Office of Highway Safety

Road Safety Audit Review

Town:	Colchester	**Date Reviewed:**	July 13, 2015
Route:	US 2 at Exit 17 Ramp	**Mile points:**	US 2: 1.86-2.11

Location Map

RSAR Process

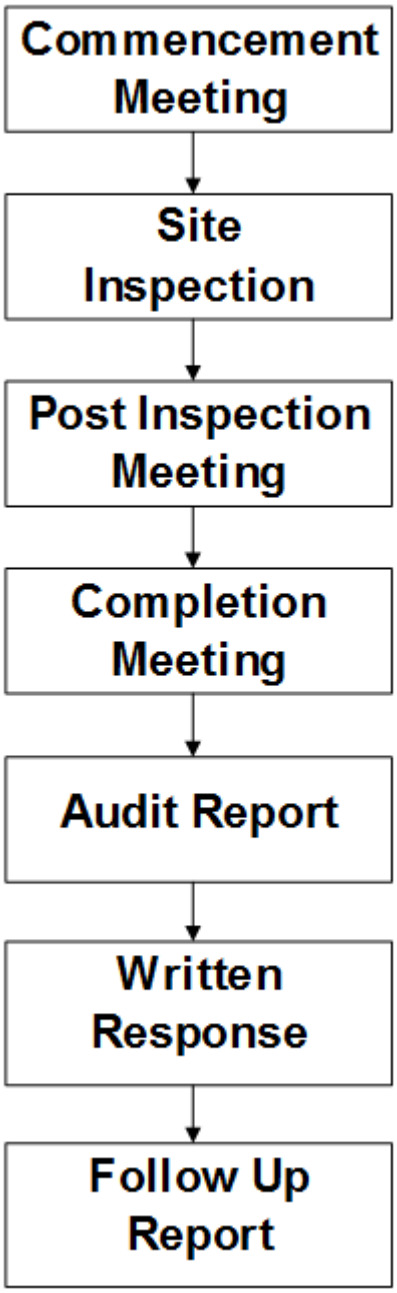
A ***Road Safety Audit Review*** (RSAR) is a formal examination of an existing road in which an independent, multi-discipline team (the Audit Team) reports on potential safety issues.

Office of Highway Safety

Road Safety Audit Review

According to the Federal Highway Administration (FHWA), the purpose of a RSAR is to determine which elements of the road may present a safety concern, to what extent and under what circumstances as well as to identify opportunities to mitigate the identified safety concerns.

Figure 1 - Road Safety Audit Process



The RSAR process is composed of several steps as shown in Figure 1. The process starts with a ***Commencement Meeting*** during which the Audit Team reviews data and gathers community concerns. A ***Site Inspection*** is then performed by the Audit Team. The site visit involves the identification of safety deficiencies as seen in the field. The Audit Team will usually drive through the location of interest to "get a feel" for the area, traveling through each approach in the case of intersections. The team is to then drive at a slower speed to make observations. If needed, the team will also walk the location. Following the site inspection, the Audit Team holds a ***Post Inspection Meeting.*** It is during this meeting that the team members discuss their observations and identify safety issues. The team is to reach a consensus on the importance of each safety issue mentioned. Only those issues for which a consensus is reached are included in the RSAR findings. A RSAR report (Written Report) is prepared.

The ***Written Report*** identifies safety concerns and proposes guidance. These issues and solutions are presented in a tabular format associated to each Responsible Entity for ease of reporting. The ***Responsible Entities*** are any groups who own a roadway feature or who are responsible for making an improvement or for initiating further studies. These could include for example, the VTrans design section, the local town, the local police or the local RPC.

Location

The location of this RSAR is the area of US 2 between the I-89 off ramps (north and south) at exit 17.

Purpose of the RSAR

This RSAR was conducted as part of a Vermont Highway Safety Alliance effort lead by the Enforcement Focus Group. The locations selected for this effort were originally identified as high crash locations and ranked high in terms of fatal and injury crashes. In addition, the final locations were further selected for their potential of reducing crashes through enforcement.

The audit team recognized that a scoping study of this area had been done and that some significant long term improvements will take place in several years and decided to focus mostly on short to mid-term solutions.

The RSAR herein has sought to identify potential safety hazards and physical features which may affect road user safety. However, it is possible that not every deficiency has been identified. It should further be recognized that the implementation of the guidance in this report may contribute to improve the level of safety of the facility reviewed but not necessarily remove all the risks.

RSAR Participants

Mario Dupigny-Giroux from the Office of Highway Safety, VTRANS, was the RSAR coordinator.

The other participants were:

Tom Fields,	Office of Highway Safety, VTRANS
Johnathan Kaiser,	Office of Highway Safety, VTRANS
Dick Hosking,	District 5, VTRANS
Sai Sarepalli,	CCRPC

Information Reviewed

Geometry

This section of US 2 includes the two intersections with the northbound I-89 on/off ramp and the on/off southbound ramp. Both of these intersections are signalized intersections. The northbound off ramp also includes a slip lane away from the signalized intersection that is controlled with a yield sign.

US 2 has one through lane in each direction. There is also a dedicated auxiliary westbound left turn lane at the southbound ramp that is controlled with a permitted/protected signal phase.

Lighting is provided at each intersection and along the corridor.

Speed Limit

The posted speed limit is 50 mph on US 2.

Traffic Volumes

The 2012 Average Annual Daily Traffic on US 2 was 13600 vehicles per day west of the southbound ramp while it was 13400 vehicles per day between the southbound ramp and the northbound ramp, and 14400 vehicles per day east of the northbound ramp.

Signs and Markings

Traveling westbound on US 2 from the US 7 intersection, a motorist would see first the US 2 and junction 89 route markers. Then this motorist would see a guide sign for I-89 north with Georgia, St Albans and Montreal as destinations, and then past the traffic signal, this motorist would see the merge sign for the northbound off ramp slip lane. Past the slip lane, this motorist would see a bike sign supplemented with a share the road plaque and then a US 2 west route marker. Past the bridge, this motorist would then observe a lane assignment sign for the left turn lane and a guide sign for I-89 south. At the signal, this motorist would then see a yield on green ball sign.

Eastbound, a motorist approaching the southbound ramps would see a signal ahead sign next to a I-89 south guide sign. Past the southbound ramps signal, then this motorist would see a junction US 7 route marker followed by a bike sign supplemented with a share the road plaque just before the bridge. Once the motorist drove past the bridge, he or she would then see a I-89 route marker with a left arrow followed by a I-89 north guide sign.

All signal heads have back plates on them.

Pavement Conditions

Pavement conditions on US 2 is rated as good by VTrans (VTransparency Portal).

Bridge

Bridge 18A is located on US 2 at mile point 2.014 over I-89.

Bridge 18A is inspected on a twelve-month frequency due to its poor substructure. The 2015 review revealed that the northern ends of each pier cap were heavily spalled with rebar exposed and that random bearings were also partially undermined. One of the past inspections concluded that this bridge needed to be either reconstructed or fully replaced.

Past Projects

Project NHG SGNL(22) was for the installation of traffic signals at the Exit 17 on-ramp intersections on US 2. This project was completed in 2004.

An advance warning sign and flashing beacons were installed on I-89 northbound to warn motorists of traffic queuing onto I-89 from the northbound off ramp (Work order 14-184, completed May 2015).

STP SURF(36) was for the resurfacing of US 2 and was completed in 2014. The location of the beginning of the left turn lane was moved from being west of the northbound slip lane to east of the slip lane.

STPG SIGN(45) was for the replacement of signs on US 2 and was completed in 2014.

Project BF 028-1(29) is for the scoping of alternatives for bridge number 18A on US 2 in Colchester, over I-89.

Future Projects

Project NH 028-1(31) is for improvements to the US 2 and US 7 intersection and the US 2 and Exit 17 south and north on/off intersections. This project also includes the replacement of Bridge 18A and corresponding roadway improvements.

Traffic Studies

2003 Highway Safety Improvement Study (HSIP):

This corridor was reviewed in 2003 under the highway safety improvement program. The on/off ramps were not controlled with traffic signals at the time.

Crash patterns from this review are discussed later on in this report under crash data.

Because traffic signals were in the process of being installed and that it was believed that the crash patterns that had been identified would be reduced by the presence of traffic signals, no formal recommendations were made by this review.

Exit 17 Scoping Study:

The Chittenden County Regional Planning Commission (CCRPC) initiated the Exit 17 Scoping Study in the spring of 2013[1]. The purpose of the Exit 17 Scoping Study was to develop alternatives that reduce traffic congestion at the ramps as well as improve safety.

The study investigated two long term solutions. Option 1, a 6-lane bridge alternative, would consist of a new 6-lane bridge across I-89 having four lanes in the westbound direction and two in the eastbound direction along with reconfigured signalized intersections at the US 2/US 7 intersection and at the I-89 ramps. Option 1 would also eliminate the two right-turn ramps from I-89 northbound to US 2 westbound and US 2 eastbound to I-89 southbound.

[1] http://www.ccrpcvt.org/wp-content/uploads/2016/01/Exit17ScopingStudy_FinalReport.pdf

Option 2 is a 3-lane bridge alternative that would consist of a new 3-lane bridge across I-89 complemented by a new loop ramp in the northwest quadrant of the interchange to serve as an I-89 southbound on-ramp for traffic proceeding westbound on US 2. As with option 1, the signalized intersections at the US 2/US 7 intersection and at the I-89 ramps would be reconfigured to provide greater capacity. In option 2, the US 2/I-89 southbound ramps intersection would be relocated approximately 300 feet west of the current location and the existing high-speed right-turn ramp from I-89 northbound to US 2 westbound would be replaced with an un-channelized approach controlled by a traffic signal. Long Term Option 2 is shown below.

In addition to longer term solutions, the study identified also near term solutions. Specifically, the study suggested the implementation of a reduced speed zone in interchange area, the upgrading of signal controllers and the implementation of adaptive signal control technologies as well as prohibiting right-turn on red from southbound US 7 to US 2 (as this movement conflicts with northbound left turns).

The study further recognized that capacity expansion at the I-89 northbound ramps and the US 2/US 7 intersection could be pursued and constructed in advance of the construction of a new bridge.

Crash History

Crash history was reviewed at the intersection for the five-year period covering the years 2010 to 2014.

This intersection is defined as a high crash intersection in the 2010-2014 listing.

A collision diagram and the crash narratives for each of the crashes are provided at the end of this report.

There were forty-five crashes reported within this section during the 2010-2014 period. Of these, fifty-five percent took place at the southbound ramp intersection, twenty-two percent at the northbound off ramp slip lane intersection and twenty-two percent at the northbound off ramp.

At the southbound off ramp, there are four principal crash patterns. The most predominant pattern are rear-end crashes involving westbound traffic (8 out 25, 32%). The second crash pattern of importance are right angle crashes between a westbound left turning vehicle (going onto the southbound on ramp) and an eastbound vehicle (7 out 25, 28%). The third crash pattern at the southbound off ramp are right angle crashes between an eastbound vehicle and a vehicle entering the intersection from the off ramp (6 out of 25, 24%). The final crash pattern at the southbound off ramp intersection are rear-end crashes among eastbound vehicles (4 out of 25, 16%).

Two crash patterns are common at the northbound off ramp. The first are right angle crashes between a vehicle turning left off the ramp and an eastbound vehicle (5 out of 10, 50%). The second pattern are rear-end crashes between two eastbound vehicles on US 2 (4 out of 10, 40%).

At the slip lane intersection where traffic is entering US 2 to go west from the northbound off ramp, there are two crash patterns that stand out. The first, are rear-end crashes on the ramp (5 out of 10, 50%). The second crash patterns at this point are sideswipe crashes between a vehicle entering US 2 from the slip lane and a westbound vehicle.

The major cause for the right angle crashes between a vehicle coming off the ramp and a westbound vehicle at either off ramps was the running of the red light by the westbound vehicle on US 2. Running the red light was mostly due to being distracted but also to a lesser extent to deliberately going through the red light or not knowing that there was a light.

Similarly, the major cause for crashes between an eastbound vehicle and a westbound left turning vehicle onto the southbound on ramp was due to the left turning vehicle not yielding to oncoming traffic when the left turning traffic was facing a green ball.

At the northbound off ramp slip lane, the cause of the rear-end crashes was due to the vehicle in front of the rear-ending vehicle starting to move then stopping again because of oncoming westbound traffic on US 2.

In a previous 2003 HSIP review of the same section, crashes were reviewed for the 1998-2001 reporting period. There were no traffic signals at the ramps during that period and crashes were somewhat different of those experienced with the signals in place.

For the 1998-2001 period, it was found that the majority of the crashes took place at the southbound off ramp (20 out of 23 crashes).

It was determined that thirty percent of the crashes at the southbound ramp took place because traffic was heavy and somebody in the left lane stopped to turn left waived somebody from the ramp to enter US 2 and this entering vehicle go hit by a westbound vehicle.

A pattern that is still present today was right angle crashes between an eastbound vehicle and a westbound left turning vehicle entering the southbound on-ramp.

Current Local Concerns

Queuing on the northbound I-89 off-ramp extends onto the Interstate with vehicles queuing on the I-89 shoulder (this observation was also noted in a 2003 HSIP safety review by VTrans).

As reported by the Exit 17 Scoping Study, several roadway segments and signalized intersections are currently experience moderate congestion during the AM and PM peak periods. As an example, the study mentions that eastbound left turns at the I-89 northbound on-ramp intersection block through movements on US 2 due to the through and left turn movements sharing a single lane.

Identified Safety Concerns

This section lists the areas of safety concern identified by the audit team during the site inspection and from the analysis of available data. This section also reports the potential safety enhancements suggested by the audit team. The concerns are not listed in order of importance.

Concern: Left Turn Crashes at the Southbound On Ramp Signal

There is an important crash pattern at the southbound on ramp signal involving left turn motorists and eastbound motorists. In most cases, the left turning motorists are not yielding to oncoming traffic when they are facing a green ball.

Safety Enhancements:

Provide a protected only left turn phase at this intersection. Evaluate what the effect would be on capacity.

If a protected only left turn phase is not desirable due to extreme delays, replace the five-section head with a flashing yellow arrow four-section head to improve understanding by motorists.

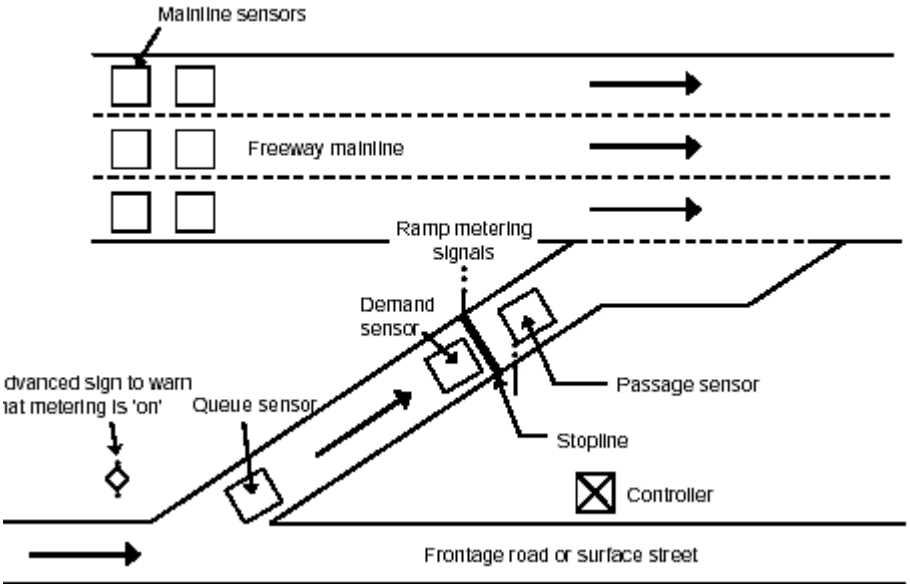
A long term measure would be to eliminate the left turning movement onto the southbound off ramp. One approach would be to construct the new southbound on ramp that is suggested by the Exit 17 Scoping Study and that would require motorists to go through the signal and continue right onto the ramp.

Concern: Issue with Rear-End and Merging Crashes at the Northbound Off Ramp Slip Lane

Traffic that is coming off I-89 northbound and that is continuing west on US 2 must merge with US 2 westbound traffic. Rear-end crashes at the end of the slip lane caused by the leading motorist moving and then stopping again are common. Some merging crashes are also evident.

Safety Enhancements:

In the mid-term, consider ramp-metering at this location. Ramp metering has been found to reduce crashes and travel time. The concept is illustrated below (source: Traffic Detector



Handbook[2])

In the long term, remove the slip lane and increase the number of turning lanes on the northbound off ramp at the traffic signal.

Concern: Issue with Right Angle Crashes at Southbound and Northbound Off Ramp

Right angle crashes between a vehicle coming off the southbound or the northbound ramps and a westbound vehicle on US 2 represent an important crash pattern. These crashes are caused by the US 2 vehicle running the red light. Being distracted or not aware of the signal indications is the reason that was cited the most by the drivers at fault in the crash reports. Intentionally running the red light was also cited but to a much lesser degree.

Safety Enhancements:

Ensure that the yellow and all red phases as well as the end of green phase are suitable.

Make the signal more conspicuous by adding yellow retroreflective tape around each backplate.

At the northbound ramp intersection, adjust the placement of the signal heads so that the two signal heads for westbound traffic are better centered over the through westbound lane (red Xs on the picture below).

[2] https://www.fhwa.dot.gov/publications/research/operations/its/06108/03.cfm

Add a supplemental near side signal head on the luminaire pole just before the northbound on ramp.

Similarly, add also a supplemental near-side signal head on the luminaire pole just before the southbound off ramp.

Concern: Rear-End Crashes Are Common At the Two Traffic Signals

Eastbound and westbound rear-end crashes represent, overall, the most predominant crash type along this corridor.

Safety Enhancements:

Review the coordination plans.

Mid-term, follow the near-term recommendations of the Exit 17 Scoping Study and implement adaptive signal control technologies.

Summary of Safety Enhancements

The safety concerns and potential actions that were identified in the previous sections are further summarized in the next table. These potential enhancements will be presented to the Director of the Office of Highway Safety for further consideration.

Potential Safety Enhancements Summary Table

Safety Concern	Safety Enhancement	Responsibility	Safety Payoff	Time Frame	Cost
Left Turn Crashes at the Southbound On Ramp Signal	Provide a protected only left turn phase at this intersection. Evaluate what the effect would be on capacity	VTrans (TSMO)	High (99% red in angle, CMFID 333)	Short	Low
	If a protected only left turn phase is not desirable due to extreme delays, replace the five-section head with a flashing yellow arrow four-section head to improve understanding by motorists	VTrans (TSMO)	Med (19% red in angle, CMFID 4177	Short	Med
	A long term measure would be to eliminate the left turning movement onto the southbound off ramp. One approach would be to construct the new southbound on ramp that is suggested by the Exit 17 Scoping Study and that would require motorists to go through the signal and continue right onto the ramp	VTrans (AMP)	High?	Long	High
Issue with Rear-End and Merging Crashes at the Northbound Off Ramp Slip Lane	Consider ramp-metering at this location	VTrans (TSMO, Traffic Design)	High (36%, CMFID 5436)	Mid	Med
	Remove the slip lane and increase the number of turning lanes on the northbound off ramp at the traffic signal	VTrans (AMP)	High?	Long	High
Issue with Right Angle Crashes at Southbound and Northbound Off Ramp	Ensure that the yellow and all red phases as well as the end of green phase are suitable	VTrans (TSMO)	Low (8%, CMFID 380)	Short	Low
	Make the signal more conspicuous by adding yellow retroreflective tape around each backplate	VTrans (TSMO)	Med (15%, CMFID 1410)	Short	Low
	At the northbound ramp intersection, adjust the placement of the signal heads so that the two signal heads for westbound traffic are better centered over the through westbound lane	VTrans (TSMO)	Low (7%, CMFID 1430)	Short-Mid	Low-Med
	Add a supplemental near side signal head on the luminaire pole just before the northbound on ramp	VTrans (TSMO)	Med (10-28%[3])	Mid	Med

[3] http://safety.fhwa.dot.gov/tools/crf/resources/fhwasa08011/page2.cfm#linktarget_6 Add signal (additional primary head)

Safety Concern	Safety Enhancement	Responsibility	Safety Payoff	Time Frame	Cost
	Similarly, add also a supplemental near-side signal head on the luminaire pole just before the southbound off ramp	VTrans (TSMO)	Med (10-28%[4])	Mid	Med
Rear-End Crashes Are Common At the Two Traffic Signals	Review the coordination plans	VTrans (TSMO)	Med (7-16%[5])	Short	Low
	Mid-term, follow the near-term recommendations of the Exit 17 Scoping Study and implement adaptive signal control technologies	VTrans (AMP)	High (22%[6])	Mid	Mid-High

[4] http://safety.fhwa.dot.gov/tools/crf/resources/fhwasa08011/page2.cfm#linktarget_6 Add signal (additional primary head)
[5] http://safety.fhwa.dot.gov/tools/crf/resources/fhwasa08011/page2.cfm#linktarget_6 (provide signal coordination)
[6] http://rhythmtraffic.com/safety-benefits-associated-with-adaptive-traffic-signal-control/