



BOSTON REGION METROPOLITAN PLANNING ORGANIZATION

Stephanie Pollack, MassDOT Secretary and CEO and MPO Chairman
Karl H. Quackenbush, Executive Director, MPO Staff

TECHNICAL MEMORANDUM

DATE: May 21, 2015
TO: Larry Dunkin, Town Planner, Milford
FROM: Seth Asante, MPO Staff
RE: Safety and Operations Analyses—Milford
Selected Intersection: Medway Road at Kmart Driveway in Milford

This memorandum summarizes the analyses and improvement strategies developed for the section of Route 109 near the Kmart and McDonald's driveways in Milford. The opening sections of the memorandum give a background of the study and describe the existing conditions and problems of concern to the community. Following that is an assessment of the safety and operations problems and potential improvement strategies. The final sections of the memo present the study recommendations. This memo also includes technical appendices that contain methods and data applied in the study and detailed reports of the intersection capacity analyses.

1. BACKGROUND

The purpose of the Safety and Operations Analyses at Selected Intersections study is to examine mobility and safety issues at major intersections in the Boston Region Metropolitan Planning Organization (MPO) area's arterial highways; where many crashes occur, roadways experience congestion, or need improvements for buses, bicyclists, and pedestrians. For the past ten years, the MPO has been conducting these planning studies, and municipalities are very receptive to them. These studies give municipalities an opportunity to look at the needs of these sites, starting at the conceptual level, before they commit funds for design and engineering. Eventually, if the project qualifies for federal funds, the study's documentation also is useful to the Massachusetts Department of Transportation (MassDOT). The studies support MPO visions and goals, which include increasing transportation safety, maintaining the transportation system, reducing congestion, and advancing mobility and access management.

After an initial selection process¹, the Boston Region MPO approved four locations (from a short list of 21 intersections) for study based on a series of

¹ Seth Asante, memorandum to Boston Region MPO, Safety and Operations Analyses at Selected Intersections—FFY 2014, Task 1: Intersection Selection Procedure, December 19, 2013.

criteria including, high crash rating, number of pedestrian and bicycle crashes, transit significance², regional significance³, and implementation potential.⁴ The four locations approved for study are:

- Washington Street (Route 53) and Broad Street in Weymouth
- Medway Road (Route 109) and Kmart Driveway in Milford
- High Street (Route 109) and Nahatan Street in Westwood
- High Street (Route 109) and Pond Street in Westwood

The Milford location was selected because it experiences safety problems and is on MassDOT's Statewide 2010–2012 Top-200 Intersection Crash List.

1.2 Public Participation

MPO staff worked with the Milford Town Planner, Larry Dunkin, to finalize study's work scope, existing conditions and problems, and proposed improvement concepts. The town provided crash data, developments expected in the study area, and previously discussed improvement concepts. The study documents were reviewed by the town planner and MassDOT Highway Division District 3 staff. Appendix A presents MassDOT's comments, which have been addressed and incorporated into this memorandum.

2 ROADWAY, INTERSECTIONS, AND LAND USES

2.1 Roadway

Route 109/Medway Road

Route 109 is predominantly a two-lane, two-way arterial roadway that passes through eight communities from east to west: Dedham, Westwood, Dover, Walpole, Medfield, Millis, Medway, and Milford. Although Route 109 is a state-numbered route, it is locally controlled. The roadway, functionally classified as a principal arterial, is part of the National Highway System (NHS) program and is eligible for federal funds. In Milford, Route 109 is called Medway Road and it provides access to/from I-495 and communities east of Milford. Medway Road near Kmart Driveway features two 11-foot-wide travel lanes in each direction and five-foot continuous, connected sidewalks on the south side of Medway Road. The right-of-way varies between 50 and 60 feet. The posted speed limit is generally 30 miles per hour (mph) in both directions. Figure 1 presents an aerial image of the study area. Because of its close proximity, MPO staff has included the intersection of Medway Road and Beaver Street in the analysis.

2 Transit Significance: Location carries bus route(s) or is adjacent to a transit stop or station.

3 Regional Significance: Location carries high proportion of regional traffic or noticeable commuter bicycle traffic

4 Implementation Potential: Location is under MassDOT jurisdiction, has a Transportation Improvement Program (TIP) "conceptual" status, or a strong commitment from a city or town.

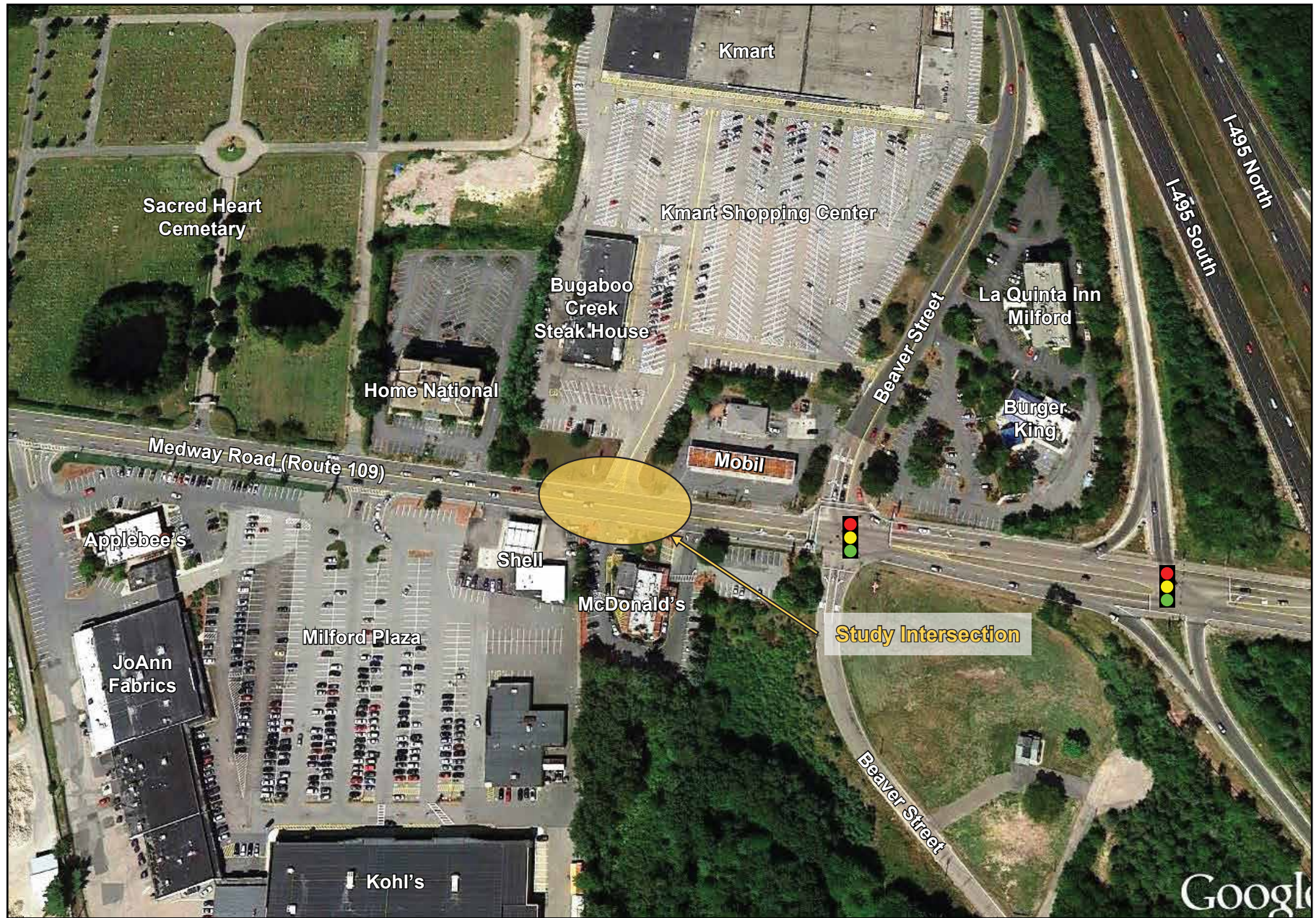
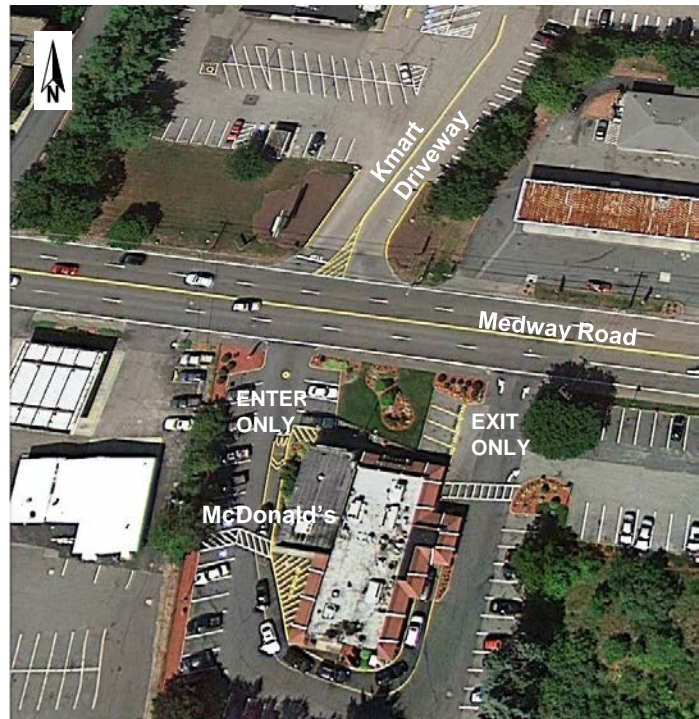


FIGURE 1
Study Intersection and Surroundings

2.2 Intersections

Medway Road and Driveways for Kmart and McDonald's

Medway Road and the driveways for Kmart and McDonald's form a four-legged unsignalized intersection (Figure 1). Motorists can access both driveways from each direction on Medway Road. Motorists exiting from the Kmart driveway can only turn right and head westbound on Medway Road. McDonald's driveway (directly across from Kmart's driveway) is designated "enter only"—motorists exiting from McDonald's have a separate "exit only" driveway about 100 feet east of the entry driveway. Access to and from both driveways is challenging and associated with many crashes.



Medway Road at Kmart Driveway

Medway Road and Beaver Street Intersection

Medway Road and Beaver Street form a four-legged signalized intersection (Figure 1), which is located about 250 feet from the Kmart/McDonald's intersection. The primary traffic flow through the intersection is along Medway Road. The traffic signal equipment is fully actuated and coordinated and has Opticom receivers to handle emergency services such as preempting traffic queues. The intersection has multi-lane approaches because of high traffic volume during peak periods.



Medway Road at Beaver Street

Medway Road westbound approach widens to three lanes approximately 200 feet prior to the intersection and continues as two lanes through the intersection. Left turns are prohibited at the westbound approach so drivers access properties south of the intersections by turning left at the Birch Street intersection located to the west of this intersection. Medway Road eastbound approach has two lanes (a shared through/left lane and an exclusive through lane).

Beaver Street is one-way northbound; the northbound approach widens to three lanes (one lane each for turning left or right) approximately 200 feet prior to the intersection and continues as one past the intersection. The Beaver Street southbound approach widens to three lanes (two lanes for turning left and one lane for turning right).

The pedestrian signals are functioning well. Sidewalks (approximately five feet wide) are present along one side of Medway Road, and crosswalks are present on the west leg of Medway Road and the north leg of Beaver Street. The curb ramps do not meet Americans with Disability Act requirements as they lack detectable warning plates.

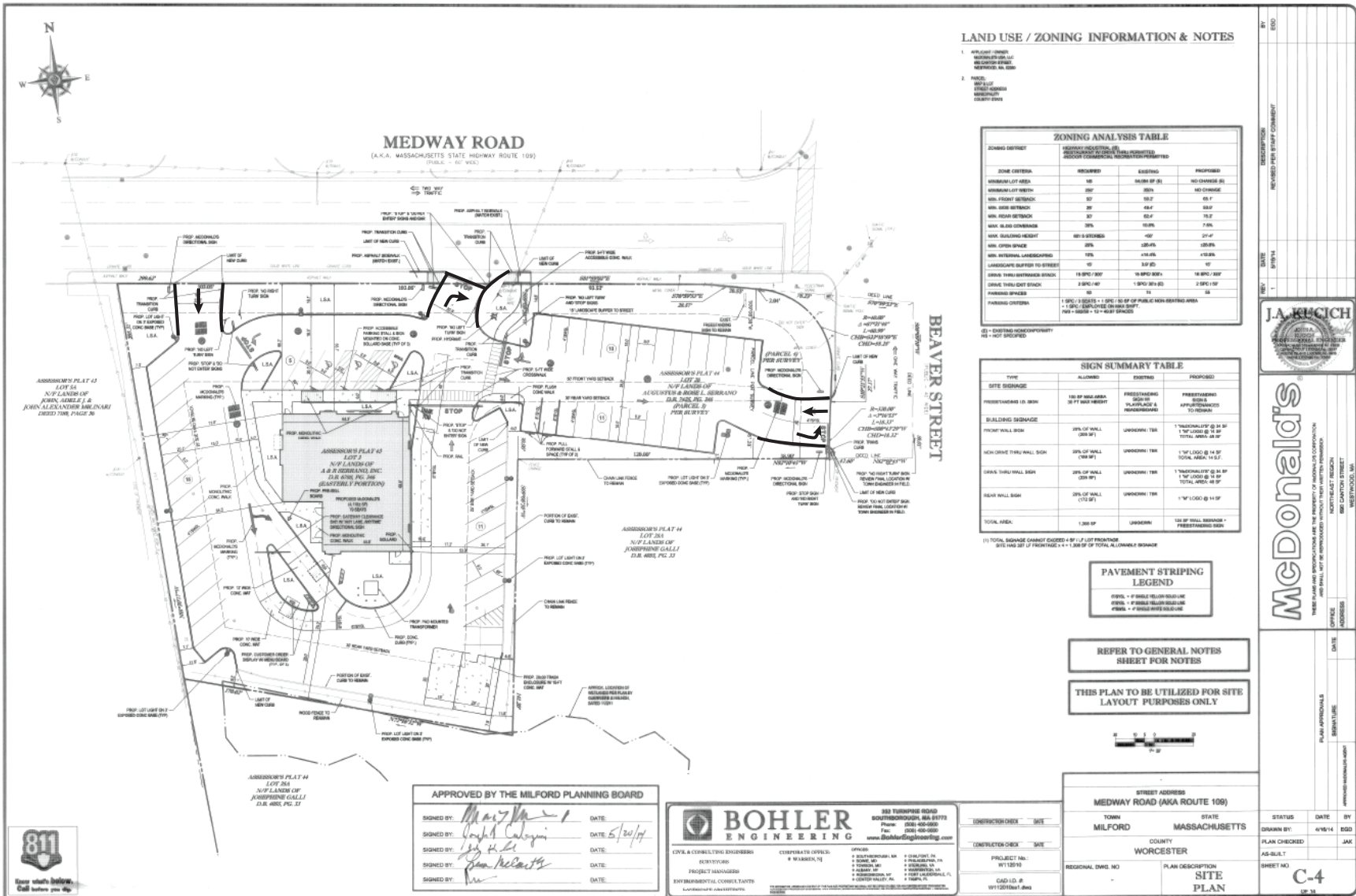
2.3 Land Uses

Land use in the area is zoned commercial (Figure 1). On the south side of Medway Road are a McDonald's restaurant, Shell gas station, and the Milford Plaza, which contains a Kohl's department store and several other stores and restaurants. On the north side of Medway Road is a Kmart, Bugaboo creek Steak House, Mobil gas station, and a Burger King restaurant.

Recently, Milford approved development plans for renovation of McDonald's, which allow for a new driveway off Beaver Street and converting the exiting driveway on Medway Road into a right-turn-only exit (Figure 2). In addition, the town is exploring ideas to convert Beaver Street's south leg into a two-way roadway to allow development of land south of the Medway Road and Beaver Street intersection.

3 VEHICLE, PEDESTRIAN, AND BICYCLE COUNTS

MPO staff collected traffic volume data to assess the study area's operational characteristics (Appendix B). Staff also conducted turning-movement counts (TMCs) at the driveways and Beaver Street intersection in April 2014 during weekday morning and evening peak-travel periods from 7:00 to 9:00 AM and 4:00 to 6:00 PM. Staff counted heavy vehicles, including school buses and trucks, separately; pedestrian and bicycle counts were conducted simultaneously with the TMCs.



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FIGURE 2
Driveway and Traffic Circulation Plans for McDonald's Restaurant Renovation

Safety and Operations Analyses at Selected Intersections—FFY 2014

Based on the counts, staff estimated the average daily traffic (ADT) volume on Medway Road at between 27,300 and 31,500 vehicles per day. The ADT on Beaver Street was approximately 10,800 vehicles per day on the north leg and 5,300 vehicles per day on the south leg. Figure 3 shows the peak-hour turning movement volumes. During the AM peak travel period, the primary traffic flow (peak direction) is westbound on Medway Road, including a high volume of traffic turning right onto Beaver Street. During the PM peak travel period, the primary traffic flow direction is reversed—eastbound on Medway Road. In addition, a high volume of traffic southbound on Beaver Street turns left onto Medway Road; and a high-volume turns right northbound on Beaver Street. The presence of trucks in the study-area intersections during the AM and PM peak travel periods ranged between 6.0-and-7.0 percent, which is considered high for peak-period traffic conditions. Staff did not detect any roadway geometry—such as turning radii, which would inhibit truck traffic flow—other than the traffic congestion that exists during peak hours. Only one pedestrian was observed during the counting period. No bicyclists were observed during the counting period. High traffic volumes and absence of a residential area close to the intersections contributed to the low pedestrian and bicycle counts.

4 SAFETY CONDITIONS

4.1 Crash Summary

Staff obtained 2010-to-2012 crash records from the MassDOT Registry of Motor Vehicles (RMV). Table 1 presents a summary of crashes at each intersection in terms of severity, manner of collision, weather conditions, ambient light conditions, and time of occurrence. Between 2010 and 2012, 99 crashes were reported in the segment of Medway Road between the Kmart driveway and the Beaver Street intersection. This intersection is ranked 34th on the 2012 Statewide Top-200 Intersection Crash List; the intersection crash cluster used for the Kmart intersection includes the Beaver Street intersection.

Figure 4 shows the amount and location of the crashes; the Medway Road and Beaver Street intersection had 50 crashes and the segment of Medway Road between the Kmart driveway and Mobil gas station driveway had 49 crashes. The majority of the crashes (more than 70 percent) were angle-type crashes resulting from failing to yield the right of way or not using caution when entering an intersection. Appendix C contains the crash data and crash rate worksheets.

4.2 Crash Rate

Staff calculated intersection crash rates using the MassDOT Highway Division methodology, based on the entire three-year period (shown at the bottom of Table 1). The most recent statewide average crash rate for intersections in



FIGURE 3
Turning Movement Counts

TABLE 1
Crash Summary (2010-2012)

Characteristics	Kmart/McDonald's Intersection	Beaver Street Intersection
Crash Severity	--	--
Non-fatal injury	6	4
Property damage only	33	44
Not reported or unknown	10	2
Manner of Collision	--	--
Angle	36	30
Rear-end	4	12
Sideswipe, opposite direction	1	0
Sideswipe, same direction	0	5
Single vehicle collision	2	1
Head-on	1	0
Unknown	5	0
Road Surface Condition	--	--
Dry	40	39
Wet	6	10
Snow	3	0
Not reported or unknown	0	1
Ambient Light	--	--
Daylight	42	41
Dark - lighted roadway	4	8
Dawn	0	1
Dusk	2	0
Not reported or unknown	1	0
Weather Conditions	--	--
Clear	32	35
Cloudy	10	5
Rain	6	9
Snow	1	0
Not reported or unknown	0	1
Travel Period	--	--
Peak period	15	23
Off-peak period	34	37
Total Crashes (2010-2012)	49	50
Three-year average crash rate (rounded)	16	17
Average crash rate	2.92	1.59
MassDOT Highway Division District 3 average crash rate	0.66	0.89

* The AM peak period is 7:00 AM to 9:00 AM, and the PM peak period is 4:00 PM to 6:00 PM.
Source: Central Transportation Planning Staff.

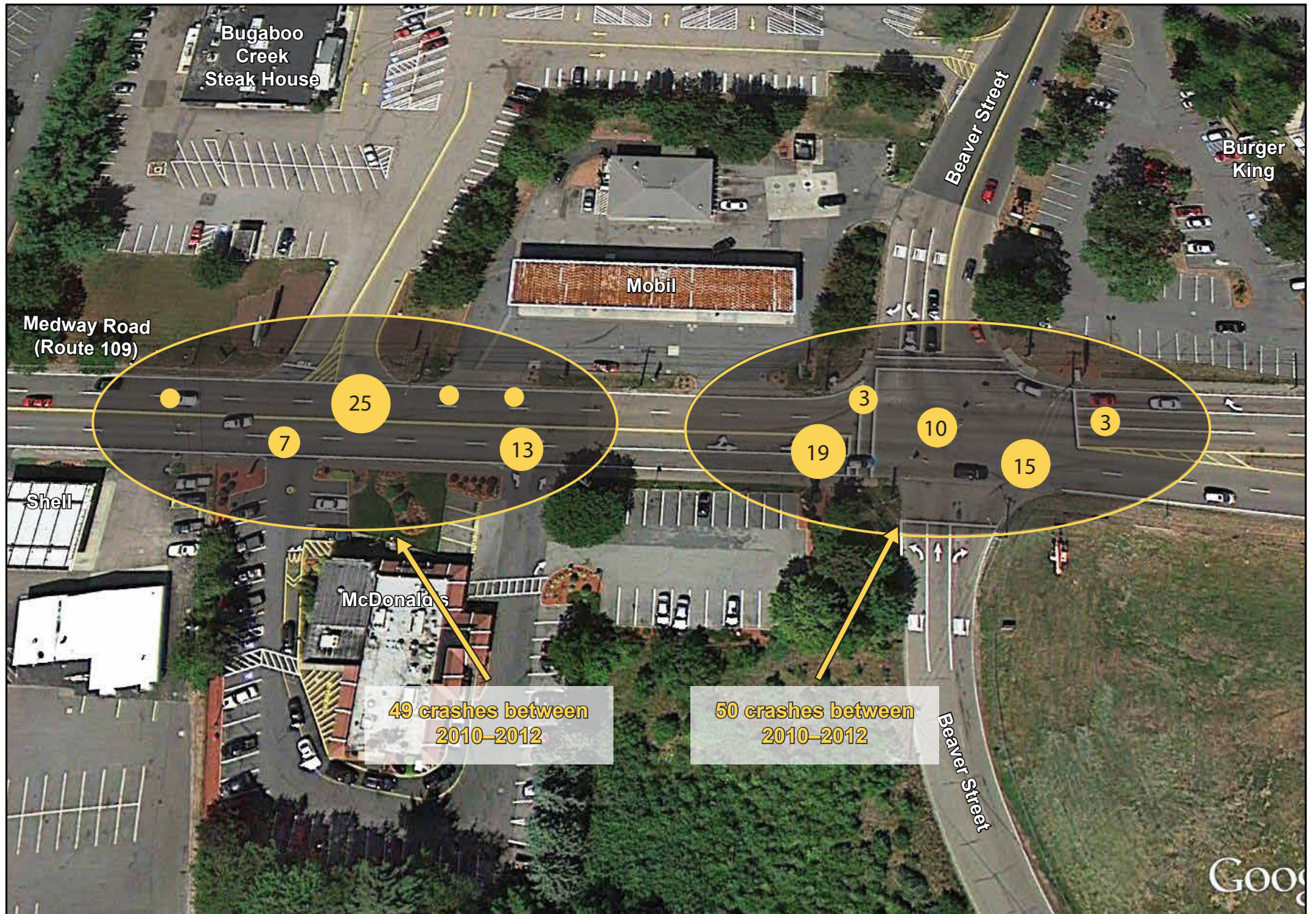


FIGURE 4
Number and Location of Crashes

MassDOT Highway Division District 3 (which includes the Town of Milford) is 0.89 crashes per million entering vehicles (mev) for signalized intersections and 0.66 crashes per mev for unsignalized intersections. The values are based on MassDOT RMV crash information queried on January 23, 2013. Crash rates for the Medway Road and Beaver Street intersection and the intersection of Medway Road and Kmart/McDonald's driveways were significantly higher than the District 3 average crash rates for signalized and unsignalized intersections, respectively.

4.3 Collision Diagram

MPO staff used police crash reports obtained from the Milford Police Department to prepare a collision diagram useful for examining patterns and developing safety strategies. Figure 5 shows the collision diagram of the crashes. The numbers in the collision diagram uniquely identify each crash and, for more detail about the crash, may be used to cross reference the crash records provided in Appendix C. As seen in Figure 5, the majority of crashes involve:

- Motorists turning into the driveways of Kmart or McDonald's
- Motorists exiting from McDonald's and turning left to head westbound on Medway Road
- Rear-end and angle collisions at the Beaver Street intersection

Analyses of the police crash records indicated that many of the crashes at the intersection of Medway Road and the driveways for Kmart and McDonald's were courtesy-type crashes. Courtesy crashes usually occur on roadways with two or more travel lanes in one direction—when motorists in the rightmost lane stop and allow traffic in business driveways to turn left across travel lanes and head in the opposite direction—oncoming drivers in the leftmost lane do not see other motorists entering the roadway and crashes occur. Similarly, when motorists in the left lane stop and allow traffic in the opposing direction to turn left into business driveways—oncoming drivers in the rightmost lane do not see them entering the roadway and crashes occur.

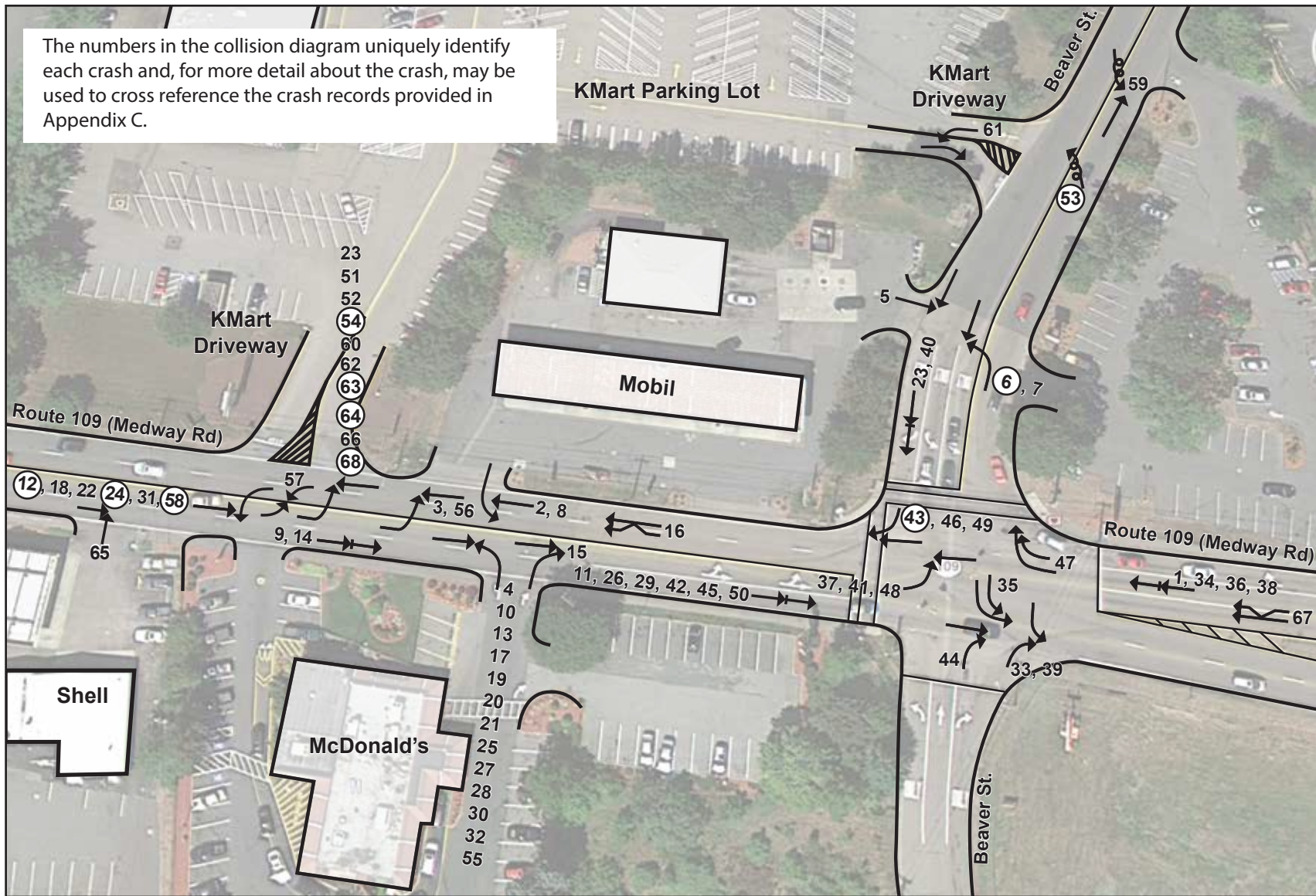
5 EXISTING TRAFFIC OPERATIONS CONDITIONS

Using the data and information collected, MPO staff built a traffic analysis network for the AM and PM peak hours with Synchro to assess the capacity and quality of traffic flow at the intersections.⁵ The analyses were conducted in a manner consistent with the Highway Capacity Manual⁶ (HCM) methodologies (detail worksheets of the analyses are included in Appendix D).









⁵ Trafficware Inc., Synchro Studio 8, Synchro plus SimTraffic, Build 801, Version 563, Sugar Land, Texas.

⁶ Highway Capacity Manual, HCM 2010, Volume 3: Interrupted Flow, Transportation Research Board of the National Academies, Washington D.C., December 2010.






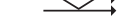
The numbers in the collision diagram uniquely identify each crash and, for more detail about the crash, may be used to cross reference the crash records provided in Appendix C.



SYMBOLS

	Moving Vehicle		Parked Vehicle
	Backing Vehicle		Fixed Object
	Non-Involved Vehicle		Bicycle
	Pedestrian		Animal

TYPES OF CRASH

	Head On		Rear End
	Angle		Sideswipe
	Turning Move		Out of Control

SEVERITY

34	32	3
Property Damage	Injury Accident	Fatal Accident

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FIGURE 5
Collision Diagram
2011-2013

*Safety and Operations
Analyses at Selected
Intersections-FFY 2014*

The HCM methodology demonstrates the driving conditions at signalized and unsignalized intersections in terms of levels of service (LOS) ratings from A through F. LOS A represents the best operating conditions (little to no delay), while LOS F represents the worst operating conditions (very long delay). LOS E represents operating conditions at capacity (limit of acceptable delay).

Table 2 shows the control delays associated with each LOS for signalized and unsignalized intersections. Table 3 presents the results of the LOS analysis in terms of delays and queues. The Medway Road and Beaver Street intersection operates satisfactorily during the AM peak period (LOS D or better). During the PM peak period the Beaver Street northbound movements experience high delay (LOS F). The intersection of Medway Road and the driveways of Kmart and McDonald's operate desirably at LOS A during both peak periods.

TABLE 2
Levels of Service and Control Delays at Intersections

Level of Service	Signalized Intersections Control Delay (seconds per vehicle)	Unsignalized Intersections Control Delay (seconds per vehicle)
A	≤ 10	≤ 10
B	> 10-20	> 10-15
C	> 20-35	> 15-25
D	> 35-55	> 25-35
E	> 55-80	> 35-50
F	> 80	> 50

Source: Central Transportation Planning Staff.

6 FUTURE CONDITIONS

To forecast, on a systematic basis, future traffic volume changes resulting from changes in the transportation network or in land use, a planning model is used. The transportation-planning model used in this study is the Boston Region MPO's most recent regional travel demand model set used in the Long-Range Transportation Plan. Its socioeconomic components are based on forecasts produced by the Metropolitan Area Planning Council. The model is calibrated at a regional level for 164 cities and towns, including all of the 101 cities and towns in the MPO region. The primary tool used in model calibration is the transportation planning model set implemented TransCAD software. Based on the planning model, traffic on Medway Road is expected to grow at 0.33 percent per year, which results in a total traffic increase of 3 percent between 2014 and 2024.

TABLE 3
Existing LOS, Delay, and Queue at Peak Hours

Intersection/Approach	Move ment	AM LOS	AM Delay ^a	AM Queue ^b	PM LOS	PM Delay	PM Queue
Medway Road at Beaver Street							
Medway Road Eastbound	L+T	B	10.6	84	B	18.3	206
Medway Road Westbound	T	B	12.5	192	B	15.2	135
Medway Road Westbound	R	A	2.4	42	A	2.7	41
Beaver Street Northbound	L	D	37.3	33	D	35.1	48
Beaver Street Northbound	T	D	44.2	85	D	37.3	85
Beaver Street Northbound	R	D	13.2	43	F	137.2	#416
Beaver Street Southbound	L	C	34.4	97	D	44	211
Beaver Street Southbound	R	A	1.8	12	A	7.8	45
Total Intersection	All	B	13.9	--	D	39	--
Medway Road at Kmart and McDonald's Restaurant Driveways							
Medway Road Eastbound	L+T+R	A	0.7	0	A	1.7	0
Medway Road Westbound	L+T+R	A	0.5	0	A	0.8	0
Kmart Entrance Southbound	R	B	11.5	2	B	11.7	12
Total Intersection	All	A	0.7	--	A	2	--

^a Delay in seconds per vehicle. ^b 95th percentile queue length in feet. # = The 95th percentile volume exceeds capacity.

Source: Central Transportation Planning Staff.

7 IMPROVEMENT STRATEGIES

Based on existing conditions analyses and discussions with the town planner, the problems in the study area are:

- Large number of crashes at the intersection of Medway Road and the driveways to Kmart and McDonald's
- Large number crashes at the Medway Road and Beaver Street intersection
- Poor access and egress to and from adjacent businesses
- Lack of turn lanes on Medway Road

MPO staff developed and analyzed several short- and long-term strategies to improve safety and traffic operations. The projected growth factor from the regional model set was used to expand the existing peak-hour turning-movement volumes to 2024 future turning-movement volumes, which was used to test the improvement strategies. The improvement strategies that staff evaluated include:

- **Alternative 1:** Convert Kmart driveway to right-in right-out channelization with forced turn island
- **Alternative 2:** Convert Medway Road eastbound left travel lane into a two-way left-turn lane (TWLTL)
- **Alternative 3:** Install a raised median near the driveways of Kmart and McDonald's to prohibit left turns
- **Alternative 4:** Install a traffic signal at the intersection of Medway Road and the Kmart and McDonald's driveways
- **Alternative 5:** Modify Fay, Spofford, & Thorndike (FS&T) multilane roundabout proposal for the Beaver Street intersection to address safety near the driveways of Kmart and McDonald's

7.1 Short-Term Improvements

Alternative 1: Convert Kmart Driveway to Right-in Right-out Channelization

Alternative 1 converts the driveway to Kmart into a right-in right-out channelization with a forced turn island (Figure 6). In addition, it incorporates the access and circulation plans proposed in the McDonald's renovations. Alternative 1 has the following benefits:

- Reduces large number crashes involving left-turn movements into Kmart driveway
- Reduces large number of crashes involving drivers exiting from McDonald's heading westbound on Medway Road
- Preserves existing cross-section of Medway Road and lane assignment at Beaver Street intersection

Alternative 1 has the following disadvantages:

- Does not address left-turn crashes involving drivers exiting Medway Road to McDonald's
- Limits access for Kmart customers eastbound on Medway Road—they would need to use the Kmart driveway on Beaver Street via a left turn at the Beaver Street intersection; hence diverting traffic to the Beaver Street intersection

Table 4 shows the results of traffic operations analysis at the Beaver Street intersection, which indicates a desirable LOS D or better. Estimates of the safety benefit of Alternative 1 suggest as much as a 70-percent reduction in left-turn related crashes⁷. This low-cost improvement, consisting of a channelized island, signs, and signal retiming is estimated to cost about \$50,000.

⁷ Crash Modification Factors Clearinghouse, US Department of Transportation, Federal Highway Administration, <http://www.cmfclearinghouse.org/index.cfm>.

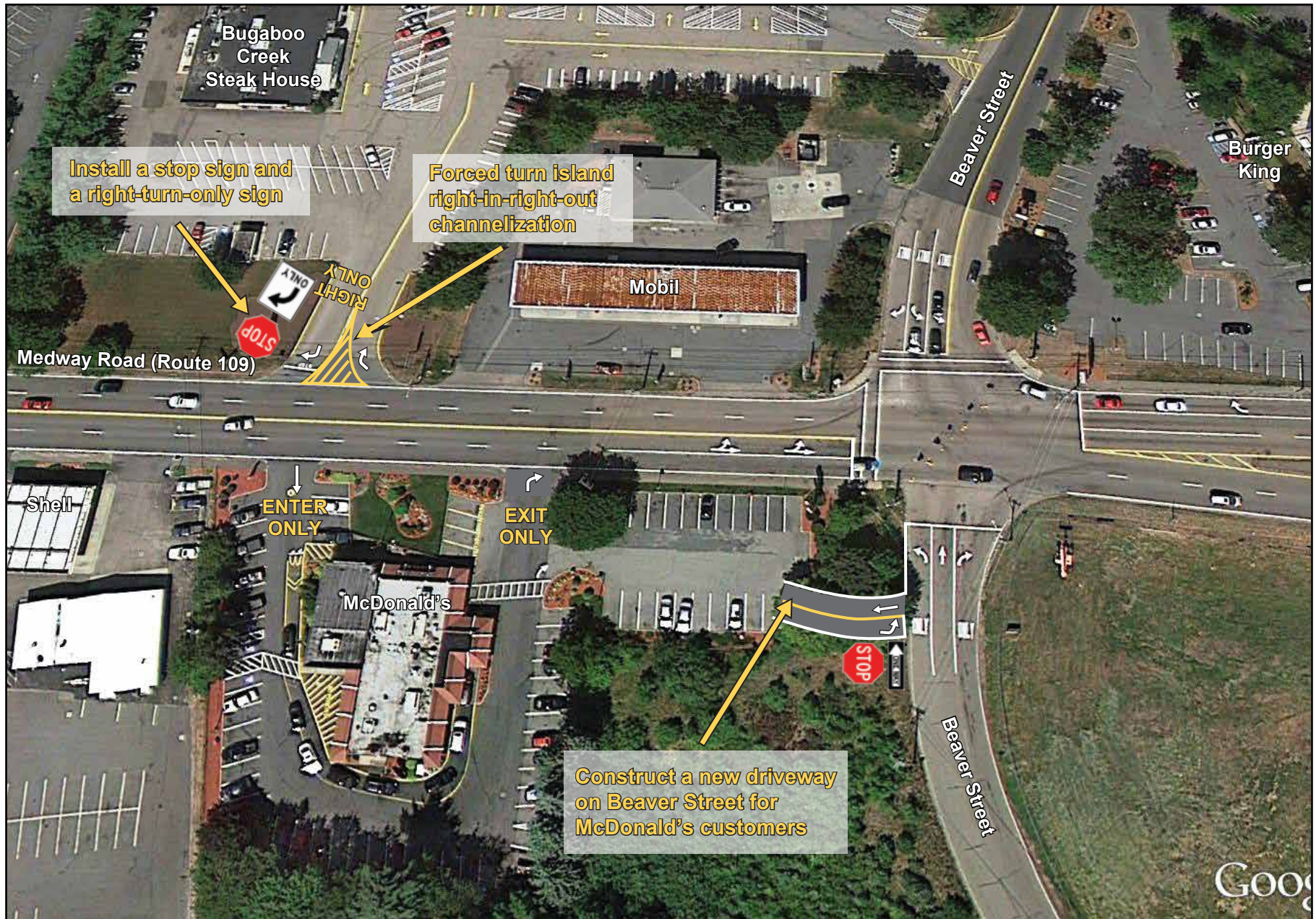


FIGURE 6
Alternative 1—Install a Forced Island to Convert
Kmart Driveway to Right-in-Right-Out Channelization

TABLE 4
Alternative 1: Future Year (2024) Peak-Hour Level of Service

Intersection/Approach	Move ment	AM LOS	AM Delay ^a	AM Queue ^b	PM LOS	PM Delay	PM Queue
Medway Road at Beaver Street (Signal Control)	--	--	--	--	--	--	--
Medway Road Eastbound	L+T	B	11.5	94	C	24.9	288
Medway Road Westbound	T	B	13.3	200	B	15.3	140
Medway Road Westbound	R	A	2.5	42	A	2.7	41
Beaver Street Northbound	L	D	37.3	33	D	35.2	49
Beaver Street Northbound	T	D	44.6	87	D	37.6	87
Beaver Street Northbound	R	B	13.2	44	F	164.3	#441
Beaver Street Southbound	L	D	35.2	100	D	45.2	#223
Beaver Street Southbound	R	A	2	13	A	7.7	46
Total Intersection	All	B	14.4	--	D	44.4	--

^a Delay in seconds per vehicle. ^b 95th percentile queue length in feet. # = The 95th percentile volume exceeds capacity.
Source: Central Transportation Planning Staff.

Alternative 2: Convert Medway Road Eastbound Left Travel Lane into Two-Way Left-Turn Lane (TWLTL)

Alternative 2 converts the Medway Road eastbound left travel lane into a two-way left-turn lane to provide access to businesses on Medway Road. The TWLTL would extend from the Milford Plaza’s west entrance to the Mobil gas station. Alternative 2 includes the proposed access and circulation plans for the McDonald’s renovation and the right-in right-out channelization of Alternative 1. Figure 7 shows the improvements proposed in Alternative 2, which provides the following benefits:

- Separate left-turn lane for motorists entering or exiting from business driveways
- Reduces large number crashes involving left-turn movements into Kmart driveway
- Reduces left-turn crashes involving drivers exiting Medway Road to McDonald’s
- Reduces crashes involving drivers exiting from McDonald’s heading westbound on Medway Road

Alternative 2 limits access for Kmart customers eastbound on Medway Road as in Alternative 1.



FIGURE 7
**Alternative 2—Convert the Medway Road Eastbound
Left Travel Lane into a Two-Way Left-Turn Lane**

Table 5 displays results of traffic operations analysis at the Beaver Street intersection, which indicates that Alternative 2 would operate at a desirable LOS D or better. Estimates of the safety benefit of prohibiting left turns at the driveway to Kmart suggest as much as a 70-percent reduction in left-turn related crashes; estimates of the safety benefit of a TWLTL suggest as much as a 37-percent reduction in crashes⁸. This low-cost improvement, consisting of pavement stripping, channelized island, and signal retiming would cost about \$70,000.

TABLE 5
Alternatives 2 and 3: Future Year (2024) Peak-Hour Level of Service

Intersection/Approach	Move- ment	AM LOS	AM Delay ^a	AM Queue ^b	PM LOS	PM Delay	PM Queue
Medway Road at Beaver Street (Signal Control)	--	--	--	--	--	--	--
Medway Road Eastbound	L	B	11.2	29	C	30.8	155
Medway Road Eastbound	T	B	12.1	185	D	39.9	#579
Medway Road Westbound	T	B	12.2	200	B	18.9	156
Medway Road Westbound	R	A	2.2	41	A	3.4	46
Beaver Street Northbound	L	D	41.3	34	C	27.9	43
Beaver Street Northbound	T	D	50.3	92	C	29.2	77
Beaver Street Northbound	R	D	14	46	E	65.8	#394
Beaver Street Southbound	L	D	41.1	108	E	61.5	#266
Beaver Street Southbound	R	A	7.4	26	A	8.7	48
Total Intersection	All	B	15.1	--	D	38	--

^a Delay in seconds per vehicle. ^b 95th percentile queue length in feet. # = The 95th percentile volume exceeds capacity. Source: Central Transportation Planning Staff.

Alternative 3: Install a Raised Median Near the Kmart and McDonald’s Driveways

Alternative 3 is a variation of Alternative 2 to prohibit left turns from Medway Road to Kmart and McDonald’s with a raised median (Figure 8). Alternative 3 has the following benefits:

- Reduces crashes that occur near the Kmart and McDonalds driveways
- Reduces large number of crashes involving drivers exiting from McDonald’s heading westbound on Medway

⁸ Crash Modification Factors Clearinghouse, US Department of Transportation, Federal Highway Administration, <http://www.cmfclearinghouse.org/index.cfm>.

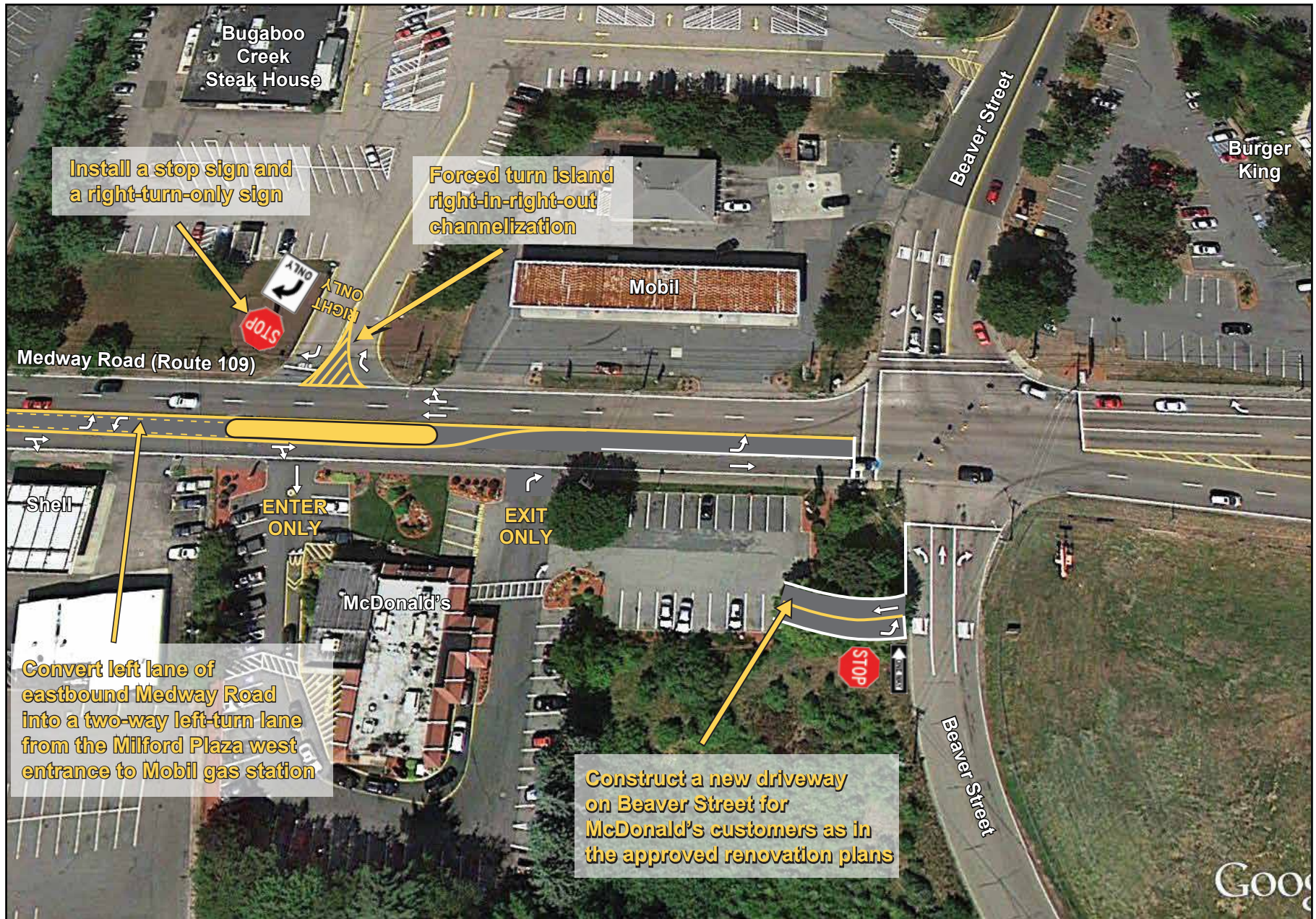


FIGURE 8
Alternative 3—Install a Raised Island
and a Two-Way Left-Turn Lane

Alternative 3 has the following disadvantages:

- Limits access for Kmart customers eastbound on Medway Road—they would need to use the Kmart driveway on Beaver Street by turning left at the Beaver Street intersection
- Limits access for McDonald's customers westbound on Medway Road

Alternative 3 produces similar LOS at the Beaver Street intersection as in Alternative 2 (Table 5 above). Estimates of the safety benefit of a raised median suggest as much as a 70-percent reduction in left-turn related crashes and as much as a 44-percent reduction in injury-related crashes.⁹ It is estimated to cost approximately \$80,000 to implement the improvements in Alternative 3.

7.2 Long-Term Improvements

Alternative 4: Signalize Intersection of Medway Road and the Driveways to Kmart and McDonald's

Alternative 4 would install a new traffic signal at the intersection of Medway Road and the driveways to Kmart and McDonald's and coordinates with nearby traffic signals to improve safety and access and operations (Figure 9). The proposal also incorporates new access and circulation plans for the McDonald's renovation. Alternative 4 provides the following benefits:

- Enhances safety and access and egress from Medway Road to Kmart and McDonald's
- Avoids diverting traffic to the Beaver Street intersection

Alternative 4 has the following disadvantages:

- Creates a closely spaced signalized intersection
- Would affect signals at I-495 ramp; arterial junctions were not evaluated in this study

Apart from signal warrant 7—crash experience, intended for situations where the severity and frequency of crashes are the principal reasons to consider installing a traffic control signal, the remaining eight signal warrants might not be met given the low traffic volumes exiting the business driveways. Table 6 shows results of the traffic operations analysis, which indicates that the new traffic signal would operate at desirable level of service (LOS D or better). The safety benefits of installing a traffic signal suggest a 67-to-77 percent reduction in angle crashes and about a 38-percent increase in rear-end crashes.¹⁰ Installing a new traffic signal is a relatively high-cost improvement, estimated to cost approximately \$1.5 million.

⁹ Crash Modification Factors Clearinghouse, U.S. Department of Transportation, Federal Highway Administration, <http://www.cmfclearinghouse.org/index.cfm>

¹⁰ Ibid

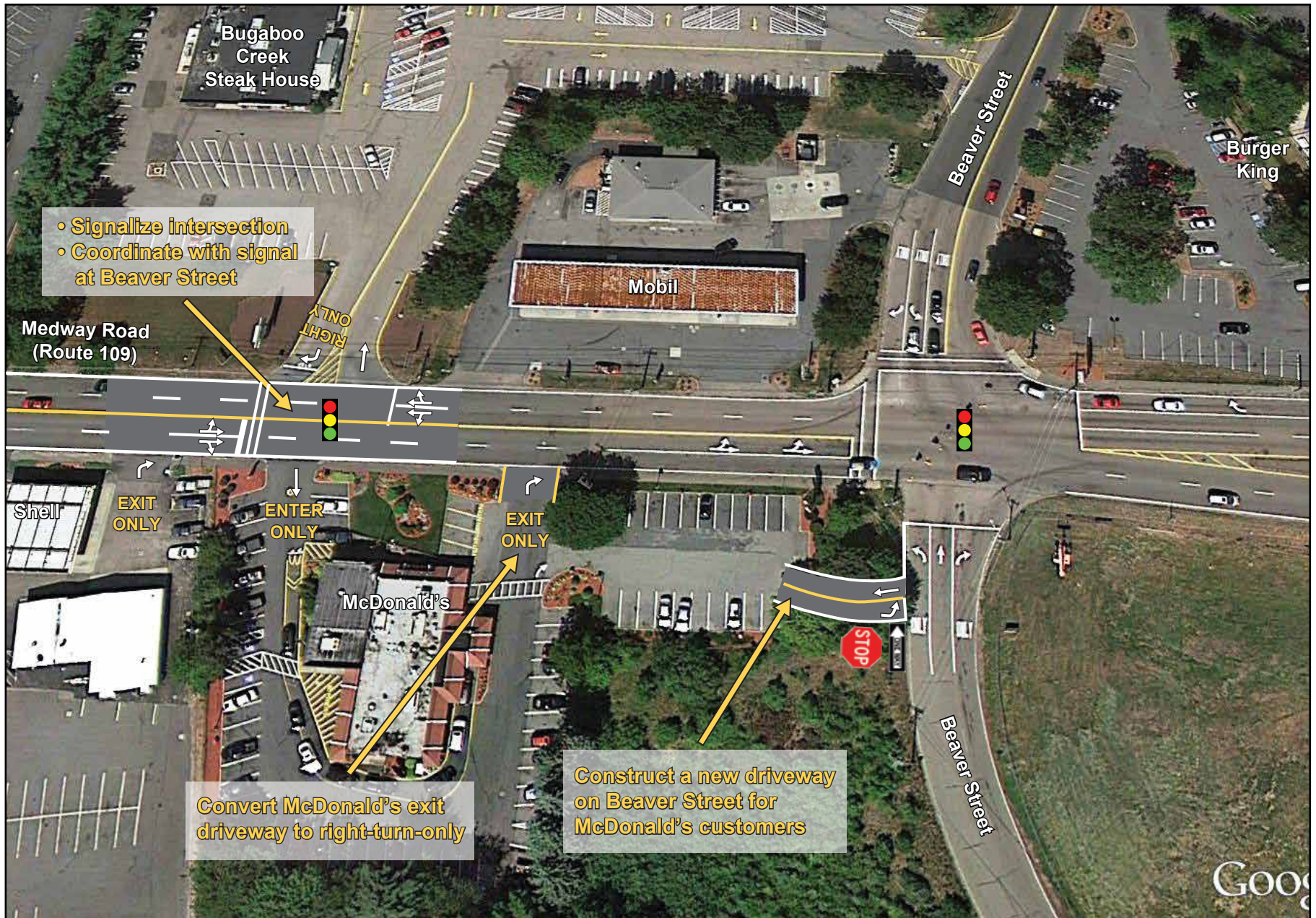


FIGURE 9
Alternative 4—Install a Traffic Signal at the Intersection of Medway Road and the Driveways to Kmart Stores/McDonald's Restaurant

TABLE 6
Alternative 4: Future Year (2024) Peak-Hour Level of Service

Intersection/Approach	Move- ment	AM LOS	AM Delay^a	AM Queue^b	PM LOS	PM Delay	PM Queue
Medway Road at Beaver Street (Signal Control)							
Medway Road Eastbound	L+T	B	10.2	86	C	30.6	279
Medway Road Westbound	T	B	12.2	200	C	22.6	177
Medway Road Westbound	R	A	2.2	41	A	4.1	53
Beaver Street Northbound	L	D	41.3	34	C	24.8	41
Beaver Street Northbound	T	D	50.3	92	C	26.1	72
Beaver Street Northbound	R	B	14	46	D	51.2	#360
Beaver Street Southbound	L	D	41.1	108	D	48.5	#243
Beaver Street Southbound	R	A	7.4	26	A	8	46
Total Intersection	All	B	14.8	--	C	31.6	--
Medway Road at Kmart Entrance (Signal Control)							
Medway Road Eastbound	L+T+R	A	0.2	0	A	0.4	0
Medway Road Westbound	L+T+R	A	1	10	A	1.3	12
Kmart Entrance Southbound	R	A	0.4	0	D	1.6	0
Total Intersection	All	A	0.7	--	A	0.9	--

^a Delay in seconds per vehicle. ^b 95th percentile queue length in feet. # = The 95th percentile volume exceeds capacity.
Source: Central Transportation Planning Staff.

Alternative 5: Modify FS&T Multilane Roundabout Proposal to Address Safety and Access Management Issues

This proposal was first recommended by FS&T (Appendix E) to address the idea of converting Beaver Street's south leg to a two-way roadway to allow development of the land located south of the intersection. The purpose of the FS&T study, which was completed in June 2009, was to assess the feasibility of the roadway network for a proposed roundabout at the Medway Road and Beaver Street intersection to provide direct access to the Bear Hill Industrial Area via Medway Road and Beaver Street. Currently, access to the industrial area is provided via a left turn at the intersection of Medway Road and Birch Street at one-half mile west of Beaver Street. The town asked MPO staff to review the proposal to determine if it could be modified to address safety issues at the Kmart/McDonalds driveway.

MPO staff recognizes that this proposal would change the existing traffic pattern at the Medway Road and Beaver Street intersection. It also would change traffic volumes on Medway Road west of the intersection and on Beaver Street south of the intersection. Development of the land south of the intersection would generate additional traffic that would affect roadways in the area. MPO staff recommends a detailed traffic impact study for this alternative because the economic development, scenario-planning analyses, and market-area analyses

are beyond the scope of this study. In addition, comments from MassDOT's Highway Division District 3, recommend that the town perform further evaluations of this concept.

Figure 10 shows a roundabout concept that MPO staff developed to improve safety, operations, and access to nearby businesses through right-in/right-out only channelization. Alternative 5 has the following benefits:

- Improves safety for motorists exiting Medway Road to Kmart and McDonald's
- Enhances access to Kmart and McDonald's

Alternative 5 has the following disadvantages:

- Creates circuitous circulation
- Requires more space to construct (would impact abutting properties)
- Creates traffic-management issues during construction

Preliminary assessment of the roundabout concept is presented in Table 7. The analyses consider only background growth and assume that about 25 percent of westbound through traffic on Medway Road at the Beaver Street intersection would turn left onto Beaver Street southbound. The preliminary analyses did not consider the effect of new developments on traffic. Staff used Sidra intersection roundabout analysis software to analyze the roundabout alternative.¹¹ The results indicate that a roundabout would function well and would improve overall traffic operations and reduce delays and queues. The safety benefit of converting a signalized intersection to a multilane roundabout shows as much as a 37-percent reduction for all crash types and as much as a 74-percent reduction in serious and minor injury crashes. It is estimated to cost about \$2.0 million to construct.

8 RECOMMENDATIONS AND DISCUSSION

The above analyses and evaluations indicate that the intersection of Medway Road and the driveways for Kmart and McDonald's need some enhancements to improve safety and access for motorists. With 99 crashes, this intersection is ranked 34th on the 2010–2012 Statewide Top-200 Intersection Crash List.

¹¹ Sidra Intersection 6, Akcelik and Associates Pty Limited, Greythorn, Victoria, Australia.

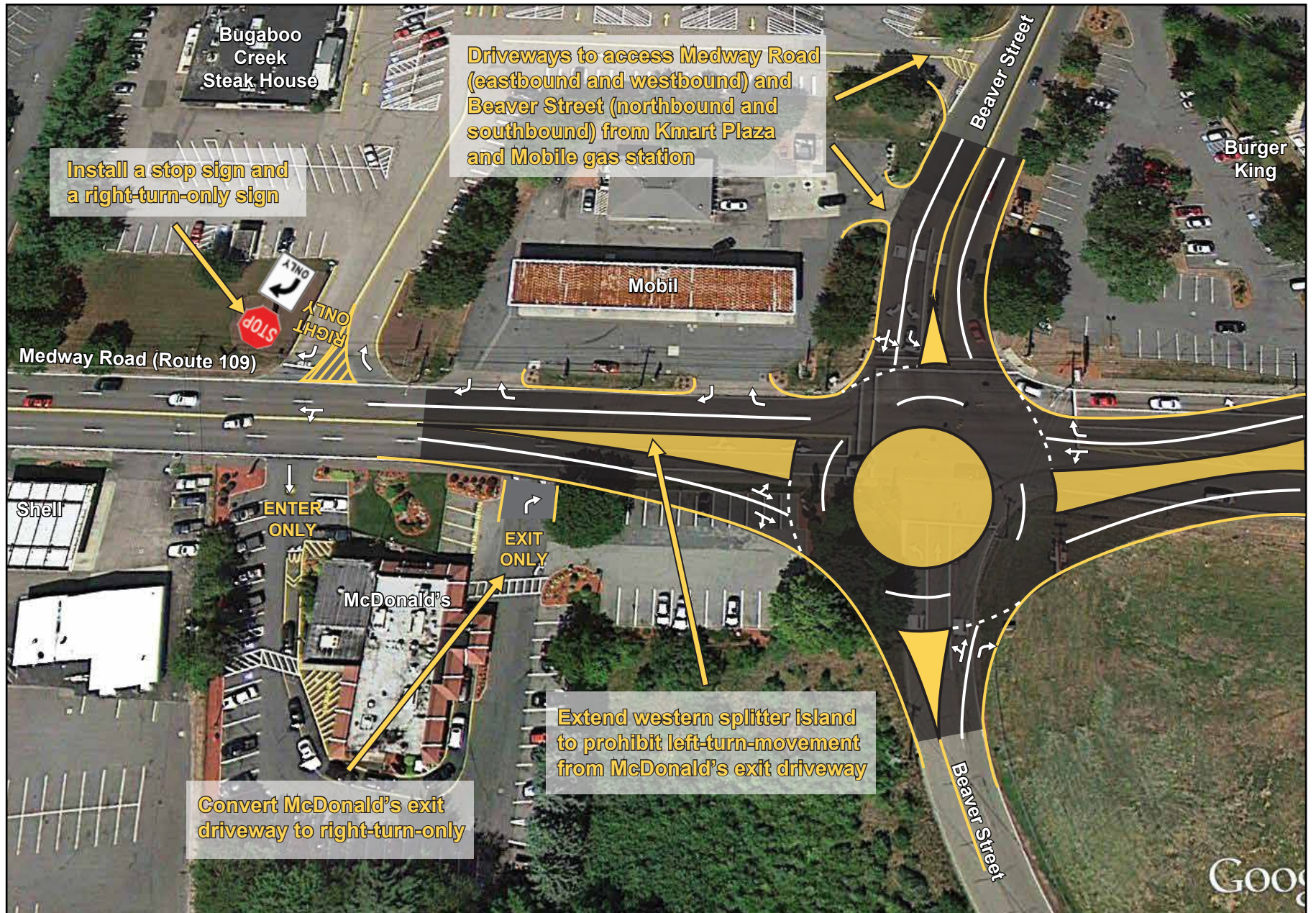


FIGURE 10
Alternative 5—Modify Fay, Spofford & Thorndike Roundabout Proposal to
Address Safety Issues at the Driveways to Kmart and McDonald's Restaurant

TABLE 7
Alternative 5: Future Year (2024) Peak-Hour Level of Service

Intersection / Approach	Move- ment	AM LOS	AM Delay ^a	AM Queue ^b	PM LOS	PM Delay	PM Queue
Medway Road at Beaver Street Roundabout	--	--	--	--	--	--	--
Medway Road Eastbound	L+T	A	8.1	25	D	25.8	115
Medway Road Eastbound	T+R	A	7.9	25	C	25	115
Medway Road Westbound	L+T	B	13.6	100	B	10.5	50
Medway Road Westbound	R	B	13.6	100	B	10.4	50
Beaver Street Northbound	L+T	A	7.1	25	D	36.5	80
Beaver Street Northbound	R	A	7.3	25	C	34.4	80
Beaver Street Southbound	L	B	10.4	25	B	12.8	50
Beaver Street Southbound	L+T+R	A	10	25	B	12.5	50
Total Intersection	All	B	11.5	--	C	20	--

^a Delay in seconds per vehicle. ^b 95th percentile queue length in feet. # = The 95th percentile volume exceeds capacity.
 Source: Central Transportation Planning Staff.

MPO staff developed five alternatives to improve safety and access. Staff also evaluated the alternatives in terms of safety efficiency, congestion reduction, cost, and access to businesses. Cost and effectiveness are the two primary factors for selecting the preferred alternative. Alternatives 1 to 3 are short-term, low-cost solutions and they address many of the safety and access issues. Alternatives 4 and 5 are long-term, high-cost solutions—they address safety and access issues as well.

For the short-term alternatives, MPO staff recommends Alternative 2, as it provides turn lanes on Medway Road for safe access to businesses in the area. In addition, Alternative 2 provides the highest safety and operations benefits among the short-term alternatives. MassDOT Highway District 3 also supports Alternative 2. MPO staff does not recommend Alternative 1 because it reduces crashes only near the Kmart driveway, not at other driveways such as McDonald’s. Although Alternative 3 has safety benefits comparable to Alternative 2, staff does not recommend it because it limits access to some businesses such as McDonald’s.

For the long-term alternatives, MPO staff recommends Alternative 5 because it improves safety, traffic operations, and access to businesses on Medway Road. In addition, Alternative 5 supports Milford’s intention to convert Beaver Street south of the intersection to a two-way roadway in order to improve access to the Bear Hill Industrial Area and to develop land located south of the Medway Road and Beaver Street intersection. We do not recommend Alternative 4 because close proximity to the traffic signal at Medway Road and Beaver Street would create queue storage problems affecting traffic operations.

Alternative 2 is a cost-effective solution and can be implemented with minimal traffic disruption. In addition, Alternative 2 offers many of the benefits of Alternative 5. The reason why Alternative 5 is beneficial in the long term is that it improves access to the Bear Hill Industrial Area but Alternative 2 does not. In addition, Alternative 5 would facilitate economic development in the vicinity—this benefit would not be achieved with Alternative 2.

8.1 Next Steps

This study gives Milford an opportunity to begin looking at the needs of the intersection of Medway Road and driveways to Kmart and McDonald's, and plan for design and engineering. The next steps after this planning study are:

- Conduct a road safety audit to discuss additional safety improvements for the location because it is an HSIP crash cluster
- Implement preferred low-cost, short-term improvement (Alternative 2)

Implementation of the long-term, high-cost improvement (Alternative 5) would require cooperation between MassDOT and Milford to begin the project notification and review process and preliminary design and engineering. MassDOT Highway Division's project development process is included in Appendix F. Finally, the study supports MPO visions and goals, which include increasing transportation safety, preserving and maintaining the transportation system, reducing congestion, and advancing mobility.

SA/sa

cc: Joseph Frawley, MassDOT Highway Division, District 3

APPENDIX A

Public Participation

Seth Asante

From: Campbell, Alolade (DOT)
Sent: Thursday, February 19, 2015 9:28 AM
To: 'sasante@ctps.org'
Cc: Sullivan, Ann (DOT); Frawley, Joseph (DOT)
Subject: Medway Road/Kmart Driveway Intersection in Milford Review Comments

Dear Seth,

MassDOT District 3 has reviewed all the five alternatives that are developed and analyzed to improve the safety and traffic operation in the Town of Milford at the intersections of Medway Road (Route 109) at Driveways for Kmart and McDonald's Restaurant and Medway Road at Beaver Street. The alternatives are categorized into two classes; short term and long term. The short term alternatives are Alternatives 1-3 while Alternatives 4-5 are considered to be Long term.

Short Term

- **Alternative 1: Convert Kmart driveway to right-in-right-out channelization with forced turn island**

This does not address the angle crash for the Medway Road EB Left Turn Movements into Mobil Gas Station and as well as the Medway Road WB Left Turn Movements into McDonalds and Shell Gas Station. Therefore we do not recommend this alternative.

- **Alternative 2: Alternative 1 and Conversion of Medway Road eastbound left lane into a two-way left-turn lane**

This seems to be the best short term alternative provided that the eastbound left turn bay on Medway Road is at least 160 feet, to accommodate queuing.

- **Alternative 3: Alternative 2 and Installation of a raised median in the vicinity of the driveway to Kmart and McDonald to prohibit left turns.**

This alternative tries to prohibit the Medway Road WB Left Turn Movements into McDonalds however it does not prevent motorist heading to McDonalds from making a U- turn immediately after the raised median. Therefore we do not recommend this alternative.

Long Term

- **Alternative 4: Installation of a traffic signal at the intersection of Medway Road and Kmart/McDonalds driveways.**

This long term alternative is not recommended because of the short distance between the proposed traffic signal and the Medway Road / Beaver Street intersection. Secondly, the signal warrants might not be met given the low traffic volumes exiting the business driveways.

- **Alternative 5: Multilane Roundabout at Medway Road at Beaver Street.**

This long term alternative seems to be better alternative but should be evaluated further by the Town. The District recommends that the roundabout be further analyzed using Sidra and Vissim Traffic Software.

If you have any questions regarding these comments please contact Alolade Campbell (508) 929-3887 or Joseph Frawley, Traffic Operation Engineer P.E., (508) 929-3916.

From: Frawley, Joseph (DOT)
Sent: Tuesday, February 03, 2015 4:27 PM
To: Campbell, Alolade (DOT)
Subject: Fwd: Medway Road/Kmart Driveway Intersection in Milford

Lola,

Please review the attached technical memo from CTPS. We can discuss this before comments are submitted. The location is on Route 109 in Milford, but is not State Highway.

Thanks,
Joe

Sent from my Verizon Wireless 4G LTE smartphone

----- Original message -----

From: Seth Asante
Date: 01/30/2015 4:24 PM (GMT-05:00)
To: "Frawley, Joseph (DOT)"
Cc: "Sullivan, Ann (DOT)"
Subject: Medway Road/Kmart Driveway Intersection in Milford

Hello Joe,

Would you please review the attached CTPS memo about safety and operations analyses for the intersection of Medway Road (Route 109) and Kmart/McDonald's Restaurant driveways in Milford? The study was conducted for the Town of Milford and I would appreciate it if you would let me have your comments by February 13, 2015.

Thank you,
Seth

Seth A. Asante | Chief Transportation Planner
CENTRAL TRANSPORTATION PLANNING STAFF
857.702.3644 | sasante@ctps.org

APPENDIX 6

Turning-Movement Count Data

Central Transportation Planning Staff
 Medway Road and Kmart/McDonalds Driveways
 03/7/2014

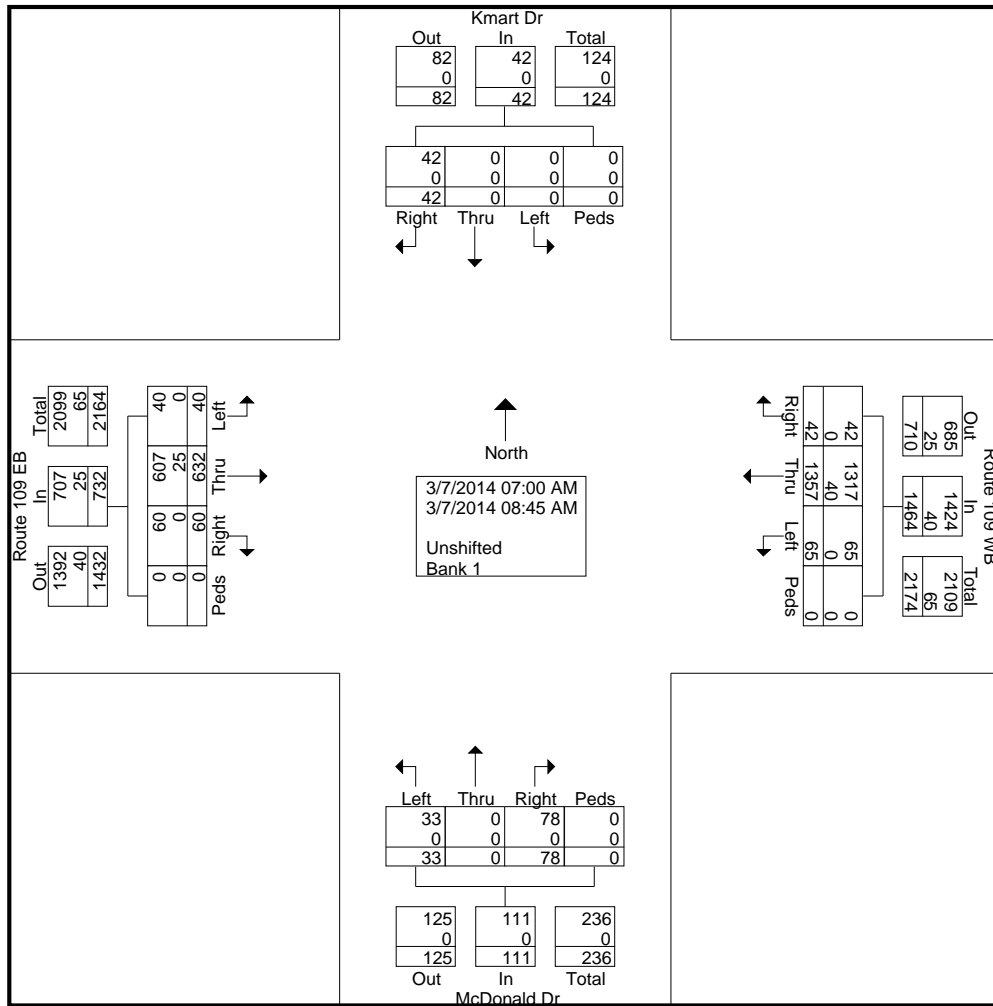
File Name : mcdkmart am
 Site Code : 03071402
 Start Date : 3/7/2014
 Page No : 1

Groups Printed- Unshifted - Bank 1

Start Time	Kmart Dr From North					Route 109 WB From East					McDonald Dr From South					Route 109 EB From West					Int. Total
	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	
07:00 AM	4	0	0	0	4	6	114	9	0	129	9	0	6	0	15	8	65	4	0	77	225
07:15 AM	4	0	0	0	4	4	129	9	0	142	11	0	2	0	13	7	77	7	0	91	250
07:30 AM	7	0	0	0	7	6	154	7	0	167	8	0	4	0	12	6	88	5	0	99	285
07:45 AM	5	0	0	0	5	5	158	9	0	172	12	0	4	0	16	8	86	3	0	97	290
Total	20	0	0	0	20	21	555	34	0	610	40	0	16	0	56	29	316	19	0	364	1050
08:00 AM	5	0	0	0	5	4	208	8	0	220	10	0	3	0	13	7	73	5	0	85	323
08:15 AM	6	0	0	0	6	5	207	7	0	219	13	0	5	0	18	9	77	6	0	92	335
08:30 AM	4	0	0	0	4	6	223	5	0	234	7	0	6	0	13	8	84	4	0	96	347
08:45 AM	7	0	0	0	7	6	164	11	0	181	8	0	3	0	11	7	82	6	0	95	294
Total	22	0	0	0	22	21	802	31	0	854	38	0	17	0	55	31	316	21	0	368	1299
Grand Total	42	0	0	0	42	42	1357	65	0	1464	78	0	33	0	111	60	632	40	0	732	2349
Apprch %	100	0	0	0		2.9	92.7	4.4	0		70.3	0	29.7	0		8.2	86.3	5.5	0		
Total %	1.8	0	0	0	1.8	1.8	57.8	2.8	0	62.3	3.3	0	1.4	0	4.7	2.6	26.9	1.7	0	31.2	
Unshifted	42	0	0	0	42	42	1317	65	0	1424	78	0	33	0	111	60	607	40	0	707	2284
% Unshifted	100	0	0	0	100	100	97.1	100	0	97.3	100	0	100	0	100	100	96	100	0	96.6	97.2
Bank 1	0	0	0	0	0	0	40	0	0	40	0	0	0	0	0	0	25	0	0	25	65
% Bank 1	0	0	0	0	0	0	2.9	0	0	2.7	0	0	0	0	0	0	4	0	0	3.4	2.8

Central Transportation Planning Staff
 Medway Road and Kmart/McDonalds Driveways
 03/7/2014

File Name : mcdkmart am
 Site Code : 03071402
 Start Date : 3/7/2014
 Page No : 2



Central Transportation Planning Staff
 Medway Road and Kmart/McDonalds Driveways
 03/7/2014

File Name : mcdkmart am
 Site Code : 03071402
 Start Date : 3/7/2014
 Page No : 3

Start Time	Kmart Dr From North					Route 109 WB From East					McDonald Dr From South					Route 109 EB From West					Int. Total
	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	
Peak Hour Analysis From 07:00 AM to 08:45 AM - Peak 1 of 1																					
Peak Hour for Entire Intersection Begins at 08:00 AM																					
08:00 AM	5	0	0	0	5	4	208	8	0	220	10	0	3	0	13	7	73	5	0	85	323
08:15 AM	6	0	0	0	6	5	207	7	0	219	13	0	5	0	18	9	77	6	0	92	335
08:30 AM	4	0	0	0	4	6	223	5	0	234	7	0	6	0	13	8	84	4	0	96	347
08:45 AM	7	0	0	0	7	6	164	11	0	181	8	0	3	0	11	7	82	6	0	95	294
Total Volume	22	0	0	0	22	21	802	31	0	854	38	0	17	0	55	31	316	21	0	368	1299
% App. Total	100	0	0	0		2.5	93.9	3.6	0		69.1	0	30.9	0		8.4	85.9	5.7	0		
PHF	.786	.000	.000	.000	.786	.875	.899	.705	.000	.912	.731	.000	.708	.000	.764	.861	.940	.875	.000	.958	.936

Peak Hour Analysis From 07:00 AM to 08:45 AM - Peak 1 of 1

Peak Hour for Each Approach Begins at:

	07:30 AM					08:00 AM					07:45 AM					07:30 AM				
+0 mins.	7	0	0	0	7	4	208	8	0	220	12	0	4	0	16	6	88	5	0	99
+15 mins.	5	0	0	0	5	5	207	7	0	219	10	0	3	0	13	8	86	3	0	97
+30 mins.	5	0	0	0	5	6	223	5	0	234	13	0	5	0	18	7	73	5	0	85
+45 mins.	6	0	0	0	6	6	164	11	0	181	7	0	6	0	13	9	77	6	0	92
Total Volume	23	0	0	0	23	21	802	31	0	854	42	0	18	0	60	30	324	19	0	373
% App. Total	100	0	0	0		2.5	93.9	3.6	0		70	0	30	0		8	86.9	5.1	0	
PHF	.821	.000	.000	.000	.821	.875	.899	.705	.000	.912	.808	.000	.750	.000	.833	.833	.920	.792	.000	.942

Central Transportation Planning Staff
 Medway Road and Kmart/McDonalds Driveways
 03/7/2014

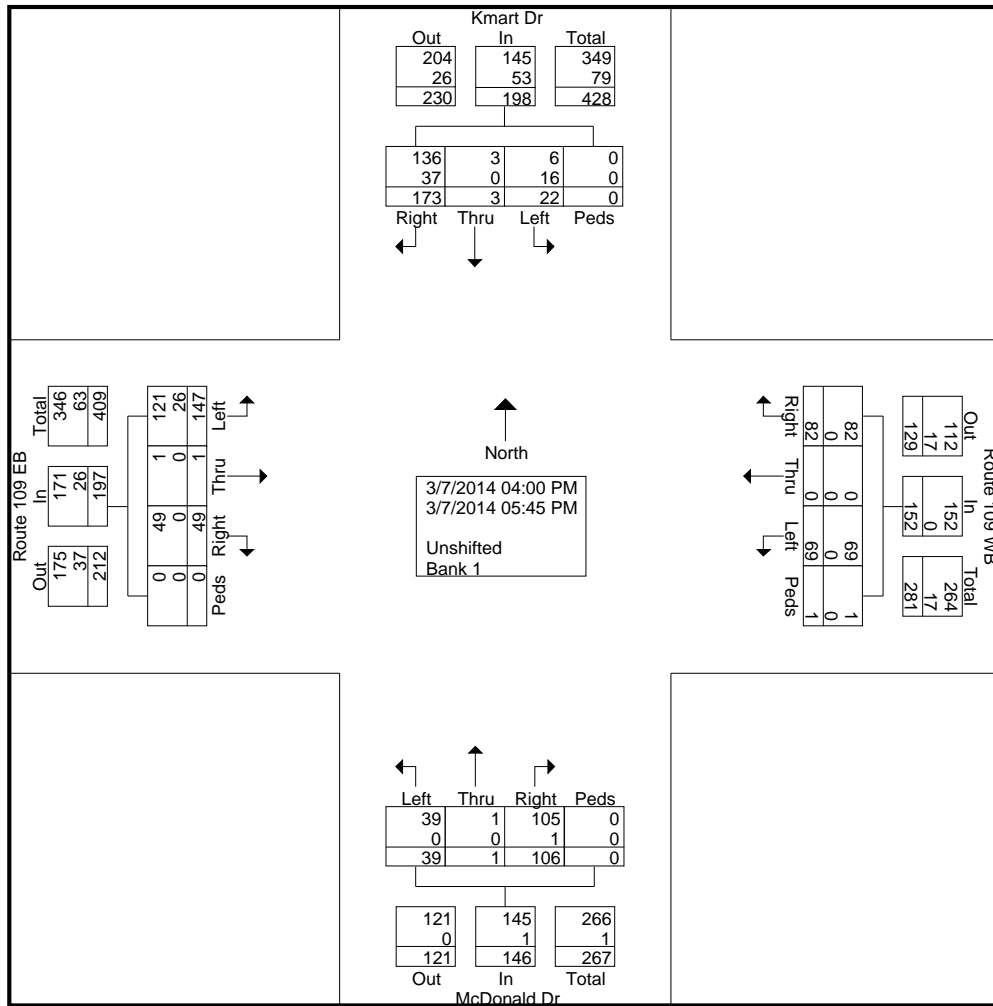
File Name : McDKmart
 Site Code : 03071401
 Start Date : 3/7/2014
 Page No : 1

Groups Printed- Unshifted - Bank 1

Start Time	Kmart Dr From North					Route 109 WB From East					McDonald Dr From South					Route 109 EB From West					Int. Total
	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	
04:00 PM	22	2	1	0	25	9	0	7	0	16	11	1	1	0	13	7	1	13	0	21	75
04:15 PM	25	0	6	0	31	4	0	11	0	15	15	0	5	0	20	0	0	27	0	27	93
04:30 PM	25	0	5	0	30	4	0	9	0	13	16	0	4	0	20	7	0	25	0	32	95
04:45 PM	21	1	0	0	22	14	0	12	0	26	11	0	9	0	20	5	0	16	0	21	89
Total	93	3	12	0	108	31	0	39	0	70	53	1	19	0	73	19	1	81	0	101	352
05:00 PM	23	0	2	0	25	14	0	3	1	18	8	0	6	0	14	14	0	20	0	34	91
05:15 PM	20	0	5	0	25	9	0	7	0	16	12	0	6	0	18	7	0	8	0	15	74
05:30 PM	17	0	1	0	18	15	0	11	0	26	13	0	4	0	17	3	0	20	0	23	84
05:45 PM	20	0	2	0	22	13	0	9	0	22	20	0	4	0	24	6	0	18	0	24	92
Total	80	0	10	0	90	51	0	30	1	82	53	0	20	0	73	30	0	66	0	96	341
Grand Total	173	3	22	0	198	82	0	69	1	152	106	1	39	0	146	49	1	147	0	197	693
Apprch %	87.4	1.5	11.1	0		53.9	0	45.4	0.7		72.6	0.7	26.7	0		24.9	0.5	74.6	0		
Total %	25	0.4	3.2	0	28.6	11.8	0	10	0.1	21.9	15.3	0.1	5.6	0	21.1	7.1	0.1	21.2	0	28.4	
Unshifted	136	3	6	0	145	82	0	69	1	152	105	1	39	0	145	49	1	121	0	171	613
% Unshifted	78.6	100	27.3	0	73.2	100	0	100	100	100	99.1	100	100	0	99.3	100	100	82.3	0	86.8	88.5
Bank 1	37	0	16	0	53	0	0	0	0	0	1	0	0	0	1	0	0	26	0	26	80
% Bank 1	21.4	0	72.7	0	26.8	0	0	0	0	0	0.9	0	0	0	0.7	0	0	17.7	0	13.2	11.5

Central Transportation Planning Staff
 Medway Road and Kmart/McDonalds Driveways
 03/7/2014

File Name : McDKmart
 Site Code : 03071401
 Start Date : 3/7/2014
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Central Transportation Planning Staff
 Medway Road and Kmart/McDonalds Driveways
 03/7/2014

File Name : McDKmart
 Site Code : 03071401
 Start Date : 3/7/2014
 Page No : 3

Start Time	Kmart Dr From North					Route 109 WB From East					McDonald Dr From South					Route 109 EB From West					Int. Total
	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	
Peak Hour Analysis From 04:00 PM to 05:45 PM - Peak 1 of 1																					
Peak Hour for Entire Intersection Begins at 04:15 PM																					
04:15 PM	25	0	6	0	31	4	0	11	0	15	15	0	5	0	20	0	0	27	0	27	93
04:30 PM	25	0	5	0	30	4	0	9	0	13	16	0	4	0	20	7	0	25	0	32	95
04:45 PM	21	1	0	0	22	14	0	12	0	26	11	0	9	0	20	5	0	16	0	21	89
05:00 PM	23	0	2	0	25	14	0	3	1	18	8	0	6	0	14	14	0	20	0	34	91
Total Volume	94	1	13	0	108	36	0	35	1	72	50	0	24	0	74	26	0	88	0	114	368
% App. Total	87	0.9	12	0		50	0	48.6	1.4		67.6	0	32.4	0		22.8	0	77.2	0		
PHF	.940	.250	.542	.000	.871	.643	.000	.729	.250	.692	.781	.000	.667	.000	.925	.464	.000	.815	.000	.838	.968

Peak Hour Analysis From 04:00 PM to 05:45 PM - Peak 1 of 1

Peak Hour for Each Approach Begins at:

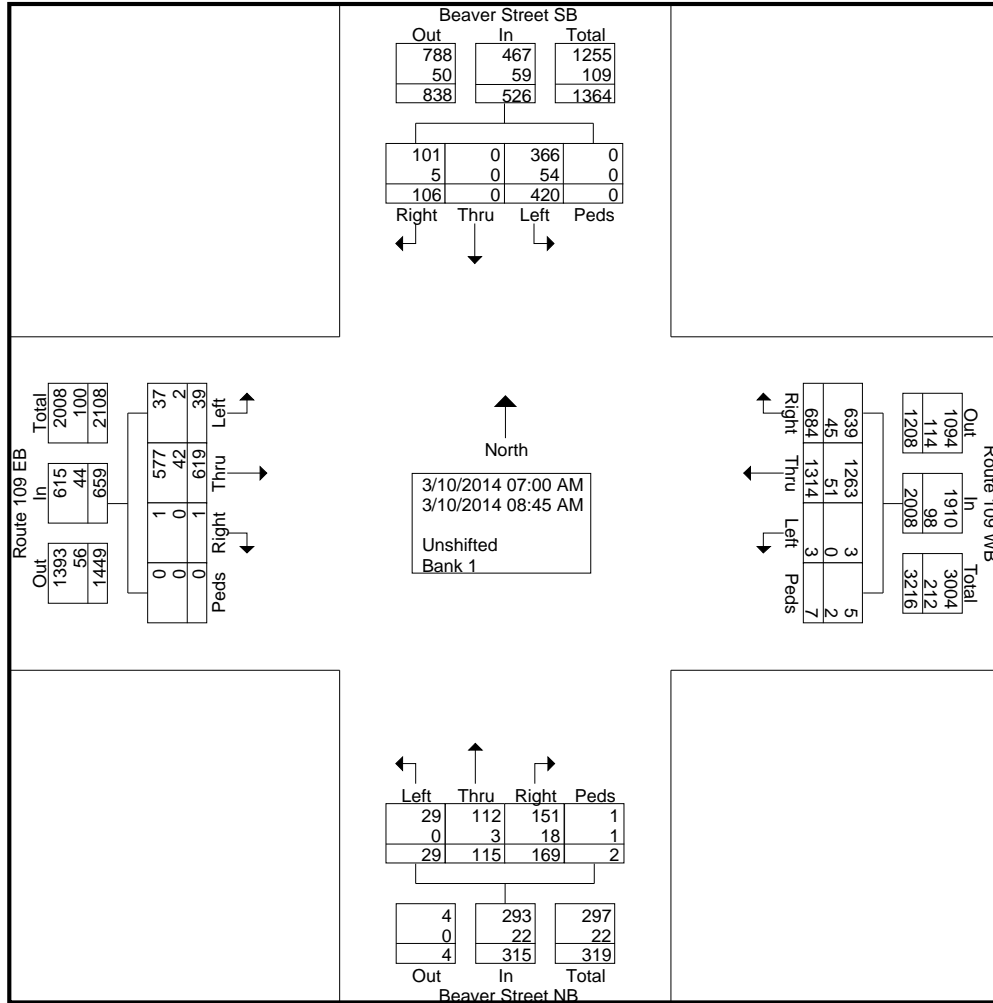
	04:00 PM					04:45 PM					04:15 PM					04:15 PM					
+0 mins.	22	2	1	0	25	14	0	12	0	26	15	0	5	0	20	0	0	27	0	27	
+15 mins.	25	0	6	0	31	14	0	3	1	18	16	0	4	0	20	7	0	25	0	32	
+30 mins.	25	0	5	0	30	9	0	7	0	16	11	0	9	0	20	5	0	16	0	21	
+45 mins.	21	1	0	0	22	15	0	11	0	26	8	0	6	0	14	14	0	20	0	34	
Total Volume	93	3	12	0	108	52	0	33	1	86	50	0	24	0	74	26	0	88	0	114	
% App. Total	86.1	2.8	11.1	0		60.5	0	38.4	1.2		67.6	0	32.4	0		22.8	0	77.2	0		
PHF	.930	.375	.500	.000	.871	.867	.000	.688	.250	.827	.781	.000	.667	.000	.925	.464	.000	.815	.000	.838	

Central Transportation Planning Staff
 Medway Road and Beaver Street
 3/10/14

File Name : Rte109Beaver am
 Site Code : 03101401
 Start Date : 3/10/2014
 Page No : 1

Groups Printed- Unshifted - Bank 1

Start Time	Beaver Street SB From North					Route 109 WB From East					Beaver Street NB From South					Route 109 EB From West					Int. Total
	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	
07:00 AM	12	0	51	0	63	80	105	0	0	185	18	11	5	0	34	0	60	2	0	62	344
07:15 AM	12	0	57	0	69	64	122	0	1	187	21	8	1	1	31	0	75	3	0	78	365
07:30 AM	14	0	46	0	60	78	146	0	1	225	32	11	2	0	45	0	81	7	0	88	418
07:45 AM	16	0	70	0	86	93	150	0	1	244	35	18	5	0	58	1	91	3	0	95	483
Total	54	0	224	0	278	315	523	0	3	841	106	48	13	1	168	1	307	15	0	323	1610
08:00 AM	13	0	55	0	68	105	205	0	1	311	27	22	2	0	51	0	72	4	0	76	506
08:15 AM	14	0	43	0	57	92	199	0	0	291	19	22	4	0	45	0	82	3	0	85	478
08:30 AM	10	0	49	0	59	83	220	0	0	303	9	10	5	1	25	0	89	5	0	94	481
08:45 AM	15	0	49	0	64	89	167	3	3	262	8	13	5	0	26	0	69	12	0	81	433
Total	52	0	196	0	248	369	791	3	4	1167	63	67	16	1	147	0	312	24	0	336	1898
Grand Total	106	0	420	0	526	684	1314	3	7	2008	169	115	29	2	315	1	619	39	0	659	3508
Apprch %	20.2	0	79.8	0		34.1	65.4	0.1	0.3		53.7	36.5	9.2	0.6		0.2	93.9	5.9	0		
Total %	3	0	12	0	15	19.5	37.5	0.1	0.2	57.2	4.8	3.3	0.8	0.1	9	0	17.6	1.1	0	18.8	
Unshifted	101	0	366	0	467	639	1263	3	5	1910	151	112	29	1	293	1	577	37	0	615	3285
% Unshifted	95.3	0	87.1	0	88.8	93.4	96.1	100	71.4	95.1	89.3	97.4	100	50	93	100	93.2	94.9	0	93.3	93.6
Bank 1	5	0	54	0	59	45	51	0	2	98	18	3	0	1	22	0	42	2	0	44	223
% Bank 1	4.7	0	12.9	0	11.2	6.6	3.9	0	28.6	4.9	10.7	2.6	0	7		0	6.8	5.1	0	6.7	6.4



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Start Time	Beaver Street SB From North					Route 109 WB From East					Beaver Street NB From South					Route 109 EB From West					Int. Total
	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	
Peak Hour Analysis From 07:00 AM to 08:45 AM - Peak 1 of 1																					
Peak Hour for Entire Intersection Begins at 07:45 AM																					
07:45 AM	16	0	70	0	86	93	150	0	1	244	35	18	5	0	58	1	91	3	0	95	483
08:00 AM	13	0	55	0	68	105	205	0	1	311	27	22	2	0	51	0	72	4	0	76	506
08:15 AM	14	0	43	0	57	92	199	0	0	291	19	22	4	0	45	0	82	3	0	85	478
08:30 AM	10	0	49	0	59	83	220	0	0	303	9	10	5	1	25	0	89	5	0	94	481
Total Volume	53	0	217	0	270	373	774	0	2	1149	90	72	16	1	179	1	334	15	0	350	1948
% App. Total	19.6	0	80.4	0		32.5	67.4	0	0.2		50.3	40.2	8.9	0.6		0.3	95.4	4.3	0		
PHF	.828	.000	.775	.000	.785	.888	.880	.000	.500	.924	.643	.818	.800	.250	.772	.250	.918	.750	.000	.921	.962

Peak Hour Analysis From 07:00 AM to 08:45 AM - Peak 1 of 1

Peak Hour for Each Approach Begins at:

	07:15 AM					08:00 AM					07:30 AM					07:45 AM				
+0 mins.	12	0	57	0	69	105	205	0	1	311	32	11	2	0	45	1	91	3	0	95
+15 mins.	14	0	46	0	60	92	199	0	0	291	35	18	5	0	58	0	72	4	0	76
+30 mins.	16	0	70	0	86	83	220	0	0	303	27	22	2	0	51	0	82	3	0	85
+45 mins.	13	0	55	0	68	89	167	3	3	262	19	22	4	0	45	0	89	5	0	94
Total Volume	55	0	228	0	283	369	791	3	4	1167	113	73	13	0	199	1	334	15	0	350
% App. Total	19.4	0	80.6	0		31.6	67.8	0.3	0.3		56.8	36.7	6.5	0		0.3	95.4	4.3	0	
PHF	.859	.000	.814	.000	.823	.879	.899	.250	.333	.938	.807	.830	.650	.000	.858	.250	.918	.750	.000	.921

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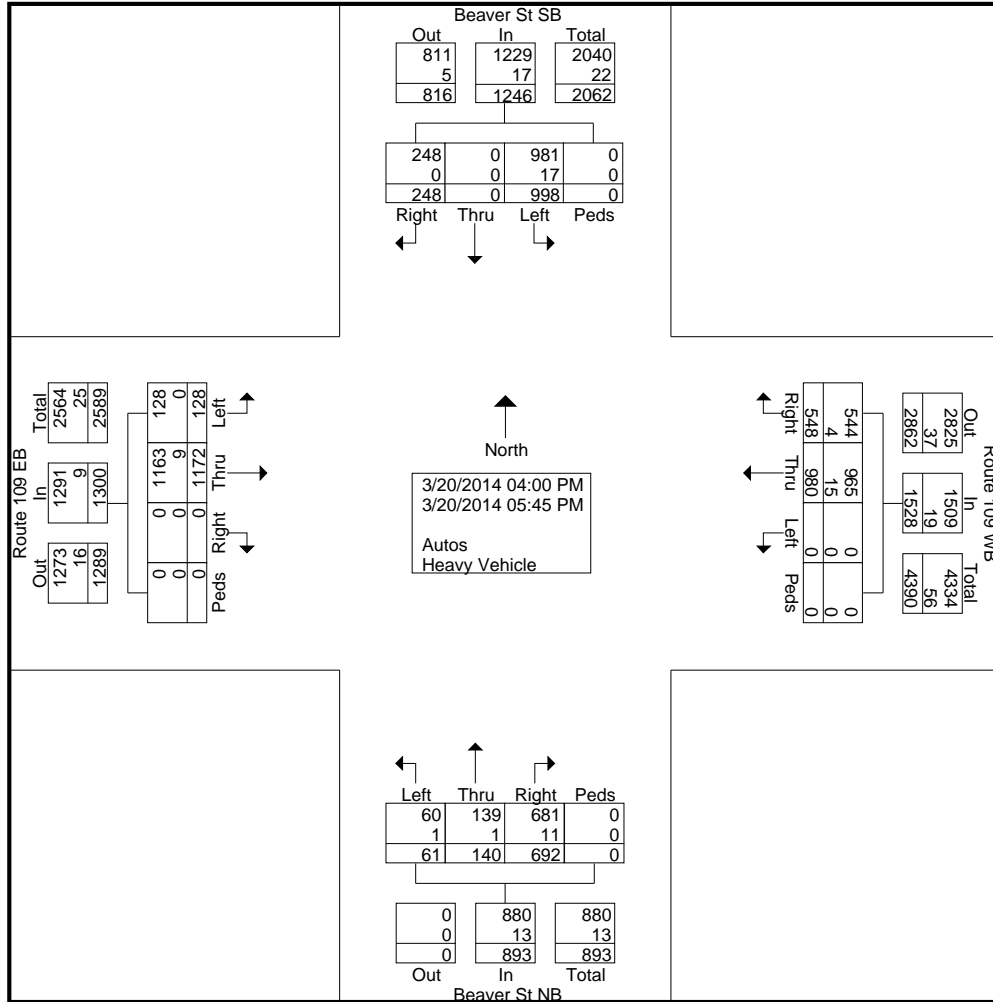
Groups Printed- Autos - Heavy Vehicle

Start Time	Beaver St SB From North					Route 109 WB From East					Beaver St NB From South					Route 109 EB From West					Int. Total
	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	
04:00 PM	30	0	125	0	155	60	93	0	0	153	92	16	8	0	116	0	135	16	0	151	575
04:15 PM	32	0	114	0	146	69	97	0	0	166	90	18	6	0	114	0	139	18	0	157	583
04:30 PM	29	0	136	0	165	66	101	0	0	167	114	14	8	0	136	0	149	23	0	172	640
04:45 PM	36	0	96	0	132	65	106	0	0	171	85	16	6	0	107	0	137	15	0	152	562
Total	127	0	471	0	598	260	397	0	0	657	381	64	28	0	473	0	560	72	0	632	2360
05:00 PM	26	0	149	0	175	61	149	0	0	210	89	22	6	0	117	0	180	15	0	195	697
05:15 PM	26	0	129	0	155	74	152	0	0	226	96	20	13	0	129	0	159	14	0	173	683
05:30 PM	36	0	141	0	177	80	150	0	0	230	74	21	9	0	104	0	119	15	0	134	645
05:45 PM	33	0	108	0	141	73	132	0	0	205	52	13	5	0	70	0	154	12	0	166	582
Total	121	0	527	0	648	288	583	0	0	871	311	76	33	0	420	0	612	56	0	668	2607
Grand Total	248	0	998	0	1246	548	980	0	0	1528	692	140	61	0	893	0	1172	128	0	1300	4967
Apprch %	19.9	0	80.1	0		35.9	64.1	0	0		77.5	15.7	6.8	0		0	90.2	9.8	0		
Total %	5	0	20.1	0	25.1	11	19.7	0	0	30.8	13.9	2.8	1.2	0	18	0	23.6	2.6	0	26.2	
Autos	248	0	981	0	1229	544	965	0	0	1509	681	139	60	0	880	0	1163	128	0	1291	4909
% Autos	100	0	98.3	0	98.6	99.3	98.5	0	0	98.8	98.4	99.3	98.4	0	98.5	0	99.2	100	0	99.3	98.8
Heavy Vehicle	0	0	17	0	17	4	15	0	0	19	11	1	1	0	13	0	9	0	0	9	58
% Heavy Vehicle	0	0	1.7	0	1.4	0.7	1.5	0	0	1.2	1.6	0.7	1.6	0	1.5	0	0.8	0	0	0.7	1.2

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	Beaver St SB From North					Route 109 WB From East					Beaver St NB From South					Route 109 EB From West					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
Peak Hour Analysis From 04:00 PM to 05:15 PM - Peak 1 of 1																					
Peak Hour for Entire Intersection Begins at 04:30 PM																					
04:30 PM	29	0	136	0	165	66	101	0	0	167	114	14	8	0	136	0	149	23	0	172	640
04:45 PM	36	0	96	0	132	65	106	0	0	171	85	16	6	0	107	0	137	15	0	152	562
05:00 PM	26	0	149	0	175	61	149	0	0	210	89	22	6	0	117	0	180	15	0	195	697
05:15 PM	26	0	129	0	155	74	152	0	0	226	96	20	13	0	129	0	159	14	0	173	683
Total Volume	117	0	510	0	627	266	508	0	0	774	384	72	33	0	489	0	625	67	0	692	2582
% App. Total	18.7	0	81.3	0		34.4	65.6	0	0		78.5	14.7	6.7	0		0	90.3	9.7	0		
PHF	.813	.000	.856	.000	.896	.899	.836	.000	.000	.856	.842	.818	.635	.000	.899	.000	.868	.728	.000	.887	.926

Peak Hour Analysis From 04:00 PM to 05:15 PM - Peak 1 of 1

Peak Hour for Each Approach Begins at:

	04:30 PM					04:30 PM					04:30 PM					04:30 PM					
+0 mins.	29	0	136	0	165	66	101	0	0	167	114	14	8	0	136	0	149	23	0	172	
+15 mins.	36	0	96	0	132	65	106	0	0	171	85	16	6	0	107	0	137	15	0	152	
+30 mins.	26	0	149	0	175	61	149	0	0	210	89	22	6	0	117	0	180	15	0	195	
+45 mins.	26	0	129	0	155	74	152	0	0	226	96	20	13	0	129	0	159	14	0	173	
Total Volume	117	0	510	0	627	266	508	0	0	774	384	72	33	0	489	0	625	67	0	692	
% App. Total	18.7	0	81.3	0		34.4	65.6	0	0		78.5	14.7	6.7	0		0	90.3	9.7	0		
PHF	.813	.000	.856	.000	.896	.899	.836	.000	.000	.856	.842	.818	.635	.000	.899	.000	.868	.728	.000	.887	

APPENDIX 7

Crash Data

2010-2012_Rte109-KmartShell

OBJECT ID	Crash Number	Crash Year	Crash Time	Date	Crash Severity	Manner of Collision	Vehicle Traveled Direction	Road Surface Condition	Ambient Light Conditions	Weather Condition
1	2830430	2010	6:44 AM	26-Nov-2010	Property damage only (none ir	Angle	V1:Northbound / V2:Westbound	Wet	Daylight	Rain
2	2604379	2010	2:11 PM	15-Apr-2010	Non-fatal injury	Angle	V1:Eastbound / V2:Westbound	Dry	Daylight	Clear
3	2604390	2010	5:04 PM	18-Apr-2010	Property damage only (none ir	Angle	V1:Westbound / V2:Eastbound	Dry	Daylight	Cloudy
4	2604392	2010	10:54 AM	19-Apr-2010	Property damage only (none ir	Angle	V1:Southbound / V2:Northbound	Dry	Daylight	Cloudy
5	2605402	2010	6:11 PM	17-May-2010	Not Reported	Angle	V1:Southbound / V2:Eastbound	Dry	Daylight	Clear
6	2605404	2010	12:30 PM	18-May-2010	Not Reported	Angle	V1:Not reported	Dry	Daylight	Cloudy
7	2829994	2010	6:46 PM	05-Aug-2010	Property damage only (none ir	Angle	V1:Not reported / V2:Westbound	Dry	Daylight	Clear
8	2614039	2010	8:58 AM	23-Jun-2010	Property damage only (none ir	Head-on	V1:Eastbound / V2:Westbound	Dry	Daylight	Clear
9	2614044	2010	1:40 PM	27-Jun-2010	Property damage only (none ir	Angle	V1:Eastbound / V2:Westbound	Dry	Daylight	Clear
10	2829951	2010	6:59 PM	07-Jul-2010	Property damage only (none ir	Angle	V1:Eastbound / V2:Eastbound	Dry	Daylight	Clear
11	2830336	2010	3:03 PM	07-Oct-2010	Property damage only (none ir	Angle	V1:Eastbound / V2:Southbound	Dry	Daylight	Clear
12	2830354	2010	1:26 PM	14-Oct-2010	Non-fatal injury	Angle	V1:Eastbound / V2:Westbound / V3:S	Dry	Daylight	Clear
13	2830167	2010	5:09 PM	30-Oct-2010	Property damage only (none ir	Angle	V1:Eastbound / V2:Southbound	Dry	Daylight	Clear
14	2830395	2010	10:38 AM	03-Dec-2010	Property damage only (none ir	Rear-to-rear	V1:Westbound / V2:Eastbound	Dry	Daylight	Clear
15	2830398	2010	4:07 PM	04-Dec-2010	Property damage only (none ir	Angle	V1:Eastbound / V2:Northbound	Dry	Dusk	Clear
16	2830410	2010	2:41 PM	11-Dec-2010	Property damage only (none ir	Angle	V1:Westbound / V2:Eastbound	Dry	Daylight	Cloudy
17	2830824	2011	3:46 PM	27-Jan-2011	Not Reported	Unknown	V1:Southbound / V2:Southbound	Snow	Daylight	Clear
18	2831011	2011	10:02 AM	12-Feb-2011	Not Reported	Unknown	V1:Not reported	Dry	Daylight	Clear
19	2831047	2011	1:42 PM	25-Feb-2011	Not Reported	Unknown	V1:Not reported	Wet	Daylight	Rain
20	2830921	2011	3:00 PM	05-Apr-2011	Property damage only (none ir	Angle	V1:Eastbound / V2:Westbound	Wet	Daylight	Rain
21	2831373	2011	7:29 PM	07-Jun-2011	Property damage only (none ir	Angle	V1:Northbound / V2:Eastbound	Dry	Daylight	Clear
22	2830504	2011	12:40 PM	21-Jun-2011	Property damage only (none ir	Rear-end	V1:Westbound / V2:Westbound	Dry	Daylight	Clear
23	2830535	2011	1:03 PM	24-Jun-2011	Property damage only (none ir	Angle	V1:Eastbound / V2:Westbound	Dry	Daylight	Clear/Cloudy
24	2830538	2011	11:53 AM	26-Jun-2011	Property damage only (none ir	Angle	V1:Eastbound / V2:Westbound	Dry	Daylight	Clear
25	2830560	2011	7:31 AM	07-Jul-2011	Property damage only (none ir	Angle	V1:Eastbound / V2:Westbound	Dry	Daylight	Clear
26	2830526	2011	5:21 PM	31-Jul-2011	Not Reported	Unknown	V1:Eastbound	Dry	Daylight	Clear
27	2830787	2011	1:02 PM	22-Aug-2011	Not Reported	Rear-end	V1:Not reported	Dry	Daylight	Clear
28	2830788	2011	1:07 PM	22-Aug-2011	Property damage only (none ir	Angle	V1:Southbound / V2:Westbound	Dry	Daylight	Clear
29	2830846	2011	3:53 PM	13-Sep-2011	Non-fatal injury	Single vehicle cr	V1:Northbound	Dry	Daylight	Clear
30	2830677	2011	6:12 PM	22-Sep-2011	Property damage only (none ir	Rear-to-rear	V1:Northbound / V2:Not reported	Wet	Daylight	Cloudy/Rain
31	2832221	2011	1:11 PM	08-Oct-2011	Non-fatal injury	Angle	V1:Eastbound / V2:Westbound	Dry	Daylight	Clear
32	2830947	2011	4:38 PM	18-Oct-2011	Property damage only (none ir	Sideswipe, oppo	V1:Westbound / V2:Eastbound	Dry	Daylight	Clear
33	2843447	2011	7:55 PM	13-Dec-2011	Property damage only (none ir	Angle	V1:Eastbound / V2:Northbound	Dry	Other	Clear
34	2891149	2012	11:20 AM	06-Jan-2012	Property damage only (none ir	Angle	V1:Westbound / V2:Eastbound	Dry	Daylight	Cloudy
35	2891177	2012	1:26 AM	17-Jan-2012	Property damage only (none ir	Angle	V1:Southbound / V2:Not reported	Snow	Dark - lighted rc	Snow
36	2892011	2012	2:18 PM	20-Jan-2012	Property damage only (none ir	Angle	V1:Northbound / V2:Westbound	Dry	Daylight	Clear
37	2933907	2012	5:05 PM	08-Feb-2012	Property damage only (none ir	Angle	V1:Westbound / V2:Southbound	Dry	Dusk	Clear

2010-2012_Rte109-KmartShell

OBJECT ID	Crash Number	Crash Year	Crash Time	Date	Crash Severity	Manner of Collision	Vehicle Traveled Direction	Road Surface Condition	Ambient Light Conditions	Weather Condition
38	3004232	2012	10:51 AM	24-Mar-2012	Property damage only (none ir	Angle	V1:Eastbound / V2:Westbound	Dry	Daylight	Cloudy
39	3117913	2012	10:00 PM	03-May-2012	Non-fatal injury	Angle	V1:Northbound / V2:Eastbound	Dry	Dark - lighted rc	Clear
40	3223737	2012	6:51 AM	19-Jul-2012	Property damage only (none ir	Angle	V1:Northbound / V2:Eastbound	Dry	Daylight	Cloudy
41	3156426	2012	11:13 AM	24-Jun-2012	Not Reported	Angle	V1:Westbound	Dry	Daylight	Clear
42	3223674	2012	6:43 PM	05-Jul-2012	Property damage only (none ir	Single vehicle cr	V1:Eastbound	Dry	Daylight	Clear
43	3223747	2012	8:21 PM	25-Jul-2012	Not Reported	Angle	V1:Not reported	Dry	Dark - lighted rc	Clear
44	3265272	2012	5:51 PM	18-Sep-2012	Property damage only (none ir	Angle	V1:Eastbound / V2:Southbound	Wet	Daylight	Rain
45	3299674	2012	2:55 PM	29-Nov-2012	Property damage only (none ir	Angle	V1:Eastbound / V2:Westbound	Dry	Daylight	Clear
46	3323475	2012	5:31 PM	07-Dec-2012	Non-fatal injury	Angle	V1:Westbound / V2:Eastbound	Wet	Dark - lighted rc	Rain
47	3323520	2012	2:37 PM	19-Dec-2012	Property damage only (none ir	Angle	V1:Westbound / V2:Eastbound	Dry	Daylight	Cloudy
48	3323542	2012	12:14 PM	29-Dec-2012	Property damage only (none ir	Angle	V1:Eastbound / V2:Westbound	Dry	Daylight	Cloudy
49	3323545	2012	11:38 AM	30-Dec-2012	Not Reported	Unknown	V1:Not reported	Snow	Daylight	Cloudy

2010-2012Rte109-Beaver

Object ID	Crash Number	Crash Year	Crash Time	Date	Crash Severity	Manner of Collision	Vehicle Traveled Direction	Road		Weather Conditions
								Surface Condition	Ambient Light Conditions	
1	2730746	2010	3:30 PM	09-Jan-2010	Property damage only (none ir	Angle	V1:Eastbound / V2:Southbound	Dry	Daylight	Clear
2	2593041	2010	5:23 PM	20-Jan-2010	Property damage only (none ir	Rear-end	V1:Westbound / V2:Westbound / V3:	Dry	Dark - lighted roadway	Clear
3	2602728	2010	1:01 PM	03-Feb-2010	Property damage only (none ir	Rear-end	V1:Eastbound / V2:Eastbound	Dry	Daylight	Cloudy
4	2602745	2010	5:53 PM	11-Feb-2010	Property damage only (none ir	Angle	V1:Eastbound / V2:Westbound	Dry	Dark - lighted roadway	Clear
5	2604377	2010	6:25 PM	14-Apr-2010	Property damage only (none ir	Head-on	V1:Westbound / V2:Eastbound	Dry	Daylight	Clear
6	2604611	2010	10:10 PM	17-Apr-2010	Property damage only (none ir	Head-on	V1:Westbound / V2:Eastbound	Wet	Dark - lighted roadway	Rain
7	2605390	2010	7:14 AM	12-May-2010	Non-fatal injury	Angle	V1:Northbound / V2:Southbound	Dry	Daylight	Clear
8	2605740	2010	5:13 PM	26-May-2010	Property damage only (none ir	Angle	V1:Southbound / V2:Eastbound	Dry	Daylight	Clear
9	2829980	2010	5:17 PM	30-Jul-2010	Property damage only (none ir	Angle	V1:Eastbound / V2:Eastbound	Dry	Daylight	Clear
10	2829968	2010	9:26 PM	24-Jul-2010	Non-fatal injury	Rear-end	V1:Eastbound / V2:Eastbound	Dry	Dark - lighted roadway	Clear
11	2830016	2010	12:56 PM	15-Aug-2010	Unknown	Angle	V1:Not reported / V2:Southbound	Dry	Daylight	Clear
12	2830235	2010	10:43 AM	23-Aug-2010	Property damage only (none ir	Angle	V1:Southbound / V2:Eastbound	Wet	Daylight	Rain
13	2830281	2010	5:01 PM	10-Sep-2010	Property damage only (none ir	Angle	V1:Westbound / V2:Southbound	Dry	Daylight	Clear
14	2830329	2010	8:20 AM	05-Oct-2010	Property damage only (none ir	Angle	V1:Northbound / V2:Eastbound	Wet	Daylight	Rain
15	2831066	2011	3:52 PM	03-Mar-2011	Property damage only (none ir	Angle	V1:Eastbound / V2:Eastbound	Dry	Daylight	Clear
16	2830736	2011	5:10 PM	03-Jan-2011	Property damage only (none ir	Angle	V1:Westbound / V2:Eastbound / V3:E	Dry	Dark - lighted roadway	Clear
17	2831090	2011	11:07 AM	09-Jan-2011	Property damage only (none ir	Sideswipe, same di	V1:Northbound / V2:Southbound	Dry	Daylight	Clear
18	2831263	2011	2:57 PM	13-Jan-2011	Property damage only (none ir	Sideswipe, same di	V1:Southbound	Dry	Daylight	Clear
19	2830556	2011	3:49 PM	20-Jan-2011	Property damage only (none ir	Angle	V1:Eastbound / V2:Northbound	Dry	Daylight	Clear
20	2831138	2011	11:12 AM	19-Apr-2011	Property damage only (none ir	Angle	V1:Southbound / V2:Westbound	Dry	Daylight	Cloudy
21	2831285	2011	3:32 PM	06-May-2011	Property damage only (none ir	Rear-end	V1:Eastbound / V2:Eastbound	Dry	Daylight	Clear
22	2830509	2011	12:40 PM	24-Jun-2011	Property damage only (none ir	Angle	V1:Not reported / V2:Eastbound	Unknown	Daylight	Unknown
23	2830540	2011	11:02 AM	28-Jun-2011	Property damage only (none ir	Rear-end	V1:Eastbound / V2:Eastbound	Dry	Daylight	Clear
24	2830760	2011	7:56 AM	15-Aug-2011	Non-fatal injury	Angle	V1:Southbound / V2:Eastbound	Wet	Daylight	Rain
25	2830821	2011	2:36 PM	01-Sep-2011	Property damage only (none ir	Angle	V1:Westbound / V2:Westbound	Dry	Daylight	Clear
26	3324518	2011	9:35 AM	22-Nov-2011	Property damage only (none ir	Sideswipe, same di	V1:Westbound / V2:Westbound / V3:	Dry	Daylight	Clear
27	3324650	2011	1:55 PM	02-Dec-2011	Property damage only (none ir	Angle	V1:Eastbound / V2:Northbound	Dry	Daylight	Clear
28	3324652	2011	7:29 PM	02-Dec-2011	Not Reported	Angle	V1:Not reported	Dry	Dark - lighted roadway	Clear
29	3324657	2011	2:43 PM	07-Dec-2011	Property damage only (none ir	Rear-end	V1:Eastbound / V2:Eastbound	Wet	Daylight	Rain
30	2843369	2011	12:34 PM	28-Dec-2011	Property damage only (none ir	Angle	V1:Eastbound / V2:Westbound	Dry	Daylight	Clear
31	3156389	2012	3:03 PM	08-Jun-2012	Property damage only (none ir	Angle	V1:Westbound / V2:Southbound	Dry	Daylight	Clear
32	2891146	2012	5:51 PM	05-Jan-2012	Property damage only (none ir	Rear-end	V1:Eastbound / V2:Eastbound	Dry	Dark - lighted roadway	Clear
33	2892003	2012	6:41 AM	18-Jan-2012	Property damage only (none ir	Angle	V1:Southbound / V2:Westbound	Dry	Dawn	Clear
34	2892017	2012	9:04 AM	23-Jan-2012	Property damage only (none ir	Rear-end	V1:Westbound	Dry	Daylight	Clear
35	2892027	2012	3:00 PM	26-Jan-2012	Property damage only (none ir	Angle	V1:Eastbound	Wet	Daylight	Rain
36	2933918	2012	5:40 PM	17-Feb-2012	Property damage only (none ir	Rear-end	V1:Southbound / V2:Eastbound	Dry	Dark - lighted roadway	Clear
37	2933929	2012	3:15 PM	28-Feb-2012	Property damage only (none ir	Angle	V1:Northbound / V2:Southbound	Dry	Daylight	Clear
38	3004212	2012	12:35 PM	15-Mar-2012	Property damage only (none ir	Angle	V1:Eastbound / V2:Northbound	Dry	Daylight	Cloudy
39	3057051	2012	5:55 PM	01-Apr-2012	Property damage only (none ir	Rear-end	V1:Southbound / V2:Southbound	Wet	Daylight	Rain
40	3117781	2012	9:33 AM	12-May-2012	Non-fatal injury	Angle	V1:Southbound / V2:Westbound	Dry	Daylight	Clear
41	3117871	2012	5:25 PM	18-May-2012	Property damage only (none ir	Angle	V1:Southbound / V2:Southbound	Dry	Daylight	Clear

2010-2012Rte109-Beaver

Object ID	Crash Number	Crash Year	Crash Time	Date	Crash Severity	Manner of Collision	Vehicle Traveled Direction	Road		Weather Conditions
								Surface Condition	Ambient Light Conditions	
42	3117880	2012	5:09 PM	23-May-2012	Property damage only (none ir	Rear-end	V1:Westbound / V2:Westbound	Dry	Daylight	Clear
43	3156371	2012	2:43 PM	04-Jun-2012	Property damage only (none ir	Angle	V1:Eastbound / V2:Westbound	Wet	Daylight	Rain
44	3223751	2012	6:55 AM	30-Jul-2012	Property damage only (none ir	Rear-end	V1:Eastbound / V2:Eastbound	Dry	Daylight	Clear
45	3247974	2012	1:12 PM	18-Aug-2012	Property damage only (none ir	Single vehicle crast	V1:Northbound	Dry	Daylight	Cloudy
46	3248003	2012	9:21 AM	30-Aug-2012	Property damage only (none ir	Angle	V1:Westbound / V2:Eastbound	Dry	Daylight	Clear
47	3265247	2012	2:22 PM	04-Sep-2012	Property damage only (none ir	Sideswipe, same di	V1:Eastbound / V2:Eastbound	Wet	Daylight	Rain/Cloudy
48	3265261	2012	9:47 AM	14-Sep-2012	Property damage only (none ir	Angle	V1:Eastbound / V2:Westbound	Dry	Daylight	Clear
49	3285588	2012	5:59 PM	10-Oct-2012	Property damage only (none ir	Sideswipe, same di	V1:Southbound / V2:Southbound / V3	Wet	Daylight	Cloudy
50	3299785	2012	2:15 PM	10-Nov-2012	Property damage only (none ir	Angle	V1:Eastbound / V2:Northbound	Dry	Daylight	Clear

INTERSECTION CRASH RATE WORKSHEET

CITY/TOWN : Milford COUNTY : DA DATE : 3/10/2014

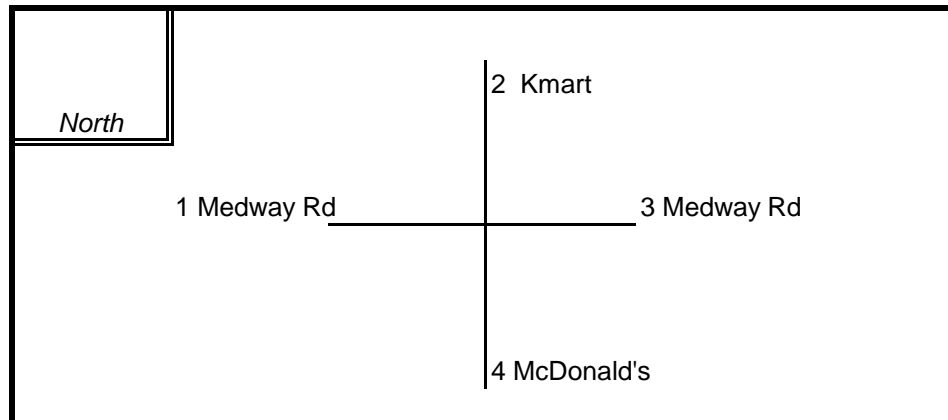
DISTRICT : 3 UNSIGNALIZED : SIGNALIZED :

~ INTERSECTION DATA ~

MAJOR STREET : Medway Road

MINOR STREET(S) : Kmart/ McDonald's Driveways

**INTERSECTION
 DIAGRAM
 (Label Approaches)**



PEAK HOUR VOLUMES

APPROACH :	1	2	3	4	5	Total Peak Hourly Approach Volume
DIRECTION :	EB	SB	WB	NB		
PEAK HOURLY VOLUMES (AM/PM) :	689	108	508	74		1,379

" K " FACTOR : **0.090** INTERSECTION ADT (V) = TOTAL DAILY APPROACH VOLUME : **15,322**

TOTAL # OF CRASHES : **49** # OF YEARS : **3** AVERAGE # OF CRASHES PER YEAR (A) : **16.33**

CRASH RATE CALCULATION :

2.92

$$\text{RATE} = \frac{(A * 1,000,000)}{(V * 365)}$$

Comments : High-crash location, ranks 34th on the 2012 Top-200 Intersection Crash List

Project Title & Date: Safety and Operations Analysis at Selected Intersections

INTERSECTION CRASH RATE WORKSHEET

CITY/TOWN : Milford COUNTY : 3/10/2014

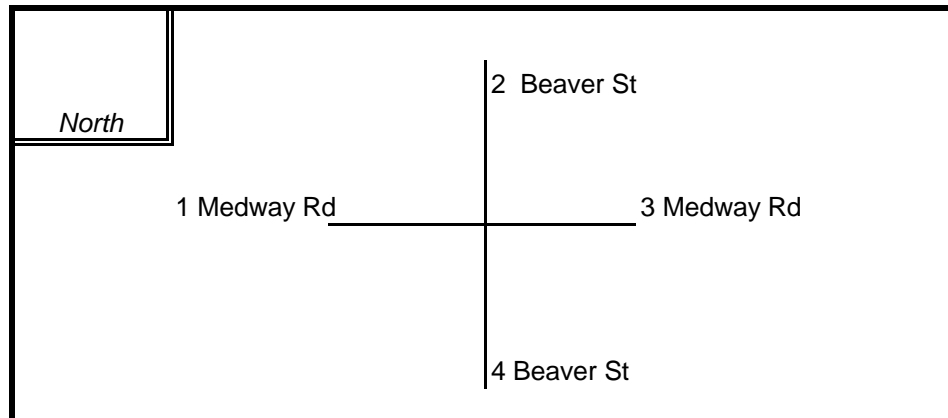
DISTRICT : 3 UNSIGNALIZED : SIGNALIZED :

~ INTERSECTION DATA ~

MAJOR STREET : Medway Road

MINOR STREET(S) : Beaver St

**INTERSECTION
 DIAGRAM
 (Label Approaches)**



PEAK HOUR VOLUMES

APPROACH :	1	2	3	4	5	Total Peak Hourly Approach Volume
DIRECTION :	EB	SB	WB	NB		
PEAK HOURLY VOLUMES (AM/PM) :	692	627	774	489		2,582

" K " FACTOR : INTERSECTION ADT (V) = TOTAL DAILY APPROACH VOLUME :

TOTAL # OF CRASHES : # OF YEARS : AVERAGE # OF CRASHES PER YEAR (A) :

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

Comments : _____

Project Title & Date: Safety and Operations Analysis at Selected Intersections

Crash Data for Collision Diagram (2011 to 2013)

Collision ID	Crash Year	Crash Time	Crash Date1	Crash Severity	Manner of Collision	Road Surface	Ambient Light	Weather Condition	Vehicle Action	Vehicle Composition
1	2011	2:43 PM	07-Dec-2011	Property damage only (n	Rear-end	Wet	Daylight	Rain	V1: Slowing or stopped in traffic / V2:Travelling straight ahead	
2	2011	1:07 PM	22-Aug-2011	Property damage only (n	Angle	Dry	Daylight	Clear	V1: Entering traffic lane / V2:Travelling st	V1: Passenger car / V2:Passenger car
3	2011	7:31 AM	07-Jul-2011	Property damage only (n	Angle	Dry	Daylight	Clear	V1: Turning left / V2:Travelling straight ah	V1: Passenger car / V2:Passenger car
4	2011	4:23 PM	30-Dec-2011	Property damage only (n	Angle	Dry	Daylight	Clear	V1: Entering traffic lane / V2: Traveling straight ahead	
5	2012	5:47 PM	08-Dec-2012	Property damage only (n	Angle	Wet	Daylight	Cloudy	V1: Entering traffic lane / V2: Travelling straight ahead	
6	2013	2:47 PM	03-Sep-2013	Non-fatal injury	Angle	Dry	Daylight	Cloudy	V1: Turning left / V2:Travelling straight ahead	
7	2013	3:48 PM	15-Aug-2013	Property damage only (n	Angle	Dry	Daylight	Clear	V1: Travelling straight ahead / V2:Turning left	
8	2012	6:41 AM	18-Jan-2012	Property damage only (n	Angle	Dry	Dawn	Clear	V1: Turning left / V2:Travelling straight ahead	
9	2013	5:39 PM	12-Feb-2013	Property damage only (n	Rear-end	Dry	Dark - lighted rc	Clear	V1: Slowing or stopped in traffic / V2:Travelling straight ahead	
10	2013	1:53 PM	28-Mar-2013	Property damage only (n	Angle	Dry	Daylight	Clear	V1: Entering traffic lane / V2: Travelling straight ahead	
11	2013	1:22 PM	24-Mar-2013	Property damage only (n	Rear-end	Dry	Daylight	Clear	V1: Slowing or stopped in traffic / V2:Slowing or stopped in traffic / V3: Traveling straight ahead	
12	2013	10:48 AM	19-Mar-2013	Non-fatal injury	Angle	Wet	Daylight	Freezing rain	V1: Travelling straight ahead / V2:Turning left	
13	2013	1:58 PM	03-Mar-2013	Property damage only (n	Angle	Dry	Daylight	Clear	V1: Travelling straight ahead / V2:Turning left	
14	2013	4:30 PM	13-Mar_2013	Property damage only (n	Rear-end	Dry	Daylight	Clear	V1: Slowing or stopped in traffic / V2:Slowing or stopped in traffic / V3: Traveling straight ahead	
15	2013	6:25 AM	22-May-2013	Property damage only (n	Angle	Wet	Daylight	Cloudy	V1: Travelling straight ahead / V2:Turning right	
16	2013	5:12 PM	30-May-2013	Property damage only (n	Sideswipe, same	Dry	Daylight	Clear	V1: Changing traffic lane / V2 Traveling straight ahead	
17	2013	6:31 PM	02-Aug-2013	Property damage only (n	Angle	Dry	Daylight	Clear	V1: Turning left / V2:Travelling straight ahead	
18	2013	4:07 PM	17-Nov-2013	Property damage only (n	Angle	Wet	Daylight	Rain	V1: Turning left / V2:Travelling straight ahead	
19	2013	8:34 PM	29-Nov-2013	Property damage only (n	Angle	Dry	Dark - lighted rc	Clear	V1: Travelling straight ahead / V2:Entering traffic lane	
20	2013	1:53 PM	05-Dec-2013	Property damage only (n	Angle	Dry	Daylight	Clear	V1: Entering traffic lane / V2: Travelling straight ahead	
21	2011	3:49 PM	20-Jan-2011	Property damage only (n	Angle	Dry	Daylight	Clear	V1: Slowing or stopped in traffic / V2:Turning left	
22	2011	5:10 PM	03-Jan-2011	Property damage only (n	Angle	Dry	Dark - lighted rc	Clear	V1: Turning left / V2:Travelling straight ahead / V3:Parked	
23	2011	3:00 PM	05-Apr-2011	Property damage only (n	Angle	Wet	Daylight	Rain	V1: Travelling straight ahead / V2:Turning	V1: Passenger car / V2:Passenger car
24	2011	7:56 AM	15-Aug-2011	Non-fatal injury	Angle	Wet	Daylight	Rain	V1: Turning left / V2:Travelling straight ahead	
25	2011	1:55 PM	02-Dec-2011	Property damage only (n	Angle	Dry	Daylight	Clear	V1: Travelling straight ahead / V2:Turning left	
26	2012	5:40 PM	17-Feb-2012	Property damage only (n	Rear-end	Dry	Dark - lighted rc	Clear	V1: Travelling straight ahead / V2:Stopped in traffic	
27	2012	12:35 PM	15-Mar-2012	Property damage only (n	Angle	Dry	Daylight	Cloudy	V1: Travelling straight ahead / V2:Entering traffic lane	
28	2012	2:43 PM	04-Jun-2012	Property damage only (n	Angle	Wet	Daylight	Rain	V1: Travelling straight ahead / V2:Entering traffic lane	
29	2012	6:55 AM	30-Jun-2012	Property damage only (n	Rear-end	Dry	Daylight	Clear	V1: Travelling straight ahead / V2:Stopped in traffic	
30	2012	6:51 AM	19-Jul-2012	Property damage only (n	Angle	Dry	Daylight	Wet	V1: Travelling straight ahead / V2:Entering traffic lane	
31	2012	9:21 AM	30-Aug-2012	Property damage only (n	Angle	Dry	Daylight	Clear	V1: Travelling straight ahead / V2:Turning left	
32	2012	2:15 PM	10-Nov-2012	Property damage only (n	Angle	Dry	Daylight	Clear	V1: Travelling straight ahead / V2:Entering traffic lane	
33	2011	11:07 AM	09-Jan-2011	Property damage only (n	Sideswipe, same	Dry	Daylight	Clear	V1: Turning right / V2:Turning left	
34	2012	9:04 PM	23-Jan-2012	Property damage only (n	Rear-end	Dry	Daylight	Clear	V1: Slowing or stopped in traffic / V2:Traveling straight ahead	
35	2011	2:57 PM	13-Jan-2011	Property damage only (n	Sideswipe, same	Dry	Daylight	Clear	V1: Turning left	
36	2012	6:41 PM	17-Feb-2012	Property damage only (n	Rear-end	Dry	Dark - lighted rc	Clear	V1:Travelling straight ahead / V2:Slowing or stopped in traffic / V3: Slowing or stopped in traff	
37	2012	5:02 PM	02-Feb-2012	Property damage only (n	Angle	Wet	Dark - lighted rc	Rain	V1: Travelling straight ahead / V2:Turning left	
38	2013	3:10 PM	30-Mar-2013	Non-fatal injury	Rear-end	Dry	Daylight	Clear	V1: Slowing or stopped in traffic / V2:Traveling straight ahead	
39	2011	3:52 PM	03-Mar-2011	Property damage only (n	Angle	Dry	Daylight	Clear	V1: Turning right / V2:Turning left	
40	2012	5:55 PM	01-Apr-2012	Property damage only (n	Rear-end	Wet	Daylight	Rain	V1: Slowing or stopped in traffic / V2:Traveling straight ahead	
41	2013	12:30 PM	31-May-2013	Non-fatal injury	Angle	Dry	Daylight	Clear	V1: Turning left / V2:Travelling straight ahead	
42	2011	3:32 PM	06-May-2011	Property damage only (n	Rear-end	Dry	Daylight	Clear	V1: Slowing or stopped in traffic / V2:Travelling straight ahead	
43	2012	9:33 AM	12-May-2012	Non-fatal injury	Angle	Dry	Daylight	Clear	V1: Turning right / V2:Traveleing straight ahead	
44	2013	6:04 PM	14-Jun-2013	Property damage only (n	Angle	Dry	Daylight	Clear	V1: Turning right / V2:Traveleing straight ahead	
45	2011	11:02 AM	28-Jun-2011	Property damage only (n	Rear-end	Dry	Daylight	Clear	V1: Slowing or stopped in traffic / V2:Slowing or stopped in traffic	

Crash Data for Collision Diagram (2011 to 2013)

Collision ID	Crash Year	Crash Time	Crash Date1	Crash Severity	Manner of Collision	Road Surface	Ambient Light	Weather Condition	Vehicle Action	Vehicle Composition
46	2012	3:03 PM	08-Jun-2012	Property damage only (n	Angle	Dry	Daylight	Clear	V1:Traveleing straight ahead / V2: Turning right	
47	2011	2:36 PM	01-Sep-2011	Property damage only (n	Angle	Dry	Daylight	Clear	V1: Turning right / V2:Turning right	
48	2012	9:47 AM	14-Sep-2012	Property damage only (n	Angle	Dry	Daylight	Clear	V1: Turning left / V2:Travelling straight ahead	
51	2011	11:53 AM	26-Jun-2011	Property damage only (n	Angle	Dry	Daylight	Clear	V1: Turning left / V2:Travelling straight at	V1: Passenger car / V2:Passenger car
52	2011	1:03 PM	24-Jun-2011	Property damage only (n	Angle	Dry	Daylight	Clear/Cloudy	V1: Turning left / V2:Travelling straight at	V1: Passenger car / V2:Passenger car
54	2011	1:11 PM	08-Oct-2011	Non-fatal injury	Angle	Dry	Daylight	Clear	V1: Turning left / V2:Travelling straight at	V1: Truck/trailer / V2:Passenger car
55	2011	4:38 PM	18-Oct-2011	Property damage only (n	Sideswipe, oppo	Dry	Daylight	Clear	V1: Turning left / V2:Travelling straight at	V1: Passenger car / V2:Passenger car
56	2012	11:20 AM	06-Jan-2012	Property damage only (n	Angle	Dry	Daylight	Cloudy	V1: Travelling straight ahead / V2:Turning	V1: Passenger car / V2:Passenger car
57	2012	10:51 AM	24-Mar-2012	Property damage only (n	Angle	Dry	Daylight	Cloudy	V1: Turning left / V2:Turning left	V1: Passenger car / V2:Passenger car
58	2012	10:00 PM	03-May-2012	Non-fatal injury	Angle	Dry	Dark - lighted rc	Clear	V1: Travelling straight ahead / V2:Turning	V1: Passenger car / V2:Passenger car
59	2012	7:52 AM	02-May-2012	Non-fatal injury	Sideswipe, same	Dry	Daylight	Cloudy	V1: Travelling straight ahead / V2:Travelli	V1: Passenger car / V2:Passenger car
60	2012	2:55 PM	29-Nov-2012	Property damage only (n	Angle	Dry	Daylight	Clear	V1: Turning left / V2:Travelling straight at	V1: Passenger car / V2:Light truck(van, mini-van, pan
61	2012	12:14 PM	29-Dec-2012	Property damage only (n	Angle	Dry	Daylight	Cloudy	V1: Slowing or stopped in traffic / V2:Tra	V1: Passenger car / V2:Tractor and semi-trailor
62	2012	2:37 PM	19-Dec-2012	Property damage only (n	Angle	Dry	Daylight	Cloudy	V1: Travelling straight ahead / V2:Turning	V1: Passenger car / V2:Passenger car
63	2012	5:31 PM	07-Dec-2012	Property damage only (n	Angle	Wet	Dark - lighted rc	Rain	V1: Travelling straight ahead / V2:Turning	V1: Passenger car / V2:Passenger car
64	2013	12:11 PM	04-Jan-2013	Non-fatal injury	Angle	Dry	Dark - lighted rc	Clear	V1: Turning left / V2:Travelling straight at	V1: Passenger car / V2:Passenger car
65	2013	6:43 PM	13-Apr-2013	Property damage only (n	Angle	Dry	Daylight	Clear	V1: Slowing or stopped in traffic / V2:Unk	V1: Passenger car / V2:Unknown
66	2013	12:30 PM	22-Jul-2013	Property damage only (n	Angle	Dry	Daylight	Clear	V1: Turning left / V2:Travelling straight at	V1: Passenger car / V2:Passenger car
67	2013	11:50 PM	02-Aug-2013	Non-fatal injury	Sideswipes	Dry	Daylight	Clear	V1: Travelling straight ahead / V2:Travelli	V1:Other / V2: Passenger car
68	2013	3:17 PM	14-Aug-2013	Non-fatal injury	Angle	Dry	Daylight	Clear	V1: Travelling straight ahead / V2:Turning	V1: Passenger car / V2:Passenger car

APPENDIX 8

Level of Service Analysis

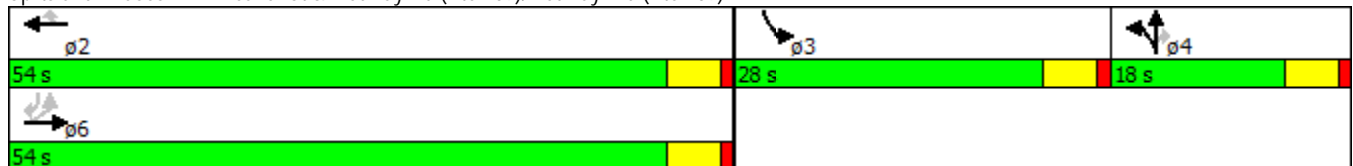
Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	15	340	0	0	775	375	20	75	90	220	0	55
Satd. Flow (prot)	0	3399	0	0	3406	1524	1703	1792	1524	3303	0	1524
Flt Permitted		0.913					0.950			0.950		
Satd. Flow (perm)	0	3109	0	0	3406	1524	1703	1792	1524	3303	0	1524
Satd. Flow (RTOR)						391			94			76
Adj. Flow (vph)	16	354	0	0	807	391	21	78	94	229	0	57
Lane Group Flow (vph)	0	370	0	0	807	391	21	78	94	229	0	57
Turn Type	Perm	NA			NA	Perm	Split	NA	Perm	Prot		Perm
Protected Phases		6			2		4	4		3		
Permitted Phases	6					2			4			6
Total Split (s)	54.0	54.0			54.0	54.0	18.0	18.0	18.0	28.0		54.0
Total Lost Time (s)		5.0			5.0	5.0	5.0	5.0	5.0	5.0		5.0
Act Effct Green (s)		49.3			49.3	49.3	9.2	9.2	9.2	16.1		49.3
Actuated g/C Ratio		0.57			0.57	0.57	0.11	0.11	0.11	0.18		0.57
v/c Ratio		0.21			0.42	0.38	0.12	0.41	0.39	0.38		0.06
Control Delay		10.6			12.5	2.4	37.3	44.2	13.2	34.4		1.8
Queue Delay		0.0			0.0	0.0	0.0	0.0	0.0	0.0		0.0
Total Delay		10.6			12.5	2.4	37.3	44.2	13.2	34.4		1.8
LOS		B			B	A	D	D	B	C		A
Approach Delay		10.6			9.2			28.3				
Approach LOS		B			A			C				
Queue Length 50th (ft)		52			132	0	11	42	0	59		0
Queue Length 95th (ft)		84			192	42	33	85	43	97		12
Internal Link Dist (ft)		266			400			487			431	
Turn Bay Length (ft)						200	150		150	200		200
Base Capacity (vph)		1759			1927	1032	255	269	308	877		895
Starvation Cap Reductn		0			0	0	0	0	0	0		0
Spillback Cap Reductn		0			0	0	0	0	0	0		0
Storage Cap Reductn		0			0	0	0	0	0	0		0
Reduced v/c Ratio		0.21			0.42	0.38	0.08	0.29	0.31	0.26		0.06

Intersection Summary

Cycle Length: 100
 Actuated Cycle Length: 87.1
 Control Type: Actuated-Uncoordinated
 Maximum v/c Ratio: 0.42
 Intersection Signal Delay: 13.9
 Intersection Capacity Utilization 53.0%
 Analysis Period (min) 15

Intersection LOS: B
 ICU Level of Service A

Splits and Phases: 1: Beaver St & Medway Rd (Rte 109)/Medway Rd (Rte 109)



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	70	625	0	0	510	270	35	75	385	510	0	120
Satd. Flow (prot)	0	3522	0	0	3539	1583	1770	1863	1583	3433	0	1583
Flt Permitted		0.828					0.950			0.950		
Satd. Flow (perm)	0	2930	0	0	3539	1583	1770	1863	1583	3433	0	1583
Satd. Flow (RTOR)						293			127			130
Adj. Flow (vph)	76	679	0	0	554	293	38	82	418	554	0	130
Lane Group Flow (vph)	0	755	0	0	554	293	38	82	418	554	0	130
Turn Type	Perm	NA			NA	Perm	Split	NA	Perm	Prot		Perm
Protected Phases		6			2		4	4		3		
Permitted Phases	6					2			4			3
Total Split (s)	48.0	48.0			48.0	48.0	18.0	18.0	18.0	24.0		24.0
Total Lost Time (s)		5.0			5.0	5.0	5.0	5.0	5.0	5.0		5.0
Act Effct Green (s)		43.0			43.0	43.0	13.9	13.9	13.9	18.1		18.1
Actuated g/C Ratio		0.48			0.48	0.48	0.15	0.15	0.15	0.20		0.20
v/c Ratio		0.54			0.33	0.32	0.14	0.29	1.19	0.80		0.31
Control Delay		18.3			15.2	2.7	35.1	37.3	137.2	44.0		7.8
Queue Delay		0.0			0.0	0.0	0.0	0.0	0.0	0.0		0.0
Total Delay		18.3			15.2	2.7	35.1	37.3	137.2	44.0		7.8
LOS		B			B	A	D	D	F	D		A
Approach Delay		18.3			10.9			114.8				
Approach LOS		B			B			F				
Queue Length 50th (ft)		152			98	0	19	42	-232	153		0
Queue Length 95th (ft)		206			135	41	48	85	#416	211		45
Internal Link Dist (ft)		266			400			491			640	
Turn Bay Length (ft)							200			200		200
Base Capacity (vph)		1399			1690	909	272	287	351	724		436
Starvation Cap Reductn		0			0	0	0	0	0	0		0
Spillback Cap Reductn		0			0	0	0	0	0	0		0
Storage Cap Reductn		0			0	0	0	0	0	0		0
Reduced v/c Ratio		0.54			0.33	0.32	0.14	0.29	1.19	0.77		0.30

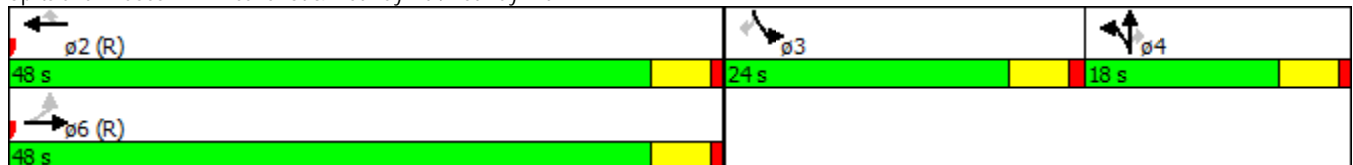
Intersection Summary

Cycle Length: 90
 Actuated Cycle Length: 90
 Offset: 0 (0%), Referenced to phase 2:WBT and 6:EBTL, Start of Green
 Control Type: Actuated-Coordinated
 Maximum v/c Ratio: 1.19
 Intersection Signal Delay: 39.0
 Intersection Capacity Utilization 69.4%
 Analysis Period (min) 15
 Intersection LOS: D
 ICU Level of Service C

~ Volume exceeds capacity, queue is theoretically infinite.
 Queue shown is maximum after two cycles.

95th percentile volume exceeds capacity, queue may be longer.
 Queue shown is maximum after two cycles.

Splits and Phases: 1: Beaver St & Medway Rd /Medway Rd



Intersection												
Int Delay, s/veh	0.7											
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Vol, veh/h	20	315	30	35	800	20	0	0	0	0	0	20
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Free	Free	Stop	Stop	Stop	Stop	Stop	Stop
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	-	-	-	-	-	0
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	96	96	96	96	96	96	96	96	96	96	96	96
Heavy Vehicles, %	6	6	6	6	6	6	2	2	2	2	2	2
Mvmt Flow	21	328	31	36	833	21	0	0	0	0	0	21
Major/Minor	Major1			Major2			Minor2					
Conflicting Flow All	854	0	0	359	0	0	1123	1318	427			
Stage 1	-	-	-	-	-	-	917	917	-			
Stage 2	-	-	-	-	-	-	206	401	-			
Critical Hdwy	4.22	-	-	4.22	-	-	6.84	6.54	6.94			
Critical Hdwy Stg 1	-	-	-	-	-	-	5.84	5.54	-			
Critical Hdwy Stg 2	-	-	-	-	-	-	5.84	5.54	-			
Follow-up Hdwy	2.26	-	-	2.26	-	-	3.52	4.02	3.32			
Pot Cap-1 Maneuver	756	-	-	1168	-	-	199	156	576			
Stage 1	-	-	-	-	-	-	350	349	-			
Stage 2	-	-	-	-	-	-	808	599	-			
Platoon blocked, %	-	-	-	-	-	-	-	-	-			
Mov Cap-1 Maneuver	756	-	-	1168	-	-	181	0	576			
Mov Cap-2 Maneuver	-	-	-	-	-	-	181	0	-			
Stage 1	-	-	-	-	-	-	329	0	-			
Stage 2	-	-	-	-	-	-	780	0	-			
Approach	EB			WB			SB					
HCM Control Delay, s	0.7			0.5			11.5					
HCM LOS							B					
Minor Lane/Major Mvmt	EBL	EBT	EBR	WBL	WBT	WBR	SBLn1					
Capacity (veh/h)	756	-	-	1168	-	-	576					
HCM Lane V/C Ratio	0.028	-	-	0.031	-	-	0.036					
HCM Control Delay (s)	9.9	0.2	-	8.2	0.2	-	11.5					
HCM Lane LOS	A	A	-	A	A	-	B					
HCM 95th %tile Q(veh)	0.1	-	-	0.1	-	-	0.1					

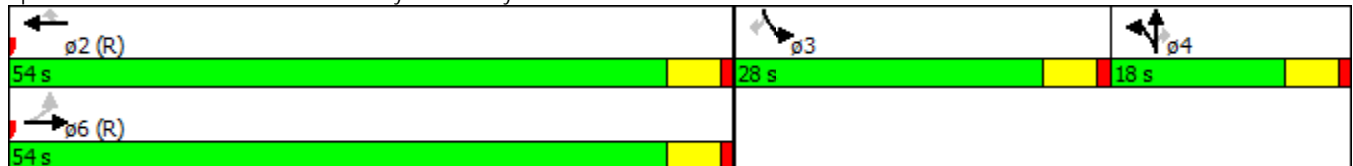
Intersection												
Int Delay, s/veh	2											
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Vol, veh/h	90	645	30	35	595	40	0	0	0	0	0	110
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Free	Free	Stop	Stop	Stop	Stop	Stop	Stop
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	-	-	-	-	-	0
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	92	92	92	92	92	92	92	92	92	92	92	92
Heavy Vehicles, %	2	2	2	2	2	2	2	2	2	2	2	2
Mvmt Flow	98	701	33	38	647	43	0	0	0	0	0	120
Major/Minor	Major1			Major2			Minor2					
Conflicting Flow All	690	0	0	734	0	0	1291	1674	345			
Stage 1	-	-	-	-	-	-	745	745	-			
Stage 2	-	-	-	-	-	-	546	929	-			
Critical Hdwy	4.14	-	-	4.14	-	-	6.84	6.54	6.94			
Critical Hdwy Stg 1	-	-	-	-	-	-	5.84	5.54	-			
Critical Hdwy Stg 2	-	-	-	-	-	-	5.84	5.54	-			
Follow-up Hdwy	2.22	-	-	2.22	-	-	3.52	4.02	3.32			
Pot Cap-1 Maneuver	900	-	-	867	-	-	155	95	651			
Stage 1	-	-	-	-	-	-	430	419	-			
Stage 2	-	-	-	-	-	-	544	344	-			
Platoon blocked, %	-	-	-	-	-	-	-	-	-			
Mov Cap-1 Maneuver	900	-	-	867	-	-	117	0	651			
Mov Cap-2 Maneuver	-	-	-	-	-	-	117	0	-			
Stage 1	-	-	-	-	-	-	399	0	-			
Stage 2	-	-	-	-	-	-	443	0	-			
Approach	EB			WB			SB					
HCM Control Delay, s	1.7			0.8			11.8					
HCM LOS							B					
Minor Lane/Major Mvmt	EBL	EBT	EBR	WBL	WBT	WBR	SBLn1					
Capacity (veh/h)	900	-	-	867	-	-	651					
HCM Lane V/C Ratio	0.109	-	-	0.044	-	-	0.184					
HCM Control Delay (s)	9.5	0.7	-	9.3	0.3	-	11.8					
HCM Lane LOS	A	A	-	A	A	-	B					
HCM 95th %tile Q(veh)	0.4	-	-	0.1	-	-	0.7					

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	35	340	0	0	775	375	20	75	90	220	0	55
Satd. Flow (prot)	1703	1792	0	0	3406	1524	1703	1792	1524	3303	0	1524
Flt Permitted	0.292						0.950			0.950		
Satd. Flow (perm)	523	1792	0	0	3406	1524	1703	1792	1524	3303	0	1524
Satd. Flow (RTOR)						402			97			76
Adj. Flow (vph)	38	365	0	0	832	402	21	80	97	236	0	59
Lane Group Flow (vph)	38	365	0	0	832	402	21	80	97	236	0	59
Turn Type	Perm	NA			NA	Perm	Split	NA	Perm	Prot		Perm
Protected Phases		6			2		4	4		3		
Permitted Phases	6					2			4			3
Total Split (s)	54.0	54.0			54.0	54.0	18.0	18.0	18.0	28.0		28.0
Total Lost Time (s)	5.0	5.0			5.0	5.0	5.0	5.0	5.0	5.0		5.0
Act Effct Green (s)	59.2	59.2			59.2	59.2	9.8	9.8	9.8	16.0		16.0
Actuated g/C Ratio	0.59	0.59			0.59	0.59	0.10	0.10	0.10	0.16		0.16
v/c Ratio	0.12	0.34			0.41	0.38	0.13	0.46	0.41	0.45		0.19
Control Delay	11.2	12.1			12.2	2.2	41.3	50.3	14.0	41.1		7.4
Queue Delay	0.0	0.0			0.0	0.0	0.0	0.0	0.0	0.0		0.0
Total Delay	11.2	12.1			12.2	2.2	41.3	50.3	14.0	41.1		7.4
LOS	B	B			B	A	D	D	B	D		A
Approach Delay		12.0			8.9			31.5				
Approach LOS		B			A			C				
Queue Length 50th (ft)	10	111			140	0	12	49	0	71		0
Queue Length 95th (ft)	29	185			200	41	34	92	46	108		26
Internal Link Dist (ft)		266			400			491			431	
Turn Bay Length (ft)	50						200			200		200
Base Capacity (vph)	309	1060			2017	1066	223	234	283	759		409
Starvation Cap Reductn	0	0			0	0	0	0	0	0		0
Spillback Cap Reductn	0	0			0	0	0	0	0	0		0
Storage Cap Reductn	0	0			0	0	0	0	0	0		0
Reduced v/c Ratio	0.12	0.34			0.41	0.38	0.09	0.34	0.34	0.31		0.14

Intersection Summary

Cycle Length: 100
 Actuated Cycle Length: 100
 Offset: 0 (0%), Referenced to phase 2:WBT and 6:EBTL, Start of Green
 Control Type: Actuated-Coordinated
 Maximum v/c Ratio: 0.46
 Intersection Signal Delay: 15.1
 Intersection Capacity Utilization 53.8%
 Analysis Period (min) 15
 Intersection LOS: B
 ICU Level of Service A

Splits and Phases: 1: Beaver St & Medway Rd/Medway Rd

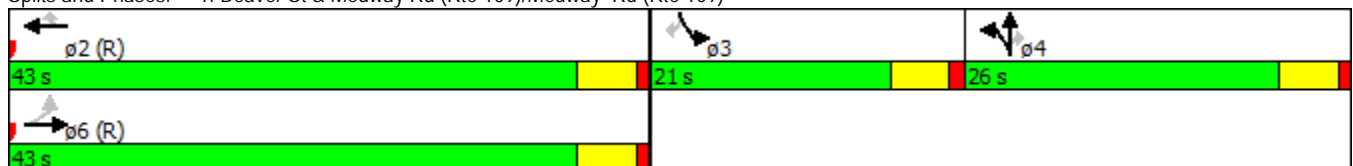


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	160	625	0	0	510	270	35	75	385	510	0	120
Satd. Flow (prot)	1770	1863	0	0	3539	1583	1770	1863	1583	3433	0	1583
Flt Permitted	0.375						0.950			0.950		
Satd. Flow (perm)	699	1863	0	0	3539	1583	1770	1863	1583	3433	0	1583
Satd. Flow (RTOR)						302			90			134
Adj. Flow (vph)	179	700	0	0	571	302	39	84	431	571	0	134
Lane Group Flow (vph)	179	700	0	0	571	302	39	84	431	571	0	134
Turn Type	Perm	NA			NA	Perm	Split	NA	Perm	Prot		Perm
Protected Phases		6			2		4	4		3		
Permitted Phases	6					2			4			3
Total Split (s)	43.0	43.0			43.0	43.0	26.0	26.0	26.0	21.0		21.0
Total Lost Time (s)	5.0	5.0			5.0	5.0	5.0	5.0	5.0	5.0		5.0
Act Effct Green (s)	38.0	38.0			38.0	38.0	21.0	21.0	21.0	16.0		16.0
Actuated g/C Ratio	0.42	0.42			0.42	0.42	0.23	0.23	0.23	0.18		0.18
v/c Ratio	0.61	0.89			0.38	0.36	0.09	0.19	0.98	0.94		0.34
Control Delay	30.8	39.9			18.9	3.4	27.9	29.2	68.5	61.5		8.7
Queue Delay	0.0	0.0			0.0	0.0	0.0	0.0	0.0	0.0		0.0
Total Delay	30.8	39.9			18.9	3.4	27.9	29.2	68.5	61.5		8.7
LOS	C	D			B	A	C	C	E	E		A
Approach Delay		38.0			13.5			59.6				
Approach LOS		D			B			E				
Queue Length 50th (ft)	77	358			114	0	17	38	200	166		0
Queue Length 95th (ft)	155	#579			156	46	43	77	#394	#266		48
Internal Link Dist (ft)		266			400			491			640	
Turn Bay Length (ft)	50					250	200			200		200
Base Capacity (vph)	295	786			1494	842	413	434	438	610		391
Starvation Cap Reductn	0	0			0	0	0	0	0	0		0
Spillback Cap Reductn	0	0			0	0	0	0	0	0		0
Storage Cap Reductn	0	0			0	0	0	0	0	0		0
Reduced v/c Ratio	0.61	0.89			0.38	0.36	0.09	0.19	0.98	0.94		0.34

Intersection Summary

Cycle Length: 90
 Actuated Cycle Length: 90
 Offset: 0 (0%), Referenced to phase 2:WBT and 6:EBTL, Start of Green
 Control Type: Actuated-Coordinated
 Maximum v/c Ratio: 0.98
 Intersection Signal Delay: 38.0 Intersection LOS: D
 Intersection Capacity Utilization 85.1% ICU Level of Service E
 Analysis Period (min) 15
 # 95th percentile volume exceeds capacity, queue may be longer.
 Queue shown is maximum after two cycles.

Splits and Phases: 1: Beaver St & Medway Rd (Rte 109)/Medway Rd (Rte 109)

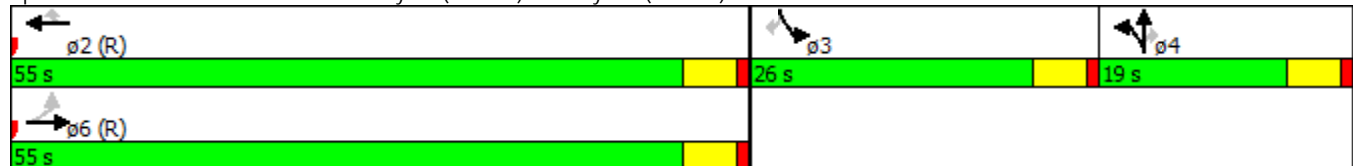


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	15	340	0	0	775	375	20	75	90	220	0	55
Satd. Flow (prot)	0	3399	0	0	3406	1524	1703	1792	1524	3303	0	1524
Flt Permitted		0.911					0.950			0.950		
Satd. Flow (perm)	0	3103	0	0	3406	1524	1703	1792	1524	3303	0	1524
Satd. Flow (RTOR)						402			97			76
Adj. Flow (vph)	16	365	0	0	832	402	21	80	97	236	0	59
Lane Group Flow (vph)	0	381	0	0	832	402	21	80	97	236	0	59
Turn Type	Perm	NA			NA	Perm	Split	NA	Perm	Prot		Perm
Protected Phases		6			2		4	4		3		
Permitted Phases	6					2			4			3
Total Split (s)	55.0	55.0			55.0	55.0	19.0	19.0	19.0	26.0		26.0
Total Lost Time (s)		5.0			5.0	5.0	5.0	5.0	5.0	5.0		5.0
Act Effct Green (s)		59.2			59.2	59.2	9.8	9.8	9.8	16.0		16.0
Actuated g/C Ratio		0.59			0.59	0.59	0.10	0.10	0.10	0.16		0.16
v/c Ratio		0.21			0.41	0.38	0.13	0.46	0.41	0.45		0.19
Control Delay		10.2			12.2	2.2	41.3	50.3	14.0	41.1		7.4
Queue Delay		0.0			0.0	0.0	0.0	0.0	0.0	0.0		0.0
Total Delay		10.2			12.2	2.2	41.3	50.3	14.0	41.1		7.4
LOS		B			B	A	D	D	B	D		A
Approach Delay		10.2			8.9			31.5				
Approach LOS		B			A			C				
Queue Length 50th (ft)		54			140	0	12	49	0	71		0
Queue Length 95th (ft)		86			200	41	34	92	46	108		26
Internal Link Dist (ft)		266			400			491			431	
Turn Bay Length (ft)							200			200		200
Base Capacity (vph)		1837			2017	1066	238	250	296	693		380
Starvation Cap Reductn		0			0	0	0	0	0	0		0
Spillback Cap Reductn		0			0	0	0	0	0	0		0
Storage Cap Reductn		0			0	0	0	0	0	0		0
Reduced v/c Ratio		0.21			0.41	0.38	0.09	0.32	0.33	0.34		0.16

Intersection Summary

Cycle Length: 100
 Actuated Cycle Length: 100
 Offset: 0 (0%), Referenced to phase 2:WBT and 6:EBTL, Start of Green, Master Intersection
 Control Type: Actuated-Coordinated
 Maximum v/c Ratio: 0.46
 Intersection Signal Delay: 14.8
 Intersection Capacity Utilization 53.8%
 Analysis Period (min) 15
 Intersection LOS: B
 ICU Level of Service A

Splits and Phases: 1: Beaver St & Medway Rd (Rte 109)/Medway Rd (Rte 109)

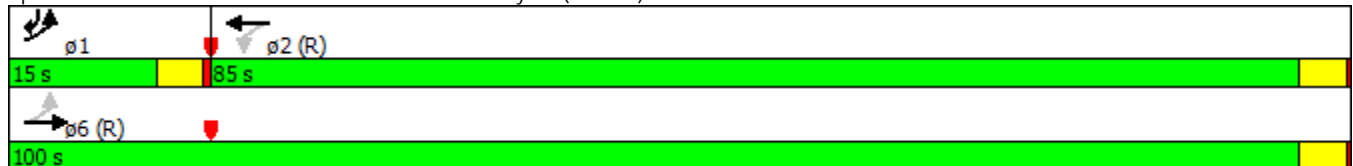


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	20	315	30	35	800	20	0	0	0	0	0	25
Satd. Flow (prot)	0	3355	0	0	3389	0	0	0	0	0	0	1611
Flt Permitted		0.895			0.923							
Satd. Flow (perm)	0	3011	0	0	3134	0	0	0	0	0	0	1611
Satd. Flow (RTOR)					9							275
Adj. Flow (vph)	21	338	32	38	858	21	0	0	0	0	0	27
Lane Group Flow (vph)	0	391	0	0	917	0	0	0	0	0	0	27
Turn Type	pm+pt	NA		Perm	NA							Over
Protected Phases	1	6			2							1
Permitted Phases	6			2								
Total Split (s)	15.0	100.0		85.0	85.0							15.0
Total Lost Time (s)		4.0			4.0							4.0
Act Effct Green (s)		97.6			91.9							5.5
Actuated g/C Ratio		0.98			0.92							0.06
v/c Ratio		0.13			0.32							0.08
Control Delay		0.2			0.9							0.4
Queue Delay		0.0			0.1							0.0
Total Delay		0.2			1.0							0.4
LOS		A			A							A
Approach Delay		0.2			1.0							
Approach LOS		A			A							
Queue Length 50th (ft)		0			10							0
Queue Length 95th (ft)		0			10							0
Internal Link Dist (ft)		398			266			104				26
Turn Bay Length (ft)												
Base Capacity (vph)		2950			2881							421
Starvation Cap Reductn		0			736							0
Spillback Cap Reductn		0			0							0
Storage Cap Reductn		0			0							0
Reduced v/c Ratio		0.13			0.43							0.06

Intersection Summary

Cycle Length: 100
 Actuated Cycle Length: 100
 Offset: 0 (0%), Referenced to phase 2:WBTL and 6:EBTL, Start of Green
 Control Type: Actuated-Coordinated
 Maximum v/c Ratio: 0.32
 Intersection Signal Delay: 0.7
 Intersection Capacity Utilization 41.7%
 Analysis Period (min) 15
 Intersection LOS: A
 ICU Level of Service A

Splits and Phases: 2: McDonalds Dr/Kmart Dr & Medway Rd (Rte 109)

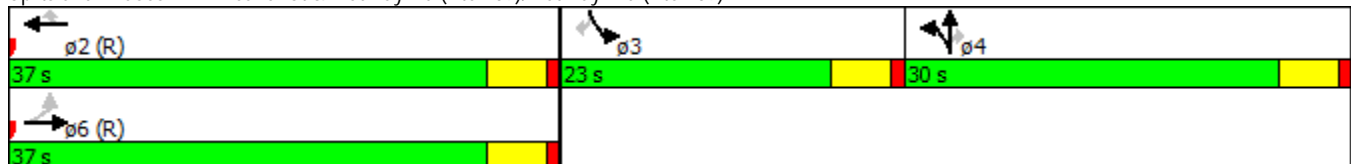


	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group												
Lane Configurations		↕↕			↕↕	↕	↕	↕	↕	↕↕		↕
Volume (vph)	70	625	0	0	510	270	35	75	385	510	0	120
Satd. Flow (prot)	0	3522	0	0	3539	1583	1770	1863	1583	3433	0	1583
Flt Permitted		0.786					0.950			0.950		
Satd. Flow (perm)	0	2782	0	0	3539	1583	1770	1863	1583	3433	0	1583
Satd. Flow (RTOR)						302			85			134
Adj. Flow (vph)	78	700	0	0	571	302	39	84	431	571	0	134
Lane Group Flow (vph)	0	778	0	0	571	302	39	84	431	571	0	134
Turn Type	Perm	NA			NA	Perm	Split	NA	Perm	Prot		Perm
Protected Phases		6			2		4	4		3		
Permitted Phases	6					2			4			3
Total Split (s)	37.0	37.0			37.0	37.0	30.0	30.0	30.0	23.0		23.0
Total Lost Time (s)		5.0			5.0	5.0	5.0	5.0	5.0	5.0		5.0
Act Effct Green (s)		34.1			34.1	34.1	23.3	23.3	23.3	17.6		17.6
Actuated g/C Ratio		0.38			0.38	0.38	0.26	0.26	0.26	0.20		0.20
v/c Ratio		0.74			0.43	0.38	0.09	0.17	0.91	0.85		0.32
Control Delay		29.8			22.6	4.1	24.8	26.1	51.2	48.5		8.0
Queue Delay		0.8			0.0	0.0	0.0	0.0	0.0	0.0		0.0
Total Delay		30.6			22.6	4.1	24.8	26.1	51.2	48.5		8.0
LOS		C			C	A	C	C	D	D		A
Approach Delay		30.6			16.2			45.5				
Approach LOS		C			B			D				
Queue Length 50th (ft)		205			129	0	16	36	190	161		0
Queue Length 95th (ft)		279			177	53	41	72	#360	#243		46
Internal Link Dist (ft)		266			400			491			640	
Turn Bay Length (ft)							200			200		200
Base Capacity (vph)		1054			1341	787	491	517	501	686		423
Starvation Cap Reductn		85			0	0	0	0	0	0		0
Spillback Cap Reductn		0			0	0	0	0	0	0		0
Storage Cap Reductn		0			0	0	0	0	0	0		0
Reduced v/c Ratio		0.80			0.43	0.38	0.08	0.16	0.86	0.83		0.32

Intersection Summary

Cycle Length: 90
 Actuated Cycle Length: 90
 Offset: 0 (0%), Referenced to phase 2:WBT and 6:EBTL, Start of Green, Master Intersection
 Control Type: Actuated-Coordinated
 Maximum v/c Ratio: 0.91
 Intersection Signal Delay: 31.6 Intersection LOS: C
 Intersection Capacity Utilization 71.1% ICU Level of Service C
 Analysis Period (min) 15
 # 95th percentile volume exceeds capacity, queue may be longer.
 Queue shown is maximum after two cycles.

Splits and Phases: 1: Beaver St & Medway Rd (Rte 109)/Medway Rd (Rte 109)

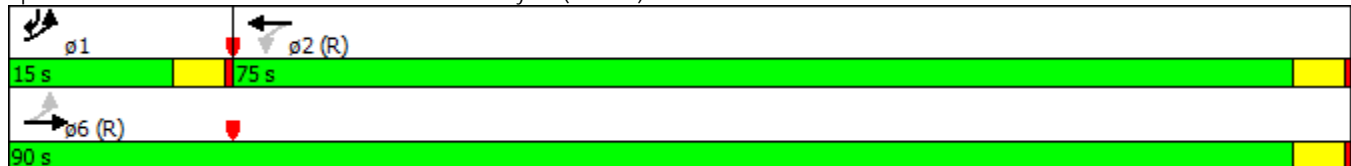


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	88	620	30	35	595	40	0	0	0	0	0	110
Satd. Flow (prot)	0	3497	0	0	3497	0	0	0	0	0	0	1611
Flt Permitted		0.771			0.880							
Satd. Flow (perm)	0	2712	0	0	3086	0	0	0	0	0	0	1611
Satd. Flow (RTOR)					24							366
Adj. Flow (vph)	99	694	34	39	666	45	0	0	0	0	0	123
Lane Group Flow (vph)	0	827	0	0	750	0	0	0	0	0	0	123
Turn Type	pm+pt	NA		Perm	NA							Over
Protected Phases	1	6			2							1
Permitted Phases	6			2								
Total Split (s)	15.0	90.0		75.0	75.0							15.0
Total Lost Time (s)		4.0			4.0							4.0
Act Effct Green (s)		86.0			76.5							5.5
Actuated g/C Ratio		0.96			0.85							0.06
v/c Ratio		0.31			0.29							0.28
Control Delay		0.4			1.2							1.6
Queue Delay		0.0			0.1							0.0
Total Delay		0.4			1.3							1.6
LOS		A			A							A
Approach Delay		0.4			1.3							
Approach LOS		A			A							
Queue Length 50th (ft)		0			14							0
Queue Length 95th (ft)		0			12							0
Internal Link Dist (ft)		398			266			27				26
Turn Bay Length (ft)												
Base Capacity (vph)		2639			2626							518
Starvation Cap Reductn		0			584							0
Spillback Cap Reductn		122			0							0
Storage Cap Reductn		0			0							0
Reduced v/c Ratio		0.33			0.37							0.24

Intersection Summary

Cycle Length: 90
 Actuated Cycle Length: 90
 Offset: 77 (86%), Referenced to phase 2:WBTL and 6:EBTL, Start of Green
 Control Type: Actuated-Coordinated
 Maximum v/c Ratio: 0.31
 Intersection Signal Delay: 0.9
 Intersection LOS: A
 Intersection Capacity Utilization 47.2%
 ICU Level of Service A
 Analysis Period (min) 15

Splits and Phases: 2: McDonalds Dr/Kmart Dr & Medway Rd (Rte 109)



LANE SUMMARY

Site: Medway Road and Beaver Street AM

Long-Term Alternative
 Roundabout
 Design Life Analysis (Practical Capacity): Results for 10 years

Lane Use and Performance													
	Demand Flows			Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue		Lane Config	Lane Length ft	Cap. Adj. %	Prob. Block. %
	Total veh/h	HV %	Cap. veh/h					Veh	Dist ft				
South: Beaver Street													
Lane 1 ^d	102	6.0	668	0.153	100	7.1	LOS A	0.4	10.1	Full	1600	0.0	0.0
Lane 2	97	6.0	646	0.150	98 ⁵	7.3	LOS A	0.4	10.4	Full	1600	0.0	0.0
Approach	199	6.0		0.153		7.2	LOS A	0.4	10.4				
East: Medway Road													
Lane 1	616	6.0	954	0.646	100	13.6	LOS B	3.5	91.0	Full	1600	0.0	0.0
Lane 2 ^d	621	6.0	961	0.646	100	13.6	LOS B	3.3	85.9	Full	1600	0.0	0.0
Approach	1237	6.0		0.646		13.6	LOS B	3.5	91.0				
North: Beaver Street													
Lane 1	145	6.0	540	0.268	100	10.4	LOS B	0.8	19.7	Full	1600	0.0	0.0
Lane 2 ^d	151	6.0	565	0.268	100	10.0	LOS B	0.7	18.9	Full	1600	0.0	0.0
Approach	296	6.0		0.268		10.2	LOS B	0.8	19.7				
West: Medway Road													
Lane 1	199	6.0	732	0.272	100	8.1	LOS A	0.8	21.0	Full	1600	0.0	0.0
Lane 2 ^d	204	6.0	750	0.272	100	7.9	LOS A	0.8	20.0	Full	1600	0.0	0.0
Approach	404	6.0		0.272		8.0	LOS A	0.8	21.0				
Intersection	2136	6.0		0.646		11.5	LOS B	3.5	91.0				

Level of Service (LOS) Method: Delay & v/c (HCM 2010).

Roundabout LOS Method: Same as Sign Control.

Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.

LOS F will result if v/c > irrespective of lane delay value (does not apply for approaches and intersection).

Intersection and Approach LOS values are based on average delay for all lanes (v/c not used as specified in HCM 2010).

Roundabout Capacity Model: US HCM 2010.

HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

Gap-Acceptance Capacity: Traditional M1.

HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

⁵ Lane under-utilisation found by the program

^d Dominant lane on roundabout approach

LANE SUMMARY

Site: Medway Road and Beaver Street PM

Long-Term Alternative
 Roundabout
 Design Life Analysis (Practical Capacity): Results for 10 years

Lane Use and Performance													
	Demand Flows			Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue		Lane Config	Lane Length ft	Cap. Adj. %	Prob. Block. %
	Total veh/h	HV %	Cap. veh/h					Veh	Dist ft				
South: Beaver Street													
Lane 1	268	2.0	364	0.735	100	36.5	LOS E	3.2	81.8	Full	1600	0.0	0.0
Lane 2 ^d	288	2.0	392	0.735	100	34.4	LOS D	3.2	80.3	Full	1600	0.0	0.0
Approach	556	2.0		0.735		35.4	LOS E	3.2	81.8				
East: Medway Road													
Lane 1	435	2.0	879	0.495	100	10.5	LOS B	2.2	54.6	Full	1600	0.0	0.0
Lane 2 ^d	441	2.0	892	0.495	100	10.4	LOS B	2.0	51.8	Full	1600	0.0	0.0
Approach	876	2.0		0.495		10.5	LOS B	2.2	54.6				
North: Beaver Street													
Lane 1	348	2.0	694	0.502	100	12.8	LOS B	2.1	53.3	Full	1600	0.0	0.0
Lane 2 ^d	359	2.0	716	0.502	100	12.5	LOS B	2.0	51.0	Full	1600	0.0	0.0
Approach	707	2.0		0.502		12.7	LOS B	2.1	53.3				
West: Medway Road													
Lane 1	459	2.0	607	0.757	100	25.8	LOS D	4.5	115.1	Full	1600	0.0	0.0
Lane 2 ^d	478	2.0	632	0.757	100	25.0	LOS C	4.4	111.4	Full	1600	0.0	0.0
Approach	938	2.0		0.757		25.4	LOS D	4.5	115.1				
Intersection	3077	2.0		0.757		20.0	LOS C	4.5	115.1				

Level of Service (LOS) Method: Delay & v/c (HCM 2010).

Roundabout LOS Method: Same as Sign Control.

Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.

LOS F will result if v/c > irrespective of lane delay value (does not apply for approaches and intersection).

Intersection and Approach LOS values are based on average delay for all lanes (v/c not used as specified in HCM 2010).

Roundabout Capacity Model: US HCM 2010.

HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

Gap-Acceptance Capacity: Traditional M1.

HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

^d Dominant lane on roundabout approach

APPENDIX 9

Roundabout Proposal

MEMORANDUM

DATE: June 17, 2009
TO: Mr. Larry L. Dunkin, AICP – Town Planner
FROM: Douglas C. Prentiss, P.E., PTOE/Sarah E. Weimer
SUBJECT: Beaver Street Round-About Feasibility Study- Milford, Massachusetts

INTRODUCTION

Fay Spofford & Thorndike (FST) has been contracted by the Town of Milford to conduct a Feasibility Study for assessing the roadway network for a proposed roundabout at the Medway Street (Route 109)/Beaver Street signalized intersection in Milford, Massachusetts. The intent of this circulation change is to provide direct access to the Bear Hill Industrial Area from Medway Street in the I-495 area. Presently Beaver Street is one-way northbound at this intersection, so only egress is provided from the Bear Hill Industrial Area at this location. All other legs at this intersection are two-way. Access and egress to the Bear Hill Industrial Area is provided via the signalized intersection of Medway Street (Route 109)/Birch Street. This intersection is approximately ½ mile west of the Beaver Street location, thus a significant number of drivers destined for the Bear Hill Industrial Area who travel on this section of Medway Street, could otherwise enter the Industrial Area via Beaver Street.

To gain insight with the vehicle operations in the area, a field reconnaissance was conducted of the area on May 14, 2009 to collect signal timing and phasing information, roadway and lane widths, identify traffic control features and area land uses.

Documents available to us for this study that have been completed in the area, include:

- *Technical Memorandum- South Central Estates II*; Gillon Associates; February 8, 2000;
- *Traffic Impact & Access Study-Proposed Quarry Place*; MS transportation Systems, Inc. May 2003;
- *Traffic Impact Assessment-; Proposed Housing Subdivision on Beaver Street*; Gillon Associates; November, 2004

EXISTING CONDITIONS

Medway Street (Route 109)/Beaver Street

The Medway Street (Route 109)/Beaver Street intersection is presently signalized and operates with split phasing for the north and southbound approaches. Land use in the area consists of vacant land in the southeast quadrant, a McDonalds restaurant on the southwest quadrant, a Mobil gas station on the northwest corner and a Burger King on the northeast corner of the intersection. Pedestrian accommodations are provided at this intersection.

Medway Street (Route 109)/I-495 Southbound Ramps

This signalized intersection is approximately 450 feet east of the Medway Street/Beaver Street intersection, and provides access to/from the southbound ramps. Land use is vacant in all quadrants at the intersection. The lane configuration at these intersections is shown in Table 1.

Table 1 – Intersection Configurations				
Intersection	Intersection Approaches			
	Northbound	Southbound	Eastbound	Westbound
Medway/Beaver	- One left turn lane -One through lane -One right turn lane	-Two left turn lanes -One right turn lane	-One through lane -One shared through/left turn lane	-One right turn lane -Two through lanes
Medway/I-495 SB Ramps	NA	-Two left turn lanes -One free right turn lane under yield control	-Two through lanes - -One free right turn lane to I-495 southbound, not under the signal system	-One left turn lane -Two through lanes

NA = not applicable. Departure lanes only

PROPOSED CONDITIONS

The configuration of the intersection of Medway Street (Route 109)/I-495 Southbound Ramps will remain unchanged. However the Medway Street (Route 109)/Beaver Street will be considered for a two-lane roundabout. This proposed scheme can be seen in Figure 1. The alignment of the roundabout is shifted to the south so that a portion of the vacant land in the southeast quadrant is utilized, as well as a portion of the McDonald’s parcel, which is under re-development. All approaches to the roundabout are proposed to be two-lane.

ANALYSIS

For the analysis to follow, it should be pointed out that AM and PM traffic data for this assessment was derived from the traffic studies noted above to create the 2009 Existing Conditions.

To analyze the 2009 Existing Conditions and the 2009 Build Conditions with roundabout, traffic analysis was conducted using procedures outlined in the Highway Capacity Manual (HCM) and SimTraffic. The critical element in this analysis is the limiting distance between the two intersections and the re-assignment of turning traffic to the Beaver Street intersection. The critical distance (425') is westbound in the morning at the Medway Street (Route 109)/Beaver Street intersection and eastbound in the evening peak hour (450') at the Medway Street (Route 109)/I-495 Southbound Ramps. Analysis results showing Level of Service and vehicle queues at these intersections are show in Table 2 for the 2009 Existing Condition and results indicate no back-ups or vehicle queuing into adjacent intersections.

For the 2009 Build Conditions with roundabout, the analysis results are shown in Table 3. It should be pointed out that only the critical eastbound through and westbound through

movements are shown in Table 3 as these movements have the respective limiting distances between intersections as noted earlier.

Intersection	Time Period	Critical Movement	Delay (sec)	95% Q (ft)	LOS
Medway/Beaver	AM/PM	WB Thru	11.3/16.4	170/130	B/B
		WB Right	2.3/3.8	39/0	A/A
		EB left/Thru	9.5/86.0	81/418+	A/F
		NB Left	38.1/28.4	37/55	D/C
		NB Thru	52.8/31.9	96+/105	D/C
		NB Right	16.1/522.2	52/690+	B/F
		SB Left	28.6/70.2	102/315+	C/E
		SB Right	7.3/6.5	41/52	A/A
		OVERALL	13.0/120.8	NA	B/F
Medway/I-495 SB Ramps	AM/PM	WB Thru	6.8/7.2	100/118	A/A
		WB Left	51.6/107.8	133+/201+	D/F
		EB Thru	13.5/18.6	134/265	B/B
		SB left	19.9/21.7	62/99	B/C
		OVERALL	23.2/22.0	NA	C/C

+ Vehicle queue may be longer; **bold-face** = critical movements between intersections

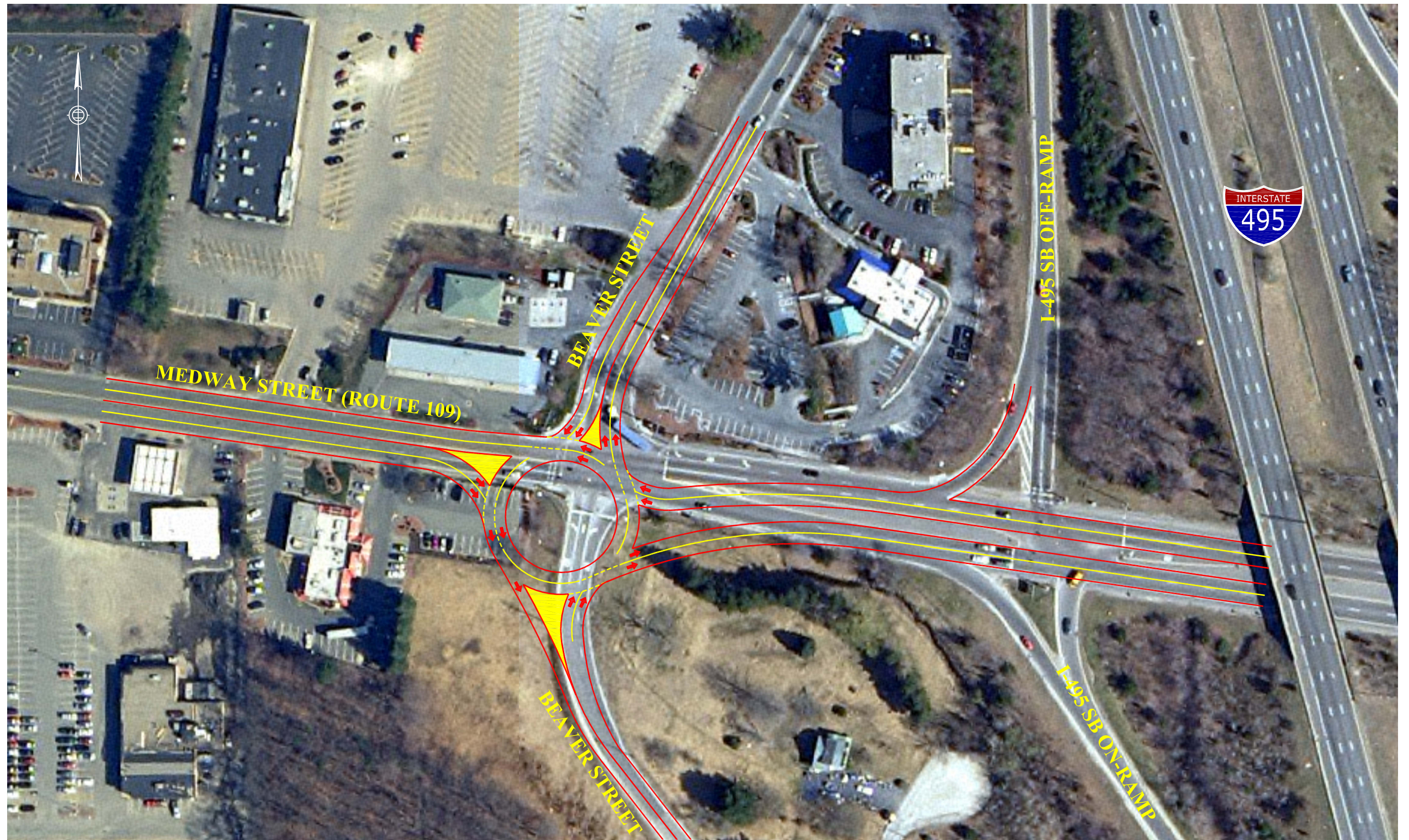
Intersection	Time Period	Critical Movement	Critical Distance	Maximum Queue	Delay (seconds)
Medway/Beaver	AM	WB Thru	425'	371'	7.8
	PM	WB Thru	425'	269'	103.1
Intersection	AM/PM				
Medway/I-495 SB Ramps	AM	EB Thru	450'	133'	13.5
	PM	EB Thru	450'	265'	18.6

Bold-face = critical movements between intersections

As can be seen from Table 3, the calculated vehicle queues from the respective stop lines are within the critical distances, although vehicle delays are longer in the PM peak period.

CONCLUSION

Based on this feasibility assessment and assumptions related to traffic diversions, it appears placement of a roundabout at the Beaver Street intersection with Medway Street is feasible. Any preliminary design should consider compliance with the MassHighway Design Guide and considerations of the volume of truck traffic traveling this corridor.



APPENDIX F

**MassDOT Highway Division
Project Development Process**

Overview of the Project Development Process

Transportation decision making is complex and can be influenced by legislative mandates, environmental regulations, financial limitations, agency programmatic commitments, and partnering opportunities. Decision-makers and reviewing agencies, when consulted early and often throughout the project development process, can ensure that all participants understand the potential impact these factors can have on project implementation. Project development is the process that takes a transportation improvement from concept through construction.

The MassDOT Highway Division has developed a comprehensive project development process, which is contained in Chapter 2 of the *MassDOT Highway Division's Project Development and Design Guide*. The eight-step process covers a range of activities extending from identification of a project need, through completion of a set of finished contract plans, to construction of the project. The sequence of decisions made through the project development process progressively narrows the project focus and, ultimately, leads to a project that addresses the identified needs. The descriptions provided below are focused on the process for a highway project, but the same basic process will need to be followed for non-highway projects as well.

1. Needs Identification

For each of the locations at which an improvement is to be implemented, MassDOT leads an effort to define the problem, establishes project goals and objectives, and defines the scope of the planning needed for implementation. To that end, it has to complete a Project Need Form (PNF), which states in general terms the deficiencies or needs related to the transportation facility or location. The PNF documents the problems and explains why corrective action is needed. For this study, the information defining the need for the project will be drawn primarily, perhaps exclusively, from the present report. Also, at this point in the process, MassDOT meets with potential participants, such as the Metropolitan Planning Organization (MPO) and community members, to allow for an informal review of the project.

The PNF is reviewed by the MassDOT Highway Division district office whose jurisdiction includes the location of the proposed project. MassDOT also sends the PNF to the MPO, for informational purposes. The outcome of this step determines whether the project requires further planning, whether it is already well supported by prior planning studies, and, therefore, whether it is ready to move forward into the design phase, or whether it should be dismissed from further consideration.

2. Planning

This phase will likely not be required for the implementation of the improvements proposed in this planning study, as this planning report should constitute the outcome of this step. However, in general, the purpose of this implementation step is for the project

proponent to identify issues, impacts, and approvals that may need to be obtained, so that the subsequent design and permitting processes are understood.

The level of planning needed will vary widely, based on the complexity of the project. Typical tasks include: define the existing context, confirm project need, establish goals and objectives, initiate public outreach, define the project, collect data, develop and analyze alternatives, make recommendations, and provide documentation. Likely outcomes include consensus on the project definition to enable it to move forward into environmental documentation (if needed) and design, or a recommendation to delay the project or dismiss it from further consideration.

3. Project Initiation

At this point in the process, the proponent, MassDOT Highway Division, fills out a Project Initiation Form (PIF) for each improvement, which is reviewed by its Project Review Committee (PRC) and the MPO. The PRC is composed of the Chief Engineer, each District Highway Director, and representatives of the Project Management, Environmental, Planning, Right-of-Way, Traffic, and Bridge departments, and the MassDOT Federal Aid Program Office (FAPO). The PIF documents the project type and description, summarizes the project planning process, identifies likely funding and project management responsibility, and defines a plan for interagency and public participation. First the PRC reviews and evaluates the proposed project based on the MassDOT's statewide priorities and criteria. If the result is positive, MassDOT Highway Division moves the project forward to the design phase and to programming review by the MPO. The PRC may provide a Project Management Plan to define roles and responsibilities for subsequent steps. The MPO review includes project evaluation based on the MPO's regional priorities and criteria. The MPO may assign project evaluation criteria score, a Transportation Improvement Program (TIP) year, a tentative project category, and a tentative funding category.

4. Environmental Permitting, Design, and Right-of-Way Process

This step has four distinct but closely integrated elements: public outreach, environmental documentation and permitting (if required), design, and right-of-way acquisition (if required). The outcome of this step is a fully designed and permitted project ready for construction. However, a project does not have to be fully designed in order for the MPO to program it in the TIP. The sections below provide more detailed information on the four elements of this step of the project development process.

Public Outreach

Continued public outreach in the design and environmental process is essential to maintain public support for the project and to seek meaningful input on the design elements. The public outreach is often in the form of required public hearings, but can

also include less formal dialogues with those interested in and affected by a proposed project.

Environmental Documentation and Permitting

The project proponent, in coordination with the Environmental Services section of the MassDOT Highway Division, will be responsible for identifying and complying with all applicable federal, state, and local environmental laws and requirements. This includes determining the appropriate project category for both the Massachusetts Environmental Protection Act (MEPA) and the National Environmental Protection Act (NEPA).

Environmental documentation and permitting is often completed in conjunction with the Preliminary Design phase described below.

Design

There are three major phases of design. The first is Preliminary Design, which is also referred to as the 25-percent submission. The major components of this phase include full survey of the project area, preparation of base plans, development of basic geometric layout, development of preliminary cost estimates, and submission of a functional design report. Preliminary Design, although not required to, is often completed in conjunction with the Environmental Documentation and Permitting. The next phase is Final Design, which is also referred to as the 75-percent and 100-percent submission. The major components of this phase include preparation of a subsurface exploratory plan (if required), coordination of utility relocations, development of traffic management plans through construction zones, development of final cost estimates, and refinement and finalization of the construction plans. Once Final Design is complete, a full set of Plans, Specifications, and Estimates (PS&E) is developed for the project.

Right-of-Way Acquisition

A separate set of Right-of-Way plans are required for any project that requires land acquisition or easements. The plans must identify the existing and proposed layout lines, easements, property lines, names of property owners, and the dimensions and areas of estimated takings and easements.

5. Programming (Identification of Funding)

Programming, which typically begins during the design phase, can actually occur at any time during the process, from planning to design. In this step, which is distinct from project initiation, the proponent requests that the MPO place the project in the region's Transportation Improvement Program (TIP). The proponent requesting the project's listing on the TIP can be the community or it can be one of the MPO member agencies (the Regional Planning Agency, MassDOT, and the Regional Transit Authority). The MPO then considers the project in terms of state and regional needs, evaluation criteria,

and compliance with the regional Transportation Plan and decides whether to place it in the draft TIP for public review and then in the final TIP.

6. Procurement

Following project design and programming of a highway project, the MassDOT Highway Division publishes a request for proposals. It then reviews the bids and awards the contract to the qualified bidder with the lowest bid.

7. Construction

After a construction contract is awarded, MassDOT Highway Division and the contractor develop a public participation plan and a management plan for the construction process.

8. Project Assessment

The purpose of this step is to receive constituents' comments on the project development process and the project's design elements. MassDOT Highway Division can apply what is learned in this process to future projects. Table 8 gives the schematic timetable of the project development process.

Project Development Schematic Timetable

Step	Schedule Influence	Typical Duration
<p>Step I: Problem/Need/Opportunity Identification</p> <p>The proponent completes a PNF. This form is reviewed by the MassDOT district office, which guides the proponent in subsequent steps of the process.</p>	<p>The PNF may be prepared quickly by the proponent to include any readily available supporting data. The district office will return comments to the proponent within one month of receiving the PNF.</p>	<p>One-to-three months</p>
<p>Step II: Planning</p> <p>Project planning can range from agreeing on a clear solution to a detailed analysis of alternatives and their impacts.</p>	<p>For some projects, no planning beyond preparation of the PNF is required. Some projects require a planning study centered on specific issues associated with a proposed solution or a narrow family of alternatives. Complex projects likely would require a detailed alternatives analysis.</p>	<p>Project Planning Report: three-to-24+ months</p>
<p>Step III: Project Initiation</p> <p>The proponent prepares and submits a PIF and a TEC form. The MPO and MassDOT district office informally review the PIF and TEC; and the PRC formally reviews them.</p>	<p>The PIF includes refinement of the preliminary information contained in the PNF. Additional information summarizing the results of the planning process, such as the project planning report, is included with the PIF and TEC. The schedule is determined by PRC staff (depending on project complexity) and meeting schedule.</p>	<p>One-to-four months</p>
<p>Step IV: Design, Environmental, and Right-of-Way</p> <p>The proponent completes the project design. Concurrently, the proponent completes necessary environmental permitting analyses and files permit applications. Any right-of-way needed for the project is identified and the acquisition process begins.</p>	<p>The schedule depends upon the size of the project and the complexity of the design, permitting, and right-of-way issues. The MassDOT district and appropriate sections complete the design review.</p>	<p>Three- to-48+ months</p>
<p>Step V: Programming</p> <p>The MPO considers the project in terms of its regional priorities and determines whether to include the project in the draft TIP, which is made available for public comment, and includes a project description and funding source.</p>	<p>The schedule for this step is subject to each MPO's programming cycle and meeting schedule. It is possible that the MPO will not include a project in its draft TIP based on its review and approval procedures.</p>	<p>Three-to-12+ months</p>

Step	Schedule Influence	Typical Duration
<p>Step VI: Procurement</p> <p>The project is advertised for construction and a contract is awarded.</p>	<p>Administration of competing projects can influence the advertising schedule.</p>	<p>One-to-12 months</p>
<p>Step VII: Construction</p> <p>The construction process is initiated including public notification and any anticipated public involvement. Construction continues to project completion.</p>	<p>The duration of this step is entirely dependent upon project complexity and phasing.</p>	<p>Three-to-60+ months</p>
<p>Step VIII: Project Assessment</p> <p>The construction period is complete and project elements and processes are evaluated on a voluntary basis.</p>	<p>The duration of this step is dependent upon the proponent's approach and any required follow-up.</p>	<p>One month</p>

Source: MassDOT Highway Division Project Development and Design Guide.