

Road Safety Assessment

US Route 1 (Tower Hill Road) | South Kingstown, RI

OCTOBER 2017



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1

Introduction

The Highway Safety Improvement Program (HSIP) was created under Section 1401 of SAFETEA-LU with the purpose of reducing traffic fatalities and serious injuries on public roadways. The Moving Ahead for Progress in the 21st Century Act (MAP-21) then the Fixing America's Surface Transportation (FAST) Act provided continuations of the HSIP, which is authorized under United States Code Title 23 Section 148 (23 U.S.C. 148). As part of the Rhode Island Department of Transportation (RIDOT) HSIP, RIDOT has created several programs that target specific safety improvements such as Roadway Departure, Intersection Safety, Safety Corridor, Interchange Improvements, RI*STARS, Vulnerable Road User, Local Safety, and Safety Data Collection programs.

For the state to reach its goals set forth in their Strategic Highway Safety Plan (SHSP) to halve fatalities and serious injuries by 2030, the RIDOT developed the Roadway Departure Mitigation Program to mitigate crash issues on state- and locally-maintained roadways as well as provide funding (when available) to implement crash measures.

The goal of the program has been to target roadway segments with high frequencies of crashes for roadway safety assessments. The current Roadway Departure Mitigation Program efforts have been focused on the four subprograms: Median Barrier, Horizontal Curve, Rumble Strip, Roadside Improvement Program.

US Route 1 (Tower Hill Road) was identified due to a request from a local state senator to RIDOT regarding concerns for safety along US Route 1 (Tower Hill Road). Due to other areas of US Route 1 (Tower Hill Road) that do have a crash history, RIDOT felt it was necessary to review this segment of US Route 1 (Tower Hill Road).

Based on the historic crashes at this location, it falls under the Roadway Departure Mitigation Program.

For all locations investigated as part of the HSIP, RIDOT conducts a Road Safety Assessment (RSA) where RIDOT and an interdisciplinary team evaluate existing conditions and identify possible factors contributing to crash history and severity at these locations. The findings are then prioritized in order of perceived importance and associated with potential opportunities for targeted improvement/corrective mitigation. The potential improvements to be considered are either spot or systemic and are categorized as immediate-, near-, or long-term, representing the timeframe in which they should or could be implemented.

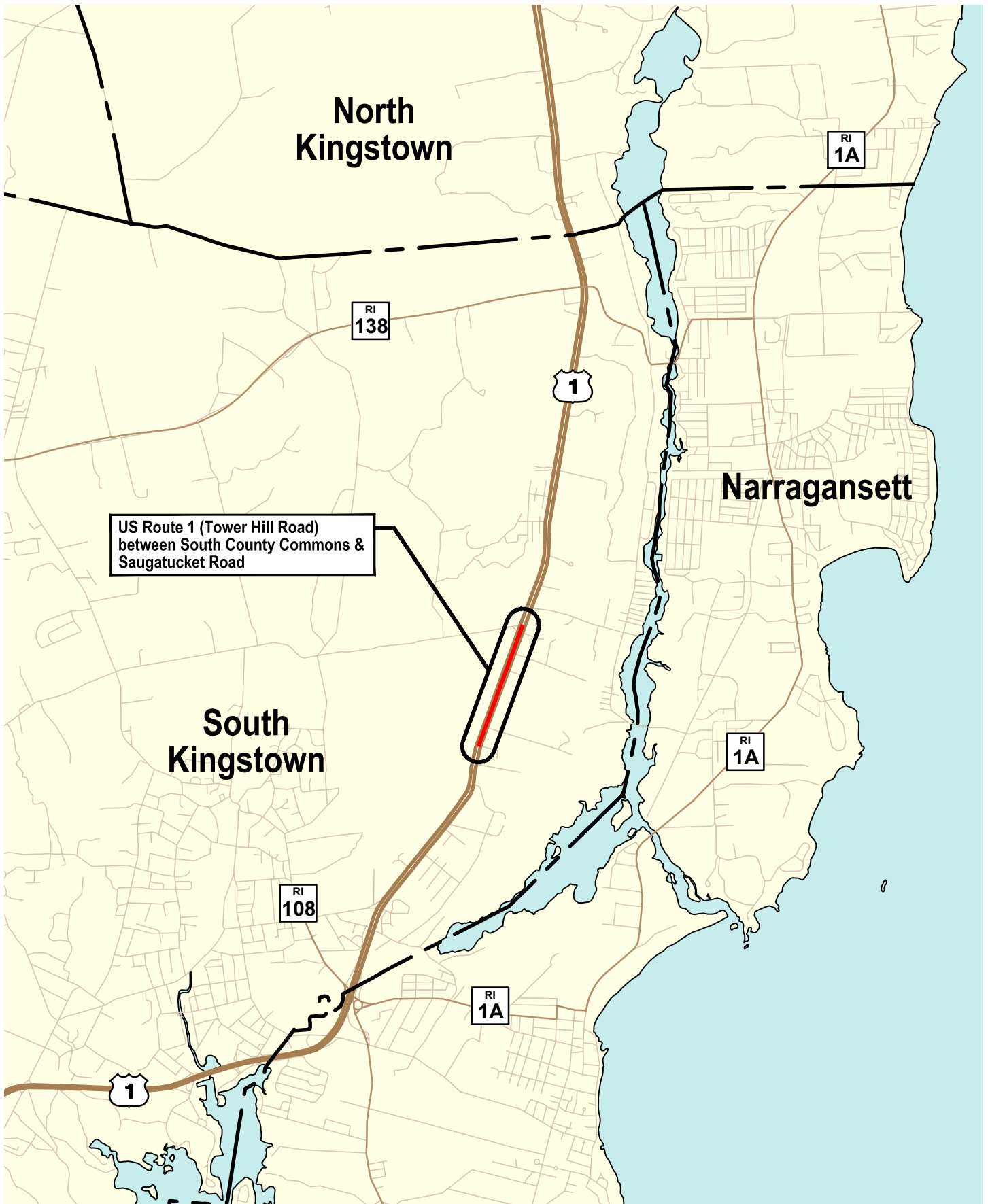
1.1 Study Area

Residents in coordination with their State Representative have identified safety concerns on US Route 1 (Tower Hill Road). The focus of this report is US Route 1 (Tower Hill Road), between South County Commons and Saugatucket Road.

US Route 1 (Tower Hill Road) is a four-lane (two lanes in each direction) freeway/expressway that has a generally north-south orientation. There is a center median with cable guardrail separating the northbound and southbound travel lanes throughout the study area. US Route 1 (Tower Hill Road) provides a connection from North Kingstown to Westerly. The land use in this area is mostly residential use with some commercial use.

The intersections throughout the corridor are all unsignalized, with stop control on the side street, except for the southern limit. At South County Commons, the southern limit, the intersection is a four-leg intersection controlled by a traffic signal. The northern limit, at Saugatucket Road, is a three-leg intersection which intersections the US Route 1 southbound. At this intersection, Saugatucket Road traffic is controlled by a stop sign.

Figure 1-1 depicts the location of the study area.



General Assessment Area
US Route 1 (Tower Hill Road)
South Kingstown, RI
Roadway Departure Mitigation Program

Figure 1-1



2

Roadway Safety Assessment

2.1 Objective of Road Safety Assessment



For all locations investigated as part of the HSIP, RIDOT conducts a Road Safety Assessment (RSA). The FHWA defines a Roadway Safety Assessment (RSA) as a “formal safety performance evaluation of an existing or future road or intersection by an independent, multidisciplinary team”. RSAs are a valuable tool for transportation agencies to evaluate road safety issues contributing to injuries and deaths and to identify opportunities for improvement. The success of RSAs has led to the FHWA including the RSA process as one of its nine “proven safety countermeasures”.

Some element of safety is considered in every project; however, sometimes conditions merit a more detailed safety review. RSAs examine these conditions in detail by pulling together an interdisciplinary team that looks at the issues from different perspectives – perspectives that are often not a part of a traditional safety review. RSAs also consider safety from a human factors point of view, which aims to answer the following questions:

- › How and why are people reacting to the roadway conditions?
- › What do people sense and how do they react to those senses?
- › What are the associated risks with those elements?

2.2 Road Safety Assessment Interdisciplinary Team

An interdisciplinary team approach is a key factor in the success of Roadway Safety Assessments. Interactions between all road users (e.g., pedestrians and motor vehicles, commuter traffic and recreational vehicle traffic, bicycles and motor vehicles, etc.) are investigated to determine potential risks and to identify programs and measures to help reduce those risks and create safer environments for all road users. By working with an interdisciplinary team of stakeholders the views of each of the unique users can be captured and integrated into solutions and countermeasures.

The Interdisciplinary RSA Team for the US Route 1 road assessment consisted of engineers and stakeholders from the Town of Glocester, the Rhode Island Department of Transportation (RIDOT), and local police department representatives. Representatives from VHB facilitated the RSA. The members of the RSA team are as follows:

- › Joshua Rosen – Town Engineer, South Kingstown, RI
- › Chelsea Siefert – Director of Planning, South Kingstown, RI
- › Lt. Mark Healey – Police, South Kingstown, RI
- › Maureen McHugh - RIDOT
- › Skye Levin – VHB
- › Rachel Dooley – VHB

2.3 Crash Analysis

Crash data for the assessment area was provided by the Rhode Island Department of Transportation (RIDOT) for the five-year period between January 1, 2011 and December 31, 2015. The crashes were reviewed by severity and crash type. Severity is measured using the KABCO method which assigns a severity type to each crash. K-type crashes result in a fatality, A-type crashes result in an incapacitating injury, B-type crashes result in an evident injury, C-type crashes result in complaints of pain, and O-type crashes result in property damage only. **Figure 2-1** provides a collision diagram detailing the crashes along US Route 1.

Along US Route 1, between South County Commons and Saugatucket Road, 53 total crashes along the corridor that occurred between 2011 and 2015. Of those 53 crashes, 24 are roadway departure crashes occurred along the segment. One of the total crashes (2%) was K-type, one of the crashes (12%) was B-type injury crash, 12 of those crashes (23%) were C-type injury crashes while the remaining 74 percent were property damage only crashes. It should also be noted that the one fatal crash (K-type injury) was roadway departure related.

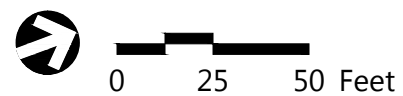


SOURCE:
 CRASH DATA PROVIDED BY RIDOT
 TRAFFIC RESEARCH UNIT.
 CRASH DATA PROVIDED DATES
 FROM 2011 THROUGH 2015.

SYMBOLS	
	MOVING VEHICLE
	BACKING VEHICLE
	PEDESTRIAN
	BICYCLE
	PARKED VEHICLE
	FIXED OBJECT

TYPES OF COLLISION	
	REAR END
	HEAD ON
	SIDE SWIPE
	OUT OF CONTROL
	LEFT TURN
	ANGLE

SEVERITY	
K	FATAL INJURY CRASH
A	INCAPACITATING INJURY CRASH
B	NON-INCAPACITATING INJURY CRASH
C	COMPLAINT INJURY CRASH
O	NO INJURY/PROPERTY DAMAGE ONLY CRASH



Collision Diagram

Tower Hill Road (US Route 1)
 South Kingstown, RI

Figure 2-1a

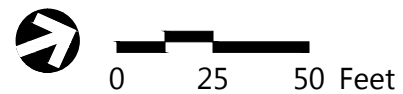


SOURCE:
 CRASH DATA PROVIDED BY RIDOT
 TRAFFIC RESEARCH UNIT.
 CRASH DATA PROVIDED DATES
 FROM 2011 THROUGH 2015.

SYMBOLS	
←	MOVING VEHICLE
←→	BACKING VEHICLE
- - -	PEDESTRIAN
⋯	BICYCLE
▭	PARKED VEHICLE
□	FIXED OBJECT

TYPES OF COLLISION	
←→	REAR END
←→	HEAD ON
←→	SIDE SWIPE
←→	OUT OF CONTROL
←→	LEFT TURN
↑	ANGLE

SEVERITY	
K	FATAL INJURY CRASH
A	INCAPACITATING INJURY CRASH
B	NON-INCAPACITATING INJURY CRASH
C	COMPLAINT INJURY CRASH
O	NO INJURY/PROPERTY DAMAGE ONLY CRASH



Collision Diagram

Tower Hill Road (US Route 1)
 South Kingstown, RI

Figure 2-1b



TOWER HILL ROAD (US ROUTE 1)

237635-C

277968-O

279438-O

363496-O

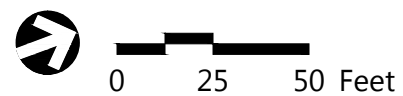
248709-O

SOURCE:
CRASH DATA PROVIDED BY RIDOT
TRAFFIC RESEARCH UNIT.
CRASH DATA PROVIDED DATES
FROM 2011 THROUGH 2015.

SYMBOLS	
	MOVING VEHICLE
	BACKING VEHICLE
	PEDESTRIAN
	BICYCLE
	PARKED VEHICLE
	FIXED OBJECT

TYPES OF COLLISION	
	REAR END
	HEAD ON
	SIDE SWIPE
	OUT OF CONTROL
	LEFT TURN
	ANGLE

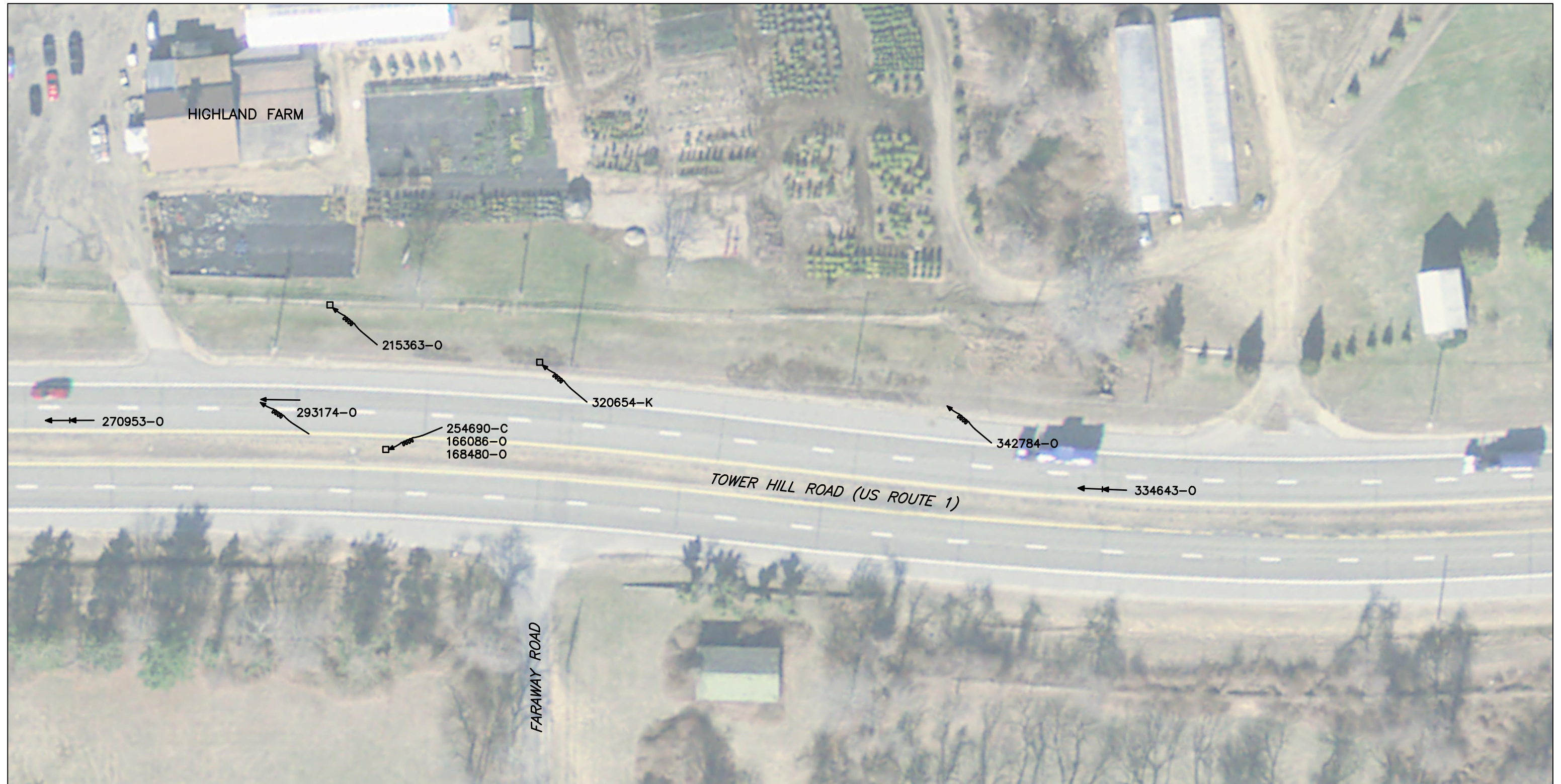
SEVERITY	
K	FATAL INJURY CRASH
A	INCAPACITATING INJURY CRASH
B	NON-INCAPACITATING INJURY CRASH
C	COMPLAINT INJURY CRASH
O	NO INJURY/PROPERTY DAMAGE ONLY CRASH



Collision Diagram

Tower Hill Road (US Route 1)
South Kingstown, RI

Figure 2-1c



SOURCE:
 CRASH DATA PROVIDED BY RIDOT
 TRAFFIC RESEARCH UNIT.
 CRASH DATA PROVIDED DATES
 FROM 2011 THROUGH 2015.

SYMBOLS	
	MOVING VEHICLE
	BACKING VEHICLE
	PEDESTRIAN
	BICYCLE
	PARKED VEHICLE
	FIXED OBJECT

TYPES OF COLLISION	
	REAR END
	HEAD ON
	SIDE SWIPE
	OUT OF CONTROL
	LEFT TURN
	ANGLE

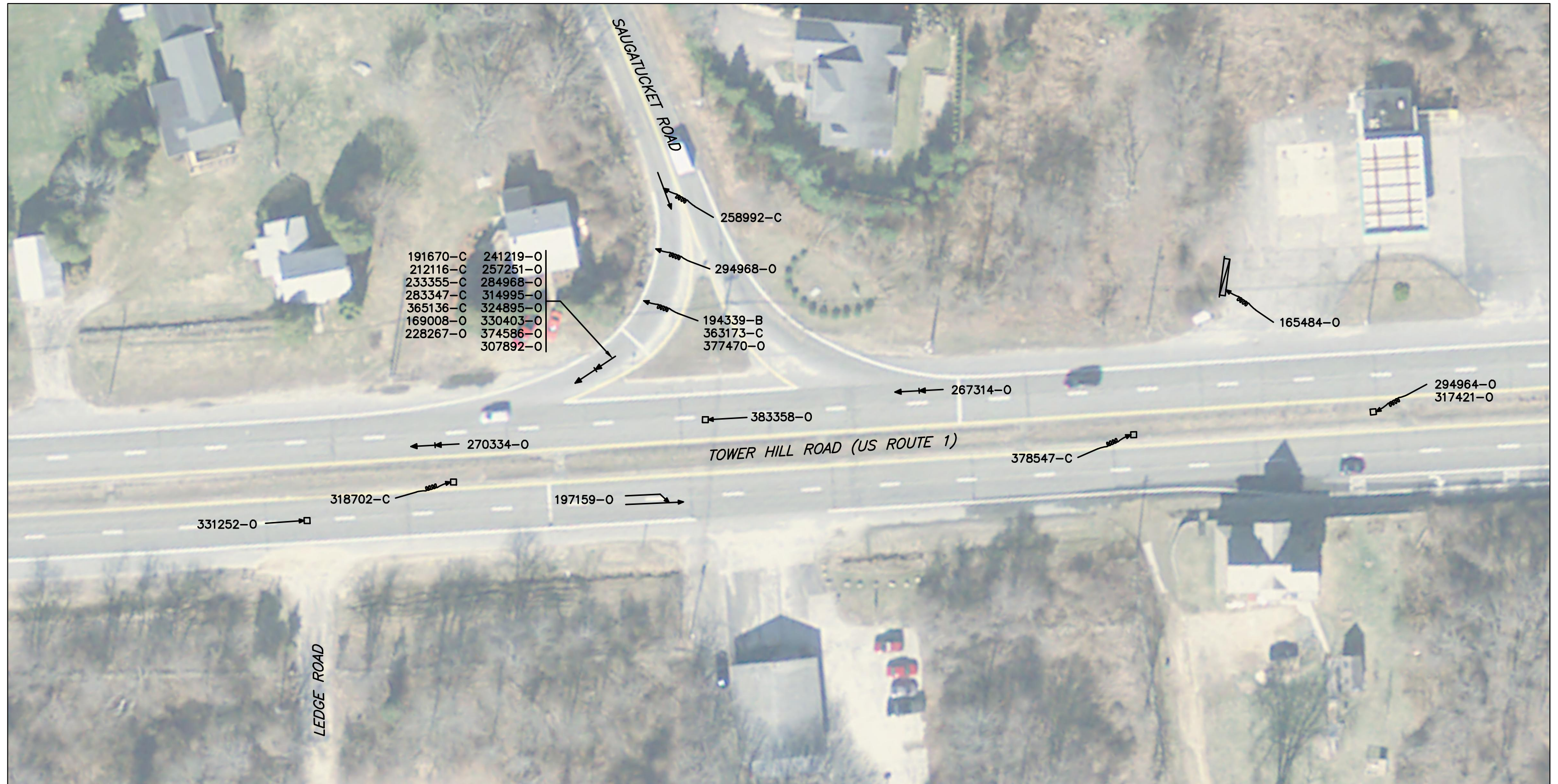
SEVERITY	
K	FATAL INJURY CRASH
A	INCAPACITATING INJURY CRASH
B	NON-INCAPACITATING INJURY CRASH
C	COMPLAINT INJURY CRASH
O	NO INJURY/PROPERTY DAMAGE ONLY CRASH



Collision Diagram

Tower Hill Road (US Route 1)
 South Kingstown, RI

Figure 2-1d

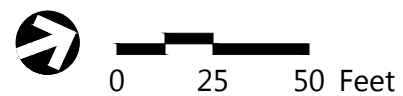


SOURCE:
 CRASH DATA PROVIDED BY RIDOT
 TRAFFIC RESEARCH UNIT.
 CRASH DATA PROVIDED DATES
 FROM 2011 THROUGH 2015.

SYMBOLS	
	MOVING VEHICLE
	BACKING VEHICLE
	PEDESTRIAN
	BICYCLE
	PARKED VEHICLE
	FIXED OBJECT

TYPES OF COLLISION	
	REAR END
	HEAD ON
	SIDE SWIPE
	OUT OF CONTROL
	LEFT TURN
	ANGLE

SEVERITY	
K	FATAL INJURY CRASH
A	INCAPACITATING INJURY CRASH
B	NON-INCAPACITATING INJURY CRASH
C	COMPLAINT INJURY CRASH
O	NO INJURY/PROPERTY DAMAGE ONLY CRASH



Collision Diagram

Tower Hill Road (US Route 1)
 South Kingstown, RI



Figure 2-1e



2.4 RSA Findings and Suggestions for Improvement

Based on a review of the provided crash data and of the existing field conditions, the RSA participants identified several key safety-related findings within the assessment area. These findings were prioritized in order of perceived importance and associated with potential opportunities for targeted improvement/corrective mitigation. The potential improvements to be considered are either spot or systemic and are categorized as immediate-, near-, or long-term, representing the timeframe in which they should or could be implemented.

Table 2-1 summarizes the findings and suggestions for each location included in this assessment.

Table 2-1 Summary of RSA Findings and Suggestions for US Route 1 (Tower Hill Road)

OBSERVATION	IMMEDIATE TERM IMPROVEMENTS Under 6 months	NEAR TERM IMPROVEMENTS Under 2 years	LONGER TERM IMPROVEMENTS Over 2 years	COMMENTS
<p>History of Roadway Departure Crashes – A number of roadway departure crashes occurred along the corridor within the last five years.</p> 	<p>ENGINEERING:</p> <p>1.1 Install post mounted delineators in both directions on the left and right-side of the roadway to better delineate the edge of pavement.</p> <p>1.2 Restripe US Route 1 to provide a larger left side shoulder and smooth striping of the curve.</p>	<p>ENGINEERING:</p> <p>1.3 Consider the installation of High Friction Surface Treatment (HFST) on US Route 1 within the curve.</p> <p>1.4 Replace missing recessed pavement markers (RPM) throughout the corridor.</p>	<p>ENGINEERING:</p> <p>1.5 Consider the installation of rumble strip/stripes.</p>	<p>Longer-term improvements are intended to address persistent safety issues if observed in the future.</p> <p>Rumble strip/stripes shall only be considered at locations with no residential areas adjacent to the roadway.</p>
<p>Inadequate Vehicle Sight Lines – Inadequate vehicle sight lines, at the intersection of US Route 1 at Saugatucket Road, presents a potential hazard. This is caused by overgrown vegetation, the horizontal and vertical curves of the channelized right-turn onto US Route 1 from Saugatucket Road.</p> 	<p>ENGINEERING:</p> <p>1.6 Trim overgrown vegetation along US Route 1 at the intersection with Saugatucket Road.</p>			
<p>Missing and Inconsistent Guardrail – Guardrail along the corridor was observed to be non-complaint or inconsistently placed leaving hazards (trees, ledge, slopes, etc.) within the clear zone unprotected.</p>	<p>ENGINEERING:</p> <p>1.7 Evaluate the existing guardrail along the corridor to determine if the current installation is appropriate. Revise guardrail accordingly.</p> <p>1.8 Review clear zones along the corridor. If a roadside hazard is within the clear zone remove the hazard if feasible. If not, protect the hazard accordingly.</p>	<p>ENGINEERING:</p> <p>1.9 Consider replacing a section of cable guardrail within the curve on US Route 1 per RIDOT guidance to install semi-rigid (w-beam, thrie beam) guardrail within curves.</p>		
<p>Drainage Issues – Water was observed to pond in the left lane at the edge of pavement.</p>	<p>ENGINEERING:</p> <p>1.10 Perform drainage analysis to determine the need for additional improvements.</p>			

OBSERVATION	IMMEDIATE TERM IMPROVEMENTS Under 6 months	NEAR TERM IMPROVEMENTS Under 2 years	LONGER TERM IMPROVEMENTS Over 2 years	COMMENTS
<p>Lack of signage– Guide/regulatory/warning signs are small, inconsistent, unclear, obstructed, or missing along US Route 1 (Tower Hill Road).</p>	<p>ENGINEERING:</p> <p>1.11 Consider a comprehensive sign audit to verify sign height, retro-reflectivity, current sign standards, consistency, redundancy, and unnecessary signs. Revise signs accordingly.</p> <p>1.12 Install reflective sign strips on all sign posts.</p>			
<p>Speeding – Vehicle appear to be traveling at a high rate of speed on US Route 1 (Tower Hill Road).</p>  <p>Wakefield Street, West Warwick</p>	<p>ENFORCEMENT:</p> <p>1.13 Consider a speeding enforcement campaign on US Route 1 to discourage speeding.</p> <p>ENGINEERING:</p> <p>1.14 Remove all speed limit signs along the corridor and install new signs space more appropriately.</p>	<p>ENGINEERING:</p> <p>1.15 Install dynamic speed feedback signs to discourage speeding along the corridor.</p>		<p>Since the completion of the Roadway Safety Assessment, a speed study was completed, as described in Chapter 3.</p>
<p>Lack of sufficient street lighting – No street lighting provided along the corridor which may contribute to the number of crashes at this location.</p>	<p>ENGINEERING:</p> <p>1.16 Conduct lighting study to determine deficiencies and potential improvements.</p>	<p>ENGINEERING:</p> <p>1.17 Implement area-wide lighting installation to improve safety for vehicles and other road users.</p>		<p>Coordinate with National Grid for lighting improvements.</p>
<p>Complex Intersection Geometry – Wide intersection geometry with a channelized median at the intersection of US Route 1 at Saugatucket Road in combination with the horizontal curve and high travel speeds along US Route 1 result in driver confusion and rear-end and roadway departure crashes at this location.</p> 	<p>ENGINEERING:</p> <p>1.18 Install stop ahead signs on Saugatucket Road.</p> <p>1.19 Install intersection warning signs on US Route 1 to warn vehicles of the approaching unsignalized intersection.</p>	<p>ENGINEERING:</p> <p>1.20 Consider the installation of High Friction Surface Treatment (HFST) on the entrance to Saugatucket Road from US Route 1.</p>	<p>ENGINEERING:</p> <p>1.21 Install acceleration and deceleration lanes at the intersection of US Route 1 and Saugatucket Road.</p> <p>1.22 Consider geometric reconstruction to “T” up intersection of US Route 1 at Saugatucket Road.</p>	<p>Longer-term improvements are intended to address persistent safety issues if observed in the future.</p>



3

Countermeasure Implementation

All recommendations from this RSA have been reviewed and vetted by the assessment team. This chapter provides a high-level evaluation of the proposed mitigation measures for implementation feasibility and appropriateness.

3.1 Implementation Plan

Table 3-1 presents the implementation plan for the RSA recommendations, including the timeframe in which each recommendation could reasonably be implemented. In addition, the table lists the “Safety Benefit - Costs” (where applicable) and the status of the recommendation.

The “Safety Benefit-Cost” column is a preliminary determination of the actual safety benefit expected as well as the cost to implement each recommendation made by the RSA team. Safety benefit estimates are subjective and may be based on the relative percent of crashes that may be reduced by the enhancement based on site specific crash data, statewide systemic crash trends, and known and documented crash reduction factors. Implementation costs are order-of-magnitude estimates based on recent contracts and other sources. The following exhibit illustrates the general guidance uses when making this determination.

Safety Benefit	Implementation Costs
High – Enhancement greatly reduces (>20%) crash types and severities experienced and/or addresses high risk facility types.	High – > \$100K
Medium – Enhancement reduces (<20%) crash types and severities experienced or addresses high risk facility types.	Medium – \$10K - \$100K
Low – Enhancement offers general safety benefits but not directly related to crash types and severities experienced or high risk facility types.	Low – <\$10K

3.2 Funding

The implementation of recommendations is contingent on available funding. Per the Fixing America's Transportation (FAST) Act legislation, the RIDOT is responsible for the reduction of fatalities and serious injuries on all public roadways, regardless of ownership. Therefore, the RIDOT has the potential to provide partial or full funding for several of the improvements identified in this report as part of the Roadway Departure Mitigation Program.

Any funding requested by the Town to implement the recommendations listed in the RSA should go through the HSIP Eligibility request process, which requires the Town to provide justification of the projected safety benefits for recommended improvements. RIDOT will then determine if it is eligible for HSIP funds and distribute the funds needed (dependent on availability) to the local agency so that they can administer the design and/or construction of the improvements.

Table 3-1 Implementation Matrix – US Route 1 (Tower Hill Road)

Mitigation Measures – Town of South Kingstown	Timeframe			Preliminary Costs	Status
	Immediate Term	Near Term	Long Term		
1.1 Install post mounted delineators in both directions on the left and right side of the roadway to better delineate the edge of pavement.	X			High Benefit – Low Cost	
1.2 Restripe US Route 1 to provide a larger left side shoulder and smooth striping of the curve.	X			Medium Benefit – Low Cost	
1.3 Consider the installation of High Friction Surface Treatment (HFST) on US Route 1 within the curve.		X		High Benefit – Low Cost	
1.4 Replace missing recessed markers (RPM) throughout the corridor.		X		Medium Benefit – Low Cost	
1.5 Consider the installation of rumble strip/stripes.			X	High Benefit- Medium Cost	
1.6 Trim overgrown vegetation along US Route 1 at the intersection with Saugatucket Road.	X			High Benefit – Low Cost	
1.7 Evaluate the existing guardrail along the corridor to determine if the current installation is appropriate. Revise guardrail accordingly.	X			Medium Benefit – Medium Cost	
1.8 Review clear zones along the corridor. If a roadside hazard is within the clear zone, remove the hazard, if possible. If not, protect the hazard accordingly.	X			Low Benefit – Low Cost	
1.9 Consider replace the section of cable guardrail within the curve on US Route 1 per RIDOT guidance to install semi-rigid (w-beam, thrie beam) guardrail within curves.		X		Low Benefit – Medium Cost	
1.10 Perform drainage analysis to determine the need for additional improvements.	X			Medium Benefit – Medium Cost	
1.11 Consider a comprehensive sign audit to verify sign height, retro-reflectivity, current sign standards, consistency, redundancy, and unnecessary signs. Revise signs accordingly.	X			High Benefit – Low Cost	

Mitigation Measures – Town of South Kingstown	Timeframe			Preliminary Costs	Status
	Immediate Term	Near Term	Long Term		
1.12 Install reflective sign strips on all sign posts.	X			Medium Benefit – Low Cost	
1.13 Consider a speeding enforcement campaign on US Route to discourage speeding.	X			n/a	
1.14 Remove all speed limit signs along the corridor and install new signs spaced more appropriately.	X			Medium Benefit – Low Cost.	
1.15 Install dynamic speed feedback signs to discourage speeding along the corridor.		X		High Benefit – Medium Cost	
1.16 Conduct lighting study to determine deficiencies and potential improvements.	X			Low Benefit – Low Cost	
1.17 Implement area-wide lighting installation to improve safety for vehicles and other road users.		X		Low Benefit – Medium Cost	
1.18 Install stop ahead signs on Saugatucket Road.	X			High Benefit – Low Cost	
1.19 Install intersection warning signs on US Route 1 to warn vehicles of the approaching unsignalized intersection.	X			High Benefit – Low Cost	
1.20 Consider the installation of High Friction Surface Treatment (HFST) on the entrance to Saugatucket Road from US Route 1 southbound.		X		High Benefit – Low Cost	
1.21 Install acceleration and deceleration lanes at the intersection of US Route 1 and Saugatucket Road.			X	Medium Benefit – Low Cost	
1.22 Consider geometric reconstruction to “T” up the intersection of US Route 1 at Saugatucket Road.			X	Low Benefit – High Cost	

3.3 Supporting Data

The following field work was completed to help inform the recommendations and suggestions.

3.3.1 Speed Study

High travel speeds were cited as a potential safety issue on US Route 1 in the vicinity of Saugatucket Road. To help better identify safety issues along this corridor a speed study was completed.

The posted speed limit along US Route 1 is 50 mph. Speed measurements were collected by VHB in September 2017 along US Route 1 southbound, south of Saugatucket Road. The speed measurements were collected during off peak periods using a radar gun. The 85th percentile speeds were determined from this study. The 85th percentile speed is a speed at or below which 85 percent of the observed traffic on the roadway travel, and is used as a typical measure of prevailing speed in the traffic engineering profession. **Table 3-2** shows the results of the speed study.

Table 3-2 Speed Data Summary

	Posted Speed Limit (mph)	85 th Percentile Speed (mph)	Average Speed (mph)
US Route 1 south of Saugatucket Road			
Southbound	50	57	52

As shown in **Table 3-2**, the 85th percentile and average speed are both higher than the posted speed limit by seven mph and two mph, respectively. The full results from the speed study can be found in **Appendix B**.

3.3.2 Ball-Bank Indicator Evaluation

To evaluate the impacts of roadway curvature on speed, a ball-bank test was completed at the horizontal curve on US Route 1, just south of Saugatucket Road, which has a crash history. Based on the Manual on Uniform Traffic Control Devices (MUTCD), a ball-bank evaluation was performed during free flow conditions should indicate what advisory speed should be signed at a horizontal curve. At the posted speed limit of 50 mph, the maximum allowable ball-bank measure is 12 degrees.

Table 3-3 provides the results of the ball-bank evaluation at all three locations reviewed.

Table 3-3 Ball-Bank Evaluation Summary

Location	Posted Speed Limit (mph)	Advisory Speed (mph) ¹	Note
US Route 1 – South of Saugatucket Road	50	50	Advisory speed not applicable

1 Advisory speed as indicated by maximum ball-bank reading at 12 degrees for 50 mph speed limits, and rounded to the nearest multiple of 5mph.

As shown in **Table 3-3**, the curve evaluated does not require an advisory speed. The full results from the ball-bank evaluation can be found in **Appendix C**.

3.3.3 Existing Conditions (Sign and Pavement Marking) Inventory

Following the RSA, a sign and pavement marking inventory was completed at the intersection to identify existing signage, particularly concerning curve warning signage and speed limit signage. Key observations include the following:

- › Vegetation overgrowth: vegetation overgrowth along US Route 1 obstructs the sight lines for vehicles exiting Saugatucket Road.
- › Inadequate Signage: Advanced warning signs are missing or not placed with enough warning of the approaching intersection and the curve.
- › Pavement Condition: The existing pavement condition along US Route 1 is good to fair condition which would be adequate for high friction surface treatment installation.

3.4 Findings

The following considerations should be reviewed in determining the feasibility and appropriateness of implementing the proposed mitigation measures.

3.4.1 Countermeasure Effectiveness

3.4.1.1 Enhanced Horizontal Curve Signage

Horizontal curve signage provides an advanced visual queue to vehicles approaching a change in roadway conditions. The horizontal curve signs should be installed to provide ample viewing time in advance of the curve and in an appropriate location.

The Crash Modification Factor (CMF) Clearinghouse provides a modification factor for "Install of chevron signs and curve warning signs"¹. This modification factor is based upon arterials with no specified speed limit. Although the proposed signage is not exactly the same as the recommended countermeasure, due to the fact that chevrons signs are not warranted, we can assume that the advanced curve warning

¹ Crash Modification Factor Clearinghouse. US Department of Transportation, Federal Highway Administration. <http://www.cmfclearinghouse.org/detail.cfm?facid=1910>. Accessed: January 13, 2017.

sign and left side supplement curve warning sign would enhance safety equally as much.

The CMF Clearinghouse concluded that:

- › Roadway departure crashes of all severities have the potential to be reduced by approximately 44%.

FHWA has also reviewed the effectiveness of warning signage on horizontal curves and their impact on crashes which is included in FHWA's "Low-Cost Treatments for Horizontal Curve Safety"².

The FHWA concluded that:

- › An evaluation from 1968 of curve warnings signs report that the installation of warning signs has the potential to reduce crashes by 18 percent with proper use.

Given these findings, enhanced horizontal curve signage including advanced curve warning signs are proposed in advance of the s-curve on US Route 1 southbound.

3.4.1.2 High Friction Surface Treatment

High friction surface treatment (HFST) is an application that involves a high-quality aggregate to increase pavement friction at existing or potentially high crash areas. The higher pavement friction assists motorists in maintaining control of their vehicle in both dry and wet conditions.

Based on the CMF Clearinghouse and NCHRP Report 617³, crashes across all types and severities can be reduced by 24 percent. (#194)⁴. The installation of HFST has the potential to reduce the number of crashes from 19 to 14.

HFST is proposed along US Route 1 southbound within the S-curve and on the entrance to Saugatucket Road from US Route 1 southbound based on a crash history of roadway departure crashes under wet roadway conditions. HFST is not considered on US Route 1 northbound as this time as there is not a crash history at that location.

3.4.1.3 Replacement/Installation of Guardrail

Guardrail is a roadside barrier used to deflect vehicles as they depart from the traveled way towards the roadside. The installation of guardrail is warranted by using the procedures discussed in the *AASHTO Roadside Design Guide*. Overall, guardrail is installed to shield objects such as non-recoverable slopes, roadside structures, or other objects that cannot be removed or relocated outside of the clear zone.

² Low-Cost Treatments for Horizontal Curve Safety. US Department of Transportation, Federal Highway Administration. 2006.

³ Accident Modification Factors for Traffic Engineering and ITS Improvements. Report: NCHRP 617. Harkey, D.L., et. al., Transportation Research Board, 2008.

⁴ "Increased Pavement Friction" Crash Modification Factor Clearinghouse. US Department of Transportation, Federal Highway Administration. <http://www.cmfclearinghouse.org/detail.cfm?facid=194>. Accessed: August 25, 2016.

The CMF Clearinghouse does not provide information concerning the impact that the replace and/or installation of guardrail has on crashes. However, FHWA has studied the potential benefits through on-going analysis.

The FHWA determined the following:

- › The total number of crashes may not be reduced, however; the severity of the crashes will be reduced by the installation of guardrail.
- › The guardrail when installed with reflectors has been shown to delineate the edge of the roadway and the horizontal curve.

The implementation of replacement/installation of guardrail would prevent vehicles from departing the roadway and striking any roadside features. The replacement and/or installation of guardrail is recommended based upon the field evaluation of the existing roadside conditions. It is recommended that semi-rigid steel guardrail be considered within the s-curve on US Route 1 rather than the cable guardrail in that area to avoid continuous maintenance.

3.4.2 Implementation

The following countermeasures will be implemented through the Roadway Departure Mitigation Program:

- › Enhance horizontal curve signage including advanced warning signs,
- › Enhance intersection signing including advanced warning signs with "Saugatucket Rd" plaque, and
- › Install high friction surface treatment along US Route 1 southbound within the S-curve and on the entrance to Saugatucket Road.

Conceptual Plan Nos. 1-2 summarize the countermeasures to be implemented along US Route 1 and Saugatucket Road.

3.4.3 Cost Estimate

A cost estimate was completed for the countermeasures to be implemented, as summarized in **Table 3-3**. The detailed cost estimate can be found in **Appendix D**.

Table 3-3 Cost Estimate Summary

Improvement	Cost	Notes
Signing	\$12,500.00	
Tree trimming	-	Complete by work order
High Friction	\$97,800.00	
Subtotal	\$110,300.00	
Construction Contingencies	\$92,400.00	
Construction Total	\$202,700.00	

Appendix A – Crash Data

US Route 1 (South County Commons to Saugatucket Road) 1/1/2011 - 12/31/2015

Case #	Date	Day of the Week	Time	At Street	Direction	Location	Distance from Ref. Intersection (ft)	Lighting	Weather	Crash Type	Collision with	Severity	Emphasis Area
168480	1/20/2011	Thursday	2:38 AM	Saugatucket Road	SB	Segment	1200	Dark - Lighted	Clear	Collision with Roadside Object	Vehicle-Fixed Object	O	Roadway Departure
165484	2/21/2011	Monday	7:12 AM	Saugatucket Road	SB	Intersection	50	Daylight	Snow	Collision with Roadside Object	Vehicle-Fixed Object	O	Roadway Departure
166086	2/27/2011	Sunday	2:52 AM	Saugatucket Road	SB	Segment	1200	Dark - Not Lighted	Snow	Collision with Roadside Object	Vehicle-Fixed Object	O	Roadway Departure
169008	3/24/2011	Thursday	2:49 PM	Saugatucket Road	EB	Intersection	0	Daylight	Cloudy	Rear end	Vehicle-Vehicle	O	Intersection
191670	9/27/2011	Tuesday	5:06 PM	Saugatucket Road	EB	Intersection	0	Daylight	Cloudy	Rear end	Vehicle-Vehicle	C	Intersection
193818	10/7/2011	Friday	4:38 PM	Saugatucket Road	NB	Segment	500	Dark - Lighted	Clear	Other (animal, etc.)	Vehicle-Fixed Object	O	None
194339	10/23/2011	Sunday	12:47 AM	Saugatucket Road	SB	Intersection	1	Dark - Lighted	Clear	Collision with Roadside Object	Vehicle-Fixed Object	B	Roadway Departure
197159	11/1/2011	Tuesday	1:20 AM	Ledge Road	NB	Intersection	200	Dark - Not Lighted	Clear	Sideswipe - Same Direction	Vehicle-Vehicle	O	Intersection
212116	3/21/2012	Wednesday	12:54 PM	Saugatucket Road	EB	Intersection	0	Daylight	Clear	Rear end	Vehicle-Vehicle	C	Intersection
215363	4/20/2012	Friday	7:00 AM	South County Commons	SB	Segment	5280	Daylight	Clear	Collision with Roadside Object	Vehicle-Fixed Object	O	Roadway Departure
228867	8/9/2012	Thursday	8:10 AM	Saugatucket Road	EB	Intersection	0	Daylight	Clear	Rear end	Vehicle-Vehicle	O	Intersection
233355	9/12/2012	Wednesday	2:00 PM	Saugatucket Road	EB	Intersection	0	Daylight	Clear	Rear end	Vehicle-Vehicle	C	Intersection
237635	10/15/2012	Monday	8:53 AM	South County Commons	SB	Segment	500	Daylight	Clear	Collision with Roadside Object	Vehicle-Fixed Object	C	Roadway Departure
237904	10/24/2012	Wednesday	12:09 PM	South County Commons	SB	Segment	1000	Daylight	Clear	Rear end	Vehicle-Vehicle	C	None
241219	11/18/2012	Sunday	3:16 PM	Saugatucket Road	EB	Intersection	0	Daylight	Clear	Rear end	Vehicle-Vehicle	O	Intersection
243208	12/7/2012	Friday	5:21 AM	South County Commons	SB	Segment	1000	Dark - Unknown Lighting	Clear	Collision with Roadside Object	Vehicle-Fixed Object	O	Roadway Departure
246860	1/6/2013	Sunday	7:06 AM	South County Commons	SB	Segment	750	Daylight	Snow	Collision with Roadside Object	Vehicle-Fixed Object	O	Roadway Departure
248709	1/21/2013	Monday	3:33 PM	Saugatucket Road	SB	Segment	2000	Dark - Not Lighted	Snow	Collision with Roadside Object	Vehicle-Fixed Object	O	Roadway Departure
254690	3/12/2013	Tuesday	9:55 AM	Saugatucket Road	SB	Segment	1000	Daylight	Clear	Collision with Roadside Object	Vehicle-Fixed Object	C	Roadway Departure
257251	3/30/2013	Saturday	3:16 PM	Saugatucket Road	EB	Intersection	0	Daylight	Clear	Rear end	Vehicle-Vehicle	O	Intersection
258992	4/19/2013	Friday	3:50 PM	Saugatucket Road		Intersection	0	Daylight	Rain	Angle	Vehicle-Vehicle	C	Roadway Departure
267314	6/26/2013	Wednesday	4:13 PM	Saugatucket Road	SB	Intersection	0	Daylight	Clear	Rear end	Vehicle-Vehicle	O	Intersection
270334	7/19/2013	Friday	8:37 AM	Saugatucket Road	SB	Intersection	10	Daylight	Clear	Rear end	Vehicle-Vehicle	O	Intersection
270953	7/21/2013	Sunday	10:03 AM	Saugatucket Road	SB	Segment	1000	Daylight	Rain	Rear end	Vehicle-Vehicle	O	None
277968	9/25/2013	Wednesday	4:41 AM	Saugatucket Road	SB	Segment	1000	Dark - Not Lighted	Clear	Collision with Roadside Object	Vehicle-Fixed Object	O	Roadway Departure
279438	10/6/2013	Sunday	9:05 PM	Saugatucket Road	SB	Segment	1750	Dark - Not Lighted	Rain	Head on	Vehicle-Vehicle	O	None
283347	11/7/2013	Thursday	7:35 AM	Saugatucket Road	EB	Intersection	0	Daylight	Rain	Rear end	Vehicle-Vehicle	C	Intersection
284968	11/19/2013	Tuesday	3:45 PM	Saugatucket Road	EB	Intersection	0	Daylight	Clear	Rear end	Vehicle-Vehicle	O	Intersection
293174	1/21/2014	Tuesday	3:24 PM	Saugatucket Road	SB	Segment	300	Daylight	Snow	Head on	Vehicle-Vehicle	O	None
294964	2/3/2014	Monday	10:28 AM	Saugatucket Road	SB	Intersection	300	Daylight	Snow	Collision with Roadside Object	Vehicle-Fixed Object	O	Roadway Departure
294968	2/3/2014	Monday	12:00 PM	Saugatucket Road	WB	Segment	300	Daylight	Snow	Other (animal, etc.)		O	Roadway Departure
306680	4/25/2014	Friday	2:13 AM	South County Commons	NB	Segment	500	Dark - Not Lighted	Clear	Collision with Roadside Object	Vehicle-Fixed Object	O	Roadway Departure
307892	5/21/2014	Wednesday	2:02 PM	Saugatucket Road	EB	Intersection	1	Daylight	Clear	Rear end	Vehicle-Vehicle	O	Intersection
310729	6/13/2014	Friday	2:40 PM	Saugatucket Road	SB	Segment	2500	Daylight	Rain	Collision with Roadside Object	Vehicle-Fixed Object	O	Roadway Departure
314995	7/17/2014	Thursday	9:30 AM	Saugatucket Road	EB	Intersection	0	Daylight	Clear	Rear end	Vehicle-Vehicle	O	Intersection
317421	8/10/2014	Sunday	2:13 AM	Saugatucket Road	SB	Segment	500	Dark - Not Lighted	Clear	Collision with Roadside Object	Vehicle-Fixed Object	O	Roadway Departure
318702	8/21/2014	Thursday	1:37 PM	Saugatucket Road	NB	Intersection	150	Daylight	Clear	Collision with Roadside Object	Vehicle-Fixed Object	C	Roadway Departure
320654	9/7/2014	Sunday	11:00 PM	Saugatucket Road	SB	Segment	300	Dark - Lighted	Clear	Collision with Roadside Object	Vehicle-Fixed Object	K	Roadway Departure
324895	10/12/2014	Sunday	7:38 PM	Saugatucket Road	EB	Intersection	0	Dark - Lighted	Clear	Rear end	Vehicle-Vehicle	O	Intersection
330403	11/18/2014	Tuesday	12:37 PM	Saugatucket Road	EB	Intersection	0	Daylight	Clear	Rear end	Vehicle-Vehicle	O	Intersection
331252	11/30/2014	Sunday	8:15 PM	Ledge Road	SB	Intersection	0	Dark - Not Lighted	Clear	Other (animal, etc.)	Vehicle-Fixed Object	O	None
334643	12/24/2014	Wednesday	8:02 AM	Saugatucket Road	SB	Segment	500	Daylight	Rain	Rear end	Vehicle-Vehicle	O	None
342784	2/15/2015	Sunday	4:57 PM	Saugatucket Road	SB	Intersection	100	Dusk	Snow	Collision with Roadside Object	Vehicle-Fixed Object	O	Roadway Departure
347205	3/15/2015	Sunday	1:24 PM	South County Commons	SB	Segment	1000	Daylight	Clear	Collision with Roadside Object	Vehicle-Fixed Object	O	Distracted Driving
348613	3/24/2015	Tuesday	12:49 PM	South County Commons	NB	Segment	500	Daylight	Clear	Other (animal, etc.)	Vehicle-Fixed Object	O	None
358816	6/15/2015	Monday	12:16 AM	South County Commons	SB	Segment	1000	Dark - Not Lighted	Clear	Other (animal, etc.)	Vehicle-Fixed Object	O	None
363496	7/12/2015	Sunday	6:51 AM	Saugatucket Road	SB	Segment	1000	Daylight	Clear	Collision with Roadside Object	Vehicle-Fixed Object	O	Roadway Departure
363173	7/20/2015	Monday	12:40 PM	Saugatucket Road	SB	Intersection	0	Daylight	Clear	Collision with Roadside Object	Vehicle-Fixed Object	C	Roadway Departure
365136	8/3/2015	Monday	12:10 PM	Saugatucket Road	EB	Intersection	0	Daylight	Clear	Rear end	Vehicle-Vehicle	C	Intersection
374586	10/15/2015	Thursday	6:57 PM	Saugatucket Road	EB	Intersection	0	Dark - Not Lighted	Clear	Rear end	Vehicle-Vehicle	O	Intersection
377470	11/6/2015	Friday	2:43 PM	Saugatucket Road	SB	Intersection	0	Daylight	Clear	Collision with Roadside Object	Vehicle-Fixed Object	O	Roadway Departure
378547	11/6/2015	Friday	10:17 PM	Saugatucket Road	NB	Intersection	200	Dark - Lighted	Clear	Collision with Roadside Object	Motorcycle-Fixed Object	C	Roadway Departure
383358	12/18/2015	Friday	9:15 PM	Saugatucket Road	SB	Segment	0	Dark - Unknown Lighting	Cloudy	Other (animal, etc.)	Vehicle-Fixed Object	O	None

Appendix B – Speed Study



Computations

Project: US 1 (Tower Hill Rd) at Saugatucket Rd RSA
 Location: US 1 (Tower Hill Rd) - south of Saugatucket Rd
 Calculated by: RV
 Checked by: _____
 Title: Speed Study

Project # 72700.13
 Sheet 1 of 1
 Date: 9/5/2017
 Date: _____

Direction	Southbound	
1	51	
2	49	
3	52	
4	45	
5	51	
6	59	
7	52	
8	55	
9	52	
10	54	
11	50	
12	48	
13	49	
14	59	
15	50	
16	45	
17	48	
18	49	
19	63	
20	59	
21	54	
22	56	
23	50	
24	49	
25	54	
26	47	
27	53	
28	52	
29	48	
30	55	
31	59	
32	56	
33	57	
34	55	
35	48	
36	49	
37	49	
38	56	
39	44	
40	49	
41		
42		
43		
44		
45		
46		
47		
48		
49		
50		
50th Percentile	52	#DIV/0!
85th Percentile	57	#NUM!

Appendix C – Ball-Bank Indicator Evaluation



Computations

Project:	US Route 1 RSA	Project #	72700.13
Location:	South Kingstown, RI	Sheet	1 of 1
Calculated by:	RV	Date:	9/5/2017
Checked by:	KJC	Date:	9/12/2017
Title	Ball Bank Indicator Evaluation		

Posted Speed: 50 mph

25 mph		
Trial		
1		
2		
3		
4		
5		
Average		

30 mph		
Trial		
1		
2		
3		
4		
5		
Average		

35 mph		
Trial		
1		
2		
3		
4		
5		
Average		

40 mph		
Trial		
1		
2		
3		
4		
5		
Average		

45 mph		
Trial		
1		
2		
3		
4		
5		
Average		

50 mph		
Trial	Southbound	Northbound
1	7	
2	8	
3	7	
4	8	
5	8	
Average	8	

Appropriate Advisory Speed = n/a mph

Appendix D – Cost Estimate

US Route 1 - South Kingstown



1 Cedar Street - Suite 400
 Providence, RI 02903
 Phone: 401 272 8100

SUMMARY

Roadway Construction

\$110,300.00

Drainage		\$	-
Utilities			
Maintenance & Protection of Traffic	15%	\$	16,545.00
Traffic Signals		\$	-
Lighting		\$	-
Landscaping		\$	-
Signing and Striping		\$	-
Miscellaneous	10%	\$	11,030.00
	Subtotal		\$27,575.00

Roadway Construction Subtotal \$137,875.00

Roadway Construction Total **\$137,875.00**

Mobilization (RI TAC 6/17/1999)	15%	\$	20,681.25
Maintenance and Movement of Traffic Protection	10%	\$	13,787.50
	Subtotal		\$172,343.75

Engineer & Construction Contingency **\$ 20,681.25**

PRELIMINARY CONSTRUCTION TOTAL \$193,025.00

Police Detail **\$ 9,651.25**

CONSTRUCTION COST TOTAL \$202,700.00

