REPORT

WINOOSKI AVENUE CIRCULATION STUDY – FINAL REPORT

RSG
the science of insight

6.9.2017

PREPARED FOR:
CCRPC & CITY OF BURLINGTON

180 Battery Street, Suite 350
Burlington, VT 05401
802.383.0118
www.rsginc.com

SUBMITTED BY:
RSG

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1.0 EXECUTIVE SUMMARY

This project is Phase 1 of a 2-phase multimodal Winooski Avenue Corridor Study. A traffic microsimulation model was developed during this phase, implemented in the TransModeler™ software program, to investigate traffic implications associated with five alternative traffic patterns, with the goal of providing a north-south corridor for all travel modes in Burlington. The study area for the microsimulation model extends from the intersection of Riverside Avenue & North Winooski Avenue south to the intersection of Shelburne Road & Willard Street. It encompasses Winooski Avenue, Union Street, and Willard Street, as well as some cross streets. Traffic scenarios included:

1. Complete Street on Winooski Avenue, Winooski as primary bicycle corridor
2. Two-Way Flow on North Winooski Avenue
3. Two-Way Flow on all of Winooski Avenue, Union as primary bicycle corridor
4. One-Way Pair: Counter-Clockwise Flow
5. One-Way Pair: Clockwise Flow

These scenarios provide a means to create active transportation facilities without altering the existing curb-to-curb width of City streets. They provide varying levels of infrastructure improvements and changes to the existing traffic circulation pattern. Phase 1 work does not include a detailed investigation into all issues and impacts of these scenarios and it does not test all possibilities for making each scenario viable in terms of traffic operations.

This study reports three performance measures to examine the effectiveness of these scenarios: delay, level-of-service, and queue length. The performance measures for the Complete Street on Winooski Avenue scenario are similar to the No Build. There is a modest increase in delay on many approaches, but level of service, as modeled, is acceptable at all key intersections. A four to three lane conversion happens from Main Street to Pearl Street on Winooski Avenue and no other travel lane configurations changed outside of this area. This scenario will require the least amount of parking removal of the first three scenarios.

Performance on Winooski Avenue becomes slightly worse in the Two-Way North Winooski and Two-Way All Winooski scenarios. Performance improved on Union Street as traffic moves from Union to Winooski. While most approaches in these scenarios perform at an acceptable level of service, the public will likely notice some loss of performance along Winooski Avenue.

The performance measures in the one-way pair scenarios are significantly worse than the other scenarios with many approaches failing. In the PM scenario, there is not enough capacity to accommodate the traffic leaving the Downtown Area. The Winooski Avenue Traffic Microsimulation Model did not significantly change the lane configurations and preserved all parking spaces, so adding turn lanes and upgrading intersections may improve the performance measures. It is also possible that additional lanes would be required to make

a one-way pair scenario viable. In some places, adding lanes would require removing parking or expanding the curb-to-curb road width.

This study finds that the Complete Street on Winooski Avenue would have the least impact on traffic circulation of the scenarios studied. The one-way pair scenarios could create significant room for pedestrian scale improvements, especially in the downtown area, but additional study is required to determine what improvements are needed to make the traffic circulation perform at an acceptable level.

Results from this study will inform Phase 2 tasks expected to be undertaken in 2017 – 2018. While Phase 1 modeled several traffic scenarios, Phase 2 will be a comprehensive transportation and land use study of the entire Winooski Avenue corridor from Howard Street in the south to Riverside Avenue in the north, developing multimodal improvement strategies that address safety, capacity and connectivity. It will also include a broad public involvement process and follow the guidance established in PlanBTV Downtown and Waterfront, PlanBTV Walk/Bike, and Burlington's Transportation Plan.

2.0 INTRODUCTION

2.1 | PROJECT OVERVIEW

There has been considerable interest in the City of Burlington, VT in coordinating transportation improvements along a north-south corridor that would connect the Old North End to the South End to provide complete streets facilities and redevelopment along the corridor. Although bicycle and pedestrian scale infrastructure is currently present in some places, no continuous route exists. Providing these improvements requires changing lane configurations and possibly changing traffic patterns, but some improvements may be accomplished within the existing curb-to-curb width. The Chittenden County Regional Planning Commission (CCRPC) and the City of Burlington retained RSG to investigate the vehicular impacts associated with several options that would accomplish this goal. The second phase of this project will use these conclusions in conjunction with a public process to determine how best to provide these facilities.

The study corridor extends from the intersection of Riverside Avenue & North Winooski Avenue south to the intersection of Shelburne Road & Willard Street. It encompasses Winooski Avenue, Union Street, and Willard Street, as well as the cross streets proximate to the study corridor (Figure 1). Most destinations within the study area are on Winooski Avenue, so Winooski Avenue is considered the preferred corridor to implement these facilities. This study focuses on 2015 traffic volumes only. Future traffic volumes should be considered in subsequent studies.

This project investigates traffic implications associated with the potential implementation of the following five alternative traffic patterns. Section 3.0 of this report presents details on assumptions and elements included in each of these five alternatives. An overall comparison of traffic conditions across all five scenarios and the existing condition is then presented in Section 4.0.

1. Complete Street on Winooski Avenue, Winooski as primary bicycle corridor
2. Two-Way Flow on North Winooski Avenue
3. Two-Way Flow on all of Winooski Avenue, Union as primary bicycle corridor
4. One-Way Pair: Counter-Clockwise Flow
5. One-Way Pair: Clockwise Flow

Section 5.0 provides general conclusions and notes issues to be aware of in Phase 2.

Following the report, three appendices provide additional details on the model calibration process, regional impacts tested with the CCRPC regional travel demand model, and performance measures at all study area intersections for every scenario.

2.2 | MICROSIMULATION MODEL

RSG developed the Winooski Avenue Traffic Microsimulation Model to support a comprehensive assessment of the transportation implications associated with creating a north-south corridor for all travel modes in Burlington.

The microsimulation model is an origin/destination based model in which individual vehicles are simulated through a detailed representation of the study area street network.

The model is implemented in the TransModeler™ software program, and was originally developed from a subarea extraction from the CCRPC regional travel demand model (implemented in the TransCAD™ software program), with initial origin/destination, roadway network, and transportation analysis zones (TAZ) derived from the regional model.

The Winooski Avenue Traffic Microsimulation Model includes detailed information on roadway classifications, speeds, geometrics, intersection controls, signal timings, and traffic volumes. After extraction from the regional model, roadway network details were refined based on aerial imagery and local knowledge. Current signal timings were obtained from the City of Burlington and are represented in the model. The model generates traffic demand on the roadway network between 73 unique TAZs using origin/destination (O/D) matrices for the weekday AM and PM peak hours and is calibrated to 2016 design hour volume (DHV) conditions (see Appendix A for details).

FIGURE 1: TRAFFIC MICROSIMULATION MODEL NETWORK EXTENTS

3.0 SCENARIOS

3.1 | SCENARIOS INTRODUCTION

With a goal of providing a north-south corridor for all travel modes through the center of Burlington, the project team considered several options for reconfiguring the available curb-to-curb roadway space along Winooski Avenue and Union Street. These include changes to the number of available vehicle lanes, changes to the directions of one-way flow, and considerations for expansion of one-way flow designations. Ultimately the following five scenarios were chosen for analysis with the microsimulation model.

1. Complete Street on Winooski Avenue, Winooski as primary bicycle corridor
2. Two-Way Flow on North Winooski Avenue
3. Two-Way Flow on all of Winooski Avenue, Union as primary bicycle corridor
4. One-Way Pair: Counter-Clockwise Flow
5. One-Way Pair: Clockwise Flow

The existing condition is also examined with the microsimulation model and serves as a baseline for comparison of the five alternatives. A detailed list of assumptions and project elements assumed in each of these model runs is presented below followed by a brief summary of model results for each scenario. A detailed comparison on model results included in Section 4.0. The purpose of this study is to provide traffic guidance and not to explore all possible facility configurations.

3.2 | EXISTING CONDITIONS

The Existing Conditions scenario assumes that all current road conditions are in place. No changes are required for this scenario. Existing intersection configurations, intersection controls (stop or signal), and lane geometries are represented. For signalized intersections, the existing signal timings are implemented in the model.

With the current roadway configuration, vehicle traffic on Winooski Avenue is limited to one-way flow in the southbound direction from Union Street south to Pearl Street and again from Maple Street south to St Paul Street. Traffic on Union Street is limited to one-way flow in the northbound direction from King Street north to Winooski Avenue. Figure 2 presents the existing locations of one-way vehicular flows within the project study area.

Sharrows are currently present on North Winooski Avenue north of the intersection with North Union Street. The City has long-term plans to install dedicated bike facilities on this section of North Winooski, but for this study it was modeled as the current lane configuration.

FIGURE 2: EXISTING ROADWAY NETWORK

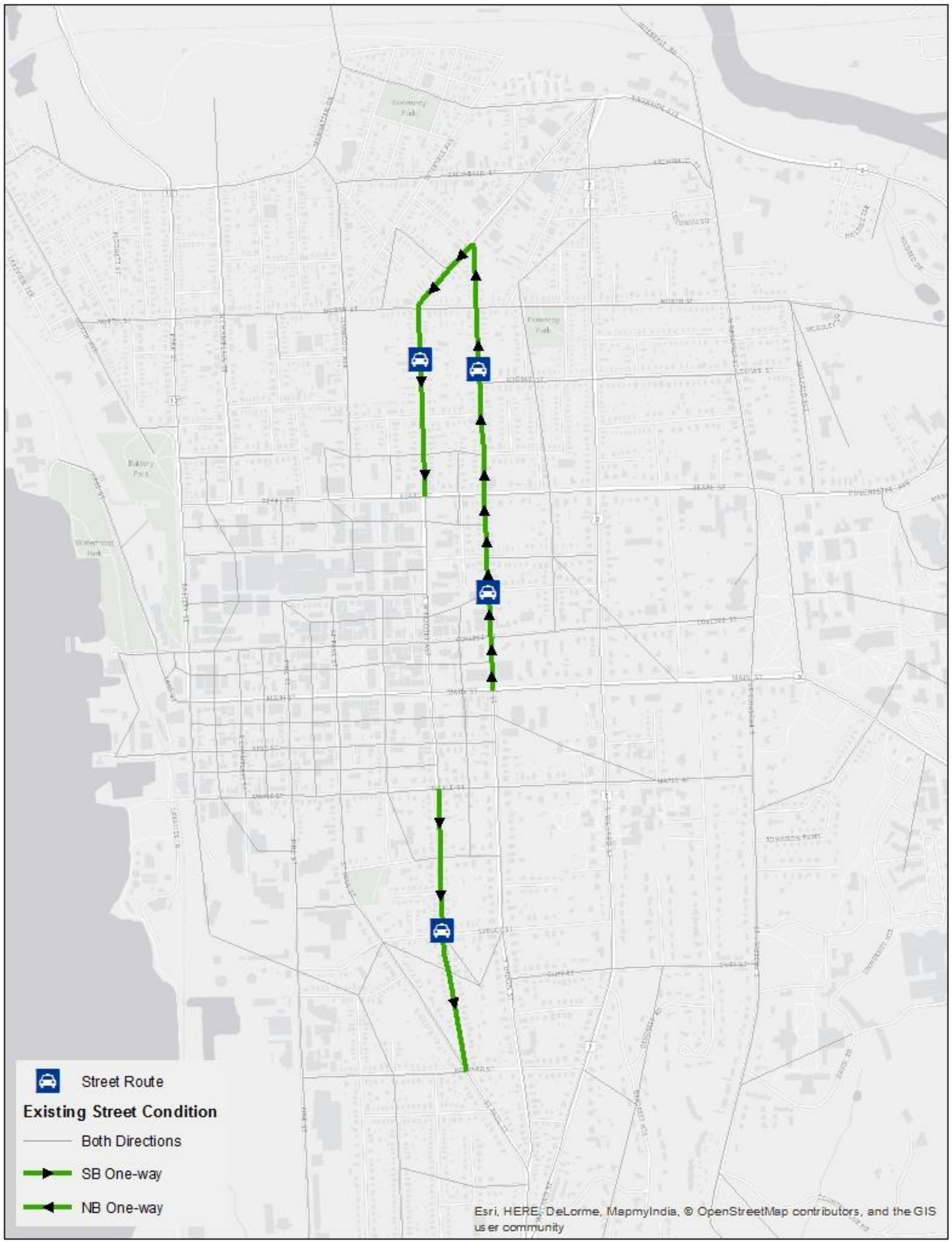


Figure 3 presents the location of existing north/south bike lanes within the project study area. Bike lanes currently exist on Winooski Avenue in the southbound direction from Union Street through Pearl Street and in both the southbound and northbound directions from Maple Street through St Paul Street. On Winooski Avenue north of Union Street, there currently exist sharrows in both the southbound and northbound directions. On Union Street, buffered bike lanes currently exist in the northbound direction from Main Street north to Winooski Avenue. On Willard Street, bike lanes currently exist in the northbound direction from Cliff Street north to North Street.

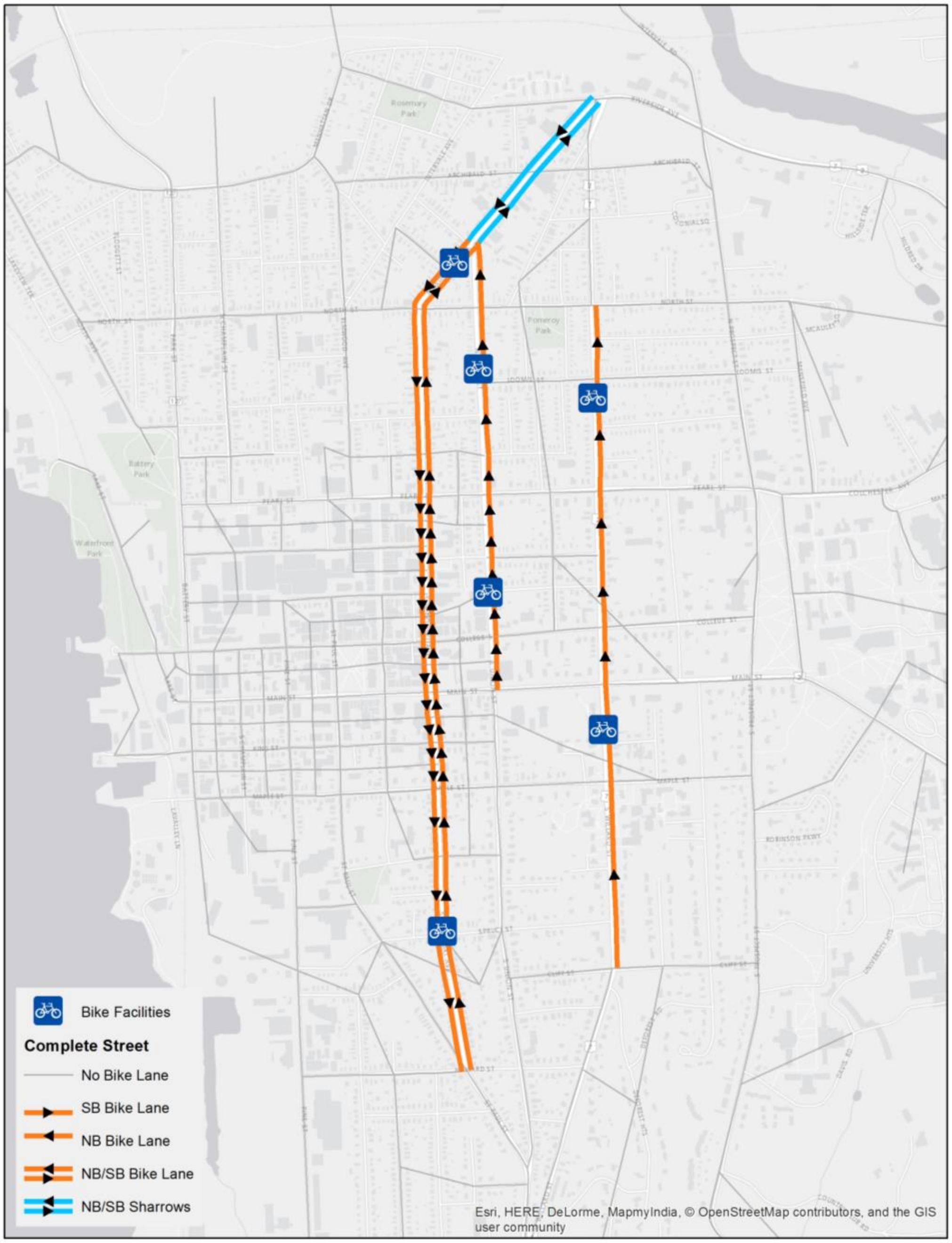
There are currently no bike lanes provided on Winooski Avenue between Pearl Street and Maple Street, on Union Street south of King Street, or southbound on Willard Street.

FIGURE 3: EXISTING NORTH/SOUTH BICYCLE FACILITIES

3.3 | COMPLETE STREET ON WINOOSKI AVENUE, WINOOSKI AS PRIMARY BICYCLE CORRIDOR

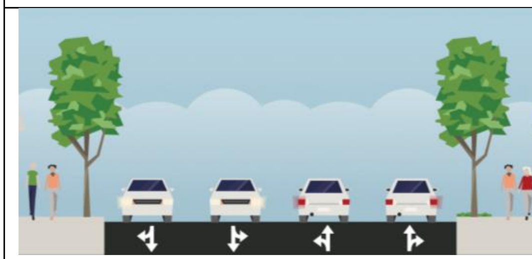
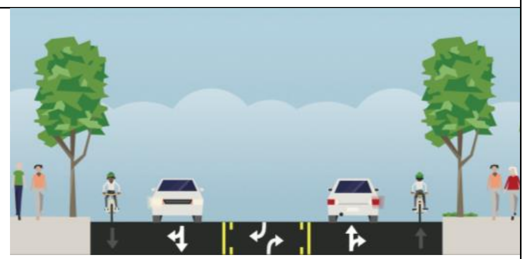
This scenario alters lane configurations to allow bike lanes on both sides of Winooski Avenue from Union Street south through St Paul Street (Figure 4). This scenario requires no changes to the directionality of existing one-way streets, so it maintains the existing vehicular traffic patterns (Figure 2). However, some places do not contain adequate curb-to-curb width to both install bike lanes and maintain all existing lanes of traffic.

FIGURE 4: BICYCLE LANE CONCEPT FOR WINOOSKI AVENUE BICYCLE CORRIDOR



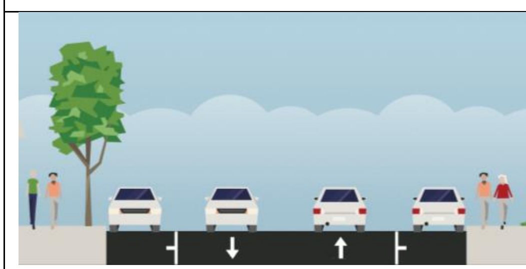
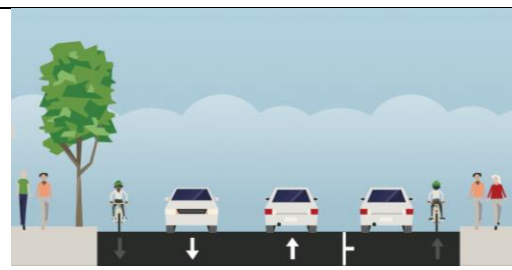
From Pearl Street south to Main Street, the entire curb-to-curb width of Winooski Avenue is currently dedicated to vehicular traffic. Bike lanes can be added by converting the four-lane cross section to three lanes (Figure 5).

FIGURE 5: WINOOSKI AVENUE BETWEEN PEARL ST AND MAIN ST CONCEPT

Existing Condition	Complete Street Alternative
	

Keeping the current direction of travel and adding a bike lane from Main Street south to Maple Street requires removing parking on one side of Winooski Avenue and shifting travel lanes to the middle of the pavement to provide room for the bike lanes, but no vehicle travel lanes need to be removed (Figure 6).

FIGURE 6: WINOOSKI AVENUE SOUTH OF MAIN STREET CONCEPT

Existing Condition	Complete Street Alternative
	

Similarly, parking on one side of the street will likely need to be removed North of Pearl Street to provide room for a bike lane and maintain the current direction of vehicular travel, although it may be possible to create two narrow bike lanes with narrower parking spaces. Further investigation will be required if the City chooses to add a northbound bike lane on North Winooski Avenue. Southbound bike lanes currently exist north of Pearl Street, and bike lanes on both side of the street currently exist south of Maple Street. This concept of creating bike lanes on both sides of Winooski Avenue is one option but others exist. It will be up to the City to explore other possibilities in Phase 2.

Of the five scenarios, this one would be the least disruptive to surrounding traffic patterns while still creating a full north-south bike corridor.

A detailed microsimulation scenario was created to project traffic impacts associated with this roadway alternative. The microsimulation scenario converts Winooski Avenue between Pearl Street and Main Street to one lane flow in each direction with a two-way-left-turn lane in the middle. Exclusive left-turn lane pockets are retained at the signalized Pearl Street, Cherry Street, Bank Street, College Street, and Main Street intersections – in place of the center two-way left-turn lane. All other roadway network details remained unchanged from the existing conditions model.

The model indicates that performance under this scenario is similar to existing conditions.

3.4 | TWO-WAY FLOW ON NORTH WINOOSKI

This scenario replaces the existing one-way southbound traffic flow section of North Winooski Avenue from North Union Street to Pearl Street with two-way traffic flow. Similar to the previous scenario, this alternative also includes a reduction from four lanes to three lanes on Winooski Avenue from Pearl Street south through Main Street, as described in Section **Error! Reference source not found.**. Figure 7 presents a map of proposed roadway changes.

FIGURE 7: TWO-WAY FLOW ON NORTH WINOOSKI VEHICLE MAP

This scenario allows for new bike lanes along both sides of Winooski Avenue from Pearl Street through Main Street, and, with conversion of parking, could allow for a complete north/south bike corridor, similar to the previous alternative. However, to accommodate the new northbound travel lane north of Pearl Street, one lane of parking will need to be removed. Maintaining bike lanes on both sides of this section of Winooski Avenue may require the removal of additional on-street parking. By allowing northbound vehicular flows on Winooski Avenue north of Pearl Street, a slight improvement in performance is projected on Union Street, where northbound bike lanes currently exist and would remain.

FIGURE 8: BICYCLE LANE CONCEPT FOR TWO-WAY FLOW ON NORTH WINOOSKI AVE

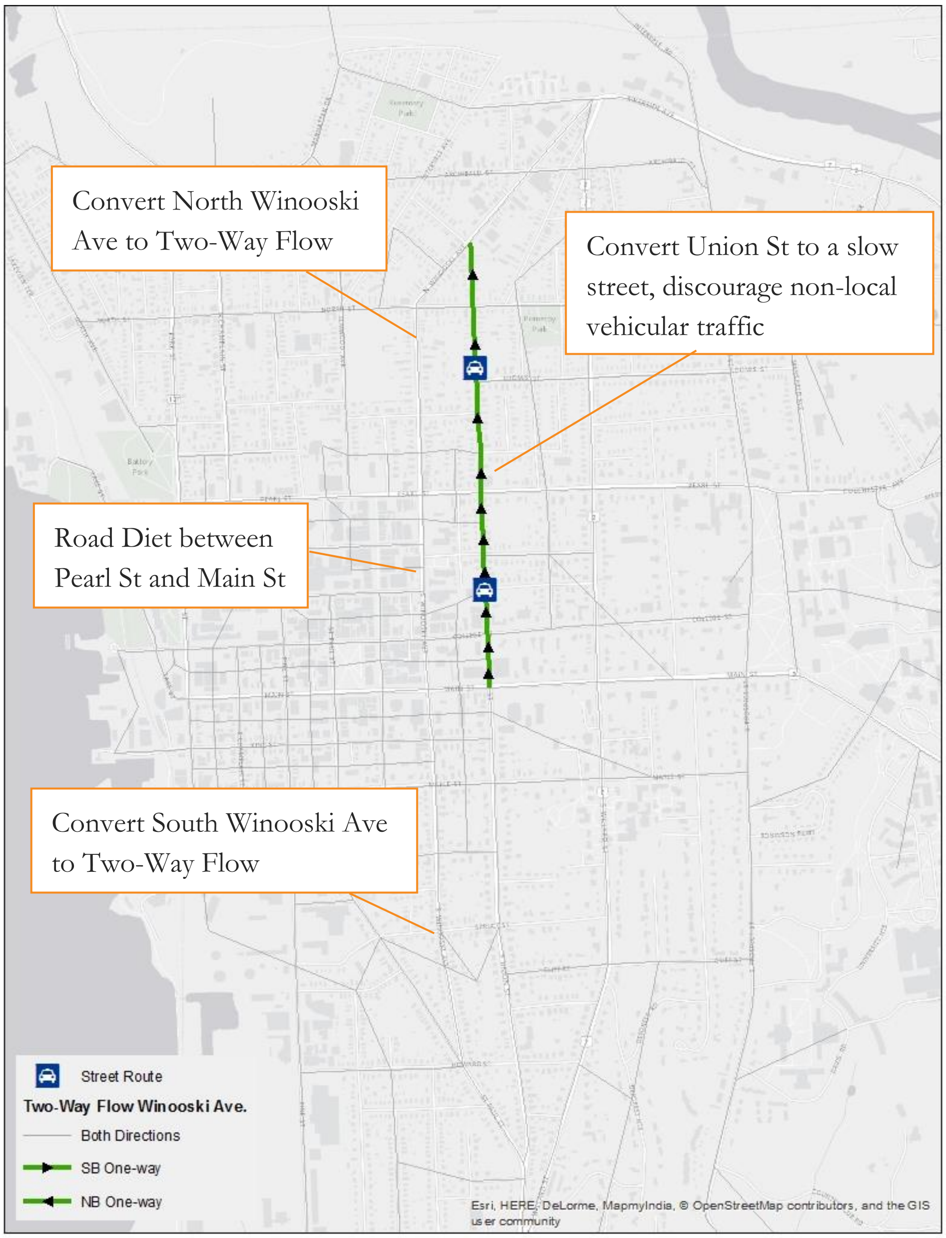
To assess traffic implications associated with this scenario in the Microsimulation model, Winooski Avenue from North Union Street to Pearl Street is changed to two-way flow and Winooski Avenue from Pearl Street to Main Street is changed from four lanes to three lanes (one travel lane in each direction and a center two-way left-turn lane), again with left-turn pockets retained at existing signalized intersections. Traffic signal timings are changed where necessary to accommodate the new traffic pattern.

Model results indicate that traffic performance will be mostly acceptable under this scenario, but it will not perform as well as existing conditions.

3.5 | TWO-WAY FLOW ON ALL OF WINOOSKI, UNION AS PRIMARY BICYCLE CORRIDOR

This scenario opens all of Winooski Avenue to two-way traffic flow. The existing southbound traffic sections from North Union Street to Pearl Street and from Maple Street to St Paul Street would be replaced with two-way traffic flow. This change is expected to draw northbound traffic away from Union Street and to Winooski Avenue, resulting in greater vehicular access on Winooski Avenue and reduced traffic on Union Street (Figure 9).

FIGURE 9: TWO-WAY FLOW ON ALL OF WINOOSKI VEHICLE MAP



This concept considers developing Union Street as a "slow street" for vehicular traffic and a dedicated corridor for bicycle traffic. As with the previous two alternatives, this scenario includes the road diet conversion on Winooski Avenue from Pearl Street through Main Street, which converts the existing four lane section to a three lane section and adds bike lanes in both directions. While this alternative creates a bike corridor on Union Street, it maintains bicycle access on Winooski Avenue between Pearl Street and Main Street (Figure 10).

By moving the bicycle facilities to Union Street, more parking can be retained on North Winooski Avenue. No parking on Winooski Avenue needs to be removed north of North Street but one lane of parking may need to be removed between North Street and Pearl Street. There is the potential for parking removal on Union Street depending on the desired bicycle and roadway facility design.

FIGURE 10: BICYCLE LANE CONCEPT FOR TWO-WAY FLOW ON ALL OF WINOOSKI AVE

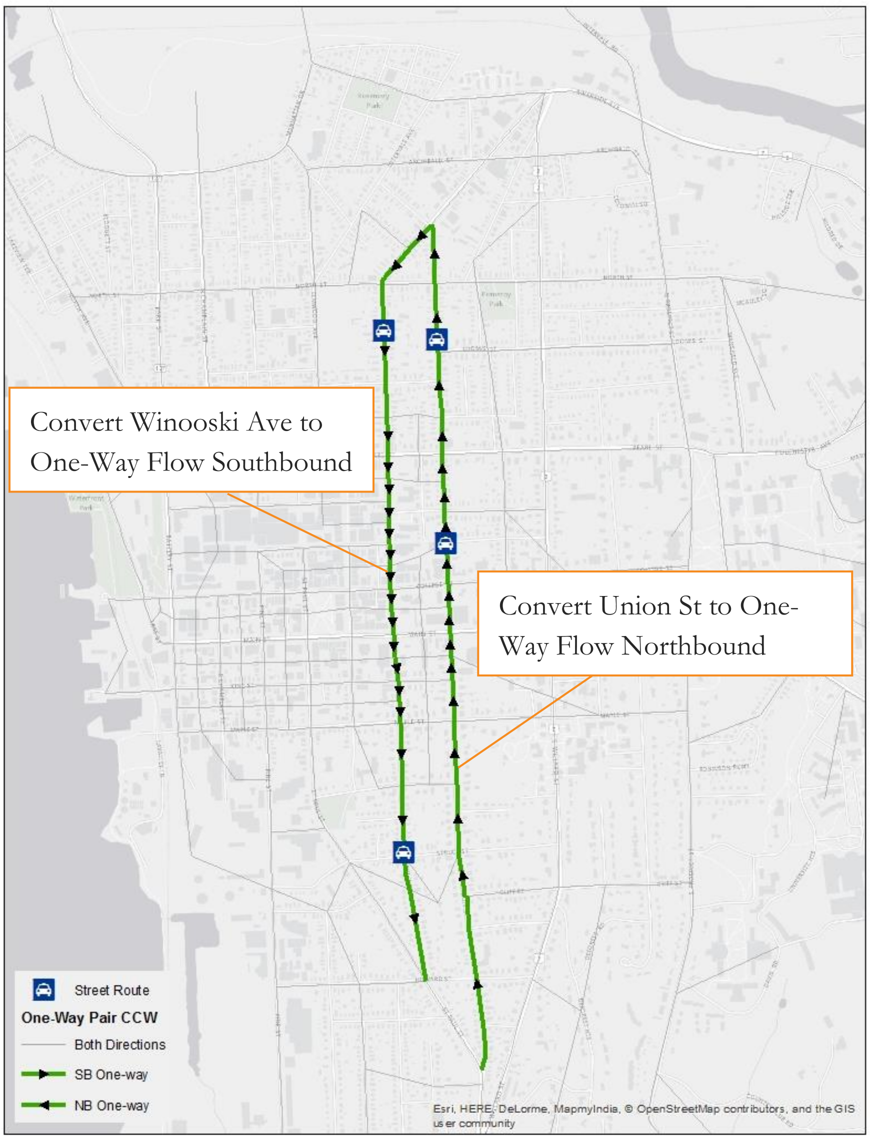
To assess traffic implications associated with this scenario in the Microsimulation model, the entire extent of Winooski Avenue, including north of Pearl Street and south of Maple Street, is changed to two-way flow and Winooski Avenue from Pearl Street to Main Street is changed from four lanes to three lanes (one travel lane in each direction and a center two-way left-turn lane), again with left-turn pockets retained at existing signalized intersections. Signal timings are changed where necessary to accommodate the traffic pattern. Travel speeds and capacities are reduced on Union Street to represent a local street.

Model results indicate that traffic performance will be noticeably reduced in this scenario, but it may still be within acceptable limits.

3.6 | ONE-WAY PAIR WITH COUNTER-CLOCKWISE FLOW

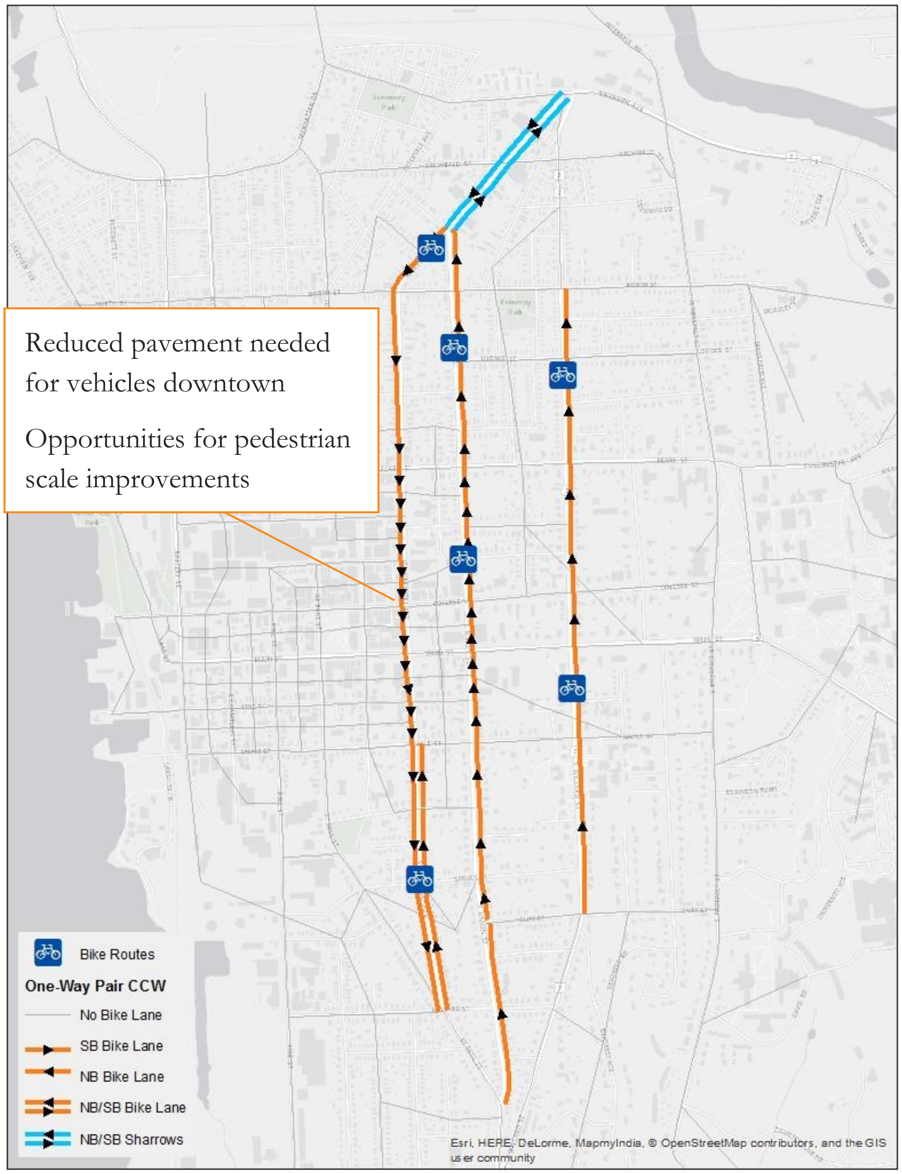
While Winooski Avenue and Union Street currently operate with some one-way traffic sections, the one-way sections are disconnected and do not form a full one-way loop. For this project, two one-way pair scenarios are examined, with the first directing traffic in a counter-clockwise one-way pair flow (southbound on Winooski Avenue and northbound on Union Street). This configuration fills in one-way flow gaps between the existing one-way flow sections. Two lanes of travel (in one direction only) are provided where there are currently two-lanes of travel (between Pearl Street and Main Street) and one lane of travel is provided for all other sections (Figure 11).

FIGURE 11: COUNTER-CLOCKWISE ONE-WAY PAIR VEHICLE MAP



Conversion to one-way flow has the potential to free up pavement for alternate uses. While a one-way pair of bicycle lanes adjacent to vehicle lanes is one alternative for adding bicycle infrastructure in this scenario (Figure 12), it is not the only option, and alternate configurations may be considered. Additionally, this conversion may allow for additional parking or additional bike facilities in some areas. Counter-clockwise flow would maintain existing traffic controls since the flow is consistent with existing conditions.

FIGURE 12: BICYCLE LANE CONCEPT FOR COUNTER-CLOCKWISE ONE-WAY PAIR



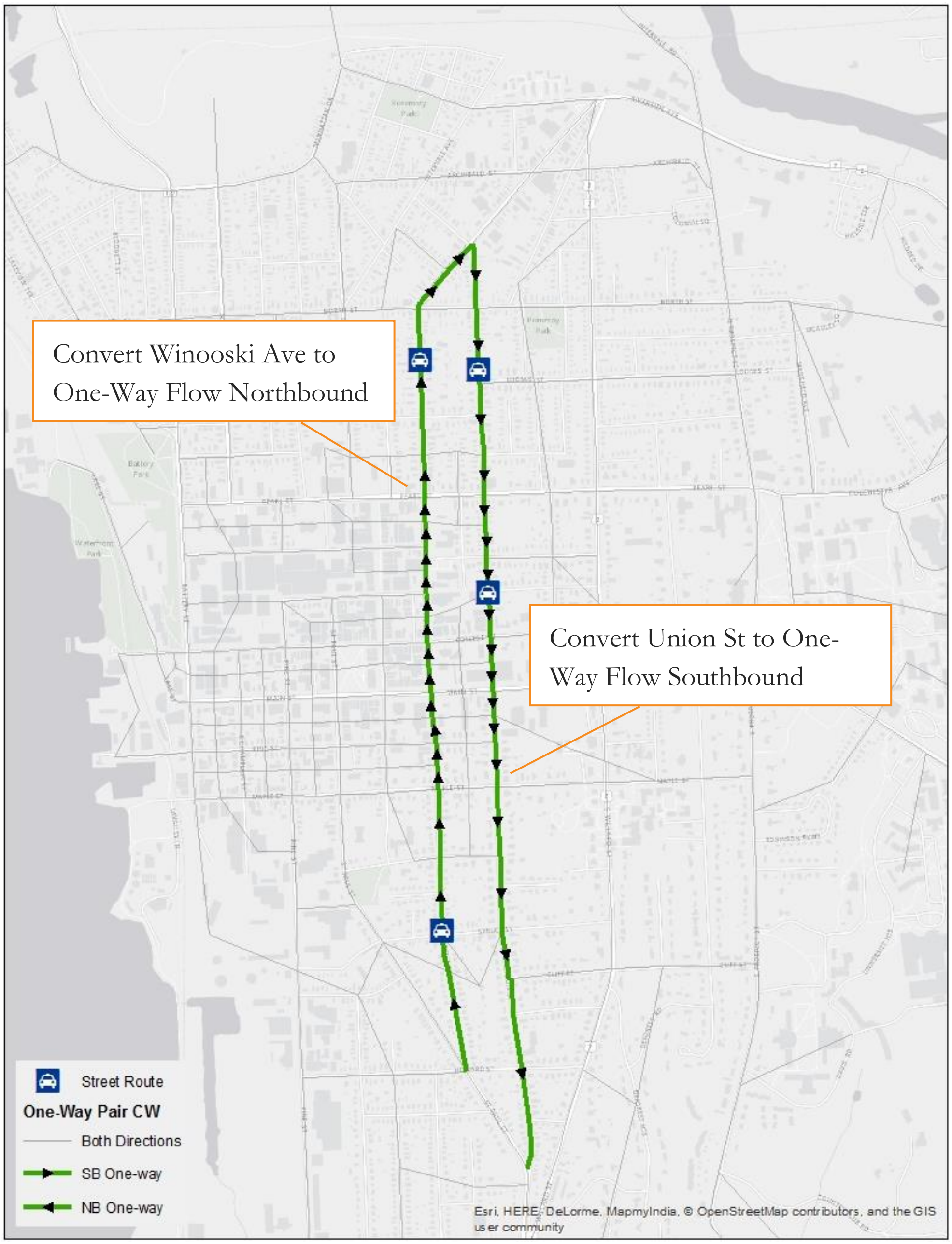
To assess traffic implications associated with this scenario in the Microsimulation model, the entire extent of Winooski Avenue is changed to one-way flow in the southbound direction and the entirety of Union Street is changed to one-way flow in the northbound direction. Two travel lanes are maintained on Winooski Avenue from Pearl Street to Main Street, as are turn lanes at key intersections. Signal timings are changed where necessary to accommodate the new traffic pattern.

Model results indicate that the lane configurations do not have adequate capacity to accommodate the traffic volumes in some areas. Additional study is required to determine the extent of improvements necessary to make a counter-clockwise one-way flow viable.

3.7 | ONE-WAY PAIR WITH CLOCKWISE FLOW

A second alternative for creating a one-way pair flow system is to route traffic in a clockwise direction (northbound on Winooski Avenue and southbound on Union Street). This configuration would flip the direction of existing one-way flow sections and would fill in the gaps to create a full one-way loop (Figure 13).

FIGURE 13: CLOCKWISE ONE-WAY PAIR VEHICLE MAP



Flipping the direction of the existing one-way flow segments would require reconstruction of existing signalized intersections but would allow for right-turn movements to complete the one-way loop rather than left-turn movements. Right turn movements have been found to be more efficient, so this traffic pattern will enable more efficient traffic flow compared to a counter-clockwise flow.

Two lanes of travel are provided where there are currently two-lanes of travel (between Pearl Street and Main Street) and one lane of travel is provided for all other sections.

FIGURE 14: BICYCLE LANE CONCEPT FOR CLOCKWISE ONE-WAY PAIR

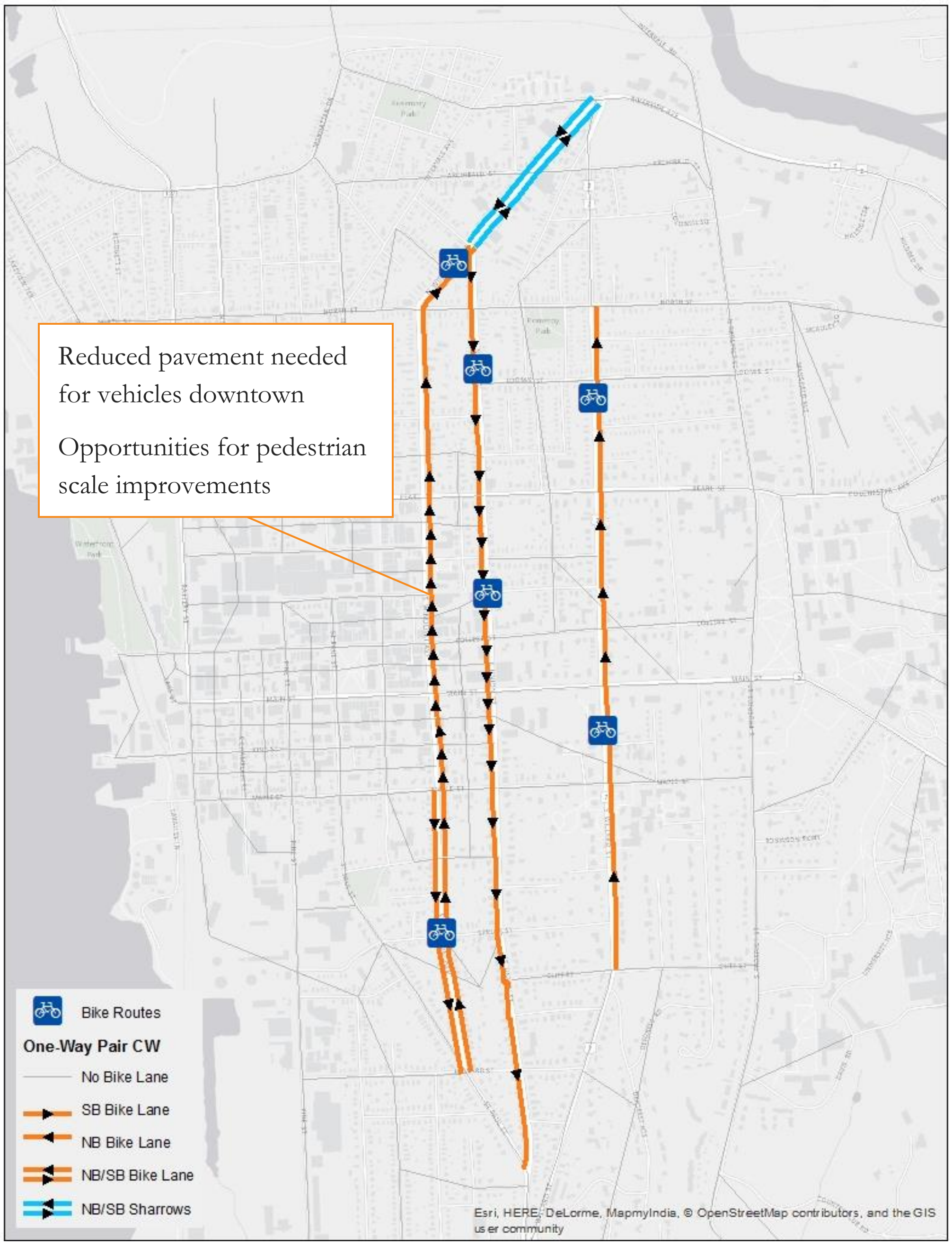


Figure 14 shows bicycle lanes adjacent to vehicle lanes and following the clockwise one-way pair flow direction. While this configuration is one alternative for adding bicycle infrastructure in this scenario, it is not the only option, and alternate configurations may be considered. Additionally, conversion to a one-way pair flow pattern may allow for additional parking or additional pedestrian scale improvement in some areas, especially downtown.

As with the counter-clockwise one-way flow scenario, conversion to one-way flow has the potential to free up pavement for alternate uses. However, there would be significant expense in changing the direction of traffic controls.

To assess traffic implications associated with this scenario in the Microsimulation model, the entire extent of Winooski Avenue is changed to one-way flow in the northbound direction and the entirety of Union Street is changed to one-way flow in the southbound direction. Two travel lanes are maintained on Winooski Avenue from Main Street to Pearl Street, as are turn lanes at key intersections. Traffic signal timings are changed where necessary to accommodate the new traffic pattern.

Model results indicate that this scenario performs better than the counter-clockwise one-way flow scenario, but it performs significantly worse than existing conditions. Additional study is required to determine what improvements are necessary to make one-way flow viable and the costs of those improvements.

4.0 IMPACTS COMPARISON

4.1 | PERFORMANCE MEASURES

The microsimulation model results are used to compare the relative impact of each scenario in regards to traffic congestion. Three performance measures are used to describe congestion: average peak hour vehicle delays, Levels-of-Service, and average maximum queue lengths. These measurements are standard ways to measure the efficiency of traffic flow and identify problem areas in traffic studies. They are explained in greater detail and given context below. Volume to capacity ratio is also a standard measurement in traffic studies, but it is not appropriate for microsimulation models as capacity is not known in microsimulation.

The 2010 Highway Capacity Manual[1] defines six qualitative grades to describe the level of service at an intersection. Level-of-Service (LOS) is based on the average control delay per vehicle, which for this report is the average simulated delay for all vehicles passing through a given intersection over 30 simulation runs. Figure 15 shows the various LOS grades and descriptions for signalized and unsignalized intersections.

[1] Transportation Research Board, National Research Council, *Highway Capacity Manual* (Washington, DC: National Academy of Sciences, 2010).

FIGURE 15: LEVEL-OF-SERVICE CRITERIA FOR SIGNALIZED AND UNSIGNALIZED INTERSECTIONS

LOS	CHARACTERISTICS	UNSIGNALIZED TOTAL DELAY (SEC)	SIGNALIZED TOTAL DELAY (SEC)
A	Little or no delay	≤ 10.0	≤ 10.0
B	Short delays	10.1-15.0	10.1-20.0
C	Average delays	15.1-25.0	20.1-35.0
D	Long delays	25.1-35.0	35.1-55.0
E	Very long delays	35.1-50.0	55.1-80.0
F	Extreme delays	> 50.0	> 80.0

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

VTrans LOS policy is provided below to give these performance measures context. However, these standards generally apply to non-urban intersections and only apply to State facilities. Some roads in this study are state maintained, including Winooski Avenue and Willard Street.

The VTrans policy on level of service for signalized and all-way stop intersections is that an overall LOS of C should be maintained for state-maintained highways and other streets accessing the state's facilities. Reduced LOS may be acceptable on a case-by-case basis when considering, at minimum, current and future traffic volumes, delays, volume to capacity ratios, crash rates, and negative impacts as a result of improvement necessary to achieve LOS C. The policy on level of service for two-way and one-way stop intersections is that LOS D should be maintained for side roads with volumes exceeding 100 vehicles/hour for a single lane approach or 150 vehicles/hour for a two-lane approach. No LOS criteria are in effect for volumes less than these, and the volumes on most side streets in this study are above these thresholds.

Given the urban nature of the project study area, reduced levels of service do not necessarily represent unacceptable levels of delay, as the improvements necessary to provide the standard LOS may not be desirable in such an environment. For example, increasing the number of travel lanes to improve LOS can alter the aesthetic character of a road corridor, reduce parking, make it less friendly and less safe for pedestrians including shoppers and residents, and increase maintenance expenses. The City considers all potential uses within the available right-of-way when balancing LOS with other community impacts.

4.2 | PERFORMANCE OUTCOMES

Thirty simulation runs of the microsimulation model were conducted and performance measures were recorded for each scenario. Due to the stochastic nature of microsimulation, each model run produces different results and the variability of the results between runs cannot be known beforehand. In some cases, large variations can be observed between model runs. For this project, it was found that 30 runs provided enough simulations to remove the effects of this variability. The LOS and delay reported here are based on the average delay over the peak hour. If traffic is significantly worse in one part of the hour than another, drivers out during the busier time may experience worse delay than is reported here.

Figure 16**Error! Reference source not found.** and Figure 17**Error! Reference source not found.** present the weekday AM and PM congestion results for the nine intersections in the center of the project study area. To draw attention to poorly operating intersections, approaches with LOS E and queues between 15 and 20 vehicles are highlighted in orange, and approaches with LOS F and queues greater than 20 are highlighted in red. LOS E may be acceptable in this urban environment depending on the tradeoffs of a particular situation.

Detailed results for additional study area intersections are presented in Appendix B.

FIGURE 16: WEEKDAY AM PEAK HOUR CONGESTION RESULTS

	No Build			Complete Street on Winooski			Two-Way North Winooski			Two-Way All Winooski			One-Way Pair: Counter-Clockwise			One-Way Pair: Clockwise		
	Delay	LOS	Queue	Delay	LOS	Queue	Delay	LOS	Queue	Delay	LOS	Queue	Delay	LOS	Queue	Delay	LOS	Queue
Winooski Ave & Pearl St																		
Overall	**27**	**C**	-	**29**	**C**	-	**34**	**C**	-	**35**	**C**	-	**25**	**C**	-	**18**	**B**	-
EB	26	C	5	28	C	6	34	C	7	35	D	7	23	C	6	21	C	6
WB	27	C	9	29	C	10	38	D	10	38	D	10	24	C	13	21	C	6
NB	19	B	3	22	C	3	28	C	4	29	C	5		n/a		15	B	6
SB	31	C	7	31	C	7	32	C	8	34	C	9	28	C	7		n/a	
Winooski Ave & College St																		
Overall	**12**	**B**	-	**13**	**B**	-	**14**	**B**	-	**15**	**B**	-	**13**	**B**	-	**50**	**D**	-
EB	28	C	5	28	C	5	28	C	5	30	C	5	23	C	5	507	F	33
WB	28	C	7	28	C	7	28	C	8	27	C	9	30	C	8	30	C	13
NB	7	A	3	8	A	3	7	A	3	11	B	4		n/a		11	B	6
SB	6	A	4	6	A	4	6	A	4	7	A	4	5	A	4		n/a	
Winooski Ave & Main St																		
Overall	**14**	**B**	-	**16**	**B**	-	**14**	**B**	-	**17**	**B**	-	**14**	**B**	-	**12**	**B**	-
EB	8	A	3	9	A	3	8	A	4	9	A	4	7	A	3	7	A	3
WB	13	B	6	14	B	6	13	B	6	15	B	6	12	B	5	8	A	3
NB	27	C	5	25	C	4	25	C	3	29	C	7		n/a		24	C	5
SB	19	B	5	22	C	7	22	C	7	23	C	8	21	C	8		n/a	
Union St & Pearl St																		
Overall	**11**	**B**	-	**12**	**B**	-	**11**	**B**	-	**10**	**A**	-	**24**	**C**	-	**22**	**C**	-
EB	5	A	4	5	A	3	4	A	3	4	A	3	8	A	4	11	B	8
WB	9	A	6	9	A	6	9	A	5	8	A	6	14	B	9	28	C	15
NB	28	C	4	30	C	5	27	C	4	31	C	5	37	D	12		n/a	
SB		n/a			n/a			n/a			n/a			n/a		37	D	11
Union St & College St																		
Overall	**12**	**B**	-	**12**	**B**	-	**12**	**B**	-	**11**	**B**	-	**14**	**B**	-	**39**	**E**	-
EB	9	A	2	9	A	2	9	A	2	9	A	2	12	B	4	12	B	4
WB	13	B	5	13	B	5	13	B	5	12	B	5	15	B	5	38	E	12
NB	12	B	4	12	B	5	13	B	5	10	B	3	16	C	6			
SB		n/a			n/a			n/a			n/a			n/a		44	E	9
Union St & Main St																		
Overall	**8**	**A**	-	**10**	**A**	-	**9**	**A**	-	**7**	**A**	-	**10**	**B**	-	**13**	**B**	-
EB	5	A	3	8	A	4	5	A	3	4	A	3	6	A	4	5	A	3
WB	3	A	6	5	A	8	3	A	7	3	A	6	3	A	5	9	A	12
NB	25	C	4	26	C	4	26	C	5	31	C	6	27	C	5		n/a	
SB		n/a			n/a			n/a			n/a			n/a		28	C	6
Willard St & Pearl St																		
Overall	**20**	**B**	-	**20**	**C**	-	**21**	**C**	-	**21**	**C**	-	**21**	**C**	-	**23**	**C**	-
EB	13	B	7	13	B	7	13	B	7	15	B	8	13	B	7	21	C	12
WB	11	B	6	11	B	5	11	B	6	11	B	6	11	B	6	14	B	9
NB	43	D	12	42	D	12	45	D	12	43	D	12	48	D	13	20	B	4
SB	25	C	6	26	C	6	26	C	6	26	C	6	24	C	6	33	C	9
Willard St & College St																		
Overall	**13**	**B**	-	**13**	**B**	-	**13**	**B**	-	**13**	**B**	-	**12**	**B**	-	**15**	**B**	-
EB	20	C	4	20	B	3	20	B	3	20	C	3	15	B	4	18	B	3
WB	21	C	8	22	C	8	22	C	8	22	C	8	21	C	8	21	C	8
NB	3	A	3	3	A	3	3	A	3	3	A	3	4	A	5	6	A	5
SB	12	B	5	11	B	4	12	B	5	12	B	5	12	B	4	14	B	7
Willard St & Main St																		
Overall	**19**	**B**	-	**20**	**B**	-	**21**	**C**	-	**20**	**C**	-	**18**	**B**	-	**23**	**C**	-
EB	10	A	5	11	B	5	12	B	6	10	B	5	11	B	6	12	B	4
WB	11	B	7	12	B	7	12	B	7	12	B	7	12	B	7	13	B	7
NB	29	C	10	29	C	10	30	C	10	27	C	9	26	C	9	29	C	9
SB	40	D	10	38	D	10	40	D	11	43	D	12	33	C	8	45	D	14

FIGURE 17: WEEKDAY PM PEAK HOUR CONGESTION RESULTS

	No Build			Complete Street on Winooski			Two-Way North Winooski			Two-Way All Winooski			One-Way Pair: Counter-Clockwise			One-Way Pair: Clockwise		
	Delay	LOS	Queue	Delay	LOS	Queue	Delay	LOS	Queue	Delay	LOS	Queue	Delay	LOS	Queue	Delay	LOS	Queue
Winooski Ave & Pearl St																		
Overall	**31**	**C**	-	**32**	**C**	-	**40**	**D**	-	**43**	**D**	-	**34**	**C**	-	**40**	**D**	-
EB	36	D	9	36	D	9	41	D	9	43	D	9	33	C	10	55	E	13
WB	30	C	10	31	C	10	43	D	10	46	D	10	33	C	15	44	D	9
NB	24	C	8	24	C	7	36	D	10	40	D	11		n/a		33	C	11
SB	36	D	6	38	D	6	38	D	8	42	D	9	43	D	7		n/a	
Winooski Ave & College St																		
Overall	**17**	**B**	-	**20**	**B**	-	**18**	**B**	-	**21**	**C**	-	**52**	**D**	-	**47**	**D**	-
EB	36	D	10	37	D	11	37	D	10	37	D	11	127	F	38	184	F	37
WB	28	C	7	30	C	8	28	C	8	31	C	9	43	D	9	25	C	13
NB	12	B	5	12	B	5	11	B	5	15	B	7		n/a		20	B	8
SB	10	A	6	14	B	6	11	B	5	14	B	5	37	D	10		n/a	
Winooski Ave & Main St																		
Overall	**24**	**C**	-	**30**	**C**	-	**29**	**C**	-	**37**	**D**	-	**84**	**F**	-	**22**	**C**	-
EB	27	C	13	35	D	15	37	D	19	50	D	25	212	F	28	25	C	16
WB	17	B	7	24	C	8	20	C	8	28	C	8	33	C	7	12	B	6
NB	26	C	6	24	C	6	26	C	5	32	C	10		n/a		33	C	9
SB	29	C	8	31	C	10	32	C	10	34	C	10	38	D	12		n/a	
Union St & Pearl St																		
Overall	**21**	**C**	-	**23**	**C**	-	**21**	**C**	-	**20**	**B**	-	**41**	**D**	-	**25**	**C**	-
EB	14	B	10	14	B	9	10	A	6	9	A	6	18	B	7	17	B	12
WB	14	B	8	16	B	9	16	B	9	15	B	8	39	D	22	29	C	15
NB	39	D	8	40	D	9	39	D	7	44	D	12	56	E	20		n/a	
SB		n/a			n/a			n/a			n/a			n/a		47	D	11
Union St & College St																		
Overall	**20**	**C**	-	**26**	**D**	-	**21**	**C**	-	**17**	**C**	-	**102**	**F**	-	**53**	**F**	-
EB	17	C	6	20	C	7	18	C	5	16	C	6	133	F	20	19	C	6
WB	18	C	7	20	C	7	18	C	7	17	C	6	52	F	16	75	F	20
NB	23	C	8	33	D	11	24	C	9	18	C	7	111	F	16		n/a	
SB		n/a			n/a			n/a			n/a			n/a		46	E	9
Union St & Main St																		
Overall	**14**	**B**	-	**18**	**B**	-	**19**	**B**	-	**19**	**B**	-	**53**	**D**	-	**33**	**C**	-
EB	6	A	6	9	A	8	10	A	8	7	A	5	58	E	16	12	B	8
WB	14	B	14	18	B	18	19	B	19	20	B	18	25	C	18	58	E	31
NB	30	C	7	32	C	8	32	C	8	40	D	13	88	F	15		n/a	
SB		n/a			n/a			n/a			n/a			n/a		30	C	9
Willard St & Pearl St																		
Overall	**26**	**C**	-	**24**	**C**	-	**26**	**C**	-	**26**	**C**	-	**45**	**D**	-	**77**	**E**	-
EB	20	C	13	21	C	12	20	B	12	21	C	13	25	C	15	56	E	25
WB	15	B	9	17	B	11	21	C	14	19	B	13	33	C	20	103	F	38
NB	56	E	18	42	D	16	45	D	16	45	D	16	89	F	36	121	F	31
SB	29	C	6	27	C	6	29	C	6	28	C	6	29	C	9	52	D	12
Willard St & College St																		
Overall	**17**	**B**	-	**17**	**B**	-	**21**	**C**	-	**19**	**B**	-	**44**	**D**	-	**44**	**D**	-
EB	23	C	9	23	C	9	23	C	9	23	C	9	57	E	18	28	C	10
WB	31	C	12	31	C	11	35	D	13	34	C	11	70	E	23	48	D	17
NB	4	A	5	4	A	5	5	A	7	5	A	7	20	B	16	22	C	15
SB	15	B	7	16	B	8	23	C	12	20	C	11	68	E	23	64	E	27
Willard St & Main St																		
Overall	**23**	**C**	-	**24**	**C**	-	**29**	**C**	-	**23**	**C**	-	**61**	**E**	-	**41**	**D**	-
EB	12	B	7	14	B	8	12	B	7	10	A	6	66	E	30	18	B	10
WB	18	B	9	19	B	9	20	B	9	17	B	8	40	D	27	44	D	18
NB	39	D	16	40	D	17	57	E	21	31	C	12	63	E	27	46	D	20
SB	37	D	12	40	D	14	47	D	15	48	D	15	86	F	17	68	E	17

The performance measures for the Complete Street on Winooski Avenue scenario are similar to the No Build scenario. There is a modest increase in delay on many approaches, but level of service, as modeled, is acceptable at all key intersections.

These results are expected. Corridors tend to fail at intersections, and the intersection lane configurations are not changing greatly from the No Build scenario. When a four-lane corridor has many curb cuts and short blocks, often the left lanes operate as de facto left-turn lanes because locals know that they will be stuck behind a left turner if they travel in the left lane. Therefore, combining the two left lanes into one two-way left-turn lane should be expected to have minimal effects on traffic flow. Additionally, no travel lane configurations changed outside of Main Street to Pearl Street on Winooski Avenue.

Performance on Winooski Avenue becomes slightly worse in the Two-Way North Winooski and Two-Way All Winooski scenarios, while performance measures improve on Union Street as traffic moves from Union to Winooski. While only one of the approaches in these scenarios performs at LOS E and none at LOS F, the public will likely notice some loss of performance along Winooski Avenue in these scenarios.

The performance measures in the one-way pair scenarios are significantly worse than the other scenarios with many approaches failing. In the PM scenario, there is not enough capacity to accommodate the traffic leaving the Downtown Area. The Winooski Avenue Traffic Microsimulation Model did not significantly change the lane configurations and preserved all parking spaces in the one-way pair sceanrios, and adding turn lanes and upgrading intersections may improve the performance measures. It is also possible that additional lanes would be required to make a one-way pair scenario viable. In some places, adding lanes would require removing parking or expanding the curb-to-curb road width.

Figure 18 and Figure 19 present data on the frequency of queues spilling back through adjacent intersections. For example, the southbound approach at Main Street and Winooski Avenue in the PM No Build was seen to spill back 4% of the time, i.e., during 4% of the peak hour, the queue at this approach extended through the next intersection to the north (College Street and Winooski Avenue). For external model links (eastbound approaches to Winooski Avenue and Westbound Approaches to Willard Street) adjacent intersections are not modeled and the percent spillback values represent the percent of time the queue extends to the end of the model link, which is not necessarily the distance to an adjacent intersection. Because of this, external queue spillback information is less sensitive and the relative difference between scenarios is more important.

FIGURE 18: AM PEAK HOUR QUEUE SPILLBACK RESULTS

Legend
X% < 1%
X% 1% to < 10%
XX% 10% to 25%
XX% > 25%

Intersection	Approach	No Build	Complete Street on Winooski	Two-Way North Winooski	Two-Way All Winooski	One-Way: Counter-Clockwise	One-Way: Clockwise
Winooski Ave & Pearl St	EB	0%	0%	0%	0%	0%	0%
	WB	0%	0%	0%	0%	1%	0%
	NB	0%	0%	0%	0%	n/a	16%
	SB	0%	0%	0%	0%	0%	n/a
Winooski Ave & College St	EB	0%	0%	0%	0%	0%	0%
	WB	0%	0%	0%	0%	0%	0%
	NB	0%	0%	0%	0%	n/a	3%
	SB	0%	1%	1%	0%	0%	n/a
Winooski Ave & Main St	EB	0%	0%	0%	0%	0%	0%
	WB	2%	2%	2%	2%	15%	9%
	NB	0%	0%	0%	0%	n/a	0%
	SB	1%	2%	1%	3%	0%	n/a
Union St & Pearl St	EB	0%	0%	0%	0%	0%	0%
	WB	0%	0%	0%	0%	0%	1%
	NB	0%	0%	0%	0%	0%	n/a
	SB	n/a	n/a	n/a	n/a	n/a	22%
Union St & College St	EB	0%	0%	0%	0%	0%	0%
	WB	0%	0%	0%	0%	0%	0%
	NB	0%	0%	0%	0%	0%	n/a
	SB	n/a	n/a	n/a	n/a	n/a	34%
Union St & Main St	EB	0%	0%	0%	0%	0%	0%
	WB	0%	0%	0%	0%	0%	0%
	NB	0%	0%	0%	0%	0%	n/a
	SB	n/a	n/a	n/a	n/a	n/a	0%
Willard St & Pearl St	EB	0%	0%	0%	0%	0%	0%
	WB	0%	0%	0%	0%	0%	0%
	NB	0%	0%	0%	0%	0%	0%
	SB	0%	0%	0%	0%	0%	0%
Willard St & College St	EB	0%	0%	0%	0%	0%	0%
	WB	0%	0%	0%	0%	0%	0%
	NB	0%	0%	0%	0%	0%	0%
	SB	0%	0%	0%	0%	0%	0%
Willard St & Main St	EB	0%	0%	0%	0%	0%	0%
	WB	0%	0%	0%	0%	0%	0%
	NB	0%	0%	0%	0%	0%	0%
	SB	0%	0%	0%	1%	0%	1%

FIGURE 19: PM PEAK HOUR QUEUE SPILLBACK RESULTS

Legend

- X% < 1%
- X% 1% to < 10%
- XX% 10% to 25%
- XX% > 25%

Intersection	Approach	No Build	Complete Street on Winooski	Two-Way North Winooski	Two-Way All Winooski	One-Way: Counter-Clockwise	One-Way: Clockwise
Winooski Ave & Pearl St	EB	0%	0%	0%	0%	0%	0%
	WB	0%	0%	0%	1%	6%	1%
	NB	1%	0%	1%	4%	n/a	30%
	SB	0%	0%	0%	0%	2%	n/a
Winooski Ave & College St	EB	0%	0%	0%	0%	2%	0%
	WB	0%	0%	0%	0%	0%	2%
	NB	0%	0%	0%	1%	n/a	15%
	SB	3%	9%	4%	7%	40%	n/a
Winooski Ave & Main St	EB	0%	0%	0%	0%	20%	0%
	WB	6%	9%	9%	7%	27%	14%
	NB	0%	0%	0%	0%	n/a	1%
	SB	4%	8%	6%	9%	8%	n/a
Union St & Pearl St	EB	0%	0%	0%	0%	0%	7%
	WB	0%	0%	0%	0%	8%	3%
	NB	0%	0%	0%	0%	7%	n/a
	SB	n/a	n/a	n/a	n/a	n/a	11%
Union St & College St	EB	0%	0%	0%	0%	31%	0%
	WB	0%	0%	0%	0%	2%	1%
	NB	0%	1%	0%	0%	36%	n/a
	SB	n/a	n/a	n/a	n/a	n/a	34%
Union St & Main St	EB	0%	0%	0%	0%	24%	1%
	WB	0%	0%	0%	0%	4%	3%
	NB	0%	0%	0%	1%	19%	n/a
	SB	n/a	n/a	n/a	n/a	n/a	0%
Willard St & Pearl St	EB	0%	0%	0%	0%	0%	4%
	WB	0%	0%	0%	0%	3%	5%
	NB	0%	0%	0%	0%	5%	1%
	SB	0%	0%	0%	0%	1%	2%
Willard St & College St	EB	0%	0%	0%	0%	0%	0%
	WB	0%	0%	0%	0%	2%	1%
	NB	0%	0%	0%	0%	11%	7%
	SB	0%	0%	0%	0%	1%	3%
Willard St & Main St	EB	0%	0%	0%	0%	4%	0%
	WB	0%	0%	0%	0%	1%	0%
	NB	0%	0%	0%	0%	5%	2%
	SB	1%	1%	3%	3%	14%	8%

In all scenarios except for the one-way pair scenarios, no intersection approaches are reported to spillback more than 10 percent of the time, and only modest increases are projected over the No Build condition. In both one-way pair scenarios, several intersections are projected to experience queue spillbacks over 10 percent of the time, with some approaches projected to spillback to adjacent intersections for over 25 percent of the time.

Moderate increases in queue spillback observed in the non-one-way pair scenarios may be addressable through targeted signal timing adjustments or may be an acceptable exchange for better accommodating non-motorized travel modes. However, the larger increases in queue spillback observed for both one-way pair scenarios indicate the presence of persistent cycle failures during the peak hours, which would require larger intersection improvements to address.

5.0 CONCLUSIONS

5.1 | PHASE 1 CONCLUSIONS

The Winooski Avenue Traffic Microsimulation Model was used to investigate the traffic implications of five alternative traffic patterns. The following scenarios were created in the TransModeler™ software program:

1. Complete Street on Winooski avenue, Winooski as primary bicycle corridor
2. Two-Way Flow on North Winooski Avenue
3. Two-Way Flow on all of Winooski Avenue, Union as primary bicycle corridor
4. One-Way Pair: Counter-Clockwise Flow
5. One-Way Pair: Clockwise Flow

The Complete Street on Winooski Avenue scenario has the advantage of being the least disruptive while still providing a full north-south bicycle corridor. The Two-Way Flow on Winooski Avenue scenarios shift traffic from Union Street to Winooski Avenue to promote safer biking conditions on Union Street. The One-Way Pair scenarios reduce the amount of pavement width dedicated to vehicles by turning Winooski Avenue and Union Street into a one-way pair loop. Changing the travel lanes to one way provides room for additional parking and/or pedestrian amenities on Winooski Avenue between Main Street and Pearl Street, but these scenarios are the most disruptive to vehicular traffic.

Creating a complete street on all of Winooski Avenue using a four-lane to three-lane conversion between Pearl Street and Main Street produced acceptable performance measures. Installing bicycle facilities along the entire length of Winooski Avenue may require removing parking spaces depending on the existing curb to curb width and future plans for the streets, but it would be the least disruptive to surrounding traffic patterns.

The two scenarios that create two-way flow on either North Winooski Avenue or both North and South Winooski Avenue have the advantage of making Union Street more attractive to bicycles but at the expense of some additional delay on Winooski Avenue. Creating a corridor long slow street on Union Street has the advantage of promoting pedestrian scale infrastructure in what are largely residential neighborhoods. However, most of the destinations are along Winooski Avenue and not Union Street. It may still be desirable to create bike lanes on Winooski Avenue, which could require removing additional parking in some areas. These scenarios would mean gaining active transportation support at the expense of parking spaces and modest impacts to driving delay.

Turning Winooski Avenue and Union Street into one-way pairs has the advantage of opening up significant right-of-way on Winooski Avenue between Main Street and Pearl

Street. This space could be used for parking, pedestrian improvements, or additional bike infrastructure. Such improvements could make the area more attractive to development and extend the downtown east. However, these patterns show the worst performance and would require additional study and infrastructure investment to be viable. Further, the clockwise flow pattern, which is the less disruptive of the two scenarios, would reverse current flow patterns and cause multiple intersections to be rebuilt at significant expense. The counter-clockwise flow pattern would be easier to implement but would still require additional investigation and infrastructure investment to be viable.

5.2 | ISSUES TO CONSIDER IN PHASE 2

This report presents potential traffic impacts associated with the five study alternatives. The report does not include an exhaustive investigation into all options and does not test all possibilities for making each scenario viable in terms of traffic operations. Specifically, the scenario alternatives work within the existing curb-to-curb pavement widths and assume existing intersection controls. Traffic operations in any scenario could likely be improved with enough investment in intersection and roadway upgrades. However, the level of investment may be high in some cases and may encounter public pushback.

Adding bike lanes under any scenario will likely require removing at least some on-street parking, so the City should consider the benefits of creating a north-south bike corridor along with the potential impacts to on-street parking. These benefits include bringing more economic activity to places proximate to the bike lanes, reducing the number of vehicles on the road, promoting pedestrian scale infrastructure, and helping to redevelop strategic areas of the City.

As the Winooski Avenue Corridor Study moves into Phase 2, City Staff and consultants should consider the following issues and opportunities associated with each of the five scenario alternatives.

1. **Bicycle Corridor on all of Winooski:**
   - This scenario has the least impact on surrounding traffic.
   - It requires removing some parking. Staff should consider the tradeoffs between travel lane widths, bike lane widths and types, e.g. buffered, protected, and room for parking spaces.
2. **Two-Way Flow on North Winooski Ave:**
   - This scenario requires more parking removal than the previous scenario.
   - Reduced traffic on North Union Street may provide additional opportunities for bike/pedestrian scale improvements.
3. **Two-Way Flow on all of Winooski Ave:**
   - This scenario requires more parking removal than two-way flow on North Winooski Avenue.
   - The character of Union Street as a slow street or how this is accomplished is not determined in this study. The street could have only local traffic, speed bumps, raised crosswalks, or other mechanisms to slow traffic. The bike lanes could be

striped, buffered, protected, or not defined depending on the design and the amount of pavement width available. Forcing traffic on Union Street to move slowly or only allowing local traffic may be all the protection that bicyclists need.

4. **One-Way Pair: Counter-Clockwise Flow:**
   - The one-way pair provides the greatest amount of free pavement along Winooski Avenue for bike/pedestrian improvements.
   - Counter-clockwise flow utilizes current one-way flows, thereby requiring less changes to intersection controls than clockwise flow.
   - One-way flow will cause significant changes to travel patterns in the downtown area.
   - Assuming no roadway expansion, performance measures found in this study are not acceptable, so this scenario is not a viable option in the short term.
   - This scenario may be a possibility in the long term – investigate adding lanes, turn lanes, and signals and change signal timing.
5. **One-Way Pair: Clockwise Flow:**
   - The one-way pair provides the greatest amount of free pavement along Winooski Avenue for bike/pedestrian improvements.
   - Clockwise flow is opposite the current one-way flows, so all intersection controls on Winooski Avenue and Union Street will need to be altered if not rebuilt.
   - Clockwise flow is more efficient than counter-clockwise flow since drivers use right turns to switch between the paired streets.
   - One-way flow will cause significant changes to travel patterns in the downtown area.
   - Assuming no roadway expansion, performance measures found in this study are not acceptable, so this scenario is not a viable option in the short term.
   - This scenario may be a possibility in the long term – investigate adding lanes, turn lanes, and signals and change signal timing.

6.0 APPENDICES

6.1 | APPENDIX A – CALIBRATION REPORT

MEMO

TO:	Peter Keating; Jason Charest, PE, Nicole Losch, PTP
FROM:	Bob Chamberlin, PE/PTOE; David Grover, PE; Ben Swanson
DATE:	August 23, 2016
SUBJECT:	Winooski Avenue Traffic Model Calibration Report

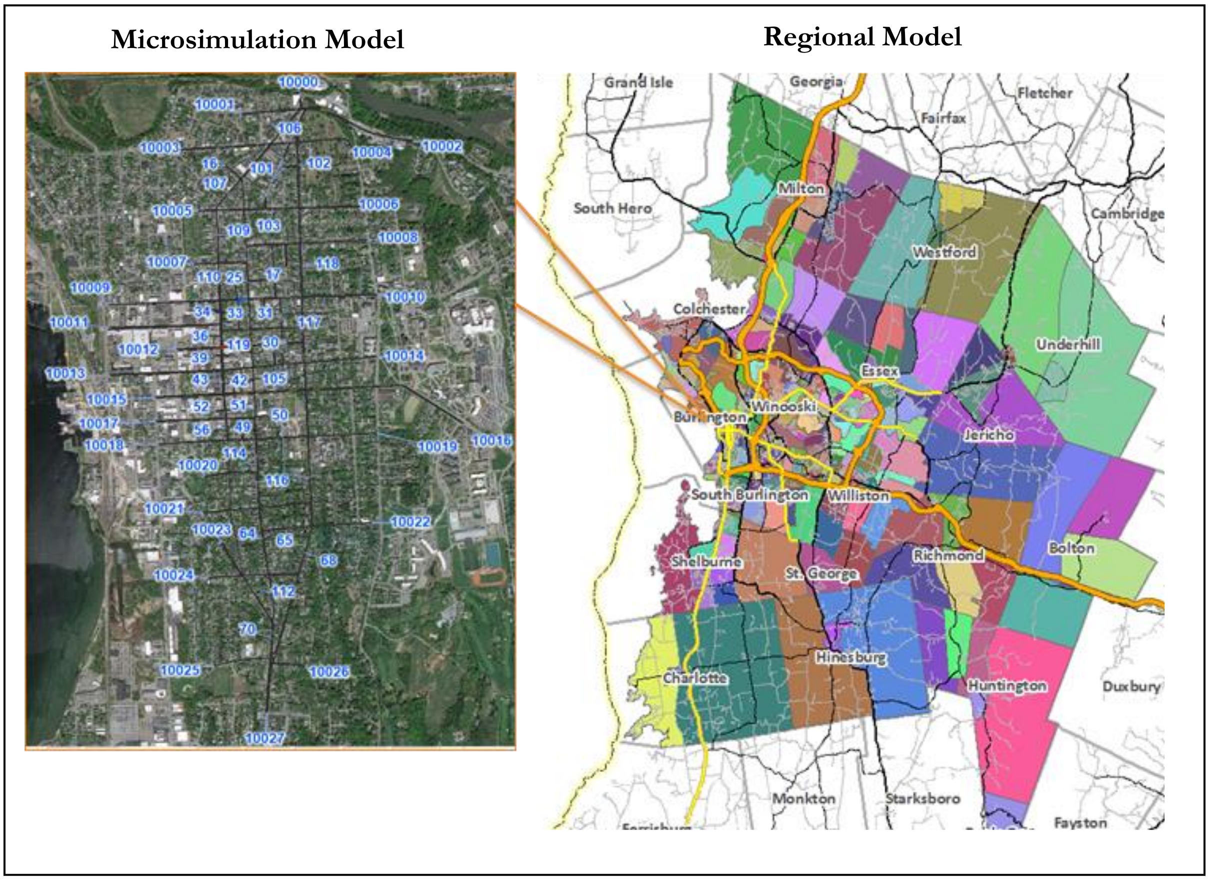
1.0 INTRODUCTION

The Winooski Avenue Traffic Microsimulation Model has been developed to support a comprehensive assessment of the transportation implications associated with installing bicycle infrastructure along a north-south corridor in Burlington, VT. The study corridor extends from the intersection of Riverside Avenue and Winooski Avenue south to the intersection of Shelburne Road and Willard Street. It encompasses Winooski Avenue, Union Street, and Willard Street, as well as the cross streets proximate to the study corridor (). The microsimulation model is calibrated to weekday AM and PM peak design hour conditions and is developed in the TransModeler software program.

The model was developed by clipping the relevant links from the regional transportation demand model of the Chittenden County Regional Planning Commission (CCRCP). Then roadway and intersection geometry was refined and additional links were added to provide a higher level of detail.

FIGURE 1: MICROSIMULATION MODEL EXTENT

FIGURE 2: REGIONAL MODEL EXTENT



2.0 MICROSIMULATION MODEL CALIBRATION

The Winooski Avenue Traffic Microsimulation Model includes detailed information on roadway classification, speeds, geometrics, intersection controls, signal timings, and traffic volumes. The model generates travel demand on the roadway network between 73 unique TAZs using origin/destination (O/D) matrices for the weekday AM and PM peak hours. The peak hour O/D matrices were developed to match intersection turning movement counts at 35 intersections.

TARGET TRAFFIC VOLUME DATA

Existing intersection turning movement counts were obtained from VTrans and the CCRPC, and additional count data was collected by RSG in October 2015 (Figure 3 and Figure 4). Turning movement count data for the weekday AM and PM peak hours were adjusted to represent design hour volume (DHV) conditions using VTrans permanent count station P6D001 on VT-127 in Burlington, which is the closest CTC to the project area. To be conservative, no count was adjusted downward, i.e. a ratio of less than 1 was assumed to be 1.

Intersection turning movement counts were balanced where appropriate so that the same number of trips exiting one intersection approach enter an adjacent intersection approach. These adjusted and balanced counts form the model calibration set.

FIGURE 3: TURNING MOVEMENT COUNT LOCATIONS MAP

FIGURE 4: TURNING MOVEMENT COUNT INTERSECTIONS

#	Intersection	Counter	#	Intersection	Counter
101	Winooski Avenue / Riverside Avenue	VTrans	202	Union Street / Archibald Street	RSG
102	Winooski Avenue / Archibald Street	VTrans	204	Union Street / North Street	CCRCP
103	Winooski Avenue / Union Street	CCRCP	206	Union Street / Pearl Street	VTrans
104	Winooski Avenue / North Street	VTrans	210	Union Street / City Market	RSG
106	Winooski Avenue / Pearl Street	VTrans	211	Union Street / College Street	CCRCP
107	Winooski Avenue / Cherry Street	VTrans	212	Union Street / Main Street	VTrans
108	Winooski Avenue / Parking Garage	RSG	213	Union Street / King Street	RSG
109	Winooski Avenue / Bank Street	RSG	214	Union Street / Maple Street	VTrans
110	Winooski Avenue / City Market	RSG	215	Union Street / Spruce Street	CCRCP
111	Winooski Avenue / College Street	CCRCP	216	Union Street / Howard Street	CCRCP
112	Winooski Avenue / Main Street	VTrans	301	Willard Street / Riverside Avenue	VTrans
113	Winooski Avenue / King Street	VTrans	302	Willard Street / Archibald Street	CCRCP
114	Winooski Avenue / Maple Street	VTrans	304	Willard Street / North Street	VTrans
115	Winooski Avenue / Spruce Street	VTrans	306	Willard Street / Pearl Street	VTrans
116	Winooski Avenue / Howard Street	CCRCP	311	Willard Street / College Street	CCRCP
117	Union Street / St. Paul Street	VTrans	312	Willard Street / Main Street	VTrans
118	Willard Street / Shelburne Road	CCRCP	314	Willard Street / Maple Street	CCRCP
			316	Willard Street / Howard Street	CCRCP

DEVELOPMENT OF AM AND PM PEAK HOUR TRIP TABLES

An important step in the model calibration process is the estimation of an origin-destination trip matrix ("O/D matrix"). The O/D matrix represents the zone-to-zone vehicle trips during the analysis peak hours. Including external TAZs, the model has 73 TAZs, which generates a 73 by 73 matrix of potential vehicle trips (i.e. 5,329 origin/destination pairs).

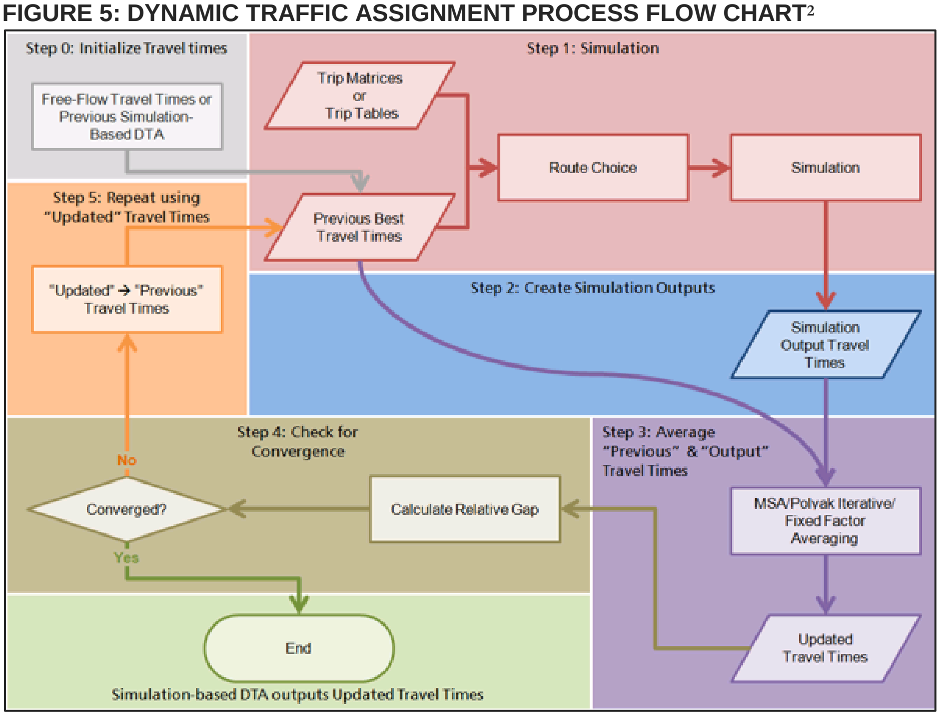
The calibration process involves assigning an estimated O/D matrix to the roadway network and comparing the simulated vehicle travel paths against the calibration set. Every left, through, and right turn estimated in the model is compared against the actual number of left turns, through movements, and right turns within the calibration set, and then the estimated O/D matrix is adjusted based on this comparison. The estimation process is repeated until satisfactory calibration targets between simulated and actual traffic volumes are met.

Calibration involves the iterative process of estimating the O/D matrix and comparing results with target volumes. Mathematically, the process used is referred to as an "under-specified multivariable optimization", which means that, without complete information on origin-destination flow from other sources, there is no unique solution to the O/D Matrix. For the Winooski Avenue Microsimulation Model there are several sources of information that are used to inform and constrain the O/D estimation process, including regional OD patterns from the CCRPC regional model, screenline counts at model externals, and land use information on model TAZs. Caliper's origin destination matrix estimation (ODME) tool was also used to facilitate this process. Through iterative refinement of the model network and adjustments to O/D matrices target calibration was achieved.

TRIP ASSIGNMENT

Dynamic Traffic Assignment (DTA) is the process by which traffic between origin and destination pairs is distributed to all potential route paths. The DTA process involves a series of simulation runs from which travel times and turning delays are recorded for all links and turning movements within the model. For each simulation run, travel times and delays are compared with previous travel times and delays. Subsequent simulation runs slightly modify the route choices between all origin/destination pairs and repeat the comparison of new travel times and delays with previous averages. The DTA process is considered complete when the iterative fluctuations in route choice no longer create significant changes to the overall travel times and delays. The goal of the DTA process is to arrive at a set of stable travel times and delays that route traffic between origin/destination pairs with the least amount of overall delay possible. Figure 5 presents a flow chart of the DTA process.

FIGURE 5: DYNAMIC TRAFFIC ASSIGNMENT PROCESS FLOW CHART[2]



[2] Image courtesy Caliper Corporation

CALIBRATION PERFORMANCE

Figure 6 and Figure 7 below show the distribution of model output compared to target traffic count volumes during the AM and PM peak hours, respectively. A 45-degree line represents a perfect correlation of model output and target volumes.

FIGURE 6: TARGET VOLUMES VS. MODEL VOLUMES – AM PEAK HOUR

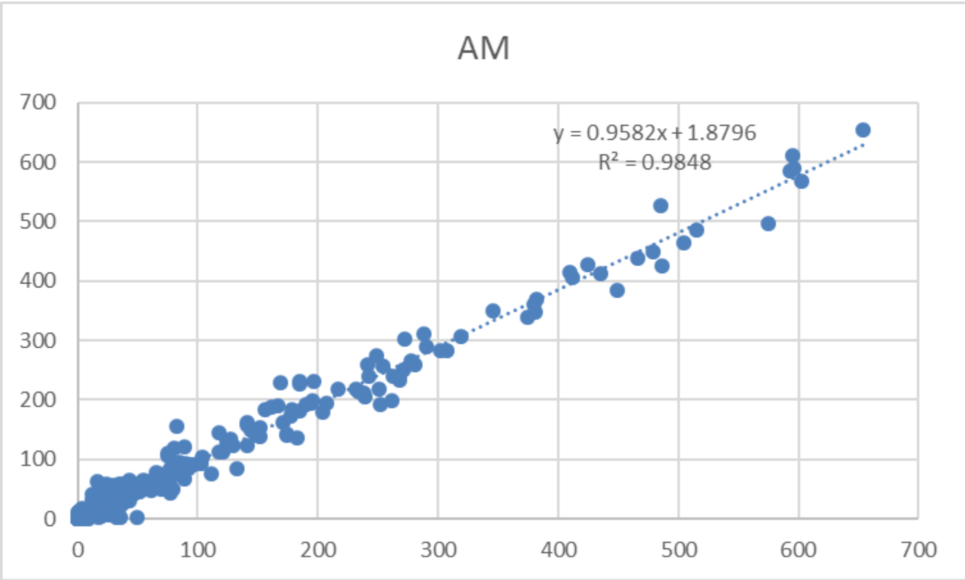
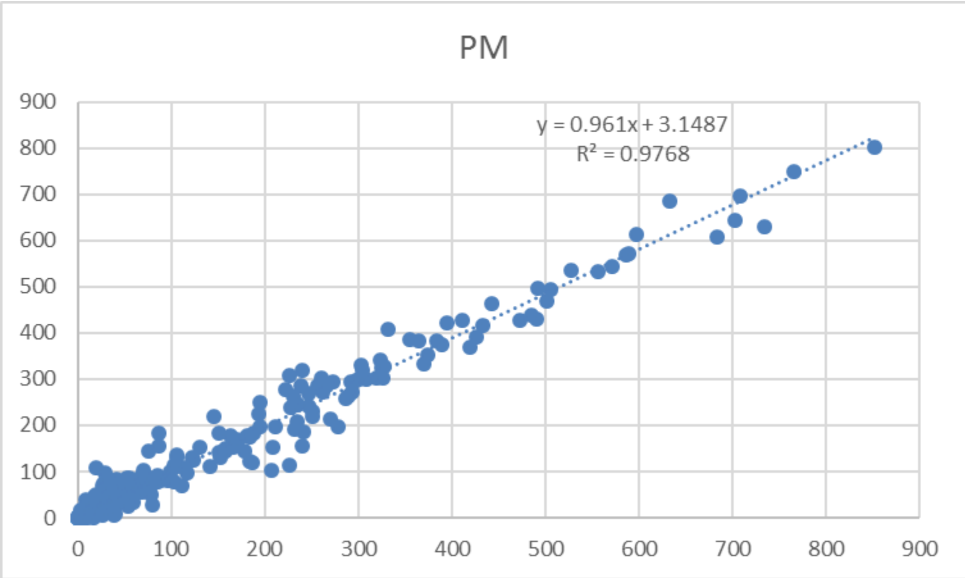


FIGURE 7: TARGET VOLUMES VS. MODEL VOLUMES – PM PEAK HOUR



There are two levels of calibration standards to which the model has been compared. The first calibration threshold relates to the standards that are conventionally applied to regional travel demand models. These standards have been developed by the Federal Highway Administration (FHWA) to provide an overall threshold of quality for transportation models used for regional transportation planning and are shown below in Figure 8.

FIGURE 8: CALIBRATION RELATIVE TO RECOMMENDED THRESHOLDS FOR REGIONAL MODELS

	Target	AM	PM
Root Mean Squared Error	<40%	19%	22%
R^2	>= 0.88	0.985	0.977
Percent Error (Region)	+/- 5%	-2%	0%

Additional standards have been developed specifically for microsimulation travel models. These standards were first published in 2004 by FHWA.[3] These standards 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:

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

In practice, a GEH value less than 5 indicates the model volume is a good fit with the target. A GEH between 5 and 10 indicates potential errors or a lack in model accuracy at the subject count area, and a GEH greater than 10 indicates an unacceptable level of correlation.

Figure 9 presents the performance of the Winooski Avenue Corridor microsimulation model relative to the turning movement calibration targets for the GEH statistic.

FIGURE 9: MICROSIMULATION CALIBRATION METRIC COMPARISON

	Target	AM	PM
GEH <=5, by movement	>85%	98%	94%
5<GEH<=10, by movements	<=15%	2%	6%
GEH >10, by movement	0%	0%	0%

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

6.2 | APPENDIX B – ADDITIONAL PERFORMANCE MEASURES AND SPILLBACK TABLES

	AM Peak Hour																	
	No Build			Complete Street on Winooski			Two-Way North Winooski			Two-Way All Winooski			One-Way Pair: Counter-Clockwise			One-Way Pair: Clockwise		
	Delay	LOS	Queue	Delay	LOS	Queue	Delay	LOS	Queue	Delay	LOS	Queue	Delay	LOS	Queue	Delay	LOS	Queue
Winooski Ave & Riverside Ave																		
Overall	**20**	**B**	**-**	**21**	**C**	**-**	**18**	**B**	**-**	**18**	**B**	**-**	**21**	**C**	**-**	**13**	**B**	**-**
EB	22	C	12	23	C	12	20	C	12	20	B	11	22	C	12	14	B	9
WB	19	B	9	22	C	10	18	B	9	18	B	9	21	C	10	12	B	6
NB	14	B	5	15	B	5	14	B	5	14	B	5	17	B	6	13	B	4
SB	31	C	2	31	C	2	30	C	2	31	C	2	29	C	2	24	C	1
Winooski Ave & Archibald St																		
Overall	**14**	**B**	**-**	**14**	**B**	**-**	**14**	**B**	**-**	**14**	**B**	**8**	**15**	**B**	**8**	**15**	**B**	**8**
EB	17	B	8	17	B	8	16	B	7	17	B	8	16	B	8	16	B	8
WB	16	B	4	15	B	3	15	B	3	16	B	4	18	B	5	17	B	5
NB	11	B	4	11	B	3	10	B	4	10	B	3	11	B	3	11	B	3
SB	13	B	9	13	B	8	12	B	8	12	B	8	13	B	8	12	B	4
Winooski Ave & Union St																		
Overall	**11**	**B**	**-**	**11**	**B**	**-**	**10**	**A**	**-**	**10**	**B**	**-**	**11**	**B**	**-**	**9**	**A**	**-**
EB	7	A	1	7	A	1	7	A	1	7	A	1	7	A	1	8	A	1
WB	7	A	2	7	A	2	7	A	1	7	A	1	8	A	2		n/a	
NB		n/a			n/a		8	A	1	8	A	2		n/a		9	A	2
SB	13	B	6	13	B	6	12	B	5	12	B	5	12	B	6	10	A	4
Winooski Ave & North St																		
Overall	**10**	**B**	**-**	**10**	**B**	**-**	**10**	**B**	**-**	**11**	**B**	**-**	**11**	**B**	**-**	**8**	**A**	**-**
EB	10	A	5	10	A	5	10	B	6	11	B	6	10	A	5	9	A	5
WB	13	B	4	12	B	4	11	B	4	13	B	3	14	B	4	8	A	3
NB		n/a			n/a		9	A	2	13	B	3		n/a		9	A	4
SB	10	A	6	10	A	7	10	A	6	10	A	6	10	A	6		n/a	
Winooski Ave & Pearl St																		
Overall	**27**	**C**	**-**	**29**	**C**	**-**	**34**	**C**	**-**	**35**	**C**	**-**	**25**	**C**	**-**	**18**	**B**	**-**
EB	26	C	5	28	C	6	34	C	7	35	D	7	23	C	6	21	C	6
WB	27	C	9	29	C	10	38	D	10	38	D	10	24	C	13	21	C	6
NB	19	B	3	22	C	3	28	C	4	29	C	5		n/a		15	B	6
SB	31	C	7	31	C	7	32	C	8	34	C	9	28	C	7		n/a	
Winooski Ave & Cherry St																		
Overall	6	A	-	8	A	-	7	A	-	7	A	-	5	A	-	5	A	-
EB	16	B	4	17	B	4	17	B	4	17	B	4	14	B	3	28	C	5
WB		n/a			n/a			n/a			n/a			n/a			n/a	
NB	7	A	3	11	B	4	8	A	3	7	A	4		n/a		2	A	3
SB	3	A	3	5	A	7	4	A	6	4	A	6	4	A	5		n/a	
Winooski Ave & Bank St																		
Overall	4	A	-	6	A	-	5	A	-	5	A	-	5	A	-	3	A	-
EB	19	B	2	21	C	2	22	C	2	22	C	2	8	A	1	26	C	2
WB	32	C	1	47	D	1	22	C	1	31	C	1	76	E	2	23	C	1
NB	3	A	2	3	A	2	3	A	2	2	A	3		n/a		1	A	3
SB	4	A	3	5	A	4	5	A	4	5	A	4	4	A	4		n/a	
Winooski Ave & College St																		
Overall	**12**	**B**	**-**	**13**	**B**	**-**	**14**	**B**	**-**	**15**	**B**	**-**	**13**	**B**	**-**	**50**	**D**	**-**
EB	28	C	5	28	C	5	28	C	5	30	C	5	23	C	5	507	F	33
WB	28	C	7	28	C	7	28	C	8	27	C	9	30	C	8	30	C	13
NB	7	A	3	8	A	3	7	A	3	11	B	4		n/a		11	B	6
SB	6	A	4	6	A	4	6	A	4	7	A	4	5	A	4		n/a	
Winooski Ave & Main St																		
Overall	**14**	**B**	**-**	**16**	**B**	**-**	**14**	**B**	**-**	**17**	**B**	**-**	**14**	**B**	**-**	**12**	**B**	**-**
EB	8	A	3	9	A	3	8	A	4	9	A	4	7	A	3	7	A	3
WB	13	B	6	14	B	6	13	B	6	15	B	6	12	B	5	8	A	3
NB	27	C	5	25	C	4	25	C	3	29	C	7		n/a		24	C	5
SB	19	B	5	22	C	7	22	C	7	23	C	8	21	C	8		n/a	
Winooski Ave & King St																		
Overall	**10**	**B**	**-**	**10**	**A**	**-**	**10**	**A**	**-**	**10**	**B**	**-**	**10**	**B**	**-**	**20**	**C**	**-**
EB	8	A	2	8	A	2	8	A	1	9	A	2	8	A	2	9	A	2
WB	8	A	2	8	A	2	8	A	2	9	A	2	8	A	2	13	B	4
NB	8	A	2	8	A	2	8	A	1	9	A	3		n/a		25	C	10
SB	12	B	4	11	B	4	11	B	3	12	B	3	11	B	4		n/a	

	AM Peak Hour																	
	No Build			Complete Street on Winooski			Two-Way North Winooski			Two-Way All Winooski			One-Way Pair: Counter-Clockwise			One-Way Pair: Clockwise		
	Delay	LOS	Queue	Delay	LOS	Queue	Delay	LOS	Queue	Delay	LOS	Queue	Delay	LOS	Queue	Delay	LOS	Queue
Winooski Ave & Maple St																		
Overall	**8**	**A**	-	**8**	**A**	-	**8**	**A**	-	**9**	**A**	-	**9**	**A**	-	**14**	**B**	-
EB	9	A	2	9	A	2	9	A	2	10	B	3	9	A	2	11	B	3
WB	8	A	2	8	A	2	8	A	2	10	A	3	8	A	2	13	B	4
NB		n/a			n/a			n/a		9	A	3		n/a		17	C	7
SB	8	A	3	8	A	3	8	A	3	9	A	2	8	A	3		n/a	
Winooski Ave & Howard St																		
Overall	**21**	**C**	-	**21**	**C**	-	**21**	**C**	-	**22**	**C**	-	**22**	**C**	-	**15**	**B**	-
EB	18	B	4	18	B	3	19	B	4	22	C	4	19	B	4	25	C	4
WB	16	B	3	16	B	3	16	B	3	17	B	4	19	B	3	27	C	7
NB	23	C	12	23	C	12	23	C	13	24	C	14	23	C	13	14	B	13
SB	15	B	5	15	B	4	15	B	4	15	B	4	16	B	4	7	A	3
SEB	27	C	5	28	C	8	28	C	8	29	C	8	28	C	4		n/a	
Union St & Pearl St																		
Overall	**11**	**B**	-	**12**	**B**	-	**11**	**B**	-	**10**	**A**	-	**24**	**C**	-	**22**	**C**	-
EB	5	A	4	5	A	3	4	A	3	4	A	3	8	A	4	11	B	8
WB	9	A	6	9	A	6	9	A	5	8	A	6	14	B	9	28	C	15
NB	28	C	4	30	C	5	27	C	4	31	C	5	37	D	12		n/a	
SB		n/a			n/a			n/a			n/a			n/a		37	D	11
Union St & College St																		
Overall	**12**	**B**	-	**12**	**B**	-	**12**	**B**	-	**11**	**B**	-	**14**	**B**	-	**39**	**E**	-
EB	9	A	2	9	A	2	9	A	2	9	A	2	12	B	4	12	B	4
WB	13	B	5	13	B	5	13	B	5	12	B	5	15	B	5	38	E	12
NB	12	B	4	12	B	5	13	B	5	10	B	3	16	C	6			
SB		n/a			n/a			n/a			n/a			n/a		44	E	9
Union St & Main St																		
Overall	**8**	**A**	-	**10**	**A**	-	**9**	**A**	-	**7**	**A**	-	**10**	**B**	-	**13**	**B**	-
EB	5	A	3	8	A	4	5	A	3	4	A	3	6	A	4	5	A	3
WB	3	A	6	5	A	8	3	A	7	3	A	6	3	A	5	9	A	12
NB	25	C	4	26	C	4	26	C	5	31	C	6	27	C	5		n/a	
SB		n/a			n/a			n/a			n/a			n/a		28	C	6
Union St & Howard St																		
Overall	**9**	**A**	-	**8**	**A**	-	**8**	**A**	-	**8**	**A**	-	**8**	**A**	-	**8**	**A**	-
EB	9	A	2	9	A	2	9	A	2	8	A	1	8	A	2	8	A	1
WB	8	A	1	8	A	1	8	A	1	7	A	1	7	A	1	7	A	1
NB	9	A	3	9	A	4	9	A	4	8	A	2	8	A	3		n/a	
SB	8	A	1	7	A	1	7	A	1	8	A	1		n/a		9	A	4
Willard St & Pearl St																		
Overall	**20**	**B**	-	**20**	**C**	-	**21**	**C**	-	**21**	**C**	-	**21**	**C**	-	**23**	**C**	-
EB	13	B	7	13	B	7	13	B	7	15	B	8	13	B	7	21	C	12
WB	11	B	6	11	B	5	11	B	6	11	B	6	11	B	6	14	B	9
NB	43	D	12	42	D	12	45	D	12	43	D	12	48	D	13	20	B	4
SB	25	C	6	26	C	6	26	C	6	26	C	6	24	C	6	33	C	9
Willard St & College St																		
Overall	**13**	**B**	-	**13**	**B**	-	**13**	**B**	-	**13**	**B**	-	**12**	**B**	-	**15**	**B**	-
EB	20	C	4	20	B	3	20	B	3	20	C	3	15	B	4	18	B	3
WB	21	C	8	22	C	8	22	C	8	22	C	8	21	C	8	21	C	8
NB	3	A	3	3	A	3	3	A	3	3	A	3	4	A	5	6	A	5
SB	12	B	5	11	B	4	12	B	5	12	B	5	12	B	4	14	B	7
Willard St & Main St																		
Overall	**19**	**B**	-	**20**	**B**	-	**21**	**C**	-	**20**	**C**	-	**18**	**B**	-	**23**	**C**	-
EB	10	A	5	11	B	5	12	B	6	10	B	5	11	B	6	12	B	4
WB	11	B	7	12	B	7	12	B	7	12	B	7	12	B	7	13	B	7
NB	29	C	10	29	C	10	30	C	10	27	C	9	26	C	9	29	C	9
SB	40	D	10	38	D	10	40	D	11	43	D	12	33	C	8	45	D	14

PM Peak Hour	No Build			Complete Street on Winooski			Two-Way North Winooski			Two-Way All Winooski			One-Way Pair: Counter-Clockwise			One-Way Pair: Clockwise		
	Delay	LOS	Queue	Delay	LOS	Queue	Delay	LOS	Queue	Delay	LOS	Queue	Delay	LOS	Queue	Delay	LOS	Queue
Winooski Ave & Riverside Ave																		
Overall	**24**	**C**	-	**26**	**C**	-	**23**	**C**	-	**28**	**C**	-	**21**	**C**	-	**20**	**C**	-
EB	25	C	12	26	C	14	25	C	12	31	C	14	22	C	12	21	C	11
WB	26	C	12	29	C	13	25	C	12	29	C	14	22	C	10	22	C	9
NB	17	B	9	19	B	10	18	B	9	20	B	11	16	B	7	16	B	9
SB	30	C	2	30	C	2	29	C	2	33	C	3	28	C	2	27	C	2
Winooski Ave & Archibald St																		
Overall	**28**	**C**	-	**29**	**C**	-	**28**	**C**	-	**26**	**C**	-	**26**	**C**	-	**24**	**C**	-
EB	35	D	13	38	D	12	38	D	13	35	D	12	38	D	13	34	C	13
WB	31	C	14	32	C	15	30	C	15	28	C	14	25	C	13	22	C	11
NB	21	C	7	22	C	8	21	C	9	21	C	9	19	B	7	19	B	8
SB	19	B	6	21	C	8	17	B	7	17	B	7	19	B	7	16	B	4
Winooski Ave & Union St																		
Overall	**9**	**A**	-	**10**	**A**	-	**10**	**B**	-	**11**	**B**	-	**10**	**A**	-	**11**	**B**	-
EB	7	A	1	7	A	1	7	A	1	8	A	1	9	A	1	8	A	1
WB	8	A	3	8	A	3	9	A	3	9	A	2	9	A	3		n/a	
NB		n/a			n/a		11	B	3	13	B	5		n/a		12	B	5
SB	12	B	4	12	B	5	12	B	5	12	B	5	11	B	6	9	A	3
Winooski Ave & North St																		
Overall	**15**	**B**	-	**15**	**B**	-	**16**	**B**	-	**17**	**B**	-	**17**	**B**	-	**17**	**B**	-
EB	12	B	5	12	B	5	17	B	8	18	B	7	13	B	6	21	C	7
WB	19	B	9	19	B	9	17	B	7	18	B	7	22	C	10	15	B	6
NB		n/a			n/a		15	B	5	16	B	6		n/a		16	B	8
SB	14	B	7	14	B	6	14	B	7	14	B	7	17	B	8		n/a	
Winooski Ave & Pearl St																		
Overall	**31**	**C**	-	**32**	**C**	-	**40**	**D**	-	**43**	**D**	-	**34**	**C**	-	**40**	**D**	-
EB	36	D	9	36	D	9	41	D	9	43	D	9	33	C	10	55	E	13
WB	30	C	10	31	C	10	43	D	10	46	D	10	33	C	15	44	D	9
NB	24	C	8	24	C	7	36	D	10	40	D	11		n/a		33	C	11
SB	36	D	6	38	D	6	38	D	8	42	D	9	43	D	7		n/a	
Winooski Ave & Cherry St																		
Overall	9	A	-	11	B	-	10	A	-	12	B	-	15	B	-	48	D	-
EB	22	C	7	23	C	8	22	C	7	26	C	9	33	C	16	137	F	27
WB		n/a			n/a			n/a			n/a			n/a			n/a	
NB	7	A	4	8	A	4	8	A	5	11	B	7		n/a		31	C	12
SB	5	A	4	8	A	9	6	A	7	8	A	8	12	B	8		n/a	
Winooski Ave & Bank St																		
Overall	7	A	-	11	B	-	9	A	-	10	B	-	27	C	-	12	B	-
EB	27	C	4	31	C	4	29	C	4	30	C	4	50	D	4	63	E	5
WB	26	C	2	25	C	2	27	C	1	29	C	2	99	F	2	28	C	2
NB	4	A	2	5	A	3	4	A	3	4	A	3		n/a		6	A	4
SB	5	A	4	10	B	7	8	A	5	10	B	6	24	C	11		n/a	
Winooski Ave & College St																		
Overall	**17**	**B**	-	**20**	**B**	-	**18**	**B**	-	**21**	**C**	-	**52**	**D**	-	**47**	**D**	-
EB	36	D	10	37	D	11	37	D	10	37	D	11	127	F	38	184	F	37
WB	28	C	7	30	C	8	28	C	8	31	C	9	43	D	9	25	C	13
NB	12	B	5	12	B	5	11	B	5	15	B	7		n/a		20	B	8
SB	10	A	6	14	B	6	11	B	5	14	B	5	37	D	10		n/a	
Winooski Ave & Main St																		
Overall	**24**	**C**	-	**30**	**C**	-	**29**	**C**	-	**37**	**D**	-	**84**	**F**	-	**22**	**C**	-
EB	27	C	13	35	D	15	37	D	19	50	D	25	212	F	28	25	C	16
WB	17	B	7	24	C	8	20	C	8	28	C	8	33	C	7	12	B	6
NB	26	C	6	24	C	6	26	C	5	32	C	10		n/a		33	C	9
SB	29	C	8	31	C	10	32	C	10	34	C	10	38	D	12		n/a	
Winooski Ave & King St																		
Overall	**21**	**C**	-	**19**	**C**	-	**17**	**C**	-	**20**	**C**	-	**45**	**E**	-	**15**	**C**	-
EB	14	B	5	14	B	5	13	B	5	16	C	6	98	F	21	17	C	6
WB	9	A	2	9	A	2	9	A	2	9	A	1	10	B	2	11	B	3
NB	9	A	1	9	A	1	8	A	1	10	B	3		n/a		17	C	7
SB	29	D	7	25	D	6	22	C	6	27	D	7	38	E	9		n/a	

PM Peak Hour

	No Build			Complete Street on Winooski			Two-Way North Winooski			Two-Way All Winooski			One-Way Pair: Counter-Clockwise			One-Way Pair: Clockwise		
	Delay	LOS	Queue	Delay	LOS	Queue	Delay	LOS	Queue	Delay	LOS	Queue	Delay	LOS	Queue	Delay	LOS	Queue
Winooski Ave & Maple St																		
Overall	**13**	**B**	**-**	**13**	**B**	**-**	**12**	**B**	**-**	**15**	**B**	**-**	**23**	**C**	**-**	**17**	**C**	**-**
EB	11	B	3	11	B	3	10	B	3	12	B	3	10	B	3	11	B	3
WB	11	B	3	11	B	3	11	B	3	14	B	4	11	B	3	13	B	4
NB		n/a			n/a			n/a		11	B	4		n/a		21	C	9
SB	15	B	6	15	B	6	14	B	6	17	C	6	31	D	11		n/a	
Winooski Ave & Howard St																		
Overall	**28**	**C**	**-**	**28**	**C**	**-**	**28**	**C**	**-**	**32**	**C**	**-**	**30**	**C**	**-**	**29**	**C**	**-**
EB	31	C	7	32	C	8	33	C	8	40	D	9	31	C	8	35	D	8
WB	24	C	4	23	C	3	21	C	4	28	C	4	28	C	3	92	F	18
NB	28	C	16	28	C	16	28	C	16	35	C	22	30	C	18	14	B	15
SB	22	C	6	23	C	7	23	C	7	22	C	7	24	C	7	8	A	4
SEB	35	C	13	35	C	14	34	C	13	37	D	14	36	D	15		n/a	
Union St & Pearl St																		
Overall	**21**	**C**	**-**	**23**	**C**	**-**	**21**	**C**	**-**	**20**	**B**	**-**	**41**	**D**	**-**	**25**	**C**	**-**
EB	14	B	10	14	B	9	10	A	6	9	A	6	18	B	7	17	B	12
WB	14	B	8	16	B	9	16	B	9	15	B	8	39	D	22	29	C	15
NB	39	D	8	40	D	9	39	D	7	44	D	12	56	E	20		n/a	
SB		n/a			n/a			n/a			n/a			n/a		47	D	11
Union St & College St																		
Overall	**20**	**C**	**-**	**26**	**D**	**-**	**21**	**C**	**-**	**17**	**C**	**-**	**102**	**F**	**-**	**53**	**F**	**-**
EB	17	C	6	20	C	7	18	C	5	16	C	6	133	F	20	19	C	6
WB	18	C	7	20	C	7	18	C	7	17	C	6	52	F	16	75	F	20
NB	23	C	8	33	D	11	24	C	9	18	C	7	111	F	16		n/a	
SB		n/a			n/a			n/a			n/a			n/a		46	E	9
Union St & Main St																		
Overall	**14**	**B**	**-**	**18**	**B**	**-**	**19**	**B**	**-**	**19**	**B**	**-**	**53**	**D**	**-**	**33**	**C**	**-**
EB	6	A	6	9	A	8	10	A	8	7	A	5	58	E	16	12	B	8
WB	14	B	14	18	B	18	19	B	19	20	B	18	25	C	18	58	E	31
NB	30	C	7	32	C	8	32	C	8	40	D	13	88	F	15		n/a	
SB		n/a			n/a			n/a			n/a			n/a		30	C	9
Union St & Howard St																		
Overall	**10**	**A**	**-**	**10**	**A**	**-**	**10**	**B**	**-**	**8**	**A**	**-**	**10**	**A**	**-**	**28**	**D**	**-**
EB	11	B	4	11	B	3	11	B	3	9	A	2	11	B	4	8	A	2
WB	8	A	1	8	A	1	8	A	1	8	A	1	8	A	1	12	B	2
NB	10	B	4	10	A	4	11	B	5	9	A	3	10	A	4		n/a	
SB	8	A	1	8	A	2	8	A	1	8	A	1		n/a		32	D	15
Willard St & Pearl St																		
Overall	**26**	**C**	**-**	**24**	**C**	**-**	**26**	**C**	**-**	**26**	**C**	**-**	**45**	**D**	**-**	**77**	**E**	**-**
EB	20	C	13	21	C	12	20	B	12	21	C	13	25	C	15	56	E	25
WB	15	B	9	17	B	11	21	C	14	19	B	13	33	C	20	103	F	38
NB	56	E	18	42	D	16	45	D	16	45	D	16	89	F	36	121	F	31
SB	29	C	6	27	C	6	29	C	6	28	C	6	29	C	9	52	D	12
Willard St & College St																		
Overall	**17**	**B**	**-**	**17**	**B**	**-**	**21**	**C**	**-**	**19**	**B**	**-**	**44**	**D**	**-**	**44**	**D**	**-**
EB	23	C	9	23	C	9	23	C	9	23	C	9	57	E	18	28	C	10
WB	31	C	12	31	C	11	35	D	13	34	C	11	70	E	23	48	D	17
NB	4	A	5	4	A	5	5	A	7	5	A	7	20	B	16	22	C	15
SB	15	B	7	16	B	8	23	C	12	20	C	11	68	E	23	64	E	27
Willard St & Main St																		
Overall	**23**	**C**	**-**	**24**	**C**	**-**	**29**	**C**	**-**	**23**	**C**	**-**	**61**	**E**	**-**	**41**	**D**	**-**
EB	12	B	7	14	B	8	12	B	7	10	A	6	66	E	30	18	B	10
WB	18	B	9	19	B	9	20	B	9	17	B	8	40	D	27	44	D	18
NB	39	D	16	40	D	17	57	E	21	31	C	12	63	E	27	46	D	20
SB	37	D	12	40	D	14	47	D	15	48	D	15	86	F	17	68	E	17

AM Peak Hour Queue Spillback Results

Legend

X%	< 1%
X%	1% to < 10%
XX%	10% to 25%
XX%	> 25%

Intersection	Approach	No Build	Complete Street on Winooski	Two-Way North Winooski	Two-Way All Winooski	One-Way: Counter-Clockwise	One-Way: Clockwise
Winooski Ave & Riverside Ave							
	EB	0%	0%	0%	0%	0%	0%
	WB	0%	0%	0%	0%	0%	0%
	NB	0%	0%	0%	0%	0%	0%
	SB	0%	0%	0%	0%	0%	0%
Winooski Ave & Archibald St							
	EB	0%	0%	0%	0%	0%	0%
	WB	0%	0%	0%	0%	0%	0%
	NB	0%	0%	0%	0%	0%	0%
	SB	0%	0%	0%	0%	0%	0%
Winooski Ave & Union St							
	EB	0%	0%	0%	0%	0%	0%
	WB	0%	0%	0%	0%	0%	n/a
	NB	n/a	n/a	0%	0%	n/a	0%
	SB	0%	0%	0%	0%	0%	0%
Winooski Ave & North St							
	EB	0%	0%	0%	0%	0%	0%
	WB	0%	0%	0%	0%	0%	0%
	NB	n/a	n/a	0%	0%	n/a	0%
	SB	0%	0%	0%	0%	0%	n/a
Winooski Ave & Pearl St							
	EB	0%	0%	0%	0%	0%	0%
	WB	0%	0%	0%	0%	1%	0%
	NB	0%	0%	0%	0%	n/a	**16%**
	SB	0%	0%	0%	0%	0%	n/a
Winooski Ave & Cherry St							
	EB	0%	0%	0%	0%	0%	0%
	NB	0%	0%	0%	0%	n/a	**53%**
	SB	0%	1%	0%	0%	0%	n/a
Winooski Ave & Bank St							
	EB	0%	0%	0%	0%	0%	0%
	WB	0%	0%	0%	0%	0%	0%
	NB	**26%**	**19%**	**18%**	**23%**	n/a	**39%**
	SB	0%	0%	0%	0%	0%	n/a
Winooski Ave & College St							
	EB	0%	0%	0%	0%	0%	0%
	WB	0%	0%	0%	0%	0%	0%
	NB	0%	0%	0%	0%	n/a	3%
	SB	0%	1%	1%	0%	0%	n/a
Winooski Ave & Main St							
	EB	0%	0%	0%	0%	0%	0%
	WB	2%	2%	2%	2%	**15%**	9%
	NB	0%	0%	0%	0%	n/a	0%
	SB	1%	2%	1%	3%	0%	n/a
Winooski Ave & King St							
	EB	0%	0%	0%	0%	0%	0%
	WB	0%	0%	0%	0%	0%	0%
	NB	0%	0%	0%	0%	n/a	2%
	SB	0%	0%	0%	0%	0%	n/a

Legend

X% < 1%

X% 1% to < 10%

XX% 10% to 25%

XX% > 25%

		No Build	Complete Street on Winooski	Two-Way North Winooski	Two-Way All Winooski	One-Way: Counter-Clockwise	One-Way: Clockwise
Winooski Ave & Maple St							
	EB	0%	0%	0%	0%	0%	0%
	WB	0%	0%	0%	0%	0%	0%
	NB	n/a	n/a	n/a	0%	n/a	0%
	SB	0%	0%	0%	0%	0%	n/a
Winooski Ave & Howard St							
	EB	0%	0%	0%	0%	0%	0%
	WB	0%	0%	0%	0%	0%	0%
	NB	0%	0%	0%	0%	0%	0%
	SB	0%	0%	0%	0%	0%	0%
	SEB	0%	0%	0%	0%	0%	n/a
Union St & Pearl St							
	EB	0%	0%	0%	0%	0%	0%
	WB	0%	0%	0%	0%	0%	1%
	NB	0%	0%	0%	0%	0%	n/a
	SB	n/a	n/a	n/a	n/a	n/a	**22%**
Union St & College St							
	EB	0%	0%	0%	0%	0%	0%
	WB	0%	0%	0%	0%	0%	0%
	NB	0%	0%	0%	0%	0%	n/a
	SB	n/a	n/a	n/a	n/a	n/a	**34%**
Union St & Main St							
	EB	0%	0%	0%	0%	0%	0%
	WB	0%	0%	0%	0%	0%	0%
	NB	0%	0%	0%	0%	0%	n/a
	SB	n/a	n/a	n/a	n/a	n/a	0%
Union St & Howard St							
	EB	0%	0%	0%	0%	0%	0%
	WB	0%	0%	0%	0%	0%	0%
	NB	0%	0%	0%	0%	0%	n/a
	SB	0%	0%	0%	0%	n/a	0%
Willard St & Pearl St							
	EB	0%	0%	0%	0%	0%	0%
	WB	0%	0%	0%	0%	0%	0%
	NB	0%	0%	0%	0%	0%	0%
	SB	0%	0%	0%	0%	0%	0%
Willard St & College St							
	EB	0%	0%	0%	0%	0%	0%
	WB	0%	0%	0%	0%	0%	0%
	NB	0%	0%	0%	0%	0%	0%
	SB	0%	0%	0%	0%	0%	0%
Willard St & Main St							
	EB	0%	0%	0%	0%	0%	0%
	WB	0%	0%	0%	0%	0%	0%
	NB	0%	0%	0%	0%	0%	0%
	SB	0%	0%	0%	1%	0%	1%

PM Peak Hour Queue Spillback Results

Legend

X% < 1%
X% 1% to < 10%
XX% 10% to 25%
XX% > 25%

		No Build	Complete Street on Winooski	Two-Way North Winooski	Two-Way All Winooski	One-Way: Counter-Clockwise	One-Way: Clockwise
Winooski Ave & Riverside Ave							
	EB	0%	0%	0%	0%	0%	0%
	WB	0%	0%	0%	0%	0%	0%
	NB	0%	0%	0%	0%	0%	0%
	SB	0%	0%	0%	0%	0%	0%
Winooski Ave & Archibald St							
	EB	0%	0%	0%	0%	0%	0%
	WB	4%	6%	5%	3%	3%	0%
	NB	0%	0%	0%	0%	0%	0%
	SB	0%	0%	0%	0%	0%	0%
Winooski Ave & Union St							
	EB	0%	0%	0%	0%	0%	0%
	WB	0%	0%	0%	0%	0%	n/a
	NB	n/a	n/a	0%	0%	n/a	0%
	SB	0%	0%	0%	0%	1%	0%
Winooski Ave & North St							
	EB	0%	0%	1%	0%	2%	1%
	WB	0%	0%	0%	0%	2%	0%
	NB	n/a	n/a	0%	0%	n/a	0%
	SB	0%	0%	0%	0%	3%	n/a
Winooski Ave & Pearl St							
	EB	0%	0%	0%	0%	0%	0%
	WB	0%	0%	0%	1%	6%	1%
	NB	1%	0%	1%	4%	n/a	**30%**
	SB	0%	0%	0%	0%	2%	n/a
Winooski Ave & Cherry St							
	EB	0%	0%	0%	0%	0%	0%
	NB	0%	0%	0%	1%	n/a	**18%**
	SB	0%	3%	1%	2%	**10%**	n/a
Winooski Ave & Bank St							
	EB	4%	3%	2%	2%	**26%**	**16%**
	WB	0%	0%	0%	0%	0%	0%
	NB	**35%**	**29%**	**30%**	**34%**	n/a	**70%**
	SB	0%	2%	0%	1%	**16%**	n/a
Winooski Ave & College St							
	EB	0%	0%	0%	0%	2%	0%
	WB	0%	0%	0%	0%	0%	2%
	NB	0%	0%	0%	1%	n/a	**15%**
	SB	3%	9%	4%	7%	**40%**	n/a
Winooski Ave & Main St							
	EB	0%	0%	0%	0%	**20%**	0%
	WB	6%	9%	9%	7%	**27%**	**14%**
	NB	0%	0%	0%	0%	n/a	1%
	SB	4%	8%	6%	9%	8%	n/a
Winooski Ave & King St							
	EB	0%	0%	0%	0%	9%	0%
	WB	0%	0%	0%	0%	0%	0%
	NB	0%	0%	0%	0%	n/a	1%
	SB	1%	1%	0%	1%	9%	n/a

Legend

X% < 1%

X% 1% to < 10%

XX% 10% to 25%

XX% > 25%

Intersection	Approach	No Build	Complete Street on Winooski	Two-Way North Winooski	Two-Way All Winooski	One-Way: Counter-Clockwise	One-Way: Clockwise
Winooski Ave & Maple St							
	EB	0%	0%	0%	0%	0%	0%
	WB	0%	0%	0%	0%	0%	0%
	NB	n/a	n/a	n/a	0%	n/a	0%
	SB	0%	0%	0%	0%	5%	n/a
Winooski Ave & Howard St							
	EB	0%	0%	0%	0%	0%	0%
	WB	0%	0%	0%	0%	0%	14%
	NB	0%	0%	0%	0%	0%	0%
	SB	0%	0%	0%	0%	0%	0%
	SEB	0%	0%	0%	0%	0%	n/a
Union St & Pearl St							
	EB	0%	0%	0%	0%	0%	7%
	WB	0%	0%	0%	0%	8%	3%
	NB	0%	0%	0%	0%	7%	n/a
	SB	n/a	n/a	n/a	n/a	n/a	11%
Union St & College St							
	EB	0%	0%	0%	0%	31%	0%
	WB	0%	0%	0%	0%	2%	1%
	NB	0%	1%	0%	0%	36%	n/a
	SB	n/a	n/a	n/a	n/a	n/a	34%
Union St & Main St							
	EB	0%	0%	0%	0%	24%	1%
	WB	0%	0%	0%	0%	4%	3%
	NB	0%	0%	0%	1%	19%	n/a
	SB	n/a	n/a	n/a	n/a	n/a	0%
Union St & Howard St							
	EB	0%	0%	0%	0%	0%	0%
	WB	0%	0%	0%	0%	0%	0%
	NB	0%	0%	0%	0%	0%	n/a
	SB	0%	0%	0%	0%	n/a	2%
Willard St & Pearl St							
	EB	0%	0%	0%	0%	0%	4%
	WB	0%	0%	0%	0%	3%	5%
	NB	0%	0%	0%	0%	5%	1%
	SB	0%	0%	0%	0%	1%	2%
Willard St & College St							
	EB	0%	0%	0%	0%	0%	0%
	WB	0%	0%	0%	0%	2%	1%
	NB	0%	0%	0%	0%	11%	7%
	SB	0%	0%	0%	0%	1%	3%
Willard St & Main St							
	EB	0%	0%	0%	0%	4%	0%
	WB	0%	0%	0%	0%	1%	0%
	NB	0%	0%	0%	0%	5%	2%
	SB	1%	1%	3%	3%	14%	8%

6.3 | APPENDIX C – REGIONAL MODEL REPORT

MEMO

DATE: August 24, 2016
SUBJECT: Winooski Avenue Regional Model Analysis Results

1.0 REGIONAL TRAVEL DEMAND MODEL

The CCRPC Regional Travel Model has been used to test for potential regional traffic shifts associated with the five Winooski Avenue corridor scenarios.

1. Bicycle Corridor on all of Winooski Ave
2. Two-Way Flow on North Winooski Ave
3. Two-Way Flow on all of Winooski Ave
4. One-Way Pair: Counter-Clockwise Flow
5. One-Way Pair: Clockwise Flow

Individual regional model runs have been conducted for each of these scenarios and projected shifts in traffic volume, as compared to the No Build scenario, are plotted for all model links. Background information on the regional travel demand model and a discussion of scenario testing results is presented below.

1.2 | BACKGROUND / MODEL SET UP

The Chittenden County Travel Demand Model, Version 3.2-3 is an integrated transportation demand model developed by Resource Systems Group (RSG) for the Chittenden County Regional Planning Commission.

The model estimates the movement of people and vehicles within the region during an average fall weekday in 2005. The 2005 Model is a daily model with hourly traffic assignments. The model operates in TransCAD 5.0 build 1545. The model includes 335 internal Transportation Analysis Zones (TAZs) covering the 18 municipalities in Chittenden County. Traffic entering and exiting the region does so through 17 external zones. While initially calibrated to 2005 socio-economic and traffic data, the model includes 6 future year scenarios in 5-year increments out to 2035, each based on expected land-use development in each 5-year increment.

1.3 | SCENARIO TESTING

Winooski Avenue scenario testing has been performed by constructing discrete alternative scenario networks for the 2015 analysis year with roadway changes specific to each scenario. The baseline "No Build" and all scenario models were run using the single time step (STS) run controls. To obtain analysis results, the No Build scenario trip distribution and mode choice outputs were copied over to all scenario alternatives and the assignment was rerun for results using the model's Run Final Assignment command.

Scenario analysis results are presented below in Figure 1 through Figure 11, which depict the total change in bi-directional link volumes resulting from the scenario elements. In these figures, projected increases of 75 or more vehicle trips are shown in dark red and decreases of 75 or more vehicle trips are shown in dark green, changes between these thresholds are shown on a gradient color scale. The overall percent change is also indicated for these links. Typical VTrans traffic study conventions indicate an increase of 75 or more trips during a peak hour is considered significant, and for new developments, requires a formal traffic impact study investigation. [1]

By design, the regional model is a coarser tool than the microsimulation model, and for this project, the regional model runs are intended to identify whether or not any of the proposed alternatives are expected to result in traffic changes beyond the microsimulation model project study area. Because the regional model uses an "all-or-nothing" assignment and due to the coarseness of the model, the presence of a projected shift is more significant than the magnitude of the projected shift. Any significant changes outside of the project study area should be examined in conjunction with the microsimulation model results in considering the potential benefits or impacts of the roadway alternatives.

WINOOSKI AVENUE BICYCLE CORRIDOR (TWLTL)

Figure 1 and Figure 2 present the net change in bi-directional traffic projected for converting Winooski Avenue from a four-lane section to a three-lane section between Pearl Street and Main Street during the weekday AM (8:00-9:00) and PM (17:00-18:00) peak hours, respectively.

As can be seen below, implementing this road diet, is projected to result in a reduction in traffic on Winooski Avenue immediately north of Main Street during the AM and PM peak hours, and an increase in traffic on Main Street west of Winooski Avenue during the PM peak hour. **Overall, this change is not expected to result in a significant impact to traffic patterns beyond the project study area**.

[1] Vermont Agency of Transportation, Development Review Section, *Traffic Impact Evaluation Study and Review Guide* (October 2008).

FIGURE 1: REGIONAL AM TRAFFIC DIVERSIONS – TWLTL

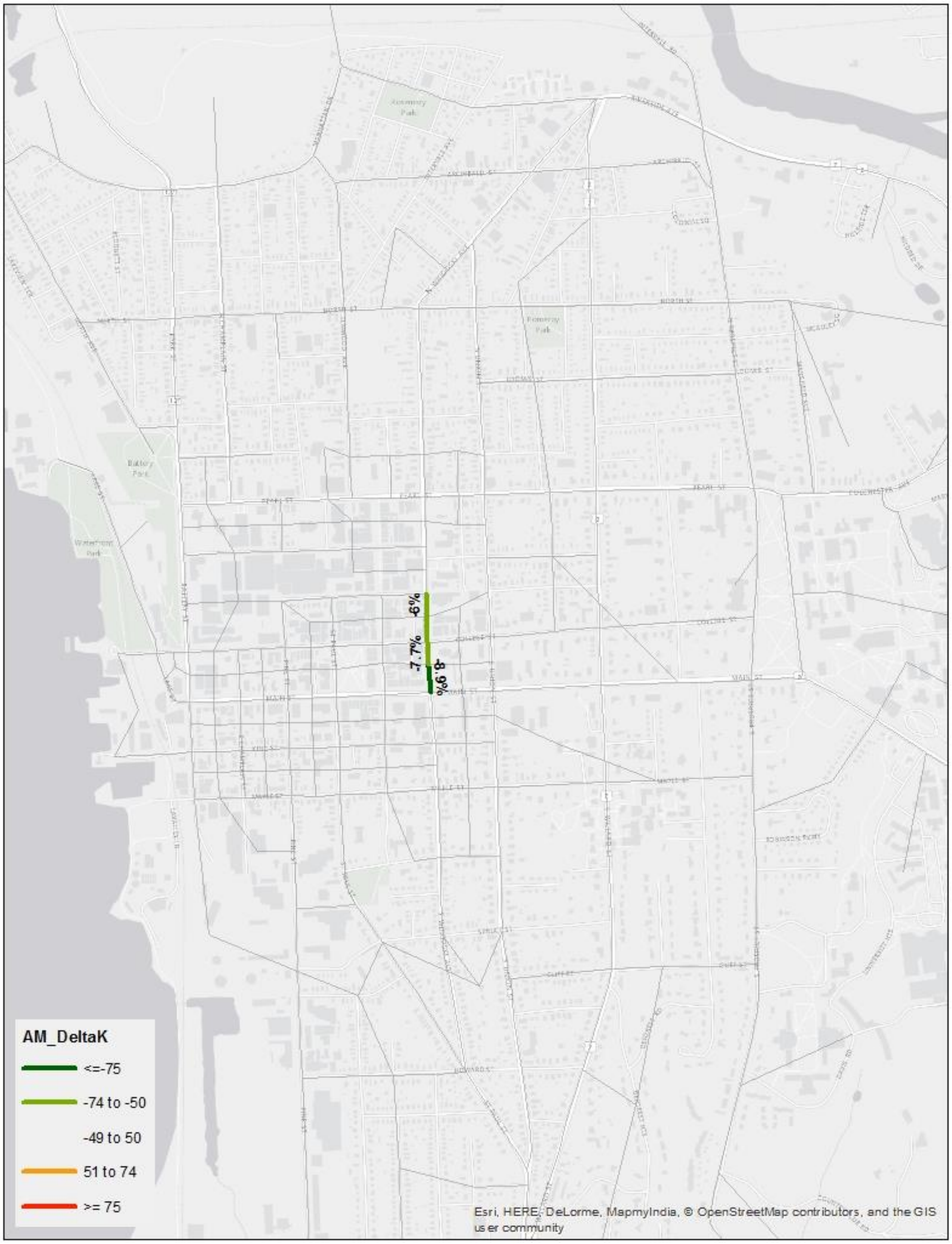
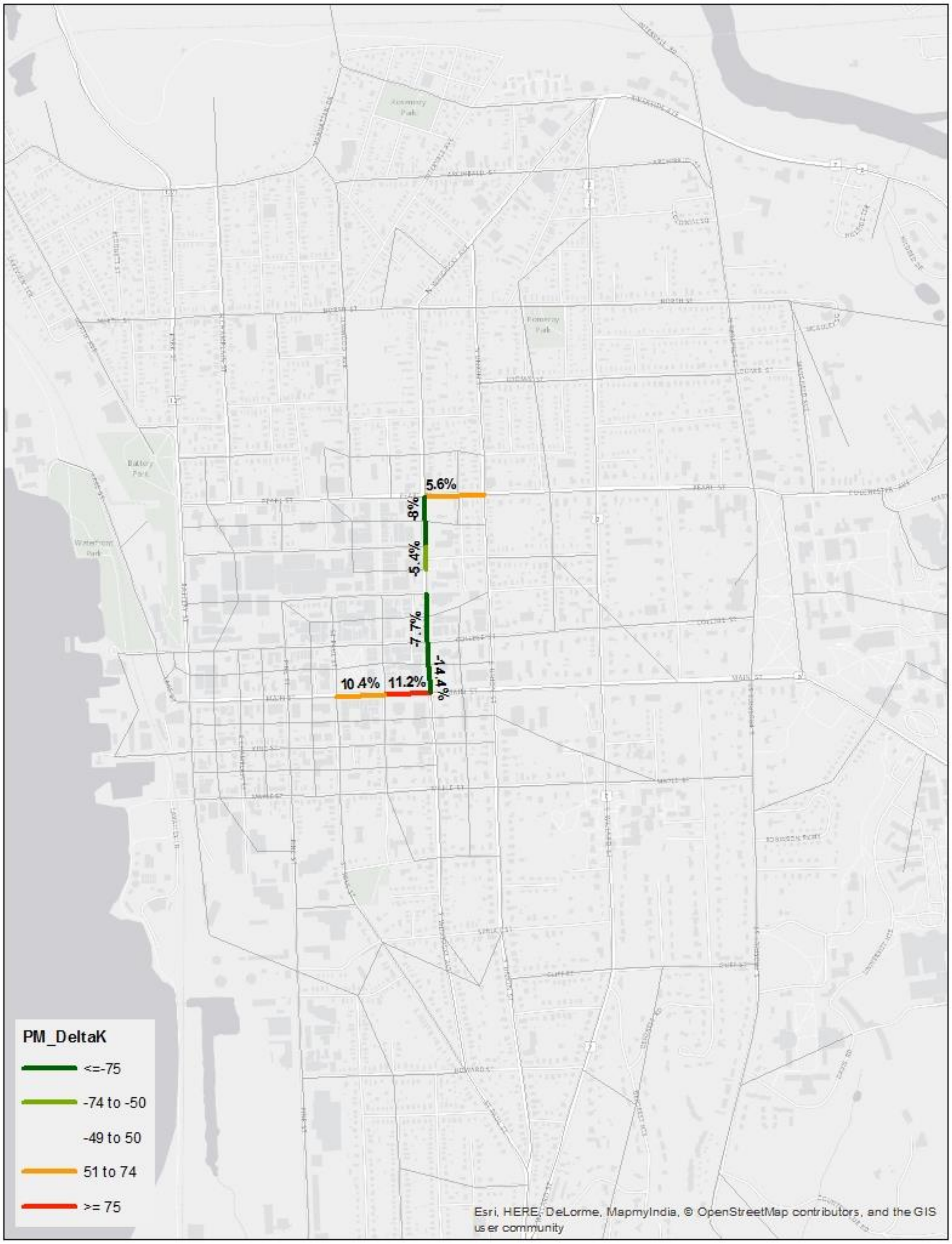


FIGURE 2: REGIONAL PM TRAFFIC DIVERSIONS – TWLTL



TWO-WAY FLOW ON NORTH WINOOSKI AVENUE

Figure 3 and Figure 4 present the net change in bi-directional traffic projected for allowing two-way traffic flow on North Winooski Avenue from Union Street to Pearl Street and for converting Winooski Avenue from a four-lane section to a three-lane section between Pearl Street and Main Street during the weekday AM (8:00-9:00) and PM (17:00-18:00) peak hours, respectively.

As can be seen below, implementing this change, is projected to result in a moderate increase in traffic on North Winooski Avenue during the AM peak hour and a larger increase in traffic on North Winooski Avenue during the PM peak hour. Corresponding reductions in traffic are projected on Union Street and Elmwood Avenue. **Overall, this change is not expected to result in a significant impact to traffic patterns beyond the project study area**.

FIGURE 3: REGIONAL AM TRAFFIC DIVERSIONS – TWO-WAY NORTH WINOOSKI AVE

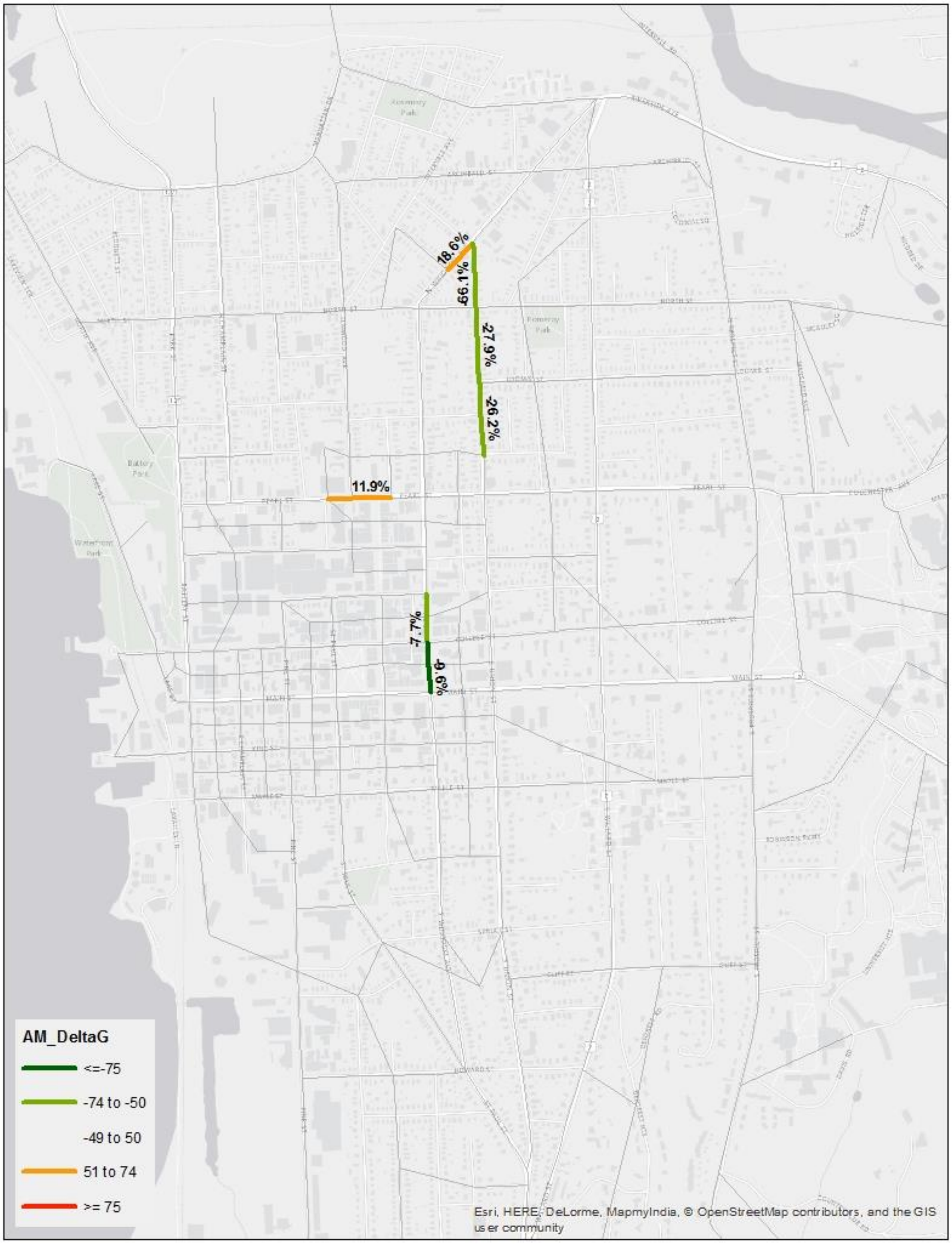
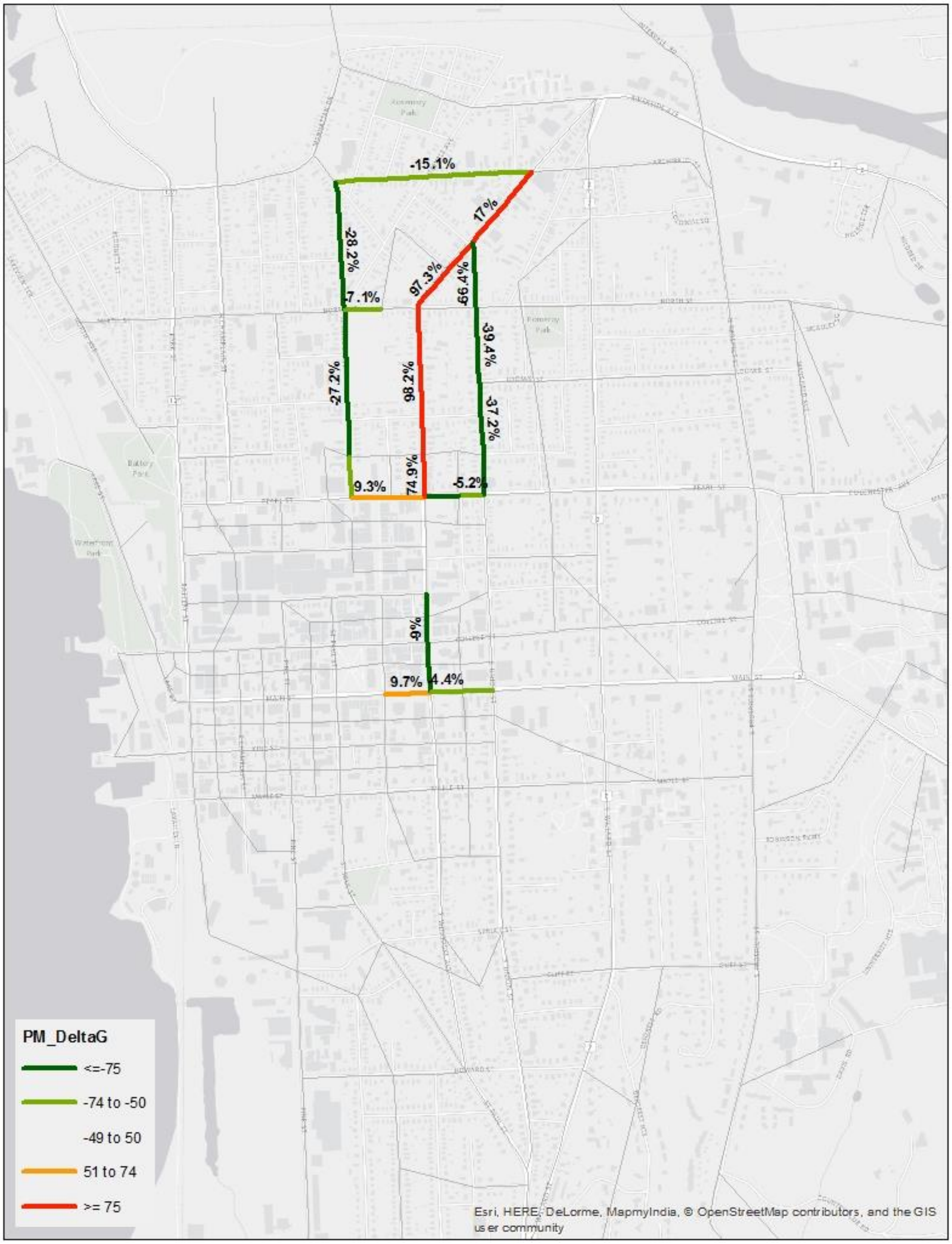


FIGURE 4: REGIONAL PM TRAFFIC DIVERSIONS – TWO-WAY NORTH WINOOSKI AVE



TWO-WAY FLOW ON ALL OF WINOOSKI AVENUE

Figure 5 and Figure 6 present the net change in bi-directional traffic projected for allowing two-way traffic flow on all of Winooski Avenue and for converting Winooski Avenue from a four-lane section to a three-lane section between Pearl Street and Main Street during the weekday AM (8:00-9:00) and PM (17:00-18:00) peak hours, respectively.

As can be seen below, implementing this change, is projected to result in a net increase in traffic on Winooski Avenue and a corresponding reduction in traffic on Union Street, Elmwood Avenue, and St Paul Street. During the AM peak hour, the dominant flows are entering downtown Burlington and the proposed change has the most notable effect on South Winooski Avenue where traffic is now allowed to enter downtown by way of South Winooski Avenue (currently one-way southbound). During the PM peak hour, the northbound flow exiting downtown is greater than in the AM peak hour, and a larger increase in traffic is observed on North Winooski Avenue (currently one-way southbound). **Overall, this change is not expected to result in a significant impact to traffic patterns beyond the project study area**.

FIGURE 5: REGIONAL AM TRAFFIC DIVERSIONS – TWO-WAY ALL OF WINOOSKI AVE

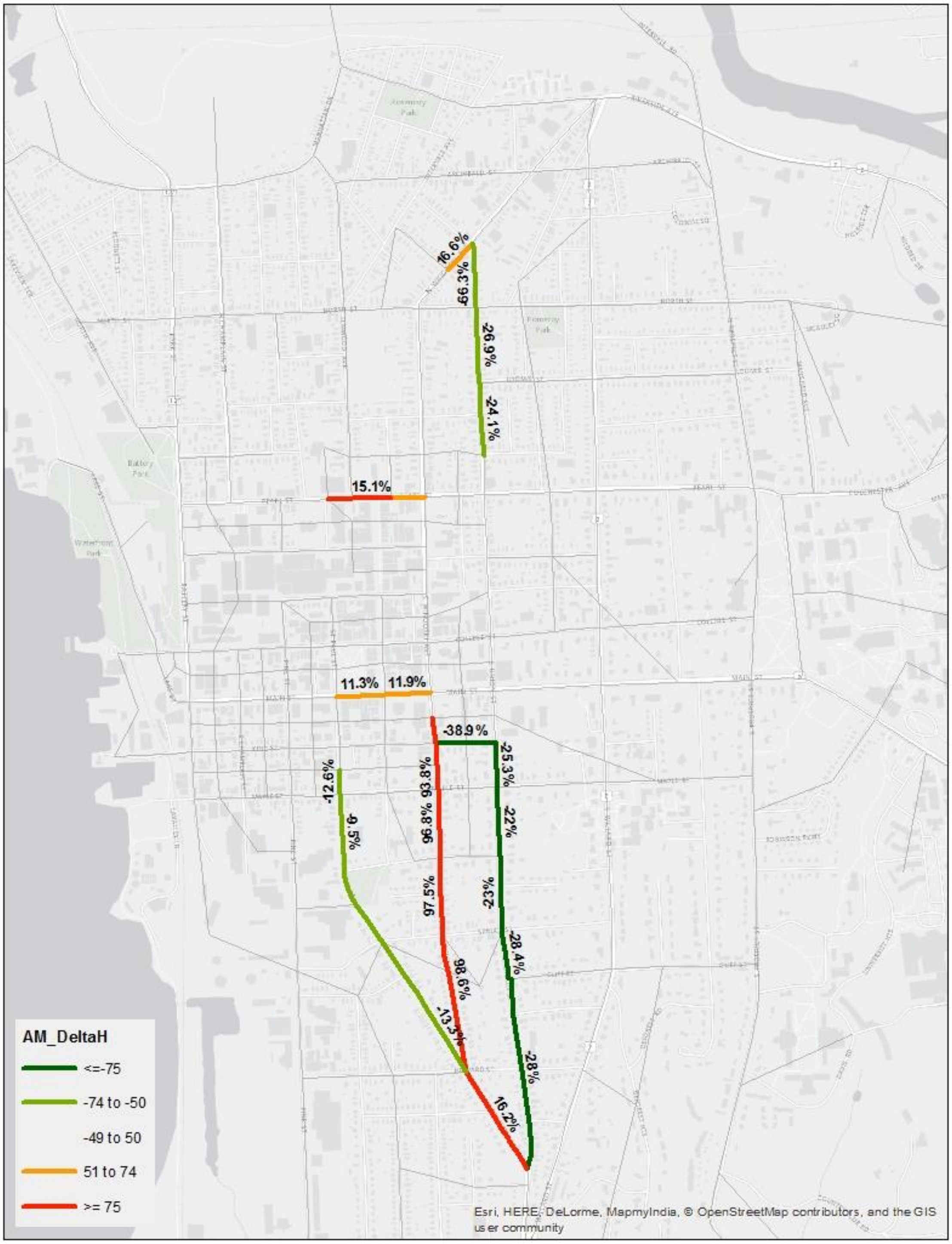
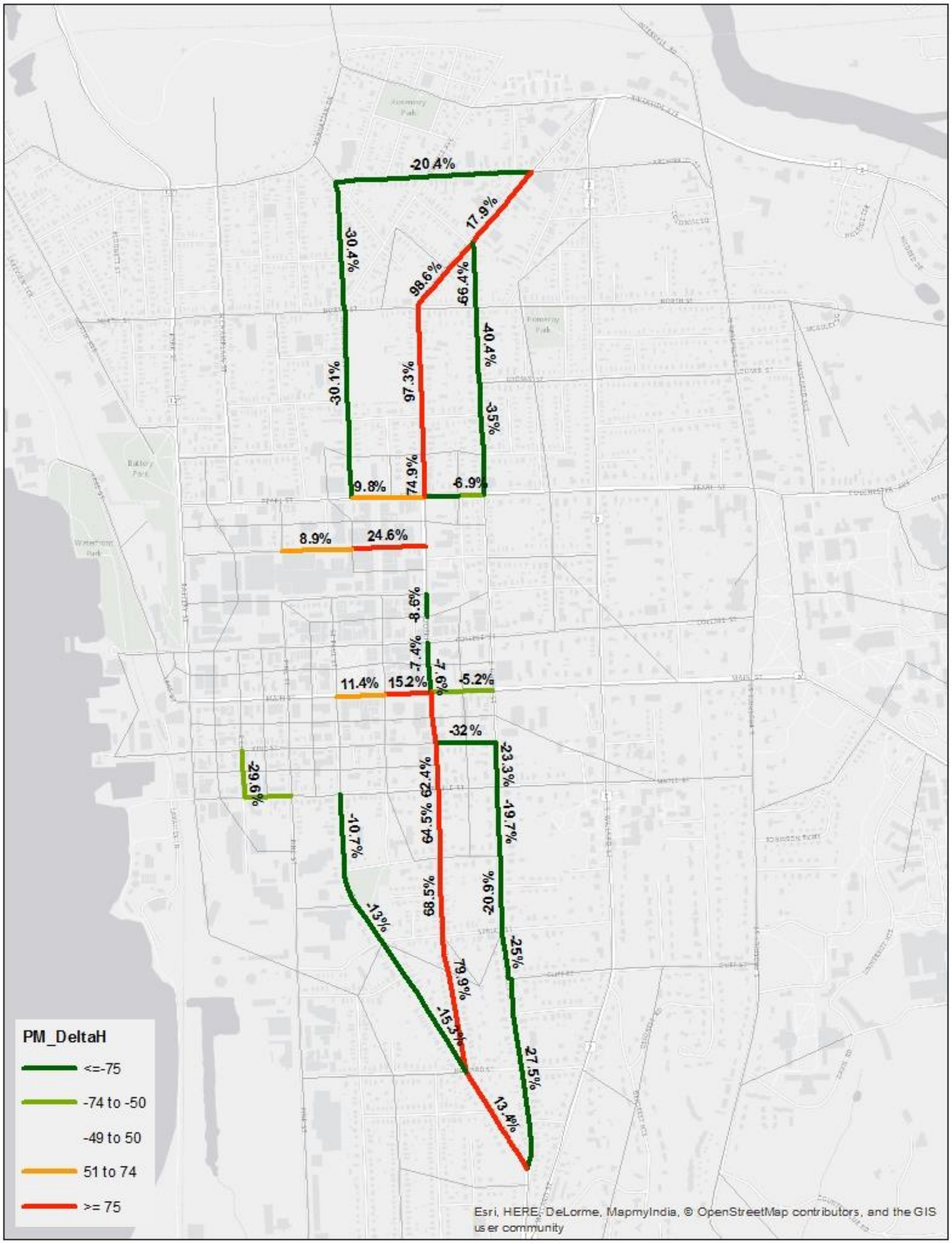


FIGURE 6: REGIONAL PM TRAFFIC DIVERSIONS – TWO-WAY ALL OF WINOOSKI AVE



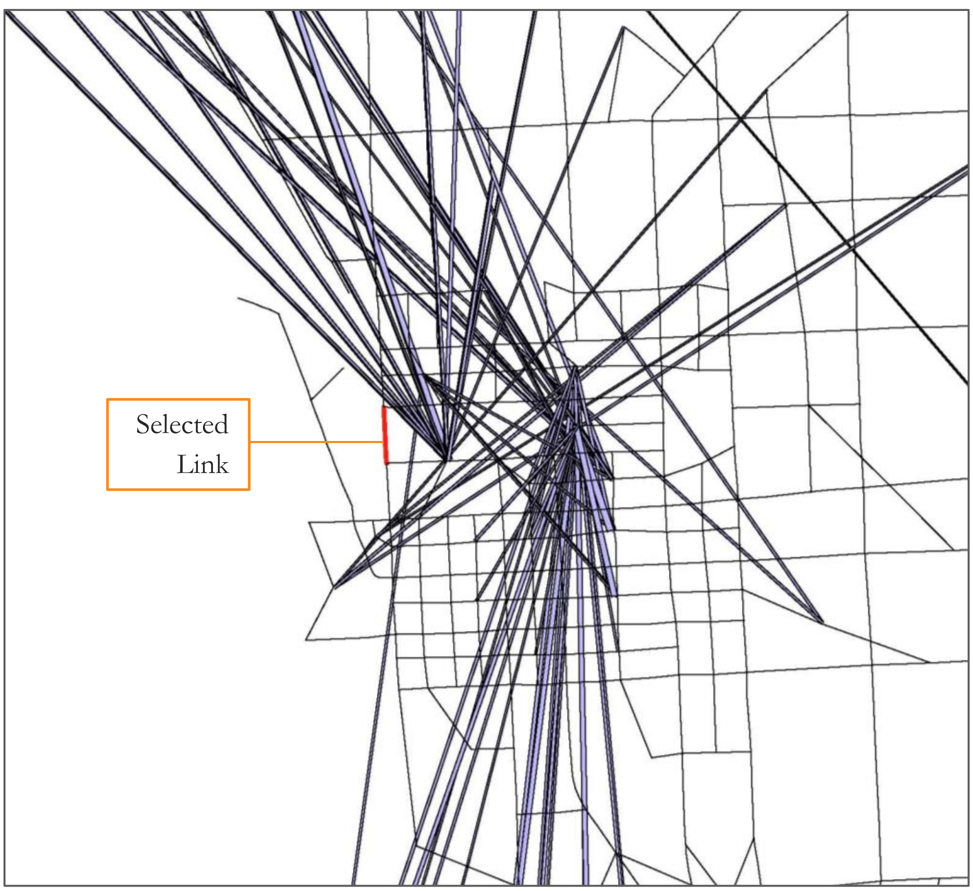
COUNTER-CLOCKWISE ONE-WAY PAIR

Figure 8 and Figure 9 present the net change in bi-directional traffic projected for creating a one-way pair flow pattern with southbound traffic on Winooski Avenue and northbound traffic on Union Street during the weekday AM (8:00-9:00) and PM (17:00-18:00) peak hours, respectively.

During the AM peak hour, implementing this change, is projected to result in traffic shifts primarily within the project study area. However, moderate increases are projected on parallel streets to the west, including Battery Street. During the PM peak hour, impacts outside of the project study area are more pronounced. Most notably, the regional model projects a shift in route choice away from Winooski Avenue and towards Battery Street, for several downtown destinations.

Figure 7 presents the results of a select-link analysis conducted for Battery Street south of Cherry Street. This map shows desire lines between origin/destination pairs for trips that are newly added to the selected link (Battery Street) during the PM peak hour for this scenario. The subject link sees an overlapping increase in trips between origin/destination pairs in downtown heading to the north and south, as a result of the scenario elements. Because the regional model uses an "all-or-nothing" assignment and due to the coarseness of the model, the presence of a projected shift is more significant than the magnitude of the projected shift.

FIGURE 7: SELECT LINK ANALYSIS FOR BATTERY STREET



Overall, this change is not expected to result in potential impacts beyond the project study area.

FIGURE 8: REGIONAL AM TRAFFIC DIVERSIONS – COUNTER-CLOCKWISE ONE-WAY PAIR

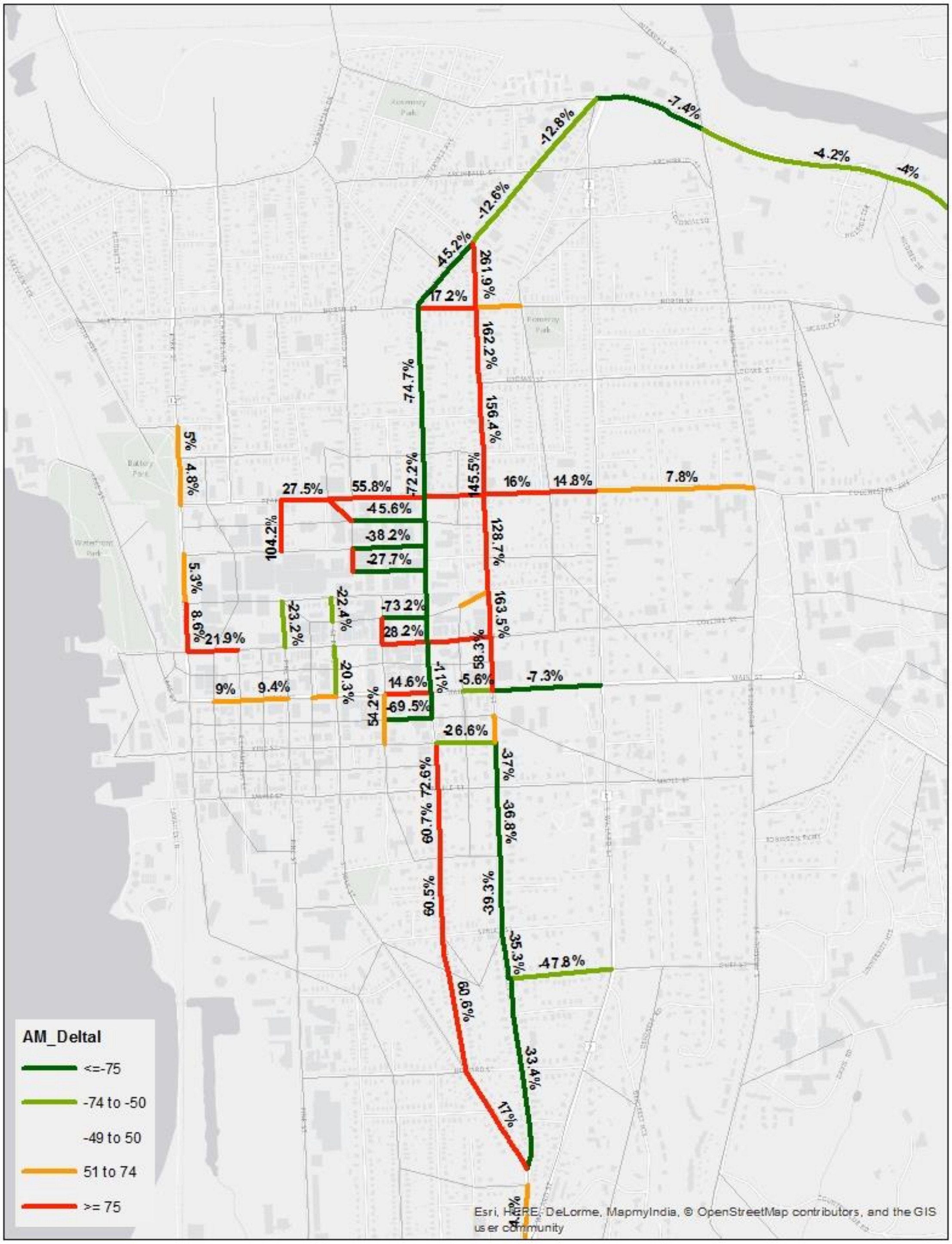
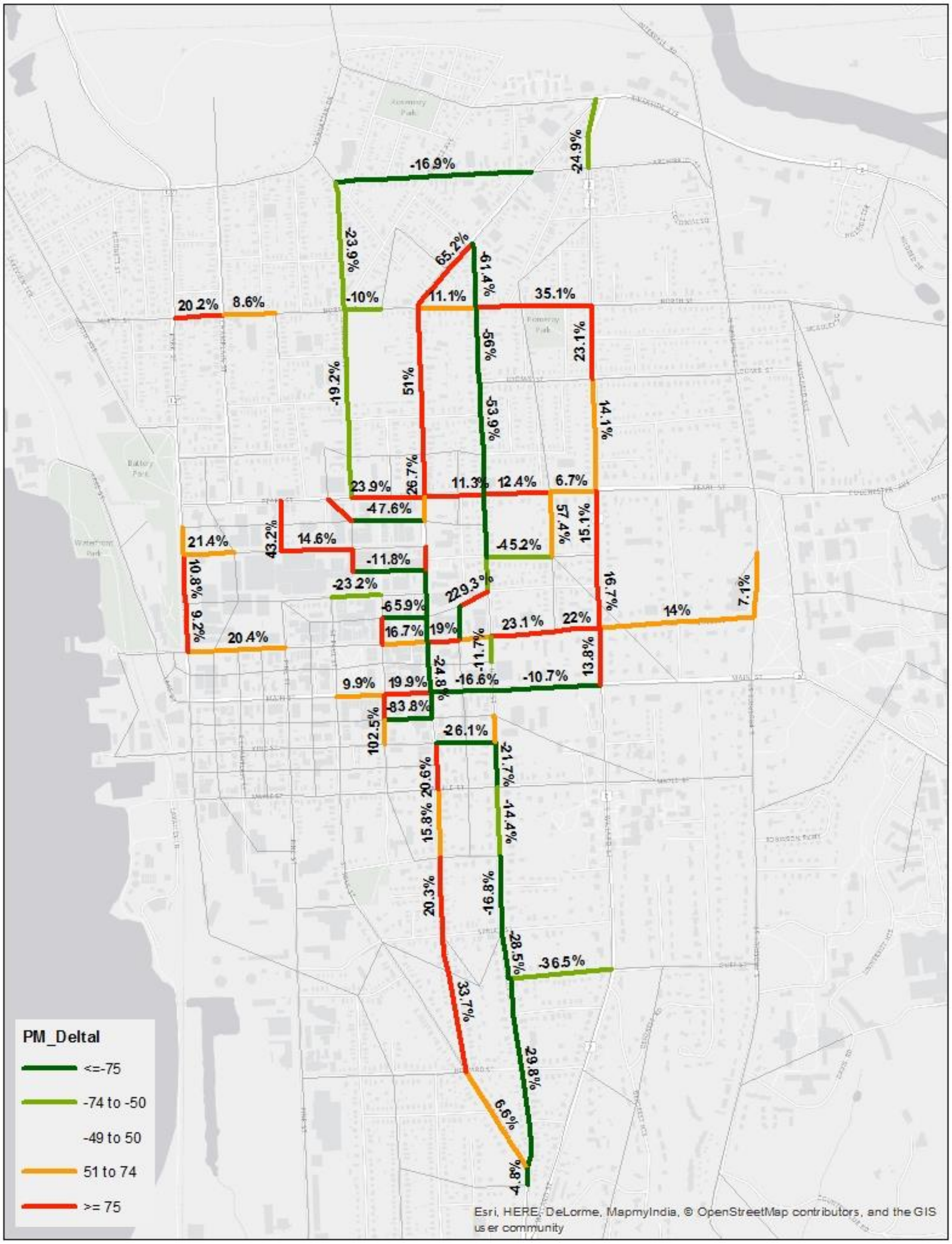


FIGURE 9: REGIONAL PM TRAFFIC DIVERSIONS – COUNTER-CLOCKWISE ONE-WAY PAIR



CLOCKWISE ONE-WAY PAIR

Figure 10 and Figure 11 present the net change in bi-directional traffic projected for creating a one-way pair flow pattern with northbound traffic on Winooski Avenue and southbound traffic on Union Street during the weekday AM (8:00-9:00) and PM (17:00-18:00) peak hours, respectively.

As with the counter-clockwise one-way pair scenario, the clockwise one-way pair scenario is projected to result in some traffic shifts from the study area corridors outside of the project study area. Most notably, the regional model projects a shift in route choice away from Winooski Avenue and towards Battery Street, for several downtown destinations.

Overall, this change is not expected to result in potential impacts beyond the project study area.

FIGURE 10: REGIONAL AM TRAFFIC DIVERSIONS – CLOCKWISE ONE-WAY PAIR

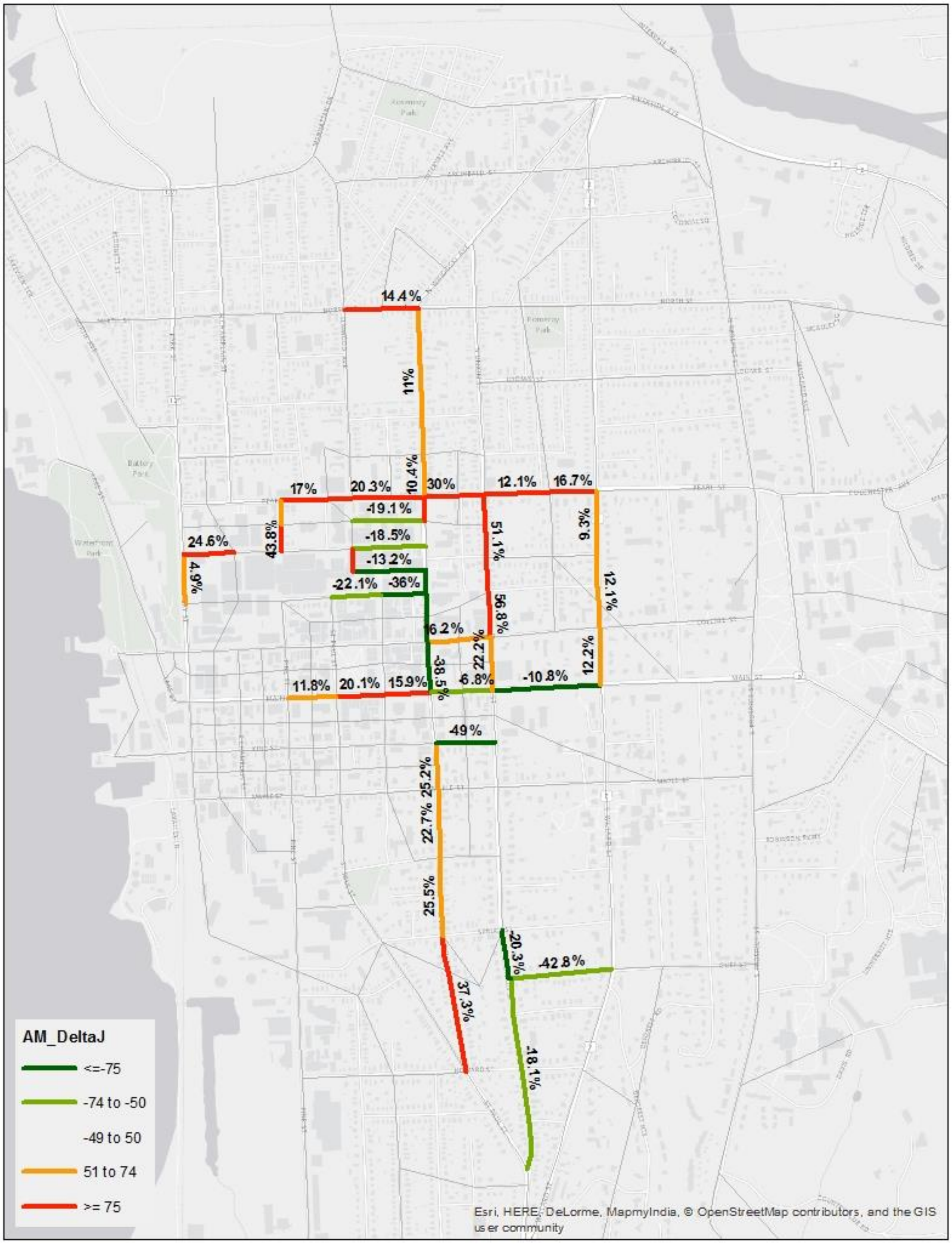


FIGURE 11: REGIONAL PM TRAFFIC DIVERSIONS – CLOCKWISE ONE-WAY PAIR