Procedures for Speed Zoning on State Highways and Municipal Roads

Standards and Practices to Promote Safe and Efficient Travel in Massachusetts

Revised September, 2021

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Definitions

10 mph pace is a calculated 10 mph range that encompasses the largest total number of vehicles in the sample.

50th percentile speed, or median speed, is a measured value of prevailing speeds at which 50% of all vehicles are traveling at or below in free-flowing traffic.

85th percentile speed is a measured value of prevailing speeds at which 85% of all vehicles are traveling at or below in free-flowing traffic.

95th percentile speed is a measured value of prevailing speeds at which 95% of all vehicles are traveling at or below in free-flowing traffic.

Annual Average Daily Traffic (AADT) is a count of all traffic on a road segment over an entire year, divided by 365. In absence of permanent count stations, AADT is typically estimated by averaging a count over a shorter-term, such as 7 or 14 days, and then adjusting for seasonal variabilities.

Free-flow speed is the rate of travel that a driver will typical choose on a tangent roadway section during ideal conditions, including: daylight, good weather, unsaturated flow, and free from influence areas such as traffic signals or work zones.

Mean speed, or average speed, is calculated by summing all of the measured speeds collected and dividing by the total sample size.

Mode speed is a calculated value of speed that occurs most frequently in the sample.

Regulatory speed limits are those that are established and approved by MassDOT per MGL c. 90 § 18. Upon approval by MassDOT, regulatory speed limits may then be posted and are enforceable by law.

Statutory speed limits are based on the specific categories of roadways as established by the State Legislature (MGL c. 90 §§ 17 and 17C). These speed limits are not posted, with exception to area-wide signs posted at jurisdictional boundaries or warning signs posted on specific streets.

Target speed is the operating speed at which vehicles should ideally travel on a roadway in a specific context.

A **Transition Zone** connects a roadway that provides high-speed mobility outside a community to the same road within a community that provides local access and accommodates pedestrians, on-street parking, bicyclists, and other features that discourage higher speeds. A transition zone is the section of roadway where drivers need to be aware that the roadway conditions are changing, in an effort to allow them time to react and slow down to the appropriate speed.

Part 1. Introduction

It is the Massachusetts Department of Transportation – Highway Division's (MassDOT) objective to provide means to promote safe and efficient traffic flow in the Commonwealth for all road users. To achieve this goal, speed limits on streets and highways should be set at a rate that is in the best interest of the public's right to use a roadway in a reasonable and proper manner. The ideal speed limit maintains safe operating speeds for all road users, is acceptable to the prudent driver, and is enforceable by police.

Oftentimes, communities and MassDOT are asked to reduce the speed limit on a roadway because concerned community members want to reduce the vehicle speeds. However, modifying a speed limit without making other changes will likely have little effect on reducing speeds. To effectively reduce vehicle speeds, setting speed limits should be included only as a part of a broader strategy that includes geometric changes to the road and other educational and enforcement components.

While Massachusetts legislation has empowered communities to establish statutory speed limits under certain circumstances "without further authority," regulatory speed limits in Massachusetts shall only be established after an engineering study has been conducted in compliance with standard traffic engineering practices outlined in Sections 1A.09 and 2B.13 of the MUTCD. The purpose of this document is to provide procedures for uniformly instituting speed limits on all streets and highways throughout the Commonwealth of Massachusetts.

Part 2. Laws Governing Massachusetts Speed Regulations

Fig. 2-1: Typical Speed Limit Sign (Source: MUTCD)

Sections 17, 17A, 17C, 18 and 18B of Chapter 90 of the Massachusetts General Laws (MGL) govern speed limits on all streets and highways throughout the Commonwealth, with exception to the Massachusetts Turnpike, the Central Artery and Boston Harbor Tunnels, the Tobin Bridge, and parkways that are maintained by the Department of Conservation and Recreation (DCR). In addition, MassDOT and all municipalities are required by MGL c. 85 § 2 to conform to the *Manual on Uniform Traffic Control Devices* (MUTCD) for the posting of all regulatory and warning signage, including speed limit signs, on all streets and highways.

MGL c. 90 § 17 sets the basic premise of speed limits in Massachusetts. It states: "No person operating a motor vehicle on any way shall run it at a rate of speed greater than is reasonable and proper, having regard to traffic and the use of the way and the safety of the public."[1] This is fundamentally important, for no form of regulation or control may supersede it. A road may be legally posted for 30 mph, but weather conditions, traffic, construction activity, emergency scenes, etc. may establish the "reasonable and proper" limit to be much lower.

Under satisfactory operating conditions, speed limits can be classified into two different categories: regulatory (posted) speed limits and statutory (unposted, with some exceptions) speed limits. MGL c. 90

[1] https://malegislature.gov/Laws/GeneralLaws/PartI/TitleXIV/Chapter90/Section17. Retrieved 8/23/2021.

§§ 18 and 18B establish the requirements for posting regulatory speed limits. MGL c. 90 §§ 17, 17A and 17C cover the criteria for statutory speed limits.

A regulatory speed limit is one that has completed a thorough traffic engineering study, has a Special Speed Regulation that has been signed by the roadway owner, the Registry of Motor Vehicles, and the MassDOT Traffic & Safety Engineering Section, and has the appropriate numerical speed limit signage erected to clearly define the special speed zones. A detailed description of these procedures may be found in **Part 4** of this document. With exception to Safety Zones as noted in **Section 10.c**, the establishment of a regulatory speed limit must follow this procedure, or it is in violation of MGL c. 90 § 18 and is therefore considered unenforceable.

A statutory speed limit is speed limit that is established by legislation, or by statute. Statutory speed limits exist in the absence of Special Speed Regulations. Statutory limits are based on the concept that uniform categories of roadways can operate safely at certain maximum speeds under ideal conditions. With exception to School Zones, if a Special Speed Regulation exists it will always supersede the statutory speed limit. On roads without posted speed limits, MGL c. 90 § 17 requires that drivers operate motor vehicles at a rate of speed that is no greater than reasonable and proper with regard to the use of the road and safety of the public. The law states:

> "It shall be prima facie evidence of a rate of speed greater than is reasonable and proper if a motor vehicle is operated in excess of:
>
> 1. 50 miles per hour on a divided highway outside of a thickly settled or business district for at least ¼ of a mile.
> 2. 40 miles per hour on an undivided highway outside of a thickly settled or business district for at least ¼ of a mile.
> 3. 30 miles per hour in a thickly settled or business district for at least ⅛ of a mile.
> 4. 20 miles per hour in a legally established school zone."[2]

MGL c. 90 § 17C allows municipalities to establish a statutory speed limit of 25 miles per hour in thickly settled or business districts on any city or town way that is not a State Highway. Additional information on this option may be found in **Section 10.e**.

MGL c. 90 § 1 defines a thickly settled or business district as "the territory contiguous to any way which is built up with structures devoted to business, or the territory contiguous to any way where dwelling houses are situated at such distances as will average less than two hundred feet between them for a distance of a quarter of a mile or over."[3]

The distance requirements associated with the enforcement of MGL c. 90 § 17 should be noted. Instantaneous radar or laser readings are not adequate; to be in violation, the motor vehicle must be

[2] https://malegislature.gov/Laws/GeneralLaws/PartI/TitleXIV/Chapter90/Section17. Retrieved 8/23/2021.
[3] https://malegislature.gov/Laws/GeneralLaws/PartI/TitleXIV/Chapter90/Section1. Retrieved 8/23/2021.

shown to have been in excess of these speed limits for at least the entire distance associated with each respective speed limit.

Finally, in Massachusetts the numerical speed limits represent the maximum speed under ideal driving conditions. However, it is the responsibility of each motorist to reduce their speed for unfavorable weather conditions, poor visibility, heavy traffic volume, vehicle condition, and for his/her own driving abilities.

Part 3. Purpose of Speed Regulation

There are many factors, both conscious and subconscious, that influence how and why a driver chooses the rate at which they travel; posted speed limits are just one of many. These factors include[4]:

1) Time of day
2) Length of trip
3) Purpose of trip
4) Number of passengers
5) Type of vehicle
6) Presence and/or history of enforcement (personnel or officially marked vehicle)
7) The interval since witnessing a crash or results of a crash
8) Driver skill
9) Emotional condition of driver
10) Lane width
11) Speed of other vehicles
12) Adjacent land use and intensity
13) Pavement wetness (including standing and running water)
14) Pavement type and condition
15) Traffic volume
16) Presence of Pedestrians, especially children
17) Presence and location of cyclists
18) Ambient light
19) Type of passengers
20) Weather
21) Familiarity of driver with road
22) Condition of vehicle
23) Urgency of trip
24) Running speed for previous 5 or 10 miles of travel
25) Personality of driver
26) Vehicle parking
27) Recent traffic violation and points earned
28) Shoulder width and condition
29) Restrictive lateral clearance
30) Presence of snow, ice, mud, and/or sand on pavement
31) Pavement roughness
32) Alcohol and/or other drugs
33) Personal schedule of driver (Late or on time)
34) Traffic Control Devices
35) In-Vehicle Distractions (Cellular phones, etc.)

To effectively reduce vehicle speeds, setting speed limits should be included only as a part of a broader strategy that includes geometric changes to the road and other educational and enforcement components. Studies have shown that arbitrarily raising or lowering posted speed limits alone will result in a difference of less than 2 mph in mean and 85th percentile speeds. This small change is not practically meaningful, and it appears that "new posted speed limits alone, without some additional engineering, enforcement, or educational measures, [do] not have a major effect on driver behavior or encourage most

[4] *Speed Zoning for Highways, Roads & Streets in Florida*, Florida DOT, Revised August 2018. https://fdotwww.blob.core.windows.net/sitefinity/docs/default-source/traffic/speedzone/2019-01-28_speed-zoning-manual_august-2018.pdf?sfvrsn=ac20bad7_0.

drivers to comply with the posted speed limit."[5] There is also no evidence that shows arbitrarily lowering or raising the posted speed limit will have a statistically significant impact on crash reductions.

Based upon this information, the purpose of creating a speed zone should not solely be based upon an anticipation of reducing speeds. Rather, the zone should be established to increase safety for all road users by setting a reasonable and proper speed that prudent drivers will follow. A speed limit that has been established in accordance with standard traffic engineering practices will diminish the likelihood of vehicles traveling unsafely at disparate rates, aids in driver expectancy, and assists in law enforcement's ability to enforce.

Part 4. Process for Establishing New Speed Limits

With exception to those noted in **Part 10**, MassDOT requires Special Speed Regulations for all new speed limits on all State Highways and municipally owned streets and highways. However, the steps for initiating this process are contingent upon road ownership.

For locally owned ways, the city or town should put a request for a new Special Speed Regulation in writing to their MassDOT District Office. The District may advise the municipality on matters such as extents of proposed speed zones, overlap with any existing Special Speed Regulations, and other items that may assist in the municipality's development of the traffic engineering study (see **Part 5**).

> *"The overall goal of setting the speed limit is almost always to increase safety within the context of retaining reasonable mobility."*
>
> *--- ITE*

A municipality may utilize USLIMITS2, an online FHWA tool that can benefit agencies without ready access to engineers experienced in conducting speed studies for setting appropriate speed limits, as well as providing an objective second opinion and increase confidence in speed limit setting decisions. All of the necessary inputs are described in **Part 5**.

Upon receipt of the completed traffic engineering study, the District will review for accuracy and either provide a recommendation to Traffic and Safety or provide a response to the municipality if there is not agreement over the proposed appropriate speed limit posting. The Traffic & Safety Section will then prepare the Special Speed Regulation and return it to the city or town for approval by the body that governs their municipal traffic code. Once the municipality has adopted the regulation, signed copies are returned to the Traffic & Safety Section where they are signed and approved by the State Traffic Engineer and the Registrar of Motor Vehicles. Following this final approval from MassDOT, the municipality may erect the new speed limit signage and the limit is now enforceable. The municipality is required to notify the District Office that the signs have been erected so that MassDOT personnel may review for conformance. A flow chart of this process is shown in **Fig. 4-1**.

[5] Parker Jr., M. R., *Effects of Raising and Lowering Speed Limits on Selected Roadway Sections*, FHWA-RD-9 7-084 (McLean, Virginia: Martin R. Parker Associates for the Federal Highway Administration, January, 1997), 43.

On State Highways, revisions to existing speed limits are established by either a request from the municipality, through the MassDOT Traffic & Safety Section's updates to the Special Speed Regulations on State Highways, or at the District's discretion if changes to road characteristics have altered driver behavior. For requests that come from cities and towns, it is at the District's discretion to review the request for reasonability, which may include a review in changes to road geometrics, road users, traffic control, surrounding land use, and/or crash history prior to forwarding to the Traffic & Safety Section. The process for developing a new regulation is similar to that on municipally-owned streets, except that MassDOT is responsible for the Traffic Engineering Study and installation of signs.

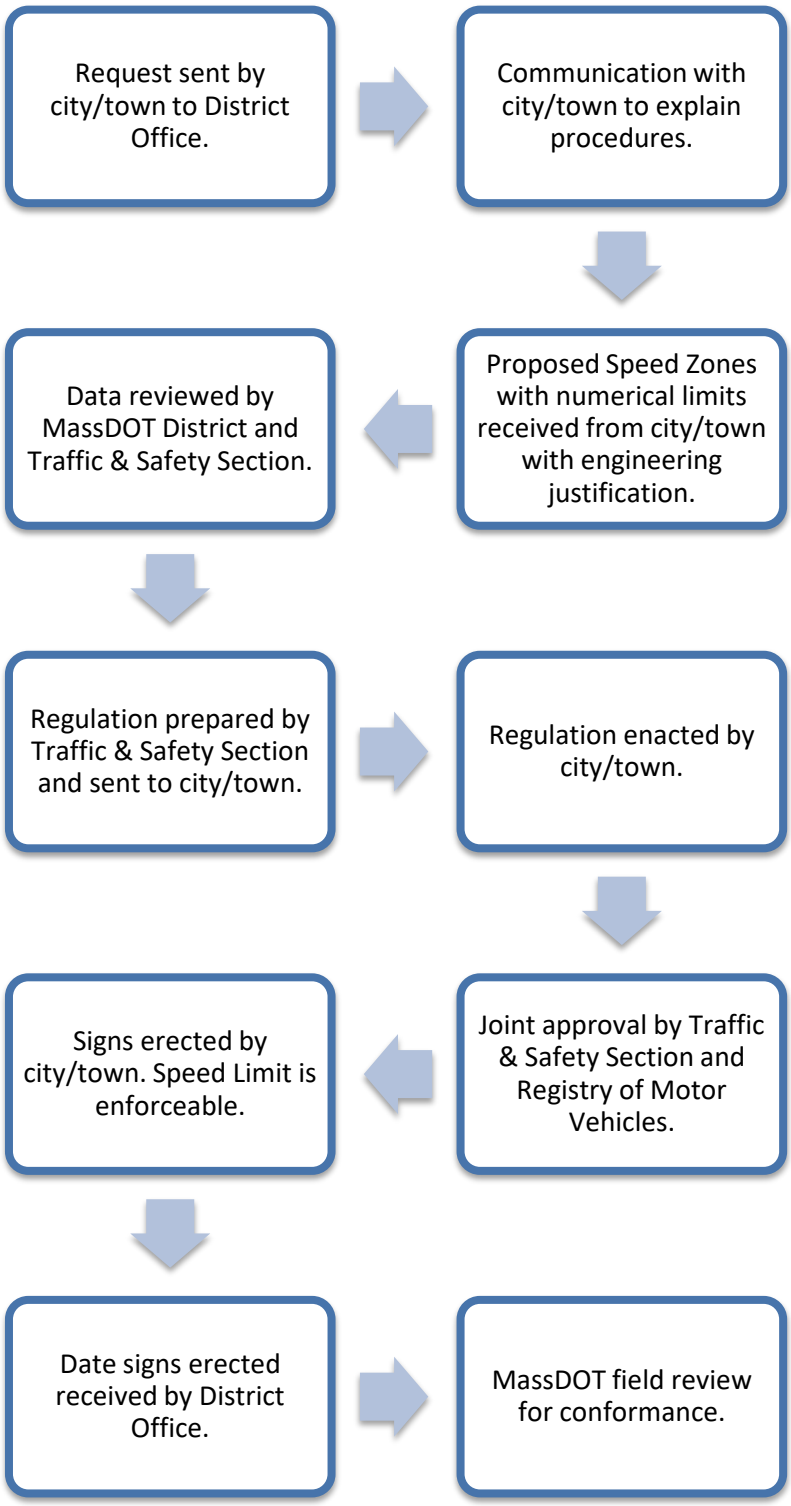

Fig. 4-1: Speed Limit Procedures on Municipal Roads

Part 5. Traffic Engineering Studies for Special Speed Regulations

MassDOT conforms to MUTCD standards and guidance for developing Special Speed Regulations both because it is the law, but also to ensure that speed limits are applied consistently across all streets and highways within the Commonwealth. Specifically, when developing a Special Speed Regulation, it must "be established on the basis of an engineering study that has been performed in accordance with traffic engineering practices. The engineering study shall include an analysis of the current speed distribution of free-flowing vehicles."[6] But, in keeping with the context of the environment and to maximize safety of all road users, additional factors besides speed are also used in determining the speed limit. The purpose of this study is to document the conditions that will justify a proposed speed limit that is safe, reasonable, and self-enforcing to which most drivers will adhere.

The following sections outline the complete traffic engineering study that MassDOT requires to create a Special Speed Regulation.

5.a Data Collection Needed for Speed Limit Setting

While observed speed is an important factor in determining the speed limit for the roadway, it is certainly not the only factor. It is important to understand the characteristics of the roadway and surrounding area and to record the information so that all relevant factors can be used to determine the appropriate speed limit. Below is a listing of factors to be captured. Methods to collect this information are described in the following sections.

Roadway Information

- Section length (in miles)
- Adverse alignment (horizontal and/or vertical curves)
- One- or two-way roadway
- Divided or undivided roadway
- Number of through lanes
- Area type (residential, commercial, developed, undeveloped)
- Number of driveways
- Number of signals or other controlled approaches to intersections
- On-street parking activity and usage
- Pedestrian activity
- Bicyclist activity
- Average Annual Daily Traffic (AADT)
- Functional classification

Speed Data

- 85th percentile speed
- 50th percentile speed
- Mean speed
- Mode speed
- 10 mph pace speed

[6] Federal Highway Administration, *Manual on Uniform Traffic Control Devices for Streets and Highways* (2009), 56.

Crash Data

- Number of crashes during recent 5-year period
- Number of injury crashes during recent 5-year period
- Crash rate (crashes per 100 million vehicle miles traveled)
- Injury crash rate (injury crashes per 100 million vehicle miles traveled)
- Average crash rate for similar roads
- Average injury crash rate for similar roads

5.b Capturing Roadway Characteristics

Most basic roadway characteristics may be initially documented using web-based mapping tools. A field visit should be performed to verify this information.

AADT should be obtained through a actual counts. MassDOT has historical count information for many roads in the Commonwealth publicly available on the Traffic and Volume Classification website. However, if data is not available for the subject road, an approximated AADT can be obtained from MassDOT GeoDOT Road Inventory. This may be done by zooming to the subject roadway, selecting it, and a popup box will appear with the AADT information, as shown in **Fig. 5-1**.

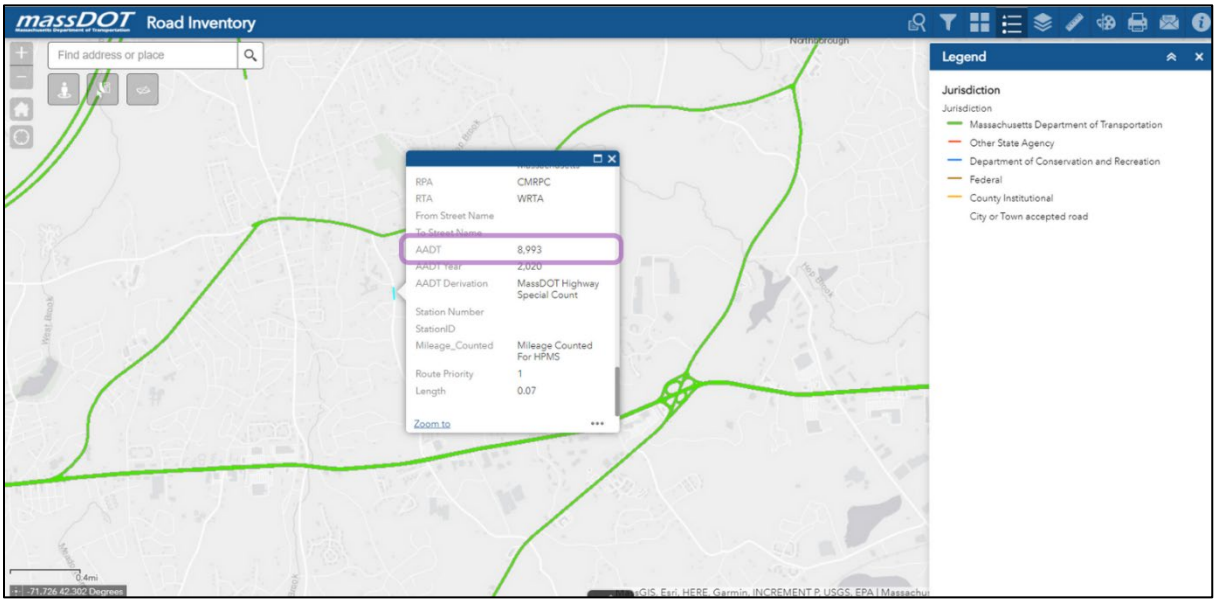

Fig. 5-1: Screenshot of GeoDOT Showing AADT

Additionally, GeoDOT may also be used to obtain information like Federal Functional Classification and urban/rural information may also be obtained from this tool, as shown in **Fig. 5-2**.

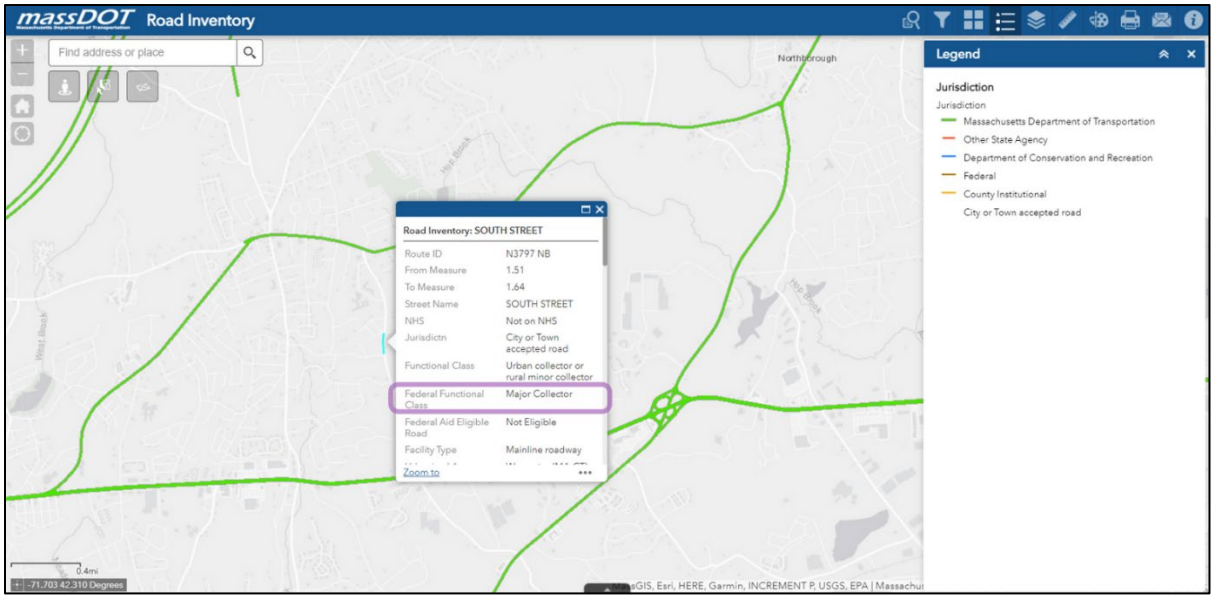

Fig. 5-2: Screenshot of GeoDOT Showing Federal Functional Classification

5.c Trial Runs

Upon establishment of the extents of the proposed speed zone(s), at least one trial run each should be made over the entire length by engineers and/or law enforcement officers using at least three different drivers, for a minimum of three total runs. To do so, an observer should sit directly behind the driver and record readings of the speedometer and odometer for every tenth of a mile on a Speed Control Trial Run Sheet, as shown in **Fig. 5-3**, while each driver operates the vehicle at the maximum comfortable safe speed. The location of any traffic control devices that may affect free-flow speeds should be noted. Roadway characteristics pulled from an actual or virtual drive through (using Google Streetview or Bing StreetSide) should be verified during the trial runs.

After the three trial runs in each direction are completed, the median speed at each tenth of a mile may then be used to draw a speed curve.

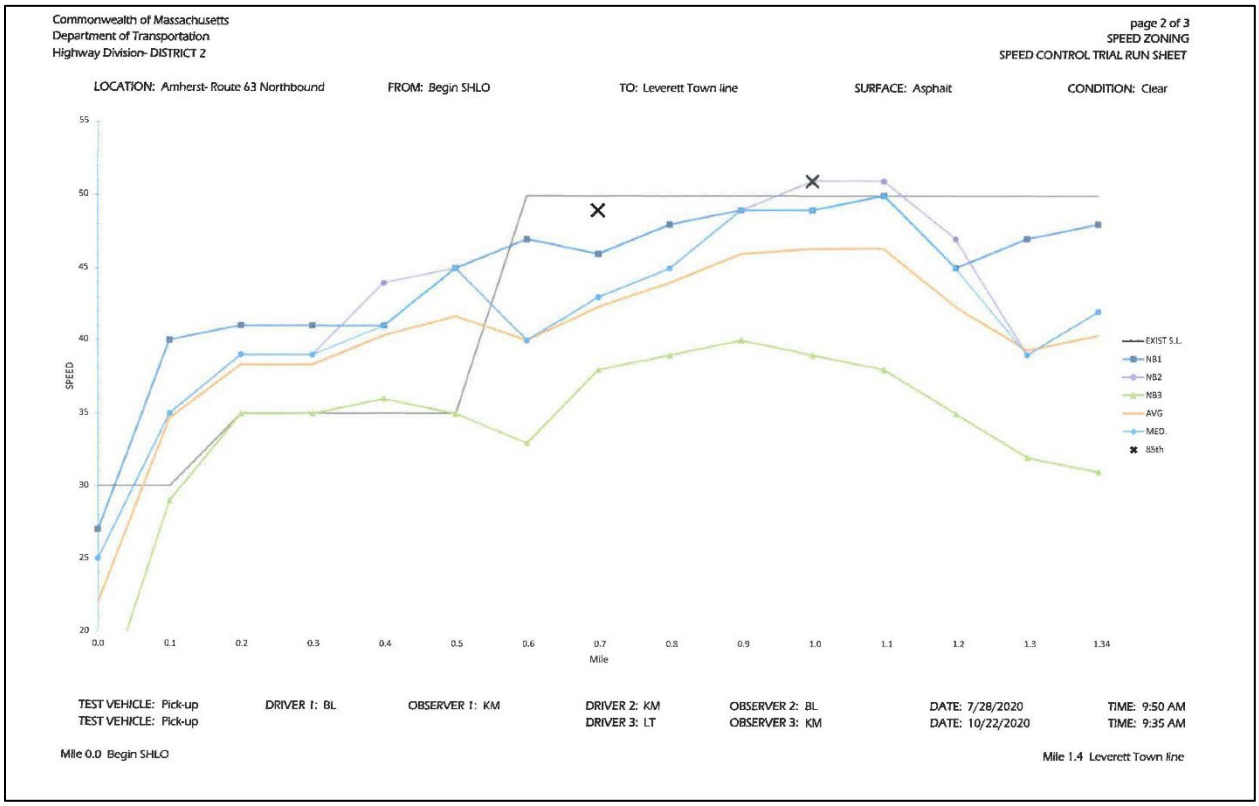

Fig. 5-3: Example of a Speed Control Trial Run Sheet

5.d Speed Data Collection

Spot speed observations of free-flow traffic are a significantly important step in developing a traffic engineering study as one basis for Special Speed Regulations since they represent what random drivers believe to be a safe operating speed. Ideally, these observations should be taken continuously throughout a proposed speed zone, but realistically it is not practical to do so. As a general rule of thumb, speed check stations should be located at intervals not to exceed 0.25 miles, depending upon the locality and the uniformity of physical and traffic conditions. In urban areas it may be necessary to reduce this spacing, whereas in rural areas it may be increased. However, there must be at least one observation for each direction of travel in each speed zone. Trial runs through the area may be of help in locating the appropriate speed check stations.

In general, spot speed observations should not be conducted in close proximity to a traffic signal, roundabout, or other intersection design that may impact vehicle speeds. However, if the intention is to create a Transition Zone from a higher speed, free-flow segment to segments that due to context or design will encourage lower vehicle speeds, then observations should be made at intervals and locations where the speed limit is expected to be stepped down, typically in 10 mph increments. The use and placement of Reduced Speed Limit Ahead warning signs, per **Section 10.b**, should also be considered when identifying spot speed observation locations.

Observations should be made on a weekday, at off-peak hours, and under ideal weather conditions. In most cases, speed data collection is conducted in a passenger car or light truck but should not look like a police vehicle (roof-mounted lights, etc.) so that motorists do not perceive the recorder's presence as an enforcement activity and adjust their driving behavior. The recording vehicle should also be parked in such a way that it does not affect the speed of vehicles using the roadway, preferably being positioned off the traveled way out of plain view.

Speeds should be measured by a radar or laser gun. Both instruments are extremely accurate and provide the user with invaluable data when used properly. Care should be taken that the manufacturer's instructions are followed properly to ensure that collected data is correct and accurate for speed zoning purposes. A city or town requesting the establishment of a speed limit on a locally owned state numbered route may request MassDOT's assistance in this step since many municipalities do not possess the proper equipment to do the work; however, municipalities are solely responsible for data collection on non-numbered, locally owned roads. MassDOT will always collect speed data on State Highways.

With exception to functionally classified local roadways, automated traffic recording systems (ATRs), such as pneumatic tubes or automated video or radar recording devices, are not acceptable for speed measurements unless it can be demonstrated that they are able to capture only vehicles that meet the required criteria, such as capturing only the lead vehicle in a platoon and ignoring turning and passing vehicles. Local roadways that have higher volumes or significant vehicle platooning may still require manual speed recordings to verify ATR readings.

A minimum of 100 speed observations should be recorded in each direction at each station. The recorded speeds should be documented on a Speed Distribution Worksheet, such as the example shown in **Fig. 5-4**. On roads carrying low traffic volumes, observations may be terminated after two hours even if 100 vehicles have not been recorded. Passenger cars should be noted with an "X" and other vehicles such as trucks and buses shall be recorded as "T," "B," etc. At locations where traffic volumes are low and one hundred cars cannot be recorded within two hours the observations may not be reliable and the need for speed zoning should be reexamined to determine if it will ultimately be beneficial.

If a platoon of closely spaced vehicles passes the observation station, only the speed of the first vehicle in the platoon should be recorded since the trailing ones are limited by the speed of the lead vehicle. In addition, vehicles involved in short passing or turning maneuvers should not be recorded since they are usually traveling at an atypical rate of speed. Speed measurements should be recorded as frequently as possible, but it is not necessary to check the speed of every vehicle that passes by the speed check station.

For each observation station, the following information should be recorded on the Speed Distribution Worksheet:

1. 95^{th} percentile speed;
2. 85^{th} percentile speed;
3. 50^{th} percentile speed;
4. Mode; and
5. Pace.

Establishing the n^{th} percentile speed from the data collected on the Speed Distribution Worksheet is determined by calculating what n% of the total number of vehicles recorded is. For example, if 100 vehicles are logged, the 85^{th} percentile speed is calculated by determining 85% of 100 (0.85 X 100 = 85) and then counting up from the slowest vehicle recorded until the 85^{th} slowest vehicle is reached; the speed of the 85^{th} slowest vehicle is the 85^{th} percentile speed. Alternatively, this count could be done in reverse noting that the 16^{th} fastest vehicle is the same as the 85^{th} slowest.

The mode speed determined by summing the total number of vehicles traveling at each speed and identifying the line that has the highest total. The 10-mph pace can then by determined by identifying the 10-mph range that encompasses the greatest number of vehicles recorded.

Upon completion of all observations, calculation for all speed percentiles and distributions should be calculated while still in the field. Any significant rises or drops in 85^{th} percentile speeds between consecutive observations should be examined, and additional observations should be taken if deemed necessary.

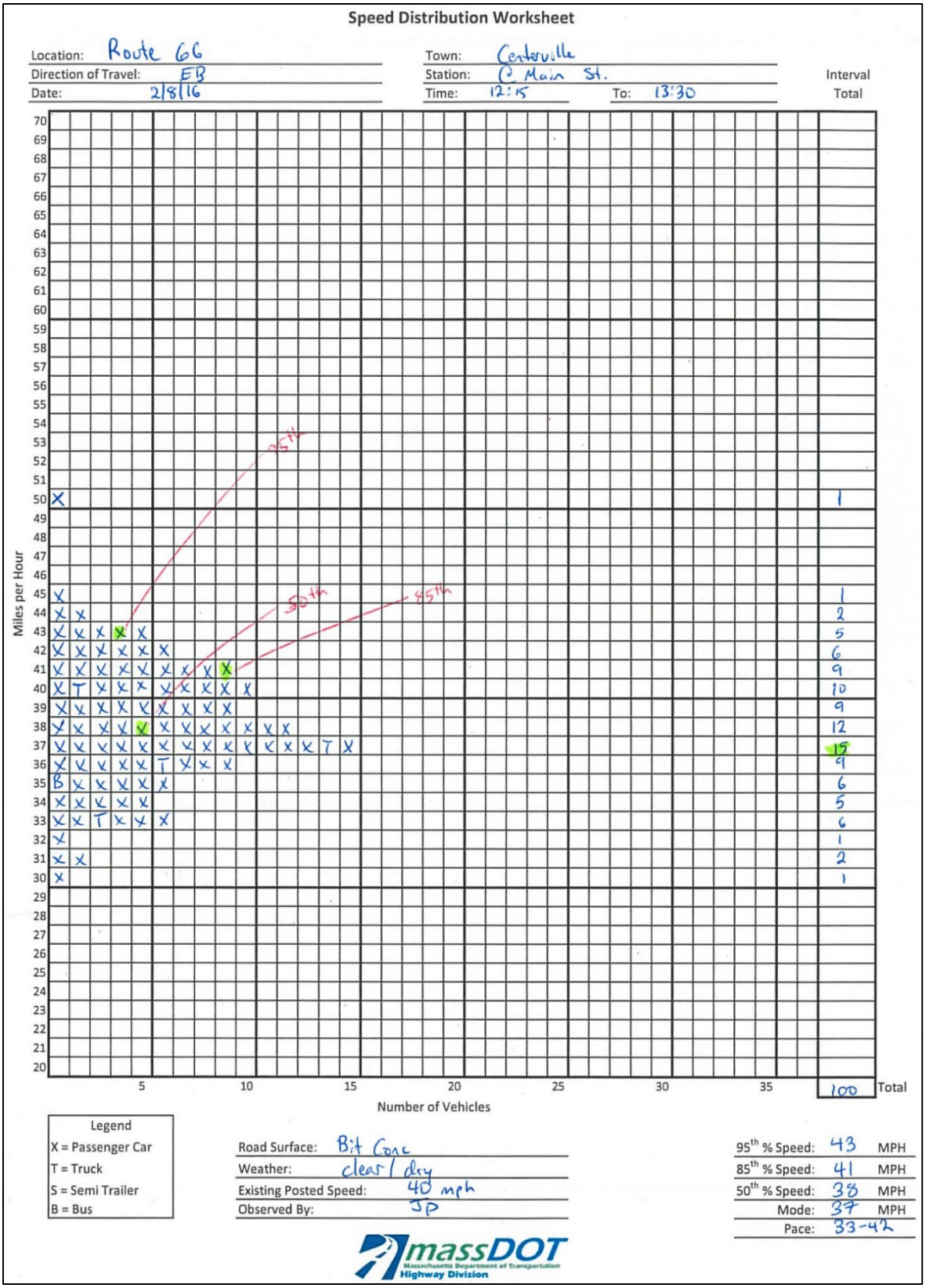

Fig. 5-4: Sample Speed Distribution Worksheet

5.e Crash Data

A review of the recent crash history within the proposed speed zone is required unless the genesis of the new speed zone is a significant roadway reconstruction that has changed the profile, alignment, cross-section, etc. Crash reports from the most recent 5 years of data should be pulled and both the standard reporting items and the police officer's narrative should be reviewed, and number of crashes and injury crashes should be recorded. Crashes that are identified by having a Manner of Collision that are typically associated with driving in excess of what is considered reasonable and proper such as angle, single vehicle, or rear-end; First Harmful Events that are collisions with fixed objects; and any collisions with non-motorists such as pedestrians or bicycles should be flagged. Note that exceeding the speed limit as a Driver Contributing Code is not always identified by the reporting police officer on a crash report and, even if a speeding citation is issued, is not likely a true and accurate representation of whether speed was a factor in the crash but this should be included as well.

For locally owned roadways where the municipality will be collecting the necessary data and making the speed zoning request, the preferred crash data source is the local police department. However, absent actual police reports, MassDOT's Query and Visualization Tool (found within the MassDOT IMPACT Crash Data Portal) may alternatively be used to identify crashes. The following steps should be taken:

1. Select Crash Fields of interest (or "Select All"). Once the fields of interest are selected, click on "Select Query Type" (shown in the top right corner) to move on to the next step.

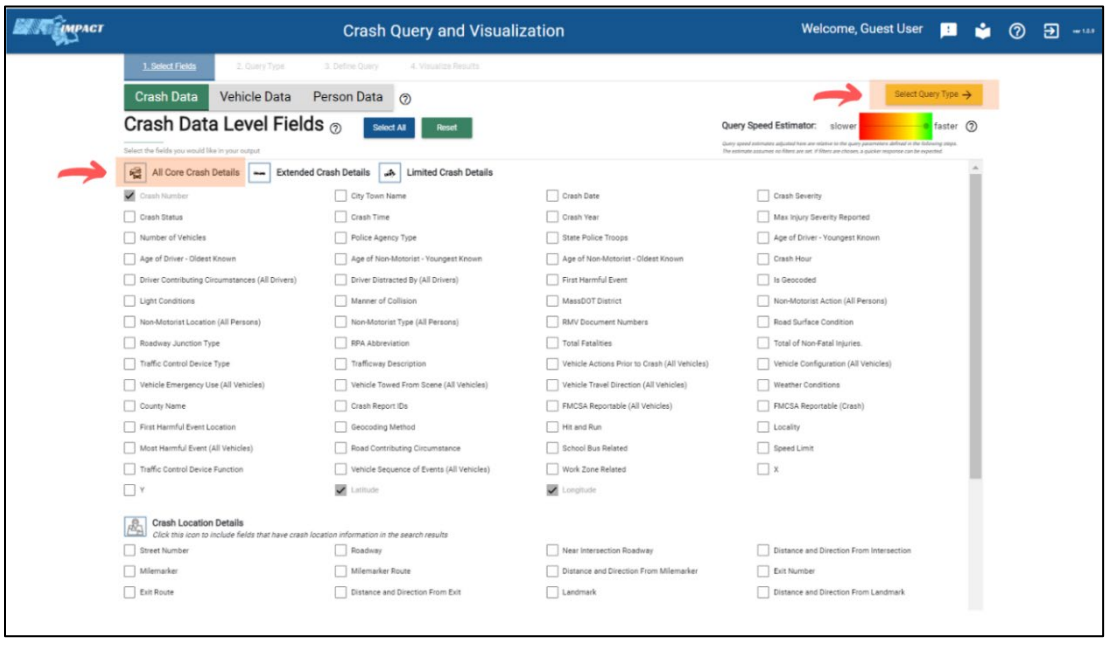

Fig. 5-5: Selecting Crash Fields of Interest

2. Select “Spatial Search” and, once inside, select the date range for the 5 most recent years of closed crash data.

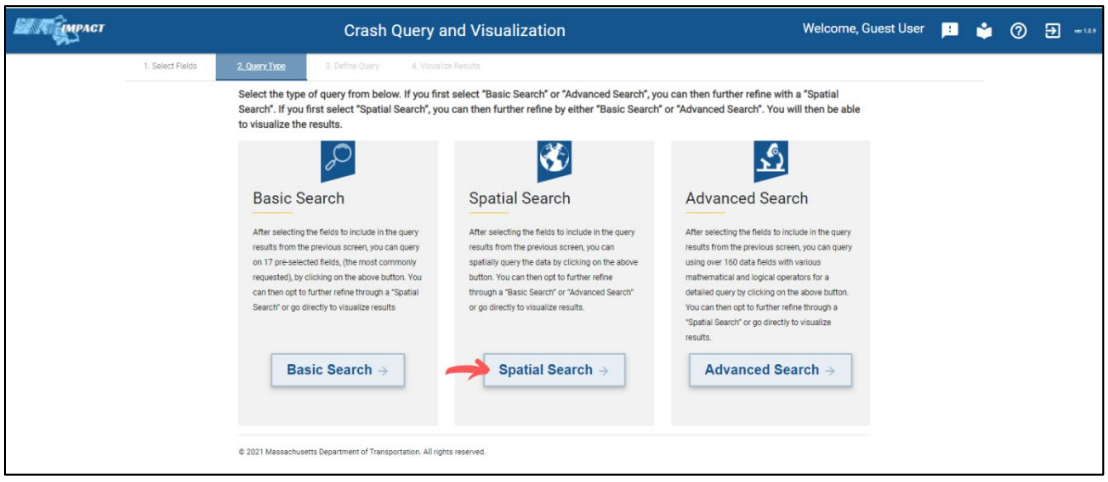

Fig. 5-6: Using Spatial Search Option

3. If the study area is an entire street/route in a municipality, zoom to the study area in the map and select the “Find” option. Then select “Street” in “Step 1. Select Location Type” and select the study town and street name. The buffer can be defined (depending on what area was selected). Once query is set up, click on “Visualize Results” on the top right corner to obtain a listing of all crashes and skip Step 5.

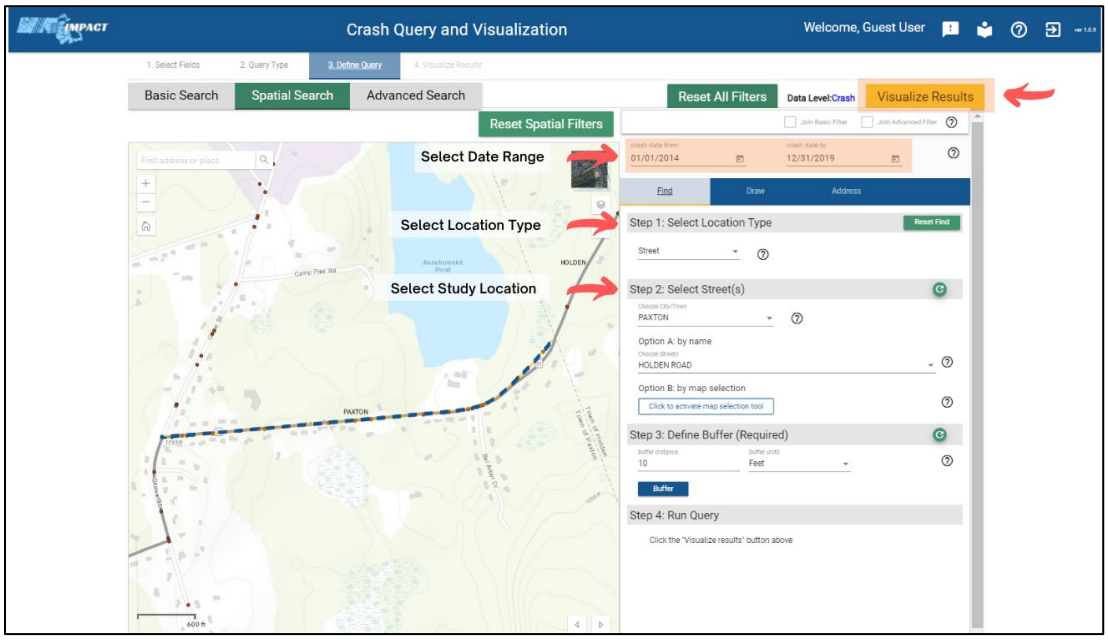

Fig. 5-7: Selecting an Entire Street

4. If the study area is not the entire length within a municipality, zoom to the study area and select “Draw” and then select “Area” to draw a polygon around the extents of the proposed speed zone. The buffer can be defined (depending on what area was selected). Click on “Visualize Results” on the top right corner to obtain a listing of all crashes.

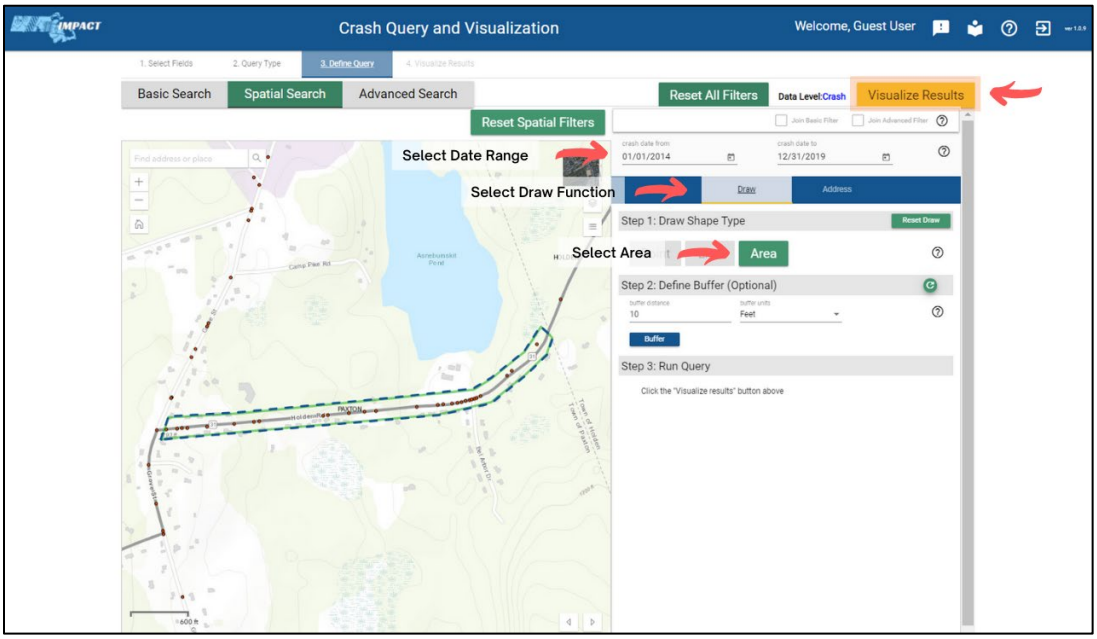

Fig. 5-8: Drawing a Polygon Around the Study Area

5. Once in the “Visualize Results” screen, select the “Export Tools” located on the bottom tool banner to export the crash information to Excel.

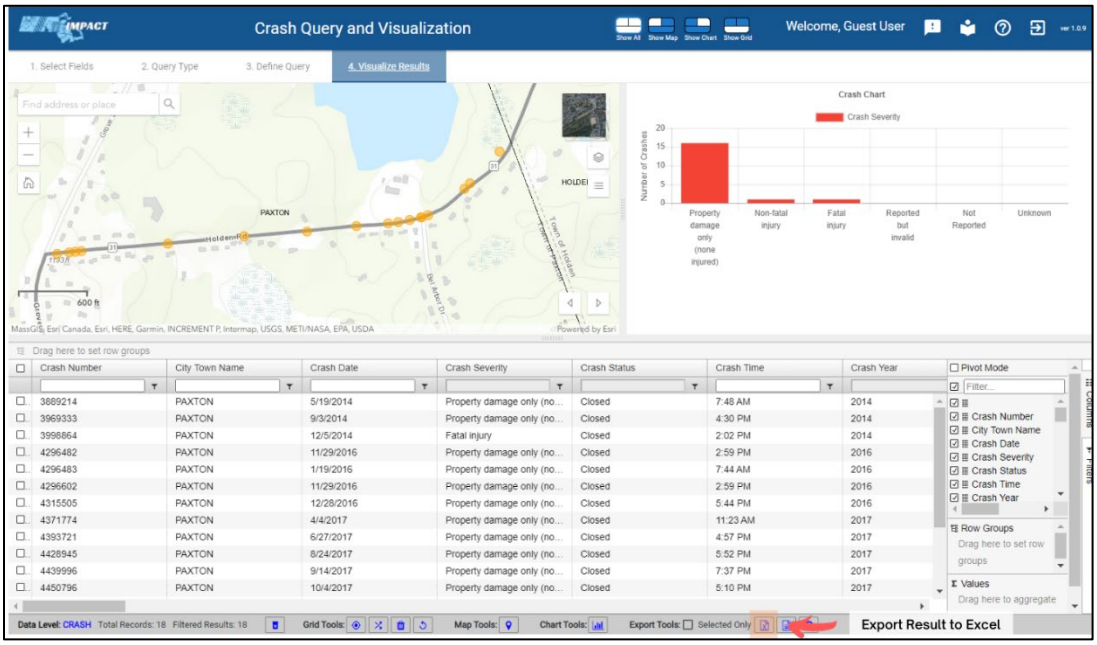

Fig. 5-9: Exporting Data to Excel

6. Once the review of the crash data has been completed, regardless of whether it is by using actual crash reports or the IMPACT Query and Visualization Tool, total number of crashes and total number of injury crashes should be noted. Due to limitations associated with geo-locating crashes on interstate highways and other limited-access roadways, it may not be realistic to perform a detailed collision analysis on those facility types. In those cases, a broader safety analysis may be acceptable.

   The average crash rate and average injury crash rate should then be determined using the following formulae:

$$Crash\ Rate = \frac{C \times 1{,}000{,}000}{L \times V \times Y \times 365}$$

$$Injury\ Crash\ Rate = \frac{I \times 1{,}000{,}000}{L \times V \times Y \times 365}$$

   Where:
   $C = number\ of\ crashes\ over\ all\ years\ of\ analysis\ (5\ years)$
   $I = number\ of\ injury\ crashes\ over\ all\ years\ of\ analysis\ (5\ years)$
   $L = length\ of\ segment, in\ miles$
   $V = AADT, in\ vehicles\ per\ day$
   $Y = number\ of\ years\ of\ crash\ data\ (5\ years)$

7. Obtain the statewide average crash rate for similar roadway types in Massachusetts from the MassDOT Crash Rates by Functional Classification webpage and record this information. This can then be compared to the average crash rate for the subject location.

5.f Mapping of Conditions

Upon completion of all speed data collection, a Speed Control Summary Sheet should be prepared for the extents of the proposed speed zone(s). All existing geometric conditions and constraints should be noted, including vertical curves, grade (if known), traffic volumes, side streets and major driveways, pedestrian and bicyclist amenities and adjacent land uses. Horizontal curves and any existing curve warning signage should also be noted. Crash data should be included as well. The median speed from the trial runs should be noted, but segments within two tenths of a mile of a traffic control device that will affect free-flow speed, such as a traffic signal, should be noted. The 50th percentile, 85th percentile, and mode speeds should be listed for each direction at their respective observation stations. If existing speed zones are present, they should also be noted with their respective limits. An example of a Speed Control Summary Sheet is shown in **Fig. 5-10**.

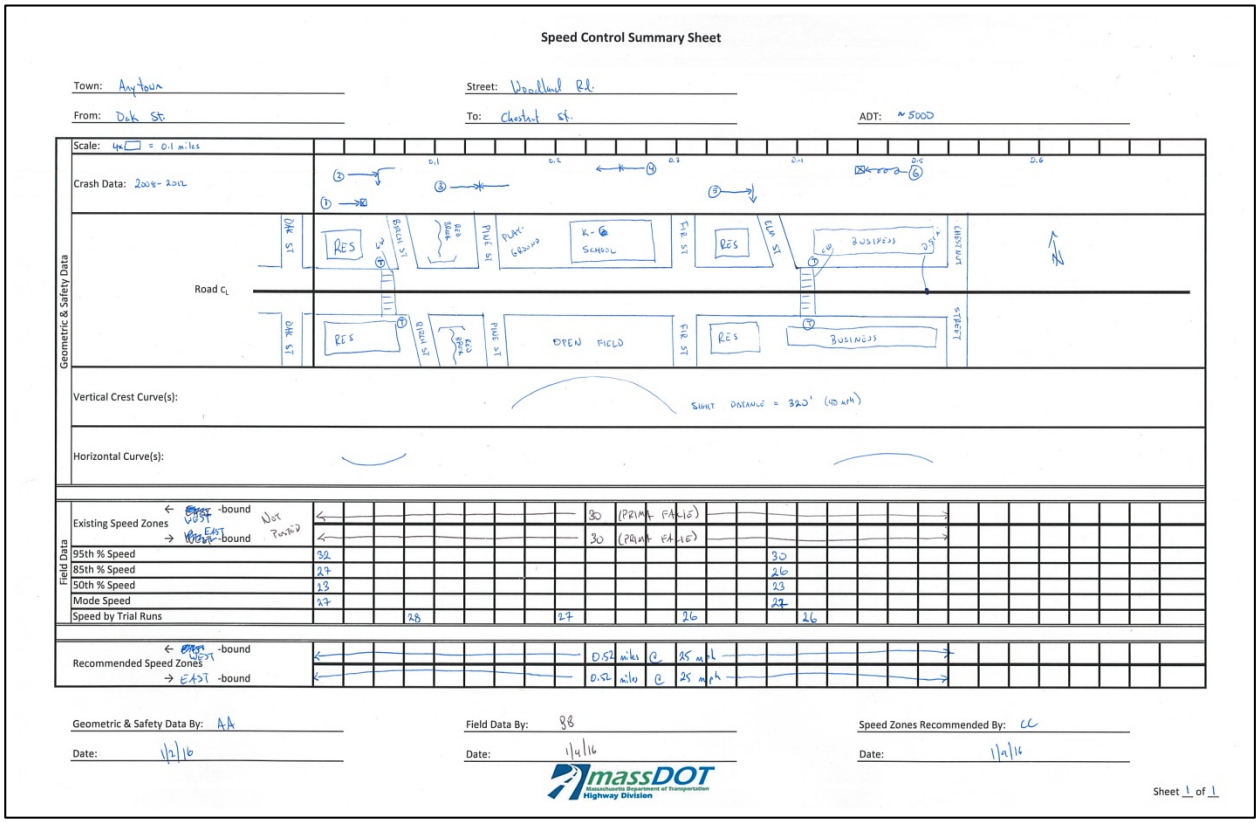

Fig. 5-10: Sample Speed Control Summary Sheet

5.g Speed Range

The speed range within the vicinity of the observation stations is determined after analyzing the data collected. The following criteria are used to determine safe speed values for each location:

a. The sight distance should be measured at any critical vertical or horizontal curves. Using this measured distance, the design speed should be determined from the appropriate table in AASHTO's *A Police on Geometric Design of Highways and Streets*, latest edition. This speed should be compared to the observed 85th percentile speed and the lower of the two should be selected as the upper value for the Safe Speed Range.
b. The observed 85th percentile speed should be noted at each location and the 7 mph below that value should be selected as the lower value for the Safe Speed Range.

The speed range should be indicated on the Speed Control Summary Sheet for all observation areas.

5.h Establishing Speed Limits and Length of Speed Zones

The observed 85th percentile speed is typically one of the bases for establishing speed zones. This method assumes that most motorists are prudent and capable of selecting safe speeds and is in conformance with the MUTCD. Thus, speeds established in this manner meet the legal requirement that they be "reasonable and proper." However, it is also recognized that drivers receive their cues from roadway geometry, adjacent land use, and surrounding road users and context but may not adjust their speed if the cues are

not present (if drivers do not see the pedestrian activity taking place). Therefore, when establishing speed zones, roadway geometry, adjacent land use, road users and context must be factored in and the observed 85th percentile speed is not just used in isolation. In sections with transit stops, adjacent land uses and other context where non-motorist activity is anticipated (even if not observed during the speed zoning process), the area may be zoned lower than the 85th percentile, but in no cases more than 7 miles per hour lower.

In sections that have been identified as having an unusual rate of crashes that can be attributed to speeding the area may be zoned lower than the 85th percentile speed, but in no case more than 7 miles per hour lower. This should be considered more as an exception than the rule and should be done only where enforcement agencies will ensure consistent enforcement which will increase the effectiveness of the zone to an acceptable level of conformance.

Where physical constraints exist such as narrow shoulders that lack sufficient space for maneuvering in the event of an emergency or other conditions or adjacent land uses that may require increased caution on the part of motorists, it may be desirable to use a limit lower than the 85th percentile as long as the value remains within the safe speed range.

In some unique cases, the 85th percentile speeds will differ considerably by direction at a particular location. For example, a relatively heavy development on one side of the road may cause motorists nearest to it to travel at a lower rate of speed. In such cases it is acceptable to zone for different speeds in opposite directions.

The length of all speed zones shall be computed to the nearest tenth of a mile. Each speed zone should be as long as possible while taking into consideration the constraints due to stopping sight distance and changes in adjacent land use. Zones should, generally, be a minimum of ½ mile in length.

In general, speed zones should not be changed due to the presence of a horizontal curve. Advisory speeds on horizontal curves should be based upon the speed zone on the upstream tangent roadway section and are further described in **Section 10.a** of this document.

In a transition zone, where a street or highway enters a residential or business district from a less densely developed area, graduated speed zones should be considered, when feasible. Graduated speed zones may be less than ½ mile but shall still be at least two tenths of a mile long. In addition, if the speed limit is reduced from one zone by more than 10 mph, a Reduced Speed Limit Ahead (MUTCD code W3-5) sign shall be used in accordance with the MUTCD and **Section 10.b** of this document.

Under all conditions the final speed limit selected shall be a multiple of 5.

5.i Verification

After the proposed speed limits and zone lengths have been determined, repeat the trial speed runs, driving in each direction over each part of the zone at the recommended speed for that direction. Make notes on whether the limits and the lengths of the separate zones appear to be satisfactory. If some

revisions to the zones appear to be necessary, make the required adjustments and recheck with test runs accordingly.

Upon completion of the final trial speed runs, USLIMITS2 may be used to validate the proposed speed zones. Any differences between the two methodologies should be noted, but any speed zone that is proposed to be higher than the recommendation from USLIMITS2 should be carefully reviewed and revised, as needed.

After all the necessary field data has been collected and analyzed, it should be forwarded to the appropriate MassDOT District Office so that the results of the study may be reviewed. For locally owned streets and highways a tentative agreement between the municipality and the District Office should be reached as to what speed limits will be established because the speed zones cannot receive full approval until it is reviewed by the MassDOT Traffic and Safety Engineering Section in Boston.

Part 6. Secondary Impacts of New Speed Zones

Collection of new speed data and approval of a Special Speed Regulation by MassDOT may impact other parts of the roadway network. These modifications need not be a part of the Special Speed Regulation but remain a vital safety component of overall operations. Potential items within the extents of the new regulation that should be reviewed following the establishment of a new regulation include:

- All curves, particularly horizontal curves, should be examined for potential additions, modifications, or deletions to warning signage. More details on the use of these signs may be found in **Section 10.a**.
- Points where the differential between two adjacent speed zones is 10 mph or greater should have additional warning signage in conformance with the MUTCD and **Section 10.b**.
- The timing of yellow and all-red clearance intervals at traffic signals should be reviewed to meet current engineering guidance.

Part 7. Follow-up Studies

Once new speed limit signs have been in place for at least six months it may be beneficial to conduct a follow-up spot speed observations to determine the zone's effectiveness and to evaluate any changes in speed patterns. The comparison of the speed observations made before and after the zoning should be recorded. Consideration should be given to revising numerical limits which vary by 7 mph or more from the newly recorded 85th percentile speeds. If changed, a new Special Speed Regulation will be required.

After new speed zones have been in effect for at least one year, it may be beneficial to review police crash reports for the 12+ months, if available. While it should be acknowledged that one year of data is not sufficient for a true crash analysis, this snapshot should be able to provide insight into whether speed-related crashes have changed in frequency and if the new speed zones have affected overall safety.

Part 8. Rescinding Special Speed Regulations

A municipality may decide to rescind an existing Special Speed Regulation on a municipal way. Doing so should only take place after careful consideration, as rescinding a Special Speed Regulation will change the speed laws, including enforcement methods, that govern the street will from MGL c. 90 § 18 to MGL c. 90 §§ 17 or 17C (as described in **Part 2**) and any regulatory speed limit signs will have to be removed.

If a city or town moves to rescind a Special Speed Regulation on a municipal way, it should specifically reference the regulation number and whether the recission is for all or a portion of the regulation. If only a portion of the regulation is to be rescinded, it should clearly be noted in the action made by the body that governs the municipal traffic code. Upon approval by the municipality, a certified copy of the action shall be sent to:

State Traffic Engineer
Attention: Regulations Engineer
MassDOT Highway Division
10 Park Plaza, 7th Floor
Boston, MA 02116

Upon notification of the recession, MassDOT will prepare a modified or rescinded Special Speed Regulation, depending upon the action taken by the municipality. Similar to the creation of a new Special Speed Regulation, this document will be signed by the Registrar of Motor Vehicles and the State Traffic Engineer, and copies will be supplied to the District Office and the municipality. At this time the municipality shall remove the regulatory speed limit signs and the speed enforcement of the road will revert to MGL c. 90 §§ 17 or 17C. Any new speed signage shall conform to the standards shown in **Part 10** and the MUTCD.

Part 9. Speed Limit Signs

Standard Speed Limit (MUTCD code R2-1) signs, as shown in **Fig. 9-1**, are rectangular in shape with black, non-reflective legend and border on white, reflectorized sheeting. The white sheeting material used should conform to ASTM D4956 Type III or better. The actual dimensions of the sign should conform to those shown in **Table 9-1**.

Where Special Speed Regulations exist, an R2-1 sign must be placed at each location where a change in the numerical limit occurs. In unusually long zones, confirmatory speed signs should also be erected at strategic locations, such as downstream of major intersections, to remind the driver of the legal speed limit. On Interstates and other controlled-access facilities confirmatory signs are usually erected downstream from all on-ramps.

Fig. 9-1: Standard R2-1 (Speed Limit) Sign with Dimensions
(Source: *Standard Highway Signs*, 2004)

	A	B	C	D	E	F	G	H	J	K	L
Single-Lane Road	24	30	.375	.625	4	*4E	2	*10E	9.563	7.313	1.5
Multi-Lane Road	30	36	.5	.75	5	*5E	2	*12E	11.979	9.167	1.875
Expressway	36	48	.625	.875	6	*6E	5	*14E	14.375	11	2.25
Freeway	48	60	.75	1.25	8	*8E	6	*16E	19.125	14.625	3

*Series E Standard Alphabet for Traffic Control Devices

Table 9-1: R2-1 (Speed Limit) Sign Standard Dimensions, in Inches (Source: MUTCD)

Part 10. Other Speed Signage

In addition to the speed zoning procedures discussed earlier in this document, there are several other types of speed signage that may be found on streets and highway in Massachusetts. These may be generally categorized as one of the following types:

- Advisory speed plaques; conforming to the requirements of the MUTCD;
- Regulatory speeds, conforming to MGL c. 90 §§ 18 and 18B; or
- Statutory speeds, conforming to MGL c. 90 §§ 17, 17A and 17C.

10.a Advisory Speed Signs and Plaques

Advisory speed plaques are used to supplement other warning signs of a condition that may require a reduction in operating speed. Advisory speeds are most commonly used to supplement horizontal alignment signs such as Turn (MUTCD code W1-1), Curve (W1-2), or Winding Road (W1-5), but may be used under condition where a geometric or other roadside condition necessitates an advisory speed. *Advisory speed plaques (W13-1P), displaying "XX MPH" cannot be used alone; they must supplement a primary warning sign.*

The speed exhibited on all advisory speed signs and plaques is the maximum comfortable and safe speed, rather than an actual speed limit, so the signs are designed with a black legend on a yellow background. Advisory speeds are not enforceable limits.

Fig. 10-1: W1-1 Sign w/ W13-1P Plaque (Source: MUTCD)

Use of a ball-bank indicator is the simplest and most widely used device to measure safe, comfortable speeds on horizontal curves. A ball-bank indicator is a curved level that measures the combined effect of the body roll angle, the centrifugal force, and the superelevation angle as a vehicle negotiates a horizontal curve at various speeds.

In order to properly set advisory speeds through changes in horizontal alignment, the guidance found in FHWA's *Procedures for Setting Advisory Speeds on Curves* should be incorporated. If a ball-bank indicator is used, **Table 10-1** should be the basis of the criteria for determining the advisory speed through horizontal curves:

Ball-Bank Reading	Speed
16 degrees	20 mph or less
14 degrees	25 mph to 30 mph
12 degrees	35 mph and higher

Table 10-1: Maximum Ball-Bank Readings for Various Advisory Speeds (Source: MUTCD)

In addition to the use of a ball-bank indicator, other methods to determine advisory speeds through curves include manual calculation using a design speed equation or driving the curves using an accelerometer that can provide a determination of the side friction factors.

The use of advisory speed plaques in conjunction with Turn (W1-1), Curve (W1-2), Reverse Turn (W1-3), Reverse Curve (W1-4), Winding Road (W1-5), combination Curve/Intersection (W10-1 series), Chevrons (W1-8), One Direction Large Arrow (W1-6) shall conform to the Table 2C-5 of the MUTCD. These standards are based upon the difference between the speed limit and the calculated advisory speed. If the speed limit is:

- 10 mph or greater than the calculated advisory speed, an advisory speed plaque must be used;
- 5 mph greater than the calculated advisory speed, an advisory speed plaque is optional; and
- Equal to or less than the calculated advisory speed, an advisory speed plaque cannot be used.*

**Under this condition it is strongly encouraged to perform a speed study on the tangent sections of road upstream and downstream from the horizontal curve to determine if the speed limit has been set artificially*

low. While seemingly counterintuitive, it may be appropriate to raise the speed limit to a rate that matches travel speeds on tangent sections in order to fully utilize proper curve warning signs and advisory speed plaques.

Advisory speed signs and plaques may be installed by municipalities on any locally-owned street or highway without permission from MassDOT as long as the selected speed is based on an engineering study and their use conforms to the MUTCD.

10.b Reduced Speed Limit Ahead Signs

Fig. 10-2: W3-5 Sign (Source: MUTCD)

Reduced Speed Limit Ahead (MUTCD code W3-5) signs are warning signs that inform road users of an upcoming reduction in the regulatory speed limit. The MUTCD recommends their use any time the speed limit is being reduced by more than 10 mph. When used properly it can be an effective tool to reduce the likelihood of sudden drops in free-flow speed.

Under conditions where a School Zone will reduce the speed limit by 10 mph or more, a Reduced School Zone Speed Limit ahead (S4-5) sign should be used in place of a standard Reduced Speed Limit Ahead sign.

Reduced Speed Limit Ahead signs are advisory and cannot be used in place of a regulatory Speed Limit sign. The legal speed limit becomes enforceable only at the point at which the Speed Limit sign is placed.

10.c Safety Zone Speed Limits

Safety Zone speed limits are the only regulatory speed limits that municipalities can adopt on city- and town-owned ways without approval from MassDOT. Safety Zones cannot be placed on State Highway without prior written approval of MassDOT. Speed limits within a Safety Zone must be set at 20 mph and are intended to be used in areas where vulnerable road users are likely to be present, such as parks and playgrounds, senior citizen housing and centers, hospitals or other medical facilities, high schools and higher education centers, and daycare facilities. Please note that Safety Zones should not be used in place of School Zones for streets adjacent to grades 1-8 schools.

To establish a Safety Zone, the following minimum criteria should apply:

- The street should be adjacent to a land use that is likely to attract vulnerable road users.
- The Safety Zone should contain one or more areas that have potential conflicts between motor vehicles and vulnerable road users that warrant a reduction in speeds such as crosswalks, driveways, or side streets.
- The minimum length of the Safety Zone should be at least ¼ of a mile and it should not extend more than 500’ beyond a side street unless an applicable land use continues along the adjacent block.

Fig. 10-3: MA-R2-8 Sign

Regulatory speed limit signs, including Safety Zone speed limit signs, are required to conform to the MUTCD, per MGL c. 85 § 2. Therefore, an engineering study must be performed to validate the posting of

signage. The engineering study "shall include an analysis of the current speed distribution of free-flowing vehicles."

Proper signage is also necessary to inform road users of the downstream end of a Safety Zone. In an area where a legal Special Speed Regulation has been enacted, the Safety Zone should be terminated with a Speed Limit (MUTCD code R2-1) sign that corresponds to the regulatory limit shown in the regulation. If the Safety Zone is in an area that has no Special Speed Regulation, it should be terminated with an End Speed Zone (MassDOT code MA-R2-7) sign.

Cities and towns are responsible for modifying their Municipal Traffic Code to reflect the locations of all Safety Zones prior to the posting any signage.

10.d School Zone Speed Limits

School Zone speed limits are a statutory speed limit but may be marked with regulatory (black legend on white background) signage. Speed limits within a School Zone must be set at 20 mph, but the limit is only in effect during days of the week and hours of the day when children are accessing the school grounds. School Zone warrants, design, and operation are governed by the Massachusetts Amendments to the MUTCD. The following is a summary of these criteria, but the full document should be reviewed to ensure all standards are met:

- The school property abuts the public right of way within the limits of the proposed School Zone;
- School children have direct access to the street or roadway from the school property;
- There is a marked, ADA-compliant crosswalk within the School Zone; and
- The school includes one or more grades between Grade 1 and Grade 8, inclusive.

Fig. 10-4: R2-1 Sign with S4-3P and S4-1P Plaques (Source: MUTCD)

Cities and towns are responsible for modifying their Municipal Traffic Code to reflect the locations and days and times of operation for all School Zones prior to the posting any signage. The sign assembly that is used to identify the school zone speed limit for drivers should be similar to Fig. 10-4; the assembly may also contain sign plaques stating the days of the week and times of day (MUTCD code S4-6P) or "When Children Are Present" (S4-2P) or it may be supplemented with either a single yellow flashing beacon above the sign, or one yellow flashing beacon above and one below the sign that flash alternately, and a plaque stating "When Flashing" (S4-4P).

10.e Thickly Settled or Business Districts

Thickly Settled or Business Districts, as defined in MGL c. 90 § 1, have a default statutory speed limit of 30 mph unless the municipality has adopted MGL c. 90 § 17C., wherein the statutory speed limit in these areas is reduced to 25 mph. However, if a Special Speed Regulation has been enacted on this section of roadway the regulatory speed will govern. With exception to School Zone Speed Limits discussed in Section 9.d, *Special Speed Regulations will always supersede a statutory speed limit*.

> *A thickly settled or business district is "the territory contiguous to any way which is built up with structures devoted to business, or the territory contiguous to any way where dwelling houses are situated at such distances as will average less than two hundred feet between them for a distance of a quarter of a mile or over."*
>
> *--- MGL c. 90 § 1*

A municipality has the option of adopting MGL c. 90 § 17C on either a city- or town-wide basis or on a street-by-street basis. MassDOT recommends the former since it allows for consistent messaging and is less likely to create confusion for motor vehicle operators. In addition, adopting the 25 mph statutory limit on a city- or town-wide basis will allow vehicles to place MA-R2-9A or MA-R2-9B regulatory (black legend on white background) signs on municipal ways at jurisdictional boundaries while staying in conformance with the MUTCD, whereas MA-W13-4 warning (black legend on yellow background) signs may only be used for individual streets (Fig. 10-5).

Cities and towns are responsible for modifying their Municipal Traffic Code if they have adopted the 25 mph statutory limit in Thickly Settled or Business Districts. In the case that it is adopted on a street-by-street basis, those streets and the extents of those limits should clearly be identified. In addition, MGL c. 90 § 17C requires the municipality to notify MassDOT if the 25 mph statutory limit is adopted.

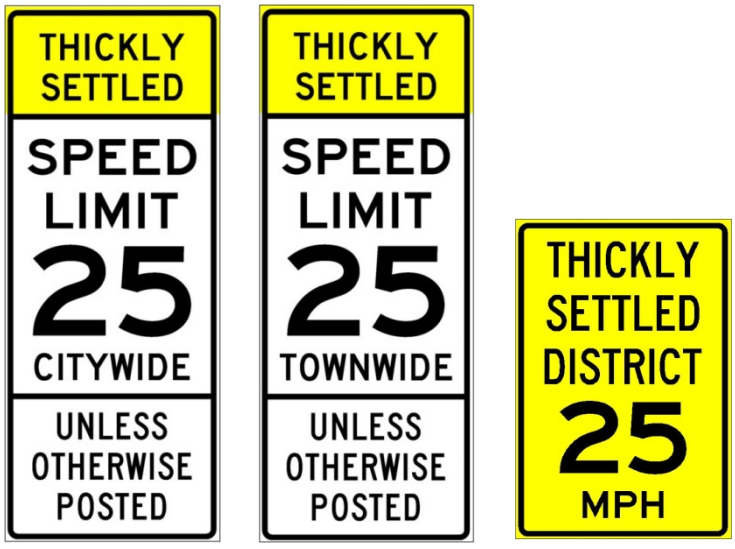

Fig. 10-5: MA-R2-9A, MA-R2-9B, and MA-W13-4 Signs

10.f Speed Feedback Signs

Speed Feedback Signs (SFS) may be a valuable tool in reducing vehicle speeds under many different conditions, including work zones, areas where it is not possible to make physical roadway changes, or where constant police enforcement is not practical. Newer SFS systems may also log and store speeds over time so that the owner may track changes to speed profiles over time to determine its effectiveness and also to identify possible patterns of violators which can be used to deploy enforcement at times when it will be most efficient.

However, SFS systems are not a panacea for long-term reductions in speed profiles under all conditions. Under most scenarios, general speeds will drop immediately after installation due to a "novelty" effect of the device; the extent speeds increase back to the pre-installation rate over time is oftentimes related to the setting in which it was installed. Research has shown that SFS systems are not effective everywhere, and when used they may only be effective over short distances.[7,8,9] Therefore, MassDOT advises that SFS systems are limited to the following conditions:

- In School Zones, where the speed limit may vary by times of day;
- In Transition Zones, where a regulatory speed limit decreases;
- On approaches to signalized intersections on high-speed roadways; and
- In work zones, where traffic flow may unexpected slow or stop.

A SFS should always be installed below a speed limit sign; it should never be installed by itself. In addition, MassDOT advises that the size of the "Speed Limit" and number legends should be mimicked by the "Your Speed" and the changeable speed display legends.

[7] Rose, Elisabeth R. and Ullman, Gerald L., *Evaluation of Dynamic Speed Display Signs*, (College Station, TX: Texas Transportation Institute, September, 2003).
[8] Jeihani, Mansoureh, et al, *Evaluating the Effectiveness of Dynamic Speed Display Signs*, (Baltimore, MD: Morgan State University, September, 2012).
[9] Sandberg, Wayne, et al, *Long-Term Effectiveness of Dynamic Speed Monitoring Displays for Speed Management at Speed Limit Transitions*, (Washington, Dakota, and Ramsey Counties, MN: 2009).