Technical Memorandum

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

From: Mike Wasielewski, P.E., PTOE

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

Date: November 21, 2018

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

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

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

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

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

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

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

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

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

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

Summary of Evaluation Data

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Discussion of Evaluation Data

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

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

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

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

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

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

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

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

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

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

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

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

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

Locations 5-8 along the Route 20 Corridor

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

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

Conclusions

Route 117

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

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

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

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

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

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

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

Sudbury Center

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

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

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

Route 20

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

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

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

Recommendations

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

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

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

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

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

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

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

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

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

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

Estimated Costs for Budgeting

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

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

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