026 Optimized W/Diverted Traffic AM Peak			
		Delay (sec)	95% Queue (ft)	v/c ¹	LOS ²	Delay (sec)	95% Queue (ft)	v/c ¹	LOS ²
Thoreau St at Main St	EB TL	18.2	453	0.7	B	13.4	190	0.39	B
	EB R	20.6	433	0.75	C	22.7	427	0.79	C
	WB L	9.54	22	0.11	A	7.6	22	0.07	A
	WB TR	9.6	228	0.45	A	9.8	228	0.46	A
	NB LTR	30.6	178	0.74	C	27.9	178	0.71	C
	SB LTR	21.4	146	0.51	C	20.1	146	0.49	C
	TOTAL	18.7		0.76	B	18.8		0.78	B

Main St EB/WB, Thoreau St NB/SB

Table 9 and Table 10 show the AM peak hour with an acceptable LOS for all approaches for both study intersections. No change in timing was required for the condition without adding diverted traffic during the AM peak hour. The LOS for the Sudbury Road at Thoreau street degrades from a C to D with the additional diverted traffic added and the increased average delay per vehicle increases from 20.9 seconds to 46 seconds.

Table 11: Thoreau Street at Sudbury Road 2026 PM Build

Intersection	Movement	2026 Optimized Conditions PM Peak				2026 Optimized W/Diverted Traffic PM Peak			
		Delay (sec)	95% Queue (ft)	v/c ¹	LOS ²	Delay (sec)	95% Queue (ft)	v/c ¹	LOS ²
Thoreau St at Sudbury Rd	SE LT	62.3	279	0.85	E	61.2	313	0.86	E
	SE R	37.2	30	0.11	D	35.9	29	0.1	D
	NW L	31.3	49	0.19	C	30.7	48	0.2	C
	NW TR	34.7	256	0.49	C	33.4	252	0.46	C
	NE LTR	75.5	760	1.03	E	87.5	793	1.06	F
	SW L	16.8	42	0.1	B	18.1	44	0.1	B
	SW TR	15	218	0.26	B	16.2	229	0.27	B
	Total	52.9		0.89	D	57.6		0.9	E

Sudbury Rd NE/SW, Thoreau St NW/SE

Table 12: Thoreau Street at Main Street 2026 PM Build

Intersection	Movement	2026 Optimized Conditions PM Peak				2026 Optimized W/Diverted Traffic PM Peak			
		Delay (sec)	95% Queue (ft)	v/c ¹	LOS ²	Delay (sec)	95% Queue (ft)	v/c ¹	LOS ²
Thoreau St at Main St	EB TL	25.8	305	0.67	C	24.4	278	0.62	C
	EB R	20.2	109	0.31	C	20.4	115	0.34	C
	WB L	15.2	34	0.21	B	14.8	34	0.2	B
	WB TR	28.4	407	0.85	C	28.4	407	0.85	C
	NB LTR	40.2	433	0.9	D	40.2	433	0.9	D
	SB LTR	14.5	32	0.12	B	14.5	32	0.12	B
	TOTAL	28.9		0.95	C	28.5		0.95	C

Main St EB/WB, Thoreau St NB/SB

Table 11 and Table 12 show the PM peak hour with an acceptable LOS for most approaches for both intersections. Signal timing and cycle length changes are required for both the optimized and diverted traffic conditions at the Sudbury Road at Thoreau Street intersection. The addition of the diverted traffic during the PM peak hour for the Sudbury Road at Thoreau Street increases delay from 75.5 seconds to 87.5 seconds for the northeast approach, which degrades the LOS from an E to an F. An ideal solution would be to add an exclusive left on the Sudbury Road northeast approach but this is not easily accomplished due to right-of-way constraints.

7. Recommendations

This section presents recommendations for the streets confirmed by the analysis to be experiencing cut-through traffic (Table 13). **Conditions on all street segments should be monitored to determine whether these recommendations are effective or additional mitigation is necessary.**

It should be noted that the analysis methodology used in this study (described in Section 4) can be applied to future streets of concern to verify whether they are experiencing cut-through traffic. A neighborhood petition process for advancing cut-through analysis and mitigation is proposed at the end of this section and will be used for future streets of concern.

Table 13: Confirmed Cut-Through Streets

Downtown Concord	
1	Everett St
2	Middle St
3	Academy Ln
4	Devens St
5	Nashawtuc Rd/ Musketaquid Rd
6	Wood St
7	River St
8	Hawthorne Lane
North Concord	
9	Westford Rd
10	Liberty St
11	Barnes Hill Rd/ Estabrook Rd
West Concord	
12	Old Bridge Rd
13	Orchard Rd
14	Hillside Ave/Old Stow Rd
15	Pine St
16	West St
17	Upland Rd

7.1 Downtown Concord

The segments shown in red in Figure 18 are verified to be cut-throughs. Figure 18 shows that the recommendations for mitigating cut-through traffic in the downtown area involve one-way/do not enter and/or turn restrictions by time of day. There is not a recommendation for Everett St because limiting access would significantly impact access to the school as well as to Cambridge Turnpike. In addition, there was no neighborhood champion.

7.2 North Concord

The segments shown in red in Figure 19 are verified cut-throughs. A neighborhood champion for the Liberty St and Barnes Hill Rd/ Estabrook Rd neighborhood has not come forward at this point to advance cut-through traffic mitigation. Although traffic does use Westford Road, access to or through this roadway cannot be restricted.



Figure 19: Cut-Throughs in North Concord

7.3 West Concord

The segments shown in red in Figure 20 and Figure 21 are verified cut-throughs. Recommendations for mitigating cut-through traffic on Old Bridge Rd, Orchard Rd, Hillside Ave/Old Stow Rd, Pine St, and Upland Rd involve Do Not Enter restrictions by time of day. There is not a recommendation for West Street because it provides access to the school and if restricted it would significantly impact residents.



Figure 20: Recommendations for Cut-Throughs in West Concord (north of Route 62)



Figure 21: Recommendations for Cut-Throughs in West Concord (south of Route 62)

7.4 Petition Process

For future streets of concern, the analysis methodology described in Section 4 can be used to verify whether a street is experiencing cut-through traffic. If it is, a neighborhood can circulate a petition to advance mitigation and to verify that there is a widespread concern of cut-through traffic.

The petition form is available on the Town's website and the process is as follows:

- Town staff will identify an “area of influence” in the neighborhood. The area of influence includes properties abutting the street and properties on intersecting streets within a reasonable distance of the problem street. The Engineering Division will provide a map and addresses for the area of influence.
- The petition must be signed by at least 75 percent of the owners or residents of properties within the “area of influence.” Each property is entitled to one signature. Valid signatures include those from (1) a property owner or spouse, (2) an adult head of household, or (3) an adult renting the property.

Petitions for six of the neighborhoods have been initiated and are provided in Appendix I.

Appendix A. Literature Review

This section reviews the current state of practice for how other locations are attempting to reduce cut-through traffic.

A.1 (2016) ITE New England Section Technical Committee, Traffic Calming Guidelines

The ITE Guidelines focus on using traffic calming to discourage cut-through traffic and were developed as complement to the concept of Complete Streets. The Guidelines note that *“all traffic calming plans should attempt to identify the problem that causes arterial traffic to divert to neighborhood roads. Correcting the root cause of the congestion is often easier than correcting the symptom of excessive arterial traffic penetrating the neighborhoods. A traffic calming plan should address the surrounding neighborhood and transportation system, not just the affected street. Without an area wide comprehensive approach, traffic will simply move from one local street to another.”* This is the same approach as the Concord Cut-Through Traffic Study will take as recommendations are developed.

The Guidelines recommend the following process, emphasizing the need for public participation:

- Initiate the Study
- Identify Problems and Issues (collect data, quantify problems)
- Develop a Plan (examine arterial streets first, examine neighborhood streets)
- Review the Process
- Implement the Plan
- The Guidelines also note that design considerations must include:
 - Safety
 - Maintenance
 - Emergency vehicles
 - Diversions to other residential streets
 - Self-enforcement
 - Roadway drainage
 - Costs/financing

A.2 City of San Jose, California, Traffic Calming Toolkit

This toolkit provides a useful example for the Town of Concord to consider. It begins by establishing threshold criteria for consideration of traffic calming project:

- Local Streets (25 mph posted speed limit, 1,000 – 3,000 vehicles/day):
 - 85th percentile speed of 33 mph or more, OR
 - 40% or more of the daily traffic is cut-through traffic, where cut-through traffic is defined as traffic entering a neighborhood with a destination outside of that neighborhood
- Neighborhood Collector Streets – connects local streets to major streets (25 or 30 mph posted speed limit, 1,000 – 6,000 veh/day):
 - 85th percentile speed of 33 mph or more on 25 mph posted streets, OR

- 85th percentile speed of 37 mph or more on 30 mph posted streets

The toolkit then establishes a prioritization system for implementing traffic calming:

Speed	2 points for each mph difference between the 85 th percentile speed and the posted or <i>prima facie</i> speed limit
Volume	1 point for each 500 vehicles over 1,000 vehicles per day; 5 points if 40 – 65% or more ADT on local street is cut-through traffic between arterials or major roadways; 10 points if higher than 65%
Crash History	5 points for each speed-related crash in the past 3 years
Pedestrian Generators (15 points max.)	5 points for each school, park or trail access, library or community center along roadway; 3 points if within 1 block; 2 points if within 2 blocks
Unique Conditions (15 points max.)	5 points for designation as a Bike Route or as a General Plan pedestrian corridor, or for proximity to neighborhood business district or existing/planned transit hub; 5 points for evidence of crashes or speeding, such as long skid marks or broken glass; 5 points for missing sidewalk section; 5 points for unique roadway geometry that substantially restricts visibility; 5 points for high crash rate

This example will be considered as an overall methodology for identifying future cut-through segments is developed.

A.3 City of Sunnyvale, California, Neighborhood Traffic Calming

Although more focused on traffic calming than on cut-through traffic specifically, this study offers a process for implementing traffic calming projects, including using the following criteria to identify candidate roadways:

- Street must be classified as “residential”
- Petition from representative number of residents must verify concern
- Traffic volume and speed data thresholds:
 - Speeding problem: 85% of the vehicles driving on the roadway are traveling at speeds above 32 miles per hour or 95th percentile speed of 35 miles per hour
 - Cut-through problem: street carries more than 1000 vehicles per day

The study also proposes implementing traffic calming solutions in stages (described below), followed by data collection to determine if the measures were successful. Projects were implemented as first come, first served. The trade-offs of traffic calming projects are also described.

- Stage 1: radar speed trailer, traffic enforcement, signage and pavement markings

- Stage 2: traffic calming study and more restrictive calming measures (traffic circles, chokers, chicanes, speed humps/tables, one-way streets, forced turn islands, diagonal diverters, street closures, etc.)
 - Stage 2 criteria:
 - Installation must not result in traffic diversion to other neighborhood streets
 - At least 60% of impacted residents and 100% of residents within 100 feet of the proposed device shall support the installation
 - Devices shall be located a minimum of 25 feet from driveways, manholes, drain inlets, fire hydrants, water valves, street monuments, and other appurtenances
 - Devices shall only be installed where a minimum safe stopping distance can be provided
 - Emergency response times and access cannot be negatively affected

A.4 (2000) Texas Transportation Institute Research, Project Number 167707 Comprehensive Engineering Approach to Achieving Safe Neighborhoods

This report describes a model that “can predict the percent of arterial drivers that cut-through the adjacent neighborhood streets.” Variables include average arterial travel speed, signal density and degree of saturation of signalized intersections on the arterial. However, this model is only valid for four-lane arterials with free flow speeds of 30-50 MPH and signal densities of 4-6 signal/mile, and therefore does not apply to the Town of Concord.

A.5 (2018) Loudon County, Virginia Department of Transportation and Capital Infrastructure, Village of Waterford Cut Through Traffic Study

This study used a license plate survey and traffic counts to determine cut-through traffic volumes on streets. It notes key requirements for initiating the Virginia Department of Transportation’s (VDOT’s) cut-through policy:

- The functional classification of the street(s) in question must be “local residential street.”
- Verification by the county/town that cut-through traffic on the local residential street to be studied is 40% or more of the total one-hour, single direction volume, and that a minimum of 150 cut-through trips occur in one hour in one direction.
- Verification by the county/town that a petition outlining the perceived problem and signed by at least 75 percent of the total occupied households within the primary use area is valid.
- Identification of an alternative route for the through traffic if travel is restricted on the street(s) in question.

A.6 (2015) Town of Atherton, California, Presentation to Town Council Neighborhood Traffic Management Program (NTMP)

This presentation focused on traffic calming rather than cut-through traffic. It offered the following distinction for neighborhood traffic management strategies:

- Passive controls (road striping, signage, parking controls, enforcement, speed feedback)
- Physical controls for speed reduction (speed humps, traffic circles, rumble strips)
- Physical controls for volume reduction (turn movement restrictions, diverters, partial or full roadway closures)

A.7 (2008) City of Anaheim, California, Neighborhood Traffic Management Program (NTMP)

This report offers a basic process for implementing traffic calming projects and a toolbox of traffic calming devices grouped into non-physical devices, speed control devices, and volume control devices. More significantly, the report provides guidelines for applying the toolbox (Chapter 4) to ensure that the device suits the specific concern (speeding, traffic volumes, or vehicle safety); roadway type (local streets (midblock or intersection), collectors, or transit routes); roadway characteristics (speeds, volumes, grades, etc.); and anticipated effectiveness (expected change in speed and volume after implementation).

A.8 Collier County/Naples Metropolitan Planning Organization (Florida), Neighborhood Traffic Management Program (NTMP)

This report describes a public process for initiating a request for traffic calming on a street. The process involves neighborhood petitions, field counts and observations, and an overall working group approach (comprised of citizens and staff) to develop education, enforcement, and engineering solutions.

A.9 ITE and Drive Michigan Safely, Speed Control in Residential Areas

This report recommends using license plate surveys, along with speed and traffic volume studies, to identify the speed-related problems on residential streets.

A.10 (2016) Town of Lexington, Massachusetts, Traffic Calming Study

This study used a screening matrix to assess the impact of various traffic calming strategies to mobility, safety, geometrics, noise and air pollution, and anticipated schedule and cost. The study recommended locations for speed humps, raised intersections, traffic circles, turn restrictions, road closures, installation of stop signs (pending warrant analysis), additional pedestrian facilities, and reduced intersection radii. Reduction in cut-through traffic was considered an added benefit but was not the main focus of the study.

A.11 (1990) Virginia Transportation Research Council, An Operating Guide for the Control of Residential Cut-Through Traffic

This guide recommends using a license plate survey to collect data for cut-through studies.

A.12 (in progress) Town of Belmont, Massachusetts, Town-wide Traffic Study

The purpose of this study (currently in progress) is to analyze travel patterns, determine the extent of cut-through traffic, and identify strategies to eliminate, reduce, or mitigate cut-through traffic volumes. Similar to preliminary findings for Concord, the study has so far found that:

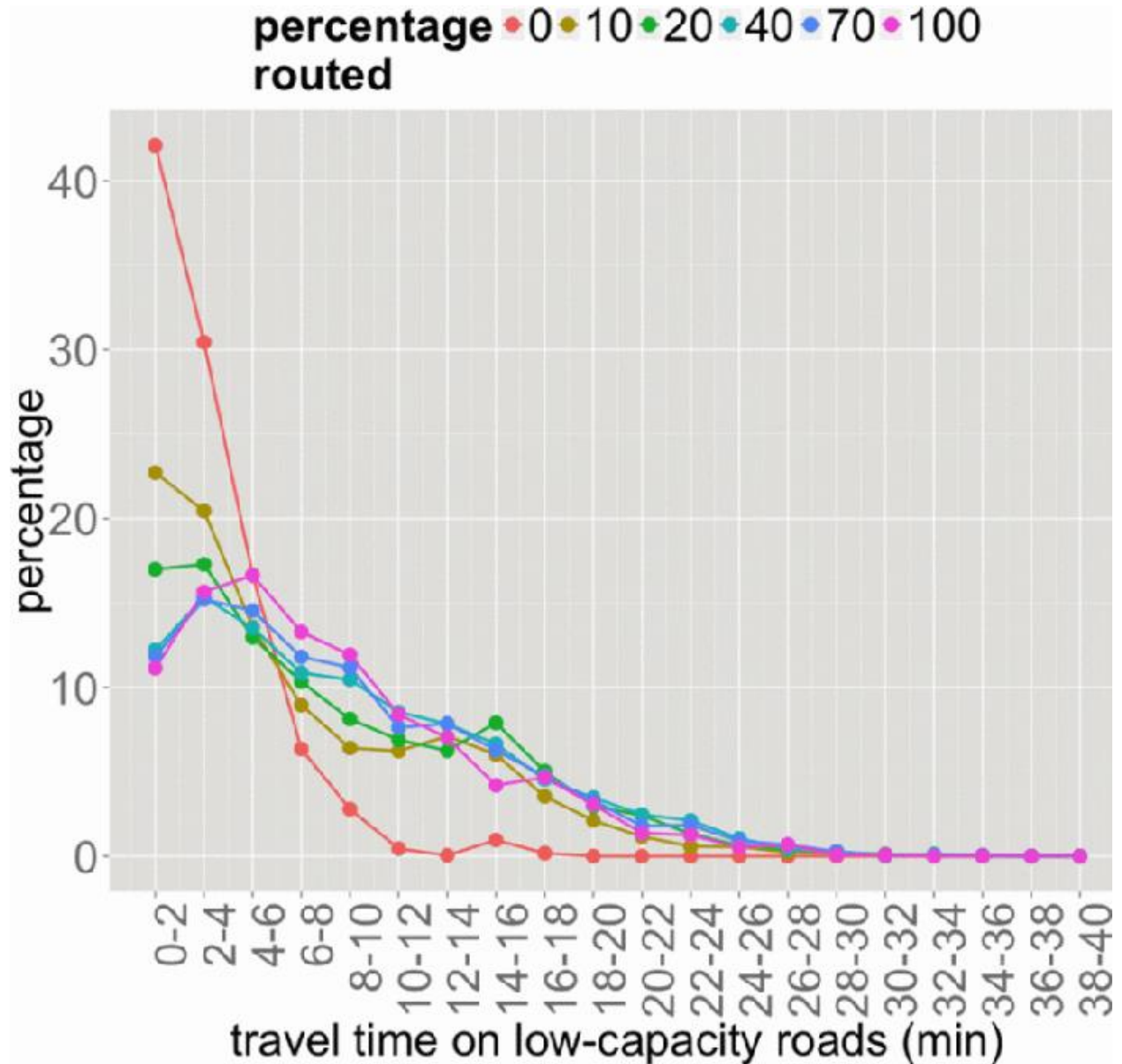
- Regional congestion contributes to cut-through traffic in Belmont
- High percentage of cut-through traffic is from immediate adjacent towns
- Peak traffic flow is generally directional based on time of day
- Neighborhoods near congested main roads experience high cut-through traffic volumes

The study used a combination of turning movement counts, automated traffic recorders, media access control (MAC) addresses, and a license plate survey to collect data. Next steps for completing the study are to develop recommendations to keep through traffic on main routes and evaluate the feasibility of various strategies.

A.13 (2018) The Atlantic, “The Perfect Selfishness of Mapping Apps”⁴

⁴ <https://www.theatlantic.com/technology/archive/2018/03/mapping-apps-and-the-price-of-anarchy/555551/>

This article references University of California work (discussed in more detail below) that confirms that mapping applications are drawing travelers to “low capacity roads” as shown below.



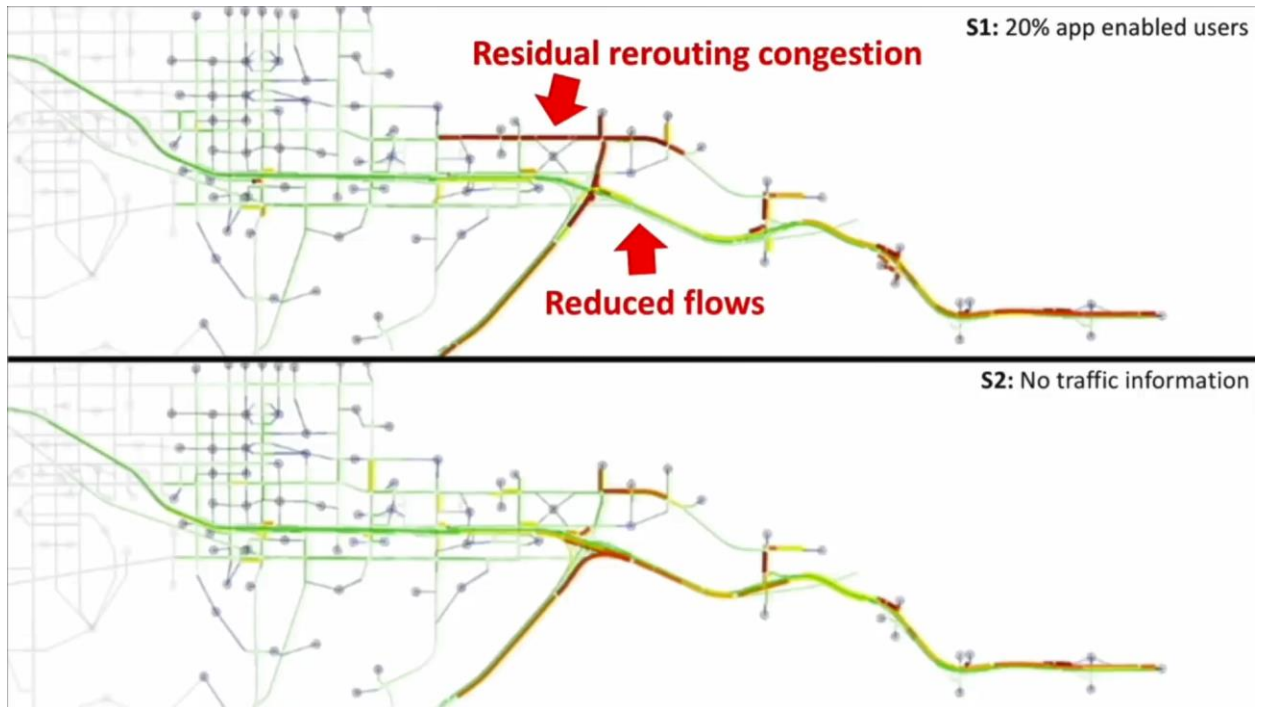
A.14 (2017) University of California, Berkeley Cal Future Forum, Alexandre Bayen “The Impact of Routing Apps on Traffic: The Good, the Bad and the Ugly”⁵ and (2018) Berkeley News, “Why traffic apps make congestion worse”⁶

UC researchers have applied economic principles (such as the Nash Equilibrium and Game Theory) and found that traffic is getting worse overall due to wayfinding apps such as Waze and Google Maps. As a significant portion of travelers are able to ‘act selfishly’ rather than cooperating for the performance of the system as a whole, the entire system deteriorates. That is, by detouring drivers from high capacity highways and arterials to

⁵ <https://vcresearch.berkeley.edu/video/calfutureforum/alexandre-bayen>
⁶ https://news.berkeley.edu/story_jump/why-traffic-apps-make-congestion-worse/

residential streets, more significant backlogs are created on streets that are not designed for larger volumes and can take much longer to recover from a bottleneck event such as a vehicle crash.

The research team simulated traffic flows responding to a crash on a freeway under two scenarios: one in which 20% of travelers had traffic apps and one in which no traffic information was provided. The result was that the first scenario had residual re-routing congestion after the crash was cleared and freeway traffic resumed normal flow, as shown below.



In response to these situations, municipalities often implement infrastructure changes to discourage cut-through traffic. However, the researchers indicate that communities will not be able to ‘build their way out’ of the problem with this approach. Rather, they suggest, the app developers should share data and collaborate to distribute drivers across different routes on the network. In addition, “transportation engineers must keep up with popular technologies and more nimbly respond to problems that emerge when millions of drivers adopt a new commuting strategy. We need to devise policy and technologies that help app makers work collaboratively with city planners.”

A.15 (2017) New York Magazine, “For the Good of Society — and Traffic! — Delete Your Map App”⁷

This article notes the huge growth in the use of wayfinding apps and ride-sharing companies like Uber and Lyft, which either use these apps or have their own: “In 2011, Waze had 7 million downloads; that number climbed to 50 million by 2013, and 65 million in 185 countries by 2016. Meanwhile, Google Maps has well over 1 billion monthly users.”

The article goes on to cite the UC Berkeley research, noting that usually the only tool that a municipality has to respond to traffic pattern changes stemming from the use of wayfinding apps is infrastructure. This results in a cyclical problem: “If cities thwart map apps and ride-share services through infrastructure changes with the

⁷ <http://nymag.com/intelligencer/2017/12/waze-and-google-maps-create-traffic-in-cities.html>

intent to slow traffic down, it has the effect of slowing down traffic. So, the algorithm may tell drivers to go down another side street, and the residents who've been griping to the mayor may be pleased, but traffic, on the city whole, has been negatively affected, making everyone's travel longer than before."

Two unique neighborhood responses cited by the article include Takoma Park, Maryland, where residents went so far as to falsify reports of bottlenecks to stop the apps' algorithm from directing drivers down their street. Eventually the apps detected the false reports and those neighborhood users were blocked.

The second response, from Israel, involves a neighborhood that has filed a class action lawsuit against Waze.

A.16 Findings

Most of the available literature focuses on traffic calming rather than cut-through traffic. Most recommended methodologies for studying cut-through traffic involve license plate surveys, or a combination of license plate surveys and other techniques such as traffic counts. There are plenty of traffic calming toolboxes available that include the suitability of different devices for a set of given roadway characteristics. Despite not using a license plate survey, the methodology proposed for identifying and analyzing roadways in the Concord Cut-Through Traffic Study is consistent with other approaches.

The literature review suggests that few communities have confronted the challenge of cut-through traffic head on and have instead grouped it into an overarching traffic calming program. The studies completed for Lexington and Belmont indicate that other Massachusetts communities are challenged by regional traffic cutting through local residential streets as well.

UC Berkeley researchers have confirmed that the use of wayfinding apps has greatly exacerbated the problem of cut-through traffic. Researchers suggest that new, collaborative approaches focusing on technology and policy are needed to address the issue. The approach of constructing or installing new infrastructure, which is often the only tool available to municipalities, is inadequate.

- Cut-through traffic is a regional issue with which many communities in Massachusetts and the world have to grapple. Yet few appear to have tackled it.
- Most of the available literature focuses on traffic calming rather than cut-through traffic.
- Research confirms that wayfinding apps are increasing cut-through traffic in local neighborhoods, and infrastructure updates are currently the only available tool that municipalities have to respond.
- The methodology proposed for identifying and analyzing roadways in the Concord Cut-Through Traffic Study appears to be logical given the state of the practice.

Appendix B. Regional Traffic Patterns

Figure 22 shows the number of employees by zip code and major routes in the Boston Metropolitan region. The identification of major employment centers in the region helps us understand commute patterns. The map shows employment centers in Boston and Cambridge, as well as the Rt128 Corridor.

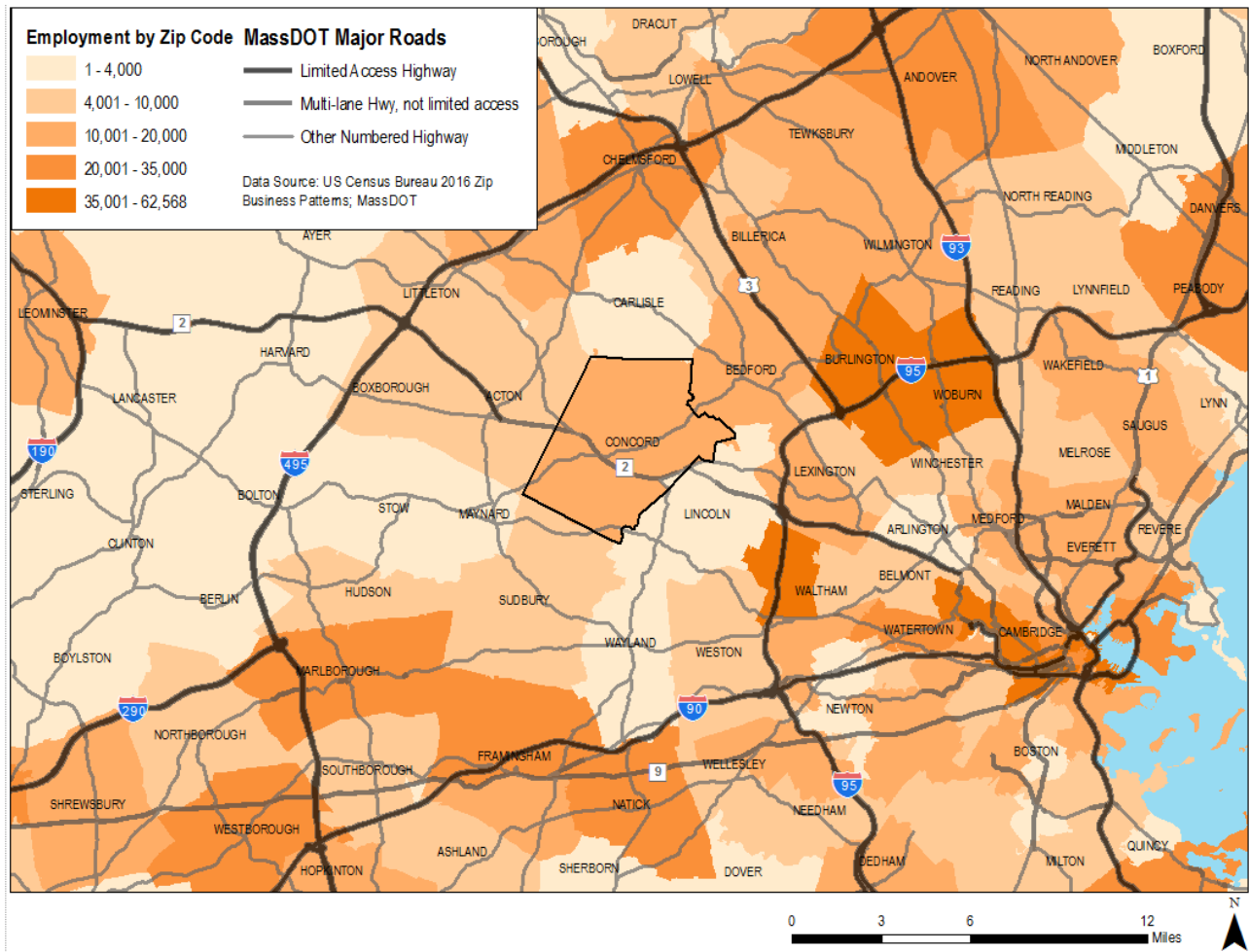


Figure 22: Employment Centers in the Region

The Boston Region Metropolitan Planning Organization/Central Transportation Planning Staff monitors the regional transportation network of Expressways Highways and Arterial Roadways. Performance measures are published using data from 2015. Route 2 through Concord is on the regional Express Highway network. Route 62 through Concord is classified as an arterial roadway. A review of the performance measures in and around Concord indicates that:

- Route 2 through Concord in the AM Peak Hour experiences some of the slowest average speeds in the region with eastbound morning traffic traveling at 25 mph. In the evening, average speed is slightly higher in some segments through Concord, but most segments are still between 25mph and 35mph.
- Route 62 through Concord is generally operating at speeds within 70-100% of the posted speed limit during the peak periods in both directions, with increased congestion around Route 2.

- Between 2012 and 2015 travel speed on Route 2 during the peak periods decreased more than 5 miles per hour.
- Increased congestion and travel times on the regional express highway network can be linked to an increase in traffic volumes traveling on the local road network to avoid congestion.



2015 Arterial Highway Performance Dashboard

Regional Overview Map Data by Route Reset Application Download data Help

AM Speed Index

Speed Index
(Average speed / posted speed limit)

- Less than 40 percent
- 40.00-49.99 percent
- 50.00-69.99 percent
- 70-90 percent
- More than 90 percent



Figure 23: 2015 AM Speed Index (source: Boston Region MPO/CTPS)



2015 Arterial Highway Performance Dashboard

Regional Overview Map | Data by Route | Reset Application | Download data | Help

PM Speed Index

- Speed Index
(Average speed/posted speed limit)
- Less than 40 percent
 - 40.00-49.99 percent
 - 50.00-69.99 percent
 - 70-90 percent
 - More than 90 percent

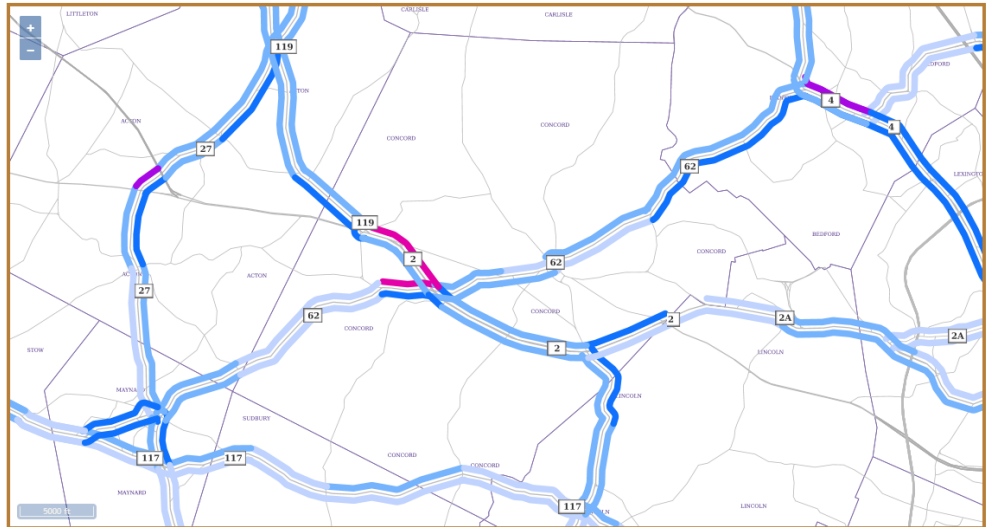


Figure 24: 2015 PM Speed Index (source: Boston Region MPO/CTPS)



2015 Arterial Highway Performance Dashboard

[Regional Overview Map](#) [Data by Route](#) [Reset Application](#) [Download data](#) [Help](#)

AM Travel Time Index

Travel Time Index
(Peak-period travel time/free-flow travel time)

- More than 2.0000 TTI
- 1.3000-2.0000 TTI
- 1.1500-1.2999 TTI
- Less than 1.1500 TTI

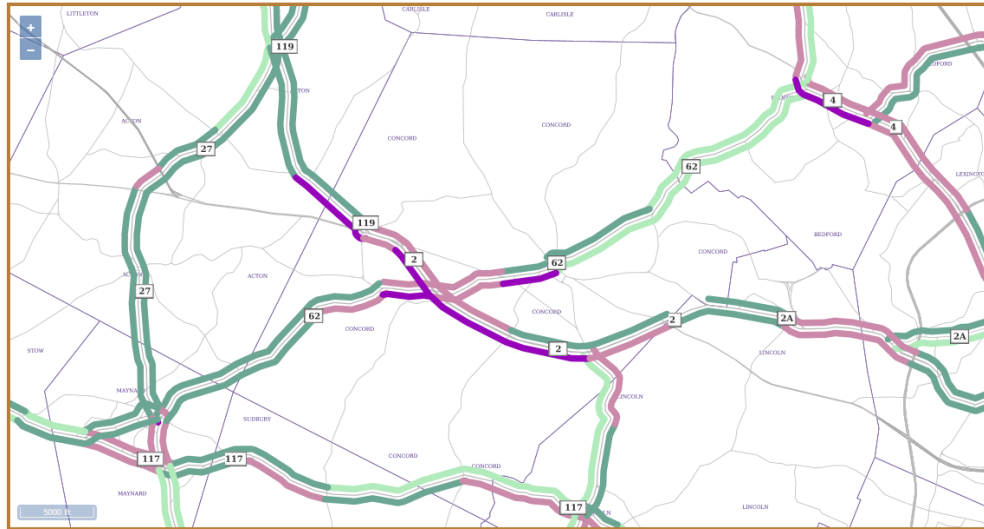


Figure 25: 2015 AM Travel Time Index (source: Boston Region MPO/CTPS)



2015 Arterial Highway Performance Dashboard

[Regional Overview Map](#) [Data by Route](#) [Reset Application](#) [Download data](#) [Help](#)

PM Travel Time Index

Travel Time Index
(Peak-period travel time/free-flow travel time)

- More than 2.0000 TTI
- 1.3000-2.0000 TTI
- 1.1500-1.2999 TTI
- Less than 1.1500 TTI

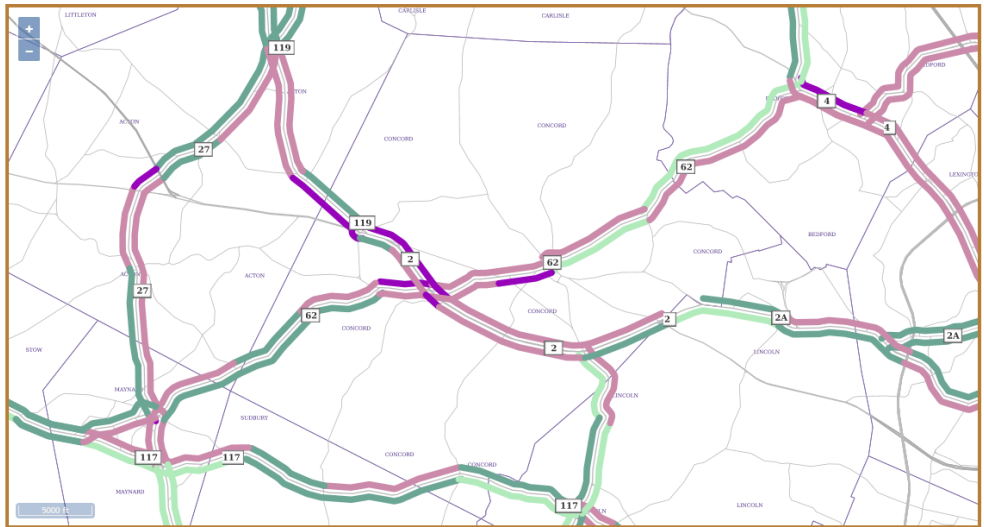


Figure 26: 2015 PM Travel Time Index (source: Boston Region MPO/CTPS)

CONGESTION

No one likes driving during rush-hour, waiting for a late bus, or getting stuck in a traffic jam. Individual incidents are frustrating. When congestion occurs regularly—at bottlenecks, work zones, crash sites, and during weather events—it can profoundly impact mobility, safety, air quality, and health. The Boston Region MPO's Congestion Management Process (CMP) is used to monitor traffic congestion on approximately 970 expressway miles and 1,200 arterial miles in eastern Massachusetts.

The Boston Region MPO monitors, analyzes, and develops strategies to manage congestion. One way to quantify congestion is to calculate the speed index, which is the ratio of observed speed to the posted speed limit on a roadway segment. The speed index is a better indication of congestion than average vehicle speeds because the speed index compares ideal conditions with actual conditions. The roadway speeds are provided by INRIX, a company that collects vehicle probe data (GPS data collected in real-time from vehicles traveling on roadways). The congestion data that is on display on this dashboard was collected in 2012.

Congestion across Boston Region Arterial Routes

The speed index of arterial roadways in the Boston region is displayed in the graphic below. The speed index indicates congestion more accurately than travel speed alone because low travel speed may be a result of low speed limits on certain arterial facilities. Click on individual routes to explore the degree to which congestion slows travel on the Boston region's many arterials during morning and evening rush hours. The AM peak period is between 6:30 AM and 9:30 AM, and the PM peak period is between 3:30 PM and 6:30 PM on arterial roadways. A value of 0.7 or lower is considered congested.

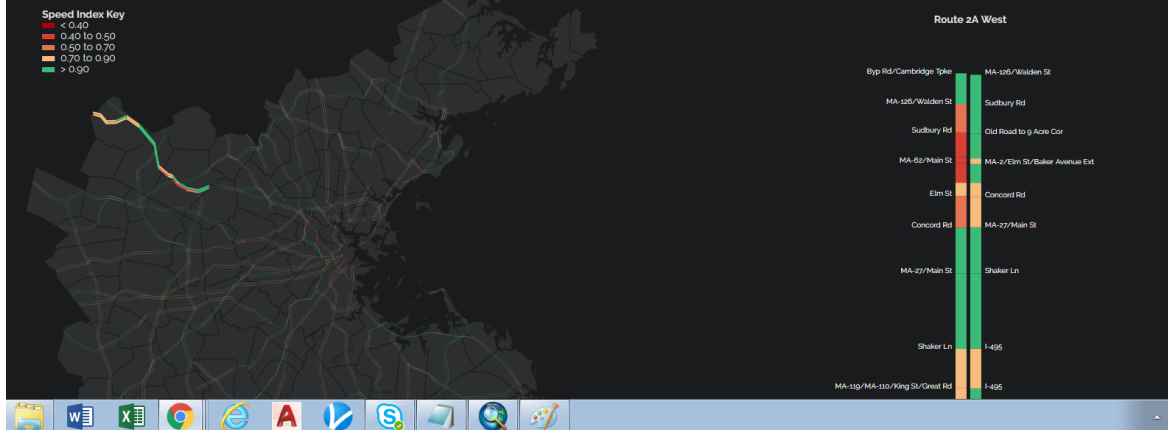


Figure 29: 2012 Route 2A West Speed Index (source: Boston Region MPO/CTPS)

CONGESTION

No one likes driving during rush-hour, waiting for a late bus, or getting stuck in a traffic jam. Individual incidents are frustrating. When congestion occurs regularly—at bottlenecks, work zones, crash sites, and during weather events—it can profoundly impact mobility, safety, air quality, and health. The Boston Region MPO's Congestion Management Process (CMP) is used to monitor traffic congestion on approximately 970 expressway miles and 1,200 arterial miles in eastern Massachusetts.

The Boston Region MPO monitors, analyzes, and develops strategies to manage congestion. One way to quantify congestion is to calculate the speed index, which is the ratio of observed speed to the posted speed limit on a roadway segment. The speed index is a better indication of congestion than average vehicle speeds because the speed index compares ideal conditions with actual conditions. The roadway speeds are provided by INRIX, a company that collects vehicle probe data (GPS data collected in real-time from vehicles traveling on roadways). The congestion data that is on display on this dashboard was collected in 2012.

Congestion across Boston Region Arterial Routes

The speed index of arterial roadways in the Boston region is displayed in the graphic below. The speed index indicates congestion more accurately than travel speed alone because low travel speed may be a result of low speed limits on certain arterial facilities. Click on individual routes to explore the degree to which congestion slows travel on the Boston region's many arterials during morning and evening rush hours. The AM peak period is between 6:30 AM and 9:30 AM, and the PM peak period is between 3:30 PM and 6:30 PM on arterial roadways. A value of 0.7 or lower is considered congested.

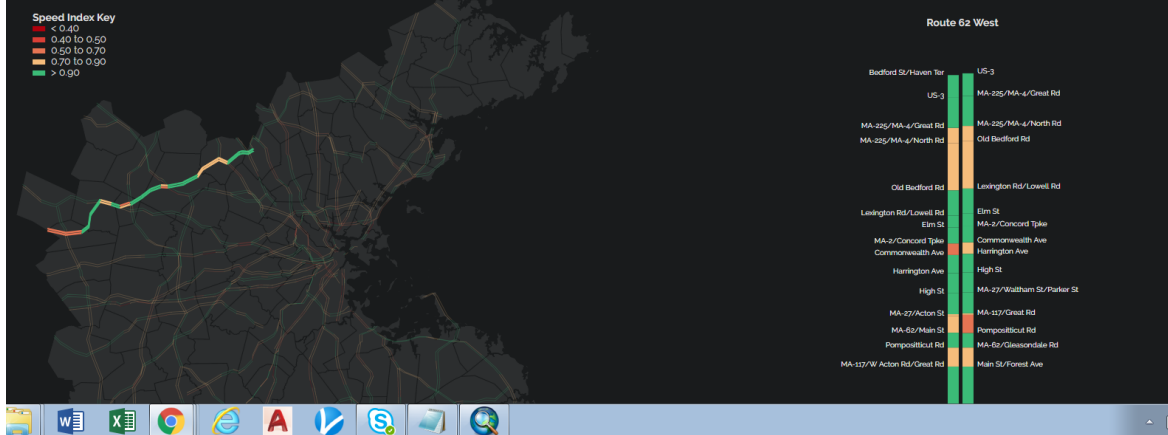
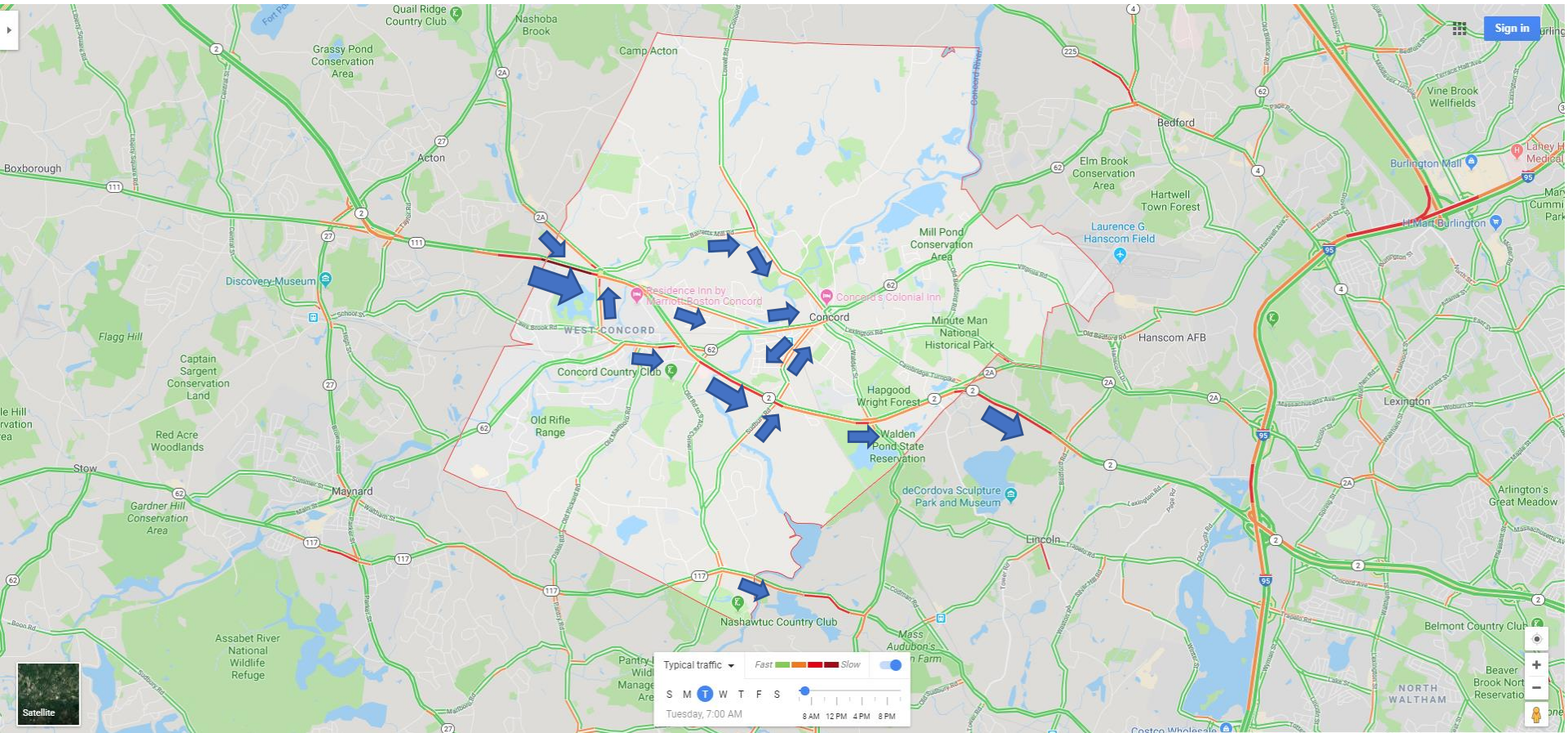


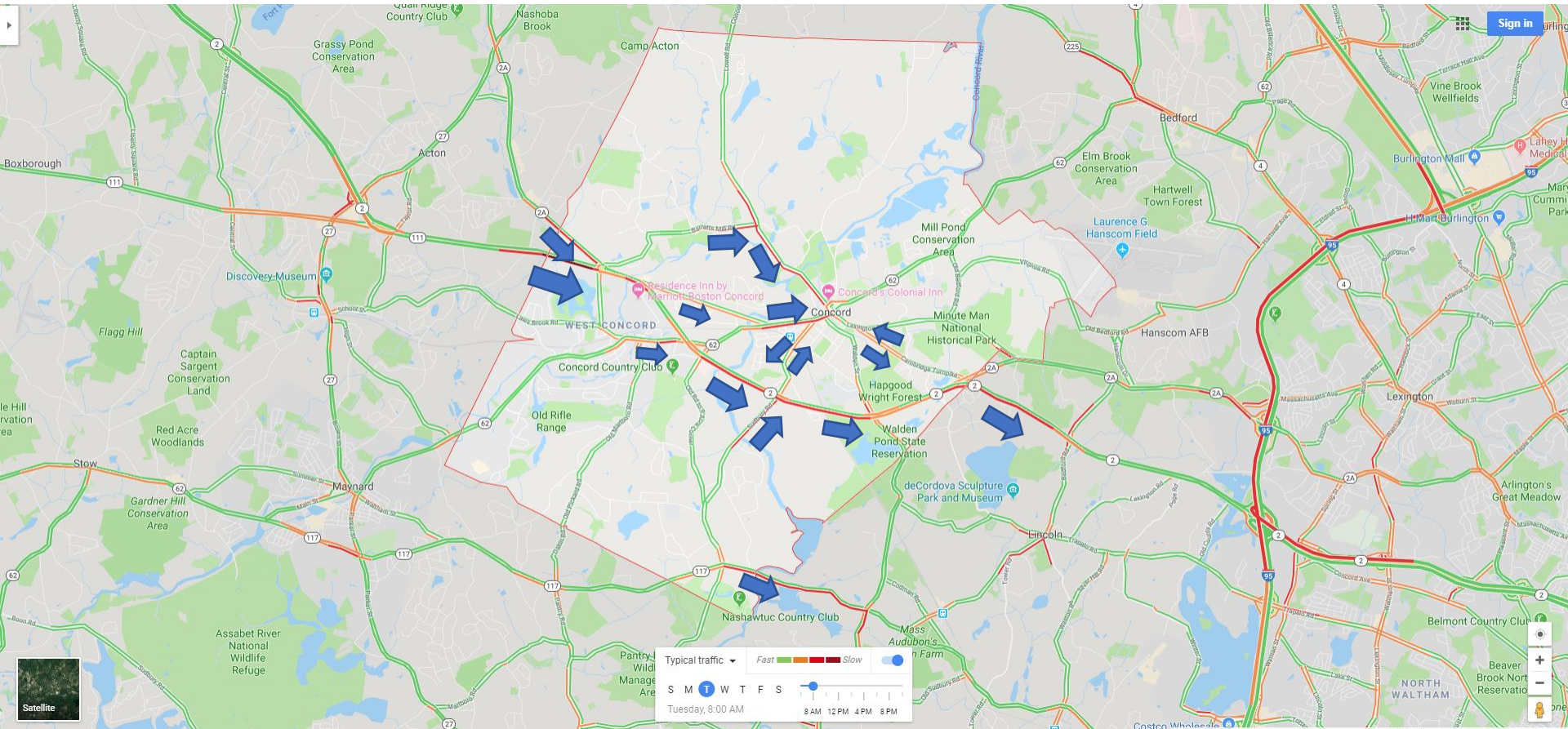
Figure 30: 2012 Route 62 West Speed Index (source: Boston Region MPO/CTPS)

Typical Traffic Patterns: Weekday 7AM



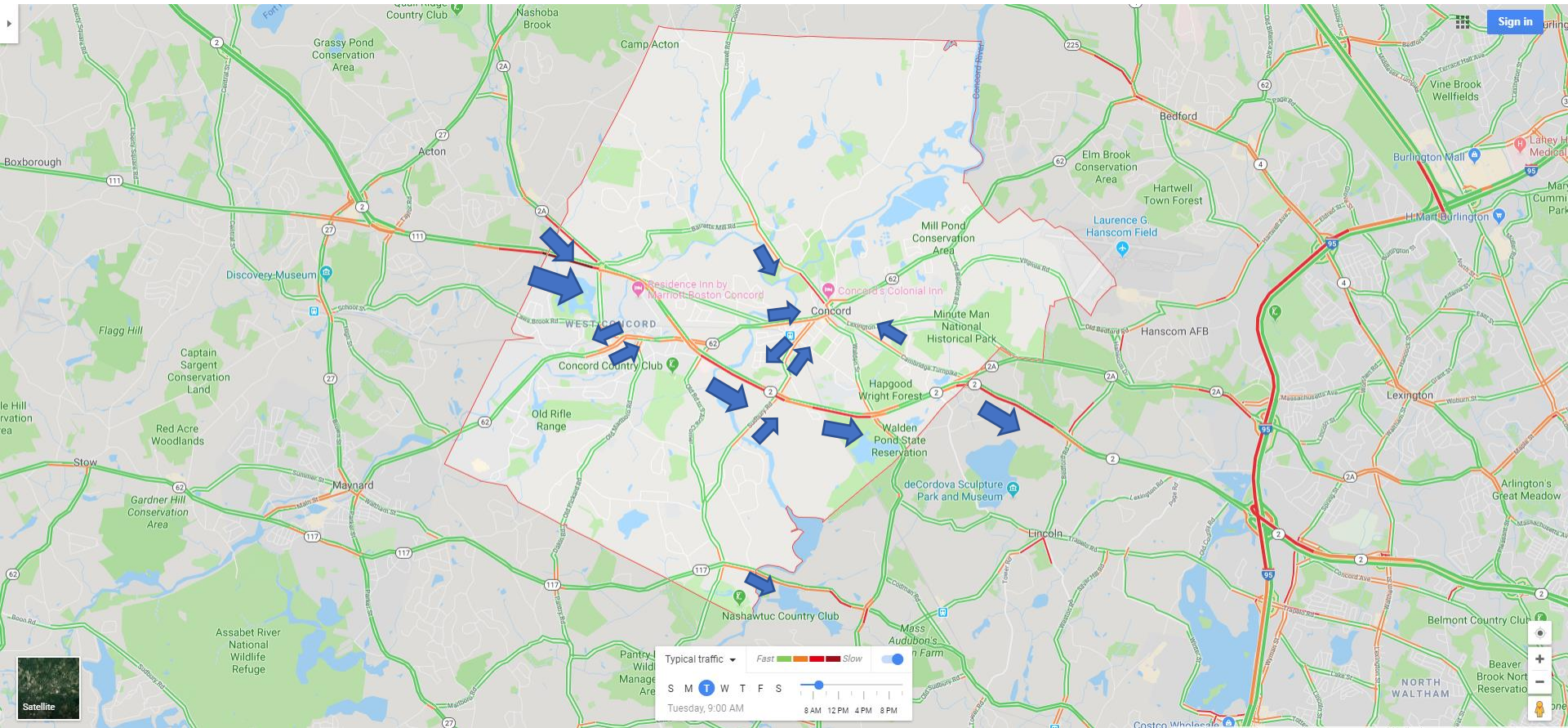
Source: Google Maps

Typical Traffic Patterns: Weekday 8AM



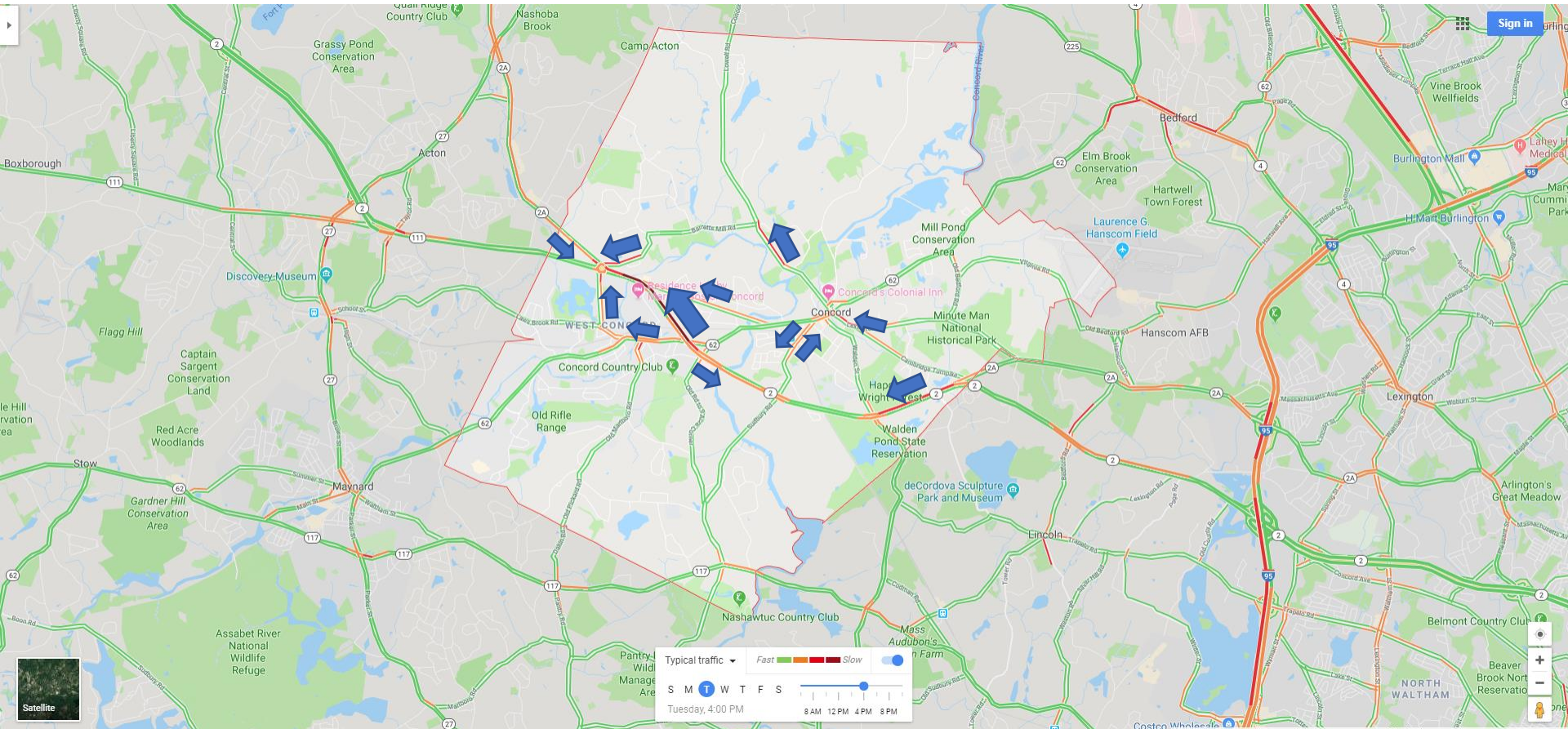
Source: Google Maps

Typical Traffic Patterns: Weekday 9AM



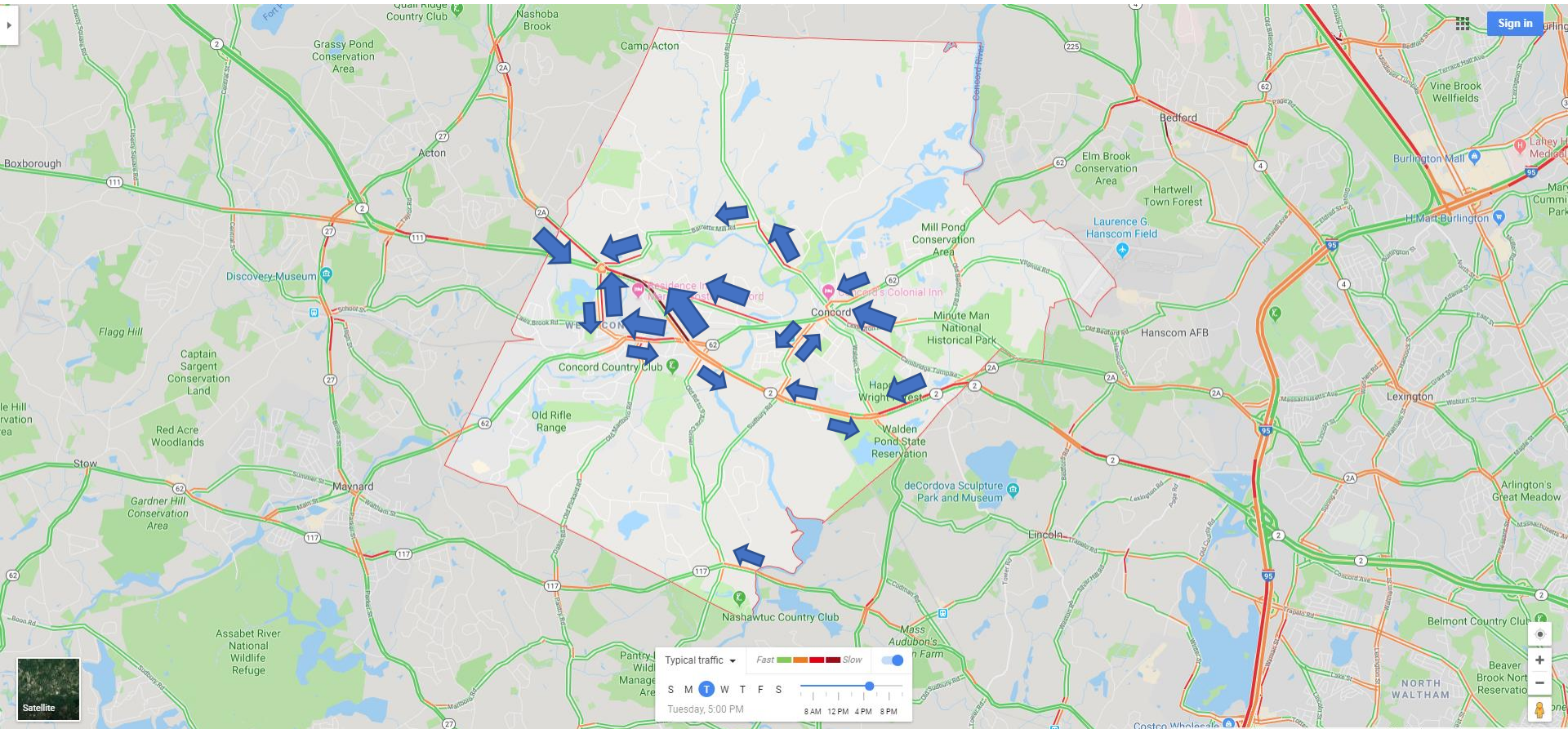
Source: Google Maps

Typical Traffic Patterns: Weekday 4PM



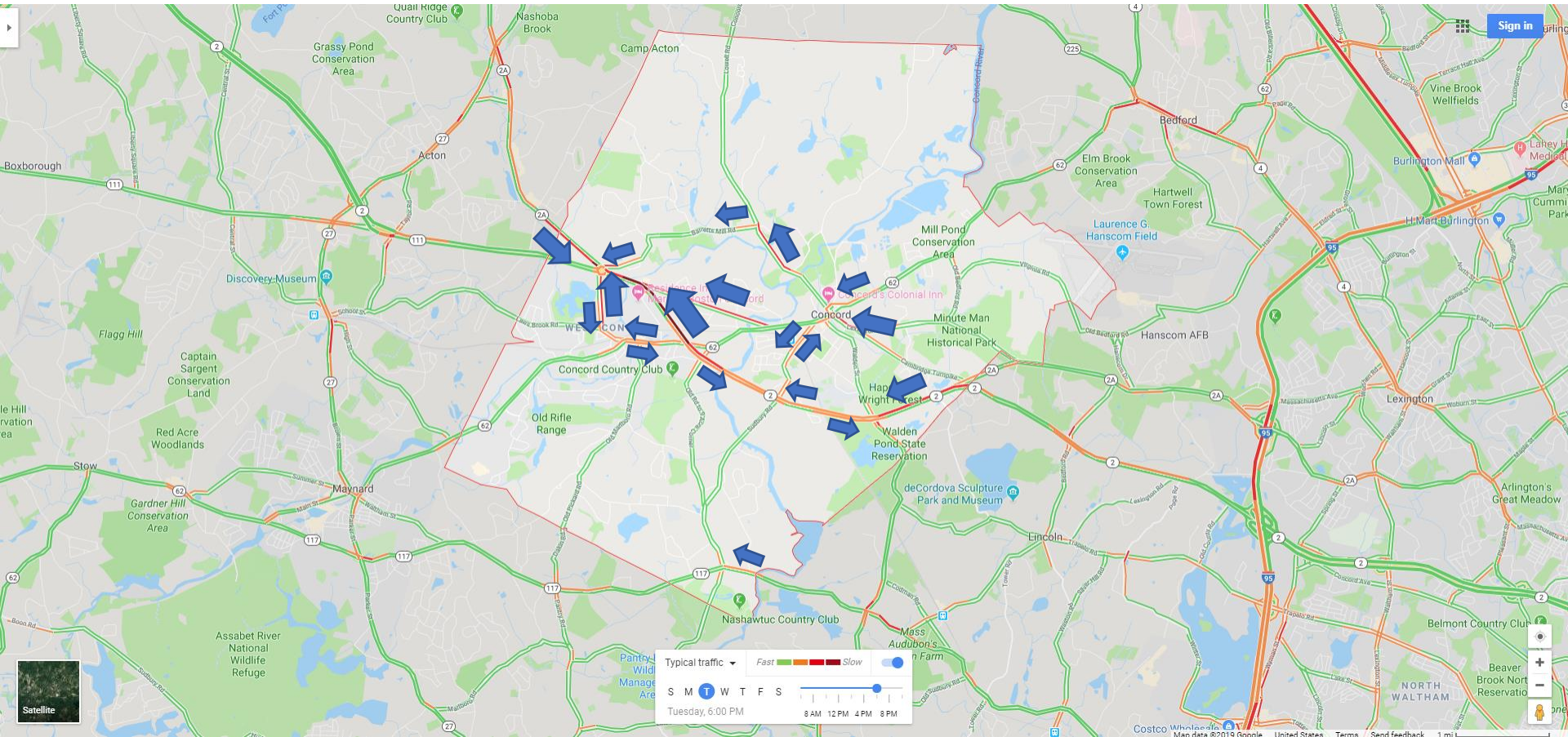
Source: Google Maps

Typical Traffic Patterns: Weekday 5PM



Source: Google Maps

Typical Traffic Patterns: Weekday 6PM



Source: Google Maps

Appendix C. Crash History

In addition, a review of crash data was undertaken to indicate any existing safety issues to be considered. This review found that there are no HSIP Crash Clusters in Concord. Crash data (from MassDOT and local police) indicate that of the 1,130 crashes that occurred in Concord between 2014 and 2016, 232 of them occurred within 50' of one of the 49 cut-through segments identified by the Town (Figure 31). Seven of these involved bicyclists and three of them involved pedestrians. In addition to the major routes, Commonwealth Avenue, Baker Avenue Extension, Marlboro Road and Stow Street appear to have higher numbers of crashes.

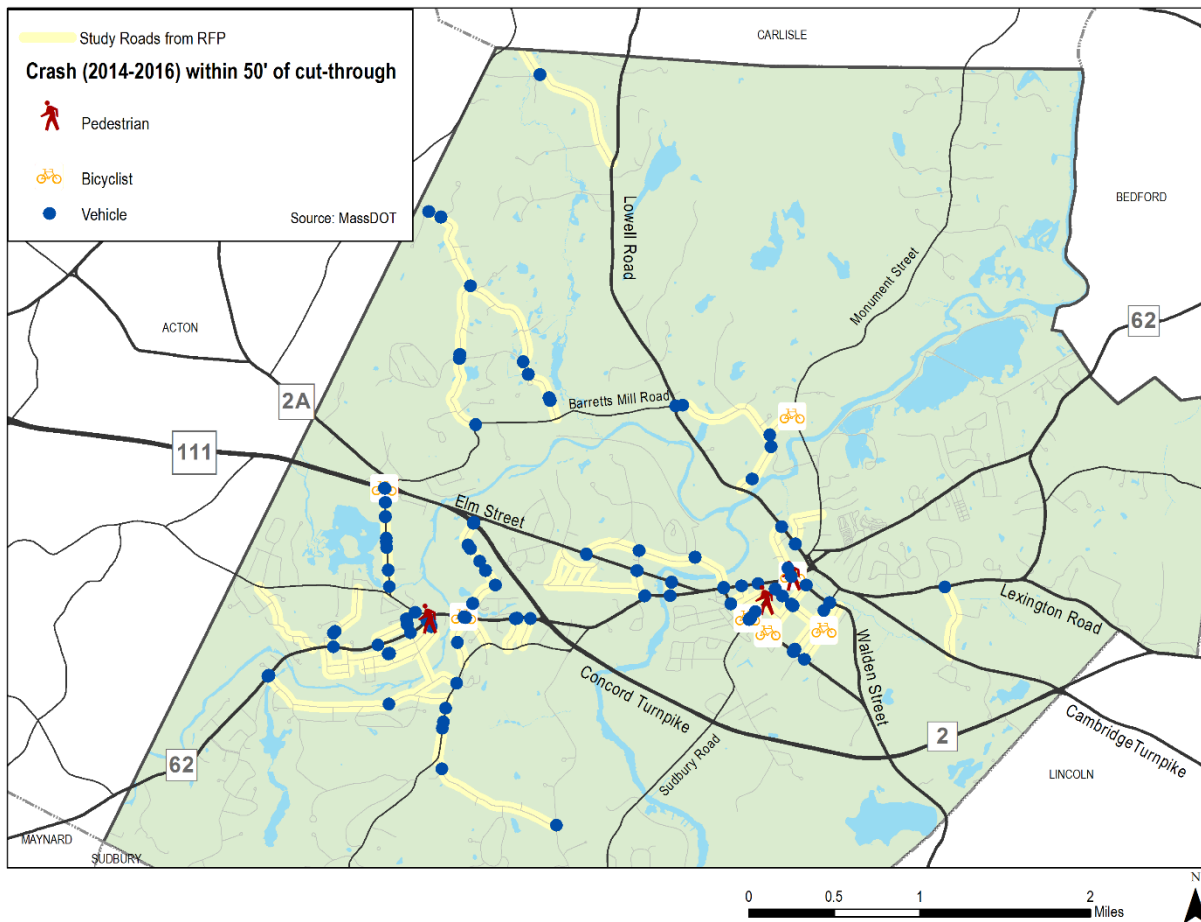


Figure 31: Crashes (2014-2016) within 50' of Cut-Through

For the 232 crashes within 50' of an identified cut-through, 34% (78) were angle crashes, 23% (54) were rear-end, and 18% (43) were single vehicle, as shown in Figure 13. The road surface and ambient lighting conditions of these crashes are shown in Figure 33 and Figure 34, respectively.

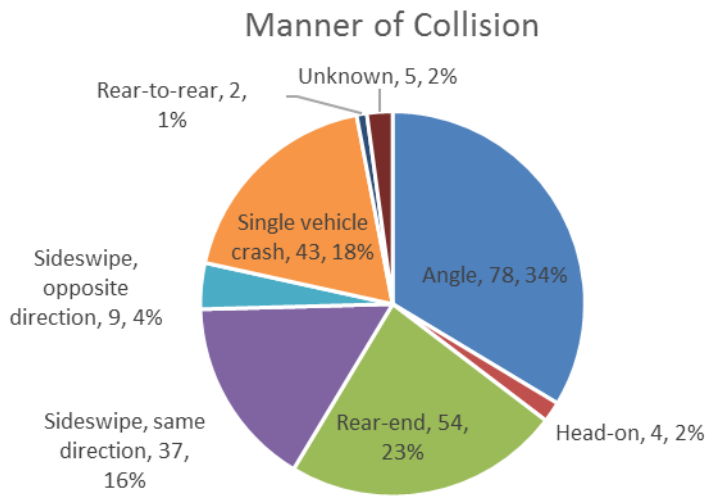


Figure 32: Manner of Collision, 2014-2016 (Source: MassDOT)

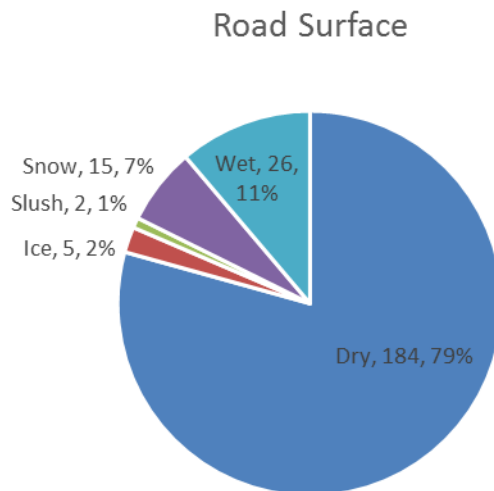


Figure 33: Road Surface at Time of Crash, 2014-2016 (Source: MassDOT)

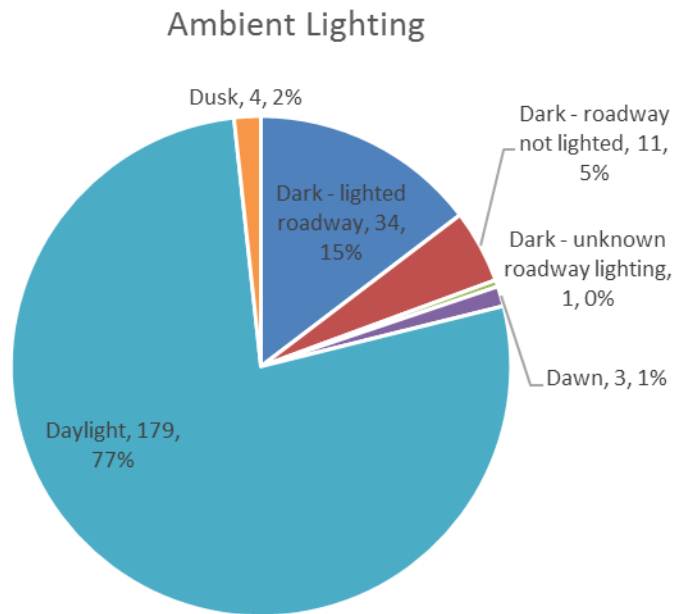
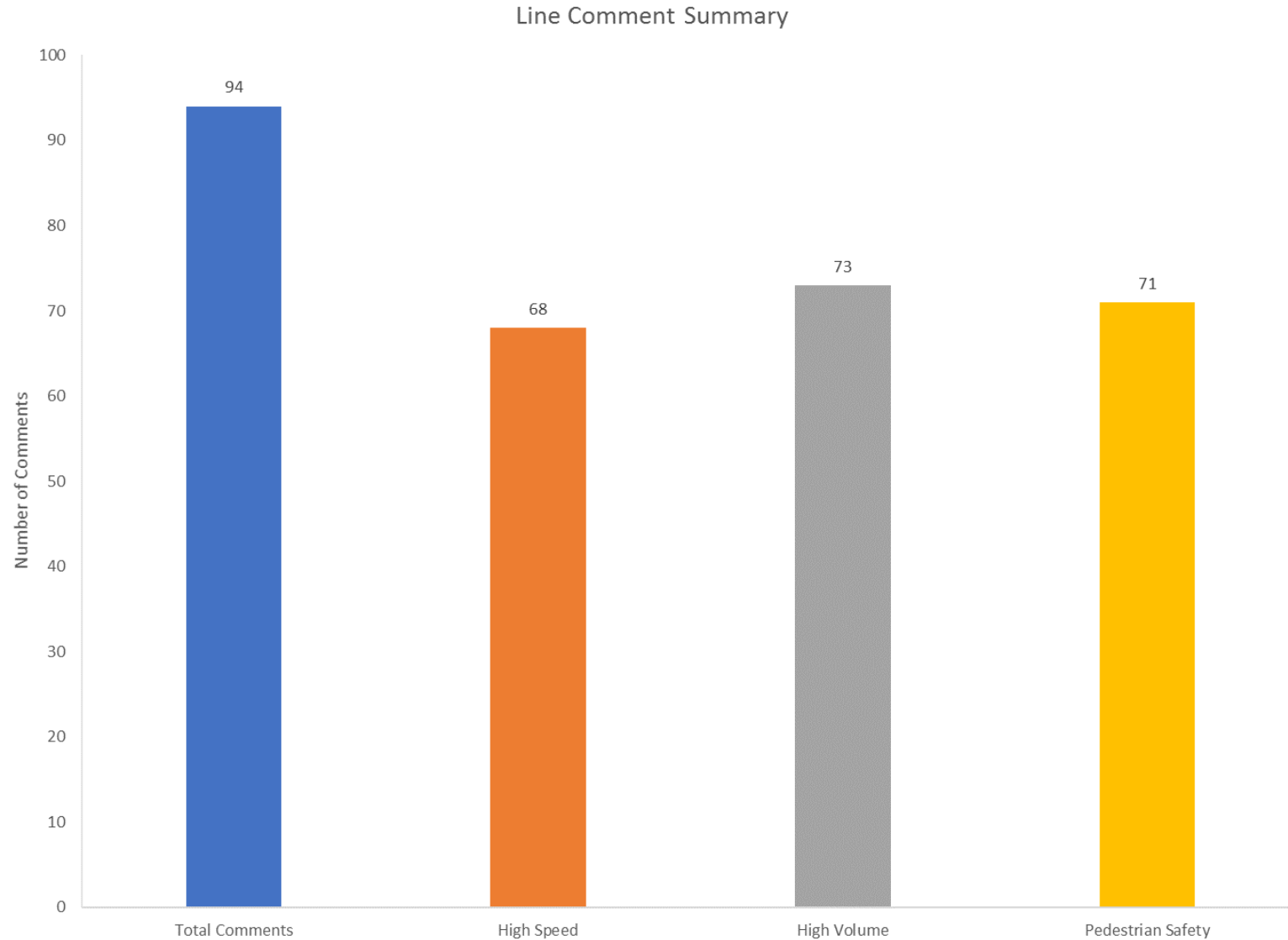


Figure 34: Ambient Lighting at Time of Crash, 2014-2016 (Source: MassDOT)

Appendix D. Wikimap Summary

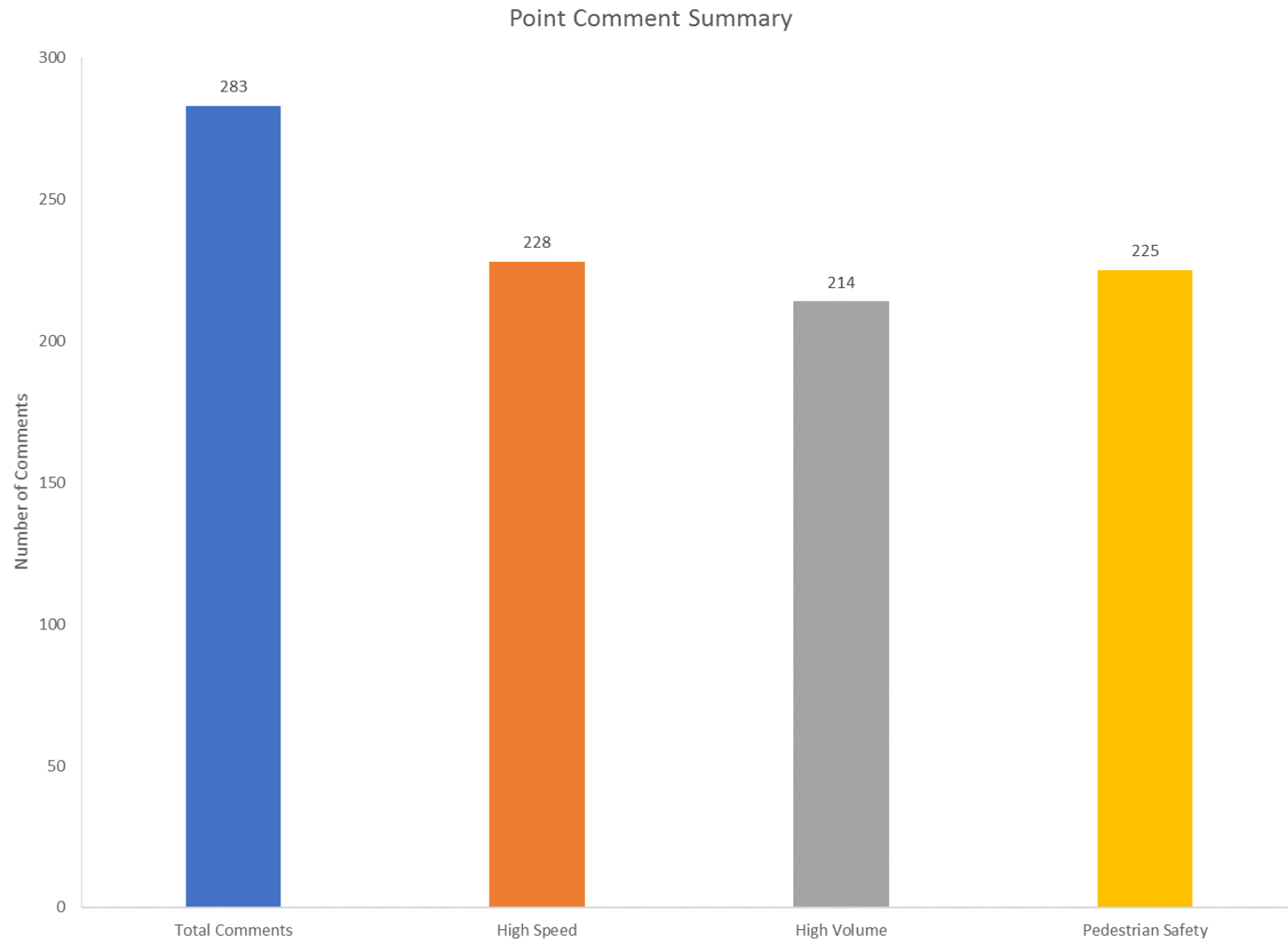
Line Comments

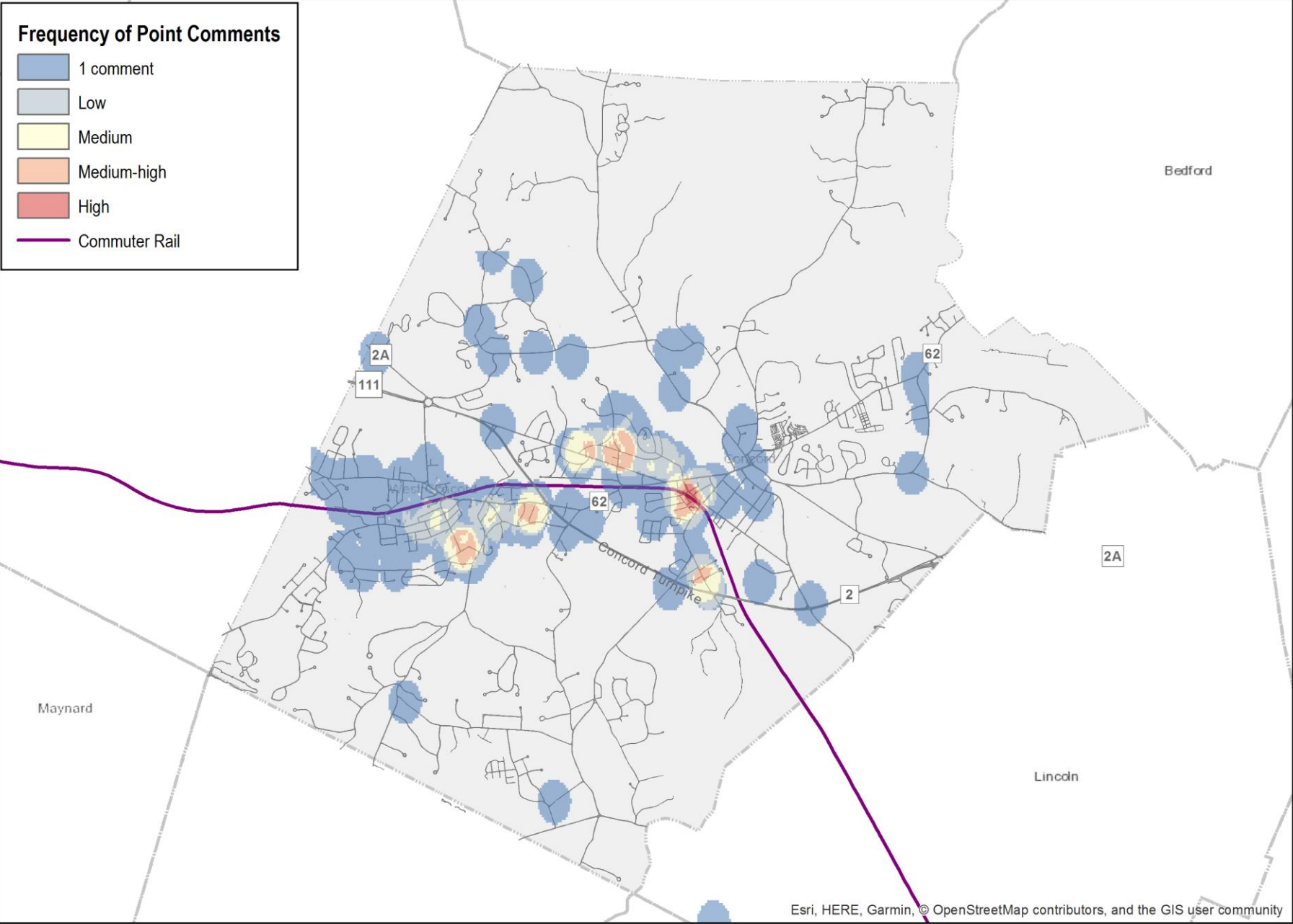
- 94 comments total
 - Of these, 68 cited “High Speed” as an issue
 - 73 cited “High Volume” as an issue
 - 71 cited “Pedestrian Safety” as an issue
 - *46 cited all three as issues*

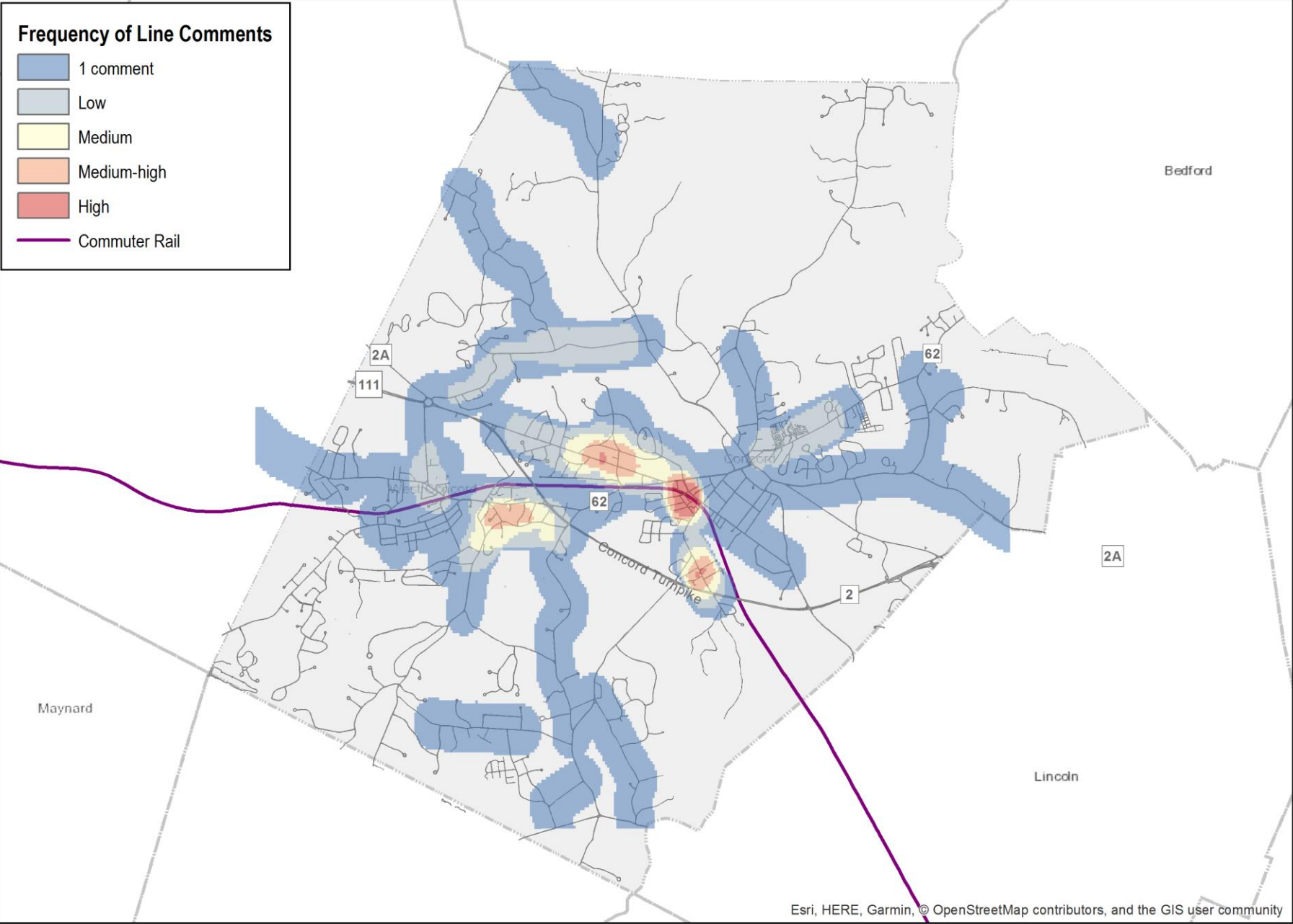


Point Comments

- 283 comments total
 - Of these, 228 cited “High Speed” as an issue
 - 214 cited “High Volume” as an issue
 - 225 cited “Pedestrian Safety” as an issue
 - *161 cited all three as issues*







Areas with a medium-high or high frequency of comments

1. Downtown Concord
2. Musketaquid/Elm/Simon Willard Neighborhood
3. MacArthur/Orchard Neighborhood
4. Fairhaven Neighborhood
5. Upland/Pine Neighborhood

Appendix E. Public Meeting Sign-in Sheets

Concord Cut-Through Traffic Study

Sign In Sheet

May 1, 2019

Name	Association (resident, elected official, etc.)
1 Felice Giff	Resident
2 Feland Giff	"
3 M. Marlow	Resident
4 Nancy Smegitt	"
5 Erich Veyhl	"
6 Belie Dyorn	"
7 Lauryn Old	"
8 Bob Freitman	"
9 Dudley Gier	Resident
10 Pam Gier	Resident
11 Mike Pithas	Resident
12 Dan Connolly	"
13 Nancy Kerr	resident
14 Kern Jordanis	resident
15 Jonathan Smith	RESIDENT

Concord Cut-Through Traffic Study

Sign In Sheet

May 1, 2019

Name	Association (resident, elected official, etc.)
1 Tamera Myles	Resident
2 Terrellman	Resident and SB
3 Faith Howard	Resident
4 RICHARD FATHMAN	Resident
5 Robin Garrison	Resident
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	

Downtown
1~~st~~ 9th
Hawthorn

Cut-Through Study

9/5/19

Name	Email	Neighborhood / Street
Richard Monaghan	RWM158@gmail.com	158 Abbott St.
Saul O'Connell	LULUOR@aol.com	
Carmin Reiss	carmin.reiss@gmail.com	52 Devens St
Jon Lytman	Jon.Lytman@gmail.com	47 Devens
Maggie Terris	MST36@aol.com	36 Devens
Joseph O'Connell	jocconnor@concordma.gov	Police
Ron Holsinger	rholsinger@concordma.gov	
Lynn Huggins	lhuggins@msn.com	5A Hawthorne Ln.
Tom Melander	tommelande@hotmail.com	212 Hawthorn
Chelle Melander	chellemelande@comcast.net	"
Pennie Driscoll	penniefivce@gmail.com	148 Hawthorn Lane

Concord Tester

Miskam

CJT through meeting

9/5/19

Name	Email	Neighborhood
Deckmann cogill	dreckmann.cogill@concordma.gov	Jscobys
Jay Khetani	jbkhetani@gmail.com	Simon Willard
Susie Winstanley	susie.windcomcast.net	neighbor
JACOB ZWICKER	jzwicker@concordma.gov	Asst. TE
Adam Miklosko	Amiklosko@concordma.gov	Higleyka
Rita Reine	RReine@concordma.gov	CPW
Kevin Monahan	kmonahan@concordma.gov	
Luciano	luciano.rabih@jackets.com	TREOS
Patrick West	iaggat@rcn.com	neighbor
Kim West	kmpwest@yahoo.com	neighbor
Joseph O'Connor	jocannon@concordma.gov	Police
Adam Winstanley	awinstanley@winent.com	Neighbor

West Concord (North of 62)

Concord Cutthrough Study

9/5/19

<u>Name</u>	<u>email</u>	<u>Neighborhood</u>
Connie Levine	connielevine@concord.ma.gov	Central Center
Mari Weinberg	tel: 978-769-8627	Hillside Ave. WEST CONCORD
Marcia Schloss	marcialou28@gmail.com	Hillside
Joseph O'Connor	jacconnor@concordma.gov	Blice
Ron Holsinger	rholsinger@concordma.gov	
Aaron Miklosko	Amiklosko@CONCORDMA.GOV	CPW
Jacob Zwicker	jzwicker@CONCORDMA.GOV	CPW-ENG
Rick Rene	R.Rene@CONCORDMA.GOV	CPW

West Concord (South of 62)

	Cut through Study Name	Meeting Email	9/15/19 Neighborhood
	John Flaherty	joffla560@gmail	Upland/HARRINGTON
	Christen Lekorenos	cmlekorenos@gmail	upland/Harrington
	Javier Urcid	urcid@braudeis.edu	Upland/Pine
	Luke Bulino	lukebulino@gmail.com	MacArthur Rd
*	Billie Wyeth	billiewyeth@gmail.com	Orchard Road
	Kate Connolly	drinkwater.kate@gmail.com	Orchard Rd
	Karen Jourdenais	karenjourdenais@gmail.com	Upland Rd.
*	Nancy Kerr	KERRNAN@gmail.com	Upland Rd
	Joseph O'Connor	jocconnor@concordma.gov	Police
	Mary Babcock	mbabcock@yahoo.com	Upland Rd
	Lindsay Carlisle	LPCARLISLE@yahoo.com	Upland Rd
	Laura Mills	laurakmills@hotmail.com	Upland Rd
	Kevin Monahan	KMONAHAN@concordma.gov	Police
*	Dorrie Kehoz	dorriekehoz@concordma.gov	MacArthur
	JACOB ZWICKER	jzwicker@concordma.gov	AEST. Town Engineer
	AARON MIKLOSKO	AMIKLOSKO@concordma.gov	CPW
	RICHARD REINE	RREINE@concordma.gov	CPW

Appendix F. Speed Data

Concord Cut-Through Traffic Study



Street name (Location of counter)	Date counts taken	Dir.	15th Percentile (mph)	50th Percentile (mph)	85th Percentile (mph)	95th Percentile (mph)	Mean Speed (mph)	10mph Pace (mph)	Number in Pace	Percent in Pace (%)	Vehicles >20mph	Vehicles >20mph (%)
Academy Ln (Between Sudbury and Middle St)	4/30/2019	SB	8	16	21	23	16	15-24	602	73.9	174	21.3
	5/1/2019	SB	10	16	21	23	17	15-24	543	79.2	153	22.2
	4/30/2019	NB	15	19	23	26	20	15-24	472	85.4	244	44.1
	5/1/2019	NB	14	19	23	26	19	15-24	477	84.6	245	43.5
Baker Ave Ext (North of Baker Ave)	4/30/2019	SB	19	22	27	28	23	20-29	1223	81.6	478	31.9
	5/1/2019	SB	19	22	27	28	23	20-29	1220	82.4	468	31.6
	4/30/2019	NB	19	22	27	28	23	20-29	1316	82.7	461	29.0
	5/1/2019	NB	18	22	27	28	23	20-29	1300	80.1	480	29.6
Barnes Hill Rd (West of Lowell Rd)	4/30/2019	EB	25	31	35	38	31	30-39	855	72.0	753	63.4
	5/1/2019	EB	23	30	35	38	31	30-39	651	63.8	581	56.9
	4/30/2019	WB	19	27	32	33	26	25-34	1386	69.2	597	29.8
	5/1/2019	WB	10	24	31	33	23	20-29	1157	53.3	457	21.0
Belknap St (South of Main St)	4/30/2019	SB	14	18	22	25	18	15-24	102	79.1	49	38.0
	5/1/2019	SB	10	17	22	23	17	15-24	75	75.0	33	32.8
	4/30/2019	NB	14	18	22	24	18	15-24	187	80.6	85	36.7
	5/1/2019	NB	14	18	23	26	19	15-24	161	82.6	74	38.2
Bow St (North of Lowell Rd)	4/30/2019	SB	19	25	30	33	25	20-29	132	64.4	168	81.8
	5/1/2019	SB	18	24	29	33	25	20-29	127	68.6	145	78.6
	4/30/2019	NB	17	23	27	28	23	20-29	103	76.3	99	73.2
	5/1/2019	NB	16	21	26	28	22	20-29	83	72.8	77	67.2
Brown St (18 Brown St, South of Main St)	4/30/2019	SB	9	17	21	23	17	15-24	175	76.1	59	25.7
	5/1/2019	SB	10	17	21	23	17	15-24	188	80.0	60	25.7
	4/30/2019	NB	9	16	20	22	16	15-24	153	77.7	30	15.1
	5/1/2019	NB	9	16	20	22	16	15-24	150	76.9	33	16.8
Central St (130 Central St, Between West St and Pine St)	4/30/2019	EB	15	21	26	29	22	20-29	192	68.8	68	24.3
	5/1/2019	EB	14	20	26	28	20	15-24	179	62.8	55	19.2
	4/30/2019	WB	18	23	28	32	24	20-29	230	72.1	128	40.2
	5/1/2019	WB	16	21	27	30	22	20-29	260	69.9	100	26.9
Chase Rd (15 Chase Rd, South of Central St)	4/30/2019	SB	10	18	22	23	18	15-24	63	77.8	32	40.0
	5/1/2019	SB	10	17	21	23	17	15-24	66	76.7	23	26.5
	4/30/2019	NB	9	19	23	25	18	15-24	53	70.7	32	42.1
	5/1/2019	NB	14	18	22	24	18	15-24	60	82.2	27	37.3
Church St (50 Church St, just south of Highland St)	4/30/2019	SB	15	21	25	28	21	20-29	1122	72.6	294	19.0
	5/1/2019	SB	16	21	25	28	21	20-29	1144	74.6	281	18.3
	4/30/2019	NB	17	21	25	28	22	20-29	1491	80.7	338	18.3
	5/1/2019	NB	17	21	25	28	22	20-29	1528	80.5	364	19.2
Commonwealth Ave (294 Commonwealth Ave, north of Laws Brook Rd)	4/30/2019	SB	27	32	37	40	33	30-39	2589	75.4	2489	72.5
	5/1/2019	SB	27	32	37	39	33	30-39	2446	74.6	2349	71.6
	4/30/2019	NB	25	31	36	38	31	30-39	3593	68.3	3338	63.4
	5/1/2019	NB	20	30	36	38	29	30-39	3101	59.1	2896	55.2
College Rd (North of Barretts Mill Rd)	4/30/2019	SB	19	22	27	28	23	20-29	260	82.8	243	77.5
	5/1/2019	SB	19	23	27	29	24	20-29	285	88.0	275	85.0
	4/30/2019	NB	16	20	23	27	21	15-24	181	80.4	137	61.1
	5/1/2019	NB	16	21	24	27	21	15-24	189	80.4	152	64.8
Conant St (45 Conant St, south of Laws Brook Rd)	4/30/2019	SB	22	26	31	33	27	25-34	1324	73.3	1230	68.1
	5/1/2019	SB	22	26	32	33	27	25-34	1298	72.9	1217	68.3
	4/30/2019	NB	22	26	31	33	27	25-34	1325	74.9	1224	69.2
	5/1/2019	NB	21	26	31	33	27	25-34	1311	73.6	1180	66.2
Cottage St (North of Old Marlboro Rd)	4/30/2019	SB	14	19	23	24	19	15-24	954	86.3	53	4.8
	5/1/2019	SB	14	19	23	25	19	15-24	937	83.8	60	5.2
	4/30/2019	NB	15	20	25	28	20	15-24	1214	69.9	304	17.5
	5/1/2019	NB	15	20	25	28	21	15-24	1186	67	332	18.9
Crescent Rd (East of Hosmer Rd)	4/30/2019	EB	16	25	30	33	24	20-29	21	58.3	18	51.1
	5/1/2019	EB	18	24	28	33	25	20-29	17	70.8	11	45.8
	4/30/2019	WB	9	20	27	31	20	20-29	21	53.8	10	26.2
	5/1/2019	WB	15	22	27	31	22	20-29	21	63.6	10	30.9
Derby St (34 Derby St, between Riverside Ave and Central St)	4/30/2019	SB	9	17	22	24	17	15-24	104	73.2	48	33.8
	5/1/2019	SB	9	18	22	23	17	15-24	121	73.8	60	36.5
	4/30/2019	NB	14	19	23	25	19	15-24	149	81.4	90	49.0
	5/1/2019	NB	14	18	22	24	18	15-24	180	81.8	87	39.6
Devens St (Between Hubbard St and Sudbury St)	4/30/2019	EB	15	20	25	28	21	15-24	246	70.7	198	57.0
	5/1/2019	EB	12	20	24	28	19	15-24	220	65.1	173	51.1
	4/30/2019	WB	15	20	25	28	21	15-24	249	68.8	207	57.2
	5/1/2019	WB	15	20	24	28	20	15-24	273	74.8	195	53.5
Everett St	4/30/2019	SB	14	22	28	32	22	20-29	908	59.8	529	34.9

Concord Cut-Through Traffic Study



Street name (Location of counter)	Date counts taken	Dir.	15th Percentile (mph)	50th Percentile (mph)	85th Percentile (mph)	95th Percentile (mph)	Mean Speed (mph)	10mph Pace (mph)	Number in Pace	Percent in Pace (%)	Vehicles >20mph	Vehicles >20mph (%)
(Between Thoreau St and Stow St)	5/1/2019	SB	18	24	28	32	24	20-29	1023	68.6	654	43.9
	4/30/2019	NB	15	24	30	33	23	20-29	850	59.8	621	43.7
	5/1/2019	NB	19	25	30	33	26	20-29	814	67.6	671	55.7
Frances St (19 Frances St, south of Central St)	4/30/2019	SB	7	16	20	23	15	15-24	74	69.2	19	17.4
	5/1/2019	SB	7	16	19	22	15	15-24	80	72.7	15	13.8
	4/30/2019	NB	4	15	21	23	14	15-24	41	56.2	17	23.0
Garland Rd (North of Nashoba Rd)	5/1/2019	NB	7	16	21	23	16	15-24	55	71.4	17	21.8
	4/30/2019	SB	6	16	22	25	16	14-23	16	61.5	6	23.1
	5/1/2019	SB	6	16	24	28	16	14-23	19	50.0	11	28.4
Harrington Ave (561 Harrington Ave, west of Old Marlboro Rd)	4/30/2019	NB	9	16	21	23	16	15-24	19	73.1	6	22.3
	5/1/2019	NB	4	14	20	22	14	15-24	16	51.6	6	18.1
	4/30/2019	EB	23	27	32	33	28	25-34	908	78.9	329	28.6
Hawthorne Ln (North of Cambridge Tpke)	5/1/2019	EB	23	27	32	33	28	25-34	962	81.1	359	30.3
	4/30/2019	WB	23	27	32	34	28	24-34	941	77.6	374	30.9
	5/1/2019	WB	23	27	32	33	28	25-34	1000	78.1	337	26.3
Highland St (50 Highland St, west of Church St)	4/30/2019	SB	14	18	23	26	18	15-24	199	77.4	92	35.8
	5/1/2019	SB	11	17	22	23	17	15-24	207	77.0	72	26.8
	4/30/2019	NB	18	24	31	35	25	20-29	170	62.3	212	77.8
Homser St (North of Nashoba Rd)	5/1/2019	NB	15	22	29	33	23	20-29	146	56.4	175	67.5
	4/30/2019	EB	5	15	21	23	15	15-24	56	57.7	24	24.7
	5/1/2019	EB	5	15	20	23	14	15-24	49	57.6	15	17.4
Hubbard St (South of Stow Rd)	4/30/2019	WB	4	14	20	22	14	15-24	36	52.9	12	17.6
	5/1/2019	WB	4	14	19	22	14	15-24	40	56.3	11	14.9
	4/30/2019	SB	15	21	26	28	21	20-29	14	66.7	13	61.9
Keyes Rd (South of Lowell Rd)	5/1/2019	SB	9	19	23	26	18	15-24	19	67.9	13	47.9
	4/30/2019	NB	15	21	27	30	22	20-29	24	63.2	24	63.7
	5/1/2019	NB	10	20	26	28	19	18-27	20	57.1	18	50.9
Laurel St (North of Thoreau St)	4/30/2019	SB	15	20	25	28	21	15-24	504	73.3	120	17.4
	5/1/2019	SB	16	20	24	27	21	15-24	534	78.0	98	14.3
	4/30/2019	NB	15	20	24	27	21	15-24	572	76.4	104	13.9
Liberty St (East of Lowell St)	5/1/2019	NB	15	20	24	27	21	15-24	534	78.8	96	14.2
	4/30/2019	SB	22	27	32	33	28	25-34	1609	75.1	577	26.9
	5/1/2019	SB	22	27	32	33	28	25-34	1637	74.4	582	26.4
MacArthur Rd (North of Old Marlboro Rd)	4/30/2019	NB	25	30	36	39	31	25-34	1320	67.8	1092	56.1
	5/1/2019	NB	25	30	36	39	31	25-34	1306	63.0	1172	56.6
	4/30/2019	SB	16	22	28	31	22	20-29	167	67.3	172	69.4
Middle St (East of Thoreau St)	5/1/2019	SB	16	23	28	32	23	20-29	136	65.1	149	71.1
	4/30/2019	NB	15	21	26	28	21	20-29	218	67.3	205	63.2
	5/1/2019	NB	15	20	25	28	21	20-29	212	71	176	59
Musketaquid Rd (West of Nashawtic Rd)	4/30/2019	EB	30	35	41	46	37	30-39	189	75.0	225	89.4
	5/1/2019	EB	30	35	39	43	36	30-39	177	74.1	205	85.6
	4/30/2019	WB	30	35	38	42	36	30-39	948	79.3	1069	89.4
Nashoba Rd (West of Wood St)	5/1/2019	WB	30	35	38	41	35	30-39	1045	85.8	1074	88.2
	4/30/2019	SB	17	22	27	30	23	20-29	68	70.8	30	31.7
	5/1/2019	SB	15	22	27	31	22	20-29	61	67.8	26	28.4
Old Bridge Rd (North of Old Marlboro Rd)	4/30/2019	NB	16	21	26	28	22	20-29	62	72.1	21	24.2
	5/1/2019	NB	14	20	24	27	20	15-24	63	73.3	11	12.3
	4/30/2019	EB	17	23	28	31	24	20-29	438	72.6	235	38.9
Old Stow Rd (East of Hillside Ave)	5/1/2019	EB	18	23	28	31	23	20-29	344	75.1	166	36.2
	4/30/2019	WB	17	22	28	31	23	20-29	178	72.4	82	33.4
	5/1/2019	WB	17	22	28	31	23	20-29	155	70.5	78	35.6
Old Stow Rd (East of Hillside Ave)	4/30/2019	EB	23	28	33	37	29	25-34	373	73.0	202	39.6
	5/1/2019	EB	23	29	34	38	29	25-34	361	64.8	249	44.7
	4/30/2019	WB	21	27	33	37	28	25-34	115	60.8	69	36.3
Old Stow Rd (East of Hillside Ave)	5/1/2019	WB	20	28	36	40	29	25-34	99	52.9	76	40.4
	4/30/2019	EB	20	27	32	35	27	25-34	97	63.8	98	64.6
	5/1/2019	EB	17	25	32	36	25	20-29	94	53.7	91	52.1
Old Stow Rd (East of Hillside Ave)	4/30/2019	WB	21	26	32	36	27	25-34	92	66.7	91	66.2
	5/1/2019	WB	18	25	31	33	25	20-29	85	59.4	73	50.9
	4/30/2019	SB	24	28	32	35	29	25-34	661	79.4	290	34.9
Old Stow Rd (East of Hillside Ave)	5/1/2019	SB	24	28	33	36	29	25-34	678	76.4	348	39.2
	4/30/2019	NB	22	27	32	34	28	25-34	401	75.5	166	31.2
	5/1/2019	NB	21	27	32	35	28	25-34	391	69.8	192	34.4
Old Stow Rd (East of Hillside Ave)	4/30/2019	EB	15	19	22	23	20	15-24	1239	95.1	21	1.6
	5/1/2019	EB	15	19	22	23	20	15-24	1089	95.2	18	1.5
	4/30/2019	WB	14	18	22	23	19	15-24	564	94.0	6	1.1
5/1/2019	WB	14	18	22	23	18	15-24	645	92.5	6	0.9	

Concord Cut-Through Traffic Study

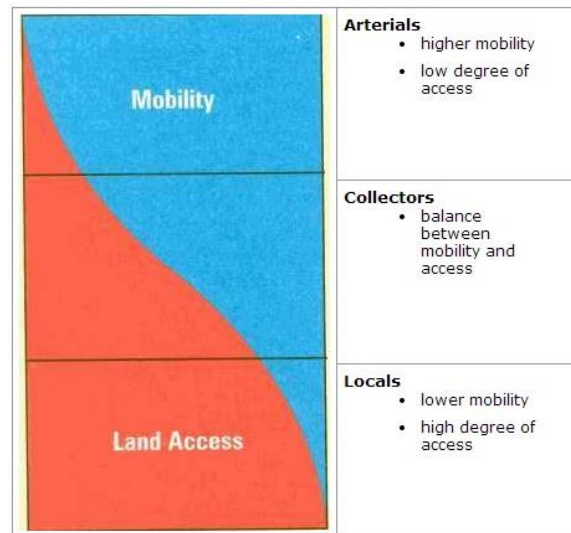


Street name (Location of counter)	Date counts taken	Dir.	15th Percentile (mph)	50th Percentile (mph)	85th Percentile (mph)	95th Percentile (mph)	Mean Speed (mph)	10mph Pace (mph)	Number in Pace	Percent in Pace (%)	Vehicles >20mph	Vehicles >20mph (%)
Orchard Rd (North of Old Marlboro Rd)	4/30/2019	SB	15	21	26	28	22	20-29	151	68.6	141	64.1
	5/1/2019	SB	16	21	25	28	21	15-24	173	75.2	141	61.4
	4/30/2019	NB	15	21	25	28	21	17-26	219	68.9	194	61.1
	5/1/2019	NB	15	20	23	27	20	15-24	220	79.7	149	53.8
Pine St (North of Upland Rd)	4/30/2019	SB	27	32	37	39	33	30-39	1288	75.1	478	27.8
	5/1/2019	SB	27	32	37	39	33	30-39	1220	73.8	476	28.8
	4/30/2019	NB	29	33	37	39	34	30-39	1530	81.8	642	34.4
	5/1/2019	NB	29	33	37	40	34	30-39	1570	81.3	686	35.5
Pleasant St (42 Pleasant St, between Pine St and west St)	4/30/2019	EB	17	25	30	33	25	20-29	264	60.0	220	50.0
	5/1/2019	EB	18	24	30	33	25	20-29	266	64.6	189	45.9
	4/30/2019	WB	17	23	28	32	23	20-29	204	70.1	115	39.5
	5/1/2019	WB	17	23	28	32	23	20-29	191	68.0	111	39.4
Praire Rd (267 Praire Rd, south of Main St)	4/30/2019	SB	17	23	27	30	23	20-29	71	74.7	37	39.2
	5/1/2019	SB	16	22	27	28	22	20-29	87	73.1	31	26.4
	4/30/2019	NB	16	23	28	31	23	20-29	67	69.8	35	36.9
	5/1/2019	NB	11	21	27	28	21	20-29	63	64.3	28	28.6
River St (Between Main St and Elm St)	4/30/2019	SB	13	20	27	28	20	20-29	145	55.6	142	54.5
	5/1/2019	SB	14	21	26	28	21	20-29	124	66.3	116	62.1
	4/30/2019	NB	6	18	22	23	17	15-24	48	64.9	29	39.7
	5/1/2019	NB	8	17	24	27	18	15-24	32	60.4	20	37.7
Stow Rd (South of Hubbard St)	4/30/2019	SB	14	20	26	30	21	15-24	579	64.1	515	57.1
	5/1/2019	SB	15	21	27	30	22	15-24	471	63.0	471	60.3
	4/30/2019	NB	15	21	26	28	21	15-24	494	66.5	435	58.5
	5/1/2019	NB	16	22	27	31	23	20-29	446	67.1	450	67.7
Strawberry Hill Rd (North of Barretts Mill Rd)	4/30/2019	SB	26	30	33	37	31	25-34	1411	80.8	1088	62.3
	5/1/2019	SB	25	30	33	37	31	25-34	1283	80.8	953	60.1
	4/30/2019	NB	25	31	37	39	32	30-39	930	68.3	891	65.5
	5/1/2019	NB	25	31	37	39	32	30-39	815	68.3	788	66.1
Sudbury St (South of Devens St)	4/30/2019	SB	22	27	32	35	28	25-34	2210	71.4	930	30.1
	5/1/2019	SB	22	27	32	34	28	25-34	2234	72.4	837	27.1
	4/30/2019	NB	23	28	32	35	29	25-34	2032	77.8	920	35.2
	5/1/2019	NB	23	27	32	35	28	25-34	2123	78.0	854	31.4
Upland Rd (114 Upland Rd, west of Pine St)	4/30/2019	EB	19	23	28	32	24	20-29	211	73.5	115	40.0
	5/1/2019	EB	18	23	28	31	23	20-29	219	74.7	104	35.5
	4/30/2019	WB	18	23	28	32	24	20-29	225	70.8	134	42.2
	5/1/2019	WB	18	23	27	30	23	20-29	241	77.5	115	37.0
West St (22 West St, south of Main St)	4/30/2019	SB	8	16	20	22	16	15-24	412	76.0	91	16.7
	5/1/2019	SB	10	16	21	23	16	15-24	390	78.8	101	20.4
	4/30/2019	NB	12	17	22	23	18	15-24	284	78.7	114	31.6
	5/1/2019	NB	14	17	22	23	18	15-24	316	82.3	125	32.5
Westford Rd (West of Lowell Rd)	4/30/2019	EB	31	35	39	42	36	30-39	1579	81.1	1134	58.2
	5/1/2019	EB	31	36	39	43	36	30-39	1444	77.9	1125	60.7
	4/30/2019	WB	30	35	39	42	36	30-39	1309	76.4	928	54.2
	5/1/2019	WB	30	35	38	42	36	30-39	1383	80.8	907	53.0
Westvale Dr (39 Westvale Dr, east of Praire St)	4/30/2019	EB	9	19	26	29	19	15-24	28	51.9	26	48.1
	5/1/2019	EB	9	19	25	28	19	20-29	35	53.8	32	48.9
	4/30/2019	WB	14	20	25	28	20	15-24	34	68.0	27	54.8
	5/1/2019	WB	14	20	23	27	20	15-24	46	78.0	32	54.9
Williams Rd (146-230 Williams Rd, west of Mattison Dr)	4/30/2019	EB	25	30	35	38	31	25-34	796	75.0	620	58.5
	5/1/2019	EB	25	30	34	37	31	25-34	763	76.5	557	55.9
	4/30/2019	WB	27	32	37	38	33	30-39	848	75.4	792	70.4
	5/1/2019	WB	27	31	36	38	32	30-39	931	75.3	852	68.9
Wilson Rd (South of Crescent Rd)	4/30/2019	SB	12	21	26	29	20	20-29	36	62.1	34	59.0
	5/1/2019	SB	12	18	25	28	19	15-24	52	60.5	37	43.5
	4/30/2019	NB	14	20	26	29	21	15-24	31	58.5	29	55.5
	5/1/2019	NB	14	18	25	27	19	15-24	45	66.2	30	44.4
Wood St (South of Elm St)	4/30/2019	SB	20	25	29	33	26	20-29	285	74.4	226	58.9
	5/1/2019	SB	20	26	31	33	26	20-29	265	68.3	231	59.4
	4/30/2019	NB	20	25	29	32	26	20-29	296	78.9	205	54.7
	5/1/2019	NB	20	25	29	33	26	20-29	257	76.7	189	56.5

Appendix G. Roadway Functional Classification

The Roadway Functional Classification system defines the role a roadway plays in the overall road network. There are three functional classifications for the role of a roadway in the road network; arterial, collector, and local. This classification is defined by the roadway's functional ability to meet the following criteria.

In the past, Arterials were designed to provide a high level of mobility for vehicles (that is, high speed and high volumes), and were not envisioned as being used by people walking or biking, as shown in the graphic below. However, this principle is now out of date as land use patterns have evolved such that destinations (especially commercial retail) were located on arterials to gain the most exposure to passing traffic. The result has been that arterials now need to provide the "land access" previously envisioned for only local roads. Transportation engineers now look for ways to increase access by adding sidewalks, crossings, and bike facilities so that people can access these goods and services without having to drive to them.



The Federal Highway Administration and the Commonwealth of Massachusetts assigns the functional classification of every roadway in the state. Jacobs utilized this classification system to record the functional classification of each roadway that was identified as a concern by the residents of Concord. It should be noted that a functional classification that is not a "local" roadway does not meet the criteria required for cut-through treatment. Roadways defined as a "collector" or "arterial" will be exempt from further cut-through analysis because, by definition, both classifications are functionally intended to provide through travel mobility.

Figure 35 shows the federal functional classification of the roadways in Concord. In comparison to the AADT map, it appears that the roadways are all classified appropriately given their regional roles and existing traffic volumes.

The streets identified by the Town as potential cut-throughs are also shown in Figure 11 to ensure that this study focuses on residential, local streets that are being used as collectors or even arterials, rather than on streets that are classified as collectors or arterials and are simply functioning as such. Currently, two streets of the identified 49 cut-throughs are classified as Major Collectors:

- Commonwealth Avenue between the Concord Turnpike and Main Street/Laws Brook Road
- Old Marlboro Road between Williams Road and Harrington Avenue

Additionally, these roadways are carrying regional traffic comparable to other Collectors, so they are not local residential streets experiencing cut-through traffic and should be removed from further analysis.

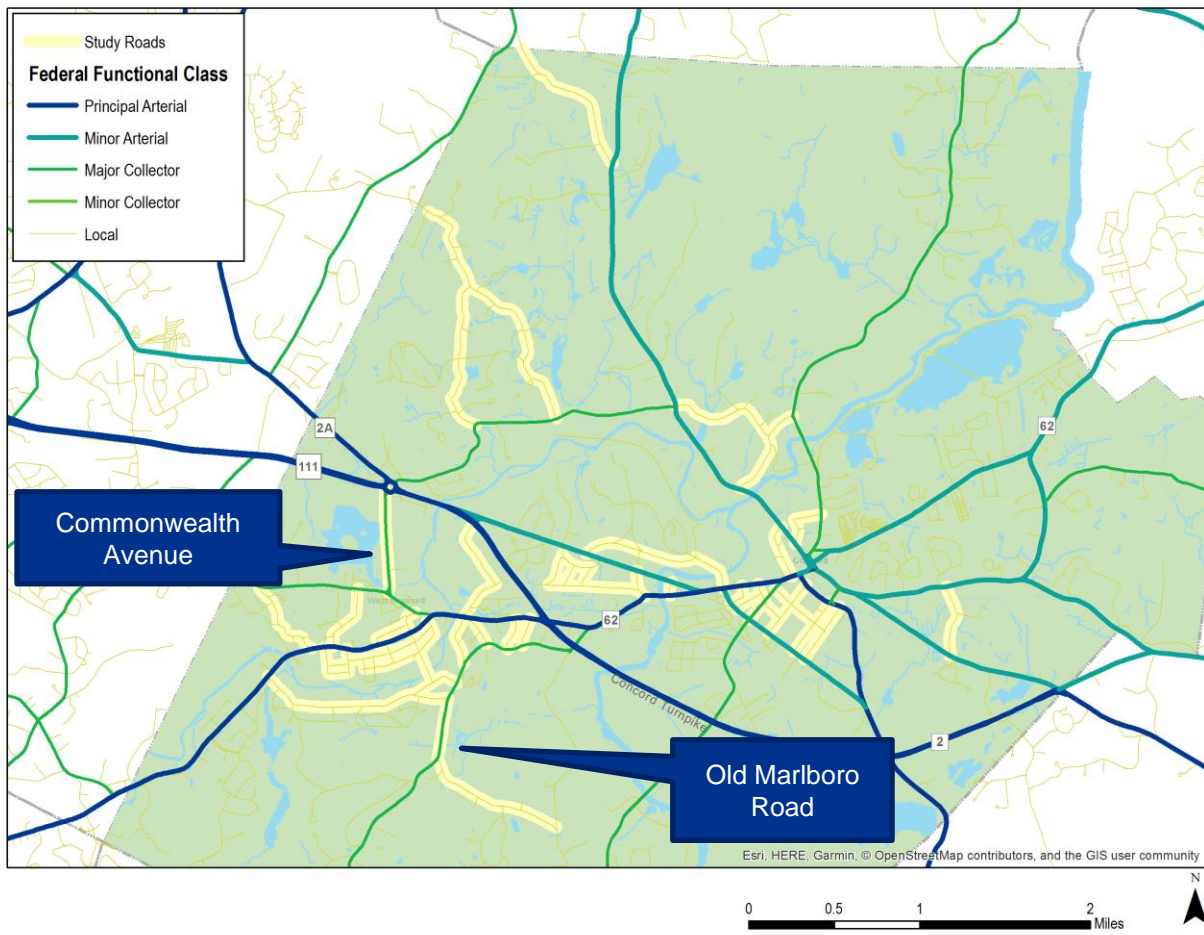


Figure 35: Roadway Functional Classification

Appendix H. Intersection Analysis Worksheets

Queues

3: Thoreau St/Nashawtuc Rd & Main Street

10/03/2019



Lane Group	EBT	EBR	WBL	WBT	NBT	SBT
Lane Group Flow (vph)	524	608	31	424	274	261
v/c Ratio	0.69	0.76	0.09	0.50	0.68	0.48
Control Delay	24.4	18.1	10.6	15.2	28.9	21.2
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	24.4	18.1	10.6	15.2	28.9	21.2
Queue Length 50th (ft)	169	105	7	127	87	77
Queue Length 95th (ft)	#362	#353	20	204	152	126
Internal Link Dist (ft)	682			827	446	549
Turn Bay Length (ft)		90	100			
Base Capacity (vph)	907	896	350	1211	530	713
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.58	0.68	0.09	0.35	0.52	0.37

Intersection Summary

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

HCM Signalized Intersection Capacity Analysis

3: Thoreau St/Nashawtuc Rd & Main Street

10/03/2019



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↖	↗	↖	↗			↕			↕	
Traffic Volume (vph)	2	475	553	28	362	15	160	19	24	80	102	3
Future Volume (vph)	2	475	553	28	362	15	160	19	24	80	102	3
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0	5.0	4.0	5.0			5.0			5.0	
Lane Util. Factor		1.00	1.00	1.00	1.00			1.00			1.00	
Frbp, ped/bikes		1.00	0.98	1.00	1.00			1.00			1.00	
Flpb, ped/bikes		1.00	1.00	1.00	1.00			1.00			1.00	
Frt		1.00	0.85	1.00	0.99			0.98			1.00	
Flt Protected		1.00	1.00	0.95	1.00			0.96			0.98	
Satd. Flow (prot)		1844	1531	1735	1814			1689			1818	
Flt Permitted		1.00	1.00	0.23	1.00			0.61			0.78	
Satd. Flow (perm)		1842	1531	426	1814			1071			1448	
Peak-hour factor, PHF	0.91	0.91	0.91	0.89	0.89	0.89	0.74	0.74	0.74	0.71	0.71	0.71
Adj. Flow (vph)	2	522	608	31	407	17	216	26	32	113	144	4
RTOR Reduction (vph)	0	0	169	0	2	0	0	4	0	0	1	0
Lane Group Flow (vph)	0	524	439	31	422	0	0	270	0	0	260	0
Confl. Peds. (#/hr)	3		3	2		2	3		2	2		3
Confl. Bikes (#/hr)									1			
Heavy Vehicles (%)	3%	3%	3%	4%	4%	4%	6%	6%	6%	2%	2%	2%
Turn Type	Perm	NA	Perm	pm+pt	NA		Perm	NA		Perm	NA	
Protected Phases		6		5	2			4			4	
Permitted Phases	6		6	2			4			4		
Actuated Green, G (s)		27.8	27.8	34.1	34.1			25.1			25.1	
Effective Green, g (s)		27.8	27.8	34.1	34.1			25.1			25.1	
Actuated g/C Ratio		0.40	0.40	0.49	0.49			0.36			0.36	
Clearance Time (s)		5.0	5.0	4.0	5.0			5.0			5.0	
Vehicle Extension (s)		3.0	3.0	3.0	3.0			3.0			3.0	
Lane Grp Cap (vph)		739	615	253	893			388			525	
v/s Ratio Prot				0.00	c0.23							
v/s Ratio Perm		0.28	c0.29	0.06				c0.25			0.18	
v/c Ratio		0.71	0.71	0.12	0.47			0.69			0.50	
Uniform Delay, d1		17.3	17.4	11.0	11.6			18.8			17.1	
Progression Factor		1.00	1.00	1.00	1.00			1.00			1.00	
Incremental Delay, d2		3.1	3.9	0.2	0.4			5.3			0.7	
Delay (s)		20.4	21.3	11.2	12.0			24.1			17.9	
Level of Service		C	C	B	B			C			B	
Approach Delay (s)		20.9			12.0			24.1			17.9	
Approach LOS		C			B			C			B	

Intersection Summary

HCM 2000 Control Delay	19.0	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.73		
Actuated Cycle Length (s)	69.2	Sum of lost time (s)	16.0
Intersection Capacity Utilization	76.8%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

Timing Report, Sorted By Phase

3: Thoreau St/Nashawtuc Rd & Main Street

10/03/2019

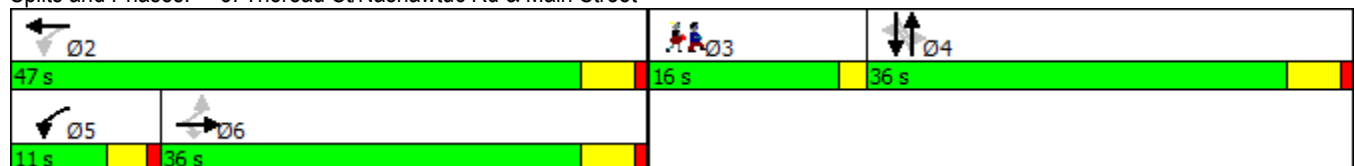


Phase Number	2	3	4	5	6
Movement	WBTL	Ped	NBSB	WBL	EBTL
Lead/Lag		Lead	Lag	Lead	Lag
Lead-Lag Optimize		Yes	Yes	Yes	Yes
Recall Mode	Min	None	None	None	Min
Maximum Split (s)	47	16	36	11	36
Maximum Split (%)	47.5%	16.2%	36.4%	11.1%	36.4%
Minimum Split (s)	23	16	23	9.5	23
Yellow Time (s)	4	2	4	3	4
All-Red Time (s)	1	0	1	1	1
Minimum Initial (s)	5	5	5	5	5
Vehicle Extension (s)	3	3	3	3	3
Minimum Gap (s)	3	3	3	3	3
Time Before Reduce (s)	0	0	0	0	0
Time To Reduce (s)	0	0	0	0	0
Walk Time (s)		5			
Flash Dont Walk (s)		9			
Dual Entry	Yes	No	Yes	No	Yes
Inhibit Max	Yes	Yes	Yes	Yes	Yes
Start Time (s)	0	47	63	0	11
End Time (s)	47	63	0	11	47
Yield/Force Off (s)	42	61	94	7	42
Yield/Force Off 170(s)	42	52	94	7	42
Local Start Time (s)	88	36	52	88	0
Local Yield (s)	31	50	83	95	31
Local Yield 170(s)	31	41	83	95	31

Intersection Summary

Cycle Length	99
Control Type	Actuated-Uncoordinated
Natural Cycle	90

Splits and Phases: 3: Thoreau St/Nashawtuc Rd & Main Street



Queues

7: Sudbury Rd & Thoreau St

10/03/2019



Lane Group	SET	SER	NWL	NWT	NET	SWL	SWT
Lane Group Flow (vph)	144	145	133	201	364	16	447
v/c Ratio	0.45	0.34	0.30	0.30	0.72	0.04	0.60
Control Delay	32.5	4.8	18.1	16.6	35.7	17.6	22.3
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	32.5	4.8	18.1	16.6	35.7	17.6	22.3
Queue Length 50th (ft)	41	0	24	35	96	3	117
Queue Length 95th (ft)	116	2	102	140	#314	22	368
Internal Link Dist (ft)	659			610	500		1136
Turn Bay Length (ft)		75	80			80	
Base Capacity (vph)	586	628	486	1133	504	464	1140
Starvation Cap Reductn	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0
Reduced v/c Ratio	0.25	0.23	0.27	0.18	0.72	0.03	0.39




















Intersection Summary

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

HCM Signalized Intersection Capacity Analysis

7: Sudbury Rd & Thoreau St

10/03/2019

														
Movement	SEL	SET	SER	NWL	NWT	NWR	NEL	NET	NER	SWL	SWT	SWR		
Lane Configurations														
Traffic Volume (vph)	19	86	106	113	141	30	50	179	26	16	399	35		
Future Volume (vph)	19	86	106	113	141	30	50	179	26	16	399	35		
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900		
Total Lost time (s)		5.0	5.0	5.0	4.5			5.5		6.0	5.5			
Lane Util. Factor		1.00	1.00	1.00	1.00			1.00		1.00	1.00			
Frbp, ped/bikes		1.00	0.91	1.00	0.99			0.99		1.00	1.00			
Flpb, ped/bikes		0.99	1.00	0.99	1.00			1.00		1.00	1.00			
Frt		1.00	0.85	1.00	0.97			0.99		1.00	0.99			
Flt Protected		0.99	1.00	0.95	1.00			0.99		0.95	1.00			
Satd. Flow (prot)		1812	1421	1750	1799			1717		1746	1816			
Flt Permitted		0.91	1.00	0.47	1.00			0.83		0.38	1.00			
Satd. Flow (perm)		1656	1421	874	1799			1441		696	1816			
Peak-hour factor, PHF	0.73	0.73	0.73	0.85	0.85	0.85	0.70	0.70	0.70	0.97	0.97	0.97		
Adj. Flow (vph)	26	118	145	133	166	35	71	256	37	16	411	36		
RTOR Reduction (vph)	0	0	120	0	7	0	0	3	0	0	3	0		
Lane Group Flow (vph)	0	144	25	133	194	0	0	361	0	16	444	0		
Confl. Peds. (#/hr)	23		26	23		20	26		23	20		23		
Confl. Bikes (#/hr)									1					
Heavy Vehicles (%)	3%	3%	3%	2%	2%	2%	7%	7%	7%	3%	3%	3%		
Turn Type	Perm	NA	Perm	pm+pt	NA		Perm	NA		pm+pt	NA			
Protected Phases		2		1	6			8		7	4			
Permitted Phases	2		2	6			8			4				
Actuated Green, G (s)		12.3	12.3	24.6	24.6			22.3		30.3	30.3			
Effective Green, g (s)		12.3	12.3	24.6	24.6			22.3		30.3	30.3			
Actuated g/C Ratio		0.17	0.17	0.35	0.35			0.31		0.43	0.43			
Clearance Time (s)		5.0	5.0	5.0	4.5			5.5		6.0	5.5			
Vehicle Extension (s)		3.0	3.0	3.0	3.0			3.0		3.0	3.0			
Lane Grp Cap (vph)		286	245	386	622			451		326	773			
v/s Ratio Prot				0.03	c0.11					0.00	c0.24			
v/s Ratio Perm		c0.09	0.02	0.09				c0.25		0.02				
v/c Ratio		0.50	0.10	0.34	0.31			0.80		0.05	0.57			
Uniform Delay, d1		26.6	24.8	16.7	17.0			22.4		13.5	15.5			
Progression Factor		1.00	1.00	1.00	1.00			1.00		1.00	1.00			
Incremental Delay, d2		1.4	0.2	0.5	0.3			9.6		0.1	1.0			
Delay (s)		28.0	24.9	17.2	17.3			31.9		13.6	16.5			
Level of Service		C	C	B	B			C		B	B			
Approach Delay (s)		26.5			17.3			31.9			16.4			
Approach LOS		C			B			C			B			
Intersection Summary														
HCM 2000 Control Delay			22.5									HCM 2000 Level of Service	C	
HCM 2000 Volume to Capacity ratio			0.66											
Actuated Cycle Length (s)			71.1							25.5				
Intersection Capacity Utilization			69.5%										ICU Level of Service	C
Analysis Period (min)			15											
c	Critical Lane Group													

Timing Report, Sorted By Phase
7: Sudbury Rd & Thoreau St

10/03/2019

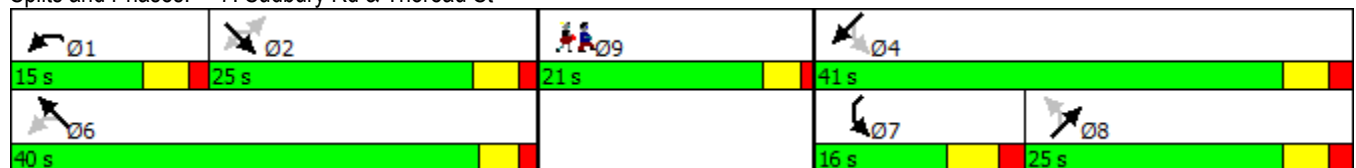


Phase Number	1	2	4	6	7	8	9
Movement	NWL	SETL	SWTL	NWTL	SWL	NETL	Ped
Lead/Lag	Lead	Lag			Lead	Lag	
Lead-Lag Optimize	Yes	Yes			Yes	Yes	
Recall Mode	None	Min	None	Min	None	None	None
Maximum Split (s)	15	25	41	40	16	25	21
Maximum Split (%)	14.7%	24.5%	40.2%	39.2%	15.7%	24.5%	20.6%
Minimum Split (s)	10	23	23.5	22.5	11	23.5	22
Yellow Time (s)	3.5	3.5	3.5	3	4	3.5	3
All-Red Time (s)	1.5	1.5	2	1.5	2	2	1
Minimum Initial (s)	5	5	5	5	5	5	5
Vehicle Extension (s)	3	3	3	3	3	3	3
Minimum Gap (s)	3	3	3	3	3	3	3
Time Before Reduce (s)	0	0	0	0	0	0	0
Time To Reduce (s)	0	0	0	0	0	0	0
Walk Time (s)							7
Flash Dont Walk (s)							11
Dual Entry	No	Yes	Yes	Yes	No	Yes	No
Inhibit Max	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Start Time (s)	0	15	61	0	61	77	40
End Time (s)	15	40	0	40	77	0	61
Yield/Force Off (s)	10	35	96.5	35.5	71	96.5	57
Yield/Force Off 170(s)	10	35	96.5	35.5	71	96.5	46
Local Start Time (s)	87	0	46	87	46	62	25
Local Yield (s)	97	20	81.5	20.5	56	81.5	42
Local Yield 170(s)	97	20	81.5	20.5	56	81.5	31

Intersection Summary

Cycle Length	102
Control Type	Actuated-Uncoordinated
Natural Cycle	90

Splits and Phases: 7: Sudbury Rd & Thoreau St



Queues

3: Thoreau St/Nashawtuc Rd & Main Street

10/03/2019



Lane Group	EBT	EBR	WBL	WBT	NBT	SBT
Lane Group Flow (vph)	394	230	54	635	451	64
v/c Ratio	0.62	0.37	0.16	0.80	0.79	0.11
Control Delay	25.7	9.8	11.8	26.5	32.5	15.5
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	25.7	9.8	11.8	26.5	32.5	15.5
Queue Length 50th (ft)	159	30	13	234	170	17
Queue Length 95th (ft)	248	81	28	302	#406	33
Internal Link Dist (ft)	682			827	446	549
Turn Bay Length (ft)		90	100			
Base Capacity (vph)	813	749	357	1095	569	597
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.48	0.31	0.15	0.58	0.79	0.11

Intersection Summary

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

HCM Signalized Intersection Capacity Analysis

3: Thoreau St/Nashawtuc Rd & Main Street

10/03/2019



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↕	↗	↖	↗			↕			↕	
Traffic Volume (vph)	4	355	209	44	513	7	366	28	35	18	22	0
Future Volume (vph)	4	355	209	44	513	7	366	28	35	18	22	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0	5.0	4.0	5.0			5.0			5.0	
Lane Util. Factor		1.00	1.00	1.00	1.00			1.00			1.00	
Frpb, ped/bikes		1.00	0.96	1.00	1.00			1.00			1.00	
Flpb, ped/bikes		1.00	1.00	1.00	1.00			0.99			1.00	
Frt		1.00	0.85	1.00	1.00			0.99			1.00	
Flt Protected		1.00	1.00	0.95	1.00			0.96			0.98	
Satd. Flow (prot)		1880	1539	1767	1858			1760			1718	
Flt Permitted		0.99	1.00	0.29	1.00			0.71			0.78	
Satd. Flow (perm)		1870	1539	542	1858			1307			1375	
Peak-hour factor, PHF	0.91	0.91	0.91	0.82	0.82	0.82	0.95	0.95	0.95	0.63	0.63	0.63
Adj. Flow (vph)	4	390	230	54	626	9	385	29	37	29	35	0
RTOR Reduction (vph)	0	0	95	0	1	0	0	3	0	0	0	0
Lane Group Flow (vph)	0	394	135	54	634	0	0	448	0	0	64	0
Confl. Peds. (#/hr)	6		12	11		5	12		11	5		6
Confl. Bikes (#/hr)									1			
Heavy Vehicles (%)	1%	1%	1%	2%	2%	2%	1%	1%	1%	8%	8%	8%
Turn Type	Perm	NA	Perm	pm+pt	NA		Perm	NA		Perm	NA	
Protected Phases		6		5	2			4			4	
Permitted Phases	6		6	2			4			4		
Actuated Green, G (s)		24.5	24.5	32.4	32.4			31.4			31.4	
Effective Green, g (s)		24.5	24.5	32.4	32.4			31.4			31.4	
Actuated g/C Ratio		0.33	0.33	0.44	0.44			0.43			0.43	
Clearance Time (s)		5.0	5.0	4.0	5.0			5.0			5.0	
Vehicle Extension (s)		3.0	3.0	3.0	3.0			3.0			3.0	
Lane Grp Cap (vph)		620	510	302	815			556			585	
v/s Ratio Prot				0.01	c0.34							
v/s Ratio Perm		0.21	0.09	0.07				c0.34			0.05	
v/c Ratio		0.64	0.26	0.18	0.78			0.81			0.11	
Uniform Delay, d1		20.9	18.1	13.2	17.6			18.5			12.8	
Progression Factor		1.00	1.00	1.00	1.00			1.00			1.00	
Incremental Delay, d2		2.1	0.3	0.3	4.7			8.3			0.1	
Delay (s)		23.0	18.3	13.4	22.4			26.9			12.9	
Level of Service		C	B	B	C			C			B	
Approach Delay (s)		21.3			21.7			26.9			12.9	
Approach LOS		C			C			C			B	

Intersection Summary

HCM 2000 Control Delay	22.5	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.87		
Actuated Cycle Length (s)	73.8	Sum of lost time (s)	16.0
Intersection Capacity Utilization	75.5%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

Timing Report, Sorted By Phase

3: Thoreau St/Nashawtuc Rd & Main Street

10/03/2019

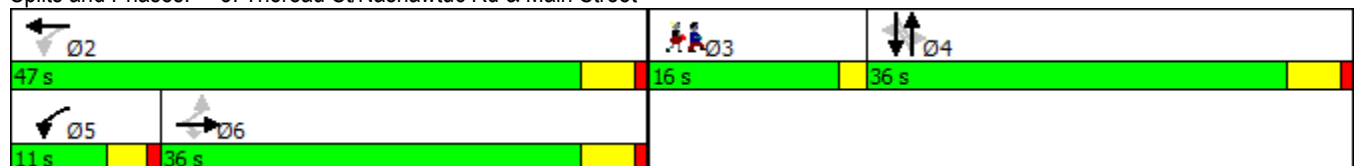


Phase Number	2	3	4	5	6
Movement	WBTL	Ped	NBSB	WBL	EBTL
Lead/Lag		Lead	Lag	Lead	Lag
Lead-Lag Optimize					
Recall Mode	Min	None	None	None	Min
Maximum Split (s)	47	16	36	11	36
Maximum Split (%)	47.5%	16.2%	36.4%	11.1%	36.4%
Minimum Split (s)	23	16	23	9.5	23
Yellow Time (s)	4	2	4	3	4
All-Red Time (s)	1	0	1	1	1
Minimum Initial (s)	5	5	5	5	5
Vehicle Extension (s)	3	3	3	3	3
Minimum Gap (s)	3	3	3	3	3
Time Before Reduce (s)	0	0	0	0	0
Time To Reduce (s)	0	0	0	0	0
Walk Time (s)		7			
Flash Dont Walk (s)		11			
Dual Entry	Yes	No	Yes	No	Yes
Inhibit Max	Yes	Yes	Yes	Yes	Yes
Start Time (s)	0	47	63	0	11
End Time (s)	47	63	0	11	47
Yield/Force Off (s)	42	61	94	7	42
Yield/Force Off 170(s)	42	50	94	7	42
Local Start Time (s)	88	36	52	88	0
Local Yield (s)	31	50	83	95	31
Local Yield 170(s)	31	39	83	95	31

Intersection Summary

Cycle Length	99
Control Type	Actuated-Uncoordinated
Natural Cycle	90

Splits and Phases: 3: Thoreau St/Nashawtuc Rd & Main Street



Queues

7: Sudbury Rd & Thoreau St

10/03/2019



Lane Group	SET	SER	NWL	NWT	NET	SWL	SWT
Lane Group Flow (vph)	249	114	34	242	624	31	225
v/c Ratio	0.58	0.22	0.09	0.38	1.18	0.09	0.30
Control Delay	31.2	2.3	17.2	17.5	126.7	16.9	16.0
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	31.2	2.3	17.2	17.5	126.7	16.9	16.0
Queue Length 50th (ft)	50	0	6	42	~207	5	39
Queue Length 95th (ft)	188	0	34	162	#623	33	163
Internal Link Dist (ft)	659			610	500		1136
Turn Bay Length (ft)		75	80			80	
Base Capacity (vph)	556	626	432	1155	527	437	1159
Starvation Cap Reductn	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0
Reduced v/c Ratio	0.45	0.18	0.08	0.21	1.18	0.07	0.19

Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.

Queue shown is maximum after two cycles.




















95th percentile volume exceeds capacity, queue may be longer.

Queue shown is maximum after two cycles.

HCM Signalized Intersection Capacity Analysis

7: Sudbury Rd & Thoreau St

10/03/2019

												
Movement	SEL	SET	SER	NWL	NWT	NWR	NEL	NET	NER	SWL	SWT	SWR
Lane Configurations												
Traffic Volume (vph)	50	132	83	29	156	49	100	306	31	30	178	40
Future Volume (vph)	50	132	83	29	156	49	100	306	31	30	178	40
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0	5.0	5.0	4.5			5.5		6.0	5.5	
Lane Util. Factor		1.00	1.00	1.00	1.00			1.00		1.00	1.00	
Frbp, ped/bikes		1.00	0.91	1.00	0.98			0.99		1.00	0.99	
Flpb, ped/bikes		0.99	1.00	0.99	1.00			0.99		1.00	1.00	
Frt		1.00	0.85	1.00	0.96			0.99		1.00	0.97	
Flt Protected		0.99	1.00	0.95	1.00			0.99		0.95	1.00	
Satd. Flow (prot)		1796	1433	1751	1766			1714		1748	1775	
Flt Permitted		0.84	1.00	0.38	1.00			0.85		0.28	1.00	
Satd. Flow (perm)		1525	1433	697	1766			1482		507	1775	
Peak-hour factor, PHF	0.73	0.73	0.73	0.85	0.85	0.85	0.70	0.70	0.70	0.97	0.97	0.97
Adj. Flow (vph)	68	181	114	34	184	58	143	437	44	31	184	41
RTOR Reduction (vph)	0	0	86	0	11	0	0	2	0	0	7	0
Lane Group Flow (vph)	0	249	28	34	231	0	0	622	0	31	218	0
Confl. Peds. (#/hr)	33		33	36		36	33		36	36		33
Confl. Bikes (#/hr)									1			
Heavy Vehicles (%)	3%	3%	3%	2%	2%	2%	7%	7%	7%	3%	3%	3%
Turn Type	Perm	NA	Perm	pm+pt	NA		Perm	NA		pm+pt	NA	
Protected Phases		2		1	6			8		7	4	
Permitted Phases	2		2	6			8			4		
Actuated Green, G (s)		17.3	17.3	25.0	25.0			22.0		30.3	30.3	
Effective Green, g (s)		17.3	17.3	25.0	25.0			22.0		30.3	30.3	
Actuated g/C Ratio		0.25	0.25	0.35	0.35			0.31		0.43	0.43	
Clearance Time (s)		5.0	5.0	5.0	4.5			5.5		6.0	5.5	
Vehicle Extension (s)		3.0	3.0	3.0	3.0			3.0		3.0	3.0	
Lane Grp Cap (vph)		374	351	280	626			462		258	762	
v/s Ratio Prot				0.00	c0.13					0.00	c0.12	
v/s Ratio Perm		c0.16	0.02	0.04				c0.42		0.05		
v/c Ratio		0.67	0.08	0.12	0.37			1.35		0.12	0.29	
Uniform Delay, d1		24.0	20.5	15.5	16.9			24.2		15.4	13.1	
Progression Factor		1.00	1.00	1.00	1.00			1.00		1.00	1.00	
Incremental Delay, d2		4.4	0.1	0.2	0.4			169.7		0.2	0.2	
Delay (s)		28.4	20.6	15.7	17.3			193.9		15.6	13.3	
Level of Service		C	C	B	B			F		B	B	
Approach Delay (s)		26.0			17.1			193.9			13.6	
Approach LOS		C			B			F			B	
Intersection Summary												
HCM 2000 Control Delay			91.3			HCM 2000 Level of Service				F		
HCM 2000 Volume to Capacity ratio			0.97									
Actuated Cycle Length (s)			70.5			Sum of lost time (s)			24.5			
Intersection Capacity Utilization			74.8%			ICU Level of Service				D		
Analysis Period (min)			15									
c	Critical Lane Group											

Queues

3: Thoreau St/Nashawtuc Rd & Main Street

10/03/2019



Lane Group	EBT	EBR	WBL	WBT	NBT	SBT
Lane Group Flow (vph)	580	673	34	458	247	225
v/c Ratio	0.68	0.79	0.10	0.46	0.72	0.49
Control Delay	24.1	20.1	9.5	12.8	34.2	23.8
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	24.1	20.1	9.5	12.8	34.2	23.8
Queue Length 50th (ft)	223	163	6	115	98	84
Queue Length 95th (ft)	#453	#433	22	228	178	146
Internal Link Dist (ft)	682			827	446	549
Turn Bay Length (ft)		90	100			
Base Capacity (vph)	850	857	370	1134	508	682
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.68	0.79	0.09	0.40	0.49	0.33

Intersection Summary

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

HCM Signalized Intersection Capacity Analysis

3: Thoreau St/Nashawtuc Rd & Main Street

10/03/2019



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↕	↗	↖	↗			↕			↕	
Traffic Volume (vph)	2	532	619	31	405	17	179	21	27	90	114	3
Future Volume (vph)	2	532	619	31	405	17	179	21	27	90	114	3
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0	5.0	4.0	5.0			5.0			5.0	
Lane Util. Factor		1.00	1.00	1.00	1.00			1.00			1.00	
Frbp, ped/bikes		1.00	0.98	1.00	1.00			1.00			1.00	
Flpb, ped/bikes		1.00	1.00	1.00	1.00			1.00			1.00	
Frt		1.00	0.85	1.00	0.99			0.98			1.00	
Flt Protected		1.00	1.00	0.95	1.00			0.96			0.98	
Satd. Flow (prot)		1844	1531	1735	1815			1688			1818	
Flt Permitted		1.00	1.00	0.23	1.00			0.62			0.80	
Satd. Flow (perm)		1843	1531	419	1815			1095			1478	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	2	578	673	34	440	18	195	23	29	98	124	3
RTOR Reduction (vph)	0	0	155	0	1	0	0	5	0	0	1	0
Lane Group Flow (vph)	0	580	518	34	457	0	0	242	0	0	224	0
Confl. Peds. (#/hr)	3		3	2		2	3		2	2		3
Confl. Bikes (#/hr)									1			
Heavy Vehicles (%)	3%	3%	3%	4%	4%	4%	6%	6%	6%	2%	2%	2%
Turn Type	Perm	NA	Perm	pm+pt	NA		Perm	NA		Perm	NA	
Protected Phases		6		5	2			4			4	
Permitted Phases	6		6	2			4			4		
Actuated Green, G (s)		32.1	32.1	39.7	39.7			21.4			21.4	
Effective Green, g (s)		32.1	32.1	39.7	39.7			21.4			21.4	
Actuated g/C Ratio		0.45	0.45	0.56	0.56			0.30			0.30	
Clearance Time (s)		5.0	5.0	4.0	5.0			5.0			5.0	
Vehicle Extension (s)		3.0	3.0	3.0	3.0			3.0			3.0	
Lane Grp Cap (vph)		832	691	300	1013			329			444	
v/s Ratio Prot				0.01	c0.25							
v/s Ratio Perm		0.31	c0.34	0.06				c0.22			0.15	
v/c Ratio		0.70	0.75	0.11	0.45			0.74			0.51	
Uniform Delay, d1		15.6	16.2	9.3	9.3			22.3			20.5	
Progression Factor		1.00	1.00	1.00	1.00			1.00			1.00	
Incremental Delay, d2		2.6	4.5	0.2	0.3			8.3			0.9	
Delay (s)		18.2	20.6	9.5	9.6			30.6			21.4	
Level of Service		B	C	A	A			C			C	
Approach Delay (s)		19.5			9.6			30.6			21.4	
Approach LOS		B			A			C			C	

Intersection Summary

HCM 2000 Control Delay	18.7	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.76		
Actuated Cycle Length (s)	71.1	Sum of lost time (s)	16.0
Intersection Capacity Utilization	84.4%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Timing Report, Sorted By Phase

3: Thoreau St/Nashawtuc Rd & Main Street

10/03/2019

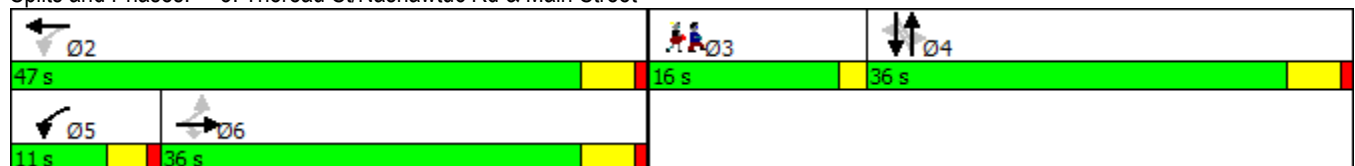


Phase Number	2	3	4	5	6
Movement	WBTL	Ped	NBSB	WBL	EBTL
Lead/Lag		Lead	Lag	Lead	Lag
Lead-Lag Optimize		Yes	Yes	Yes	Yes
Recall Mode	Min	None	None	None	Min
Maximum Split (s)	47	16	36	11	36
Maximum Split (%)	47.5%	16.2%	36.4%	11.1%	36.4%
Minimum Split (s)	23	16	23	9.5	23
Yellow Time (s)	4	2	4	3	4
All-Red Time (s)	1	0	1	1	1
Minimum Initial (s)	5	5	5	5	5
Vehicle Extension (s)	3	3	3	3	3
Minimum Gap (s)	3	3	3	3	3
Time Before Reduce (s)	0	0	0	0	0
Time To Reduce (s)	0	0	0	0	0
Walk Time (s)		5			
Flash Dont Walk (s)		9			
Dual Entry	Yes	No	Yes	No	Yes
Inhibit Max	Yes	Yes	Yes	Yes	Yes
Start Time (s)	0	47	63	0	11
End Time (s)	47	63	0	11	47
Yield/Force Off (s)	42	61	94	7	42
Yield/Force Off 170(s)	42	52	94	7	42
Local Start Time (s)	88	36	52	88	0
Local Yield (s)	31	50	83	95	31
Local Yield 170(s)	31	41	83	95	31

Intersection Summary

Cycle Length	99
Control Type	Actuated-Uncoordinated
Natural Cycle	90

Splits and Phases: 3: Thoreau St/Nashawtuc Rd & Main Street



Queues

7: Sudbury Rd & Thoreau St

10/03/2019



Lane Group	SET	SER	NWL	NWT	NET	SWL	SWT
Lane Group Flow (vph)	127	129	138	209	310	20	528
v/c Ratio	0.42	0.31	0.32	0.32	0.60	0.05	0.68
Control Delay	33.6	3.7	19.5	17.8	30.0	16.7	24.1
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	33.6	3.7	19.5	17.8	30.0	16.7	24.1
Queue Length 50th (ft)	41	0	30	43	80	4	151
Queue Length 95th (ft)	131	16	113	157	#376	25	#481
Internal Link Dist (ft)	659			610	500		1136
Turn Bay Length (ft)		75	80			80	
Base Capacity (vph)	571	618	473	1107	521	493	1115
Starvation Cap Reductn	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0
Reduced v/c Ratio	0.22	0.21	0.29	0.19	0.60	0.04	0.47

Intersection Summary

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

HCM Signalized Intersection Capacity Analysis

7: Sudbury Rd & Thoreau St

10/03/2019



Movement	SEL	SET	SER	NWL	NWT	NWR	NEL	NET	NER	SWL	SWT	SWR
Lane Configurations		↕	↕	↕	↕			↕		↕	↕	
Traffic Volume (vph)	21	96	119	127	158	34	56	200	29	18	447	39
Future Volume (vph)	21	96	119	127	158	34	56	200	29	18	447	39
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0	5.0	5.0	4.5			5.5		6.0	5.5	
Lane Util. Factor		1.00	1.00	1.00	1.00			1.00		1.00	1.00	
Frbp, ped/bikes		1.00	0.90	1.00	0.99			0.99		1.00	1.00	
Flpb, ped/bikes		0.99	1.00	0.99	1.00			1.00		1.00	1.00	
Frt		1.00	0.85	1.00	0.97			0.99		1.00	0.99	
Flt Protected		0.99	1.00	0.95	1.00			0.99		0.95	1.00	
Satd. Flow (prot)		1811	1414	1749	1797			1718		1744	1816	
Flt Permitted		0.90	1.00	0.48	1.00			0.82		0.43	1.00	
Satd. Flow (perm)		1652	1414	884	1797			1421		784	1816	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	23	104	129	138	172	37	61	217	32	20	486	42
RTOR Reduction (vph)	0	0	108	0	8	0	0	3	0	0	3	0
Lane Group Flow (vph)	0	127	21	138	201	0	0	307	0	20	525	0
Confl. Peds. (#/hr)	23		26	23		20	26		23	20		23
Confl. Bikes (#/hr)									1			
Heavy Vehicles (%)	3%	3%	3%	2%	2%	2%	7%	7%	7%	3%	3%	3%
Turn Type	Perm	NA	Perm	pm+pt	NA		Perm	NA		pm+pt	NA	
Protected Phases		2		1	6			8		7	4	
Permitted Phases	2		2	6			8			4		
Actuated Green, G (s)		11.8	11.8	24.3	24.3			23.8		31.9	31.9	
Effective Green, g (s)		11.8	11.8	24.3	24.3			23.8		31.9	31.9	
Actuated g/C Ratio		0.16	0.16	0.34	0.34			0.33		0.44	0.44	
Clearance Time (s)		5.0	5.0	5.0	4.5			5.5		6.0	5.5	
Vehicle Extension (s)		3.0	3.0	3.0	3.0			3.0		3.0	3.0	
Lane Grp Cap (vph)		268	230	379	602			466		372	799	
v/s Ratio Prot				0.04	c0.11					0.00	c0.29	
v/s Ratio Perm		c0.08	0.01	0.09				0.22		0.02		
v/c Ratio		0.47	0.09	0.36	0.33			0.66		0.05	0.66	
Uniform Delay, d1		27.5	25.8	17.6	18.0			20.9		12.8	16.0	
Progression Factor		1.00	1.00	1.00	1.00			1.00		1.00	1.00	
Incremental Delay, d2		1.3	0.2	0.6	0.3			3.3		0.1	2.0	
Delay (s)		28.9	26.0	18.2	18.4			24.2		12.9	18.0	
Level of Service		C	C	B	B			C		B	B	
Approach Delay (s)		27.4			18.3			24.2			17.8	
Approach LOS		C			B			C			B	

Intersection Summary

HCM 2000 Control Delay	20.9	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.63		
Actuated Cycle Length (s)	72.5	Sum of lost time (s)	25.5
Intersection Capacity Utilization	75.7%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

Timing Report, Sorted By Phase
7: Sudbury Rd & Thoreau St

10/03/2019

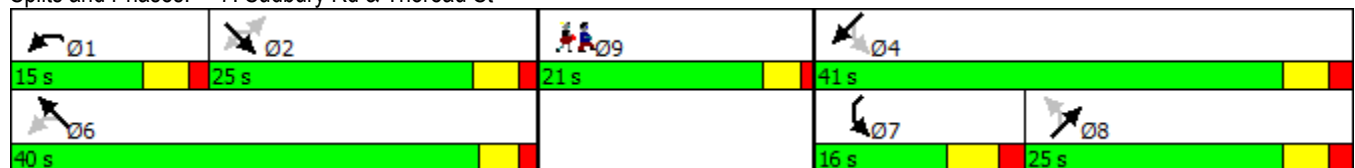


Phase Number	1	2	4	6	7	8	9
Movement	NWL	SETL	SWTL	NWTL	SWL	NETL	Ped
Lead/Lag	Lead	Lag			Lead	Lag	
Lead-Lag Optimize	Yes	Yes			Yes	Yes	
Recall Mode	None	Min	None	Min	None	None	None
Maximum Split (s)	15	25	41	40	16	25	21
Maximum Split (%)	14.7%	24.5%	40.2%	39.2%	15.7%	24.5%	20.6%
Minimum Split (s)	10	23	23.5	22.5	11	23.5	22
Yellow Time (s)	3.5	3.5	3.5	3	4	3.5	3
All-Red Time (s)	1.5	1.5	2	1.5	2	2	1
Minimum Initial (s)	5	5	5	5	5	5	5
Vehicle Extension (s)	3	3	3	3	3	3	3
Minimum Gap (s)	3	3	3	3	3	3	3
Time Before Reduce (s)	0	0	0	0	0	0	0
Time To Reduce (s)	0	0	0	0	0	0	0
Walk Time (s)							7
Flash Dont Walk (s)							11
Dual Entry	No	Yes	Yes	Yes	No	Yes	No
Inhibit Max	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Start Time (s)	0	15	61	0	61	77	40
End Time (s)	15	40	0	40	77	0	61
Yield/Force Off (s)	10	35	96.5	35.5	71	96.5	57
Yield/Force Off 170(s)	10	35	96.5	35.5	71	96.5	46
Local Start Time (s)	87	0	46	87	46	62	25
Local Yield (s)	97	20	81.5	20.5	56	81.5	42
Local Yield 170(s)	97	20	81.5	20.5	56	81.5	31

Intersection Summary

Cycle Length	102
Control Type	Actuated-Uncoordinated
Natural Cycle	90

Splits and Phases: 7: Sudbury Rd & Thoreau St



Queues

3: Thoreau St/Nashawtuc Rd & Main Street

10/03/2019



Lane Group	EBT	EBR	WBL	WBT	NBT	SBT
Lane Group Flow (vph)	441	257	60	711	506	72
v/c Ratio	0.66	0.40	0.18	0.82	0.96	0.13
Control Delay	27.2	10.8	11.5	26.8	57.7	17.3
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	27.2	10.8	11.5	26.8	57.7	17.3
Queue Length 50th (ft)	185	40	15	279	242	22
Queue Length 95th (ft)	284	97	30	356	#478	36
Internal Link Dist (ft)	682			827	446	549
Turn Bay Length (ft)		90	100			
Base Capacity (vph)	757	706	347	1019	526	556
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.58	0.36	0.17	0.70	0.96	0.13

Intersection Summary

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

HCM Signalized Intersection Capacity Analysis

3: Thoreau St/Nashawtuc Rd & Main Street

10/03/2019



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↕	↗	↖	↗	↖		↕			↕	
Traffic Volume (vph)	4	398	234	49	575	8	410	31	39	20	25	0
Future Volume (vph)	4	398	234	49	575	8	410	31	39	20	25	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0	5.0	4.0	5.0			5.0			5.0	
Lane Util. Factor		1.00	1.00	1.00	1.00			1.00			1.00	
Frbp, ped/bikes		1.00	0.96	1.00	1.00			1.00			1.00	
Flpb, ped/bikes		1.00	1.00	1.00	1.00			0.99			1.00	
Frt		1.00	0.85	1.00	1.00			0.99			1.00	
Flt Protected		1.00	1.00	0.95	1.00			0.96			0.98	
Satd. Flow (prot)		1880	1540	1768	1858			1759			1719	
Flt Permitted		0.99	1.00	0.26	1.00			0.71			0.78	
Satd. Flow (perm)		1870	1540	481	1858			1297			1375	
Peak-hour factor, PHF	0.91	0.91	0.91	0.82	0.82	0.82	0.95	0.95	0.95	0.63	0.63	0.63
Adj. Flow (vph)	4	437	257	60	701	10	432	33	41	32	40	0
RTOR Reduction (vph)	0	0	92	0	1	0	0	3	0	0	0	0
Lane Group Flow (vph)	0	441	165	60	710	0	0	503	0	0	72	0
Confl. Peds. (#/hr)	6		12	11		5	12		11	5		6
Confl. Bikes (#/hr)									1			
Heavy Vehicles (%)	1%	1%	1%	2%	2%	2%	1%	1%	1%	8%	8%	8%
Turn Type	Perm	NA	Perm	pm+pt	NA		Perm	NA		Perm	NA	
Protected Phases		6		5	2			4			4	
Permitted Phases	6		6	2			4			4		
Actuated Green, G (s)		27.4	27.4	36.7	36.7			31.2			31.2	
Effective Green, g (s)		27.4	27.4	36.7	36.7			31.2			31.2	
Actuated g/C Ratio		0.35	0.35	0.47	0.47			0.40			0.40	
Clearance Time (s)		5.0	5.0	4.0	5.0			5.0			5.0	
Vehicle Extension (s)		3.0	3.0	3.0	3.0			3.0			3.0	
Lane Grp Cap (vph)		657	541	314	875			519			550	
v/s Ratio Prot				0.01	c0.38							
v/s Ratio Perm		0.24	0.11	0.08				c0.39			0.05	
v/c Ratio		0.67	0.30	0.19	0.81			0.97			0.13	
Uniform Delay, d1		21.4	18.3	12.9	17.6			22.9			14.8	
Progression Factor		1.00	1.00	1.00	1.00			1.00			1.00	
Incremental Delay, d2		2.7	0.3	0.3	5.8			31.3			0.1	
Delay (s)		24.1	18.7	13.2	23.4			54.2			14.9	
Level of Service		C	B	B	C			D			B	
Approach Delay (s)		22.1			22.6			54.2			14.9	
Approach LOS		C			C			D			B	

Intersection Summary

HCM 2000 Control Delay	30.0	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.97		
Actuated Cycle Length (s)	77.9	Sum of lost time (s)	16.0
Intersection Capacity Utilization	82.5%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Timing Report, Sorted By Phase

3: Thoreau St/Nashawtuc Rd & Main Street

10/03/2019

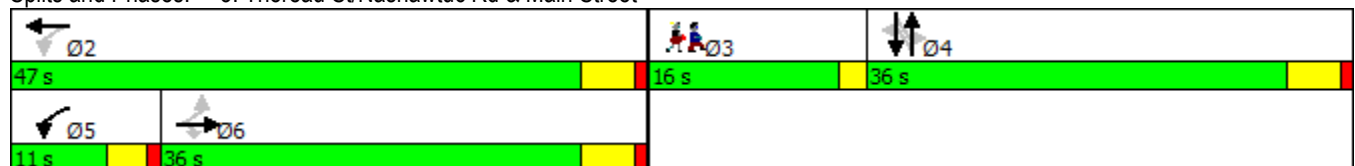


Phase Number	2	3	4	5	6
Movement	WBTL	Ped	NBSB	WBL	EBTL
Lead/Lag		Lead	Lag	Lead	Lag
Lead-Lag Optimize					
Recall Mode	Min	None	None	None	Min
Maximum Split (s)	47	16	36	11	36
Maximum Split (%)	47.5%	16.2%	36.4%	11.1%	36.4%
Minimum Split (s)	23	16	23	9.5	23
Yellow Time (s)	4	2	4	3	4
All-Red Time (s)	1	0	1	1	1
Minimum Initial (s)	5	5	5	5	5
Vehicle Extension (s)	3	3	3	3	3
Minimum Gap (s)	3	3	3	3	3
Time Before Reduce (s)	0	0	0	0	0
Time To Reduce (s)	0	0	0	0	0
Walk Time (s)		7			
Flash Dont Walk (s)		11			
Dual Entry	Yes	No	Yes	No	Yes
Inhibit Max	Yes	Yes	Yes	Yes	Yes
Start Time (s)	0	47	63	0	11
End Time (s)	47	63	0	11	47
Yield/Force Off (s)	42	61	94	7	42
Yield/Force Off 170(s)	42	50	94	7	42
Local Start Time (s)	88	36	52	88	0
Local Yield (s)	31	50	83	95	31
Local Yield 170(s)	31	39	83	95	31

Intersection Summary

Cycle Length	99
Control Type	Actuated-Uncoordinated
Natural Cycle	100

Splits and Phases: 3: Thoreau St/Nashawtuc Rd & Main Street



Queues

7: Sudbury Rd & Thoreau St

10/03/2019



Lane Group	SET	SER	NWL	NWT	NET	SWL	SWT
Lane Group Flow (vph)	280	127	38	271	700	35	251
v/c Ratio	0.61	0.23	0.10	0.37	1.51	0.11	0.36
Control Delay	33.0	3.2	16.7	16.8	262.4	18.2	18.4
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	33.0	3.2	16.7	16.8	262.4	18.2	18.4
Queue Length 50th (ft)	85	0	7	48	~379	9	69
Queue Length 95th (ft)	#233	0	37	183	#715	37	183
Internal Link Dist (ft)	659			610	500		1136
Turn Bay Length (ft)		75	80			80	
Base Capacity (vph)	489	576	443	1029	465	377	1031
Starvation Cap Reductn	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0
Reduced v/c Ratio	0.57	0.22	0.09	0.26	1.51	0.09	0.24

Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.

Queue shown is maximum after two cycles.




















95th percentile volume exceeds capacity, queue may be longer.

Queue shown is maximum after two cycles.

HCM Signalized Intersection Capacity Analysis

7: Sudbury Rd & Thoreau St

10/03/2019

												
Movement	SEL	SET	SER	NWL	NWT	NWR	NEL	NET	NER	SWL	SWT	SWR
Lane Configurations												
Traffic Volume (vph)	56	148	93	32	175	55	112	343	35	34	199	45
Future Volume (vph)	56	148	93	32	175	55	112	343	35	34	199	45
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0	5.0	5.0	4.5			5.5		6.0	5.5	
Lane Util. Factor		1.00	1.00	1.00	1.00			1.00		1.00	1.00	
Frbp, ped/bikes		1.00	0.92	1.00	0.98			0.99		1.00	0.99	
Flpb, ped/bikes		0.99	1.00	0.99	1.00			0.99		1.00	1.00	
Frt		1.00	0.85	1.00	0.96			0.99		1.00	0.97	
Flt Protected		0.99	1.00	0.95	1.00			0.99		0.95	1.00	
Satd. Flow (prot)		1799	1443	1755	1768			1712		1749	1774	
Flt Permitted		0.83	1.00	0.36	1.00			0.85		0.24	1.00	
Satd. Flow (perm)		1508	1443	661	1768			1467		434	1774	
Peak-hour factor, PHF	0.73	0.73	0.73	0.85	0.85	0.85	0.70	0.70	0.70	0.97	0.97	0.97
Adj. Flow (vph)	77	203	127	38	206	65	160	490	50	35	205	46
RTOR Reduction (vph)	0	0	93	0	10	0	0	2	0	0	7	0
Lane Group Flow (vph)	0	280	34	38	261	0	0	698	0	35	244	0
Confl. Peds. (#/hr)	33		33	36		36	33		36	36		33
Confl. Bikes (#/hr)									1			
Heavy Vehicles (%)	3%	3%	3%	2%	2%	2%	7%	7%	7%	3%	3%	3%
Turn Type	Perm	NA	Perm	pm+pt	NA		Perm	NA		pm+pt	NA	
Protected Phases		2		1	6			8		7	4	
Permitted Phases	2		2	6			8			4		
Actuated Green, G (s)		20.2	20.2	29.6	29.6			21.2		29.8	29.8	
Effective Green, g (s)		20.2	20.2	29.6	29.6			21.2		29.8	29.8	
Actuated g/C Ratio		0.27	0.27	0.40	0.40			0.28		0.40	0.40	
Clearance Time (s)		5.0	5.0	5.0	4.5			5.5		6.0	5.5	
Vehicle Extension (s)		3.0	3.0	3.0	3.0			3.0		3.0	3.0	
Lane Grp Cap (vph)		407	389	318	699			415		218	706	
v/s Ratio Prot				0.01	c0.15					0.01	c0.14	
v/s Ratio Perm		c0.19	0.02	0.04				c0.48		0.06		
v/c Ratio		0.69	0.09	0.12	0.37			1.68		0.16	0.35	
Uniform Delay, d1		24.5	20.4	14.7	16.0			26.8		17.5	15.7	
Progression Factor		1.00	1.00	1.00	1.00			1.00		1.00	1.00	
Incremental Delay, d2		4.8	0.1	0.2	0.3			317.1		0.3	0.3	
Delay (s)		29.3	20.5	14.8	16.4			343.9		17.8	16.0	
Level of Service		C	C	B	B			F		B	B	
Approach Delay (s)		26.5			16.2			343.9			16.2	
Approach LOS		C			B			F			B	

Intersection Summary

HCM 2000 Control Delay	153.4	HCM 2000 Level of Service	F
HCM 2000 Volume to Capacity ratio	1.07		
Actuated Cycle Length (s)	74.8	Sum of lost time (s)	24.5
Intersection Capacity Utilization	81.6%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

Timing Report, Sorted By Phase

7: Sudbury Rd & Thoreau St

10/03/2019

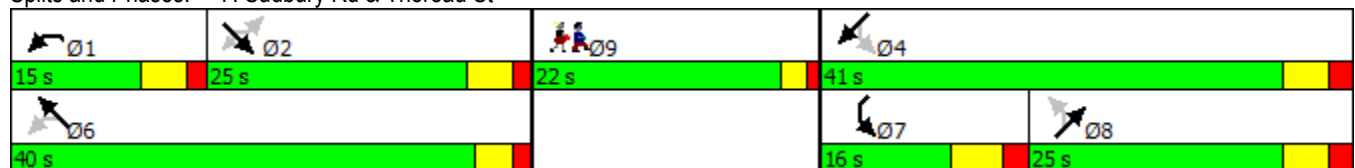


Phase Number	1	2	4	6	7	8	9
Movement	NWL	SETL	SWTL	NWTL	SWL	NETL	Ped
Lead/Lag	Lead	Lag			Lead	Lag	
Lead-Lag Optimize							
Recall Mode	None	Min	None	Min	None	None	None
Maximum Split (s)	15	25	41	40	16	25	22
Maximum Split (%)	14.6%	24.3%	39.8%	38.8%	15.5%	24.3%	21.4%
Minimum Split (s)	11	11	12	10.5	12	12	22
Yellow Time (s)	3.5	3.5	3.5	3	4	3.5	2
All-Red Time (s)	1.5	1.5	2	1.5	2	2	1
Minimum Initial (s)	6	6	6	6	6	6	5
Vehicle Extension (s)	3	3	3	3	3	3	3
Minimum Gap (s)	3	3	3	3	3	3	3
Time Before Reduce (s)	0	0	0	0	0	0	0
Time To Reduce (s)	0	0	0	0	0	0	0
Walk Time (s)							7
Flash Dont Walk (s)							11
Dual Entry	No	Yes	Yes	Yes	No	Yes	No
Inhibit Max	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Start Time (s)	0	15	62	0	62	78	40
End Time (s)	15	40	0	40	78	0	62
Yield/Force Off (s)	10	35	97.5	35.5	72	97.5	59
Yield/Force Off 170(s)	10	35	97.5	35.5	72	97.5	48
Local Start Time (s)	88	0	47	88	47	63	25
Local Yield (s)	98	20	82.5	20.5	57	82.5	44
Local Yield 170(s)	98	20	82.5	20.5	57	82.5	33

Intersection Summary

Cycle Length	103
Control Type	Actuated-Uncoordinated
Natural Cycle	150

Splits and Phases: 7: Sudbury Rd & Thoreau St



Queues

3: Thoreau St/Nashawtuc Rd & Main Street

10/08/2019



Lane Group	EBT	EBR	WBL	WBT	NBT	SBT
Lane Group Flow (vph)	580	673	34	458	247	225
v/c Ratio	0.68	0.79	0.10	0.46	0.72	0.49
Control Delay	24.1	20.1	9.5	12.8	34.2	23.8
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	24.1	20.1	9.5	12.8	34.2	23.8
Queue Length 50th (ft)	223	163	6	115	98	84
Queue Length 95th (ft)	#453	#433	22	228	178	146
Internal Link Dist (ft)	682			827	446	549
Turn Bay Length (ft)		90	100			
Base Capacity (vph)	850	857	370	1134	508	682
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.68	0.79	0.09	0.40	0.49	0.33

Intersection Summary

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

HCM Signalized Intersection Capacity Analysis

3: Thoreau St/Nashawtuc Rd & Main Street

10/08/2019



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↖	↗	↖	↗			↕			↕	
Traffic Volume (vph)	2	532	619	31	405	17	179	21	27	90	114	3
Future Volume (vph)	2	532	619	31	405	17	179	21	27	90	114	3
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0	5.0	4.0	5.0			5.0			5.0	
Lane Util. Factor		1.00	1.00	1.00	1.00			1.00			1.00	
Frbp, ped/bikes		1.00	0.98	1.00	1.00			1.00			1.00	
Flpb, ped/bikes		1.00	1.00	1.00	1.00			1.00			1.00	
Frt		1.00	0.85	1.00	0.99			0.98			1.00	
Flt Protected		1.00	1.00	0.95	1.00			0.96			0.98	
Satd. Flow (prot)		1844	1531	1735	1815			1688			1818	
Flt Permitted		1.00	1.00	0.23	1.00			0.62			0.80	
Satd. Flow (perm)		1843	1531	419	1815			1095			1478	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	2	578	673	34	440	18	195	23	29	98	124	3
RTOR Reduction (vph)	0	0	155	0	1	0	0	5	0	0	1	0
Lane Group Flow (vph)	0	580	518	34	457	0	0	242	0	0	224	0
Confl. Peds. (#/hr)	3		3	2		2	3		2	2		3
Confl. Bikes (#/hr)									1			
Heavy Vehicles (%)	3%	3%	3%	4%	4%	4%	6%	6%	6%	2%	2%	2%
Turn Type	Perm	NA	Perm	pm+pt	NA		Perm	NA		Perm	NA	
Protected Phases		6		5	2			4			4	
Permitted Phases	6		6	2			4			4		
Actuated Green, G (s)		32.1	32.1	39.7	39.7			21.4			21.4	
Effective Green, g (s)		32.1	32.1	39.7	39.7			21.4			21.4	
Actuated g/C Ratio		0.45	0.45	0.56	0.56			0.30			0.30	
Clearance Time (s)		5.0	5.0	4.0	5.0			5.0			5.0	
Vehicle Extension (s)		3.0	3.0	3.0	3.0			3.0			3.0	
Lane Grp Cap (vph)		832	691	300	1013			329			444	
v/s Ratio Prot				0.01	c0.25							
v/s Ratio Perm		0.31	c0.34	0.06				c0.22			0.15	
v/c Ratio		0.70	0.75	0.11	0.45			0.74			0.51	
Uniform Delay, d1		15.6	16.2	9.3	9.3			22.3			20.5	
Progression Factor		1.00	1.00	1.00	1.00			1.00			1.00	
Incremental Delay, d2		2.6	4.5	0.2	0.3			8.3			0.9	
Delay (s)		18.2	20.6	9.5	9.6			30.6			21.4	
Level of Service		B	C	A	A			C			C	
Approach Delay (s)		19.5			9.6			30.6			21.4	
Approach LOS		B			A			C			C	

Intersection Summary

HCM 2000 Control Delay	18.7	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.76		
Actuated Cycle Length (s)	71.1	Sum of lost time (s)	16.0
Intersection Capacity Utilization	84.4%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Timing Report, Sorted By Phase
 3: Thoreau St/Nashawtuc Rd & Main Street

10/08/2019

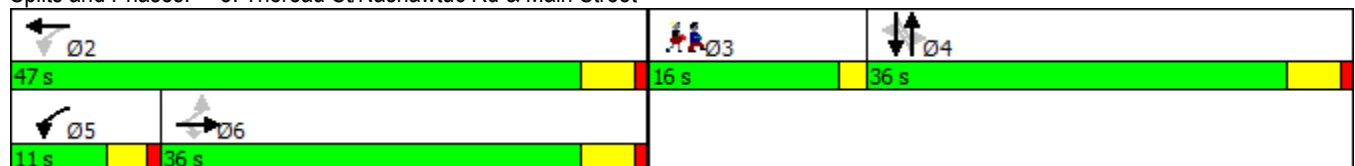


Phase Number	2	3	4	5	6
Movement	WBTL	Ped	NBSB	WBL	EBTL
Lead/Lag		Lead	Lag	Lead	Lag
Lead-Lag Optimize		Yes	Yes	Yes	Yes
Recall Mode	Min	None	None	None	Min
Maximum Split (s)	47	16	36	11	36
Maximum Split (%)	47.5%	16.2%	36.4%	11.1%	36.4%
Minimum Split (s)	23	16	23	9.5	23
Yellow Time (s)	4	2	4	3	4
All-Red Time (s)	1	0	1	1	1
Minimum Initial (s)	5	5	5	5	5
Vehicle Extension (s)	3	3	3	3	3
Minimum Gap (s)	3	3	3	3	3
Time Before Reduce (s)	0	0	0	0	0
Time To Reduce (s)	0	0	0	0	0
Walk Time (s)		5			
Flash Dont Walk (s)		9			
Dual Entry	Yes	No	Yes	No	Yes
Inhibit Max	Yes	Yes	Yes	Yes	Yes
Start Time (s)	0	47	63	0	11
End Time (s)	47	63	0	11	47
Yield/Force Off (s)	42	61	94	7	42
Yield/Force Off 170(s)	42	52	94	7	42
Local Start Time (s)	88	36	52	88	0
Local Yield (s)	31	50	83	95	31
Local Yield 170(s)	31	41	83	95	31

Intersection Summary

Cycle Length	99
Control Type	Actuated-Uncoordinated
Natural Cycle	90

Splits and Phases: 3: Thoreau St/Nashawtuc Rd & Main Street



Queues

7: Sudbury Rd & Thoreau St

10/08/2019



Lane Group	SET	SER	NWL	NWT	NET	SWL	SWT
Lane Group Flow (vph)	127	129	138	209	310	20	528
v/c Ratio	0.42	0.31	0.32	0.32	0.60	0.05	0.68
Control Delay	33.6	3.7	19.5	17.8	30.0	16.7	24.1
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	33.6	3.7	19.5	17.8	30.0	16.7	24.1
Queue Length 50th (ft)	41	0	30	43	80	4	151
Queue Length 95th (ft)	131	16	113	157	#376	25	#481
Internal Link Dist (ft)	659			610	500		1136
Turn Bay Length (ft)		75	80			80	
Base Capacity (vph)	571	618	473	1107	521	493	1115
Starvation Cap Reductn	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0
Reduced v/c Ratio	0.22	0.21	0.29	0.19	0.60	0.04	0.47

Intersection Summary

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

HCM Signalized Intersection Capacity Analysis

7: Sudbury Rd & Thoreau St

10/08/2019



Movement	SEL	SET	SER	NWL	NWT	NWR	NEL	NET	NER	SWL	SWT	SWR
Lane Configurations		↕	↕	↕	↕			↕		↕	↕	
Traffic Volume (vph)	21	96	119	127	158	34	56	200	29	18	447	39
Future Volume (vph)	21	96	119	127	158	34	56	200	29	18	447	39
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0	5.0	5.0	4.5			5.5		6.0	5.5	
Lane Util. Factor		1.00	1.00	1.00	1.00			1.00		1.00	1.00	
Frbp, ped/bikes		1.00	0.90	1.00	0.99			0.99		1.00	1.00	
Flpb, ped/bikes		0.99	1.00	0.99	1.00			1.00		1.00	1.00	
Frt		1.00	0.85	1.00	0.97			0.99		1.00	0.99	
Flt Protected		0.99	1.00	0.95	1.00			0.99		0.95	1.00	
Satd. Flow (prot)		1811	1414	1749	1797			1718		1744	1816	
Flt Permitted		0.90	1.00	0.48	1.00			0.82		0.43	1.00	
Satd. Flow (perm)		1652	1414	884	1797			1421		784	1816	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	23	104	129	138	172	37	61	217	32	20	486	42
RTOR Reduction (vph)	0	0	108	0	8	0	0	3	0	0	3	0
Lane Group Flow (vph)	0	127	21	138	201	0	0	307	0	20	525	0
Confl. Peds. (#/hr)	23		26	23		20	26		23	20		23
Confl. Bikes (#/hr)									1			
Heavy Vehicles (%)	3%	3%	3%	2%	2%	2%	7%	7%	7%	3%	3%	3%
Turn Type	Perm	NA	Perm	pm+pt	NA		Perm	NA		pm+pt	NA	
Protected Phases		2		1	6			8		7	4	
Permitted Phases	2		2	6			8			4		
Actuated Green, G (s)		11.8	11.8	24.3	24.3			23.8		31.9	31.9	
Effective Green, g (s)		11.8	11.8	24.3	24.3			23.8		31.9	31.9	
Actuated g/C Ratio		0.16	0.16	0.34	0.34			0.33		0.44	0.44	
Clearance Time (s)		5.0	5.0	5.0	4.5			5.5		6.0	5.5	
Vehicle Extension (s)		3.0	3.0	3.0	3.0			3.0		3.0	3.0	
Lane Grp Cap (vph)		268	230	379	602			466		372	799	
v/s Ratio Prot				0.04	c0.11					0.00	c0.29	
v/s Ratio Perm		c0.08	0.01	0.09				0.22		0.02		
v/c Ratio		0.47	0.09	0.36	0.33			0.66		0.05	0.66	
Uniform Delay, d1		27.5	25.8	17.6	18.0			20.9		12.8	16.0	
Progression Factor		1.00	1.00	1.00	1.00			1.00		1.00	1.00	
Incremental Delay, d2		1.3	0.2	0.6	0.3			3.3		0.1	2.0	
Delay (s)		28.9	26.0	18.2	18.4			24.2		12.9	18.0	
Level of Service		C	C	B	B			C		B	B	
Approach Delay (s)		27.4			18.3			24.2			17.8	
Approach LOS		C			B			C			B	

Intersection Summary

HCM 2000 Control Delay	20.9	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.63		
Actuated Cycle Length (s)	72.5	Sum of lost time (s)	25.5
Intersection Capacity Utilization	75.7%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

Timing Report, Sorted By Phase
7: Sudbury Rd & Thoreau St

10/08/2019

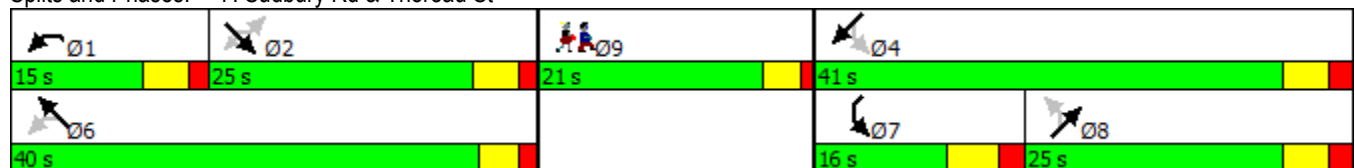


Phase Number	1	2	4	6	7	8	9
Movement	NWL	SETL	SWTL	NWTL	SWL	NETL	Ped
Lead/Lag	Lead	Lag			Lead	Lag	
Lead-Lag Optimize	Yes	Yes			Yes	Yes	
Recall Mode	None	Min	None	Min	None	None	None
Maximum Split (s)	15	25	41	40	16	25	21
Maximum Split (%)	14.7%	24.5%	40.2%	39.2%	15.7%	24.5%	20.6%
Minimum Split (s)	10	23	23.5	22.5	11	23.5	22
Yellow Time (s)	3.5	3.5	3.5	3	4	3.5	3
All-Red Time (s)	1.5	1.5	2	1.5	2	2	1
Minimum Initial (s)	5	5	5	5	5	5	5
Vehicle Extension (s)	3	3	3	3	3	3	3
Minimum Gap (s)	3	3	3	3	3	3	3
Time Before Reduce (s)	0	0	0	0	0	0	0
Time To Reduce (s)	0	0	0	0	0	0	0
Walk Time (s)							7
Flash Dont Walk (s)							11
Dual Entry	No	Yes	Yes	Yes	No	Yes	No
Inhibit Max	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Start Time (s)	0	15	61	0	61	77	40
End Time (s)	15	40	0	40	77	0	61
Yield/Force Off (s)	10	35	96.5	35.5	71	96.5	57
Yield/Force Off 170(s)	10	35	96.5	35.5	71	96.5	46
Local Start Time (s)	87	0	46	87	46	62	25
Local Yield (s)	97	20	81.5	20.5	56	81.5	42
Local Yield 170(s)	97	20	81.5	20.5	56	81.5	31

Intersection Summary

Cycle Length	102
Control Type	Actuated-Uncoordinated
Natural Cycle	90

Splits and Phases: 7: Sudbury Rd & Thoreau St



Queues

3: Thoreau St/Nashawtuc Rd & Main Street

10/03/2019



Lane Group	EBT	EBR	WBL	WBT	NBT	SBT
Lane Group Flow (vph)	441	257	60	711	506	72
v/c Ratio	0.67	0.41	0.20	0.86	0.90	0.12
Control Delay	29.4	12.4	14.3	33.2	43.3	14.9
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	29.4	12.4	14.3	33.2	43.3	14.9
Queue Length 50th (ft)	199	46	17	319	234	22
Queue Length 95th (ft)	305	109	34	407	#433	32
Internal Link Dist (ft)	682			827	446	549
Turn Bay Length (ft)		90	100			
Base Capacity (vph)	662	630	301	828	564	583
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.67	0.41	0.20	0.86	0.90	0.12

Intersection Summary

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

HCM Signalized Intersection Capacity Analysis

3: Thoreau St/Nashawtuc Rd & Main Street

10/03/2019



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↕	↗	↖	↗	↖		↕			↕	
Traffic Volume (vph)	4	398	234	49	575	8	410	31	39	20	25	0
Future Volume (vph)	4	398	234	49	575	8	410	31	39	20	25	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0	5.0	4.0	5.0			5.0			5.0	
Lane Util. Factor		1.00	1.00	1.00	1.00			1.00			1.00	
Frpb, ped/bikes		1.00	0.96	1.00	1.00			1.00			1.00	
Flpb, ped/bikes		1.00	1.00	1.00	1.00			0.99			1.00	
Frt		1.00	0.85	1.00	1.00			0.99			1.00	
Flt Protected		1.00	1.00	0.95	1.00			0.96			0.98	
Satd. Flow (prot)		1880	1540	1768	1858			1760			1719	
Flt Permitted		0.99	1.00	0.25	1.00			0.71			0.77	
Satd. Flow (perm)		1871	1540	473	1858			1298			1347	
Peak-hour factor, PHF	0.91	0.91	0.91	0.82	0.82	0.82	0.95	0.95	0.95	0.63	0.63	0.63
Adj. Flow (vph)	4	437	257	60	701	10	432	33	41	32	40	0
RTOR Reduction (vph)	0	0	88	0	1	0	0	3	0	0	0	0
Lane Group Flow (vph)	0	441	169	60	710	0	0	503	0	0	72	0
Confl. Peds. (#/hr)	6		12	11		5	12		11	5		6
Confl. Bikes (#/hr)									1			
Heavy Vehicles (%)	1%	1%	1%	2%	2%	2%	1%	1%	1%	8%	8%	8%
Turn Type	Perm	NA	Perm	pm+pt	NA		Perm	NA		Perm	NA	
Protected Phases		6		5	2			4			4	
Permitted Phases	6		6	2			4			4		
Actuated Green, G (s)		29.4	29.4	37.8	37.8			36.0			36.0	
Effective Green, g (s)		29.4	29.4	37.8	37.8			36.0			36.0	
Actuated g/C Ratio		0.35	0.35	0.45	0.45			0.43			0.43	
Clearance Time (s)		5.0	5.0	4.0	5.0			5.0			5.0	
Vehicle Extension (s)		3.0	3.0	3.0	3.0			3.0			3.0	
Lane Grp Cap (vph)		656	540	281	838			557			578	
v/s Ratio Prot				0.01	c0.38							
v/s Ratio Perm		0.24	0.11	0.08				c0.39			0.05	
v/c Ratio		0.67	0.31	0.21	0.85			0.90			0.12	
Uniform Delay, d1		23.1	19.8	14.8	20.4			22.3			14.4	
Progression Factor		1.00	1.00	1.00	1.00			1.00			1.00	
Incremental Delay, d2		2.7	0.3	0.4	8.0			18.0			0.1	
Delay (s)		25.8	20.2	15.2	28.4			40.2			14.5	
Level of Service		C	C	B	C			D			B	
Approach Delay (s)		23.7			27.4			40.2			14.5	
Approach LOS		C			C			D			B	

Intersection Summary

HCM 2000 Control Delay	28.9	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.95		
Actuated Cycle Length (s)	83.8	Sum of lost time (s)	16.0
Intersection Capacity Utilization	82.5%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Timing Report, Sorted By Phase

3: Thoreau St/Nashawtuc Rd & Main Street

10/03/2019

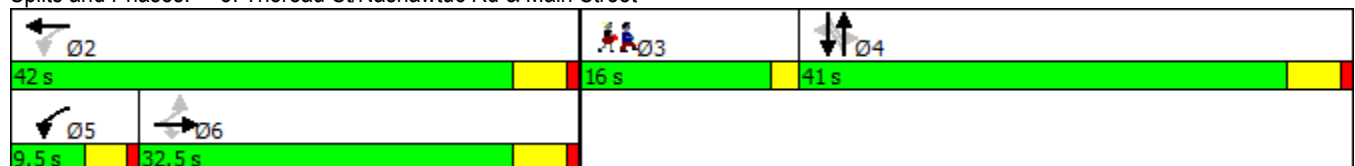


Phase Number	2	3	4	5	6
Movement	WBTL	Ped	NBSB	WBL	EBTL
Lead/Lag		Lead	Lag	Lead	Lag
Lead-Lag Optimize					
Recall Mode	Min	None	None	None	Min
Maximum Split (s)	42	16	41	9.5	32.5
Maximum Split (%)	42.4%	16.2%	41.4%	9.6%	32.8%
Minimum Split (s)	23	16	23	9.5	23
Yellow Time (s)	4	2	4	3	4
All-Red Time (s)	1	0	1	1	1
Minimum Initial (s)	5	1	5	5	5
Vehicle Extension (s)	3	3	3	3	3
Minimum Gap (s)	3	3	3	3	3
Time Before Reduce (s)	0	0	0	0	0
Time To Reduce (s)	0	0	0	0	0
Walk Time (s)		5			
Flash Dont Walk (s)		8			
Dual Entry	Yes	No	Yes	No	Yes
Inhibit Max	Yes	Yes	Yes	Yes	Yes
Start Time (s)	0	42	58	0	9.5
End Time (s)	42	58	0	9.5	42
Yield/Force Off (s)	37	56	94	5.5	37
Yield/Force Off 170(s)	37	48	94	5.5	37
Local Start Time (s)	89.5	32.5	48.5	89.5	0
Local Yield (s)	27.5	46.5	84.5	95	27.5
Local Yield 170(s)	27.5	38.5	84.5	95	27.5

Intersection Summary

Cycle Length	99
Control Type	Actuated-Uncoordinated
Natural Cycle	100

Splits and Phases: 3: Thoreau St/Nashawtuc Rd & Main Street



Queues

7: Sudbury Rd & Thoreau St

10/03/2019



Lane Group	SET	SER	NWL	NWT	NET	SWL	SWT
Lane Group Flow (vph)	280	127	38	271	700	35	251
v/c Ratio	0.80	0.29	0.16	0.50	0.98	0.09	0.26
Control Delay	61.2	10.5	31.8	34.9	62.8	20.4	19.1
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	61.2	10.5	31.8	34.9	62.8	20.4	19.1
Queue Length 50th (ft)	195	4	19	145	~562	11	85
Queue Length 95th (ft)	279	30	49	256	#760	42	218
Internal Link Dist (ft)	659			610	500		1136
Turn Bay Length (ft)		75	80			80	
Base Capacity (vph)	502	565	305	915	716	393	1086
Starvation Cap Reductn	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0
Reduced v/c Ratio	0.56	0.22	0.12	0.30	0.98	0.09	0.23

Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.

Queue shown is maximum after two cycles.




















95th percentile volume exceeds capacity, queue may be longer.

Queue shown is maximum after two cycles.

HCM Signalized Intersection Capacity Analysis

7: Sudbury Rd & Thoreau St

10/03/2019

														
Movement	SEL	SET	SER	NWL	NWT	NWR	NEL	NET	NER	SWL	SWT	SWR		
Lane Configurations														
Traffic Volume (vph)	56	148	93	32	175	55	112	343	35	34	199	45		
Future Volume (vph)	56	148	93	32	175	55	112	343	35	34	199	45		
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900		
Total Lost time (s)		5.0	5.0	5.0	4.5			5.5		6.0	5.5			
Lane Util. Factor		1.00	1.00	1.00	1.00			1.00		1.00	1.00			
Frpb, ped/bikes		1.00	0.91	1.00	0.98			1.00		1.00	0.99			
Flpb, ped/bikes		0.99	1.00	0.99	1.00			0.99		1.00	1.00			
Frt		1.00	0.85	1.00	0.96			0.99		1.00	0.97			
Flt Protected		0.99	1.00	0.95	1.00			0.99		0.95	1.00			
Satd. Flow (prot)		1795	1424	1757	1762			1721		1748	1778			
Flt Permitted		0.81	1.00	0.28	1.00			0.85		0.32	1.00			
Satd. Flow (perm)		1475	1424	514	1762			1475		591	1778			
Peak-hour factor, PHF	0.73	0.73	0.73	0.85	0.85	0.85	0.70	0.70	0.70	0.97	0.97	0.97		
Adj. Flow (vph)	77	203	127	38	206	65	160	490	50	35	205	46		
RTOR Reduction (vph)	0	0	93	0	8	0	0	2	0	0	4	0		
Lane Group Flow (vph)	0	280	34	38	263	0	0	698	0	35	247	0		
Confl. Peds. (#/hr)	33		33	36		36	33		36	36		33		
Confl. Bikes (#/hr)									1					
Heavy Vehicles (%)	3%	3%	3%	2%	2%	2%	7%	7%	7%	3%	3%	3%		
Turn Type	Perm	NA	Perm	pm+pt	NA		Perm	NA		pm+pt	NA			
Protected Phases		2		1	6			8		7	4			
Permitted Phases	2		2	6			8			4				
Actuated Green, G (s)		27.1	27.1	36.9	36.9			55.3		64.9	64.9			
Effective Green, g (s)		27.1	27.1	36.9	36.9			55.3		64.9	64.9			
Actuated g/C Ratio		0.23	0.23	0.31	0.31			0.46		0.54	0.54			
Clearance Time (s)		5.0	5.0	5.0	4.5			5.5		6.0	5.5			
Vehicle Extension (s)		3.0	3.0	3.0	3.0			3.0		3.0	3.0			
Lane Grp Cap (vph)		331	320	201	540			677		353	958			
v/s Ratio Prot				0.01	c0.15					0.00	c0.14			
v/s Ratio Perm		c0.19	0.02	0.05				c0.47		0.05				
v/c Ratio		0.85	0.11	0.19	0.49			1.03		0.10	0.26			
Uniform Delay, d1		44.7	37.0	30.9	34.0			32.6		16.6	14.9			
Progression Factor		1.00	1.00	1.00	1.00			1.00		1.00	1.00			
Incremental Delay, d2		17.7	0.1	0.5	0.7			42.9		0.1	0.1			
Delay (s)		62.3	37.2	31.3	34.7			75.5		16.8	15.0			
Level of Service		E	D	C	C			E		B	B			
Approach Delay (s)		54.5			34.3			75.5			15.2			
Approach LOS		D			C			E			B			
Intersection Summary														
HCM 2000 Control Delay			52.9									HCM 2000 Level of Service	D	
HCM 2000 Volume to Capacity ratio			0.89											
Actuated Cycle Length (s)			120.4								24.5			
Intersection Capacity Utilization			81.6%										ICU Level of Service	D
Analysis Period (min)			15											
c	Critical Lane Group													

Timing Report, Sorted By Phase

7: Sudbury Rd & Thoreau St

10/03/2019

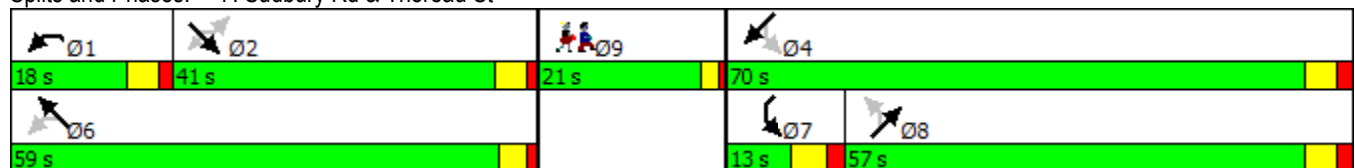


Phase Number	1	2	4	6	7	8	9
Movement	NWL	SETL	SWTL	NWTL	SWL	NETL	Ped
Lead/Lag	Lead	Lag			Lead	Lag	
Lead-Lag Optimize							
Recall Mode	None	Min	None	Min	None	None	None
Maximum Split (s)	18	41	70	59	13	57	21
Maximum Split (%)	12.0%	27.3%	46.7%	39.3%	8.7%	38.0%	14.0%
Minimum Split (s)	11	11	12	10.5	12	12	21
Yellow Time (s)	3.5	3.5	3.5	3	4	3.5	2
All-Red Time (s)	1.5	1.5	2	1.5	2	2	1
Minimum Initial (s)	6	6	6	6	6	6	5
Vehicle Extension (s)	3	3	3	3	3	3	3
Minimum Gap (s)	3	3	3	3	3	3	3
Time Before Reduce (s)	0	0	0	0	0	0	0
Time To Reduce (s)	0	0	0	0	0	0	0
Walk Time (s)							7
Flash Dont Walk (s)							11
Dual Entry	No	Yes	Yes	Yes	No	Yes	No
Inhibit Max	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Start Time (s)	0	18	80	0	80	93	59
End Time (s)	18	59	0	59	93	0	80
Yield/Force Off (s)	13	54	144.5	54.5	87	144.5	77
Yield/Force Off 170(s)	13	54	144.5	54.5	87	144.5	66
Local Start Time (s)	132	0	62	132	62	75	41
Local Yield (s)	145	36	126.5	36.5	69	126.5	59
Local Yield 170(s)	145	36	126.5	36.5	69	126.5	48

Intersection Summary

Cycle Length	150
Control Type	Actuated-Uncoordinated
Natural Cycle	150

Splits and Phases: 7: Sudbury Rd & Thoreau St



Queues

3: Thoreau St/Nashawtuc Rd & Main Street

10/04/2019



Lane Group	EBT	EBR	WBL	WBT	NBT	SBT
Lane Group Flow (vph)	309	945	34	458	247	225
v/c Ratio	0.38	0.86	0.06	0.48	0.70	0.49
Control Delay	17.5	15.5	9.2	13.1	32.7	23.5
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	17.5	15.5	9.2	13.1	32.7	23.5
Queue Length 50th (ft)	98	61	6	115	98	84
Queue Length 95th (ft)	190	#427	22	228	178	146
Internal Link Dist (ft)	682			827	446	549
Turn Bay Length (ft)		90	100			
Base Capacity (vph)	911	1133	550	1208	550	730
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.34	0.83	0.06	0.38	0.45	0.31

Intersection Summary

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

HCM Signalized Intersection Capacity Analysis

3: Thoreau St/Nashawtuc Rd & Main Street

10/04/2019



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↖	↗	↖	↗			↕			↕	
Traffic Volume (vph)	2	282	869	31	405	17	179	21	27	90	114	3
Future Volume (vph)	2	282	869	31	405	17	179	21	27	90	114	3
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0	5.0	4.0	5.0			5.0			5.0	
Lane Util. Factor		1.00	1.00	1.00	1.00			1.00			1.00	
Frbp, ped/bikes		1.00	0.98	1.00	1.00			1.00			1.00	
Flpb, ped/bikes		1.00	1.00	1.00	1.00			1.00			1.00	
Frt		1.00	0.85	1.00	0.99			0.98			1.00	
Flt Protected		1.00	1.00	0.95	1.00			0.96			0.98	
Satd. Flow (prot)		1844	1531	1735	1815			1688			1818	
Flt Permitted		1.00	1.00	0.45	1.00			0.63			0.79	
Satd. Flow (perm)		1841	1531	829	1815			1103			1475	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	2	307	945	34	440	18	195	23	29	98	124	3
RTOR Reduction (vph)	0	0	420	0	1	0	0	5	0	0	1	0
Lane Group Flow (vph)	0	309	525	34	457	0	0	242	0	0	224	0
Confl. Peds. (#/hr)	3		3	2		2	3		2	2		3
Confl. Bikes (#/hr)									1			
Heavy Vehicles (%)	3%	3%	3%	4%	4%	4%	6%	6%	6%	2%	2%	2%
Turn Type	Perm	NA	Perm	pm+pt	NA		Perm	NA		Perm	NA	
Protected Phases		6		5	2			4			4	
Permitted Phases	6		6	2			4			4		
Actuated Green, G (s)		29.8	29.8	37.3	37.3			21.1			21.1	
Effective Green, g (s)		29.8	29.8	37.3	37.3			21.1			21.1	
Actuated g/C Ratio		0.44	0.44	0.55	0.55			0.31			0.31	
Clearance Time (s)		5.0	5.0	4.0	5.0			5.0			5.0	
Vehicle Extension (s)		3.0	3.0	3.0	3.0			3.0			3.0	
Lane Grp Cap (vph)		802	667	498	989			340			455	
v/s Ratio Prot				0.00	c0.25							
v/s Ratio Perm		0.17	c0.34	0.03				c0.22			0.15	
v/c Ratio		0.39	0.79	0.07	0.46			0.71			0.49	
Uniform Delay, d1		13.1	16.6	7.6	9.4			21.0			19.3	
Progression Factor		1.00	1.00	1.00	1.00			1.00			1.00	
Incremental Delay, d2		0.3	6.1	0.1	0.3			6.9			0.8	
Delay (s)		13.4	22.7	7.6	9.8			27.9			20.1	
Level of Service		B	C	A	A			C			C	
Approach Delay (s)		20.4			9.6			27.9			20.1	
Approach LOS		C			A			C			C	

Intersection Summary

HCM 2000 Control Delay	18.8	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.78		
Actuated Cycle Length (s)	68.4	Sum of lost time (s)	16.0
Intersection Capacity Utilization	99.9%	ICU Level of Service	F
Analysis Period (min)	15		
c Critical Lane Group			

Timing Report, Sorted By Phase

3: Thoreau St/Nashawtuc Rd & Main Street

10/04/2019

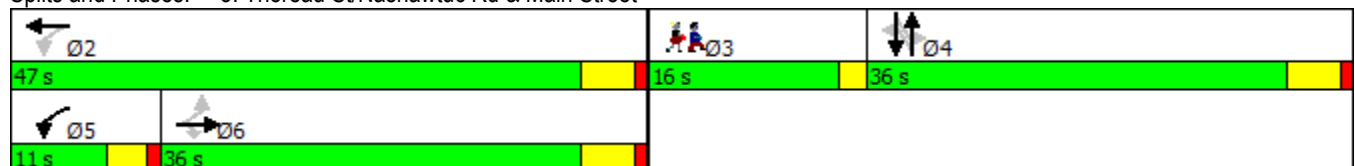


Phase Number	2	3	4	5	6
Movement	WBTL	Ped	NBSB	WBL	EBTL
Lead/Lag		Lead	Lag	Lead	Lag
Lead-Lag Optimize		Yes	Yes	Yes	Yes
Recall Mode	Min	None	None	None	Min
Maximum Split (s)	47	16	36	11	36
Maximum Split (%)	47.5%	16.2%	36.4%	11.1%	36.4%
Minimum Split (s)	23	16	23	9.5	23
Yellow Time (s)	4	2	4	3	4
All-Red Time (s)	1	0	1	1	1
Minimum Initial (s)	5	5	5	5	5
Vehicle Extension (s)	3	3	3	3	3
Minimum Gap (s)	3	3	3	3	3
Time Before Reduce (s)	0	0	0	0	0
Time To Reduce (s)	0	0	0	0	0
Walk Time (s)		5			
Flash Dont Walk (s)		9			
Dual Entry	Yes	No	Yes	No	Yes
Inhibit Max	Yes	Yes	Yes	Yes	Yes
Start Time (s)	0	47	63	0	11
End Time (s)	47	63	0	11	47
Yield/Force Off (s)	42	61	94	7	42
Yield/Force Off 170(s)	42	52	94	7	42
Local Start Time (s)	88	36	52	88	0
Local Yield (s)	31	50	83	95	31
Local Yield 170(s)	31	41	83	95	31

Intersection Summary

Cycle Length	99
Control Type	Actuated-Uncoordinated
Natural Cycle	90

Splits and Phases: 3: Thoreau St/Nashawtuc Rd & Main Street



Queues

7: Sudbury Rd & Thoreau St

10/04/2019



Lane Group	SET	SER	NWL	NWT	NET	SWL	SWT
Lane Group Flow (vph)	399	129	138	209	310	20	528
v/c Ratio	0.81	0.25	0.46	0.26	1.03	0.06	0.84
Control Delay	47.3	3.3	23.5	18.1	93.5	22.3	40.2
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	47.3	3.3	23.5	18.1	93.5	22.3	40.2
Queue Length 50th (ft)	170	0	35	51	124	6	209
Queue Length 95th (ft)	#471	21	109	151	#451	26	#509
Internal Link Dist (ft)	659			610	500		1136
Turn Bay Length (ft)		75	80			80	
Base Capacity (vph)	491	522	326	846	302	328	783
Starvation Cap Reductn	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0
Reduced v/c Ratio	0.81	0.25	0.42	0.25	1.03	0.06	0.67




















Intersection Summary

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

HCM Signalized Intersection Capacity Analysis

7: Sudbury Rd & Thoreau St

10/04/2019

												
Movement	SEL	SET	SER	NWL	NWT	NWR	NEL	NET	NER	SWL	SWT	SWR
Lane Configurations												
Traffic Volume (vph)	21	346	119	127	158	34	56	200	29	18	447	39
Future Volume (vph)	21	346	119	127	158	34	56	200	29	18	447	39
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0	5.0	5.0	4.5			5.5		6.0	5.5	
Lane Util. Factor		1.00	1.00	1.00	1.00			1.00		1.00	1.00	
Frbp, ped/bikes		1.00	0.93	1.00	0.99			0.99		1.00	1.00	
Flpb, ped/bikes		1.00	1.00	1.00	1.00			1.00		1.00	1.00	
Frt		1.00	0.85	1.00	0.97			0.99		1.00	0.99	
Flt Protected		1.00	1.00	0.95	1.00			0.99		0.95	1.00	
Satd. Flow (prot)		1836	1460	1767	1799			1717		1744	1815	
Flt Permitted		0.97	1.00	0.18	1.00			0.58		0.38	1.00	
Satd. Flow (perm)		1792	1460	337	1799			1013		703	1815	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	23	376	129	138	172	37	61	217	32	20	486	42
RTOR Reduction (vph)	0	0	96	0	7	0	0	4	0	0	3	0
Lane Group Flow (vph)	0	399	33	138	202	0	0	306	0	20	525	0
Confl. Peds. (#/hr)	23		26	23		20	26		23	20		23
Confl. Bikes (#/hr)									1			
Heavy Vehicles (%)	3%	3%	3%	2%	2%	2%	7%	7%	7%	3%	3%	3%
Turn Type	Perm	NA	Perm	pm+pt	NA		Perm	NA		pm+pt	NA	
Protected Phases		2		1	6			8		7	4	
Permitted Phases	2		2	6			8			4		
Actuated Green, G (s)		23.1	23.1	37.4	37.4			24.6		32.8	32.8	
Effective Green, g (s)		23.1	23.1	37.4	37.4			24.6		32.8	32.8	
Actuated g/C Ratio		0.26	0.26	0.42	0.42			0.28		0.37	0.37	
Clearance Time (s)		5.0	5.0	5.0	4.5			5.5		6.0	5.5	
Vehicle Extension (s)		3.0	3.0	3.0	3.0			3.0		3.0	3.0	
Lane Grp Cap (vph)		465	378	283	755			279		284	668	
v/s Ratio Prot				c0.05	0.11					0.00	c0.29	
v/s Ratio Perm		c0.22	0.02	0.16				c0.30		0.02		
v/c Ratio		0.86	0.09	0.49	0.27			1.10		0.07	0.79	
Uniform Delay, d1		31.4	25.0	18.5	16.9			32.2		19.6	25.0	
Progression Factor		1.00	1.00	1.00	1.00			1.00		1.00	1.00	
Incremental Delay, d2		14.5	0.1	1.3	0.2			82.7		0.1	6.1	
Delay (s)		45.9	25.1	19.9	17.0			114.9		19.7	31.0	
Level of Service		D	C	B	B			F		B	C	
Approach Delay (s)		40.8			18.2			114.9			30.6	
Approach LOS		D			B			F			C	
Intersection Summary												
HCM 2000 Control Delay			46.3			HCM 2000 Level of Service				D		
HCM 2000 Volume to Capacity ratio			0.86									
Actuated Cycle Length (s)			89.0			Sum of lost time (s)			24.5			
Intersection Capacity Utilization			88.8%			ICU Level of Service				E		
Analysis Period (min)			15									
c Critical Lane Group												

Timing Report, Sorted By Phase
7: Sudbury Rd & Thoreau St

10/04/2019

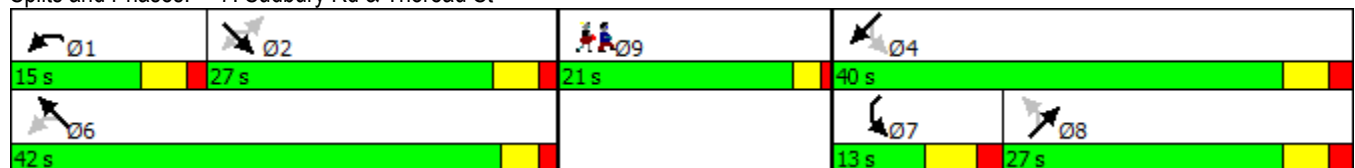


Phase Number	1	2	4	6	7	8	9
Movement	NWL	SETL	SWTL	NWTL	SWL	NETL	Ped
Lead/Lag	Lead	Lag			Lead	Lag	
Lead-Lag Optimize	Yes	Yes			Yes	Yes	
Recall Mode	None	Min	None	Min	None	None	None
Maximum Split (s)	15	27	40	42	13	27	21
Maximum Split (%)	14.6%	26.2%	38.8%	40.8%	12.6%	26.2%	20.4%
Minimum Split (s)	10	23	23.5	22.5	11	23.5	21
Yellow Time (s)	3.5	3.5	3.5	3	4	3.5	2
All-Red Time (s)	1.5	1.5	2	1.5	2	2	1
Minimum Initial (s)	5	5	5	5	5	5	5
Vehicle Extension (s)	3	3	3	3	3	3	3
Minimum Gap (s)	3	3	3	3	3	3	3
Time Before Reduce (s)	0	0	0	0	0	0	0
Time To Reduce (s)	0	0	0	0	0	0	0
Walk Time (s)							7
Flash Dont Walk (s)							11
Dual Entry	No	Yes	Yes	Yes	No	Yes	No
Inhibit Max	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Start Time (s)	0	15	63	0	63	76	42
End Time (s)	15	42	0	42	76	0	63
Yield/Force Off (s)	10	37	97.5	37.5	70	97.5	60
Yield/Force Off 170(s)	10	37	97.5	37.5	70	97.5	49
Local Start Time (s)	88	0	48	88	48	61	27
Local Yield (s)	98	22	82.5	22.5	55	82.5	45
Local Yield 170(s)	98	22	82.5	22.5	55	82.5	34

Intersection Summary

Cycle Length	103
Control Type	Actuated-Uncoordinated
Natural Cycle	100

Splits and Phases: 7: Sudbury Rd & Thoreau St



Queues

3: Thoreau St/Nashawtuc Rd & Main Street

10/04/2019



Lane Group	EBT	EBR	WBL	WBT	NBT	SBT
Lane Group Flow (vph)	408	290	60	711	506	72
v/c Ratio	0.62	0.45	0.18	0.86	0.90	0.12
Control Delay	27.9	11.9	14.1	33.2	43.3	14.9
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	27.9	11.9	14.1	33.2	43.3	14.9
Queue Length 50th (ft)	179	47	17	319	234	22
Queue Length 95th (ft)	278	115	34	407	#433	32
Internal Link Dist (ft)	682			827	446	549
Turn Bay Length (ft)		90	100			
Base Capacity (vph)	662	649	326	828	564	583
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.62	0.45	0.18	0.86	0.90	0.12

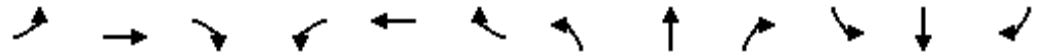
Intersection Summary

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

HCM Signalized Intersection Capacity Analysis

3: Thoreau St/Nashawtuc Rd & Main Street

10/04/2019



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↕	↗	↖	↗	↖		↕			↕	
Traffic Volume (vph)	4	368	264	49	575	8	410	31	39	20	25	0
Future Volume (vph)	4	368	264	49	575	8	410	31	39	20	25	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0	5.0	4.0	5.0			5.0			5.0	
Lane Util. Factor		1.00	1.00	1.00	1.00			1.00			1.00	
Frbp, ped/bikes		1.00	0.96	1.00	1.00			1.00			1.00	
Flpb, ped/bikes		1.00	1.00	1.00	1.00			0.99			1.00	
Frt		1.00	0.85	1.00	1.00			0.99			1.00	
Flt Protected		1.00	1.00	0.95	1.00			0.96			0.98	
Satd. Flow (prot)		1880	1540	1767	1858			1760			1719	
Flt Permitted		0.99	1.00	0.29	1.00			0.71			0.77	
Satd. Flow (perm)		1870	1540	537	1858			1298			1347	
Peak-hour factor, PHF	0.91	0.91	0.91	0.82	0.82	0.82	0.95	0.95	0.95	0.63	0.63	0.63
Adj. Flow (vph)	4	404	290	60	701	10	432	33	41	32	40	0
RTOR Reduction (vph)	0	0	107	0	1	0	0	3	0	0	0	0
Lane Group Flow (vph)	0	408	183	60	710	0	0	503	0	0	72	0
Confl. Peds. (#/hr)	6		12	11		5	12		11	5		6
Confl. Bikes (#/hr)									1			
Heavy Vehicles (%)	1%	1%	1%	2%	2%	2%	1%	1%	1%	8%	8%	8%
Turn Type	Perm	NA	Perm	pm+pt	NA		Perm	NA		Perm	NA	
Protected Phases		6		5	2			4			4	
Permitted Phases	6		6	2			4			4		
Actuated Green, G (s)		29.4	29.4	37.8	37.8			36.0			36.0	
Effective Green, g (s)		29.4	29.4	37.8	37.8			36.0			36.0	
Actuated g/C Ratio		0.35	0.35	0.45	0.45			0.43			0.43	
Clearance Time (s)		5.0	5.0	4.0	5.0			5.0			5.0	
Vehicle Extension (s)		3.0	3.0	3.0	3.0			3.0			3.0	
Lane Grp Cap (vph)		656	540	306	838			557			578	
v/s Ratio Prot				0.01	c0.38							
v/s Ratio Perm		0.22	0.12	0.08				c0.39			0.05	
v/c Ratio		0.62	0.34	0.20	0.85			0.90			0.12	
Uniform Delay, d1		22.6	20.0	14.5	20.4			22.3			14.4	
Progression Factor		1.00	1.00	1.00	1.00			1.00			1.00	
Incremental Delay, d2		1.8	0.4	0.3	8.0			18.0			0.1	
Delay (s)		24.4	20.4	14.8	28.4			40.2			14.5	
Level of Service		C	C	B	C			D			B	
Approach Delay (s)		22.8			27.4			40.2			14.5	
Approach LOS		C			C			D			B	

Intersection Summary		
HCM 2000 Control Delay	28.5	HCM 2000 Level of Service
HCM 2000 Volume to Capacity ratio	0.95	C
Actuated Cycle Length (s)	83.8	Sum of lost time (s)
Intersection Capacity Utilization	82.5%	16.0
Analysis Period (min)	15	ICU Level of Service
		E
c Critical Lane Group		

Timing Report, Sorted By Phase

3: Thoreau St/Nashawtuc Rd & Main Street

10/04/2019

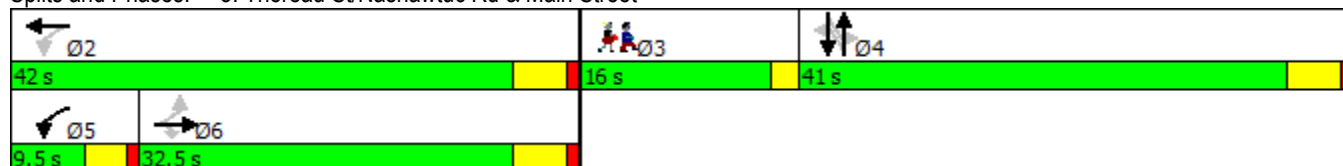


Phase Number	2	3	4	5	6
Movement	WBTL	Ped	NBSB	WBL	EBTL
Lead/Lag		Lead	Lag	Lead	Lag
Lead-Lag Optimize					
Recall Mode	Min	None	None	None	Min
Maximum Split (s)	42	16	41	9.5	32.5
Maximum Split (%)	42.4%	16.2%	41.4%	9.6%	32.8%
Minimum Split (s)	23	16	23	9.5	23
Yellow Time (s)	4	2	4	3	4
All-Red Time (s)	1	0	1	1	1
Minimum Initial (s)	5	1	5	5	5
Vehicle Extension (s)	3	3	3	3	3
Minimum Gap (s)	3	3	3	3	3
Time Before Reduce (s)	0	0	0	0	0
Time To Reduce (s)	0	0	0	0	0
Walk Time (s)		5			
Flash Dont Walk (s)		8			
Dual Entry	Yes	No	Yes	No	Yes
Inhibit Max	Yes	Yes	Yes	Yes	Yes
Start Time (s)	0	42	58	0	9.5
End Time (s)	42	58	0	9.5	42
Yield/Force Off (s)	37	56	94	5.5	37
Yield/Force Off 170(s)	37	48	94	5.5	37
Local Start Time (s)	89.5	32.5	48.5	89.5	0
Local Yield (s)	27.5	46.5	84.5	95	27.5
Local Yield 170(s)	27.5	38.5	84.5	95	27.5

Intersection Summary

Cycle Length	99
Control Type	Actuated-Uncoordinated
Natural Cycle	100

Splits and Phases: 3: Thoreau St/Nashawtuc Rd & Main Street



Queues

7: Sudbury Rd & Thoreau St

10/04/2019



Lane Group	SET	SER	NWL	NWT	NET	SWL	SWT
Lane Group Flow (vph)	321	127	38	271	700	35	251
v/c Ratio	0.81	0.27	0.17	0.47	1.01	0.09	0.27
Control Delay	59.5	9.9	30.6	33.0	72.2	22.0	20.7
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	59.5	9.9	30.6	33.0	72.2	22.0	20.7
Queue Length 50th (ft)	226	4	18	143	~589	12	90
Queue Length 95th (ft)	313	29	48	252	#793	44	229
Internal Link Dist (ft)	659			610	500		1136
Turn Bay Length (ft)		75	80			80	
Base Capacity (vph)	572	613	265	920	693	378	1055
Starvation Cap Reductn	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0
Reduced v/c Ratio	0.56	0.21	0.14	0.29	1.01	0.09	0.24

Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.

Queue shown is maximum after two cycles.




















95th percentile volume exceeds capacity, queue may be longer.

Queue shown is maximum after two cycles.

HCM Signalized Intersection Capacity Analysis

7: Sudbury Rd & Thoreau St

10/04/2019

												
Movement	SEL	SET	SER	NWL	NWT	NWR	NEL	NET	NER	SWL	SWT	SWR
Lane Configurations												
Traffic Volume (vph)	56	178	93	32	175	55	112	343	35	34	199	45
Future Volume (vph)	56	178	93	32	175	55	112	343	35	34	199	45
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0	5.0	5.0	4.5			5.5		6.0	5.5	
Lane Util. Factor		1.00	1.00	1.00	1.00			1.00		1.00	1.00	
Frbp, ped/bikes		1.00	0.91	1.00	0.98			1.00		1.00	0.99	
Flpb, ped/bikes		0.99	1.00	0.99	1.00			0.99		1.00	1.00	
Frt		1.00	0.85	1.00	0.96			0.99		1.00	0.97	
Flt Protected		0.99	1.00	0.95	1.00			0.99		0.95	1.00	
Satd. Flow (prot)		1803	1433	1760	1764			1721		1748	1777	
Flt Permitted		0.84	1.00	0.25	1.00			0.85		0.32	1.00	
Satd. Flow (perm)		1535	1433	455	1764			1474		582	1777	
Peak-hour factor, PHF	0.73	0.73	0.73	0.85	0.85	0.85	0.70	0.70	0.70	0.97	0.97	0.97
Adj. Flow (vph)	77	244	127	38	206	65	160	490	50	35	205	46
RTOR Reduction (vph)	0	0	91	0	8	0	0	2	0	0	4	0
Lane Group Flow (vph)	0	321	36	38	263	0	0	698	0	35	247	0
Confl. Peds. (#/hr)	33		33	36		36	33		36	36		33
Confl. Bikes (#/hr)									1			
Heavy Vehicles (%)	3%	3%	3%	2%	2%	2%	7%	7%	7%	3%	3%	3%
Turn Type	Perm	NA	Perm	pm+pt	NA		Perm	NA		pm+pt	NA	
Protected Phases		2		1	6			8		7	4	
Permitted Phases	2		2	6			8			4		
Actuated Green, G (s)		29.9	29.9	39.6	39.6			54.4		64.0	64.0	
Effective Green, g (s)		29.9	29.9	39.6	39.6			54.4		64.0	64.0	
Actuated g/C Ratio		0.24	0.24	0.32	0.32			0.45		0.52	0.52	
Clearance Time (s)		5.0	5.0	5.0	4.5			5.5		6.0	5.5	
Vehicle Extension (s)		3.0	3.0	3.0	3.0			3.0		3.0	3.0	
Lane Grp Cap (vph)		375	350	192	571			656		339	930	
v/s Ratio Prot				0.01	c0.15					0.00	c0.14	
v/s Ratio Perm		c0.21	0.03	0.06				c0.47		0.05		
v/c Ratio		0.86	0.10	0.20	0.46			1.06		0.10	0.27	
Uniform Delay, d1		44.1	35.8	30.2	32.8			33.9		18.0	16.1	
Progression Factor		1.00	1.00	1.00	1.00			1.00		1.00	1.00	
Incremental Delay, d2		17.1	0.1	0.5	0.6			53.6		0.1	0.2	
Delay (s)		61.2	35.9	30.7	33.4			87.5		18.1	16.2	
Level of Service		E	D	C	C			F		B	B	
Approach Delay (s)		54.1			33.1			87.5			16.5	
Approach LOS		D			C			F			B	
Intersection Summary												
HCM 2000 Control Delay			57.6			HCM 2000 Level of Service				E		
HCM 2000 Volume to Capacity ratio			0.90									
Actuated Cycle Length (s)			122.2			Sum of lost time (s)			24.5			
Intersection Capacity Utilization			83.2%			ICU Level of Service				E		
Analysis Period (min)			15									
c Critical Lane Group												

Timing Report, Sorted By Phase

7: Sudbury Rd & Thoreau St

10/04/2019

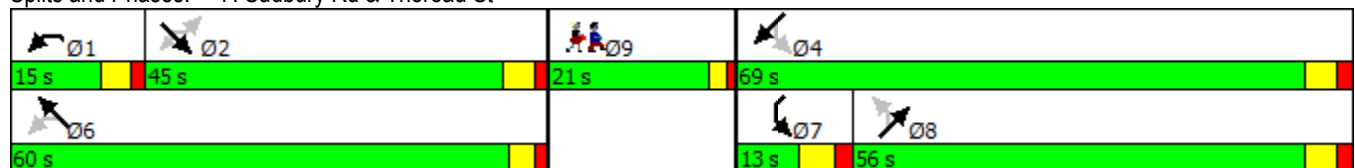


Phase Number	1	2	4	6	7	8	9
Movement	NWL	SETL	SWTL	NWTL	SWL	NETL	Ped
Lead/Lag	Lead	Lag			Lead	Lag	
Lead-Lag Optimize							
Recall Mode	None	Min	None	Min	None	None	None
Maximum Split (s)	15	45	69	60	13	56	21
Maximum Split (%)	10.0%	30.0%	46.0%	40.0%	8.7%	37.3%	14.0%
Minimum Split (s)	11	11	12	10.5	12	12	21
Yellow Time (s)	3.5	3.5	3.5	3	4	3.5	2
All-Red Time (s)	1.5	1.5	2	1.5	2	2	1
Minimum Initial (s)	6	6	6	6	6	6	5
Vehicle Extension (s)	3	3	3	3	3	3	3
Minimum Gap (s)	3	3	3	3	3	3	3
Time Before Reduce (s)	0	0	0	0	0	0	0
Time To Reduce (s)	0	0	0	0	0	0	0
Walk Time (s)							7
Flash Dont Walk (s)							11
Dual Entry	No	Yes	Yes	Yes	No	Yes	No
Inhibit Max	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Start Time (s)	0	15	81	0	81	94	60
End Time (s)	15	60	0	60	94	0	81
Yield/Force Off (s)	10	55	144.5	55.5	88	144.5	78
Yield/Force Off 170(s)	10	55	144.5	55.5	88	144.5	67
Local Start Time (s)	135	0	66	135	66	79	45
Local Yield (s)	145	40	129.5	40.5	73	129.5	63
Local Yield 170(s)	145	40	129.5	40.5	73	129.5	52

Intersection Summary

Cycle Length	150
Control Type	Actuated-Uncoordinated
Natural Cycle	150

Splits and Phases: 7: Sudbury Rd & Thoreau St



Appendix I. Neighborhood Petitions

Attachment B: Cut-through Traffic Neighborhood Petition Form (Page 1)



Please fill out this form and return with attached sheets to:

Concord Police Department
Community Safety Officer
219 Walden Street, P.O. Box 519
Concord, MA. 01742
Fax: 978-369-8420

THE UNDERSIGNED AGREE TO THE FOLLOWING:

1. All persons signing this petition do hereby certify that they own property or reside within the following area: _____

2. All persons signing this petition do hereby agree to the following problem in the defined area:

3. All persons signing this petition do hereby agree that the following contact person(s) represents the neighborhood in matters pertaining to items 1 and 2 above:

Name of key contact person #1 (please print): _____

Address, City, and Zip Code: _____

Telephone (day): _____ E-mail: _____

Name of key contact person #2 (optional) (please print): _____

Address, City, and Zip Code: _____

Telephone (day): _____ E-mail: _____

Date Submitted: _____

(Please attach additional pages if necessary to discuss the request.)

Attachment B: Cut-through Traffic Neighborhood Petition Form (Page 1)



Please fill out this form and return with attached sheets to:

Concord Police Department
Community Safety Officer
219 Walden Street, P.O. Box 519
Concord, MA. 01742
Fax: 978-369-8420

THE UNDERSIGNED AGREE TO THE FOLLOWING:

1. All persons signing this petition do hereby certify that they own property or reside within the following area:

Hillside Avenue Neighborhood which extends from Laws Brook Road and along Old Stow Road ending at Main Street. This neighborhood is further defined and inclusive of Summit Street, Hill Street, Bluejay Drive, Buck Master Drive and Old Stow Road.

2. All persons signing this petition do hereby agree to the following problem in the defined area:

As part of study conducted by the town Hillside Avenue has been identified as a street that is experiencing increased traffic volume from vehicles using the street as a cut-through. In order to avoid using Laws Brook Road to access Main Street, vehicles cut across Hillside and Old Stow to reach Main Street.

The attached map identifies a measure to address and limit the cut-through traffic. The measures proposed on the map account for the possibility of traffic shifting to other neighborhood streets as a result of the restricting traffic at Hillside Avenue. The map also identifies an area of influence, showing other streets that could be impacted. A 75% approval for the identified measure within the area of influence.

Attachment B: Cut-through Traffic Neighborhood Petition Form (Page 2)

3. All persons signing this petition do hereby agree that the following contact person(s) represents the neighborhood in matters pertaining to items 1 and 2 above:

Name of key contact person #1 (please print): _____

Address, City, and Zip Code: _____

Telephone (day): _____ E-mail: _____

Name of key contact person #2 (optional) (please print): _____

Address, City, and Zip Code: _____

Telephone (day): _____ E-mail: _____

Date Submitted: _____

(Please attach additional pages if necessary to discuss the request.)

Attachment B: Cut-through Traffic Neighborhood Petition Form (Page 1)



Please fill out this form and return with attached sheets to:

Concord Police Department
Community Safety Officer
219 Walden Street, P.O. Box 519
Concord, MA. 01742
Fax: 978-369-8420

THE UNDERSIGNED AGREE TO THE FOLLOWING:

1. All persons signing this petition do hereby certify that they own property or reside within the following area:

Pine Street Neighborhood which extends from Main Street to Old Marlboro Road and is bordered by Prairie Street and Derby Street. This neighborhood is further defined and inclusive of Pine Street, Upland Road, and the portion of Harrington Avenue between Upland Road and Old Marlboro Road.

2. All persons signing this petition do hereby agree to the following problem in the defined area:
As part of study conducted by the town Pine Street and Upland Road have been identified as streets that are experiencing increased traffic volume from vehicles using the street as a cut-through. . Commuters are utilizing Pine Street as a cut-through street to avoid downtown Concord during morning and evening commuting hours.

The attached map identifies a measure to address and limit the cut-through traffic. The map also identifies an area of influence, showing other streets that could be impacted. A 75% approval for the identified measure within the area of influence.

Attachment B: Cut-through Traffic Neighborhood Petition Form (Page 2)

3. All persons signing this petition do hereby agree that the following contact person(s) represents the neighborhood in matters pertaining to items 1 and 2 above:

Name of key contact person #1 (please print): _____

Address, City, and Zip Code: _____

Telephone (day): _____ E-mail: _____

Name of key contact person #2 (optional) (please print): _____

Address, City, and Zip Code: _____

Telephone (day): _____ E-mail: _____

Date Submitted: _____

(Please attach additional pages, if necessary, to discuss the request.)

Attachment B: Cut-through Traffic Neighborhood Petition Form (Page 1)



Please fill out this form and return with attached sheets to:

Concord Police Department
Community Safety Officer
219 Walden Street, P.O. Box 519
Concord, MA. 01742
Fax: 978-369-8420

THE UNDERSIGNED AGREE TO THE FOLLOWING:

1. All persons signing this petition do hereby certify that they own property or reside within the following area:
MacArthur Street Neighborhood which extends from Main Street to Old Marlboro Road and is bordered by Cottage Street and Orchard Road. This neighborhood is further defined and inclusive of Crest Street, Bridgecourt Lane, and MacArthur Road.
Road.
2. All persons signing this petition do hereby agree to the following problem in the defined area:
As part of study conducted by the town, Old Bridge Road, and Orchard Road have been identified as streets that are experiencing increased traffic volume from vehicles using the street as a cut-through. Commuters are avoiding the heavy commuter traffic along Main Street and are hoping to avoid an intersection/exit along Route 2.

The attached map identifies a measure to address and limit the cut-through traffic. The measures proposed on the map account for the possibility of traffic shifting to other neighborhood streets as a result of the restricting traffic at Orchard Road and Old Bridge Road. The map also identifies an area of influence, showing other streets that could be impacted. A 75% approval for the identified measure within the area of influence.

Attachment B: Cut-through Traffic Neighborhood Petition Form (Page 2)

3. All persons signing this petition do hereby agree that the following contact person(s) represents the neighborhood in matters pertaining to items 1 and 2 above:

Name of key contact person #1 (please print): _____

Address, City, and Zip Code: _____

Telephone (day): _____ E-mail: _____

Name of key contact person #2 (optional) (please print): _____

Address, City, and Zip Code: _____

Telephone (day): _____ E-mail: _____

Date Submitted: _____

(Please attach additional pages, if necessary, to discuss the request.)

Attachment B: Cut-through Traffic Neighborhood Petition Form (Page 1)



Please fill out this form and return with attached sheets to:

Concord Police Department
Community Safety Officer
219 Walden Street, P.O. Box 519
Concord, MA. 01742
Fax: 978-369-8420

THE UNDERSIGNED AGREE TO THE FOLLOWING:

1. All persons signing this petition do hereby certify that they own property or reside within the following area: The Meskatequid Road Neighborhood is divided into two section north and south of Elm Street. The north section is bound by Elm Street to the south, Nashawtuc to the east, The northern limits of Attawan Road to the north and to the east. The south section in bound by Elm Street to the north, River Street to the east, Nashoba Drive to the south and Wilson Road to the west.
2. All persons signing this petition do hereby agree to the following problem in the defined area: As part of study conducted by the town, Masketaquid Road, Wood Street and River Street, have been identified as streets that are experiencing increased traffic volume from vehicles using the street as a cut-through. Vehicles use Musketaquid Road to Nashawtuc Road and exit onto Main Street to avoid Elm Street. Vehicles use River and Wood Streets to avoid the Elm Street/Main Street intersection.

The attached map identifies a measure to address and limit the cut-through traffic during the AM peak hour. The measures proposed on the map account for the possibility of traffic shifting to other neighborhood streets as a result of the restricting traffic at Musketaquid at Elm Street. The map also identifies an area of influence, showing other streets that could be impacted. A 75% approval for the identified measure within the area of influence.

Attachment B: Cut-through Traffic Neighborhood Petition Form (Page 2)

3. All persons signing this petition do hereby agree that the following contact person(s) represents the neighborhood in matters pertaining to items 1 and 2 above:

Name of key contact person #1 (please print): _____

Address, City, and Zip Code: _____

Telephone (day): _____ E-mail: _____

Name of key contact person #2 (optional) (please print): _____

Address, City, and Zip Code: _____

Telephone (day): _____ E-mail: _____

Date Submitted: _____

(Please attach additional pages if necessary to discuss the request.)

Attachment B: Traffic Neighborhood Petition Form (Page 1)



Please fill out this form and return with attached sheets to:

Concord Police Department
Community Safety Officer
219 Walden Street, P.O. Box 519
Concord, MA. 01742
Fax: 978-369-8420

THE UNDERSIGNED AGREE TO THE FOLLOWING:

1. All persons signing this petition do hereby certify that they own property or reside within the following area: The following streets in Concord Downtown: Devens Street, Academy Lane, Middle Street and Sudbury Road from Thoreau to Academy.
2. All persons signing this petition do hereby agree to the following problem in the defined area: As part of study conducted by the town, Middle Street, Academy Lane and Devens Street have been identified as streets that are experiencing increased traffic volume from vehicles using the street as a cut-through. In order to avoid using Thoreau Street and Main Street vehicles use Middle Street, Academy Lane and Devens Street as cut-through streets. The attached map identifies a measure to address and limit the cut-through traffic during the AM peak hour. The map also identifies an area of influence, showing other streets that could be impacted. A 75% approval for the identified measure within the area of influence.

Attachment B: Traffic Neighborhood Petition Form (Page 2)

3. All persons signing this petition do hereby agree that the following contact person(s) represents the neighborhood in matters pertaining to items 1 and 2 above:

Name of key contact person #1 (please print): _____

Address, City, and Zip Code: _____

Telephone (day): _____ E-mail: _____

Name of key contact person #2 (optional) (please print): _____

Address, City, and Zip Code: _____

Telephone (day): _____ E-mail: _____

Date Submitted: _____

(Please attach additional pages if necessary to discuss the request.)

Attachment B: Cut-through Traffic Neighborhood Petition Form (Page 1)



Please fill out this form and return with attached sheets to:

Concord Police Department
Community Safety Officer
219 Walden Street, P.O. Box 519
Concord, MA. 01742
Fax: 978-369-8420

THE UNDERSIGNED AGREE TO THE FOLLOWING:

1. All persons signing this petition do hereby certify that they own property or reside within the following area: Hawthorne Lane between Cambridge Turnpike and Lexington Road.
2. All persons signing this petition do hereby agree to the following problem in the defined area: As part of study conducted by the town, Hawthorne Lane has been identified as a street that is experiencing increased traffic volume from vehicles using the street as a cut-through. Traffic is using Hawthorne Lane to avoid the intersection of Cambridge Turnpike and Lexington Road. The attached map identifies a measure to address and limit the cut-through traffic during the PM peak hour. The map also identifies an area of influence, showing other streets that could be impacted. A 75% approval for the identified measure within the area of influence.

Attachment B: Cut-through Traffic Neighborhood Petition Form (Page 2)

3. All persons signing this petition do hereby agree that the following contact person(s) represents the neighborhood in matters pertaining to items 1 and 2 above:

Name of key contact person #1 (please print): _____

Address, City, and Zip Code: _____

Telephone (day): _____ E-mail: _____

Name of key contact person #2 (optional) (please print): _____

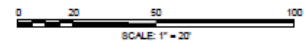
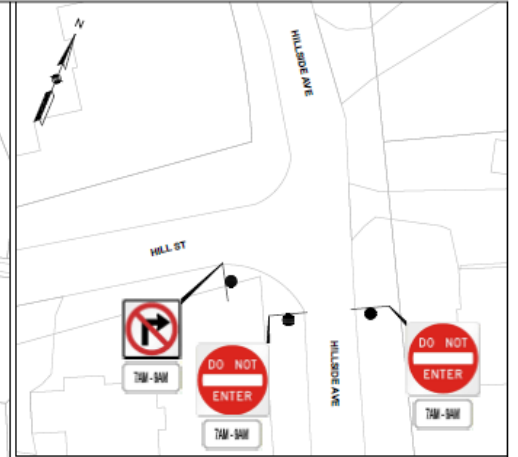
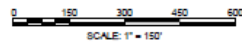
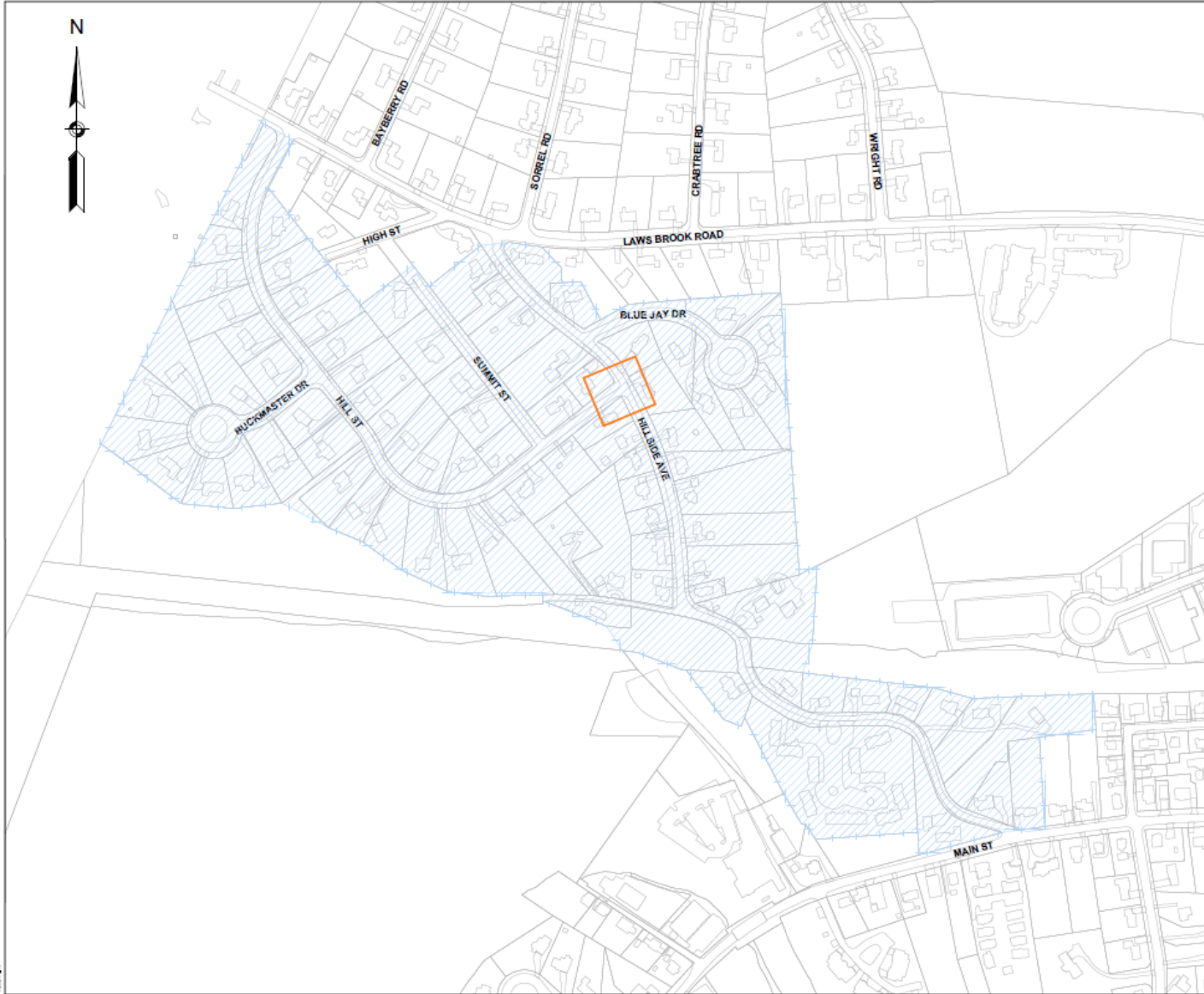
Address, City, and Zip Code: _____

Telephone (day): _____ E-mail: _____

Date Submitted: _____

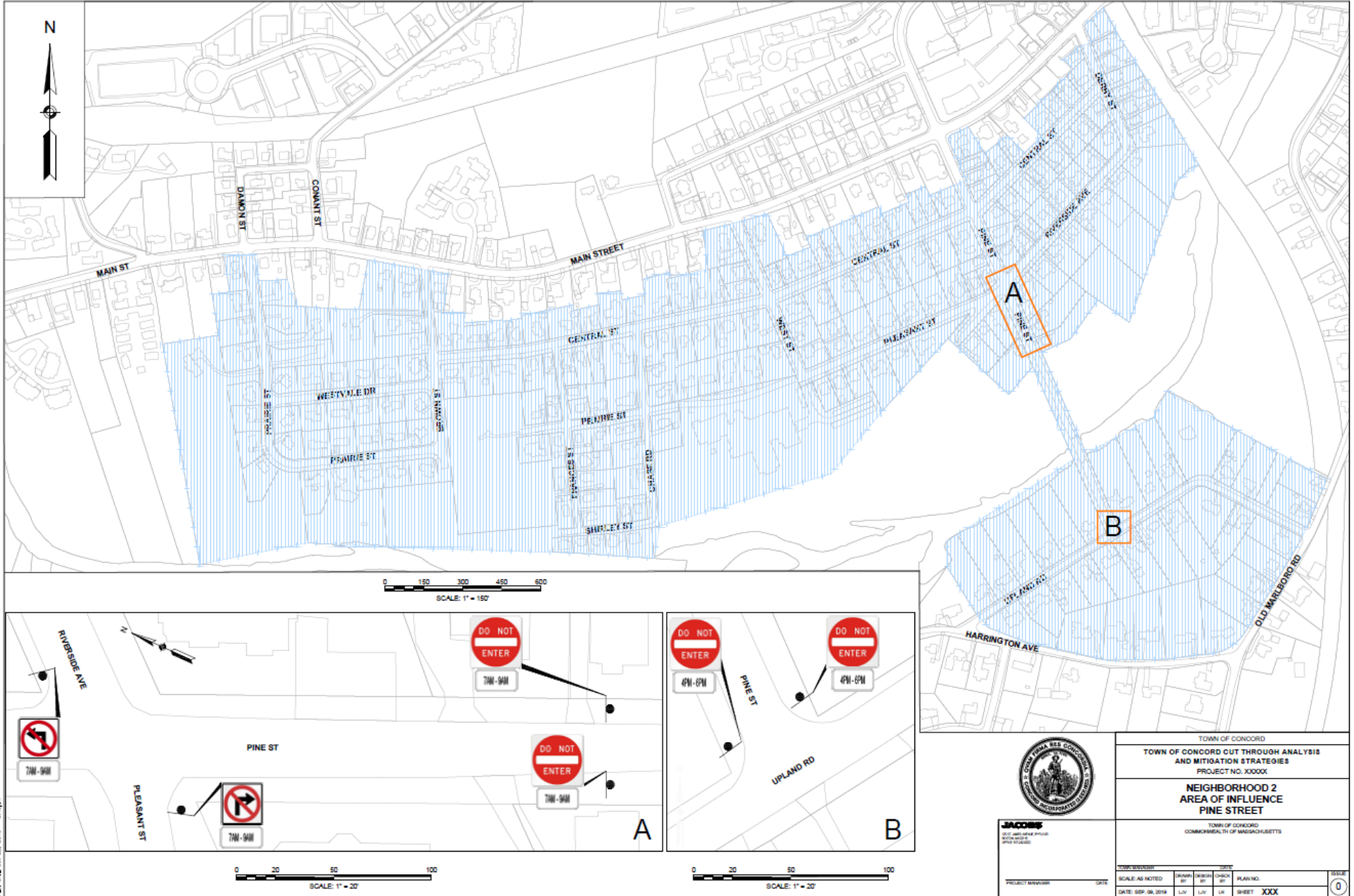
(Please attach additional pages if necessary to discuss the request.)

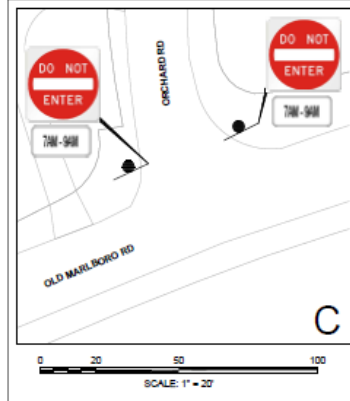
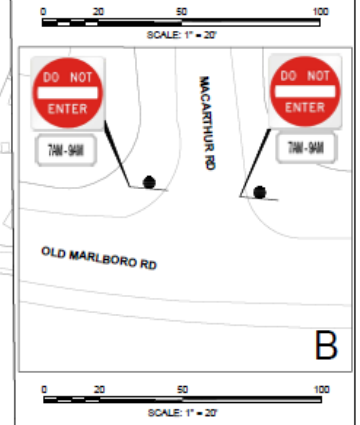
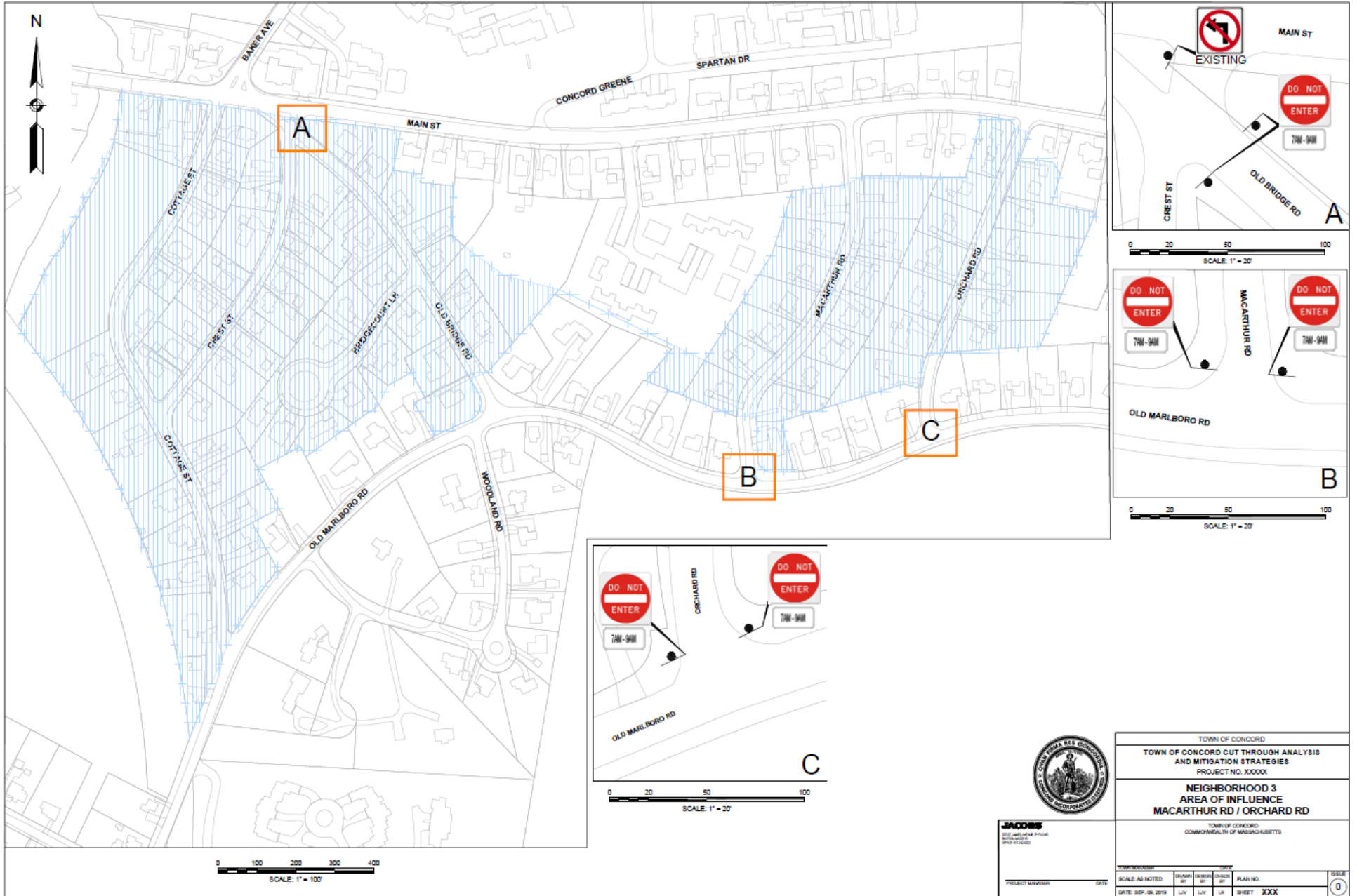
Appendix J. Area of Influence Maps



TOWN OF CONCORD
 TOWN OF CONCORD CUT THROUGH ANALYSIS
 AND MITIGATION STRATEGIES
 PROJECT NO. X000X
NEIGHBORHOOD 1
AREA OF INFLUENCE
HILLSIDE AVE / OLD STOW RD

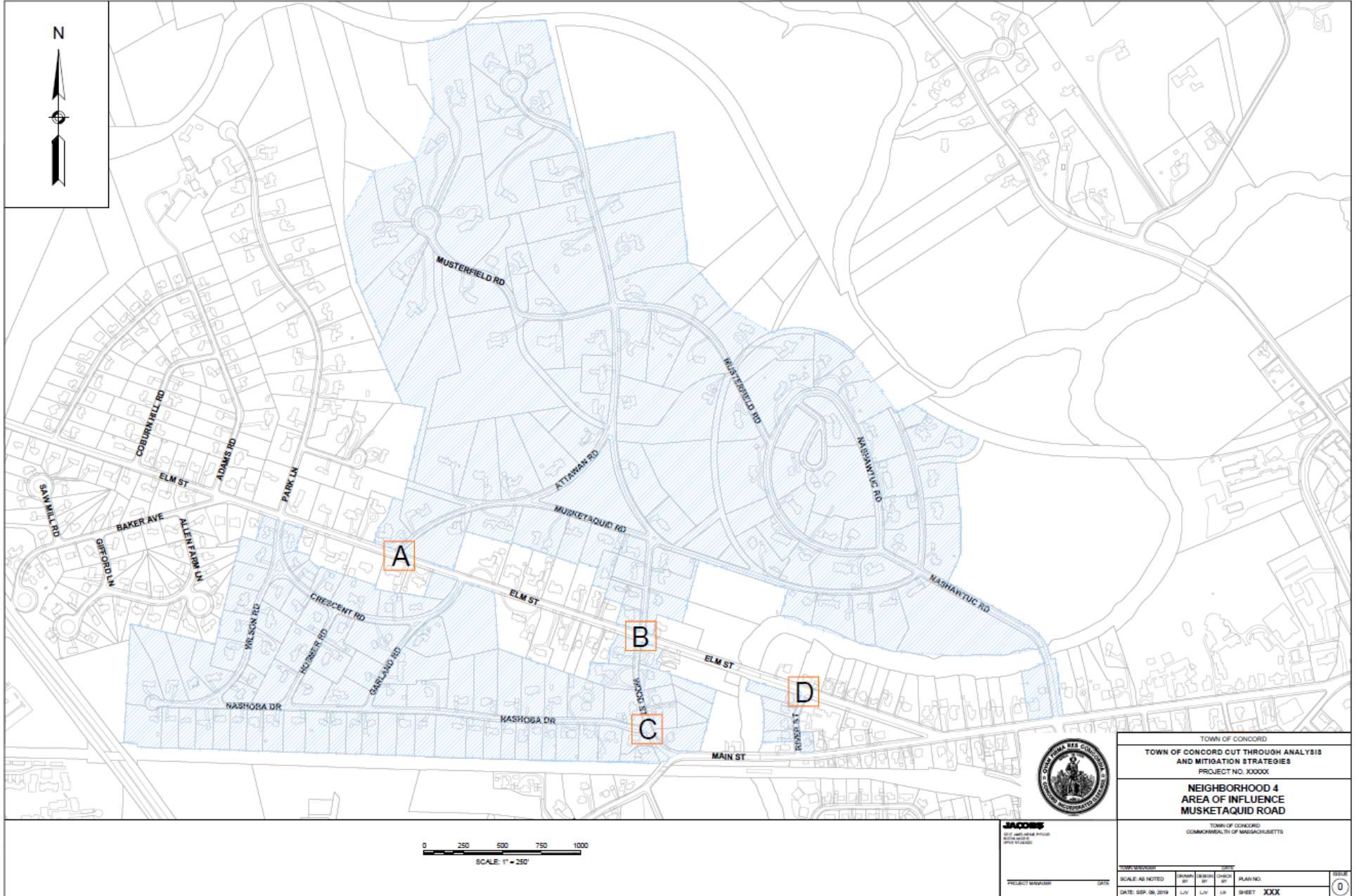
		TOWN OF CONCORD COMMONWEALTH OF MASSACHUSETTS	
SCALE: AS NOTED DATE: SEP. 26, 2019	DRAWN BY: LJV	CHECKED BY: LR	SHEET: XXX PLAN NO.: DATE: SEP. 26, 2019
PROJECT NUMBER:	DATE:	SCALE:	SHEET:
			0





TOWN OF CONCORD													
TOWN OF CONCORD CUT THROUGH ANALYSIS AND MITIGATION STRATEGIES													
PROJECT NO. XXXXX													
NEIGHBORHOOD 3													
AREA OF INFLUENCE													
MACARTHUR RD / ORCHARD RD													
TOWN OF CONCORD COMMONWEALTH OF MASSACHUSETTS													
<table border="1"> <thead> <tr> <th>SCALE AS NOTED</th> <th>DRAWN BY</th> <th>DESIGN BY</th> <th>CHECK BY</th> <th>DATE</th> <th>PLAN NO.</th> </tr> </thead> <tbody> <tr> <td>DATE: SEP. 06, 2019</td> <td>LVJ</td> <td>LVJ</td> <td>LR</td> <td></td> <td>SHEET XXX</td> </tr> </tbody> </table>		SCALE AS NOTED	DRAWN BY	DESIGN BY	CHECK BY	DATE	PLAN NO.	DATE: SEP. 06, 2019	LVJ	LVJ	LR		SHEET XXX
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DATE: SEP. 06, 2019	LVJ	LVJ	LR		SHEET XXX								
<table border="1"> <tr> <td>PROJECT MANAGER</td> <td>DATE</td> </tr> </table>		PROJECT MANAGER	DATE										
PROJECT MANAGER	DATE												

JACOBS
 100 WEST MAIN STREET
 SUITE 2000
 CONCORD, MA 01733



TOWN OF CONCORD
 TOWN OF CONCORD CUT THROUGH ANALYSIS
 AND MITIGATION STRATEGIES
 PROJECT NO. XXXXX
**NEIGHBORHOOD 4
 AREA OF INFLUENCE
 MUSKETAQUID ROAD**
 TOWN OF CONCORD
 COMMONWEALTH OF MASSACHUSETTS



DATE: SEP. 06, 2019

DATE	BY	CHKD	DATE	BY	CHKD	DATE	BY
SCALE AS NOTED	DRWING	DATE	DATE	DATE	DATE	DATE	DATE
DATE: SEP. 06, 2019	LVY	LVY	LVY	LVY	LVY	LVY	LVY
PROJECT NUMBER	DATE	DATE	DATE	DATE	DATE	DATE	DATE
SCALE AS NOTED	DRWING	DATE	DATE	DATE	DATE	DATE	DATE
DATE: SEP. 06, 2019	LVY	LVY	LVY	LVY	LVY	LVY	LVY
PROJECT NUMBER	DATE	DATE	DATE	DATE	DATE	DATE	DATE



TOWN OF CONCORD			
TOWN OF CONCORD CUT THROUGH ANALYSIS AND MITIGATION STRATEGIES			
PROJECT NO. XXXXX			
NEIGHBORHOOD 4 AREA OF INFLUENCE MUSKETAQUID ROAD			
TOWN OF CONCORD COMMONWEALTH OF MASSACHUSETTS			
TOWN MANAGER DATE:		DATE:	
SCALE: AS NOTED	DRAWN BY: LJV	CHECKED BY: LJV	DATE: SEP. 06, 2019
PROJECT MANAGER	DATE	PLAN NO.	SHEET XXX