CAPE COD COMMISSION

Analysis of High-Crash Locations in Dennisport

October 17, 2012

CAPE COD
COMMISSION

EXECUTIVE SUMMARY

This brief safety study presents analysis of traffic volumes, analysis of traffic crashes, and possible safety countermeasures at three high-crash locations in Dennisport.

The intersection of Upper County Road and Depot Street has been the site of many safety improvements over the last few decades, but still experienced thirteen (13) crashes from 2009 through 2011. Since the intersection was converted into a four-way stop-controlled intersection with a flashing red beacon, the crashes have been relatively minor.

Continued maintenance of advanced warning signs and markings and vegitative management is critical to safety at this site. Additionally, short-term improvements such as additional signage on the westbound approach, a retroreflective backplate on the warning beacon, and additional bicycle and pedestrian accomodations should be conisdered.

With twenty (20) and fifteen (15) crashes respectively, the intersections of Main Street (Route 28) with Sea Street and with Depot Street are roughly 600 feet apart and face many of the same safety problems. Both intersections have poor operational performance from the minor approaches with vehicles often facing excessive wait times to enter the intersections. Entering the intersection can be challenging given the somewhat limited sightlines, apparent speeding on Main Street (Route 28), and confusion caused by the many curb cuts within the function area of the intersections.

Short terms improvements at these intersections such as removal of sight distance obstructions and advanced warning signs and markings may provide some relief, but longer term solutions should be explored. Access management and traffic calming in the vicinity of intersection would be quite beneficial as well as additional bicycle and pedestrian accommodations. An investigation of the long-term need to upgrade to a traffic signal or roundabout should be conducted.

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BACKGROUND

In the process of reviewing the Chapter H Application from the Town of Dennis to increase the Development of Regional Impact (DRI) thresholds in Dennisport, Cape Cod Commission transportation staff identified three (3) high crash locations that could potentially be impacted. These intersections include Upper County Road and Depot Street, Main Street (Route 28) and Sea Street, and Main Street (Route 28) and Depot Street.

The three (3) high crash locations discussed in this document are well known to the town. All three are highlighted in the Chapter H application and referenced in the Town of Dennis Local Comprehensive Plan (2002). In the plan, there is discussion of the problems and potential solutions at each location. Many of the suggestions from that plan have been since implemented, but a crash problem still exists at all three intersections. In an effort to assist the town, Commission staff analyzed the three (3) intersections and in this document present possible solutions to the safety problems. As part of the redevelopment of Dennisport, the Town of Dennis should work towards implementing the safety mitigation strategies discussed herein.

UPPER COUNTY ROAD AT DEPOT STREET

According to Massachusetts Department of Transportation (MassDOT) crash records and Town of Dennis Police Records, the intersection of Upper County Road and Depot Street experienced a total of thirteen (13) crashes from 2009 through 2011. (Note: MassDOT crash records are only available through 2010.)

EXISTING CONDITIONS

This four-leg intersection experiences significant traffic volumes from all four (4) approaches. As shown in the Figure 1, representing a Saturday peak hour counted on July 30, 2005, the volumes on Upper County Road are roughly twice that on Depot Street.

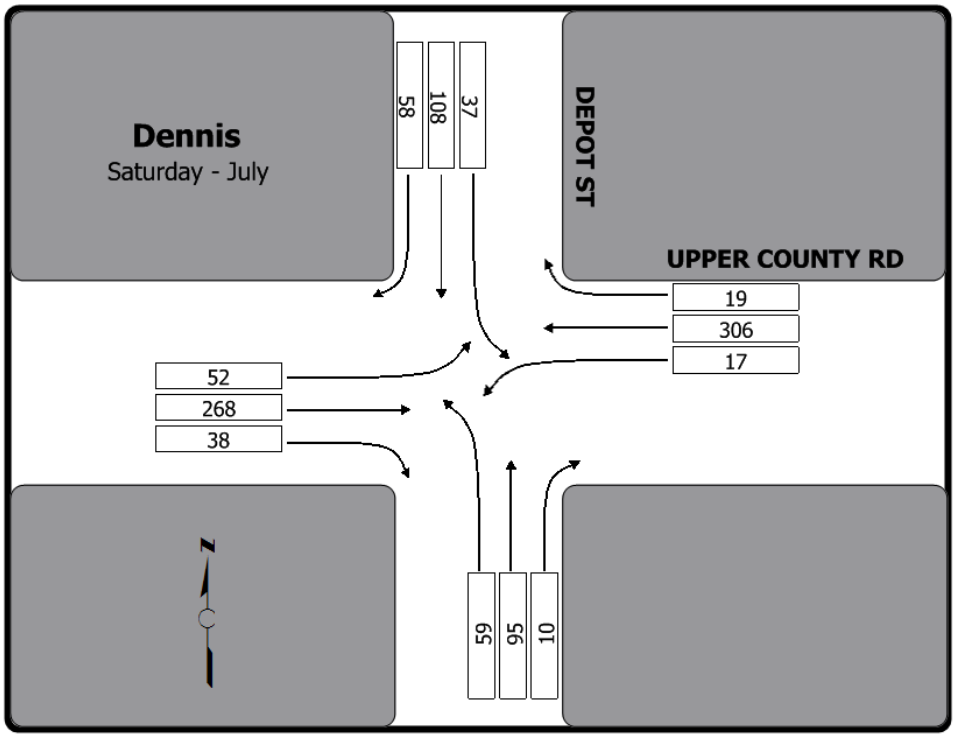


FIGURE 1. TURNING MOVEMENT COUNT DATA - UPPER COUNTY ROAD AND DEPOT STREET (11AM-12PM SATURDAY, JULY 30, 2005)

Reflecting these volumes, the intersection used to operate as a two-way stop controlled intersection with traffic on Depot Street required to stop. To alert drivers to the intersection, a flashing red beacon facing both Depot Street approaches and a flashing yellow beacon facing both Upper County Road approaches was hung over the center of the intersection.

Following a high number of crashes in 2004 and 2005, including several crashes resulting in injuries, the intersection was modified to function as a four-way stop-controlled intersection with a flashing red beacon facing each approach.

Approaching from the north and from the south, there is good visibility of the intersection, the flashing beacon, two stops signs, the "Stop Ahead" sign, and the "Stop Ahead" pavement marking. Approaching from the west and from the east there are both "Stop Ahead" signs and pavement markings in advance of the intersections; however, the signs (see right) are not MUTCD compliant as the image of the stop sign does not have a white border which would increase the sign contrast. From the east a slight bend in the road somewhat limits visibility of the stop sign on the right side of the road. There is a sidewalk on the south side of Upper County Road with a crossing on the south side of the intersection.

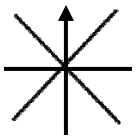
Facing North	Facing South
Facing East	Facing West

CRASH EXPERIENCE

Despite a significant reduction in number and severity of crashes observed at the intersection following these safety improvements, a safety problem still exists. Of the thirteen (13) crashes from 2009-2011, eleven (11) were angle crashes and two (2) were rear-end crashes. The one reported injury crash involved a bicyclist who did not stop while traveling through the intersection.

The crashes are plotted on a collision diagram on the following page. The most frequent crash type was between vehicles heading straight through the intersection from the south and from the west. The high number of crashes, but relatively low number of injuries suggests that may of the crashes are low-speed crashes. This is confirmed by the narratives that suggests most vehicles come to a stop or nearly come to a stop before entering the intersection.

Collision Diagram



Indicate North by arrow

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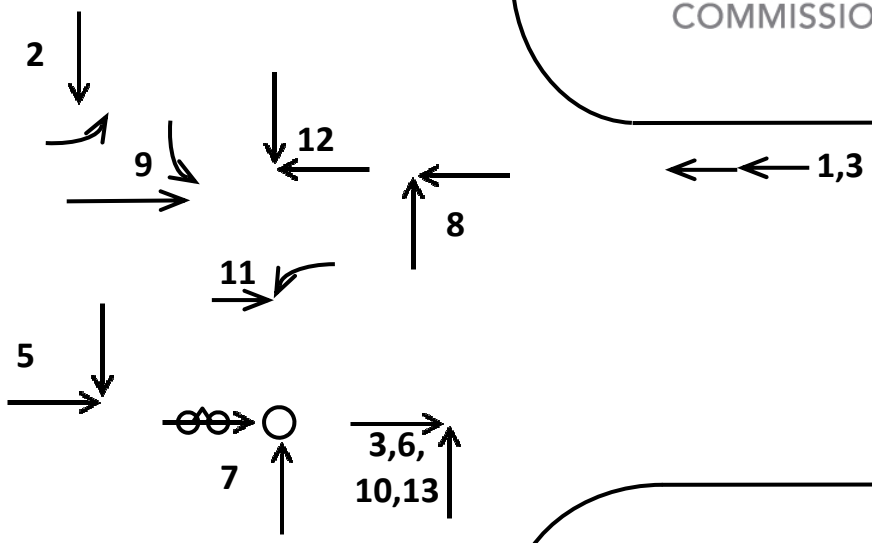


Name: Upper County Road

Name: Depot Street

SYMBOLS	TYPES OF COLLISIONS	CRASH INFORMATION
Moving Vehicle	Rear-End	Each crash is numbered and additional information is included on the accident summary.
Backing Vehicle	Head On	
Non-involved Vehicle	Side Swipe	Notes:
Pedestrian	Out of Control	
Bicyclist	Turning Movement	
Parked Vehicle	Right Angle	
Fixed Object		
Fatal Crash		
Injury Crash		

INTERSECTION Upper County Road AND Depot Street

CRASHES FROM 2009 TO 2011

Crash Summary (Page 1 of 2)		
#	Crash Date	Crash Narrative
1	12/5/2009	MV1 was traveling west on Upper County Rd and was stopped at the stop sign. MV2 was also traveling west on Upper County Rd. MV2 failed to stop in time and collided with the rear of MV1. 1256/mbd
2	7/12/2010	Veh #1 attempting to make left turn from Upper County Rd. to travel north on Depot St. Veh#2 Stopped at stop sign at the intersection of Depot St. Southbound and Upper County Rd. Operator of Veh#1 stated he did not see Veh#2. A witness and operator of Veh#2 both state Veh#2 was stopped at the stop sign as Veh#1 began making the turn. Oper. of Veh#1 cut the corner too sharply and hit Veh#2 on the driver's side front corner with the driver's side rear corner of Veh#1. 1256/mbd
3	8/18/2010	Vehicle 1 and Vehicle 2 were traveling westbound on Upper County Road. As the operator of Vehicle 1 reached the stop sign at the intersection of Depot Street, he came to a stop. The operator of Vehicle 2 stated she stopped behind Vehicle 1, but did not come to a stop quick enough before striking the rear of Vehicle 1. There was minor damage to both vehicles.
4	8/21/2010	Vehicle 1 was stopped at the stop sign on Depot St. Vehicle 2 was stopped at the stop sign on Upper County Rd. The operator of Veh. 2 stated that after stopping, he proceeded into the intersection and was struck in the passenger side by Veh. 1. The operator of Veh. 1 stated that after stopping, he proceeded into the intersection and struck the side of Veh. 2. 1256/mbd
5	11/4/2010	On 11/04/10 at approx. 1919hrs. I was dispatched to investigate a m/v crash at the intersection of Upper County Rd and Depot St. Upon arrival I met with OPR-1 and OPR-2. No one complained of any injury. OPR-1 told me that she was traveling south on Depot St. OPR-1 stated that she stopped at the intersection of Depot St and Upper County Rd. OPR-1 told me that two vehicles stopped on Upper County Rd east bound. OPR-1 told me once the first vehicle went she pulled out and was struck by the second vehicle, OPR-2. OPR-2 told me that she was traveling east on Upper County. OPR-2 told me that she stopped at the stop sign. OPR-2 told me she pulled out and struck OPR-1 on the Pass. rear fender.1256
6	6/30/2011	Vehicle #1, north on Depot St, stopped at stop sign. Vehicle #1 then attempted to continue north on Depot and struck vehicle #2 which had failed to stop at stop sign, east on Upper County Rd. Op#2 stated that he was unaware that a four way stop was present and was pre-occupied by health issues concerning his mother. Heavy damage to both vehicles. Vehicle #1 towed by Northside Auto, OP#2 arranging own tow for his vehicle. 1256/mbd
7	7/2/2011	Vehicle 1 stopped at stop sign heading west on Upper County Rd, then proceeds to enter intersection. Vehicle 2(bicycle) traveling north on Depot St, south of intersection. Vehicle 2 enters intersection without stopping and struck vehicle 1 on drivers side. Bicyclist stated he didn't know he was suppossed to stop. Witness, who was riding behind vehicle 2, stated they did not stop at stop sign. 1256/mbd
8	7/23/2011	Vehicle 1 traveling North on Depot St stopped at the stop sign at the intersection of Upper County Rd. Vehicle 1 came to a complete stop and started to cross the intersection. Vehicle 2 traveling west on Upper County Rd was slowing for the stop sign at the intersection of Depot St. Operator 2 said (through a translator on the phone) that her foot slipped off the brake causing her vehicle to strike vehicle 1. 1256/mbd

Crash Summary (Page 2 of 2)		
#	**Crash Date**	**Crash Narrative**
9	1/7/2009	7:55 AM No injury Angle V1: Turning left / V2:Travelling straight ahead V1:S / V2:E
10	2/24/2009	4:17 PM No injury Angle V1: Travelling straight ahead / V2:Travelling straight ahead V1:E / V2:N
11	6/5/2009	3:16 PM No injury Angle V1: Turning left / V2:Travelling straight ahead V1:W / V2:E
12	6/22/2009	12:54 PM No injury Angle V1: Travelling straight ahead / V2:Travelling straight ahead V1:S / V2:W
13	9/1/2010	11:08 AM No injury Angle V1: Travelling straight ahead / V2:Travelling straight ahead V1:E / V2:N

INTERSECTION OPERATION

Frequently, operational issues at an intersection can result in safety problems. For example, drivers who have been waiting in a long queue sometimes tend to accept smaller gaps when they reach the intersection. To assess how well the intersection is operating, a Level of Service (LOS) analysis using Highway Capacity Manual 2010 software was performed. Analysis was based on the Saturday Peak Hour (11AM – 12PM) observation conducted on July 30, 2005. According to this analysis, during the peak hour, the intersection was operating at a LOS D. Given the higher volumes, the Upper County Road approaches experienced greater delay compared to the Depot Street approaches. While none of the approaches experience excessive delays (LOS F), there could be some driver frustration at this intersection.

POSSIBLE COUNTER MEASURES

Most of the typical low-cost solutions to addressing the types of crashes experienced at this intersection, such as advance warning signs and markings and a warning beacon, have already been implemented at this location. A few actions that could improve safety would be:

1. **Maintenance of sight lines,** particularly vegetation management, can be a low-cost and effective safety countermeasure. As the parcels adjacent to the intersection are privately owned, it is important to engage the land owners and emphasize the importance of maintaining sightlines to the safety of the intersection.

2. **Installation of secondary stop sign** on the left side of the road on the easterly approach similar to the installations currently on north and south approaches.

3. **Upkeep of advanced warning signs and markings** is important to ensure their continued effectiveness. Easily visible warning signs and markings are important in altering motorists that they are approaching an intersection and should be prepared to act accordingly whether that means stopping or simply being aware of side street.

4. **Backplates with reflective borders on the warning beacon** would make the warning beacon more visible and conspicuous in both daytime and nighttime conditions.

5. **Consider bicycle and pedestrian upgrades** at the intersection consistent with the needs of the area.

If the safety issues persist, more expensive, long term solutions such as signalization or installation of a roundabout should be considered. At this time these measures are not warranted, but should be kept as options for the future.

MAIN STREET (ROUTE 28) AT SEA STREET

According to Massachusetts Department of Transportation (MassDOT) crash records and Town of Dennis Police Records, the intersection of Main Street (Route 28) and Sea Street experienced a total of twenty (20) crashes from 2009 through 2011. (Note: MassDOT crash records only available through 2010.)

EXISTING CONDITIONS

The major movements of this four-leg intersection are from the east and west approached along Main Street (Route 28); however, a significant number of vehicles approach from Sea Street as well. As shown in the figure below representing a Saturday peak hour counted on July 30, 2005, the mainline traffic is in excess of 1,100 vehicles per hour (vph) with just over 200 vph entering the intersection from the Sea Street approaches.

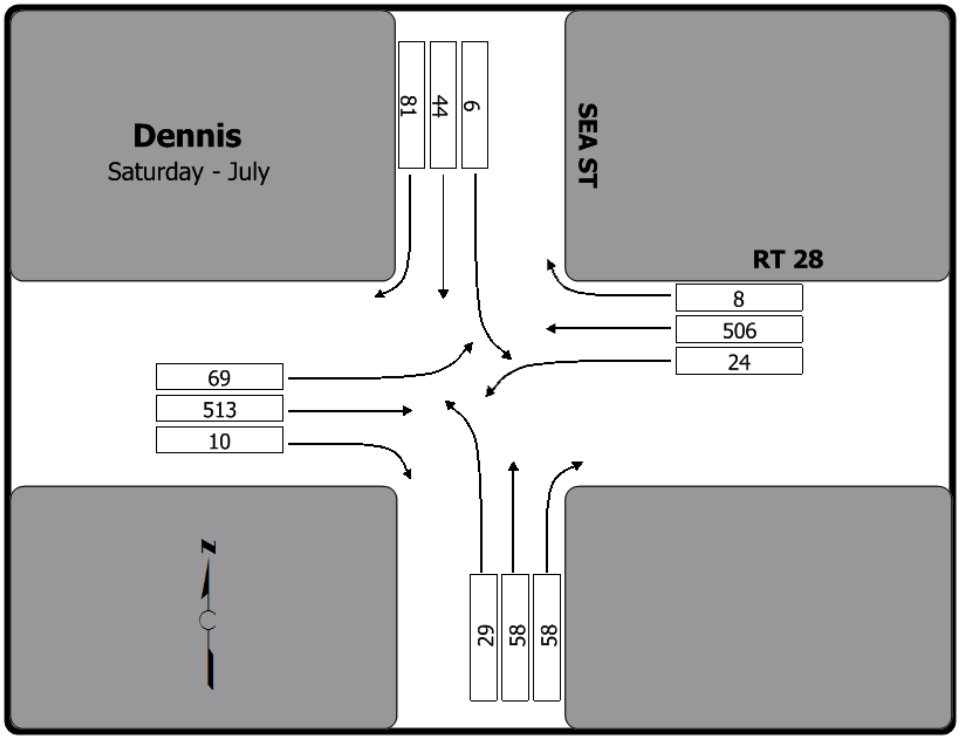


FIGURE 2. TURNING MOVEMENT COUNT DATA - MAIN STREET (ROUTE 28) AND SEA STREET (11AM-12PM SATURDAY, JULY 30, 2005)

The intersection operates as a two-way stop controlled intersection with traffic on Sea Street required to stop. The intersection is slightly skewed and with marginal sight distance available to drivers approaching from Sea Street. There are standard “Stop” signs on the Sea Street approaches in fair condition.

There are a number of expansive curb cuts within the functional area of the intersection. There is a sidewall on the north side of Main Street (Route 28) with a crosswalk on the north side of the intersection.

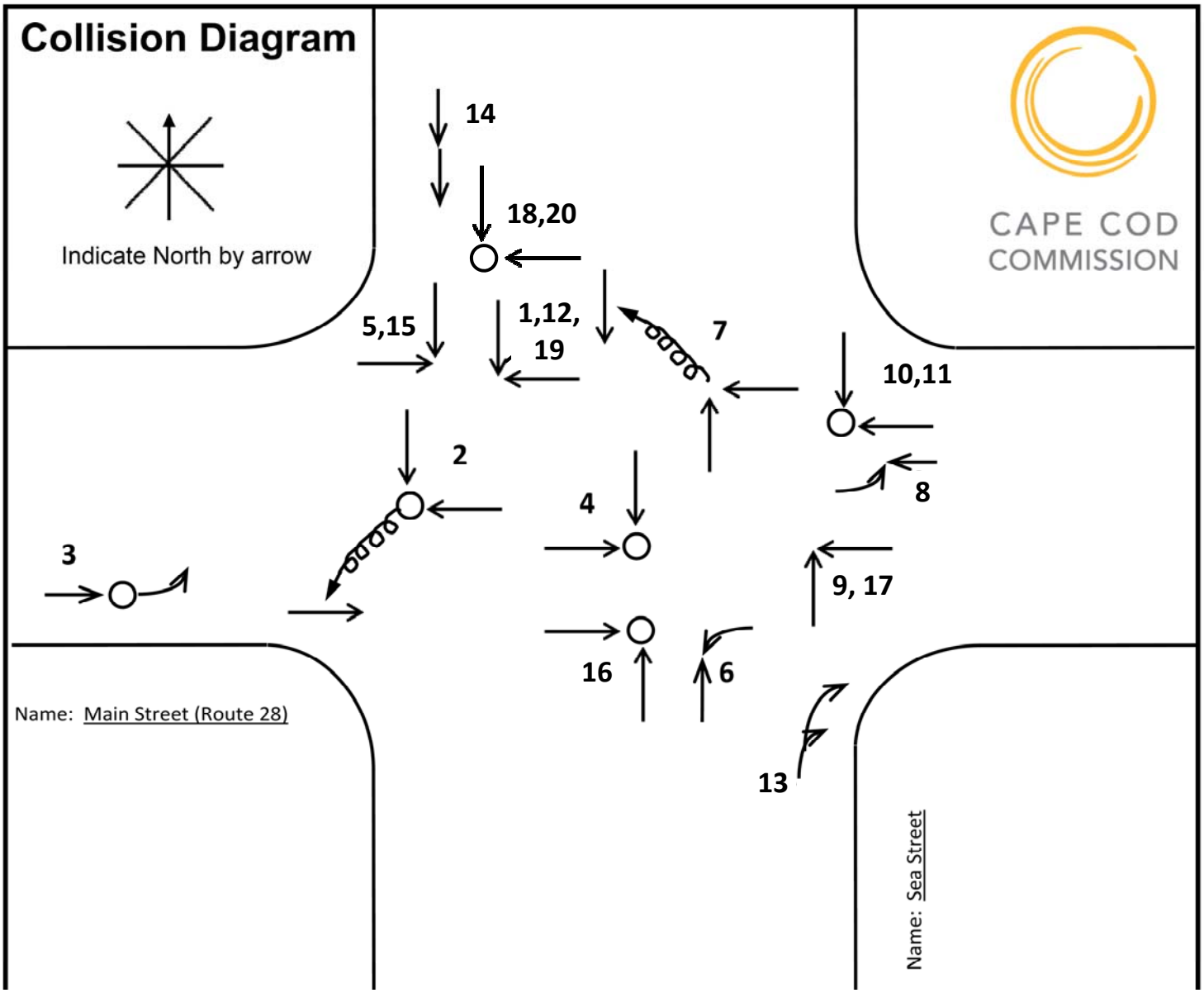
 Facing North	 Facing South
 Facing East	 Facing West

CRASH EXPERIENCE

Of the twenty (20) crashes from 2009-2011, eighteen (18) were angle crashes and two (2) were rear-end crashes. Seven (7) of the crashes were injury crashes (one of the seven was listed as a possible injury crash).

Fifteen (15) out of twenty (20) crashes and six (6) out of seven (7) injury crashes occurred between vehicles on Sea Street attempting to cross Main Street (Route 28) and being struck by a vehicle on Main Street (Route 28). Slightly more than half of these crashes involved vehicles attempting to travel south across the intersection. Many of these crashes are likely the results of a combination of poor sightlines (see below), high speed on Main Street (Route 28), and driver frustration as they often must wait an extended period before being able to enter the intersection.

Collision Diagram



SYMBOLS	TYPES OF COLLISIONS	CRASH INFORMATION
Moving Vehicle Backing Vehicle Non-involved Vehicle Pedestrian Bicyclist Parked Vehicle Fixed Object Fatal Accident Injury Accident	Rear-End Head On Side Swipe Out of Control Turning Movement Right Angle	Each crash is numbered and additional information is included on the accident summary. Notes:

INTERSECTION Upper County Road AND Depot Street

CRASHES FROM 2009 TO 2011

Crash Summary (Page 1 of 4)		
#	Crash Date	Crash Narrative
1	10/9/2009	V1 was headed south on Sea St, stopped at the stop sign at the intersection with Rt 28. V2 was travelling west on Rt 28. Starting from a stop, V1 attempted to cross over RT 28. Op of V1 stated she did not see V2 approaching and collided into the passenger side of V2 causing damage to the rear door and rear quarter panel. V1 suffered damage to the left headlight and front bumper. 1256/mbd
2	11/17/2009	On 11/17/09 at approx. 1801 Hrs. I was dispatched to investigate a M/v crash at the intersection of Rt 28 and Sea St. Upon arrival I spoke to OPR-1 and OPR-2. OPR-2 complained of minor injuries. OPR-1 told me that he was traveling west on Rt 28. OPR-1 stated that as he approached the intersection of Sea St. he observed OPR-2 pull out in front of him. OPR-1 told me that he tried to avoid OPR-2, however he was unable and struck the driver's side of OPR-2's vehicle with his front bumper. OPR-2 told me he was stopped at the intersection of Sea St. and Rt 28. OPR-2 stated that he did not see any vehicle in either direction. OPR-2 pulled onto RT 28 in attempt to cross and was struck by OPR-1. 1256/mbd
3	12/22/2009	On December 22, 2009 I responded to a motor vehicle crash at the intersection of Route 28 and Sea St. Upon arrival I observed both vehicles had parked in the parking lot of the Original Seafood Restaurant. I spoke to both Operators, who gave similar accounts of the crash. Vehicle 1 was operating eastbound on Route 28, and had stopped to take a left onto Sea St. Vehicle 2 was also operating eastbound on Route 28, and failed to stop in time, impacting Vehicle 1 from the rear. Operator of vehicle 2 was issued citation #[redacted], for Failure to Use Care in Slowing, Stopping and Turning, and for an Inspection Sticker violation. 1256/mbd
4	12/28/2009	At approx 1814 hrs on December 28, 2009 vehicle 1 was traveling south on Sea Street and vehicle 2 was traveling east on RTE 28. Vehicle 1 crossed over Rte 28 and was struck by vehicle 2. Vehicle 1 sustained moderate damage to right rear corner fender area and vehicle 2 also sustained moderate damage to the right front fender area of the vehicle. There were no injuries and both vehicles left under their own power. The driver of veh 1 was issued citation #[redacted] for failure to use care in starting and the operator of veh 2 was issued citation # M8925133 for failure to have license and registration and for no inspection sticker. 1256/mbd
5	6/26/2010	Vehicle 1 was travelling south on Sea Street and came to a stop at the intersection of Sea Street and Route 28. Vehicle 2 was travelling east on Route 28. Vehicle 1 entered the intersection in front of vehicle 2, causing the collision. The operator of vehicle 1 stated she entered the intersection after observing a vehicle operating north on Sea Street begin to enter the intersection. The operator of vehicle 1 stated she believed the intersection was clear based on this other vehicle's actions. This officer observed heavy passenger side damage to vehicle 1, and minor cosmetic damage to the front bumper of vehicle 2. 1256/mbd
6	7/2/2010	On 07/02/10 at approximately 1600 hours I responded to a MVA at the intersection of Route 28 and Sea St. The accident was reported as no PI. OP 1 stated he was attempting to pull out onto Route 28 and travel westbound. He stated because of the heavy volume of traffic he was inching out into the traffic. As he was doing so he struck V2 as it turned left onto Sea St. Op 2 stated she was traveling westbound on Route 28 and then began to turn left (South) onto Sea St when her vehicle was struck by V1.1256/mbd

Crash Summary (Page 2 of 4)		
#	Crash Date	Crash Narrative
7	7/10/2010	Vehicle # 1 was traveling west on Route 28 in the area in the area of Sea Street. Vehicle #2 stopped at the stop sign on south side and then proceeded into intersection. Vehicle #3 was stopped at the stop sign on the northside of the road. Vehicle #2 hit vehicle #1 in the westbound travel lane. The impact caused vehicle #1 to hit vehicle #3, which was still stopped at the stop sign. Operator of vehicle #2 stated that he had enough time to make it through the intersection and vehicle #1 sped up. Operator of vehicle #1 stated that she was driving and did not know what hit her. Operator of vehicle #3 stated that she heard the impact and then was struck. 1256/mbd
8	1/19/2011	V#1 East, V#2 West on rt 28. OPER V#1 stated that she was behind another car, (A), waiting to take a left onto Sea St. V#2 flashed it's lights and she followed right behind veh A and was hit by V#2. OPER V#2 stated that he saw two vehicles stopped on Rt 28, he flashed his lights for the first veh., (A), to go and V#2 followed and he was unable to avoid collision. DAMAGE: V#1 heavy right side, rear axle, V#2 heavy right front bumper and quarter. OPER V#1 failed to use care in turning. 1256/mbd
9	3/3/2011	On above date and time, police were dispatched to above location for a report of an MVA. Upon arrival, operator #1 stated that she was stopped at the stop sign on Sea St facing north when she attempted to cross Route 28 and continue north on Sea St. She stated that she did not see veh #2 travelling west on Route 28 and she collided with that vehicle. Operator #2 said he was westbound on Route 28 when veh #1 struck him on the driver's side. He said the force moved his vehicle against the curb on the north side of Route 28, causing further damage. No injuries. Veh #2 towed due to damage. 1256/mbd
10	4/22/2011	On 4-22-11 at approx 1732 hrs, Vehicle #1 was traveling west on Rte 28. The operator, [redacted] stated that she was traveling towards the intersection of Sea St and Rte 28. She stated that she saw Vehicle #2 stopped at the stop sign at Sea St facing southbound. [redacted] stated that Vehicle #2 pulled out in front of her. She tried to hit the brakes but was stopped by airbags coming towards her. The operator of Vehicle #2, [redacted] stated that he was stopped at the stop sign at Sea St. He continued south across Rte 28 to go to the Original Seafood Rest. when Vehicle #1 struck the rear driver's side of the vehicle causing Vehicle #2 to roll over and spin around. Three people were transported to CCH.mb
11	5/21/2011	Vehicle 1 was operating west on Route 28, a public way in Dennisport. Vehicle 2 was operating south on Sea St., also a public way in Dennisport. V2 stopped for stop sign then proceeded into the intersection and collided with V1. Both operators received apparent minor injuries due to the collision, however only operator of V1 requested transport to Cape Cod Hospital for evaluation/treatment.Both vehicles were towed from the scene by Northside Auto Body. CMVI Citation [redacted] issued to operator of V2 for Stop Sign violation. 1256/mbd

Crash Summary (Page 3 of 4)		
#	Crash Date	Crash Narrative
12	7/11/2011	v1 was travelling west on Route 28 during a time that traffic was heavy. V2 was heading south on Sea St and stopped,at the stop sign posted at the intersection of Sea St and Route 28. V2 attempted to cross Rt 28 to continue south on Sea St. V2 started into the traffic on Rt 28 before it was safe to do so and crashed into V1 as it was going straight ahead. Both operators and the passenger from V1 stated they were not injured. V1 had extensive damage to both passenger side doors the r rear 1/4 and the trunk. V2 had extensive damage to the front bumper, grill and hood. Op of V1 issued citation R1011542 for a stop sign violation. V2 was driven from the scene. Owner of V1 made arrangements for a tow.m
13	7/27/2011	On above date and time, police were dispatched to the above location for an MVA. Upon arrival, operator #2 stated that she was stopped at the intersection facing north, when she attempted to turn right onto RT 28, striking veh #1, which had pulled up alongside her. Operator #1 stated that he was behind veh #2 and pulled up along the right side because he thought she was going straight through the intersection. There is only one travel lane in each direction on Sea St. No injuries. Both vehicles removed under their own power.
14	8/13/2011	Vehicle #2 stopped at the intersection southbound on Sea Street and then proceeded into the intersection with Route 28, intending to continue southbound on Sea Street. Vehicle 2 stopped in the intersection for a vehicle travelling at a high rate of speed east on Rt. 28. Vehicle 1 followed behind vehicle 2, thinking she was proceeding south. Vehicle 1 struck vehicle 2 when it stopped. Neither individual was injured. Both vehicles were able to be driven. Information was exchanged and vehicles were sent on their way. 1256/mbd
15	8/18/2011	V#1 South on Sea St, V#2 East on Rt 28. OPER V#1 stated that she stopped at the stop sign, did not see anything coming and as she proceeded through V#2 hit her. OPER V#2 stated that she was east on Rt 28 and V#1 pulled out in front of her. Both vehicles moved off roadway prior to my arrival. DAMAGE: V#1 right front bumper, quarter panel and axle, V#2 front end. Citation issued to oper V#1 for Failure to grant right of way. 1256/mbd
16	8/24/2011	I responded to a two vehicle crash at the intersection of Route 28 and Sea Street in Dennisport. Upon arrival, DFD was loading operator one into the ambulance with possible injuries. Based on conversation with vehicle two occupants and later phone conversation with the operator one, I determined that vehicle one stopped at the stop sign, northbound on Sea Street. Vehicle two was travelling east on Rt. 28. Vehicle one pulled into the intersection and was struck by vehicle two in a "t-bone." Both vehicles had over 1000 dollars of damage, both required a tow. Operator 1 was transported to CCH and later issued a citation for failure to use care in starting. Occupants of vehicle 2 declined EMS.mbd

Crash Summary (Page 4 of 4)		
#	**Crash Date**	**Crash Narrative**
17	6/28/2009	2:35 PM No injury Angle V1: Travelling straight ahead / V2:Travelling straight ahead V1:W / V2:N
18	7/14/2009	2:24 PM Non-fatal injury - Possible Angle V1: Travelling straight ahead / V2:Travelling straight ahead V1:S / V2:W
19	8/1/2009	6:25 PM No injury Angle V1: Travelling straight ahead / V2:Entering traffic lane V1:W / V2:S
20	8/7/2009	8:06 PM Non-fatal injury - Incapacitating Angle V1: Entering traffic lane / V2:Travelling straight ahead V1:S / V2:W

INTERSECTION OPERATION

Frequently, operational issues at an intersection can result in safety problems. For example, drivers who have been waiting in a long queue sometimes tend to accept smaller gaps when they reach the intersection. To assess how well the intersection is operating, a Level of Service (LOS) analysis using Highway Capacity Manual 2010 software was performed. Analysis was based on the Saturday Peak Hour (11AM – 12PM) observation conducted on July 30, 2005. According to this analysis, during the peak hour, the Main Street (Route 28) approaches operated at LOS A, while the Sea Street approaches operated at LOS F. With higher left turn and through movements, the northbound Sea Street approach experienced the greatest delay.

POSSIBLE COUNTER MEASURES

From the site visit and capacity analysis, it seems that sight distance and driver frustration may be playing a role in the crashes occurring at this site. There are a number of possible countermeasures that have the potential to improve safety at this location. Of the available countermeasures those that seem most consistent with the village character include:

1. **Removal of site distance obstructions**, particularly vegetation, can be a low-cost and effective safety countermeasure. As the parcels adjacent to the intersection are privately owned, it is important to engage the land owners and emphasize the importance of maintaining sightlines to the safety of the intersection.

2. **Advanced warning signs and markings** are important tools in alerting motorists that they are approaching an intersection and should be prepared to act accordingly whether that means stopping or simply being aware of side streets. A more thorough analysis of the intersection crash reports will help reveal which approaches could benefit from these improvements.

3. **Traffic calming measures on Main Street (Route 28)** would provide cues to drivers as to the appropriate speed to travel as they enter the village center. Drivers should understand that they are entering a village area where they must anticipate more

frequent interactions with turning and parking vehicles as well as pedestrians and bicyclists. As drivers select more appropriate, slower speeds, the frequency and severity of accidents at the intersection could be reduced. To allow these slower speeds to be enforceable, the speed limit on this section of Main Street (Route 28) should be reduced.

4. **Improved access management in the vicinity of the intersection** would reduce the number of conflict points and driver confusion around the intersection. There are a number of expansive curb cuts within the functional area of the intersection that are negatively impacting the operation of the intersection. In close cooperation with the abutting land owners, an effort should be taken to reduce and/or eliminate curb cuts especially those nearest to the intersection. As much as possible, curb cuts should be limited to the minor street.

5. **Consider bicycle and pedestrian upgrades** at the intersection consistent with the needs of the area.

Given that this intersection has proven to be a persistent safety hazard over the years, it would be prudent to further study this intersection to determine if long-term solutions such as a four-way stop, signalization, or installation of a roundabout should be considered. As a first step, a more intensive data collection should be performed including the following:

- Turning movement counts - weekday morning peak hour, afternoon peak hour, Saturday peak hour,
- Volume, speed , and classification data on Main Street (Route 28) and Sea Street,
- Measurements of sight lines, and
- Measurements of curb cuts in the vicinity of the intersection.

MAIN STREET (ROUTE 28) AT DEPOT STREET

According to Massachusetts Department of Transportation (MassDOT) crash records and Town of Dennis Police Records, there were a total of fifteen (15) crashes from 2009 through 2011 at the intersection of Main Street (Route 28) and Depot Street. (Note: MassDOT crash records only available through 2010.)

EXISTING CONDITIONS

The major movements of this four-leg intersection are from the east and west approached along Main Street (Route 28); however, a significant number of vehicles approach from Sea Street as well. As shown in the figure below representing a Saturday peak hour counted on August 20, 2005, the mainline traffic is in excess of 1,000 vehicles per hour (vph) with just over 230 vph entering the intersection from Depot Street.

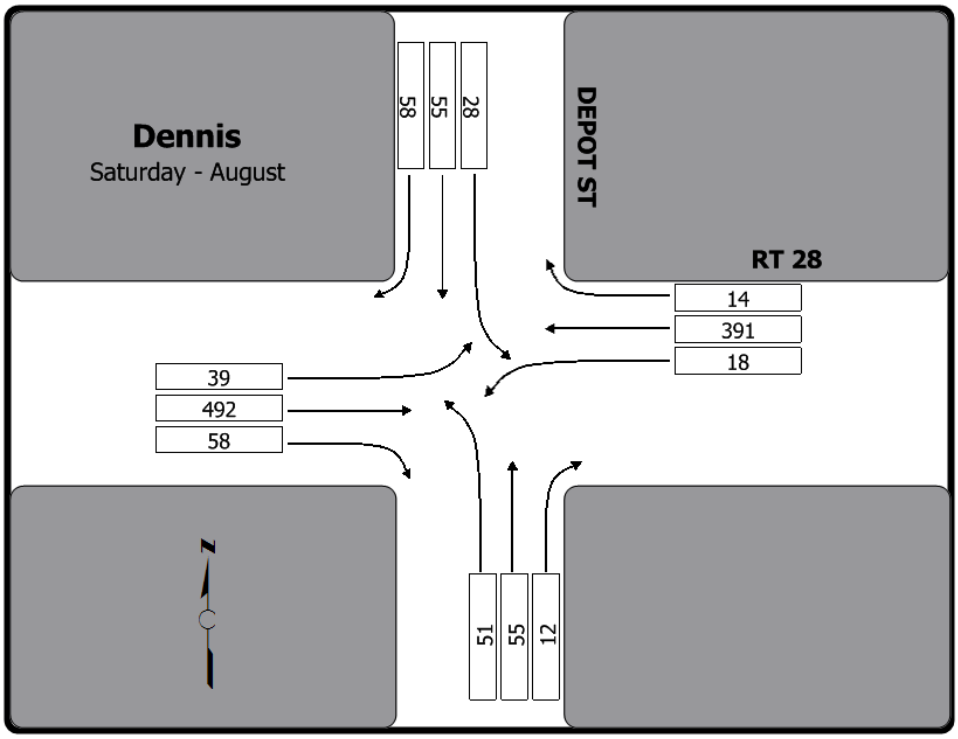
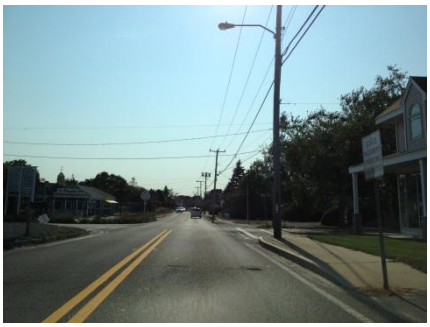


FIGURE 3. TURNING MOVEMENT COUNT DATA - MAIN STREET (ROUTE 28) AND DEPOT STREET (12PM-1PM SATURDAY, AUGUST 20, 2005)

The intersection operates as a two-way stop controlled intersection with traffic on Depot Street required to stop. There is marginal sight distance available to drivers approaching from Depot Street, particularly from the north. There are standard “Stop” signs on the Depot Street approaches in fair condition.

There are a number of expansive curb cuts within the functional area of the intersection. There is a sidewall on the north side of Main Street (Route 28) with a crosswalk on the north side of the intersection.

Facing North	Facing South
Facing East	 Facing West

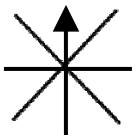
CRASH EXPERIENCE

Located just 600 feet from the intersection of Main Street (Route 28) and Sea Street, this intersection faces many of the same challenges. Of the fifteen (15) crashes from 2009-2011, eleven (11) were angle crashes, one (1) was a rear-end crash, one (1) involved a vehicle backing up, and (2) involved bicycles. Five (5) of the crashes were injury crashes. The crash reports supplied as part of the Chapter H application were analyzed and are presented in the collision diagrams on the following page. The crash narratives for each crash follow the collision diagram.

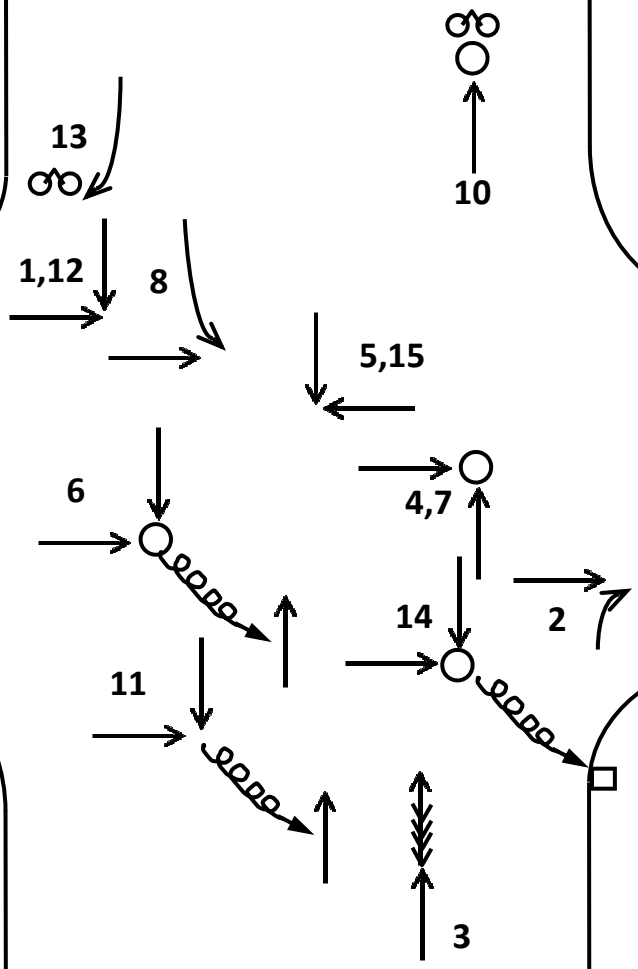
The crash diagram on the following page suggests that the most prevalent safety issue involves drivers approaching the intersection from Depot Street attempting to turn left on cross the intersection. In many cases, drivers either disregarded the stop sign or did not notice the vehicles travelling on Main Street (Route 28). While this is sometimes explained away as driver error, it is no driver's intention to be in an accident and the frequency of the crashes suggests that a structural problem exists at the intersection. Possible safety counter measures to address these structural problems are discussed later in this section.

Also of note are the two bicycle crashes. While the bicyclist was at least partially at fault in each case, their actions and intents could have been made clearer to the drivers if better bicycle accommodations were provided.

Collision Diagram



Indicate North by arrow



Name: Main Street (Route 28)

Name: Depot Street

SYMBOLS	TYPES OF COLLISIONS	CRASH INFORMATION
Moving Vehicle	Rear-End	Each crash is numbered and additional information is included on the crash summary.
Backing Vehicle	Head On	
Non-involved Vehicle	Side Swipe	Notes: #15 from MassDOT Crash Data (7/27/10 @ 3:48PM)
Pedestrian	Out of Control	
Bicyclist	Turning Movement	
Parked Vehicle	Right Angle	
Fixed Object		
Fatal Crash		
Injury Crash		

INTERSECTION Main Street (Route 28) AND Depot Street

CRASHES FROM 2009 TO 2011

Crash Summary (Page 1 of 2)

#	Crash Date	Crash Narrative
1	5/8/2009	Vehicle #1, west on Route 28, struck on passenger side front by vehicle #2, south on Depot St, which failed to stop at stop sign. Op#2 then fled scene w/o stopping and was arrested a short time later for OUI, leaving the scene, and failure to stop at stop sign.
2	7/27/2009	Cit#M153879 Veh#1 Stopped at stop sign attempting to make a right turn from the stop sign at Depot St. onto Rt. 28 (Both Public Way). Veh#2 Traveling east on Rt. 28 at the intersection with Depot St. Oper. of Veh#1 failed to use care in starting and attempted to make the turn. Oper. of Veh#2 does not have time to stop as Veh#1 hits Veh#2 on the passenger side front quarter panel. A witness stopped at stop sign directly behind Veh#1 stated, Oper. of Veh#1 pulled out in front of Veh#2 and caused the crash. 1256/mbd
3	7/31/2009	V#1 stopped at Stop Sign facing northbound at the intersection of Depot St. and Rte. 28. V# 2 directly behind V# 1. V# 1 begins to start out through the intersection; however the operator decides it was not safe to do so, so then backs up striking V# 2 on the front end causing minor damage to both vehicles. 1256/mbd
4	8/22/2009	V#1 north on Depot St, V#2 east on Rt 28. OPER V#1 stated that he stopped at the stop sign, as he started through intersection V#2 suddenly appeared and hit him. OPER V#2 stated he did not know if V#1 stopped at the stop sign, but suddenly pulled out in front of him. He attempted to swerve out of the way but collided with V#1. WITNESS stated that he was 2 cars behind V#1 and it did stop. DAMAGE: V#1 Heavy left front bumper, quarter panel and axle, V#2 moderate right front bumper and quarter panel. OPER V#1 Cit M8154480 for Stop Sign Viol. 1256/mbd
5	9/12/2009	Vehicle 1 traveling west on Route 28. Vehicle 2 traveling south on Depot St. Vehicle 2 proceeded into the intersection without stopping. Vehicle 1 struck vehicle 2 on drivers side. Both vehicles gone on my arrival. Witness stated one vehicle was a small red pick up truck. Officer [redacted] located vehicle. Driver stated he spoke with other operator and agreed to pay for their own damage. Registration plates for vehilce 1 were active to another vehicle and over the seven day grace period. I took custody of the plates and placed them into inventory [redacted] 1256/mbd
6	09/26/2009	On 9-26-2009 at approx. 0922 Hrs Veh#1 was stopped at the stop sign facing south on Depot St.waiting to proceed south on Depot St. This vehicle then pulled across Rt 28 in the path of Veh.#2 which was proceeding east on Rt 28 and collided with same in the middle of the intersection, sending Veh.#2 into Veh.#3 which was stopped at the northbound stop sign on Depot St. The operator of Veh# 3 stated that he had eye contact with the operator of Veh#1, and that the operator of Veh#1 never looked westbound as she pulled across the intersection. 1256/mbd
7	2/19/2010	Operator of V# 1 stopped at Stop Sign facing Northbound on Depot St. at the intersection of Rte. 28. V# 2 travelling Eastbound on Rte. 28 approaching Depot St. V# 1 attempts to cross Rte. 28 and strikes V# 2 on the passenger side front quarter panel causing damage to both cars. Operator of V# 1 said that there was a person riding a horse on the side of Rte. 28 that distracted her. Operator of V# 2 said that he saw the horse but did not believe that it distracted the driver. As a result of this investigation, a citation was issued to the operator of V# 1 for Failure to Use Care in Stop/Starting. TOD 1256/mbd

Crash Summary (Page 2 of 2)

#	Crash Date	Crash Narrative
8	5/11/2010	Vehicle 1 stopped at the posted stop sign at the intersection above and then proceeded to turn left to travel EB on Route 28 from Depot St. Vehicle 2 was traveling EB at that time on Route 28 and was struck by vehicle 1 as vehicle 1 turned left entering the traffic lane. Damage occurred to the front passenger side bumper of vehicle 1 and the rear driver side bumper of vehicle 2. There was no major damage, no injuries reported, and no vehicles were towed. Both vehicles then pulled ahead and off to the side and notified police. 1256/mbd
9	6/18/2010	On 06-18-10 at approx 1047 hrs, Vehicle #1 was traveling east on Rte 28. Vehicle #1 slowed and stopped to turn south on Depot St. Vehicle #2 slowed and stopped behind Vehicle #1. Vehicle #3 crashed into Vehicle #2, which crashed into Vehicle #1. 1256/mbd
10	8/10/2010	On 8/10/10 I responded to the area of Barbo's Furniture for a vehicle vs. bicycle crash. The oper. of V1 stated that she stopped at the south side of Depot St. at the stop sign then proceeded thru the intersection of Depot St/ Rte 28. When V1 went thru the intersection, the oper. observed a boy on a bike heading south on Depot St. The bike traveling south went around another vehicle in traffic and made a quick left turn and began heading east on Depot St. The oper. of V1 hit her brakes, stopping quickly, as she was only going around 7 mph. V1 hit the boy on the bike. The oper.said that the boy did not fall off the bike, he was able to step off the bike, and there was no damage. [redacted] was transported to CCH by
11	5/30/2011	On above date and time, police were dispatched to above location for a three vehicle MVA. Upon arrival, operator #1 stated he was south on Depot St approaching the intersection with Route 28. He stated that he stopped at the stop sign and attempted to cross Route 28 when he was struck by veh #2. He stated that he did not see veh #2 coming. Operator #2 said he was eastbound on Route 28 when veh #1 pulled out in front of him. He stated that he did not have time to stop. Operator #3 said he was stopped at the stop sign on Depot St facing north when veh #1 was forced into his vehicle. Below witness, who was eastbound on Route 28 behind veh #2, stated that veh #1 did not stop at the stop sign. 1256/mb
12	5/30/2011	On 05-30-11 at approx 1533 hrs, Vehicle #1 was traveling east on Route 28. The operator of vehicle #1, [redacted] stated that he saw Vehicle #2 at the intersection of Depot St and Route 28. [redacted] doesn't believe that the vehicle stopped at the stop sign. Vehicle #2 was on Depot St traveling south when it crossed in front of Vehicle #1, causing Vehicle #1 to crash into Vehicle #2. The operator of Vehicle #2, [redacted], failed to yield the right of way to Vehicle #1. 1256/mbd
13	8/6/2011	Vehicle 1 approached the intersection travelling SB on Depot St. and then stopped at the stop sign. As the vehicle proceeded to turn right with a blinker activated, the operator said he heard a crash into his truck rear of the front passenger door area. He then realized that a cyclist had come up from behind him on the passenger side and also made a right onto Route 28 to travel WB. The operator said that he remembers passing the cyclist but then did not see the cyclist again approach him from the rear. The cyclist stated that she rode SB and then turned the corner onto Route 28 to travel WB when her front tire collided with the rear passenger area of the truck. The front of her bike was damaged.mbd
14	8/17/2011	Vehicle 2 traveling south on Depot St did not stop at the stop sign at Route 28. Vehicle 2 struck vehicle 1 in the eastbound travel lane of Route 28. Vehicle 2 subsequently struck the stop sign at the south side of the intersection. Operator of Vehicle #2 [redacted] told Officer [redacted] that she thought the intersection had a "blinking light". Driver and passenger of vehicle 1 said that vehicle 2 did not stop at the stop sign. Operator 1 sustained injuries to her left knee and right arm. She was transported to Cape Cod Hospital.

INTERSECTION OPERATION

Frequently, operational issues at an intersection can result in safety problems. For example, drivers who have been waiting in a long queue sometimes tend to accept smaller gaps when they reach the intersection. To assess how well the intersection is operating, a Level of Service (LOS) analysis using Highway Capacity Manual 2010 software was performed. Analysis was based on the Saturday Peak Hour (11AM – 12PM) observation conducted on August 20, 2005. According to this analysis, during the peak hour, the Main Street (Route 28) approaches operated at LOS A, while the Depot Street approaches operated at LOS D.

POSSIBLE COUNTER MEASURES

From the site visit and capacity analysis, it seems that sight distance and driver frustration may be playing a role in the crashes occurring at this site. There are a number of possible countermeasures that have the potential to improve safety at this location. Of the available countermeasures the following seem most consistent with the village character:

1. **Removal of site distance obstructions**, particularly vegetation, can be a low-cost and effective safety countermeasure. As the parcels adjacent to the intersection are privately owned, it is important to engage the land owners and emphasize the importance of maintaining sightlines to the safety of the intersection.

2. **Advanced warning signs and markings** are important tools in alerting motorists that they are approaching an intersection and should be prepared to act accordingly whether that means stopping or simply being aware of side streets. A more thorough analysis of the intersection crash reports will help reveal which approaches could benefit from these improvements.

3. **Traffic calming measures on Main Street (Route 28)** would provide cues to drivers as to the appropriate speed to travel as they enter the village center. Drivers should understand that they are entering a village area where they must anticipate more frequent interactions with turning and parking vehicles as well as pedestrians and bicyclists. As drivers select more appropriate,

slower speeds, the frequency and severity of accidents at the intersection could be reduced. To allow these slower speeds to be enforceable, the speed limit on this section of Main Street (Route 28) should be reduced.

4. **Improved access management in the vicinity of the intersection** would reduce the number of conflict points and driver confusion around the intersection. There are a number of expansive curb cuts within the functional area of the intersection that are negatively impacting the operation of the intersection. In close cooperation with the abutting land owners, an effort should be taken to reduce and/or eliminate curb cuts especially nearest to the intersection. As much as possible curb cuts should be limited to the minor street.

5. **Consider bicycle and pedestrian upgrades** at the intersection consistent with the needs of the area.

Given that this intersection has proven to be a persistent safety hazard over the years, it would be prudent to further study this intersection to determine if long-term solutions such as a four-way stop, signalization, or installation of a roundabout should be considered. As a first step, a more intensive data collection should be performed including the following:

- Turning movement counts - weekday morning peak hour, afternoon peak hour, Saturday peak hour,
- Volume, speed , and classification data on Main Street (Route 28) and Depot Street,
- Measurements of sight lines, and
- Measurements of curb cuts in the vicinity of the intersection.

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