User Guide

Vermont Systemic Safety Lane Departure Risk Screening Tool

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Contents

Orientation

This user guide for the Vermont Systemic Safety Lane Departure Risk Screening Tool presents the concepts and usage of the tool in simple terms. A technical report that discusses the project in more detail is available. Within this user guide, click on green boxes for links to other websites or documents.

Read the technical report: Technical Report Access the Screening Tool: Risk-Based Tool

Background

The principal purpose of this project was to develop a predictive methodology to apply the systemic safety approach to lane departure crashes for proactively implementing treatments at locations with high-risk characteristics. The Vermont Agency of Transportation led the project with federal funds through the Transportation Records Coordinating Committee and with a state match from state funds. The consulting firm VHB was retained to perform the analysis work. The Operations and Safety Bureau built the screening tool to provide access to the results.

Road Safety Concepts

Learn how safety measures are implemented, what the key rural safety challenges are, what systemic safety is, what KABCO means, and what the countermeasures are that can be deployed to reduce lane departure crashes.

Three Engineering Approaches for Improving Safety

There are three ways to implement safety engineering countermeasures.

1 **Site-Specific Approach** (hot-spot or crash-based):

Improvements are made at specific sites, usually those with a high frequency of crashes.

- ✓ An example is installing a traffic signal at a high crash intersection.

2 **Systematic Approach** (policy-based):

Improvements are made to the entire road system, often as a policy.

- ✓ An example is installing centerline rumble strips with a paving project.

3 **Systemic Approach** (risk-based):

Improvements are made at locations that have the greatest risk.

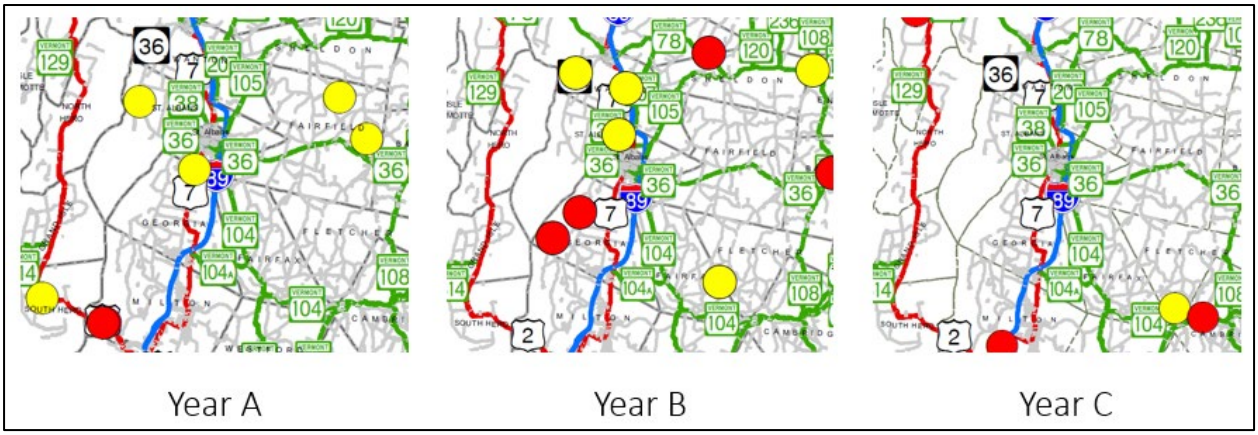
- ✓ An example is installing enhanced chevrons at curves with radii between 750 ft and 1000 ft.

The Rural Safety Problem

In Vermont, lane departure crashes account for over 70% of fatal and serious injury crashes.

While they represent a large number, the locations where roadway departure crashes occur change from year to year.

Take a look at the diagram and see that the locations of the crashes are not the same in the three years shown.



Since the locations are dispersed, there are no clusters. Lane departure crash locations are not well detected by the traditional site-specific method which looks at high frequencies of crashes.

The challenge of determining where lane departure crashes are likely to take place can be resolved by using the systemic method since, while the locations may be hard to predict, the site characteristics linked to lane departure crashes are stable and identifiable.

Systemic Safety

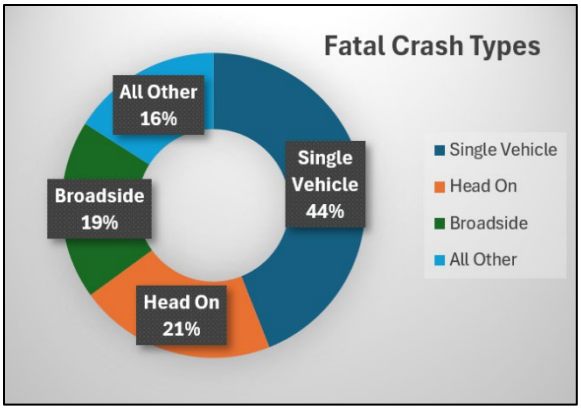
The systemic method looks at crash history to identify factors that correlate with a particular crash type. The more factors that are present at a site, the greater the likelihood of a crash happening at that site.

The systemic method aims at implementing treatments at the sites with these common factors. It is proactive, and some of the sites treated may have no observed crashes yet.

What is a Focus Crash Type?

A crash type is a category associated with a crash. It often describes the manner of collision or what a vehicle collided with.

Focus crash types are used in systemic safety analysis. They represent crash types with large proportions of fatal and serious injury crashes.

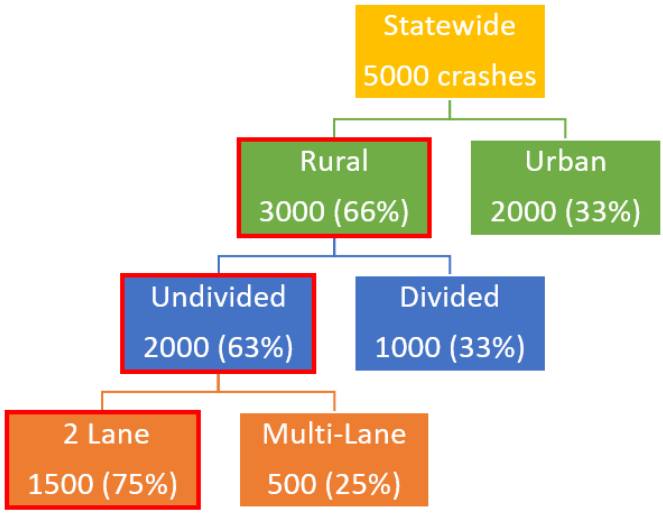


What is a Focus Facility?

A focus facility is where a focus crash type happens most frequently. A couple examples of focus facilities are rural two-lane roads and horizontal curves.

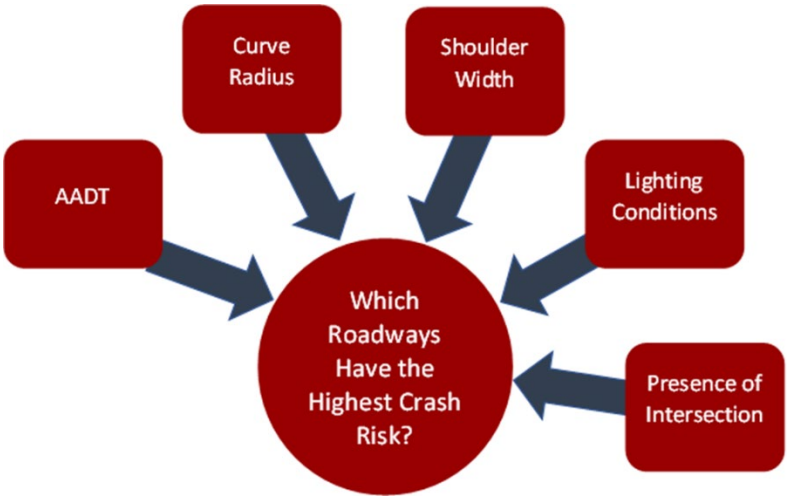
A crash tree diagram is a tool that can be used to identify a focus facility. The diagram starts from a broad universe of crash data and branches out into smaller groups following the categories with the most crashes.

In the example, statewide crashes are at the top of the tree and are divided up into rural and urban crashes. The crash tree continues down the rural branch because there are more rural crashes. Crashes on rural undivided roads are more numerous, and that is the next branch with the final branch being two-lane. The focus facility is thus a rural, undivided, two-lane road.



What are Risk Factors?

Risk factors are the common site characteristics associated with the focus crash types.



They are used to identify where crashes are most likely. However, the common elements being correlated with crashes do not necessarily imply a causal relationship or that they represent an inferior aspect of the roadway.

They are identified using overrepresentation analysis *(for example, considering horizontal curves, as when the percentage of crashes within a radii range is larger than the percentage of curves with that range, e.g., 10-degree curves represent 20% of the network, but 50% of the crashes, therefore this range is overrepresented)* or regression analysis as described next.

Binary Logit Modeling

Binary logit models are a form of regression models. They differ from linear regression in that linear regression aims at predicting the value of a variable (e.g., number of crashes) while binary logit models are used to estimate the probability that an event happens (e.g., head-on crashes will occur, yes/no). They can be used to identify risk factors.

Binary Logit General Form

$$\ln[p/(1-p)] = a + b_1X_1 + b_2X_2 + \ldots + b_kX_k$$

where,

p *: Probability that event Y = 1 given X*

Y : Dependent Variable

X_1, X_2, X_k *: Independent Variables*

$a, b_1 \ldots b_k$ *: Model Parameters*

As with linear regression, there is a dependent variable and one or more independent variables. For instance, to predict the occurrence of head-on crashes, the dependent variable, we may want to see how road width and speed limits, the independent variables, affect the likelihood of head-on crashes happening.

The association between the independent variables and an outcome is measured by the odds ratio. Odds ratios > 1 indicate a positive effect, odds ratios < 1 indicate a negative effect.

The p-value measures whether there is a relationship between the dependent and an independent variable. A relationship exists when the p-value is low (often p-value <0.05). A high p-value indicates that it cannot be concluded that a relationship exists. In this case, the variable is said to be insignificant.

Crash Severity

Crash severity is based on the highest level of injury suffered by any of those involved in a crash. For example, if two people were involved in a crash, and one suffered a serious injury and the other person suffered a non-serious injury, the crash is classified as a serious injury crash.

The KABCO scale is used to refer to the severity of a crash.

K Fatal
A Suspected Serious Injury
B Suspected Non-Serious Injury
C Possible Injury
O Property Damage Only Crashes

Lane Departure Countermeasures

Countermeasures to reduce lane departure crashes are implemented to achieve one of three objectives: keep vehicles on the road, reduce the potential for a crash to occur, and minimize crash severity.

For each objective, countermeasures are specific to certain crash types (the Lane Departure Screening Tool can assist users in selecting the appropriate treatment).

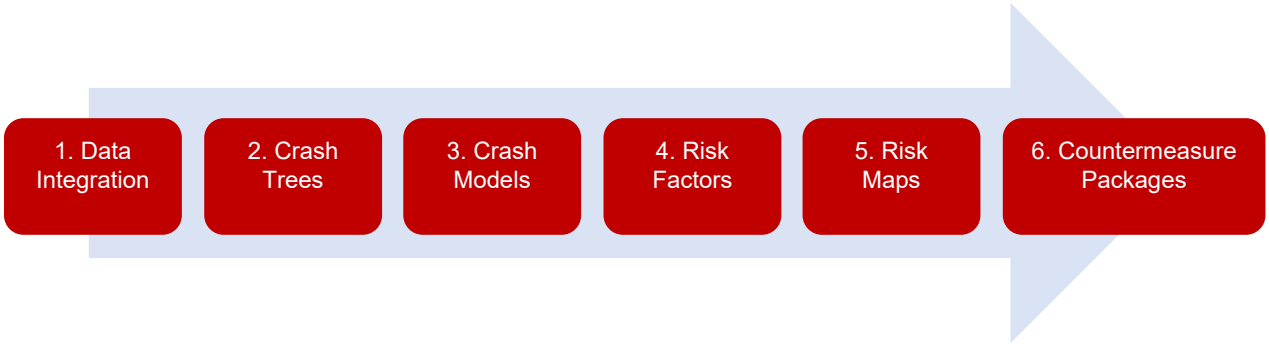
Lane Departure Objectives	
Keep vehicles on the road	Edge line markings MUTCD compliant curve warnings Delineators Sequential flashing beacons and speed feedback signs High friction surface treatments Rumble strips
Reduce the potential for crashes	Shoulders (add or widen) SafetyEdge$_{SM}$ Center line buffer Remove fixed objects to widen clear zone Flatten side slopes
Minimize crash severity	Roadside barrier Implement breakaway devices

More information is available:

FHWA Roadway Departure

The Project

The key steps for realizing the systemic lane departure project included roadway and crash data integration, the identification of focus crash types and focus facility types, the identification of risk factors, the creation of risk maps and the selection of countermeasures and prioritization of sites.



Data Integration

Crash, roadway characteristics, traffic volume, and asset data were processed and integrated from various VTrans databases.

Crash data (Years 2016-2020):

- Crash locations
- Crash severity
- Manner of collision
- Collided-with attributes
- First harmful event

Area Type:

- Urban Area Boundary to define urban/rural areas

Roadway Attributes:

- Cross Sectional
- Functional Class and Facility Type
- Speed Limit
- Annual Average Daily Traffic
- Curves (horizonal and vertical)
- Intersections (Nodes and Legs)
- Line Striping
- Tenth of a mile pavement condition
- Limited access highways
- Long and short structures

Asset Data:

- Guardrails
- Rumble strips
- Traffic signs

Focus Crash Types and Facility Types

The emphasis of this project was on lane departure crashes.

A lane departure crash is defined as a crash that occurs after a vehicle crosses an edgeline or centerline or otherwise leaves the traveled way.

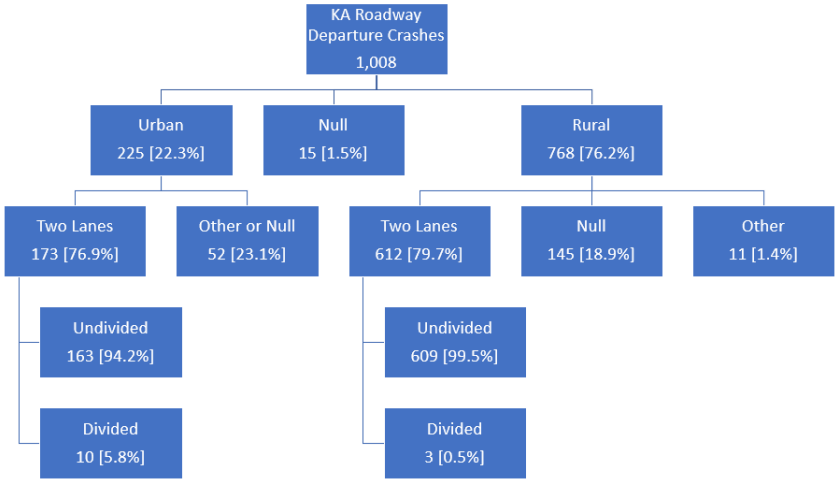
The lane departure focus crash types selected are:

- Head-on crashes
- Fixed object crashes
- Overturn or rollover crashes
- Run-off-road crashes
- Nighttime Run-off-road crashes

To identify the focus facility types, crash tree diagrams were used with these elements to identify combinations of high crash frequencies: urban vs rural, state vs local ownership, curve vs tangent, presence of an intersection, fixed object struck, and lighting.

The crash data consisted primarily of fatal and suspected serious injury crashes (KA crashes), but when KA crashes were less than 100 for a focus crash type, suspected minor injury crashes (B crashes) were included.

Crash Tree for All RwD Crashes, KA Severity



Review the crash trees:

Project Crash Trees

The focus facility types identified are:

- Rural local horizontal curves
- Rural state horizontal curves
- Rural state tangents
- Interstates

Risk Analysis Models

The evaluation of the crash trees produced 14 combinations of focus crash types and focus facility types to be evaluated for the identification of risk factors.

Rural Local Curves

1. Head-on crashes on rural local road curves
2. Overturn crashes on rural local road curves
3. Run-off road crashes on rural local road curves
4. Fixed object crashes on rural local road curves
5. Night-time run-off road crashes on rural local road curves

State Rural Curves

6. Head-on crashes on rural state curves of minor arterials and major collectors
7. Overturn crashes on rural state curves of minor arterials, major collectors, and principal arterials
8. Run-off road crashes on rural state curves of minor arterials and major collectors
9. Fixed object crashes on rural state curves of minor arterials and major collectors
10. Night-time run-off road crashes on rural state curves of minor arterials and major collectors

Interstates

11. Overturn crashes on Interstates

State Rural Tangents

12. Head on crashes on rural state tangents of minor arterials, major collectors, and principal arterials
13. Overturn crashes on rural state tangents of minor arterials, major collectors, and principal arterials
14. Run-off road crashes on rural state tangents of minor arterials and major collectors

Risk Factors

Crash prediction models using binary logic regression were developed to identify the risk factors for each of the 14 combinations.

Variables related to AADT, degree of curvature, intersections, curve geometry, vertical geometry, and roadside features were considered as independent variables.

In the development of the models, variables with a p-value exceeding 0.400 were considered insignificant and removed from the models.

A table of sample binary logit model outputs for the overturn crash type on the interstates is shown.

Variable	Odds Ratio	Standard Error	z-value	P>|z|	95% Confidence Interval		Weight
AADT over 15000 vpd	1.931	0.580	2.19	0.029	1.071	3.480	1
Presence of guardrail	0.639	0.234	-1.22	0.222	0.312	1.312	1 (if guardrail is not present)
Presence of Type A Warning signs	2.427	1.057	2.04	0.042	1.034	5.699	2
Natural Log of length of segment	2.297	0.298	6.41	0.000	1.781	2.961	N/A
Constant	0.035	0.021	-5.49	0.000	0.010	0.115	N/A
Note: Number of observations = 5,774; Log likelihood = -237.90055; Pseudo R2 = 0.1852; LR chi2(4) = 108.14; Prob > chi2 = 0.0000. N/A = not applicable							

The risk factors listed in the sample table include traffic volume exceeding 15,000 vehicles per day, the absence of guardrail and the presence of Type A warning signs. The table shows that segment length was included in the model but that it was not assigned a weight. This is because segment length is used in all the models for the only purpose of normalizing for the length of the segment but is not used as a risk factor.

The higher odds ratio (2.427) for the presence of Type A warning signs indicates that this variable has a greater influence on the occurrence of an overturn crash. For this reason, this variable is assigned a greater weight (2).

With an odds ratio below 1 (0.639), the presence of guardrail has a negative impact on the occurrence of an overturn crash. This is the reason why the absence of guardrail is selected as the risk factor.

Explore the Logit Models and Risk Factors:

Project Risk Factors

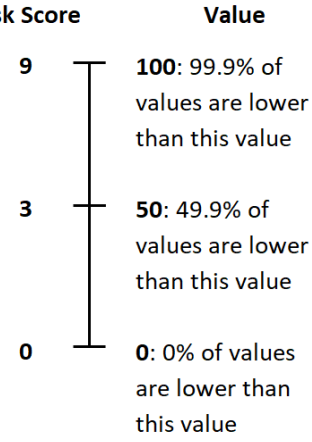
Risk Scores

Segments were scored for each focus crash type based on the presence of the risk factors within the segment and their assigned weights. A sample calculation is shown.

Segment Risk Score Calculation Example

Risk Factor	Risk Factor Value	Segment Value	Risk Weight	Risk Score
AADT	Over 15000 vehicles per day	28200	1	1
Guardrail	None	Right Guardrail Present	1 (if not present)	0
Type A Warning Sign	Present	Present	2	2
			Total Risk Score (Sum)	3

Each segment was assigned a percentile rank based on its total score relative to the other segments within its focus crash and facility types. The percentile ranks were then used to assign the segments a risk category. Five categories of risk were determined: Minimal Risk, Low Risk, Medium Risk, High Risk, Primary Risk. A segment classified as Not a Focus Facility is a segment for which a particular focus crash type facility type combination is not applicable.



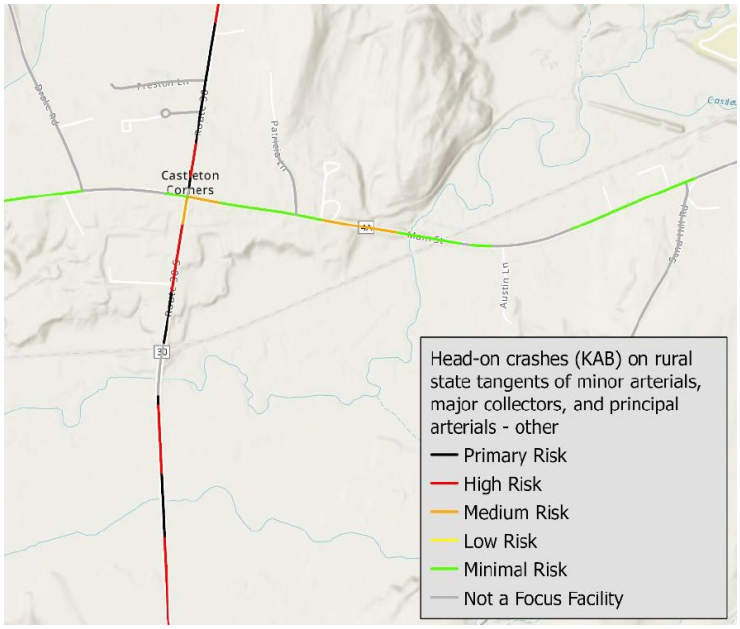
Percentile Rank Example

A percentile rank may contain more segments than its percentile category. As an illustration, the 95th percentile group represents the segments with the top 5% scores for a focus crash type and facility. However, it is possible for more than one segment to have the same score and therefore a larger percentage of segments (greater than 5%) could be associated with the 95th percentile rank.

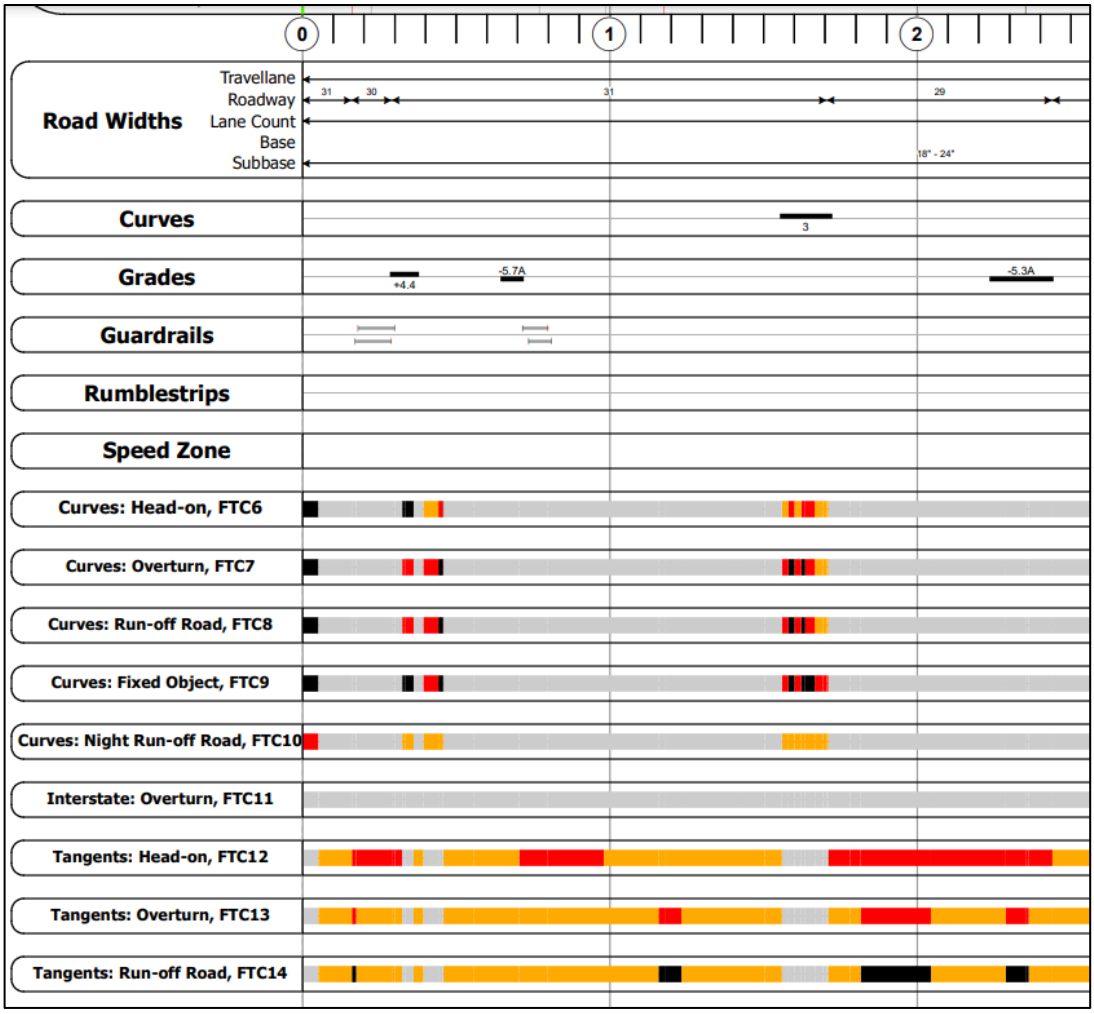
Risk Category	Percentile Score Range
Primary Risk	95-100
High Risk	85-94
Medium Risk	60-84
Low Risk	30-59
Minimal Risk	0-29

Risk Maps & Route Logs

Risk Maps were developed for each of the fourteen focus crash – focus facility combinations. Primary risk segments are shown on the maps in black while high-risk segments are shown in red.



Lane Departure Route Logs were developed for state roads. These route logs display, for a given road, the risk levels for each of the focus crash – focus facility combinations in a stacked manner along the entire road.



Interpreting Risk

Q. "Not sure why a rollover crash is likely here. It does not seem like much of a curve".

Ans. Risk is relative, not a certainty. It is possible that no rollover crashes will happen, but that, on average, if a rollover were to happen, this is a particular segment for which it would be more likely to occur. This does not characterize the road as safe versus unsafe but provides a location to proactively assess in terms of treating for the possibility of a future overturn crash.

The risk maps can be viewed directly in the Tool. The lane departure route logs can be accessed in the Tool via the menu button.

View the Lane Departure Route Logs:

Lane Departure Route Logs

Countermeasure Packages

Risk Level	Countermeasure (Focus Crash and Facility Type)	Target Crash Types and Facilities						
		Head-On Crashes, Curves and Tangents (1, 6, 12)	Overturn, Curves (2, 7)	Fixed Object Crashes, Curves (4, 9)	Run-Off-Road, Curves (3, 8)	Overturn, Interstate (11)	Nighttime Run-Off-Road Crashes, Curves and Tangents (5, 10)	Overturn, Run-Off Road, Tangents (13, 14)
High	Centerline Mumble Strips	●						
	Centerline Rumble Strips	●						
	Designate No Passing Zone	●						
	Address Trip Hazards[2]		●			●		●
	Paved Shoulder Widening		●	●	●	●	●	●
	Targeted Clear Zone Widening			●				
	Reflective Pavement Markings						●	

General standard countermeasures are proposed for all sites and more targeted treatments are suggested for medium, high and primary risk sites. The countermeasure matrix is divided into four tables. The high level countermeasure table is shown here.

In these tables, the countermeasures are applicable to all sites at the applicable risk level or above. For example, medium risk level countermeasures are applicable to medium risk, high risk, and primary risk sites.

Therefore, for primary risk sites, choose countermeasures from the medium, high or primary risk level countermeasures. For high risk sites, choose from medium or high risk level countermeasures and for medium risk sites, choose from medium risk level countermeasures only.

In suggesting these countermeasures, it is assumed that the signage recommended in the Manual on Uniform Traffic Control Devices is already present.

An entity that selects sites for remedial or preventive action should perform a more detailed diagnosis of the sites before implementing a specific countermeasure.

The Lane Departure Screening Tool provides an expanded version of the matrix that includes information about crash reduction potential, cost and maintenance concerns.

Look over the countermeasure matrix:

Countermeasure Matix

Learn more about the countermeasures:

VTrans Countermeasure Package Briefs

FHWA Countermeasure Pocket Guide

Prioritized Implementation Ranking

Primary risk sites are prioritized for the implementation of the following countermeasures for each focus crash type – focus facility type combination as applicable:

- Centerline Buffer Area
- Median Barrier
- High-Friction Surface Treatment
- Roadside Barrier
- Slope Flattening
- Clear Zone Widening
- Lighting
- Dynamic Chevrons
- Flashing Beacons

The specific relationship between the prioritized countermeasures and the focus crash type – focus facility type combinations is shown below.

Focus Facility Type #	Crash Type	Prioritized Countermeasures									
		CENTERLINE BUFFER AREA	CLEAR ZONE WIDENING	DYNAMIC CHEVRONS	FLASHING BEACONS	HFST	LIGHTING	MEDIAN BARRIER	ROADSIDE BARRIER	SHOULDER WIDENING	SLOPE FLATTENING
1	Head-on_Curve_Local	Yes				Yes		Yes			
2	Overturn_Curve_Local			Yes	Yes				Yes	Yes	Yes
3	Run-Off_Curve_Local		Yes	Yes	Yes	Yes			Yes	Yes	Yes
4	Fixed Object_Curve_Local		Yes	Yes	Yes	Yes			Yes	Yes	
5	Nighttime Run-Off_Curve_Local		Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes
6	Head-On_Curve_State	Yes				Yes		Yes			
7	Overturn_Curve_State			Yes	Yes				Yes	Yes	Yes
8	Run-Off_Curve_State		Yes	Yes	Yes	Yes			Yes	Yes	Yes
9	Fixed Object_Curve_State		Yes	Yes	Yes	Yes			Yes	Yes	
10	Night_Run_Off_Curve_State		Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes
11	Overturn_Interstate								Yes	Yes	Yes
12	Head-On_Tangent_State	Yes				Yes		Yes			
13	Overturn_Tangent_State								Yes	Yes	Yes
14	Run-Off_Tangent_State								Yes	Yes	Yes

The ranking criteria consider crash risk and feasibility of installation using available planning level data. For example, for the installation of a median barrier, the ranking criteria are:

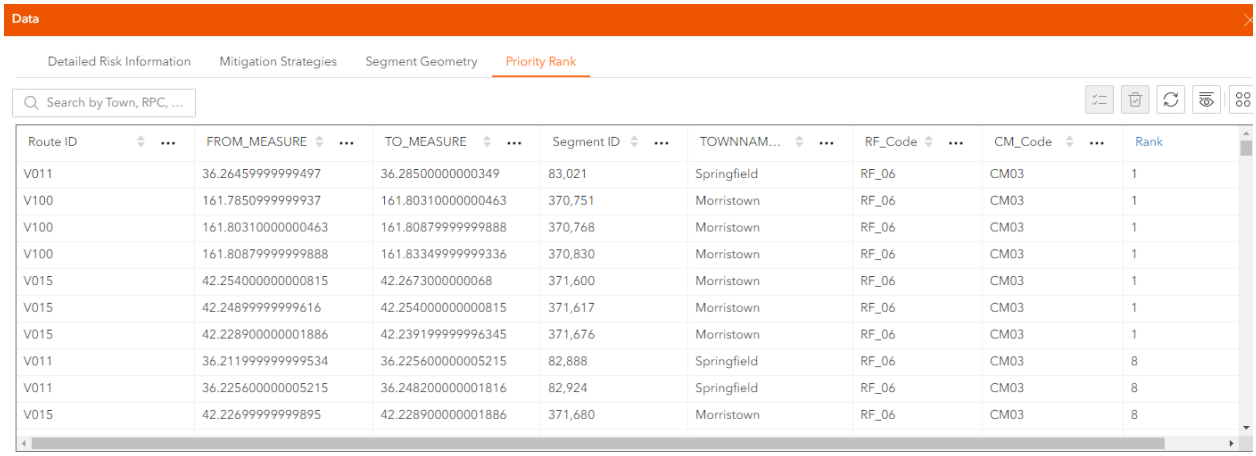
- Median is present and traversable
- 1 point for every cross-median crash
- 1 point for every 5-feet narrower than 30 ft in median width

View the countermeasure ranking criteria for primary risk sites:

Countermeasure Ranking Criteria

In the Screening Tool, the rankings of primary risk sites for the implementation of countermeasures can be viewed in a table format and they can also be displayed on a map.

The table example shown illustrates the priority ranking of primary risk sites on rural state curves for the high friction surface treatment countermeasure (CM03). In these tables, the lower the rank, the higher the priority. A site ranking of 1 is of higher priority than a site ranking of 50.



Route ID	FROM_MEASURE	TO_MEASURE	Segment ID	TOWNNAM...	RF_Code	CM_Code	Rank
V011	36.26459999999497	36.28500000000349	83,021	Springfield	RF_06	CM03	1
V100	161.7850999999937	161.80310000000463	370,751	Morristown	RF_06	CM03	1
V100	161.80310000000463	161.80879999999888	370,768	Morristown	RF_06	CM03	1
V100	161.80879999999888	161.83349999999336	370,830	Morristown	RF_06	CM03	1
V015	42.254000000000815	42.2673000000068	371,600	Morristown	RF_06	CM03	1
V015	42.24899999999616	42.254000000000815	371,617	Morristown	RF_06	CM03	1
V015	42.228900000001886	42.239199999996345	371,676	Morristown	RF_06	CM03	1
V011	36.211999999999534	36.225600000005215	82,888	Springfield	RF_06	CM03	8
V011	36.225600000005215	36.248200000001816	82,924	Springfield	RF_06	CM03	8
V015	42.22699999999895	42.228900000001886	371,680	Morristown	RF_06	CM03	8

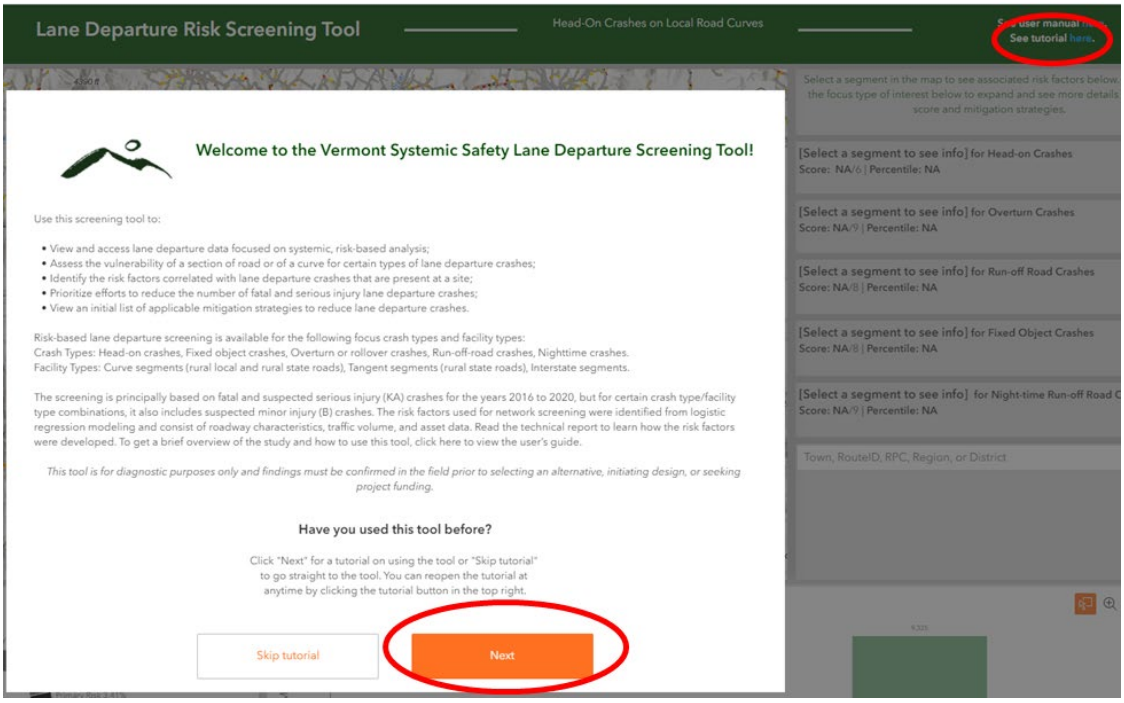
The prioritized sites can be viewed on a map. The darker colored segments represent the high priority segments.

NOTE. Only the sites with a rank of up to 500 are available in the tool. To review sites ranked beyond 500, go to the Menu in the lefthand panel of the Screening Tool and view the complete ranked dataset in Excel format (Rankings of Priority Segments for Select Countermeasures Table).

How to Use the Screening Tool

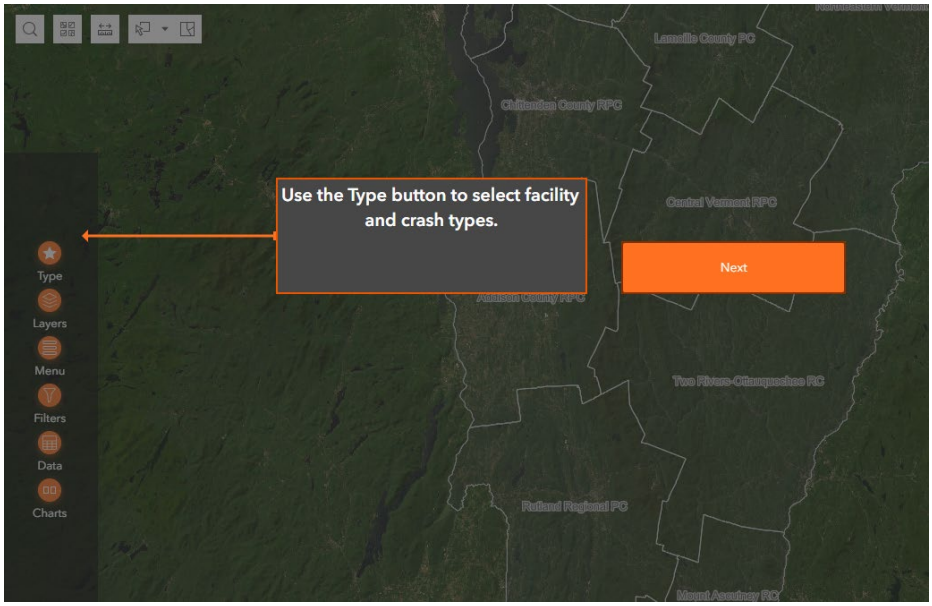
Getting Started

The application contains a short tutorial tour that goes over the key features to navigate the site. The tutorial can be viewed by clicking **Next** in the orange box at the bottom of the opening splash screen or any time during the session by clicking on **here** next to **See tutorial** at the top right corner of the page. It can also be accessed from the resource menu in the lefthand pane of the tool.

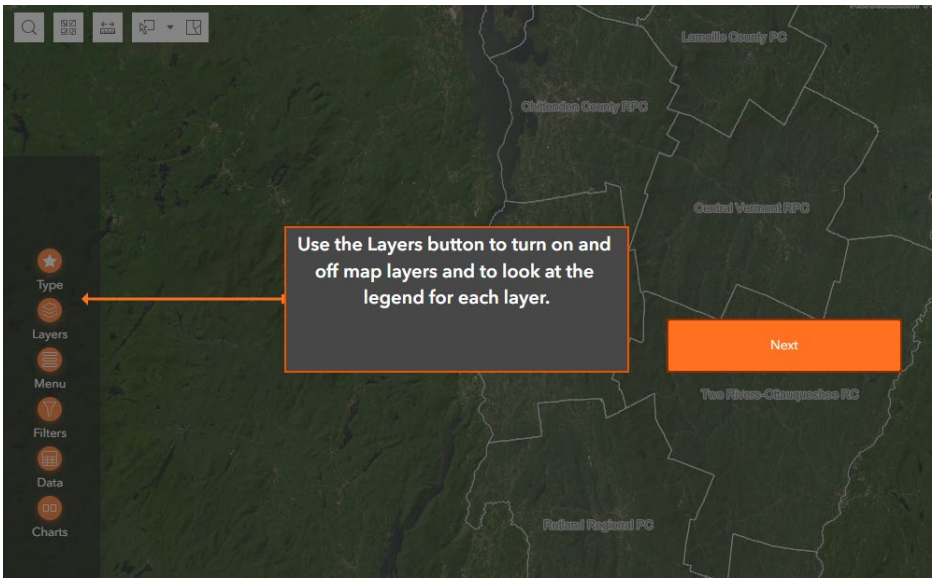


The following visuals illustrate the features of the application as presented in the tutorial.

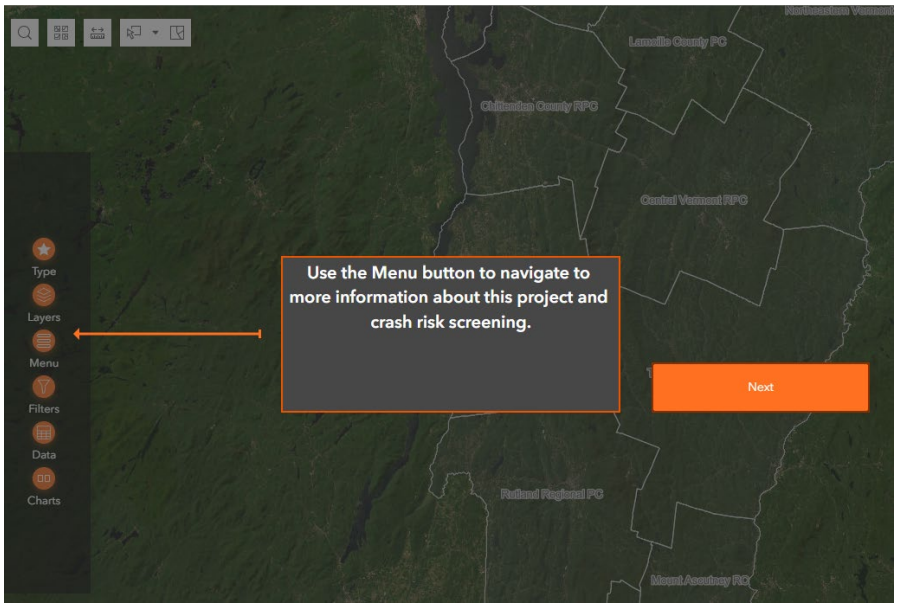
Crash Type / Facility Type Selection Button



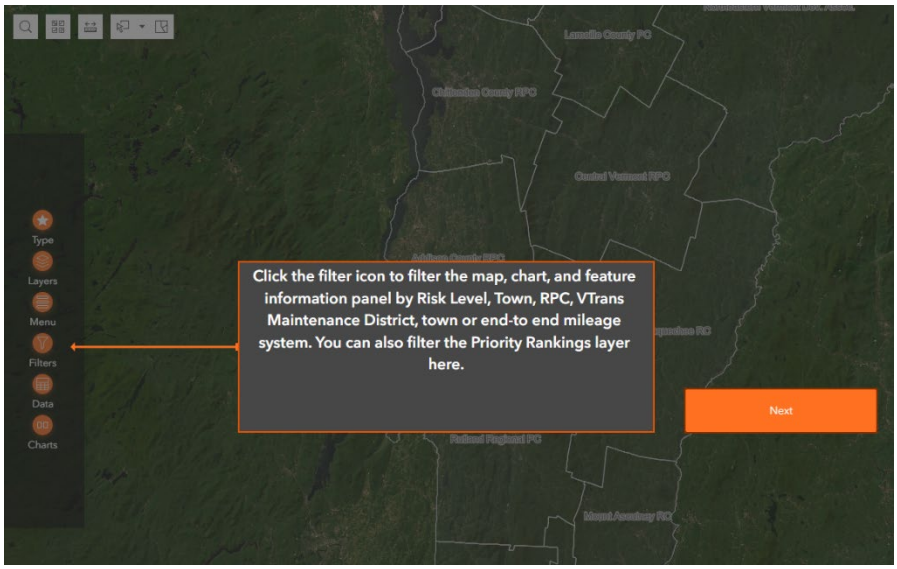
Layers Selection Button



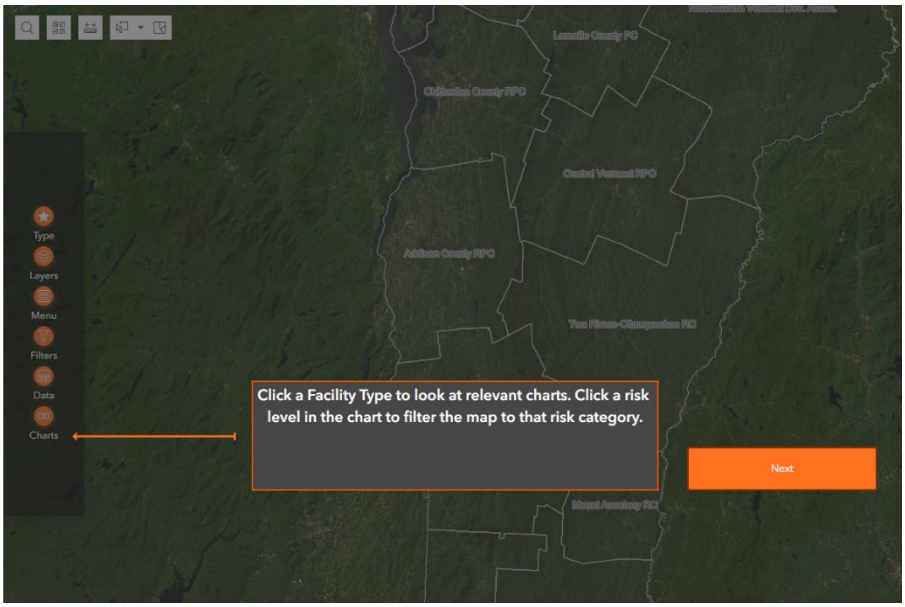
Resources Menu Button



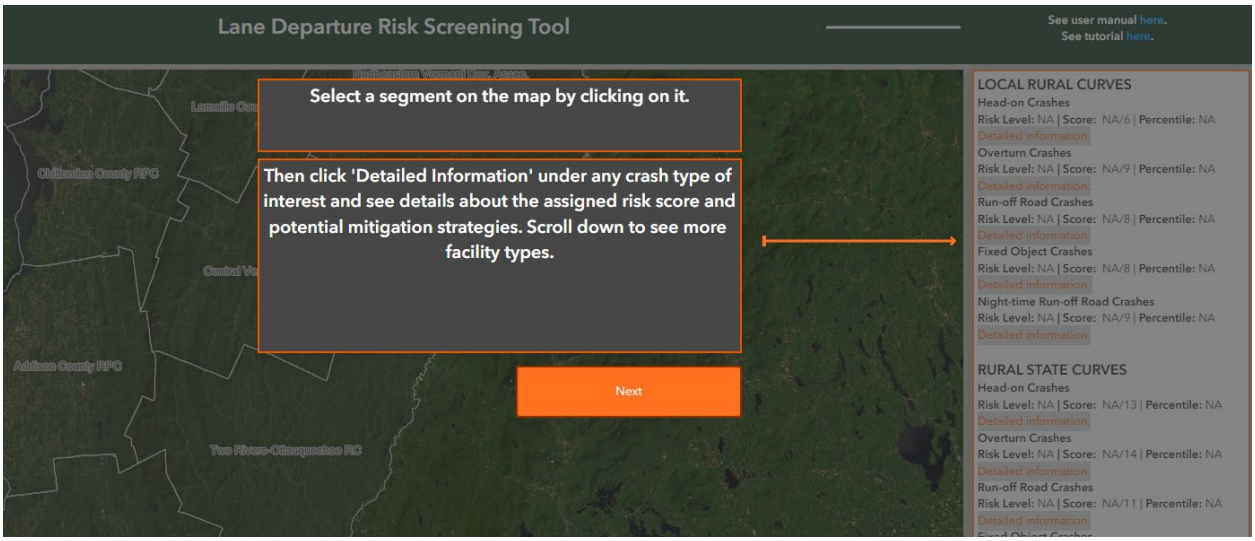
Filter Icon



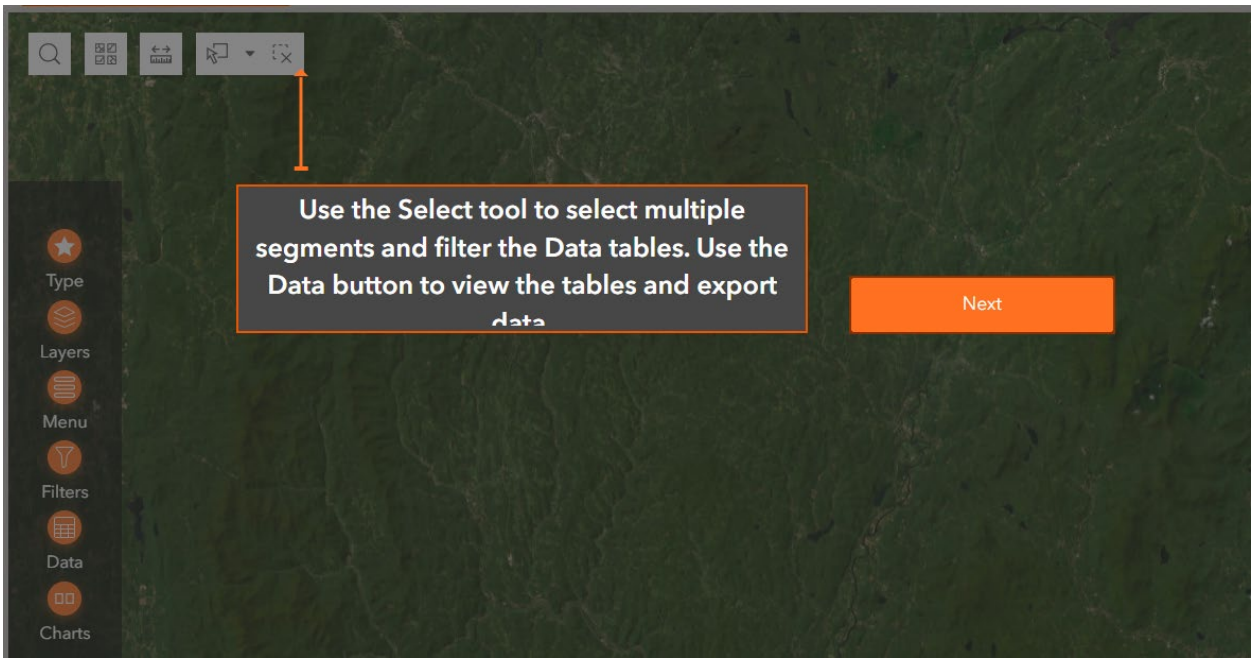
Charts Button



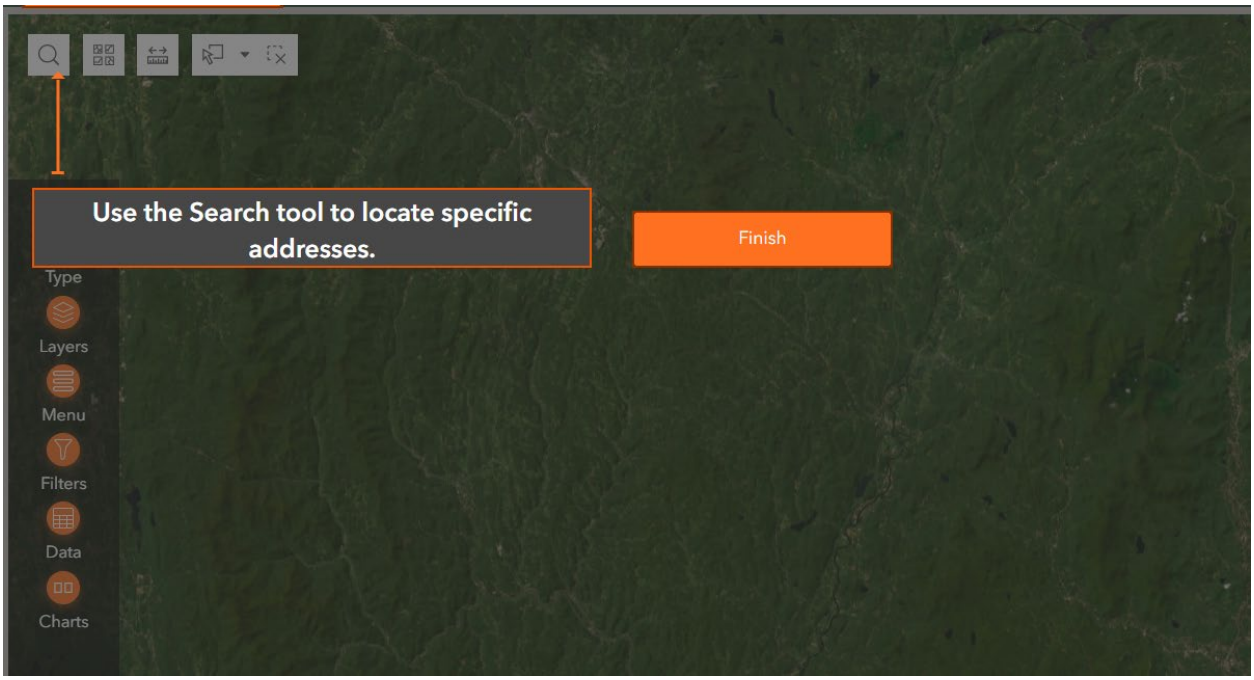
Detailed Information Tab



Selection Tool



Search Tool



Practical Usage Guide

The guidance provided in this section is intended to show users how to use the tool to answer typical questions. The examples of practical usage that are demonstrated here include the following:

Practical Usage #	Practical Usage Name	Question to Answer
Practical Usage 1	Reviewing the Systemic Safety of a Particular Road or Road Section	How is the road or road section expected to perform?
Practical Usage 2	Identifying Potential Mitigation Measures for a Site	What are the suggested countermeasures for the conditions?
Practical Usage 3	Identifying which Lane Departure Crash Sub-Type to Target for Mitigation	Which crash type is most likely to result in a crash event on this road or in a town or region?
Practical Usage 4	Developing a List of Top Sites to Review for an Area	What are the top X sites in an area, for example, what are the top 25 sites where the risk of head-on crashes is high?
Practical Usage 5	Selecting a Countermeasure and Identifying Locations for Possible Implementation	What are the locations where this countermeasure could be implemented?
Practical Usage 6	Exporting Data	How can data be exported to be used in other applications such as Excel?

Detailed steps on how to use the tool for each of the practical usages listed above are provided to assist users.

Practical Usage 1 Reviewing the Systemic Safety of a Particular Road or Road Section

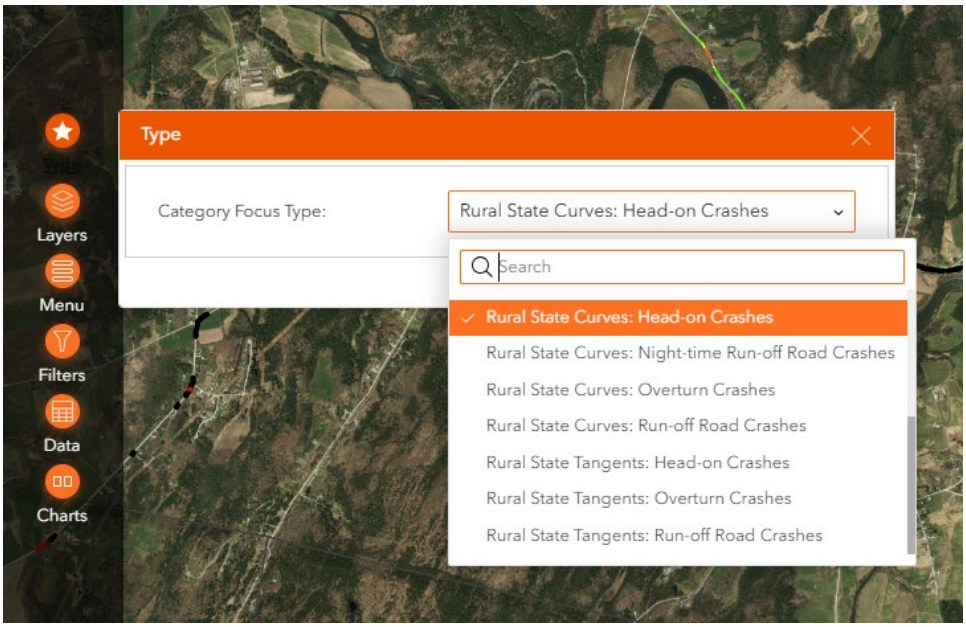
Practical Usage 1 demonstrates how to use the tool to review the systemic safety of a road or road section. A typical question to answer is: Are any parts of the road at risk for lane departure crashes?

Case Description

A user is interested in assessing the systemic safety of VT 105 around the Woods Hill Road intersection in Sheldon. The user is specifically interested in head-on crashes but is also curious about other crash types. VT 105 at this intersection follows a horizontal curve. The intersection is located at mile point 1.04. VT 105 in Sheldon is a rural road.

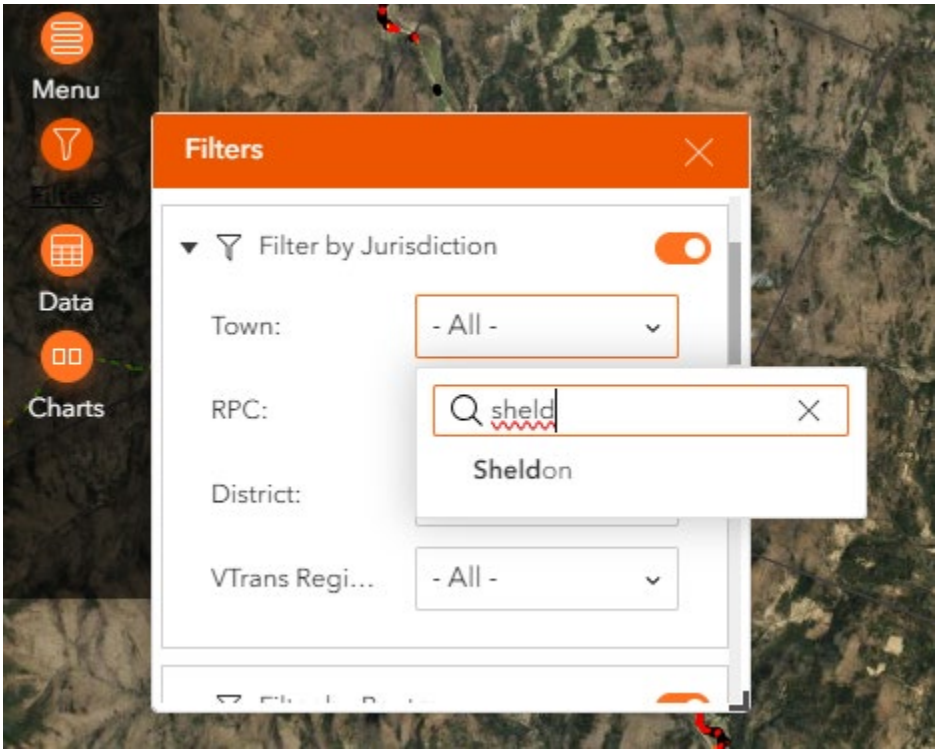
Step 1 Select a Focus Type

Because the intersection is located on a state road and on a curve, we want to select the state road curves facility type and the head-on crash type combination. In the lefthand pane, click on **Type**. Select **Rural State Curves: Head-on Crashes**. Note that selections made from the dropdown boxes remain active for all further queries until the tool is refreshed or the individual selections are changed.

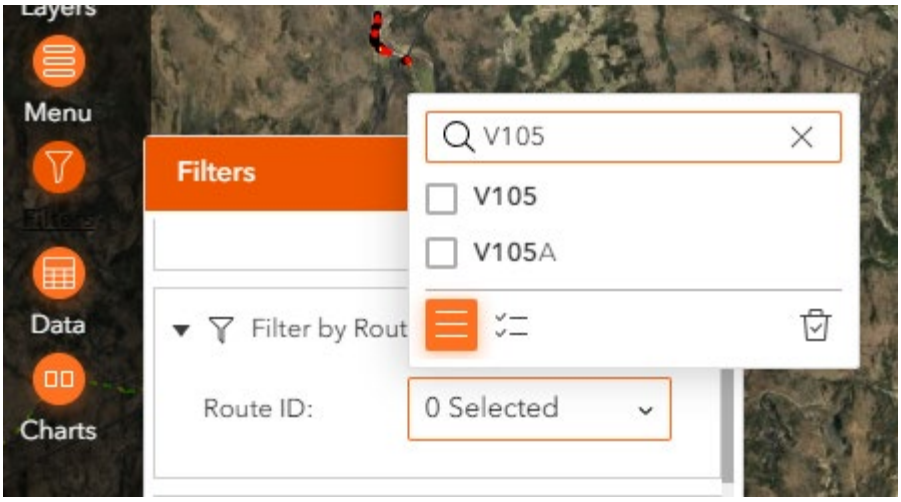


Step 2 Select the Town, the Road and the Mile Markers

Click on **Filter** in the lefthand pane and then click on **Filter by Jurisdiction**. Pick a town from the **Town** dropdown menu (in this case, Sheldon).



Go to **Filter by Route** and click on **Route ID** and pick the road from the dropdown menu (in this case, V105). The Filters widget can be expanded by clicking and dragging the bottom right corner to the size of you choosing.

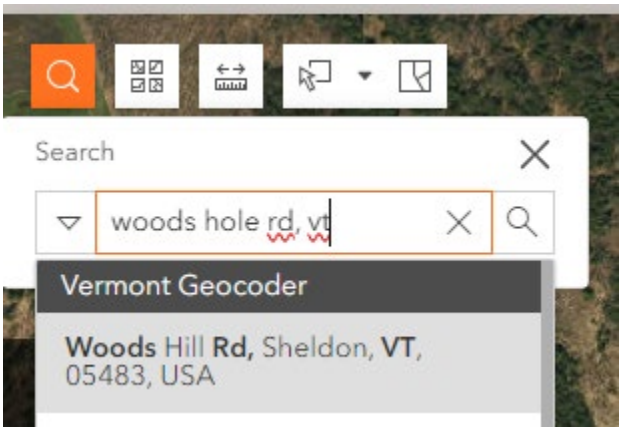


Go to **Filter by Town Mile Marker** and enter the **Town Begin** and **Town End** mile markers (in this case 0.9 and 1.10).

For each filter, make sure the filter is active (the bullet will be white on an orange background).

At this point, the map will pan to the area of VT 105 in Sheldon. NOTE. This may take several seconds to occur. Once this is done, zoom to the area of interest.

An alternative approach for locating the area of interest is to click on the **Search Icon** (magnifying glass symbol) in the left top corner of the map and enter the name of the intersecting roads and of the town. The map will zoom directly to the intersection.



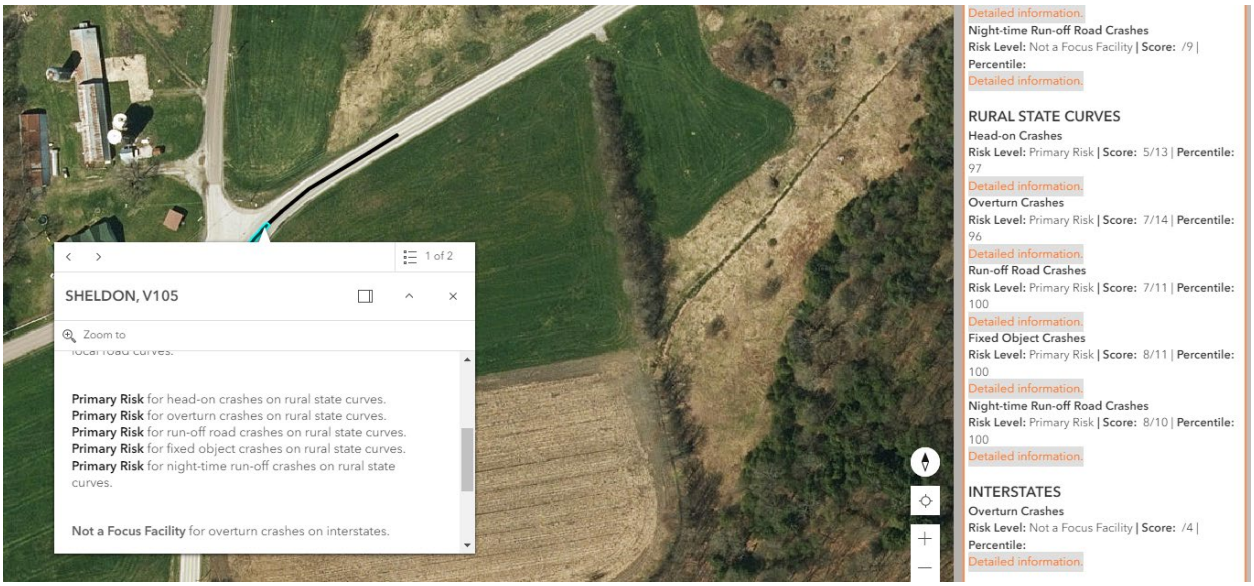
Step 3 Review the Risk Levels

Visually look at the road sections on the map to determine the risk levels for the filtered crash type (in this case Head-on Crashes).

For the curve at this intersection, the curve is divided into several smaller sections. Here, all the sections are shown in black, meaning that the overall curve is classified as primary risk for head-on crashes.

If the user clicks on a section, a new table that contains how the section is classified for other crash types will appear. In this case, the curve is also classified as primary risk for the other crash types.

In addition to viewing the risk levels on the map, the user can also view, in the righthand pane, the risk levels for all applicable crash types for the filtered facility type.



(NOTE. To view results for straight sections for the same crash type, the user will have to go back to Type and select Rural State Road Tangents: Head-on Crashes).

The user could also look at the lane departure route log for this road to view the risk levels for all crash types for both curves and tangents. To do so, select Menu and click the link for “Lane Departure Route Logs”.

Practical Usage 2 Identifying Potential Mitigation Measures for a Site

Practical Usage 2 demonstrates how to identify potential countermeasures for a road section, for a given crash type and risk level. A typical question to answer is: What are suggested countermeasures for the conditions?

Case Description

This is a continuation of the previous example for Practical Usage 1. A user was interested in assessing the systemic safety of VT 105 around the Woods Hill Road intersection in Sheldon for head-on crashes.

The user determined that the curve at this intersection was classified as primary risk for head-on crashes. The user now wants to identify which alternatives could be considered to prevent head-on crashes on this curve.

The user has completed steps 1 through 4 from Practical Usage 1.

Step 1 Select a Section of Road

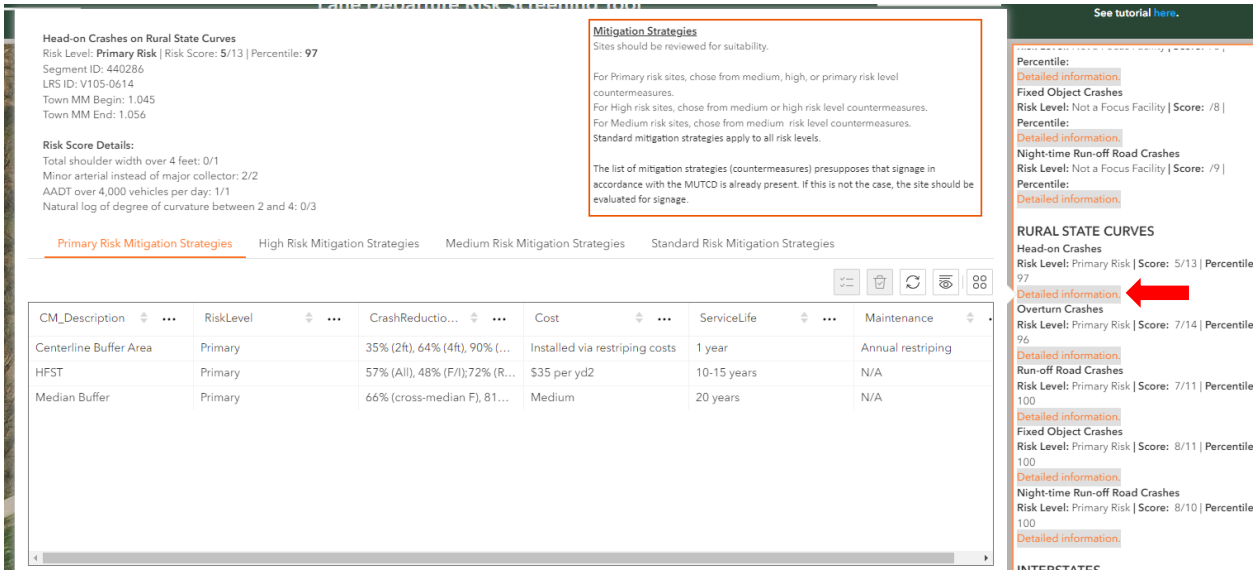
The user clicks on a section of the curve to activate the information shown in the righthand pane.

Step 2 View Detailed Information

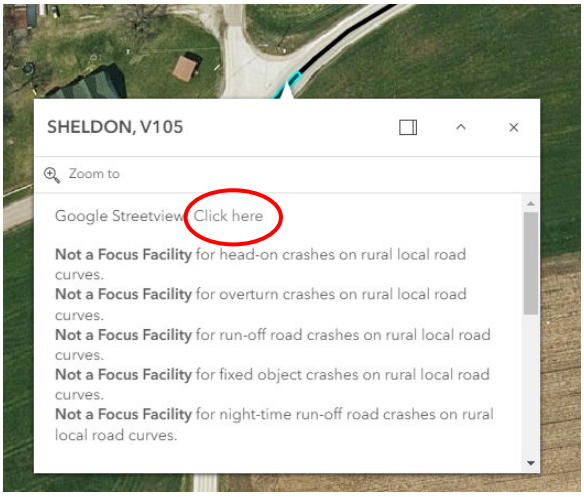
The user goes to the righthand pane and scrolls down to **Rural State Curves** and clicks, under Head-on Crashes, on Detailed Information. A mitigation strategy matrix opens.

Step 3 Review the Mitigation Strategies

The risk level of the site for head-on crashes is primary. Therefore, the user can review the countermeasures from the medium, high, or primary risk level tabs as the lower-level measures are also applicable to primary risk sites. The user clicks on each tab to view the countermeasures and select a few for further consideration.



The user must review the site to determine the suitability of each countermeasure that they are considering. The user can perform a desk review by clicking on the segment in the map and clicking on **Click Here** next to **Google Streetview** at the top of the box, below the name of the road. Depending on the assessment, a formal field review may be necessary.



Practical Usage 3 Identifying which Lane Departure Crash Sub-Type to Target for Mitigation

Practical Usage 3 demonstrates how to use the tool to identify the lane departure crash type that an entity should target for mitigation. A typical question to answer is: Which crash type is most likely to result in crash events, in a region, town or road?

Case Description

A town manager wants to proactively improve safety in their town on the local road system. As a starting point, the town manager wants to identify which lane departure crash sub-type poses the most risk in the town. The town of Sheldon will be used as the case town.

Step 1 Select a Focus Type

Click on **Type**. Select a focus crash type/facility type combination (here select **Local Rural Curves: Head-on Crashes**.

Step 2 Select a Location (jurisdiction and/or road)

Click on **Filter** in the lefthand pane and then click on **Filter by Jurisdiction**. Pick a town from the Town dropdown menu (in this case, Sheldon). Since the user in this example is interested in making a determination for the entire town, the filtering ends here.

Step 3 Compute Mileage Info

In the lefthand pane, click on **Charts**. Select the facility type that corresponds to the crash type selected in step 1 (in this case, Local Rural Curves). Two charts will appear (The top chart presents risk levels by miles, while the bottom chart displays the percentage of miles in each risk category).

Step 4 View the Mileage Breakdown by Crash Type

Click on **Head-On Crashes** in the top heading to see the breakdown for head-on crashes. Review the charts and write down or export the values (for head-on crashes, 4.2% of curve miles are rated as primary risk, 7.5% as high risk and 66.5% as medium.

Step 5 Look at Other Crash Types

Repeat step 4 for the other crash types. To look at other facility types, update the Type filter before repeating Step 4 and opening the chart relevant to the facility type of interest.

Step 6 Analyze the Results

Compare the results for the applicable crash types and identify the crash type that has the highest number of miles at the highest risk level or from a combination of risk levels.

From the analysis of the results, the town manager notes that the greatest number of miles (2.093) for the primary risk category is associated with overturn crashes. Overturn crashes on rural curves could be of interest. The town manager further decides to combine the primary and high-risk categories for each crash type and now identifies nighttime run-off-the road crashes on rural local curves as another potential crash type of interest with 3.2 miles of local rural curves. At this point, the town manager can

decide to base the town improvement program on this analysis considering one or both of the crash types identified.

(A user analyzing the rural state system may want to perform the above steps for both tangents and curves).

Practical Usage 4 Developing a List of Top Sites to Review for an Area

Practical Usage 4 illustrates how to use the tool to create a list of potential sites to review for preventive remedial action. A typical question to answer is: What are the top sites in a geographic location where the likelihood of a certain crash type happening is high?

Case Description

This is a continuation of the previous example for Practical Usage 3. A user was interested in identifying which lane departure crash sub-type posed the most risk in the town. The town manager determined that this crash sub-type was nighttime run-off-the-road crashes on local rural roads. The town manager now wants to know where nighttime run-off-the-road crashes could take place in the future and where to target improvements.

Step 1 Select a Focus Type

Click on **Type**. Select a focus crash type/facility type combination (here select **Local Rural Curves: Night-time Run-off Road Crashes**.

Step 2 Select a Location (jurisdiction and/or road)

Click on **Filter** in the lefthand pane and then click on **Filter by Jurisdiction**. Pick a town from the Town dropdown menu (in this case, Sheldon). Activate the filter by sliding the black selection bullet. In this case example, the user is interested in making a determination for the entire town, therefore the filtering ends here.

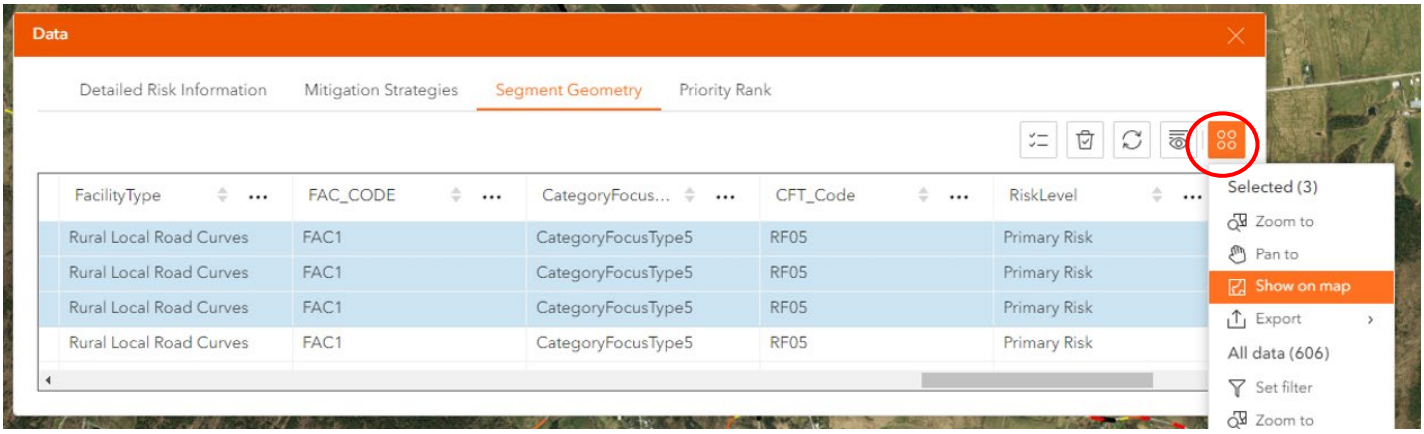
Step 3 Review the Filtered Data

In the lefthand pane, click on **Data** and go to the **Segment Geometry** Tab. Scroll right to the **RiskScore** field and sort this field in descending order. This will produce a list of the sites with the highest scores at the top.

Step 4 Create a List of Sites

Examine the table and highlight as many rows as the number of desired sites to review. Generate the list by exporting the selected records. To export the data, click on the four dots in the toolbar and then on Export.

To view the selected segments on the map, click on the four dots in the toolbar and under the menu for the selected records use one of the three viewing tools (Zoom to, Pan to, Show on map)



Another way to generate the list is, once in the **Segment Geometry** Tab, export the data to csv format and use Excel to manipulate the records. To export the data, click on the four dots in the toolbar and then on Export.

*(NOTE. In general, the top sites will be ranked in order of risk (with primary first, then high, then medium, etc). A user may want to create a list of sites that contains a number of sites from the primary risk level, some from the high-risk level and some from the medium risk level. To do this, the user can go to the **Risk Level** field and scroll down to the risk level of interest.*

The user may want to repeat these steps for one or more focus crash types and combine the data in Excel to generate a multi-crash type list).

Practical Usage 5 Selecting a Countermeasure and Identifying Locations for Possible Implementation

Practical Usage 5 explains how to use the tool to find locations where a selected countermeasure should be constructed. A typical question to answer is: What are the locations where this countermeasure could be implemented?

Case A Description

Two individuals are interested in installing signage to prevent the occurrence of nighttime run-off-road crashes. The first user is a road foreman who has the list of local road sites that was generated in Practical Usage 4. The second user is a VTrans employee who reviewed the systemic safety of a state road using the steps mentioned in Practical Usage 1.

Step 1 Chose a Countermeasure to Implement

For this case, the users are interested in low-cost signage countermeasures.

Step 2 Match the Countermeasure to a Crash a Type

Option 1, Look up the Static “Paper” Matrix

In the lefthand pane, click on **Menu** and then on **Safety Mitigation Matrix**. A new tab will open with a link to the LD Countermeasure Matrix pdf. Open the matrix and locate the countermeasure in the countermeasure matrix (for this case, the users identify Supplemental MUTCD Curve Warning Signs and Post-Mounted Delineators as two options).

Then, identify which crash types the countermeasure is associated with (The user notes that of the two types of countermeasures, Post-Mounted Delineators are the only suggested measure for nighttime run-off-road crashes).

Finally, note the risk level (the users also note that Post-Mounted Delineators are applicable to sites that are classified as medium risk and above).

Risk Level	Countermeasure (Focus Crash and Facility Type)	Target Crash Types and Facilities						
		Head-On Crashes, Curves and Tangents (1, 6, 12)	Overturn, Curves (2, 7)	Fixed Object Crashes, Curves (4, 9)	Run-Off-Road, Curves (3, 8)	Overturn, Interstate (11)	Nighttime Run-Off-Road Crashes, Curves and Tangents (5, 10)	Overturn, Run-Off Road, Tangents (13, 14)
Medium	Widened Centerline Markings	●						
	Supplemental MUTCD Curve Warning Signs[3]	●	●	●	●			
	Post-Mounted Delineators		●	●	●	●	●	●
	Shoulder Rumble Strips		●	●	●		●	●

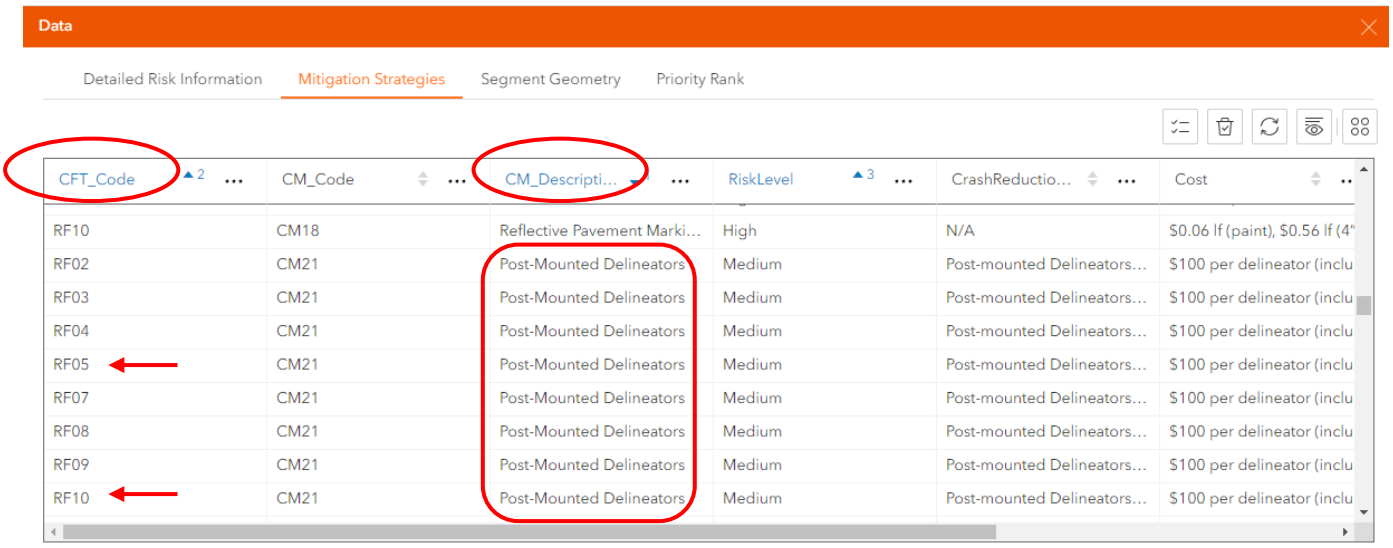
Option 2, Look up the "tool" Matrix

In the lefthand pane, click on **Data**, then click on the **Mitigation Strategies** tab.

Sort the **CM_Description** field and look in that field for the chosen countermeasure (for this case, Supplemental MUTCD Curve Warning Signs and Post-Mounted Delineators).

Look in the **CFT_Code** field for the corresponding crash types (The users note that of the two types of countermeasures, Post-Mounted Delineators are the only suggested measure for nighttime run-off-road crashes. In the **CFT_Code** column, RF5 refers to nighttime run-off-road crashes on local rural roads while RF10 refers to nighttime run-off-road crashes on rural state curves.

Finally, look in the **RiskLevel** field for the applicable risk level (the users also note that Post-Mounted Delineators are applicable to sites that are classified as medium risk and above).



Step 3 Identify and Review Locations

Identify the segments in the list of priority sites developed in Practical Usage 4 or along a specific road as in Practical Usage 1 that matches the risk level(s) isolated in Step 2.

The user must review the site to determine the suitability of the countermeasure that they are considering. The user can perform a desk review by clicking on the segment in the map and clicking on **Click Here** next to **Google Streetview** at the top of the box, below the name of the road. Depending on the assessment, a formal field review may be necessary.

(NOTE. For locations on state highways, the user can turn on the VTrans Projects layer under the Layers menu to see if a project is planned and if opportunities for harmonization exist).

Case B Description

A user wants to develop a project to implement high friction surface treatment at several locations. The user is aware that certain countermeasures were ranked for primary risk sites and that the results of this screening can be reviewed with the Screening Tool. The user wants to look at the screening to identify sites where to implement high friction surface treatment.

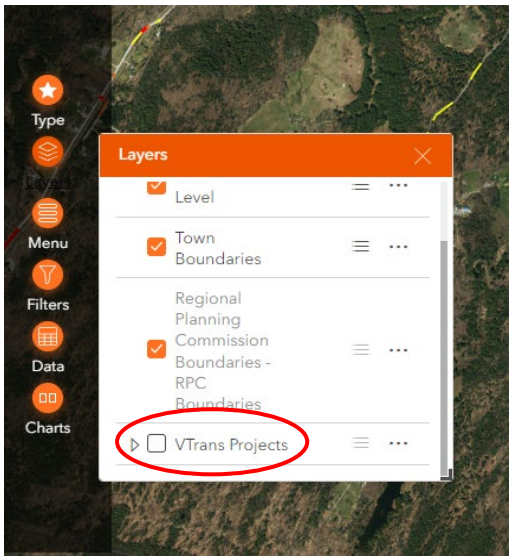
Step 1 Select a Countermeasure

Determine which countermeasures were prioritized for each facility type by looking in the table shown on page 13 of the User Guide (reproduced below).

Focus Facility Type #	Crash Type	Prioritized Countermeasures									
		CENTERLINE BUFFER AREA	CLEAR ZONE WIDENING	DYNAMIC CHEVRONS	FLASHING BEACONS	HFST	LIGHTING	MEDIAN BARRIER	ROADSIDE BARRIER	SHOULDER WIDENING	SLOPE FLATTENING
1	Head-on_Curve_Local	Yes				Yes		Yes			
2	Overturn_Curve_Local			Yes	Yes				Yes	Yes	Yes
3	Run-Off_Curve_Local		Yes	Yes	Yes	Yes			Yes	Yes	Yes
4	Fixed Object_Curve_Local		Yes	Yes	Yes	Yes			Yes	Yes	
5	Nighttime Run-Off_Curve_Local		Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes
6	Head-On_Curve_State	Yes				Yes		Yes			
7	Overturn_Curve_State			Yes	Yes				Yes	Yes	Yes
8	Run-Off_Curve_State		Yes	Yes	Yes	Yes			Yes	Yes	Yes
9	Fixed Object_Curve_State		Yes	Yes	Yes	Yes			Yes	Yes	
10	Night_Run_Off_Curve_State		Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes
11	Overturn_Interstate								Yes	Yes	Yes
12	Head-On_Tangent_State	Yes				Yes		Yes			
13	Overturn_Tangent_State								Yes	Yes	Yes
14	Run-Off_Tangent_State								Yes	Yes	Yes

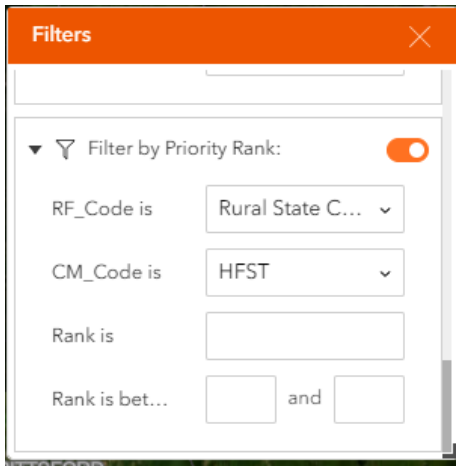
Step 2 Activate the Priority Rank Layer

In the lefthand pane, click on **Layers** and turn on the **Priority Rank** layer.



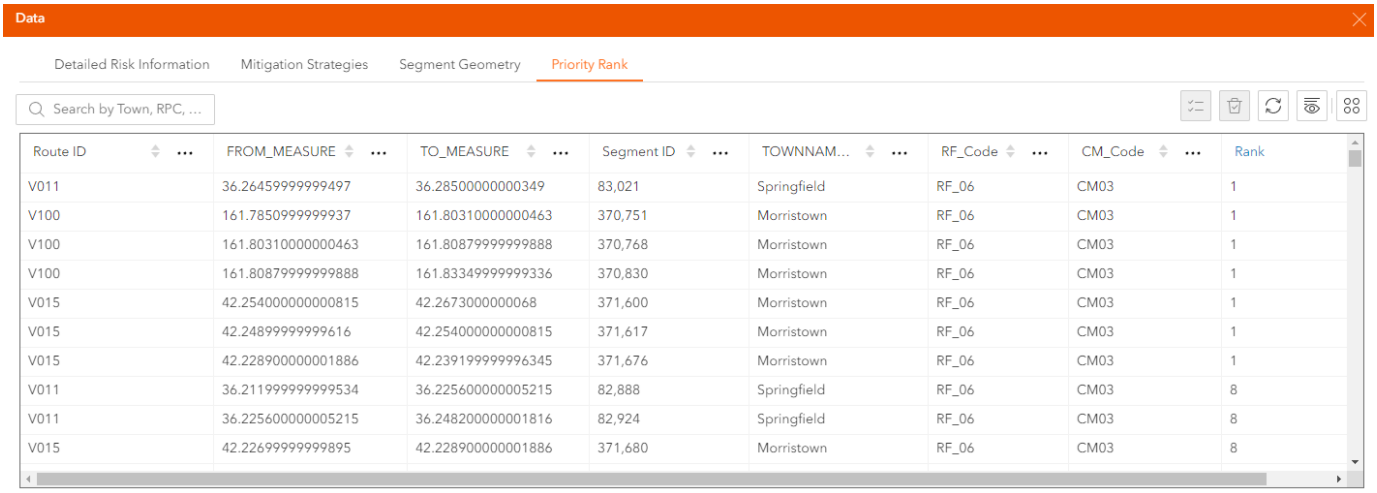
Step 3 Set Up the Priority Rank Filter

In the lefthand pane, click on **Filters**. In **Filters**, scroll down to the bottom and activate the **Filter by Priority Rank** by sliding the black bullet to the right (the bullet will turn white on an orange background). In **RF_Code is**, select the focus crash type (for this case, select Rural State Curves: Head-on). In **CM_Code is**, select the countermeasure (here HFST).



Step 4 Review the Filtered Data

In the lefthand pane, click on **Data** and go to the **Priority Rank** Tab. Scroll right to the **Rank** field and sort this field in ascending order. This will produce a list of the sites with the highest priority at the top (A priority rank of 1 is of more importance than a rank of 50).



Route ID	FROM_MEASURE	TO_MEASURE	Segment ID	TOWNNAM...	RF_Code	CM_Code	Rank
V011	36.26459999999497	36.28500000000349	83,021	Springfield	RF_06	CM03	1
V100	161.7850999999937	161.80310000000463	370,751	Morristown	RF_06	CM03	1
V100	161.80310000000463	161.80879999999888	370,768	Morristown	RF_06	CM03	1
V100	161.80879999999888	161.83349999999336	370,830	Morristown	RF_06	CM03	1
V015	42.254000000000815	42.2673000000068	371,600	Morristown	RF_06	CM03	1
V015	42.24899999999616	42.254000000000815	371,617	Morristown	RF_06	CM03	1
V015	42.228900000001886	42.239199999996345	371,676	Morristown	RF_06	CM03	1
V011	36.211999999999534	36.225600000005215	82,888	Springfield	RF_06	CM03	8
V011	36.225600000005215	36.248200000001816	82,924	Springfield	RF_06	CM03	8
V015	42.22699999999895	42.228900000001886	371,680	Morristown	RF_06	CM03	8

To view one or more sites on the map, highlight the appropriate rows and click on the four dots in the toolbar and under the menu for the selected records use one of the three viewing tools (Zoom to, Pan to, Show on map).

To export the data, click on the four dots in the toolbar and then on **Export**.

(NOTE. Only sites with a rank of up to 500 are available in the tool. To see sites ranked above 500, go to the Menu in the lefthand panel of the Screening Tool and view the complete ranked dataset in Excel format (Rankings of Priority Segments for Select Countermeasures Table).

Practical Usage 6 Exporting Data

Practical Usage 6 demonstrates how to use export data. A typical question to answer is: How can data be exported to be used in other applications such as Excel. For any data that can be exported, the key steps for exporting data are to click on the four dots in the toolbar to see the options and then on Export.

Case A Description

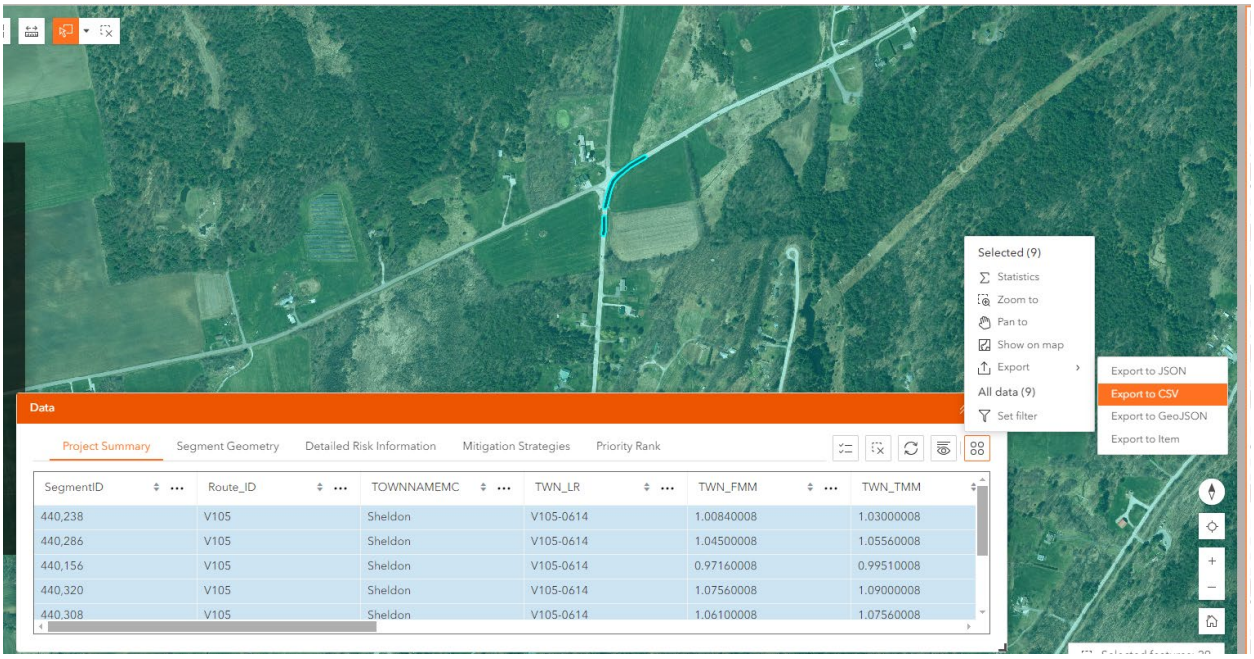
A user reviewed the systemic safety of a road (VT 17 in Addison) as in Practical Usage 1. The user wants to save the risk level information in a table format.

Step 1 Open the Data Table

On the lefthand pane, click on **Data**, then on the **Project Summary** Tab.

Step 2 Export The Data

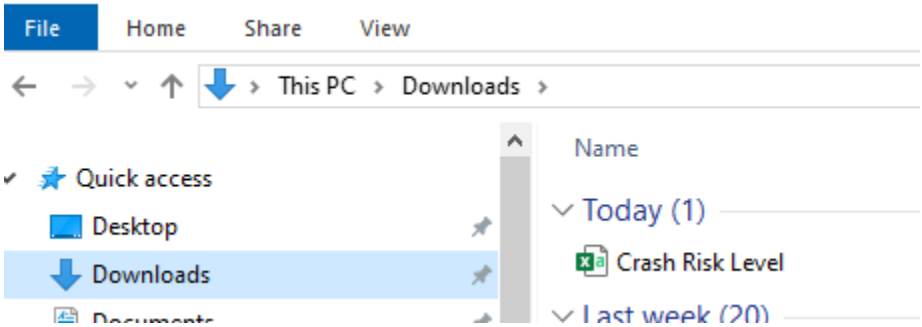
Click on the four dots in the toolbar and then on **Export**. Select **Export to CSV** to view the data in Excel.



To export only specific records, highlight the desired row or select the segments directly on the map with the selection tools in the top left corner of the map.

Step 3 Open the Exported File

In your File Explorer on your computer, go to the download folder and click on the file (Crash Risk Level) to open it.



Case B Description

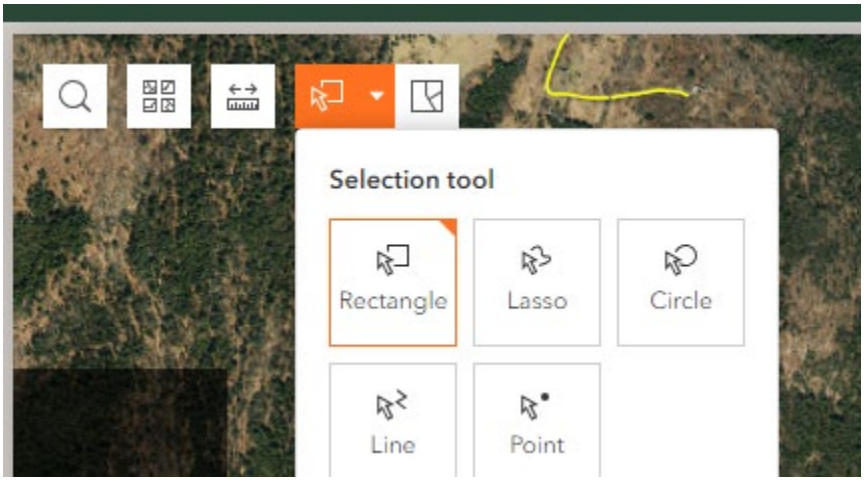
The user from Case A now wants to download the roadway data and detailed risk-based scoring for the same segments as in Case A (The user is looking at VT 17 in Addison).

Step 1 Select the Segments of Interests

The data the user is looking for can be found in the **Detailed Risk Information** tab under **Data**. All records in the current map view extent are displayed by default. The user must select the segments of interest by selecting them directly on the map or by performing a query within the data table. The Detailed Risk Information table will display the risk level for ALL facility types and crash types, regardless of what focus type is selected in the Type filter.

The steps below are for selecting the segments via the map.

To select the segments of interest using the map, click the **Select** tool in the top left of the map. The tool will turn orange when it is active. Click the arrow to expand selection options if needed.

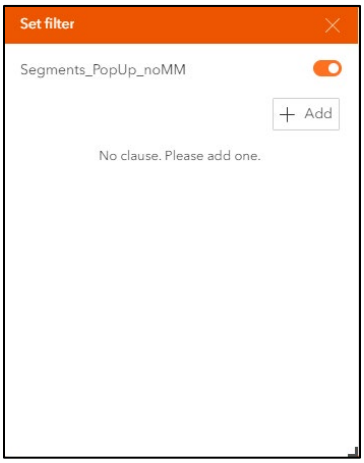


On the map, click and drag the shape over the segments of interest. Release the mouse button once all segments of interest are in the selection.

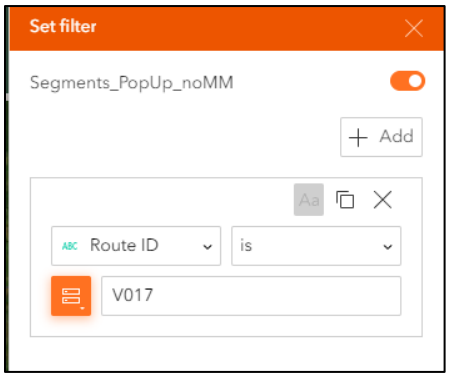
To undo the selection, click the **Select** tool button again and then click anywhere on the map or click the **Clear Selection** button next to the Select tool.

The steps below are for selecting the segments via a query.

Step 1a: On the lefthand pane, click on **Data**, then on the **Detailed Risk Information** Tab.
Step 1b: Click on the four dots in the toolbar and then on **Set filter.**
Step 1c: Click on **Add**, then on **Clause**.

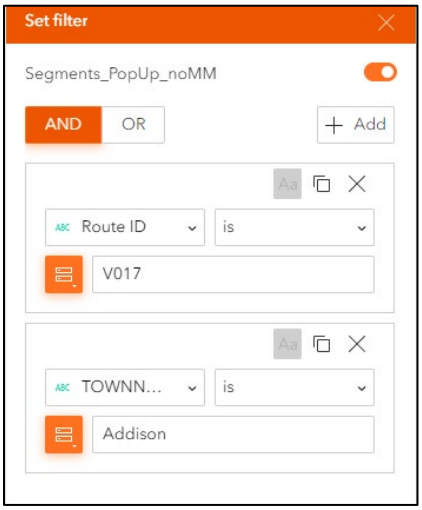


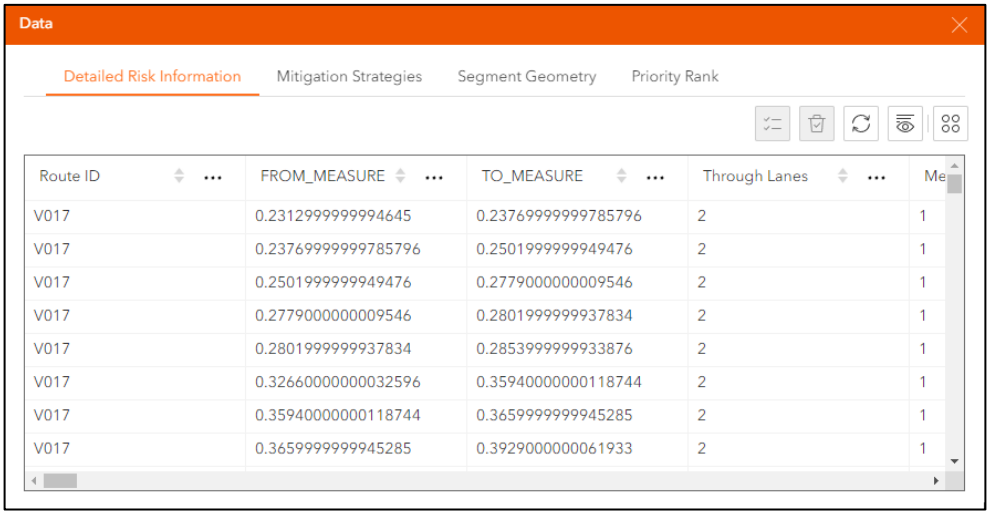
Step 1d: Select **Route ID** and then enter V017 for VT 17.



Step 1e: Click on **Add** again, then on **Clause**.

Step 1f: Select **TOWNNAME** and then enter Addison.





Route ID	FROM_MEASURE	TO_MEASURE	Through Lanes	Me
V017	0.2312999999994645	0.23769999999785796	2	1
V017	0.23769999999785796	0.2501999999949476	2	1
V017	0.2501999999949476	0.2779000000009546	2	1
V017	0.2779000000009546	0.2801999999937834	2	1
V017	0.2801999999937834	0.2853999999933876	2	1
V017	0.32660000000032596	0.35940000000118744	2	1
V017	0.35940000000118744	0.3659999999945285	2	1
V017	0.3659999999945285	0.3929000000061933	2	1

Once a selection is made, the table will filter to the segments selected.

Steps 2 and 3 are the same as in Case A and are not repeated here.

Case C Description

A user wants to export the mileage breakdown data from the charts.

Step 1 Export the Data

Follow Steps 1 – 3 of Practical Usage 3 to select the chart.

Once the chart is displayed, click on the four dots in the toolbar and then on **Export**. Select **Export to CSV** to view the data in Excel.


Head-on Crashes
Overturn Crashes
Run-off Road Crashes
Fixed Object Crashes
Night-time Run-off Road Crashes
Miles of Road
6
4
2
0
1.8
3.1
2.3
6.7
1.4
High Risk
Low Risk
Medium Risk
Minimal Ris...
Primary Ris...
All data (5)
Export
Export to JSON
Export to CSV
Percent of Total Road Miles
Minimal Risk 44.199%
Primary Risk 8.904%
High Risk 11.802%
Medium Risk 14.78%
NORTHFIELD
ROXBURY
BRAINTREE
Selected features: 0

Glossary

Term	Definition
AADT	Annual Average Daily Traffic
FHWA	Federal Highway Administration
Focus Crash Type	The crash type that represents the greatest number of severe crashes across the roadway system being analyzed and provides the greatest potential to reduce fatalities and severe injuries
Focus Facility Type	The facility type on which the focus crash type most frequently occurs
Focus Type 1	Head-on crashes on rural local road curves
Focus Type 2	Overturn crashes on rural local road curves
Focus Type 3	Run-off road crashes on rural local road curves
Focus Type 4	Fixed object crashes on rural local road curves
Focus Type 5	Night-time run-off road crashes on rural local road curves
Focus Type 6	Head-on crashes on rural state curves of minor arterials and major collectors
Focus Type 7	Overturn crashes on rural state curves of minor arterials, major collectors, and principal arterials
Focus Type 8	Run-off road crashes on rural state curves of minor arterials and major collectors
Focus Type 9	Fixed object crashes on rural state curves of minor arterials and major collectors
Focus Type 10	Night-time run-off road crashes on rural state curves of minor arterials and major collectors
Focus Type 11	Overturn crashes on Interstates
Focus Type 12	Head on crashes on rural state tangents of minor arterials, major collectors, and principal arterials
Focus Type 13	Overturn crashes on rural state tangents of minor arterials, major collectors, and principal arterials
Focus Type 14	Run-off road crashes on rural state tangents of minor arterials and major collectors
Functional Classification	Streets and highways are grouped into one of seven classes, depending on the character of the roadway and the degree of land access that they allow. These classifications are as follows: 0 = Not part of Functional Classification System 1 = Interstate 2 = Principal Arterial – other freeways and expressways 3 = Principal Arterial – other 4 = Minor Arterial 5 = Major Collector 6 = Minor Collector

	7 = Local
Horizontal Curve Type	Type of horizontal alignment: Independent horizontal curve, Component of compound curve (i.e., one curve in compound curve), Component of reverse curve (i.e., one curve in a reverse curve) - MIRE Element 194
KABCO	Crash Severity is coded using the KABCO scale, as per the Model Minimum Uniform Crash Criteria (MMUCC) based on the most severe injury to any person involved in the crash
K (Fatality)	A fatality is any injury that results in death within 30 days after the motor vehicle crash in which the injury occurred. PLEASE NOTE: The National Highway Traffic and Safety Administration's (NHTSA) definition under the Fatal Analysis Reporting System (FARS) requirement, a "fatal injury must only be used if the death occurred within thirty consecutive 24-hour time periods from the time of the crash". If a death happens after the 30-day period, code as Injury Crash type and the injury is coded as Suspected Serious Injury (A)
A (Suspected Serious Injury)	A suspected serious injury is any injury other than fatal which results in one or more of the following: ~ Severe laceration resulting in exposure of underlying tissues/muscle/organs or resulting in significant loss of blood ~ Broken or distorted extremity (arm or leg) ~ Crush injuries ~ Suspected skull, chest or abdominal injury other than bruises or minor lacerations ~ Significant burns (second and third degree burns over 10% or more of the body) ~ Unconsciousness when taken from the crash scene ~ Paralysis
B (Suspected Minor Injury)	A suspected minor injury is any injury that is evident at the scene of the crash, other than fatal or serious injuries. Examples include lump on the head, abrasions, bruises, minor lacerations (cuts on the skin surface with minimal bleeding and no exposure of deeper tissue/muscle)
C (Possible Serious Injury)	A possible injury is any injury reported or claimed which is not a fatal, suspected serious or suspected minor injury. Examples include momentary loss of consciousness, claim of injury,

	limping, or complaint of pain or nausea. Possible injuries are those which are reported by the person or are indicated by his/her behavior, but no wounds or injuries are readily evident
O Property Damage Only (No Apparent Injury)	No apparent injury is a situation where there is no reason to believe that the person received any bodily harm from the motor vehicle crash. There is no physical evidence of injury and the person does not report any change in normal function
Lane Departure Crash	FHWA defines a lane departure crash as a crash which occurs after a vehicle crosses an edge line or a center line, or otherwise leaves the traveled way
Not a Focus Facility	A segment for which a particular focus crash type facility type combination is not applicable
Risk Factor	A representation of risk in characteristics associated with the locations where the type of targeted crash types occurred
Route Log	A depiction of a given section of highway as it would look if the section was straightened out. This depiction method helps see the relationship of various features, like road widths, curves and grades, and lane departure risk levels
Systemic Safety Improvement	An improvement that is widely implemented based on high-risk roadway features that are correlated with particular crash types, rather than crash frequency
Systemic Safety Management	The systemic safety management approach is used to program implementation of proven safety treatments across a large number of sites to reduce crash potential using crash prediction models or rating systems based on roadway features correlated with particular severe crash types