Documentation for:

Airport Road / Main Street / VT116/VT17 Intersection Study

Prepared for:

Town of Bristol, Vermont

and

Addison County Regional Planning Commission

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RSG Inc. Transportation

DATA ■ ANALYSIS ■ SOLUTIONS

Prepared for:
The Addison County Regional Planning Commission and the Town of Bristol.

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1.0 INTRODUCTION

The Main Street/Airport Drive intersection in Bristol, Vermont is the main access point to Mount Abraham Union Middle/High School (MAUM/HS) and is the western gateway to the Bristol village. The intersection must accommodate current vehicular, pedestrian and bicycle traffic, as well as future increases in traffic resulting from planned developments such as the proposed Deerleap Community Center.

This study is intended to develop an intersection improvement plan that provides safe and efficient access for all users. A Steering Committee made up of representatives from the Town staff and Planning Commission, the Addison County Regional Planning Commission (ACRPC) and the Deerleap Community Center, helped define the issues, guide the plan development, and evaluate alternatives. Input was sought at several stages from the public, the middle and high schools and the Town Selectboard.

This study relies upon design standards and analysis procedures documented in the 2000 *Highway Capacity Manual*,[1] Trip Generation,[2] *A Policy on Geometric Design of Highways and Streets*,[3] *Manual on Uniform Traffic Control Devices* (MUTCD),[4] *Traffic Impact Evaluation: Study and Review Guide*,[5] and the Vermont State Standards.[6]

2.0 PURPOSE & NEED

The purpose and need statement is a two-part declaration, which provides direction and goals for the project. The statement should identify the problems and the supporting needs that must be met over the course of the analysis.

The following purpose and need statement was developed in conjunction with the Steering Committee and was presented for comment at two public /Selectboard meetings.

2.1 Purpose

The purpose of the Airport Road Intersection Study is to develop an improvement plan for the Main Street/Airport Drive intersection that provides safe and efficient access for all users to and from the Mount Abraham Union High School and adjacent Recreational Center.

2.2 Need

The following needs have been identified for this project:

- Accommodate expected future development and growth in the project area;
- Address excessive vehicle delay currently experienced during peak periods;
- Address lack of facilities for pedestrians and bicyclists;

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[1] Transportation Research Board, National Research Council, *Highway Capacity Manual* (Washington, DC: National Academy of Sciences, 2000).

[2] Institute of Transportation Engineers, *Trip Generation* 7th Edition (Washington, D.C.: Institute of Transportation Engineers, 2003).

[3] American Association of State Highway and Transportation Officials (AASHTO), *A Policy on Geometric Design of Highways and Streets*, 4th Edition (Washington DC: AASHTO, 2004).

[4] American Traffic Safety Services Association (ATSSA), ITE, and AASHTO, *Manual on Uniform Traffic Control Devices*, 2003 Edition (Washington DC: FHWA, 2003).

[5] Vermont Agency of Transportation, Development Review Section, *Traffic Impact Evaluation Study and Review Guide* (January 2003).

[6] State of Vermont Agency of Transportation, *Vermont State Standards* (Montpelier: VTrans, 1 July 1997).

- Address geometric deficiencies such as sight distance, curvature, and approach grades.

3.0 EXISTING CONDITIONS

3.1 Study Area

The study area is located at the western end of the downtown Bristol area, and is anchored by the VT 17/VT 116/Airport Drive intersection. Boundaries to the area include the MAUHS to the northwest, the Recreation Center buildings and fields to the northeast, and Lovers Lane to the south.

MAUM/HS serves grades 7-12, including roughly 900 students in daily attendance, plus faculty and staff. Student population growth is expected to be relatively flat over the next few years. The existing Recreation Park is co-run by the Bristol Recreation Club and the Town of Bristol Recreation Department. Parking lots, athletic fields, and maintenance buildings take up the remaining acreage immediately north of the intersection.

Airport Drive, a rural local road which runs north-south, provides exclusive access to the MAUHS, the American Legion hall, and the Recreation Center grounds. The speed limit is 25 mph. This stop-controlled approach intersects VT 17/VT 116 at an eastbound, up-hill, s-curve.

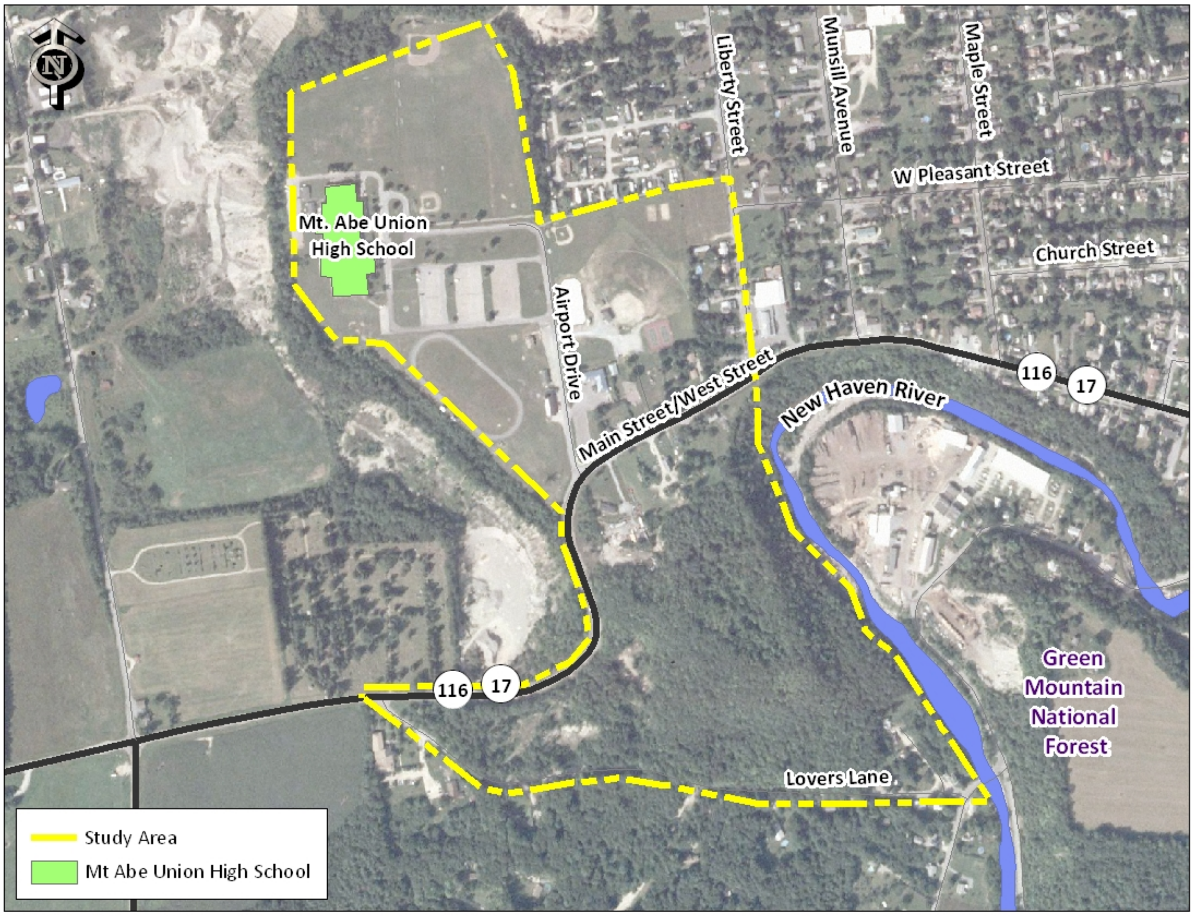
VT 17/VT 116, a rural minor arterial which runs east-west through the study area, transitions from 40 mph to 30 mph just west of the study intersection. In the study area, VTrans designates VT 17/116 a rural minor arterial with an Annual Average Daily Traffic (AADT) volume of 6,000 vehicles per day west of Airport Road, and 6,700 east of Airport Road, as measured by VTrans in 2008.[1]

Lovers Lane, a local road, intersects VT 17/VT 116 roughly ¼ mile west of the Airport Drive intersection. The land between VT 17/VT 116 and Lovers Lane is primarily owned by the Town of Bristol, with difficult access due to topography, from VT116/17 or Lover's lane.

The study area bounds are shown in Figure 1.

[1] The AADTs were measured between VT 17 West and Airport Road, and between Airport Road and North Street, respectively.

Figure 1: Study Area



3.2 Previous Studies

The Deerleap Community Center has completed two studies to date: an architectural planning study and an engineering feasibility study. This report draws many details regarding the planned development from these two reports.

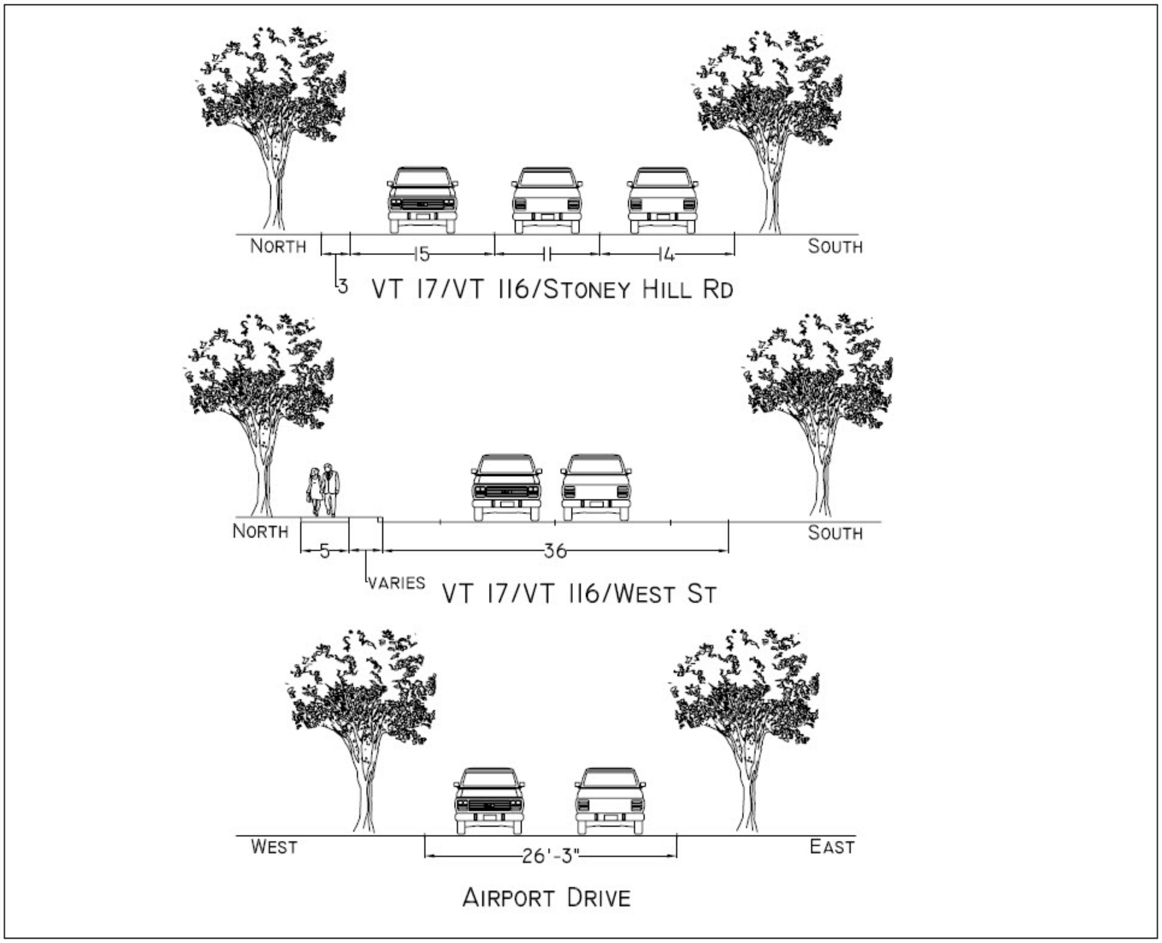
The *Downtown Bristol Traffic Study (February 2003)* focused on the assessment of parking facilities, bicycle and pedestrian facilities, and traffic conditions and deficiencies with regard to flow, efficiency, access and safety. Key recommendations that pertain to this study include:

- In-town speed limits should be reduced to 25 mph (currently 30 mph)
- Five foot sidewalks should be constructed along one or both sides of Airport Drive
- Existing crosswalks on Main Street should be replaced with raised/textured crosswalks to improve the visibility and safety of pedestrians
- A traffic calming project from Airport Drive to the Lord's Prayer Rock should be pursued

3.3 Cross Section

Roadway cross sections were measured in the field. Lane widths, shoulder widths and sidewalks vary on VT 17/VT 116 throughout the study area; therefore two cross sections are presented for this road – the first is on Stoney Hill Road, just west of the Airport Drive intersection, and the second is on West Street, just east of the study intersection.

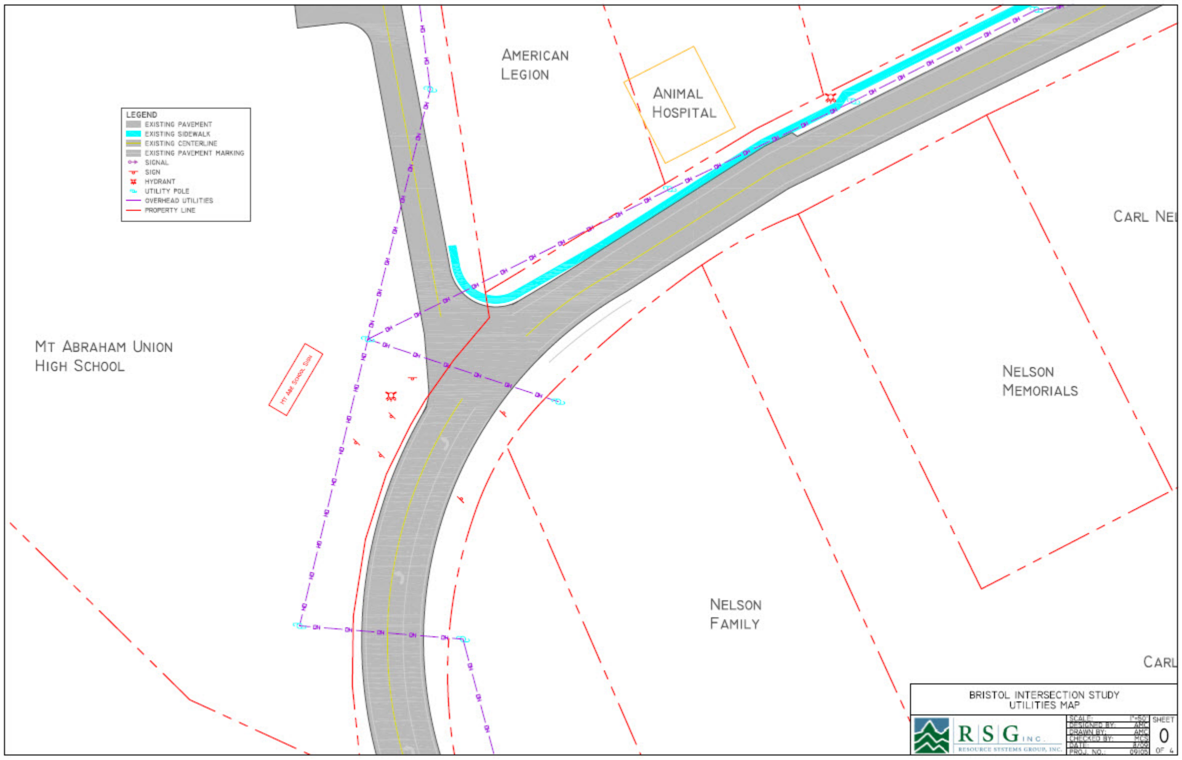
Figure 2: Roadway Cross-Sections



3.4 Utilities and Right of Way

Figure 3 shows the location of known above ground utilities, utility/light poles, signs and hydrants in the study area. An unmapped waterline exists on the north side of VT17/ VT116. These locations are approximate based on field inventories and photographs; a detailed survey should be completed to confirm exact location of utilities prior to construction.

Figure 3: Utilities and Right-of-Way Lines



Based on the tax mapping, the Right of Way along VT 17/VT 116 appears to be 4 rods or 66 ft. wide in the project area. Airport Road does not appear to be in a public right of way, but is shown on the MAUM/HS property. Parcel lines in the study area are also shown in Figure 3.

3.5 Hydrology

Hydrology in the study area consists of surface drainage leading southwest along VT17/VT116. Drainage and appropriate stormwater treatment will need to be addressed for any proposed alternative.

3.6 Pedestrian Facilities

In the study area, sidewalks and crosswalks currently exist on the north side of VT 17/VT 116, but not the south side. There are no sidewalks on Airport Road or on VT 17/116 west of the Airport Road intersection. Crosswalks in this area are also absent.

Figure 4: Pedestrian Facilities

The *Vermont Pedestrian and Bicycle Facility Planning and Design Manual* states that a 2-lane roadway with an AADT of less than 9,000 vehicles per day is an acceptable candidate for a marked crosswalk.[1] VT 17/116 in Bristol has an estimated 2008 AADT of 6,000 vehicles per day, according to VTrans.

However, the manual also recommends that "a minimum of 20 pedestrian crossing per peak hour (or 15 or more elderly and/or child pedestrians) exist at a location before placing a high priority on the installation of a marked crosswalk alone."[2] Based on the size of the school (900 students + faculty and staff) and its proximity to the downtown area, it is anticipated that the intersection of VT 17/VT 116/Airport Road would meet this threshold. At this time, we recommend conducting a pedestrian count to verify this assumption, and if the threshold is met, to consider installing a crosswalk.

The *Vermont Pedestrian and Bicycle Facility Planning and Design Manual* also states that marked crosswalks may be placed at intersections on roadway approaches not regulated by traffic controls (signals, stop signs, yield signs) if the speed limit is 40 mph or less and there are sidewalks and/or shoulders on both sides of the approach.[3] At this time, there are sidewalks running along the north side of Main Street only. Sidewalks along the south side of Main Street and on at least the west side of Airport Road should be installed before a connecting crosswalk is constructed. The locations of these crosswalks are addressed for each of the proposed alternatives.

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[1] Vermont Agency of Transportation, *Vermont Pedestrian and Bicycle Facility Planning and Design Manual* (VTrans, 2002) 3-44.

[2] Ibid.

[3] Ibid

3.7 Traffic Volumes

Resource Systems Group analyzed the two highest peak hours from the actual turning movement counts. The AM peak our is 7:30 to 8:30, and the PM peak hour is from 2:30-3:30 (the hour following school dismissal). Vermont highway planning conventions for intersection studies typically analyze traffic conditions in the base year (the current or study year) and ten years in the future. Therefore, our base year of analysis will be 2009 and our future analysis year will be 2019.

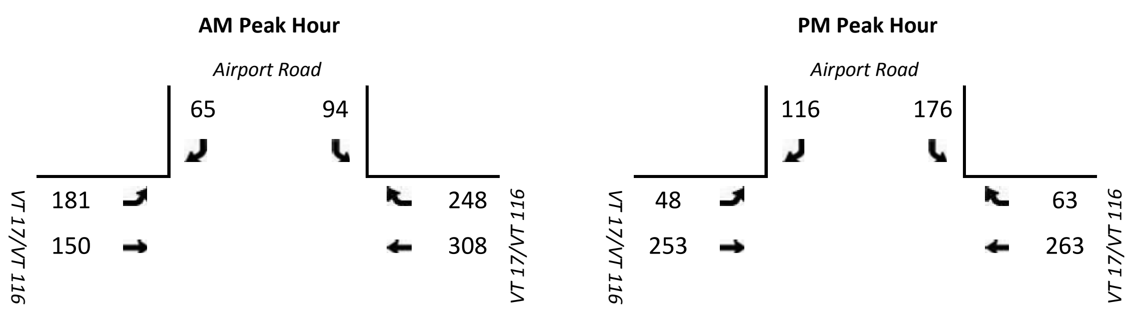
3.7.1 Volume Adjustment Factors

The Addison County Regional Planning Commission (ACRPC) conducted turning movement counts in the study area in June 2009. The peak hour traffic volumes from these counts are adjusted to represent the design hourly volume (DHV)[1] in 2009 and 2019 using two adjustment factors:

1. An annual adjustment factor, which represents general background traffic growth, is based on the VTrans 20-year Growth Factor from the 2008 Red Book for Rural Primary and Secondary Roads. This results in a 0.65% annual rate, or 6.7% between 2009 and 2019.
2. A Design Hourly Volume adjustment factor, which represents traffic volumes during the 30th highest hour of the year, is based on temporary traffic counter S6A127.[2] This resulted in a DHV adjustment of 1.12.

Figure 5 shows the scenario volumes during the AM and PM peak hours.

Figure 5: 2009 AM and PM Peak Hour Volumes



Raw traffic volumes and adjustments are provided in Appendix A.

3.8 Level of Service

3.8.1 Level-of-Service Definition

Level-of-service (LOS) is a qualitative measure describing the operating conditions as perceived by motorists driving in a traffic stream. LOS is estimated using the procedures outlined in the 2000 Highway Capacity Manual. In addition to traffic volumes, key inputs include the number of lanes at each intersection and the traffic signal timing plans. The LOS results are based on the existing lane configurations and control types (signalized or unsignalized) at each study intersection.

[1] The DHV is the 30th highest hour of traffic for the year and is used as the design standard in Vermont.

[2] Located on VT 116, 0.1 miles east of VT 17 (west).

The 2000 Highway Capacity Manual defines six qualitative grades to describe the level of service at an intersection. Level-of-Service is based on the average control delay per vehicle. Figure 6 shows the various LOS grades and descriptions for signalized and unsignalized intersections.

Figure 6: Level-of-Service Criteria for Signalized and Unsignalized Intersections

LOS	Characteristics	Unsignalized Total Delay (sec)	Signalized Total Delay (sec)
A	Little or no delay	≤ 10.0	≤ 10.0
B	Short delays	10.1-15.0	10.1-20.0
C	Average delays	15.1-25.0	20.1-35.0
D	Long delays	25.1-35.0	35.1-55.0
E	Very long delays	35.1-50.0	55.1-80.0
F	Extreme delays	> 50.0	> 80.0

The delay thresholds for LOS at signalized and unsignalized intersections differ because of the driver's expectations of the operating efficiency for the respective traffic control conditions. According to HCM procedures, an overall LOS cannot be calculated for two-way stop-controlled intersections because not all movements experience delay. In signalized and all-way stop-controlled intersections, all movements experience delay and an overall LOS can be calculated.

The VTrans policy on level of service is:

- Overall LOS C should be maintained for state-maintained highways and other streets accessing the state's facilities
- Reduced LOS may be acceptable on a case-by-case basis when considering, at minimum, current and future traffic volumes, delays, volume to capacity ratios, crash rates, and negative impacts as a result of improvement necessary to achieve LOS C.
- LOS D should be maintained for side roads with volumes exceeding 100 vehicles/hour for a single lane approach (150 vehicles/hour for a two-lane approach) at two-way stop-controlled intersections.

For the VT 17/VT 116/Airport Road intersection, LOS D should be maintained on the sideline approach (Airport Road).

Detailed Synchro (for unsignalized and signalized analysis) and aaSydra (for roundabout analysis) LOS worksheets are available in Appendix B.

3.8.2 Level-of-Service Results

The Highway Capacity Manual congestion reports within Synchro (v7), a traffic analysis software package from Trafficware, were used to assess congestion at the study intersections.

In the 2009 scenarios, the southbound approach experiences LOS E in the AM peak hour, which falls below VTrans guidelines.

Figure 7: AM and PM Peak Hour LOS Results

	AM Peak Hour 2009			PM Peak Hour 2009		
Unsignalized Intersections	LOS	Delay	v/c	LOS	Delay	v/c
STOP **VT 16/Airport Road**						
Eastbound Left	A	10	0.20	A	8	0.04
Southbound Left/Right	E	36	0.61	D	27	0.67

3.8.3 Queues

SimTraffic was used to determine average maximum queues at the study intersection in the AM and PM peak hours. The results are presented in Figure 8.

Figure 8: 2009 AM and PM Queues

Unsignalized Intersections	AM Peak Hour 2009	PM Peak Hour 2009
STOP **VT 16/Airport Road**		
Eastbound Left	55	16
Westbound Thru/Right	8	0
Southbound Left/Right	68	84

There are no excessive queues in the 2009 AM or PM scenarios.

Detailed queuing worksheets are provided in Appendix C.

3.9 Safety

3.9.1 Crash Histories

Crash histories were collected from VTrans (January 2003-December 2007) along VT 17/VT 116 from Lovers Lane to Liberty Street. VTrans maintains a statewide database of all reported crashes along all state highways and federal aid road segments.[1]

A reportable crash is a collision with at least one of the following results caused by the event:

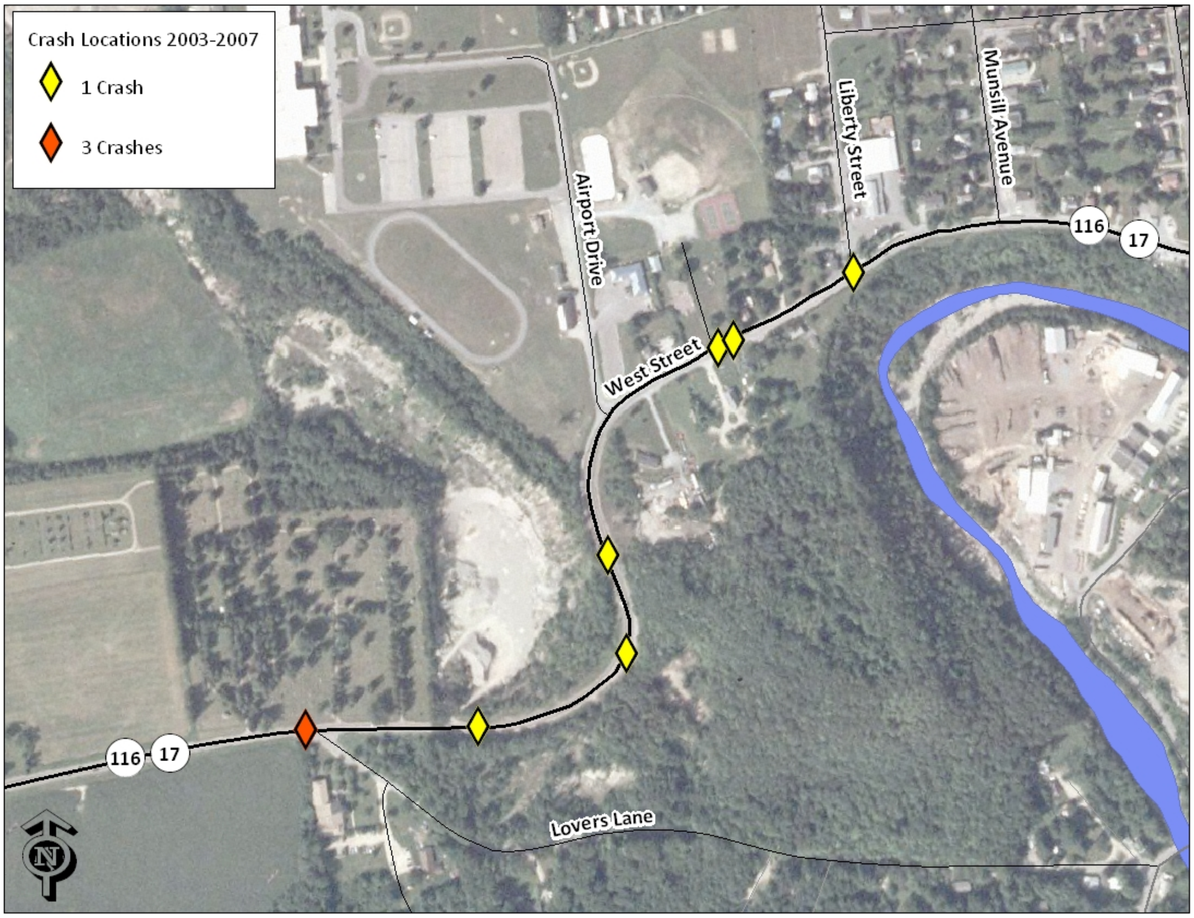
- property damage exceeding $1,000
- personal injury
- fatality

There are a total of 10 crashes that occurred in the study area; nine occurred in 2004 or 2005, and only one occurred in 2007. Four collisions were single-vehicle crashes; three were rear-ends. There are no significant patterns with regard to time of day, day of week, month of year, weather, or number of injuries. There are no crashes that occurred exactly at the study intersection.

Crash locations are shown in Figure 9.

[1] This data is exempt from Discovery or Admission under 23 U.S.C. 409.

Figure 9: Crash Locations in the Study Area, 2003 – 2007



In addition to the reported crashes obtained through VTrans, an attendee at the Local Concerns meeting indicated that there was one crash in 2008 at the study intersection. Based on the crash report, which was later obtained from the Bristol Police Department, this crash was caused by a driver that was under the influence of drugs or alcohol. For this reason, this crash is not considered to be caused by an engineering deficiency at the intersection.

A complete list of crash summary data from VTrans is available in Appendix D.

3.9.2 High Crash Locations

In order to be classified as a High Crash Location (HCL), an intersection or road section (0.3 mile section) must meet the following two conditions:

1. It must have at least 5 crashes over a 5-year period
2. The Actual Crash Rate must exceed the Critical Crash Rate.

Based on the most current crash data available from VTrans (2003-2007), there are no High Crash Locations in the study area.

3.9.3 Sight Distances

Stopping sight distance is the distance required for a vehicle, traveling at the design speed, to stop before reaching a stationary object in its path, such as a stopped vehicle. Intersection (or corner) sight distance is the distance required for drivers to stop or adjust their speed, as appropriate, to avoid colliding with a potentially conflicting vehicle leaving an intersection.

The provision of adequate stopping sight distance is critical for safe operations. The *2004 Policy on Geometric Design of Highways and Streets*[1] states that, "[i]f the available sight distance for an entering or crossing vehicle is at least equal to the appropriate stopping sight distance for the major road, then drivers have sufficient sight distance to anticipate and avoid collisions." The *2004 Policy on Geometric Design of Highways and Streets*[2] goes on to state that, "intersection sight distances that exceed stopping sight distances are desirable along the major road."

In the field, the available stopping sight distance is measured from a point 3.5 feet above the road surface of the major road approach lanes to a point 2.0 feet above the road surface at the stop bar of the minor street approach.[3] The available intersection sight distance is measured from a point 3.5 feet above the road surface at a point on the minor road approach 14.5 feet from the stop bar to a point 3.5 feet above the road surface of the major road approach lanes.[4] The minimum stopping sight distances are calculated based on factors such as design speed, response times, and grades as reported in the *2004 Policy on Geometric Design of Highways and Streets.*[5]

The required corner sight distance for vehicles making a left from Airport Road onto VT 17/116 is 441 feet, but only 300 feet was measured in the field. The required corner sight distance for vehicles making a right turn from Airport Road is 287 feet, which is sufficient based on field measurements.

Figure 10 shows photographs taken in the field of some of the approximate sight distances for the Airport Road intersection.

Figure 10: Sight Distance Photographs at Airport Road

View Along West Street, looking East

View Along West St, looking West

[1] American Association of State Highway and Transportation Officials, *A Policy on Geometric Design of Highways and Streets*, Fifth Edition (Washington D.C.: American Association of State Highway and Transportation Officials, 2004), pg. 651.

[2] American Association of State Highway and Transportation Officials, *A Policy on Geometric Design of Highways and Streets*, Fifth Edition (Washington D.C.: American Association of State Highway and Transportation Officials, 2004), pg. 651.

[3] American Association of State Highway and Transportation Officials, *A Policy on Geometric Design of Highways and Streets*, Fifth Edition (Washington D.C.: American Association of State Highway and Transportation Officials, 2004), pg. 127.

[4] American Association of State Highway and Transportation Officials, *A Policy on Geometric Design of Highways and Streets*, Fifth Edition (Washington D.C.: American Association of State Highway and Transportation Officials, 2004), pg. 653,657, 659.

[5] American Association of State Highway and Transportation Officials, *A Policy on Geometric Design of Highways and Streets*, Fifth Edition (Washington D.C.: American Association of State Highway and Transportation Officials, 2004), pg. 659.

3.10 Turn Lane Warrant Analysis

Using the scenario volumes, we conducted a turn lane warrant to establish the necessity of adding right turn lanes to the study intersection when unsignalized, westbound and southbound. Using VTrans methodology for unsignalized intersections and a Typical State Design Manual[1] methodology, we found that a westbound right turn lane is warranted in all AM scenarios; however a southbound right turn lane is only warranted in the PM scenarios using the second methodology (Figure 11).

Figure 11: Turn Lane Warrants Summary

	Westbound Right Turn Lane (on West Street)		Southbound Right Turn Lane (on Airport Road)	
	AM	PM	AM	PM
VTrans				
2009	Yes	No	No	No
2019	Yes	No	No	No
Typical State Design Manual				
2009	Yes	No	No	Yes
2019	Yes	No	No	Yes

We used the VTrans methodology as defined in the *Pavement Marking Placement Guide*[2] for calculating the required storage lengths for the warranted turn lane. This information is provided in Figure 12 for the signalized and unsignalized scenarios.[3][4]

Figure 12: Turn Lane Lengths (ft)

	Unsignalized	Signalized
Westbound Right Turn Lane (on West Street)	250	50

The turn warrant analysis worksheets are available in Appendix E.

3.11 Signal Warrant

A signal warrant analysis is a set of tests that are run to determine whether a traffic signal would significantly improve operations, mobility, and safety at an intersection. There are a total of 8 warrants:

1. Eight-Hour Vehicular Traffic Warrant: when a large amount of intersecting traffic occurring over an 8-hour period is the principal reason for installing a traffic signal, or where excessive delays occur on minor approaches to an intersection.

3. Peak Hour Warrant: when the minor-street traffic suffers unduly delay when entering or crossing the major-street during the average peak hour is the principal reason for installing a traffic signal.
4. Pedestrian Volume Warrant: when the traffic volumes on a major street are so heavy that pedestrians experience excessive delays.
5. School Crossing Warrant: when school children crossing a major street are the principal reason for installing a traffic signal.
6. Coordinated Signal System Warrant: when maintaining proper platooning of vehicles is the principal reason for installing a traffic signal.
7. Crash Experience Warrant: when the severity and frequency of accidents is the principal reason for installing a traffic signal.
8. Roadway Network Warrant: when the concentration and organization of traffic flow is the principal reason for installing a traffic signal.

A signal warrant analysis is considered advisory only. This means that simply meeting any warrant may not be sufficient cause for installing a traffic signal. For example, meeting the peak hour warrant is usually not sufficient in and of itself to warrant installing a traffic signal. The rationale for this is that one hour (or less) of congestion in a day is probably not severe enough to justify the investment in the traffic signal controller and related equipment and software. Experience in Vermont suggests that meeting at least two other warrants is needed to justify investment in a traffic signal. This condition is met at the VT 17 – Airport Road intersection.

AM and PM peak hour turning movement counts were conducted at the VT 17 – Airport Road intersection on 6 June 2009. These peak hour counts were used to estimate 12-hour volumes based on traffic flows in 15-minute intervals from a 12-hour count conducted at VT 17 – VT 116 on 24 June 2008. This projected 12-hour count was adjusted to average 2009 traffic conditions. A 2019 scenario was also assessed, which incorporates the addition of annual growth and development traffic volumes. We also collected accident data from VTrans.

Based on the existing information gathered for this traffic study, the following warrants are met in 2009:

- Four-Hour Vehicular Traffic Warrant
- Peak Hour Warrant

The detailed signal warrant is available in Appendix E.

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[1] Typical State Design Manual Right Turn Lane Methodology, David J. DeBaie, Turn Lane Warrants: Concepts, Standards, Application in Review, 2004 ITE, District 1 Annual Meeting

[2] The following equation was used to calculate the required storage lengths: Storage Length = Volume of Right Turns per hour / 60 cycles per hour * 2 * 25' vehicle length. Department of Planning and Preconstruction, Traffic and Safety Division, Pavement Marking Placement Guide (Vermont Agency of Transportation: October 1991) 20.

[3] This is the storage lane length and does not include the taper or centerline shift lengths, which we can calculate if requested.

[4] Recommended storage lengths for turning lanes at signalized intersections are taken from the queue lengths as reported in the HCS2000 report.

4.0 ENVIRONMENTAL ASSESSMENT

4.1 Natural Resources

The following sections provide a broad review of Natural Resources in the study area. These findings are based on Geographic Information System (GIS) data provided by the groups or organizations listed for each category. A more detailed analysis should be undertaken to assess the presence of natural resources in the study area as this project moves forward into the design stages.

4.1.1 Wetlands

Based on the Vermont Significant Wetlands Inventory, there are no significant wetlands or buffer zones in the study area.

4.1.2 Lakes/Ponds/Streams/Rivers

The New Haven River runs southeast of the study area, but there are no other significant water bodies in the actual project area.

4.1.3 Endangered Species

Based on the 2009 Rare, Threatened and Endangered Species and Significant Communities list from the Vermont Department of Fish and Wildlife, there is a community of a statewide threatened animal in the vicinity of Lovers Lane. Ranked according to a 1-5 scale, this species is classified as "S2," meaning rare in the state, but "G5," meaning globally common. Although the type of animal is not named, it has a state status of "threatened," which means that it is protected under the Vermont Endangered Species Law. This species was last observed in 1997.

4.1.4 Flora/Fauna

There were no recorded vehicle/animal collisions in 2006, based on VTrans data. Additionally, there are no deer wintering areas in the study area based on 2008 data from the Vermont Agency of Natural Resources.

In 2006, VTrans created a "wildlife crossing value" (WCV) for its roadways across the state to recognize animal habitats that have been bisected by roadways. Each roadway is rated on a scale from 1 – 10 with 1 being very few crossings and 10 being a very high number of crossings; only rankings above five are published. In the study area, VT 17 does not have a WCV greater than five.

4.1.5 Stormwater

Based on data from the Vermont Agency of Natural Resources, there are no "stormwater" impaired watersheds or subwatersheds in the study area.

4.1.6 Hazardous Wastes

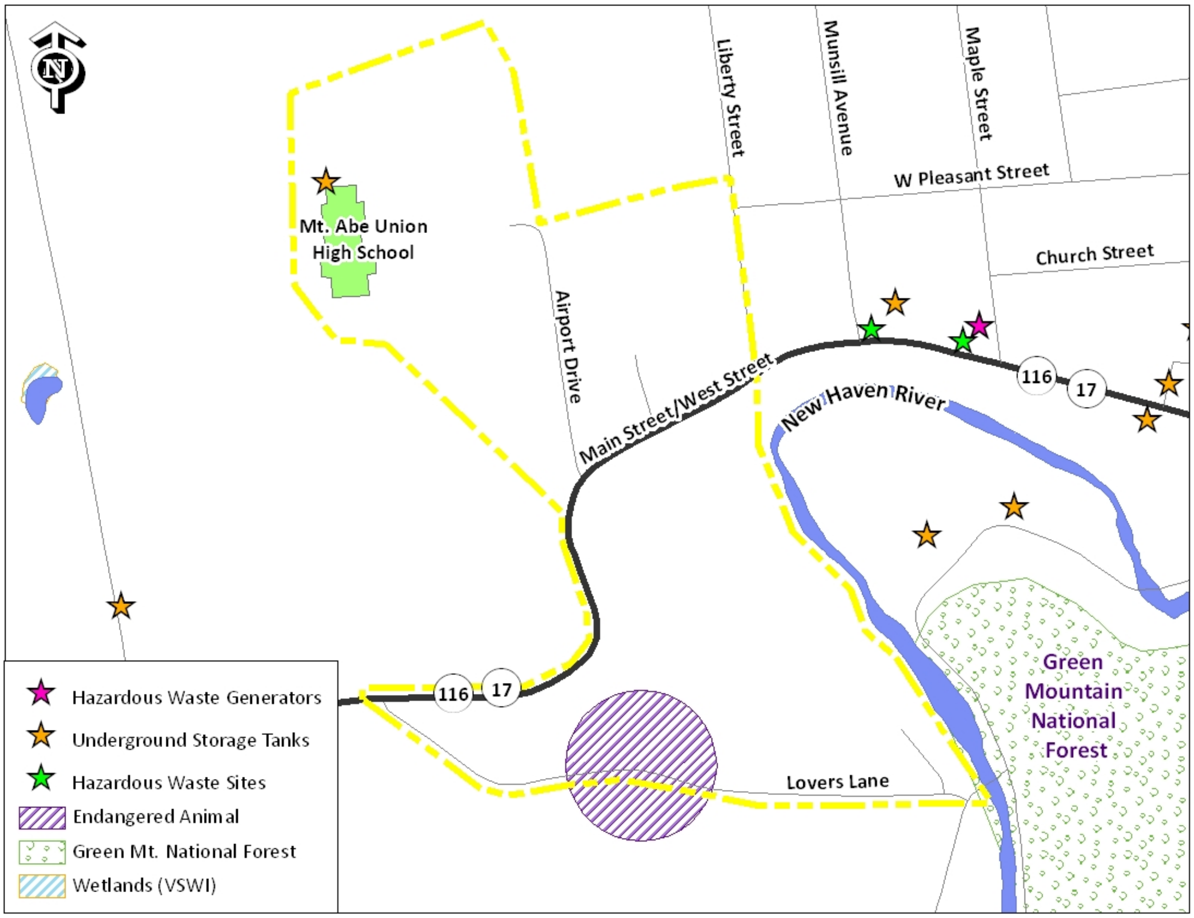
There are no hazardous waste sites or generators in the study area, based on the statewide site list published by the Vermont Agency of Natural Resources, which was last updated in 2009.

There are is one underground storage tank in the vicinity of Mt. Abe Union High School.

4.1.7 Forest Land

Although there is designated Forest Land south of the New Haven River, there is no Forest Land in the study area. Additionally, no Environmental Management Areas have been identified by the Green Mountain National Forest

Figure 13: Natural Resources in the Study Area



4.2 Cultural Resources

The following sections provide a broad review of Cultural Resources in the study area. These findings are based on Geographic Information System (GIS) data provided by the groups or organizations listed for each category. A more detailed analysis should be undertaken to assess the presence of cultural resources in the study area as this project moves forward into the design stages.

4.2.1 Historic Archaeological and Architectural Sites

The National Register of Historic Places identifies 19 architectural buildings on Main Street as part of the Bristol Downtown Historic District.

4.2.2 Public Lands

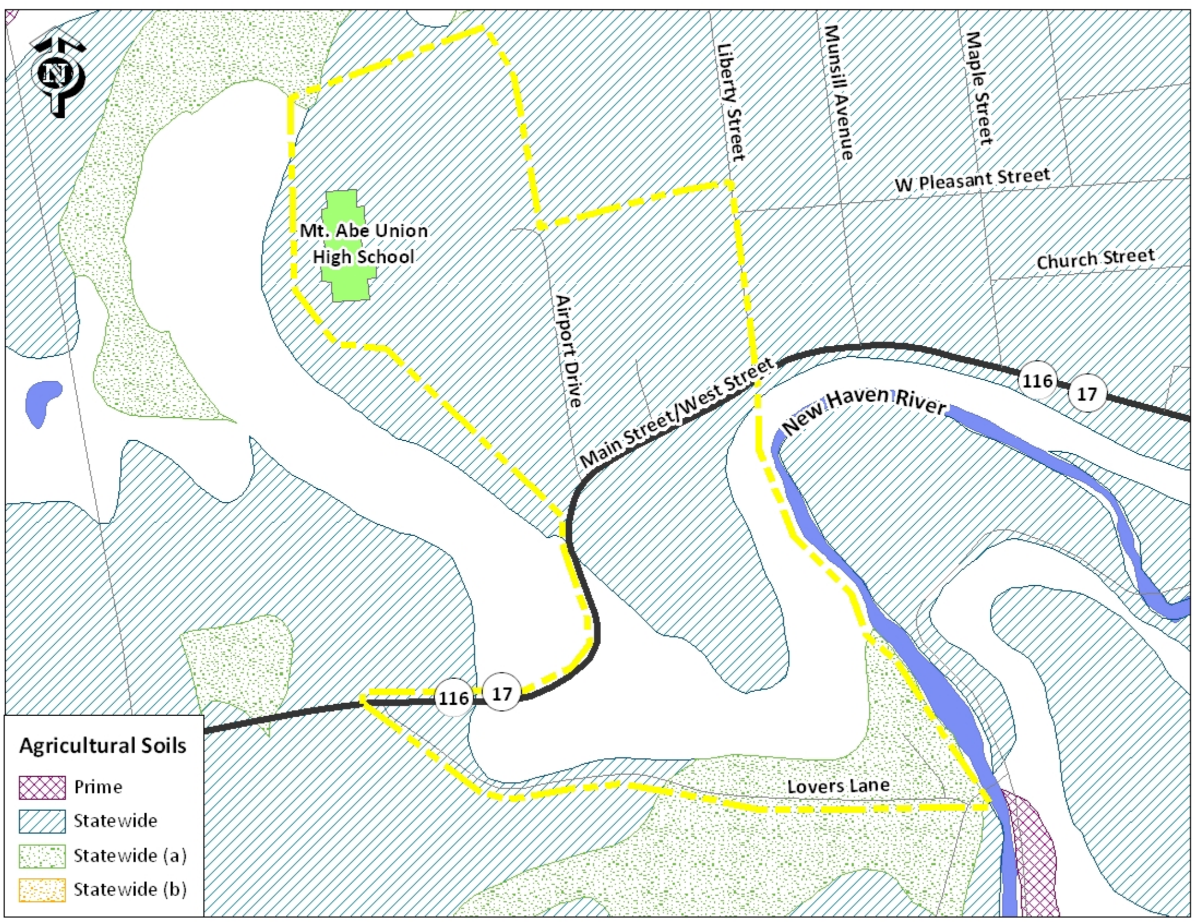
Based on data from the Vermont Public Lands Database, last updated in 2004, there are no public lands in the study area. However, the Federal Government identifies the Recreation Center property as public lands in its 4(f) database. Properties protected under Section 4(f) cannot be converted to uses for other means – in this case it is likely a new roadway serving the school would not be allowed.

4.2.3 Agricultural Lands

The Natural Resources Conservation Service identifies soils that are considered agriculturally important for the production of food, feed, fiber, forage and oilseed crops. These are typically broken into three categories: prime soils, soils of statewide importance, and soils of local importance. Statewide and local soils can then be further broken down into (a) and (b) categories, which are soils that could be of statewide or local importance if the needs for sufficient slope, drainage, and other criteria are met.

Soils of statewide importance occupy the majority of the study area, however given the long term land use and village setting of the project area, it is unlikely that this would be an impediment to any improvements.

Figure 14: Cultural Resources in the Study Area



4.3 Permitting

A wide variety of permits are available for various circumstances. Figure 15 presents the most common of those permits and assesses whether or not they are relevant to this study.

Note that if federal funds will be used for design and construction of improvements, a Categorical Exclusion Environmental Analysis will need to be submitted to VTrans and the Federal Highway Administration for review and approval.

Figure 15: Possible Permits

Permit & Most Likely Trigger(s)	Applies?
Act 250 Land Use Permit -Commercial impact to sites of more than 10 acres -substantial change to a preexisting development that qualifies	Possibly (see note 1)
401 Water Quality Permit -Impacts to wetlands or water courses	No
404 Corps of Engineers Permit -Dredging and Filling activities	No
Stream Alternation Permit -More than 3,000 sq ft impacted by fill placement below the OHW	No
State ANR Conditional Use Determination -Impact to Class 1 and 2 wetlands or buffer areas	No
Stormwater Discharge Permit -Additional impervious surface over 5,000 s.f. -Changes to the existing permitted drainage system	Possibly (2)
Construction General Permit -Disturb more than one acre of land	Possibly (2)
Shoreland Encroachment Permit -Disturbance to shorelines	No
Endangered and Threatened Species Permit -Impact to rare, threatened or endangered species and natural communities	No
VTrans Access Permit -Required for any improvements made within the state Right-of-Way	Possibly (2)
NEPA Process -Required for any project using Federal funds	Possibly (2)
Section 4(f) Permit -Required for any improvements made to a public park, recreation area, or wildlife or waterfowl refuge or any publicly or privately owned historic site	Possibly (3)

1) If improvements are proposed as part of the Deerleap proposal
2) depending on the alternative
3) part of the NEPA Process

Those permits that are listed as "possible" will be evaluated per alternative in section *7.2 Evaluation Matrix*.

5.0 ALTERNATIVE INVESTIGATION

5.1 Identified Issues

The existing conditions, from section 3.0 above, were presented at a 25 August Selectboard meeting. In addition to this meeting, we solicited input and feedback from various stakeholders, including MAUHS faculty and staff, Recreation Center staff, local business owners and residents. The following is a compiled list of issues that were identified by all interested parties in the study area:

- VT 17/VT 116/Airport Road is a highly congested intersection, particularly on the southbound approach (Airport Drive) and for the Eastbound Left (Stoney Hill Road) during peak traffic hours (7:30-8:30 AM and 2:30 – 3:30 PM)
- Insufficient sight distance
- Intersection is not well defined
- A sidewalk on Airport Drive is needed
- A sidewalk on Stoney Hill Road is needed
- Other pedestrian accesses to MAUHS & Recreation Center are needed
- Winter drivability is an issue on the eastbound approach (Stoney Hill Road)
- Lighting on pedestrian accesses is deficient
- Speeds coming up Stoney Hill Road are too high

These issues were used to guide the development of solutions and/or alternatives for the project.

5.2 Development of Alternatives

Based on the feedback from various stakeholders and the project steering committee, which consists of representatives from the Town of Bristol, the Addison County Regional Planning Commission, the Bristol Planning Commission and the Deerleap Community Center, a variety of potential alternatives and/or short-term/low-cost suggestions were developed. The following is a comprehensive list of solutions that were discussed:

- The addition of a traffic signal
- The addition of a crosswalk, which would give access to the school
- The addition of improved on/off road pedestrian access from Lover's Lane to the school
- Changes to intersection geometry and/or location of the study intersection
- The addition of an alternate access from the school/recreation facilities to the town road system (e.g. access to Liberty Street)
- The relocation of Airport Road to terminate on VT 17/VT 116 via the Recreation Center property
- The reconfiguration of the study intersection into a single-lane roundabout
- Hire a traffic control officer during peak hours and large events
- Install advance warning signs
- Clear trees and brush
- Create two, well-defined exiting lanes on Airport Drive

These potential modifications were condensed into four primary alternatives, with various elements of others distilled into short-term/low-cost options. These alternatives are:

1. Do Nothing (no change)
2. Traffic Signal
3. Roundabout
4. Re-align Airport Road

These alternatives are explored in depth in the upcoming sections. The low-cost/short-term recommendations will be compiled as a group of "other recommendations" at the end of this section.

Large-format 11x17 conceptual plans for each alternative are provided in Appendix F.

5.3 Alternative 1: Do Nothing

This alternative assumes that no changes will be made to the existing intersection configuration; that is, everything will remain the same. While this alternative incurs no cost, it also offers no benefit. This alternative primarily serves as the basis on which to assess the other three alternatives.

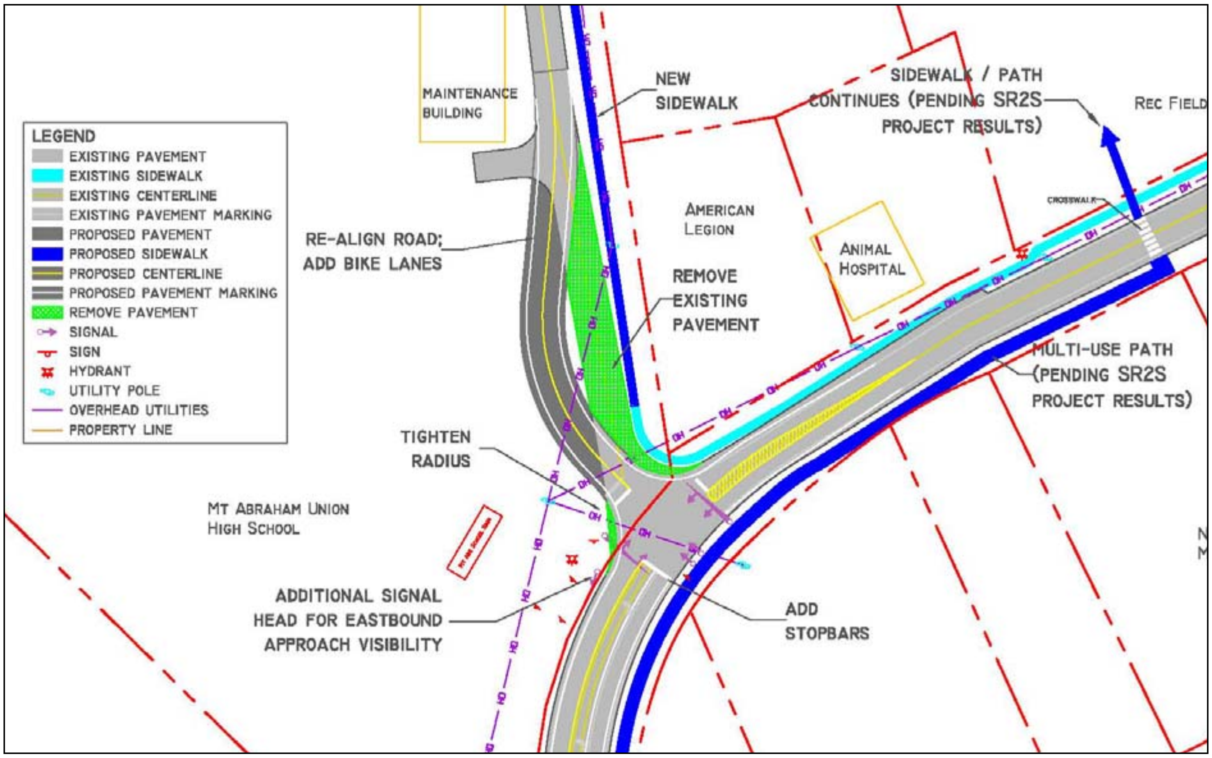
5.4 Alternative 2: Traffic Signal

Alternative 2 explores the impacts of installing a traffic signal at the VT 17/VT116/Airport Road intersection. This alternative primarily addresses congestion issues, but will also improve sight distance issues (by providing unopposed right-of-way to one approach at a time). Winter driveability is a concern with this alternative, as vehicles on the eastbound approach will be required to stop at a red light on Stoney Hill Road, whereas now they can proceed without obstruction.

Crosswalks, sidewalks, a multi-use path, and a slight roadway re-alignment to improve the intersection geometry are also included in this alternative. Signal timing plans that include an exclusive, pedestrian-actuated phase are also assumed.

This alternative is shown in Figure 16.

Figure 16: Alternative 2 – Traffic Signal

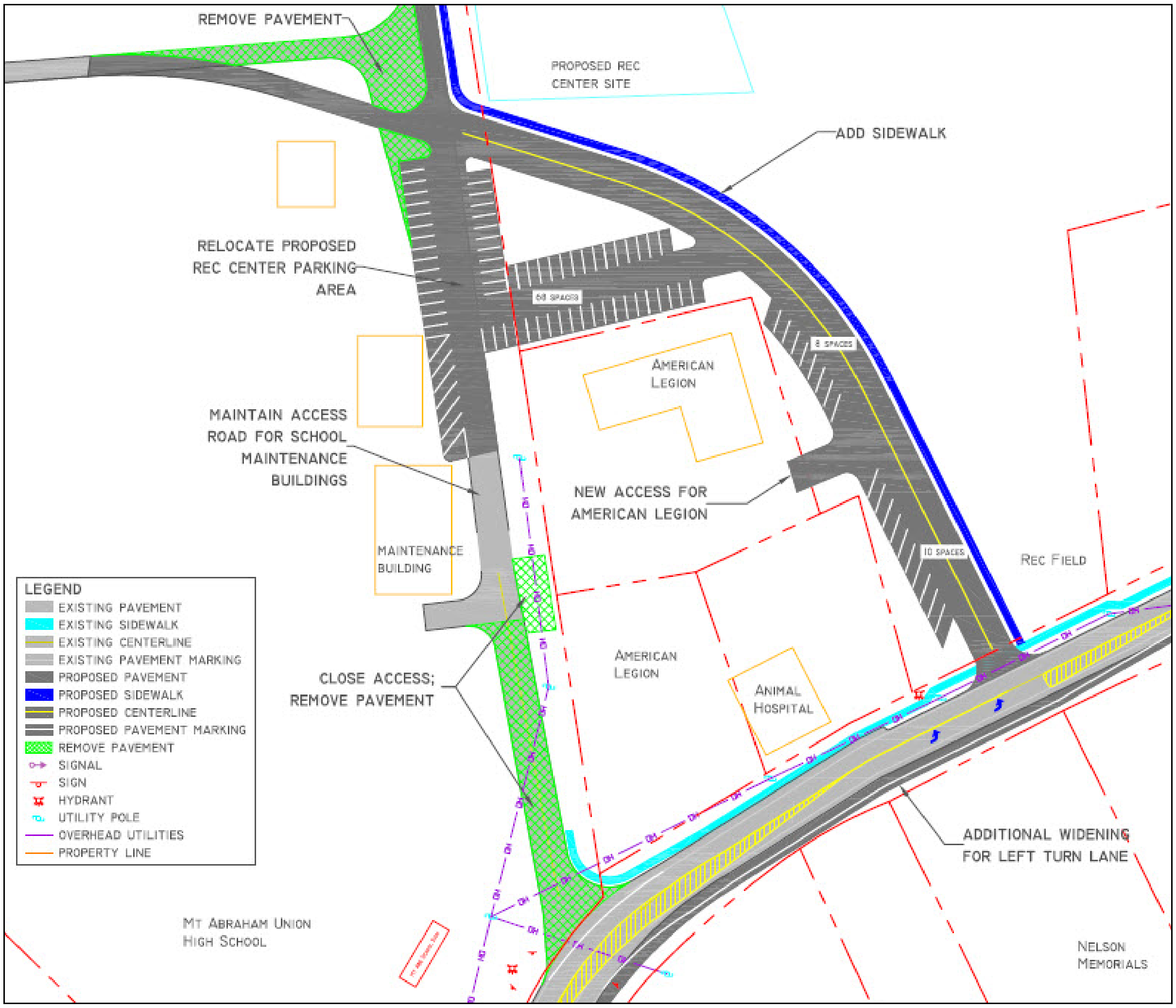


5.5 Alternative 3: Move Intersection

The third alternative moves Airport Road so that the existing roadway is partially removed and relocated to access VT 17/VT116 via the Recreation Center property. The re-alignment will move the intersection away from the existing hill and curve on Stoney Hill Road, which will provide a better intersection alignment, improved sight distance, and reduce concerns about winter driveability. The move is within the Town limits, and also within the school and Recreation Center Right-of-Way.

This alternative requires the reconfiguration of the existing conceptual plans for the Deerleap Community Center, because the re-alignment disturbs the planned parking area. Other modifications include a new access to the American Legion, and the existing eastbound left-turn lane will need to be re-installed. Sidewalks, crosswalks, and a multi-use path are also incorporated into this design, which is presented in Figure 17.

Figure 17: Alternative 3 – Move Intersection



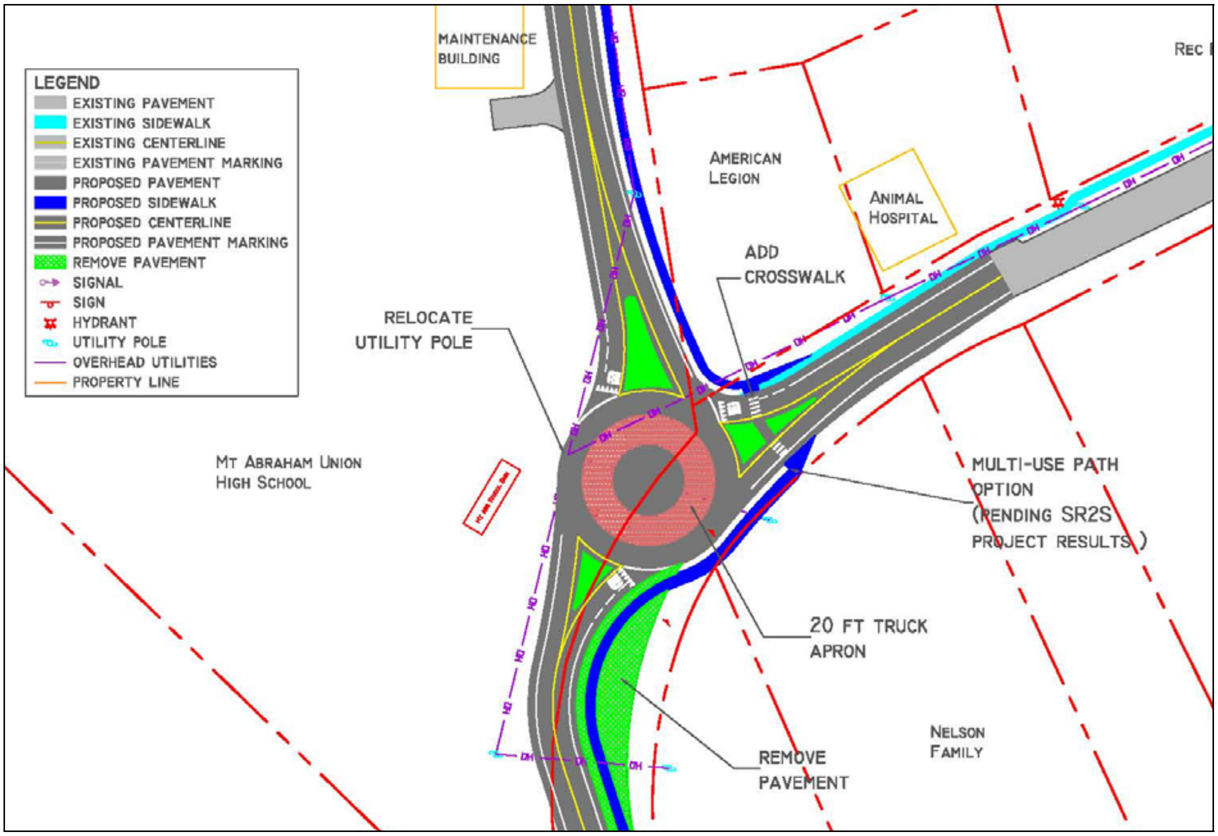
5.6 Alternative 4: Roundabout

The fourth alternative explores the impacts of installing a single-lane roundabout at the study intersection. This alternative addresses congestion, safety concerns, and pedestrian access. In order to install a roundabout at this intersection, utility poles will need to be relocated and significant regarding will also be needed.

Benefits of installing a roundabout include: reduced vehicle speeds at all times of the day; a Town gateway treatment; and lower operation and maintenance costs than traffic signals.

Crosswalks, sidewalk extensions, and a multi-use path are also included in this alternative. The roundabout is shown in Figure 18. The conceptual plan is drawn to minimize right-of-way and utility impacts while optimizing vehicle entry curves.

Figure 18: Alternative 4 – Roundabout



5.7 Short-Term Measures

In addition to the three alternatives provided below, various short-term, low-cost measures to improve the existing intersection were identified throughout the assessment process. Although the three actionable alternatives presented so far (traffic signal, re-alignment, and roundabout) are possible solutions, there are many smaller tasks that can be taken on to improve the operational, pedestrian, and safety issues discussed so far. These include:

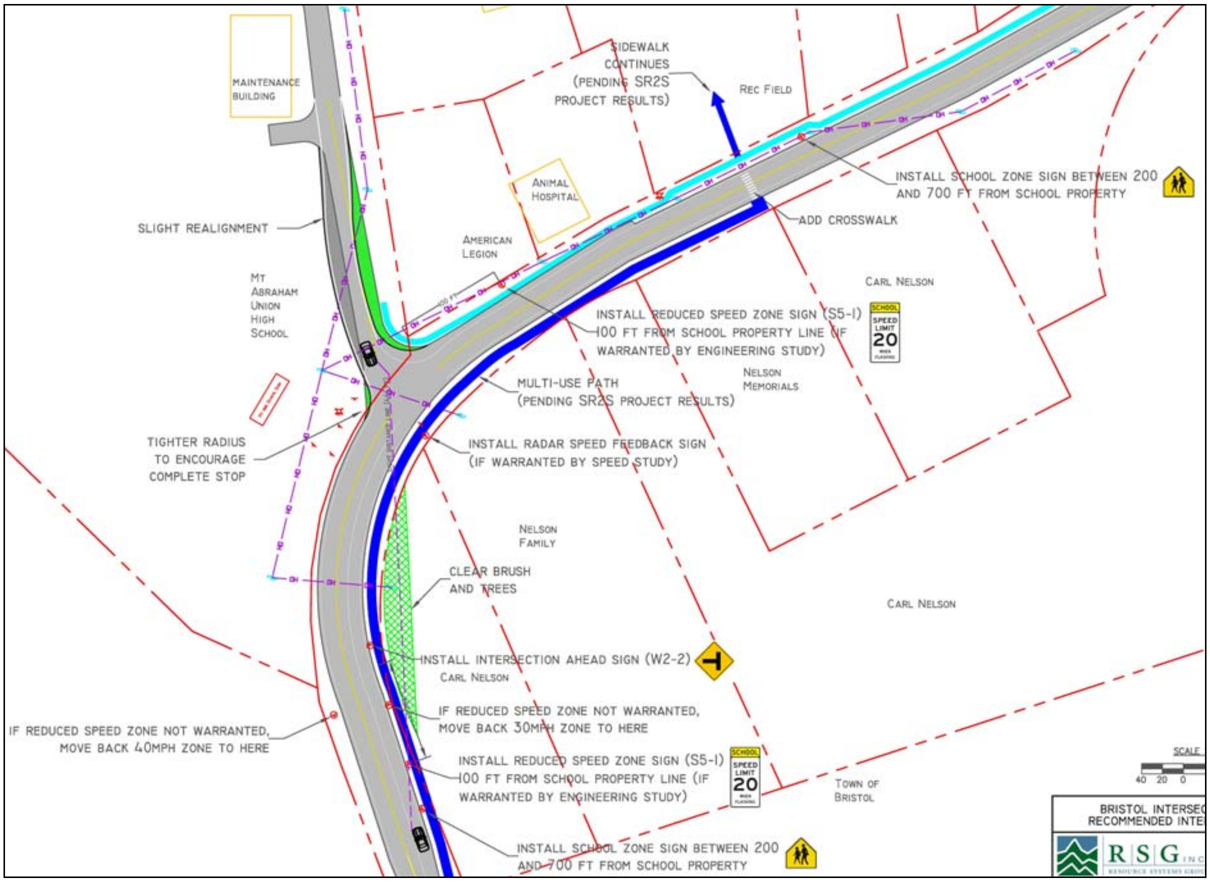
- **Clearing and Trimming Trees and Brush** – to improve sight distance at the study intersection. Note that the trees and brush that need to be cleared are on private property, and that permission from the owner or a right-of-way purchase will be required prior to clearing and trimming.
- **Move Existing Speed Transition Point** – to transition from 40mph to 30mph well in advance of the study intersection, as opposed to transitioning at the study intersection, as it does now. This will give vehicles an opportunity to reduce vehicle speeds well in advance of entering the study area. This may require that a portion of VT 17/VT 116 be converted to a Class 1 Town highway, rather than a Federal Aid State highway, which implies that the Town of Bristol would be responsible for maintenance and plowing.
- **Install School Speed Zone and School Crossing Signs** – to enforce lower speed limits (20mph) during school arrival and departure hours. The Manual on Uniform Traffic Control Devices (MUTCD) specifies that reduced speed zone signs (S5-1) should be installed 100 ft from school property, and advanced warning signs (S1-1) should be installed between 200 ft and 700 ft from school property. Due to the narrow frontage of MAUHS property on VT 17/VT 116, installing these signs based on the Recreation Center property, rather than

school property, should be explored. Installing a flashing beacon on the reduced speed zone sign is also an option that should be further explored. *Note: Final recommendations are dependent on the Safe Routes to School study currently underway for the MAUHS*

- **Install an Intersection Ahead Warning Sign –** on the Eastbound approach, to alert drivers to the Airport Road intersection and encourage cautious driving and reduced vehicle speeds (W2-2).
- **Install a Radar Speed Feedback Sign –** to alert drivers to the speeds they are driving as they enter the Town of Bristol. This sign will assist with enforcement efforts, which are unlikely to be able to provide 24/7 surveillance. To install this sign within the State Right-of-Way, the following conditions must be met: 1. a speed study must be conducted that shows that the 85th percentile speed (the speed that 85% of vehicles are traveling at or below) is at least 3mph over the posted speed limit; 2. the speed limit transitions (i.e. from 40mph to 30mph, or to a School Speed Zone); and 3. the speed limit is less than 35mph. Since the second two requirements are met at this location, a formal speed study to verify that the first requirement is met is recommended.
- **Install an 8ft Multi-Use Path –** on the south/east side of VT 16/VT 117 on the eastbound approach, to provide access for bicycles and pedestrians from Lovers Lane to the MAUHS. A crosswalk at the terminus of the path, across from the Recreation Center property, and a 5ft sidewalk through the Recreation Center property to the school, is also recommended. *Note: Final recommendations are dependent on the Safe Routes to School study currently underway for the MAUHS.*
- **Re-Align Airport Road Approach** – to encourage southbound vehicles to come to a complete stop and westbound vehicles to slow down before making a right turn.

Figure 19 shows a summary of the short-term recommendations that are proposed. These changes can be undertaken individually or all together, and can be added to any of the three formal alternatives proposed above.

Figure 19: Other Recommendations



6.0 FUTURE CONDITIONS

6.1 Future Development

There are two planned developments in the vicinity of the study intersection, both of which are included in the future year (2019) scenarios:

- *Deerleap Community Center* – the existing recreation center (which includes "The Hub" – a teen center, an outdoor ice skating rink and basketball court, playing fields and bleachers, tennis courts, skate park, BMX bike park, children's playground, picnic pavilion, and a seasonal concession stand and restrooms) is being proposed for redevelopment into an improved community center. This new community center, which would turn the existing ice skating park into a covered facility for multi-seasonal use, would include an expanded and improved venue for The Hub, a café, a multipurpose meeting room, administrative offices, daycare and senior centers, as well as provide a public fitness center and associated retail uses.
- *Nelson Residential Development* – the Nelson Family has proposed a 10-unit subdivision of single family homes just southeast of the study intersection.

6.2 Trip Generation

Trip generation refers to the number of new vehicle trips originating at or destined for a particular development.

To determine the expected trip generation for these developments, we first considered that the PM peak hour in this study does not coincide with the typical PM peak hour (e.g. a rush hour between 4 - 6 PM), but rather captures the traffic at the end of the school day (2:30 – 3:30 PM). While it is anticipated that the PM peak hours of the Community Center and the High School will not directly coincide with one another, and that the Community Center will generate fewer trips than the High School, it is assumed that the Community Center will add vehicle trips to the existing network, given that there are additional land uses from what exists today (i.e. meeting rooms, fitness center, etc.)

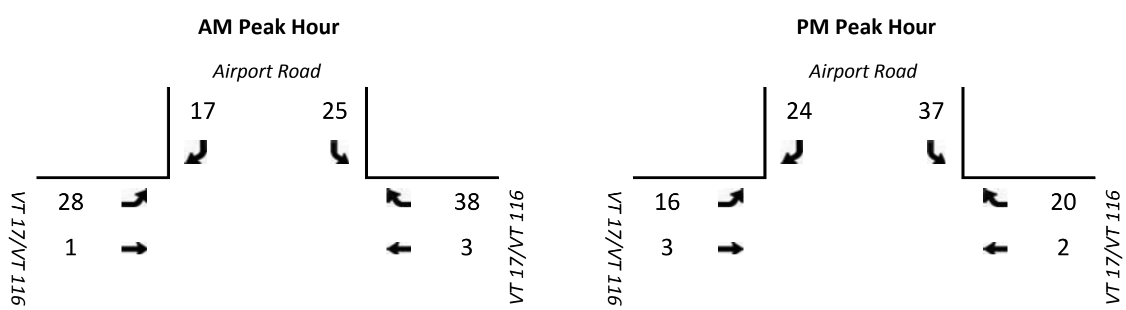
The Institute of Transportation Engineer's Trip Generation (8th ed.) was used to determine the number of vehicle trips generated by each development. ITE Code 495: Recreational Community Center was used for the Deerleap facility, which includes an enclosed ice arena, fields, meeting rooms, and other associated uses. These volumes are presented in Figure 20.

Figure 20: Future Development Volumes

				AM		PM	
Development	**ITE Code**	**Land Use**	**Size**	**Enter**	**Exit**	**Enter**	**Exit**
Nelson Residential Development	210	Single-Family Detached Housing	10 units	2	6	6	4
Deerleap Community Center	495	Recreational Community Center	66,535 sq ft	66	42	36	61
			Subtotal	68	48	42	65
			TOTAL	115		107	

The volumes from these developments are distributed throughout the study intersection in proportion to background traffic. Figure 21 shows the distributed trips. Raw turning movement volumes, adjustments, and trip generation calculations are available in Appendix A.

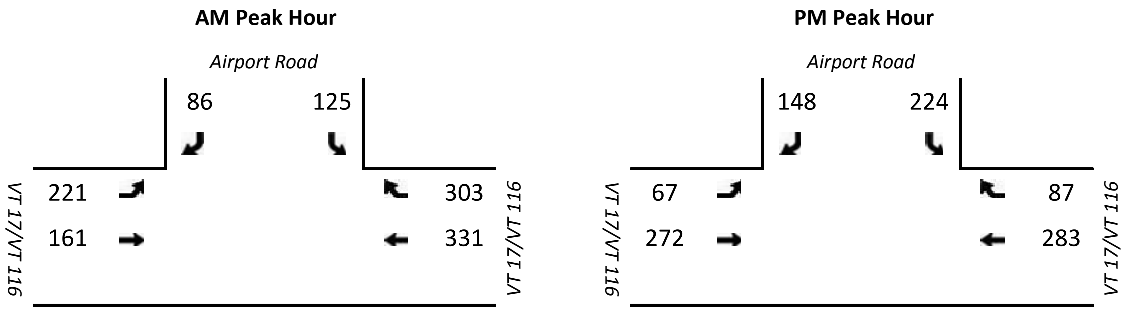
Figure 21: Trip Distribution



6.3 Future Traffic Assessment

The 2019 future scenario includes the 2009 traffic volumes with the addition of background traffic growth and the trip generation from future developments. These volumes are presented in Figure 22.

Figure 22: 2019 AM and PM Peak Hour Volumes



6.3.1 Level of Service

The 2019 volumes are assessed using Synchro to determine Level of Service for each of the proposed alternatives. Note that the second alternative, the re-aligned road, is assumed to be unsignalized in the conceptual plans, but could also be a candidate for signalization.

The results of the LOS analysis for 2009 and 2019 are presented in Figure 23.

Figure 23: 2019 AM and PM Level of Service

Alternative 0: No Build & Alternative 2: Re-Align

	AM Peak Hour						PM Peak Hour					
		2009			2019			2009			2019	
Unsignalized Intersection	LOS	Delay	v/c	LOS	Delay	v/c	LOS	Delay	v/c	LOS	Delay	v/c
VT 16/Airport Road												
Eastbound Left	A	9.6	0.20	B	10.4	0.27	A	8.1	0.04	A	8.3	0.06
Southbound Left/Right	E	35.9	0.61	F	121.2	1.05	D	26.5	0.67	F	66.9	0.96

Alternative 1: Traffic Signal

	AM Peak Hour						PM Peak Hour					
		2009			2019			2009			2019	
Signalized	LOS	Delay	v/c	LOS	Delay	v/c	LOS	Delay	v/c	LOS	Delay	v/c
VT 16/Airport Road												
Overall	B	10.6	0.57	B	13.3	0.73	A	9.8	0.52	B	11.4	0.62
Eastbound Left	B	14.0	0.67	C	23.6	0.8	A	8.0	0.15	A	9.1	0.24
Eastbound Thru	A	6.1	0.18	A	5.7	0.17	A	9.2	0.44	B	10.1	0.47
Westbound Thru/Right	B	10.0	0.66	A	9.7	0.66	B	10.2	0.55	B	12.1	0.63
Southbound Left/Thru	B	13.4	0.34	B	19.5	0.52	B	10.2	0.49	B	12.0	0.61

Alternative 3: Roundabout

	AM Peak Hour						PM Peak Hour					
		2009			2019			2009			2019	
Roundabout	LOS	Delay	v/c	LOS	Delay	v/c	LOS	Delay	v/c	LOS	Delay	v/c
VT 16/Airport Road												
Overall	A	7.2	0.482	A	7.5	0.570	A	7.1	0.293	A	7.3	0.367
VT 17/116 Eastbound Approach	A	7.4	0.284	A	7.8	0.340	A	6.3	0.292	A	6.8	0.347
VT 17/116 Westbound Approach	A	6.8	0.482	A	7.1	0.570	A	7.1	0.242	A	7.0	0.284
Airport Drive Approach	A	7.8	0.163	A	8.1	0.222	A	7.9	0.285	A	8.1	0.367

The stop-controlled intersection shows the existing operational deficiencies, which further degrade in 2019. Note that in the 2019 AM peak hour, the v/c ratio exceeds 1.0, which indicates a critical issue where the approach volume exceeds available capacity.

Both the traffic signal and roundabout alternative experience little to no delay during both peak hours in the existing and future condition.

Detailed Level of Service worksheets are provided in Appendix B.

6.3.2 Queues

Figure 24 presents the average maximum queues, as reported from SimTraffic, for each scenario. Note that the southbound approach queues are mitigated with the signal or roundabout alternatives, although the roundabout creates the shortest average maximum queues for all approaches.

Figure 24: 2009 and 2019 AM and PM Queues

Alternative 0: No Build & Alternative 2: Re-Align

	AM Peak Hour		PM Peak Hour	
Unsignalized Intersections	2009	2019	2009	2019
VT 116/Airport Road				
Eastbound Left	55	72	16	22
Westbound Thru/Right	8	12	0	1
Southbound Left/Right	68	174	84	149

Alternative 1: Traffic Signal

	AM Peak Hour		PM Peak Hour	
Signalized Intersections	2009	2019	2009	2019
VT 116/Airport Road				
Eastbound Left	87	152	33	39
Eastbound Thru	39	51	74	78
Westbound Thru/Right	115	158	85	108
Southbound Left/Thru	61	89	80	99

Alternative 3: Roundabout

	AM Peak Hour		PM Peak Hour	
Roundabout	2009	2019	2009	2019
VT 116/Airport Road				
VT 17/116 Eastbound Approach	48	61	48	60
VT 17/116 Westbound Approach	96	126	39	49
Airport Drive Approach	25	36	45	63

Detailed queuing worksheets are provided in Appendix C.

6.4 Safety

The existing intersection has not been shown to have a significant crash history (section *3.9 Safety*). However, there is a perceived safety problem, based on feedback from local officials, business owners, and residents. Insufficient sight distance and poor intersection geometry have been documented in this report, and support the local feeling that the intersection is unsafe. It is also important to note that while crashes are easily identified and reported, the number of "near misses" is not quantifiable.

The following statistics refer to crash reduction factors, which compare before-and-after studies of intersections with and without signals, with and without roundabouts, etc.[1] Although these factors cannot be applied to the crash history for this project (because there is no substantial crash history), they do provide a sense of safety benefit that can be achieved with each alternative.

Other impacts to safety, besides crash reduction factors, are also provided.

[1] All crash reduction factors are excerpted from "Crash Reduction Factors for Traffic Engineering and Intelligent Transportation System Improvements: State of Knowledge Report" by NCHRP, 11/05.

- **Alternative 1: Signalization**
  - Decreases injury accidents at urban 3-leg intersections by 14%
  - Reduces sight distance requirements
- **Alternative 2: Move Roadway & Intersection**
  - Improved sight distance
  - New intersection accesses VT 17/VT116 inside the 30mph speed zone (rather than at the transition point) and away from Stoney Hill
- **Alternative 3: Roundabout**
  - All traffic must reduce speeds; typical entry speeds at a single-lane roundabout are 15-20mph
  - Decreases all accidents on rural single-lane intersections by 58%
  - Decreases injury accidents on rural single-lane intersections by 82%

Based on these data, improved safety is a benefit of each of these alternatives. However, the Roundabout is likely to provide the greatest safety benefit to the most users.

7.0 ALTERNATIVE SELECTION

7.1 Cost Estimates

Order-of-magnitude cost estimates are provided in Figure 25. Note that Right-of-Way costs are not included.

Figure 25: Cost Estimates

7.2 Comparison Table

The following comparison table highlights the key findings from the analysis presented in this report. Boxes highlighted in orange indicate no change or a negative impact; boxes highlighted in green indicate a positive impact.

A more technical and detailed assessment is presented in section *7.3 Evaluation Matrix*.

Figure 26: Alternative Comparison Table

	Do Nothing	1 - Signal & realign	2 - Move Intersection	3 - Roundabout	Short Term Measures
Cost*	$0	$268,000	$190,000	$550,000	<$50,000
Right of Way Impacts	None	1	3	3	2
Park Impacted Adversely? (per Section 4F legislation)	No	No	Likely	No	No
Level of Service/Delay	D/E/F	A/B	D/E/F	A	D/E/F
Impact to Community Center Plans	No	No	Yes	No	No
Airport Drive Approach	No Change	Improved	Improved	Improved	Improved
Congestion	No Change	Improved	No Change	Improved	No Change
Pedestrian Access	No Change	Improved	Improved	Improved	Improved
Winter Driveability	No Change	No Change	Improved	Improved	No Change
Safety	No Change	Improved	Improved	Improved	Improved
Sight Distance	Insufficient	Sufficient	Sufficient	Sufficient	Sufficient

7.3 Evaluation Matrix

A summary of the potential impacts for each alternative is presented in the Evaluation Matrix in Figure 27.

Figure 27: Evaluation Matrix

	Bristol Intersection Study	0 - Do Nothing	1 - Signal	2 - Move Intersect	3 - Roundabout
COST	Conceptual Cost Estimate (construction cost + contingency)	$0	$268,000	$190,000	$550,000
ENGINEERING	Utility Impacts	No	Yes	Yes	Yes
	ADA Compliance	Yes	Yes	Yes	Yes
	Right of Way Impacts	No	School Property	School, Am Legion & Rec Center Property	School, Nelson & American Legion Property
ENVIRONMENTAL IMPACTS	Prime Soils	No	Statewide Soils	Statewide Soils	Statewide Soils
	Archaeological	No	No	No	No
	Historic Structures/Sites	No	No	No	No
	Floodplain	No	No	No	No
	Fish and Wildlife	No	No	No	No
	Rare, Threatened & Endangered	No	No	No	No
	Public Lands	No	No	No	No
	Noise	No	No	No	No
	Wetlands	No	No	No	No
LOCAL & REGIONAL ISSUES	Community Character	No	Yes	Yes	Yes
	Economic Impacts	No	Yes	Yes	Yes
PERMITS	Act 250	No	No	No	No
	401 Water Quality	No	No	No	No
	404 Corps of Engineers Permit	No	No	No	No
	Stream Alteration	No	No	No	No
	Conditional Use Determination	No	No	No	No
	Storm Water Discharge	No	Not Likely	Likely	Likely
	Construction General Permit	No	Yes	Yes	Yes
	Shoreland Encroachment	No	No	No	No
	Endangered & Threatened Species	No	No	No	No
	VTrans Utilities ROW/Access Permit	No	Yes	Yes	Yes
	SHPO Clearance	No	No	No	No
	NEPA Process Required	No	No	Yes	No
	4(f) Process Required	No	No	Yes	No
Other	Level of Service	D/E/F	A/B	D/E/F	A
	Impact to Community Center Plans	No	No	Yes	No
	Impact to Community Center Plans	No	No	Yes	No
	Pedestrian Access	No Change	Improved	Improved	Improved
	Winter Driveability	No Change	No Change	Improved	Improved
	Safety	No Change	Improved	Improved	Improved
	Sight Distance	Insufficient	Sufficient	Sufficient	Sufficient

assumes federal funds used

7.4 Public Involvement

The information gathered to this point was presented to the Bristol Selectboard and the public at two meetings: the Local Concerns Meeting and Alternatives Presentation on 10 August and 21 September 2009, respectively.

Feedback from the Local Concerns meeting is summarized in section *5.1 Identified Issues*. These comments, which primarily focused on safety, sight distance, and pedestrian access, guided the development of the three study alternatives.

At the Alternatives presentation meeting, there was general interest in all three alternatives. Concerns for the traffic signal focused on winter driveability (e.g. trucks needing to stop at a red light on a steep hill). Concerns for the realignment focused on impact to the Deerleap Community Center and pedestrian access. Concerns for the roundabout focused on queues, ability to navigate the roundabout, and potential funding sources (the roundabout is likely eligibile for more federal funding than the other two alternatives).

Notes from both of these meetings are provided in Appendix G.

7.5 Preferred Alternative

It is in the best interest of the stakeholder group, namely the existing Recreation Center, MAUHS, and the Town of Bristol, to pursue several or all of the short-term recommendations, as outlined in section *5.7 Short-Term Measures*. Once the plans for the proposed Deerleap Community Center are finalized, with regard to layout, hours of operation, and land use type, the study intersection should be re-assessed to determine a preferred alternative. In the meantime, implementing the short-term recommendations will improve access, sight distance, safety, and driver awareness in the study area.

Therefore, based on the information available to date and the relatively unknown nature of the Deerleap Community Center, there is no preferred alternative at this time.

7.6 Project Timeline

Many of the short-term recommendations, such as new signage, a radar feedback sign, and clearing and trimming, can be implemented in the very near term (within two years). Other recommendations, such as re-aligning the roadway and installing a multi-use path or sidewalk, will likely fall in the three to five year range.

The timeline for the other alternatives is largely dependent on the finalization of the Deerleap Community Center's redevelopment plans. Once finalized, each of these projects is likely to be installed in three to five years, including time to scope, design, permit, and construct the project.

7.7 Potential Funding Sources

For each of these alternatives, there are several funding sources that are available. The following sections provide a summary of the most common sources that are typically pursued for transportation project funding.

7.7.1 Federal and State Transportation Funds

Federal transportation funds are provided through several standard programs and typically require a non-federal match. The match is most often covered with state funds (approved by the Legislature) and local funds (in municipal capital budgets approved by the voters). Non-federal match could also be provided from private sector sources. All projects or services in Addison County that use federal funds must be included on the ACRPC's Transportation Improvement Program (TIP).[1] Federal/state programs that may fund some portion of the recommendations include the following:

- ***Surface Transportation Program/VTrans Capital Program (STP)*** – Projects on the federal aide highway system can be funded through the Surface Transportation Program. STP funds have the most flexible uses of any federal transportation funds and may be used for highway,

[1] The TIP identifies federally funded, multimodal transportation projects and operations in the ACRPC region. It authorizes the implementing agency (e.g., Vermont Agency of Transportation) to obligate federal funds for listed projects and operations over the next four federal fiscal years.

transit, park and ride lot, and non-motorized facility construction and improvements. STP funds are distributed to a variety of transportation programs. The non-federal match is 20%. For projects that are completely on the state system, the state covers the 20% match.[1] When local roads or bridges are involved, a local match of 10%–20% may be required depending on the classification of the highways involved and other factors. Projects using STP funds must be on the ACRPC TIP and included in a state's Transportation Capital Program approved by the Legislature.

- ***Transportation Enhancement Program (TE)*** – Transportation enhancements include several types of projects, such as bicycle and pedestrian facilities; landscaping, gateways, and other scenic beautification projects; and rehabilitation of historic transportation buildings, structures, and facilities.[2] This competitive grant program provides a maximum of 80% federal funds with the non-federal match often funded by the applicant.
- ***Bicycle and Pedestrian Program (B/P)*** – This competitive grant program is similar to the transportation enhancement program and could be used to fund specific bicycle and pedestrian facility improvements identified.
- ***Congestion Mitigation and Air Quality (CMAQ)*** – CMAQ Funds are intended for projects that reduce congestion and improve air quality. VTrans uses most of its CMAQ funds to support public transit. These funds have a three year time limit for specific projects and could be applied toward capital or operational costs for initiating transit recommendations in the plan.
- ***State Highway Safety Program (SHSP) & Highway Safety Improvement Program (HSIP)*** – These programs are part of federal legislation (TEA-21 and SAFETEA-LU) designed to reduce traffic crashes and resulting deaths, injuries, and property damage. Safety improvements such as traffic signals or roundabouts are typically eligible for 100% Federal Funds. Eligibility may be limited due to a lack of known crash history at the project intersection.

7.7.2 Local Funds

Local funds can be used to match federal- or state-funded projects or to finance the complete cost of a project. Property taxes are the primary source of local funds, but other sources, such as impact fees, can be used to help pay for transportation projects.

- ***Traffic Impact Fees*** – Traffic or transportation impact fees are used to fund a list of projects identified in their capital improvement plans. Through impact fees, new developments pay a "fair-share" of the costs related to updating and improving infrastructure based on the amount of "impact" the development would have on that infrastructure. The impact fees would be calculated to pay for a specific list of projects that are identified in adopted ordinances and have helped to pay for them.[3]
- ***Municipal Bonds*** – Some municipalities choose to use municipal bonds to fund large infrastructure projects. Local governments have several options available to raise revenue for paying back a bond. The most common options are briefly described below. Careful review of the advantages of each method, including reliable estimates on how these options affect local tax rates, is necessary before selecting an appropriate funding mechanism. Municipal bonds could be used to finance the reconstruction of a major intersection such as Airport Road and VT 17/116.

[1] VT116/17 west of the project intersection is owned and maintained by the state. Therefore, the state would cover the non-federal match. East of the project intersection is a Class 1 Town Highway and a local match of 10% would likely be required.

[2] Visit the VTrans transportation enhancement website for a complete listing of eligible activities. http://www.aot.state.vt.us/progdev/Sections/LTF/Enhancements%20Program/EnhancementsHomePage.htm

[3] For example - current impact fees are $144.56/PM peak hour vehicle trip generated in South Burlington and $300/PM peak hour trip generated in Williston.

- Special Assessment Tax District – A special assessment district can be created where property owners, who presumably benefit from the investment, pay a special tax to cover the cost of bond payments. Special assessment districts could be established for a designated area of a municipality or could be distributed across an entire municipality.
- Tax Increment Financing District – A tax increment financing district (TIF) can be established that dedicates the non-school taxes generated by increased property values to pay off the bond. A TIF is most appropriate where property values are expected to increase significantly. For most municipalities, only the municipal portion of the property tax can be retained (the balance goes to the state education tax pool), significantly reducing the amount of revenue that can be generated from a TIF.
- Transportation Impact Fees – Impact fees, as described above, can also be used to pay for a bond. Because impact fees depend on the pace of development, they do not generate the constant revenue stream necessary for bond payments.
- Local Option Sales Taxes – The State of Vermont allows the following taxes to be collected as part of the Local Option Sales Tax (LOST): A 1% sales tax; a 1% meals and alcoholic beverages tax; and a 1% rooms tax. LOST is permitted for Vermont municipalities that were affected a certain way by Act 60 and Act 68. Only certain municipalities are allowed to implement Local Option Sales Taxes (Bristol is NOT currently on the list of eligible municipalities).

7.7.3 Private Funds

Developers, institutions such as the Deerleap Community Center, or any entity that is seeking to develop or redevelop land, are often charged impact fees and/or pay for and implement additional modifications to the transportation system. These contributions are negotiated through the development review process but may also arise through the planning and project development processes.

7.7.4 Community Development Block Grants

Federal (HUD) funds to support community redevelopment activities. These activities may include transportation-related projects such as streetscaping, lighting, sidewalk/pedestrian amenities. They must be applied in neighborhoods meeting certain economic criteria. F for more information see the Vermont Community Development Program in the Department of Housing and Community Affairs website at http://www.dhca.state.vt.us/VCDP/index.htm.

7.8 Act 250 Criterion

There are two criteria that are concerned with transportation facilities in the Act 250 process: Criterion 5 and Criterion 9k. The specific requirements of these are:

- **Criterion 5 – Highways and Other Means of Transportation:** Demonstrate that the project will not cause unreasonable congestion or unsafe conditions with respect to the use of highways and other means of transportation.
- **Criterion 9K – Public Investments:** Demonstrate that the project will not endanger any adjacent public investment.

A Traffic Impact Study (TIS) is typically sufficient to address these requirements. However, it should be noted that the TIS will only address the transportation side of Criterion 9K ; public investments such as parks or public buildings are not covered by this assessment.

Once the Deerleap Community Center plans are finalized, a detailed TIS should be conducted to satisfy local and state permitting needs.

8.0 PROJECT SUMMARY

The VT 17/VT 116/Airport Road intersection provides access to the Mount Abraham Union High School and the adjacent existing Recreation Center, which includes an ice hockey rink, ball fields, and a community center for teenagers after school (called "The Hub"). The Recreation Center is currently planned for redevelopment, into the Deerleap Community Center. The new facility will potentially include an indoor hockey rink with bleachers and locker rooms, meeting space, a fitness center, and associated retail uses. Final plans for this project have yet to be determined.

The Airport Road approach to the intersection currently experiences Level of Service E in the AM Peak Hour, and sight distances are obstructed by overgrown trees and brush on the south side of VT 17/VT 116. There is not a significant history of crashes at the study intersection, but the local sentiment indicates that safety is a concern at the intersection. This feeling is likely attributable to the issues of poor intersection geometry, limited sight distance, the proximity to the school and the associate user group.

An assessment of turn lane warrants (in the unsignalized condtion[1]) suggests that the westbound right turn lane is warranted under existing and future conditions. The southbound right turn lane is warranted in the future condition only. A traffic signal is also warranted in both scenarios, under the 4-hour and peak hour warrants. Current geometry is sufficient in the signalized condition both now and in the future design year.

Agricultural soils of statewide importance can be found throughout the study area, and the Recreation Center property is considered protected public land. Otherwise, there are no other significant environmental constraints in the project area.

Bicycle and Pedestrian facilities consist of a sidewalk network that runs along the north side of VT 17/VT 116, beginning at the Airport Road intersection and heading eastward into town. There are no sidewalk connections from this point to the school, the Recreation Center, or down Stoney Hill Road towards Lovers Lane.

In response to these issues, three transportations alternatives are considered: a traffic signal, re-align the roadway, and a roundabout. A list of short-term, low-cost recommendations that will improve safety and driver awareness at the study intersection is also provided.

The 2019 traffic assessment for each of the alternatives shows that the traffic signal and roundabout will both reduce congestion and improve safety. The realignment will address safety and winter driveability concerns.

9.0 RECOMMENDATIONS

The recommended action at this time is for the Town of Bristol to proceed with some or all of the short-term safety recommendations as soon as possible. Given that the intersection is currently experiencing significant peak hour delay and that lane and signal warrants are met, it is recommended that as soon as possible, a long term plan of action be implemented by:

1. choosing a preferred long term alternative - either the signal or the roundabout
2. pursue possible funding avenues, including identifying potential partners

Once the Deerleap Community Center plans are finalized it is likely that these congestion and safety improvements will be required to be in place before being put into operation, depending on the exact size and nature of the project.

[1] The need for additional turn lanes at signalized intersections are determined by the capacity analysis.

Appendix A:
Traffic Volumes, Adjustments and Trip Generation

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Trip Generation - Airport Road Intersection

Existing Trips

	ITE Code	ITE Land Use Name	Size	Weekday AM Enter	Weekday AM Exit	Weekday PM Enter	Weekday PM Exit
	210	Single-Family Detached Housing	10 units	2	6	6	4
Proposed	495	Recreational Community Center	66,535 sq ft	66	42	36	61
			Subtotal	68	48	42	65
			TOTAL	115		107	

AM Peak Hour of Adjacent Street Traffic

ITE Code 210 Single-Family Detached Housing

Name	Nelson Family Development					Number of Studies	286
Size	10	Number of Dwelling Units				Average Size of Independent Variable	194
% Enter	25%					Range of Rates (low)	0.33
% Exit	75%					Range of Rates (high)	2.27
Passby Rate	0%					Standard Deviation	0.90
		Total TG	Prim. Enter	Prim. Exit	Pass. Enter	Pass. Exit	110%AvgRt	0.83
Average Trip Rate	0.75	8	2	6	0	0	
r^2	0.89	17	4	13	0	0	

ITE Code 495 Recreational Community Center

Name	Deerleap Community Center					Number of Studies	3
Size	67	1000 Sq. Feet Gross Area				Average Size of Independent Variable	76
% Enter	61%					Range of Rates (low)	1.08
% Exit	39%					Range of Rates (high)	2.71
Passby Rate	0%					Standard Deviation	1.45
		Total TG	Prim. Enter	Prim. Exit	Pass. Enter	Pass. Exit	110%AvgRt 1.78
Average Trip Rate	1.62	108	66	42	0	0	
r^2	n/a	n/a	n/a	n/a	n/a	n/a	

PM Peak Hour of Adjacent Street Traffic

ITE Code 210 Single-Family Detached Housing

Name	Nelson Family Development					Number of Studies	314
Size	10	Number of Dwelling Units				Average Size of Independent Variable	208
% Enter	63%					Range of Rates (low)	0.42
% Exit	37%					Range of Rates (high)	2.98
Passby Rate	0%					Standard Deviation	1.05
		Total TG	Prim. Enter	Prim. Exit	Pass. Enter	Pass. Exit	110%AvgRt 1.11
Average Trip Rate	1.01	10	6	4	0	0	
r^2	0.91	3	2	1	0	0	

ITE Code 495 Recreational Community Center

Name	Deerleap Community Center					Number of Studies	4
Size	67	1000 Sq. Feet Gross Area				Average Size of Independent Variable	73
% Enter	37%					Range of Rates (low)	1.05
% Exit	63%					Range of Rates (high)	2.78
Passby Rate	0%					Standard Deviation	1.28
		Total TG	Prim. Enter	Prim. Exit	Pass. Enter	Pass. Exit	110%AvgRt 1.60
Average Trip Rate	1.45	96	36	61	0	0	
r^2	n/a	n/a	n/a	n/a	n/a	n/a	

09/30/09 11:41 AM

Raw Count Data

VT 17/VT 116/Lovers Lan
Bristol, VT
6/1/2009

	EB	WB	NB	SB	
LT					
TH	296	333			
RT					629
Enter	296	333	0	0	629
Exit	296	333	0	0	629
% Trucks					
Peds					PHF
Peak Hour					

01/00/00
Main St/Airport Road
Bristol, VT
6/3/2009
1st Wednesday
RSG Count

0	EB	WB	NB	SB	
LT	162	0	0	84	
TH	134	275	0	0	
RT	0	222	0	58	935
Enter	296	497	0	142	935
Exit	218	333	384	0	935
Trucks	0.0%	0.0%	0.0%	0.0%	
Peds	0	0	0	0	PHF
k Hour	7:30 AM - 8:30 AM Peak				0.81

DHV & Annual Adjustments to 2009

ATR/CTC ID	S6A127		
Location	Bristol: VT116 0.1 mi E of VT17(west)		
Poll Group	Rural Primary and Secondary		
ATR/CTC Year	2008	Annual Growth	0.7%
ATR/CTC AADT	6,000	Corr. AADT	6,039
TM Count Year	2009		
DHV (Equation)	680	DHV Adj.	1.12
DHV (K-Factor)	680	Annual Adj.	1.00
Corr. Count	608	Total Adj.	1.12

TM Count Year	2009		
		DHV Adj.	1.12
		Annual Adj.	1.00
		Total Adj.	1.12

Existing Condition 2009

	EB	WB	NB	SB	
LT	0	0	0	0	
TH	331	372	0	0	
RT	0	0	0	0	703
Enter	331	372	0	0	703
Exit	331	372	0	0	703

	EB	WB	NB	SB	
LT	181	0	0	94	
TH	150	308	0	0	
RT	0	248	0	65	1046
Enter	331	556	0	159	1046
Exit	244	372	429	0	1046

Trip Generation

	Enter	Exit	
10 Housing Units	2	6	8
Rec Center	66	42	108

	EB	WB	NB	SB	
LT					
TH	28	39			
RT					67
Enter	28	39	0	0	67
Exit	28	39	0	0	67

	EB	WB	NB	SB	
LT	28			25	
TH	1	3			
RT		38		17	112
Enter	29	41	0	42	112
Exit	26	20	66	0	112

Annual Adj.

1.067

1.067

Future No Build 2019

	EB	WB	NB	SB	
LT	0	0	0	0	
TH	353	397	0	0	
RT	0	0	0	0	751
Enter	353	397	0	0	751
Exit	353	397	0	0	751

	EB	WB	NB	SB	
LT	193	0	0	100	
TH	160	328	0	0	
RT	0	265	0	69	1116
Enter	353	593	0	169	1116
Exit	260	397	458	0	1116

Future Build 2019

	EB	WB	NB	SB	
LT	0	0	0	0	
TH	381	436	0	0	
RT	0	0	0	0	817
Enter	381	436	0	0	817
Exit	381	436	0	0	817

	EB	WB	NB	SB	
LT	221	0	0	125	
TH	161	331	0	0	
RT	0	303	0	86	1227
Enter	382	634	0	211	1227
Exit	286	418	524	0	1227

09/30/09 11:41 AM

Raw Count Data

VT 17/VT 116/Lovers Lane
Bristol, VT
6/1/2009

	EB	WB	NB	SB	
LT					
TH	269	339			
RT					608
Enter	269	339	0	0	608
Exit	269	339	0	0	608
% Trucks					
Peds					PHF
Peak Hour					

01/00/00
Main St/Airport Road
Bristol, VT
6/3/2009
1st Wednesday
RSG Count

0	EB	WB	NB	SB	
LT	43	0	0	157	
TH	226	235	0	0	
RT	0	56	0	104	821
Enter	269	291	0	261	821
Exit	383	339	99	0	821
Trucks	0.0%	0.0%	0.0%	0.0%	
Peds	0	0	0	0	PHF
k Hour	2:30 PM - 3:30 PM Peak				0.60

DHV & Annual Adjustments to 2009

ATR/CTC ID	S6A127		
Location	Bristol: VT116 0.1 mi E of VT17(west)		
Poll Group	Rural Primary and Secondary		
ATR/CTC Year	2008	Annual Growth	0.65%
ATR/CTC AADT	6,000	Corr. AADT	6,039
TM Count Year	2009		
DHV (Equation)	680	DHV Adj.	1.12
DHV (K-Factor)	680	Annual Adj.	1.00
Corr. Count	608	Total Adj.	1.12

TM Count Year	2009		
		DHV Adj.	1.12
		Annual Adj.	1.00
		Total Adj.	1.12

Existing Condition 2009

	EB	WB	NB	SB	
LT	0	0	0	0	
TH	301	379	0	0	
RT	0	0	0	0	680
Enter	301	379	0	0	680
Exit	301	379	0	0	680

	EB	WB	NB	SB	
LT	48	0	0	176	
TH	253	263	0	0	
RT	0	63	0	116	918
Enter	301	325	0	292	918
Exit	428	379	111	0	918

Trip Generation

	Enter	Exit	
10 Housing Units	6	4	10
Rec Center	36	61	96

	EB	WB	NB	SB	
LT					
TH	38	24			
RT					62
Enter	38	24	0	0	62
Exit	38	24	0	0	62

	EB	WB	NB	SB	
LT	16			37	
TH	3	2			
RT		20		24	101
Enter	18	22	0	61	101
Exit	39	26	36	0	101

Annual Adj.

1.067

1.067

Future No Build 2019

	EB	WB	NB	SB	
LT	0	0	0	0	
TH	321	405	0	0	
RT	0	0	0	0	726
Enter	321	405	0	0	726
Exit	321	405	0	0	726

	EB	WB	NB	SB	
LT	51	0	0	187	
TH	270	280	0	0	
RT	0	67	0	124	980
Enter	321	347	0	311	980
Exit	457	405	118	0	980

Future Build 2019

	EB	WB	NB	SB	
LT	0	0	0	0	
TH	359	428	0	0	
RT	0	0	0	0	787
Enter	359	428	0	0	787
Exit	359	428	0	0	787

	EB	WB	NB	SB	
LT	67	0	0	224	
TH	272	283	0	0	
RT	0	87	0	148	1081
Enter	339	370	0	372	1081
Exit	496	431	154	0	1081

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Appendix B:
Level of Service Worksheets

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HCM Unsignalized Intersection Capacity Analysis 2009 AM
3: Int 8/14/2009

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lanes	1	1			1>	0				1>		0
Volume (veh/h)	181	150			308	248				94		65
Sign Control		Free			Free					Stop		
Grade		0%			0%					0%		
Peak Hour Factor	0.92	0.92			0.92	0.92				0.92		0.92
Hourly flow rate (vph)	197	163			335	270				102		71
Pedestrians												
Lane Width (ft)												
Walking Speed (ft/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (ft)												
pX, platoon unblocked												
vC, conflicting volume	604									1026		470
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	604									1026		470
tC, single (s)	4.1									6.4		6.2
tC, 2 stage (s)												
tF (s)	2.2									3.5		3.3
p0 queue free %	80									51		88
cM capacity (veh/h)	973									207		594

Direction, Lane #	EB 1	EB 2	WB 1	SB 1
Volume Total	197	163	604	173
Volume Left	197	0	0	102
Volume Right	0	0	270	71
cSH	973	1700	1700	283
Volume to Capacity	0.20	0.10	0.36	0.61
Queue Length 95th (ft)	19	0	0	93
Control Delay (s)	9.6	0.0	0.0	35.9
Lane LOS	A			E
Approach Delay (s)	5.3		0.0	35.9
Approach LOS				E

Intersection Summary				
Average Delay	7.1			
Intersection Capacity Utilization		60.6%	ICU Level of Service	B
Analysis Period (min)	15			

Synchro 7 - Report
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HCM Signalized Intersection Capacity Analysis 2009 AM - Signalized
3: Int 8/14/2009

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	1	1			1>	0				1>		0
Volume (vph)	181	150			308	248				94		65
Ideal Flow (vphpl)	1900	1900			1900	1900				1900		1900
Total Lost time (s)	6.0	6.0			6.0					6.0		
Lane Util. Factor	1.00	1.00			1.00					1.00		
Frt	1.00	1.00			0.94					0.94		
Flt Protected	0.95	1.00			1.00					0.97		
Satd. Flow (prot)	1770	1863			1751					1709		
Flt Permitted	0.33	1.00			1.00					0.97		
Satd. Flow (perm)	616	1863			1751					1709		
Peak-hour factor, PHF	0.92	0.92			0.92	0.92				0.92		0.92
Adj. Flow (vph)	197	163			335	270				102		71
RTOR Reduction (vph)	0	0			55	0				44		0
Lane Group Flow (vph)	197	163			550	0				129		0
Turn Type	Perm											
Protected Phases		4			8					6		
Permitted Phases	4											
Actuated Green, G (s)	18.6	18.6			18.6					8.7		
Effective Green, g (s)	18.6	18.6			18.6					8.7		
Actuated g/C Ratio	0.47	0.47			0.47					0.22		
Clearance Time (s)	6.0	6.0			6.0					6.0		
Vehicle Extension (s)	3.0	3.0			3.0					3.0		
Lane Grp Cap (vph)	292	882			829					378		
v/s Ratio Prot		0.09			0.31					c0.08		
v/s Ratio Perm	c0.32											
v/c Ratio	0.67	0.18			0.66					0.34		
Uniform Delay, d1	8.0	6.0			7.9					12.9		
Progression Factor	1.00	1.00			1.00					1.00		
Incremental Delay, d2	6.0	0.1			2.0					0.5		
Delay (s)	14.0	6.1			10.0					13.4		
Level of Service	B	A			A					B		
Approach Delay (s)		10.4			10.0					13.4		
Approach LOS		B			A					B		

Intersection Summary

HCM Average Control Delay	10.6	HCM Level of Service		B
HCM Volume to Capacity ratio	0.57			
Actuated Cycle Length (s)	39.3	Sum of lost time (s)		12.0
Intersection Capacity Utilization		65.6%	ICU Level of Service	C
Analysis Period (min)	15			

c Critical Lane Group

Synchro 7 - Report
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HCM Unsignalized Intersection Capacity Analysis 2009 PM
3: Int 8/14/2009

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lanes	1	1			1>	0				1>		0
Volume (veh/h)	48	253			263	63				176		116
Sign Control		Free			Free					Stop		
Grade		0%			0%					0%		
Peak Hour Factor	0.92	0.92			0.92	0.92				0.92		0.92
Hourly flow rate (vph)	52	275			286	68				191		126
Pedestrians												
Lane Width (ft)												
Walking Speed (ft/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (ft)												
pX, platoon unblocked												
vC, conflicting volume	354									699		320
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	354									699		320
tC, single (s)	4.1									6.4		6.2
tC, 2 stage (s)												
tF (s)	2.2									3.5		3.3
p0 queue free %	96									51		83
cM capacity (veh/h)	1204									388		721

Direction, Lane #	EB 1	EB 2	WB 1	SB 1
Volume Total	52	275	354	317
Volume Left	52	0	0	191
Volume Right	0	0	68	126
cSH	1204	1700	1700	475
Volume to Capacity	0.04	0.16	0.21	0.67
Queue Length 95th (ft)	3	0	0	121
Control Delay (s)	8.1	0.0	0.0	26.5
Lane LOS	A			D
Approach Delay (s)	1.3		0.0	26.5
Approach LOS				D

Intersection Summary				
Average Delay	8.8			
Intersection Capacity Utilization		47.9%	ICU Level of Service	A
Analysis Period (min)	15			

Synchro 7 - Report
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HCM Signalized Intersection Capacity Analysis   2009 PM - Signalized
3: Int 8/14/2009

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	1	1			1>	0				1>		0
Volume (vph)	48	253			263	63				176		116
Ideal Flow (vphpl)	1900	1900			1900	1900				1900		1900
Total Lost time (s)	6.0	6.0			6.0					6.0		
Lane Util. Factor	1.00	1.00			1.00					1.00		
Frt	1.00	1.00			0.97					0.95		
Flt Protected	0.95	1.00			1.00					0.97		
Satd. Flow (prot)	1770	1863			1814					1711		
Flt Permitted	0.55	1.00			1.00					0.97		
Satd. Flow (perm)	1023	1863			1814					1711		
Peak-hour factor, PHF	0.92	0.92			0.92	0.92				0.92		0.92
Adj. Flow (vph)	52	275			286	68				191		126
RTOR Reduction (vph)	0	0			20	0				59		0
Lane Group Flow (vph)	52	275			334	0				258		0
Turn Type	Perm											
Protected Phases		4			8					6		
Permitted Phases	4											
Actuated Green, G (s)	11.1	11.1			11.1					10.2		
Effective Green, g (s)	11.1	11.1			11.1					10.2		
Actuated g/C Ratio	0.33	0.33			0.33					0.31		
Clearance Time (s)	6.0	6.0			6.0					6.0		
Vehicle Extension (s)	3.0	3.0			3.0					3.0		
Lane Grp Cap (vph)	341	621			605					524		
v/s Ratio Prot		0.15			c0.18					c0.15		
v/s Ratio Perm	0.05											
v/c Ratio	0.15	0.44			0.55					0.49		
Uniform Delay, d1	7.8	8.7			9.1					9.4		
Progression Factor	1.00	1.00			1.00					1.00		
Incremental Delay, d2	0.2	0.5			1.1					0.7		
Delay (s)	8.0	9.2			10.2					10.2		
Level of Service	A	A			B					B		
Approach Delay (s)		9.0			10.2					10.2		
Approach LOS		A			B					B		

Intersection Summary

HCM Average Control Delay	9.8	HCM Level of Service	A
HCM Volume to Capacity ratio	0.52		
Actuated Cycle Length (s)	33.3	Sum of lost time (s)	12.0
Intersection Capacity Utilization	52.9%	ICU Level of Service	A
Analysis Period (min)	15		

c   Critical Lane Group

HCM Unsignalized Intersection Capacity Analysis 2019 AM
3: Int 8/14/2009

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lanes	1	1			1>	0				1>		0
Volume (veh/h)	221	161			331	303				125		86
Sign Control		Free			Free					Stop		
Grade		0%			0%					0%		
Peak Hour Factor	0.92	0.92			0.92	0.92				0.92		0.92
Hourly flow rate (vph)	240	175			360	329				136		93
Pedestrians												
Lane Width (ft)												
Walking Speed (ft/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (ft)												
pX, platoon unblocked												
vC, conflicting volume	689									1180		524
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	689									1180		524
tC, single (s)	4.1									6.4		6.2
tC, 2 stage (s)												
tF (s)	2.2									3.5		3.3
p0 queue free %	73									12		83
cM capacity (veh/h)	905									154		553

Direction, Lane #	EB 1	EB 2	WB 1	SB 1
Volume Total	240	175	689	229
Volume Left	240	0	0	136
Volume Right	0	0	329	93
cSH	905	1700	1700	219
Volume to Capacity	0.27	0.10	0.41	1.05
Queue Length 95th (ft)	27	0	0	249
Control Delay (s)	10.4	0.0	0.0	121.2
Lane LOS	B			F
Approach Delay (s)	6.0		0.0	121.2
Approach LOS				F

Intersection Summary				
Average Delay	22.7			
Intersection Capacity Utilization		70.4%	ICU Level of Service	C
Analysis Period (min)	15			

Synchro 7 - Report
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HCM Signalized Intersection Capacity Analysis 2019 AM - Signalized
3: Int 8/14/2009

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	1	1			1>	0				1>		0
Volume (vph)	221	161			331	303				125		86
Ideal Flow (vphpl)	1900	1900			1900	1900				1900		1900
Total Lost time (s)	6.0	6.0			6.0					6.0		
Lane Util. Factor	1.00	1.00			1.00					1.00		
Frt	1.00	1.00			0.94					0.95		
Flt Protected	0.95	1.00			1.00					0.97		
Satd. Flow (prot)	1770	1863			1743					1710		
Flt Permitted	0.29	1.00			1.00					0.97		
Satd. Flow (perm)	536	1863			1743					1710		
Peak-hour factor, PHF	0.92	0.92			0.92	0.92				0.92		0.92
Adj. Flow (vph)	240	175			360	329				136		93
RTOR Reduction (vph)	0	0			52	0				39		0
Lane Group Flow (vph)	240	175			637	0				190		0
Turn Type	Perm											
Protected Phases		4			8					6		
Permitted Phases	4											
Actuated Green, G (s)	29.1	29.1			29.1					11.1		
Effective Green, g (s)	29.1	29.1			29.1					11.1		
Actuated g/C Ratio	0.56	0.56			0.56					0.21		
Clearance Time (s)	6.0	6.0			6.0					6.0		
Vehicle Extension (s)	3.0	3.0			3.0					3.0		
Lane Grp Cap (vph)	299	1039			972					364		
v/s Ratio Prot		0.09			0.37					c0.11		
v/s Ratio Perm	c0.45											
v/c Ratio	0.80	0.17			0.66					0.52		
Uniform Delay, d1	9.3	5.6			8.1					18.2		
Progression Factor	1.00	1.00			1.00					1.00		
Incremental Delay, d2	14.3	0.1			1.6					1.3		
Delay (s)	23.6	5.7			9.7					19.5		
Level of Service	C	A			A					B		
Approach Delay (s)		16.1			9.7					19.5		
Approach LOS		B			A					B		

Intersection Summary

HCM Average Control Delay 13.3 HCM Level of Service B
HCM Volume to Capacity ratio 0.73
Actuated Cycle Length (s) 52.2 Sum of lost time (s) 12.0
Intersection Capacity Utilization 75.4% ICU Level of Service D
Analysis Period (min) 15
c Critical Lane Group

Synchro 7 - Report
Page 0

HCM Unsignalized Intersection Capacity Analysis 2019 PM
3: Int 8/14/2009

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lanes	1	1			1>	0				1>		0
Volume (veh/h)	67	272			283	87				224		148
Sign Control		Free			Free					Stop		
Grade		0%			0%					0%		
Peak Hour Factor	0.92	0.92			0.92	0.92				0.92		0.92
Hourly flow rate (vph)	73	296			308	95				243		161
Pedestrians												
Lane Width (ft)												
Walking Speed (ft/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (ft)												
pX, platoon unblocked												
vC, conflicting volume	402									796		355
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	402									796		355
tC, single (s)	4.1									6.4		6.2
tC, 2 stage (s)												
tF (s)	2.2									3.5		3.3
p0 queue free %	94									27		77
cM capacity (veh/h)	1156									334		689

Direction, Lane #	EB 1	EB 2	WB 1	SB 1
Volume Total	73	296	402	404
Volume Left	73	0	0	243
Volume Right	0	0	95	161
cSH	1156	1700	1700	420
Volume to Capacity	0.06	0.17	0.24	0.96
Queue Length 95th (ft)	5	0	0	285
Control Delay (s)	8.3	0.0	0.0	66.9
Lane LOS	A			F
Approach Delay (s)	1.6		0.0	66.9
Approach LOS				F

Intersection Summary			
Average Delay	23.5		
Intersection Capacity Utilization	55.4%	ICU Level of Service	B
Analysis Period (min)	15		

Synchro 7 - Report
Page 0

HCM Signalized Intersection Capacity Analysis   2019 PM - Signalized
3: Int 8/14/2009

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	1	1			1>	0				1>		0
Volume (vph)	67	272			283	87				224		148
Ideal Flow (vphpl)	1900	1900			1900	1900				1900		1900
Total Lost time (s)	6.0	6.0			6.0					6.0		
Lane Util. Factor	1.00	1.00			1.00					1.00		
Frt	1.00	1.00			0.97					0.95		
Flt Protected	0.95	1.00			1.00					0.97		
Satd. Flow (prot)	1770	1863			1803					1711		
Flt Permitted	0.48	1.00			1.00					0.97		
Satd. Flow (perm)	903	1863			1803					1711		
Peak-hour factor, PHF	0.92	0.92			0.92	0.92				0.92		0.92
Adj. Flow (vph)	73	296			308	95				243		161
RTOR Reduction (vph)	0	0			25	0				57		0
Lane Group Flow (vph)	73	296			378	0				347		0
Turn Type	Perm											
Protected Phases		4			8					6		
Permitted Phases	4											
Actuated Green, G (s)	12.1	12.1			12.1					12.0		
Effective Green, g (s)	12.1	12.1			12.1					12.0		
Actuated g/C Ratio	0.34	0.34			0.34					0.33		
Clearance Time (s)	6.0	6.0			6.0					6.0		
Vehicle Extension (s)	3.0	3.0			3.0					3.0		
Lane Grp Cap (vph)	303	624			604					569		
v/s Ratio Prot		0.16			c0.21					c0.20		
v/s Ratio Perm	0.08											
v/c Ratio	0.24	0.47			0.63					0.61		
Uniform Delay, d1	8.7	9.5			10.1					10.1		
Progression Factor	1.00	1.00			1.00					1.00		
Incremental Delay, d2	0.4	0.6			2.0					1.9		
Delay (s)	9.1	10.1			12.1					12.0		
Level of Service	A	B			B					B		
Approach Delay (s)		9.9			12.1					12.0		
Approach LOS		A			B					B		

Intersection Summary
HCM Average Control Delay 11.4 HCM Level of Service B
HCM Volume to Capacity ratio 0.62
Actuated Cycle Length (s) 36.1 Sum of lost time (s) 12.0
Intersection Capacity Utilization 60.4% ICU Level of Service B
Analysis Period (min) 15
c Critical Lane Group

Synchro 7 - Report
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VT17/VT116 /Airport Drive

9/30/2009 11:50
M. Smith

2009 AM

Roundabout

Vehicle Movements

Mov ID	Turn	Dem Flow (veh/h)	%HV	Deg of Satn (v/c)	Aver Delay (sec)	Level of Service	95% Back of Queue (ft)	Prop. Queued	Eff. Stop Rate	Aver Speed (mph)
VT17/116										
3L	L	181	2.2	0.284	9.3	LOS A	48	0.27	0.61	29.4
8R	R	150	2.0	0.284	5.1	LOS A	48	0.27	0.45	32.9
Approach		**331**	**2.1**	**0.284**	**7.4**	**LOS A**	**48**	**0.27**	**0.54**	**30.9**
VT17/116										
17L	L	308	1.9	0.481	9.0	LOS A	96	0.44	0.64	22.8
14R	R	248	2.0	0.482	4.1	LOS A	96	0.44	0.46	23.9
Approach		**556**	**2.0**	**0.482**	**6.8**	**LOS A**	**96**	**0.44**	**0.56**	**23.3**
Airport Drive										
15L	L	94	2.1	0.163	11.0	LOS B	25	0.44	0.69	28.3
12R	R	65	1.5	0.163	3.2	LOS A	25	0.44	0.38	24.3
Approach		**159**	**1.9**	**0.163**	**7.8**	**LOS A**	**25**	**0.44**	**0.56**	**26.5**
All Vehicles		**1046**	**2.0**	**0.482**	**7.2**	**LOS A**	**96**	**0.38**	**0.55**	**25.6**

Symbols which may appear in this table:

Following Degree of Saturation
x = 1.00 for Short Lane with resulting Excess Flow
* x = 1.00 due to minimum capacity

Following LOS
- Based on density for continuous movements

Following Queue
- Density for continuous movement

VT17/VT116 /Airport Drive

9/30/2009 11:50
M. Smith

2009 PM

Roundabout

Vehicle Movements

Mov ID	Turn	Dem Flow (veh/h)	%HV	Deg of Satn (v/c)	Aver Delay (sec)	Level of Service	95% Back of Queue (ft)	Prop. Queued	Eff. Stop Rate	Aver Speed (mph)
VT17/116										
3L	L	48	2.1	0.293	9.9	LOS A	48	0.38	0.65	29.1
8R	R	253	2.0	0.292	5.6	LOS A	48	0.38	0.51	32.3
Approach		**301**	**2.0**	**0.292**	**6.3**	**LOS A**	**48**	**0.38**	**0.53**	**31.7**
VT17/116										
17L	L	263	1.9	0.242	8.1	LOS A	39	0.17	0.57	23.2
14R	R	63	1.6	0.242	3.2	LOS A	39	0.17	0.34	24.6
Approach		**326**	**1.8**	**0.242**	**7.1**	**LOS A**	**39**	**0.17**	**0.53**	**23.5**
Airport Drive										
15L	L	176	2.3	0.285	11.0	LOS B	45	0.42	0.69	28.4
12R	R	116	1.7	0.285	3.2	LOS A	45	0.42	0.38	24.4
Approach		**292**	**2.1**	**0.285**	**7.9**	**LOS A**	**45**	**0.42**	**0.57**	**26.6**
All Vehicles		**919**	**2.0**	**0.293**	**7.1**	**LOS A**	**48**	**0.32**	**0.54**	**26.5**

Symbols which may appear in this table:

Following Degree of Saturation
x = 1.00 for Short Lane with resulting Excess Flow
* x = 1.00 due to minimum capacity

Following LOS
- Based on density for continuous movements

Following Queue
- Density for continuous movement

VT17/VT116 /Airport Drive

9/30/2009 11:50
M. Smith

2019 AM

Roundabout

Vehicle Movements

Mov ID	Turn	Dem Flow (veh/h)	%HV	Deg of Satn (v/c)	Aver Delay (sec)	Level of Service	95% Back of Queue (ft)	Prop. Queued	Eff. Stop Rate	Aver Speed (mph)
VT17/116										
3L	L	221	1.8	0.341	9.6	LOS A	61	0.33	0.63	29.2
8R	R	161	1.9	0.340	5.3	LOS A	61	0.33	0.47	32.6
Approach		**382**	**1.8**	**0.340**	**7.8**	**LOS A**	**61**	**0.33**	**0.56**	**30.5**
VT17/116										
17L	L	331	2.1	0.570	9.4	LOS A	126	0.54	0.67	22.6
14R	R	303	2.0	0.570	4.5	LOS A	126	0.54	0.51	23.7
Approach		**634**	**2.1**	**0.570**	**7.1**	**LOS A**	**126**	**0.54**	**0.59**	**23.1**
Airport Drive										
15L	L	125	1.6	0.222	11.3	LOS B	36	0.48	0.71	28.2
12R	R	86	2.3	0.222	3.4	LOS A	36	0.48	0.41	24.2
Approach		**211**	**1.9**	**0.222**	**8.1**	**LOS A**	**36**	**0.48**	**0.59**	**26.4**
All Vehicles		**1227**	**2.0**	**0.570**	**7.5**	**LOS A**	**126**	**0.47**	**0.58**	**25.4**

Symbols which may appear in this table:

Following Degree of Saturation
x = 1.00 for Short Lane with resulting Excess Flow
* x = 1.00 due to minimum capacity

Following LOS
- Based on density for continuous movements

Following Queue
- Density for continuous movement

VT17/VT116 /Airport Drive

9/30/2009 11:52
M. Smith

2019 PM

Roundabout

Vehicle Movements

Mov ID	Turn	Dem Flow (veh/h)	%HV	Deg of Satn (v/c)	Aver Delay (sec)	Level of Service	95% Back of Queue (ft)	Prop. Queued	Eff. Stop Rate	Aver Speed (mph)
VT17/116										
3L	L	67	1.5	0.347	10.2	LOS B	60	0.45	0.68	28.9
8R	R	272	1.8	0.346	6.0	LOS A	60	0.45	0.55	31.9
Approach		**339**	**1.8**	**0.347**	**6.8**	**LOS A**	**60**	**0.45**	**0.57**	**31.2**
VT17/116										
17L	L	283	2.1	0.284	8.2	LOS A	49	0.22	0.58	23.2
14R	R	87	2.3	0.283	3.3	LOS A	49	0.22	0.35	24.5
Approach		**370**	**2.2**	**0.284**	**7.0**	**LOS A**	**49**	**0.22**	**0.52**	**23.4**
Airport Drive										
15L	L	224	1.8	0.367	11.2	LOS B	63	0.47	0.71	28.2
12R	R	148	2.0	0.366	3.4	LOS A	63	0.47	0.40	24.2
Approach		**372**	**1.9**	**0.367**	**8.1**	**LOS A**	**63**	**0.47**	**0.59**	**26.4**
All Vehicles		**1081**	**1.9**	**0.367**	**7.3**	**LOS A**	**63**	**0.38**	**0.56**	**26.4**

Symbols which may appear in this table:

Following Degree of Saturation
x = 1.00 for Short Lane with resulting Excess Flow
* x = 1.00 due to minimum capacity

Following LOS
- Based on density for continuous movements

Following Queue
- Density for continuous movement

Appendix C:
Queuing Worksheets

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Queuing and Blocking Report
Baseline 8/14/2009

Intersection: 3: Int

Movement	EB	WB	SB
Directions Served	L	TR	LR
Maximum Queue (ft)	63	17	360
Average Queue (ft)	22	1	149
95th Queue (ft)	53	7	278
Link Distance (ft)		1536	898
Upstream Blk Time (%)			
Queuing Penalty (veh)			
Storage Bay Dist (ft)	435		
Storage Blk Time (%)			
Queuing Penalty (veh)			

Network Summary
Network wide Queuing Penalty: 0

SimTraffic Report
Page 0

Queuing and Blocking Report
Baseline 8/14/2009

Intersection: 3: Int

Movement	EB	EB	WB	SB
Directions Served	L	T	TR	LR
Maximum Queue (ft)	88	172	218	191
Average Queue (ft)	39	78	108	99
95th Queue (ft)	74	140	185	168
Link Distance (ft)		1791	1536	898
Upstream Blk Time (%)				
Queuing Penalty (veh)				
Storage Bay Dist (ft)	435			
Storage Blk Time (%)				
Queuing Penalty (veh)				

Network Summary
Network wide Queuing Penalty: 0

SimTraffic Report
Page 0

Queuing and Blocking Report
Baseline 8/14/2009

Intersection: 3: Int

Movement	EB	WB	SB
Directions Served	L	TR	LR
Maximum Queue (ft)	180	67	428
Average Queue (ft)	72	12	174
95th Queue (ft)	129	42	357
Link Distance (ft)		1536	898
Upstream Blk Time (%)			
Queuing Penalty (veh)			
Storage Bay Dist (ft)	435		
Storage Blk Time (%)			
Queuing Penalty (veh)			

Network Summary
Network wide Queuing Penalty: 0

SimTraffic Report
Page 0

Queuing and Blocking Report
Baseline 8/14/2009

Intersection: 3: Int

Movement	EB	EB	WB	SB
Directions Served	L	T	TR	LR
Maximum Queue (ft)	324	189	411	192
Average Queue (ft)	152	51	158	89
95th Queue (ft)	293	157	317	155
Link Distance (ft)		1791	1536	898
Upstream Blk Time (%)				
Queuing Penalty (veh)				
Storage Bay Dist (ft)	435			
Storage Blk Time (%)	1	0		
Queuing Penalty (veh)	1	0		

Network Summary
Network wide Queuing Penalty: 2

SimTraffic Report
Page 0

Queuing and Blocking Report
Baseline 8/14/2009

Intersection: 3: Int

Movement	EB	WB	SB
Directions Served	L	TR	LR
Maximum Queue (ft)	52	13	198
Average Queue (ft)	16	0	84
95th Queue (ft)	45	5	152
Link Distance (ft)		1536	898
Upstream Blk Time (%)			
Queuing Penalty (veh)			
Storage Bay Dist (ft)	435		
Storage Blk Time (%)			
Queuing Penalty (veh)			

Network Summary
Network wide Queuing Penalty: 0

SimTraffic Report
Page 0

Queuing and Blocking Report
Baseline 8/14/2009

Intersection: 3: Int

Movement	EB	EB	WB	SB
Directions Served	L	T	TR	LR
Maximum Queue (ft)	78	159	179	226
Average Queue (ft)	33	74	85	80
95th Queue (ft)	62	129	146	148
Link Distance (ft)		1791	1536	898
Upstream Blk Time (%)				
Queuing Penalty (veh)				
Storage Bay Dist (ft)	435			
Storage Blk Time (%)				
Queuing Penalty (veh)				

Network Summary
Network wide Queuing Penalty: 0

SimTraffic Report
Page 0

Queuing and Blocking Report
Baseline 8/14/2009

Intersection: 3: Int

Movement	EB	WB	SB
Directions Served	L	TR	LR
Maximum Queue (ft)	112	43	180
Average Queue (ft)	55	8	68
95th Queue (ft)	99	30	130
Link Distance (ft)		1536	898
Upstream Blk Time (%)			
Queuing Penalty (veh)			
Storage Bay Dist (ft)	435		
Storage Blk Time (%)			
Queuing Penalty (veh)			

Network Summary
Network wide Queuing Penalty: 0

SimTraffic Report
Page 0

Queuing and Blocking Report
Baseline 8/14/2009

Intersection: 3: Int

Movement	EB	EB	WB	SB
Directions Served	L	T	TR	LR
Maximum Queue (ft)	168	103	282	135
Average Queue (ft)	87	39	115	61
95th Queue (ft)	142	85	206	114
Link Distance (ft)		1791	1536	898
Upstream Blk Time (%)				
Queuing Penalty (veh)				
Storage Bay Dist (ft)	435			
Storage Blk Time (%)				
Queuing Penalty (veh)				

Network Summary
Network wide Queuing Penalty: 0

SimTraffic Report
Page 0

Appendix D:
Safety Information

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Study Area Crashes, 2003-2007

Street Name	Number	Town	MM	Date	Time	Weather	Contributing Circumstances	Direction Of Collision	# Inj	# Fat	Dir
VT-116	0103/1812-04	Bristol	6.10	1/29/2004	8:24	Clear	Driving too fast for conditions, No improper driving	Rear End	0	0	N
VT-116	0103/12338-04	Bristol	6.11	9/14/2004	11:20	Clear	Operating vehicle in erratic, reckless, careless, negligent, or aggressive manner, Inattention	Rear End	0	0	
VT-116	0103/13472-04	Bristol	6.19	10/11/2004	13:00	Cloudy	Failed to yield right of way, No improper driving	Left Turn and Thru, Angle Broadside -->v--	1	0	E
VT-116	0111/9663-05	Bristol	5.94	6/12/2005	23:09	Cloudy	Operating vehicle in erratic, reckless, careless, negligent, or aggressive manner	Single Vehicle Crash	2	0	S
VT-116	0111/11650-05	Bristol	5.68	6/16/2005	15:36	Clear	No improper driving	Single Vehicle Crash	1	0	
VT-116	0111/9795-05	Bristol	5.88	7/13/2005	1:34	Clear	Failure to keep in proper lane or running off road, Under the influence of medication/drugs/alcohol	Single Vehicle Crash	0	0	E
VT-116	0111/12889-05	Bristol	5.68	9/21/2005	14:50	Clear	No improper driving, Failed to yield right of way	Same Direction Sideswipe	0	0	E
VT-116	0111/14524-05	Bristol	5.78	10/15/2005	23:04	Clear	Failure to keep in proper lane or running off road	Single Vehicle Crash	0	0	W
VT-116	0417/9160-07	Bristol	5.68	7/17/2007	16:33	Cloudy	Followed too closely, Driving too fast for conditions, No improper driving	Rear End	0	0	W

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Appendix E:
Signal & Turn Lane Warrants

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Turn Lane Warrants

Descriptive Data

Intersection	VT 17/Airport Road - Westbound Right
Location	Bristol, VT

Base Year	2009
Future Year	2019
Speed Limit (mph)	30
2- or 4-Lane Highway	2

	EB	WB	NB	SB
Channelized Right Turn	No	No	No	No
Left Turn Lane	Yes	No	No	No
Major or Minor	major		minor	

Traffic Volumes

	AM Peak Hour								PM Peak Hour							
	2009				2019				2009				2019			
	EB	WB	NB	SB	EB	WB	NB	SB	EB	WB	NB	SB	EB	WB	NB	SB
LT	181	0	0	94	193	0	0	100	48	0	0	176	51	0	0	187
TH	150	308	0	0	160	328	0	0	253	263	0	0	270	280	0	0
RT	0	248	0	65	0	265	0	69	0	63	0	116	0	67	0	124
Enter	331	556	0	159	353	593	0	169	301	325	0	292	321	347	0	311
Exit	244	372	429	0	260	397	458	0	428	379	111	0	457	405	118	0

Calculations

Left Turn Lane Warrant: Harmelink Methodology

	EB	WB	NB	SB	EB	WB	NB	SB	EB	WB	NB	SB	EB	WB	NB	SB
Advancing Volume	331	556	0	159	353	593	0	169	301	325	0	292	321	347	0	311
Opposing Volume	308	331	94	0	328	353	100	0	263	301	176	0	280	321	187	0
% Left Turns	55%	0%	-	59%	55%	0%	-	59%	16%	0%	-	60%	16%	0%	-	60%
Adv. Volume not to exceed	278	-	-	-	272	-	-	-	397	-	-	-	389	-	-	-
Warranted?	Yes	-	-	-	Yes	-	-	-	No	-	-	-	No	-	-	-

Left Turn Lane Warrant: Kikuchi and Chakroborty Methodology

	EB	WB	NB	SB	EB	WB	NB	SB	EB	WB	NB	SB	EB	WB	NB	SB
PLTF	0	1	0	0	0	1	0	0	0	1	0	0	0	1	0	0
PLTT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PLTW	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0
Adv. Volume not to exceed	405	885	517	576	395	863	514	576	489	917	471	576	479	896	465	576
Warranted?	No	-	-	-	No	-	-	-	No	-	-	-	No	-	-	-

Right Turn Lane Warrant: VTrans Methodology for Two- and Four-Lane Highways

	EB	WB	NB	SB	EB	WB	NB	SB	EB	WB	NB	SB	EB	WB	NB	SB
Advancing Volume	150	556	0	159	160	593	0	169	253	325	0	292	270	347	0	311
% Right Turns	0%	45%	-	41%	0%	45%	-	41%	0%	19%	-	40%	0%	19%	-	40%
Adv. Volume not to exceed	-	469	-	-	-	469	-	-	-	592	-	-	-	592	-	-
Warranted for 2-Lane Highway?	-	Yes	-	-	-	Yes	-	-	-	No	-	-	-	No	-	-
Warranted for 4-Lane Highway?	-	Yes	-	-	-	Yes	-	-	-	No	-	-	-	No	-	-

Right Turn Lane Warrant: Typical State Design Manual Methodology

	EB	WB	NB	SB	EB	WB	NB	SB	EB	WB	NB	SB	EB	WB	NB	SB
Advancing Volume	331.1	555.9	0	158.8	353.2	593.1	0	169.4	300.9	325.5	0	291.9	321	347.2	0	311.4
Right Turn Volume	0	248.3	0	64.87	0	264.9	0	69.21	0	62.63	0	116.3	0	66.82	0	124.1
Right Turns Not to Exceed	0	0	0	78.82	0	0	0	77.41	0	0	0	61.08	0	0	0	0
Right Turns Not to Exceed	76	46	120	0	73	41	120	0	80	77	120	0	77	74	120	78
Warranted?	-	Yes	-	-	-	Yes	-	-	-	No	-	-	-	No	-	-

Summary Tables

		WB Right Turn Lane	
		AM	PM
VTrans			
	2009	Yes	No
	2019	Yes	No
Typical State Design Manual			
	2009	Yes	No
	2019	Yes	No

Turn Lane Warrants

Descriptive Data

Intersection	VT 17/Airport Road - Southbound Right
Location	Bristol, VT

Base Year	2009
Future Year	2019
Speed Limit (mph)	30
2- or 4-Lane Highway	2

	EB	WB	NB	SB
Channelized Right Turn	No	No	No	No
Left Turn Lane	Yes	No	No	No
Major or Minor	minor		major	

Traffic Volumes

	AM Peak Hour								PM Peak Hour							
	2009				2019				2009				2019			
	EB	WB	NB	SB	EB	WB	NB	SB	EB	WB	NB	SB	EB	WB	NB	SB
LT	181	0	0	94	193	0	0	100	48	0	0	176	51	0	0	187
TH	150	308	0	0	160	328	0	0	253	263	0	0	270	280	0	0
RT	0	248	0	65	0	265	0	69	0	63	0	116	0	67	0	124
Enter	331	556	0	159	353	593	0	169	301	325	0	292	321	347	0	311
Exit	244	372	429	0	260	397	458	0	428	379	111	0	457	405	118	0

Calculations

Left Turn Lane Warrant: Harmelink Methodology

	EB	WB	NB	SB	EB	WB	NB	SB	EB	WB	NB	SB	EB	WB	NB	SB
Advancing Volume	331	556	0	159	353	593	0	169	301	325	0	292	321	347	0	311
Opposing Volume	308	331	94	0	328	353	100	0	263	301	176	0	280	321	187	0
% Left Turns	55%	0%	-	59%	55%	0%	-	59%	16%	0%	-	60%	16%	0%	-	60%
Adv. Volume not to exceed	-	-	#####	#####	-	-	#####	#####	-	-	#####	#####	-	-	#####	#####
Warranted?	-	-	#####	#####	-	-	#####	#####	-	-	#####	#####	-	-	#####	#####

Left Turn Lane Warrant: Kikuchi and Chakroborty Methodology

	EB	WB	NB	SB	EB	WB	NB	SB	EB	WB	NB	SB	EB	WB	NB	SB
PLTF	0	1	0	0	0	1	0	0	0	1	0	0	0	1	0	0
PLTT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PLTW	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0
Adv. Volume not to exceed	405	885	517	576	395	863	514	576	489	917	471	576	479	896	465	576
Warranted?	-	-	-	No	-	-	-	No	-	-	-	No	-	-	-	No

Right Turn Lane Warrant: VTrans Methodology for Two- and Four-Lane Highways

	EB	WB	NB	SB	EB	WB	NB	SB	EB	WB	NB	SB	EB	WB	NB	SB
Advancing Volume	150	556	0	159	160	593	0	169	253	325	0	292	270	347	0	311
% Right Turns	0%	45%	-	41%	0%	45%	-	41%	0%	19%	-	40%	0%	19%	-	40%
Adv. Volume not to exceed	-	-	#####	475	-	-	#####	475	-	-	#####	477	-	-	#####	477
Warranted for 2-Lane Highway?	-	-	#####	No	-	-	#####	No	-	-	#####	No	-	-	#####	No
Warranted for 4-Lane Highway?	-	-	#####	No	-	-	#####	No	-	-	#####	No	-	-	#####	No

Right Turn Lane Warrant: Typical State Design Manual Methodology

	EB	WB	NB	SB	EB	WB	NB	SB	EB	WB	NB	SB	EB	WB	NB	SB
Advancing Volume	331.1	555.9	0	158.8	353.2	593.1	0	169.4	300.9	325.5	0	291.9	321	347.2	0	311.4
Right Turn Volume	0	248.3	0	64.87	0	264.9	0	69.21	0	62.63	0	116.3	0	66.82	0	124.1
Right Turns Not to Exceed	0	0	0	78.82	0	0	0	77.41	0	0	0	61.08	0	0	0	0
Right Turns Not to Exceed	76	46	120	0	73	41	120	0	80	77	120	0	77	74	120	78
Warranted?	-	-	-	No	-	-	-	No	-	-	-	Yes	-	-	-	Yes

Summary Tables

		SB Right Turn Lane	
		AM	PM
VTrans			
	2009	No	No
	2019	No	No
Typical State Design Manual			
	2009	No	Yes
	2019	No	Yes

Signal Warrant Analysis -- MUTCD 2003 Edition
Resource Systems Group, Inc.

Intersection: VT 17 - Airport Road, Bristol VT
Count Date: 6/3/2009

Population <10,000?	y	Use Warrant 1, Condition A?	N	Apply Peak Hour Warrant?	Y
Speed (mph):	30	Use Warrant 1, Condition B?	Y	Are there school children?	Y
Analysis Year:	2009	Combine Conditions A and B of Warrant 1?	Y	Coordinated Signal System?	N
Adjustment Factor:	0.93	Distance to nearest traffic control signal (ft):	3200	In Coordinated System, distance to next signal?	0
				# Crashes in last year?	0
				Common intersection of 2 or more major routes?	N

	Major?	# Lanes
EB	Y	1
WB	Y	1
NB	N	1
SB	N	1

Raw Total Volumes

	Eastbound						Westbound						Northbound						Southbound					
Time	lt	(t)	th	(t)	rt	(t)	lt	(t)	th	(t)	rt	(t)	lt	(t)	th	(t)	rt	(t)	lt	(t)	th	(t)	rt	(t)
6:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6:15 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6:30 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6:45 AM	3	0	26	0	0	0	0	0	35	0	5	0	0	0	0	0	0	0	1	0	0	0	4	0
7:00 AM	11	0	47	0	0	0	0	0	47	0	17	0	0	0	0	0	0	0	6	0	0	0	3	0
7:15 AM	16	0	45	0	0	0	0	0	39	0	23	0	0	0	0	0	0	0	5	0	0	0	7	0
7:30 AM	33	0	32	0	0	0	0	0	84	0	33	0	0	0	0	0	0	0	13	0	0	0	11	0
7:45 AM	62	0	34	0	0	0	0	0	61	0	69	0	0	0	0	0	0	0	20	0	0	0	12	0
8:00 AM	54	0	33	0	0	0	0	0	67	0	87	0	0	0	0	0	0	0	32	0	0	0	17	0
8:15 AM	13	0	35	0	0	0	0	0	63	0	33	0	0	0	0	0	0	0	19	0	0	0	18	0
8:30 AM	2	0	30	0	0	0	0	0	58	0	7	0	0	0	0	0	0	0	4	0	0	0	4	0
8:45 AM	3	0	43	0	0	0	0	0	61	0	3	0	0	0	0	0	0	0	9	0	0	0	3	0
9:00 AM	13	0	46	0	0	0	0	0	46	0	18	0	0	0	0	0	0	0	15	0	0	0	10	0
9:15 AM	11	0	38	0	0	0	0	0	38	0	15	0	0	0	0	0	0	0	13	0	0	0	9	0
9:30 AM	13	0	44	0	0	0	0	0	43	0	17	0	0	0	0	0	0	0	14	0	0	0	10	0
9:45 AM	13	0	45	0	0	0	0	0	45	0	17	0	0	0	0	0	0	0	15	0	0	0	10	0
10:00 AM	11	0	37	0	0	0	0	0	36	0	14	0	0	0	0	0	0	0	12	0	0	0	8	0
10:15 AM	10	0	35	0	0	0	0	0	35	0	13	0	0	0	0	0	0	0	12	0	0	0	8	0
10:30 AM	10	0	35	0	0	0	0	0	34	0	13	0	0	0	0	0	0	0	11	0	0	0	8	0
10:45 AM	9	0	33	0	0	0	0	0	32	0	12	0	0	0	0	0	0	0	11	0	0	0	7	0
11:00 AM	13	0	44	0	0	0	0	0	43	0	17	0	0	0	0	0	0	0	14	0	0	0	10	0
11:15 AM	11	0	37	0	0	0	0	0	37	0	14	0	0	0	0	0	0	0	12	0	0	0	8	0
11:30 AM	11	0	39	0	0	0	0	0	39	0	15	0	0	0	0	0	0	0	13	0	0	0	9	0
11:45 AM	13	0	45	0	0	0	0	0	44	0	17	0	0	0	0	0	0	0	15	0	0	0	10	0
12:00 PM	12	0	42	0	0	0	0	0	42	0	16	0	0	0	0	0	0	0	14	0	0	0	10	0
12:15 PM	13	0	44	0	0	0	0	0	43	0	17	0	0	0	0	0	0	0	14	0	0	0	10	0
12:30 PM	13	0	46	0	0	0	0	0	46	0	17	0	0	0	0	0	0	0	15	0	0	0	10	0
12:45 PM	13	0	44	0	0	0	0	0	43	0	17	0	0	0	0	0	0	0	14	0	0	0	10	0
1:00 PM	11	0	37	0	0	0	0	0	36	0	14	0	0	0	0	0	0	0	12	0	0	0	8	0
1:15 PM	12	0	40	0	0	0	0	0	39	0	15	0	0	0	0	0	0	0	13	0	0	0	9	0
1:30 PM	11	0	37	0	0	0	0	0	36	0	14	0	0	0	0	0	0	0	12	0	0	0	8	0
1:45 PM	11	0	38	0	0	0	0	0	38	0	14	0	0	0	0	0	0	0	13	0	0	0	9	0
2:00 PM	2	0	35	0	0	0	0	0	40	0	8	0	0	0	0	0	0	0	3	0	0	0	4	0
2:15 PM	7	0	49	0	0	0	0	0	47	0	10	0	0	0	0	0	0	0	14	0	0	0	11	0
2:30 PM	21	0	81	0	0	0	0	0	65	0	24	0	0	0	0	0	0	0	95	0	0	0	56	0
2:45 PM	3	0	27	0	0	0	0	0	32	0	8	0	0	0	0	0	0	0	27	0	0	0	16	0
3:00 PM	8	0	58	0	0	0	0	0	88	0	15	0	0	0	0	0	0	0	19	0	0	0	15	0
3:15 PM	11	0	60	0	0	0	0	0	50	0	9	0	0	0	0	0	0	0	16	0	0	0	17	0
3:30 PM	12	0	55	0	0	0	0	0	63	0	2	0	0	0	0	0	0	0	19	0	0	0	12	0
3:45 PM	13	0	87	0	0	0	0	0	59	0	9	0	0	0	0	0	0	0	22	0	0	0	18	0
4:00 PM	12	0	66	0	0	0	0	0	38	0	13	0	0	0	0	0	0	0	16	0	0	0	8	0
4:15 PM	14	0	78	0	0	0	0	0	54	0	23	0	0	0	0	0	0	0	14	0	0	0	15	0
4:30 PM	17	0	74	0	0	0	0	0	46	0	20	0	0	0	0	0	0	0	16	0	0	0	14	0
4:45 PM	13	0	80	0	0	0	0	0	62	0	16	0	0	0	0	0	0	0	21	0	0	0	9	0
5:00 PM	10	0	84	0	0	0	0	0	66	0	23	0	0	0	0	0	0	0	21	0	0	0	10	0
5:15 PM	29	0	86	0	0	0	0	0	56	0	22	0	0	0	0	0	0	0	13	0	0	0	4	0
5:30 PM	17	0	67	0	0	0	0	0	43	0	18	0	0	0	0	0	0	0	16	0	0	0	12	0
5:45 PM	11	0	60	0	0	0	0	0	32	0	23	0	0	0	0	0	0	0	11	0	0	0	9	0

Adjusted Volumes (Vol * Adjustment Factor)

Time	EB	WB	NB	SB	Major	Minor	lax Min	Peds	School
6:30 AM	138	154	0	24	292	24	24	0	0
7:30 AM	275	462	0	132	737	132	132	0	0
8:30 AM	174	228	0	62	402	62	62	0	0
9:30 AM	193	205	0	83	398	83	83	0	0
10:30 AM	178	188	0	76	366	76	76	0	0
11:30 AM	203	216	0	88	419	88	88	0	0
12:30 PM	199	211	0	86	411	86	86	0	0
1:30 PM	176	193	0	68	369	68	68	0	0
2:30 PM	250	271	0	243	521	243	243	0	0
3:30 PM	313	243	0	115	556	115	115	0	0
4:30 PM	365	289	0	100	655	100	100	0	0
5:30 PM	144	108	0	45	252	45	45	0	0

W1 A		W1 B		W1 Combo		W2	W3	W4		W5	W6	W7	
	N		N		N	N	N+man.	N	N	N	n/a		N
	Y		Y		Y	Y	Y	N	N	N	n/a		N
	N		N		N	N	N+man.	N	N	N	n/a		N
	N		N		N	N	N+man.	N	N	N	n/a		N
	N		N		N	N	N+man.	N	N	N	n/a		N
	N		N		N	N	N+man.	N	N	N	n/a		N
	N		N		N	N	N+man.	N	N	N	n/a		N
	N		N		N	N	N+man.	N	N	N	n/a		N
	Y		N		Y	Y	Y	N	N	N	n/a		N
	Y		Y		Y	Y	N+man.	N	N	N	n/a		N
	N		Y		Y	Y	N+man.	N	N	N	n/a		N
	N		N		N	N	N+man.	N	N	N	n/a		N
n/a	n/a	0 of 8	3 of 8	0 of 8	4 of 8	4 of 1	2 of 4	0 of 4	0 of 1	0	n/a	0 of 8	0 of 8

Warrant Analyses	
Warrant 1a: Eight-Hour Vehicular Volume Warrant is Not Applicable	n/a
Warrant 1b: Eight-Hour Interruption of Continuous Traffic Warrant is Not Met	Not Met
Warrant 1c: Eight-Hour Combination of Warrants is Not Met	No
Warrant 2: Four-Hour Vehicular Volume Warrant is Met	Yes
Warrant 3: Peak Hour Warrant is Met	Yes

Signal Warrant Analysis -- MUTCD 2003 Edition
Resource Systems Group, Inc.

Intersection:	VT 17 - Airport Road, Bristol VT
Count Date:	6/3/2009

Population <10,000?	y	Use Warrant 1, Condition A?	N	Coordinated Signal System?	N
Speed (mph):	30	Use Warrant 1, Condition B?	Y	In Coordinated System, distance to next signal?	0
Analysis Year:	2019	Combine Conditions A and B of Warrant 1?	Y	# Crashes in last year?	0
Adjustment Factor:	0.99	Distance to nearest traffic control signal (ft):	3200	Common intersection of 2 or more major routes?	N

Apply Peak Hour Warrant?	Y
Are there school children?	Y

	Major?	# Lanes
EB	Y	1
WB	Y	1
NB	N	1
SB	N	1

Raw Total Volumes

	Eastbound						Westbound						Northbound						Southbound					
Time	lt	(t)	th	(t)	rt	(t)	lt	(t)	th	(t)	rt	(t)	lt	(t)	th	(t)	rt	(t)	lt	(t)	th	(t)	rt	(t)
6:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6:15 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6:30 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6:45 AM	3	0	26	0	0	0	0	0	35	0	5	0	0	0	0	0	0	0	1	0	0	0	4	0
7:00 AM	11	0	47	0	0	0	0	0	47	0	17	0	0	0	0	0	0	0	6	0	0	0	3	0
7:15 AM	16	0	45	0	0	0	0	0	39	0	23	0	0	0	0	0	0	0	5	0	0	0	7	0
7:30 AM	33	0	32	0	0	0	0	0	84	0	33	0	0	0	0	0	0	0	13	0	0	0	11	0
7:45 AM	62	0	34	0	0	0	0	0	61	0	69	0	0	0	0	0	0	0	20	0	0	0	12	0
8:00 AM	54	0	33	0	0	0	0	0	67	0	87	0	0	0	0	0	0	0	32	0	0	0	17	0
8:15 AM	13	0	35	0	0	0	0	0	63	0	33	0	0	0	0	0	0	0	19	0	0	0	18	0
8:30 AM	2	0	30	0	0	0	0	0	58	0	7	0	0	0	0	0	0	0	4	0	0	0	4	0
8:45 AM	3	0	43	0	0	0	0	0	61	0	3	0	0	0	0	0	0	0	9	0	0	0	3	0
9:00 AM	13	0	46	0	0	0	0	0	46	0	18	0	0	0	0	0	0	0	15	0	0	0	10	0
9:15 AM	11	0	38	0	0	0	0	0	38	0	15	0	0	0	0	0	0	0	13	0	0	0	9	0
9:30 AM	13	0	44	0	0	0	0	0	43	0	17	0	0	0	0	0	0	0	14	0	0	0	10	0
9:45 AM	13	0	45	0	0	0	0	0	45	0	17	0	0	0	0	0	0	0	15	0	0	0	10	0
10:00 AM	11	0	37	0	0	0	0	0	36	0	14	0	0	0	0	0	0	0	12	0	0	0	8	0
10:15 AM	10	0	35	0	0	0	0	0	35	0	13	0	0	0	0	0	0	0	12	0	0	0	8	0
10:30 AM	10	0	35	0	0	0	0	0	34	0	13	0	0	0	0	0	0	0	11	0	0	0	8	0
10:45 AM	9	0	33	0	0	0	0	0	32	0	12	0	0	0	0	0	0	0	11	0	0	0	7	0
11:00 AM	13	0	44	0	0	0	0	0	43	0	17	0	0	0	0	0	0	0	14	0	0	0	10	0
11:15 AM	11	0	37	0	0	0	0	0	37	0	14	0	0	0	0	0	0	0	12	0	0	0	8	0
11:30 AM	11	0	39	0	0	0	0	0	39	0	15	0	0	0	0	0	0	0	13	0	0	0	9	0
11:45 AM	13	0	45	0	0	0	0	0	44	0	17	0	0	0	0	0	0	0	15	0	0	0	10	0
12:00 PM	12	0	42	0	0	0	0	0	42	0	16	0	0	0	0	0	0	0	14	0	0	0	10	0
12:15 PM	13	0	44	0	0	0	0	0	43	0	17	0	0	0	0	0	0	0	14	0	0	0	10	0
12:30 PM	13	0	46	0	0	0	0	0	46	0	17	0	0	0	0	0	0	0	15	0	0	0	10	0
12:45 PM	13	0	44	0	0	0	0	0	43	0	17	0	0	0	0	0	0	0	14	0	0	0	10	0
1:00 PM	11	0	37	0	0	0	0	0	36	0	14	0	0	0	0	0	0	0	12	0	0	0	8	0
1:15 PM	12	0	40	0	0	0	0	0	39	0	15	0	0	0	0	0	0	0	13	0	0	0	9	0
1:30 PM	11	0	37	0	0	0	0	0	36	0	14	0	0	0	0	0	0	0	12	0	0	0	8	0
1:45 PM	11	0	38	0	0	0	0	0	38	0	14	0	0	0	0	0	0	0	13	0	0	0	9	0
2:00 PM	2	0	35	0	0	0	0	0	40	0	8	0	0	0	0	0	0	0	3	0	0	0	4	0
2:15 PM	7	0	49	0	0	0	0	0	47	0	10	0	0	0	0	0	0	0	14	0	0	0	11	0
2:30 PM	21	0	81	0	0	0	0	0	65	0	24	0	0	0	0	0	0	0	95	0	0	0	56	0
2:45 PM	3	0	27	0	0	0	0	0	32	0	8	0	0	0	0	0	0	0	27	0	0	0	16	0
3:00 PM	8	0	58	0	0	0	0	0	88	0	15	0	0	0	0	0	0	0	19	0	0	0	15	0
3:15 PM	11	0	60	0	0	0	0	0	50	0	9	0	0	0	0	0	0	0	16	0	0	0	17	0
3:30 PM	12	0	55	0	0	0	0	0	63	0	2	0	0	0	0	0	0	0	19	0	0	0	12	0
3:45 PM	13	0	87	0	0	0	0	0	59	0	9	0	0	0	0	0	0	0	22	0	0	0	18	0
4:00 PM	12	0	66	0	0	0	0	0	38	0	13	0	0	0	0	0	0	0	16	0	0	0	8	0
4:15 PM	14	0	78	0	0	0	0	0	54	0	23	0	0	0	0	0	0	0	14	0	0	0	15	0
4:30 PM	17	0	74	0	0	0	0	0	46	0	20	0	0	0	0	0	0	0	16	0	0	0	14	0
4:45 PM	13	0	80	0	0	0	0	0	62	0	16	0	0	0	0	0	0	0	21	0	0	0	9	0
5:00 PM	10	0	84	0	0	0	0	0	66	0	23	0	0	0	0	0	0	0	21	0	0	0	10	0
5:15 PM	29	0	86	0	0	0	0	0	56	0	22	0	0	0	0	0	0	0	13	0	0	0	4	0
5:30 PM	17	0	67	0	0	0	0	0	43	0	18	0	0	0	0	0	0	0	16	0	0	0	12	0
5:45 PM	11	0	60	0	0	0	0	0	32	0	23	0	0	0	0	0	0	0	11	0	0	0	9	0

Adjusted Volumes (Vol * Adjustment Factor)

Time	EB	WB	NB	SB	Major	Minor	lax Mino	Peds	School
6:30 AM	147	165	0	26	312	26	26	0	0
7:30 AM	294	493	0	141	787	141	141	0	0
8:30 AM	186	243	0	66	429	66	66	0	0
9:30 AM	206	218	0	89	424	89	89	0	0
10:30 AM	190	201	0	82	391	82	82	0	0
11:30 AM	217	230	0	93	447	93	93	0	0
12:30 PM	213	226	0	92	438	92	92	0	0
1:30 PM	188	206	0	73	393	73	73	0	0
2:30 PM	267	289	0	259	556	259	259	0	0
3:30 PM	334	259	0	123	593	123	123	0	0
4:30 PM	390	309	0	107	699	107	107	0	0
5:30 PM	154	115	0	48	269	48	48	0	0

W1 A		W1 B		W1 Combo		W2	W3	W4		W5	W6	W7	
	N		N		N	N	N+man.	N	N	N	n/a		N
	Y		Y		Y	Y	Y	N	N	N	n/a		N
	N		N		N	N	N+man.	N	N	N	n/a		N
	N		N		Y	N	N+man.	N	N	N	n/a		N
	N		N		N	N	N+man.	N	N	N	n/a		N
	N		N		Y	N	N+man.	N	N	N	n/a		N
	N		N		Y	N	N+man.	N	N	N	n/a		N
	N		N		N	N	N+man.	N	N	N	n/a		N
	Y		Y		Y	Y	Y	N	N	N	n/a		N
	Y		Y		Y	Y	N+man.	N	N	N	n/a		N
	Y		Y		Y	Y	N+man.	N	N	N	n/a		N
	N		N		N	N	N+man.	N	N	N	n/a		N
n/a	n/a	0 of 8	4 of 8	0 of 8	7 of 8	4 of 1	2 of 4	0 of 4	0 of 1	0	n/a	0 of 8	0 of 8

Warrant Analyses	
Warrant 1a: Eight-Hour Vehicular Volume Warrant is Not Applicable	n/a
Warrant 1b: Eight-Hour Interruption of Continuous Traffic Warrant is Not Met	Not Met
Warrant 1c: Eight-Hour Combination of Warrants is Not Met	No
Warrant 2: Four-Hour Vehicular Volume Warrant is Met	Yes
Warrant 3: Peak Hour Warrant is Met	Yes

Appendix F:

Conceptual Plans – 11x17

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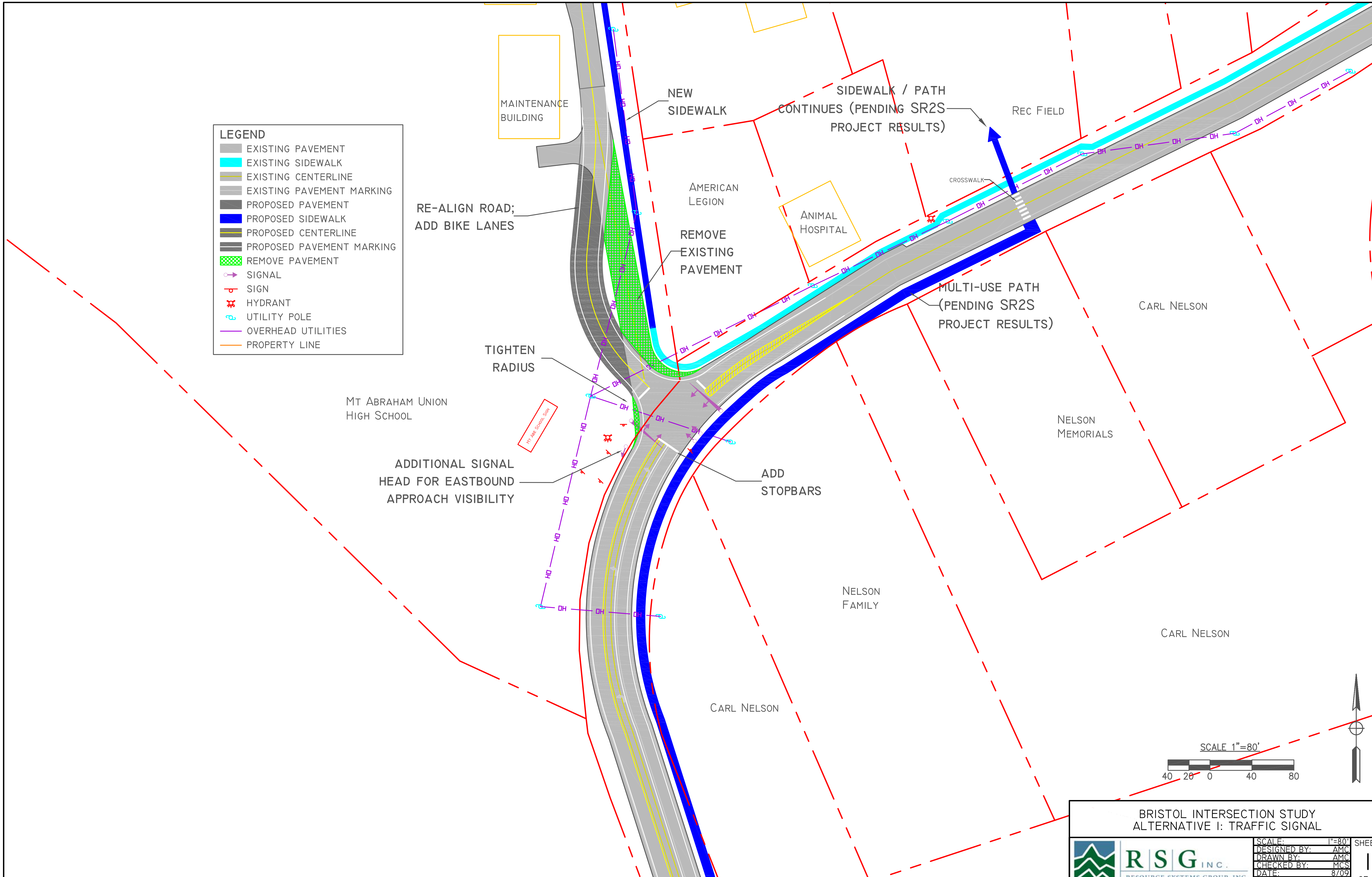
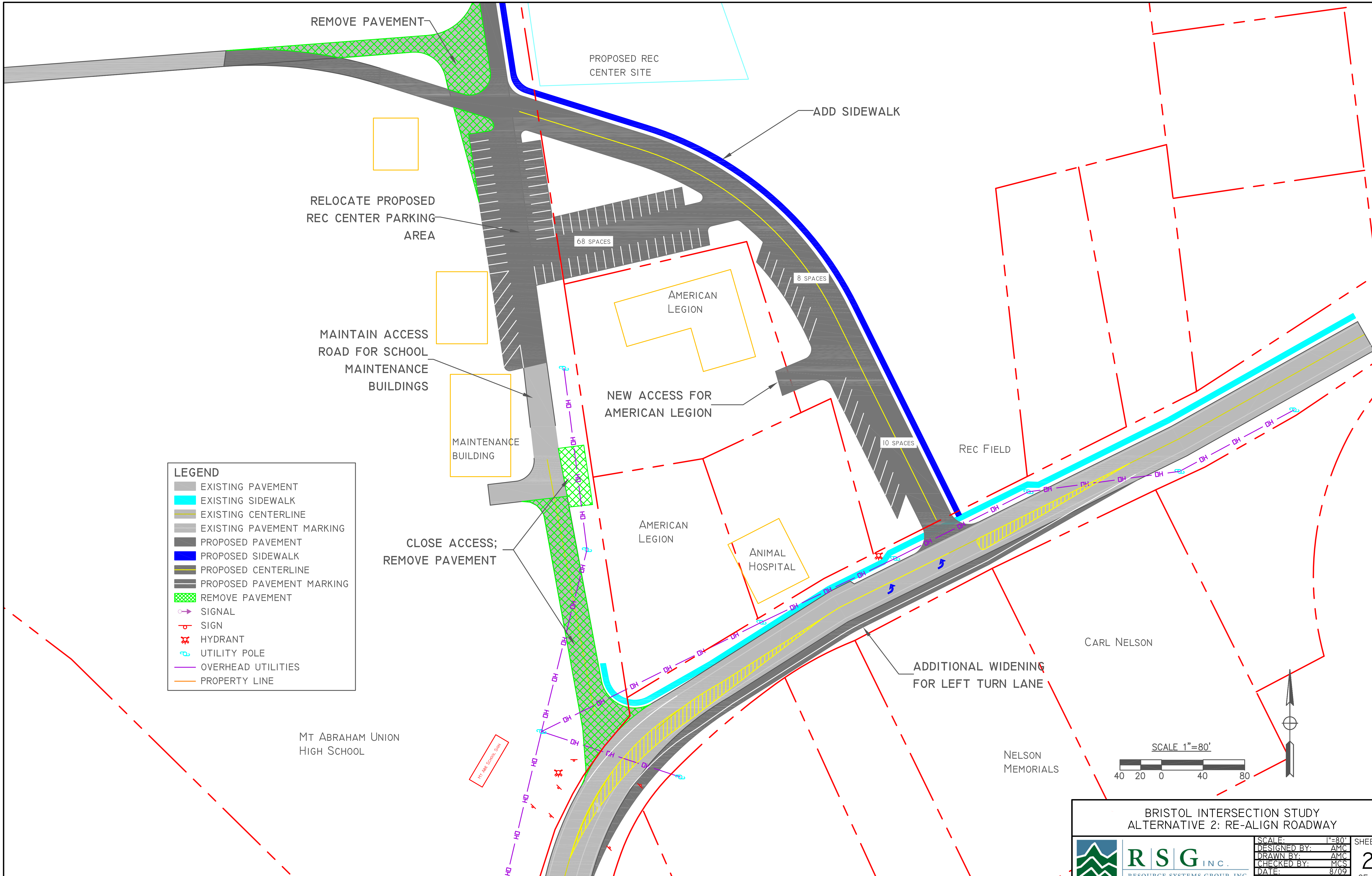
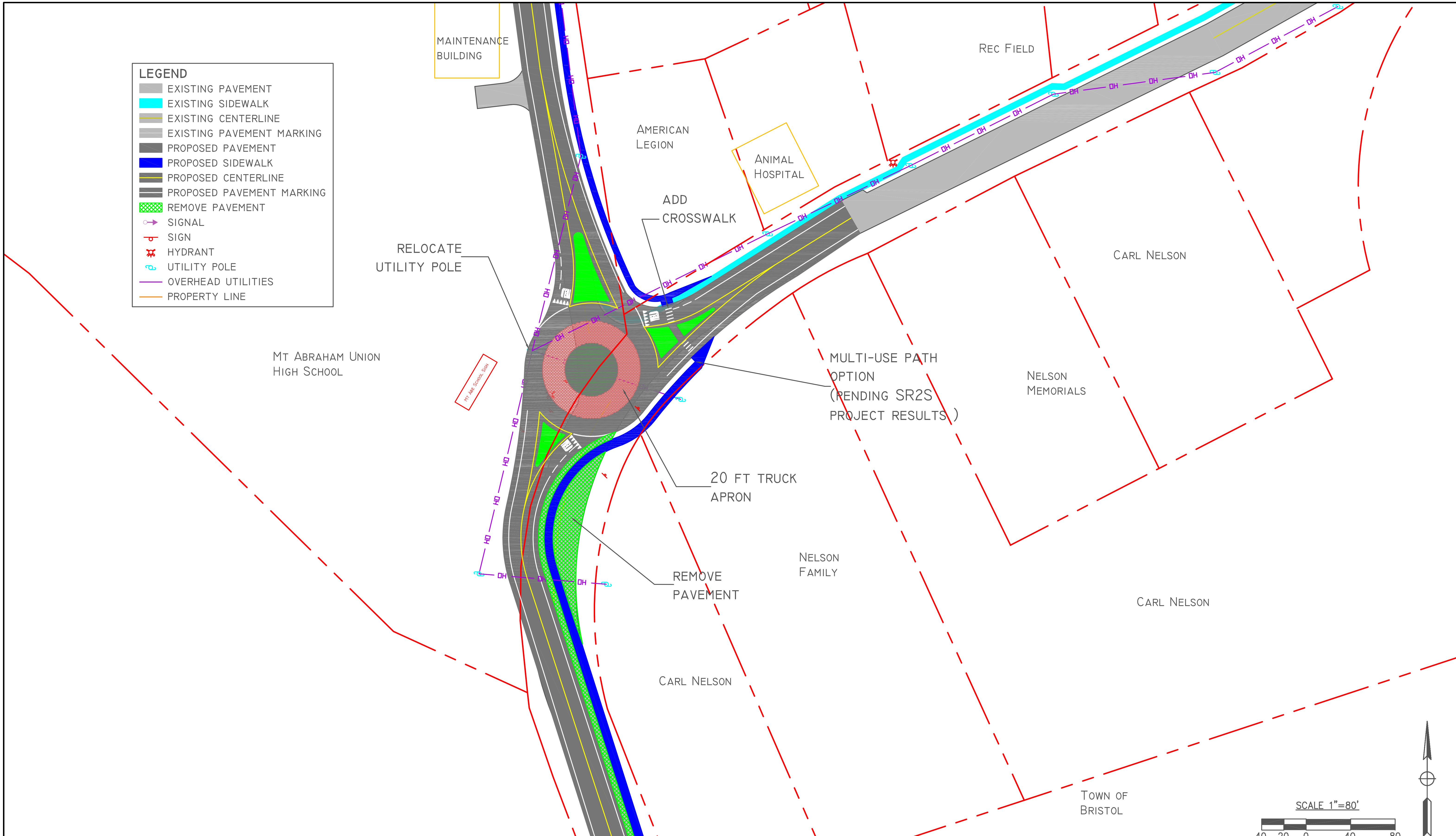

LEGEND
EXISTING PAVEMENT
EXISTING SIDEWALK
EXISTING CENTERLINE
EXISTING PAVEMENT MARKING
PROPOSED PAVEMENT
PROPOSED SIDEWALK
PROPOSED CENTERLINE
PROPOSED PAVEMENT MARKING
REMOVE PAVEMENT
SIGNAL
SIGN
HYDRANT
UTILITY POLE
OVERHEAD UTILITIES
PROPERTY LINE
MAINTENANCE BUILDING
NEW SIDEWALK
SIDEWALK / PATH CONTINUES (PENDING SR2S PROJECT RESULTS)
REC FIELD
AMERICAN LEGION
ANIMAL HOSPITAL
CROSSWALK
RE-ALIGN ROAD; ADD BIKE LANES
REMOVE EXISTING PAVEMENT
MULTI-USE PATH (PENDING SR2S PROJECT RESULTS)
CARL NELSON
TIGHTEN RADIUS
MT ABRAHAM UNION HIGH SCHOOL
NELSON MEMORIALS
ADDITIONAL SIGNAL HEAD FOR EASTBOUND APPROACH VISIBILITY
ADD STOPBARS
NELSON FAMILY
CARL NELSON
CARL NELSON
SCALE 1"=80'
40 20 0 40 80
BRISTOL INTERSECTION STUDY
ALTERNATIVE I: TRAFFIC SIGNAL
RSG INC.
RESOURCE SYSTEMS GROUP, INC.
SCALE: 1"=80'
DESIGNED BY: AMC
DRAWN BY: AMC
CHECKED BY: MCS
DATE: 8/09
PROJ. NO.: 09105
SHEET 1 OF 4


REMOVE PAVEMENT
PROPOSED REC CENTER SITE
ADD SIDEWALK
RELOCATE PROPOSED REC CENTER PARKING AREA
68 SPACES
8 SPACES
10 SPACES
AMERICAN LEGION
MAINTAIN ACCESS ROAD FOR SCHOOL MAINTENANCE BUILDINGS
NEW ACCESS FOR AMERICAN LEGION
MAINTENANCE BUILDING
REC FIELD
CLOSE ACCESS; REMOVE PAVEMENT
AMERICAN LEGION
ANIMAL HOSPITAL
LEGEND
EXISTING PAVEMENT
EXISTING SIDEWALK
EXISTING CENTERLINE
EXISTING PAVEMENT MARKING
PROPOSED PAVEMENT
PROPOSED SIDEWALK
PROPOSED CENTERLINE
PROPOSED PAVEMENT MARKING
REMOVE PAVEMENT
SIGNAL
SIGN
HYDRANT
UTILITY POLE
OVERHEAD UTILITIES
PROPERTY LINE
ADDITIONAL WIDENING FOR LEFT TURN LANE
CARL NELSON
MT ABRAHAM UNION HIGH SCHOOL
NELSON MEMORIALS
SCALE 1"=80'
40 20 0 40 80
BRISTOL INTERSECTION STUDY
ALTERNATIVE 2: RE-ALIGN ROADWAY
RSG INC.
RESOURCE SYSTEMS GROUP, INC.
SCALE: 1"=80'
DESIGNED BY: AMC
DRAWN BY: AMC
CHECKED BY: MCS
DATE: 8/09
PROJ. NO.: 09105
SHEET 2 OF 4

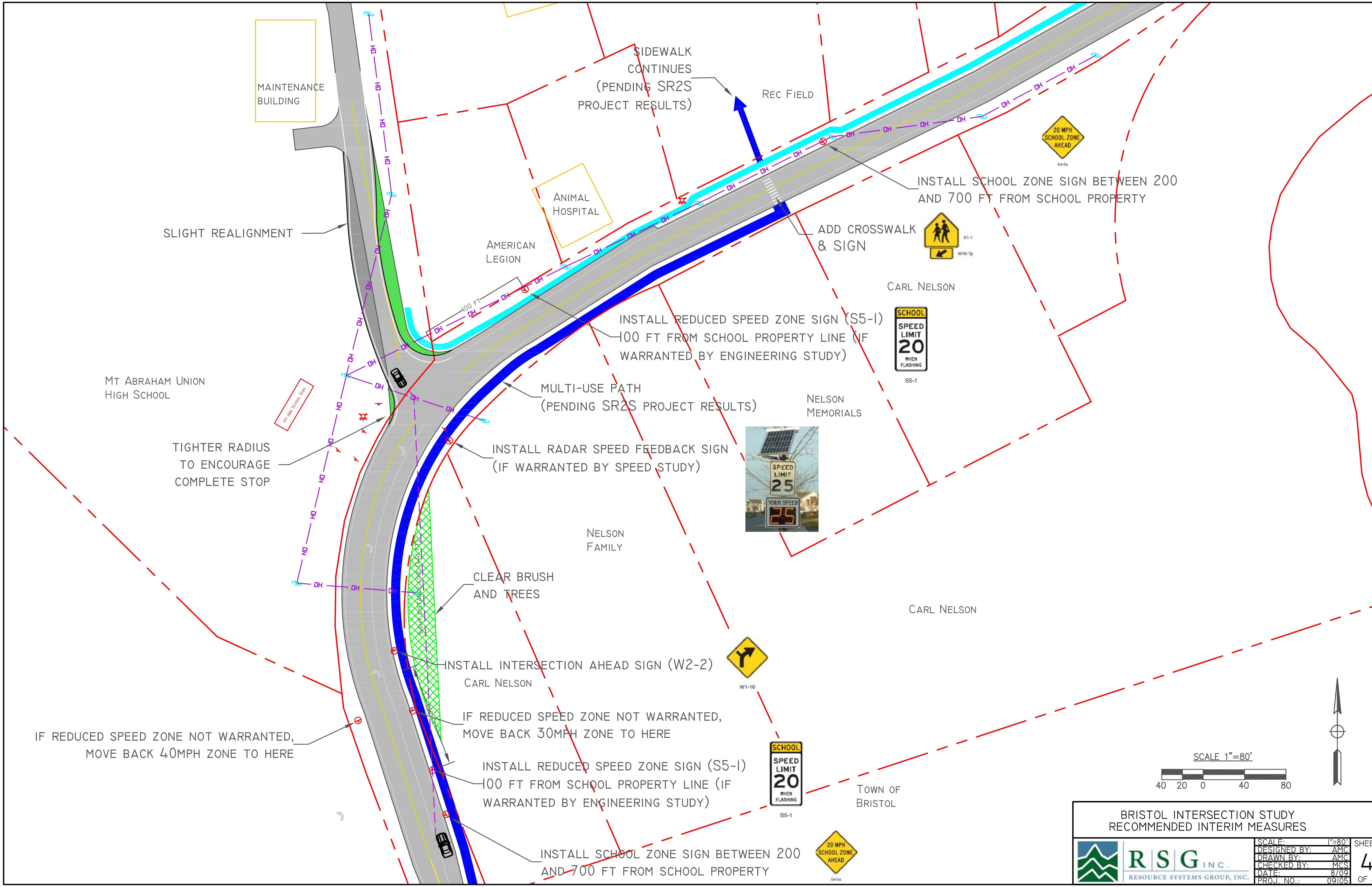


BRISTOL INTERSECTION STUDY
ALTERNATIVE 3: ROUNDABOUT

RSG INC.
RESOURCE SYSTEMS GROUP, INC.

SCALE:	1"=80'
DESIGNED BY:	AMC
DRAWN BY:	AMC
CHECKED BY:	MCS
DATE:	8/09
PROJ. NO.:	09105

SHEET 3 OF 4



MAINTENANCE BUILDING
SIDEWALK CONTINUES (PENDING SR2S PROJECT RESULTS)
REC FIELD
INSTALL SCHOOL ZONE SIGN BETWEEN 200 AND 700 FT FROM SCHOOL PROPERTY
20 MPH SCHOOL ZONE AHEAD
S4-5a
ANIMAL HOSPITAL
SLIGHT REALIGNMENT
AMERICAN LEGION
ADD CROSSWALK & SIGN
S1-1
W16-7p
CARL NELSON
100 FT
INSTALL REDUCED SPEED ZONE SIGN (S5-1) 100 FT FROM SCHOOL PROPERTY LINE (IF WARRANTED BY ENGINEERING STUDY)
SCHOOL SPEED LIMIT 20 WHEN FLASHING
S5-1
MT ABRAHAM UNION HIGH SCHOOL
MT ABE SCHOOL SIGN
MULTI-USE PATH (PENDING SR2S PROJECT RESULTS)
NELSON MEMORIALS
TIGHTER RADIUS TO ENCOURAGE COMPLETE STOP
INSTALL RADAR SPEED FEEDBACK SIGN (IF WARRANTED BY SPEED STUDY)
SPEED LIMIT 25
YOUR SPEED
NELSON FAMILY
CLEAR BRUSH AND TREES
CARL NELSON
INSTALL INTERSECTION AHEAD SIGN (W2-2)
W1-10
CARL NELSON
IF REDUCED SPEED ZONE NOT WARRANTED, MOVE BACK 30MPH ZONE TO HERE
IF REDUCED SPEED ZONE NOT WARRANTED, MOVE BACK 40MPH ZONE TO HERE
INSTALL REDUCED SPEED ZONE SIGN (S5-1) 100 FT FROM SCHOOL PROPERTY LINE (IF WARRANTED BY ENGINEERING STUDY)
SCHOOL SPEED LIMIT 20 WHEN FLASHING
S5-1
TOWN OF BRISTOL
INSTALL SCHOOL ZONE SIGN BETWEEN 200 AND 700 FT FROM SCHOOL PROPERTY
20 MPH SCHOOL ZONE AHEAD
S4-5a
SCALE 1"=80'
40 20 0 40 80
BRISTOL INTERSECTION STUDY
RECOMMENDED INTERIM MEASURES
RSG INC.
RESOURCE SYSTEMS GROUP, INC.
SCALE: 1"=80'
DESIGNED BY: AMC
DRAWN BY: AMC
CHECKED BY: MCS
DATE: 8/09
PROJ. NO.: 09105
SHEET 4 OF 4

Appendix G:
Notes from Public Meetings

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Airport Road Intersection Study - Local Concerns Meeting

Holley Hall - Bristol, VT

10 August 2009, 7:00 PM

The meeting kicked off with an introduction from Bill Bryant, the Town Administrator, followed by comments from Rick Kehne, the Transportation Planner for the Addison County Regional Planning Commission (ACRPC). Mark Smith from Resource Systems Group (RSG) gave a brief presentation, providing background to the project and a summary of existing conditions. The floor was then opened up for questions and comments, which are summarized below.

Selectboard and Public Questions and Comments

- If there haven't been accidents at this intersection, is it really a problem?
    - Although accidents would be an indication of a problem, we have no way of quantifying minor collisions or near misses. Additionally, accidents are just one part of the picture – public concern, engineering standards, and operational deficiencies should also be considered.
    - Note: there was a major collision in the last 12 months – Bill Bryant will forward the police report to RSG.
- If a vehicle is sitting in the eastbound left turn lane, it blocks the sight line between eastbound thru, westbound thru, and southbound vehicles.
- Creating two distinct southbound lanes will exacerbate an existing sight distance deficiency.
- There is no well-defined or well-lit connection from the school to the adjacent residential community to the east. The existing path is subject to mud and ice, and does not have lights.
    - Note: the Town recently applied for funding for lights for this path and the request was denied.
- There should be a sidewalk on Airport Drive. At present, bicyclists and pedestrians are forced to walk on the grass or in the road; this becomes a bigger problem in the winter months when snow piles narrow the roadway and eliminate refuge areas. Vehicles go very fast on Airport Drive, especially eastbound right turns from West St.
- There is currently not a good way to get from the high school to the Rec Center. Pedestrians are forced to cross the parking areas and to cross at ill-defined intersections.
- Stoney Hill Road is steep, narrow, and blind. Additionally, it is abutted by ditches or a gravel pit, so there is no refuge for pedestrians.

Subject: Alternatives Presentation – Regular Selectboard Meeting
Date/Time/Location: 21 September 2009, 7:00 PM, Howden Hall
Project: Airport Road Intersection Study

Attending:

Steering Committee:
Rick Kehne (ACRPC)
Linda Stearns (Deer Leap Project)
Bill Bryant (Town Administrator)
Peter Grant (Planning Commission, RPC-TAC Rep)
Public and Selectboard (see attendance list)
Presenting:
Amanda Clancy (RSG)
Mark Smith (RSG)
Prepared By:M. Smith/A. Clancy, RSG

MEETING NOTES

Mark Smith presented the project objectives, results from previous Local Concerns meeting and the details of various alternatives studied. Comments and questions included:

Regarding the potential school zone – could the Recreation Park property frontage be included when delineating the limits of the zone? *Response: This should be explored with VTrans when applying for the speed zone approval.*

The southbound approach should have two lanes. *Response: This is included in the analysis and while it could help for capacity in the unsignalized condition, it is not needed in the signalized or roundabout alternative.*

The signal will stop traffic on hill, causing problems in winter conditions. *Response: maximum queues will be reduced compared to the existing left turn condition, however the frequency of stops will certainly increase.*

Where would the future business park entrance line up? *Response: The development drive to the Nelson property has tentatively been shown opposite the Recreation Park property – potentially lining up with the proposed intersection in the re-aligned alternative.*

The Recreation Center should not give up land for new/relocated driveway.

Pedestrian crossing at the Recreation Park is a good idea – that's where pedestrians cross now.

Regarding roundabout queues – stopping trucks eastbound could be a new problem in wintertime. *Response: roundabout queues will be less than signal queues; but it is correct that through traffic does not have to stop in the existing condition.*

Roundabout reduces speeds and could reduce the need for enforcement.

Can you move the intersection further east? *Response: only by impacting the American Legion property, which was avoided in the conceptual plans..*

The American Legion once discussed expanding their facility – was this considered? *Response: We had no prior knowledge of this discussion.*

Was a separate entrance for the Community Center considered? *Response: No. Since the existing intersection is problematic, the benefit of this study was to eliminate the existing deficiencies. Therefore, this was not considered.*

Would access to the proposed business center impact the existing intersection alternative designs? *Response: Based on the location for the business center access that has been tentatively discussed (across from the Rec Park), the intersection separation appears to meet general guidelines (intersections should be separated by 500 feet or more.)*

Is the roundabout eligible for more funding than the other alternatives? *Response: Roundabouts and signals are eligible for 100% federal funds. The realignment alternative would likely require more local funding.*

Do projects in the State jurisdiction improve the chance of being funded? *Response: Yes, some but not all funding sources have matches that change depending on jurisdiction.*

Won't a constant stream of school buses exiting from Airport Road block the eastbound traffic in the roundabout alternative? *Response: Buses are scheduled to alternate based on whether they turn left or right at the study intersection. Buses that turn right will create sufficient breaks in the circulating traffic for eastbound traffic to travel through the roundabout.*

The meeting wrapped up with an explanation of next steps. The report is due September 30th – any comments must be received by then to be addressed in the report. The Selectboard deferred on deciding on a preferred alternative pending further details of the Deerleap project, and indicated that they would explore some of the short-term recommendations in the interim.

END OF MEETING NOTES

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Appendix H:
Detailed Cost Estimate

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Bristol Intersection Study Cost Estimates
10 September 2009

Created by: AMC
Checked by: MCS

Alt 1: Traffic Signal

		Unit Cost	Qty	Units		Total Cost
Signal Equipment & Installation	$	125,000	1	LS	$	125,000
Common Excavation	$	12	1200	CY	$	14,400
Excavation of Surfaces and Pavements	$	20	100	CY	$	2,000
Cold Planing	$	2	400	SY	$	800
Subbase of Crushed Stone (Pavement)	$	20	300	CY	$	6,000
Bituminous Concrete Pavement	$	80	280	Ton	$	22,400
5ft Concrete Sidewalk without Curb	$	87		LF	$	-
8ft Bituminous Multiuse Path	$	116		LF	$	-
8 ft Crosswalks	$	20		LF	$	-
Pavement Markings	$	4,000	1	LS	$	4,000
Durable Letter or Symbol	$	60	6	Each	$	360
Landscaping, topsoil, seed, mulch	$	20,000	1	LS	$	20,000
Engineers trailer / testing equip	$	2,000	1		$	2,000
Drainage/Stormwater		10%			$	7,200
Miscellaneous Expenses		10%			$	7,200
				Subtotal	**$**	**211,000**
Mob/demob		4%			$	8,440
Traffic Control		5%			$	10,600
Preliminary/Final Design		12%			$	25,320
Construction Engineering		5%			$	10,550
Contingency		10%			$	21,100
				Total	**$**	**287,000**

Assume:

- *paving required for realigned approach only*
- *sidewalks and/or bike paths are assumed part of the Safe Routes to School Project, thus are not included*
- *does not include ROW costs*
- *existing intersection lighting is sufficient*

Bristol Intersection Study Cost Estimates
10 September 2009

Created by: AMC
Checked by: MCS

Alt 2: Move Intersection

		Unit Cost	Qty	Units		Total Cost
Excavation of Surfaces and Pavements	$	20	100	CY	$	2,000
Common Excavation	$	12	1100	CY	$	13,200
Subbase of Crushed Stone (Pavement)	$	20	1100	CY	$	22,000
Cold Planing	$	2	400	SY	$	800
Bituminous Concrete Pavement	$	65	700	Ton	$	45,500
Cast-in-Place Concrete Curb	$	35	200	LF	$	7,000
5ft Concrete Sidewalk without Curb	$	87		LF	$	-
8ft Bituminous Multiuse Path	$	116		LF	$	-
8ft Crosswalks	$	20		LF	$	-
Pavement Markings	$	2	3000	LF	$	6,000
Durable Letter or Symbol	$	60	3	Each	$	180
Landscaping, topsoil, seed, mulch	$	10,000	1	LS	$	10,000
lighting & electrical service	$	8,000	2	LS	$	16,000
Engineers trailer / testing equip	$	2,000	1		$	2,000
Drainage/Stormwater		15%			$	10,800
Miscellaneous Expenses		10%			$	7,200
				Subtotal	**$**	**143,000**
Mob/demob		4%			$	5,720
Traffic Control		5%			$	7,200
Preliminary/Final Design		12%			$	17,160
Construction Engineering		5%			$	7,150
Contingency		10%			$	14,300
				Total	**$**	**195,000**

Assume:

sidewalks and/or bike paths are assumed part of the Safe Routes to School Project, thus are not included
does not include demolition of existing structures or replacement of any impacted rec facilities
does not include ROW costs
parking shown is associated with the Rec Center - cost not included
does not include the cost of a traffic signal

Bristol Intersection Study Cost Estimates
10 September 2009

Created by: AMC
Checked by: MCS

Alt 3: Roundabout

		Unit Cost	Qty	Units		Total Cost
Excavation of Surfaces and Pavements	$	20	500	CY	$	10,000
Common Excavation	$	12	3800	CY	$	45,600
Cold Planing	$	2	400	SY	$	800
Subbase of Crushed Stone (Pavement)	$	20	1500	CY	$	30,000
Bituminous Concrete Pavement	$	80	600	Ton	$	48,000
Cast-in-Place Concrete Curb	$	35	1064	LF	$	37,233
Brick Paving (mod)/Truck Apron	$	75	681	SY	$	51,041
5ft Concrete Sidewalk without Curb	$	87		LF	$	-
8ft Bituminous Multiuse Path	$	116		LF	$	-
8ft Crosswalks	$	20	32	LF	$	640
Pavement Markings	$	2	1800	LF	$	3,600
Durable Letter or Symbol	$	60	30	Each	$	1,800
Remove Signs	$	20		Each	$	-
Relocate Salvaged Signs	$	200	5	Each	$	1,000
Relocate Hydrant	$	3,000	1	Each	$	3,000
Landscaping, topsoil, seed, mulch	$	20,000	1	LS	$	20,000
lighting & electrical service	$	8,000	6	LS	$	48,000
Engineers trailer / testing equip	$	5,000	1		$	5,000
Drainage/Stormwater		15%			$	45,900
Miscellaneous Expenses		10%			$	30,600
				Subtotal	**$**	**382,000**
Mob/demob		4%			$	15,280
Traffic Control		10%			$	38,200
Preliminary/Final Design		12%			$	45,840
Construction Engineering		8%			$	30,560
Contingency		10%			$	38,200
				Total	**$**	**550,000**

Assume:

sidewalks and/or bike paths are assumed part of the Safe Routes to School Project, thus are not included
does not include ROW costs
does not include overhead utility relocation cost