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DRAFT MEMORANDUM

DATE August 19, 2011
TO Town of Sudbury
FROM Chen-Yuan Wang, Sarah Kurpiel (MAPC), Efi Pagitsas, and Cathy Buckley
RE Community Transportation Technical Assistance Program – Town of Sudbury

INTRODUCTION

The Community Transportation Technical Assistance Program provides technical analysis and advice on local transportation issues to municipal officials. Staff members of the Boston Region Metropolitan Planning Organization (MPO) and Metropolitan Area Planning Council (MAPC) jointly assist with this program. This analysis is the third of four studies of this program approved for funding in the MPO's FFY 2011 Unified Planning Work Program.

Upon a request from the Town of Sudbury, MAPC and MPO transportation engineers and planners met with Sudbury officials on Friday, May 6, 2011, to examine traffic congestion and pedestrian safety issues in the vicinity of the Lincoln-Sudbury High School. This memorandum contains a summary of existing conditions, issues, and concerns, includes analyses of traffic and crash data. Improvement options are then proposed for the identified issues.

PARTICIPANTS

Participating in the May 6 site visit were:

- Scott Carpenter, Lincoln-Sudbury High School Superintendent
- Kevin Rosseley, Lincoln-Sudbury High School Building Supervisor
- Rick Glavin, Sudbury Police Chief
- Jody Kablack, Sudbury Planning and Community Development Director
- Bill Miles, Sudbury Fire Chief
- Bill Place, Sudbury Public Works Director
- Sarah Kurpiel, Metropolitan Area Planning Council
- Cathy Buckley, then member of the Boston Region MPO staff
- Chen-Yuan Wang, Boston Region MPO staff

EXISTING CONDITIONS

Lincoln-Sudbury High School is a regional school with approximately 1,600 students and 160 staff. The school, located northeast of the intersection of Concord Road and Lincoln Road, has four driveways, all on Lincoln Road, to access the school parking lots and buildings (see Figure 1). A large majority of the students arrive at the school by personal vehicles (either to park or to be dropped off). Most of them approach the school through the intersection of Concord Road and Lincoln Road.

The intersection of Concord Road and Lincoln Road (referred to as “the intersection” in this report from here on) is currently unsignalized, with the Lincoln Road approach traffic controlled by a stop sign. Concord Road, connecting Route 117 to the north with the town center to the south, is a two-lane roadway carrying about 10,000 to 12,000 vehicles per weekday in the vicinity of the school. Lincoln Road is one of the major roadways connecting Lincoln and Sudbury. It is a two-lane roadway carrying about 6,200 vehicles per weekday. Both roadways are classified as urban collectors.

Figure 1 shows the school buildings and grounds, the intersection layout, and the pedestrian facilities within and outside of the school grounds. There are sidewalks only on the east side of Concord Road, and there are none on either side of Lincoln Road. The sidewalk on the east side of Concord Road is about 6 feet wide. There are two crosswalks across Lincoln Road. One is located near the intersection and connects to a path leading to the school buildings and other facilities. It serves the students walking and bicycling to school from the south along Concord Road. The other crosswalk is located just west of Sawmill Lane and serves mainly the students from the neighborhood immediately across from the school. For the students from the north or northwest, the following two pedestrian facilities are available: the sidewalk along Concord Road and a crosswalk about a quarter mile north of the school at the intersection of Concord Road at Thompson Drive. However, for students walking from the neighborhood directly west of the school, there are no crosswalks in the immediate vicinity of the school allowing them to cross Concord Road.

For students, staff, and visitors who drive to school or are being dropped off or picked up, there are four school driveways, all on Lincoln Road. From west to east, the first driveway, located nearest to the intersection, is for two-way traffic and connects Lincoln Road to the visitors’ parking lot and the school’s main buildings. The second driveway is two lanes wide and is the primary exit-only driveway from the drop-off area, main parking lot, and visitors’ parking lot. The third driveway is two lanes wide and is designated as one-way, for entering traffic only. From this driveway, traffic, including school buses, enters the main parking lot, designated drop-off area, and sport facilities. The last driveway is two-lane, two-way, and connects directly to the school’s ring road and the tennis courts. The ring road serves the main parking lot, the athletic fields, and the schools. It begins from the last driveway, encircles the parking lot, and proceeds to the front of the three school buildings, then, after crossing the drop-off area lanes, it connects with the primary exit driveway. The ring road is about 1,800 feet long. Along the road, there are curb cuts to and from the main parking lot and in front of the school buildings and three crosswalks that connect the main parking lot to the sidewalk in front of the buildings.

Currently, the roadway segment parallel to Lincoln Road and located between the primary entrance and exit driveways is designated as a student drop-off area. This segment is one-way westbound, two lanes wide, and about 375 feet long, and can hold approximately 15 vehicles dropping off students. Students are dropped off onto the sidewalk located at the southern edge of the main parking lot. During the drop-off period, access from the drop-off area and the main parking lot to the visitors' parking lot area is temporarily blocked. All of the vehicles carrying students have to enter from the third or the last driveway, drop students off at the designated drop-off area, and exit from the second driveway.

ISSUES AND CONCERNS

The town and school officials expressed to the study team concerns about two major issues: (1) traffic congestion and circulation in the vicinity of the school buildings and main entrance during the morning drop-off period, and (2) pedestrian safety in the school vicinity, especially the need for a safe crossing on Concord Road to the school.

Traffic Congestion during the Morning Drop-Off Period

Concord Road and Lincoln Road in the school vicinity carry rather high volumes of traffic in the morning. In the morning peak hour, traffic congestion and delays on Concord and Lincoln roads near the school are daily occurrences. The congestion is mainly due to the school's drop-off activities in the morning, from roughly 7:30 to 7:50 AM. Sometimes the congestion at the nearby intersection and roadway segments does not dissipate until after school begins, at 8:00, and sometimes until 8:15 or later.

The congestion actually starts from the school's drop-off area within the school grounds. The length of the drop-off area and the driveway leading to it, coupled with the operation of the drop-off area and the amount of time students take to disembark from the vehicles, is not sufficient to accommodate the extensive queue of vehicles seeking to be served by the drop-off area. The queue from the drop-off area spills back onto Lincoln Road and Concord Road. During the peak drop-off, the entire eastbound section of Lincoln Road from the entry driveway to the Concord Road intersection and beyond on both sides of Concord Road is occupied by queued vehicles, a distance of approximately 1,200 feet. Staff estimated that the queue is at least 50 vehicles long. The northbound queue on Concord Road is mainly due to the high volume of traffic seeking to turn right onto Lincoln Road, as most of the students are arriving from the area south of the school. The southbound queue is usually caused by vehicles waiting to make left turns into Lincoln Road, most also destined for the school.

During field observation, staff noted the following:

- Vehicles form a single queue using only the traffic lane closest to the sidewalk. This is appropriate, as students disembark the vehicles from the right side, where the sidewalk is.
- Students were seen remaining in the vehicle that drops them off until their vehicle in the queue arrived at the front of the queue (closer to the school entrance), causing delays in the drop-off process. Instead, vehicles should be dropping off students at the first

available spot the driver finds parallel to the sidewalk and let the student walk the rest of the way on sidewalk to the school entrance.

- The school allows entering vehicles to form an additional traffic queue in the adjacent outside lane, from which students can also disembark. However, that lane was underutilized; parents and students may perceive a safety hazard in dropping off students from the outside lane, which is adjacent to a parking area and has no sidewalk. Another reason could be that students would then have to cross the traffic between stopped or moving vehicles to reach the sidewalk at the drop-off area on the other side of the street. In addition, dropping off students from the left lane blocks drivers who are dropping off students in the right lane from bypassing the right-lane queue of vehicles in front of them to exit through the middle driveway. Maybe this blocked egress is the reason why most drivers drop off at the front of the queue despite the signs erected to encourage drop-off at the first available space to pull out.
- Sometimes students being dropped-off take their time while exiting the vehicle at the front of the queue, causing delays for the rest of the vehicles in the queue.

Generally, traffic still queues up and moves slowly in the two-lane drop-off area, despite school efforts to encourage a faster drop-off process through the display of various messages on posted signs.¹

To mitigate the long and slow queue in the drop-off area, it would be ideal if more students arrived by bus instead of being dropped off. On the day of the field visit, May 6, participants made several observations and discussed likely factors that could influence higher bus usage:

- School buses have very low student ridership; each carries only a handful of students in the morning.
- It is likely that the low usage is due to several factors that make school buses inconvenient, including:
 - A very early pickup time.
 - A correspondingly early drop-off time for high school students. (Usually buses arrive at the high school before 7:00, almost an hour before classes begin, so that the same buses can then be used to pick up and deliver the middle and elementary school students.)
 - School bus routes may be long in order to cover a large area with fewer buses, meaning that it is faster for students to be driven to school by their parents or for driving-age students to drive themselves to school.

¹ The school displays a series of message signs with instructions to parent-drivers on how to use the drop-off area in order to reduce queues, including “Avoid delays – drop off before 7:30 AM,” “Pick-up after 3 PM saves congestion,” and “When you first come to a stop, please drop-off passengers.”

It also appears that very few students bicycle to school. While the weather on the day of the site visit was pleasant, staff noted that only five bicycles were parked on campus. Traffic and safety concerns may affect the parents' or students' decisions regarding bicycling to school.

The school's main parking lot provides about 585 parking spaces. Up to 425 spaces are available for students, who drive to school and park there for an annual parking fee. During school days, the parking lot is about 90 percent occupied. In addition, some students (about a dozen or so) park their cars free of charge in a nearby ballpark, Featherland Park, about a quarter mile south of the school. In total, there are nearly 400 students driving to school. A majority of them arrive at the school at the same time as when most students are getting dropped off, between 7:30 and 7:50 AM.

Pedestrian Safety Issues

School officials expressed concerns about a safe walking environment for students on the roadways near the school. The primary concern is that the lack of a sidewalk on the western side of Concord Road, combined with the perceived high traffic speed on Concord Road, is posing dangers to the safety of students crossing the roadway. It was observed that students wishing to cross the road are coming from homes in the immediate vicinity of the school.

Currently, the posted speed limit for Concord Road from the vicinity of the school to the town center is 35 miles per hour. About a quarter of a mile south of the high school, a segment of Concord Road is designated as school zone.² North of the high school, over a quarter mile away and north of Thompson Drive, Concord Road has a posted speed limit of 40 mph. In addition to the speed limit variations, the section of Concord Road abutting the high school is on a horizontal curve. Drivers in that section, especially on the southbound approach toward the high school, have a limited sight distance. The presence of this curve and resulting limited sight distance for drivers makes the construction of a crosswalk across Concord Road infeasible for safety reasons.

As mentioned, there are sidewalks only on the east side of Concord Road. There are no sidewalks on the western side of Concord Road, where a sparsely populated residential neighborhood is located, with a number of private driveways connected to the roadway. With the horizontal curve and no sidewalks on the west side, it appears to be impossible to identify a suitable location for the construction of a safe crosswalk so that students living in the neighborhood can cross Concord Road. This challenging segment of Concord Road contains about 15 households.

On Lincoln Road, the speed limit at the section abutting the high school is 30 mph. About a quarter mile east, beyond Oakridge Road, the speed limit is 35 mph. Although the traffic speed is less of a concern on Lincoln Road, the pedestrian facilities appear to be insufficient in the section abutting the high school. Currently, there are two crosswalks on Lincoln Road: one is located just east of the Concord Road intersection and the other is located further east, near the exit of the high school's main parking lot. However, there are no sidewalks on either side of the

² This section, about 800 feet in length, is a designated school zone for the Nixon Elementary School. It has a speed limit of 20 mph during the hours when the school is open.

roadway. It would be desirable to have sidewalks connecting the two crosswalks and a pedestrian path leading to the school buildings from the crosswalk further east of the intersection.

To slow down traffic, the Town installed school-zone warning signs at two locations approaching the high school from the two roadways. One sign is on Lincoln Street just east of the intersection, facing eastbound traffic. It indicates a school zone, a 30-mph speed limit, and the school hours, 7:15 AM–3:15 PM (see Photo 1.) The other sign, located on Concord Road just south of Thompson Drive near the crosswalk (see Photo 2), is facing southbound traffic and is a stand-alone warning sign simply displaying the indication “School Zone.”



Photo 1
School Zone Sign on Lincoln Road Eastbound

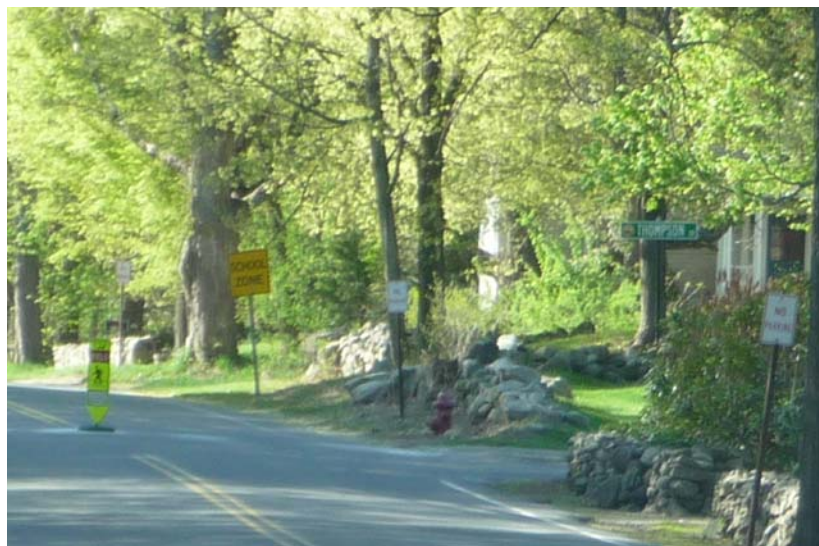


Photo 2
School Zone Sign on Concord Road Southbound

In the past, the Town had approached the Massachusetts Department of Transportation (MassDOT) Highway District 3 to explore the potential of setting up an official 20-mph “School Zone” speed restriction on the two roadway sections in the vicinity of the school. MassDOT determined that a school zone designation could not be made due to MassDOT’s policy about school zone designations. Based on the 2006 Massachusetts Addendum to the 2003 Federal Manual on Uniform Traffic Control Devices (MUTCD), only schools with one or more grades below Grade 9 are eligible for school zone designation.³ In addition, the addendum requires that a school zone must contain a marked crosswalk. However, MassDOT staff determined that a crosswalk across Concord Road in the vicinity of the school would be unsafe due to the horizontal curve in that area. Staff discussions with MassDOT District 3 indicated that the present MassDOT addendum is still in effect, although there has been an update of the definition of “school” in the 2009 MUTCD⁴ indicating that school zones may be considered for schools with only grades 9 and higher.⁵ Note that MassDOT, by law (Chapter 90, Section 18), is responsible for designating roadway speed limits for all roads in Massachusetts.

ANALYSES OF TRAFFIC AND CRASH DATA

Following the on-site meeting, the Sudbury Police Department collected traffic speed and volume data for this study. The data, 24-hour traffic volumes collected in two consecutive weekdays, were taken at three locations: (1) Concord Road just north of Lincoln Road, (2) Concord Road just south of Lincoln Road, and (3) Lincoln Road just east of Concord Road (at the crosswalk). Appendix A shows the hourly traffic volumes by direction at the three locations, with the data on Concord Road further categorized by speed ranges. The data indicate that Concord Road carries approximately 12,000 vehicles on an average weekday (in both directions) south of Lincoln Road and about 10,000 vehicles north of Lincoln Road. Lincoln Road just east of Concord Road carries about 6,200 vehicles on a typical weekday.

The data on Concord Road were further analyzed by speed ranges and percentiles (see Appendix B). Analysis indicates that the 85th percentile speed of the traffic approaching the intersection from Concord Road in both directions is 37 mph and that of the traffic leaving the intersection is 39 mph.⁶ Apparently, the present design of the road allows for this amount of excess, and minor design modifications would be required in order to reduce vehicle speeds to the posted speed limit.

³ See the Massachusetts Addendum to the Manual on Uniform Traffic Control Devices (2003 Edition) and the Standard Municipal Traffic Code, MassDOT, October 2006, Section 7G-2, “Warrants for School Zones,” Page 60.

⁴ The latest edition of the Federal MUTCD (2009) defines “school” as “a public or private educational institution recognized by the state education authority for one or more grades K through 12 or as otherwise defined by the State” (see Section 1A.13, Definition 184).

⁵ On July 22, 2011, the Sudbury Board of Selectmen wrote to Senator James B. Eldridge describing Sudbury’s need for a “School Zone” designation and requesting that he initiate “the appropriate action to discuss an amendment to the Massachusetts Amendments to the Manual of Uniform Traffic Control (MUTCD, 2003) and the Standard Municipal Traffic Code (October 2006) with the Mass. Department of Transportation . . . (for) Sudbury and other communities (to be) better equipped to manage traffic issues around school properties, and keep the students safe.”

⁶ The 85th percentile of traffic is the speed at or below which 85 percent of the vehicles observed are actually traveling on a road. MassDOT officials use this method to make the final determination regarding speed limits on a municipality’s roadways.

In addition, staff obtained the most recently available (2006–08) crash data from the MassDOT Registry Division for the intersection of Concord Road at Lincoln Road. The data are presented in Appendix C. There were six reported crashes at the intersection during the 3-year period. None of them involved pedestrians or bicyclists (see Table C-1 in Appendix C). They were all angle collisions⁷ involving motor vehicles and resulting in property damage only. There were no reported crashes in 2008.⁸ This information suggests that traffic safety at the intersection of Concord Road and Lincoln Road is not at an alarming level based on the crash data.

Staff also reviewed crash data for the section of Lincoln Road from Sawmill Lane to Oak Ridge Road, which includes the school entry and exit points from and to the street, a distance of less than 200 feet. There were six reported crashes during the three-year period on this segment (see Table C-2 in Appendix C). Half of the crashes resulted in personal injuries. The crashes consist of an angle collision, a rear-end collision, a single-vehicle collision, and three unidentified types of collision. None of the crashes involved pedestrians or bicycles.

Based on the available traffic counts and the crash data, staff performed a traffic signal warrant analysis for the intersection. According to the 2009 MUTCD, an engineering study of traffic conditions, pedestrian characteristics, and physical characteristics of the location should be performed to determine whether installation of a traffic control signal is justified at a particular location. The investigation should include applicable factors contained in the following traffic signal warrants and other factors related to existing operations and safety at the study location:

1. Eight-Hour Vehicular Volume Warrant
2. Four-Hour Vehicular Volume Warrant
3. Peak-Hour Warrant
4. Pedestrian Volume Warrant
5. School Crossing Warrant
6. Coordinated Signal System Warrant
7. Crash Experience Warrant
8. Roadway Network Warrant
9. Intersection near a Grade Crossing

The applicable factors for this intersection are contained in Warrants 1, 2, and 7. The analysis is presented in Appendix D. Table D-1 shows the examination of Warrants 1, 2, and 7 based on hourly volumes of an average weekday day, which were derived from two midweek days' 24-hour traffic counts collected by the Sudbury Police Department (see Appendix A for the detailed summary of hourly volumes). Analysis indicates that the intersection meets the conditions required by Warrant 1 (Eight-Hour Vehicular Volume Warrant) and Warrant 2 (Four-Hour Vehicular Volume Warrant). Warrant 7 is not satisfied, as recent 12-month crash data do not indicate that there have been five or more crashes at this location that are susceptible to correction by a traffic signal.

⁷ An angle collision is the prevailing crash type at unsignalized intersections.

⁸ Some crashes may not be reported to MassDOT's Registry of Motor Vehicles Division.

IMPROVEMENT OPTIONS

Based on field observations, the identified issues and concerns, and the analyses of existing conditions, staff developed several improvement and traffic management options for the consideration of the high school and Town officials. The objectives of the proposed improvements are to mitigate the traffic congestion and to improve pedestrian safety in the vicinity of the school. Some recommendations focus on one of these two objectives more than the other.

The alternatives are discussed below in three categories: (1) school traffic management improvements, (2) short-term improvement alternatives, and (3) long-term improvement alternatives. The school traffic management improvements are mostly traffic management measures with minimal or no additions or modifications to the existing roadway facilities outside the school property. The short-term improvements would require additions or modifications of the existing roadway facilities and traffic controls but could be implemented within a relatively short time period. The long-term improvements are major roadway modifications that would require further engineering study and design and would need more time and resources to implement.

School Traffic Management Improvements

As identified in the analysis of existing conditions, the key to reducing congestion in the area during the morning peak hours is to reduce the amount of traffic that spills onto Lincoln and Concord roads from the school entrance driveway. The drop-off traffic issue and associated spill into the traffic streams of Lincoln and Concord roads would require a comprehensive management plan within the school grounds to ensure the safe and efficient drop-off of students at the school and the safety of the driving public, including those arriving at the school to park or drop off students. Queues and stop-and-go conditions must be mitigated, because, in addition to delays, they are often the cause of rear-end crashes.

To that end, the drop-off traffic spillover must be addressed by making improvements in two areas:

- Redesignation and redesign of the storage and parent drop-off space within the school property
- Measures to reduce the time required for each student drop-off

At present, the service rate (drop-off rate) at the existing designated area is slow, and the available storage is enough for about 15 vehicles. During the peak 20 minutes of students' arrival at the school, as many as 600 vehicles seek access to the entry driveway, most of them by turning left from Lincoln Road. MPO staff estimate that approximately half are destined for the parking lot and half for the drop-off area. Due to delays and inadequate storage space in the drop-off area, a long queue of eastbound vehicles forms on Lincoln Road, proceeding slowly towards the left turn into the school premises. The formed queue is estimated to be 1,200 feet long and spills

over onto Concord Road northbound, causing queues and delays of Concord Road southbound traffic that often reach past Thompson Drive.

To increase the available storage for the queued vehicles waiting to turn left into the main driveway of the school, MPO staff believe that it would be more effective and safer if the line of vehicles was extended inside the school property along the school's ring road. Under this consideration, the present bus drop-off area and the present parent drop-off areas would switch locations.

The school's ring road circles around the main parking lot. The ring road curb adjacent to the school buildings is currently used only for the school bus drop-off. Designating the ring road sidewalk in front of the buildings as the new parent drop-off location would allow drop-off activities on the roadway segment of about 500 feet for about 20 stopping vehicles and would store at least 40 additional vehicles in the remaining ring road section of over 1,000 feet (see Figure 2). It would remove a significant portion of the drop-off traffic queues from the adjacent streets to the school property. The traffic flow pattern would remain the same as the existing operation, with no changes at the existing entry and exit points.

The school has expressed concerns about the potential conflicts between the drop-off traffic and those students walking to the school buildings after parking their vehicles in the main parking lot. Presently, there are three marked crosswalks from the parking lot to the school buildings. However, many students were observed crossing the ring road at other locations that are closer to their parked cars. Students are possibly emboldened by the sparse traffic on the ring road during the school opening period in the morning. Since this plan would increase traffic on the ring road, students must be encouraged to use the marked crosswalks by the use of signage and school announcements.

The potential traffic-pedestrian conflicts on the ring road can be minimized by the following measures:

- Define a speed limit of 10 mph for the section of the ring road adjacent to the school facilities and post signs at appropriate locations.
- Designate the ring road as a two lane, one-way facility. The outer lane would be used for drop-off and the inner lane would be signed for traffic entering the parking lot and for bypassing parked drop-off vehicles.
- Designate the beginning of the new parent drop-off area just upstream of the second crosswalk to reduce the drop-off traffic's interference with students crossing at the crosswalks and to allow more storage space for the traffic queuing from the exit driveway.⁹
- Advise and encourage students to use the designated crosswalk locations whenever they walk to or from the parking lot.
- Replace the existing crosswalks with raised crosswalks for additional visibility.¹⁰

⁹ The students would be advised to use the first two crosswalks as much as they can.

¹⁰ The raised crosswalks could also serve as a traffic-calming measure for the ring road traffic at times other than the drop-off period.

Usually the traffic-pedestrian conflicts are minimal when the traffic speed is slow, as the drivers and the pedestrians can better see each other and react in time. This plan is expected to be most beneficial to local traffic without creating adverse safety conditions within the school grounds. The key to its effective implementation is to ensure orderly and continuous slow-speed traffic on the ring road.

The second measure to reduce congestion and spillover onto Lincoln and Concord roads would be expediting the drop-off process. The school, with the cooperation of the parents, should advise and encourage students to be prepared upon arrival on the school premises to exit their parents' vehicle expeditiously. During the field visit, it was noted that drivers stayed in the slow-moving queue until they reached the front of the drop-off area to drop off students. Instead, drivers should drop off students at the moment the vehicle comes to a stop in the queue. Changing the present behavioral pattern is expected to have a significant impact on the existing traffic conditions, and it would encourage the students to walk a little further on the sidewalk, a healthy habit. This tactic would be applied to the new drop-off designation, as some of the students might have to walk a short distance from their individual drop-off spot to the building entrance. School staff may have to be present during the peak student arrival period to manage the queue and expedite drop-offs. In addition to designating qualified staff to guide, encourage, and supervise an orderly drop-off process, the school could utilize senior students (through a community-service type of program) to open the car doors or provide other assistance to students who are slow in exiting their cars.

An additional measure for reducing the traffic congestion is to increase the student bus ridership. The staff suggests two ways to increase the ridership. They are:

- Adjust the high school bus arrival schedule by adding more buses to serve the Sudbury school district, allowing for later pickups and drop-offs of high school students by school buses
- Adjust the high school starting time to a somewhat earlier time to make the school bus schedule more appealing

However, both measures appear to be expensive and difficult to implement at this moment. The school and town traffic committee can further investigate these measures with more insightful information about the conditions and associated costs of altering the arrival schedule of buses.

Short-Term Improvement Options for Traffic and Pedestrian Safety

To improve pedestrian safety in the area, MPO staff propose the following short-term measures based on the on-site meeting discussions and the analysis of existing conditions. Some of the proposed improvements would also benefit students bicycling to school by utilizing additional sidewalks and crosswalks.

1. Install a sidewalk on the west side of Concord Road, and a connecting crosswalk

As requested by school and Town officials, staff looked into the potential of installing a crosswalk on Concord Road near the school. Ideally, the crosswalk would be located at or

near the intersection of Concord Road at Lincoln Road. The crosswalk should connect to pedestrian paths or sidewalks on both sides of the crossing, and adequate sight distance should be provided for drivers and pedestrians to see one another. Although a raised crosswalk could help calm the traffic at the intersection, we do not currently propose one at this location, because it is not compatible with the prevailing traffic speed on Concord Road.

In this preliminary study, staff propose to install the crosswalk on Concord Road just south of Lincoln Road. The location north of Lincoln Road is not suitable due to roadway curvature that limits the sight distance for drivers approaching the intersection. The location south of Lincoln Road is more visible for drivers from both directions, and it is near a major driveway leading to most of the houses in the neighborhood (see Figure 3).

Staff also propose installing a sidewalk in conjunction with the proposed crosswalk, as suggested by MassDOT Highway District 3. The sidewalk would be located on the west side of Concord Road, with a width of at least 5 feet and a length of about 1,500 feet (from north of the intersection to Featherland Park in the south). It would connect the proposed crosswalk and the crosswalk on Concord Road at the park and provide access to the school, the park, and adjacent neighborhoods.

In addition, a series of signs and pavement markings are proposed as essential accompanying elements to the installation of the crosswalk. These include:

- Install School Advance Warning Assembly (MUTCD S1-1 and W16-9p) on both approaches about 300 feet before the intersection (see Photo 3 for an example)
- Install School Crosswalk Warning Assembly (MUTCD S1-1 and W16-7p) at both ends of the proposed crosswalk facing approaching traffic (see the yellow sign in the distance in Photo 3)
- Install Yield Lines (shark teeth) on both sides of the crosswalk to alert drivers that they must yield to pedestrians (see Photo 4 for an example)
- Install a series of at least three “SLOW” pavement markings on both approaches, about 200 to 300 feet before the intersection

Finally, the Town should discuss this proposal with MassDOT Highway District 3 for comments and design modifications before proceeding to design and construction.

2. Install warning signs and add a sidewalk on Lincoln Road

The two crosswalks on Lincoln Road appear to be located appropriately relative to the existing intersection, roadway, and neighborhood layouts. Currently there is a “State Law: Yield to Pedestrian in Crosswalk” sign on the north side of the street at the westernmost crosswalk (near Concord Road). The sign is helpful for alerting drivers approaching the crosswalk, especially for those turning from Concord Road onto the crosswalk. Ideally,



Photo 3
Example of School Advance Warning Assembly
(Source: FHWA Safety Office)



Photo 4
Yield Lines at Pedestrian Crossing Locations
(Source: FHWA Safety Office)

the sign should be placed in the middle of the crosswalk for maximum visibility. There is no such sign placed at the easternmost crosswalk, near Sawmill Lane. To supplement drivers' awareness of these two crossing locations, staff propose the following improvements on Lincoln Road:

- Install a "State Law: Yield to Pedestrian in Crosswalk" sign in the middle of the eastern crosswalk
- Install School Crosswalk Warning Assembly (MUTCD S1-1 and W16-7p) at both ends of the two crosswalks facing approaching traffic
- Install School Advance Warning Assembly (MUTCD S1-1 and W16-9p) on the westbound approach about 300 feet before the east crosswalk (just east of Oak Ridge Road)

Currently, no part of Lincoln Road has sidewalks on both sides. Staff propose that the Town add a sidewalk section at least 5 feet wide and about 400 feet long on the south side of Lincoln Road. The sidewalk would connect the two existing crosswalks and provide access to the school from adjacent neighborhoods, Concord Road, and other neighborhoods along Concord Road.

3. Install a pedestrian path from the eastern crosswalk (on Lincoln Road) to the school buildings

Currently, there is no pedestrian path leading to the school facilities for students after they cross Lincoln Road at the eastern crosswalk. A sidewalk on the west side of the second school driveway and a crosswalk connecting to the sidewalk in front of the school buildings should be constructed for a complete pedestrian route.

Long-Term Improvement Options

To further enhance pedestrian safety and to reduce traffic congestion in the area, staff briefly reviewed a few long-term improvement alternatives for the intersection of Concord Road at Lincoln Road. These alternatives include:

1. Modify the intersection layout

Although the intersection has only one travel lane on each approach, its layout is relatively wide, with channelized right turns on both streets. Staff propose two different ideas for modifying the intersection. The first is to tighten the design of the intersection, with the main purpose of improving pedestrian safety. The crosswalk on Lincoln Road just east of the intersection is at a location not easily visible by drivers turning right from Concord Road in the channelized right-turn lane. Removing the channelized right-turn lane and replacing it with a right-turning lane at a right angle with Lincoln Road would slow the right-turning traffic, while still allowing some northbound through traffic to bypass the right-turning traffic.

The second idea is to maintain the channelized right-turn lane, add a southbound exclusive left-turn lane on Concord Road, and move the crosswalk westward. The addition of the left-turn lane would significantly reduce the intersection delays, especially in the morning peak period, but it would probably require moving the intersection slightly toward the northeast.¹¹ Many factors would affect the redesign of this intersection. At this preliminary stage, we would suggest a further engineering study to examine these and other potential ideas for right-of-way and feasibility issues in order to design the necessary changes for the intersection.

2. Install traffic signal control at the intersection

The preliminary signal warrants analysis indicated that the intersection qualifies for the installation of a traffic signal. This determination was based on the traffic counts collected by the Town. To quickly examine its potential operational conditions, staff used CINCH¹² to synthesize turning-movement volumes from the counts collected by the Sudbury Police, and used Synchro¹³ to perform intersection capacity analyses for the morning peak hour.

Analyses indicated that the traffic signal would operate at level of service B with an acceptable overall intersection delay, whether the intersection is under the existing layout or under the designs presented above (see Appendix E for detailed results from the Synchro analyses). The tested alternatives also include an exclusive pedestrian signal phase, which would enhance pedestrian safety by stopping all the traffic at the intersection when the pedestrian phase is activated.

3. Conversion to a modern roundabout

The intersection could be redesigned as a modern roundabout in order to decrease traffic speeds on Concord Road and improve pedestrian safety. Modern roundabouts are circular traffic intersections designed with yield control for all approaches and low circulating speeds of approximately 20 miles per hour. A roundabout would provide pedestrian refuge islands for students, allowing them to cross the roadway one lane at a time.

Staff used Synchro to perform a preliminary intersection capacity analysis for this alternative and found that a typical single-lane modern roundabout would operate acceptably in the morning peak hour. In general, a volume-to-capacity (V/C) ratio of 0.85 is regarded as a threshold for approaching traffic at a modern roundabout. The analysis showed that the V/C ratios at all the approaches at this intersection would be much lower than 0.85 (see Appendix F).

¹¹ There appears to be room for these changes, as the northeast corner of the intersection is owned by the Town.

¹² CINCH is a computer program developed by MPO staff that uses available volumes for intersection approaching and exiting to synthesize turning-movement volumes at a given intersection.

¹³ Synchro is a computer program developed and distributed by Trafficware Ltd. It can perform capacity analysis for an individual intersection or a series of intersections.

A modern roundabout would generally require more space than a regular intersection. The construction of a roundabout appears to be feasible within the existing right-of-way by utilizing the northeast corner of the intersection and avoiding land takings. However, its feasibility should be further examined through an engineering design study.

Conclusion

The long-term alternatives above are generally much more expensive than the proposed short-term improvements, and require further engineering analyses and design studies. Furthermore, they are likely to be unnecessary if the short-range elements were to be implemented and the congestion at the intersection in the future would continue to last only 20 minutes. The main purpose of presenting long-term alternatives is to provide the readers with a complete range of options for a safer and more effective way of processing traffic and allowing pedestrians to cross Concord and Lincoln roads safely.

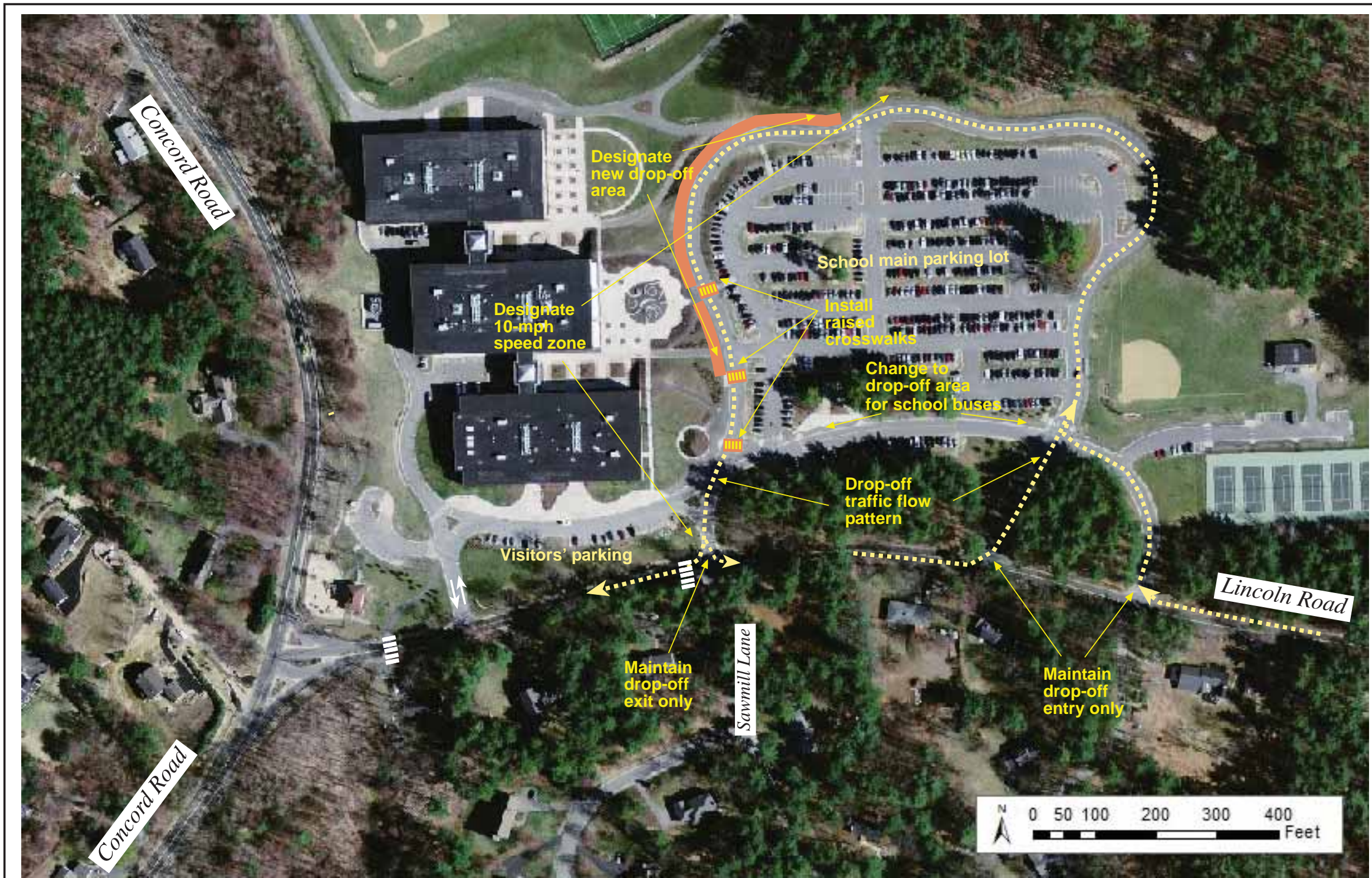
More important, neither the short- nor the long-term options for the intersection can influence the long queues and associated issues stemming from student drop-offs. The exact design of the intersection needs to be considered seriously, either in association with a solution to the spillover queue at the high school, or after that issue has been resolved.

Finally, staff believe that there are opportunities for restructuring and managing more effectively the student drop-off area in a way that reduces, and even eliminates, the major spillover effect on Lincoln Road, Concord Road, and the intersection of the two roads. Some of these ideas were presented in this study and include relocation of the drop-off area, an appeal to the parents and students on how to use the space, and structured supervision and gentle enforcement to encourage expeditious drop-offs.

CW/SK/EP/CB/cw/ep



FIGURE 1
Existing Conditions



BOSTON REGION MPO

FIGURE 2
Conceptual Diagram of
Proposed School Traffic Management Plan

CTTAP -
 Town of
 Sudbury

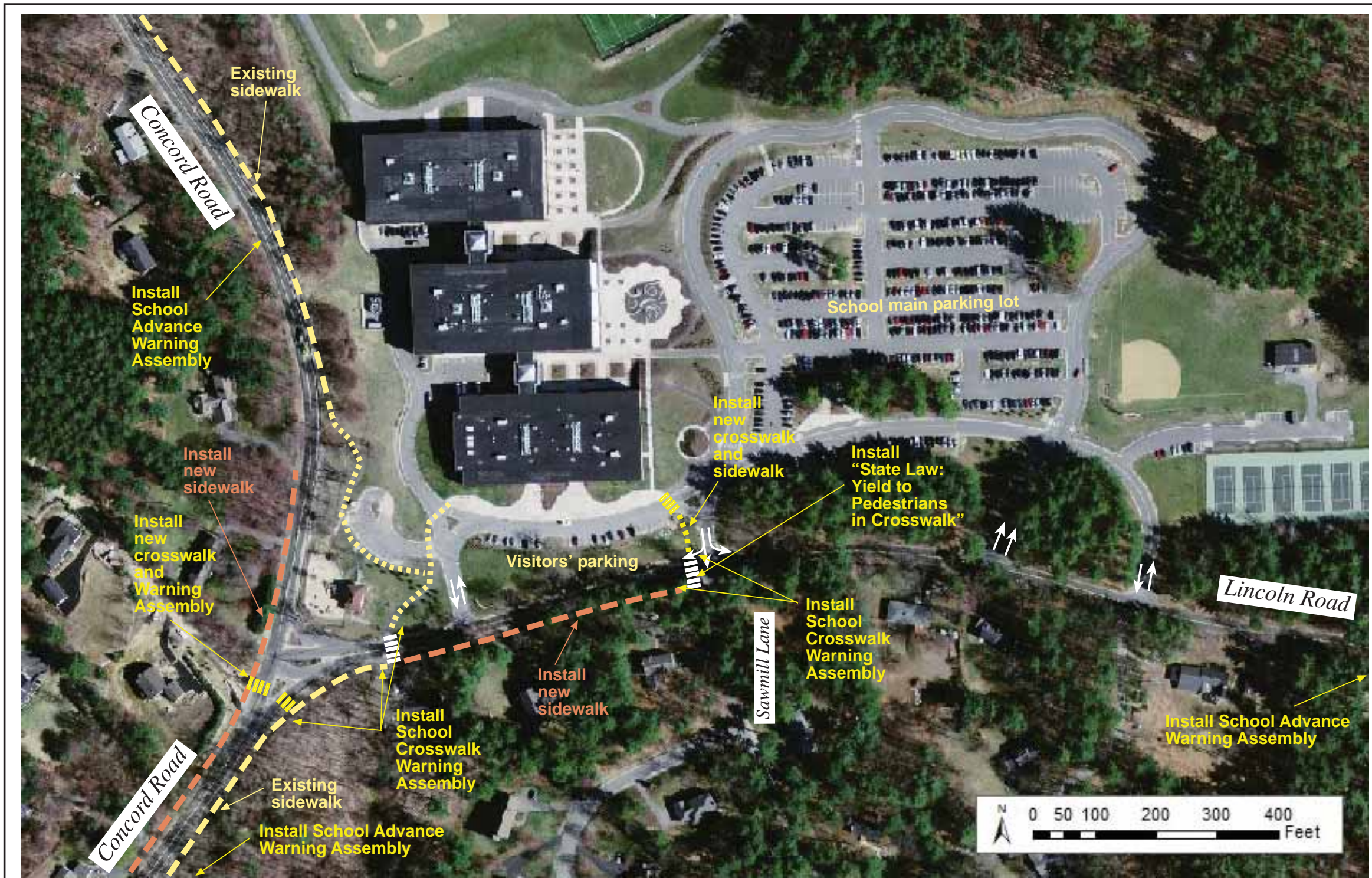


FIGURE 3
Locations of Some Proposed Short-Term Improvements

Appendix A

**Summary of Weekday Hourly Traffic Volumes by Speed Ranges
May/June 2011
Sudbury Police Department**

Sudbury Police Department

415 Boston Post Rd.
Sudbury, MA 01776

Site Code:
Station ID:
Concord Rd just North of Lincoln Rd

Latitude: 0' 0.000 Undefined

Start Time	23-May-11		Tue		Wed		Thu		Fri		Sat		Sun		Week Average	
	Southboun	Northbo	Southbo	Northbo	Southbo	Northbo	Southbo	Northbo	Southbo	Northbo	Southbo	Northbo	Southbo	Northbo	Southbo	Northbo
12:00 AM	*	*	*	*	*	*	15	16	16	26	*	*	*	*	16	21
01:00	*	*	*	*	*	*	7	7	11	8	*	*	*	*	9	8
02:00	*	*	*	*	*	*	7	14	10	2	*	*	*	*	8	8
03:00	*	*	*	*	*	*	3	2	4	2	*	*	*	*	4	2
04:00	*	*	*	*	*	*	11	12	7	12	*	*	*	*	9	12
05:00	*	*	*	*	*	*	33	67	29	67	*	*	*	*	31	67
06:00	*	*	*	*	*	*	145	163	168	151	*	*	*	*	156	157
07:00	*	*	*	*	413	323	446	329	*	*	*	*	*	*	430	326
08:00	*	*	*	*	454	386	430	346	*	*	*	*	*	*	442	366
09:00	*	*	*	*	282	272	273	254	*	*	*	*	*	*	278	263
10:00	*	*	*	*	224	202	185	229	*	*	*	*	*	*	204	216
11:00	*	*	*	*	257	280	224	214	*	*	*	*	*	*	240	247
12:00 PM	*	*	*	*	298	396	261	271	*	*	*	*	*	*	280	334
01:00	*	*	*	*	318	321	268	238	*	*	*	*	*	*	293	280
02:00	*	*	*	*	315	342	301	383	*	*	*	*	*	*	308	362
03:00	*	*	*	*	367	359	369	436	*	*	*	*	*	*	368	398
04:00	*	*	*	*	437	333	419	419	*	*	*	*	*	*	428	376
05:00	*	*	*	*	424	457	401	526	*	*	*	*	*	*	412	492
06:00	*	*	*	*	352	410	383	329	*	*	*	*	*	*	368	370
07:00	*	*	*	*	226	267	203	200	*	*	*	*	*	*	214	234
08:00	*	*	*	*	111	165	154	219	*	*	*	*	*	*	132	192
09:00	*	*	*	*	90	111	82	113	*	*	*	*	*	*	86	112
10:00	*	*	*	*	43	56	51	59	*	*	*	*	*	*	47	58
11:00	*	*	*	*	37	30	25	33	*	*	*	*	*	*	31	32
Lane	0	0	0	0	4648	4710	4696	4879	245	268	0	0	0	0	4794	4933
Day	0	0	0	0	9358	9575	9575	9575	513	513	0	0	0	0	9727	9727
AM Peak					08:00	08:00	07:00	08:00	06:00	06:00					08:00	08:00
Vol.					454	386	446	346	168	151					442	366
PM Peak					16:00	17:00	16:00	17:00							16:00	17:00
Vol.					437	457	419	526							428	492

Comb. Total	0	0	9358	9575	513	0	0	9727
ADT	ADT 9,575		AADT 9,575					

Sudbury Police Department

415 Boston Post Rd.
Sudbury, MA 01776

Site Code:
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Concord Rd just North of Lincoln Rd

Latitude: 0' 0.000 Undefined

Southbound

Start Time	1	16	21	26	31	36	41	46	51	56	61	66	71	76	Total	Pace Speed	Number in Pace
5/25/11	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
01:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
02:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
03:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
04:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
05:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
06:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
07:00	219	16	20	62	66	28	2	0	0	0	0	0	0	0	413	1-10	149
08:00	23	4	16	87	217	98	9	0	0	0	0	0	0	0	454	31-40	315
09:00	14	0	3	25	132	93	14	1	0	0	0	0	0	0	282	31-40	225
10:00	6	1	7	19	96	82	13	0	0	0	0	0	0	0	224	31-40	178
11:00	10	0	7	45	100	81	14	0	0	0	0	0	0	0	257	31-40	181
12 PM	7	9	13	40	137	87	5	0	0	0	0	0	0	0	298	31-40	224
13:00	17	8	24	63	121	72	13	0	0	0	0	0	0	0	318	31-40	193
14:00	18	8	12	47	142	81	7	0	0	0	0	0	0	0	315	31-40	223
15:00	16	4	21	50	163	99	13	1	0	0	0	0	0	0	367	31-40	262
16:00	27	14	28	84	162	108	13	1	0	0	0	0	0	0	437	31-40	270
17:00	22	0	6	72	170	143	10	1	0	0	0	0	0	0	424	31-40	313
18:00	16	5	14	69	127	110	11	0	0	0	0	0	0	0	352	31-40	237
19:00	0	1	1	27	90	88	19	0	0	0	0	0	0	0	226	31-40	178
20:00	1	1	0	11	48	44	5	1	0	0	0	0	0	0	111	31-40	92
21:00	1	0	1	10	44	28	6	0	0	0	0	0	0	0	90	31-40	72
22:00	0	0	0	3	23	15	2	0	0	0	0	0	0	0	43	31-40	38
23:00	0	0	1	3	9	15	9	0	0	0	0	0	0	0	37	32-41	25
Total	397	71	174	717	1847	1272	165	5	0	0	0	0	0	0	4648		
Percent	8.5%	1.5%	3.7%	15.4%	39.7%	27.4%	3.5%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%			
AM Peak	07:00	07:00	07:00	08:00	08:00	08:00	09:00	09:00							08:00		
Vol.	219	16	20	87	217	98	14	1							454		
PM Peak	16:00	16:00	16:00	16:00	17:00	17:00	19:00	15:00							16:00		
Vol.	27	14	28	84	170	143	19	1							437		

Sudbury Police Department

415 Boston Post Rd.
Sudbury, MA 01776

Site Code:
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Concord Rd just North of Lincoln Rd

Latitude: 0' 0.000 Undefined

Southbound

Start Time	1	16	21	26	31	36	41	46	51	56	61	66	71	76	999	Total	Pace Speed	Number in Pace
5/26/11	0	0	0	1	6	3	4	1	0	0	0	0	0	0	0	15	30-39	9
01:00	0	0	0	2	1	3	1	0	0	0	0	0	0	0	0	7	32-41	5
02:00	0	0	0	0	3	2	2	0	0	0	0	0	0	0	0	7	31-40	5
03:00	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	3	23-32	2
04:00	1	0	0	2	3	5	0	0	0	0	0	0	0	0	0	11	29-38	8
05:00	0	0	1	0	14	8	8	2	0	0	0	0	0	0	0	33	31-40	22
06:00	2	0	6	13	56	59	9	0	0	0	0	0	0	0	0	145	31-40	115
07:00	249	28	44	62	40	20	3	0	0	0	0	0	0	0	0	446	1-10	169
08:00	25	3	16	99	178	104	4	1	0	0	0	0	0	0	0	430	30-39	282
09:00	16	2	8	67	133	41	6	0	0	0	0	0	0	0	0	273	26-35	200
10:00	9	5	15	35	66	50	5	0	0	0	0	0	0	0	0	185	31-40	116
11:00	12	5	11	29	96	65	6	0	0	0	0	0	0	0	0	224	31-40	161
12 PM	6	12	10	51	114	60	8	0	0	0	0	0	0	0	0	261	31-40	174
13:00	4	3	11	57	120	67	6	0	0	0	0	0	0	0	0	268	31-40	187
14:00	18	10	24	52	111	84	2	0	0	0	0	0	0	0	0	301	31-40	195
15:00	16	10	19	86	157	78	2	1	0	0	0	0	0	0	0	369	26-35	243
16:00	17	2	15	76	188	107	13	1	0	0	0	0	0	0	0	419	31-40	295
17:00	27	5	13	81	156	108	11	0	0	0	0	0	0	0	0	401	31-40	264
18:00	12	2	20	78	166	90	14	1	0	0	0	0	0	0	0	383	31-40	256
19:00	3	0	1	20	93	69	16	1	0	0	0	0	0	0	0	203	31-40	162
20:00	2	0	6	27	76	39	4	0	0	0	0	0	0	0	0	154	31-40	115
21:00	1	0	2	15	30	29	5	0	0	0	0	0	0	0	0	82	31-40	59
22:00	0	0	1	4	23	18	5	0	0	0	0	0	0	0	0	51	31-40	41
23:00	0	0	0	0	9	13	3	0	0	0	0	0	0	0	0	25	31-40	22
Total	421	87	223	857	1841	1122	137	8	0	0	0	0	0	0	0	4696		
Percent	9.0%	1.9%	4.7%	18.2%	39.2%	23.9%	2.9%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%			
AM Peak	07:00	07:00	07:00	08:00	08:00	08:00	06:00	05:00								07:00		
Vol.	249	28	44	99	178	104	9	2								446		
PM Peak	17:00	12:00	14:00	15:00	16:00	17:00	19:00	15:00								16:00		
Vol.	27	12	24	86	188	108	16	1								419		

Sudbury Police Department

415 Boston Post Rd.
Sudbury, MA 01776

Site Code:
Station ID:
Concord Rd just North of Lincoln Rd

Latitude: 0' 0.000 Undefined

Southbound

Start Time	15	20	25	30	35	40	45	50	55	60	65	70	75	999	Total	Pace Speed	Number in Pace
5/27/11	0	0	0	1	8	5	2	0	0	0	0	0	0	0	16	30-39	13
01:00	0	0	0	1	8	1	1	0	0	0	0	0	0	0	11	26-35	9
02:00	0	0	0	1	4	2	3	0	0	0	0	0	0	0	10	30-39	6
03:00	0	0	0	0	1	3	0	0	0	0	0	0	0	0	4	29-38	4
04:00	0	0	0	0	4	3	0	0	0	0	0	0	0	0	7	29-38	7
05:00	1	0	0	5	11	7	5	0	0	0	0	0	0	0	29	28-37	18
06:00	3	2	10	19	66	59	8	1	0	0	0	0	0	0	168	31-40	125
07:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
08:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
09:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
10:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
11:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
12 PM	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
13:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
14:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
15:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
16:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
17:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
18:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
19:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
20:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
21:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
22:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
23:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Total	4	2	10	27	102	80	19	1	0	0	0	0	0	0	245		
Percent	1.6%	0.8%	4.1%	11.0%	41.6%	32.7%	7.8%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%			
AM Peak	06:00	06:00	06:00	06:00	06:00	06:00	06:00	06:00							06:00		
Vol.	3	2	10	19	66	59	8	1							168		
PM Peak																	
Vol.																	
Total	822	160	407	1601	3790	2474	321	14	0	0	0	0	0	0	9589		
Percent	8.6%	1.7%	4.2%	16.7%	39.5%	25.8%	3.3%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%			

15th Percentile : 26 MPH
 50th Percentile : 33 MPH
 85th Percentile : 38 MPH
 95th Percentile : 40 MPH

Stats
 10 MPH Pace Speed : 31-40 MPH
 Number in Pace : 6264
 Percent in Pace : 65.3%
 Number of Vehicles > 30 MPH : 6599
 Percent of Vehicles > 30 MPH : 68.8%
 Mean Speed(Average) : 31 MPH

Sudbury Police Department

415 Boston Post Rd.
Sudbury, MA 01776

Site Code:
Station ID:
Concord Rd just North of Lincoln Rd

Latitude: 0' 0.000 Undefined

Northbound

Start Time	1	16	21	26	31	36	41	46	51	56	61	66	71	76	Total	Pace Speed	Number in Pace
5/25/11	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
01:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
02:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
03:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
04:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
05:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
06:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
07:00	32	4	46	89	72	70	10	0	0	0	0	0	0	0	323	26-35	161
08:00	13	2	8	31	146	155	30	1	0	0	0	0	0	0	386	31-40	301
09:00	12	2	7	35	90	115	11	0	0	0	0	0	0	0	272	31-40	205
10:00	4	0	5	16	62	97	17	1	0	0	0	0	0	0	202	31-40	159
11:00	8	2	12	39	92	105	22	0	0	0	0	0	0	0	280	31-40	197
12 PM	15	0	11	112	128	107	22	0	0	0	0	1	0	0	396	26-35	240
13:00	14	5	21	59	93	114	15	0	0	0	0	0	0	0	321	31-40	207
14:00	23	8	16	61	103	107	24	0	0	0	0	0	0	0	342	31-40	210
15:00	15	1	17	37	114	142	31	2	0	0	0	0	0	0	359	31-40	256
16:00	11	2	12	27	113	145	22	1	0	0	0	0	0	0	333	31-40	258
17:00	20	1	22	62	141	169	40	2	0	0	0	0	0	0	457	31-40	310
18:00	16	4	25	114	101	125	25	0	0	0	0	0	0	0	410	31-40	226
19:00	5	1	19	63	58	105	15	1	0	0	0	0	0	0	267	31-40	163
20:00	0	1	12	21	56	65	10	0	0	0	0	0	0	0	165	31-40	121
21:00	1	1	6	14	41	35	13	0	0	0	0	0	0	0	111	31-40	76
22:00	0	0	2	1	15	27	11	0	0	0	0	0	0	0	56	31-40	42
23:00	0	0	2	2	11	13	1	1	0	0	0	0	0	0	30	31-40	24
Total	189	34	243	783	1436	1696	319	9	0	0	0	1	0	0	4710		
Percent	4.0%	0.7%	5.2%	16.6%	30.5%	36.0%	6.8%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%			
AM Peak	07:00	07:00	07:00	07:00	08:00	08:00	08:00	08:00	08:00						08:00		
Vol.	32	4	46	89	146	155	30	1							386		
PM Peak	14:00	14:00	18:00	18:00	17:00	17:00	17:00	15:00				12:00			17:00		
Vol.	23	8	25	114	141	169	40	2				1			457		

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Latitude: 0' 0.000 Undefined

Northbound	1	16	21	26	31	36	41	46	51	56	61	66	71	76	Total	Pace	Number
Start Time	15	20	25	30	35	40	45	50	55	60	65	70	75	999	Speed	in Pace	
5/27/11	1	0	2	4	5	11	2	0	0	0	0	1	0	0	26	31-40	16
01:00	0	0	0	0	0	6	2	0	0	0	0	0	0	0	8	33-42	8
02:00	0	0	1	0	0	1	0	0	0	0	0	0	0	0	2	12-21	1
03:00	0	0	0	0	0	2	0	0	0	0	0	0	0	0	2	28-37	2
04:00	0	0	0	0	4	4	3	1	0	0	0	0	0	0	12	32-41	9
05:00	0	0	3	3	13	36	12	0	0	0	0	0	0	0	67	33-42	51
06:00	4	0	2	14	31	83	16	1	0	0	0	0	0	0	151	31-40	114
07:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
08:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
09:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
10:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
11:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
12 PM	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
13:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
14:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
15:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
16:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
17:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
18:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
19:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
20:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
21:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
22:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
23:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

Total	5	0	8	21	53	143	35	2	0	0	0	1	0	0	268		
Percent	1.9%	0.0%	3.0%	7.8%	19.8%	53.4%	13.1%	0.7%	0.0%	0.0%	0.0%	0.4%	0.0%	0.0%			
AM Peak	06:00		05:00	06:00	06:00	06:00	06:00	04:00				00:00			06:00		
Vol.	4		3	14	31	83	16	1				1			151		

PM Peak																	
Vol.																	
Total	426	95	542	1567	2963	3552	676	34	0	0	0	2	0	0	9857		
Percent	4.3%	1.0%	5.5%	15.9%	30.1%	36.0%	6.9%	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%			

15th Percentile : 27 MPH
 50th Percentile : 34 MPH
 85th Percentile : 39 MPH
 95th Percentile : 42 MPH

Stats
 10 MPH Pace Speed : 31-40 MPH
 Number in Pace : 6515
 Percent in Pace : 66.1%
 Number of Vehicles > 30 MPH : 7227
 Percent of Vehicles > 30 MPH : 73.3%
 Mean Speed(Average) : 33 MPH

Sudbury Police Department

415 Boston Post Rd.
Sudbury, MA 01776

Site Code:
Station ID:
Concord Rd just South of Lincoln Rd

Latitude: 0' 0.000 Undefined

Southbound

Start Time	1	16	21	26	31	36	41	46	51	56	61	66	71	76	Total	Pace Speed	Number in Pace
6/1/11	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
01:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
02:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
03:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
04:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
05:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
06:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
07:00	31	2	10	46	222	136	10	0	0	0	0	0	0	0	457	31-40	358
08:00	21	1	12	116	196	102	7	0	0	0	0	0	0	0	455	26-35	312
09:00	19	0	8	46	134	102	11	0	0	0	0	0	0	0	320	31-40	236
10:00	20	7	10	46	136	107	9	0	0	0	0	0	0	0	335	31-40	243
11:00	20	0	7	56	173	131	18	0	1	0	0	0	0	0	406	31-40	304
12 PM	20	2	9	66	164	109	17	0	0	0	0	0	0	0	387	31-40	273
13:00	24	2	5	40	128	130	20	1	0	0	0	0	0	0	350	31-40	258
14:00	31	5	7	49	168	146	40	1	0	0	0	0	0	0	447	31-40	314
15:00	21	0	2	45	217	216	22	2	0	1	0	0	0	0	526	31-40	433
16:00	35	2	19	90	242	195	18	1	0	0	0	0	0	0	602	31-40	437
17:00	15	0	6	52	183	161	30	0	0	0	0	0	0	0	447	31-40	344
18:00	8	0	4	56	146	119	18	2	0	0	0	0	0	0	353	31-40	265
19:00	0	0	6	56	82	47	29	1	1	0	0	0	0	0	222	26-35	138
20:00	0	0	3	21	20	14	4	0	0	0	0	0	0	0	62	26-35	41
21:00	0	0	1	8	25	16	9	0	0	0	0	0	0	0	59	31-40	41
22:00	0	0	0	7	17	17	3	1	0	0	0	0	0	0	45	31-40	34
23:00	0	0	1	2	9	12	2	0	0	0	0	0	0	0	26	31-40	21
Total	265	21	110	802	2262	1760	267	9	2	1	0	0	0	0	5499		
Percent	4.8%	0.4%	2.0%	14.6%	41.1%	32.0%	4.9%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%			
AM Peak	07:00	10:00	08:00	08:00	07:00	07:00	11:00										07:00
Vol.	31	7	12	116	222	136	18			1							457
PM Peak	16:00	14:00	16:00	16:00	16:00	15:00	14:00	15:00	19:00	15:00							16:00
Vol.	35	5	19	90	242	216	40	2	1	1							602

Sudbury Police Department

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Sudbury, MA 01776

Site Code:
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Latitude: 0' 0.000 Undefined

Southbound

Start Time	1	16	21	26	31	36	41	46	51	56	61	66	71	76	999	Total	Pace Speed	Number in Pace
6/2/11	0	0	0	3	2	5	1	0	0	0	0	0	0	0	0	11	32-41	8
01:00	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0	4	28-37	4
02:00	0	0	0	0	2	2	1	1	0	0	0	0	0	0	0	6	28-37	4
03:00	0	0	1	3	2	1	1	0	0	0	0	0	0	0	0	8	23-32	6
04:00	0	0	1	2	10	9	8	2	0	0	0	0	0	0	0	32	30-39	19
05:00	6	0	0	5	24	55	24	2	0	0	0	0	0	0	0	116	32-41	80
06:00	28	3	5	56	145	87	15	0	0	0	0	0	0	0	0	339	31-40	232
07:00	25	0	0	24	144	169	23	0	0	0	0	0	0	0	0	385	31-40	313
08:00	28	1	4	46	185	120	10	1	0	0	0	0	0	0	0	395	31-40	305
09:00	28	1	6	49	120	88	21	1	0	0	0	0	0	0	0	314	31-40	208
10:00	14	0	6	17	83	131	30	0	0	0	0	0	0	0	0	281	31-40	214
11:00	11	0	12	30	101	140	33	3	0	0	0	0	0	0	0	330	31-40	241
12 PM	4	0	0	21	89	125	45	2	0	0	0	0	0	0	0	286	31-40	214
13:00	26	5	10	62	166	118	19	1	0	0	0	0	0	0	0	407	31-40	284
14:00	36	4	14	64	164	165	23	1	0	0	0	0	0	0	0	471	31-40	329
15:00	23	1	2	47	205	173	38	1	0	0	0	0	0	0	0	490	31-40	378
16:00	44	0	3	59	248	196	39	1	0	0	0	0	0	0	0	590	31-40	444
17:00	46	0	10	102	255	189	41	1	0	0	0	0	0	0	0	644	31-40	444
18:00	11	0	2	26	105	137	40	3	0	0	0	0	0	0	0	324	31-40	242
19:00	11	0	1	17	76	71	21	3	0	0	0	0	0	0	0	200	31-40	147
20:00	2	0	0	9	31	37	6	0	0	0	0	0	0	0	0	85	31-40	68
21:00	3	0	0	7	13	32	7	1	0	0	0	0	0	0	0	63	31-40	45
22:00	1	0	1	4	15	24	8	0	0	0	0	0	0	0	0	53	31-40	39
23:00	2	1	3	33	71	22	6	1	1	0	0	0	0	0	0	140	26-35	104
Total	349	16	81	686	2258	2098	460	25	1	0	0	0	0	0	0	5974		
Percent	5.8%	0.3%	1.4%	11.5%	37.8%	35.1%	7.7%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%			
AM Peak	06:00	06:00	11:00	06:00	08:00	07:00	11:00	11:00								08:00		
Vol.	28	3	12	56	185	169	33	3								395		
PM Peak	17:00	13:00	14:00	17:00	17:00	16:00	12:00	18:00	23:00							17:00		
Vol.	46	5	14	102	255	196	45	3	1							644		

Sudbury Police Department

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Sudbury, MA 01776

Site Code:
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Latitude: 0' 0.000 Undefined

Southbound

Start Time	1	16	21	26	31	36	41	46	51	56	61	66	71	76	Total	Pace Speed	Number in Pace
6/3/11	0	0	0	4	7	13	5	1	0	0	1	0	0	0	31	31-40	20
01:00	0	0	0	2	2	6	1	0	0	0	0	0	0	0	11	32-41	9
02:00	0	0	0	0	2	0	2	0	0	0	0	0	0	0	4	23-32	2
03:00	1	0	0	1	2	4	1	0	0	0	0	0	0	0	9	30-39	7
04:00	1	1	0	3	5	7	8	1	0	0	0	0	0	0	26	34-43	15
05:00	5	0	3	5	21	54	18	1	0	0	0	0	0	0	107	31-40	75
06:00	60	1	2	80	123	48	15	2	0	0	0	0	0	0	331	26-35	203
07:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
08:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
09:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
10:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
11:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
12 PM	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
13:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
14:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
15:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
16:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
17:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
18:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
19:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
20:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
21:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
22:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
23:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Total	67	2	5	95	162	132	50	5	0	0	1	0	0	0	519		
Percent	12.9%	0.4%	1.0%	18.3%	31.2%	25.4%	9.6%	1.0%	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%			
AM Peak	06:00	04:00	05:00	06:00	06:00	05:00	05:00	06:00			00:00				06:00		
Vol.	60	1	3	80	123	54	18	2			1				331		
PM Peak																	
Vol.																	
Total	681	39	196	1583	4682	3990	777	39	3	1	1	0	0	0	11992		
Percent	5.7%	0.3%	1.6%	13.2%	39.0%	33.3%	6.5%	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%			

15th Percentile : 28 MPH
 50th Percentile : 34 MPH
 85th Percentile : 39 MPH
 95th Percentile : 42 MPH

Stats
 10 MPH Pace Speed : 31-40 MPH
 Number in Pace : 8672
 Percent in Pace : 72.3%
 Number of Vehicles > 30 MPH : 9493
 Percent of Vehicles > 30 MPH : 79.2%
 Mean Speed(Average) : 33 MPH

Sudbury Police Department

415 Boston Post Rd.
Sudbury, MA 01776

Site Code:
Station ID:
Concord Rd just South of Lincoln Rd

Latitude: 0' 0.000 Undefined

Northbound

Start Time	1	16	21	26	31	36	41	46	51	56	61	66	71	76	Total	Pace Speed	Number in Pace
6/2/11	0	0	0	1	3	1	1	0	0	0	0	0	0	0	6	24-33	4
01:00	0	0	0	0	3	0	0	0	0	0	0	0	0	0	3	24-33	3
02:00	0	0	0	0	1	0	0	1	1	0	0	1	0	0	4	42-51	2
03:00	0	0	0	1	0	7	1	1	0	0	0	0	0	0	10	36-45	8
04:00	2	0	1	5	21	33	8	0	0	0	0	0	0	0	70	31-40	54
05:00	9	0	2	7	72	113	16	0	0	0	0	0	0	0	219	31-40	185
06:00	16	1	10	157	316	77	5	0	0	0	0	0	0	0	582	26-35	473
07:00	25	6	5	61	318	138	5	0	0	0	0	0	0	0	558	31-40	456
08:00	27	1	26	136	247	76	3	0	1	0	0	0	0	0	517	26-35	383
09:00	83	10	12	80	112	61	8	0	0	0	0	0	0	0	366	26-35	192
10:00	13	0	2	24	118	109	5	1	0	0	0	0	0	0	272	31-40	227
11:00	14	0	3	23	125	95	10	0	0	0	0	0	0	0	270	31-40	220
12 PM	8	0	0	36	139	99	7	0	0	0	0	0	0	0	289	31-40	238
13:00	23	3	12	73	161	90	10	0	1	0	0	0	0	0	373	31-40	251
14:00	23	0	6	54	221	125	9	2	0	0	0	0	0	0	440	31-40	346
15:00	28	4	11	55	179	127	17	0	0	0	0	0	0	0	421	31-40	306
16:00	47	8	21	86	326	163	16	0	0	0	0	0	0	0	667	31-40	489
17:00	34	1	6	30	185	119	14	0	0	0	0	0	0	0	389	31-40	304
18:00	6	0	0	19	118	89	19	1	0	0	0	0	0	0	252	31-40	207
19:00	6	1	6	19	85	58	5	0	0	0	0	0	0	0	180	31-40	143
20:00	0	0	4	9	58	44	5	0	0	0	0	0	0	0	120	31-40	102
21:00	0	0	2	10	36	29	5	0	0	0	0	0	0	0	82	31-40	65
22:00	1	0	0	6	25	16	4	0	0	0	0	0	0	0	52	31-40	41
23:00	0	0	0	10	21	6	2	0	0	0	0	0	0	0	39	26-35	31
Total	365	35	129	902	2890	1675	175	6	3	0	0	1	0	0	6181		
Percent	5.9%	0.6%	2.1%	14.6%	46.8%	27.1%	2.8%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%			
AM Peak	09:00	09:00	08:00	06:00	07:00	07:00	05:00	02:00	02:00			02:00			06:00		
Vol.	83	10	26	157	318	138	16	1	1			1			582		
PM Peak	16:00	16:00	16:00	16:00	16:00	16:00	18:00	14:00	13:00						16:00		
Vol.	47	8	21	86	326	163	19	2	1						667		

Sudbury Police Department

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Latitude: 0' 0.000 Undefined

Northbound

Start Time	1	16	21	26	31	36	41	46	51	56	61	66	71	76	Total	Pace Speed	Number in Pace
6/3/11	0	0	0	0	7	14	1	0	0	0	0	0	0	0	22	31-40	21
01:00	0	0	0	1	4	2	0	0	0	0	0	0	0	0	7	28-37	7
02:00	0	0	0	0	1	3	1	0	0	0	0	0	0	0	5	32-41	5
03:00	0	1	0	3	6	6	3	1	0	0	0	0	0	0	20	28-37	12
04:00	0	0	1	7	15	29	10	0	1	0	0	0	0	0	63	31-40	44
05:00	1	0	1	15	102	99	13	0	0	0	0	0	0	0	231	31-40	201
06:00	192	45	47	119	171	62	3	0	0	0	0	0	0	0	639	26-35	290
07:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
08:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
09:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
10:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
11:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
12 PM	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
13:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
14:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
15:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
16:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
17:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
18:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
19:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
20:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
21:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
22:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
23:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Total	193	46	49	145	306	215	31	1	1	0	0	0	0	0	987		
Percent	19.6%	4.7%	5.0%	14.7%	31.0%	21.8%	3.1%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%			
AM Peak	06:00	06:00	06:00	06:00	06:00	05:00	05:00	03:00	04:00						06:00		
Vol.	192	45	47	119	171	99	13	1	1						639		

PM Peak Vol.	799	103	329	2280	5631	2834	309	10	4	0	0	1	0	0	12300
Percent	6.5%	0.8%	2.7%	18.5%	45.8%	23.0%	2.5%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	

15th Percentile : 27 MPH
 50th Percentile : 33 MPH
 85th Percentile : 38 MPH
 95th Percentile : 40 MPH

Stats
 10 MPH Pace Speed : 31-40 MPH
 Number in Pace : 8465
 Percent in Pace : 68.8%
 Number of Vehicles > 30 MPH : 8789
 Percent of Vehicles > 30 MPH : 71.5%
 Mean Speed(Average) : 31 MPH

Sudbury Police Department

415 Boston Post Rd.
Sudbury, MA 01776

Site Code:
Station ID:
Lincoln Rd at Crosswalk

Latitude: 0' 0.000 Undefined

Start Time	30-May-11		Tue		Wed		Thu		Fri		Sat		Sun		Week Average	
	Westbound	Eastbou	Westbou	Eastbou	Westbou	Eastbou	Westbou	Eastbou	Westbou	Eastbou	Westbou	Eastbou	Westbou	Eastbou	Westbou	Eastbou
12:00 AM	*	*	*	*	*	*	11	5	166	28	*	*	*	*	88	16
01:00	*	*	*	*	*	*	2	2	6	3	*	*	*	*	4	2
02:00	*	*	*	*	*	*	0	0	1	3	*	*	*	*	0	2
03:00	*	*	*	*	*	*	1	1	0	2	*	*	*	*	0	2
04:00	*	*	*	*	*	*	1	2	1	5	*	*	*	*	1	4
05:00	*	*	*	*	*	*	18	55	16	59	*	*	*	*	17	57
06:00	*	*	*	*	*	*	33	168	53	200	*	*	*	*	43	184
07:00	*	*	*	*	240	508	241	518	*	*	*	*	*	*	240	513
08:00	*	*	*	*	109	302	78	256	*	*	*	*	*	*	94	279
09:00	*	*	*	*	250	374	228	354	*	*	*	*	*	*	239	364
10:00	*	*	*	*	97	126	88	118	*	*	*	*	*	*	92	122
11:00	*	*	*	*	170	163	119	130	*	*	*	*	*	*	144	146
12:00 PM	*	*	*	*	314	230	117	106	*	*	*	*	*	*	216	168
01:00	*	*	*	*	243	171	155	128	*	*	*	*	*	*	199	150
02:00	*	*	*	*	144	224	294	208	*	*	*	*	*	*	219	216
03:00	*	*	*	*	238	196	190	111	*	*	*	*	*	*	214	154
04:00	*	*	*	*	301	307	238	270	*	*	*	*	*	*	270	288
05:00	*	*	*	*	315	132	431	348	*	*	*	*	*	*	373	240
06:00	*	*	*	*	225	58	294	85	*	*	*	*	*	*	260	72
07:00	*	*	*	*	327	57	135	87	*	*	*	*	*	*	231	72
08:00	*	*	*	*	71	29	53	48	*	*	*	*	*	*	62	38
09:00	*	*	*	*	25	25	21	36	*	*	*	*	*	*	23	30
10:00	*	*	*	*	11	9	22	16	*	*	*	*	*	*	16	12
11:00	*	*	*	*	14	11	25	21	*	*	*	*	*	*	20	16
Lane	0	0	0	0	3094	2922	2795	3073	243	300	0	0	0	0	3065	3147
Day	0	0	0	0	6016	5868	5868	5868	543	543	0	0	0	0	6212	6212
AM Peak					09:00	07:00	07:00	07:00	00:00	06:00					07:00	07:00
Vol.					250	508	241	518	166	200					240	513
PM Peak					19:00	16:00	17:00	17:00							17:00	16:00
Vol.					327	307	431	348							373	288

Comb. Total	0	0	6016	5868	543	0	0	6212
ADT	ADT 5,868	AADT 5,868						

Appendix B

**Summary of Traffic Speed Percentiles and Vehicle Classifications
May/June 2011
Sudbury Police Department**

Sudbury Police Department

415 Boston Post Rd.
Sudbury, MA 01776

Site Code:
Station ID:
Concord Rd just North of Lincoln Rd

Southbound

Latitude: 0' 0.000 Undefined

Report for Report From 5/25/11 7:00:00 AM to 5/27/11 7:00:00 AM

CLASS STATISTICS - Modified Scheme F

Class	Bikes	Cars & Trailers	2 Axle Long	Buses	2 Axle 6 Tire	3 Axle Single	4 Axle Single	<5 Axl Double	5 Axle Double	>6 Axl Double	<6 Axl Multi	6 Axle Multi	>6 Axl Multi	No Class
Count	77	7361	1237	76	193	73	1	52	10	2	3	0	1	15
Percent	0.8	80.9	13.6	0.8	2.1	0.8	0.0	0.6	0.1	0.0	0.0	0.0	0.0	0.2

SPEED STATISTICS - 15 to 70+ by 5 MPH

Speed in MPH	1 - 15	16 - 20	21 - 25	26 - 30	31 - 35	36 - 40	41 - 45	46 - 50	51 - 55	56 - 60	61 - 65	66 - 70	71 - 75	76 - 999
Count	334	160	407	1601	3790	2474	321	14	0	0	0	0	0	0
Percent	3.7	1.8	4.5	17.6	41.6	27.2	3.5	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Over Speed	15	20	25	30	35	40	45	50	55	60	65	70	75	999
Count	8767	8607	8200	6599	2809	335	14	0	0	0	0	0	0	0
Percent	96.3	94.6	90.1	72.5	30.9	3.7	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Percentile	5%	10%	15%	45%	50%	55%	85%	90%	95%					
Speed	19	26	28	33	33	34	37	38	40					

Average 32
(Mean)

Pace Speed 29-38
Number in 6606
Pace
Percent in 72.6
Pace

Sudbury Police Department

415 Boston Post Rd.
Sudbury, MA 01776

Site Code:
Station ID:
Concord Rd just North of Lincoln Rd

Northbound

Latitude: 0' 0.000 Undefined

Report for Report From 5/25/11 7:00:00 AM to 5/27/11 7:00:00 AM

CLASS STATISTICS - Modified Scheme F

Class	Bikes	Cars & Trailers	2 Axle Long	Buses	2 Axle 6 Tire	3 Axle Single	4 Axle Single	<5 Axl Double	5 Axle Double	>6 Axl Double	<6 Axl Multi	6 Axle Multi	>6 Axl Multi	No Class
Count	93	7380	1574	83	210	57	3	48	10	0	2	0	0	8
Percent	1.0	77.9	16.6	0.9	2.2	0.6	0.0	0.5	0.1	0.0	0.0	0.0	0.0	0.1

SPEED STATISTICS - 15 to 70+ by 5 MPH

Speed in MPH	1 - 15	16 - 20	21 - 25	26 - 30	31 - 35	36 - 40	41 - 45	46 - 50	51 - 55	56 - 60	61 - 65	66 - 70	71 - 75	76 - 999
Count	37	95	542	1567	2963	3552	676	34	0	0	0	2	0	0
Percent	0.4	1.0	5.7	16.6	31.3	37.5	7.1	0.4	0.0	0.0	0.0	0.0	0.0	0.0
Over Speed	15	20	25	30	35	40	45	50	55	60	65	70	75	999
Count	9431	9336	8794	7227	4264	712	36	2	2	2	2	0	0	0
Percent	99.6	98.6	92.9	76.3	45.0	7.5	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Percentile	5%	10%	15%	45%	50%	55%	85%	90%	95%					
Speed	24	27	28	34	35	36	39	40	41					

Average 34
(Mean)

Pace Speed 31-40
Number in 6515
Pace
Percent in 68.8
Pace

Sudbury Police Department

415 Boston Post Rd.
Sudbury, MA 01776

Site Code:
Station ID:
Concord Rd just North of Lincoln Rd

COMBINED - Southbound, Northbound

Latitude: 0' 0.000 Undefined

Report for Report From 5/25/11 7:00:00 AM to 5/27/11 7:00:00 AM

CLASS STATISTICS - Modified Scheme F

Class	Bikes	Cars & Trailers	2 Axle Long	Buses	2 Axle 6 Tire	3 Axle Single	4 Axle Single	<5 Axl Double	5 Axle Double	>6 Axl Double	<6 Axl Multi	6 Axle Multi	>6 Axl Multi	No Class
Count	170	14741	2811	159	403	130	4	100	20	2	5	0	1	23
Percent	0.9	79.4	15.1	0.9	2.2	0.7	0.0	0.5	0.1	0.0	0.0	0.0	0.0	0.1

SPEED STATISTICS - 15 to 70+ by 5 MPH

Speed in MPH	1 - 15	16 - 20	21 - 25	26 - 30	31 - 35	36 - 40	41 - 45	46 - 50	51 - 55	56 - 60	61 - 65	66 - 70	71 - 75	76 - 999
Count	371	255	949	3168	6753	6026	997	48	0	0	0	2	0	0
Percent	2.0	1.4	5.1	17.1	36.4	32.5	5.4	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Over Speed	15	20	25	30	35	40	45	50	55	60	65	70	75	999
Count	18198	17943	16994	13826	7073	1047	50	2	2	2	2	0	0	0
Percent	98.0	96.6	91.5	74.5	38.1	5.6	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Percentile	5%	10%	15%	45%	50%	55%	85%	90%	95%					
Speed	23	26	28	34	34	35	38	39	41					

Average 33
(Mean)

Pace Speed 30-39
Number in 12973
Pace
Percent in 69.9
Pace

Sudbury Police Department

415 Boston Post Rd.
Sudbury, MA 01776

Site Code:
Station ID:
Concord Rd just South of Lincoln Rd

Southbound

Latitude: 0' 0.000 Undefined

Report for Report From 6/1/11 7:00:00 AM to 6/3/11 7:00:00 AM

CLASS STATISTICS - Modified Scheme F

Class	Bikes	Cars & Trailers	2 Axle Long	Buses	2 Axle 6 Tire	3 Axle Single	4 Axle Single	<5 Axl Double	5 Axle Double	>6 Axl Double	<6 Axl Multi	6 Axle Multi	>6 Axl Multi	No Class
Count	110	8555	2072	168	269	97	1	29	17	0	0	0	0	26
Percent	1.0	75.4	18.3	1.5	2.4	0.9	0.0	0.3	0.1	0.0	0.0	0.0	0.0	0.2

SPEED STATISTICS - 15 to 70+ by 5 MPH

Speed in MPH	1 - 15	16 - 20	21 - 25	26 - 30	31 - 35	36 - 40	41 - 45	46 - 50	51 - 55	56 - 60	61 - 65	66 - 70	71 - 75	76 - 999
Count	33	39	196	1583	4682	3990	777	39	3	1	1	0	0	0
Percent	0.3	0.3	1.7	14.0	41.3	35.2	6.8	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Over Speed	15	20	25	30	35	40	45	50	55	60	65	70	75	999
Count	11311	11272	11076	9493	4811	821	44	5	2	1	0	0	0	0
Percent	99.7	99.4	97.6	83.7	42.4	7.2	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Percentile	5%	10%	15%	45%	50%	55%	85%	90%	95%					
Speed	27	29	30	34	35	35	39	40	41					

Average 35
(Mean)

Pace Speed 30-39
Number in 8776
Pace
Percent in 77.4
Pace

Sudbury Police Department

415 Boston Post Rd.
Sudbury, MA 01776

Site Code:
Station ID:
Concord Rd just South of Lincoln Rd

Northbound

Latitude: 0' 0.000 Undefined

Report for Report From 6/1/11 7:00:00 AM to 6/3/11 7:00:00 AM

CLASS STATISTICS - Modified Scheme F

Class	Bikes	Cars & Trailers	2 Axle Long	Buses	2 Axle 6 Tire	3 Axle Single	4 Axle Single	<5 Axl Double	5 Axle Double	>6 Axl Double	<6 Axl Multi	6 Axle Multi	>6 Axl Multi	No Class
Count	95	9566	1482	167	241	75	4	32	18	1	1	2	0	12
Percent	0.8	81.8	12.7	1.4	2.1	0.6	0.0	0.3	0.2	0.0	0.0	0.0	0.0	0.1

SPEED STATISTICS - 15 to 70+ by 5 MPH

Speed in MPH	1 - 15	16 - 20	21 - 25	26 - 30	31 - 35	36 - 40	41 - 45	46 - 50	51 - 55	56 - 60	61 - 65	66 - 70	71 - 75	76 - 999
Count	195	103	329	2280	5631	2834	309	10	4	0	0	1	0	0
Percent	1.7	0.9	2.8	19.5	48.1	24.2	2.6	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Over Speed	15	20	25	30	35	40	45	50	55	60	65	70	75	999
Count	11501	11398	11069	8789	3158	324	15	5	1	1	1	0	0	0
Percent	98.3	97.5	94.6	75.1	27.0	2.8	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Percentile	5%	10%	15%	45%	50%	55%	85%	90%	95%					
Speed	25	28	29	33	33	34	37	38	39					

Average 33
(Mean)

Pace Speed 29-38
Number in 9254
Pace
Percent in 79.1
Pace

Sudbury Police Department

415 Boston Post Rd.
Sudbury, MA 01776

Site Code:
Station ID:
Concord Rd just South of Lincoln Rd

COMBINED - Southbound, Northbound

Latitude: 0' 0.000 Undefined

Report for Report From 6/1/11 7:00:00 AM to 6/3/11 7:00:00 AM

CLASS STATISTICS - Modified Scheme F

Class	Bikes	Cars & Trailers	2 Axle Long	Buses	2 Axle 6 Tire	3 Axle Single	4 Axle Single	<5 Axl Double	5 Axle Double	>6 Axl Double	<6 Axl Multi	6 Axle Multi	>6 Axl Multi	No Class
Count	205	18121	3554	335	510	172	5	61	35	1	1	2	0	38
Percent	0.9	78.7	15.4	1.5	2.2	0.7	0.0	0.3	0.2	0.0	0.0	0.0	0.0	0.2

SPEED STATISTICS - 15 to 70+ by 5 MPH

Speed in MPH	1 - 15	16 - 20	21 - 25	26 - 30	31 - 35	36 - 40	41 - 45	46 - 50	51 - 55	56 - 60	61 - 65	66 - 70	71 - 75	76 - 999
Count	228	142	525	3863	10313	6824	1086	49	7	1	1	1	0	0
Percent	1.0	0.6	2.3	16.8	44.8	29.6	4.7	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Over Speed	15	20	25	30	35	40	45	50	55	60	65	70	75	999
Count	22812	22670	22145	18282	7969	1145	59	10	3	2	1	0	0	0
Percent	99.0	98.4	96.1	79.3	34.6	5.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Percentile	5%	10%	15%	45%	50%	55%	85%	90%	95%					
Speed	26	28	30	33	34	34	38	39	40					

Average 34
(Mean)

Pace Speed 29-38
Number in 17820
Pace
Percent in 77.3
Pace

Appendix C

Summary of 2006–2008 MassDOT Crash Data

Table C-1 Summary of Crashes at the Intersection of Concord Road at Lincoln Road

Statistics Period		2006	2007	2008	3-Year	Annual
Total Number of Crashes		3	3	0	6	2
Severity	Property Damage Only	3	3	0	6	2
	Personal Injury	0	0	0	0	0
	Fatality	0	0	0	0	0
	Not Reported	0	0	0	0	0
Collision Type	Angle	3	3	0	6	2
	Rear-end	0	0	0	0	0
	Sideswipe	0	0	0	0	0
	Head-on	0	0	0	0	0
	Single Vehicle	0	0	0	0	0
	Not Reported	0	0	0	0	0
Involved Pedestrian(s)		0	0	0	0	0
Involved Cyclist(s)		0	0	0	0	0
Occurred during Weekday Peak Periods*		0	2	0	2	1
Wet or Icy Pavement Conditions		0	1	0	1	0
Dark/Lighted Conditions		2	0	0	2	1

* Weekday Peak Periods defined as 7:00-10:00 AM and 3:30-6:30 PM

Table C-2 Summary of Crashes in the Section of Lincoln Road between Concord Road and Oak Ridge Road (including high school parking entrance and exit)

Statistics Period		2006	2007	2008	3-Year	Annual
Total Number of Crashes		3	2	1	6	2
Severity	Property Damage Only	1	1	1	3	1
	Personal Injury	2	1	0	3	1
	Fatality	0	0	0	0	0
	Not Reported	0	0	0	0	0
Collision Type	Angle	1	0	0	1	0
	Rear-end	1	0	0	1	0
	Sideswipe	0	0	0	0	0
	Head-on	0	0	0	0	0
	Single Vehicle	0	1	0	1	0
	Not Reported	1	1	1	3	1
Involved Pedestrian(s)		0	0	0	0	0
Involved Cyclist(s)		0	0	0	0	0
Occurred during Weekday Peak Periods*		2	1	0	3	1
Wet or Icy Pavement Conditions		1	1	0	2	1
Dark/Lighted Conditions		0	1	0	1	0

* Weekday Peak Periods defined as 7:00-10:00 AM and 3:30-6:30 PM

Appendix D

Preliminary Traffic Signal Warrants Analysis

TABLE D-1

Summary of Hourly Volumes and Warrant Fulfillment

Hourly Period Starting	Concord Road (major street)		Sum of NB and SB	Lincoln Road (minor street)	Volumes above the Required Minimum		
	NB	SB		WB	Warrant 1	Warrant 2	Warrant 7
6:00	611	157	767	43			
7:00	562	430	991	240	X	X	X
8:00	533	442	975	94			
9:00	361	278	639	239	X	X	X
10:00	300	205	505	92			
11:00	324	241	565	144			
12:00	333	280	612	216	X		X
13:00	354	293	647	199	X		X
14:00	460	308	768	219	X	X	X
15:00	441	368	809	214	X	X	X
16:00	593	428	1021	270	X	X	X
17:00	341	413	754	373	X	X	X
18:00	211	368	579	260	X	X	X
19:00	148	215	363	231			

Note: X = traffic volume meets the warrant requirement.

Warrant 1 is fulfilled. It requires that the traffic conditions (observed vehicular volumes higher than the specified minimum volumes) exist for each of any 8 hours of an average day. Condition A was applied in this case.

Warrant 2 is fulfilled. It requires that the traffic conditions (minimum volumes specified differently from Warrant 1) exist for each of any 4 hours of an average day.

Warrant 7 (Crash Experience) is not fulfilled. It requires that the traffic conditions (vehicular volumes higher than 80 percent of the volumes specified in Warrant 1, Condition A). The traffic volumes meet the requirement, but the recent crash data do not include five or more correctable crashes.

Appendix E

Intersection Capacity Analysis: Traffic Signal Alternatives for Weekday AM Peak Hour

Intersection Capacity Analysis

Concord Road at Lincoln Road, Sudbury

8/18/2011



Lane Group	WBL	NBT	SBL	SBT	ø9
Lane Configurations					
Volume (vph)	120	200	130	300	
Lane Group Flow (vph)	260	641	0	467	
Turn Type			Perm		
Protected Phases	8	2		6	9
Permitted Phases			6		
Detector Phase	8	2	6	6	
Switch Phase					
Minimum Initial (s)	4.0	4.0	4.0	4.0	4.0
Minimum Split (s)	20.0	20.0	20.0	20.0	25.0
Total Split (s)	20.0	45.0	45.0	45.0	25.0
Total Split (%)	22.2%	50.0%	50.0%	50.0%	28%
Yellow Time (s)	3.5	3.5	3.5	3.5	3.5
All-Red Time (s)	0.5	0.5	0.5	0.5	0.5
Lost Time Adjust (s)	0.0	0.0	0.0	0.0	
Total Lost Time (s)	4.0	4.0	4.0	4.0	
Lead/Lag					
Lead-Lag Optimize?					
Recall Mode	None	Max	Max	Max	None
Act Effect Green (s)	13.2	41.7		41.7	
Actuated g/C Ratio	0.20	0.63		0.63	
v/c Ratio	0.69	0.57		0.67	
Control Delay	31.7	9.8		17.9	
Queue Delay	0.0	0.0		0.0	
Total Delay	31.7	9.8		17.9	
LOS	C	A		B	
Approach Delay	31.7	9.8		17.9	
Approach LOS	C	A		B	
Queue Length 50th (ft)	72	78		89	
Queue Length 95th (ft)	#215	335		#408	
Internal Link Dist (ft)	1440	561		572	
Turn Bay Length (ft)					
Base Capacity (vph)	454	1123		694	
Starvation Cap Reductn	0	0		0	
Spillback Cap Reductn	0	0		0	
Storage Cap Reductn	0	0		0	
Reduced v/c Ratio	0.57	0.57		0.67	

Intersection Summary

Cycle Length: 90

Actuated Cycle Length: 66.2

Natural Cycle: 100

Control Type: Actuated-Uncoordinated

Maximum v/c Ratio: 0.69

Intersection Signal Delay: 16.7

Intersection LOS: B

Intersection Capacity Utilization 81.5%

ICU Level of Service D

Analysis Period (min) 15

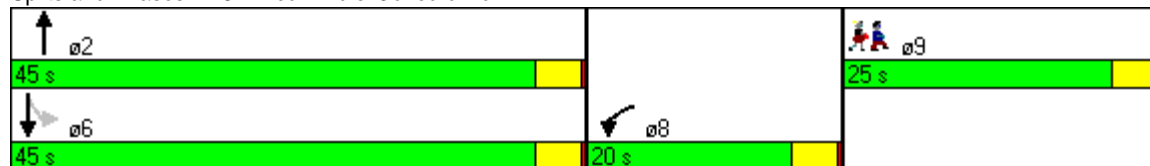
95th percentile volume exceeds capacity, queue may be longer.

Queue shown is maximum after two cycles.

Intersection Capacity Analysis Concord Road at Lincoln Road, Sudbury

8/18/2011

Splits and Phases: 3: Lincoln Rd & Concord Rd



Intersection Capacity Analysis
 Concord Road at Lincoln Road, Sudbury

8/18/2011



Lane Group	WBL	NBT	SBL	SBT	ø9
Lane Configurations					
Volume (vph)	120	200	130	300	
Lane Group Flow (vph)	260	641	141	326	
Turn Type			Perm		
Protected Phases	8	2		6	9
Permitted Phases			6		
Detector Phase	8	2	6	6	
Switch Phase					
Minimum Initial (s)	4.0	4.0	4.0	4.0	4.0
Minimum Split (s)	20.0	20.0	20.0	20.0	25.0
Total Split (s)	20.0	45.0	45.0	45.0	25.0
Total Split (%)	22.2%	50.0%	50.0%	50.0%	28%
Yellow Time (s)	3.5	3.5	3.5	3.5	3.5
All-Red Time (s)	0.5	0.5	0.5	0.5	0.5
Lost Time Adjust (s)	0.0	0.0	0.0	0.0	
Total Lost Time (s)	4.0	4.0	4.0	4.0	
Lead/Lag					
Lead-Lag Optimize?					
Recall Mode	None	Max	Max	Max	None
Act Effct Green (s)	13.2	41.7	41.7	41.7	
Actuated g/C Ratio	0.20	0.63	0.63	0.63	
v/c Ratio	0.69	0.57	0.39	0.28	
Control Delay	31.7	9.8	13.5	8.3	
Queue Delay	0.0	0.0	0.0	0.0	
Total Delay	31.7	9.8	13.5	8.3	
LOS	C	A	B	A	
Approach Delay	31.7	9.8		9.9	
Approach LOS	C	A		A	
Queue Length 50th (ft)	72	78	21	43	
Queue Length 95th (ft)	#215	335	110	165	
Internal Link Dist (ft)	1440	561		572	
Turn Bay Length (ft)					
Base Capacity (vph)	454	1123	361	1174	
Starvation Cap Reductn	0	0	0	0	
Spillback Cap Reductn	0	0	0	0	
Storage Cap Reductn	0	0	0	0	
Reduced v/c Ratio	0.57	0.57	0.39	0.28	

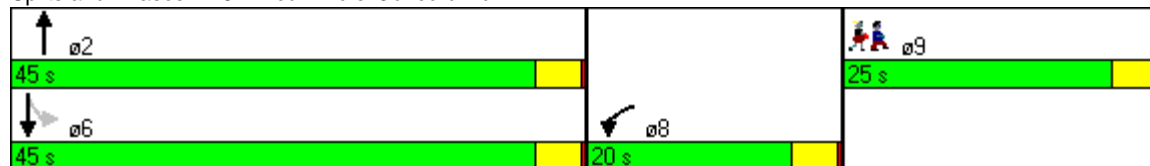
Intersection Summary

Cycle Length: 90
 Actuated Cycle Length: 66.2
 Natural Cycle: 90
 Control Type: Actuated-Uncoordinated
 Maximum v/c Ratio: 0.69
 Intersection Signal Delay: 14.0
 Intersection LOS: B
 Intersection Capacity Utilization 65.7%
 ICU Level of Service C
 Analysis Period (min) 15
 # 95th percentile volume exceeds capacity, queue may be longer.
 Queue shown is maximum after two cycles.

Intersection Capacity Analysis Concord Road at Lincoln Road, Sudbury

8/18/2011

Splits and Phases: 3: Lincoln Rd & Concord Rd



Appendix F

**Intersection Capacity Analysis
Modern Roundabout Alternative
Weekday AM Peak Hour**

HCM Unsignalized Intersection Capacity Analysis
 Concord Road at Lincoln Road, Sudbury

8/18/2011



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Right Turn Channelized						
Volume (veh/h)	120	120	200	390	130	300
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	130	130	217	424	141	326
Approach Volume (veh/h)	261		641			467
Crossing Volume (veh/h)	217		141			130
High Capacity (veh/h)	1168		1240			1251
High v/c (veh/h)	0.22		0.52			0.37
Low Capacity (veh/h)	965		1030			1039
Low v/c (veh/h)	0.27		0.62			0.45
Intersection Summary						
Maximum v/c High			0.52			
Maximum v/c Low			0.62			
Intersection Capacity Utilization			65.7%		ICU Level of Service	C