INTERSECTION SCOPING STUDY

# VT Route 117 and Skunk Hollow Road

## Jericho, Vermont

PREPARED FOR

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# 1 Introduction

## 1.1 Project Overview

The VT 117 and Skunk Hollow Road Scoping Study was a collaborative effort by the Vermont Agency of Transportation (VTrans), the Chittenden County Regional Planning Commission (CCRPC), the Town of Jericho, and VHB to identify a preferred design alternative which addresses safety and mobility concerns at the VT 117 and Skunk Hollow Road intersection. This study arrived at a preferred alternative through the traditional scoping process: existing conditions assessment, alternatives development and evaluation, public and stakeholder input, and selection of a municipally-preferred design. These steps are described in detail in the following chapters.

## 1.2 Purpose and Need Statement

At the onset of this project, a Purpose and Need Statement was developed in order to articulate the major issues at the intersection and identify the priorities which should be addressed through the alternatives developed. The Purpose and Need, which is summarized below, were developed in coordination with the project's Advisory Committee, which included representatives from the Town of Jericho, VTrans and the CCRPC.

**Purpose**

The purpose of the VT 117 and Skunk Hollow Road Intersection Scoping Study is to identify and develop a preferred approach to improve overall safety and operational efficiency through sight distance improvements and a reduction in vehicle conflict points while maintaining opportunities for multi-modal facilities, including bicycle accommodations along VT 117.

**Need**

Project needs, as defined by VTrans, the CCRPC, the Town of Jericho, and project stakeholders include the following:

- **Existing Safety Issues**: The VTrans 2012-2016 High Crash Location Report[1] identifies a 0.3-mile segment of VT 117 through the Skunk Hollow Road intersection as a High Crash Location. Over this five-year period, there were 15 reported crashes within this segment, 3 of which resulted in injuries, with an Actual/Critical crash ratio of 1.83.
- **Insufficient Sight Distances**: The current available intersection sight distance looking west along VT 117 for vehicles departing Skunk Hollow

[1] High Crash Location Report: Intersections and Segments (2012-2016), Vermont Agency of Transportation, 2017.

Road is approximately 390 feet. The sight lines are limited by a combination of vegetation, terrain, and horizontal curvature of VT 117. Per VTrans and AASHTO Green Book standards, intersection sight distances should be a minimum of 555 feet for 50 mph facilities such as VT 117 in this area.

- **Accommodation of Cyclists along VT 117 and Skunk Hollow Road**: VT 117 is categorized as a "High Use/Priority" corridor in the VTrans Bicycle Priority Map[2]. This segment of VT 117 is currently rated as being "uncomfortable for most bicyclists" due to high vehicle speeds and narrow shoulders. The CCRPC Active Transportation Plan[3] proposes bicycle facilities along VT 117. The VT 117 corridor is identified as having many current users and is a route that many other bicyclists would like to use if facilities were to be improved. The 2015 Jericho Bicycle and Pedestrian Facility Master Plan[4] specifies that this intersection be studied for safety and bicycle facility improvements. The plan also proposes a new cycling connection between Jericho Corners and VT 117 via Skunk Hollow Road.

[2] *VTrans Bicycle Corridor Priority*. Vermont Agency of Transportation Policy, Planning & Intermodal Development Division – Mapping Section. Montpelier, Vermont. March 2016.

[3] *Chittenden County Active Transportation Plan – FINAL REPORT.* Chittenden County Regional Planning Commission. Winooski, VT. January 2017.

[4] *Jericho Bicycle and Pedestrian Facility Master Plan.* RSG. Burlington, VT. May 2015.

# 2 Existing Conditions

## 2.1 Project Site Description

The intersection of VT 117 and Skunk Hollow Road is located in Jericho, Vermont directly adjacent to the Winooski River, north of Williston, and east of Essex. VT 117 is a principal arterial road which travels from US Route 2 in Richmond, Vermont to its northern terminus at Five Corners in Essex Junction, Vermont. In the vicinity of the project area, VT 117 carries approximately 5,500 vehicles per day[5]. Skunk Hollow Road is a major collector road which connects VT 117 at the south to Plains Road at the north and carries approximately 2,400 vehicles per day[6]. A map of the intersection is shown in **Figure 1.**

## 2.2 Intersection Characteristics

Key features of the project intersection are briefly described below.

Approaches: VT 117 (Eastbound)

- Functional Classification: Principal Arterial
- Posted Speed: 50 mph
- Geometry: Two 12' lanes, 1-2' shoulders

VT 117 (Westbound)

- Functional Classification: Principal Arterial
- Posted Speed: 50 mph
- Geometry: Two 12' lanes, 1-2' shoulders

Skunk Hollow Road (Southbound)

- Functional Classification: Major Collector
- Posted Speed: 35 mph
- Geometry: Two 12' lanes, 1' shoulders

Intersection Type: Unsignalized; Skunk Hollow Road Stop-Controlled

Pedestrian and Bicycle Facilities: None

[5] *2015 (Route Log) AADTs – State Highways*, Vermont Agency of Transportation Highway Division Traffic Research Unit. Vermont, June 2016.

[6] *2017 (Route Log) AADTs – Major Collectors*, Vermont Agency of Transportation Highway Division Traffic Research Unit. Vermont, April 2018.

**Figure 1: Project Area Map**


**VT 117 and Skunk Hollow Road Scoping Study** | Jeirhco, Vermont

## 2.3 Traffic Conditions

VHB conducted an AM and PM peak hour turning movement count at the project intersection on January 31, 2018. These counts showed peak hours at 7:15 – 8:15 AM and 4:45 – 5:45 PM with total traffic volumes of 966 and 1,055 vehicles, respectively. This raw count data was adjusted to a Design Hour Volume based on VTrans Traffic Impact Study Guidelines[7] and a growth rate of 1.03[8] was applied to the volumes to calculate future year volumes for the year 2023. Using this count data, a congestion analysis of existing and projected traffic on current infrastructure was conducted to yield the Levels of Service, average delays, and volume-to-capacity ratios shown in **Table 1.**

**Table 1: Existing Conditions Intersection Capacity Analysis Summary**

| | | EXISTING | | | NO BUILD | | |
|---|---|---|---|---|---|---|---|
| **AM Peak Hour** | | **2018** | | | **2023** | | |
| | **Intersection / Movement** | **v/c⁺** | **Delay*** | **LOS*** | **v/c** | **Delay** | **LOS** |
| | VT 117 and Skunk Hollow Road | | | | | | |
| | EB from VT 117 | 0.03 | 1.1 | A | 0.29 | 8.5 | A |
| | WB from VT 117 | 0.19 | 0.0 | - | 0.19 | 0.0 | - |
| | SB from Skunk Hollow Rd | 0.59 | 19.5 | C | 0.87 | 51.4 | F |
| **PM Peak Hour** | | **2018** | | | **2023** | | |
| | **Intersection / Movement** | **v/c⁺** | **Delay*** | **LOS*** | **v/c** | **Delay** | **LOS** |
| | VT 117 and Skunk Hollow Road | | | | | | |
| | EB from VT 117 | 0.23 | 5.7 | A | 0.24 | 5.8 | A |
| | WB from VT 117 | 0.30 | 0.0 | - | 0.31 | 0.0 | - |
| | SB from Skunk Hollow Rd | 0.25 | 20.3 | C | 0.26 | 20.9 | C |

⁺ *Volume to capacity ratio*

** Delay expressed in seconds per vehicle*

*** Level of Service*

### 2.3.1 Turn Lane Warrants

Turn lane warrants were conducted using the Design Hour Volumes at the VT 117/Skunk Hollow Road intersection for current and future year conditions. The left turn warrant for the eastbound approach is based on the methodology outlined in NCHRP 457 and the right-turn lane warrant for the westbound approach is based on the methodology outlined in the VTrans Traffic Impact Study guidelines. The final results of the analysis are shown in **Table 2.** Full calculations can be found in the Appendix.

[7] *Traffic Impact Study Guidelines*. Vermont Agency of Transportation Policy and Planning Division – Traffic Research Unit. Montpelier, VT. October 2008.

[8] *Continuous Traffic Counter Report (The Redbook) Based on 2017 Traffic Data.* Vermont Agency of Transportation Highway Division – Traffic Research Unit. Montpelier, VT. March 2018.

**Table 2: Turn Lane Warrant Summary**

| Time Period | Left Turn Lane Warrant? | | Right Turn Lane Warrant? | |
|---|---|---|---|---|
| | 2018 | 2023 | 2018 | 2023 |
| AM Peak Hour | No | Yes | No | No |
| PM Peak Hour | Yes | Yes | No | No |

## 2.4 Safety Assessment

A desktop review of reported crashes was conducted by VTrans and showed that the project intersection is located within a designated High Crash Location segment along VT 117. A closer review of crashes occurring at the intersection revealed 17 crashes from 2012-2016. Of these 17 crashes, four resulted in injury and the rest were property damage only. It was noted that four of the crashes were related to an eastbound left turn onto Skunk Hollow Road and ten of the reported crashes were involving a single vehicle. These left turn crashes bring attention to visibility constraints caused by curves on VT 117 north and south of the intersection. A collision diagram of the intersection is provided in **Figure 2.** A full list of crashes and their reports can be found in the Appendix.

**Figure 2: Collision Diagram (Created by VTrans)**

## 2.5 Hydrology and Hydraulics Assessment

An unnamed tributary stream to the Winooski River runs parallel to Skunk Hollow Road and crosses under VT 117 just southeast of the intersection. A hydrologic and hydraulic assessment was conducted by VHB to analyze the existing conditions of the stream crossing. An initial desktop hydrology assessment was conducted using the StreamStats program, a publicly available online tool published by the United States Geologic Survey (USGS). This online tool uses mapped stream and topographic data to delineate the contributing watershed area to a point on a stream. The tool also calculates peak-flow statistics using a built-in regression equation to estimate the flows at the chosen point for various flow events. The contributing drainage area to the stream where it crosses under VT 117 is approximately 1.81 square miles. The StreamStats output includes a watershed delineation map, peak-flow statistics, and other data that can be found in the Appendix.

Following the desktop assessment, VHB conducted a field visit to collect on-site stream parameters including bankfull width, channel slope, channel substrate, and existing culvert geometry. The existing culvert is a 95-foot-long corrugated metal pipe with an approximate 126-inch rise and 118-inch span and an overall slope of approximately 3%. The culvert floor has been retrofitted with a paved concrete invert with a series of embedded stone baffles spaced approximately 8.5 feet apart along the length of the culvert. Near the inlet of the culvert, the natural channel has been narrowed and the banks armored with rip-rap. The apparent bankfull width in the armored area directly upstream of the culvert was observed to be approximately 13 feet. The natural channel, upstream of the influence of the culvert and channel modifications, was measured to have a bankfull width of approximately 20 feet. A scour pool was observed at the culvert outlet, even though portions of the downstream channel have been armored with rap-rap. This scour pool had a maximum water depth of 1.75 feet during the site visit. A summary of the data collected during the field visit, including key parameters, and a longitudinal profile graph can be found in the Appendix.

**Figure 3: Upstream View of the Culvert, Looking South**

The data collected in the field along with StreamStats peak flow estimates were used to create a model to assess the current hydraulic conditions of the existing culvert. HY8, a hydraulic modeling software program developed by the Federal Highway Administration (FHWA), was used to model the culvert's capacity to properly convey water during major storm events. This method found that the culvert provides adequate hydraulic capacity under existing conditions. However, the existing structure does not meet other VTrans criteria for road-crossing structures, such as the width of the culvert being less than the width of the stream channel and the formation of the scour pool at the outlet. As documented in the HY8 model, stream velocities within the culvert are approximately 1.5 times higher than within the natural stream channel, leading to the formation of the scour pool and limiting aquatic organism passage during flow events. The full HY8 report can be found in the Appendix.

## 2.6 Natural Resources

A review of natural resources within the project area was conducted and an overview is provided below. This review was conducted using the Vermont Agency of Natural

Resources (ANR) Online Natural Resources Atlas[9]. A map showing the locations of these resources is provided in **Figure 4**.

| | |
|---|---|
| Rivers / Streams: | The Winooski River is located immediately to the southwest of the project intersection. There is also an unnamed stream which runs to the southeast of Skunk Hollow Road which directly feeds into the Winooski River via a culvert located below VT 117. |
| Priority Water: | This portion of the Winooski River is identified as a Priority River due to locally abundant Eurasian watermilfoil growth. |
| Wetlands: | Class 2 Wetlands exist to the south and west of the project intersection adjacent to the Winooski River. |
| Soils: | Prime Agricultural Soils are present to the southwest of the intersection, adjacent to the Winooski River. The intersection is located within an area of mostly Hartland very fine sandy loam. |
| Archaeological: | The area immediately adjacent to the intersection has no archaeological sensitivity. Two small areas of sensitivity were identified outside of but close to the limits of project disturbance. An archaeological resources assessment is provided in the Appendix. |
| Historical: | The dwelling on the southeast corner of the project intersection, known as the "Old Still House" was listed on the State Register of Historic Places in April 1980. |

[9] Vermont Natural Resource Atlas, Vermont Agency of Natural Resources, http://anrmaps.vermont.gov/websites/anra5/, Queried 22 January, 2018.

**Figure 4: Natural Resource Map (Created by CCRPC)**

# 3 Alternatives Analysis

## 3.1 Planning and Design Criteria

At the onset of the alternatives development process, planning and design criteria were assembled from various sources. These criteria provided the basis for design to ensure that the alternatives presented in this study are feasible and correlate with the existing standards at the State and Federal levels. The criteria selected for transportation improvements includes preferred lane and shoulder width, curb radii, sight distance, and others. The reference materials used to inform the criteria for this study are from the American Association of State Highways and Transportation Officials (AASHTO) and VTrans. A copy of the planning and design criteria table is shown in **Table 3**.

Planning and design criteria were also compiled for the hydrologic and hydraulic designs. These criteria are related to culvert diameter and length and hydraulic capacity. These standards are used to meet current Stream Alteration design criteria and are shown in **Table 4**.

**Table 3: Transportation Planning and Design Criteria**

| | VT Route 117 | Skunk Hollow Road | Standard Reference |
|---|---|---|---|
| Lane Width | 11′ Min. | 9′ Min. | (1) |
| Shoulder Width | 3′ Min. | 3′ Min. | (3) |
| Curb Radius | 30′ Min. | 30′ Min. | (4) |
| Intersection Sight Distance | 555′ | 555′ | (1) |
| Design Vehicle | WB-67 | SU-40 | (1) |
| Turn Lane Taper | 50:1 | N/A | (2) |

(1) *Vermont State Design Standards*. Vermont Agency of Transportation, Vermont. 22 October 1997.

(2) *A Policy on Geometric Design of Highways and Streets, 6th Ed*. American Association of State Highways and Transportation Officials, Washington, DC. 2011.

(3) *Vermont Pedestrian and Bicycle Facility Planning and Design Manual.* Vermont Agency of Transportation, Vermont. December 2002.

(4) *CADD Standard A-76 Standards for Town & Development Roads.* Vermont Agency of Transportation, Vermont. Revised 3 March 2003.

**Table 4: Hydraulics Planning and Design Criteria**

| | Standard | Standard Reference |
|---|---|---|
| Culvert Span | 1x Bankfull Width | (1) |
| Culvert Opening Height | 4x Mean Bankfull Width or Height* | (1) |
| Culvert Embedding | 30% Structure Opening Height, Diameter of Median Axis of Immobile Bed Material, or 1.5 feet | (1) |
| Passage | Aquatic Organism | (2) |

** Based on hydraulic capacity required to pass the design flow with a headwater to diameter ratio < 1*

(1) *Stream Alternation General Permit, Section C.2.5.5.* Vermont Agency of Natural Resources, Department of Environmental Conservation. Vermont. 6 April 2017.

(2) *Aquatic Organism Passage Program.* United States Fish and Wildlife Service.

## 3.2 Hydrology and Hydraulics Analysis

The proposed alternatives, described below, involve replacement of the existing culvert at VT 117, installation of a new culvert at Skunk Hollow Road, both, or neither. These hydraulic options are dependent on the roadway reconfiguration alternative, and each alternative is described in more detail below. For some alternatives, widening of VT 117 is proposed. Under these alternatives, the existing culvert would be replaced to accommodate the widening of the road. Other alternatives propose a reconfiguration of Skunk Hollow Road, which would require a new stream crossing structure be constructed.

With all of the design considerations described in **Table 4**, a proposed conditions model was built in HY8 to represent the compliant culvert design that would be proposed at the Skunk Hollow Road crossing. For the purposes of this preliminary alternatives analysis, a similarly-sized structure could also be used as the replacement culvert for the alternatives requiring widening of VT 117. The two potential culverts are described in **Table 5.**

**Table 5: Proposed Culverts Dimensions**

| | VT 117 Culvert | Skunk Hollow Road Culvert |
|---|---|---|
| Culvert Span | 20 feet | 20 feet |
| Culvert Rise | 6.5 feet | 6.5 feet |
| Culvert Length | 105 – 110 feet | 55 – 75 feet |

Another option would be to add additional segments of the same culvert geometry in order to lengthen the existing culvert. Based on the configuration and condition of the existing culvert, this is a less desirable alternative than a full replacement. However, extending the structure would be approximately $400,000 less expensive than replacing the entire structure. The full HY8 report, including the existing culvert and the proposed culvert, can be found in the Appendix.

A detailed description of each alternative is described below. A summary of the hydraulic impacts and approximate cost estimates for each alternative relating to hydraulic structures can be found in the Appendix.

## 3.3 Alternative 1 – Slope Cut for Sight Distance

The first alternative proposed at the intersection of VT 117 and Skunk Hollow Road is a baseline improvement that is recommended to be included in Alternative 2, as well. The proposed improvements include trimming trees and cutting into the northern slope of VT 117 to improve sight distance from Skunk Hollow Road.

The intersection sight distance from Skunk Hollow Road looking west along VT 117 is currently approximately 390 feet. According to the AASHTO Green Book, this is deficient sight distance for a 50-mph roadway. For this intersection, the intersection sight distance should be at least 555 feet. The proposed slope cut creates a sight line which is 555 feet, bringing the intersection up to recommended standards.

Preliminary calculations have estimated that about 1,300 cubic yards of material would need to be removed to obtain the appropriate sight lines. There is known to be ledge located in this slope which would require excavation by means of blasting, most likely. Including engineering and design, traffic control, and 25% contingency, this alternative is expected to cost approximately $100,000. Since the initial development of this project, VTrans has incorporated this alternative into the current paving project along VT 117. **Figure 5** shows the limits of the required slope cut and a profile of existing and proposed ground.

## 3.4 Alternative 2 – Left Turn Lane on VT 117

Alternative 2 builds on Alternative 1 in that it also recommends the slope cut for improved sight distance. In addition, this alternative proposes to widen VT 117 to incorporate an eastbound left turn lane onto Skunk Hollow Road. As shown previously in **Table 2**, this intersection meets the warrants for a left turn lane during the weekday evening peak hour.

In order to construct a left turn lane and widen the shoulders, VT 117 needs to be widened to the north on both sides of Skunk Hollow Road. This turn lane has a storage length of approximately 50 feet and gradually tapers into the existing alignment. 50 feet of storage is adequate for two vehicles queuing, which is sufficient based on left turn volumes. This widening accommodates an increase to three-foot shoulders to allow for safer cycling through the intersection. Since the roadway is widened in this alternative, the existing culvert under VT 117 would also need to be lengthened. Estimates were completed assuming a replacement of the existing culvert. Discussions of potential retrofits to the existing culvert are provided in Section 3.2.

Cost estimates were completed for this alternative which included the slope cut, pavement widening, and culvert modifications. Including engineering and design, traffic control, and 25% contingency, this alternative is expected to cost approximately $1,100,000. **Figure 6** shows the proposed widening of the roadway and the slope cut limits.

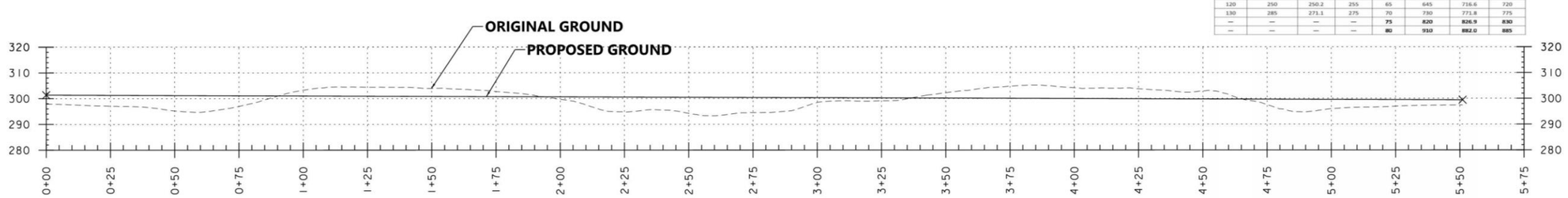
**Figure 5: Alternative 1 - Slope Cut for Sight Distance**


SCALE 1" = 40'-0"
40 0 40

# Intersection Sight Distance Slope Cut

Table 9-6. Design Intersection Sight Distance—Case B2, Left Turn from Stop

| Metric | | | | U.S. Customary | | | |
|---|---|---|---|---|---|---|---|
| Design Speed (km/h) | Stopping Sight Distance (m) | Intersection Sight Distance for Passenger Cars | | Design Speed (mph) | Stopping Sight Distance (ft) | Intersection Sight Distance for Passenger Cars | |
| | | Calculated (m) | Design (m) | | | Calculated (ft) | Design (ft) |
| 20 | 20 | 41.7 | 45 | 15 | 80 | 165.4 | 170 |
| 30 | 35 | 62.6 | 65 | 20 | 115 | 220.5 | 225 |
| 40 | 50 | 83.4 | 85 | 25 | 155 | 275.6 | 280 |
| 50 | 65 | 104.3 | 105 | 30 | 200 | 330.8 | 335 |
| 60 | 85 | 125.1 | 130 | 35 | 250 | 385.9 | 390 |
| 70 | 105 | 146.0 | 150 | 40 | 305 | 441.0 | 445 |
| 80 | 130 | 166.8 | 170 | 45 | 360 | 496.1 | 500 |
| 90 | 160 | 187.7 | 190 | 50 | 425 | 551.3 | 555 |
| 100 | 185 | 208.5 | 210 | 55 | 495 | 606.4 | 610 |
| 110 | 220 | 229.4 | 230 | 60 | 570 | 661.5 | 665 |
| 120 | 250 | 250.2 | 255 | 65 | 645 | 716.6 | 720 |
| 130 | 285 | 271.1 | 275 | 70 | 730 | 771.8 | 775 |
| — | — | — | — | **75** | **820** | **826.9** | **830** |
| — | — | — | — | **80** | **930** | **882.0** | **885** |




VT 117 and Skunk Hollow Road Intersection Scoping Study | Alternative 1
Slope Cut for Improved Sight Distance
SEPTEMBER 2018

**Figure 6: Alternative 2 – Left Turn Lane on VT 117**


VT 117 and Skunk Hollow Road Intersection Scoping Study | Alternative 2

Widened VT 117 for Turn Lane

AUGUST 2018

## 3.5 Alternative 3 – Realign Skunk Hollow Road

The third alternative analyzed as part of this scoping study involves the realignment of Skunk Hollow Road to create a perpendicular T-intersection with VT 117. By realigning the roadway, greater sight distances are provided for all approaches. This configuration also allows for Skunk Hollow Road to intersect VT 117 along a tangent section of roadway, rather than along a curve. It is proposed that the shoulders along VT 117 be widened to three-feet near the intersection to improve safety for bicyclists.

When Skunk Hollow Road is realigned, it crosses the existing stream and requires a new culvert upstream from the culvert across VT 117. The analysis and sizing of this culvert is described in Section 3.2. It is also proposed that the existing road be removed and restored to a pervious surface condition.

The major elements included in the cost estimate for this alternative are the removal of the existing roadway, construction of a new roadway, and a box culvert. Additionally, a cost for contingency, traffic control, and engineering and design were included as percentages of the total material costs. The total estimated costs for the third alternative is $1,300,000. The proposed realignment of Skunk Hollow Road is shown in **Figure 7.**

## 3.6 Alternative 4 – Realign Skunk Hollow Road with VT 117 Left Turn Lane

The next alternative analyzed as part of this scoping study is an extension of Alternative 3. The fourth alternative includes the same realignment of Skunk Hollow Road and incorporates a left turn lane on VT 117 travelling eastbound. As with the previous alternative, sight distance is improved as the intersection becomes perpendicular and wider shoulders for cyclists are proposed. A new culvert under Skunk Hollow Road is proposed in this alternative and would be the same size as is proposed in the third alternative. Also, since this alternative includes a widening of VT 117, this alternative includes a replacement of the existing culvert under VT 117.

The inclusion of a turn lane on VT 117 improves delay slightly on this approach and helps to improve safety along the corridor. By providing a separate space for vehicles waiting to turn left, the likelihood of rear end crashes is reduced. The estimated cost for this alternative, including material costs, contingency, traffic control, and engineering and design, is $2,200,000. The proposed design is shown in **Figure 8.**

**Figure 7: Alternative 3 – Realign Skunk Hollow Road**


# VT 117 and Skunk Hollow Road Intersection Scoping Study | Alternative 3

Reconfigured Skunk Hollow Road to T Intersection with VT 117

AUGUST 2018

**Figure 8: Alternative 4 – Realign Skunk Hollow Road with VT 117 Left Turn Lane**


VT 117 and Skunk Hollow Road Intersection Scoping Study | Alternative 4

Reconfigured Skunk Hollow Road and VT 117 to T Intersection with Southbound Left Turn Lane

AUGUST 2018

## 3.7 Alternative 5 – Roundabout

The final alternative examined as part of this scoping study is a single-lane roundabout in place of the current three-leg intersection. To accommodate the appropriate design vehicle movements, a 130' diameter roundabout with a 16' circulating lane width is proposed. A roundabout at this location is expected to decrease delay greatly during both the weekday morning and evening peak hour when compared with existing conditions. Roundabouts are also known for their improvements to safety and can reduce crashes by up to 30 or 40% in some cases.

Performance and safety are anticipated to improve with this alternative; however, constructability in this location is very difficult due to the proximity of the steep bank and Winooski River to the south. It is likely that a retaining wall would be required to support the southern edge of the roundabout where it is proposed to go outside of the existing right-of-way boundaries. If this is necessary, the expected costs would increase. In addition to construction on this bank, a new culvert is recommended in place of the existing one below VT 117.

Including the material and construction cost, a 25% contingency, traffic control, and engineering and design, the estimated cost of a roundabout at this intersection is $3,350,000. The proposed design is shown in **Figure 9.**

**Figure 9: Alternative 5 - Roundabout**


VT 117 and Skunk Hollow Road Intersection Scoping Study | Alternative 5

Roundabout

AUGUST 2018

## 3.8 Benefit / Cost Analysis

To aid in the evaluation of alternatives, a Benefit/Cost Analysis was conducted. The results of this assessment are summarized below.

**Costs**

*Capital Costs*

Capital Costs were calculated using estimated quantities and unit costs obtained from VTrans and research of similar previous projects. In addition to these costs, a 25% contingency, 15% mobilization and traffic control, 15% engineering and design, 10% resident engineering, and approximate right-of-way costs were calculated for each alternative.

*Operating and Maintenance Costs*

Operating and Maintenance Costs are not expected to change drastically from the current condition to future conditions. Additional maintenance costs would be taken on by the State for the construction of a new culvert or a roundabout. These involve additional cleaning, mowing, more difficult plowing, and/or other expenses. Costs associated with these were estimated based on the VTrans Highway Maintenance cost estimating tool. These are expected to begin the year that construction is completed.

**Benefits**

The benefits associated with each alternative are expected to be primarily from safety benefits. The USDOT publishes guidelines on calculating benefits using Crash Modification Factors (CMFs) and monetary values based on crash severity[10]. CMFs for each alternative were gathered from the CMF Clearinghouse[11]. In cases where more than one CMF were applicable for an alternative, it was assumed that only half of the second CMF's benefits were achieved[12]. The following CMFs were used in the benefits calculations for the alternatives:

- Change geometry to increase line of sight (CMF = 0.558)
- Install left turn lane on one leg of major approach (CMF = 0.72)
- Change intersection skew angle (CMF = 0.81)
- Conversion of stop-controlled intersection to roundabout (CMF = 0.38)

Once the proper CMF was obtained, the following formula was applied:

$$B = C * N * (1 - CMF)$$

[10] *Benefit-Cost Analysis Guidance for Discretionary Grant Programs.* Office of the Secretary, U.S. Department of Transportation. 2018.

[11] http://www.cmfclearinghouse.org/

[12] Gross, Frank and Hamidi, Ajmal, *Investigation of Existing and Alternative Methods for Combining Multiple CMFs*. Highway Safety Improvement Program. 2011.

*Where:*

*B = Benefit (2017 $)*

*C = Monetary Value of crash type*

*N = Crash Rate (crashes/year)*

*CMF = Crash Modification Factor*

These benefits were then calculated for the life span of the improvement, which was assumed to be 20 years. Benefits were valued into future years using both a conservative estimate of discount (3%) and an aggressive discounting (7%). The following formula was used to calculate the present value in a future year:

$$PV = \frac{FV}{(1+i)^t}$$

*Where:*

*PV = Present discounted value*

*FV = Future value of payment in real dollars*

*i = Real discount rate (3% or 7%)*

*t = Years in future for payment (t = 0 in 2019)*

**Benefit Cost Analysis Summary**

The BCA is summarized using two different factors, the Net Present Value (NPV) and the Benefit Cost Ratio (BCR). The NPV is the difference between the costs and benefits whereas the BCR is the ratio of benefits to costs, with benefits being in the numerator and costs in the denominator. If the BCR is a positive number, this means that the benefits outweigh the costs over the life span of the project. **Table 6** outlines the total benefits, costs, NPV, and BCR for each alternative. Where the benefits outweigh the costs, the values are shown in green. Where costs outweigh benefits, the values are shown in red.

**Table 6: Benefit Cost Analysis Summary**

| Benefits | Alternative 1 | Alternative 2 | Alternative 3 | Alternative 4 | Alternative 5 |
|---|---|---|---|---|---|
| 7% Discount Rate | $749,589 | $987,015 | $292,073 | $509,815 | $964,283 |
| 3% Discount Rate | $1,093,483 | $1,439,836 | $437,159 | $763,061 | $1,443,283 |
| **Costs** | | | | | |
| 7% Discount Rate | $85,421 | $1,026,922 | $1,110,066 | $1,871,792 | $2,863,275 |
| 3% Discount Rate | $87,961 | $1,063,004 | $1,221,885 | $2,053,103 | $3,126,331 |
| **Net Present Value (7% Discount Rate)** | **$664,168** | **-$39,906** | **-$817,992** | **-$1,361,977** | **-$1,898,992** |
| **Net Present Value (3% Discount Rate)** | **$1,005,522** | **$376,832** | **-$784,726** | **-$1,290,042** | **-$1,683,048** |
| **Benefit Cost Ratio (7% Discount Rate)** | **8.78** | **0.96** | **0.26** | **0.27** | **0.34** |
| **Benefit Cost Ratio (3% Discount Rate)** | **12.43** | **1.35** | **0.36** | **0.37** | **0.46** |

## 3.9 Evaluation Matrix

An Evaluation Matrix was prepared to assist in the evaluation of the various alternatives considered in this study. The elements considered in the matrix are summarized below. The evaluation matrix can be found in **Table 7.**

### Costs

A detailed explanation of cost calculations can be found in Section 3.8.

### Engineering

This portion of the matrix evaluates the technical merits of various components of the alternatives. For this study, the delay over the course of the weekday morning and evening peak hours from the eastbound and southbound approaches was analyzed, as well as culvert impacts, constructability, and impacts to property outside of the right-of-way.

### Purpose and Need

The Purpose and Need Statement for this project can be found in Section 1.2. This section evaluates whether or not the proposed alternative meets the objectives set forth in the need portion of the statement.

### Impacts

Expected natural resource, archeological, ecological, and other impacts are quantified here based on a review of natural resources on the ANR Natural Resources Atlas. A detailed description of the natural resources can be found in Section 2.6.

### Permits

The final section of the evaluation matrix evaluates the anticipated permits that will be needed for each alternative. Some of the permits reviewed are Act 250, Stream Alteration Permit, Construction and Operational Stormwater Discharge Permits, Section 1111, and others.

**Table 7: Evaluation Matrix**

| | | No Build | Alternative 1<br>Slope Cut | Alternative 2<br>Left Turn Lane on VT 117 | Alternative 3<br>"T" Intersection at VT 117 | Alternative 4<br>"T" Intersection at VT 117<br>VT 117 Left Turn Lane | Alternative 5<br>Roundabout |
|---|---|---|---|---|---|---|---|
| **Costs** | Construction | $0 | $60,000 | $880,000 | $1,040,000 | $1,800,000 | $2,800,000 |
| | Engineering Design | $0 | $10,000 | $100,000 | $120,000 | $200,000 | $300,000 |
| | Resident (Construction) Engineering | $0 | $10,000 | $100,000 | $80,000 | $130,000 | $200,000 |
| | Right-of-Way Acquisition | $0 | $10,000 | $10,000 | $20,000 | $20,000 | $30,000 |
| | Total | $0 | $100,000 | $1,100,000 | $1,300,000 | $2,200,000 | $3,350,000 |
| **Engineering** | 2023 AM & PM Intersection Approach Delay<br>*(Total approach delay for EB/SB approaches, in seconds)* | 86.6 | 86.6 | 84.1 | 86.6 | 84.1 | 23.2 |
| | Impacts to Existing Culvert | - | None | Likely Replace | None | Likely Replace | Likely Replace |
| | Need for New Culvert on Skunk Hollow Road | - | No | No | Yes | Yes | No |
| | Constructability | | Low Difficulty | Moderate Difficulty | Moderate Difficulty | High Difficulty | High Difficulty |
| | ROW Impacts | - | Minor | Minor | Major | Major | Major |
| **Purpose & Need** | Improves Vehicle Safety | - | Slightly Improved | Improved | Improved | Improved | Improved |
| | Improves Sight Distance from Skunk Hollow Road | - | Improved - Slope Cut | Improved - Slope Cut | Improved - Realigned Roadway | Improved - Realigned Roadway | Improved - Vehicular Movements |
| | Accomodates Cyclists | - | No | Widened Shoulders on VT 117 | Widened Shoulders on VT 117 | Widened Shoulders on VT 117 | Potential |
| **Impacts** | Agricultural Lands | - | No | No | No | No | No |
| | Archaeological | - | No | No | Potential | Potential | Potential |
| | Historic | - | No | No | Potential | Potential | Potential |
| | Hazardous Materials | - | No | No | No | No | No |
| | Floodplains | - | No Impact | No Impact | No Impact | No Impact | Yes |
| | Shoreland | - | No | No | No | No | No |
| | Fish & Wildlife | - | No | No | No | No | No |
| | Rare, Threatened & Endangered Species | - | No | No | No | No | No |
| | Public Lands - Sect. 4(f) | - | No | No | No | No | No |
| | LWCP - Sect. 6(f) | - | No | No | No | No | No |
| | Managed Lands | - | No | No | No | No | No |
| | Wetlands | - | No | No | No | No | Likely impacts to advisory wetland (presumptive class II)* |
| | Other Natural Resources | - | No | No | Impacts a significant natural community: Hemlock-Northern Hardwood Forest | | |
| **Permits** | Act 250 | - | No | No | No | No | No |
| | Section 404 - Wetlands (USACOE) | - | No | No | No | No | Unlikely* |
| | Section 401 Water Quality Certification | - | No | No | No | No | Unlikely* |
| | State Wetlands Permit | - | No | No | No | No | Unlikely* |
| | Stream Alteration Permit | - | No | Yes | Yes | Yes | Yes |
| | Construction Phase Storm Water Discharge Permit (General Permit 3-9020) | - | No | Yes | Yes | Yes | Yes |
| | Operational Phase Storm Water Discharge Permit (General Permit 3-9015) | - | No | Unlikely | Yes | Yes | Yes |
| | Lakes & Ponds | - | No | No | No | No | No |
| | Rare, Threatened, and Endangered Species | - | No | No | No | No | No |
| | Section 1111 Permit | - | Yes | Yes | Yes | Yes | Yes |

* Wetlands: Potential impact to "presumptive class II" wetlands, shown on the VT ANR Atlas as an advisory wetland (assumed to be non-jurisdictional). No VSWI wetlands in area.

# 4 Stakeholder Input and Preferred Alternative

## 4.1 Public Meetings

This project was presented three times at regularly scheduled Selectboard Meetings over the course of the project to gather public input. The first two meetings occurred on February 15, 2018 and July 19, 2018. Presentations and minutes from all public meetings are provided in the Appendix.

The February 15, 2018 meeting was a Local Concerns Meeting and presented the existing conditions, draft purpose and needs of the project, and asked the public to share their concerns about the intersection and offer ideas on potential solutions to be evaluated. Attendees discussed the potential realignment of Skunk Hollow Road to improve sight distance, concerns about traffic lights at this intersection, and the possibility for turn lanes on either or both roadways.

The July 19, 2018 public meeting was also held at a Selectboard Meeting and presentation was of the alternatives analysis completed by VHB and reviewed by the project advisory committee. This meeting focused on the associated costs, impacts, and performance of the potential alternatives. Much of the discussion centered on the opportunity to do a phased approach with shorter term solutions being implemented initially and doing further evaluation on a longer-term solution.

## 4.2 Municipally Preferred Alternative

The recommendations of this study were presented to the Jericho Selectboard on October 4, 2018. The advisory committee, which was made up of CCRPC, VTrans, Jericho, and VHB representatives, made a final recommendation to the Selectboard to adopt Alternative 1 as an immediate, short-term solution, and reevaluate Alternative 2 in five years based on updated crash data. This recommendation is a result of technical evaluation, a benefit cost analysis, and public input. This recommendation includes the following steps:

1. Remove ledge and clear trees from the northwest corner of VT 117 and Skunk Hollow Road to improve sight distance to 555 feet;
2. Evaluate crash data five years after construction to examine need for further improvement.

The Selectboard approved this option as their preferred alternative on October 4, 2018. The slope cut recommended in Alternative 1 has been added as an amendment to the current contract for the VT 117 re-paving project.

# Technical Appendix

Traffic Volume Data

Turn Lane Warrants

Crash Data Summary

Hydrology and Hydraulics Assessment

Archaeological Resources Assessment

Alternatives Plans

Unsignalized Intersection Capacity Analysis

Benefit Cost Analysis

Evaluation Matrix

Public Participation