

NORTHERN MIDDLESEX TRANSPORTATION IMPROVEMENT PROGRAM (TIP) PROJECT REVIEW AND EVALUATION STUDY



Above: East Street at Livingston Street in Tewksbury with improvements programmed in the 2011 TIP.

Below: Route 110 at Boston Road/Carlisle Road (Minots Corner) in Westford with improvements programmed in the 2012 and 2013 TIP.



AUGUST 2021

PREPARED FOR THE NORTHERN MIDDLESEX METROPOLITAN PLANNING ORGANIZATION (NMMPO)

BY THE NORTHERN MIDDLESEX COUNCIL OF GOVERNMENTS (NMCOG)



“By examining and quantifying the effectiveness of various improvement strategies and project types, the NMMPO, regional partners, and state and federal transportation agencies will develop a better understanding of how to most effectively and efficiently allocate funding resources for transportation improvements in the future.”

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PROJECT OVERVIEW

The Northern Middlesex MPO, in cooperation with the Massachusetts Department of Transportation (MassDOT) and member communities, has funded several improvement projects at high crash locations across the region aimed at improving overall safety. This report evaluates the effectiveness and impact of two projects completed through the Northern Middlesex Transportation Improvement Program (TIP). This study analyzes and compares the safety conditions before and after project completion to assess the effectiveness of these projects. Effectiveness can be measured by examining the total crashes as well as the severity of crashes at each location following the installation of improvements. By examining and quantifying the effectiveness of various improvement strategies and project types, the NMMPO, regional partners, and state and federal transportation agencies will develop a better understanding of how to most effectively and efficiently allocate funding resources in the future.

The projects evaluated in this study include two intersections: Minot's Corner (Boston Road/Carlisle Road at Route 110) in Westford and East Street at Livingston Street in Tewksbury. These projects were constructed using Federal Highway Safety Improvement Program (HSIP) funds through the TIP. The East Street and Livingston Street project was funded in 2011 at a total federal participating cost of \$1,143,250, using federal Surface Transportation Program (STP) and HSIP funding categories. The Minot's Corner project was programmed in 2012 and 2013 at a total federal participating cost of \$3,725,000 using STP and HSIP funding categories.

MONITORING TIP PROJECT SAFETY: MEASURES OF EFFECTIVENESS

In order to monitor how intersection improvement projects impact overall safety, three measures of effectiveness (MOE) were identified. These are quantifiable performance-based measures monitored by NMCOG and MassDOT over time that can be used to assess traffic safety conditions for each location. The MOEs utilized in this study include:

1. Total number of crashes;
2. EPDO Score; and
3. Intersection Crash Rate.

The Highway Safety Improvement Program (HSIP) is a core Federal Aid program designed to reduce traffic fatalities and serious injuries on all public roads. HSIP funds are utilized for the design and construction of highway projects that will reduce the number and severity of roadway crashes. Projects funded with HSIP resources must be programmed in the TIP. Funding eligibility is based on crash data and engineering assessments of identified hazardous locations. According to guidelines set by the State, an eligible cluster for HSIP funding must have a total number of "Equivalent Property Damage Only (EPDO)" crashes within the top 5% in a region. The formula for determining EPDO is as follows:

$$EPDO = (1 \times \text{Property Damage Only Crash}) + (5 \times \text{Crash Involving Injury}) + (10 \times \text{Crash involving Fatality})$$

To identify eligible HSIP clusters, MassDOT and the MPO compile crash locations or clusters into a list. These clusters are then assigned an Equivalent Property Damage Only (EPDO) value based on the number and severity of crashes, creating a ranking system. These rankings are then sorted and put into a list of top 200 crash locations for the state and for the top 100 crash locations for the region.

Crash Rates, or crashes per year measured against vehicle exposure (traffic volumes) are traditionally used in determining whether an intersection or roadway is considered safe. MassDOT maintains a database of signalized and unsignalized intersection crash rates, mainly submitted to the State as part of the design review process and for an Environmental Impact Report or Functional Design Report. With this data, the State develops average crash rates for each District and the Commonwealth as a whole.

$$\text{Crash Rate} = (\text{Average crashes per year} \times 1,000,000) / (\text{Total Peak Hourly Approach Volume} \times 365)$$

The MOE for this measure is a comparison of each intersection's crash rate before and after improvements, as well as a comparison to each District average.

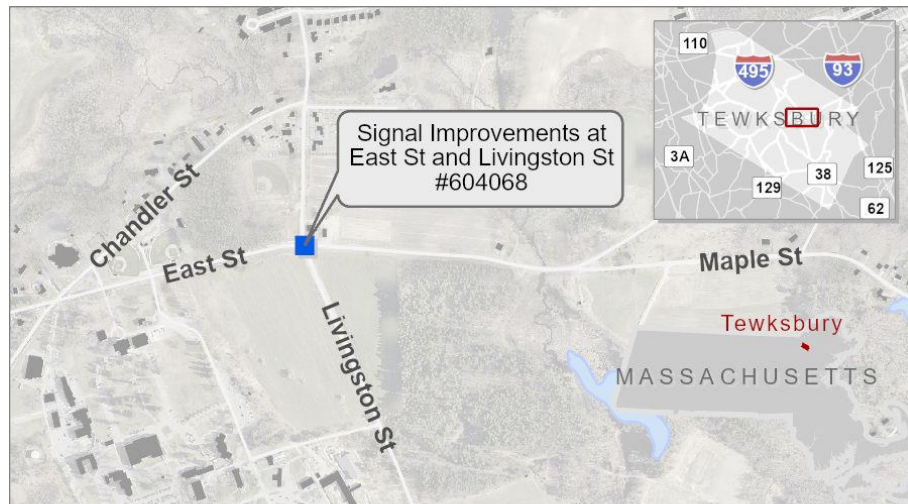
TIP PROJECT: EAST STREET AT LIVINGSTON STREET IN TEWKSBURY

CONDITIONS PRIOR TO ROADWAY IMPROVEMENTS

Prior to the completion of the TIP project, Livingston Street approached East Street from the north and south, forming a four-legged intersection with stop control on Livingston Street. Each approach was comprised of a general-purpose lane roughly 12 feet wide.

There were no sidewalks at the

intersection. The properties that abut the intersection consist of residential and agricultural land uses. Along East Street, the speed limit is 35 mph, while along Livingston Street it is 30-mph. East Street is classified as an urban arterial roadway while Livingston Street is classified as an urban collector. The Town of Tewksbury owns both roadways as well as the intersection.



Sources: MassGIS/NMCOG (roads, building footprints); 2020 Pictometry imagery
Produced by NMCOG: 7/23/2021

Map 1: East Street at North Street in Tewksbury MA

As Livingston Street approaches East Street, the pavement width widens to approximately 67 feet on the southerly approach and 82 feet on the northerly approach. The sight distance on the southbound approach was 120 feet and the sight distance looking west on both approaches was obscured by a vertical curve on East Street making it deficient. The intersection met traffic signal justification warrants for both four-hour volume and peak hour volume criteria.



Photo 1: East Street Eastbound Approach to Livingston Street (Pre Construction)

The East Street at Livingston Street intersection was the site of an unusually high number of crashes with 27 crashes reported between 2007 and 2009. The crash rate for the location (0.87 crashes per million entering vehicles) was noted to be higher than the MassDOT District 4 average rate (0.73) for a typical unsignalized intersection in the area. Angle crashes were identified as the most common type of crash.

IMPROVEMENT PROJECT DESCRIPTION

Construction of improvements at the intersection completed in 2011 included the installation of a new fully actuated traffic signal with geometric changes to improve approaches and added infrastructure for non-motorized users of the intersection. Specific changes made included the following:

- **Geometric changes**
 - East Street was widened to provide an exclusive left turn lane and a shared through lane for westbound approach.
 - Corner Radii were adjusted to accommodate truck turning movements throughout the intersection.
 - Wheelchair ramps on three corners of the intersection were installed to meet current ADA/AAB access standards at the intersection
 - New crosswalks were installed on the East Street eastbound and Livingston Street southbound approaches
 - 4-foot shoulders were provided on all approaches
 - New sidewalks were installed in the project area.



Photo 2: East Street Eastbound Approach to Livingston Street Post Construction (2019)

- **Traffic control improvements**

- A new fully actuated traffic signal control system with appropriate timing and phasing for peak hour volume requirements were installed
- As part of the signal, a protected lead phase for East Street westbound approach was provided.
- Provision of an exclusive pedestrian phase
- Provision of bicycle detection for all approaches
- Provision of emergency pre-emption for all approaches
- Upgrading of existing regulatory signage and pavement markings throughout the intersection.



Photo 3: Livingston Street Southbound Approach to East Street before Improvements (2008)

TIP PROJECT EFFECTS ON OVERALL SAFETY

After improvements were completed in 2011, the East Street at Livingston Street intersection saw a gradual decrease in crashes, declining from a high of 10 incidents in 2009 down to 2 in 2016 (Figure 1). This drop in crashes also correlates to a drop in the overall EPDO score dropping from its peak at 63 from 2007-2009 to 12 in 2015-2017, a drop of 81% (Figure 2).



Photo 4: Livingston Street Southbound Approach to East Street after Improvements (2012)

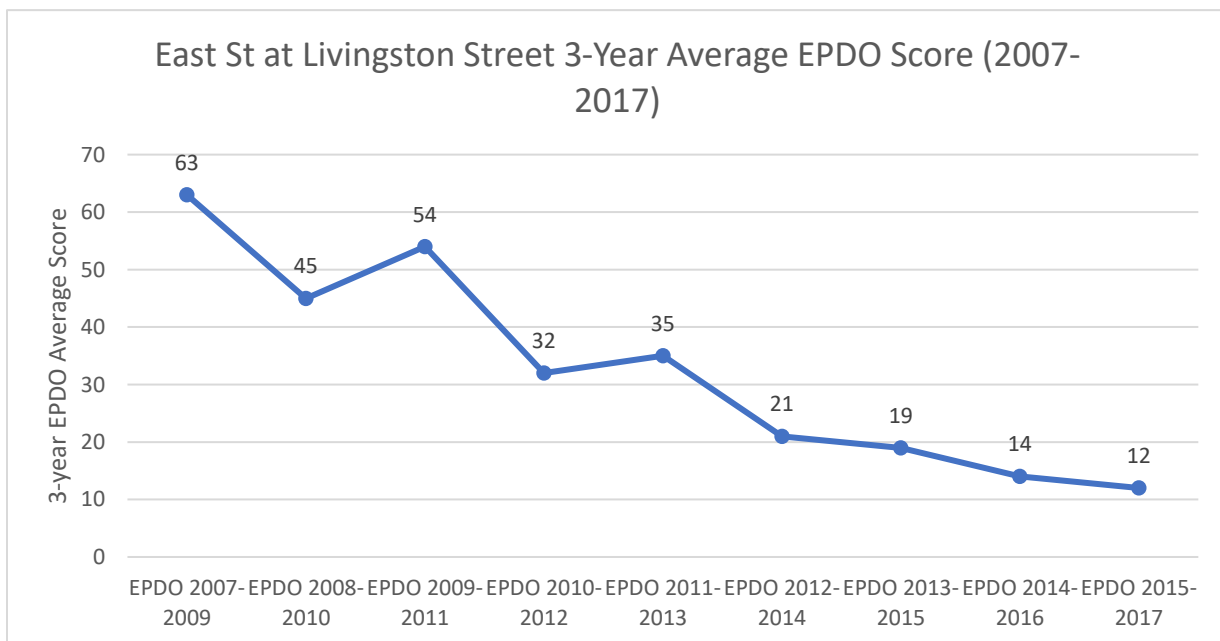


Figure 2: East Street at Livingston Street 3-Year Average EPDO Score (2007-2017)

CRASH RATE

Another effective tool used in measuring effectiveness of improvements on intersection safety is the crash rate, reported as the number of crashes that occur per million vehicles entering an intersection (MEV).

In 2006, the crash rate at East and Livingston was 0.87 crashes per MEV. After project completion, the crash rate dropped to 0.39 crashes per MEV in 2017, a considerable decrease. Furthermore, the average crash rate in MassDOT District 4 for a Signalized Intersection is 0.73 crashes per MEV. Therefore, the crash rate for East and Livingston after improvements (0.39) is considerably lower than average rates for District 4 intersections.

SAFETY IMPROVEMENT SUMMARY

The intersection has experienced a marked increase in overall safety when analyzing the measures of effectiveness used in this study. Total crashes have decreased 70%. EPDO numbers have dropped 81% and the crash rate has decreased 55% with improvements made to the intersection.

Table 1: East Street at Livingston Street MOE Summary

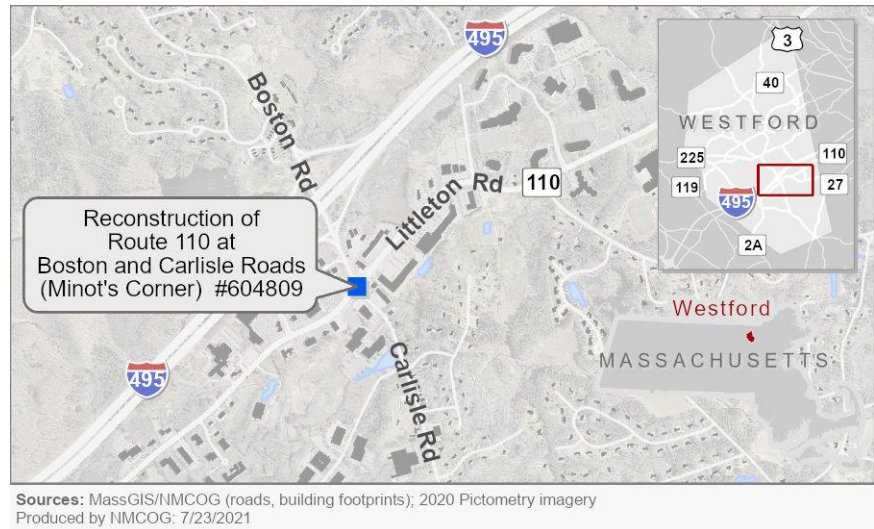
	Prior to Construction (2007-2009)	Latest Data Available Post Construction (2015-2017)	Percent Change
Total Crashes	27	8	-70%
EPDO	63	12	-81%
Crash Rate	0.87	0.39	-55%

TIP PROJECT: ROUTE 110 (LITTLETON ROAD) AT BOSTON ROAD/ CARLISLE ROAD (MINOT'S CORNER) IN WESTFORD

CONDITIONS PRIOR TO ROADWAY IMPROVEMENTS

Prior to the TIP project, Littleton Road (Route 110) was an undivided two-lane urban arterial running from Littleton in the west to Chelmsford in the east. Littleton Road (Route 110) generally consisted of one lane in each direction, with additional turn lanes at intersections. Sidewalks were present on Littleton Road (Route 110 within the project limits). Based on field reconnaissance, there were no posted speed limits on

Route 110 within the project limits, though the town-wide speed limit was 35 mph. Littleton Road (Route 110) runs generally in a northeast-southwest direction through the project area and intersects Boston Road approximately 1,100 feet south of I-495. Paved shoulders and granite curbing are provided in the area. The Minot's Corner intersection is described in detail below.



Map 2: Route 110 at Boston Road/Carlisle Road in Westford MA

Littleton Road (Route 110) at Boston Road and Carlisle Road, commonly referred to as Minot's Corner, is a signalized four-legged intersection. Before the TIP project that changed the configuration, Boston Road consisted of three lanes approaching the intersection (exclusive left turn lane, exclusive through lane, and an exclusive right turn lane) and two lanes departing the intersection). Carlisle Road consisted of two shared lanes approaching the intersection. The eastbound approach of Littleton Road (Route 110) consisted of dual left turn lanes and a shared through/right turn lane. In the westbound direction, Littleton Road (Route 110) consisted of three lanes approaching the intersection (exclusive left, through and a channelized right turn lane). Short sidewalk sections were located on the north, south and eastern corner of the



Photo 5: Minot's Corner Intersection before Improvements (2012)

intersection, but crosswalks were not present at the intersection. Land use at the intersection consisted of commercial uses as is still the case.

PROJECT DESCRIPTION

Littleton Road (Route 110) was widened within the project limits to provide two through lanes in each direction and exclusive left turn lanes at the retail site driveways and Nixon Road. At the intersection of Littleton Road (Route 110)/ Boston Road/ Carlisle Road, significant widening was undertaken to facilitate additional turning lanes. Project improvements included the following:



Photo 6: Littleton Road Eastbound Approach to Boston Road before Improvements (2012)

- Dual left turn lanes were provided on the Littleton Road (Route 110) eastbound approach, in addition to a through and a shared through/right turn lane. On the Carlisle Road northbound approach, a short exclusive left turn lane was provided, in addition to an exclusive through lane and a shared through/right turn lane. On the Littleton Road (Route 110) westbound approach, the existing exclusive left turn lane and channelized right turn lane were preserved. However, an additional through lane was added to the approach. On the Boston Road southbound approach, dual left turn lanes were provided, in addition to a through lane and an exclusive right turn lane.
- Shoulders approximately 4-foot wide were provided on both sides of Littleton Road (Route 110), for the majority of the project limits. On the north side of Littleton Road, just east of Boston Road, there is a 400-foot section that is only 2 feet wide. This spot shoulder narrowing was necessary to avoid impacting the access to the gas pumps at the adjacent gas station. The striped shoulders on Boston Road varied between 2 feet to 3 feet, in order to tie in with the 3-foot shoulders on Boston Road north of the project limits. The striped shoulders on Carlisle Road vary between 1-2 feet wide in order to tie in with the 1-foot shoulders on Carlisle Road south of the project limits.



Photo 7: Littleton Road Eastbound Approach to Boston Road after Improvements (2018)

- In addition to new traffic signal equipment required for the new geometry, changes were made to the signal phasing and operations. Previously, the Littleton Road (Route 110) westbound right turns

were under yield control only. To conform to MassDOT guidelines under proposed conditions, this movement was placed under signal control upon pedestrian actuation. In addition, the Boston Road southbound left turn operates as protected only due to the double left turn lane. Lastly, the Carlisle Road northbound left operates as a protected/permisive movement.



Photo 8: Minot's Corner after Improvements (2018)

TIP PROJECT EFFECTS ON OVERALL SAFETY

The Route 110 at Boston Road project’s effectiveness could be seen directly following the completion of the project in 2015. Following the construction of Cornerstone Square in 2012, which added 238,000 square feet of retail and office space to the intersection and generated significant traffic, there was an evident increase in crashes from 2012 to 2015, jumping from 26 to 46 in 3 years (Figure 3). However, upon completion of the Route 110 at Boston Road improvement project, there was a steep drop in crashes, from 46 to 24 crashes from 2014 to 2015 (a 48% drop), where it remained fairly consistent through 2017, the last year for which data is available. (The lowest crash number occurred in 2009,

before the project was implemented and before the Cornerstone Square development was constructed.) The 3-year EPDO score is also decreasing, albeit a bit slower. This is due to the nature of an averaged measure, which

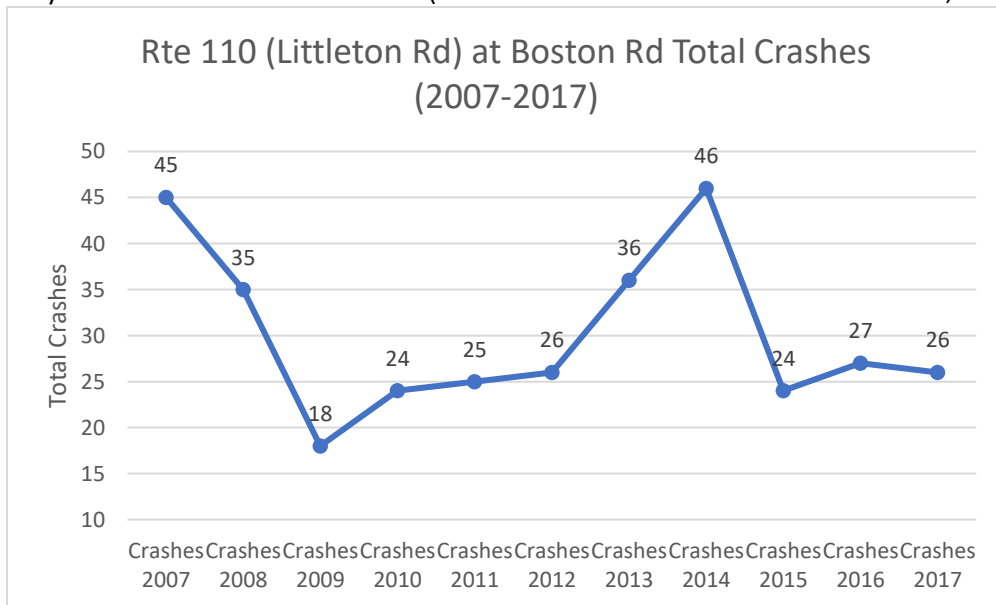


Figure 3: Route 110 (Littleton Road) at Boston Road 3-Year Average EPDO Score (2007-2017)

requires three full years of data to show pronounced results. As shown in Figure 4, the EPDO score has been dropping since the project’s completion in 2015. Staff will continue to monitor this trend.

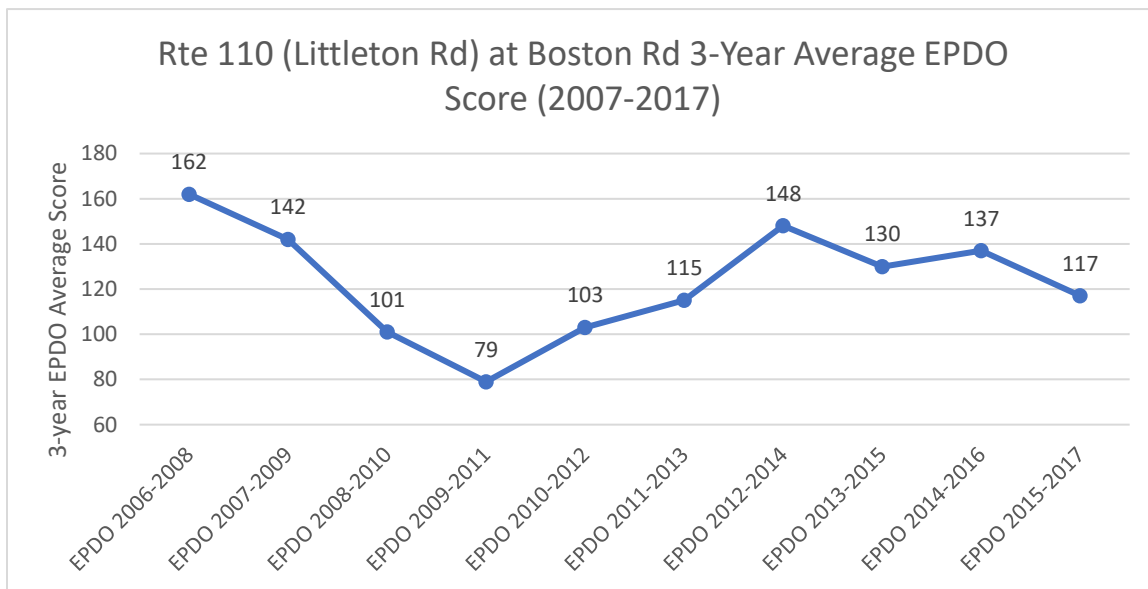


Figure 4: Route 110 (Littleton Road) at Boston Road Total Crashes (2007-2017)

CRASH RATE

Before improvements were made, the average crash rate at Minot’s Corner was 3.01 crashes per MEV in 2007. After completion, the crash rate dropped to 1.07 crashes per MEV in 2017, a considerable decrease. Furthermore, the average crash rate in MassDOT District 3 for a Signalized Intersection is 0.89 MEV. While the rate for this location is higher than the district average, it should be noted that Minot’s Corner is a large, high-volume, well-traveled intersection and the decreases in overall crash rate, despite the increased demand, clearly shows that the intersection has been made safer.

SAFETY IMPROVEMENT SUMMARY

The overall intersection safety increased based on the measures of effectiveness used in this study. Total crashes have decreased 21%. EPDO numbers have dropped 15% and the crash rate has decreased 64% as a result of the improvements made to the intersection.

Table 2: Minot's Corner MOE Summary

	Prior to Construction (2007-2009, 2007 for Crash Rate)	Latest Data Available Post Construction (2015-2017, 2017 for Crash Rate)	Percent Change
Total Crashes	98	77	-21%
EPDO	142	117	-15%
Crash Rate	3.01	1.07	-64%

CONCLUSIONS AND NEXT STEPS

After evaluating the TIP projects at East Street and Livingston Street in Tewksbury and Minot's Corner in Westford, the following conclusions can be drawn:

- The East Street and Livingston Street project in Tewksbury resulted in a quick and noticeable improvement in safety;
- The Minot's Corner project showed a decrease in overall number of crashes as well as the EPDO. Crash rate comparisons have shown a noticeable increase in intersection safety despite the higher volumes of traffic generated by large development projects in the area, such as Cornerstone Square.

NMCOG staff will continue to monitor the intersections examined in this study, as well as others in the region, as part of the NMCOG safety program outlined in the region's work program. Future iterations of the before/after TIP Project study will include updates at these intersections, as well as assessments of additional intersection improvement projects.

Appendix 1: Before & After Photos

EAST AND LIVINGSTON BEFORE & AFTER



Photo 9: East and Livingston Before improvements (2007) Eastbound East Street approach (Source: Town of Tewksbury)



Photo 10: East and Livingston after improvements (2019) Eastbound East Street approach (Source: Google Maps)



Photo 11: East and Livingston Before improvements (2008) looking at the Westbound East Street approach (Source: Google Maps)



Photo 12: East and Livingston after improvements (2019) Looking at the Westbound East Street approach (Source: Google Maps)



Photo 13: East and Livingston Before improvements (2008) looking at the Northbound Livingston Street approach (Source: Town of Tewksbury)



Photo 14: East and Livingston after improvements (2012) looking at Northbound Livingston Street approach (Source: Town of Tewksbury)



Photo 15: East and Livingston Before improvements (2007)
Southbound Livingston Street approach (Source: Town of Tewksbury)



Photo 16: East and Livingston after improvements (2019)
Southbound Livingston Street approach (Source: Google Maps)

MINOT'S CORNER BEFORE & AFTER



Photo 17: Minot's Corner Before Improvements (2012)
(Source: USGS)



Photo 18: Minot's Corner After Improvements (2018) (Source: USGS)



Photo 19: Minot's Corner Before improvements (2012)
Eastbound Route 110 approach (Source: Google Maps)



Photo 20: Minot's Corner After improvements (2018)
Eastbound Route 110 approach (Source: Google Maps)



Photo 21: Minot's Corner Before improvements (2012)
Westbound Route 110 approach (Source: Google Maps)



Photo 22: Minot's Corner After improvements (2018)
Westbound Route 110 approach (Source: Google Maps)



Photo 23: Minot's Corner Before improvements (2012)
Northbound Carlisle Road approach (Source: Google Maps)



Photo 24: Minot's Corner After improvements (2018)
Northbound Carlisle Road approach (Source: Google Maps)



Photo 25: Minot's Corner Before improvements (2012)
Southbound Boston Road approach (Source: Google Maps)



Photo 26: Minot's Corner After improvements (2018)
Southbound Boston Road approach (Source: Google Maps)

