Appendix A: Phase 2 Report

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1.0 INTRODUCTION

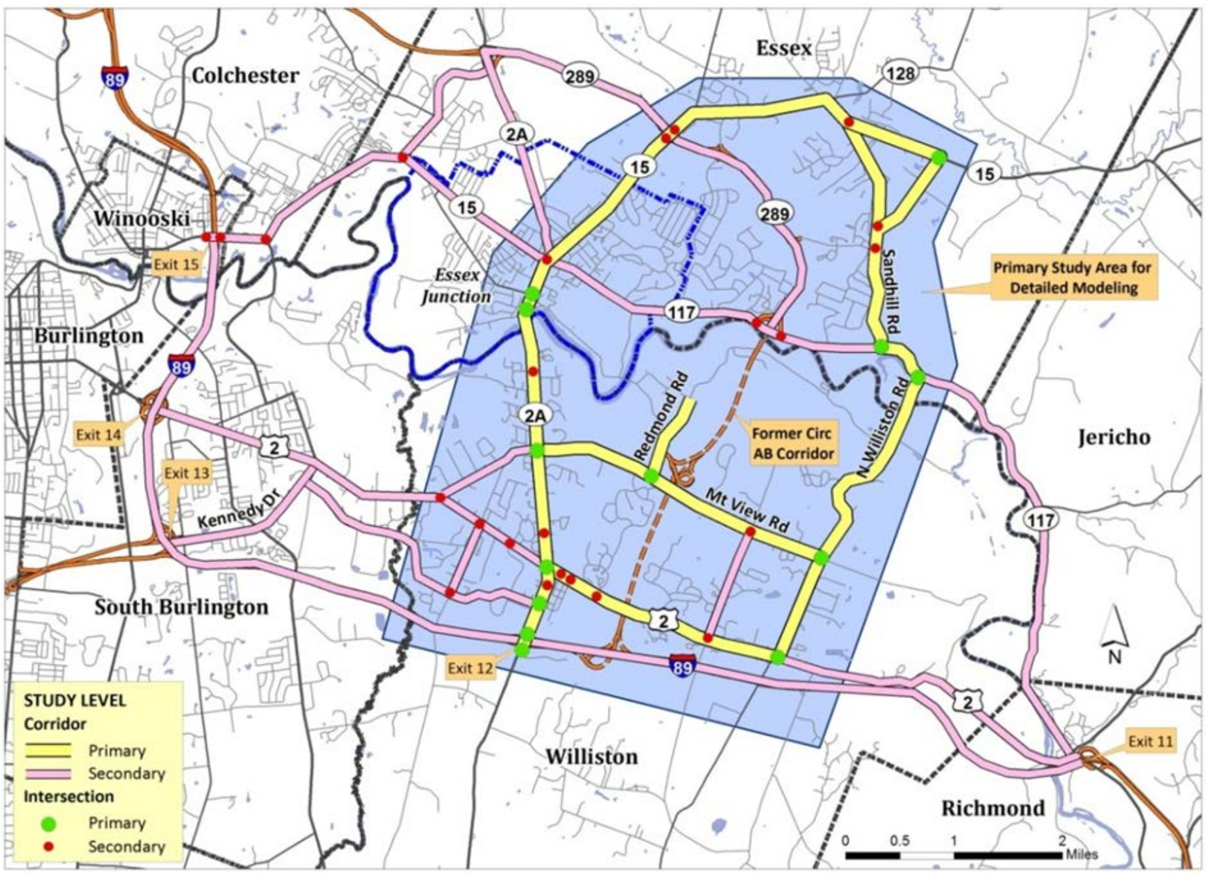
In the wake of Governor Shumlin's announcement that the Circumferential Highway (Circ) - as originally conceived - would not be built, there is now an acute need to address the resulting gap in planning for multimodal mobility and safety issues within the former Environmental Impact Study (EIS) area (Figure 1). These issues can be summarized as follows:

1. Traffic congestion;
2. Inadequate roadway design features creating safety issues for all modes of travel;
3. Inadequate accommodation of truck traffic;
4. Access and mobility between business centers.[1]

While the EIS evaluated dozens of improvement alternatives, the Governor's announcement on the Circ leaves the study area without an integrated, coordinated plan for addressing these issues. This Williston-Essex Network Transportation Study (WENTS) is motivated by a need for such a plan.

The objective of this Study is to determine a set of multimodal transportation improvements and land use policies that will improve safety and mobility in the study area.

Figure 1: Study Area



[1] Excerpted from the Circ-Williston EIS Purpose and Need Statement.

This study is comprised of 5 phases, each involving opportunities for public review and input:

- Phase 1-Evaluation of Two Major Network Strategies:
  - I-89 connector to Mountain View Road (the former Circ A, Alternative 13);
  - Redmond Road connector which follows the Redmond Road alignment and connects to VT 289 through a new bridge across the Winooski River (similar to the Circ Alternative 15).
- Phase 2-Analysis of Existing and Future Issues and Development of Network Vision/Goals;
- Phase 3-Development and Evaluation of Strategies;
- Phase 4-Development of Implementation Plan; and
- Phase 5-Development of Draft and Final Network Plan.

Phase 1 concluded with the Selectboards of Williston and Essex voting to continue consideration of the Redmond Road Connector (Major Network Strategy 2) through the duration of the project.

This Phase 2 report summarizes existing and future transportation/land use conditions and potential performance measures. Section 2.0 assesses existing land use, access management, safety, bicycle and pedestrian facilities, and transit service. Performance measures (Section 3.1) are presented for evaluating existing multimodal transportation performance. Section 3.3 applies these performance measures to the year 2010 to establish an understanding of existing conditions, while Section 3.4 assesses conditions in the year 2035. Vehicular mobility is evaluated using a traffic microsimulation model.

In the upcoming Phase 3 of WENTS, the performance measures will be used to evaluate the future transportation/land use alternatives.

1.1 Study Area

As shown in Figure 1, the study area spans Williston and Essex (including Essex Junction) and is organized into primary and secondary corridors. The primary corridor sections are shown in Table 1.

Table 1: Primary Study Corridors

	Corridor Section	from	to
Primary Corridors	VT 2A (S)	I-89 Exit 12	Beaudry Lane
	VT 2A (N)	Beaudry Lane	River St./South Street
	US 2 (W)	VT 2A	Old Stage Rd.
	Mountain View Drive	VT 2A	N. Williston Rd.
	Redmond Road	Mountain View Drive	IBM Entrance North
	Sand Hill Rd.	VT 117	VT 15
	Allen Martin Dr.	VT 15	Sand Hill Rd.
	N. Williston Road & VT 117	US 2	VT 117-Sand Hill Rd.
	VT 15	Sand Hill Rd.	Brickyard Rd.
Village Centers	US 2 (V)	Old Stage Rd.	N. Williston Rd./Oak Hill Rd.
	VT2A (V) & VT15 (V)	River St./South St.	Brickyard Rd.

Along these corridors are key intersections whose performance is analyzed under existing conditions in Section 3.3; performance under future conditions is analyzed in Phase 3 of the WENTS study. The Primary and Secondary intersections are shown in Figure 1 and Table 2.

Table 2: Study Intersections

Primary Study Intersections	Secondary Study Intersections
VT2A/Exit 12 SB	Five Corners
VT2A/Exit 12 NB	I-89 Exit 15 NB
VT2A/Marshall Ave./Maple Tree Place	I-89 Exit 15 SB
VT2A/US2	VT15/Lime Kiln Rd.
VT2A/Industrial Ave./Mountain View Dr.	VT15/Susie Wilson Rd.
Mountain View Dr./Redmond Road	VT15/VT128
VT2A/South St./River St.	**VT117/I-289 (2 ints)**
US2/Brownell Ave.	VT15/Essex Way
US2/Oak Hill Rd./N. Williston Rd.	**Sand Hill Rd./Allen Martin Parkway**
N. Williston Rd./Mountain View Rd.	**Sand Hill Rd./Allen Martin Dr.**
N. Williston Rd./VT117	**Sand Hill Rd/VT15**
Allen Martin Dr./VT15	VT289/VT15 (2 ints.)
	VT2A/Connor Way
	VT2A/Blair Park/Zephyr
	VT2A/James Brown Dr.
	US2/Simons Plaza
	US2/Talcott Rd.
	US2/Shaws (Boxwood)
	US2/Brownell Rd.
	Harvest Lane/US2
	US2/Industrial Ave.
	Marshall Ave./Brownell
	US2/OldStage Rd
	Mountain View Dr. /Old Stage Rd.
	VT117/Sand Hill Rd.

Key

Key
Signalized
Stop-controlled

2.0 EXISTING LAND USE/TRANSPORTATION CONDITIONS

The Existing Conditions assessment addresses land use, roadway characteristics, safety, bicycle/pedestrian facilities and plans, and transit service.

2.1 Land Use

This section provides an overview of land use patterns within the study area, beginning with the number of trips heading into and out of the study area. Next is a description of commuting patterns, followed by overviews of each of the primary study corridors' context. Appendix A-Land Use provides additional information for Williston, Essex, and Essex Junction.

2.1.1 Model Land Use

The assumptions for the WENTS microsimulation traffic model are consistent with, and derived from the land use assumptions for the latest countywide transportation model in the year 2010. Assumptions for future year models (e.g. 2015 and 2025) will be updated accordingly.

Table 3: Households and Employment within WENTS Study Area (2010)

Essex Junction		Essex		Williston	
Households	Employment	Households	Employment	Households	Employment
2,459	6,997	1,947	1,596	2,845	12,343

Figure 2 and Table 4 further break down housing and employment within the study area by Transportation Analysis Zone (TAZ).

Figure 2: Households and Employment within WENTS Study Area by TAZ (2010)

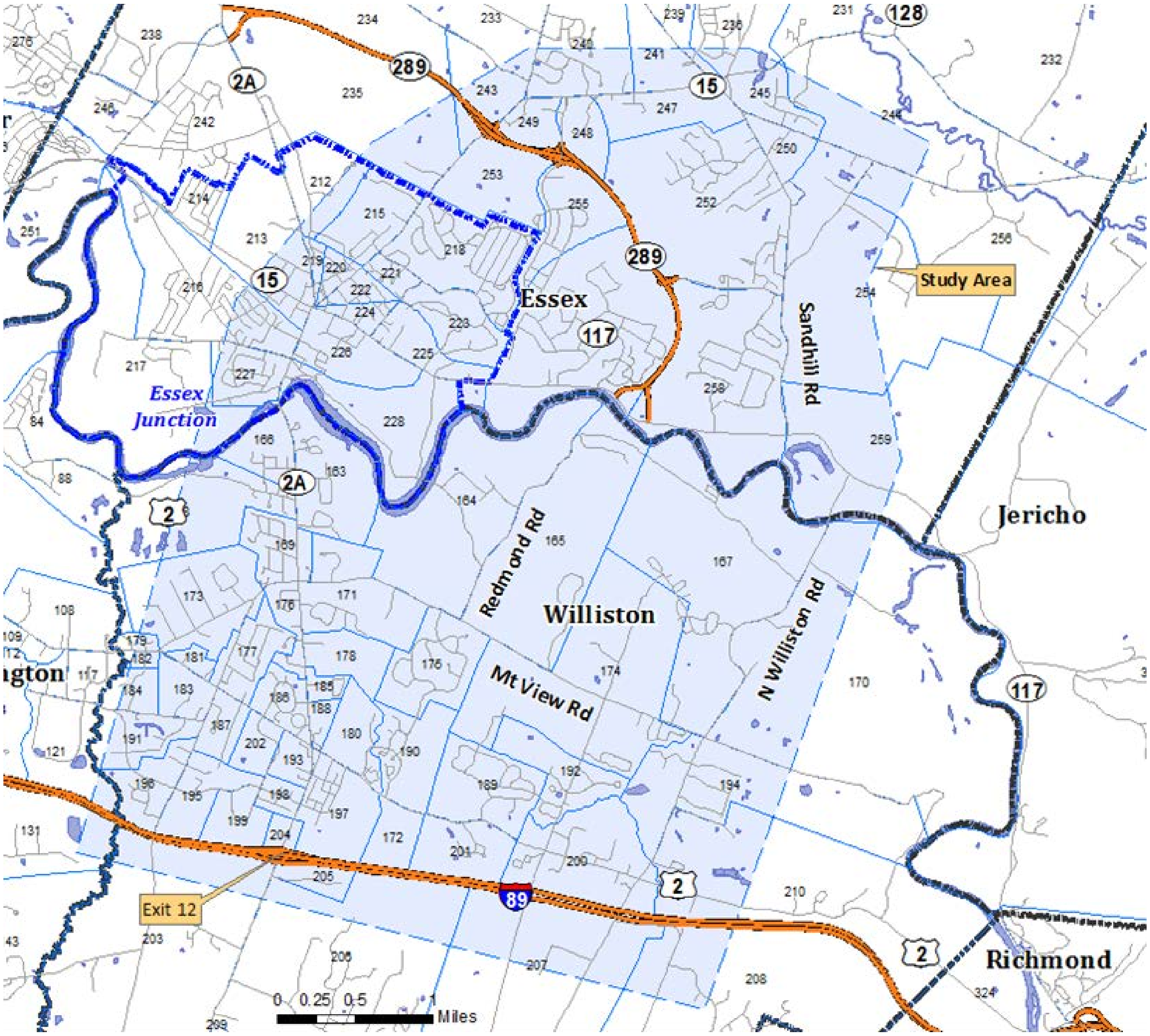


Table 4: Households and Employment within WENTS Study Area by TAZ (2010)

TAZ	Households	Retail	Commercial	Industrial	Institutional	K12	Accomodations	College_University	Special_Retail	Special_Commercial
Town of Williston:										
163	220	10	4	0	10	0	0	0	0	0
164	4	33	15	1428	0	0	0	0	0	0
165	39	1	4	17	3	1	0	1	0	0
166	18	84	92	105	57	0	0	1	42	9
167	145	4	0	0	3	0	0	0	0	0
168	79	0	10	23	1	0	0	0	0	0
169	129	6	12	1	0	0	0	0	0	0
171	133	1	20	0	0	0	0	0	0	0
172	0	0	0	3	0	0	0	0	0	0
173	2	561	152	1102	25	9	1	3	0	1
174	186	0	2	5	3	0	0	0	0	11
175	167	0	3	17	0	0	0	0	0	0
176	79	0	0	0	6	0	0	0	0	2
177	161	2	5	0	0	0	0	0	5	0
178	15	0	25	0	0	0	0	0	0	0
179	0	63	0	6	0	0	0	0	0	0
180	350	77	182	157	186	0	0	5	29	5
181	2	293	0	29	0	0	0	0	0	0
182	0	48	5	71	0	0	0	0	0	0
183	15	65	60	107	2	1	0	1	0	0
184	2	35	82	32	2	0	0	1	0	0
185	69	14	57	3	27	0	0	0	0	0
186	117	280	174	160	174	0	0	12	10	0
187	34	62	145	102	23	0	0	0	15	1
188	58	70	32	16	6	0	3	0	59	0
189	141	5	7	13	0	0	0	0	0	0
190	138	0	3	2	0	0	0	0	15	0
191	7	196	45	337	22	1	0	1	80	1
192	76	0	3	11	0	0	0	0	0	2
193	0	48	97	1	27	0	0	40	0	9
194	128	15	5	5	3	30	0	0	7	0
195	2	380	92	221	34	0	0	3	13	95
196	9	163	183	262	29	9	0	1	5	11
197	48	109	132	17	14	0	0	0	330	4
198	0	346	0	0	6	0	0	0	125	0
199	0	271	7	349	0	0	0	0	13	0
200	179	11	82	40	18	99	3	0	13	9
201	93	0	0	0	3	0	0	0	0	0
202	0	67	370	16	0	0	0	0	0	0
205	0	110	216	29	47	0	25	0	0	0
Village of Essex Junction:										
212	173	0	9	2	0	0	0	0	0	0
215	133	0	36	0	0	294	0	0	0	0
217	92	0	5	0	0	0	0	0	0	0
218	622	20	6	46	0	0	0	0	0	0
219	45	8	13	2	16	0	0	0	16	0
220	130	21	108	1	6	0	0	0	24	0
221	79	0	10	16	40	0	0	0	0	0
222	179	25	175	5	35	0	0	0	9	4
223	203	2	2	8	0	0	0	0	0	0
224	131	10	5	1	16	0	0	0	0	0
225	96	0	7	1	7	62	0	0	0	0
226	315	138	10	45	1	0	0	0	61	77
227	223	1	2	3	0	0	0	0	4	0
228	38	2	82	5496	0	0	0	0	0	2
Town of Essex:										
241	27	34	14	0	0	0	0	0	110	0
243	8	20	0	0	0	0	0	0	8	18
245	93	21	8	0	0	3	0	0	6	7
247	98	35	4	23	17	0	0	0	0	12
248	112	43	20	0	35	0	0	0	9	11
249	98	180	27	15	28	0	0	0	208	0
250	86	2	2	14	0	0	0	0	0	0
252	357	12	6	27	3	140	0	1	0	3
253	34	15	4	0	0	0	0	0	0	9
255	111	4	4	3	0	0	50	0	31	0
257	450	31	148	100	14	1	0	4	25	2
258	473	1	8	6	5	0	0	1	3	1

2.1.2 Journey to Work

The 2000 Census Transportation Planning Package was used to understand commuting patterns of residents and employees in Williston and Essex. Figure 3 and Figure 4 respectively show the percentages of residents in Williston (3,838 working residents) and Essex (10,442 working residents, including the Village of Essex Junction) that commute to other towns for work. Figure 5 and Figure 6 show where people who work in Williston (10,811 employees) and Essex (16,615 employees) (respectively) reside. These data show that linkages between Williston, Essex, Burlington, and South Burlington are particularly crucial for commuters.

Figure 3: Towns to which Williston Residents Commute for Work

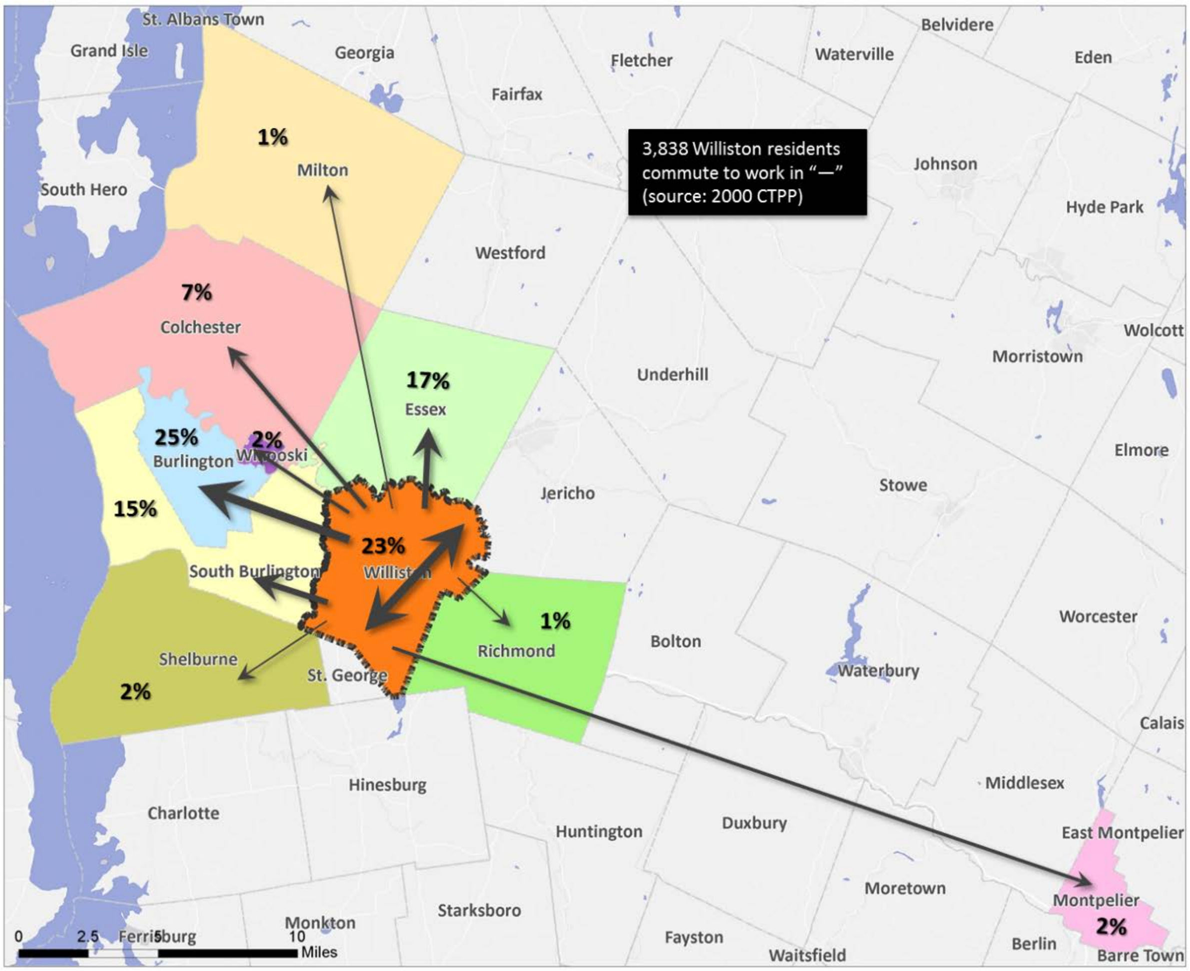


Figure 4: Towns to which Essex Residents Commute for Work

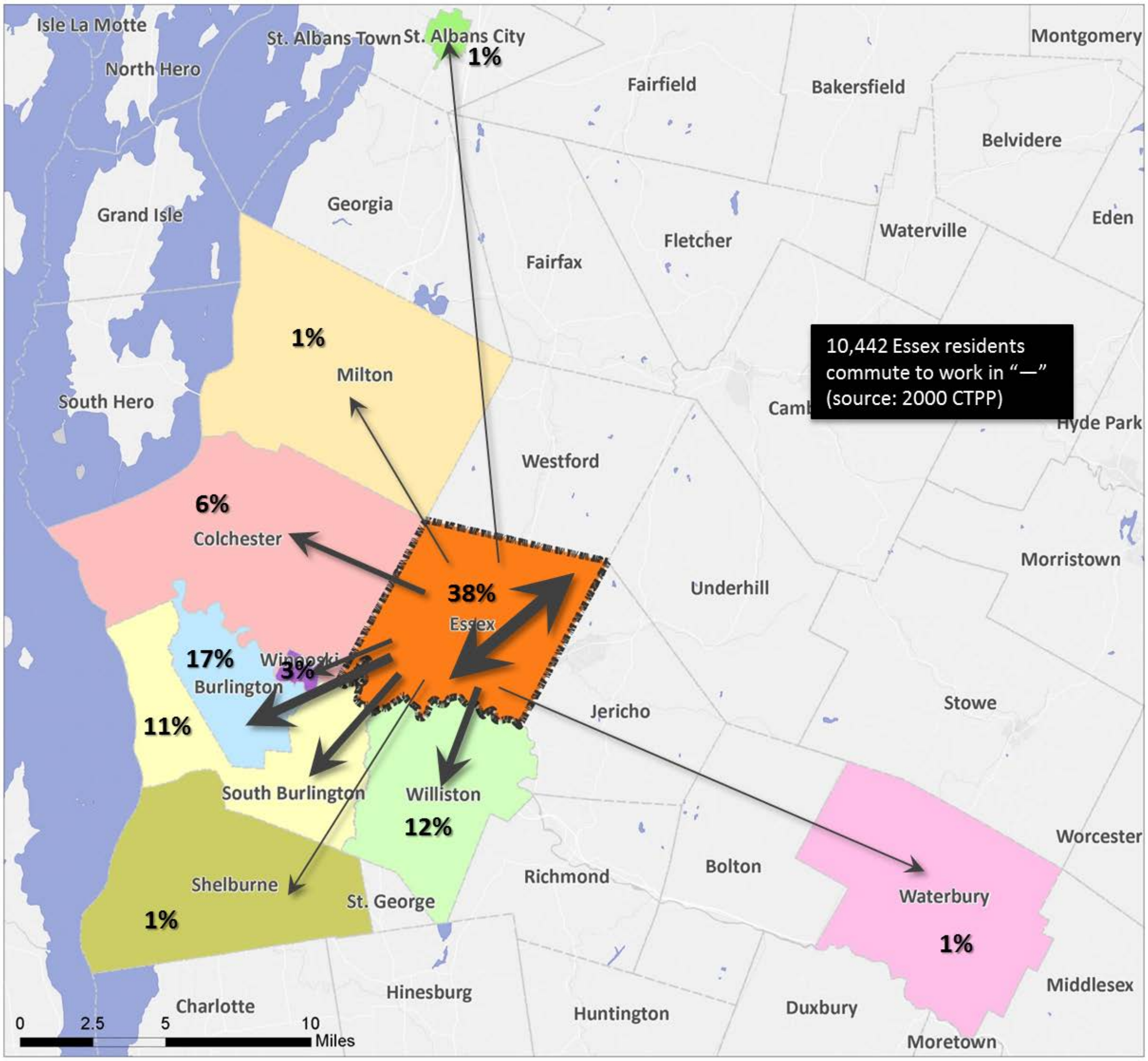


Figure 5: Towns in which Williston Employees Reside

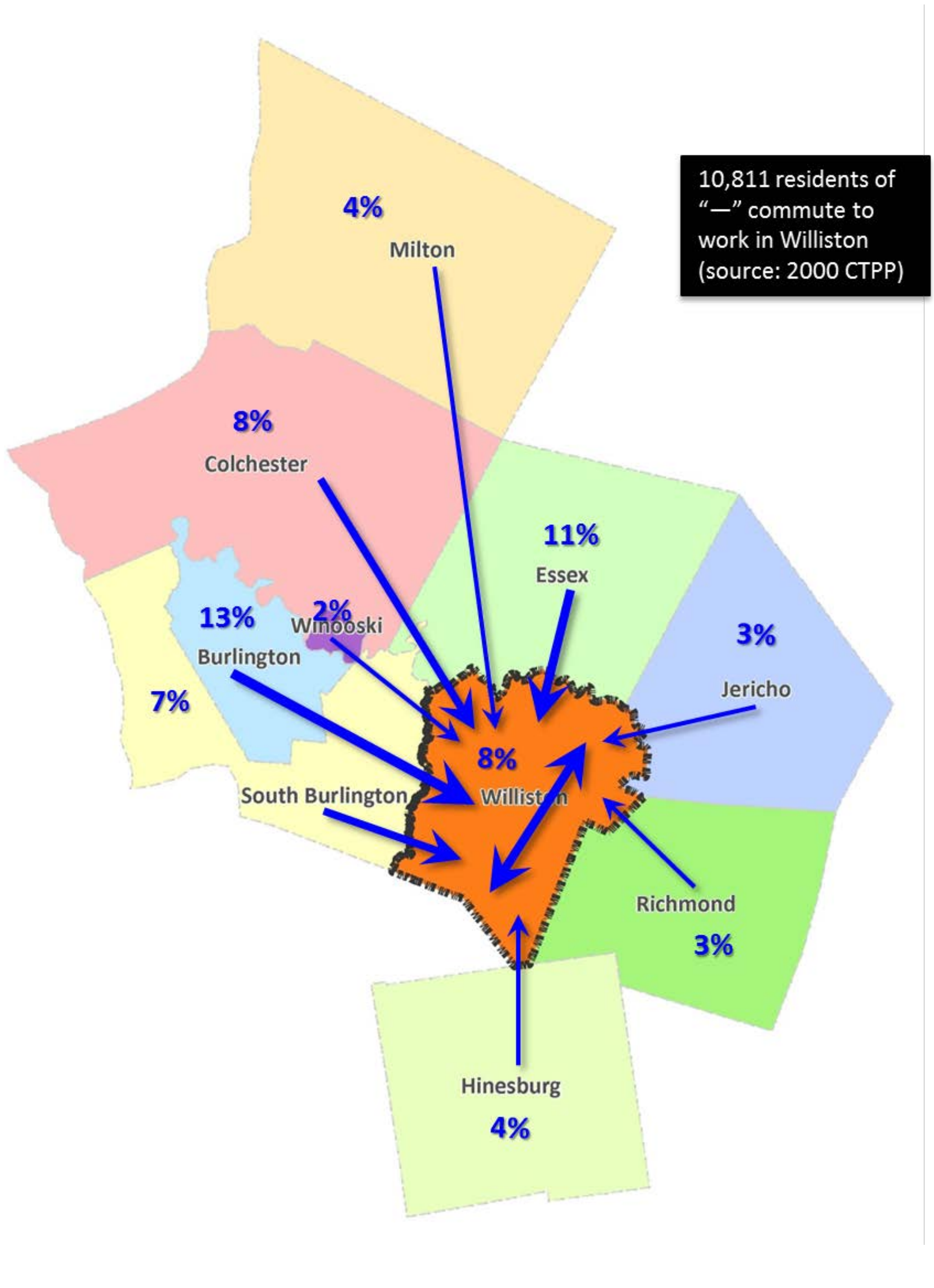
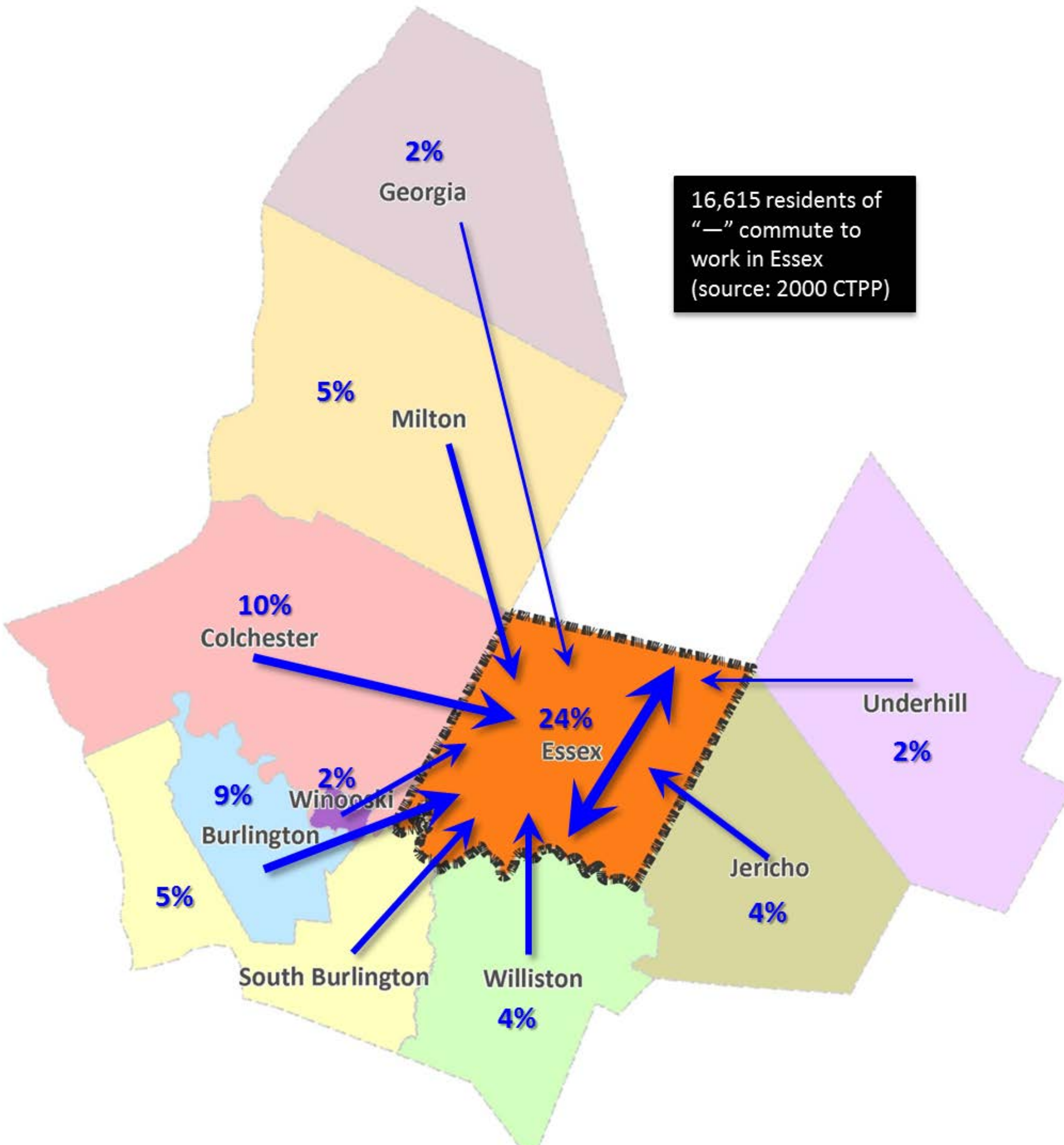


Figure 6: Towns in which Essex Employees Reside



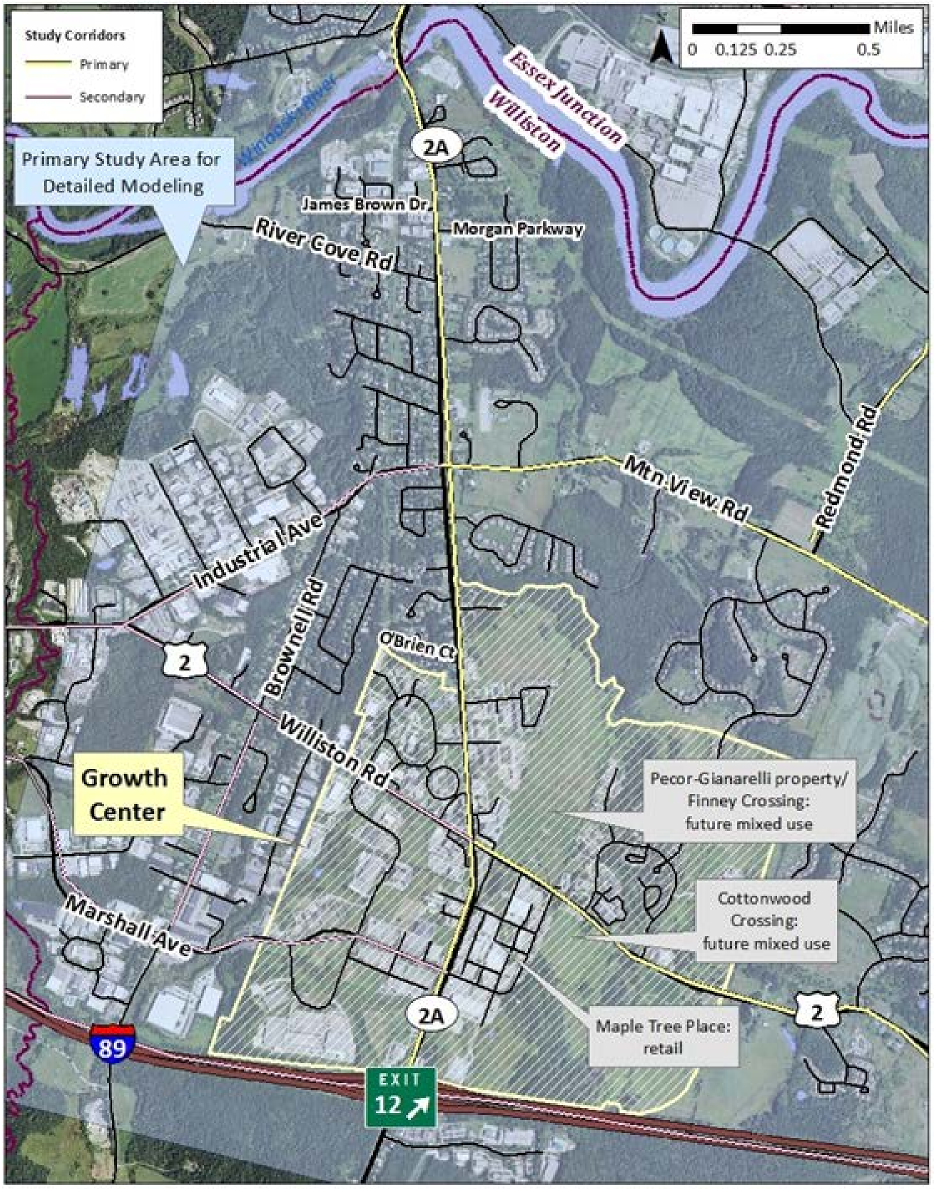
2.1.3 Corridor Context

VT 2A

As shown in Figure 7, VT 2A is the key north-south arterial serving Williston's Growth Center. The predominant land uses between I-89 and O'Brien Court are commercial and retail, interspersed with smaller pockets of open land. This area of VT 2A includes the Maple Tree Place Shopping Center and numerous big-box stores. Other land uses include restaurants, hotels, and the offices of Vermont Technical College. Significant land areas are devoted to parking to serve these uses.

From O'Brien Court to Morgan Parkway, the predominant land use is residential development, with pockets of open space. There is a mix of land uses between Morgan Parkway and the Essex-Williston town line, including Overlook Park along the Winooski River, the Green Mountain Power Essex No. 19 Hydroelectric facilities, commercial and retail activity, and residential development. Continuing north on VT 2A into Essex Junction, the adjacent land use is characterized by low-density single family dwellings.

Figure 7: VT 2A Corridor between I-89 and the Williston-Essex Town Line



US 2

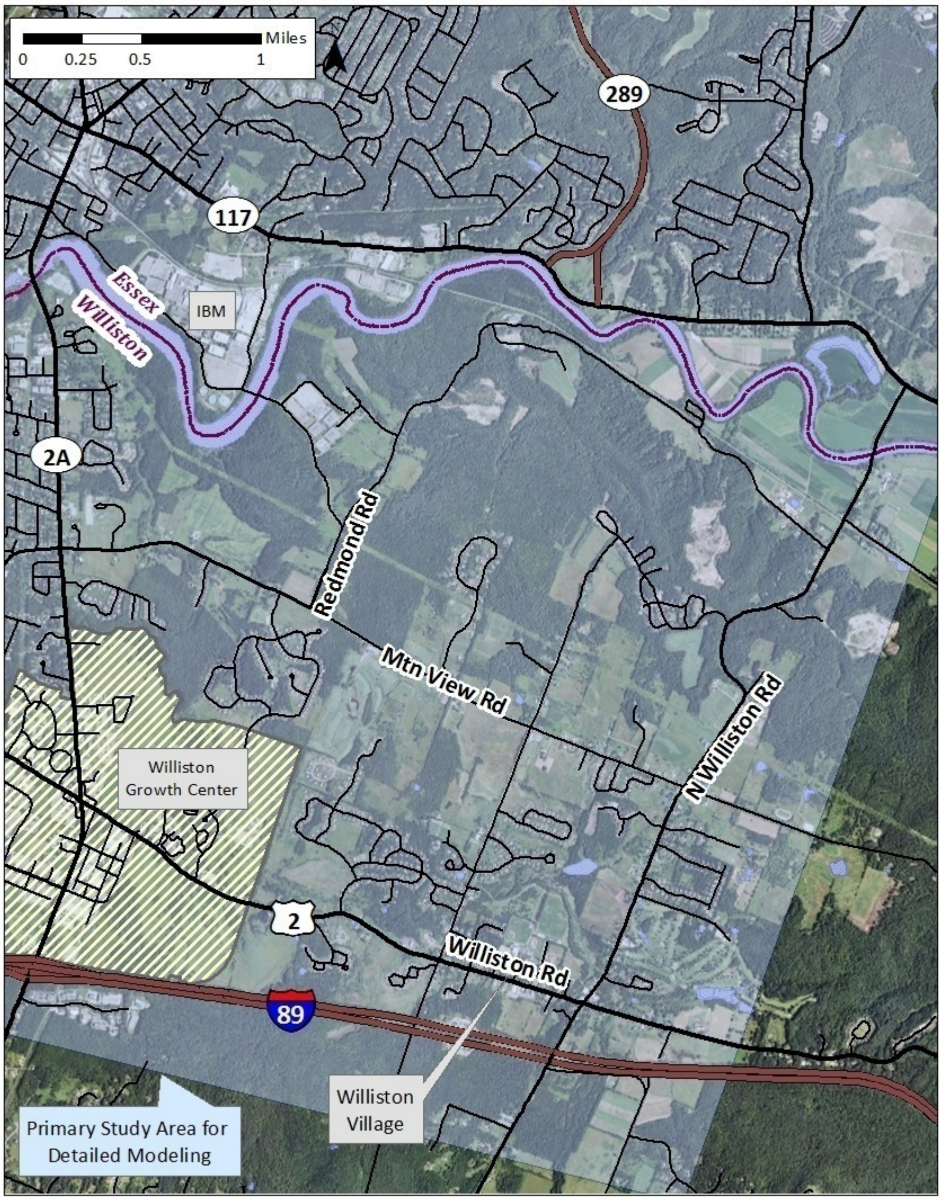
US 2 traverses Williston's Growth Center (Figure 7). East of the US2/VT2A intersection (Taft Corners), the land use transitions from commercial to mixed use residential. This area is intended to permit higher density residential development mixed with limited retail and office uses. East of this area is open land once reserved for the Circ Highway. Further east on US 2 is the Village Center District; a portion of the district is included in the Williston Village Historic District, which is on the National Register of Historic Places.

As a designated Growth Center, the majority of Williston's 20-year growth will take place around Taft Corners, with residential uses within walking distance of the theater, shops, cafes, and other businesses. However, the traffic levels and width of US 2 present a pedestrian barrier, so enhancements to enable safe crossings should be considered along with any future development.

Mountain View Road

Mountain View Road between VT2A and North Williston Road (see vicinity map in Figure 8) serves as a collector for adjacent residential neighborhoods and frontage residences. Between Mountain View Road and US2 are medium density residential land uses. The dominant land uses north of Mountain View Road are categorized as agriculture/rural residential that include large lot single family homes, agriculture properties, and largely undeveloped areas within Williston.

Figure 8: Mountain View Road, Redmond Road, and North Williston Road Corridors



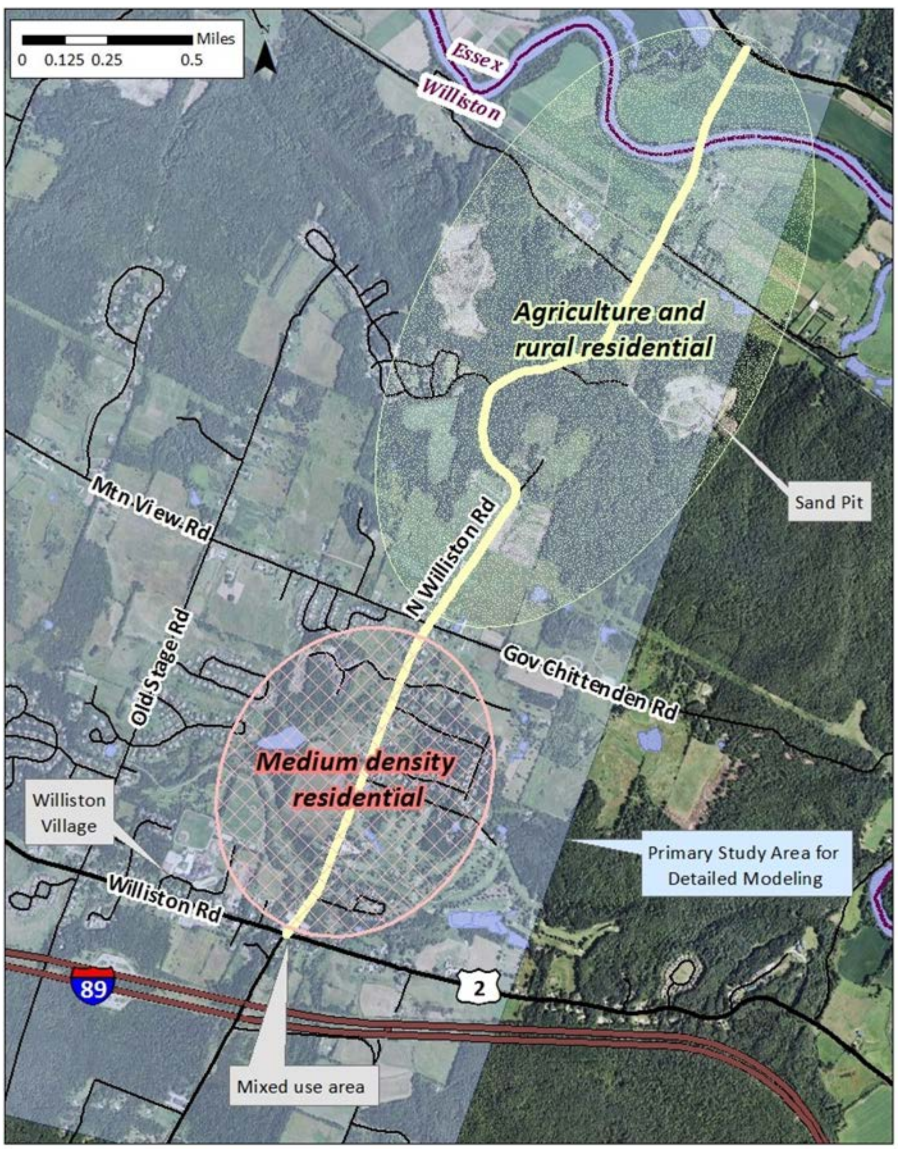
Redmond Road

The Redmond Road corridor is mostly undeveloped land and industrial land uses. At the north end is the future regional landfill to be operated by the Chittenden Solid Waste District (CSWD). IBM's facilities are located west of Redmond Road and south of the Winooski River. Redmond Road provides a third access to the IBM campus, and an alternative to the more congested entrances from the north and west.

North Williston Road

As shown in Figure 9, north of Mountain View/Governor Chittenden Road, the dominant land uses of North Williston Road are agriculture/rural residential and largely undeveloped areas. The one exception is the Sand Pit used for mining and extraction. To the south of Mountain View Road are medium density residential land uses. The land uses at the intersection of US2 and North Williston Road are a moderately dense mix of residential, institutional, and commercial uses that leads to Williston's historic village. Both southern quadrants of the intersection are residential.

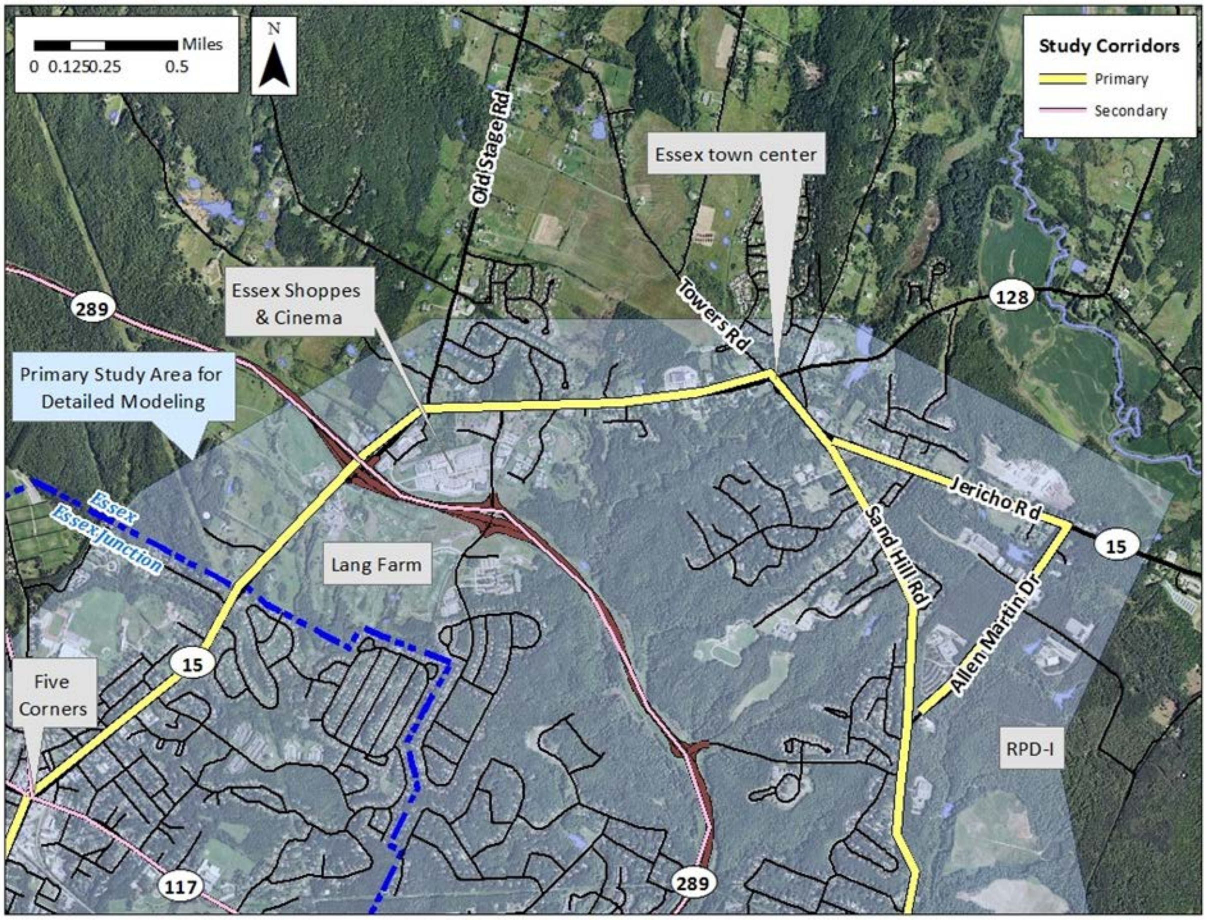
Figure 9: Land Uses on North Williston Road



VT 15

As shown in Figure 10, VT 15 connects Five Corners in Essex Junction to the Essex town center, travelling east through agricultural land uses, Lang Farm and the Essex Shoppes and Cinema, and then into higher density residential uses before reaching the intersection of VT 128, Towers Road, and Sandhill Road.

Figure 10: VT 15, Sandhill Road and Allen Martin Drive Corridors



Sandhill Road

Land uses on Sandhill Road are primarily rural residential, although many public facilities are located in the corridor, such as schools and the highway and fire departments. On the west side of the corridor are medium density residential neighborhoods consisting of single family homes, attached townhomes and semi-attached dwellings.

At its southern end, Sandhill Road traverses a small area of Industrial Land Use near River Road. The Industrial land use area provides for employment opportunities in manufacturing, warehousing, research and development and commercial uses which specifically serve the industries or their employees in areas serviced by good transportation facilities and public utilities. Other uses incompatible with industrial uses, such as residential uses, are not permitted for the health, safety and welfare of the community.

Adjacent to the Winooski River and the Industrial Area is the Flood Plain Area. The purpose of the Flood Plain Area is to reduce the potential for damage from flooding; to protect streams and water courses for erosion, siltation and pollution; and to protect the natural ecology of stream beds and lands adjacent to water courses. In these areas, no building is permitted and excavation, fill, disruption of vegetative cover or other encroachment is restricted.

Allen Martin Drive

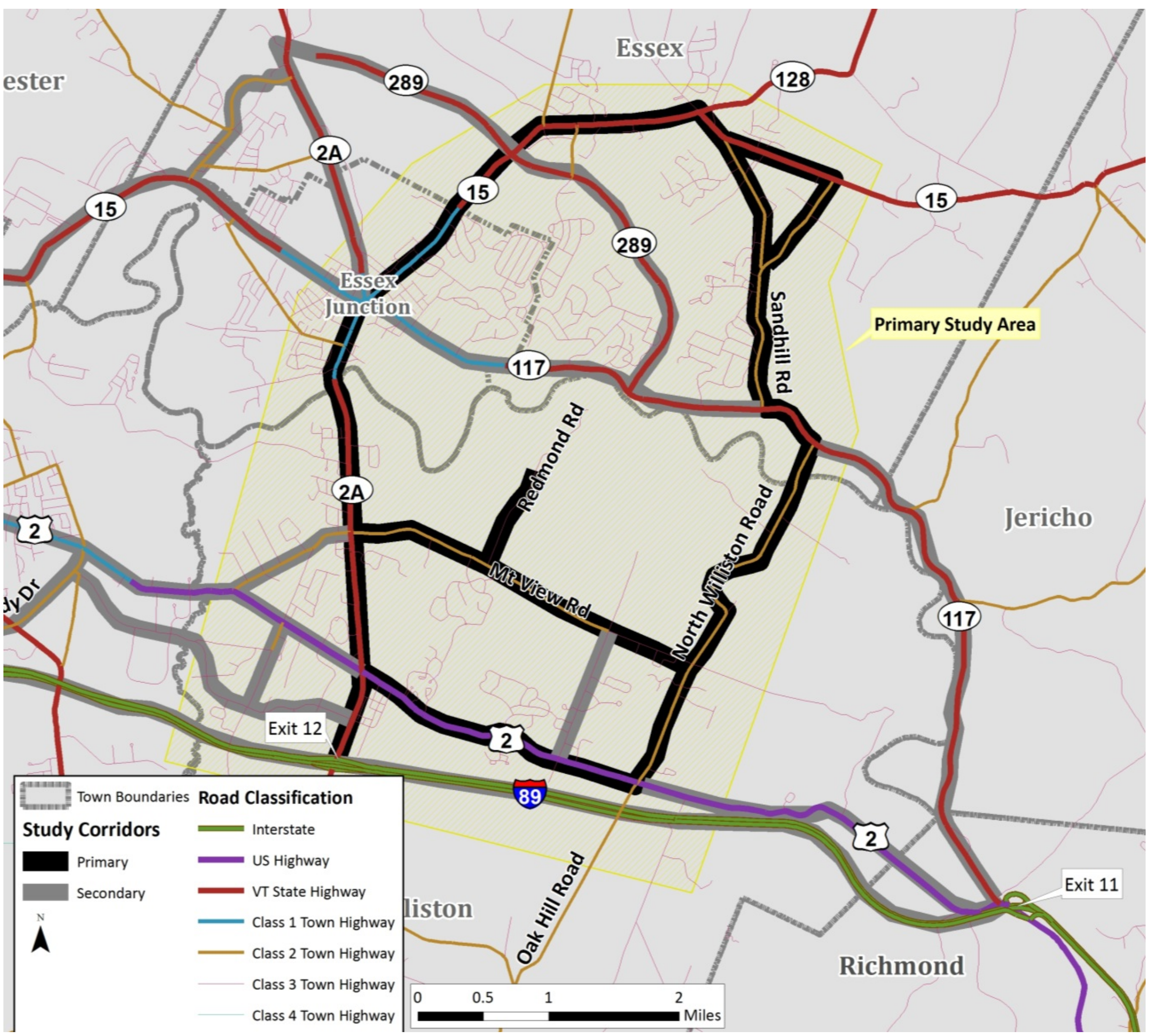
To the east of Sandhill Road and encompassing Allen Martin Drive is the Resource Protection-Industrial (RPD-I) land use area (Figure 10). This area is established for land that is comprised of forests, bodies of water, or similar natural settings. The specific objective of the RPD-I district is to protect all or part of the natural attributes for public enjoyment and, when it is deemed economically and aesthetically feasible, to carry out economic development activities in harmony with the natural surroundings. Potential uses include office, research and development facilities, laboratories, and limited commercial support services for employees of the Saxon Hill Industrial Park, such as banks, restaurants, recreation/health spas, etc.

2.2 Roadway Characteristics

2.2.1 Corridors

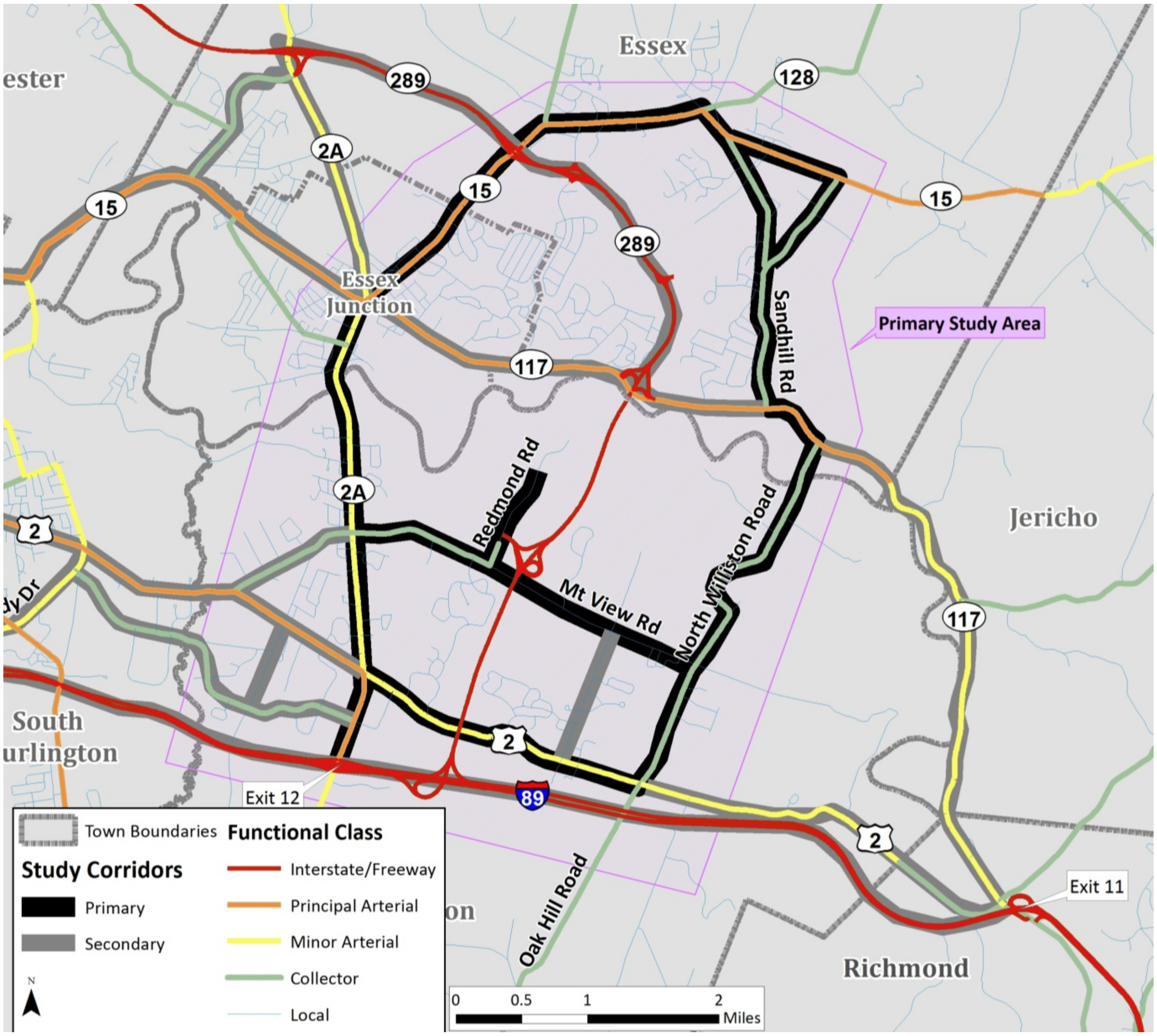
Figure 11 shows the road classifications of the study corridors; most of VT 2A and VT 15 are Vermont State Highways. In Essex Junction, particularly at Five Corners, VT 15, VT 2A, and VT 117 are Class 1 Town Highways. US 2 is a US highway, while Sandhill Road, Allen Martin Drive, North Williston Road, and Mountain View Road are Class 2 Town Highways.

Figure 11: Road Classification



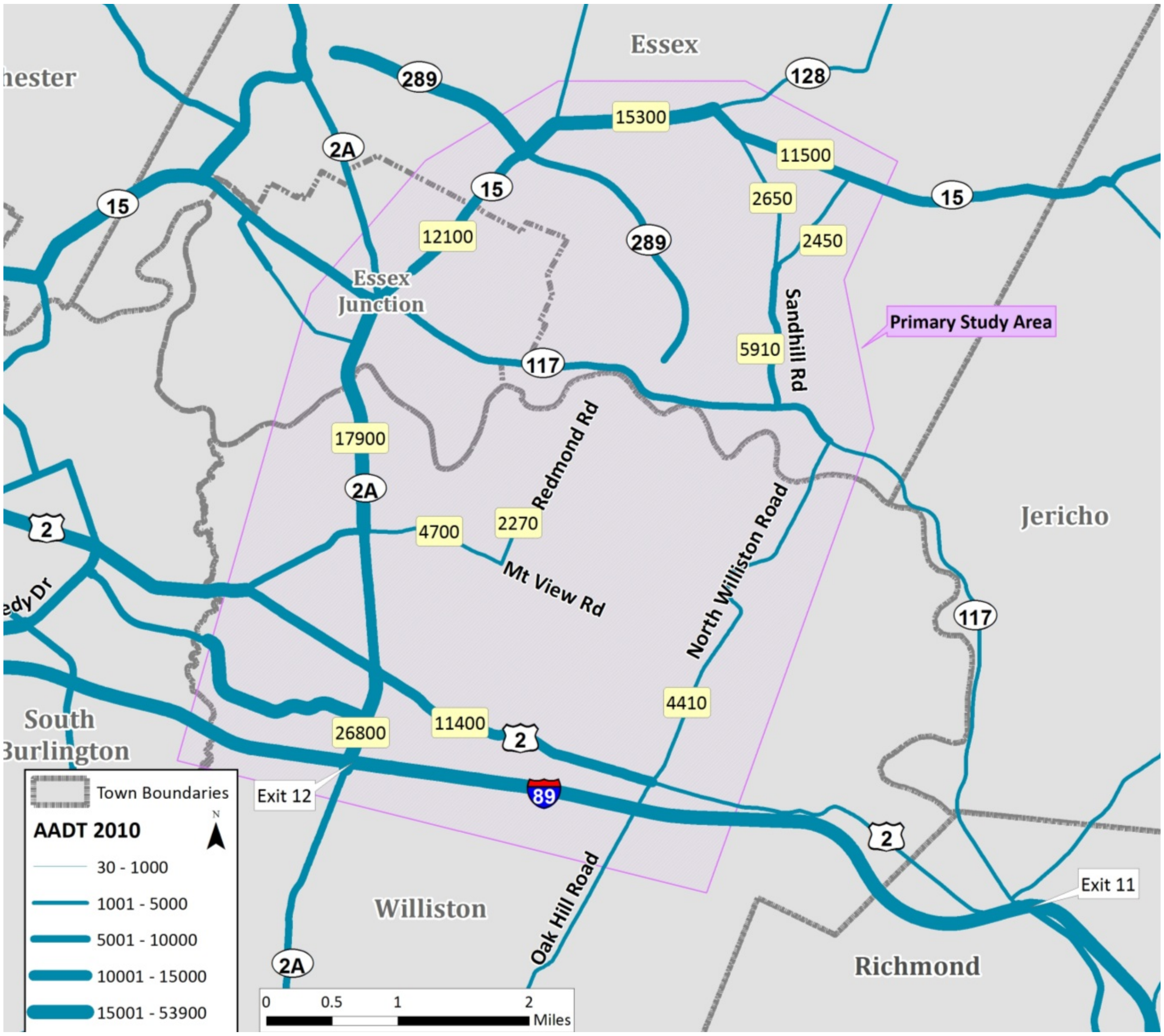
The Functional Classification of the transportation network is shown in Figure 12. The principal arterials in the study area are VT 15, VT 117, and US 2 west of VT 2A. East of VT 2A, US 2 is a minor arterial, as is VT 2A north of US 2. Sandhill Road, Allen Martin Drive, North Williston Road, and Mountain View Road west of Redmond Road are collectors. East of Redmond Road, Mountain View Road is a local road, as is Redmond Road.

Figure 12: Functional Class



The amount of daily traffic averaged over the course of one year (AADT or Annual Average Daily Traffic) for 2010 is shown in Figure 13. Of the primary corridors, VT 2A carries the most traffic, followed by VT 15 and then US 2.

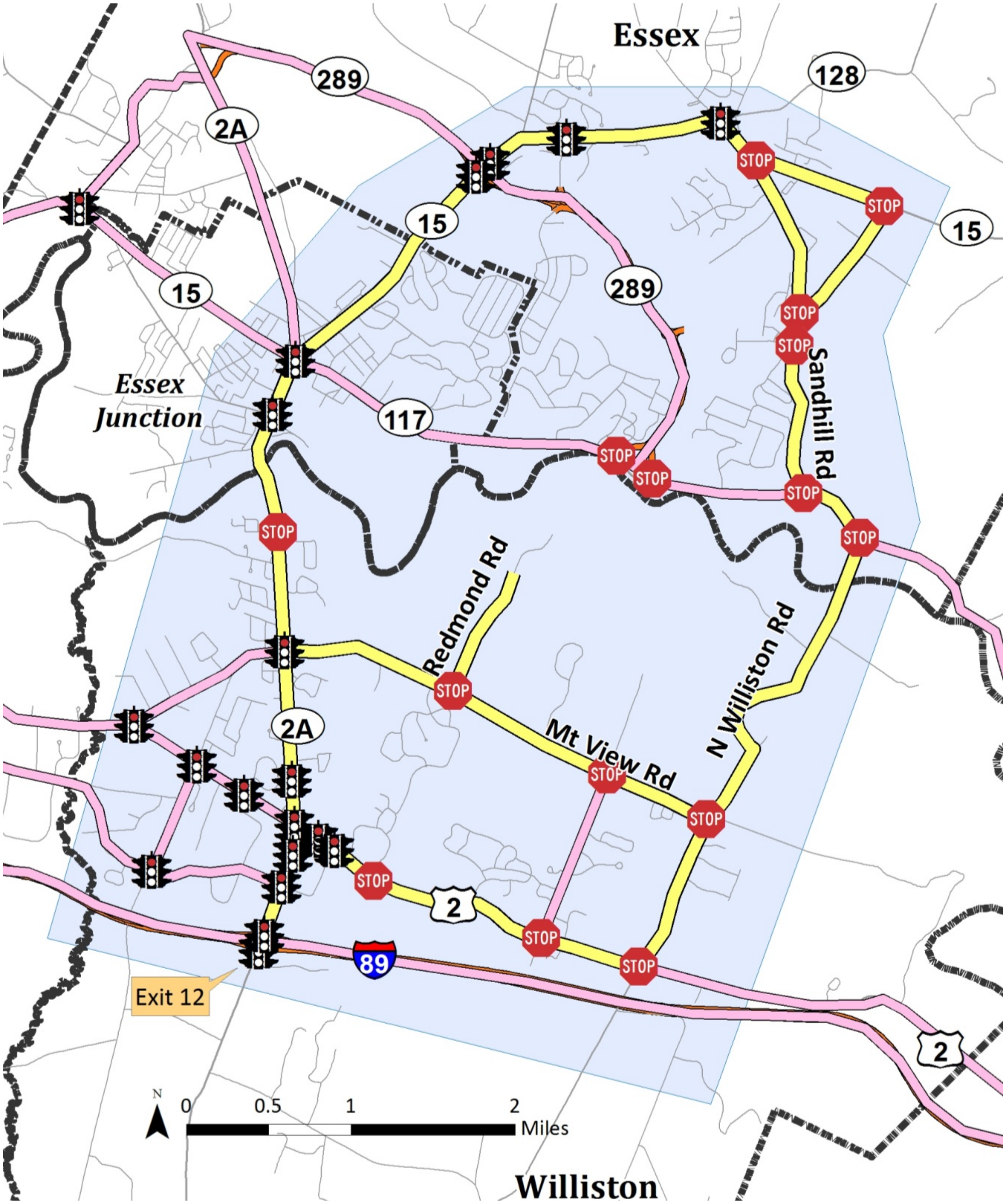
Figure 13: 2010 Annual Average Daily Traffic (AADT for Primary Study Corridors is labeled)



2.2.2 Intersections

Table 2 in Section 1.1 above lists the primary and secondary intersections analyzed for WENTS. Figure 14 below geographically illustrates that the signalized intersections are primarily on the more developed corridors of VT 15, VT 2A and the western half of US 2, while stop-controlled intersections tend to be in central and eastern part of the study area.

Figure 14: Study Intersection Control



2.2.3 Access Management

Access management is the placement and design of driveways along a road to maximize safety and the efficiency of traffic flow. By regulating the points at which vehicles can turn from a roadway into a property (that is, the driveway or access), engineers and designers can minimize traffic conflicts and promote safety. Access management requires close coordination of land use and transportation planning and design, and can result in reduced travel times and congestion, improved access to properties, and overall efficiency.

Access points connect the public roadway system to private land. Managing access to public roads and highways is an important function of land use and transportation planning. This section identifies access management deficiencies for study corridors that will be addressed in subsequent phases of the study.

2.2.3.1 Access Management Categories

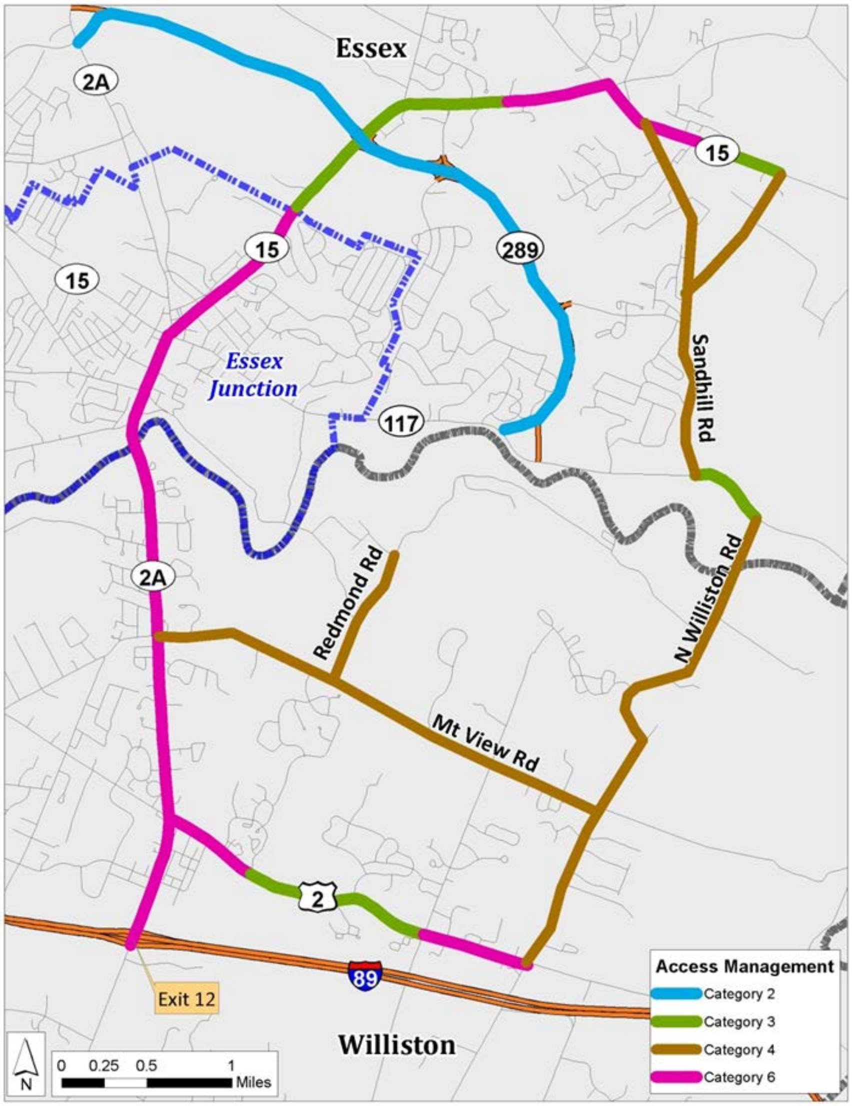
VTrans assigns one of six access management categories to highway segments based on functional class, AADT, land development characteristics (Zoning & Land Use Plans), regional growth patterns, and existing driveway density (Table 5).

Table 5: VTrans Access Management Categories

Access Category	Highway Functional Class (AADT)	Degree of Access Control	Direct Property Access	Driveway Controls	Traffic Operations Allowed	Design Features
1	Principal Arterials (Interstate)	Full	No	NA	Access at Interchanges Only with Public Hwys	Grade-Separated Interchanges
2	[1] Principal Arterials (Non-Interstate – LA) [2] Other Principal Arterials (LA) [3] Limited Access (LA) Major collectors	Full to Partial	No- Except by Access Rights	NA or Location	Access at Intersections with Public Highways	At-Grade or Grade-Separated at 1/2 to 1 Mile Intervals
3	[1] Principal Arterials (Non LA) [2] Other Principal Arterials (Non LA) [3] Minor Arterials (>5000 AADT) [4] Non-Limited Access Major Collectors on State Hwy & Class I TH's (>5000 AADT)	[1] Mandatory Restrictions to operations [2] Design Features [3] Land Use Issues	Deny, Restrict or Allow	NA or Number, Spacing and Location	NA or May Limit Turning Movements	[1] Physical Barriers [2] Signal Spacing Requirements [3] Left and/or Right Turn Lanes Required [4] Spacing of Public Hwy Intersection (1/4 to ½ Mile)
4	[1] Minor Collectors [2] Minor Arterials on State Hwy or Class I TH's (<5000 AADT) [3] Non-Limited Access Major Collectors on State Hwy & Class I TH's (<5000 AADT)	[1] Design Features [2] Land Use Issues	Yes	Number, Spacing and Locations	[1] All Turns In & Out [2] May Limit Turning Movements	Spacing of Public Highway Intersection (1/4 to ½ Mile)
5	Frontage or Service Roads	[1] Design Features [2] Land Use Issues	Yes	Number & Location	All Turns In & Out	Signal Spacing (No Less Than 300 Feet)
6	"Urban" Sections of Highways	[1] Design Features [2] Land Use Issues	Deny, Restrict or Allow	Number, Spacing & Location	[1] All Turns In & Out [2] May Limit Turning Movements	Signal Spacing (No Less Than 500 Feet)

Based on CCRPC's access management data, the primary study corridors (VT 2A, VT 15, US 2) are classified as Category 3 and Category 6 (Figure 15). VT 289 is classified as Category 2. Local roads such as Mountain View Road, Redmond Road, North Williston Road, and Sandhill Road are not designated under the state classification system. However, discussions with local officials indicate that Access Category 4 would be appropriate for the local roads.

Figure 15: Access Management Category Classifications of the Primary Study Area Corridors and VT 289



2.2.3.2 Deficiencies

VTrans has design standards for each of the six access management categories. To identify access management deficiencies for WENTS, three readily measurable design standards were applied to the intersections along the primary corridors:

1. **Intersection/Driveway spacing** – For unsignalized access spacing standards, VTrans uses the lower limit of the AASHTO stopping sight distance approach which would enable a driver traveling at the design or posted speed to monitor only one driveway at a time and, if necessary, to stop (Table 6).

Table 6: VTrans Unsignalized Access Spacing

POSTED SPEED or DESIGN SPEED (mph)	UNSIGNALIZED ACCESS SPACING* (ft)
20	115
25	155
30	200
35	250
40	305
45	360
50	425
55	495

(*Spacing shown is based on level terrain: adjustment factors are required for segments with grades)
Source: Derived from Exhibit 3-1(Pg.112) (Stopping Sight Distance) from AASHTO A Policy on Geometric Design of Highways and Streets, 2001

2. **Corner clearance at intersections** – Since there are no restrictive medians along the primary corridors, the corner clearance for both approaching and departing intersections used for evaluation is 230 feet.[1]

3. **Intersection spacing** – The standard for the spacing of all intersecting public streets, roads, highways, and other accesses that are or may become signalized is ¼ mile in Category 3 and no less than 500 feet in Category 6.

Study intersections which do not meet these three standards are shown in Table 7 and Figure 16.

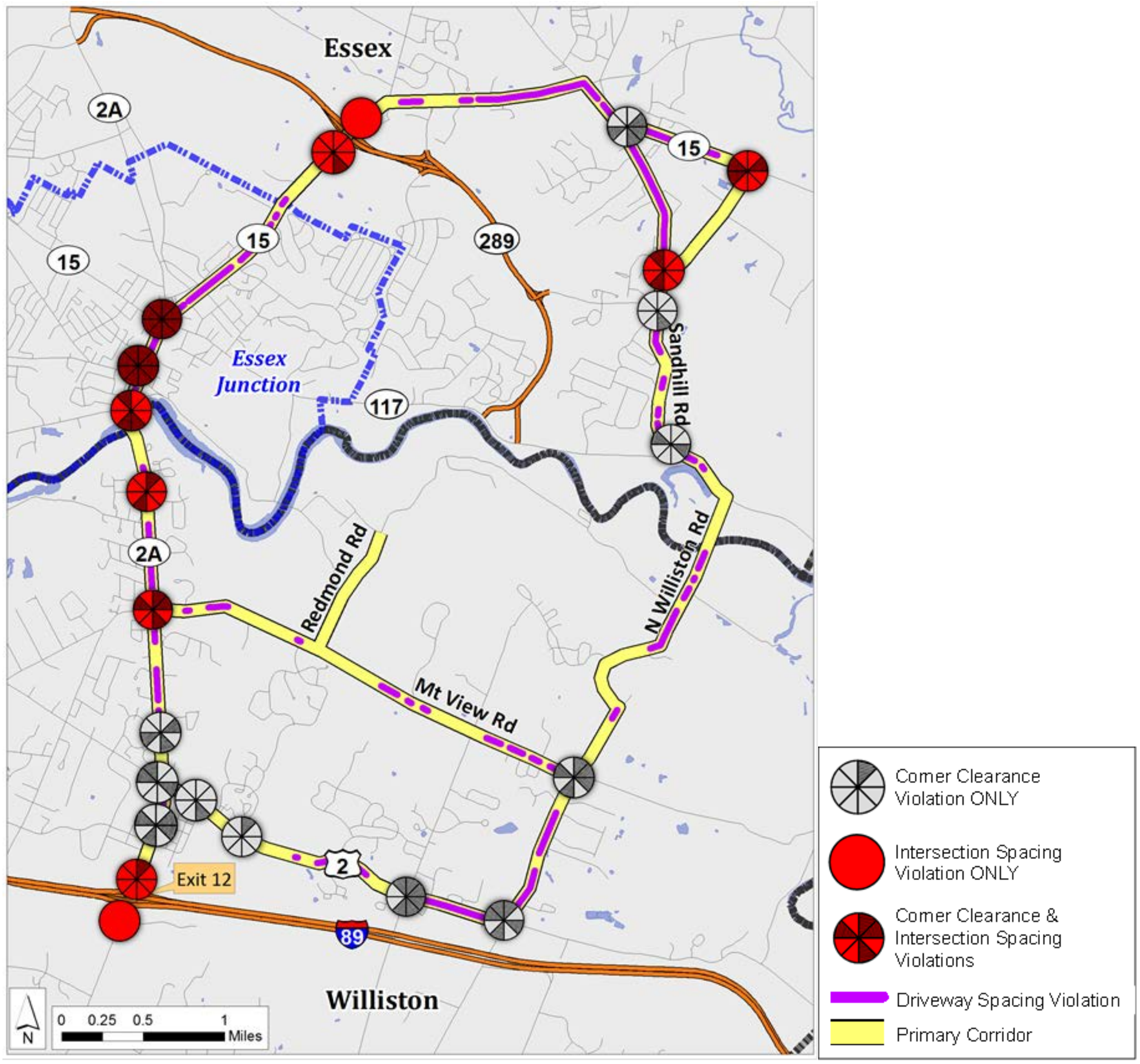
Table 7: Intersection Corner Clearance and Spacing Deficiencies

Primary Intersections	Driveway Spacing	Corner Clearance	Intersection Spacing
Allen Martin Dr/VT15	X	X	X
VT117/Sand Hill Rd	X	X	
N Williston Rd/VT117			
VT2A/South St/River St	X	X	X
VT2A/Mill St	X	X	X
VT2A/Industrial Ave/Mountain View Rd	X	X	X
VT2A/US2		X	
VT2A/Marshall Ave/Maple Tree Pl			
VT2A/Exit 12 NB	X	X	X
VT2A/Exit 12 SB			X
US2/Oak Hill Rd/N Williston Rd	X	X	
N Williston Rd/Mountain View Rd	X	X	
Mountain View Rd/Redmond Rd			

Secondary Intersections	Driveway Spacing	Corner Clearance	Intersection Spacing
Five Corners	X	X	X
VT15/I-289 SB	X	X	X
VT 15/I-289 NB	X		X
Sand Hill Rd/VT15	X	X	
Sand Hill Rd/Allen Martin Dr	X	X	X
Sand Hill Rd/Allen Martin Parkway		X	
VT2A/James Brown Dr	X	X	X
VT2A/Blair Park/Zephyr		X	
VT2A/Connor Way	X	X	
US2/Shaws (Boxwood)		X	
US2/Simons Plaza			
US2/Talcott Road East		X	
US 2/Old Stage Rd	X	X	
Mountain View Rd/Old Stage Rd			

[1] Vermont Agency of Transportation *Access Management Program Guidelines*, July 22, 2005.

Figure 16: Access Management Deficiencies



2.3 Safety

A safety-focused field review has been conducted to observe road user behaviors and interactions and to identify potential safety issues. Off-peak, morning, midday, evening, and nighttime reviews were conducted to make observations under various conditions. The following provides a summary of the existing positive safety features and potential safety issues at five study intersections which are classified by VTrans as High Crash Locations.

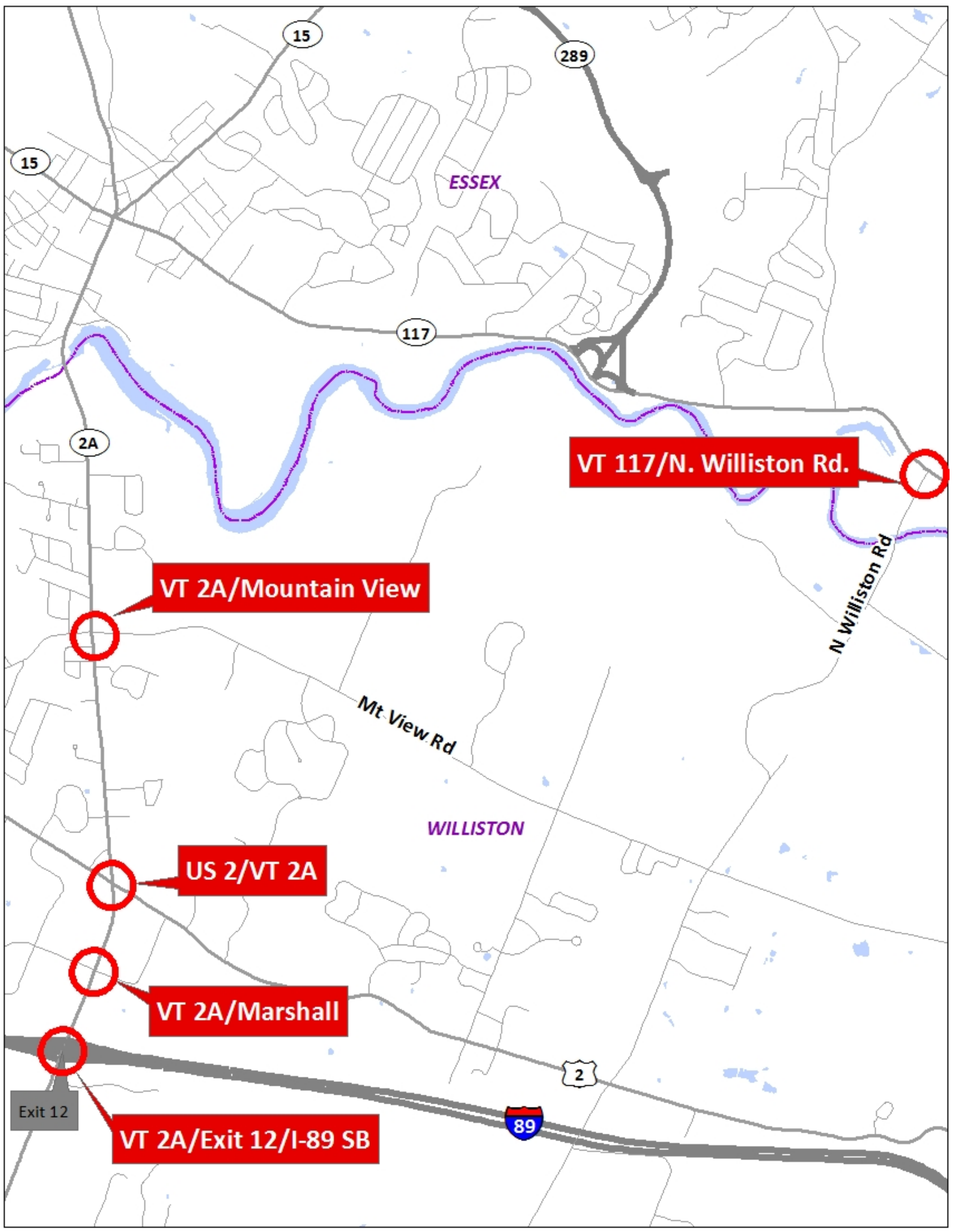
In order to be classified as a High Crash Location (HCL), an intersection or road section (0.3 mile section) must meet the following two conditions:

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

As shown in Figure 17, the VTrans *High Crash Location Report*[1] for the years 2006 to 2010 indicates that the following study locations are HCL intersections:

1. VT 2A / I-89 Exit 12 Southbound - HCL #123
2. VT 2A / Marshall Ave. / Maple Tree Place - HCL #37
3. VT 2A / US 2 - HCL #86
4. VT 2A / Industrial Ave. / Mt View Rd - HCL #81
5. VT 117 / N. Williston Rd. - HCL #83

Figure 17: Location of HCLs in the Study Area



[1] This document is exempt from discovery or admission under 23 U.S.C. 409.

2.3.1 VT 2A/I-89 Southbound Exit 12

There were a total of 24 crashes reported from 2006 to 2010 at this location.

2.3.1.1 Positive Safety Features

The following were noted as positive features with respect to safety at this location.

- **Signal Equipment**: Relatively new signal equipment includes signal backplates and 12-inch signal lenses. Both of these features help to improve the visibility of the traffic signal. Specifically, the backplates help to address issues related to sun glare and other background lighting while larger signal lenses help drivers to readily identify the signal and indication.
- **Retroreflective Signing**: There is large, retroreflective, overhead signing on the southbound ramp to alert drivers to the lane designation and appropriate lane usage. Way-finding is included on the overhead signs to guide drivers to specific routes and locations. Clear signing and way-finding can help to reduce driver confusion and last-second lane changes. The retroreflective signing enhances the visibility of the sign in low-light conditions.
- **Deceleration Lane**: There is a long deceleration lane for southbound vehicles exiting the freeway. This provides an opportunity for drivers to decelerate, identify the proper lane for their desired destination, and position their vehicle prior to the intersection.
- **Clearance Interval**: Based on field measurements, it appears that the signal is timed with a 4 second yellow interval and a 2 second all red interval. The yellow and all red time allow for vehicles to clear the intersection during the phase change before conflicting movements are allowed to enter.
- **Street Lighting**: Intersection lighting is provided by two cobra head lights. The intersection lighting helps to illuminate the intersection at night and helps drivers to identify the presence and location of the intersection.

2.3.1.2 Potential Safety Issues

Table 8 provides a summary of the identified safety issues at this intersection. Photos are provided to help illustrate several of the issues.

Table 8: Potential Safety Issues Identified at VT 2A/I-89 Southbound Exit 12

Potential Issues	Example
Issue 1: Downgrade Based on a review of the crash history, 13 of the 17 crashes, for which the direction of travel was coded, occurred on the northbound approach of VT 2A. These crashes included four rear-end crashes, three sideswipe same direction crashes, and one single vehicle crash that may be correlated with the downgrade. There are multiple skid marks on the downgrade, which is further evidence of a potential safety issue.	 View of the northbound approach along VT 2A. Photo shows the multiple skid marks at the bottom of the downgrade.

Potential Issues	Example

Issue 2: Peak period congestion

Based on a review of the crash history, there appears to be a slight increase in crashes for the morning and midday peaks, and a substantial increase in crashes for the evening peak. The crash potential was confirmed during evening peak review as long queues were observed to extend from the intersection at the southbound ramp back through Marshall Avenue to Conner Drive.

View of southbound approach of VT 2A during PM peak. Photo shows the lengthy queue that extends north through several intersections.

Issue 3: Limited lane guidance on SB ramp

Lane markings are present near the intersection to designate three lanes (left, shared thru-left, and exclusive right-turn lane), but the southbound ramp is relatively wide and designated as a single lane where the deceleration lane diverges from the freeway. Drivers tend to queue in the middle lane and do not fully utilize the dual left-turn lanes, which is the predominant movement. There are no skip marks to guide adjacent turning vehicles in the dual left-turn lanes from the southbound ramp onto VT 2A. One of the five crashes on the southbound ramp was a sideswipe same direction crash.

View of I-89 southbound off-ramp. Photo shows the relatively wide cross-section with limited pavement markings to designate lane use. A queue is building in the center lane that serves as a shared thru-left, while the left-most lane is under-utilized.

Issue 4: Poor pavement condition

More than 20 percent of the crashes occurred during wet conditions (i.e., rain, snow, or sleet).
The pavement condition at the intersection is in fair to poor condition. There is evidence of pavement rutting, particularly on the downgrade, which can contribute to wet-weather crashes.

Potential Issues	Example
	View of northbound approach along VT 2A. Photo shows the poor pavement condition (i.e., rutting and cracking).
Issue 5: Limited sight distance from NB ramp While the intersection of VT 2A and the NB ramp was not designated as one of the study locations, the field review team made observations there as well. Right-turn-on-red is permitted from the northbound off-ramp and this is a potential safety issue due to the limited sight distance at the intersection.	 View of the I-89 northbound off-ramp. Photo shows the limited sight distance due to the vegetation. Drivers must pull beyond the stop bar to position themselves to see traffic on VT 2A.
Issue 6: Pedestrian-related issues Despite the lack of pedestrian accommodations at this location, pedestrian activity was observed during the field review. There are no sidewalks on either side of VT 2A in the vicinity of the intersection, but a path has been worn on the west side of VT 2A under the overpass and a break is provided in the guardrail to allow pedestrians to access the path. There are hotels to the south of the intersection that may generate pedestrian traffic.	 View of I-89 southbound off-ramp. Photo shows a pedestrian running between cars to cross the ramp near the intersection.

2.3.2 VT 2A/Marshall Avenue/Maple Tree Place

There were a total of 86 crashes reported from 2006 to 2010 at this location.

2.3.2.1 Positive Safety Features

The following were noted as positive features with respect to safety at this location.

- **Signal Equipment**: Relatively new signal equipment includes signal backplates and 12-inch signal lenses. Both of these features help to improve the visibility of the traffic signal. Specifically, the backplates help to address issues related to sun glare and other background lighting while larger signal lenses help drivers to readily identify the signal and indication.
- **Clearance Interval**: Based on field measurements, it appears that the signal is timed with a 4 second yellow interval and a 2 second all red interval. The yellow and all red time allow for

vehicles to clear the intersection during the phase change before conflicting movements are allowed to enter.

- **Protected Phasing**: All approaches operate under fully-protected left-turn phasing. Protected left-turn phasing eliminates the need for drivers to find a suitable gap in opposing traffic and helps to address errors related to gap acceptance.
- **Pedestrian Facilities**: Pedestrian facilities include a shared-use path, sidewalks, crosswalks, audible pedestrian signals, and exclusive pedestrian phase. It is important to provide continuity and connectivity in the pedestrian network as well as designated crossings. This helps to guide pedestrians to the desired crossing locations and also alerts drivers of the potential presence of pedestrians. There are blank-out signs to prohibit right-turn-on-red when the pedestrian signal is activated. This helps to limit conflicts between crossing pedestrians and right-turning vehicles.
- **Street Lighting**: Intersection lighting is provided by two cobra head lights. The intersection lighting helps to illuminate the intersection at night and helps drivers to identify the presence and location of the intersection.

2.3.2.2 Potential Safety Issues

Table 9 provides a summary of the identified safety issues at this intersection. Photos are provided to help illustrate several of the issues.

Table 9: Potential Safety Issues Identified at VT 2A/Marshall Ave/Maple Tree Place

Potential Issues	Example
Issue 1: Peak period congestion Based on a review of the crash history, there appears to be an increase in crashes for the evening peak. The crash potential was confirmed during evening peak review as long queues were observed in the northbound left-turn lane, eastbound through and left-turn lanes, and westbound shared through/right-turn lane. Double-cycling is occurring on these approaches and several vehicles must wait for the next cycle. Long queues in the eastbound through lane block the right-turn lane in the PM peak. The queues back-up almost to Trader Lane at certain times. The queue from Trader Lane is also long and exacerbated by the northbound left-turns; this queue extends back to VT-2A at certain times of the day. More than 60 percent of crashes at this location are rear end and more than 90 percent are property damage only. This is likely associated with the congestion as there is a large number of relatively low-speed and low-severity crashes.	 View of the northbound approach of VT 2A. Photo shows a substantial queue in the northbound left-turn lane.

Potential Issues	Example

Issue 2: Driver behavior

It appears that congestion and delays are leading to undesirable driver behavior. Specifically, drivers often use the end of the yellow interval and the all red interval to enter the intersection so they do not have to wait for the next cycle. Several red-light violations were observed at the onset of the red interval.
Despite the fully-protected left-turn phasing at this intersection, 14 percent of crashes are left-turn. This is an indication of drivers violating the red interval.
Based on a review of the five-year crash history, 41 of the 86 crashes were reported as “inattention”, “distracted”, or “drowsy” driving.

Photo shows a white van entering and completing a left-turn during the red interval.

Issue 3: Limited lane guidance for dual lefts

There are no skip marks to guide adjacent turning vehicles in the dual left-turn lanes from the westbound approach onto VT 2A.
One of the ten crashes from the westbound approach was a sideswipe same direction crash.

View of the westbound approach. Photo shows the dual left-turns from Maple Tree Place and the lack of skip marks to guide adjacent drivers.

Issue 4: Right-turn trap on NB approach

There are two lanes in the northbound direction and the right lane turns into a right-turn-only lane. This may contribute to sideswipe same direction crashes when drivers are not aware of the right-turn trap and change lanes to stay in the through lane.
Based on a review of the crash history, 6 of the 67 crashes on VT 2A were coded as sideswipe same direction; 4 of the 6 sideswipes were coded as northbound and the remaining 2 were not coded.

Aerial view of VT 2A approaching the intersection of Marshall Drive / Maple Tree Place. Image shows the 4-lane cross-section that transitions to a single through lane moving left to right.

Issue 5: Poor pavement condition

Nearly 20 percent of the crashes occurred during wet conditions (i.e., rain, snow, or sleet). There is evidence of pavement rutting and smoothing along the NB and SB approaches, which may be contributing to wet-weather crashes.

Potential Issues	Example
Issue 6: Pedestrian-related issues During the field review, one pedestrian commented that the crossing time was too short to cross VT-2A. The crossing time appears to be based on the 4ft/s walking speed assumed in the old version of the MUTCD. The latest version assumes a slower walking speed to account for pedestrians with mobility restrictions. There are limited pedestrian facilities on the west side of the road and no crosswalk across the eastbound approach. The pedestrian signal in the northeast quadrant is not working properly (appears that a bulb is out).	 View of the crosswalk across Maple Tree Place. Photo shows the relatively long crossing distance for pedestrians.  View looking north from the southwest corner. Photo shows the discontinuous sidewalk and the lack of crosswalk across Marshall Avenue.

2.3.3 US 2/VT 2A

There were a total of 105 crashes reported from 2006 to 2010 at this location.

2.3.3.1 Positive Safety Features

The following were noted as positive features with respect to safety at this location.

- **Signal Equipment**: Relatively new signal equipment includes signal backplates and 12-inch signal lenses. Both of these features help to improve the visibility of the traffic signal. Specifically, the backplates help to address issues related to sun glare and other background lighting while larger signal lenses help drivers to readily identify the signal and indication.
- **Clearance Interval**: Based on field measurements, it appears that the signal is timed with a 4 second yellow interval and a 2 second all red interval. The yellow and all red time allow for vehicles to clear the intersection during the phase change before conflicting movements are allowed to enter.
- **Street Lighting**: Intersection lighting is provided by two cobra head lights. The intersection lighting helps to illuminate the intersection at night and helps drivers to identify the presence and location of the intersection.
- **Pedestrian Facilities**: Pedestrian facilities include sidewalks, crosswalks, pedestrian signals, exclusive pedestrian phase, and pedestrian refuge islands. It is important to provide continuity and connectivity in the pedestrian network as well as designated crossings. This helps to guide pedestrians to the desired crossing locations and also alerts drivers of the potential presence of pedestrians. The intersection crossing distances are relatively wide and the pedestrian refuge islands help to shorten the distance and allow slower pedestrians to make a multi-stage crossing.

There are blank-out signs to prohibit right-turn-on-red when the pedestrian signal is activated. This helps to limit conflicts between crossing pedestrians and right-turning vehicles.

	
Photo shows the no right-turn-on-red sign activated when the pedestrian phase is activated.	Photo shows the no right-turn-on-red sign “blanked-out” when the pedestrian phase is not activated.

2.3.3.2 Potential Safety Issues

Table 10 provides a summary of the identified safety issues at this intersection. Photos are provided to help illustrate several of the issues.

Table 10: Potential Safety Issues Identified at US 2/VT 2A

Potential Issues	Example
Issue 1: Peak period congestion Based on a review of the crash history, there appears to be an increase in crashes for the midday peak and even more so for the evening peak. The crash potential was confirmed as long queues and double-cycling were observed during the midday peak for the VT-2A northbound and southbound left-turn and through movements. During the evening peak, long queues and double-cycling were observed for the westbound left-turns and southbound through movements. Queues from the WB left-turn lane were also observed spilling-over to the through lane. The through vehicles utilized the right-turn lane to avoid the queue, but this is not an optimal situation. More than 40 percent of crashes at this location are rear end and 90 percent are property damage only. This is likely associated with the congestion as there is a large number of relatively low-speed and low-severity crashes.	 View of westbound approach. Photo shows the lengthy queue in the evening peak.

Potential Issues	Example
	 View of northbound approach. Photo shows the lengthy queue in the midday peak.
Issue 2: Driver behavior It appears that congestion and delays are leading to undesirable driver behavior. Specifically, the protected left-turn phase is relatively short for the NB, SB, and EB approaches. Drivers often enter the intersection late in the yellow interval to turn left. Despite the protected-permissive left-turn phasing at this intersection, nearly 20 percent of crashes are left-turn. These crashes may be associated with drivers turning left at the end of the protected phase as the opposing through movement receives the green indication. This could also be an indication of drivers making poor gap choices during the permissive left-turn phase. Based on a review of the five-year crash history, 43 of the 105 crashes were reported as “inattention” or “distracted” driving.	 Photo shows two left-turning vehicles entering the intersection during the red interval after the protected left-turn phase.  View of southbound approach. Photo shows the lengthy queue in the evening peak and undesirable behaviors where drivers are forcing their way into the queue to turn left out of driveways near the intersection.

Potential Issues	Example
Issue 3: Signalized right-turn slip lane The NB channelized right-turn lane has a separate signal that provides a protected right-turn arrow during the cycle. This creates a potential conflict with SB left-turning vehicles that enter the intersection late in the yellow or during the all red interval. The NB right-turns have a protected green arrow before the SB left-turns get to the merge point of the right-turn lane. 	 View of northbound channelized right-turn lane. Photo shows a vehicle waiting to turn right from VT 2A and two conflicting vehicles on US 2 that had just turned left from the southbound approach. The northbound vehicle will receive a green arrow before the second conflicting vehicle clears the merge point.
Issue 4: Pedestrian-related issues The crossing time appears to be based on the 4ft/s walking speed assumed in the old version of the MUTCD. The latest version assumes a slower walking speed to account for pedestrians with mobility restrictions. There is a 'sidewalk to nowhere' in the southeast quadrant. This creates a discontinuity in the pedestrian network.	 View of intersection from the northwest corner. Photo shows the long crossing distance and a pedestrian waiting to cross.

2.3.4 VT 2A/Industrial Avenue/Mountain View Road

There were a total of 49 crashes reported from 2006 to 2010 at this location.

2.3.4.1 Positive Safety Features

The following were noted as positive features with respect to safety at this location.

- **Signal Equipment**: Relatively new signal equipment includes 12-inch signal lenses. This helps to improve the visibility of the traffic signals. Larger signal lenses help drivers to readily identify the signal and indication.

- **Clearance Interval**: Based on field measurements, it appears that the signal is timed with a 4 second yellow interval and a 2 second all red interval. The yellow and all red time allow for vehicles to clear the intersection during the phase change before conflicting movements are allowed to enter.
- **Leading Left-Turn Phase**: The eastbound approach receives a leading phase, which helps to gain operational efficiencies. This is possible due to the unbalanced left-turn volumes.
- **Pedestrian Facilities**: Pedestrian facilities include sidewalks, crosswalks, pedestrian signals, exclusive pedestrian phase, and pedestrian refuge island. It is important to provide continuity and connectivity in the pedestrian network as well as designated crossings. This helps to guide pedestrians to the desired crossing locations and also alerts drivers of the potential presence of pedestrians. The intersection crossing distances are relatively wide and the pedestrian refuge island helps to shorten the distance and allow slower pedestrians to make a multi-stage crossing. There are blank-out signs to prohibit right-turn-on-red when the pedestrian signal is activated. This helps to limit conflicts between crossing pedestrians and right-turning vehicles.
- **Street Lighting**: Intersection lighting is provided by two cobra head lights. The intersection lighting helps to illuminate the intersection at night and helps drivers to identify the presence and location of the intersection.

2.3.4.2 Potential Safety Issues

Table 11 provides a summary of the identified safety issues at this intersection. Photos are provided to help illustrate several of the issues.

Table 11: Potential Safety Issues Identified at VT 2A/Industrial Ave/Mountain View Road

Potential Issues	Example
Issue 1: Peak period congestion Based on a review of the crash history, there appears to be an increase in crashes for the morning, midday, and evening peaks. The crash potential was confirmed, particularly during the midday and evening peaks as long queues and double-cycling were observed for the VT-2A southbound approach. The queues from the southbound through lane block the right-turn lane. Nearly 60 percent of crashes at this location are rear end and 96 percent are property damage only. This is likely associated with the congestion as there is a large number of relatively low-speed and low-severity crashes.	 View of the southbound approach along VT 2A. Photo shows the lengthy queue blocking the right-turn lane during the midday peak.
Issue 2: Driver behavior Based on a review of the five-year crash history, 17 of the 49 crashes were reported as “inattention” or “distracted” driving and 2 crashes were reported as “impaired” driving.	

Potential Issues	Example
Issue 3: Faded pavement markings The pavement markings are faded on all approaches to the intersection. Pavement markings provide guidance to drivers regarding lane use and position, particularly during nighttime and wet-weather conditions.	 View looking south from VT 2A. Photo shows the faded pavement markings on the southbound approach.
Issue 4: Poor pavement condition There is evidence of pavement rutting, chunking, and smoothing along the NB and SB approaches, which may be contributing to rear-end and wet-weather crashes. Nearly 60 percent of the crashes are rear-end and 14 percent of the crashes occurred during wet conditions (i.e., rain, snow, or sleet) with another 6 crashes where the weather condition was ‘unknown’.	 View looking west from the westbound approach. Photo shows an example of the poor pavement condition at this location.
Issue 5: Drainage issues There is curb-and-gutter along the NB approach with no drainage inlets near the intersection. There is also curb-and-gutter along the SB approach with just two small inlets (one of which was obstructed with debris). With the relatively wide cross-section along the intersection approaches, there is the potential for large amounts of runoff, which may be a contributing factor in the wet-weather crashes. Based on the five-year crash history, 14 percent of the crashes occurred during wet conditions (i.e., rain, snow, or sleet) and the weather condition was ‘unknown’ for 6 crashes.	 Photo shows the partially obstructed drainage inlet in the northwest corner of the intersection.

Potential Issues	Example
Issue 6: Inconsistent use of signal backplates Signal backplates are provided for some signals, but are not installed on all signals at this location. Backplates help to address issues related to sun glare and other background lighting, particularly for signals aligned in the east/west directions.	 View of signal on southbound approach. Photo shows the lack of a backplate on this signal.
Issue 7: Pedestrian-related issues The crossing time appears to be based on the 4ft/s walking speed assumed in the old version of the MUTCD. The latest version assumes a slower walking speed to account for pedestrians with mobility restrictions. There are pedestrian accommodations at the intersection, but the crosswalks are faded. There are also speakers installed for the audible pedestrian warning, but they were not functioning during the field review.	 View of crosswalks looking north from the southwest corner. Photo shows the relatively long crossing distance and faded crosswalks.

2.3.5 VT 117/North Williston Road

There were a total of 20 crashes reported from 2006 to 2010 at this location.

2.3.5.1 Potential Safety Issues

Table 12 provides a summary of the identified safety issues at this intersection. Photos are provided to help illustrate several of the issues.

Table 12: Potential Safety Issues Identified at VT 117/North Williston Road

Potential Issues	Example
Issue 1: Peak period congestion Based on a review of the crash history, there appears to be an increase in crashes for the evening peak. The crash potential was confirmed during the field review as moderate queues were observed on the stop-controlled approach (N. Williston Road) during the evening peak. During this time, there are fewer gaps on the mainline (VT 117) and drivers on the minor road must find a suitable gap. In some cases, the queue from the left-turn lane extended far enough to block the entrance to the right-turn lane. During these conditions, vehicles were observed using the shoulder to access the right-turn lane. Left-turn (45%) and angle (15%) crashes represent 60 percent of the total crashes at this location. These crash types are associated with gap-acceptance issues, particularly at a three-legged stop-controlled intersection where there are no through movements from the minor road.	 View of minor road approach on N. Williston Road (northbound approach). Photo shows a lengthy queue in the evening peak.
Issue 2: Driver behavior It appears that congestion and delays are leading to undesirable driver behavior. Specifically, drivers appear to be willing to accept smaller gaps than during off-peak conditions. Left-turn (45%) and angle (15%) crashes represent 60 percent of the total crashes at this location. These crash types are associated with gap-acceptance issues, particularly at a three-legged stop-controlled intersection where there are no through movements from the minor road. There was one fatality that resulted from an angle crash at this location during the study period and there is the potential for high-severity crashes in the future based on the crash history (predominantly left-turn and angle crashes) and the speed along the major road (45 mph). While only one crash was reported as “inattention” during the five-year crash history, there were undesirable behaviors observed during the field review. One example is the use of cell phones while waiting to turn from the minor road.	 View looking west from the mainline (VT 117). Photo shows a driver on the major road waiting for a suitable gap to turn left while another driver waits on the minor road for both directions to clear.  Photo shows a driver talking on a cell phone while waiting to turn from the minor road.

Potential Issues	Example

Issue 3: Sight obstructions

In the southwest corner, a utility pole, cabinet, and vegetation obstruct the sight distance to the eastbound approach for drivers on the minor road.
The intersection is also located on the outside of a horizontal curve. The curve, coupled with vegetation on the inside of the curve, limit sight distance to and from the intersection.
The third factor that contributes to sight obstructions at the intersection is the adjacent turn lanes from the minor road. When vehicles are in both the left- and right-turn lanes, they obstruct the view of the adjacent driver.

View of northbound approach on N. Williston Road. Photo shows a vehicle stopped well beyond the stop bar to get a better view of the eastbound approach.

View of the intersection looking east. Photo shows the limited sight distance to the east due to the horizontal curve and vegetation.

View of the northbound approach. Photo shows two adjacent vehicles that obstruct the sight distance of the other driver.

Issue 4: Poor pavement condition

There is evidence of pavement cracking, rutting, and smoothing near the intersection, which may be contributing to wet-weather crashes. Based on a review of the crash history, 10 percent of crashes occurred during wet conditions (i.e., rain, snow, or sleet), and the weather condition was not reported for 15 percent of crashes. The fatal crash at this location also occurred during wet conditions.

Potential Issues	Example
	 Examples of poor pavement condition at this location.

2.4 Bicycle and Pedestrian

Shared use paths and on-road bicycle facilities are shown in Figure 18. The *VTrans Pedestrian and Bicycle Facility Planning and Design Manual* defines a shared use path as:

> "A facility for pedestrians, bicyclists and other users that is physically separated from motorized vehicular traffic by open space or barrier and either within the highway right-of-way or within an independent right-of-way."[1]

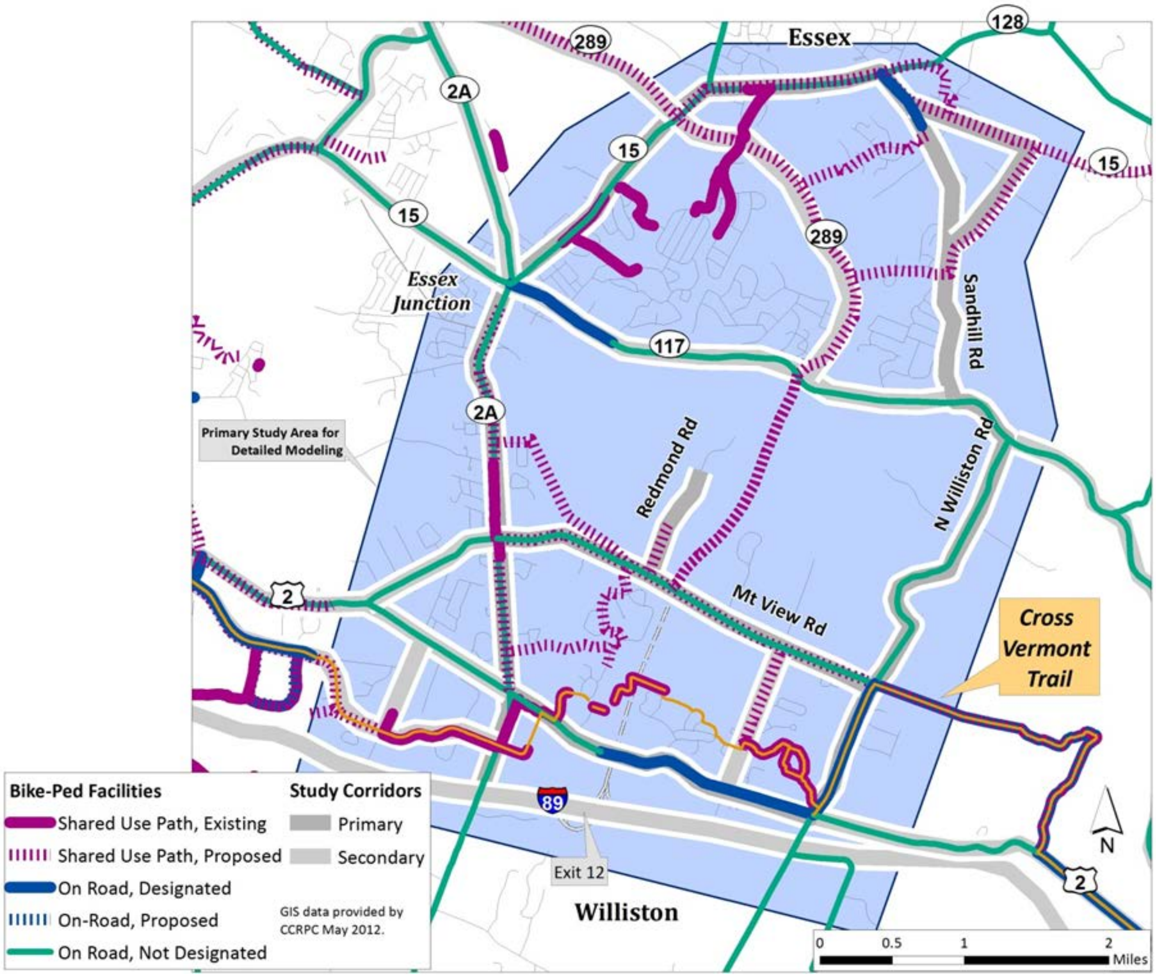
Sidewalks are not shown at this scale because they are considered to be more local facilities. These data have been verified against the Local Motion Trail Finder Bicycle and the CCRPC's 2008 *Regional Bicycle & Pedestrian Plan Update*. The final report for the regional plan indicates that:

- **A Designated On-Road Facility** is signed as a preferred route for bicyclists and may include marked bicycle lanes, paved shoulders, wide curb lanes, or shared lanes.
- **A Non-Designated Common Route** is not a formal bike route that is signed or recognized by municipal governments, but it is a popular route with bicyclists. As shown, the majority of existing bicycle facilities in the area are not formally designated.

In addition to these facilities, the Cross Vermont Trail is a 90-mile (mostly on-road) route that traverses the state along the Winooski and Wells River Valleys. It travels through the study area along Governor Chittenden Road, North Williston Road, through Maple Tree Place, Marshall Drive, Kennedy Drive, and Dorset Street.

[1] Page 5-3.

Figure 18: Bicycle Facilities in the Study Area



There are numerous shared use paths proposed in the CCRPC's 2008 *Regional Bicycle & Pedestrian Plan*, including along VT 289 and the former Circ alignment. Some of these paths are not adjacent to roads, instead following alternative alignments through fields and currently undeveloped areas.

2.5 Transit Service

Figure 19 shows the existing CCTA service in the region. The three routes that currently serve the study area are described in Table 13.

Figure 19: Transit Service in the Study Area

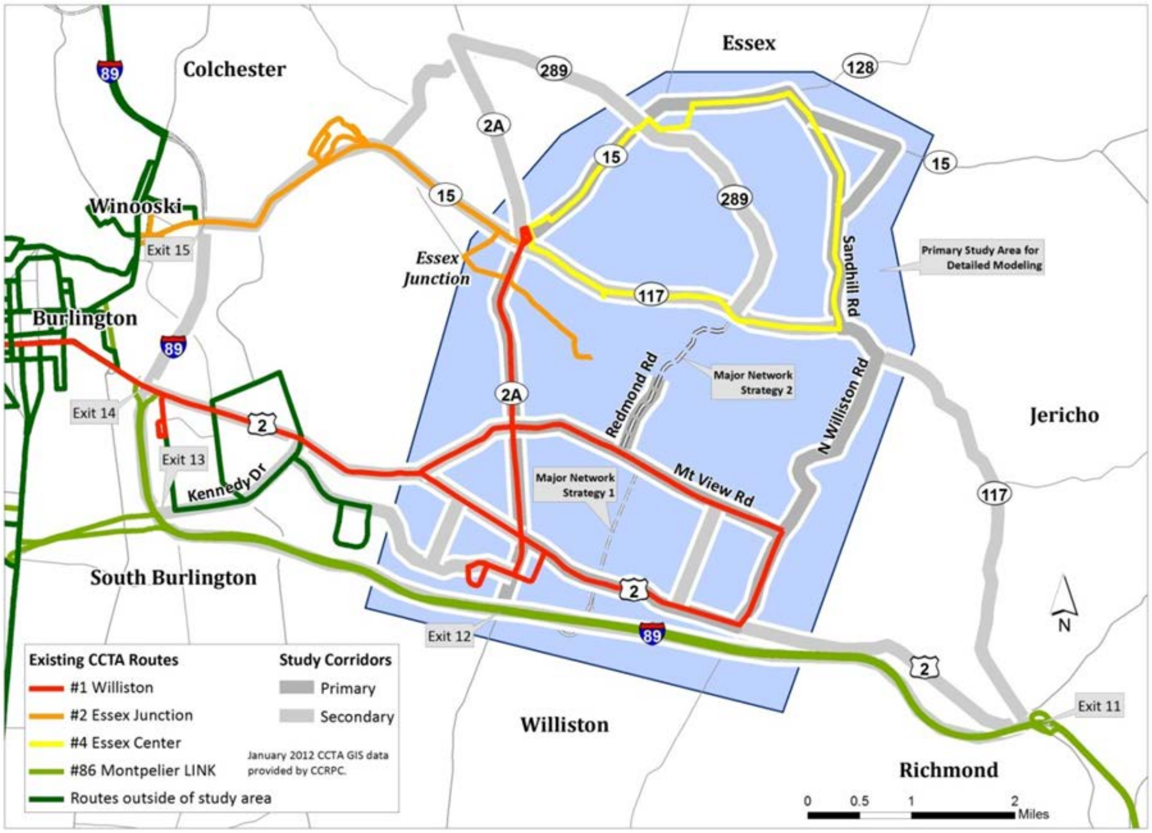


Table 13: Transit Service Details

	Description	Service Hours Departing BTV/Cherry St	Frequency
#1 Williston This route includes three variations that occur depending on the time of day	#1: connects Cherry Street in Burlington to Walmart in Williston via U-Mall	M-F 7:00AM-11:00PM Saturday 6:45 AM-11:00PM	Every 30 min. during peak, hourly other times
	#1E: on approximately every other run, #1 continues into Essex and the Amtrak Station via Maple Tree Place	M-Sat 6:15AM-6:15PM	Every 30 min. during peak, hourly other times
	# 1V: #1 skips Walmart and terminates in Williston Village	M-F 6:30AM-5:20PM	4 runs per day: 2 during AM peak, 2 during PM peak
#2 Essex Junction	Connects Cherry Street in Burlington to Essex and the Amtrak Station via Winooski (and IBM during AM peak hour and by request during PM peak hour)	M-F 5:45AM-9:40PM Saturday 6:10 AM-7:15PM	Every 15 min. during peak, every 30 min. other times
#4 Essex Center	Circulates Essex, serving Amtrak, Outlet Fair, Essex Center, Sand Hill, and IBM (by request)	(Departing Amtrak) M-F 6:00AM-9:30AM and 1:00PM-6:10PM	Every 30 min.

In addition, the LINK Express Route between Burlington and Montpelier (and eventually between Burlington and Waterbury) traverses the study area on I-89 but does not (and likely will not) stop in it. CCTA would likely only consider stopping at Exit 12 if there was a park & ride established at the interchange.

The 2010 CCTA Transit Development Plan (TDP) recommends adding Bus Rapid Transit elements to US 2 and VT 15 routes (that is, increased frequency; enhanced passenger facilities such as comfortable shelters, particularly at Taft Corners/Maple Tree Place, University Mall/future South Burlington City Center, and Essex Junction; and priority treatments for buses on the roadway, such as queue jumpers). The TDP also notes potential future service to the Lime Kiln Road area and a Cambridge LINK route via VT 15.

3.0 NETWORK PERFORMANCE

This section describes performance measures established for WENTS and the results of the traffic model for 2010.

3.1 Performance Measures

Common traffic related performance measures are assessed for the primary corridors and at primary and secondary intersections. These measures were determined by traffic model outputs and include the following:

- Average vehicle speed
- Travel time through a particular highway corridor
- Intersection Delay (average per vehicle) and corresponding Level of Service (LOS)
- Average and maximum vehicle queues

Safety measures assessed at the primary intersections include the Actual/Critical (A/C) crash rates at the primary study intersections. Improvements are based on potential crash modification factors (CMF), as described in the *Highway Safety Manual* or related study. These CMF's are measures that address and reduce crashes at a particular location and situation/deficiency.

System wide performance measures are also determined by the output of the microsimulation model. These are:

- Vehicle miles or hours traveled (VMT / VHT)
- Total greenhouse gas (GHG) emissions
- Cumulative intersection stop delay

Multimodal performance measures that are assessed include:

- Multimodal accessibility – this is a simple calculation of the % of population within a 5 minute walk of transit service. The primary variables are changes in development patterns and changes in the transit service area.
- Multimodal Level of Service is assessed on critical features for usability, safety and connectivity, as follows:

Category:	Measure:	Expressed as:
BIKE	Shoulders	% of segment with width >2 ft
	Separate Fac.	% of segment
	Connectivity	# of dead ends per mile of facility
	Conflicts	# conflicts/mi.
TRANSIT	Service	yes/no
	Headway	time
	Connectivity	# of deficiencies
PEDESTRIAN	Shoulder	% of segment with width >2 ft
	Sidewalk/path	% present
	Quality	%

Where:

- Bike connectivity "dead ends" occur where a facility that meets the 2002 *Bicycle Pedestrian Facility Design Manual* ends
- Transit connectivity deficiencies are stops without connecting sidewalks, or needed stops
- Quality of pedestrian path is a function of age/condition, separation and width (i.e. 100%=new, 5 ft., separated)
- Bike conflicts includes driveways, side streets, or obstructions
- If sidewalk is present, shoulder = n/a

Current conditions in the study area have been assessed for multimodal facility performance as follows.

Road shoulders in the project area (along primary corridors) were assessed for their conformance with the current bicycle and pedestrian standards for minimum recommended width. This assessment considers location (i.e. village or open road), speed, and functional class. It was determined that 63% of the road shoulders are substandard in the project area, and 4 "dead ends" identified (locations where an adequate shoulder becomes substandard of nonexistent).

Sidewalks along the primary corridors were cataloged assuming one is desirable on both sides of the road, except where specifically exempted by the Towns due to unfavorable grades or absence of potential users. This assessment resulted the finding that 60% of the corridors are absent of suitable sidewalks, and 25 dead ends exist.

Shared use paths were assessed with the assumption that one path, on either side, was desirable along every primary corridor. This assessment resulted in the finding that 72% of the corridors are without a suitable shred use path, and existing facilities currently have 10 "dead ends".

Transit accessibility was assessed by using GIS databases to determine what percentage of households are located within a 5 minute walk of a transit stop. The result for the existing condition is 48.6%.

3.2 Traffic Model

Existing (2010 PM Peak Hour) traffic performance is evaluated using a newly-constructed traffic microsimulation model of the WENTS study area. The process used to construct the traffic model and calibrate it to existing traffic conditions is described in Appendix B-Model Details. This model will be used to assess future conditions in Phase 3 of WENTS.

3.3 2010 PM Peak Hour (Base) Results

The calibrated Transmodeler microsimulation model was used to generate vehicle-based performance measures in the study area. This section presents the results for the corridors and the intersections.

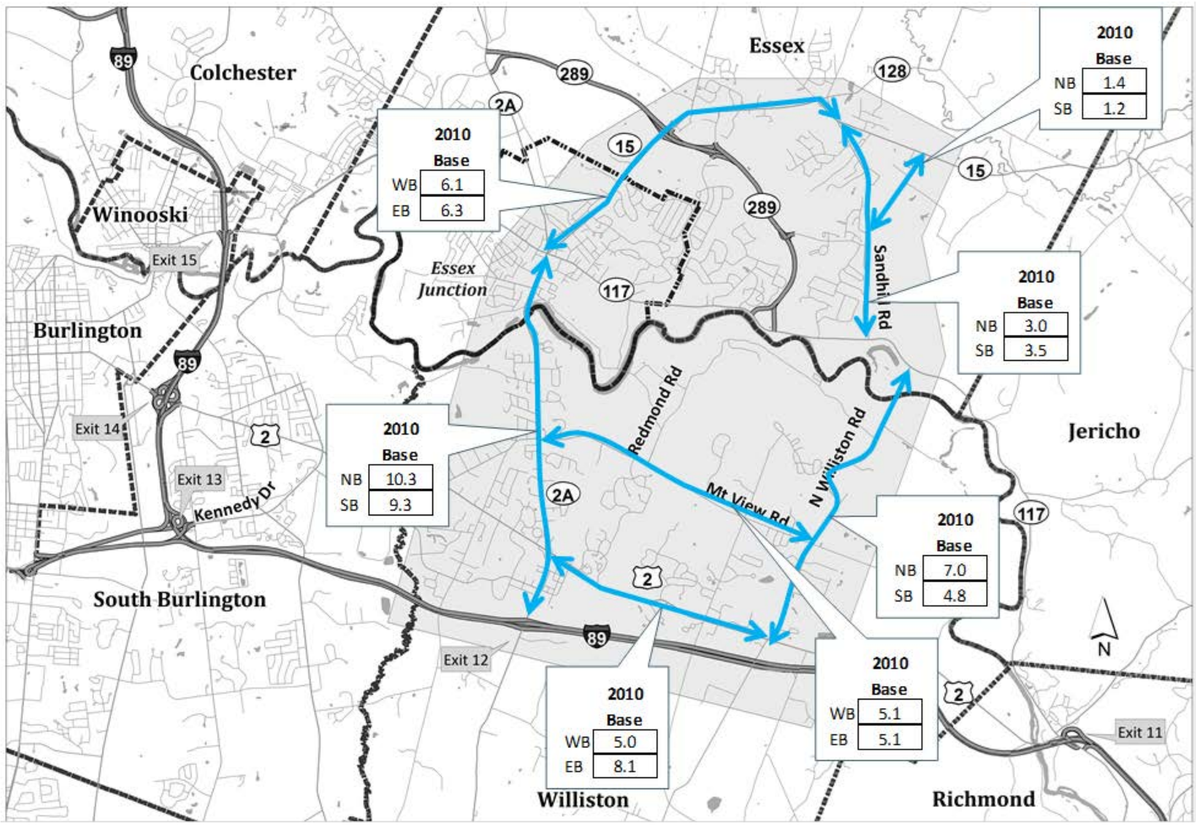
3.3.1 Corridors

Corridor performance in the PM Peak Hour is assessed using average vehicle travel time and speed. Table 14 and Figure 20 present these metrics for the 2010 PM Peak Hour/Base scenario.

Table 14: Network-wide Metrics-2010 Base

Average speed (mph)	29
Average trip duration (minutes)	9
Average trip distance (miles)	4
Average total trips	31,000
Average total VMT	130,000
Average total VHT	4,600

Figure 20: Average Corridor Travel Time in Minutes-2010 Base



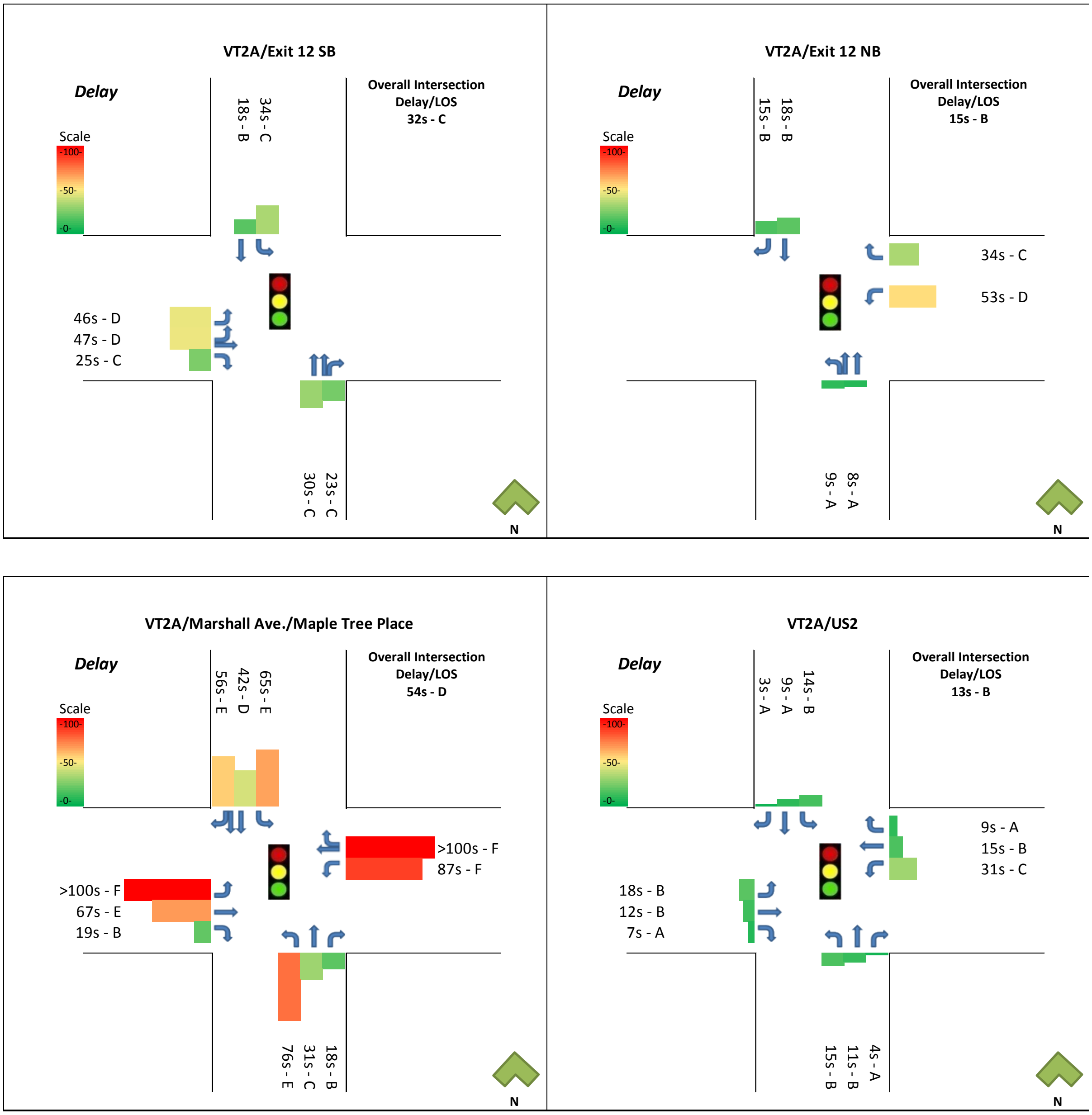
These results suggest that north-south travel is most constrained, as VT 2A and North Williston Road have the longest average travel times, particularly northbound. The corridors in Williston are generally more constrained than those in Essex.

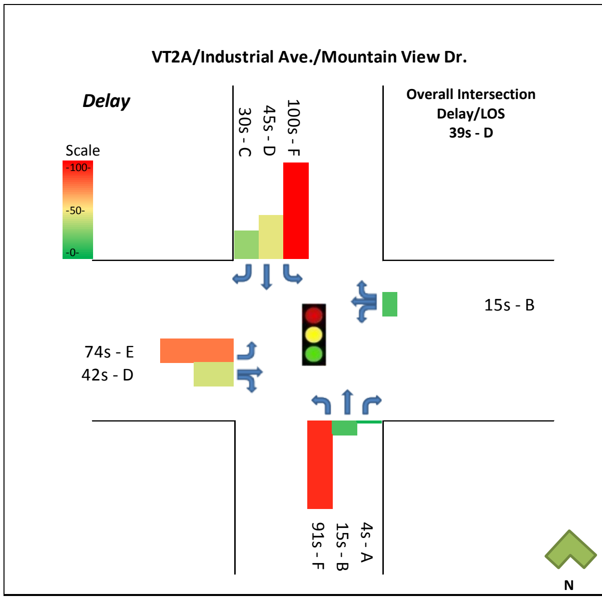
3.3.2 Intersections

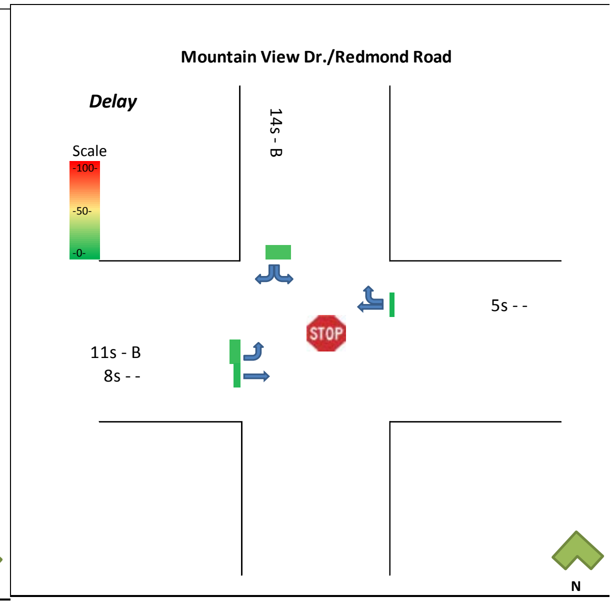
The model results for Level-of-Service (LOS) and delay (Figure 21) and vehicle queues (Figure 22) for the primary study intersections are presented here. Overall intersection LOS is only available for signalized intersections.

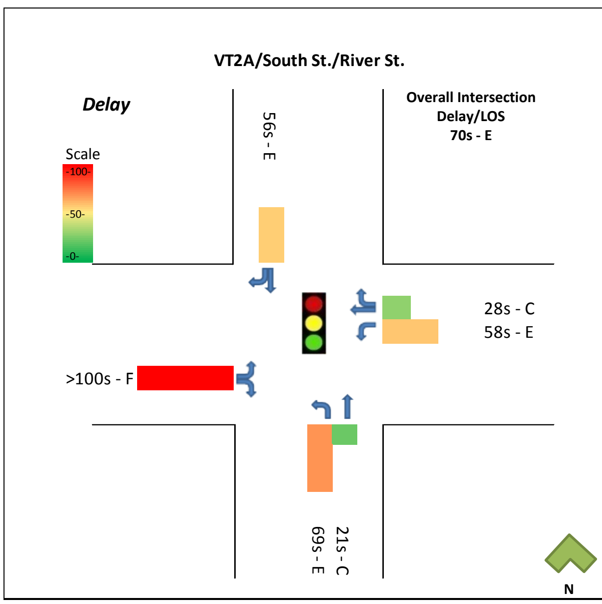
Expanding on the findings in Section 3.3.1, the model shows that the Williston intersections along VT 2A and US 2 have the greatest delay and queuing, especially at Maple Tree Place, Industrial Ave/Mountain View Drive, and South St/River St. The North Williston Road intersections at US 2 and at VT 117 also have significant delays.

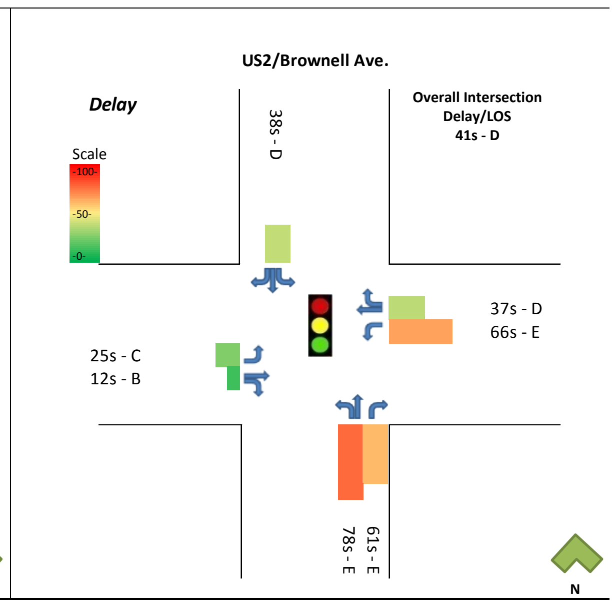
Figure 21: LOS and Delay by Lane-Primary Intersections, 2010 Base

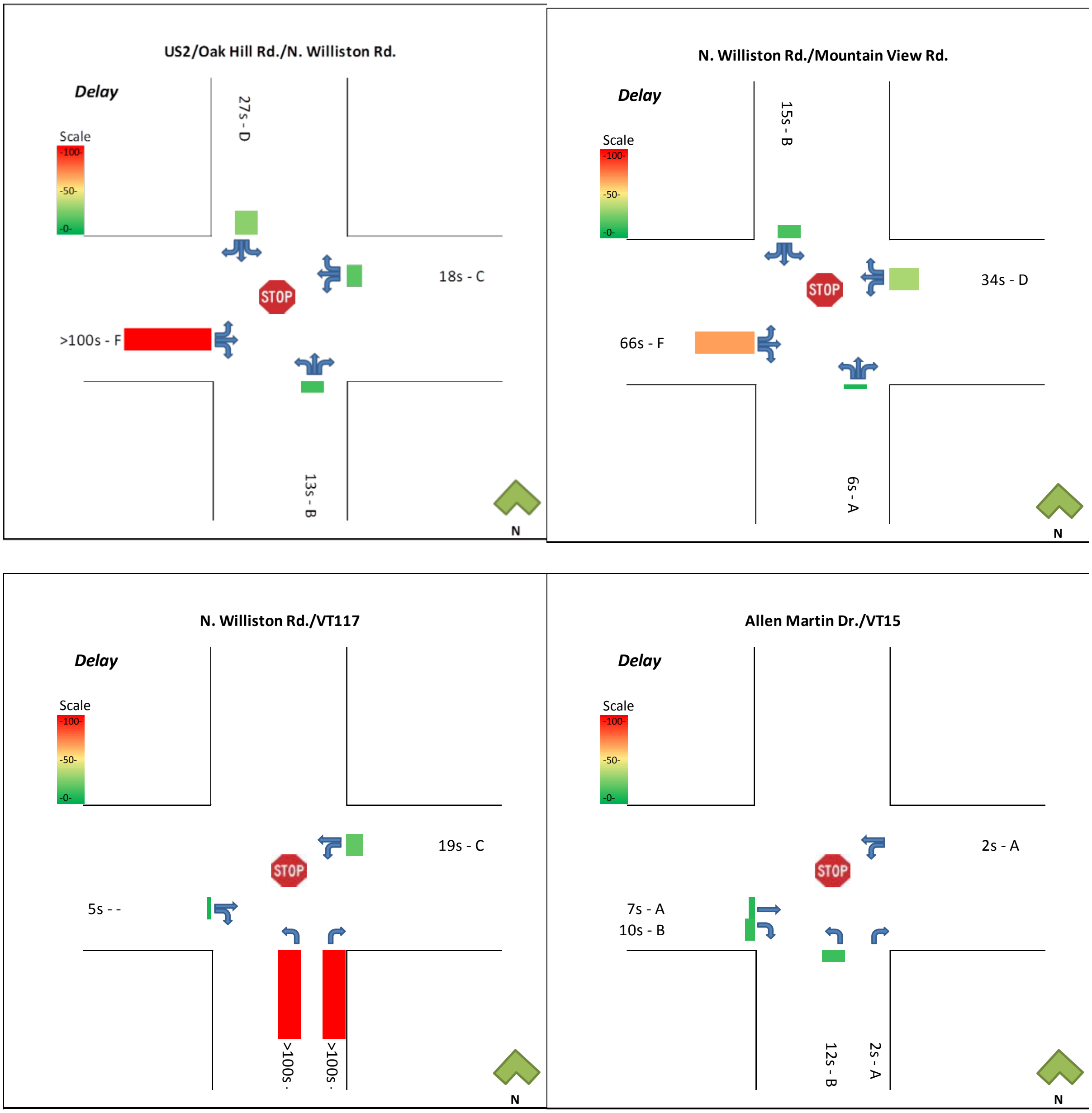



VT2A/Industrial Ave./Mountain View Dr.
Delay
Scale
-100-
-50-
-0-
30s - C
45s - D
100s - F
Overall Intersection
Delay/LOS
39s - D
15s - B
74s - E
42s - D
91s - F
15s - B
4s - A
N


Mountain View Dr./Redmond Road
Delay
Scale
-100-
-50-
-0-
14s - B
STOP
5s - -
11s - B
8s - -
N

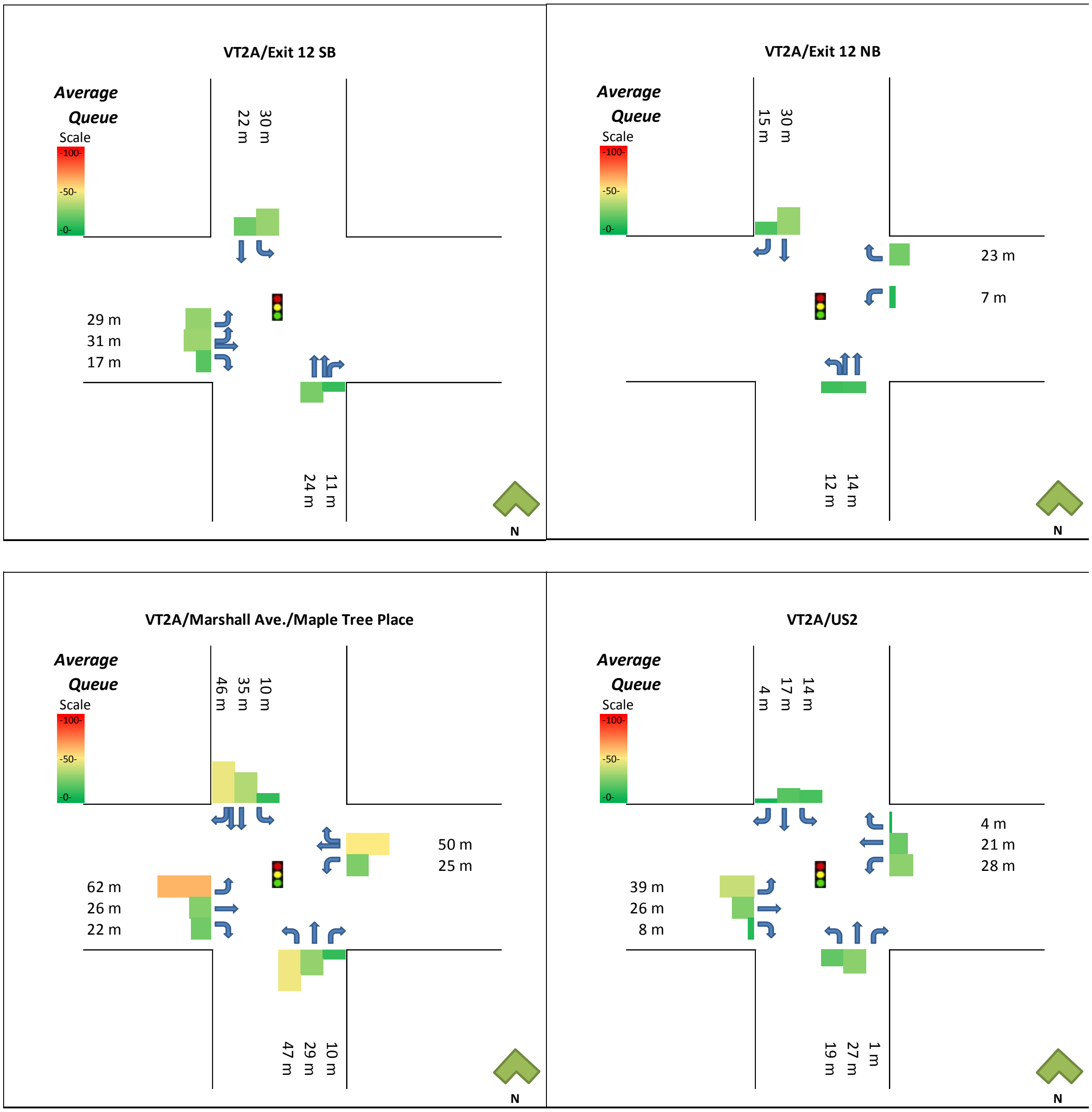

VT2A/South St./River St.
Delay
Scale
-100-
-50-
-0-
56s - E
Overall Intersection
Delay/LOS
70s - E
28s - C
58s - E
>100s - F
69s - E
21s - C
N


US2/Brownell Ave.
Delay
Scale
-100-
-50-
-0-
38s - D
Overall Intersection
Delay/LOS
41s - D
37s - D
66s - E
25s - C
12s - B
78s - E
61s - E
N

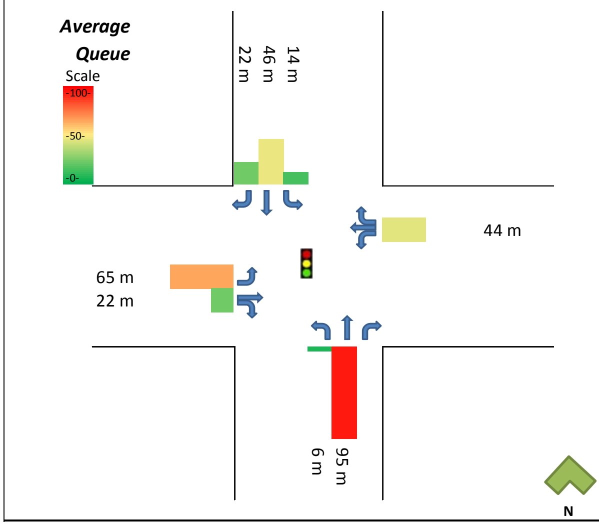


The worst queuing of these intersections takes place on the northbound approach at VT 2A-Industrial Ave/Mountain View Dr and on the eastbound approach at VT 2A-South St/River St. The northbound approach at VT 117-North Williston Road is only slightly better at 77 meters (approximately 12 car lengths).

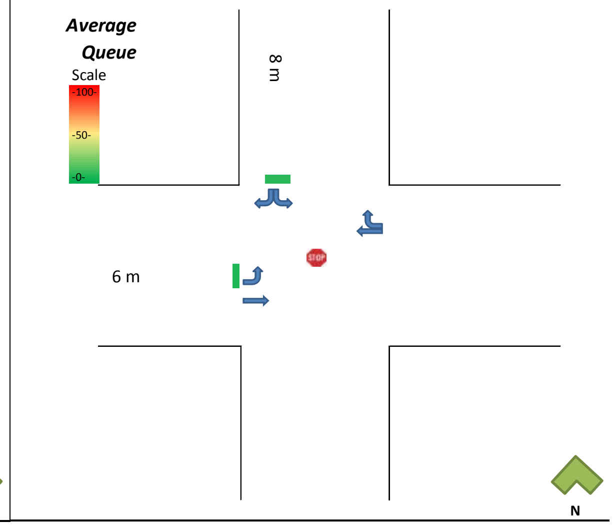
Figure 22: Average Queues in Meters by Lane-Primary Intersections, 2010 Base



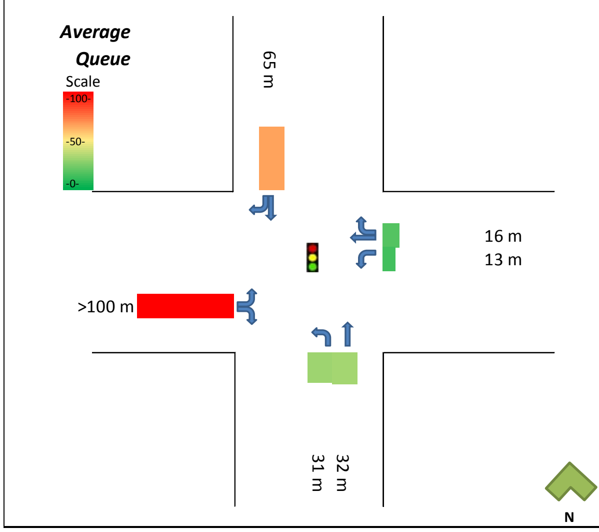
VT2A/Industrial Ave./Mountain View Dr.



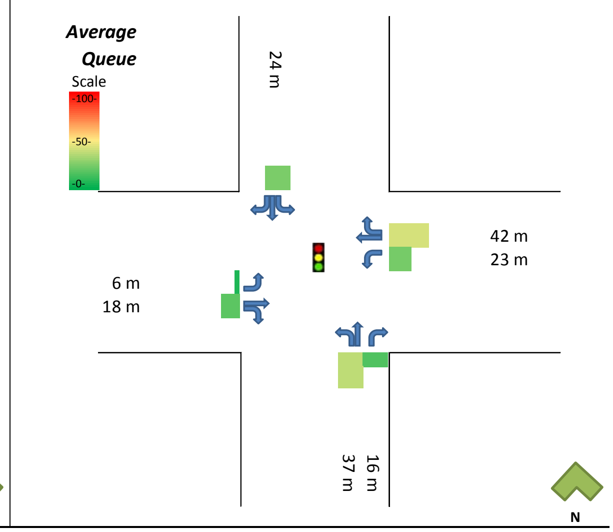
Mountain View Dr./Redmond Road

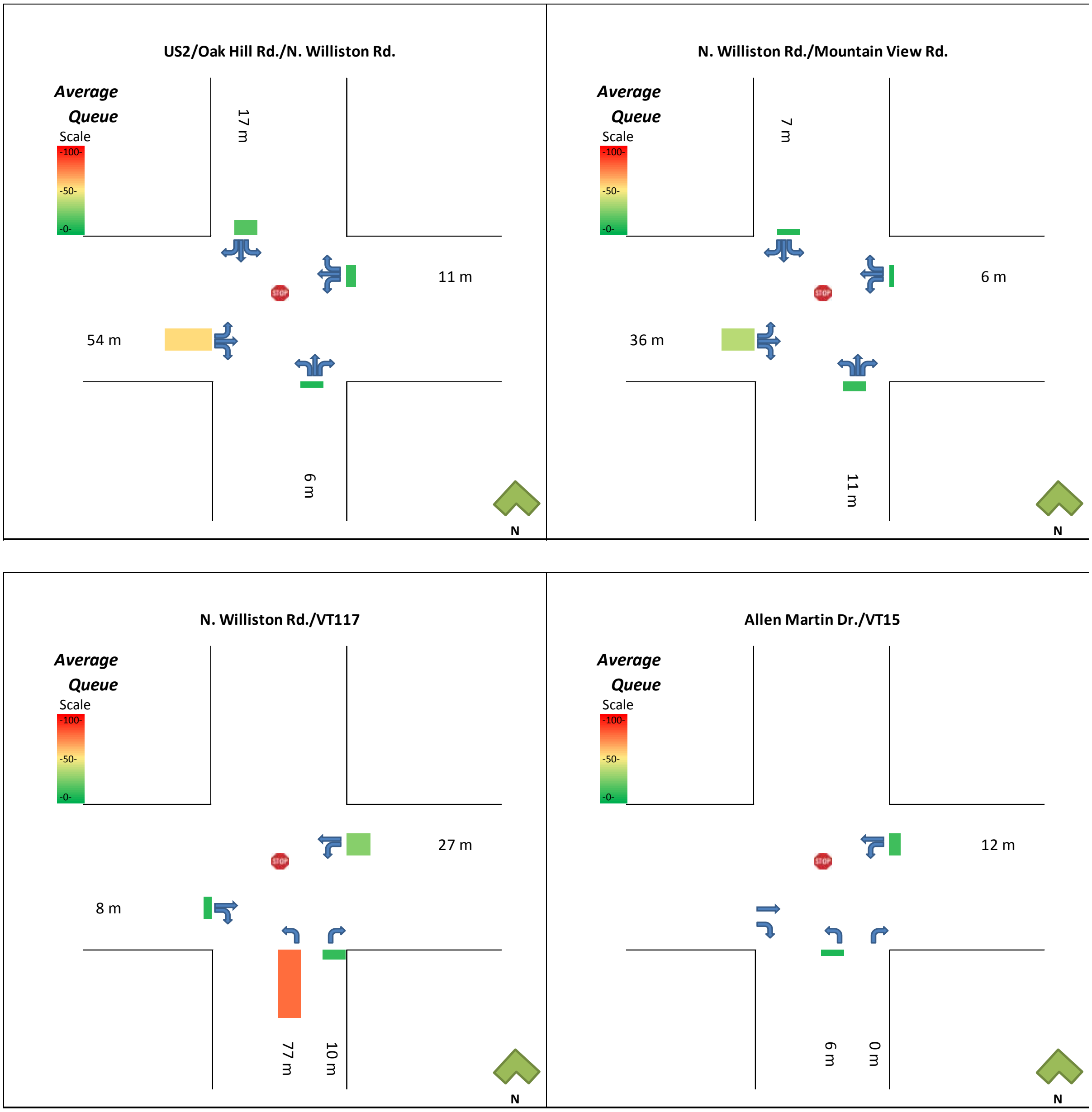


VT2A/South St./River St.



US2/Brownell Ave.





The model system produces a vehicle trajectory file, which is a second-by-second record of the speed and acceleration profile of each vehicle in the simulation. This trajectory file has been processed into an Operating Mode Distribution for linking to the Motor Vehicle Emissions Simulator (MOVES), EPA's recommended model for estimating mobile source air pollutants. Figure 23 shows the estimated vehicular emissions for the 2010 PM peak hour. As shown over 60 million grams of CO2-equivalent emissions are produced by vehicles in the study area during the 2010 PM peak hour.

Figure 23: Pollutants Expelled in the PM Peak - 2010 Base

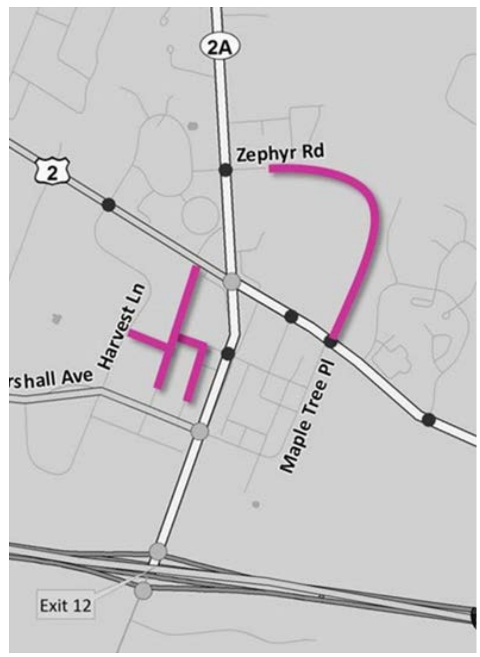
pollutant	total emissions (grams)
CH4 - Methane	1,122
N2O - Nitrous Oxide	419
Atmospheric CO2	60,026,950
CO2 Equivalent	60,180,144
Primary PM10 - Elemental Carbon	2,832
Primary PM2.5 - Elemental Carbon	2,731

3.4 2035 PM Peak Hour Results

The calibrated Transmodeler microsimulation model was used to generate vehicle-based performance measures in the study area for the future year 2035 assuming that the following core improvements have been built:

- Williston Grid Streets (Figure 24)
- Essex Town Center Connections
- CIRC Alt Phase 1 Implementation Projects in WENTS Area
  - Crescent Connector in Essex Junction
  - VT2A/James Brown Drive Improvements
  - Travel Demand Management Initiatives & Adaptive Signal Control
- CIRC Alt Phase 2 Implementation Projects in WENTS Area
  - VT15/Sand Hill Road Improvements
  - VT15 Improvements, Post Office Square to 5 Corners
  - VT15 Multiuse Path
  - US 2/Trader Lane Intersection Capacity Improvements
  - Travel Demand Management Initiatives & Adaptive Signal Control
- Address discontinuities and deficiencies to sidewalks, multiuse paths, shoulders
- Transit Service
  - Add weekday mid-day trip on the Williston Route
  - Weekday peak hour Jeffersonville to Burlington commuter route

Figure 24: Future Williston Grid Streets



This section presents the results for the corridors and the intersections.

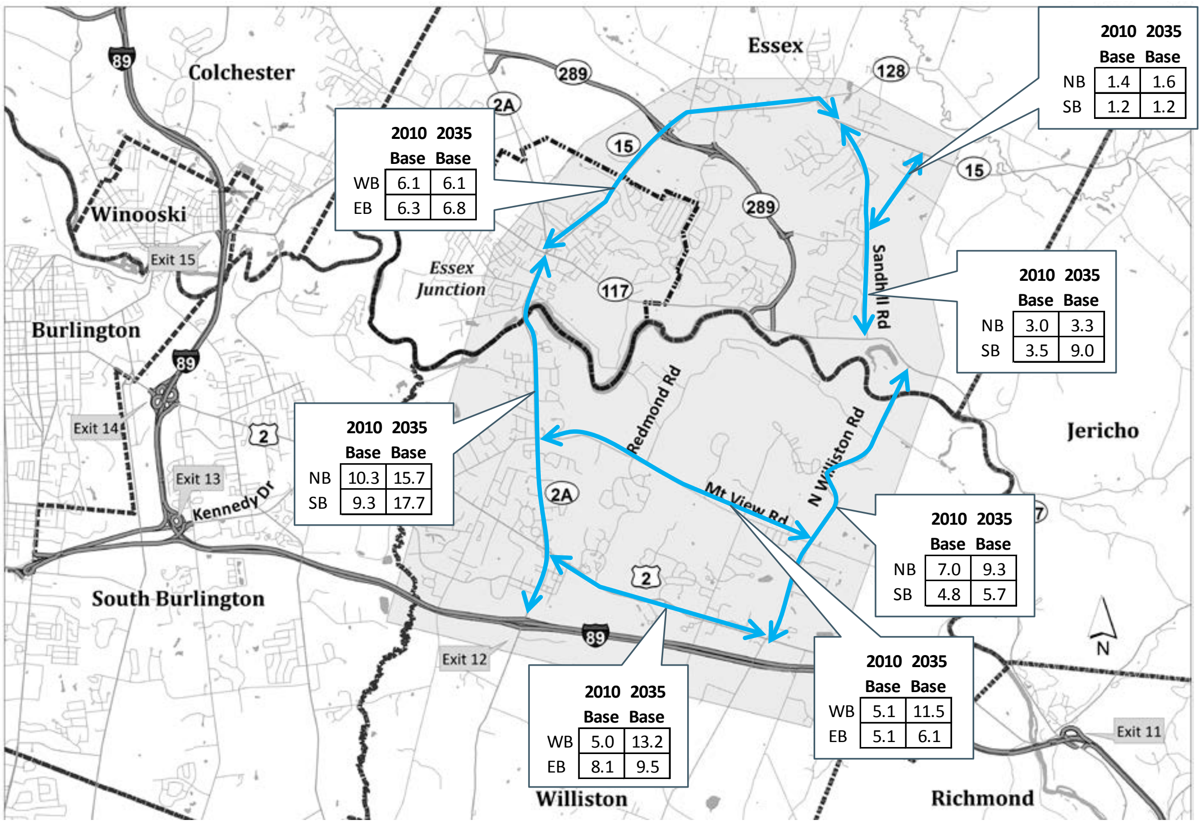
3.4.1 Corridors

Corridor performance in the PM Peak Hour is assessed using average vehicle travel time and speed. Table 15 and Figure 25 present these metrics for the 2035 PM Peak Hour/Base scenario. Compared to 2010, trips are slower and take longer to complete, presumably because there are more vehicles on the road (as indicated by increased total trips and VMT). The largest increases in travel time occur on VT 2A between Exit 12 and Five Corners, westbound US 2 and Mountain View Road, and southbound Sandhill Road.

Table 15: Network-wide Metrics: 2010 and 2035

	2010	**2035**
Average speed (mph)	29	18
Average trip duration (minutes)	9	13
Average trip distance (miles)	4	4
Average total trips	31,000	39,000
Average total VMT	130,000	150,000
Average total VHT	4,600	8,400

Figure 25: Average Corridor Travel Time in Minutes: 2010 and 2035



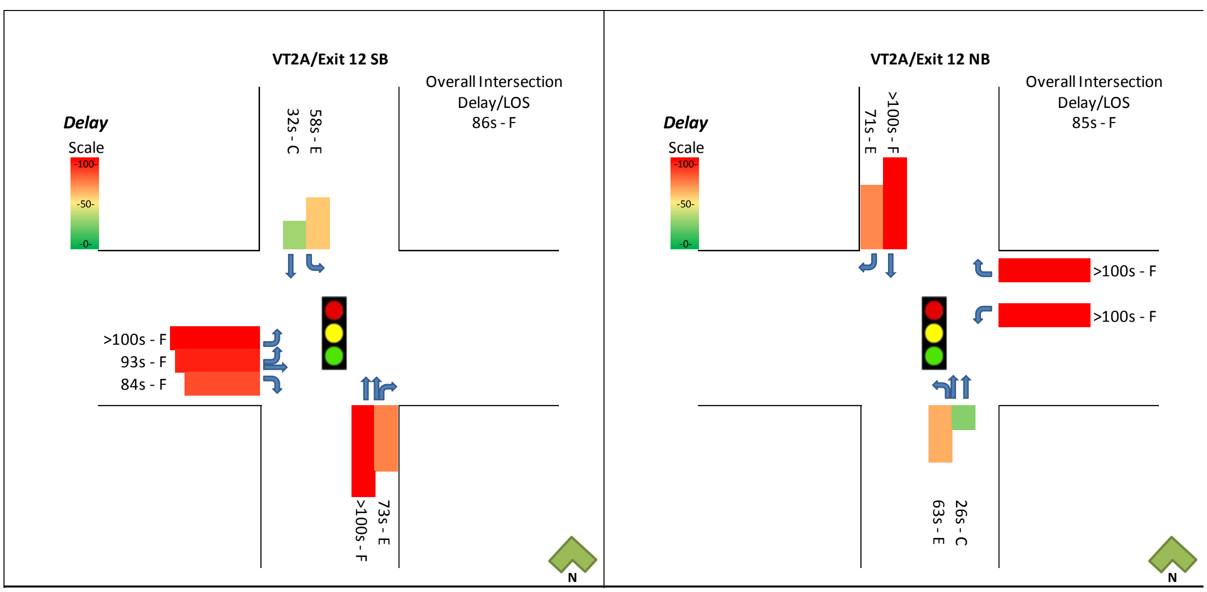
3.4.2 Intersections

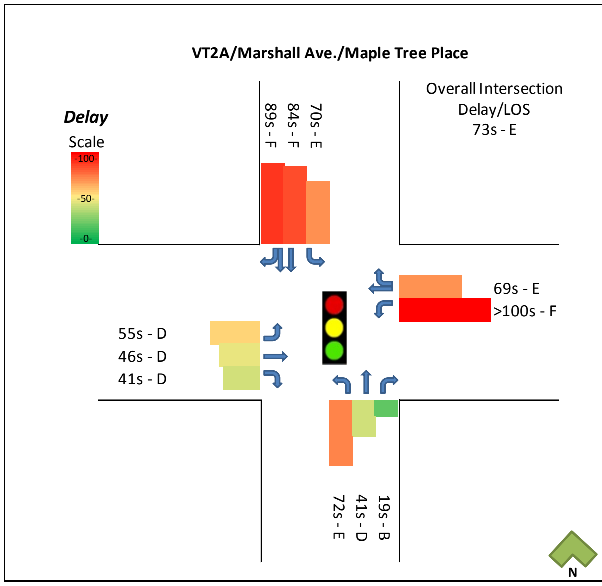
The model results for Level-of-Service (LOS) and delay (Figure 26) and vehicle queues (Figure 27) for the primary study intersections are presented here. Overall intersection LOS is only available for signalized intersections. To summarize the changes from 2010 to 2035:

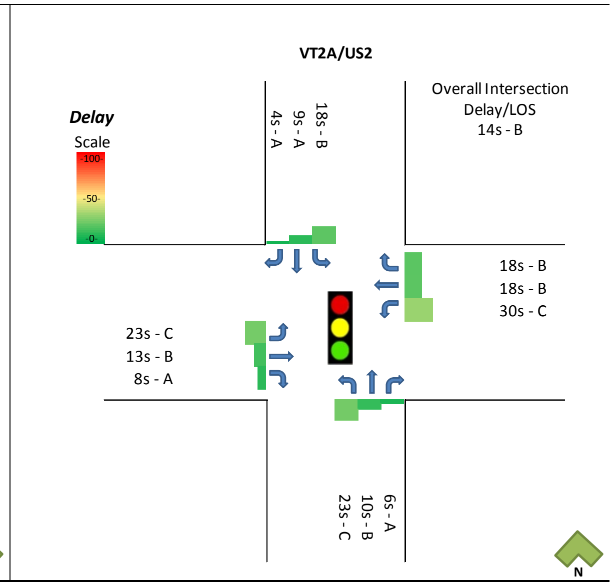
- **VT 2A/Exit 12 SOUTHBOUND**: eastbound and northbound approaches go from LOS C/D in 2010 to F in 2035; the associated delay in seconds more than doubles. Queuing for the eastbound left-turn increases from an average of 29 meters to over 100; northbound queuing increases as well.
- **VT 2A/Exit 12 NORTHBOUND:** southbound and westbound approaches go from LOS B/C/D in 2010 to F in 2035. Average southbound queuing increases from 30 meters to over 100; westbound right-turn queues increase from 23 meters to 92.

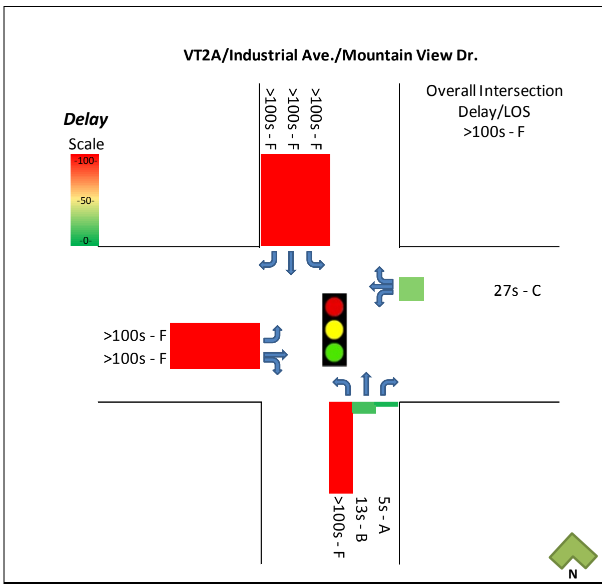
- **VT 2A/Marshall Ave/Maple Tree Place**: delay on the eastbound approach becomes more evenly distributed and improves to LOS D. LOS on the southbound approach goes from D/E in 2010 to LOS E/F in 2035. Average southbound queuing is nearly 100 meters for the through movements in 2035. Queuing on the eastbound approach improves, particularly for the left-turn.
- **VT 2A/US 2:** continues to operate at overall LOS B.
- **VT 2A/Industrial Ave/Mountain View Dr:** the southbound and eastbound approaches go from LOS C/D/E/F in 2010 to all LOS F in 2035. Overall LOS goes from D to F. Average queues on all approaches increase to about 100 meters.
- **Mountain View Dr/Redmond Rd:** relatively unchanged except that delay on the southbound approach increases from 14 seconds to 25 seconds.
- **VT 2A/South St/River St:** relatively unchanged except that delay on the southbound approach increases from 56 seconds to over 100 seconds. The westbound left-turn movement improves from LOS E to LOS C. Average queues on the southbound and northbound almost double.
- **US 2/Brownell Ave:** overall intersection delay nearly doubles. The east and westbound approaches are hardest hit, with delays more than doubling. The eastbound left-turn average queue increases from 23 meters to over 100.
- **US 2/Oak Hill Rd/North Williston Rd:** relatively unchanged except that delay on the southbound approach increases from 27 seconds in 2010 to 75 seconds in 2035.
- **North Williston Rd/Mountain View Rd:** delay on the eastbound approach increases from 66 seconds to over 100 seconds.
- **North Williston Rd/VT 117:** delay on the westbound approach increases from 19 seconds to over 100. Average queues for the left-turns on the northbound and westbound approaches increase to over 100 meters.
- **Allen Martin Dr/VT 15:** relatively unchanged.

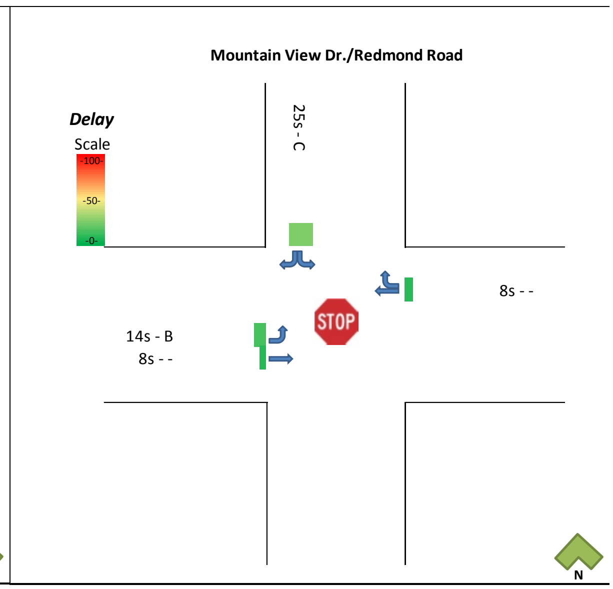
Figure 26: LOS and Delay by Lane-Primary Intersections, 2035 Base

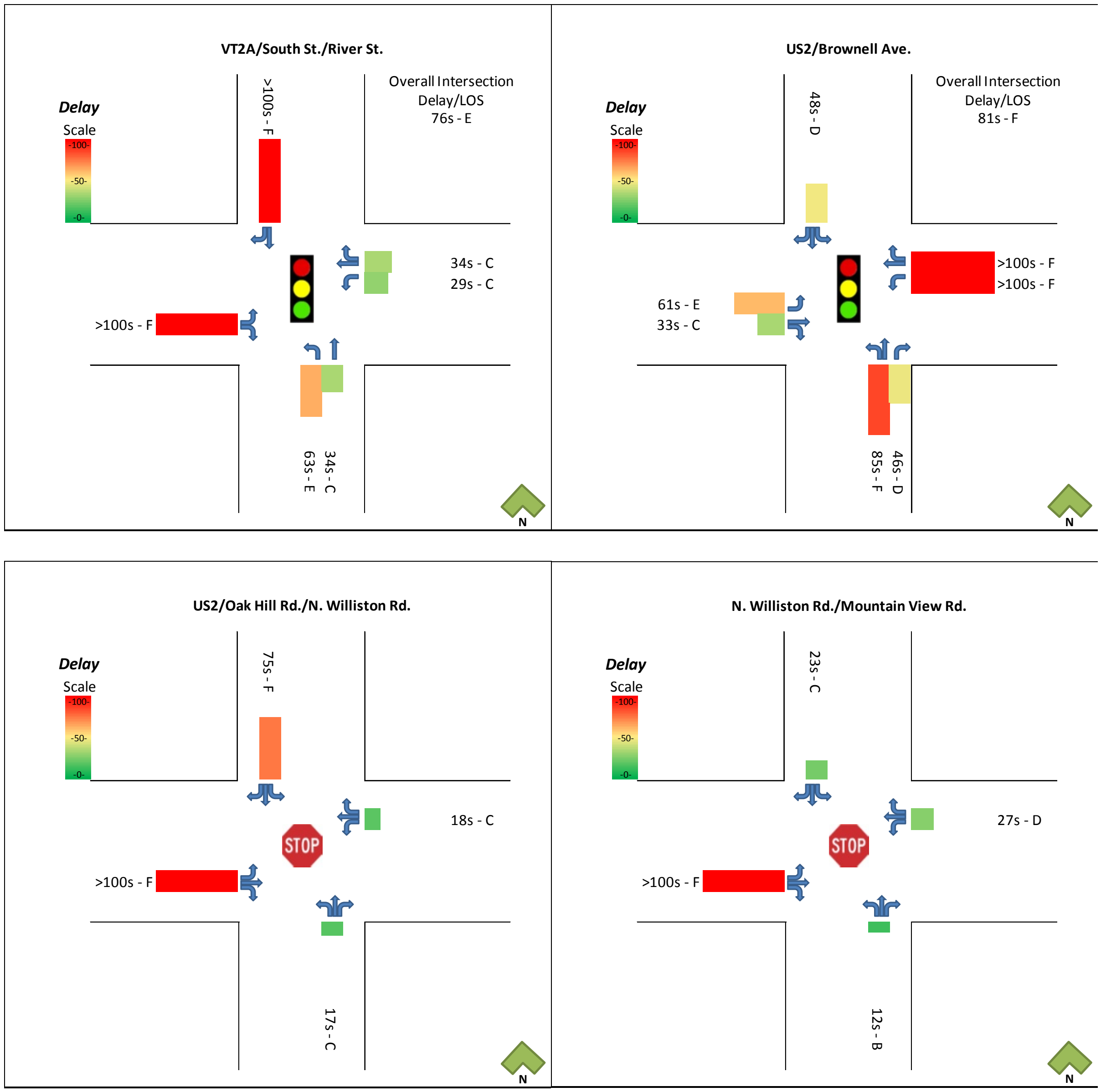



VT2A/Marshall Ave./Maple Tree Place
Delay
Scale
-100-
-50-
-0-
Overall Intersection
Delay/LOS
73s - E
89s - F
84s - F
70s - E
69s - E
>100s - F
55s - D
46s - D
41s - D
72s - E
41s - D
19s - B
N


VT2A/US2
Delay
Scale
-100-
-50-
-0-
Overall Intersection
Delay/LOS
14s - B
4s - A
9s - A
18s - B
18s - B
18s - B
30s - C
23s - C
13s - B
8s - A
23s - C
10s - B
6s - A
N


VT2A/Industrial Ave./Mountain View Dr.
Delay
Scale
-100-
-50-
-0-
Overall Intersection
Delay/LOS
>100s - F
>100s - F
>100s - F
>100s - F
27s - C
>100s - F
>100s - F
>100s - F
13s - B
5s - A
N


Mountain View Dr./Redmond Road
Delay
Scale
-100-
-50-
-0-
25s - C
8s - -
STOP
14s - B
8s - -
N


VT2A/South St./River St.
Delay
Scale
-100-
-50-
-0-
Overall Intersection
Delay/LOS
76s - E
>100s - F
34s - C
29s - C
>100s - F
63s - E
34s - C
N
US2/Brownell Ave.
Delay
Scale
-100-
-50-
-0-
Overall Intersection
Delay/LOS
81s - F
48s - D
>100s - F
>100s - F
61s - E
33s - C
85s - F
46s - D
N
US2/Oak Hill Rd./N. Williston Rd.
Delay
Scale
-100-
-50-
-0-
75s - F
18s - C
STOP
>100s - F
17s - C
N
N. Williston Rd./Mountain View Rd.
Delay
Scale
-100-
-50-
-0-
23s - C
27s - D
STOP
>100s - F
12s - B
N

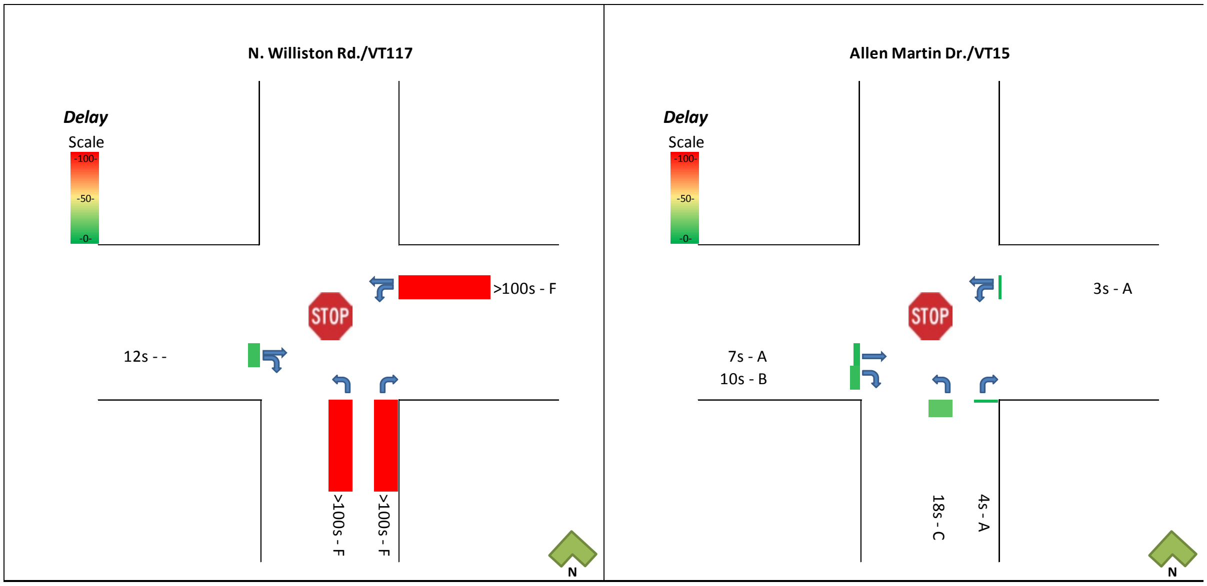
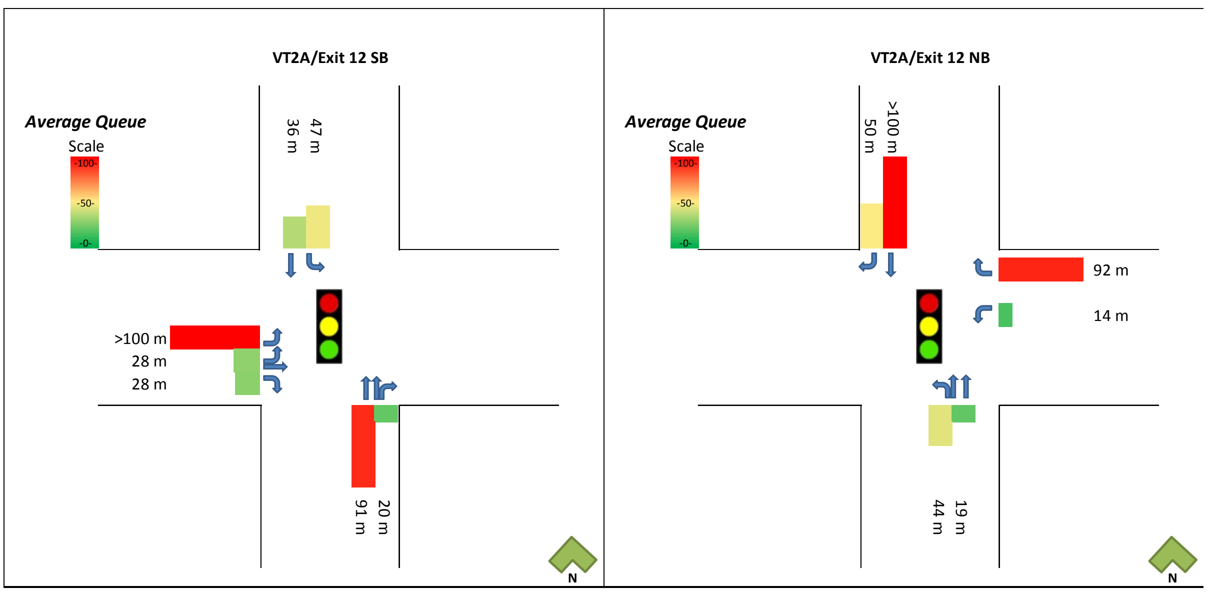
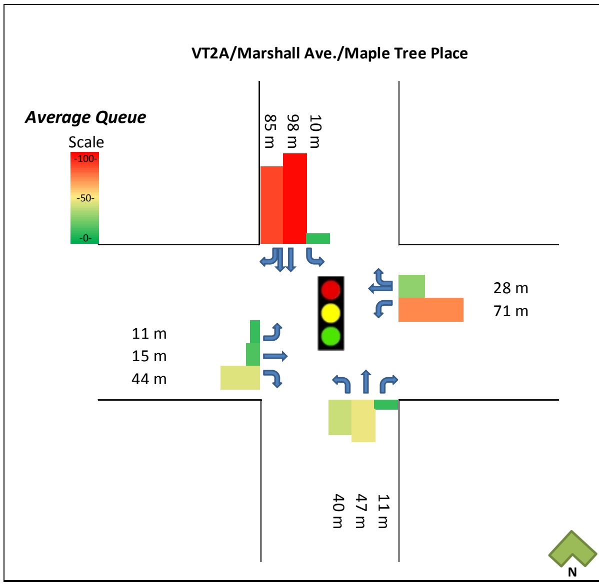
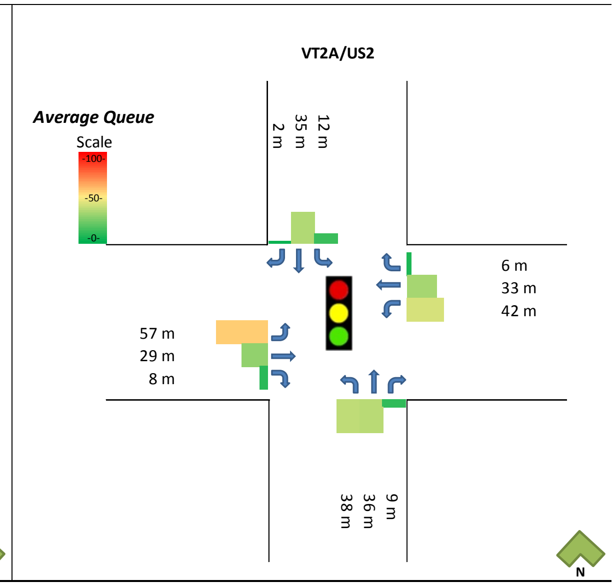
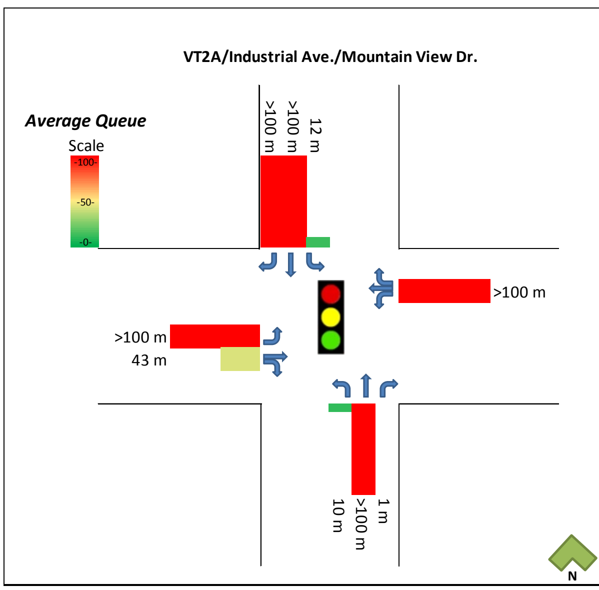


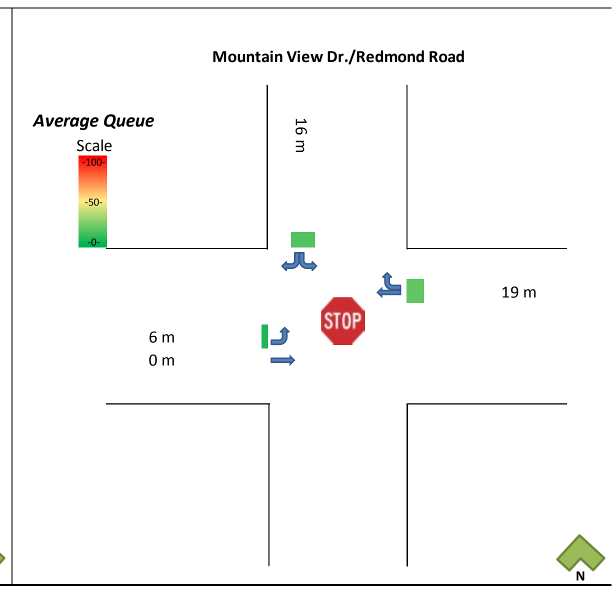
Figure 27: Average Queues in Meters by Lane-Primary Intersections, 2035 Base

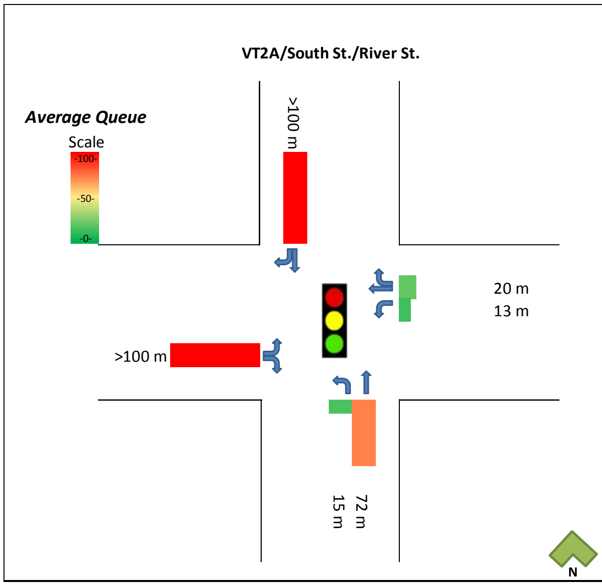


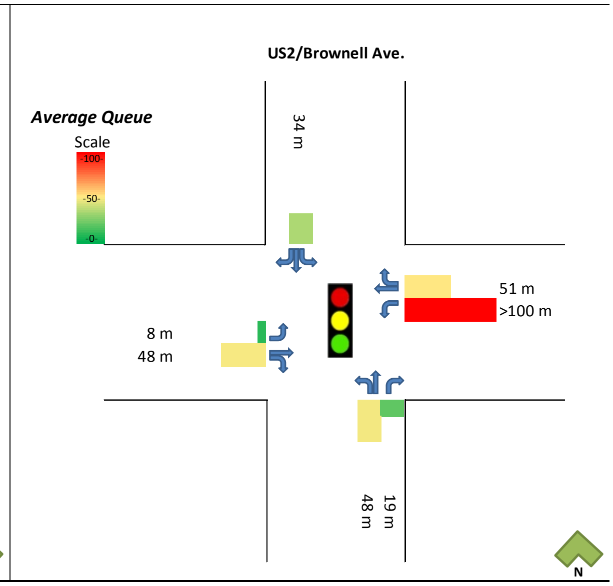

VT2A/Marshall Ave./Maple Tree Place
Average Queue
Scale
-100-
-50-
-0-
85 m
98 m
10 m
28 m
71 m
11 m
15 m
44 m
40 m
47 m
11 m
N

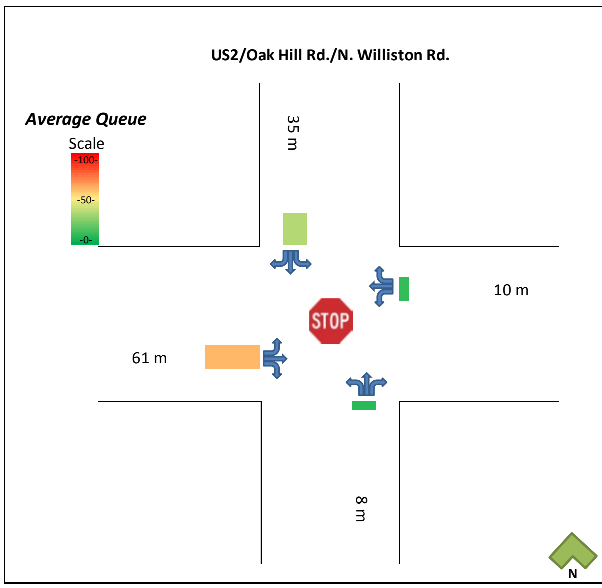

VT2A/US2
Average Queue
Scale
-100-
-50-
-0-
2 m
35 m
12 m
6 m
33 m
42 m
57 m
29 m
8 m
38 m
36 m
9 m
N

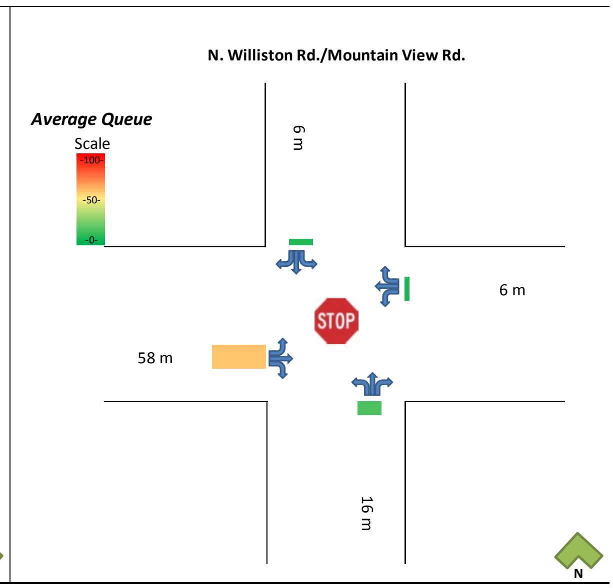

VT2A/Industrial Ave./Mountain View Dr.
Average Queue
Scale
-100-
-50-
-0-
>100 m
>100 m
12 m
>100 m
>100 m
43 m
10 m
>100 m
1 m
N


Mountain View Dr./Redmond Road
Average Queue
Scale
-100-
-50-
-0-
16 m
19 m
STOP
6 m
0 m
N


VT2A/South St./River St.
Average Queue
Scale
-100-
-50-
-0-
>100 m
20 m
13 m
>100 m
72 m
15 m
N


US2/Brownell Ave.
Average Queue
Scale
-100-
-50-
-0-
34 m
51 m
>100 m
8 m
48 m
19 m
48 m
N


US2/Oak Hill Rd./N. Williston Rd.
Average Queue
Scale
-100-
-50-
-0-
35 m
10 m
STOP
61 m
8 m
N


N. Williston Rd./Mountain View Rd.
Average Queue
Scale
-100-
-50-
-0-
6 m
6 m
STOP
58 m
16 m
N

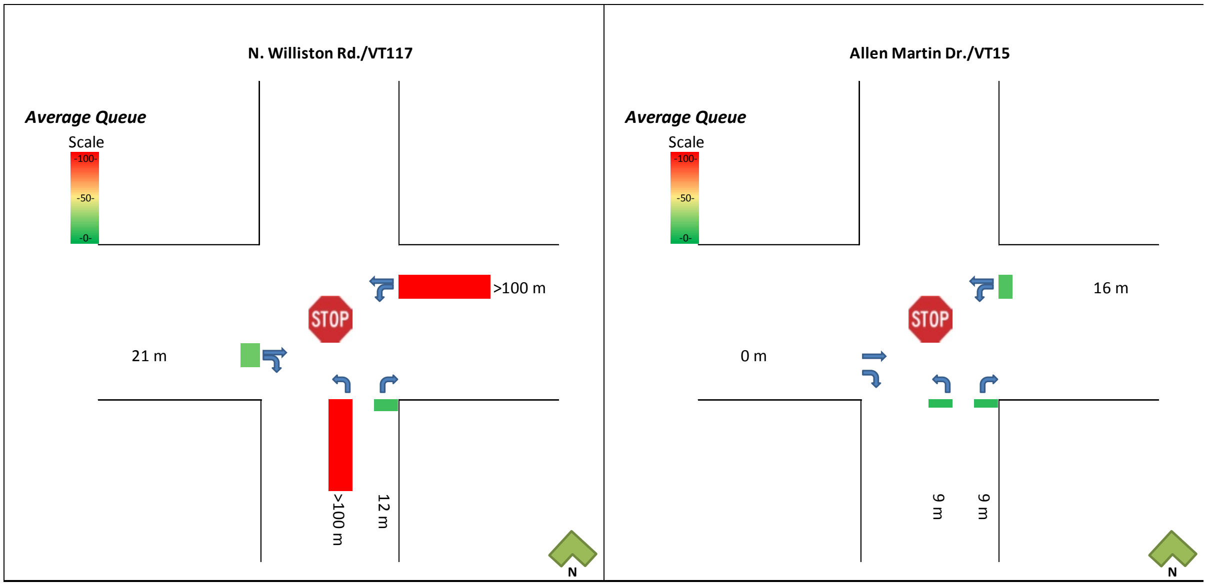


Figure 28 shows the estimated vehicular emissions for the 2035 PM peak hour. As shown over 80 million grams of CO2-equivalent emissions are produced by vehicles in the study area during the 2035 PM peak hour.

Figure 28: Pollutants Expelled in the PM Peak - 2035 Base

pollutant	total emissions (grams)
CH4 - Methane	1,574
N2O - Nitrous Oxide	743
Atmospheric CO2	81,147,337
CO2 Equivalent	81,410,252
Primary PM10 - Elemental Carbon	3,666
Primary PM2.5 - Elemental Carbon	3,537

4.0 SUMMARY

This report summarizes the existing land use, roadway characteristics, safety, bicycle/pedestrian, and transit conditions of the WENTS study area. The report also identifies the performance of vehicle mobility for 2010 and 2035 PM peak hour conditions, utilizing the output of a calibrated microsimulation traffic model.

Subsequent phases of the WENTS project will use the traffic model to evaluate alternative improvement strategies for mitigating traffic congestion in the study area.

APPENDIX A-LAND USE

Table 16 summarizes 2010 Census data for the three towns. Essex has the largest population of the three, but Essex Junction has the highest density. Williston is a regional center of commerce, business, and employment, accounting for more retail sales than any other municipality in Vermont.

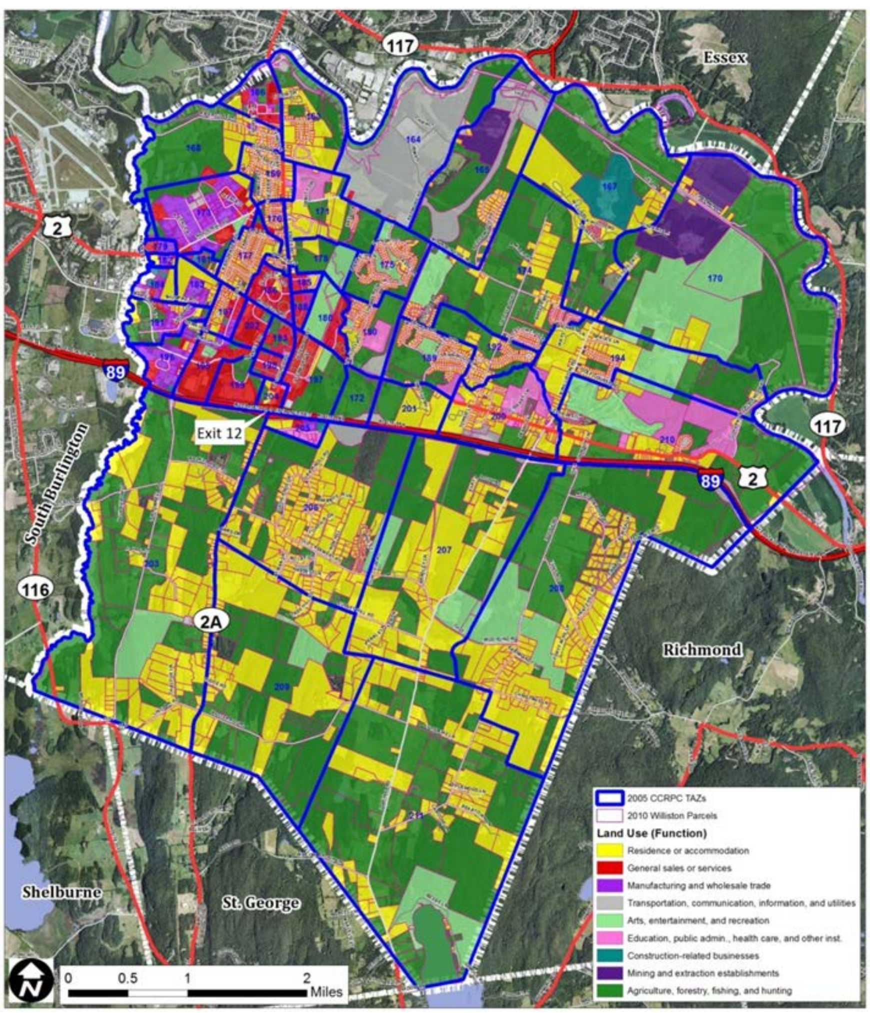
Table 16: Town Data per 2010 Census

Town	Population	Land Area (sq. mi.)	Population Density (people/sq.mi.)	Housing Units	Residential Density (units/sq.mi.)
Williston	8,698	30.7	252.1	3,036	100.1
Essex Junction	9,271	4.8	1,804.1	3,501	735.2
Essex	10,316	34.5	299.3	3,669	106.4

Town of Williston

The Town of Williston has a variety of land uses, including residential, agricultural, industrial and commercial. As shown in the Figure 29, development in Williston is concentrated north of I-89. Commercial uses are focused in the northwest corner along VT 2A and at Taft Corners (the intersection of US 2 and VT 2A), including some manufacturing uses to the west. The village center is east of Taft Corners along US 2.

Figure 29: Town of Williston Existing Land Use Map

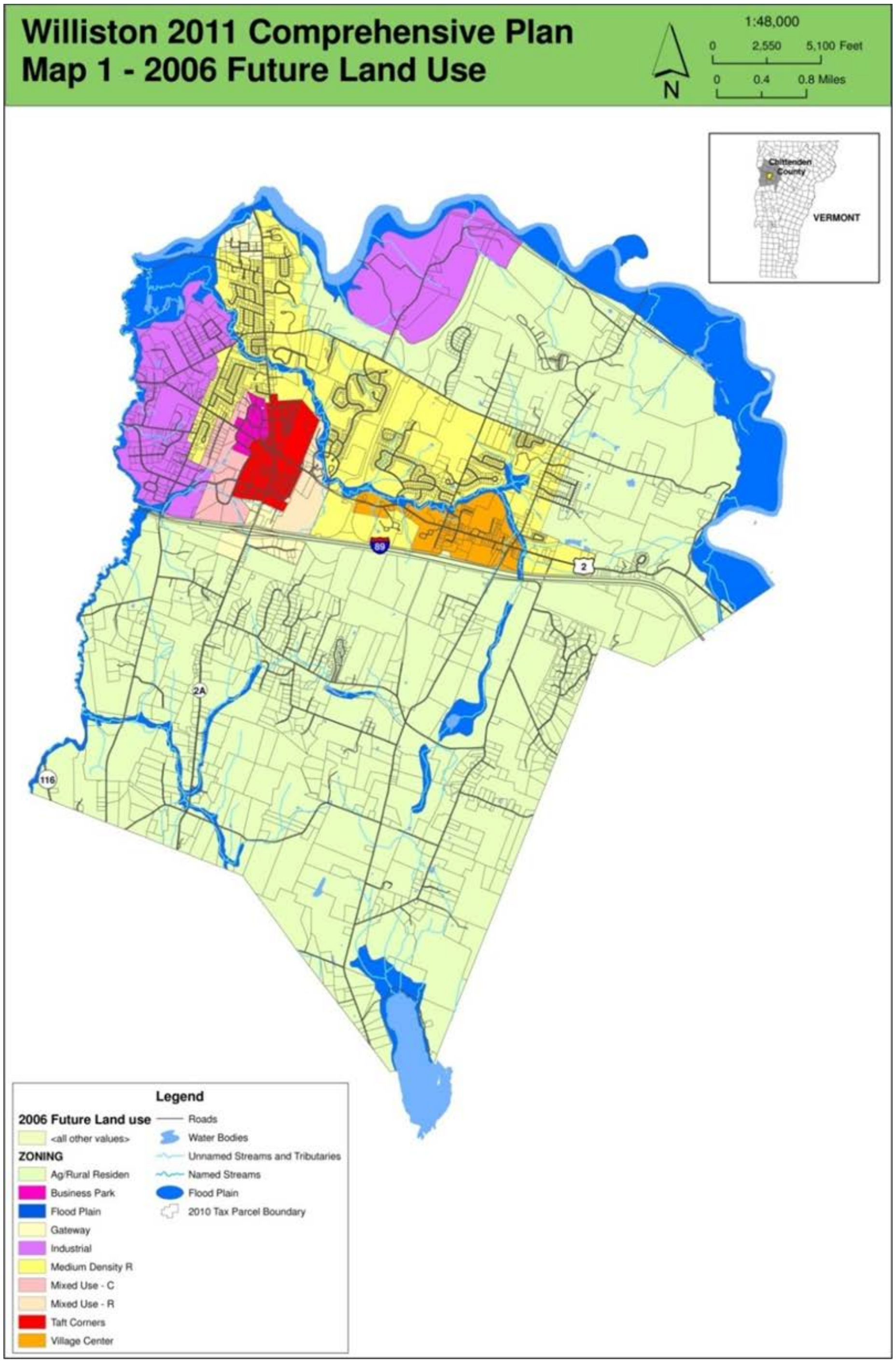


Taft Corners is a regional commercial center that employs more than 2,200 people in retail trade and nearly 4,000 in services. In FY2009, Taft Corners generated more than $2.7 million in sales tax revenue for the town. In 2008 the State designated Taft Corners a Growth Center, meaning that the majority of Williston's growth over the next 20 years will (by planning regulation) take place there in the form compact, mixed use development. This allows the Town to receive priority consideration for state funding programs such as Transportation Enhancements, Municipal

Planning Grants, and Community Development Block Grants. The Future Land Use Map (Figure 30) illustrates this pattern.

The infrastructure in place to support these land uses includes more sidewalks, bike paths, landscaping, and place-based signs than similar commercial districts. There is a grid street network development plan that the town is establishing through the planning and development process. These elements, along with increasing residential density to be achieved through the Growth Center designation, will evolve Taft Corners into a pedestrian-friendly, mixed-use town center for Williston.

Figure 30: Town of Williston Future Land Use Map



Village of Essex Junction

The Five Corners area of Essex Junction at the crossroads of VT117, VT15 and VT2A forms the Village Business District. Five Corners boasts a true village character with its existing architecture and mix of businesses and residences. Civic buildings, including the Village's municipal offices, the library, fire station, and a restaurant/inn are the major land uses surrounding this intersection. The Amtrak train station serving the region is also nearby, as well as several medium and high-density residential neighborhoods. At the center of the Five Corners intersection is the Veterans War Memorial.

As compact as Essex Junction is, Figure 31 shows that there is still a significant amount of land used for agriculture, arts/recreation, and manufacturing on the outskirts. General sales and services are concentrated along VT 15 and at Five Corners. The remaining land is mainly residential or educational/institutional. Figure 32 shows the zoning for Essex Junction.

Figure 31: Village of Essex Junction Existing Land Use Map

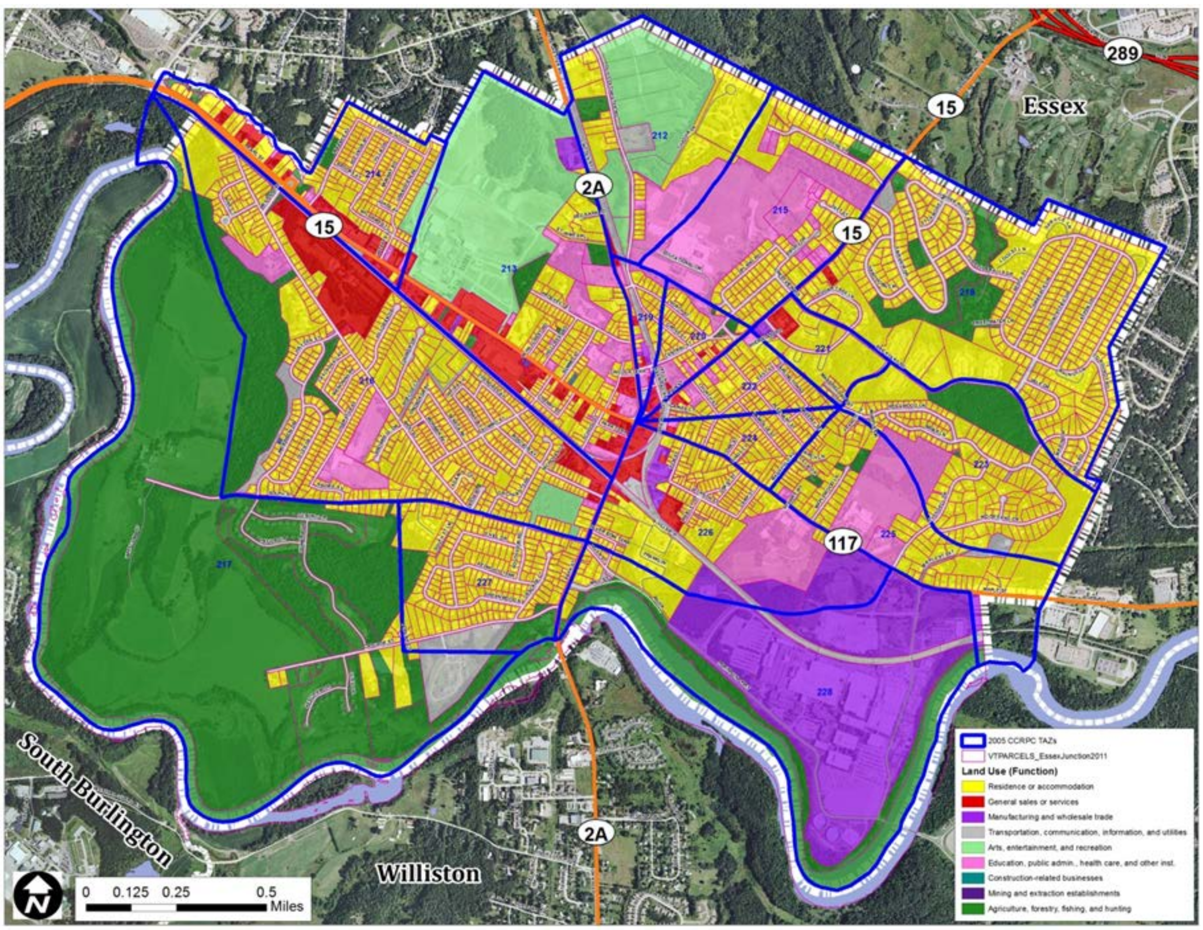
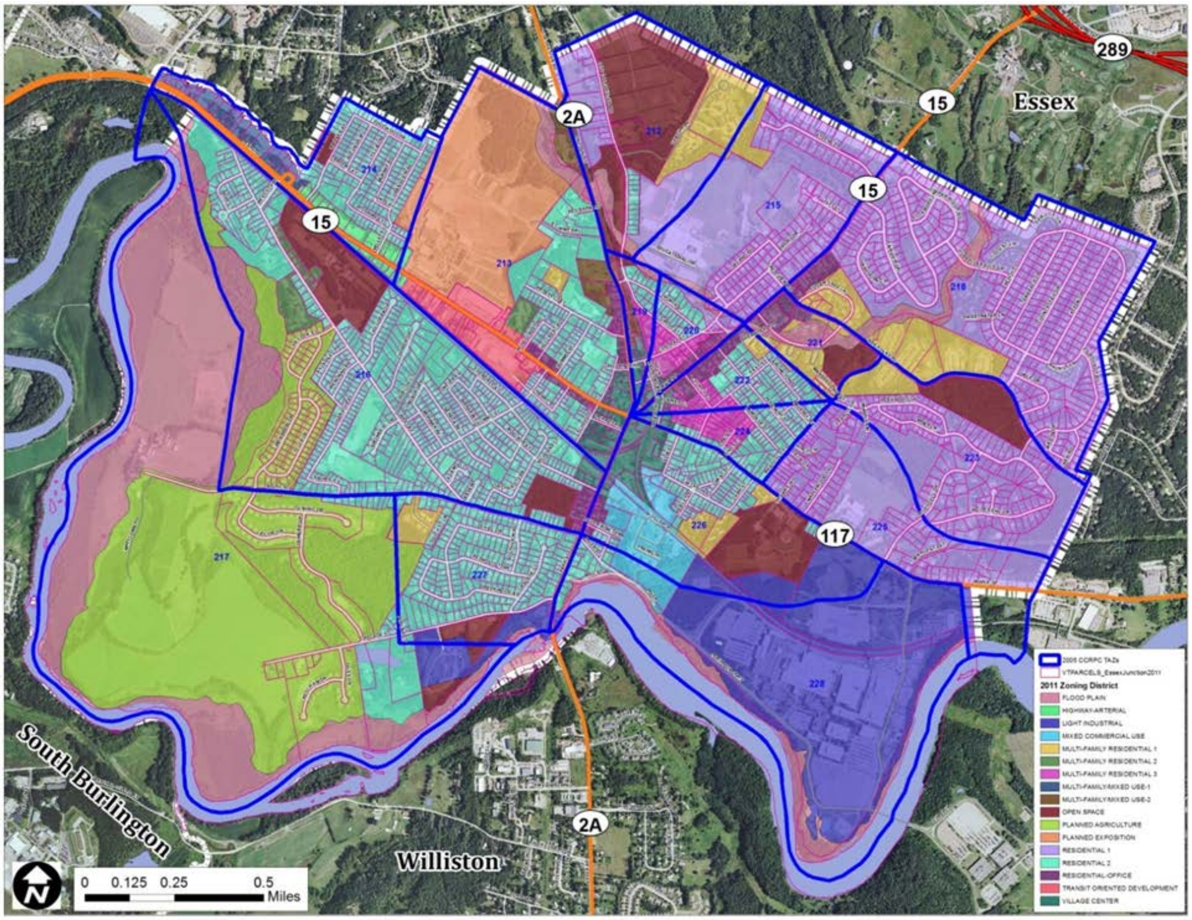


Figure 32: Village of Essex Junction Zoning Map



Town of Essex

As shown in Figure 33, roughly the northern half of Essex is low density residential and agricultural. Higher density residential and sales/services are focused along VT 15 and VT 289, as well as an enclave north of Essex Junction and west of VT 2A. The Future Land Use Map (Figure 34) represents the desired vision as identified in the Town Plan.

Social and economic activities generally take place in the historic town center and Mixed Use Commercial District at the intersection of VT 15, VT 128, and Towers Road. The types of uses that exist here include residential, civic, cultural, neighborhood commercial, home occupations, and other compatible uses that serve the needs of the community. The Town Plan's vision for the town center is to foster a place where civic spaces, cultural events, churches, community groups, pedestrians, artists and performers, and pedestrians thrive. Residential uses, which add interest and vitality to the area and accommodate those who desire high-density housing, are also encouraged in the Town Plan.

Adjacent to the town center are high density residential land uses. The zoning here encourages a wider range of housing opportunities in an area served by municipal services and facilities and public transportation. Home occupations, accessory apartments, and provisions for multi-family units on small lots are encouraged to enable some expansion of uses while avoiding strip commercial development.

The areas immediately adjacent to River Road, Sandhill Road, VT 15 and the village/town boundary have historically been the Town's residential growth centers. Because of past policies and regulations, nearly half of all homes in Essex are located on neighborhood streets as opposed to major roads.

Another major feature in Essex is Lang Farm, a mixed use, planned unit development at the intersection of VT 15 and VT 289. Lang Farm includes the Essex Shoppes and Cinema, the Essex culinary resort, and residential neighborhoods.

Figure 33: Town of Essex Existing Land Use Map

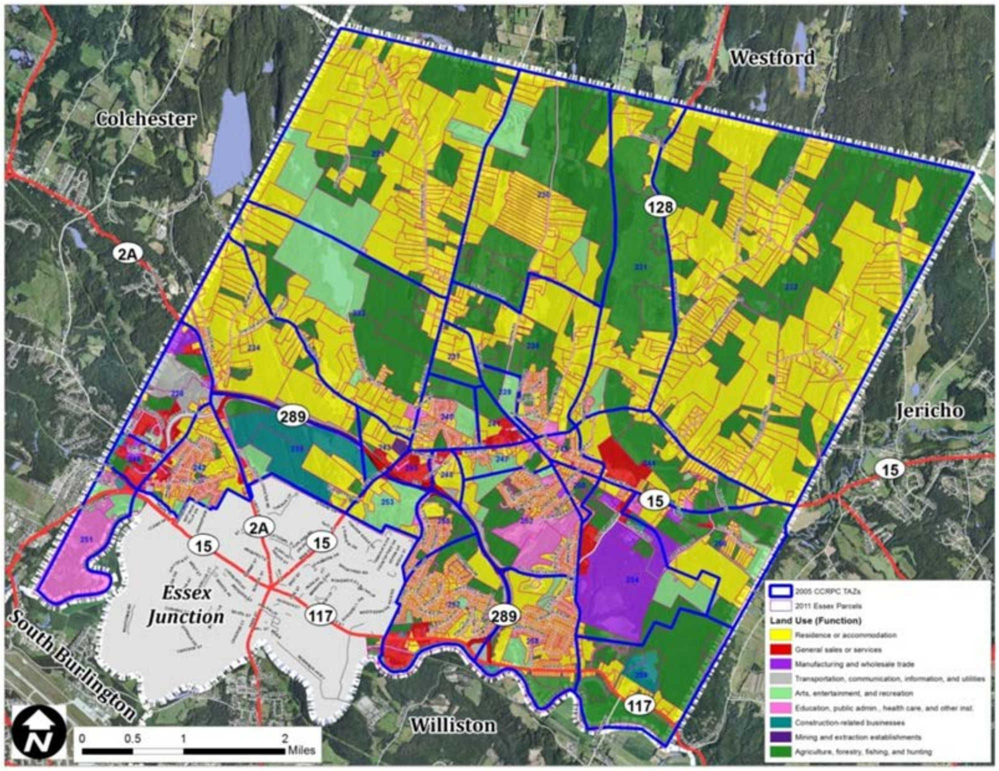
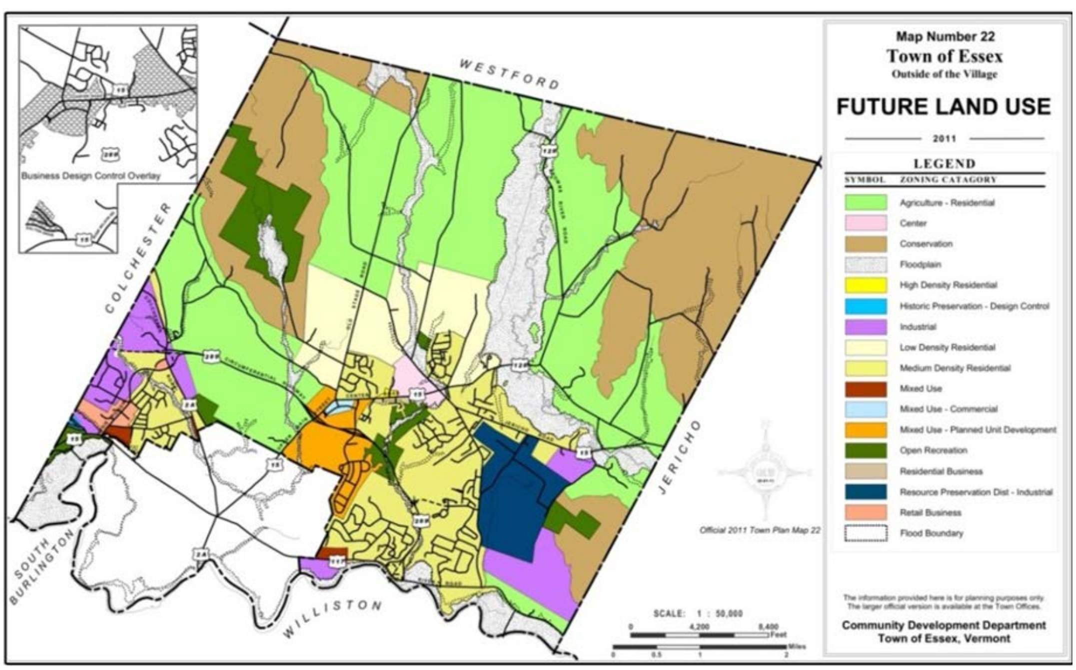


Figure 34: Town of Essex Future Land Use Map



APPENDIX B-MODEL DETAILS

A traffic microsimulation model was developed in TransModeler, a commercial software package. Traffic microsimulation is capable of tracking the trajectory of individual vehicles through a detailed roadway network.

The detail roadway network includes, but is not limited to, lane attributes such as lane width, operating speed, and alignment; vehicle and driver characteristics or behavior tendencies; intersection geometry such as number of approach lanes, turn bay lengths, and slip lanes; and intersection control – traffic signals, signal coordination, roundabouts, or interstate interchanges. Microsimulation models are particularly useful for analyzing not only congestion and performance at given intersections or road segments, but the expected motorist re-routing when changes are effected such as the addition of new roads or changes in capacity at existing routes or intersections.

The model for the WENTS study has been calibrated to 2010 PM peak hour traffic conditions for an average weekday.

This particular model network was "clipped" from the most recent version of the Chittenden County Regional Transportation Model. The regional model consists of Transportation Analysis Zones (TAZs) where land use is allocated into three major categories – residential, retail employment, and non-retail employment. For projecting future traffic conditions, future land uses are estimated through a land use allocation model (LUAM). Future land uses generate person trips that are split into different modes of transport – driving, ride sharing, walking/biking, and transit. Trips travel from TAZ to TAZ, utilizing the transportation network. All major aspects of the regional model (land use assumptions, trip generation and expected future changes) were incorporated into the microsimulation model as a result of the "clipping". The road network of the microsimulation model is, however, considerably more detailed than that of the regional network model. As such, the results are significantly more realistic, and thus determine expected traffic performance with a much greater degree of certainty.

Data Sources of the Model

For more information and in-depth description of the regional transportation model please visit http://www.ccrpcvt.org/transportation/model/. As noted above, the details of the regional model used for this study are consistent with CCRPC's planning methods, policies and practices.

For the calibration of the microsimulation model, traffic turning movement counts collected by the CCRPC and VTrans at a total of 50 intersections were used in order to calibrate this model.

Transportation Network

The road network is represented using TransModeler, a microscopic traffic simulation software package that was developed by Caliper, the same software developer of TransCad, the CCRPC's regional modeling software. Figure 35 shows a representation of the WENTS study area road network.

Figure 35: Microsimulation Model Network

Road links are coded to represent road types differentiated by functional class (e.g. arterial, collector, local), incorporating information on road capacity and operating speed.

The model includes intersection controls (i.e. stop signs, signals, roundabouts), lane designations, circulation restrictions, and turn restrictions. The model incorporates detailed information on traffic signal timing, phasing, and sequencing.

Model Calibration

The model is calibrated to approximately 190 turning movements conducted at 50 intersections over the PM peak period (4-5 PM) over several years (2007 – 2012). All counts, regardless of the year in which they occurred, were adjusted to 2010 conditions.

Each intersection count is calibrated with respect to their turning movements. For example, a count at the intersection of 2 roadways where all turns are permitted from all approaches generates a total of 12 individual counts to be used in calibration (4 approaches X 3 turning movements -- left, through, right -- per approach). Additional counts were obtained from recent traffic studies, VTrans and from the CCRPC.

Raw traffic counts have been adjusted to reflect design hour traffic conditions. Annual adjustments to the raw counts were not made as traffic growth, as indicated by VTrans counters in the study area, has been flat over the past several years[1].

The critical process in model calibration is the estimation of an origin-destination matrix ("O-D matrix") that represents the TAZ-to-TAZ vehicle trips during the PM peak hour. Including external TAZs, the

[1] VTrans traffic counter P6D129 was used to make raw traffic volume adjustments.

microsimulation model has a total of 144 TAZs, creating to a 144 X 144 matrix of vehicle trips from and to each zone.

The calibration process involves assigning the initial estimated O-D matrix to the roadway network, as obtained from the regional model[1], and comparing the accumulated vehicle travel paths against the calibration count set. Thus, every left turn, through movement, and right turn estimated in the model is compared against the actual number of left turns, through movements, and right turns within the calibrated count set.

Calibration is an iterative process of estimating the O-D matrix and making appropriate adjustments to the model network to reflect the operating conditions experienced by motorists in the study area. Calibration involved a variety of techniques, including:

- Adjustments to zonal land use and/or changes in the number and locations of TAZs;
- Adjustments to external trips – vehicle trips entering and exiting the WENTS study area – to match screenline counts[2];
- In some cases, zone-specific traffic counts (e.g. Maple Tree Place) allow the estimation process to constrain the vehicle origins and destinations to and from specific TAZs;
- Generalized trip generation rates (e.g. PM peak hour vehicle trip generation for single family residences obtained from national sources such as the Institute of Transportation Engineers) can be customized based on local data to allow more accurate estimates of TAZ-specific origins and destinations.

After each iterative model run, the model-generated traffic volumes are compared with the intersection traffic count set. There are nationally-accepted statistical measures of fit (described below) that provide the analyst with a quantification of the calibration. When those calibration thresholds are met, the calibration process is considered complete and the resulting model is considered valid for planning purposes.

Trip Assignment

Trip assignment is performed within TransModeler assignment which "assigns" each vehicle trip to a specific route along links and through intersections in the network. The vehicle trips from the origin/destination matrix are "assigned" to the network based on a dynamic assignment algorithm which enables vehicles to select a route based on knowledge of congestion along what would otherwise be the shortest path to the destination TAZ. The outputs of the assignment module include vehicle volumes, operating speeds, and travel times on each link.

Calibration Performance

Calibration standards have been developed specifically for microsimulation travel models. These standards were first published in 2004 by the Transportation Research Board (TRB), a branch of the National Science Foundation[3]. The standards primarily rely upon the GEH statistic, which is an empirical measure of fit used to compare errors across roadways with largely different traffic flows. The GEH statistic is computed as follows:

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[1] The CCRPC regional model encompasses the entire Chittenden County region and is implemented in the TransCad software, which is the "parent" software of TransModeler

[2] "Screenline" counts refer to counts at the key arterial roadways leading into and out of the WENTS study area. Examples of screenline counts are along VT 15 east and west of the study area; US 2 east and west of the study area; VT2A north and south of the study area; and all of the vehicle entries and exits at I-89 Exit 12.

[3] "Traffic Analysis Toolbox Volume III: Guidelines for Applying Traffic Microsimulation Software". FHWA-HRT-04-040. June 2004.

$$GEH = \sqrt{\frac{(ModelVolume - CountVolume)^2}{0.5 * (ModelVolume + CountVolume)}}$$

These standards have been developed by the Federal Highway Administration (FHWA) to provide a threshold of quality for transportation models used for sub-regional transportation planning. Table 17 shows the model performance relative to the recommended FHWA standards for traffic volumes assigned to functional classes.

Table 17: Model Calibration Relative to Recommended Calibration Thresholds for Regional Travel Demand Models

	Goal	Current Model
Root Mean Squared Error	<40%	28%
Coefficient of Correlation (r)	>= 0.88	0.97
Percent Error (Region)	+/- 5%	-4%
GEH <=5, by movement	>85%	85%
5<GEH<=10, by movements	<=15%	15%
GEH >10, by movement	0%	0%

The final calibrated model meets nationally-accepted calibration standards for traffic models.

Table 18 compares actual intersection volumes measured by turning movement counts to the volumes output by the calibrated model.

Table 18: PM Peak Hour Intersection Volumes: Count versus Model

	PM Peak Hour Intersection Volumes	
Primary Study Intersections	*Count*	*Model*
VT2A/Exit 12 SB	2,018	2,137
VT2A/Exit 12 NB	2,369	2,546
VT2A/Marshall Ave./Maple Tree Place	3,473	3,222
VT2A/US2	2,479	2,461
VT2A/Industrial Ave./Mountain View Dr.	2,382	2,445
Mountain View Dr./Redmond Road	631	613
VT2A/South St./River St.	1,660	2,043
US2/Brownell Ave.	1,753	1,755
US2/Oak Hill Rd./N. Williston Rd.	1,009	1,005
N. Williston Rd./Mountain View Rd.	812	804
N. Williston Rd./VT117	1,088	1,128
Allen Martin Dr./VT15	1,034	980
Secondary Study Intersections		
Five Corners	2,339	2,478
I-89 Exit 15 NB	3,038	3,121
I-89 Exit 15 SB	2,514	2,808
VT15/Lime Kiln Rd.	3,212	3,335
VT15/Susie Wilson Rd.	3,270	3,507
VT15/VT128	1,533	1,454
VT117/I-289 (On Ramp/East)	940	805
VT117/I-289 (Off Ramp/West)	762	680
VT15/Essex Way	1,461	1,583
Sand Hill Rd./Allen Martin Parkway	666	606
Sand Hill Rd./Allen Martin Dr.	476	552
VT289/VT15 (NB Ramps/East)	1,548	1,704
VT289/VT15 (SB Ramps/West)	1,184	1,209
VT2A/Connor Way	1,491	1,670
VT2A/Blair Park/Zephyr	1,058	1,394
VT2A/James Brown Dr.	1,883	1,920
US2/Talcott Rd. (West)	1,346	1,576
US2/Talcott Rd. (East)	1,219	1,253
US2/Shaws (Boxwood)	1,213	1,078
Harvest Lane/US2	1,522	1,641
US2/Industrial Ave.	2,000	1,991
Marshall Ave./Brownell	1,373	1,279
US2/OldStage Rd	1,020	1,049
Mountain View Dr. /Old Stage Rd.	526	591
VT117/Sand Hill Rd.	989	1,105