



Centre Street (Route 123) at Plymouth Street

Municipality of Brockton

November, 2017

Prepared For:



MassDOT

On Behalf Of:

City of Brockton

Prepared By:

Old Colony Planning Council

70 School Street, Brockton, MA 02301



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Background

This Road Safety Audit (RSA) was conducted by the Old Colony Planning Council, (OCPC), at the request of the City of Brockton. The City submitted a Project Notification Form (PNF) in January of 2017 to MassDOT. The primary goal according to the PNF was, "...to improve safety and pedestrian accommodation at an intersection with a high crash rate." The PNF states that "Centre St (Route 123) is a primary connection between downtown Brockton and the adjacent towns of Abington and Rockland, while also serving to connect downtown Brockton with residential neighborhoods on the east side, and amenities such as Brockton Hospital. It functions both as a through road linking Brockton to adjacent towns and as a local street, lined with homes and businesses." The PNF stated that the intersection experiences long delays and congestion, especially during the morning and afternoon peak hours. The traffic flow on the major road, Centre Street (Route 123), is so heavy during the peak hours that side street traffic on minor street, Plymouth Street stop-controlled approaches has very few sufficient gaps in the major street traffic to make through or left and right turning movements. The LOS on the side street approaches are LOS "F" and characterized as forced flow. In addition, this intersection is included on MassDOT 2012 Statewide Top 200 Intersection Crash List. Centre Street (Route 123) to the immediate west of the intersection is included in a Highway Safety Improvement Program (HSIP) Top 5 percent Crash Clusters for the OCPC Region.

Project Data

The Road Safety Audit took place on Thursday, September 21, 2017 at the Brockton Area Transit office located at 155 Court Street, Brockton. The meeting was facilitated by OCPC staff. OCPC provided a collision diagram and the latest three year crash experience based on crash reports provided by the Brockton Police Department. In addition, OCPC provided morning and afternoon turning movement counts (which included pedestrian counts), and signal warrant analysis reports. The meeting consisted of three components.

The first portion of the meeting focused on a discussion of the issues and concerns. The participants left the BAT meeting room and walked to the intersection to visit the site for the second portion of the meeting. The discussion of issues was continued during the site visit as OCPC staff took notes. The third portion of the meeting focused on potential short term and long term potential improvements for the intersection. The agenda and the background materials are included in the appendix to this report. Table 1 lists the names and affiliations of the audit participants.

Table 1: Participating Audit Team Members

Audit Team Member	Agency/Affiliation
Elsa Chan	MassDOT Traffic Safety
Kevin Fitzgerald	MassDOT Traffic Safety
Bianca Marshall	MassDOT District 5
Chike Odunukwe	City of Brockton Department of Public Works
Nilton DePirla	Brockton Fire Department – Signal Division
Ken Thompson	Brockton Public Schools
Kelly Forrester	Brockton Area Transit
Jason Walters	MassDOT District 5 Projects
James Donovan	Brockton Fire Department – Signal Division
Dan Murphy	CDM Smith
Ray Ledoux	Brockton Area Transit
Bill McNulty	Old Colony Planning Council
Kyle Mowatt	Old Colony Planning Council
Raymond Guarino	Old Colony Planning Council

Project Location and Description

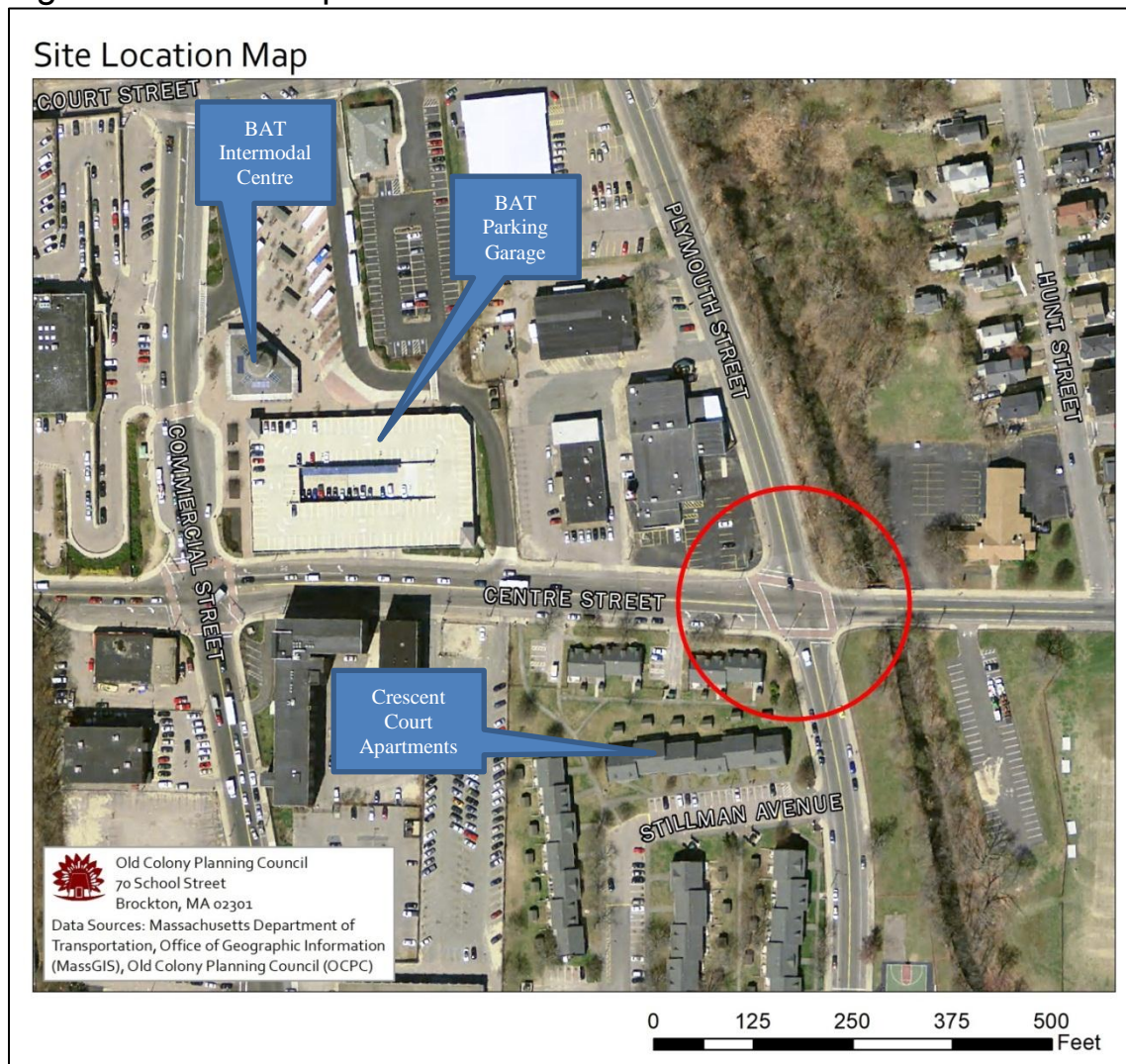
The Centre Street (Route 123)/Plymouth Street intersection is a four-way intersection (stop-controlled on the Plymouth Street northbound and southbound minor street approaches), located in Brockton downtown just east of the Brockton Area Transit (BAT) Centre. A flashing beacon is provided overhead via mast arm, with flashing red on the Plymouth Street stop approaches and yellow on the Centre Street (Route 123) approaches. The BAT Centre and BAT Parking Garage are about 600 feet to the west at Centre Street and Commercial Street. Trout Brook runs parallel to Plymouth Street to the east of the intersection and beneath Centre Street (Route 123). There are two playgrounds off of Centre Street to the east of the intersection, Snow Park on the south side of Centre Street and the O’Donnell playground on the north side of Centre Street across from Snow Park. The Salvation Army is located near to the intersection, (east of Plymouth Street across from Trout Brook). The Crescent Court Apartments, a residential development, is located on Plymouth Street, southwest of the intersection. Centre Street (Route 123) is functionally classified as an Urban Principal Arterial in Brockton, and is under Brockton jurisdiction at its intersection with Plymouth Street. The speed limit is not posted on Centre Street (Route 123) in the immediate vicinity. Centre Street is part of the NHS System.

Plymouth Street is an urban minor arterial that functions as a bypass between Court Street and Crescent Street (Route 27), with the Plouffe School located at the corner of Crescent Street (Route 27) and Plymouth Street.

Although the minor street northbound and southbound Plymouth Street approaches provide one shared through, left turn, and right turn lane, both of these approaches are wide enough so that a de-facto right turn lane occurs as vehicles turning right go around vehicles waiting to turn left. The Centre Street (Route 123) westbound approach into the intersection (over the brook) provides a single shared right turn, through, and left turn lane. The Centre Street (Route 123) eastbound approach into the intersection

provides a shared through left turn lane and an exclusive right turn lane. This eastbound approach has a four lane cross-section and is approximately 65 feet in width, which presents a long, hazardous crossing for pedestrians. There are four twelve foot lanes plus two eight foot shoulders used for parking on Centre Street (Route 123) west of the intersection. Some motorists use the south side of the eastbound Centre Street approach for commuter rail parking. The time restrictions are posted across from the BAT Parking Garage near Commercial Street, but are not posted on Centre Street (Route 123) near the Centre Street (Route 123)/Plymouth Street intersection (near the Crescent Court Apartments). In addition, some motorists park on the west side of Plymouth Street (southbound direction), near the Crescent Court Apartments, south of the intersection, which also provides an eight foot shoulder. Figure 1 shows the location of the intersection.

Figure 1: Locus Map



Crash data for the Centre Street (Route 123)/Plymouth Street intersection was obtained from the Brockton Police Department for the latest available three-year period (2014-2015-2016). The data was analyzed by

OCPC in accordance with the standard practices published by the Institute of Transportation Engineers (ITE) in the *Manual of Traffic Engineering Studies*.

Crash Details and Overview

Crash reports were compiled from the Brockton Police Department for the years 2014, 2015, and 2016. There were a total of 43 crashes at the intersection within the three year study period. Eighty-one percent of the crashes (35 crashes) were angle type crashes, nine percent (four crashes) were side-swipe (same direction) crashes, five percent (two crashes) were single vehicle ran off the road type crashes, two percent (one crash) were rear-end, and two percent (one crash) involved a car hitting a pedestrian. Forty-eight percent of the crashes resulted in personal injury, while 52 percent resulted in property damage only. The majority of the crashes were spread out evenly during the day between 6 a.m. and 6 p.m. and occurred under daylight and dry conditions; however there were 14 percent or six crashes that occurred after dark and before 6 a.m. The intersection has a crash rate of 2.75 crashes per million entering vehicles. The MassDOT District 5 average for unsignalized intersections is 0.58 crashes per million entering vehicles. More detailed crash data is included in the Appendix.

Audit Observations and Potential Safety Enhancements

During the RSA meeting prior to the field visit, a brief introduction of the RSA process and a summary of traffic volumes and crash information were presented to the audit participants. Following this brief presentation, the members of the audit team were asked to discuss the existing issues that may affect safety at the intersection of Centre Street (Route 123) at Plymouth Street. The audit team then visited the site as a group, at which time observations, safety concerns, and deficiencies were identified and documented.

Provided below is a list of the safety concerns and the potential enhancements that were identified during the RSA.

Safety Issue: Lack of Sight Distance Due to Vegetation and Parked Vehicles

Sight distance for vehicles approaching the intersection on Plymouth Street from the north as well as from the south is obscured by the presence of vegetation along the east side of the intersection parallel to Trout Brook and Plymouth Street. In addition, vehicles on the Plymouth Street northbound approaches have sight blocked due to parked cars along the west side of Plymouth Street and the south side of Centre Street (Route 123).

Enhancements: Trim back the vegetation on the northeast and southeast corners of the intersection to improve sight lines and consider prohibiting parking by posting “No



Vegetation to the right of the photo (northeast corner) obscures sight distances for vehicles waiting at stop line on the southbound approach

Parking” signs (R7-1) on Plymouth Street west side south of the intersection and on Centre Street (Route 123) south side west of the intersection far enough back to prevent sight blockage.

Safety Issue: High Number of “Angle” Type Crashes

This intersection experiences a higher number of angle type crashes crash than is expected for a stop controlled four-way intersection. A large portion of these crashes occurred when the southbound vehicle on Plymouth Street failed to yield right of way to an eastbound vehicle or westbound vehicle on Centre Street (Route 123).

Enhancements: Add additional signage alerting Plymouth Street southbound drivers at the intersection that cross traffic does not stop.

Safety Issue: Vehicle parking too close to the intersection

Vehicles park on Centre Street (Route 123) along the south side of the street on the eastbound approach (in front of the housing complex) right up to the intersection. In addition, vehicles are parked too close to the intersection on Plymouth Street along the west side of the street (in front of the housing complex). The right turn radii is hindered for buses, heavy vehicles, and right turning traffic (Centre Street eastbound to Plymouth Street southbound) due to these parked cars and parking maneuvers along the west side of Plymouth Street and the south side of Centre Street (Route 123) hinder moving traffic. The parking enforcement is not done on a regular basis, and the posted time limit for parking is only posted in one location (across the street from the BAT Parking Garage). In addition, these parked cars close to the intersection hinder the sight distance for Plymouth Street northbound vehicles looking west.

Enhancements: Limit parking and post No Parking on Plymouth Street west side south of the intersection and on Centre Street (Route 123) south side west of the intersection far enough back to prevent sight blockage. Parking along the south side of Centre Street (Route 123) west of the intersection and parking along Plymouth Street on the west side south of the intersection, should be limited to permit parking for residents in the housing complex.



Vehicle parked too close to the intersection on the eastbound Centre Street (Route 123) approach.

Safety Issue: The exclusive right turn lane on the Centre Street (Route 123) approach causes driver confusion.

Vehicles on the Plymouth Street northbound approach stopped at the stop sign look at two lanes of approaching traffic on Centre Street eastbound. Confusion and collisions occur due to northbound traffic stopping for the Centre Street eastbound right turns to Plymouth Street but disregarding the Centre Street through movements which are sometimes behind the right turning vehicles and not seen by the Plymouth Street traffic. In addition, last minute lane changes by vehicles in the exclusive right turn lane to the

through lane on the eastbound approach create safety hazards and result in side-swipes. There is a lack of warning signs on the eastbound approach warning vehicles that the right lane is for right turn only.

Enhancement: Evaluate the need for the exclusive right turn lane on the Centre Street (Route 123) eastbound approach to the intersection. Consider implementing a road diet for Centre Street between Commercial Street and Plymouth Street, reducing the cross section from four lanes to two lanes. If the right turn lane is not removed, add advance warning that the lane is becoming a right turn only lane

Safety Issue: Stop Sign Placement

The view of the stop sign on the Plymouth Street southbound approach is blocked by other signs.

Enhancement: Place stop signs on both sides of the road and relocate signs that block the stop signs. Consider adding additional stop-ahead signs on the southbound approach on the far side of the intersection as well as on the opposite side.

Safety Issue: Stop Bar on the Centre Street Eastbound Approach

The eastbound Centre Street approach has a stop bar painted on the street but there is no stop sign control on this approach (vehicles have the right of way) and the signal facing eastbound is flashing yellow. This could add to driver confusion.

Enhancement: Remove the stop bar on the Centre Street eastbound approach.

Safety Issue: Drainage Issues and Catch Basin Locations

A catch basin is located in the crosswalk at the southwest corner of the intersection. In addition, there are signs of ponding at the base of the curb ramp.

Enhancement: Evaluate existing drainage conditions and relocate the catch basin that is within the crosswalks and other catch basins if necessary to improve drainage.



Signs of ponding on the crosswalk

Safety Issue: Speeding

RSA participants stated that they observed chronic speeding on Centre Street (Route 123), in the eastbound and westbound directions.

Enhancement: The City should consider enhanced speed enforcement and electronic speed feedback signs.

Safety Issue: Inadequate Lighting

Street lights are present at the intersection; however, these might not be enough to provide adequate lighting for the intersection after dusk. There were nine crashes that occurred under non-daylight conditions.

Enhancement: The City should consider conducting a lighting evaluation and increase the number of street lights if necessary. In addition, an upgrade of existing lighting to LED should be considered.

Safety Issue: Lack of Bicycle Accommodations

There are no bicycle accommodations on Centre Street (Route 123) or Plymouth Street, although both streets do have sufficient width for accommodations. There were bicycles observed passing through the intersection during the turning movement count.

Enhancement: Consider providing bicycle accommodations per MassDOT's New Healthy Transportation initiative Policy. Consider implementing Complete Streets elements along Center Street and Plymouth Street. Enhancements may include shared or dedicated bike lanes, as well as bicycle detention, bike route signs, and pavement markings. Bicycle lanes should be added depending upon right of way availability, as Plymouth Street will maintain parking as well. Sharrows and signage can be used on the approaches that lack right of way width (in place of bicycle lanes). Travel lanes should consider sufficient width to accommodate buses and heavy vehicles.

Safety Issue: Pedestrian Safety

Crosswalks are provided across all four legs of the intersection. The longer crossing (west leg) is in excess of 60 feet with no pedestrian refuge. There is a lack of pedestrian accommodation across the four lane cross-section on Centre Street (Route 123) west of the intersection. Pedestrians often cross mid-block in this section of Centre Street (Route 123), which is part of an HSIP Cluster for pedestrian crashes. The intersection experiences significant pedestrian activity as documented in the turning movement counts. In addition, there are crossing guards at the intersection when school (Joseph Plouffe Academy, located further south of the intersection) is in session. Audit participants also noted that pedestrians cross at unmarked crossing areas in front of the BAT Garage.

Enhancement: Consider implementing Complete Streets elements. Consider implementing a road diet for Centre Street (Route 123) between Commercial Street and Plymouth Street, reducing the cross section from four lanes to two lanes. Consider adding pedestrian bump-outs thereby reducing the crossing length to decrease the amount of time that pedestrians are exposed in the intersection. Evaluate the feasibility of adding a mid-block crossing and a Rapid Rectangular Flashing Beacon (RRFD) within the section of Route 123 west of the intersection. Consider public outreach education on pedestrian safety partnering BAT and Brockton Schools.

Safety Issue: ADA Ramps

The curb ramps lack tactile warning tiles for sight impaired pedestrians.

Enhancement: Upgrade all existing curb ramps to meet ADA compliance, including the addition of tactile warning tiles to provide warning for visually impaired pedestrians. This includes all locations at the intersection and any mid-block crossings.

Safety Issue: Lack of Advanced Warning

Audit participants cited a lack of advanced warning signs on the eastbound and westbound Centre Street (Route 123) approaches.

Enhancement: Consider installing electronic messaging speed signs, and students crossing warning signs on the Centre Street (Route 123) eastbound and westbound approaches. Consider adding lane use signs on the Centre Street (Route 123) eastbound and westbound approaches.

Safety Issue: Access Management

There is a lack of access management at the intersection, which creates extra, unexpected cross movements close to the intersection, especially on the northwest corner of the intersection on Plymouth Street and Centre Street. This driveway is in close proximity to the intersection, while there are no related crashes, vehicles entering and exiting could potential introduce angle and courtesy crashes.

Enhancement: Limit movements (right turn in and out) and/or eliminate curb cuts close to the intersection.

Safety Issue: Guard Rail

The guard rail on Centre Street, over Trout Brook, presents a danger to lane departure crashes with the potential to overturn vehicles, due to the buried end treatments.

Enhancement: Consider replacing guardrail that meets MassDOT standards.

Safety Issue: Intersection visibility

The mast arm overhead flashing beacons at the intersection, which are flashing yellow facing Centre Street (Route 123) and flashing red facing Plymouth Street, could use more visibility for advanced warning.

Enhancement: Consider updating Flashing Beacons to LED to improve signal visibility.

Safety Issue: Congestion and Delays

The intersection currently experiences poor levels of service (LOS “F” forced flow) during the morning and afternoon peak hours for the Plymouth Street northbound and southbound approach critical movements (through and left turns), based on existing peak hour level-of-service analysis completed by OCPC. There is a lack of gaps in the Centre Street (Route 123) peak hour traffic flows (eastbound and

westbound) to allow vehicles to safely turn from the side street to Centre Street. Motorists get frustrated with the delays and force their way onto the Centre Street causing near misses and crashes. The intersection is slightly skewed, with a wide turning radius on the southbound approach. The turning radius on the southbound approach should be reduced.

Enhancement: Install traffic signals at the intersection or construct a roundabout. Based on warrant analysis completed by OCPC, the intersection volumes satisfy Warrants 1, 2, and 3 of the Manual on Uniform Traffic Devices (MUTCD). In addition, the sum of the peak hour entering and circulating volumes at the intersection are well below 1,000, which indicates a single-lane roundabout would operate acceptable (based on the National Cooperative Highway Research Program's *Report 672 Roundabouts an Informational Guide*, FHWA). Traffic signals will include signal pre-emption for emergency vehicles and green time extension for BAT buses, as requested by the City of Brockton.

Safety Issue: Plymouth Street Southbound Approach Lane Use (De-facto Right turn lane)

Vehicles on the Plymouth Street southbound approach turning right from Plymouth Street to Centre Street (Route 123) will squeeze by queued vehicles waiting to continue on Plymouth Street or turning left to Centre Street (Route 123), (creating a de-facto right turn lane southbound). The right turn motorist cannot see adequately past the queued vehicles when doing this. The southbound Plymouth Street approach lane is not stripped as two lanes.

Enhancement: Decreasing the right turn radius on the Plymouth Street southbound approach and narrowing the lane width would prevent the right turn vehicles from squeezing by queued vehicles on the southbound approach. Alternatively, a right turn lane can be added to allow this movement if the volumes demand it and the sight lines can be improved.

Summary of Road Safety Audit

Based on the review of data, on-site field observations and group discussion, the RSA team identified possible enhancements that could improve safety at the intersection of Centre Street (Route 123)/Plymouth Street in Brockton. Further study and design work will need to be conducted to determine the feasibility of making some of the improvements.

Table 2 summarizes the estimated time frame and costs breakdown and Table 3 summarizes the safety issues, possible enhancements, estimated safety payoff, time frame, cost, and responsibility. Safety payoff estimates are based on engineering judgment and are categorized as low, medium, and high. The time frame is categorized as short-term (<1 year), midterm (1 to 3 years), or long-term (typically >3 years). Long-term improvements are typically considered to be substantial improvements with an expected time frame for implementation greater than 3 years. The costs are categorized as low (<\$10,000), medium (\$10,001 to \$50,000), or high (>\$50,000).

Table 2: Estimated Time Frame and Costs Breakdown

Time Frame		Costs	
Short-Term	<1 Year	Low	<\$10,000
Mid-Term	1-3 Years	Medium	\$10,001-\$50,000
Long-Term	>3 Years	High	>\$50,000

Table 3: Potential Safety Enhancement Summary

Safety Issue	Potential Safety Enhancement	Safety Payoff	Time Frame	Cost	Jurisdiction
The sight distance for vehicles approaching the intersection on Plymouth Street from the north as well as from the south is obscured by the presence of vegetation along the east side of the intersection parallel to Trout Brook and Plymouth Street. Vehicles on the Plymouth Street northbound approaches have sight blocked due to parked cars along the west side of Plymouth Street and the south side of Centre Street (Route 123).	Trim back the vegetation on the northeast and southeast corners of the intersection to improve sight lines and consider prohibiting parking by posting “No Parking” signs (R7-1) on Plymouth Street west side south of the intersection and on Centre Street (Route 123) south side west of the intersection far enough back to prevent sight blockage.	Medium	< 1 Year	Low	Brockton
This intersection experiences a higher number of angle type crashes than is expected for a stop controlled four-way intersection. A large portion of these crashes occurred when the southbound vehicle on Plymouth Street failed to yield right of way to an eastbound vehicle or westbound vehicle on Centre Street (Route 123).	Add additional signage alerting Plymouth Street southbound drivers at the intersection that cross traffic does not stop.	Medium	< 1 Year	Low	Brockton
Vehicles park on Centre Street (Route 123) along the south side of the street on the eastbound approach (in front of the housing complex) right up to the intersection. In addition, vehicles are parked too close to the intersection on Plymouth Street along the west side of the street (in front of the housing complex). The right turn radii is hindered for buses, heavy vehicles, and right turning traffic (Centre Street eastbound to Plymouth Street southbound) due to these parked cars and parking maneuvers along the west side of Plymouth Street and the south side of Centre Street (Route 123) hinder moving traffic.	Prohibit and post No Parking on Plymouth Street west side south of the intersection and on Centre Street (Route 123) south side west of the intersection far enough back to prevent sight blockage. Parking along the south side of Centre Street (Route 123) west of the intersection and along the west side of Plymouth Street should be limited to permit parking for residents.	Medium	< 1 Year	Low	Brockton

<p>Vehicles on the Plymouth Street northbound approach stopped at the stop sign look at two lanes of approaching traffic on Centre Street eastbound. Confusion and collisions occur due to northbound traffic stopping for the Centre Street eastbound right turns to Plymouth Street but disregarding the Plymouth Street through movements which are sometimes behind the right turning vehicles and not seen by the Plymouth Street traffic. In addition, last minute lane changes by vehicles in the exclusive right turn lane to the through lane on the eastbound approach create safety hazards and result in side-swipes. There is a lack of warning signs on the eastbound approach warning vehicles that the right lane is for right turn only.</p>	<p>Evaluate the need for the exclusive right turn lane on the Centre Street (Route 123) eastbound approach to the intersection. Consider implementing a road diet for Centre Street between Commercial Street and Plymouth Street, reducing the cross section from four lanes to two lanes. If the right turn lane is not removed, add advance warning that the lane is becoming a right turn only lane</p>	<p>Medium</p>	<p>< 1 Year</p>	<p>Low</p>	<p>Brockton</p>
<p>The stop sign on the Plymouth Street southbound approach is blocked by other signs.</p>	<p>Place stop signs on both sides of the road and relocate signs that block the stop signs. Consider adding additional stop-ahead signs on the southbound approach on the far side of the intersection as well as on the opposite side.</p>	<p>Low</p>	<p>< 1 Year</p>	<p>Low</p>	<p>Brockton</p>
<p>The eastbound Centre Street approach has a stop bar painted on the street but there is no stop sign control on this approach (vehicles have the right of way) and the signal facing eastbound is flashing yellow. This could add to driver confusion.</p>	<p>Remove the Stop Bar on the Centre Street eastbound approach.</p>	<p>Low</p>	<p>< 1 Year</p>	<p>Low</p>	<p>Brockton</p>
<p>A catch basin is located in the crosswalk at the southwest corner of the intersection. In addition, there are signs of ponding at the base of the curb ramp.</p>	<p>Evaluate existing drainage conditions and relocate the catch basin that is within the crosswalks and other catch basins if necessary to improve drainage.</p>	<p>Low</p>	<p>1-3 Years</p>	<p>Medium</p>	<p>Brockton</p>

<p>Chronic speeding on Centre Street (Route 123) was observed by RSA participants, in the eastbound and westbound directions.</p>	<p>The City should consider enhanced speed enforcement and electronic speed feedback signs.</p>	<p>Medium</p>	<p>< 1 Year</p>	<p>Low</p>	<p>Brockton</p>
<p>Street lights are present at the intersection; however, these might not be enough to provide adequate lighting for the intersection after dusk.</p>	<p>The City should consider conducting a lighting evaluation and increase the number of street lights if necessary. In addition, an upgrade of existing lighting to LED should be considered.</p>	<p>Low</p>	<p>< 1 Year</p>	<p>Low</p>	<p>Brockton</p>
<p>There are no bicycle accommodations on Centre Street (Route 123) or Plymouth Street, although both streets do have sufficient width for accommodations. There were bicycles observed passing through the intersection during the turning movement count.</p>	<p>Consider providing bicycle accommodations per MassDOT's New Healthy Transportation initiative Policy. Consider implementing Complete Streets elements along Center Street and Plymouth Street. Enhancements may include shared or dedicated bike lanes, as well as bicycle detention, bike route signs, and pavement markings. Bicycle lanes should be added depending upon right of way availability, as Plymouth Street will maintain parking as well. Sharrows and signage can be used on the approaches that lack right of way width (in place of bicycle lanes). Travel lanes should be sufficient to accommodate buses and heavy vehicles.</p>	<p>Medium</p>	<p>< 1 Year</p>	<p>Low</p>	<p>Brockton</p>

<p>Crosswalks are provided across all four legs of the intersection. The longer crossing (west leg) is in excess of 60 feet with no pedestrian refuge. There is a lack of pedestrian accommodation across the four lane cross-section on Centre Street (Route 123) west of the intersection. Pedestrians often cross mid-block in this section of Centre Street (Route 123), which is part of an HSIP Cluster for pedestrian crashes. The intersection experiences significant pedestrian activity as documented in the turning movement counts. In addition, there are crossing guards at the intersection when school (Joseph Plouffe Academy, located further south of the intersection) is in session. Audit participants also noted that pedestrians cross at unmarked crossing areas in front of the BAT Garage.</p>	<p>Consider implementing Complete Streets elements. Consider implementing a road diet for Centre Street (Route 123) between Commercial Street and Plymouth Street, reducing the cross section from four lanes to two lanes. Consider adding pedestrian bump-outs thereby reducing the crossing length to decrease the amount of time that pedestrians are exposed in the intersection. Evaluate the feasibility of adding a mid-block crossing and a Rapid Rectangular Flashing Beacon (RRFD) within the section of Route 123 west of the intersection. Consider public outreach education on pedestrian safety partnering BAT and Brockton Schools.</p>	<p>Medium</p>	<p>1-3 Years</p>	<p>Medium</p>	<p>Brockton</p>
<p>Curb ramps lack tactile warning tiles for sight impaired pedestrians.</p>	<p>Upgrade all existing curb ramps to meet ADA compliance, including the addition of tactile warning tiles to provide warning for visually impaired pedestrians. This includes all locations at the intersection and any mid-block crossings.</p>	<p>Low</p>	<p>< 1 Year</p>	<p>Low</p>	<p>Brockton</p>
<p>Audit participants cited a lack of warning signs on the eastbound and westbound Centre Street (Route 123) approaches.</p>	<p>Consider installing electronic messaging speed signs, and students crossing warning signs on the Centre Street (Route 123) eastbound and westbound approaches. Consider adding lane use signs on the Centre Street (Route 123) eastbound and westbound approaches.</p>	<p>Low</p>	<p>< 1 Year</p>	<p>Low</p>	<p>Brockton</p>

<p>There is a lack of access management at the intersection, which creates extra, unexpected cross movements close to the intersection, especially on the northwest of the intersection on Plymouth Street and Centre Street.</p>	<p>Limit movements (right turn in and out) and/or eliminate curb cuts close to the intersection.</p>	<p>Medium</p>	<p>< 1 Year</p>	<p>Low</p>	<p>Brockton</p>
<p>The guard rail on Centre Street, over Trout Brook, presents a danger to lane departure crashes with the potential to overturn vehicles.</p>	<p>Consider replacing guardrail that meets MassDOT standards.</p>	<p>Medium</p>	<p>1-3 Years</p>	<p>Medium</p>	<p>Brockton</p>
<p>The mast arm overhead flashing beacons at the intersection, which are flashing yellow facing Centre Street (Route 123) and flashing red facing Plymouth Street, could use more visibility for advanced warning.</p>	<p>Consider updating Flashing Beacons to LED to improve signal visibility.</p>	<p>Medium</p>	<p>< 1 Year</p>	<p>Low</p>	<p>Brockton</p>
<p>The intersection currently experiences poor levels of service (LOS “F” forced flow) during the morning and afternoon peak hours for the Plymouth Street northbound and southbound approach critical movements (through and left turns), based on existing peak hour level-of-service analysis completed by OCPC. There is a lack of gaps in the Centre Street (Route 123) peak hour traffic flows (eastbound and westbound) to allow vehicles to safely turn from the side street to Centre Street. Motorists get frustrated with the delays and force their way onto the Centre Street causing near misses and crashes. The intersection is slightly skewed, with a wide turning radius on the southbound approach. The turning radius on the southbound approach should be reduced.</p>	<p>Install traffic signals at the intersection or construct a roundabout. Based on warrant analysis completed by OCPC, the intersection volumes satisfy Warrants 1, 2, and 3 of the Manual on Uniform Traffic Devices (MUTCD). In addition, the sum of the peak hour entering and circulating volumes at the intersection are well below 1,000, which indicates a single-lane roundabout would operate acceptable (based on the National Cooperative Highway Research Program’s Report 672 Roundabouts an Informational Guide, FHWA). Traffic signals will include signal pre-emption for emergency vehicles and green time extension for BAT buses, as requested by the City of Brockton.</p>	<p>High</p>	<p>>3 Years</p>	<p>High</p>	<p>Brockton</p>

<p>Vehicles on the Plymouth Street southbound approach turning right from Plymouth Street to Centre Street (Route 123) will squeeze by queued vehicles waiting to continue on Plymouth Street or turning left to Centre Street (Route 123), (creating a de-facto right turn lane southbound). The right turn motorist cannot see adequately past the queued vehicles when doing this. The southbound Plymouth Street approach lane is not stripped as two lanes.</p>	<p>Decreasing the right turn radius on the Plymouth Street southbound approach and narrowing the lane width would prevent the right turn vehicles from squeezing by queued vehicles on the southbound approach. Alternatively, a right turn lane can be added to allow this movement if the volumes demand it and the sight lines can be improved.</p>	<p>Low</p>	<p>< 1 Year</p>	<p>Low</p>	<p>Brockton</p>
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Appendix A. RSA Meeting Agenda

Agenda

Road Safety Audit

Brockton, MA

Centre Street (Route 123) at Plymouth
Street Intersection

Meeting Location: Brockton Area Transit (BAT) Office
155 Court Street
Brockton, MA 02302
Thursday, September 21, 2017
10:00 AM – 12:00 PM

Type of meeting: Road Safety Audit
Attendees: Invited Participants to Comprise a Multidisciplinary Team
Please bring: Thoughts and Enthusiasm

10:00 AM Welcome and Introductions

10:05 AM Review of Site Specific Material - Review and Discuss Project

- Review of Traffic Data
- Existing Conditions and Known Challenges

10:45 AM Visit the Intersection and Discussion

- Identify deficiencies at the study area location
- OCPC staff will document all observations and comments

11:30 AM Wrap up Site Visit and Post Visit Discussion Meeting

- Discuss project and document and finalize potential improvements

12:00 PM Adjourn for the Day

Instructions for Participants:

- Before attending the RSA participants are encouraged to drive through the intersection and complete/consider elements on the RSA Prompt List with a focus on safety.
- All participants will be actively involved in the process throughout.
- After the RSA meeting, participants will be asked to comment and respond to the document materials to assure it is reflective of the RSA completed by the multidisciplinary team.



- CONTACT: Please direct questions regarding this RSA to Raymond Guarino, OCPC, (508) 583-1833, Ext 212, rguarino@ocpcrpa.org.
Old Colony Planning Council, 70 School Street, Brockton, MA 02301

Appendix B. RSA Audit Team Contact List

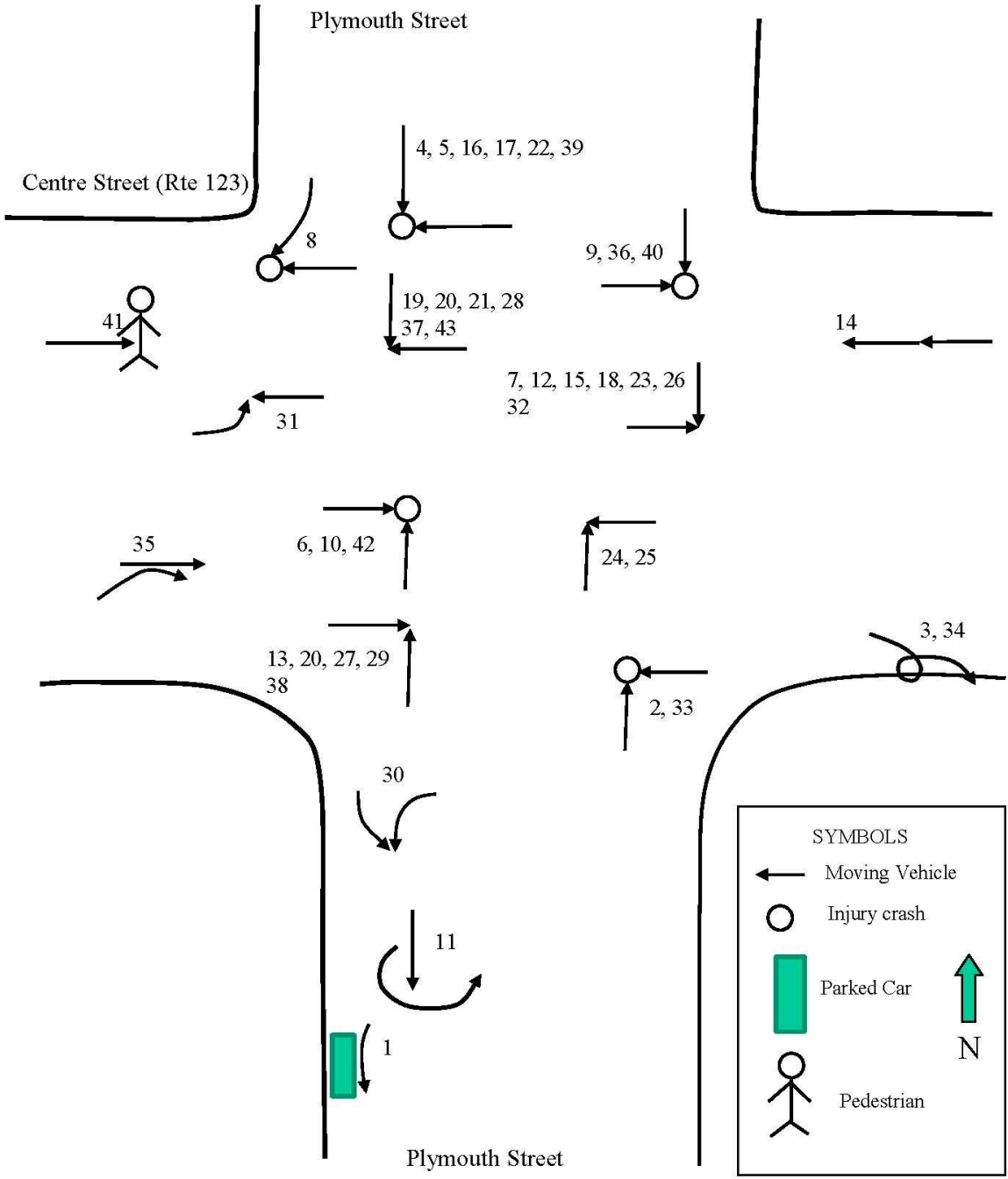
Participating Audit Team Members

Date: September 21, 2017 Location: Brockton, MA

Audit Team Members	Agency/Affiliation	Email Address	Phone Number
Elsa Chan	MassDOT Traffic Safety	Elsa.chan@state.ma.us	
Kevin Fitzgerald	MassDOT Traffic Safety	Kevin.t.fitzgerald@state.ma.us	
Bianca Marshall	MassDOT District 5	Bianca.marshall@dot.state.ma.us	
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Ken Thompson	Brockton Public Schools	kenneththompson@bpsma.org	
Kelly Forrester	Brockton Area Transit	kforrester@ridebat.com	
Ray Ledoux	Brockton Area Transit	rledoux@ridebat.com	
Chike Odunukwe	City of Brockton	codunukwe@cobma.us	
Jason Walters	MassDOT District 5 Projects	Jason.walters@state.ma.us	
James Donovan	Brockton Fire Department	jdonovan@cobma.us	
Dan Murphy	CDM Smith	murphydl@cdmsmith.com	
Bill McNulty	OCPC	wmcnulty@ocpcrpa.org	
Kyle Mowatt	OCPC	kmowatt@ocpcrpa.org	
Raymond Guarino	OCPC	rquarino@ocpcrpa.org	

Appendix C. Detailed Crash Data

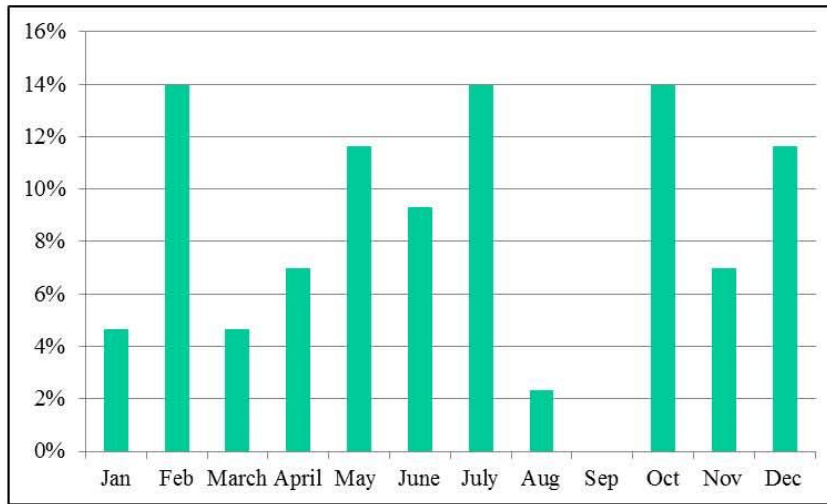
COLLISION DIAGRAM
Centre Street (Route 123) at Plymouth Street
 Collision Diagram for Crashes (2014, 2015, 2016) Prepared by
 OCPC (RG 9/2017) (source: Brockton Police Dept.)



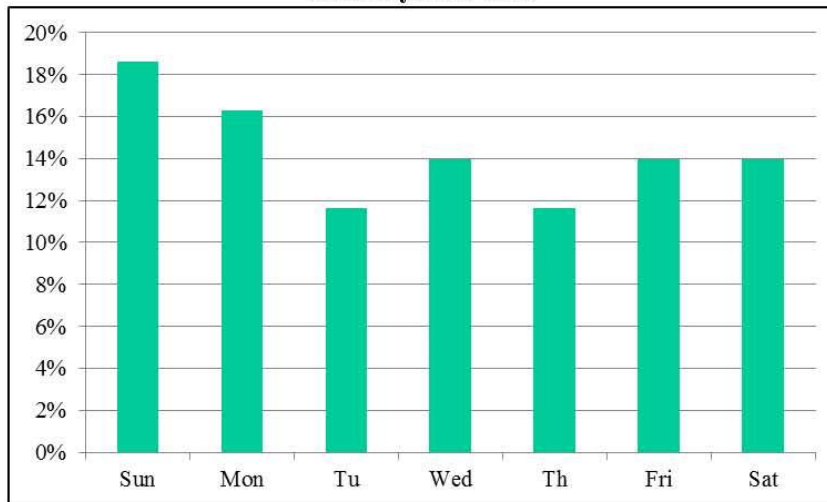
Crash Diag. Ref.	Crash Date	Crash Day	Crash Time	Manner of Coll.	Light Cond	Weather	Road Surf	Severity	Notes	Ages
1	2/14/2014	Friday	2:04 a.m.	Sideswipe	Dark	Rain	Rain wet	PDO	Driver fell asleep hit parked car	23
2	2/14/2014	Friday	1:37 p.m.	Angle	Daylight - Cloudy	Cloudy	Wet	Injury	Plymouth St NB failed to yield ROW at stop sign	41, 48
3	3/23/2014	Sunday	4:48 a.m.	ROR	Dark	Cloudy	Dry	PDO	Single vehicle hit utility pole	20
4	3/24/2014	Monday	2:35 p.m.	Angle	Daylight - Cloudy	Cloudy	Dry	Injury	Plymouth St SB cited for failing to grant ROW at Ssign	20, 55
5	4/1/2014	Tuesday	7:22 a.m.	Angle	Daylight	Clear	Dry	Injury	Plymouth St SB cited for failing to grant ROW at Ssign	54, 35
6	4/13/2014	Sunday	6:04 p.m.	Angle	Daylight	Clear	Dry	Injury	Plymouth St NB cited for failing to yield ROW at Ssign	30, 32
7	5/5/2014	Monday	11:11 a.m.	Angle	Daylight	Clear	Dry	PDO	Plymouth St NB cited for failing to yield ROW at Ssign	70, 26
8	5/6/2014	Tuesday	11:31 a.m.	Angle	Daylight	Clear	Dry	Injury	Plymouth St SB cited for failing to grant ROW at Ssign	30, 47
9	5/21/2014	Wed	4:00 p.m.	Angle	Daylight	Clear	Dry	Injury	Plymouth St SB failed to grant ROW at Ssign	22, 24
10	5/30/2014	Friday	8:16 a.m.	Angle	Daylight	Clear	Dry	Injury	Plymouth St NB cited for failing to yield ROW at Ssign	26, 49
11	6/9/2014	Monday	7:15 a.m.	Sideswipe (same direction)	Daylight	Clear	Dry	PDO	Collision due to attempted u-turn-cited for lane violation	24, 30
12	6/21/2014	Saturday	11:54 a.m.	Angle	Daylight	Clear	Dry	PDO	Plymouth St SB cited for failing to grant ROW at Ssign	47, 26
13	6/22/2014	Sunday	5:17 a.m.	Angle	Daylight	Clear	Dry	PDO	Angle collision with a motorcycle	19
14	7/14/2014	Monday	10:16 a.m.	Rear-end	Daylight	Clear	Dry	PDO		52, 22
15	10/16/2014	Thursday	9:15 a.m.	Angle	Daylight	Rain	Rain wet	PDO	Plymouth St SB failed to yield ROW at Ssign	47, 38, 68
16	10/16/2014	Thursday	4:11 p.m.	Angle	Daylight	Rain	Rain wet	Injury	Plymouth St SB mailed citation warning for failing to grant ROW at Ssign	44, 31
17	10/21/2014	Tuesday	9:46 p.m.	Angle	Dark lighted road	Clear	Dry	Injury	Plymouth St SB cited for failing to grant ROW at Ssign	55, 27
18	10/28/2014	Tuesday	2:27 p.m.	Angle	Daylight	Clear	Dry	PDO	Plymouth St SB cited for failing to grant ROW at Ssign	31, 42
19	12/3/2014	Wed	4:34 p.m.	Angle	Dark lighted road	Rain	Rain wet	PDO	Plymouth St SB failed to stop at Ssign	54, 51
20	12/15/2014	Monday	11:28 a.m.	Angle	Daylight	Clear	Dry	PDO	Plymouth St NB mailed citation for failing to grant ROW at Ssign	49, 64

Num	Date	Time	Type	Light Cond	Surface Cond	Severity	Notes		
21	1/9/2015	Friday	8:16 p.m.	Angle	Dark lighted road	Snow Snow	PDO	Plymouth St. SB could not stop due to snow	23, 50
22	1/20/2015	Tuesday	10:16 a.m.	Angle	Daylight	Clear Dry	Injury	Centre St WB mailed citation for speeding	63, 35
23	2/4/2015	Wed	6:49 a.m.	Angle	Daylight	Snow Snow	PDO	Plymouth St SB failed to stop at Ssign, mailed citation for unlicensed operation	21, 38
24	2/7/2016	Saturday	10:46 p.m.	Angle	Dark lighted road	Snow Snow	PDO	Plymouth St NB mailed citation for failing to grant ROW at Ssign-Snow prevented Centre St WB vehicle from stopping	53, 22
25	6/21/2015	Sunday	11:14 a.m.	Angle	Daylight	Rain Rain wet	PDO	Plymouth St NB operating with permit (did not have it in possession) , criminal complaint filed	30, 20
26	7/21/2015	Tuesday	7:21 a.m.	Angle	Daylight	Clear Dry	PDO	Plymouth St SB issued citation for failing to stop at Ssign	48, 24
27	7/25/2015	Saturday	6:34 p.m.	Angle	Daylight	Clear Dry	Injury	Plymouth St NB failed to stop at Ssign	57, 25
28	11/2/2015	Monday	7:50 a.m.	Angle	Daylight	Clear Dry	PDO		48, 34
29	11/21/2015	Saturday	2:50 p.m.	Angle	Daylight	Clear Dry	Injury	Plymouth St NB failed to stop for Ssign	21, 28
30	12/23/2015	Wed	2:32 p.m.	Sideswipe (same direction)	Daylight	Clear Dry	PDO	Vehicle turning left from Cetnre St WB to Plymouth St SB hit by vehicle pulling out of parking spot (SB Plymouth St)	58, 22
31	12/31/2015	Thursday	5:20 p.m.	Angle	Dark lighted road	Clear Dry	PDO	Centre St EB left turn to Plymouth St cited for failure to yield ROW to Centre St WB	38, 21
32	2/5/2016	Friday	9:30 a.m.	Angle	Daylight	Snow Snow	PDO	Plymouth St SB issued citation for failing to stop at Ssign - snow was a factor as the SB veh slid at the stop sign	58, 52
33	2/13/2016	Saturday	10:55 a.m.	Angle	Daylight	Clear Dry	Injury	Plymouth St NB to be issued citation for failure to yield ROW	66, 40
34	4/9/2016	Saturday	11:35 p.m.	Single Vehicle ROR	Dark lighted road	Clear Dry	Injury	Centre St EB went through the intersection lane departyre ran off road cited for distraction due to cell phone	48
35	5/12/2016	Thursday	3:25 p.m.	Sideswipe (same direction)	Daylight	Clear Dry	PDO	Both vehicles EB, vehicle in right turn only lane changed direction to go through and SS vehicle next to it, citation issues for lane departure	23, 53
36	7/4/2016	Monday	2:17 p.m.	Angle	Daylight	Clear Dry	Injury	Plymouth St SB cited for failure to stop to yield ROW	60, 33
37	7/10/2016	Sunday	12:31 p.m.	Angle	Daylight	Clou dy Dry	PDO	Plymouth St SB issued citation for failing to yield ROW	66, 20
38	7/16/2016	Saturday	2:31 p.m.	Angle	Daylight	Clear Dry	PDO	Plymouth St NB cited for failing to yield ROW	44, 22
39	8/21/2016	Sunday	10:21 a.m.	Angle	Daylight	Clear Dry	Injury	Plymouth St SB cited for failure to yield ROW	57, 58
40	10/5/2016	Tuesday	4:22 p.m.	Angle	Daylight	Clou dy Dry	Injury	Plymouth St SB issued warning for failing to yield ROW	18, 46
41	10/12/2016	Wed	9:47 a.m.	Pedestrian	Daylight	Clear Dry	Injury	Pedestrian struck crossing Centre Street	21, 28
42	11/4/2016	Friday	4:25 p.m.	Angle	Daylight	Clear Dry	Injury	Plymouth St NB collided with Centre St WB	38, 53
43	12/1/2016	Thursday	8:08 a.m.	Angle	Dark lighted road	Clear Dry	PDO	Plymouth St SB collided with Centre St WB	71, 66

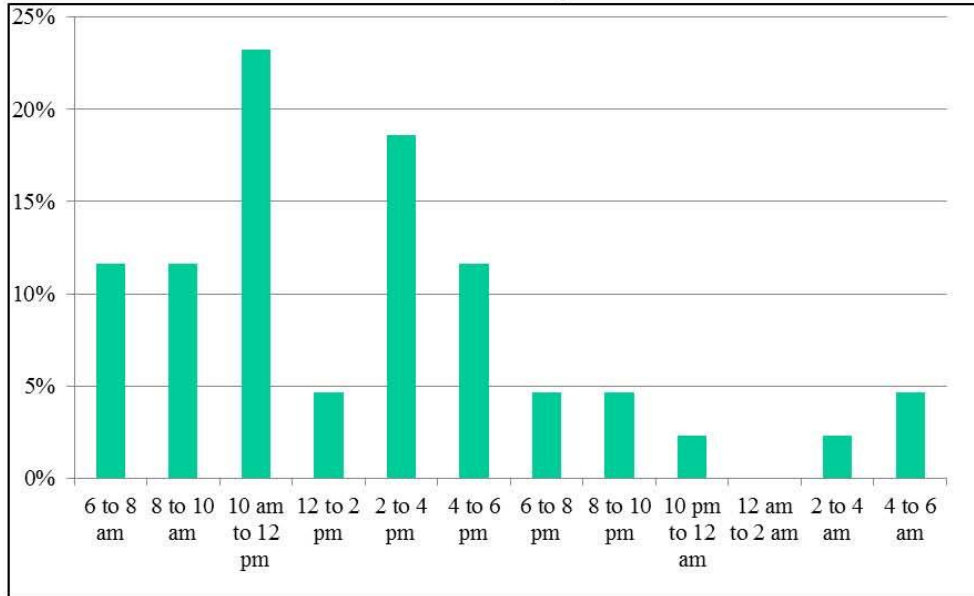
Crash Month



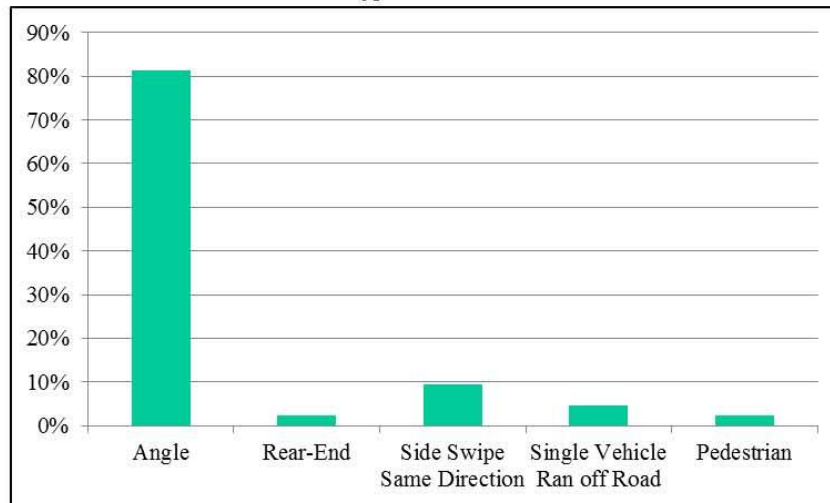
Crash day of the Week



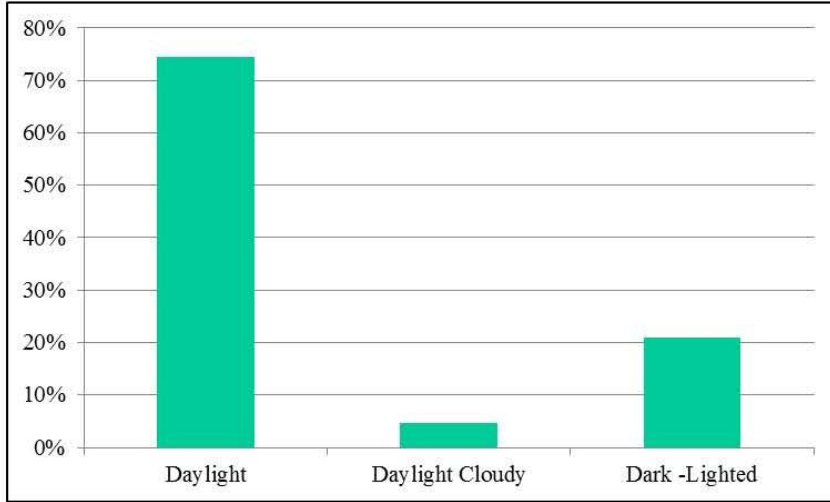
Crash Time of day



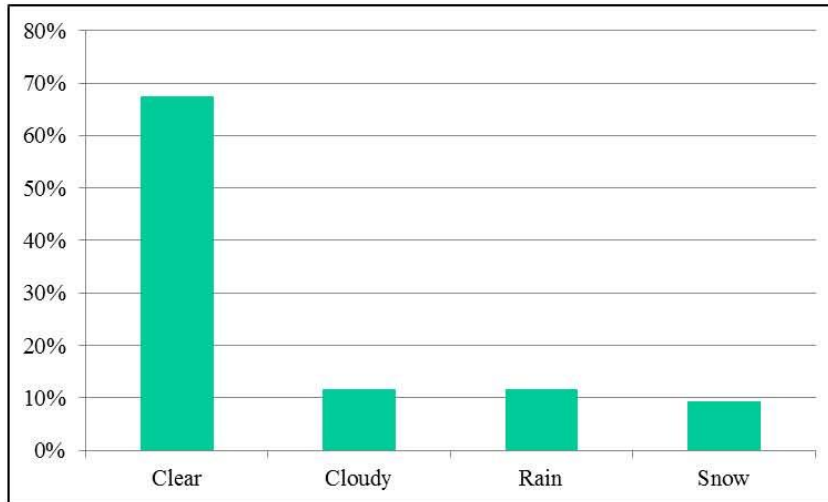
Type of Collision



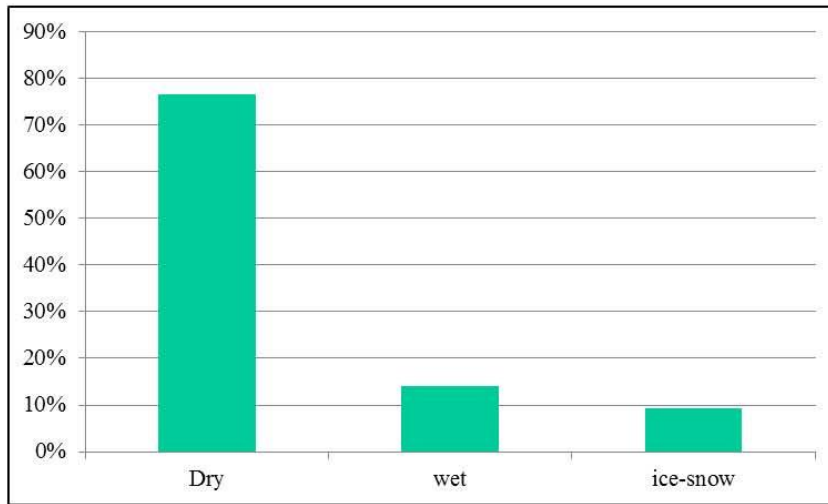
Light Conditions



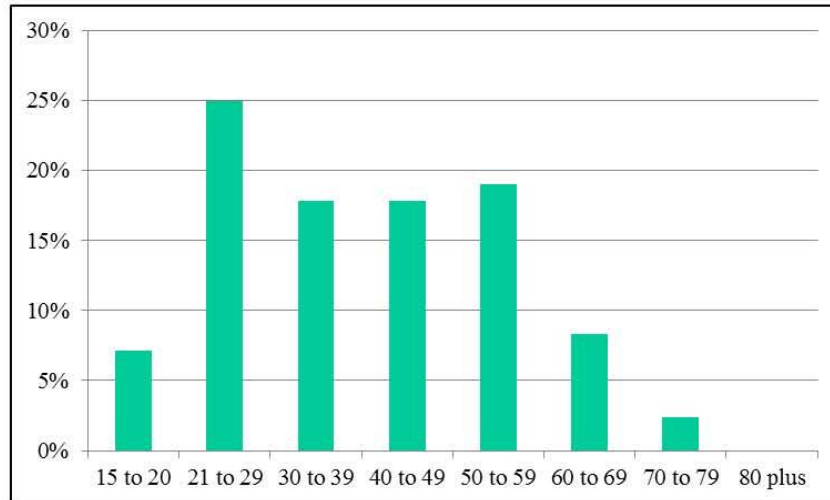
Weather



Road Surface



Driver Age



MassHighway

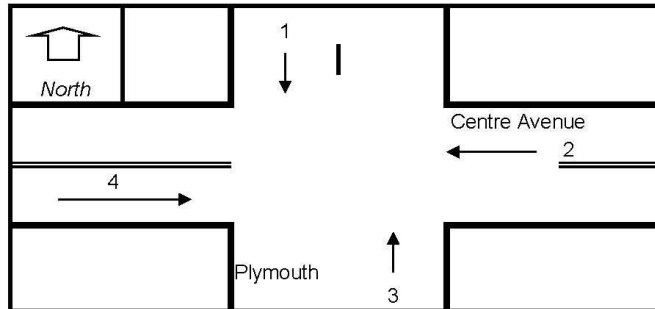
CRASH RATE WORKSHEET

CITY/TOWN : Brockton COUNTY : _____ COUNT DATE : 2017 MHD USE ONLY
 DISTRICT : 5 UNSIGNALIZED : SIGNALIZED : Source #

~ INTERSECTION DATA ~

MAJOR STREET : Centre Avenue (Route 123) RIN #
 MINOR STREET(S) : Plymouth Street RIN #
 _____ RIN #
 _____ RIN #
 _____ RIN #

**INTERSECTION
DIAGRAM**
(Label Approaches)



INTERSECTI
REF #

Peak Hour Volumes

APPROACH :	1	2	3	4	5	6
DIRECTION :	SB	WB	NB	EB	Total	
VOLUMES (AM/PM) :	161	412	235	477	1285	
" K " FACTOR :	0.09	APPROACH ADT :		14,278	ADT = TOTAL VOL/"K" FACT.	
TOTAL # OF ACCIDENTS :	43	# OF YEARS :	3	AVERAGE # OF ACCIDENTS (A) :	14.33	

CRASH RATE CALCULATION : RATE = $\frac{(A * 1,000,000)}{(ADT * 365)}$

Comments : _____

District 5 Average:	Signalized	<input type="text" value="0.76"/>	Statewide Average:	Signalized	<input type="text" value="0.77"/>
	Unsignalized	<input type="text" value="0.58"/>		Unsignalized	<input type="text" value="0.58"/>

Percentage Difference					
District 5 Average:	Signalized	261.89%	Statewide Average:	Signalized	257.19%
	Unsignalized	374.20%		Unsignalized	374.20%

Appendix D. Additional Information

Appendix E. Road Safety Audit References

Road Safety Audit References

Massachusetts Traffic Safety Toolbox, Massachusetts Highway Department,
www.mhd.state.ma.us/safetytoolbox.

Road Safety Audits, A Synthesis of Highway Practice. NCHRP Synthesis 336. Transportation Research Board, National Cooperative Highway Research Program, 2004.

Road Safety Audits. Institute of Transportation Engineers and U.S. Department of Transportation, Federal Highway Administration, www.roadwaysafetyaudits.org.

FHWA Road Safety Audit Guidelines. U.S. Department of Transportation, Federal Highway Administration, 2006.

Road Safety Audit, 2nd edition. Austroads, 2000.

Road Safety Audits. ITE Technical Council Committee 4S-7. Institute of Transportation Engineers, February 1995.