



CAPE COD  
COMMISSION

## Yarmouth

### Road Safety Audit

Union Street – Station Avenue

At U.S. Route 6 Ramps

**September 2011**





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Prepared by the Cape Cod Commission  
In cooperation with  
The Town of Brewster  
And  
MassDOT Highway Division

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## Background

All levels of government— local, regional, state, and federal—have been considering locations where crashes are most severe for many years. Several years ago the national consensus was that there should be goals to reduce crashes, and in the 2005 federal legislation: Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU), there was more emphasis on improving highway safety along with a dedicated funding program—the Highway Safety Improvement Program (HSIP).

In an effort to reduce the number of crash-related fatalities and incapacitating injuries, Massachusetts developed a Strategic Highway Safety Plan in 2006. The mission of the Safety Plan is to “Develop, promote, implement, and evaluate data-driven, multidisciplinary strategies to maximize safety for users of the roadway system.” One of the many strategies noted in the Safety Plan is to “conduct Road Safety Audits (RSA) at high-crash locations throughout the Commonwealth.” MassDOT incorporated the RSA as a requirement for securing Federal funding (Highway Safety Improvement Program [HSIP] funds) for safety projects.

The Federal Highway Administration (FHWA) defines a Road Safety Audit (RSA) as the formal safety examination of an existing or future road or intersection by an independent, multidisciplinary team. The purpose of an RSA is to identify potential safety issues and possible opportunities for safety improvements while considering all roadway users.

The Cape Cod Commission, serving as the regional planning agency for the fifteen towns on Cape Cod, has reviewed many transportation locations over the years during various processes, including the Regional Transportation Plan, the Transportation Improvement Program, and Developments of Regional Impact, considering the existing safety issues and potential improvements. In addition, the CCC began looking at specific safety locations annually through safety studies and Road Safety Audits (RSAs). A portion of the federal HSIP funds are allocated for improvements to the region’s highest crash locations.

## Introduction

The Town of Yarmouth has approximately 24,000 year-round residents and many seasonal visitors. Yarmouth has historic village areas, local shops and shopping centers, and all three east-west roadways— Route 6A, Route 6, and Route 28—for connections to other Cape Cod towns. Yarmouth, considered to be in the “Mid-Cape” has visitor attractions along with north side beaches on Cape Cod Bay, and warm water south side beaches on Nantucket Sound. In addition the easterly border of town includes Bass River.



The Union Street – Station Avenue and Route 6 Ramp intersections, based on Equivalent Property Damage Only (EPDO)<sup>1</sup>, are the fifth highest crash location on Cape Cod, and were selected by the Cape Cod Joint Transportation Committee (CCJTC) as a Road Safety Audit location. The Town of Yarmouth was contacted for a list of participants in September 2011, and the Road Safety Audit was performed with MassDOT and the Town.

## Project Data

In the spring of 2011 CCC staff requested crash reports and information from both the Town of Yarmouth and the State Police for this Road Safety Audit. With crashes on the Route 6 ramps and also at the ramp intersections with Union Street and Station Avenue, the Registry of Motor Vehicles crash records included both the state and local police as responding to crashes in the vicinity. Although the detailed crash records data were not available at the time of RSA, a summary of crash data information from state records was used to develop a crash diagram at each Route 6 ramp intersection. The crash diagrams and summary developed were reviewed by the team. Turning movement counts (TMCs) to review intersection traffic volumes were performed and also available at the RSA meeting. The crash diagrams, summary data, and the TMC data are included in the appendices.

The Road Safety Audit meeting was held on Monday, September 19, 2011, beginning at 10:30 a.m., at the Yarmouth Disposal Area Office. The multidisciplinary team also visited the site: Union Street – Station Avenue and Route 6 Ramp intersections – during the RSA meeting.

Table 1. Participating Audit Team Members

Audit Team Member	Agency/Affiliation
George Allaire	Superintendent, Yarmouth Department of Public Works
Robert Angell	Yarmouth DPW
Steven Xiarhos, Deputy Chief	Police Department
Michael A. Walker, Chief	Fire Department
Promise Otaluka	Federal Highway Administration – MA Division
Lisa Schletzbaum	MassDOT Highway Division – Safety
Pamela Haznar	MassDOT Highway Division – District 5 Projects
Barbara Lachance	MassDOT Highway Division – District 5 Traffic
Priscilla N. Leclerc	Senior Transportation Planner, Cape Cod Commission

<sup>1</sup> Based on the CCC Report: Barnstable County Intersections of Critical Safety Concern, July 2010

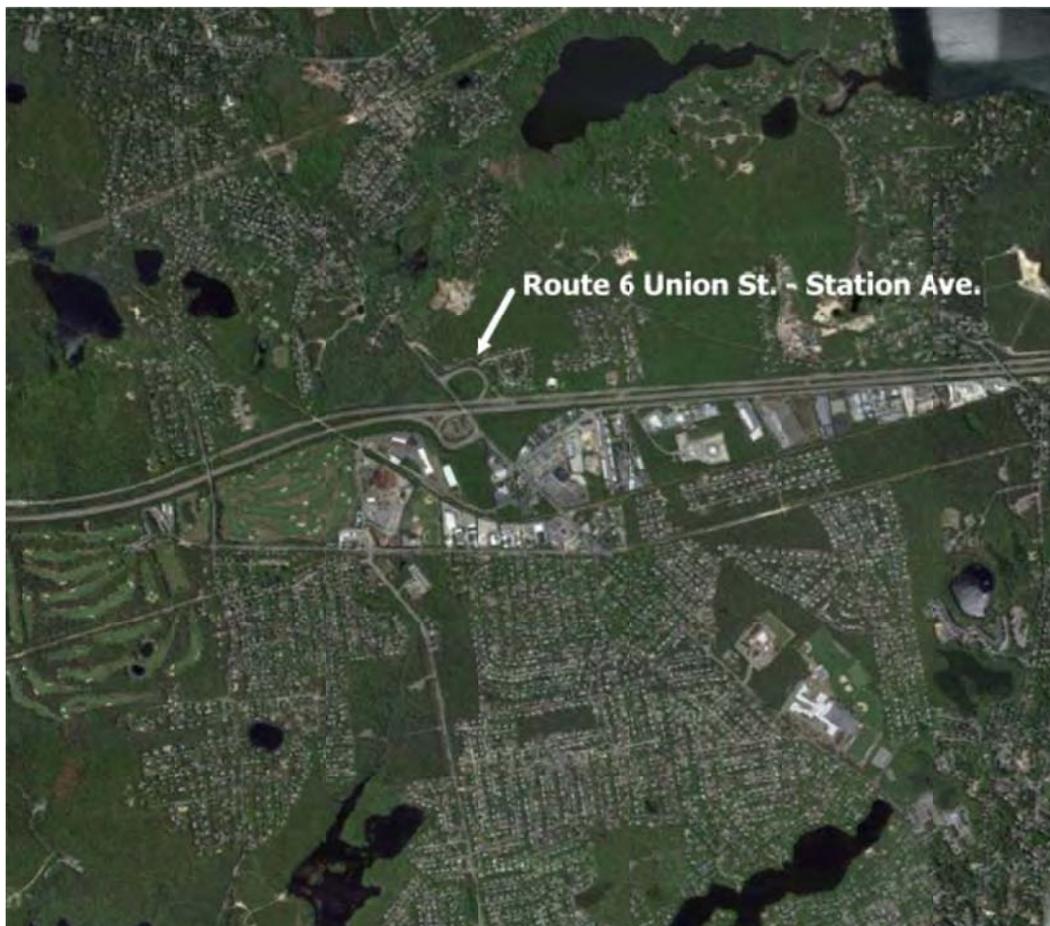


## Project Location and Description

United States Route 6 is the main limited access highway on Cape Cod, with Interchange or Exit 8 leading to Union Street –Station Avenue area in Yarmouth.

Union Street and Station Avenue in the Town of Yarmouth run in a north-south direction and connect Route 6A to the north with Route 28 in the southern part of town. It is also a major junction from United States Route 6 into Yarmouth and to the east into parts of the neighboring Town of Dennis.

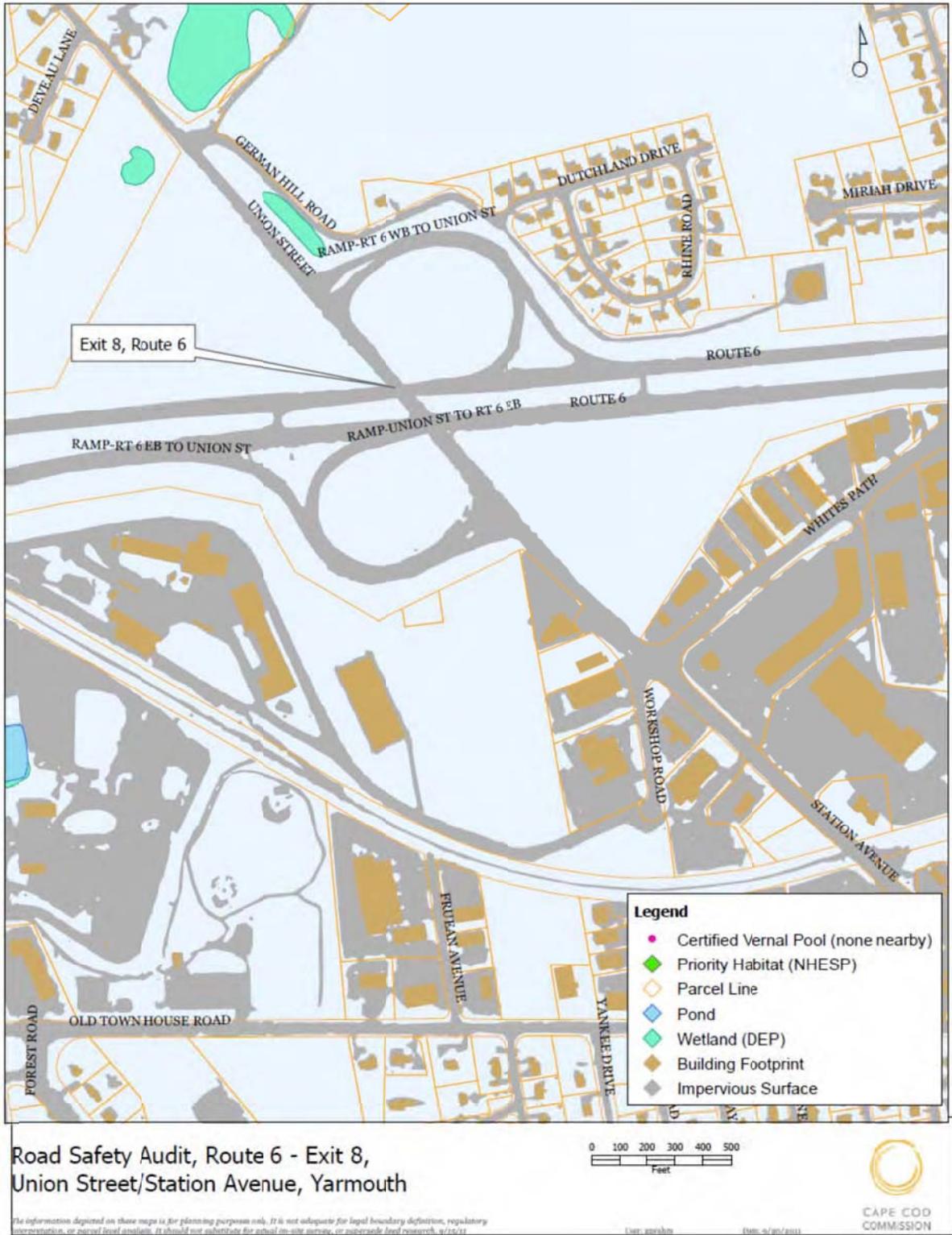
Figure 1. Locus Map





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Figure 2. Land Use and Environmental Map





## Audit Observations and Potential Safety Enhancements

The RSA Team reviewed the crash diagrams and summary that were based on the MassDOT crash database information, along with the traffic volumes, and the turning movement count information.

Previous observations by the team members were mentioned, and included:

- In approximately 45 minutes, five vehicles were seen as exiting the eastbound ramps, then taking a U-turn to get back on the EB ramp
- Perhaps the signage on Route 6 that includes the words “Dennis next two exits” is confusing for some of the drivers on Route 6—who exit and see the “Welcome to Yarmouth” sign
- The area is wide open which may encourage increased speeds
- At the ramps north of Route 6, a car was waiting for a while to take a left turn onto Union Street southbound
- Drivers exiting from the eastbound ramp to head north are deterred from taking a left turn due to the opposing volumes and/or travelling speeds; drivers turn right and then turn around further down Station Avenue
- Instead of using the eastbound ramp to head north, drivers are using another exit to avoid the left turn off the ramp
- This is not a very friendly bicycle or pedestrian location, but there were bicyclists observed going through the area

The team then walked the site and observed both the location and a sample of the traffic operations in the field.

The safety issues noted by the multidisciplinary team are:

- Conflicting traffic volumes and resulting delays
- Speed
- Signage
- Sight distance
- Bicycle and Pedestrian accommodation



## SAFETY ISSUE #1. CONFLICTING VOLUMES

### Observation:

The traffic volumes on Station Avenue averaged 1,649 vehicles per hour for the ten hours beginning at 8 a.m., and the peak hour began at 3:00 p.m. with 1,776 vehicles in that hour as counted in August 2009.

The traffic count data on Union Street north of Route 6 averaged 862 vehicles per hour for the same ten hour time frame based on a June 1996 count. The peak hour was again at 3:00 p.m. with 965 vehicles in that hour.

Casual observations showed vehicles delayed in making left turns both on exiting and entering the ramps. Vehicles travelling SB and turning right to go on Route 6 EB may hide a vehicle that is travelling SB from the view of a vehicle waiting at the end of the ramp.

Turning Movement Counts were performed at both of the Route 6 ramps on September 12, 2011, were brought to the RSA Team meeting, and are included in the appendices.

High traffic volumes along with the conflicting turning movements in and out of each of the Route 6 ramp intersections emerged as the primary safety issue. Angle crashes accounted for 40% of the 2008-2010 reported crashes. Rear-end crashes comprised about 28% of the crashes at both intersections.

It was noted that most of the crashes were not during the summer; 85% occurred in the October to May time frame.



*Station Avenue at Route 6 EB*



*mbs*



*mbs*



**Enhancement:**

Roundabouts were mentioned as a possible long-term improvement to reduce conflicts for both of the Route 6 ramp intersections with Union Street and Station Avenue. The roundabouts would remove left turns from the intersection movements and slow traffic to allow for gaps.



*Station Avenue at Route 6 EB*

Traffic signal systems (not discussed at the meeting) may also be considered for this location.

Left turn pockets were mentioned to allow for vehicles waiting to turn left onto the Route 6 ramps to be out of the north-south flow. If warranted, providing space for vehicles queued to make left turns onto either of the ramps would allow for through vehicles to proceed. This treatment was not preferred by those present due to the high volumes and perceived speeds.



*Union Street at Route 6 WB ramps*



**Observation:**

The posted speed limit on Union Street and Station Avenue in the vicinity of the Route 6 ramps is 40 miles per hour. However, the multidisciplinary team members reported that vehicles appear to be exceeding the posted speeds.

The roadway cross-section is fairly wide, and as vehicles queue for turning left, a portion of the vehicles travelling through are passing around those queued, partly on the shoulder, to continue travelling on the main route. Other vehicles choose to wait behind the left-turning vehicle.



**Enhancement:**

Perform a speed study of the Union Street and Station Avenue corridors in the area of the Route 6 ramps to determine travelling speeds and peak times, if any, for exceeding the posted speed limits.

Following the speed study, focus periodic enforcement to encourage compliance with the speed limits.



Roundabouts at both ramp locations would slow speeds in the area, while providing opportunity for vehicles to turn safely and that may reduce delays overall while improving safety.



## SAFETY ISSUE #3. SIGNAGE

### Observation:

It was mentioned that U-turns had been observed at the eastbound ramp, and that the “Dennis next 2 exits” sign on Route 6 prior to this exit may be the cause of driver confusion. At the bottom of the eastbound ramps there is a “Welcome to Yarmouth” sign.

A comment was made that the guide sign on the Route 6 eastbound off-ramp may be too close to the end of the ramp—too close to the decision point.



■ Approximate location of guide sign

### Enhancement:

Review the Route 6 guide sign language and revise accordingly.

Consider revision or removal of the sign “Dennis next 2 exits” from Route 6 EB, prior to Exit 8, Yarmouth.

Review other sign locations, including the guide sign on the EB off-ramp, for potential improvement.



Route 6 EB ramp at Station Avenue



## SAFETY ISSUE #4. SIGHT DISTANCE

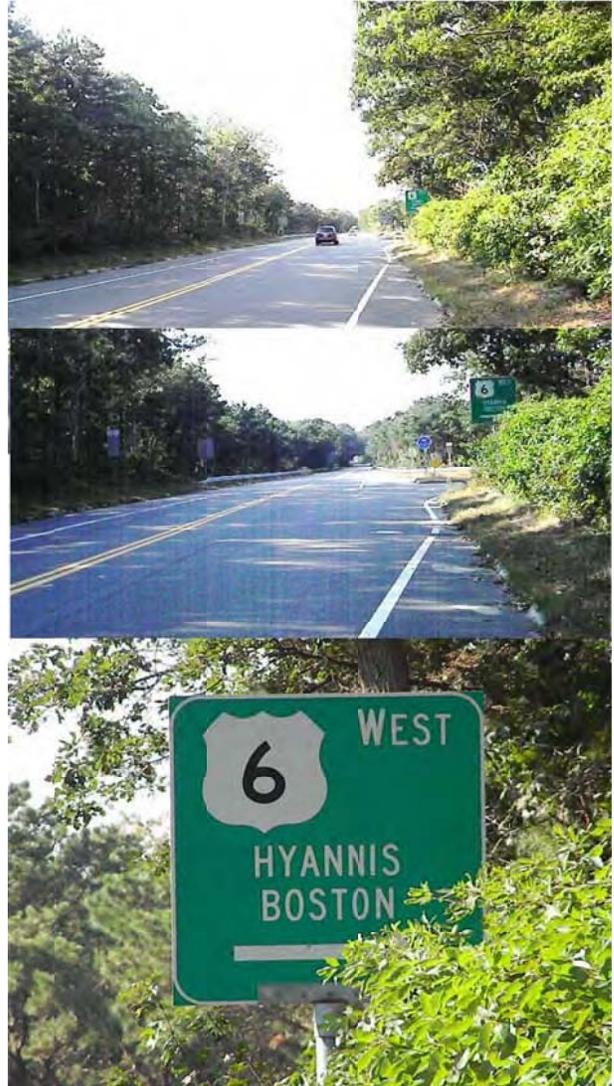
### Observation:

The vegetation in some locations is obscuring visibility.

An example is the Route 6 West sign shown in the photographs to the right.

### Enhancement:

Trim vegetation for improved visibility.



Sign for Route 6 WB on Union Street



## SAFETY ISSUE #5. BICYCLE AND PEDESTRIAN ACCOMMODATION

**Observation:** The bicycle and pedestrian accommodations in this section are limited.

There is a sidewalk on one side –the westbound side of Station Avenue that is not carried over the ramp median areas, and is discontinued just after the Route 6 overpasses.



*rn Ave.*

### **Enhancement:**

Consider improved bicycle/pedestrian accommodation when reconstruction is being considered.



*Street*



## Summary of Road Safety Audit

In the following table, the summary list of the Road Safety Audit observations and enhancements is provided to assist in the design and/or implementation of potential improvements elicited during the process. It is also recommended that for any more involved geometric changes, the design process include further analysis and public input.

Safety payoff estimates are subjective and may be based on the relative percent of crashes that may be reduced by the enhancement based on known and documented crash reduction factors, if available, or estimated crash reduction based on a stated source [for example, low (<30%), medium (31% to 70%), and high (>71%)]. The time frame is categorized as short-term (<1 year), medium-term (1 to 3 years), or long-term (>3 years). The costs are categorized as low (<\$10,000), medium (\$10,001 to \$50,000), or high (>\$50,001).

Many of the "Safety Payoff" estimates in this report were based on crash reduction factors in the *Desktop Reference for Crash Reduction Factors*, Report No. FHWA-SA-08-011 by the U.S. Department of Transportation, Federal Highway Administration, September 2008.

Table 2. Potential Safety Enhancement Summary

Safety Issue	Potential Safety Enhancement	Safety Payoff	Time Frame	Cost	Responsible Agency
<b>Conflicting Volumes</b> High volumes and left turns in and out of Route 6 ramps in both EB and WB directions	Consider a roundabout for both ramp intersections.	High	Long-term	High	MassDOT
	Left turn pockets on Union St. and Station Ave. to delineate area for turning vehicles and allow for through traffic to proceed	Low	Medium-term	Medium	MassDOT
	Consider traffic signals for both ramp intersections.	Low	Long-term	High	MassDOT
<b>Speed</b> Observations were that many vehicles are travelling over the posted speed limit	Perform a speed study to assess speeds and times of violations	Low	Medium-term	Medium	CCC or MassDOT
	Focus enforcement efforts periodically to encourage compliance with posted speed limits	Low	Medium-term	Medium	State
	Consider a roundabout for both ramp intersections.	High	Long-term	High	MassDOT
<b>Signage</b> Possible driver confusion and/or decision difficulty	Remove sign on Route 6 "Dennis next 2 exits" Assess directional signage in terms of decision points and relocate	Low	Medium-term	Medium	MassDOT
<b>Sight Distance</b> Possible driver confusion and decision difficulty	Maintain sight distances through trimming of vegetation	Low	Short-term	Low	MassDOT
<b>Bicycle and Pedestrian Accommodation</b> , sidewalk on one side discontinuous and no separate bicycle accommodation	Consider improved bicycle/pedestrian accommodation when reconstruction is being considered	Medium	Long-term	High	MassDOT

## Appendix A. RSA Meeting Agenda

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## Road Safety Audit Meeting

### Yarmouth, Route 6 On/Off-Ramps at Union Street (Exit 8)

Monday, September 19, 2011

10:30 a.m. – 12:30 p.m.

Location: Yarmouth Disposal Area Office, 606 Forest Road, South Yarmouth, MA  
02664

**10:30 a.m. Welcome and Introductions**

**10:40 a.m. Review of Site Specific Material**

- Crash & Volume Summaries– provided in advance
- Existing Geometries and Conditions

**11:30 a.m. Visit the Site**

- Assemble as a group at the site for observation of conditions
- As a group, identify areas for improvement

**12:00 noon Post Visit Discussion / Completion of RSA**

- Discuss observations and finalize findings
- Discuss potential improvements and finalize recommendations

**12:30 p.m. Adjourn for the Day**

**Next Steps:** After the RSA meeting, participants will be asked to comment and respond to the draft document materials to assure it is reflective of the RSA completed by the multidisciplinary team.

## Appendix B. RSA Audit Team Contact List

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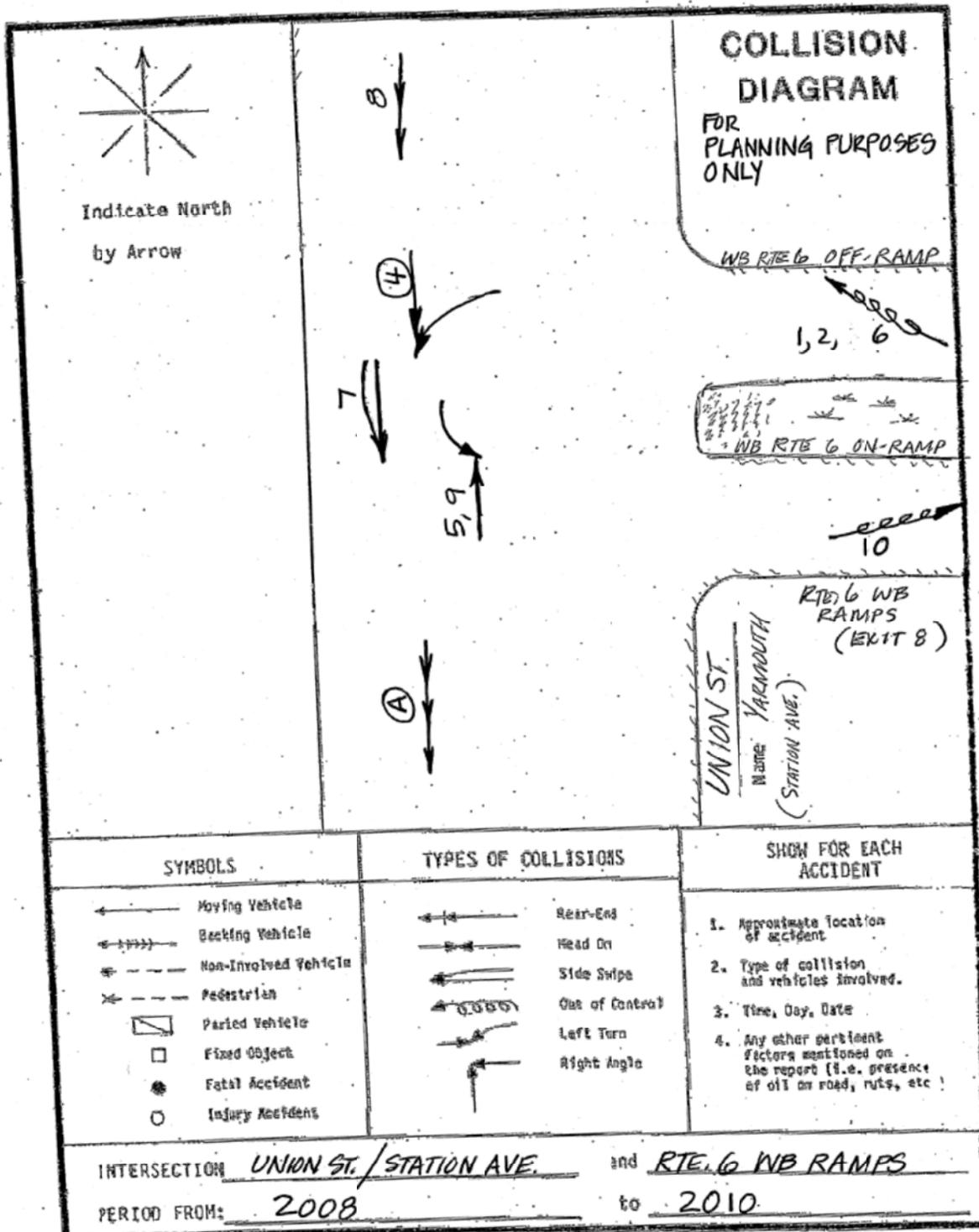
## Participating Audit Team Members

Date: September 19, 2011    Location: Yarmouth Disposal Area Office

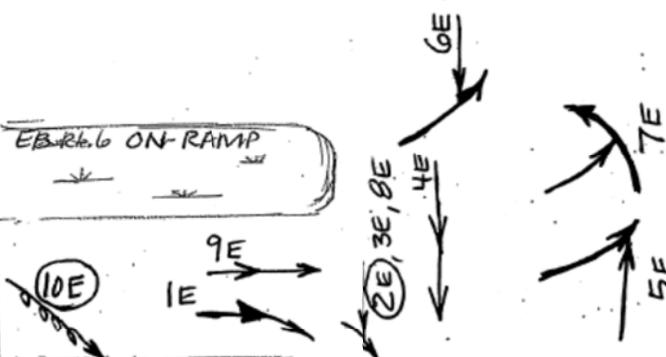
Audit Team Members	Agency/Affiliation	Email Address	Phone Number
George Allaire	Superintendent, Yarmouth Department of Public Works	gallaire@yarmouth.ma.us	508-744-5003
Robert Angell	Yarmouth DPW	rangell@yarmouth.ma.us	508-394-0141
Steven Xiarhos	Deputy Chief, Police Department	sxiarhos@yarmouth.ma.us	508-775-0445 ext. 2150
Michael A. Walker	Chief, Fire Department	mwalker@yarmouth.ma.us	508-398-2122
Promise Otaluka	Federal Highway Administration – MA Division	Promise.Otaluka@DOT.gov	617-494-2528
Lisa Schletzbaum	MassDOT Highway Division– Safety	Lisa.Schletzbaum@state.ma.us	617-973-7685
Pamela Haznar, P.E.	MassDOT Highway Division-District 5, Projects	Pamela.Haznar@state.ma.us	508-884-4239
Barbara Lachance	MassDOT Highway Division-District 5, Traffic	Barbara.Lachance@state.ma.us	508-884-4260
Priscilla N. Leclerc	Senior Transportation Planner, Cape Cod Commission	pleclerc@capecodcommission.org	508-362-3828

## Appendix C. Detailed Crash Data

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Source: MassDOT Highway Division Crash Reports for the location, 2008-2010.

 <p style="text-align: center;">Indicate North by Arrow</p>	<div style="text-align: center;">  </div>	<h2 style="text-align: center;">COLLISION DIAGRAM</h2> <p style="text-align: center;">FOR PLANNING PURPOSES ONLY</p>																												
<p>EB RTE. 6 ON-RAMP</p> <p>EB RTE. 6 OFF-RAMP RTE. 6 EB RAMP</p> <p>Name _____</p>	<p style="text-align: center;">UNION ST. Name YARMOUTH (STATION AVE.)</p>																													
<p style="text-align: center;">SYMBOLS</p> <table style="width: 100%; border-collapse: collapse;"> <tr><td style="text-align: center;">→</td><td>Moving Vehicle</td></tr> <tr><td style="text-align: center;">⇐</td><td>Backing Vehicle</td></tr> <tr><td style="text-align: center;">- - -</td><td>Non-Involved Vehicle</td></tr> <tr><td style="text-align: center;">X</td><td>Pedestrian</td></tr> <tr><td style="text-align: center;">▢</td><td>Parked Vehicle</td></tr> <tr><td style="text-align: center;">□</td><td>Fixed Object</td></tr> <tr><td style="text-align: center;">●</td><td>Fatal Accident</td></tr> <tr><td style="text-align: center;">○</td><td>Injury Accident</td></tr> </table>	→	Moving Vehicle	⇐	Backing Vehicle	- - -	Non-Involved Vehicle	X	Pedestrian	▢	Parked Vehicle	□	Fixed Object	●	Fatal Accident	○	Injury Accident	<p style="text-align: center;">TYPES OF COLLISIONS</p> <table style="width: 100%; border-collapse: collapse;"> <tr><td style="text-align: center;">⇐ →</td><td>Rear-End</td></tr> <tr><td style="text-align: center;">⇐ ⇐</td><td>Head On</td></tr> <tr><td style="text-align: center;">⇐ →</td><td>Side Swipe</td></tr> <tr><td style="text-align: center;">⇐ ↘</td><td>Out of Control</td></tr> <tr><td style="text-align: center;">⇐ ↙</td><td>Left Turn</td></tr> <tr><td style="text-align: center;">⇐ ↘</td><td>Right Angle</td></tr> </table>	⇐ →	Rear-End	⇐ ⇐	Head On	⇐ →	Side Swipe	⇐ ↘	Out of Control	⇐ ↙	Left Turn	⇐ ↘	Right Angle	<p style="text-align: center;">SHOW FOR EACH ACCIDENT</p> <ol style="list-style-type: none"> <li>1. Approximate location of accident</li> <li>2. Type of collision and vehicles involved.</li> <li>3. Time, Day, Date</li> <li>4. Any other pertinent factors mentioned on the report (i.e. presence of oil on road, ruts, etc.)</li> </ol>
→	Moving Vehicle																													
⇐	Backing Vehicle																													
- - -	Non-Involved Vehicle																													
X	Pedestrian																													
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<p>INTERSECTION <u>UNION ST./STATION AVE.</u> and <u>RTE. 6 EB RAMP</u></p> <p>PERIOD FROM: <u>2008</u> to <u>2010</u></p>																														

Source: MassDOT Highway Division Crash Reports for the location, 2008-2010.

Crash Diagram Reference Number	Crash Number	Crash Date	Crash Time	# of injuries	#r of Vehicles	Manner of Collision	Vehicle Action Prior to Crash	Vehicle Travel Directions	Vehicle Sequence of Events	Age of Driver - Youngest Known	Age of Driver - Oldest Known	Road Surface	Weather	Roadway
1	2273337	1/19/2008	9:10 PM	0	1	Single vehicle crash	V1: Travelling straight ahead	V1:W	V1:(Collision with other fixed object(wall, building, tunnel, etc.)),(Collision with tree)	21-24	21-24	Dry	Clear	Rte 6 W
2														
3*	2273372	1/22/2008	7:30 AM	0	1	Single vehicle crash	V1: Travelling straight ahead	V1:W	V1:(Ran off road right),(Collision with curb)	45-54	45-54	Dry	Clear	Rte 6 W
4	2293214	2/21/2008	11:21 AM	1	2	Rear-end	V1: Travelling straight ahead / V2:Turning left	V1:S / V2:S	V1:(Collision with motor vehicle in traffic) V2:(Collision with motor vehicle in traffic)	16-20	35-44	Dry	Clear	UNION STREET / MID CAPE HIGHWAY /
5	2491501	12/13/2008	2:00 PM	0	2	Not reported ANGLE	V1: Turning left / V2:Travelling straight ahead	V1:S / V2:N	V1:(Collision with motor vehicle in traffic) V2:	65-74	75-84	Dry	Clear	UNION STREET Rte 6
6	2437795	12/31/2008	12:10 PM	0	1	Single vehicle crash	V1: Travelling straight ahead	V1:W	V1:(Ran off road left),(Collision with embankment),(Collision with ditch),(Collision with tree)	45-54	45-54	Snow	Sleet, hail (freezing rain or drizzle)	MID CAPE HIGHWAY Rte 6
7	2437916	1/27/2009	9:02 PM	0	2	Sideswipe, same direction	V1: Travelling straight ahead / V2:Slowing or stopped in traffic	V1:S / V2:S	V1:(Collision with motor vehicle in traffic) V2:(Collision with motor vehicle in traffic)	75-84	75-84	Dry	Clear	UNION STREET
8	2574361	7/10/2009	12:13 PM	0	2	Rear-end	V1: Slowing or stopped in traffic / V2:Travelling straight ahead	V1:S / V2:S	V1:(Collision with motor vehicle in traffic) V2:(Collision with motor vehicle in traffic)	16-20	35-44	Dry	Clear	UNION STREET
9	2575071	1/8/2010	4:16 PM	0	2	Angle	V1: Turning left / V2:Travelling straight ahead	V1:W / V2:N	V1:(Collision with motor vehicle in traffic) V2:(Collision with motor vehicle in traffic)	25-34	35-44	Ice	Cloudy	STATION AVENUE
10	2678576	12/26/2010	7:00 PM	0	1	Single vehicle crash	V1: Travelling straight ahead	V1:W	V1:(Collision with guardrail)	25-34	25-34	Snow	Snow	RAMP-UNION ST TO RT 6 WB
A	2402683	10/6/2008	2:14 PM	3	3	Rear-end	V1: Travelling straight ahead / V2:Slowing or stopped in traffic / V3:Slowing or stopped in traffic	V1:S / V2:S / V3:S	V1:(Collision with motor vehicle in traffic) V2:(Collision with motor vehicle in traffic) V3:(Collision with motor vehicle in traffic)	25-34	55-64	Dry	Clear	UNION STREET

\* During the RSA Team meeting it was noted that crash diagram numbers 2 and 3 are the same crash.

Source: MassDOT Highway Division Crash Reports for the location; 2008-2010

Crash Diagram Reference Number	Crash Number	Crash Date	Crash Time	# of injuries	#r of Vehicles	Manner of Collision	Vehicle Action Prior to Crash	Vehicle Travel Directions	Vehicle Sequence of Events	Age of Driver - Youngest Known	Age of Driver - Oldest Known	Road Surface	Weather	Roadway
1E	2301788	3/26/2008	4:25 PM	0	2	Angle	V1: Travelling straight ahead / V2:Slowing or stopped in traffic	V1:E / V2:E	V1:(Collision with motor vehicle in traffic) V2:(Collision with motor vehicle in traffic)	55-64	55-64	Dry	Clear	MID CAPE HIGHWAY Rte 6 E
2E	2378415	8/2/2008	11:00 AM	1	2	Rear-end	V1: Entering traffic lane / V2:Slowing or stopped in traffic	V1:S / V2:S	V1:(Collision with motor vehicle in traffic) V2:(Collision with motor vehicle in traffic)	35-44	55-64	Not reported	Clear	UNION STREET / Rte 6
3E	2403414	11/18/2008	8:01 AM	0	2	Angle	V1: Turning right / V2:Slowing or stopped in traffic	V1:S / V2:S	V1:(Collision with motor vehicle in traffic) V2:(Collision with motor vehicle in traffic)	35-44	55-64	Dry	Clear	UNION STREET / Rte 6
4E	2443197	11/27/2008	11:37 AM	0	2	Rear-end	V1: Slowing or stopped in traffic / V2:Travelling straight ahead	V1:S / V2:S	V2:	55-64	55-64	Dry	Cloudy	UNION STREET Rte 6 / STATION AVENUE
5E	2430524	12/1/2008	6:00 AM	0	2	Unknown ANGLE	V1: Travelling straight ahead / V2:Turning left	V1:N / V2:N	V1:(Collision with unknown movable object),(Collision with impact attenuator/crash cushion) V2:	65-74	>84	Wet	Rain	/ STATION AVENUE Rte 6
6E	2460316	4/8/2009	6:18 PM	0	2	Angle	V1: Travelling straight ahead / V2:Entering traffic lane	V1:S / V2:E	V1:(Collision with motor vehicle in traffic) V2:(Collision with motor vehicle in traffic)	16-20	16-20	Dry	Clear	STATION AVENUE / MID CAPE HIGHWAY
7E	2465231	4/27/2009	6:39 PM	0	2	Angle	V1: Turning left / V2:Entering traffic lane	V1:W / V2:E	V1:(Collision with motor vehicle in traffic) V2:(Collision with motor vehicle in traffic)	21-24	65-74	Dry	Clear/Cloudy	STATION AVENUE / RAMP-RT 6 EB TO UNION ST
8E	2574445	7/24/2009	3:57 PM	0	2	Angle	V1: Travelling straight ahead / V2:Travelling straight ahead	V1:S / V2:E	V1:(Collision with motor vehicle in traffic) V2:(Collision with motor vehicle in traffic)	21-24	35-44	Dry	Clear	STATION AVENUE / RAMP-RT 6 EB TO UNION ST
9E	2574931	11/20/2009	9:55 PM	0	2	Rear-end	V1: Slowing or stopped in traffic / V2:Travelling straight ahead	V1:E / V2:E	V1:(Collision with motor vehicle in traffic) V2:(Collision with motor vehicle in traffic)	25-34	65-74	Dry	Clear/Unknown	UNION STREET / RAMP-RT 6 EB TO UNION ST / RAMP-UNION ST TO RT 6 EB
10E	2663655	11/3/2010	11:00 PM	1	1	Single vehicle crash	V1: Travelling straight ahead	V1:E	V1:(Collision with motor vehicle in traffic),(Collision with curb)	25-34	25-34	Dry	Clear	STATION AVENUE / RAMP - UNION ST TO RT 6 EB /

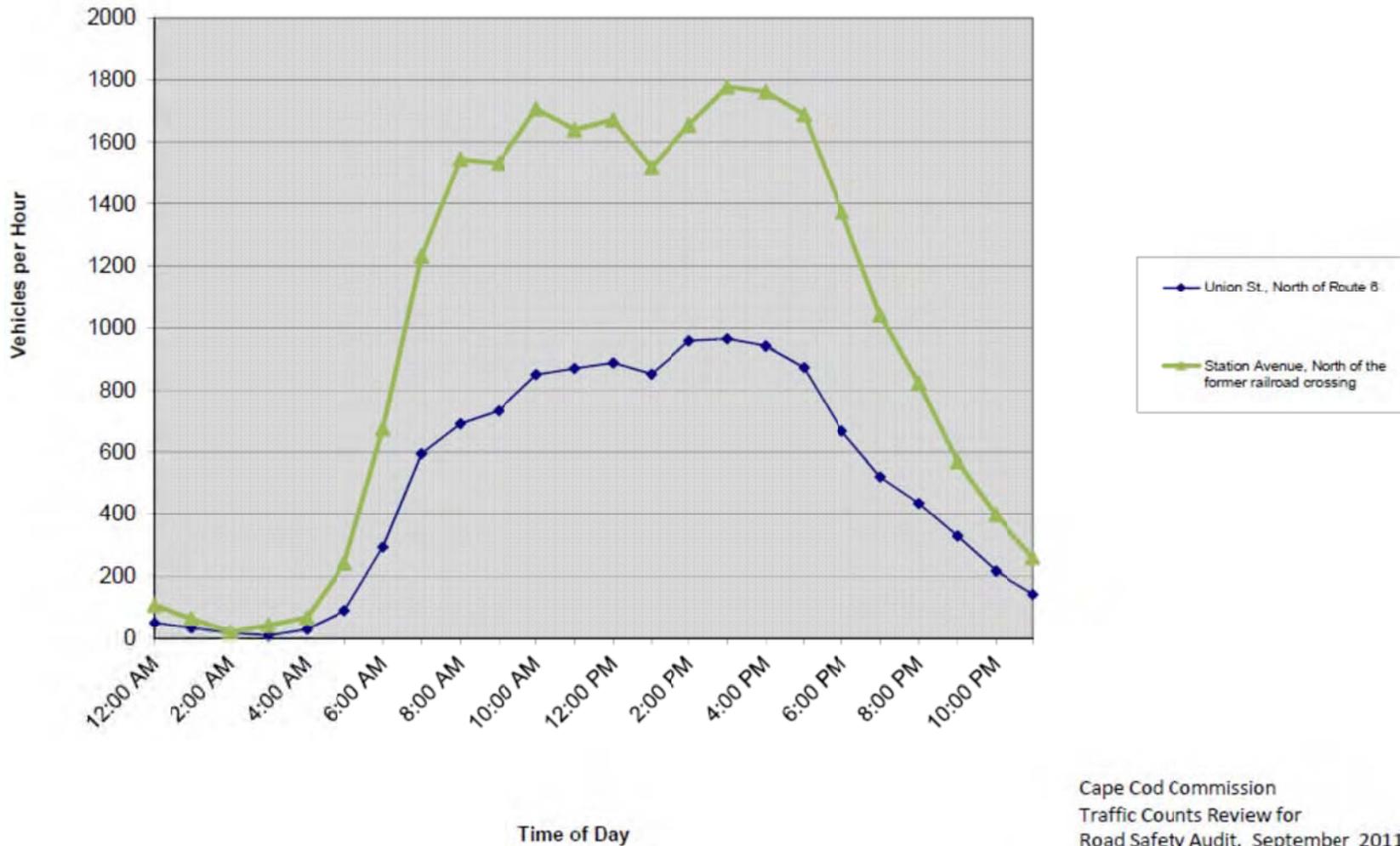
Source: MassDOT Highway Division Crash Reports for the location; 2008-2010.

## Appendix D. Additional Information

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- Hourly Traffic Volumes Graph
- Turning Movement Count:
  - Union Street at the Route 6 WB Ramps
  - Station Avenue at the Route 6 EB Ramps

Union Street / Station Ave., Yarmouth, Hourly Traffic Volumes



Cape Cod Commission  
 Traffic Counts Review for  
 Road Safety Audit, September 2011

# September 12, 2011 WESTBOUND RAMPS TMC CARS

## CAPE COD COMMISSION

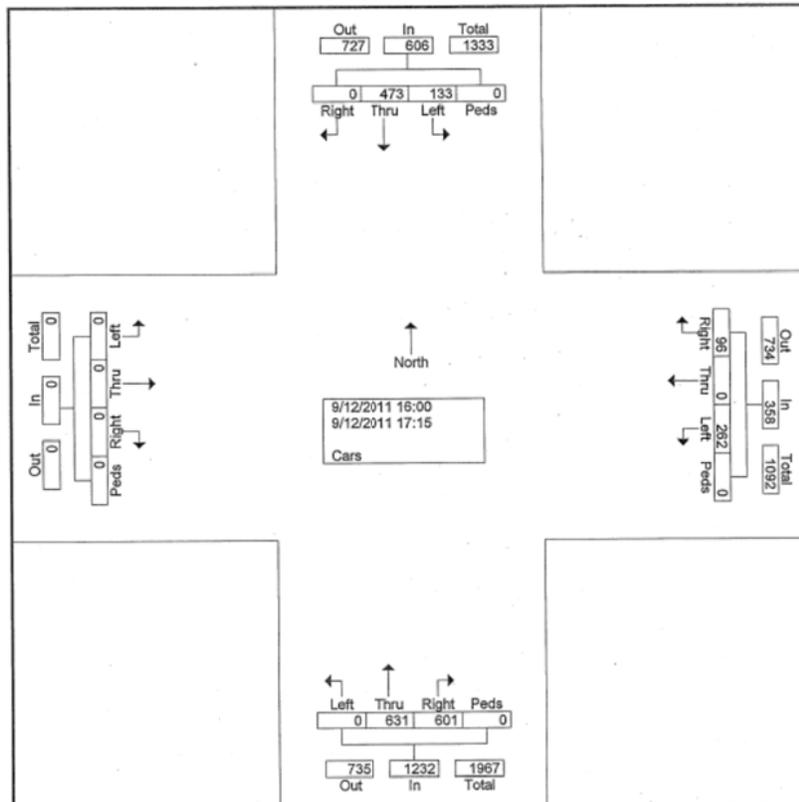
3225 Main Street • P.O. Box 226  
 Barnstable, MA 02630  
 Tel: 508.362.3828 • Fax: 508.362.3136  
 E-Mail: trans@capecodcommission.org

Counter #:5  
 Counted By:GDC  
 Location:Rt 6 WB Ramp @ Station Av  
 Date:9/12/2011

File Name : 3767\_09122011  
 Site Code : 00003767  
 Start Date : 9/12/2011  
 Page No : 1

### Groups Printed- Cars

Start Time	From North				From East				From South				From West				Int. Total
	Left	Thru	Right	Peds	Let	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds	
16:00	15	73	0	0	41	0	13	0	0	112	97	0	0	0	0	0	351
16:15	25	83	0	0	42	0	10	0	0	99	94	0	0	0	0	0	353
16:30	25	64	0	0	43	0	15	0	0	100	94	0	0	0	0	0	341
16:45	26	82	0	0	49	0	17	0	0	106	106	0	0	0	0	0	386
Total	91	302	0	0	175	0	55	0	0	417	391	0	0	0	0	0	1431
17:00	23	100	0	0	37	0	19	0	0	102	117	0	0	0	0	0	398
17:15	19	71	0	0	50	0	22	0	0	112	93	0	0	0	0	0	367
Grand Total	133	473	0	0	262	0	96	0	0	631	601	0	0	0	0	0	2196
Apprch %	21.9	78.1	0	0	73.2	0	26.8	0	0	51.2	48.8	0	0	0	0	0	
Total %	6.1	21.5	0	0	11.9	0	4.4	0	0	23.7	27.4	0	0	0	0	0	



# September 12, 2011 WESTBOUND RAMPS TMC TRUCKS

## CAPE COD COMMISSION

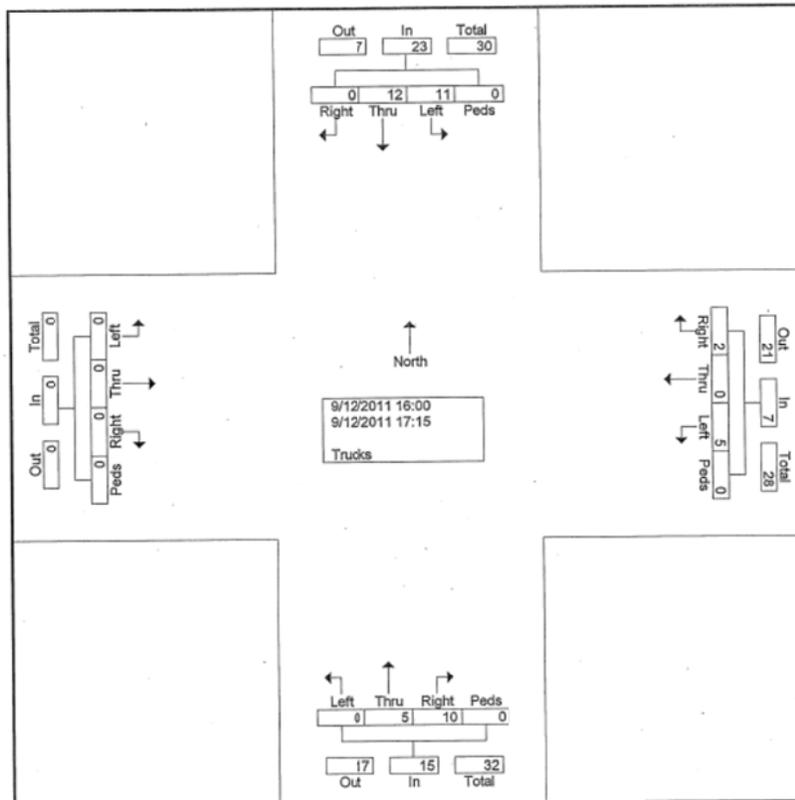
3225 Main Street • P.O. Box 226  
 Barnstable, MA 02630  
 Tel: 508.362.3828 • Fax: 508.362.3136  
 E-Mail: trans@capecodcommission.org

Counter #5  
 Counted By: GDC  
 Location: Rt 6 WB Ramp @ Station Av  
 Date: 9/12/2011

File Name : 3767\_09122011  
 Site Code : 00003767  
 Start Date : 9/12/2011  
 Page No : 1

### Groups Printed- Trucks

Start Time	From North				From East				From South				From West				Int. Total	
	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds		
16:00	2	4	0	0	3	0	1	0	0	4	2	0	0	0	0	0	0	16
16:15	3	3	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	9
16:30	2	1	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	5
16:45	0	3	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	6
<b>Total</b>	<b>7</b>	<b>11</b>	<b>0</b>	<b>0</b>	<b>4</b>	<b>0</b>	<b>2</b>	<b>0</b>	<b>0</b>	<b>4</b>	<b>8</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>36</b>
17:00	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
17:15	2	1	0	0	1	0	0	0	0	1	2	0	0	0	0	0	0	7
<b>Grand Total</b>	<b>11</b>	<b>12</b>	<b>0</b>	<b>0</b>	<b>5</b>	<b>0</b>	<b>2</b>	<b>0</b>	<b>0</b>	<b>5</b>	<b>10</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>45</b>
Approch %	47.8	52.2	0	0	71.4	0	28.6	0	0	33.3	66.7	0	0	0	0	0	0	
Total %	24.4	26.7	0	0	11.1	0	4.4	0	0	11.1	22.2	0	0	0	0	0	0	



# September 12, 2011 WESTBOUND RAMPS TMC BIKES

## CAPE COD COMMISSION

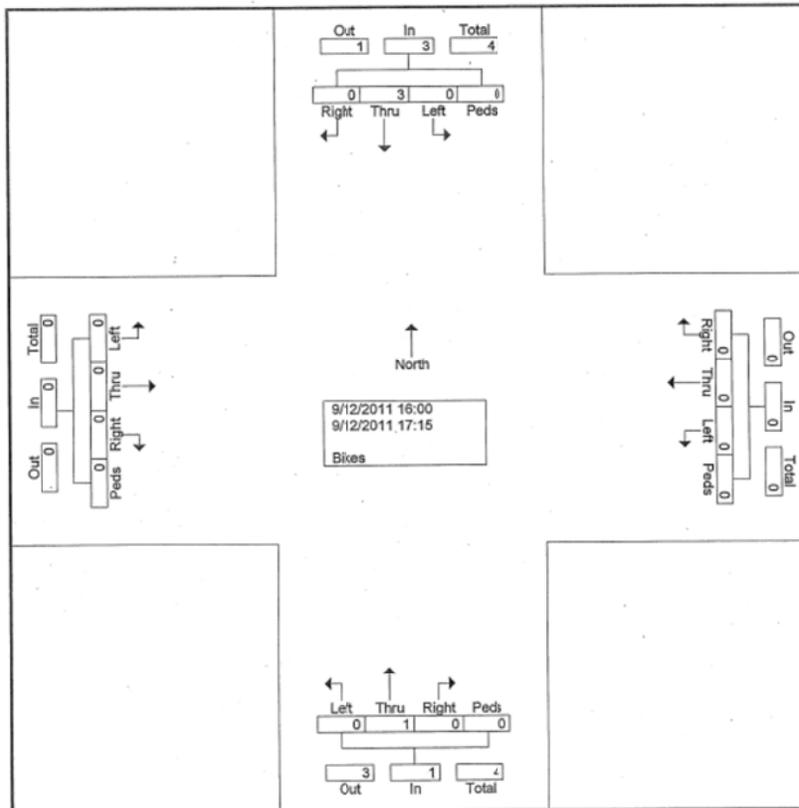
3225 Main Street • P.O. Box 226  
 Barnstable, MA 02630  
 Tel: 508.362.3828 • Fax: 508.362.3136  
 E-Mail: trans@capecodcommission.org

Counter #:5  
 Counted By:GDC  
 Location:Rt 6 WB Ramp @ Station Av  
 Date:9/12/2011

File Name : 3767\_09122011  
 Site Code : 00003767  
 Start Date : 9/12/2011  
 Page No : 1

### Groups Printed- Bikes

Start Time	From North				From East				From South				From West				In. Total
	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds	
*** BREAK ***																	
17:00	0	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	3
17:15	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Grand Total	0	3	0	0	0	0	0	0	0	1	0	0	0	0	0	0	4
Approch%	0	100	0	0	0	0	0	0	0	100	0	0	0	0	0	0	
Total%	0	75	0	0	0	0	0	0	0	25	0	0	0	0	0	0	





# September 12, 2011 WESTBOUND RAMPS TMC PEAK HOUR

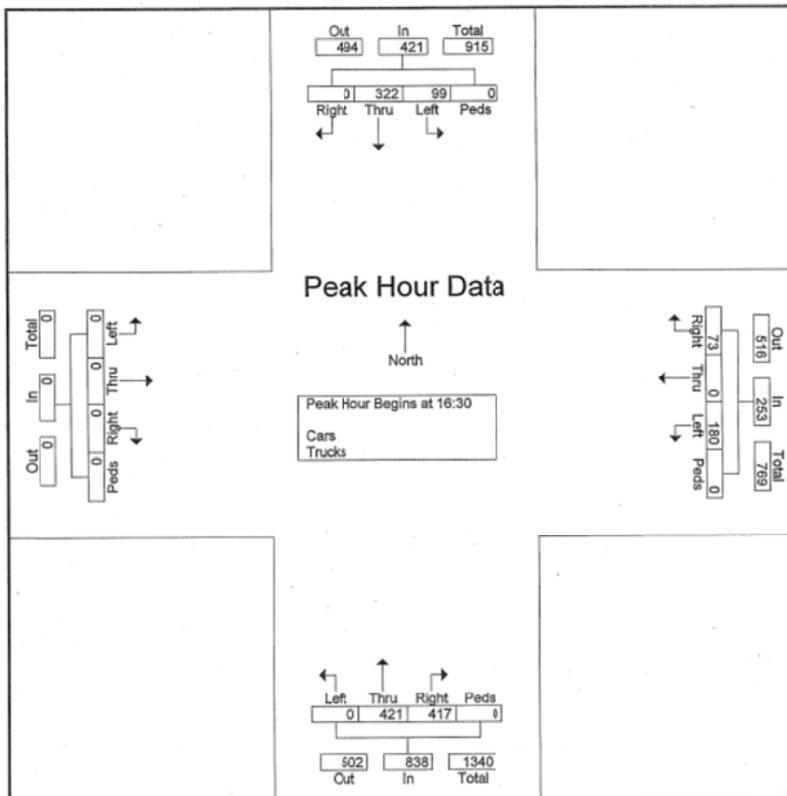
## CAPE COD COMMISSION

3225 Main Street • P.O. Box 226  
 Barnstable, MA 02630  
 Tel: 508.362.3828 • Fax: 508.362.3136  
 E-Mail: trans@capecodcommission.org

Counter #:5  
 Counted By: GDC  
 Location: Rt 6 WB Ramp @ Station Av  
 Date: 9/12/2011

File Name : 3767\_09122011  
 Site Code : 00003767  
 Start Date : 9/12/2011  
 Page No : 2

Start Time	From North					From East					From South					From West					Int. Total
	Left	Thru	Right	Peds	App. Total	Left	Thru	Right	Peds	App. Total	Left	Thru	Right	Peds	App. Total	Left	Thru	Right	Peds	App. Total	
Peak Hour Analysis From 16:00 to 17:15 - Peak 1 of 1																					
Peak Hour for Entire Intersection Begins at 16:30																					
16:30	27	65	0	0	92	43	0	15	0	58	0	100	96	0	196	0	0	0	0	0	346
16:45	26	85	0	0	111	49	0	17	0	66	0	105	109	0	215	0	0	0	0	0	392
17:00	25	100	0	0	125	37	0	19	0	56	0	102	117	0	219	0	0	0	0	0	400
17:15	21	72	0	0	93	51	0	22	0	73	0	113	95	0	208	0	0	0	0	0	374
Total Volume	99	322	0	0	421	180	0	73	0	253	0	421	417	0	838	0	0	0	0	0	1512
% App. Total	23.5	76.5	0	0		71.1	0	28.9	0		0	50.2	49.8	0		0	0	0	0		
PHF	.917	.805	.000	.000	.842	.882	.000	.830	.000	.866	.000	.911	.891	.000	.957	.000	.000	.000	.000	.000	.945



# September 12, 2011 EASTBOUND RAMPS TMC CARS

## CAPE COD COMMISSION

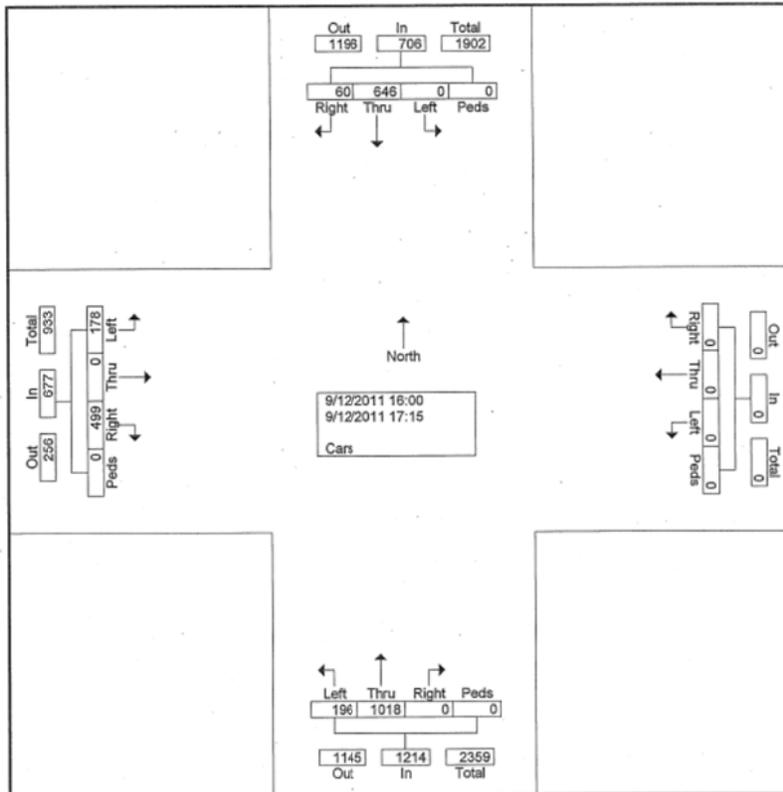
3225 Main Street • P.O. Box 226  
 Barnstable, MA 02630  
 Tel: 508.362.3828 • Fax: 508.362.3136  
 E-Mail: trans@capecodcommission.org

Counter #:4  
 Counted By:PL  
 Location: Rt 6 EB Ramp  
 Date: 9/12/2011

File Name : 3766\_09122011  
 Site Code : 00003766  
 Start Date : 9/12/2011  
 Page No : 1

### Groups Printed- Cars

Start Time	From North				From East				From South				From West				Int. Total
	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds	
16:00	0	105	6	0	0	0	0	0	44	166	0	0	30	0	64	0	415
16:15	0	113	7	0	0	0	0	0	34	164	0	0	26	0	81	0	425
16:30	0	97	9	0	0	0	0	0	29	160	0	0	37	0	104	0	436
16:45	0	101	17	0	0	0	0	0	29	183	0	0	26	0	87	0	443
Total	0	416	39	0	0	0	0	0	136	673	0	0	119	0	336	0	1719
17:00	0	115	14	0	0	0	0	0	40	177	0	0	30	0	78	0	454
17:15	0	115	7	0	0	0	0	0	20	168	0	0	29	0	85	0	424
Grand Total	0	646	60	0	0	0	0	0	196	1018	0	0	178	0	499	0	2597
Apprch %	0	91.5	8.5	0	0	0	0	0	16.1	83.9	0	0	26.3	0	73.7	0	
Total %	0	24.9	2.3	0	0	0	0	0	7.5	39.2	0	0	6.9	0	19.2	0	



# September 12, 2011 EASTBOUND RAMPS TMC TRUCKS

## CAPE COD COMMISSION

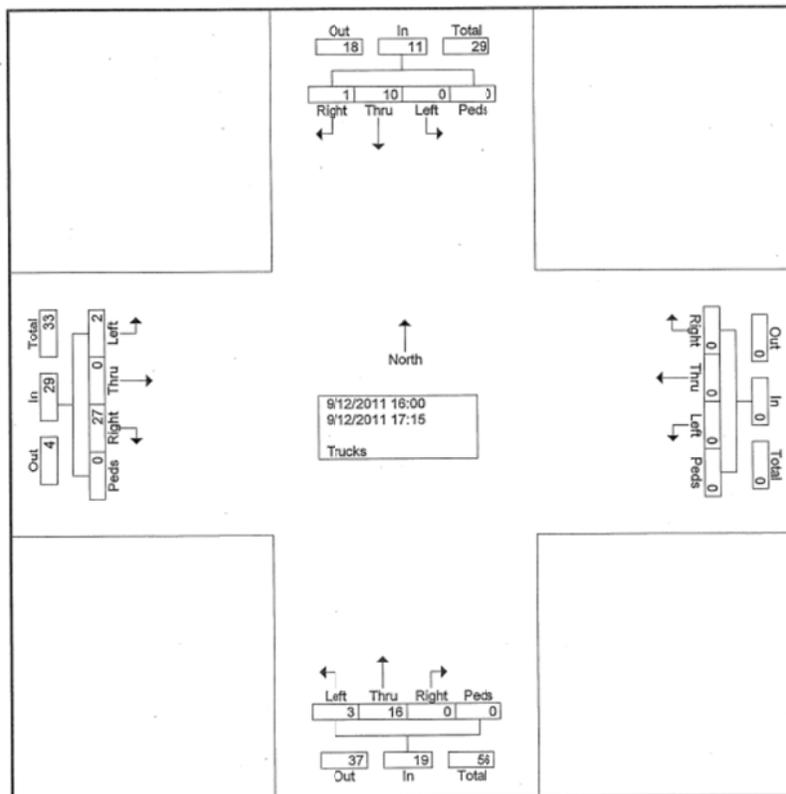
3225 Main Street • P.O. Box 226  
 Barnstable, MA 02630  
 Tel: 508.362.3828 • Fax: 508.362.3136  
 E-Mail: trans@capecodcommission.org

Counter #: 4  
 Printed By: PL  
 Location: Rt 6 EB Ramp  
 Date: 9/12/2011

File Name : 3766\_09122011  
 Site Code : 00003766  
 Start Date : 9/12/2011  
 Page No : 1

### Groups Printed- Trucks

Start Time	From North				From East				From South				From West				Int. Total
	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds	
16:00	0	4	1	0	0	0	0	0	0	7	0	0	1	0	4	0	17
16:15	0	3	0	0	0	0	0	0	0	1	0	0	0	0	7	0	11
16:30	0	0	0	0	0	0	0	0	0	2	0	0	0	0	5	0	7
16:45	0	3	0	0	0	0	0	0	3	4	0	0	0	0	4	0	14
<b>Total</b>	0	10	1	0	0	0	0	0	3	14	0	0	1	0	20	0	49
17:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	6
17:15	0	0	0	0	0	0	0	0	0	2	0	0	1	0	1	0	4
<b>Grand Total</b>	0	10	1	0	0	0	0	0	3	16	0	0	2	0	27	0	59
Apprch %	0	90.9	9.1	0	0	0	0	0	15.8	84.2	0	0	6.9	0	93.1	0	
Total %	0	16.9	1.7	0	0	0	0	0	5.1	27.1	0	0	3.4	0	45.8	0	



# September 12, 2011 EASTBOUND RAMPS TMC BIKES

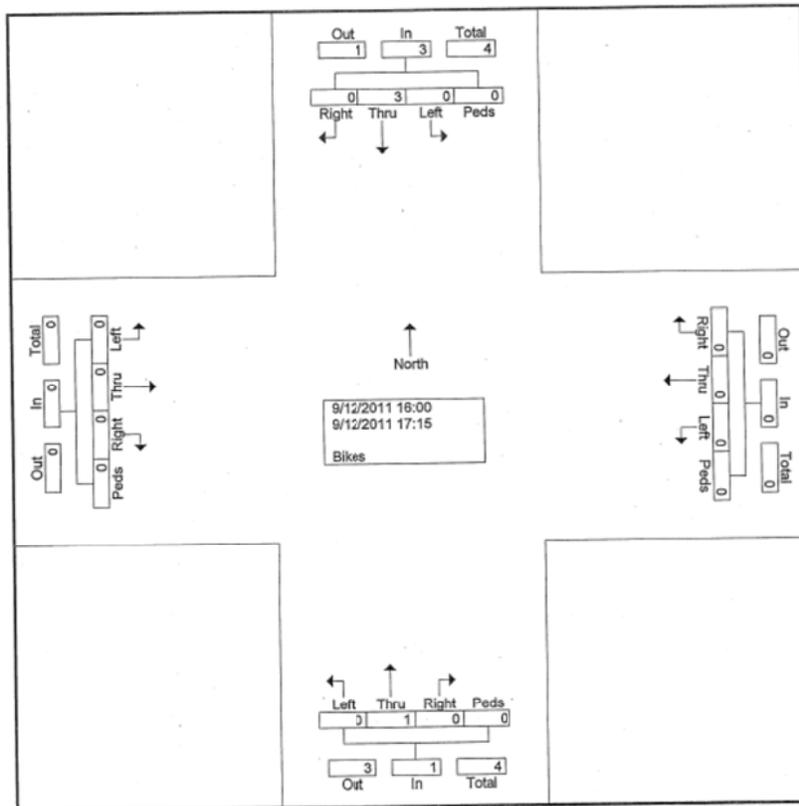
**CAPE COD COMMISSION**  
 3225 Main Street • P.O. Box 226  
 Barnstable, MA 02630  
 Tel: 508.362.3828 • Fax: 508.362.3136  
 E-Mail: trans@capecodcommission.org

Counter #4  
 Counted By: PL  
 Location: Rt 6 EB Ramp  
 Date: 9/12/2011

File Name : 3766\_09122011  
 Site Code : 00003766  
 Start Date : 9/12/2011  
 Page No : 1

### Groups Printed- Bikes

Start Time	From North				From East				From South				From West				Int. Total		
	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds			
*** BREAK ***																			
17:00	0	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	3
17:15	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Grand Total	0	3	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	4
Approch %	0	100	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	0	
Total %	0	75	0	0	0	0	0	0	0	25	0	0	0	0	0	0	0	0	



# September 12, 2011 EASTBOUND RAMPS TMC CARS and TRUCKS

## CAPE COD COMMISSION

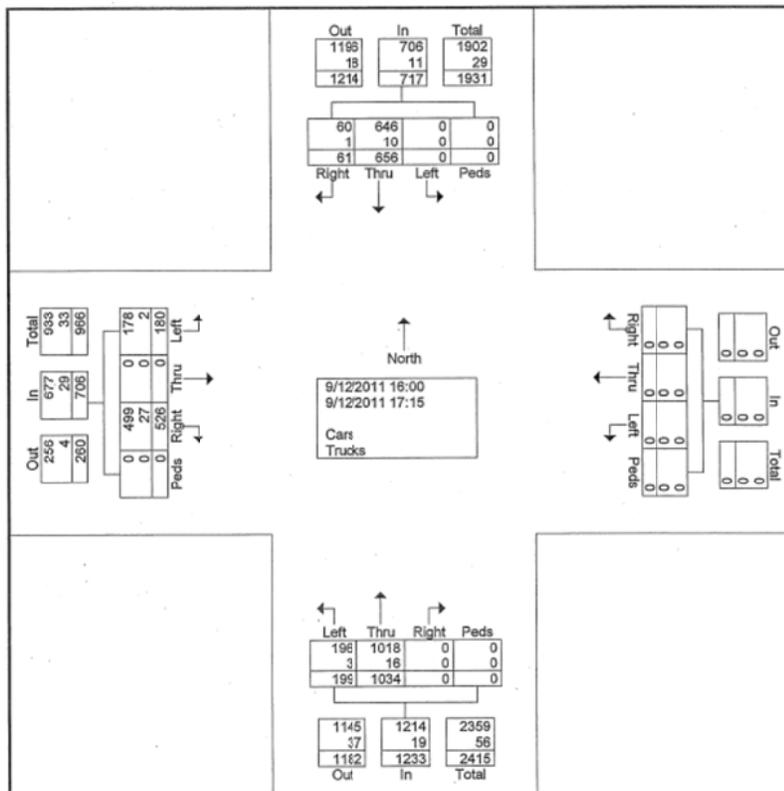
3225 Main Street • P.O. Box 226  
 Barnstable, MA 02630  
 Tel: 508.362.3828 • Fax: 508.362.3136  
 E-Mail: trans@capecodcommission.org

Counter #: 4  
 Counted By: PL  
 Location: Rt 6 EB Ramp  
 Date: 9/12/2011

File Name : 3766\_09122011  
 Site Code : 00003766  
 Start Date : 9/12/2011  
 Page No : 1

### Groups Printed- Cars - Trucks

Start Time	From North				From East				From South				From West				Int. Total
	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds	
16:00	0	109	7	0	0	0	0	0	44	173	0	0	31	0	68	0	432
16:15	0	116	7	0	0	0	0	0	34	165	0	0	26	0	88	0	436
16:30	0	97	9	0	0	0	0	0	29	162	0	0	37	0	109	0	443
16:45	0	104	17	0	0	0	0	0	32	187	0	0	26	0	91	0	457
Total	0	426	40	0	0	0	0	0	139	687	0	0	120	0	356	0	1768
17:00	0	115	14	0	0	0	0	0	40	177	0	0	30	0	84	0	460
17:15	0	115	7	0	0	0	0	0	20	170	0	0	30	0	86	0	428
Grand Total	0	656	61	0	0	0	0	0	199	1034	0	0	180	0	526	0	2556
Approch %	0	91.5	8.5	0	0	0	0	0	16.1	83.9	0	0	25.5	0	74.5	0	
Total %	0	24.7	2.3	0	0	0	0	0	7.5	38.9	0	0	6.8	0	19.8	0	
Cars	0	646	60	0	0	0	0	0	196	1018	0	0	178	0	499	0	2597
% Cars	0	98.5	98.4	0	0	0	0	0	98.5	98.5	0	0	98.9	0	94.9	0	97.8
Trucks	0	10	1	0	0	0	0	0	3	16	0	0	2	0	27	0	59
% Trucks	0	1.5	1.6	0	0	0	0	0	1.5	1.5	0	0	1.1	0	5.1	0	2.2



# September 12, 2011 EASTBOUND RAMPS TMC PEAK HOUR

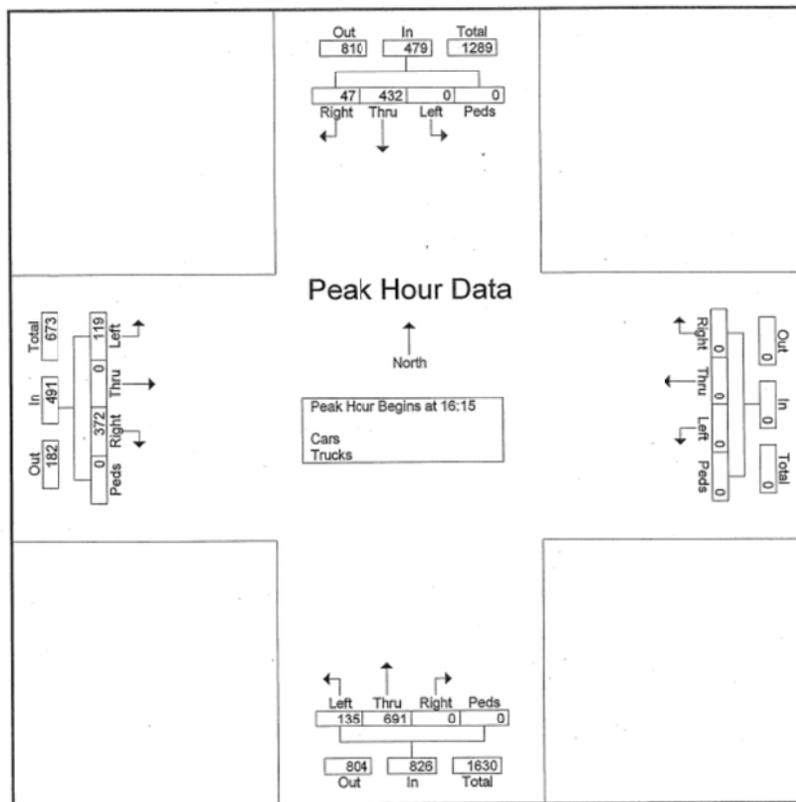
## CAPE COD COMMISSION

3225 Main Street • P.O. Box 226  
 Barnstable, MA 02630  
 Tel: 508.362.3828 • Fax: 508.362.3136  
 E-Mail: trans@capecodcommission.org

Counter #4  
 Entered By: PL  
 Location: Rt 6 EB Ramp  
 Date: 9/12/2011

File Name : 3766\_09122011  
 Site Code : 00003766  
 Start Date : 9/12/2011  
 Page No : 2

Start Time	From North					From East					From South					From West					Int. Total
	Left	Thru	Right	Peds	App. Total	Left	Thru	Right	Peds	App. Total	Left	Thru	Right	Peds	App. Total	Left	Thru	Right	Peds	App. Total	
Peak Hour Analysis From 16:00 to 17:15 - Peak 1 of 1																					
Peak Hour for Entire Intersection Begins at 16:15																					
16:15	0	116	7	0	123	0	0	0	0	0	34	165	0	0	199	26	0	88	0	114	436
16:30	0	97	9	0	106	0	0	0	0	0	29	162	0	0	191	37	0	109	0	146	443
16:45	0	104	17	0	121	0	0	0	0	0	32	187	0	0	219	26	0	91	0	117	457
17:00	0	115	14	0	129	0	0	0	0	0	40	177	0	0	217	30	0	84	0	114	460
Total Volume	0	432	47	0	479	0	0	0	0	0	135	691	0	0	825	119	0	372	0	491	1796
% App. Total	0	90.2	9.8	0		0	0	0	0	0	16.3	83.7	0	0		24.2	0	75.8	0		
PHF	.000	.931	.691	.000	.928	.000	.000	.000	.000	.000	.844	.924	.000	.000	.943	.804	.000	.853	.000	.841	.976



## Appendix E. Road Safety Audit References

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## Road Safety Audit References

*Massachusetts Traffic Safety Toolbox*, Massachusetts Highway Department,  
[www.mhd.state.ma.us/safetytoolbox](http://www.mhd.state.ma.us/safetytoolbox).

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

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

*Road Safety Audit*, 2<sup>nd</sup> edition. Austroads, 2000.

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

*Desktop Reference for Crash Reduction Factors*. Report No. FHWA-SA-08-011. U.S. Department of Transportation, Federal Highway Administration, September 2008