

## MEMORANDUM

**TO:** Ms. Nina Nazarian  
Assistant Town Administrator  
Town of Tyngsborough  
25 Bryants Lane  
Tyngsborough, MA 01879

**FROM:** Mr. Jeffrey S. Dirk, P.E., PTOE, FITE  
Principal  
Vanasse & Associates, Inc.  
35 New England Business Center Drive  
Suite 140  
Andover, MA 01810-1066  
(978) 474-8800 x830  
jdirk@rdva.com



**DATE:** March 9, 2015

**RE:** 6793

**SUBJECT:** Intersection Safety and Operations Assessment  
Westford Road at the Tyngsborough Elementary School Driveway  
Frost Road at Norris Road  
Tyngsborough, Massachusetts

---

Vanasse & Associates, Inc. (VAI) has been retained by the Town of Tyngsborough to conduct an Intersection Safety and Operations Assessment for the intersections of Westford Road at the Tyngsborough Elementary School driveway and Route 3A (Frost Road) at Norris Road in Tyngsborough, Massachusetts. The purpose of this assessment is to evaluate potential improvement strategies for these intersections that would facilitate the safe and efficient flow of vehicles, pedestrians and bicyclists during peak school and arrival and departure periods. In conjunction with this analysis, an evaluation of traffic control strategies, including the installation of traffic control signals and enhanced school zone applications, has been completed for each of the study intersections.

This study was prepared in consultation with the Town of Tyngsborough and the Massachusetts Department of Transportation (MassDOT); was performed in general accordance with MassDOT's *Transportation Impact Assessment (TIA) Guidelines* and the MassDOT standards for the preparation of Traffic Impact Assessments for Functional Design Reports (FDRs); and was conducted pursuant to the standards of the Traffic Engineering and Transportation Planning professions for the preparation of such reports.

Based on this assessment, the following improvement strategies have been recommended:

**Westford Road/Tyngsborough Elementary School Driveway** - Implementation of an enhanced school zone that would include replacement of the existing school zone signs and pavement markings along Westford Road; establishment of a 20 mile per hour (mph) school zone speed limit on Westford Road during school hours; and reconstruction of wheelchair ramps for crossing Westford Road to meet current Americans with Disabilities Act (ADA) standards. These improvements would enhance safety at the intersection and reduce travel speeds during peak school traffic periods, thereby facilitating the ability of vehicles to exit the driveway; it is envisioned that a crossing guard would continue to be required to assist students crossing Westford Road. The estimated cost to design and implement the enhanced school zone measures is \$60,000.

***Frost Road/Norris Road*** - Installation of a traffic control signal that would be active on weekdays during peak school traffic periods and during special events (i.e., graduation, sporting events, or other activities), and would be placed in flashing operation during off-peak periods; pedestrian phase would be available at all times upon pushbutton actuation. These improvements would facilitate the safe and efficient flow of vehicles, pedestrians and bicyclists during peak school arrival and departure periods and during special event conditions. The estimated cost to design and implement the recommended improvements at the Frost Road/Norris Road intersections is \$255,000.

The following details our assessment of the intersections of Westford Road at the Tyngsborough Elementary School driveway and Frost Road at Norris Road.

## **EXISTING CONDITIONS**

A comprehensive field inventory of existing conditions within the study area was conducted in June, August and September 2014. The field investigation consisted of an inventory of existing roadway geometrics; pedestrian and bicycle facilities; public transportation services; traffic volumes; and operating characteristics; as well as posted speed limits and land use information within the study area. The study area intersections are depicted on Figures 1A and 1B, and consisted of the intersections of Westford Road at the Tyngsborough Elementary School driveway and Frost Road at Norris Road, inclusive of the associated approaches to the intersections.

The following describes existing conditions within the study area.

### **Roadways**

#### **Westford Road**



Westford Road is a two-lane collector roadway that is under Town jurisdiction and traverses the study area in a general east-west direction, providing two (2) 12-foot wide travel lanes separated by a double-yellow centerline with 1-foot wide marked shoulders. A Sidewalk is provided along the south side of Westford Road between Colonial Drive and the Tyngsborough Elementary School driveway, and along the north side to the east of the school driveway. The posted speed limit along Westford Road within the study area is 30 mph. Land use along Westford Road consists of the Tyngsborough Elementary School, residential properties and areas of open and wooded space.

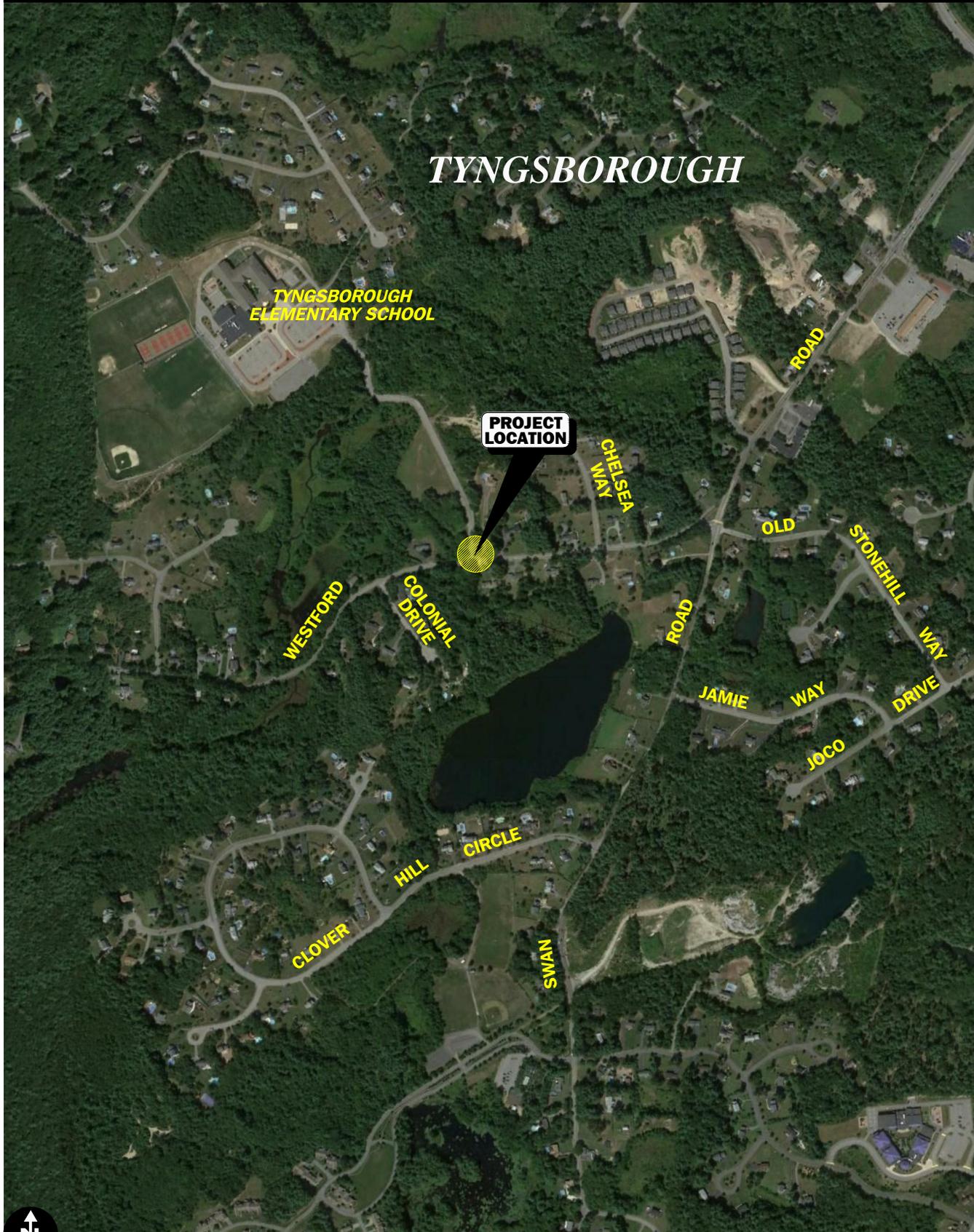


Figure 1A



Project Location Map -  
Westford Road at the  
Tyngsborough Elementary School  
Driveway



Figure 1B

Project Location Map -  
Frost Road at Norris Road



### Tyngsborough Elementary School Driveway



The Tyngsborough Elementary School driveway is a two-lane drive that is approximately 30-feet in width and accommodates two-way travel with no marked centerline, excepting through the “S” curve portion of the alignment approaching the school, or shoulders provided. A sidewalk is provided along the east side of the driveway that extends from Westford Road to the elementary school. Land use along the school driveway consists of the elementary school and areas of open and wooded space.

### Route 3A (Frost Road)



Route 3A (Frost Road) is a two-lane urban minor arterial roadway<sup>1</sup> that is under Town jurisdiction and traverses the study area in a general north-south direction, providing two (2) 11 to 12-foot wide travel lanes separated by a double-yellow centerline with 1 to 1.5-foot wide marked shoulders. A Sidewalk is provided along the west side of Frost Road. The posted speed limit along Frost Road within the study area is 35 mph. Land use along Frost Road consists of residential and commercial properties, and areas of open and wooded space.

### Norris Road



Norris Road is a two-lane collector roadway that is under Town jurisdiction and traverses the study area in a general east-west direction, providing two (2) 11-foot wide travel lanes separated by a double-yellow centerline with 1-foot wide marked shoulders. Approximately 100 feet of sidewalk is provided along the north side of Norris Road east of Frost Road. The posted speed limit along Norris Road within the study area is 25 mph. Land use along Norris Road consists of the Tyngsborough Middle School and High School, residential properties, and areas of open and wooded space.

<sup>1</sup>Roadway functional classifications defined by the MassDOT Office of Transportation Planning.

## Intersections

### Westford Road at the Tyngsborough Elementary School Driveway



The Tyngsborough Elementary School driveway intersects Westford Road from the north to form this three-legged, T-type, unsignalized intersection under STOP-sign control. Existing intersection attributes are as follows:

- The Tyngsborough Elementary School driveway approach to the intersection consists of an 11-foot wide left-turn lane and a 10-foot wide right-turn lane under STOP-sign control with marked STOP-line provided.
- A 3-way flashing beacon is centered over the intersection that provides flashing “yellow” indications for the Westford Road approaches and a flashing “red” indication for the school drive approach.
- The Westford Road east and westbound approaches provide a single general-purpose travel lane (12-foot wide).
- Directions of travel along Westford Road are separated by a double-yellow centerline with a 1-foot wide marked shoulder provided.
- Posted speed limit on the Westford Road approaches to the intersection is 30 mph.
- Sidewalks are provided along the south side of Westford Road west of the intersection, along the north side of Westford Road east of the intersection, and along the east side of the school driveway north of the intersection.
- A marked crosswalk is provided for crossing the east (Westford Road) leg of the intersection, with pedestrian crossing, school crossing and school zone warning signs provided at and in advance of the crossing on Westford Road.
- Land use in the vicinity of the intersection consists of the Tyngsborough Elementary School, residential properties and areas of open and wooded space.

## Frost Road at Norris Road



Norris Road intersects Frost Road from the east to form this three-legged, T-type, unsignalized intersection under STOP-sign control. Existing intersection attributes are as follows:

- The Norris Road approach to the intersection consists of a single 11-foot wide general-purpose travel lane under STOP-sign control with a marked STOP-line provided.
- Directions of travel along Norris Road are separated by a double-yellow centerline with a 1-foot wide marked shoulder provided.
- The Frost Road north and southbound approaches provide a single general-purpose travel lane (11 to 12-feet wide).
- Directions of travel along Frost Road are separated by a double-yellow centerline with a 1-foot wide marked shoulder provided.
- Posted speed limit on the Frost Road approaches to the intersection is 35 mph.
- Posted speed limit on the Norris Road approach to the intersection is 25 mph.
- Sidewalks are provided along the west side of Frost Road and along the north side of Norris Road east of the intersection for approximately 100 feet.
- A marked crosswalk is provided for crossing the north (Frost Road) leg of the intersection, with pedestrian crossing and school crossing warning signs provided at and in advance of the crossing on Frost Road.
- A Lowell Regional Transit Authority (LRTA) bus stop is located on Frost Road north of Norris Road.
- Land use in the vicinity of the intersection consists of residential properties and areas of open and wooded space.

## **Existing Traffic Volumes**

In order to determine existing traffic-volume demands and flow patterns within the study area, automatic traffic recorder (ATR) counts, manual turning movement counts (TMCs) and vehicle classification counts were completed in June 2014 prior to the end of the 2013-2014 school year and again in September 2014 while public schools were in regular session. The ATR counts were conducted at the following locations: Westford Road east of the Tyngsborough Elementary School driveway; the Tyngsborough Elementary School driveway north of Westford Road; Frost Road north of Norris Road; and Norris Road east of Frost Road; in order to record weekday daily traffic conditions along these roadways over an extended period. In addition, peak-period manual TMC's were performed at the intersection of Westford Road at the Tyngsborough Elementary School driveway during the weekday morning (8:30 to 9:30 AM) and afternoon (2:30 to 3:30 PM) elementary school peak traffic volume periods, and at the intersection of Frost Road at Norris Road during the weekday morning (7:00 to 9:00 AM) and afternoon (1:30 to 2:30 PM) middle school/high school peak traffic volume periods.

## **Traffic Volume Adjustments**

In order to evaluate the potential for seasonal fluctuation of traffic volumes within the study area, MassDOT weekday seasonal factors for Group 6 roadways (urban arterials, collectors and rural arterials, the functional classification of both Westford Road and Frost Road) were reviewed.<sup>2</sup> Based on a review of this data, it was determined that traffic volumes for the months of June and September are approximately 10 percent and 8 percent above average-month conditions, respectively. As such, the June and September traffic volume data was not adjusted downward to average-month conditions in order to provide a conservative (above-average) analysis condition. The 2014 Existing traffic volumes are summarized in Table 1, with the weekday morning and afternoon peak-hour traffic volumes graphically depicted on Figures 2 and 3 for the Westford Road/Tyngsborough Elementary School driveway and Frost Road/Norris Road intersections, respectively.

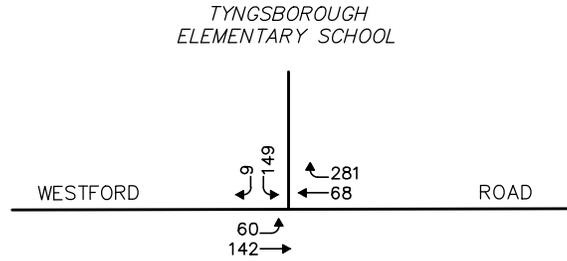
---

<sup>2</sup>MassDOT Traffic Volumes for the Commonwealth of Massachusetts; 2007 Weekday Seasonal Factors, Group 6 – Urban Arterials, Collectors and Rural Arterials.



WEEKDAY MORNING PEAK HOUR

8:30 to 9:30 AM



WEEKDAY AFTERNOON PEAK HOUR

2:30 to 3:30 PM

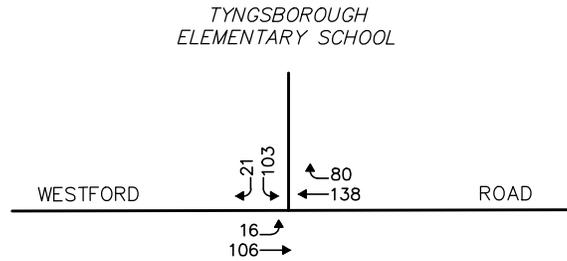
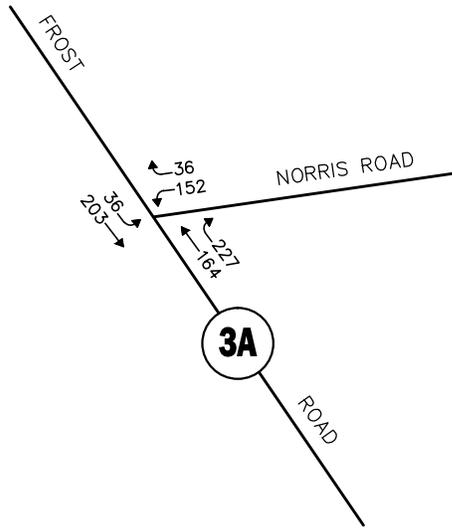


Figure 2

2014 Existing  
Peak Hour Traffic Volumes

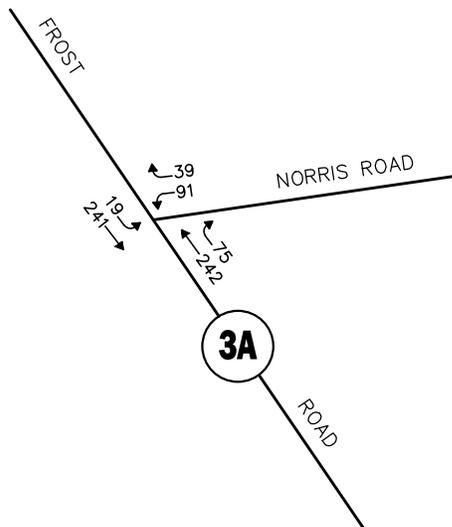
WEEKDAY MORNING PEAK HOUR

7:00 to 8:00 AM



WEEKDAY AFTERNOON PEAK HOUR

1:30 to 2:30 PM



Not To Scale



Figure 3

2014 Existing  
Peak Hour Traffic Volumes

**Table 1**  
**2014 EXISTING TRAFFIC VOLUMES**

Location	AWT <sup>a</sup>	Weekday Morning Peak-Hour			Weekday Afternoon Peak-Hour		
		VPH <sup>b</sup>	K Factor <sup>c</sup>	Directional Distribution <sup>d</sup>	VPH	K Factor	Directional Distribution
Westford Road, east of Tyngsborough Elementary School Driveway	5,060	640	12.6	54.5% WB	427	8.4	54.1 % WB
Tyngsborough Elementary School Driveway, north of Westford Road	1,935	499	25.8	68.3% NB	220	11.4	56.4 % SB
Frost Road, north of Norris Road	9,190	439	4.8	62.6 % WB	541	5.9	51.9 % NB
Norris Road, east of Frost Road	2,220	451	20.3	58.3 % EB	224	10.1	58.0 % WB

<sup>a</sup>Average weekday traffic in vehicles per day.

<sup>b</sup>Vehicles per hour.

<sup>c</sup>Percent of daily traffic occurring during the peak hour.

<sup>d</sup>Percent traveling in peak direction.

<sup>e</sup>NB = northbound; SB = southbound; EB = eastbound; WB = westbound.

As can be seen in Table 1, Westford Road, east of Tyngsborough Elementary School driveway, was found to accommodate approximately 5,060 vehicles on an average weekday (two-way, 24-hour volume), with approximately 640 vehicles per hour (vph) during the weekday morning peak-hour (8:30 to 9:30 AM) and 427 vph during the weekday afternoon peak-hour (2:30 to 3:30 PM).

The Tyngsborough Elementary School driveway was found to accommodate approximately 1,935 vehicles on an average weekday, with approximately 499 vph during the weekday morning peak-hour (8:30 to 9:30 AM) and 220 vph during the weekday afternoon peak-hour (2:30 to 3:30 PM).

Frost Road, north of Norris Road, was found to accommodate approximately 9,190 vehicles on an average weekday, with approximately 439 vph during the weekday morning peak-hour (7:00 to 8:00 AM) and 541 vph during the weekday afternoon peak-hour (1:30 to 2:30 PM).

Norris Road, east of Frost Road, was found to accommodate approximately 2,220 vehicles on an average weekday, with approximately 451 vph during the weekday morning peak-hour (7:00 to 8:00 AM) and 224 vph during the weekday afternoon peak-hour (1:30 to 2:30 PM).

### **Pedestrian and Bicycle Facilities**

A comprehensive field inventory of pedestrian and bicycle facilities within the study area was undertaken in August 2014. The field inventory consisted of a review of the location of sidewalks and pedestrian crossing locations at the study intersections, as well as the location of existing and proposed bicycle facilities.



## **Westford Road at the Tyngsborough Elementary School Driveway**

Sidewalks are provided along the south side of Westford Road between Colonial Drive and the Tyngsborough Elementary School driveway, along the north side of Westford Road to the east of the school driveway, and along the east side of the school driveway. A marked crosswalk is provided for crossing the Westford Road east leg of the intersection, with pedestrian crossing warning signs provided on Westford Road at the crossing. Advance school crossing and school zone signs are also provided on Westford Road in advance of the intersection.

At present, formal existing bicycle facilities were not identified within the immediate study area and a review of conditions along Westford Road indicate that the current roadway width is not sufficient to support bicycle travel in a shared travelled-way condition (i.e., bicycles and motor vehicle sharing the travelled-way).<sup>3</sup>

## **Frost Road at Norris Road**

Sidewalks are provided continuously along the west side of Frost Road and along the north side of Norris Road east of Frost Road for approximately 100 feet. A marked crosswalk is provided for crossing the Frost Road north leg of the intersection, with pedestrian crossing warning signs provided on Westford Road at the crossing. Advance school crossing and school zone signs are also provided on Westford Road in advance of the intersection.

At present, formal existing bicycle facilities were not identified within the immediate study area and a review of conditions along Frost Road and Norris Road indicate that the current width of these roadways is not sufficient to support bicycle travel in a shared travelled-way condition (i.e., bicycles and motor vehicle sharing the travelled-way).

## **Public Transportation Services**

The Lowell Regional Transit Authority (LRTA) provides public bus and paratransit services to the Town of Tyngsborough. Within the study area, LRTA Bus Route 10, *Dracut/Tyngsborough*, provides fixed-route bus route service with a designated (by sign) stop on Frost Road north of Norris Road. Paratransit services are provided to eligible residents of the Town through the Council on Aging by way of the LRTA Road Runner service. LRTA Bus Route 10 provides service between the Kennedy Center at Gallagher Terminal in Lowell and Ayotte's Market in Hudson, New Hampshire, and operates between 6:35 AM and 8:10 PM on weekdays, and from 8:30 AM to 6:56 PM on Saturday; no service on Sunday. Fare costs are \$1.50 one-way.

The LRTA Road Runner paratransit service is available to eligible persons with disabilities who are unable to use the LRTA fixed-route bus service. All Road Runner vehicles are equipped to provide service to individuals with wheelchairs or other mobility assistance devices. The LRTA Road Runner service operates during the same hours as the LRTA fixed route bus service, but does not operate during some holidays and when extreme weather conditions exist. Reservations for Road Runner service can be made up to one day prior and cancellations are required at least one hour in advance. Fares cost for the Road Runner service are \$1.00 for in-town trips and \$1.50 for out of town service. Public transportation service information is included in the Appendix.

---

<sup>3</sup>The minimum width required to support bicycle travel in a shared travelled-way configuration is 14-feet consisting of the travel lane and shoulder area where present.



## Spot Speed Measurements

Vehicle travel speed measurements were performed on Westford Road and Frost Road within the study area over a continuous 24-hour period in conjunction with the ATR counts. Table 2 summarizes the vehicle travel speed measurements.

**Table 2**  
**VEHICLE TRAVEL SPEED MEASUREMENTS**

	Westford Road		Frost Road	
	Eastbound	Westbound	Northbound	Southbound
Mean Travel Speed (mph)	33	34	34	35
85 <sup>th</sup> Percentile Speed (mph)	38	40	40	41
Posted Speed Limit (mph)	30	30	35	35

mph = miles per hour.

As can be seen in Table 2, the mean (average) vehicle travel speed along Westford Road within the study area was found to be approximately 34 mph. The average measured 85<sup>th</sup> percentile vehicle travel speed, or the speed at which 85 percent of the observed vehicles traveled at or below, was found to be approximately 39 mph, or 9 mph above the posted speed limit (30 mph). The 85<sup>th</sup> percentile speed is used as the basis of engineering design and in the evaluation of sight distances, and is often used in establishing posted speed limits.

The mean (average) vehicle travel speed along Frost Road within the study area was found to be approximately 35 mph, with the average measured 85<sup>th</sup> percentile vehicle travel speed found to be approximately 41 mph, or 6 mph above the posted speed limit (35 mph). The detailed speed measurements are provided in the Appendix.

## Motor Vehicle Crash Data

Motor vehicle crash information for the intersections of Westford Road at the Tyngsborough Elementary School driveway and Frost Road at Norris Road was provided by the MassDOT Highway Division Safety Management/Traffic Operations Unit for the most recent five-year period available (2008 through 2012, inclusive) in order to examine motor vehicle crash trends occurring at the intersections. The data is summarized by type, severity, and day of occurrence, and presented in Table 3.

**Table 3**  
**MOTOR VEHICLE CRASH DATA SUMMARY<sup>a</sup>**

	Westford Road/ Tyngsborough Elementary School Driveway	Frost Road/ Norris Road
Traffic Control Type: <sup>b</sup>	U	U
<i>Year:</i>		
2008	0	2
2009	0	1
2010	0	0
2011	0	3
<u>2012</u>	<u>0</u>	<u>2</u>
Total	0	8
Average	0.00	1.60
Calculated Crash Rate <sup>c</sup>	0.00	0.56
MassDOT Crash Rate <sup>d</sup>	0.60/0.58	0.60/0.58
Significant? <sup>e</sup>	No	No
<i>Severity:</i>		
Property Damage Only	0	5
Personal Injury	0	3
Fatal	0	0
<u>Unknown</u>	<u>0</u>	<u>0</u>
Total	0	8
<i>Type:</i>		
Angle	0	6
Rear-End	0	2
Head-On	0	0
Fixed Object	0	0
Sideswipe Same Direction	0	0
Sideswipe Opposite Direction	0	0
<u>Unknown/Other</u>	<u>0</u>	<u>0</u>
Total	0	8
<i>Weather Conditions:</i>		
Clear	0	7
Cloudy	0	1
Rain	0	0
Snow/Ice	0	0
<u>Unknown</u>	<u>0</u>	<u>0</u>
Total	0	8
<i>Lighting</i>		
Daylight	0	7
Dawn/Dusk	0	0
Dark (Road Lit)	0	1
Dark (Road Unlit)	0	0
Dark (No Street Lights)	0	0
<u>Other/Unknown</u>	<u>0</u>	<u>0</u>
Total	0	8
<i>Day of Week:</i>		
Monday through Friday	0	6
Saturday	0	2
<u>Sunday</u>	<u>0</u>	<u>0</u>
Total	0	8

<sup>a</sup>Source: MassDOT Safety Management/Traffic Operations Unit records, 2008 through 2012.

<sup>b</sup>Traffic Control Type: U = Unsignalized Intersection.

<sup>c</sup>Crash rate per million vehicles entering the intersection.

<sup>d</sup>Statewide/District crash rate.

<sup>e</sup>The intersection crash rate is significant if it is found to exceed MassDOT statewide or District Crash Rate for the MassDOT Highway Division District in which the intersection is located (District 4).



As can be seen in Table 3, there were no motor vehicle crashes reported at the Westford Road/Tyngsborough Elementary School driveway over the five-year review period based on the MassDOT database which reflects all crashes reportable to the Registry of Motor Vehicles (RMV). The intersection of Frost Road at Norris Road was found to have experienced a total of eight (8) reported motor vehicle crashes over the five-year review period, or approximately two (2) crashes per year. The majority of the reported crashes involved property damage only; occurred on a weekday during school hours; during daylight; under clear weather conditions; and were reported as angle-type collisions. The calculated crash rate at the intersection (average number of motor vehicle crashes reported per year per million vehicles travelling through the intersection) was 0.56, which is below the MassDOT statewide and Highway Division District 4 (the MassDOT Highway Division District in which the intersection is located) average crash rates for an unsignalized intersection. As such, the MassDOT data did not indicate a discernible safety deficiency with respect to the design or operation of the study intersections. No fatal motor vehicle crashes were reported at the study intersections over the five-year review period. The detailed MassDOT Crash Rate Worksheet is provided in the Appendix.

### **Existing Traffic Operations**

In order to evaluate existing traffic operations at the study intersections, a detailed traffic operations analysis was completed under 2014 Existing traffic volume conditions. In brief, six levels of service are defined for each type of facility. They are given letter designations ranging from “A” to “F”, with a level-of-service (LOS) “A” representing the best operating conditions and a LOS “F” representing congested or constrained operations. A LOS “E” is representative of a transportation facility that is operating at its design capacity with a LOS “D” generally defined as the limit of “acceptable” traffic operations. Since the level-of-service of a traffic facility is a function of the flows placed upon it, such a facility may operate at a wide range of levels of service depending on the time of day, day of week, or period of the year. The Synchro™ intersection capacity analysis software, which is based on the analysis methodologies and procedures presented in the 2010 *Highway Capacity Manual* (HCM),<sup>4</sup> was used to complete the level-of-service and vehicle queue analyses, the results of which are summarized in Tables 4 and 5 and described below.

#### **Westford Road at the Tyngsborough Elementary School Driveway**

As can be seen in Table 4, under 2014 Existing traffic volume conditions without police detail officer control, the critical movements at this unsignalized intersection (left-turn movements exiting the school driveway) were shown to operate at LOS “E” during the weekday morning peak school traffic volume hour and at LOS “C” during the weekday afternoon school peak traffic volume hour, with reported vehicle queues of 2 to 8 vehicles. All movements along Westford Road were shown to operate at LOS “A” during the peak periods, with reported vehicle queues of 0 to 1 vehicle.

As can be seen in Table 5, under 2014 Existing traffic volume conditions with police detail officer control,<sup>5</sup> the intersection was shown to operate at an overall LOS “A” during both the weekday morning and afternoon peak school traffic volume hours, with reported vehicle queues of 0 to 3 vehicles.

---

<sup>4</sup>*Highway Capacity Manual*, Transportation Research Board; Washington, DC; 2010.

<sup>5</sup>Intersection operations are modelled under traffic signal control to replicate operating conditions with a police detail officer present.



## Frost Road at Norris Road

As can be seen in Table 4, under 2014 Existing conditions without police detail officer control, the critical movements at this unsignalized intersection (all movements from Norris Road) were shown to operate at LOS “C” during the weekday morning peak school traffic volume hour and at LOS “D” during the weekday afternoon school peak traffic volume hour, with reported vehicle queues of 4 to 6 vehicles. All movements along Frost Road were shown to operate at LOS “A” during the peak periods with negligible vehicle queuing reported.

As can be seen in Table 5, under 2014 Existing conditions with police detail officer control, the intersection was shown to operate at an overall LOS “A” during both the weekday morning and afternoon peak school traffic volume hours, with reported vehicle queues of 1 to 4 vehicles.

**Table 4**  
**INTERSECTION OPERATIONS WITHOUT POLICE OFFICER CONTROL**

Peak Hour/Movement	2014 Existing			
	Demand <sup>a</sup>	Delay <sup>b</sup>	LOS <sup>c</sup>	Queue <sup>d</sup> 95 <sup>th</sup>
<b>Westford Road at Tyngsborough Elementary School Driveway:</b>				
<i>Weekday Morning</i>				
Westford Road EB LT/TH	162	2.6	A	1
Westford Road WB TH/RT	349	0.0	A	0
School Drive NB LT	149	46.4	E	8
School Drive SB RT	9	10.1	B	0
<i>Weekday Afternoon</i>				
Westford Road EB LT/TH	122	1.1	A	0
Westford Road WB TH/RT	218	0.0	A	0
School Drive NB LT	103	15.8	C	2
School Drive SB RT	21	10.1	B	0
<b>Frost Road at Norris Road:</b>				
<i>Weekday Morning</i>				
Norris Road WB LT/RT	188	21.3	C	4
Frost Road NB TH/RT	391	0.0	A	0
Frost Road NB LT/TH	239	1.3	A	0
<i>Weekday Evening:</i>				
Norris Road WB LT/RT	130	27.2	D	6
Frost Road NB TH/RT	317	0.0	A	0
Frost Road NB LT/TH	260	0.6	A	0

<sup>a</sup>Demand in vehicle per hour.

<sup>b</sup>Average control delay per vehicle (in seconds).

<sup>c</sup>Level-of-Service.

<sup>d</sup>Queue length in vehicle.

NB = northbound; SB = southbound; EB = eastbound; WB = westbound; LT = left-turning movements; TH = through movements; RT = right-turning movements.



**Table 5**  
**INTERSECTION OPERATIONS WITH POLICE OFFICER CONTROL**

Peak Hour/Movement	2014 Existing			
	V/C <sup>a</sup>	Delay <sup>b</sup>	LOS <sup>c</sup>	Queue <sup>d</sup> 50 <sup>th</sup> /95 <sup>th</sup>
<b>Westford Road at Tyngsborough</b>				
<b>Elementary School Driveway:</b>				
<i>Weekday Morning</i>				
Westford Road EB LT/TH	0.44	11.2	B	2/3
Westford Road WB TH/RT	0.52	4.7	A	1/2
School Drive SB LT	0.48	11.5	B	2/2
School Drive SB RT	0.03	4.6	A	0/0
<b>Overall</b>	--	<b>8.4</b>	<b>A</b>	--
<i>Weekday Afternoon</i>				
Westford Road EB LT/TH	0.28	8.6	A	1/2
Westford Road WB TH/RT	0.45	7.7	A	1/2
School Drive SB LT	0.43	9.9	A	1/1
School Drive SB RT	0.11	3.4	A	0/0
<b>Overall</b>	--	<b>8.3</b>	<b>A</b>	--
<b>Frost Road at Norris Road:</b>				
<i>Weekday Morning</i>				
Norris Road WB LT/RT	0.61	9.4	A	1/1
Frost Road NB TH/RT	0.53	5.4	A	2/3
Frost Road SB LT/TH	0.28	5.3	A	1/3
<b>Overall</b>	--	<b>6.5</b>	<b>A</b>	--
<i>Weekday Afternoon</i>				
Norris Road WB LT/RT	0.44	10.1	B	1/2
Frost Road NB TH/RT	0.50	9.0	A	2/4
Frost Road SB LT/TH	0.41	8.7	A	2/4
<b>Overall</b>	--	<b>9.2</b>	<b>A</b>	--

<sup>a</sup>Volume-to-capacity ratio.

<sup>b</sup>Average delay per vehicle (in seconds).

<sup>c</sup>Level-of-Service.

<sup>d</sup>Queue length in vehicle.

NEB = northeastbound; NWB = northwestbound; SEB = southeastbound; SWB = southwestbound;  
 LT = left-turning movements; TH = through movements; RT = right-turning movements.

## **SIGHT DISTANCE EVALUATION**

Sight distance measurements were performed at both study intersections in accordance with MassDOT and American Association of State Highway and Transportation Officials (AASHTO)<sup>6</sup> requirements. Both stopping sight distance (SSD) and intersection sight distance (ISD) measurements were performed. In brief, SSD is the distance required by a vehicle traveling at the design speed of a roadway, on wet pavement, to stop prior to striking an object in its travel path. ISD or corner sight distance (CSD) is the sight distance required by a driver entering or crossing an intersecting roadway to perceive an on-coming vehicle and safely complete a turning or crossing maneuver with on-coming traffic. In accordance with AASHTO standards, if the measured ISD is at least equal to the required SSD value for the appropriate design speed, the intersection can operate in a safe manner. Table 6 presents the measured SSD and ISD at the subject intersections.

<sup>6</sup>A Policy on Geometric Design of Highway and Streets, 6<sup>th</sup> Edition; American Association of State Highway and Transportation Officials (AASHTO); 2011.



**Table 6**  
**SIGHT DISTANCE MEASUREMENTS<sup>a</sup>**

Intersection/Sight Distance Measurement	Feet		
	Required Minimum (SSD)	ISD <sup>b</sup>	Measured
<b><i>Westford Road at Tyngsborough Elementary School Driveway</i></b>			
<i>Stopping Sight Distance:</i>			
Westford Road approaching from the east	305	--	500+
Westford Road approaching from the west	305	--	500+
<i>Intersection Sight Distance:</i>			
Looking to the east from School Drive	305	385/445	500+
Looking to the west from School Drive	305	385/445	500+
<b><i>Frost Road at Norris Road</i></b>			
<i>Stopping Sight Distance:</i>			
Frost Road approaching from the north	360	--	500+
Frost Road approaching from the south	360	--	500+
<i>Intersection Sight Distance:</i>			
Looking to the north from Norris Road	360	430/500	500+
Looking to the south from Norris Road	360	430/500	500+

<sup>a</sup>Recommended minimum values obtained from *A Policy on Geometric Design of Highways and Streets*, 6<sup>th</sup> Edition; American Association of State Highway and Transportation Officials (AASHTO); 2011; and based on a 40 mph approach speed on Westford Road and a 45 mph approach speed on Frost Road.

<sup>b</sup>Values shown are the intersection sight distance for a vehicle turning right/left exiting a roadway under STOP control such that motorists approaching the intersection on the major street should not need to adjust their travel speed to less than 70 percent of their initial approach speed.

As can be seen in Table 6, the available lines of sight at the Westford Road/Tyngsborough Elementary School driveway and Frost Road/Norris Road intersections were found to exceed the recommended minimum sight distance requirements to function in a safe and efficient manner for the appropriate approach speed on both Westford Road and Frost Road (40 mph and 45 mph, respectively).



## **INTERSECTION IMPROVEMENT ALTERNATIVES AND ANALYSIS**

Based on a review of existing traffic volume and geometric conditions at the study intersections, two (2) potential improvement strategies (alternatives) were identified for evaluation: 1) traffic signal control; and 2) enhanced school zone applications. A detailed assessment of each of the two identified improvement alternatives was completed with respect to their ability to facilitate the safe and efficient flow of vehicles, pedestrians and bicyclists during peak school arrival and departure periods. The following summarizes the assessment of the identified intersection improvement strategies at each intersection, with preliminary cost estimates also provided.

### **Westford Road at the Tyngsborough Elementary School Driveway**

#### **Alternative 1 - Traffic Signal Control**

Intersection Improvement Alternative 1 would entail the installation of a traffic control signal at the intersection of Westford Road at the Tyngsborough Elementary School driveway within the confines of the existing intersection geometry (i.e., single-lane approaches on Westford Road and two-lane approach on the school driveway). In order to determine if the installation of a traffic control signal is justified at the intersection, a detailed Traffic Signal Warrants Analysis (TSWA) was completed in accordance with the methodology and procedures outlined in the Manual on Uniform Traffic Control Devices (MUTCD).<sup>7</sup>

In brief, The MUTCD establishes nine warrants or criteria to evaluate a location for the installation (or retention) of a traffic signal. At least one of the nine warrants must be satisfied in order to justify the installation or retention of a traffic signal; however, satisfaction of a warrant in and of itself does not necessarily indicate that the installation of a traffic signal is the best traffic control solution. An engineering evaluation of the location in question should indicate that the establishment of traffic signal control will improve the overall safety and/or operation of the intersection. Table 7 lists the nine warrants used to evaluate an intersection for traffic signal control as presented in the MUTCD.

**Table 7**  
**TRAFFIC SIGNAL WARRANTS**

Warrant No.	Description
1	Eight-Hour Vehicular Volume
2	Four-Hour Vehicular Volume
3	Peak-Hour
4	Pedestrian Volume
5	School Crossing
6	Coordinated Signal System
7	Crash Experience
8	Roadway Network
9	Intersection Near a Grade Crossing

<sup>7</sup>Manual on Uniform Traffic Control Devices (MUTCD); Federal Highway Administration; Washington, DC; 2009.



Each of the nine traffic signal warrants listed in Table 7 were evaluated for the intersection of Westford Road at the Tyngsborough Elementary School driveway based on the current intersection geometry and under September 2014 Existing traffic volume conditions with public school in regular session. Table 8 summarizes the results of the TSWA for the intersection with the detailed worksheets and supporting materials attached.

**Table 8**  
**TRAFFIC SIGNAL WARRANTS ANALYSIS**  
**WESTFORD ROAD/TYNGSBOROUGH ELEMENTARY**  
**SCHOOL DRIVEWAY**

Warrant No.	Description	Satisfied?
		2014 Existing
1	Eight-Hour Vehicular Volume	No
2	Four-Hour Vehicular Volume	No
3	Peak-Hour	No
4	Pedestrian Volume	No
5	School Crossing	No
6	Coordinated Signal System	No
7	Crash Experience	No
8	Roadway Network	No
9	Intersection Near a Grade Crossing	No

As can be seen in Table 8, the intersection of Westford Road at the Tyngsborough Elementary School driveway was not found to satisfy any of the warrants evaluated justifying the installation of a traffic control signal at the intersection under 2014 Existing conditions. As such, the installation of a traffic control signal is not justified at the intersection as a potential improvement measure.

**Alternative 2 – Enhanced School Zone**

Intersection Improvement Alternative 2 would entail replacement of the existing school zone signs and pavement markings along Westford Road and at the elementary school driveway to meet current MassDOT and MUTCD standards for a school zone. In addition, a 20 mph school zone speed limit would be established on Westford Road during school hours and would be supplemented by school zone speed limit signs, pavement markings and flashing yellow beacons (at the beginning of the school zone to accompany the 20 mph speed limit sign) in order to reduce travel speeds approaching the driveway. Further, new wheelchair ramps would be installed for the crosswalk across Westford Road in order to meet current accessibility standards. Figure 4 conceptually depicts the elements of the enhanced school zone installation for the intersection.

Implementation of the enhanced school zone strategy would serve to improve safety at the intersection and reduce travel speeds along Westford Road during peak school traffic periods, thereby facilitating the ability of vehicles to exit the driveway. It is envisioned that a crossing guard will continue to be required to assist students crossing Westford Road.

The estimated cost to implement the recommended improvements as depicted on Figure 4 is \$60,000, and includes engineering design, bidding services and construction.





**Figure 4**  
**Conceptual Improvement Plan**  
**Westford Road at Tyngsborough**  
**Elementary School Driveway**

## Frost Road at Norris Road

### Alternative 1 - Traffic Signal Control

Intersection Improvement Alternative 1 would entail the installation of a traffic control signal at the intersection of Frost Road at Norris Road within the confines of the existing intersection geometry (i.e., single-lane approaches on both Frost Road and Norris Road). In order to determine if the installation of a traffic control signal is justified at the intersection, a detailed TSWA was completed in accordance with the methodology and procedures outlined in the MUTCD defined previously and using the September 2014 traffic volume data. Table 9 summarizes the results of the TSWA for the intersection with the detailed worksheets and supporting materials attached.

**Table 9**  
**TRAFFIC SIGNAL WARRANTS ANALYSIS**  
**FROST ROAD AT NORRIS ROAD**

Warrant No.	Description	Satisfied?
		2014 Existing
1	Eight-Hour Vehicular Volume	No
2	Four-Hour Vehicular Volume	<b>Yes</b>
3	Peak-Hour	<b>Yes</b>
4	Pedestrian Volume	No
5	School Crossing	No
6	Coordinated Signal System	No
7	Crash Experience	No
8	Roadway Network	No
9	Intersection Near a Grade Crossing	No

As can be seen in Table 9, the intersection of Frost Road at Norris Road was found to satisfy Warrant 2, Four-Hour Vehicular Volume, and Warrant 3, Peak-Hour, justifying the installation of a traffic control signal at the intersection under 2014 Existing conditions. As such, the installation of a traffic control signal is justified at the intersection as a potential improvement measure to control traffic during school hours. Figure 5 conceptually depicts the design elements for the installation of a traffic control signal at the Frost Road/Norris Road intersection.

The installation of a traffic control signal at the Frost Road/Norris Road intersection would facilitate access to the Tyngsborough Middle School and High School and provide for controlled crossing of the intersection by pedestrians and bicyclists. The traffic control signal would be active on weekdays during peak school traffic periods and could be placed in flashing operation (i.e., flashing yellow indications for Frost Road and flashing red indications for Norris Road) during off-peak periods; the pedestrian phase would be accommodated during both peak and off-peak periods when actuated by the pedestrian pushbuttons. Actuation of the traffic signal for special events such as graduation, sporting events, or other activities can also be accommodated remotely (via phone or internet connection) or by authorized personnel at the intersection.

The estimated cost to implement the recommended improvements as depicted on Figure 5 is \$255,000, and includes engineering design, bidding services and construction.

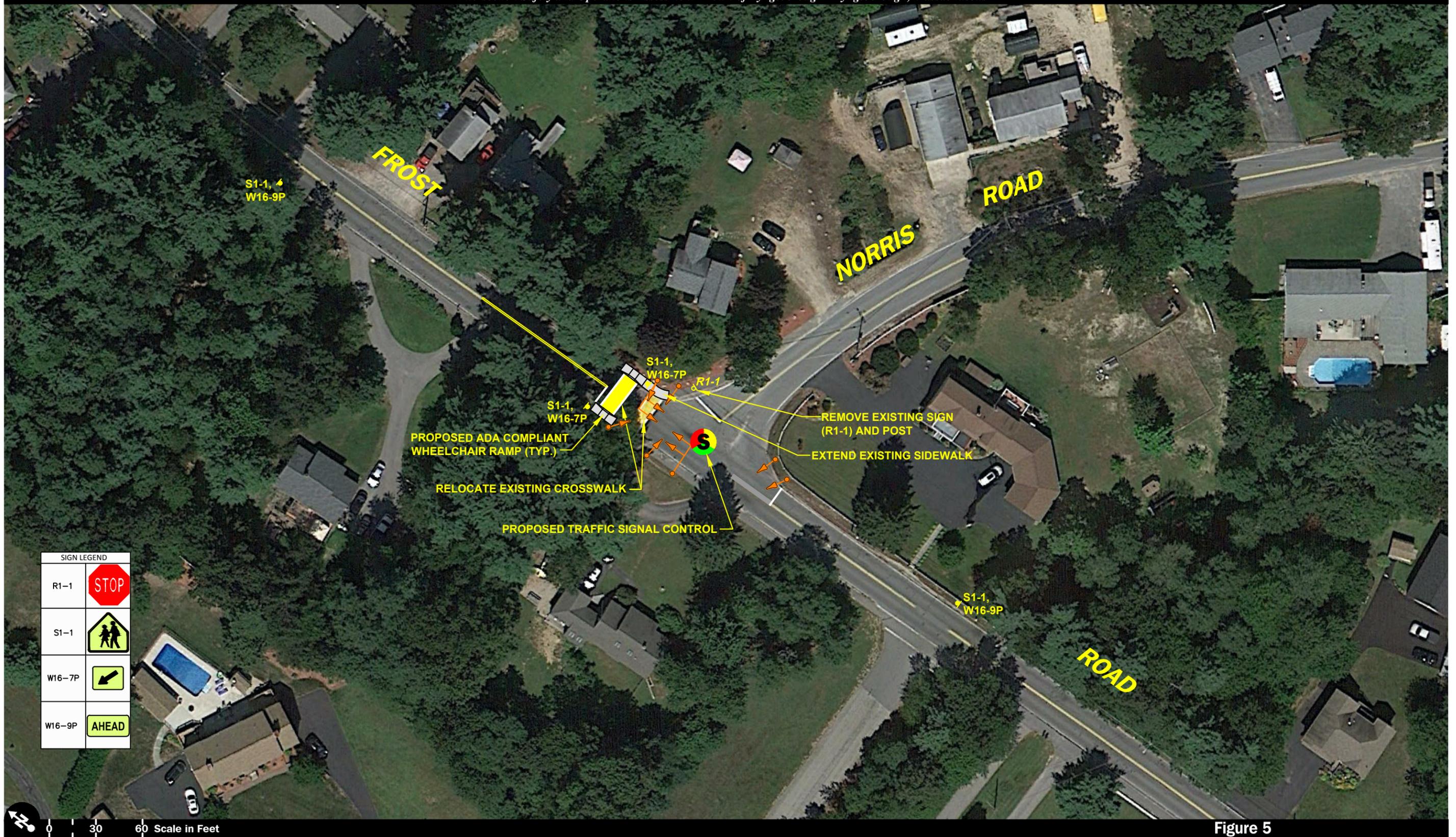


Figure 5

Conceptual Improvement Plan  
Frost Road at Norris Road with  
Traffic Signal Control

## **Alternative 2 – Enhanced School Zone**

Intersection Improvement Alternative 2 would entail replacement of the existing school zone signs and pavement markings along Frost Road and at Norris Road to meet current MassDOT and MUTCD standards for a school zone, the elements of which are depicted on Figure 6.

As depicted on Figure 6, the enhanced school zone would include: replacement of the existing school zone and pedestrian crossing signs; installation of “Intersection Ahead” warning signs (W2-1)<sup>8</sup> with supplemental street name placards (W16-8P) on Frost Road approaching the intersection; relocation of the crosswalk across Frost Road so as not to conflict with the existing residential driveway; and the installation of wheelchair ramps compliant with ADA standards. Further, a new STOP-sign would be installed on a breakaway post on the Norris Road approach to the intersection with red reflective tape added to the post to enhance visibility and motorist awareness of the stop control of the intersection.

Implementation of the enhanced school zone strategy would serve to improve safety and enhance motorist guidance at the intersection; however, a police detail officer would continue to be required at the intersection during peak school traffic arrival and departure periods and for special events to assist motorists, pedestrians and bicyclists in traversing the intersection.

The estimated cost to implement the recommended improvements as depicted on Figure 6 is \$25,000, and includes engineering design, bidding services and construction.

### **Recommended Improvement Strategy**

Considering the two improvement strategies for the Frost Road/Norris Road intersection in the context of the stated goals of facilitating the safe and efficient flow of vehicles, pedestrians and bicyclists during peak school and arrival and departure periods, Intersection Improvement Alternative 1, traffic signal control, is the recommended improvement strategy for the intersection and would provide the added advantage of traffic control during special event conditions.

---

<sup>8</sup>Sign designations are as specified in: *Manual on Uniform Traffic Control Devices* (MUTCD); Federal Highway Administration; Washington, DC; 2009.

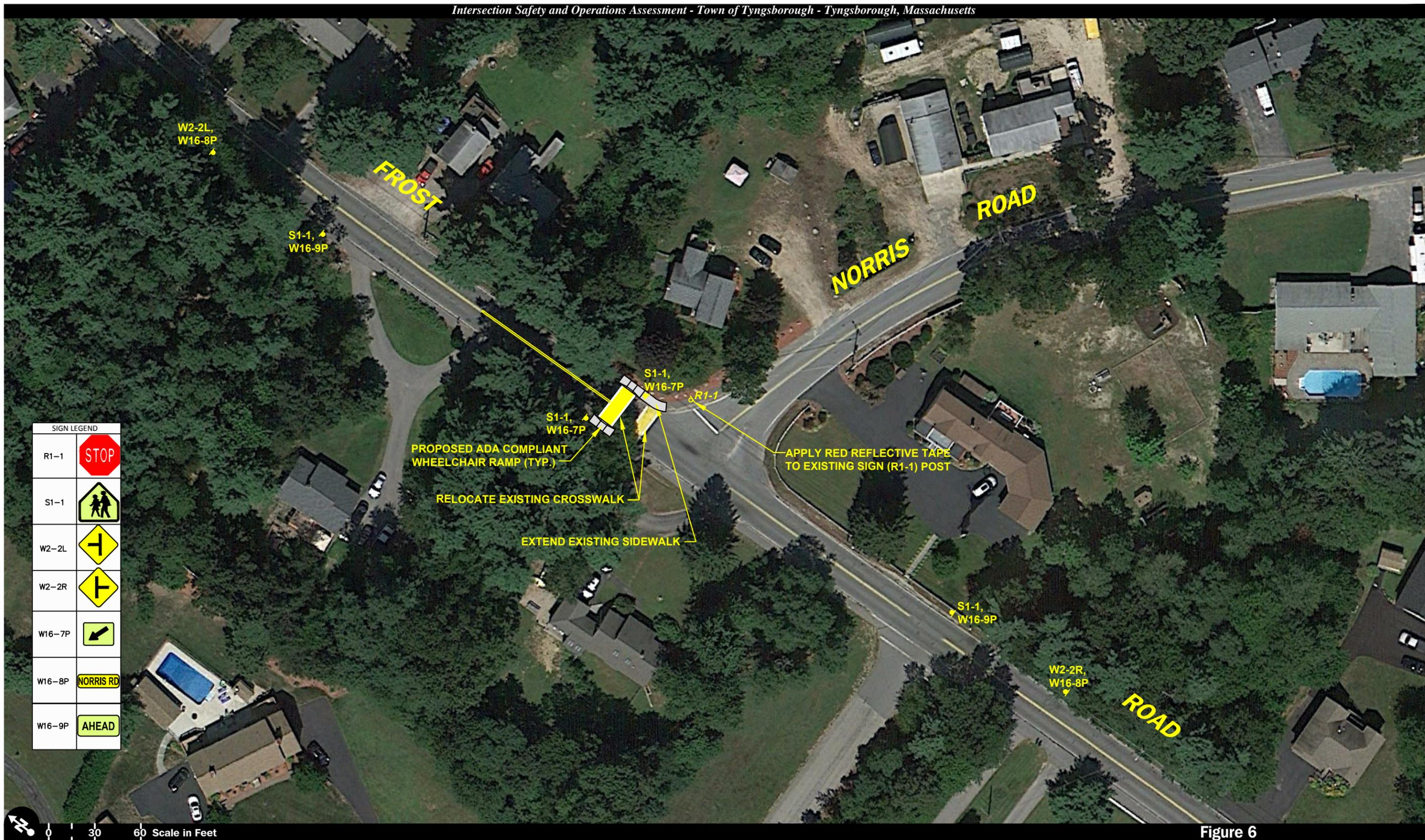


Figure 6

Conceptual Improvement Plan  
Frost Road at Norris Road -  
Enhanced School Zone

## SUMMARY

VAI was retained by the Town of Tyngsborough to conduct an Intersection Safety and Operations Assessment for the intersections of Westford Road at the Tyngsborough Elementary School driveway and Route 3A (Frost Road) at Norris Road in Tyngsborough, Massachusetts. The purpose of this assessment was to evaluate potential improvement strategies for these intersections that would facilitate the safe and efficient flow of vehicles, pedestrians and bicyclists during peak school arrival and departure periods. In conjunction with this analysis, an evaluation of traffic control strategies, including the installation of traffic control signals and enhanced school zone applications, was completed for each of the study intersections.

Based on this assessment, the following improvement strategies have been recommended:

***Westford Road/Tyngsborough Elementary School Driveway*** - Implementation of an enhanced school zone that would include replacement of the existing school zone signs and pavement markings along Westford Road; establishment of a 20 mph school zone speed limit on Westford Road during school hours; and reconstruction of wheelchair ramps for crossing Westford Road to meet current ADA standards. These improvements would enhance safety at the intersection and reduce travel speeds during peak school traffic periods, thereby facilitating the ability of vehicles to exit the driveway; it is envisioned that a crossing guard would continue to be required to assist students crossing Westford Road. The estimated cost to design and implement the enhanced school zone measures is \$60,000.

***Frost Road/Norris Road*** - Installation of a traffic control signal that would be active on weekdays during peak school traffic periods and during special events (i.e., graduation, sporting events, or other activities), and could be placed in flashing operation during off-peak periods; pedestrian phase would be available at all times upon pushbutton actuation. These improvements would facilitate the safe and efficient flow of vehicles, pedestrians and bicyclists during peak school arrival and departure periods and during special event conditions. The estimated cost to design and implement the recommended improvements at the Frost Road/Norris Road intersections is \$255,000.

cc: BG, File