Traffic update

MEMO

RECEIVED
MAR 27 2015
DEPARTMENT OF PLANNING & ZONING

RSG

TO: Patrick O'Brien
FROM: Ben Swanson
DATE: March 25, 2015
SUBJECT: Grove Street Development – Review of March 2015 Traffic Improvements

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In October 2013, RSG drafted the Traffic Impact Study (TIS) for the proposed Grove Street housing development in Burlington, Vermont. Since completion of this study, the applicant has been in discussions with Burlington Public Works (BPW) regarding the roadway and pedestrian improvements that will be completed by the applicant in association with this project. From these discussions, the following additional pedestrian improvements have been identified:

1. The proposed project will now install a second rapid rectangular flashing beacon (RRFB) at the mid-block crossing east of the Schmanska Park parking area. This existing pedestrian crossing will also receive a new bump-out to further improve pedestrian safety.
2. The section of Grove Street proximate to Schmanska Park will now be reduced to 24 feet.
3. The proposed site access width has been reduced from approximately 57 feet to approximately 43 feet at the pedestrian crossing. We understand this change was made at the request of Burlington DPW and has been reviewed and accepted by the Burlington Fire Chief.

These recent additions to the project plan further improve the pedestrian environment proximate to the project site. In conjunction with previously planned sidewalk, pedestrian crossing, and traffic calming elements, the proposed pedestrian improvements greatly enhance the existing infrastructure and provide an important pedestrian connection between South Burlington, Burlington, and Winooski.

Additionally, since completion of the original TIS, the total number of proposed residential units has decreased from 247 units (assumed in previous analysis) to 232 units. This results in a net decrease in overall site-generated traffic during both peak hours, as shown below. Any impacts from the project as currently proposed, would be slightly less than previously analyzed in the Traffic Impact Study. In addition to the substantial off-site pedestrian improvements planned for this project, and traffic impact fees leveed by the City, we had previously recommended the applicant make a fair-share contribution towards large-scale improvements at the Colchester Avenue/Riverside Avenue/Barrett Street triangle and at the US 2/White Street intersection. Based on the updated trip generation, these contributions would be approximately $5,500 and $14,500, respectively.

FIGURE 1: PREVIOUS AND CURRENT SITE TRIP GENERATION

	Previous Study (247 Units)			Current Proposal (232 Units)			Net Change (-15 units)		
	Enter	Exit	Total	Enter	Exit	Total	Enter	Exit	Total
AM Peak Hour	25	100	125	23	94	117	-1	-6	-7
PM Peak Hour	100	54	154	94	51	145	-5	-3	-8

Please feel free to contact us with any questions.

RSG INC.
TRANSPORTATION

Traffic Impact Study

Grove Street Development

Burlington, VT

October 2013

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OCT 24 2013
DEPARTMENT OF
PLANNING & ZONING

PLANNING ■ ENGINEERING ■ DESIGN

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1.0 EXECUTIVE SUMMARY

This study evaluates the traffic impacts associated with the proposed redevelopment of the SD Ireland concrete batch plant on Grove Street in Burlington, Vermont into a residential use. The proposed project includes 247 apartment units.

1.1 Key Findings

Key findings, presented in greater detail below, include:

1. The proposed Grove Street housing project would replace the existing SD Ireland concrete batch plant on Grove Street in Burlington, Vermont with a 247 unit apartment development.
2. Using trip generation rates presented by the Institute of Transportation Engineers (ITE) for this land use, we calculate this project would generate approximately 125 new vehicle trips during the AM peak hour (25 entering and 100 exiting) and 154 vehicle trips during the PM peak hour (100 entering and 54 exiting).
3. Removal of the existing SD Ireland concrete plant will result in a reduction of existing concrete plant traffic, including heavy vehicle and passenger car traffic, in this area. Based on average production levels and existing administrative operations at the plant, we expect this project to eliminate approximately 61 existing AM peak hour trips (41 entering and 20 exiting) and approximately 61 existing PM peak hour trips (22 entering and 39 existing) from the local roadways.
4. Long delays and Level of Service F conditions exist at the Riverside Avenue/Barrett Street and Colchester Avenue/Barrett Street intersections and at the US 2/White Street intersection, with or without the addition of site-generated traffic. Delays at all other study area intersections are projected to remain at acceptable levels and increase by fewer than 5 seconds per vehicle with the addition of project generated traffic.
5. A review of historic VTrans crash data identified three High Crash Locations within the study area at the Colchester Avenue/Barrett Street intersection, at the Patchen Road/White Street intersection, and at the US 2/White Street intersection.
6. RSG recently conducted the Colchester Avenue Corridor study as a planning document for the Chittenden County Regional Planning Commission and identified a preferred alternative for reconstructing the Colchester Avenue/Riverside Avenue intersection triangle and we recommend this improvement be pursued to improve both operations and safety in this area, with or without the proposed project.
7. At the US 2/White Street intersection, major improvements are currently planned as part of the City Center initiative and Market Street improvements project. Improvements on Market Street are currently slated for fiscal year 2016 in the 2013-2016 CCRPC Transportation Improvement Program (TIP). Full improvements at the US 2/White Street intersection, are currently planned but are not yet included in the near term Transportation Improvement Program.
8. At the Patchen Road/White Street intersection overall LOS B and LOS C conditions are maintained during the weekday AM and PM peak hours, respectively, with the addition of project generated traffic.
9. Using the City of Burlington's impact fee calculator, we calculate approximately $53,600 in traffic impact fees to be associated with the proposed project.
10. We have also examined the proposed site access on Grove Street and have found that stopping and corner sight distances exceed design standards in both directions.

11. We conducted a turn-lane warrant assessment and found that a dedicated left-turn lane is not warranted on Grove Street at the site access.
12. We project average vehicle delays of less than 20 seconds per vehicle for traffic exiting the site driveway and expect the access to operate safely and effectively.
13. We have examined plans for proposed off-site traffic calming and pedestrian accommodation improvements prepared by O'Leary Burke Civil Associates including new sidewalks, crosswalks, new curbing, new lighting, and a proposed solar powered speed feedback display.
14. We believe the proposed pedestrian improvements greatly enhance the existing infrastructure. The proposed sidewalk section south of the project site provides a critical pedestrian link between South Burlington and Burlington and Winooski, creating a continuous pedestrian route between these areas. Additionally, improved curbing signage and striping at crossings north of the project site will help improve pedestrian safety for all pedestrians in the area.

1.2 Recommendations

Recommendations arising from the analysis presented below include:

1. We recommend a cost sharing allocation be paid by the developer to the City of Burlington towards eventual improvements at the Colchester Avenue/Riverside Avenue/Barrett Street intersection triangle. This area currently experiences long delays and has been identified for future improvements by the Chittenden County Regional Planning Commission c. While the proposed project does not cause this issue, we suggest the developer make a fair share contribution towards the ultimate intersection improvements based on the percent increase in peak hour traffic from the proposed project and the estimated cost of the overall improvement. Based on the larger peak hour percent increase in traffic (0.43% during the PM peak) and the estimated project cost ($1.4 million)[1], we calculate a fair share contribution of approximately $6,000.
2. We recommend a cost sharing allocation be paid by the developer to the City of South Burlington towards eventual improvements at the US 2/White Street intersection. This area currently experiences long delays and has been identified for future improvements by the Chittenden County Regional Planning Commission based on heavy use by existing traffic. While the proposed project does not cause this issue, we suggest the developer make a fair share contribution towards the ultimate intersection improvements based on the percent increase in peak hour traffic from the proposed project and the estimated cost of the overall improvement. Based on the larger peak hour percent increase in traffic (0.41% during the AM peak) and the estimated project cost ($3.94 million) [2], we calculate a fair share contribution of approximately $16,000.
3. Due to the high prevalence of rear-end collisions at the Patchen Road/White Street intersection we recommend advance intersection warning signs (MUTCD W3-3) be installed on both the eastbound and westbound, White Street, approaches to this intersection. Similar signs already exist on the northbound and southbound, Patchen Road approaches (Figure 36).
4. To enhance pedestrian connectivity and to improve pedestrian accommodations proximate to the project site, we recommend all off-site traffic calming and pedestrian enhancements identified by O'Leary Burke Civil Associates be installed prior to the first certificate of occupancy for the project.

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[1] The December 2011 Colchester Avenue Corridor Plan, conducted by Resource Systems Group indicated an approximate project cost of $1.4 million to reconstruct the Colchester Avenue/Riverside Avenue/Barrett Street intersection triangle.

[2] The August 2007 US 2 Corridor Study, conducted by Resource Systems Group indicated an approximate project cost of $3.94 million to reconstruct the US 2/White Street and US 2/Patchen Road intersections.

5. In addition to the pedestrian enhancements proposed by O'Leary Burke Civil Associates we recommend the existing pedestrian warning signs at the crosswalk on Grove Street north of the paved public parking area (north of the project access) be upgraded to new fluorescent yellow warning signs (W11-2) and be accompanied by diagonal arrows indicating the crossing location (W16-7P) and that these signs be gate-posted for both northbound and southbound traffic prior to the first certificate of occupancy for the project. We recommend similar signage be installed at the second pedestrian crossing approximately 300 feet north of this parking area at the north end of the park.
6. Due to the tight turning radius for the southbound right-turn from Barrett Street onto Grove Street, we recommend the "No Parking Here To Corner" sign be relocated as indicated by O'Leary Burke Civil Associates, assuming Burlington Public Works is willing to accept the associated reduction in on-street parking.

We believe that if the above recommendations are followed, traffic associated with construction of the proposed Grove Street housing project will not cause unreasonable congestion or unsafe conditions on the surrounding road network.

2.0 INTRODUCTION

This study evaluates the traffic impacts associated with the proposed redevelopment of the SD Ireland concrete batch plant on Grove Street in Burlington, Vermont into a residential use. The proposed project includes 247 apartment units. This Traffic Impact Study includes the following items:

- The project description and study scope
- Traffic volumes with and without the project
- Estimated congestion with and without the project
- Estimated queue lengths with and without the project
- A safety analysis
- Recommendations

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

3.0 PROJECT DESCRIPTION

The proposed project would replace the existing SD Ireland concrete batch plant on Grove Street in Burlington, Vermont with 247 units of apartment housing. The proposed project site plan is shown below in Figure 1. All development traffic would access the surrounding road network via a single driveway onto Grove Street.

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

[2] Institute of Transportation Engineers, *Trip Generation* 9th Edition (Washington, D.C.: Institute of Transportation Engineers, 2012).

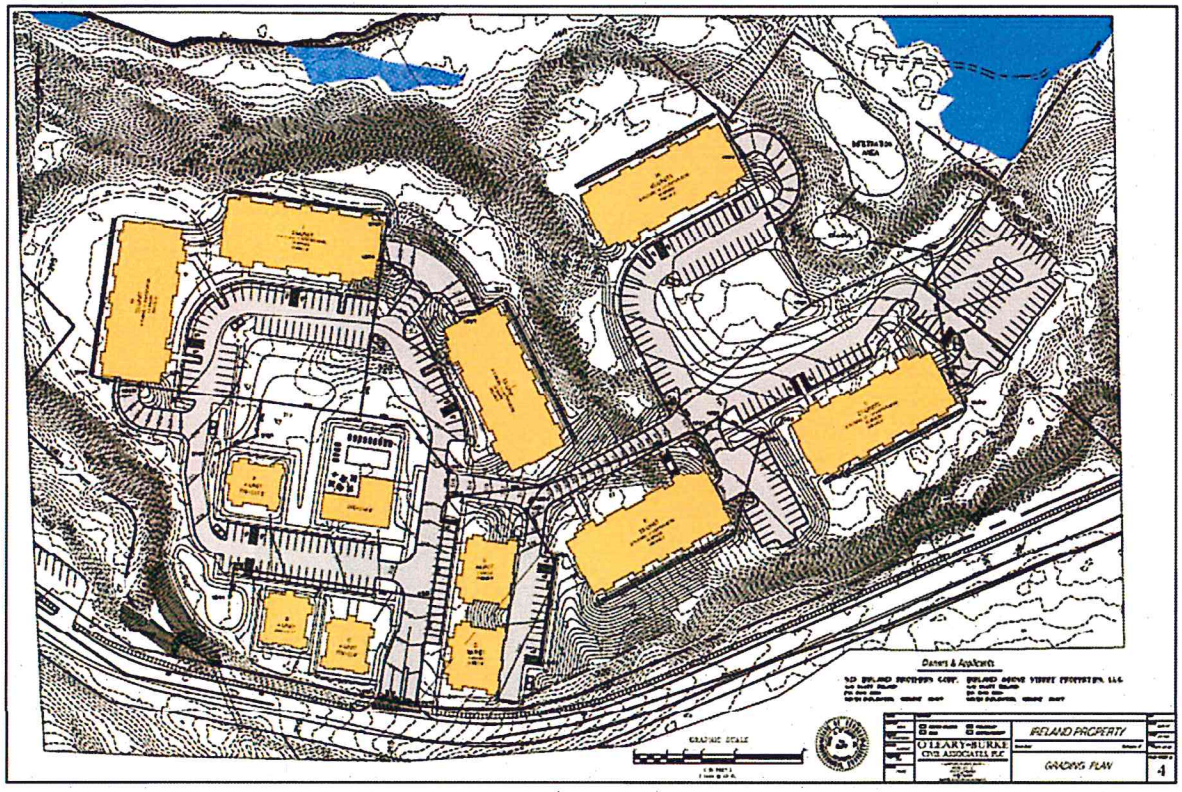
[3] American Association of State Highway and Transportation Officials (AASHTO), *A Policy on Geometric Design of Highways and Streets*, 6th Edition (Washington DC: AASHTO, 2011).

[4] American Traffic Safety Services Association (ATSSA), ITE, and AASHTO, *Manual on Uniform Traffic Control Devices*, 2009 Edition (Washington DC: FHWA, 2009).

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

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

Figure 1: Site Plan



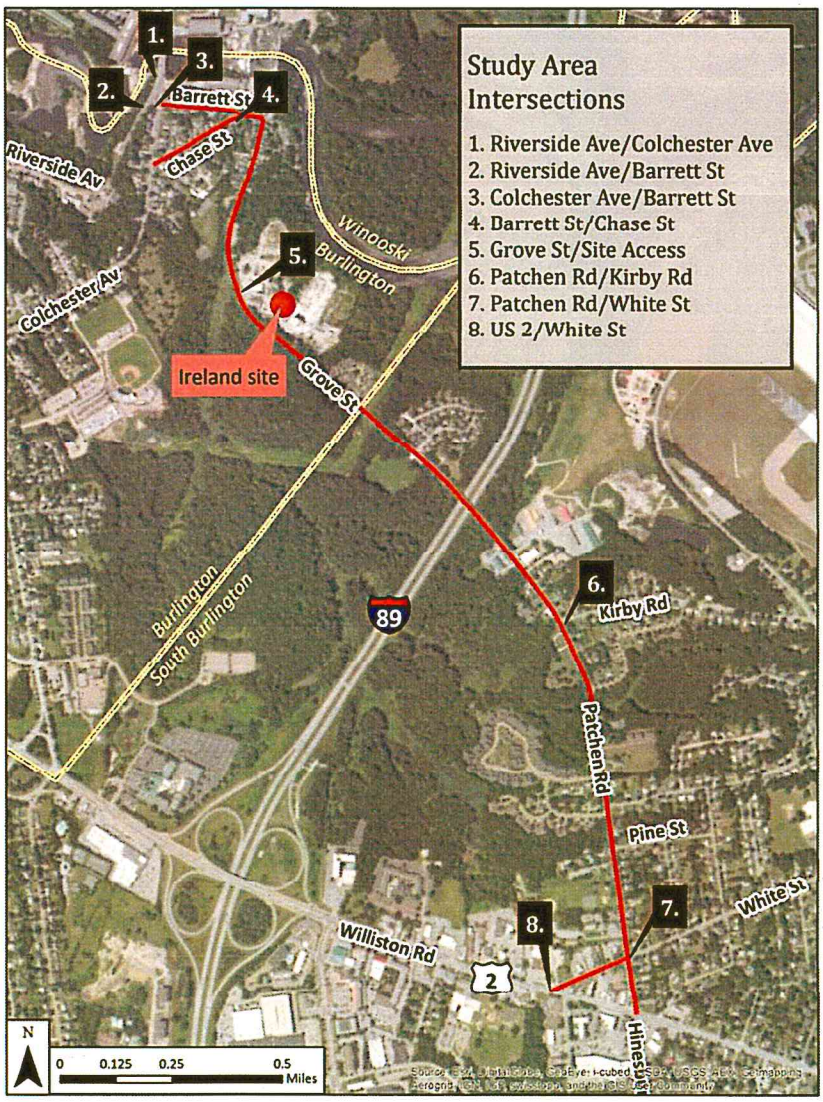
4.0 GEOGRAPHIC SCOPE OF STUDY

VTrans guidelines specify that a traffic study should be considered if the proposed development will generate 75 or more peak hour trips. The geographic scope of the study should also include the immediate access points and those intersections or highway segments receiving 75 or more project-generated peak hour trips.[1]

As presented in greater detail in Section 4.4, the Grove Street/Site Access intersection is projected to experience 75 or more peak hour trips as a result of the proposed project. Although no other intersections are projected to meet the 75 vehicle trip per hour VTrans threshold, additional analysis intersections are included based on conversations with Planning and Public Works Department staff in Burlington and South Burlington. Figure 2 presents the names and locations of the nine total study intersections.

[1] Vermont Agency of Transportation, Traffic Research Unit, *Traffic Impact Study Guidelines* (October 2008).

Figure 2: Study Area Intersections

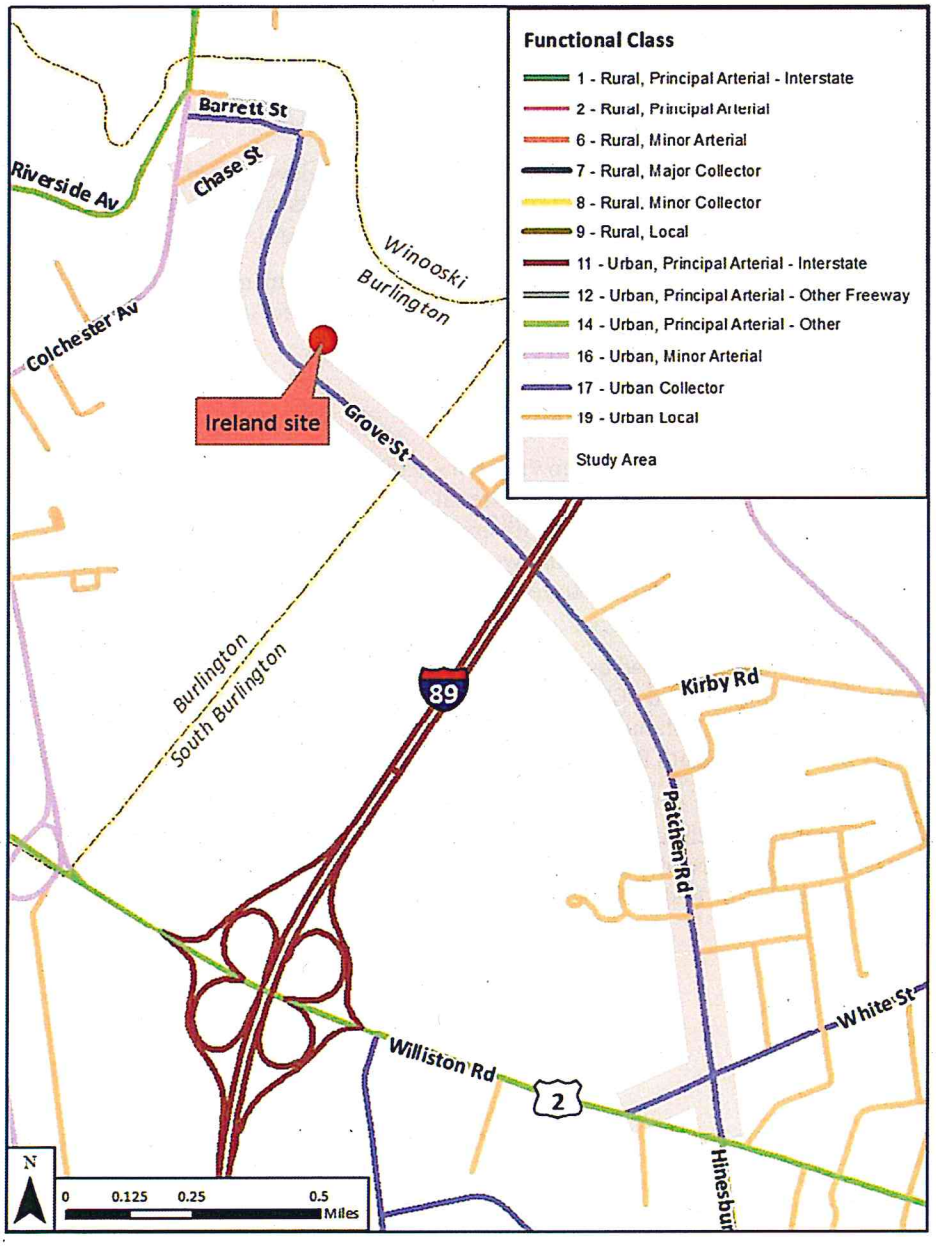


4.1 Local Traffic

In Burlington, Grove Street begins at Barrett Street and ends at the South Burlington town line. From there, Grove Street becomes Patchen Road and continues in South Burlington south to US 2. Grove Street and Patchen Road are both classified as Urban Collectors (Figure 3). In 2009 VTrans recorded an Annual Average Daily Traffic (AADT) volume of 6,000 vehicles per day on Patchen Road.[1] The speed limit on Patchen Road and Grove Street is posted at 25 mph.

[1] The AADT was measured at VTrans count station S6D332 just north of Pine Street in South Burlington.

Figure 3. Functional Classification of Study Area Roads and Adjacent Area



This analysis examines conditions during the weekday AM and PM peak design hours. Vermont traffic conventions typically call for analyzing traffic conditions in the base year (the year construction is estimated to be complete) and five years in the future. However, statewide VTrans continuous traffic count (CTC) data on all Urban roads as well as Burlington specific CTC data from count station P6D001 on VT 127 indicate no background traffic growth over the next 20 years[1]. Because no background traffic growth is projected in the study area, a separate future year analysis is not included. Therefore, the following scenarios are evaluated in this study:

[1] *Continuous Traffic Counter Grouping Study and Regression Analysis*, VTrans Traffic Research Unit, 2012

- 2016 No Build (AM and PM peak hours)
- 2016 Build, including traffic from the proposal (AM & PM peak hours)

4.2 Other Development Volumes

Other development volumes (ODVs) represent trips generated by anticipated developments in the study area that have been permitted but not yet constructed. Trips generated by ODVs are included in every scenario because we assume they are already present on the road network in the No Build scenario.

We have spoken with Planning Department staff in both Burlington and South Burlington and identified the City Center[1] project in South Burlington and the 110 Riverside Avenue[2] project in Burlington to be included in the background traffic volumes.

4.3 Scenario Volumes and Adjustments

RSG conducted weekday turning movement counts from 7:00 AM – 9:00 AM and from 4:00 PM – 6:00 PM at five of the study intersections on December 18, 2012. Additional 2009 turning movement count data from VTrans were used for the US 2/White Street and the Riverside Avenue/Colchester Avenue intersections. Weekday AM peak hour (7:30-8:30 AM) and weekday PM peak hour (4:30-5:30 PM) traffic count volumes from these counts were then adjusted to represent the design hour volume (DHV)[3] in 2016 using the following two adjustment factors:

7. Design hour adjustment factors are based on VTrans short term counter S6D213, located on White Street west of Patchen Road and CCRPC counter D022, located on Colchester Avenue just south of Mill Street.[4] Design Hour Volume (DHV) adjustment factors increase Burlington intersection counts by 17% and South Burlington intersection counts by 22% to achieve design hour conditions.
8. An annual adjustment factor, which represents general background traffic growth, is based on average growth trends for urban roads in Vermont, as presented in the 2012 VTrans Redbook.[5] As noted above, the 2012 VTrans Redbook projects no future background growth on urban roads.

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[1] The City Center project is a major initiative in South Burlington that includes new streets and encourages mixed use-development. Traffic volumes for this ODV were obtained from the Market Street improvements Traffic Study conducted by Vanasse Hangen Brustlin, Inc.

[2] This project consists of a 57 unit apartment building located at 110 Riverside Avenue in Burlington, VT.

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

[4] VTrans count station S6D213 had an AADT of 6,700 in 2009 and CCRPC counter D022 had an AADT of 14,800 in 2009, which was the most recent year of available data at both counters.

[5] As presented in the 2012 VTrans Redbook, historic traffic trends in Vermont indicate no background growth for Urban roadways or at Burlington specific CTC station P6D001.

4.4 Trip Generation

Trip generation refers to the number of new vehicle trips originating at or destined for a particular development. For this analysis we used trip generation rates from the Institute of Transportation Engineer's *Trip Generation*[1] to estimate peak hour site-generated traffic. Considering the 247 proposed units of apartment housing, we have estimated new project trip generation at the site using ITE Land Use Code 220 (Apartment). During the weekday AM peak hour we project the site will generate 125 vehicle trips (25 entering and 100 exiting). During the weekday PM peak hour we project the site will generate 154 vehicle trips (100 entering and 54 exiting).

Figure 4: Trip Generation Summary

AM Peak Hour: 125 trips (25 enter, 100 exit)
PM Peak Hour: 154 trips (100 enter, 54 exit)

New vehicle trips were distributed onto the surrounding road network following background residential traffic patterns obtained from traffic counts conducted by RSG at the Patchen Road/Valley Ridge Road intersection, approximately 0.4 miles to the south.[2] Beyond the initial distribution at the site driveway, site traffic was distributed based on background traffic patterns.

While the proposed residential use will add traffic to the study area road network, the removal of the existing SD Ireland concrete batch plant will remove existing concrete-related traffic from the study area road network. To account for existing concrete plant related traffic, we have discussed current operation levels with plant management. From this discussion, we understand the plant produces on average approximately 600 yards of material per day with approximately 6.5 yards per delivery vehicle. Additionally, the site requires approximately 50 yards of aggregate per day, 8 loads of cement per day, and also dispatches approximately 35 pump loads per day and 20 block, boom, and form trucks per day. Summing up all truck activity results in approximately 205 truckloads per day generated from this site. We understand the plant typically operates from 6:00 AM to 6:00 PM and that plant operations are reasonably consistent over the course of the 12 hour day. The plant employs approximately 100 people, including administrative staff who occupy approximately 17,500 square feet of office space on-site. Based on plant production and truck information, along with ITE trip generation rates for general office use (ITE Land Use 710), we assume the plant currently generates approximately 61 one-way trips during the weekday AM peak hour (41 entering and 20 exiting) and approximately 61 one-way trips during the weekday PM peak hour (22 entering and 39 exiting) on an average day.

Figure 5 presents a summary of assumptions and estimates for the existing traffic generated by the SD Ireland concrete batch plant.

[1] Institute of Transportation Engineers, *Trip Generation* 9th Edition (Washington, D.C.: Institute of Transportation Engineers, 2012).

[2] The weekday AM peak hour count was conducted on 25 January 2013 and the weekday PM peak hour count was conducted on 18 December 2012.

Figure 5: Existing Concrete Plant Traffic Summary

Technical Operations

Concrete Production	
600	yards of concrete per average day
6.5	yards of concrete per truck load
92	loads of concrete per day

Raw Materials and Support Trucks	
50	loads of aggregate per day
35	pump loads per day
20	block boom and form loads per day
8	loads of cement per day
113	raw material and support loads per day

Hourly Trip Summary	
205	truck loads per day
12	hours per day of operation
17	truck loads per hour
34	truck trips per hour

Administrative Support

ITE Land Use 710 (General Office)	
17,500	square feet of administrative space
1.56	AM peak hour trips/1,000 sq. ft.
1.49	PM peak hour trips/1,000 sq. ft.

Administrative Peak Hour Distribution	
88%	enter during AM peak hour
12%	exit during AM peak hour
17%	enter during PM peak hour
83%	exit during PM peak hour

Hourly Trip Summary	
24	enter during AM peak hour
3	exit during AM peak hour
4	enter during AM peak hour
22	exit during AM peak hour

Existing Operations Trip Generation Summary

41 enter during AM peak hour
20 exit during AM Peak hour

22 enter during PM peak hour
39 exit during PM Peak hour

Figure 6 through Figure 9 present the distribution of new housing development traffic and the reduction of concrete plant generated traffic.

Figure 6: AM Peak Hour Grove Street Housing Trip Generation

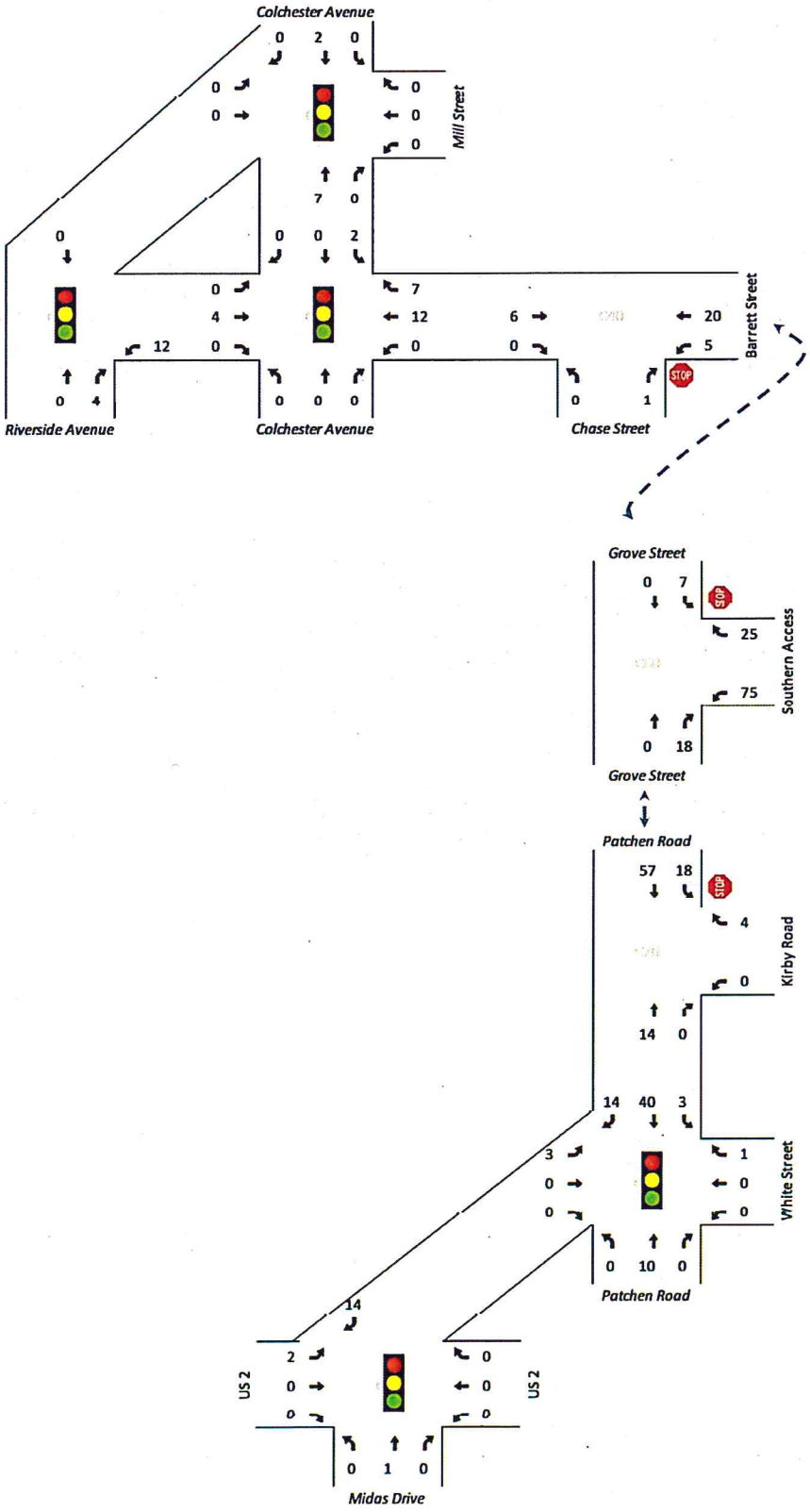


Figure 7: PM Peak Hour Grove Street Housing Trip Generation

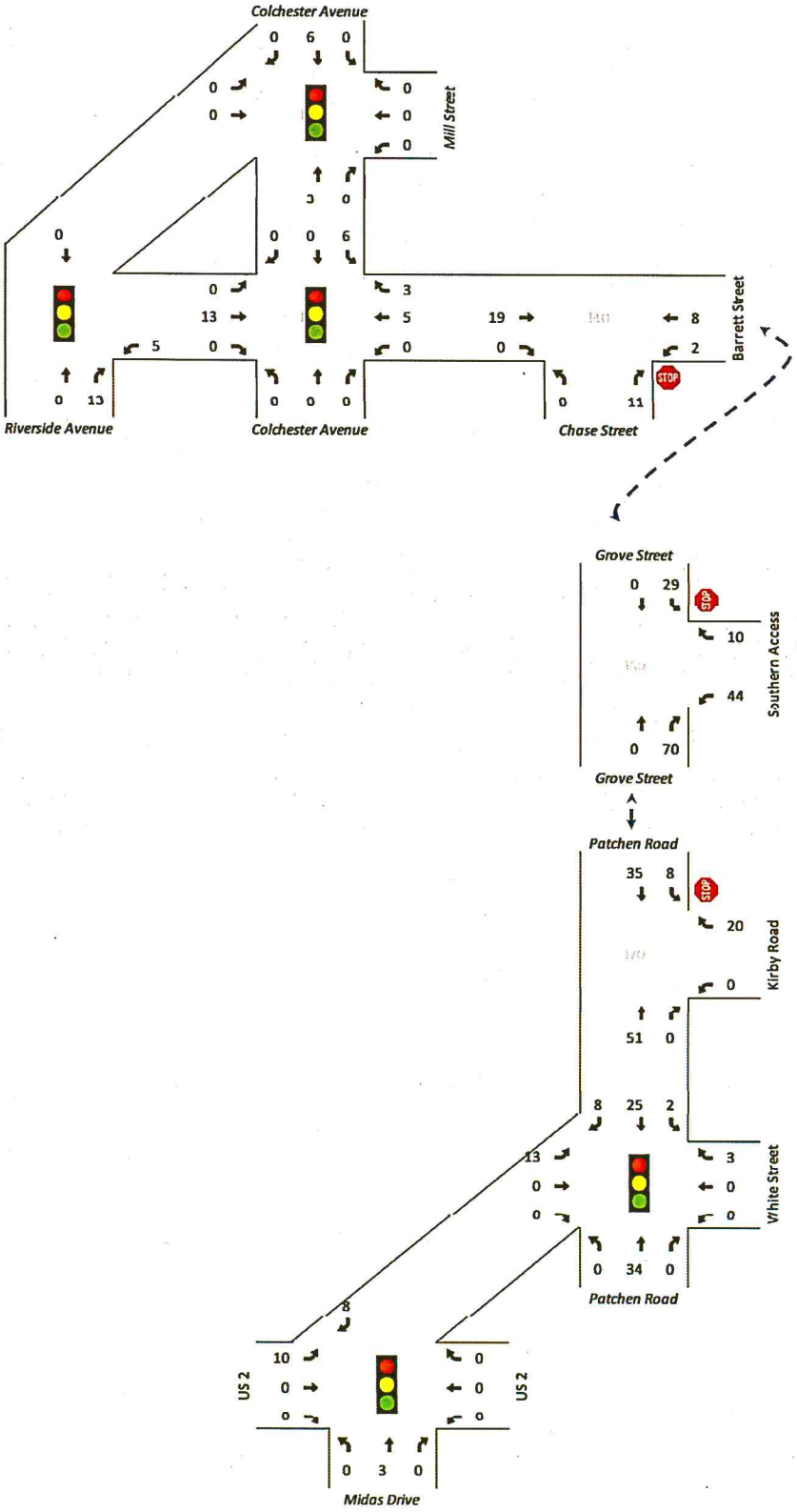


Figure 8: AM Peak Hour SD Ireland Concrete Trip Reduction

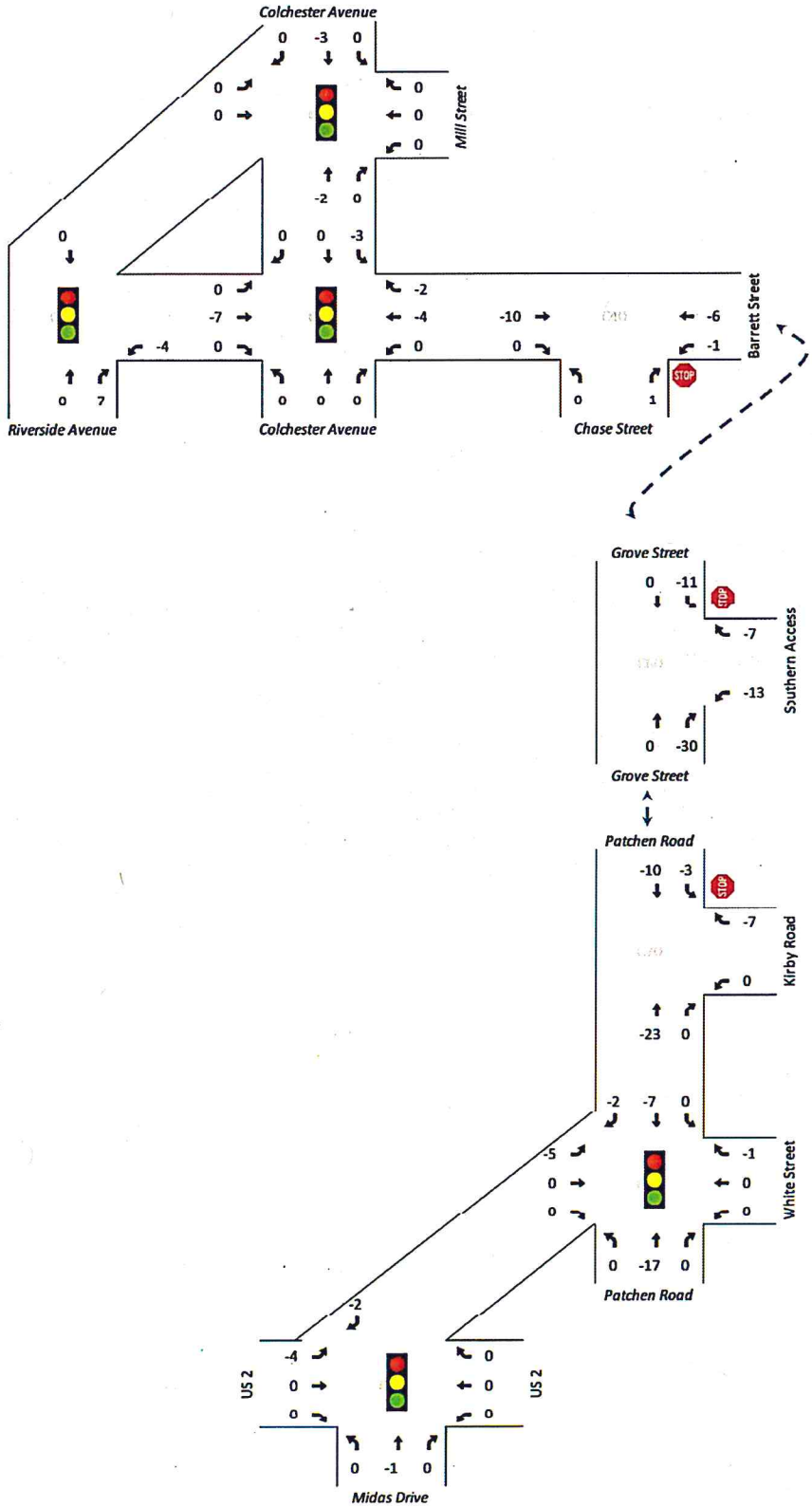
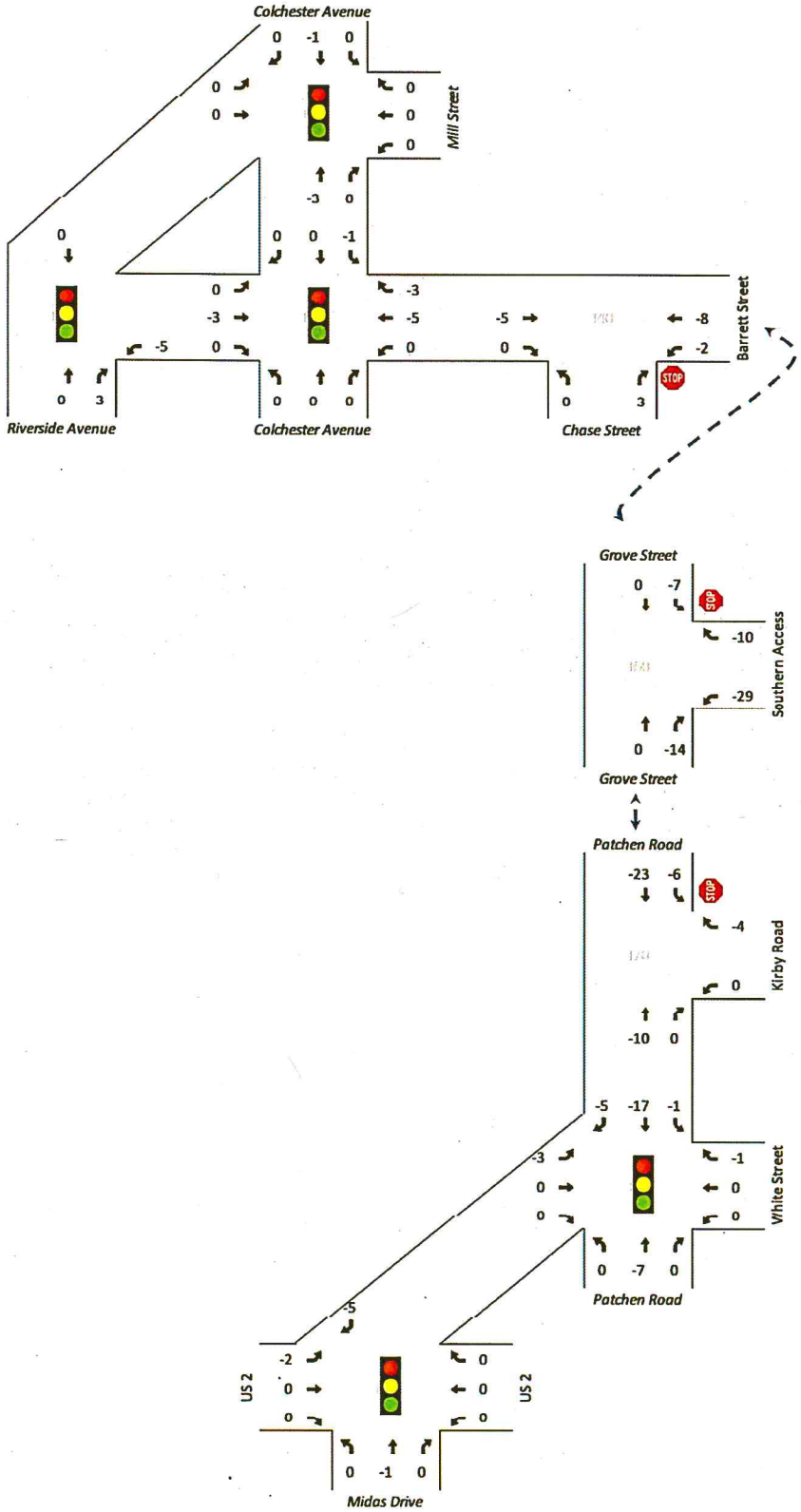


Figure 9: PM Peak Hour SD Ireland Concrete Trip Reduction



4.5 Scenario Volume Graphics

Weekday AM and PM peak hour volumes for the 2016 No Build and Build scenarios are presented in Figure 10 through Figure 13. No Build volumes represent the design hour adjusted count volumes plus the addition of other development traffic (ODVs) as noted above. Build scenario volumes add project generated traffic and remove existing Ireland concrete traffic from the No Build volumes.

Figure 10: 2016 AM Peak Hour No Build Scenario Volumes

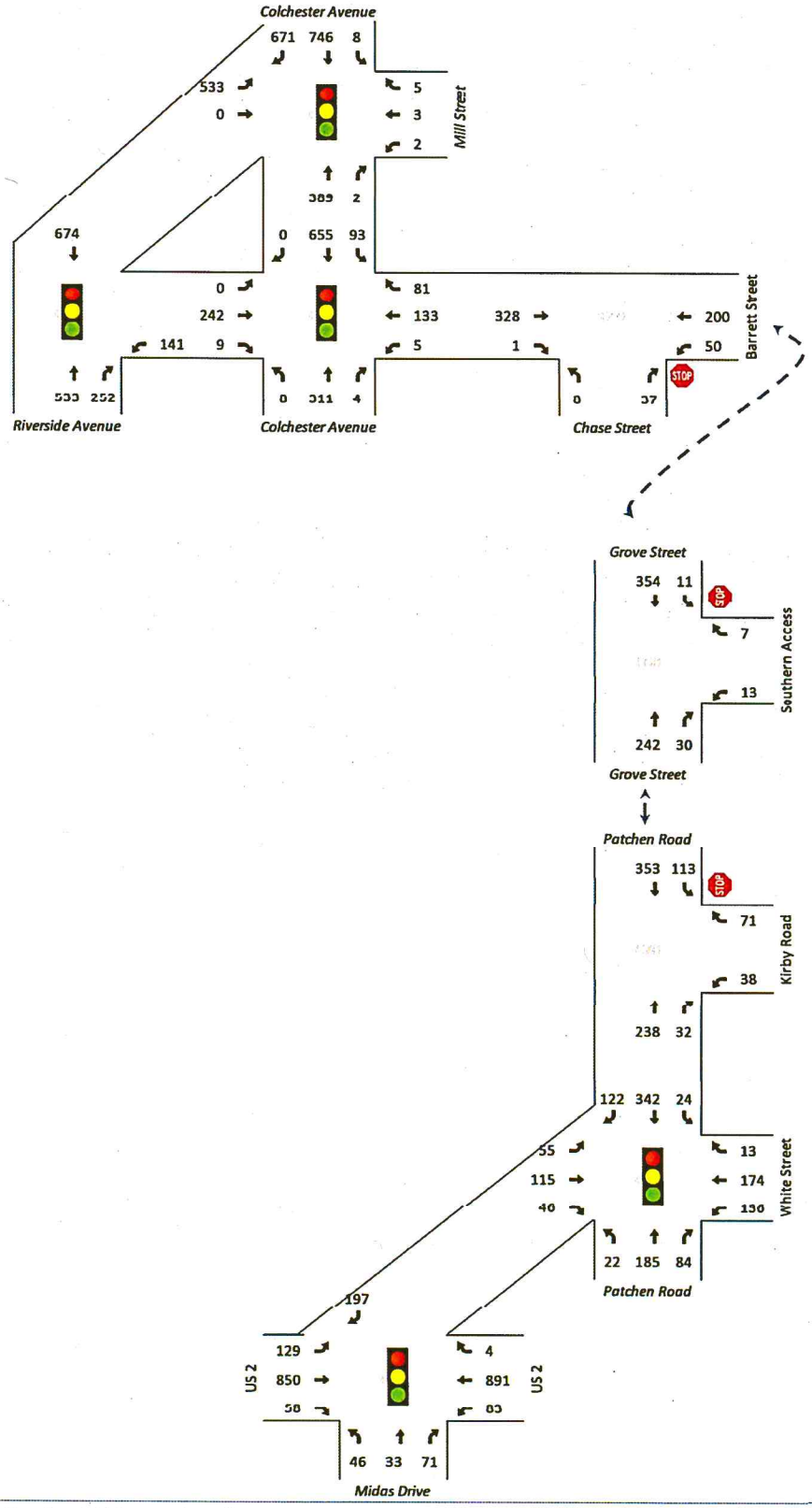


Figure 11: 2016 PM Peak Hour No Build Scenario Volumes

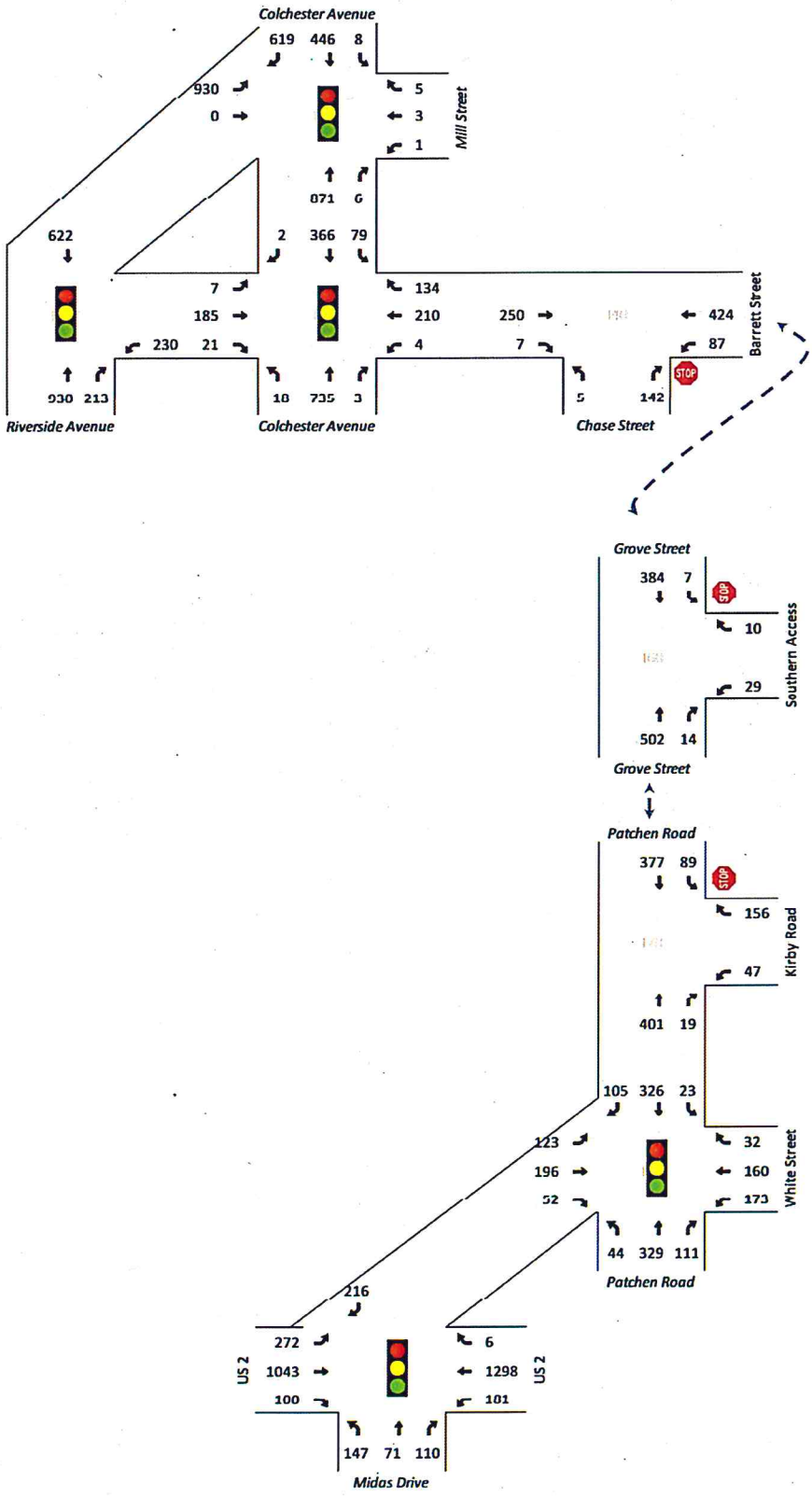


Figure 12: 2016 AM Peak Hour Build Scenario Volumes

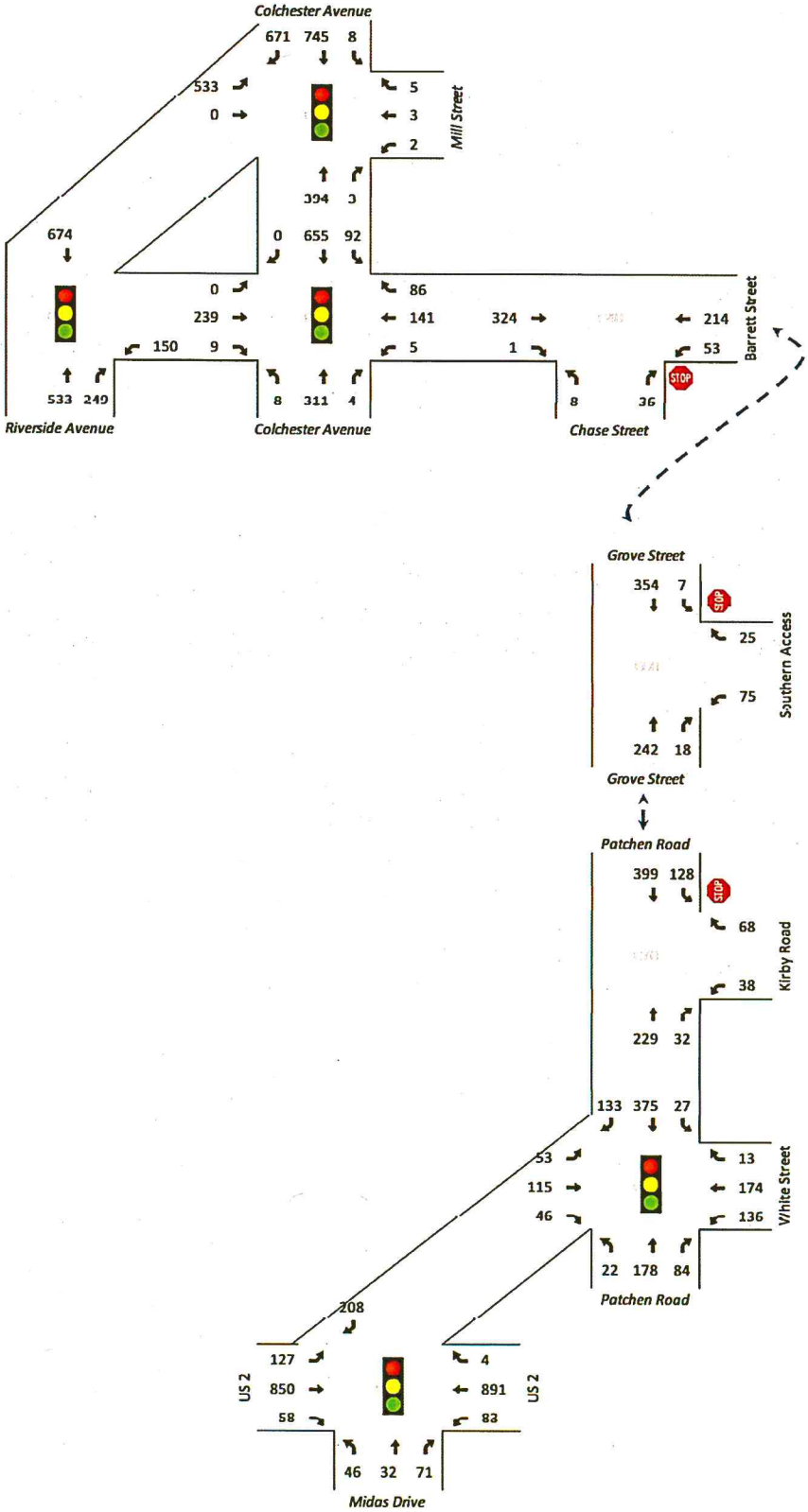
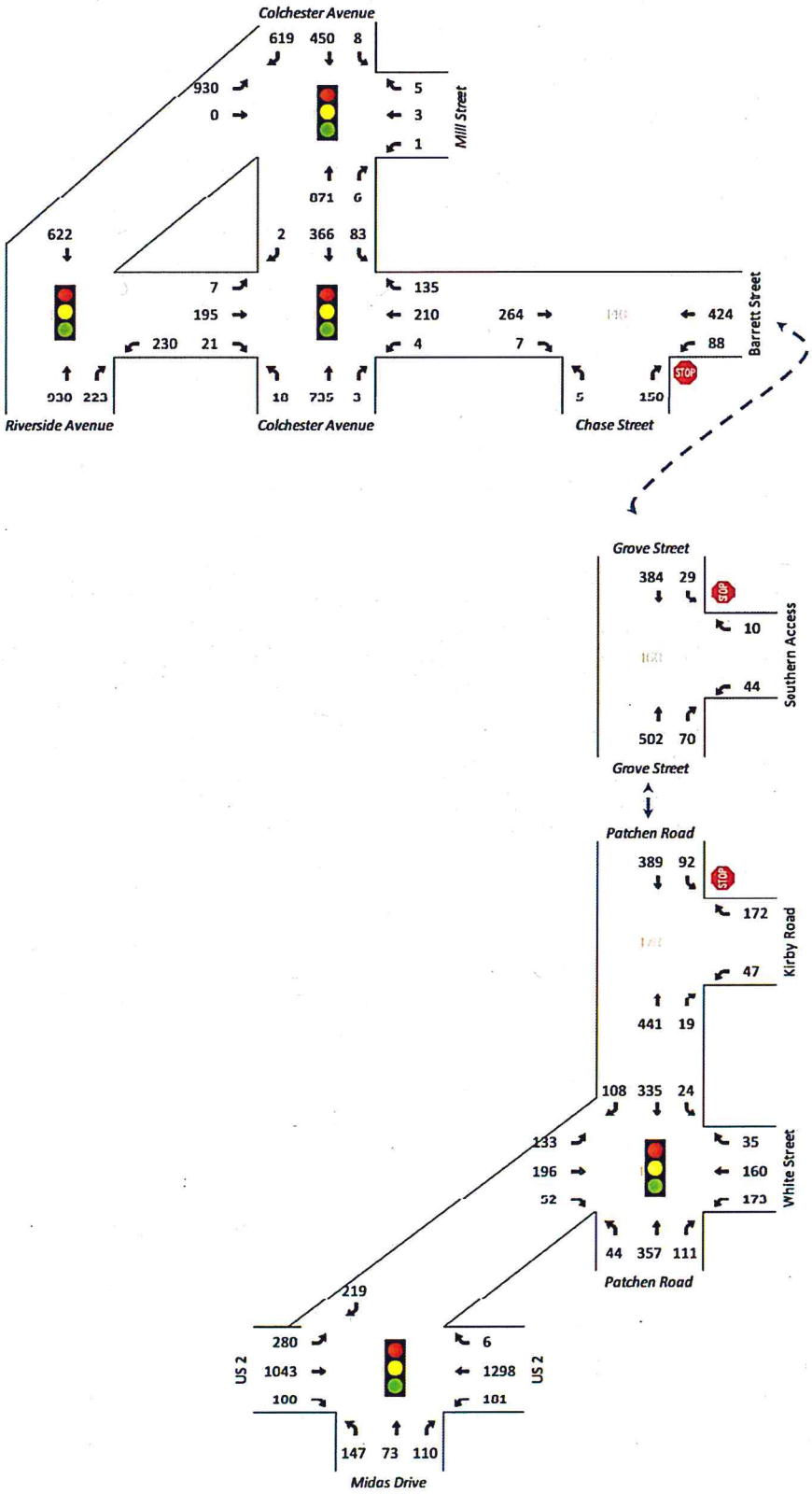


Figure 13: 2016 PM Peak Hour Build Scenario Volumes



5.0 CONGESTION ANALYSIS

5.1 Level-of-Service Definition

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

The 2000 Highway Capacity Manual defines six qualitative grades to describe the level of service at an intersection. Level-of-Service is based on the average control delay per vehicle. Figure 14 shows the various LOS grades and descriptions for signalized and unsignalized intersections.

Figure 14: Level-of-Service Criteria for Signalized and Unsignalized Intersections

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

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

The VTrans policy on level of service is:

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

5.2 Level-of-Service Results

The Highway Capacity Manual congestion reports within Synchro (v8), a traffic analysis software package from Trafficware, routinely relied upon by transportation engineering professionals, were used to assess congestion at the study intersections. Figure 15 and Figure 16 present the LOS results at signalized and unsignalized intersections, respectively.

As can be seen below, relatively long delays and Level of Service F conditions exist during the PM peak hour at the Riverside Avenue/Barrett Street/Colchester Avenue intersections and at the US 2/White Street intersection, with or without the addition of site-generated traffic. Delays at all other study area

intersections are projected to remain at acceptable levels and increase by 3 seconds per vehicle or less with the addition of project-generated traffic.

Figure 15: Level-of-Service Results at Signalized Intersections

Signalized Intersections	Level-of-Service Results											
	AM No Build			AM Build			PM No Build			PM Build		
	LOS	Delay	v/c	LOS	Delay	v/c	LOS	Delay	v/c	LOS	Delay	v/c
Colchester Ave/Riverside Ave/Mill St												
Overall	B	17	0.66	B	18	0.66	C	25	0.62	C	25	0.62
EB, exiting Riverside Ave	B	12	-	B	12	-	F	58	-	F	58	-
WB, exiting Mill St	D	41	-	D	41	-	D	40	-	D	40	-
NB, along Colchester Ave	A	4	-	A	4	-	A	5	-	A	5	-
SB, along Colchester Ave	C	23	-	C	23	-	B	12	-	B	12	-
Riverside Ave/Barrett St												
Overall	C	25	0.60	C	25	0.60	F	>100	0.75	F	>100	0.76
WB, exiting Barrett St	C	21	-	C	22	-	C	29	-	C	29	-
NB, along Riverside Ave	D	43	-	D	43	-	F	>100	-	F	>100	-
SB, along Riverside Ave	A	4	-	A	4	-	A	4	-	A	4	-
Colchester Ave/Barrett St												
Overall	B	18	0.68	C	20	0.69	F	>100	0.82	F	>100	0.83
EB, from Riverside Ave	A	7	-	A	7	-	A	8	-	A	8	-
WB, exiting Barrett St	E	74	-	F	84	-	F	>100	-	F	>100	-
NB, along Colchester Ave	B	19	-	B	20	-	D	43	-	D	43	-
SB, along Colchester Ave	A	5	-	A	5	-	A	3	-	A	3	-
Patchen Rd/White St												
Overall	B	17	0.62	B	18	0.66	C	26	0.71	C	27	0.73
EB, along White St	B	19	-	B	19	-	C	28	-	C	31	-
WB, along White St	C	30	-	C	31	-	D	51	-	D	53	-
NB, along Patchen Rd	A	10	-	A	10	-	B	16	-	B	16	-
SB, along Patchen Rd	B	13	-	B	14	-	B	14	-	B	15	-
US 2/White Street												
Overall	B	15	0.56	B	15	0.55	F	>100	1.08	F	>100	1.08
EB, along US 2	A	7	-	A	7	-	F	>100	-	F	>100	-
WB, along US 2	B	13	-	B	13	-	F	>100	-	F	>100	-
NB, exiting Midas Drive	D	50	-	D	50	-	F	89	-	F	90	-
SB, exiting White Street	D	35	-	D	35	-	D	44	-	D	44	-

Figure 16: Level-of-Service Results at Unsignalized Intersections

Unsignalized Intersections	Level-of-Service Results											
	AM No Build			AM Build			PM No Build			PM Build		
	LOS	Delay	v/c	LOS	Delay	v/c	LOS	Delay	v/c	LOS	Delay	v/c
Barrett St/Chase St												
EB Through/Right, along Barrett St	A	<1	0.19	A	<1	0.19	A	<1	0.15	A	<1	0.16
WB Left/Through, along Barrett St	A	2	0.04	A	2	0.04	A	2	0.07	A	2	0.07
NB Left/Right, exiting Chase St	B	11	0.07	B	11	0.07	B	11	0.19	B	11	0.20
Grove St/Site Access												
WB Left/Right, exiting Site Access	B	13	0.04	B	13	0.17	C	18	0.13	C	19	0.16
NB Through/Right, along Patchen Rd	A	<1	0.16	A	<1	0.15	A	<1	0.30	A	<1	0.34
SB Left/Through, along Patchen Rd	A	<1	0.01	A	<1	0.01	A	<1	0.01	A	<1	0.03
Patchen Rd/Kirby Rd												
WB Left/Right, exiting Kirby Rd	B	14	0.22	B	15	0.23	C	18	0.42	C	20	0.48
NB Through/Right, along Patchen Rd	A	<1	0.16	A	<1	0.15	A	<1	0.25	A	<1	0.27
SB Left/Through, along Patchen Rd	A	3	0.09	A	3	0.10	A	2	0.08	A	2	0.08

6.0 QUEUING ANALYSIS

In addition to the congestion analysis, estimated queues were evaluated using SimTraffic (v8).[1] The longest average maximum queues per intersection approach are presented in Figure 17. Relatively long queues currently exist within the Colchester Avenue/Riverside Avenue/Barrett Street triangle of intersections and remain in the build condition.[2] Afternoon peak hour queues are also relatively long on US 2 and queues of approximately 10 vehicles in length are experienced at the Patchen Road/White Street intersection, but are not expected to increase significantly with the addition of project traffic.

[1] Ten hour-long simulations were averaged together to estimate queue lengths. As each run is different, a difference in a few cars should not be seen as significant.

[2] Long WB queues on Barrett Street at Chase Street are the by-product of over-congested conditions at the Colchester Avenue/Barrett Street intersection and are not a result of conditions directly at the Barrett Street/Chase Street intersection.

Figure 17: Queuing Results (# vehicles)

		Average Queue Length in Vehicles			
		AM Peak Hour		PM Peak Hour	
		No Build	Build	No Build	Build
Colchester Ave/Riverside Ave					
	EB	3	3	5	4
	WB	0	1	0	0
	NB	0	0	1	1
	SB	39	37	22	27
Riverside Ave/Barrett St					
	WB	2	2	2	2
	NB	13	12	>50	>50
	SB	5	4	4	4
Colchester Ave/Barrett St					
	EB	2	2	2	2
	WB	11	17	29	29
	NB	8	10	>50	>50
	SB	4	3	3	4
Barrett St/Chase St					
	EB	0	0	0	0
	WB	1	2	27	27
	NB	0	0	1	1
Grove St/Site Access					
	WB	1	2	2	1
	NB	0	0	0	0
	SB	0	0	0	1
Patchen Rd/Kirby Rd					
	WB	2	2	3	3
	NB	0	0	0	0
	SB	2	2	2	2
Patchen Rd/White St					
	EB	5	5	8	10
	WB	7	7	10	10
	NB	5	5	9	12
	SB	8	9	8	10
US 2/White St/Midas Dr					
	EB	7	7	54	57
	WB	7	7	>50	>50
	NB	2	3	10	11
	SB	2	2	5	5

7.0 SAFETY ANALYSIS

Crash histories were collected from VTrans (January 2006-December 2010) for the study area. VTrans maintains a statewide database of all reported crashes along all state highways and federal aid road segments.[1] Patterns within the crash data were examined and VTrans designated High Crash Locations (HCLs) were investigated in greater detail.

Based on the most recent *VTrans High Crash Location Report* (2006-2010)[2], there are three designated High Crash Location (HCL) intersections within the study area.

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

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

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

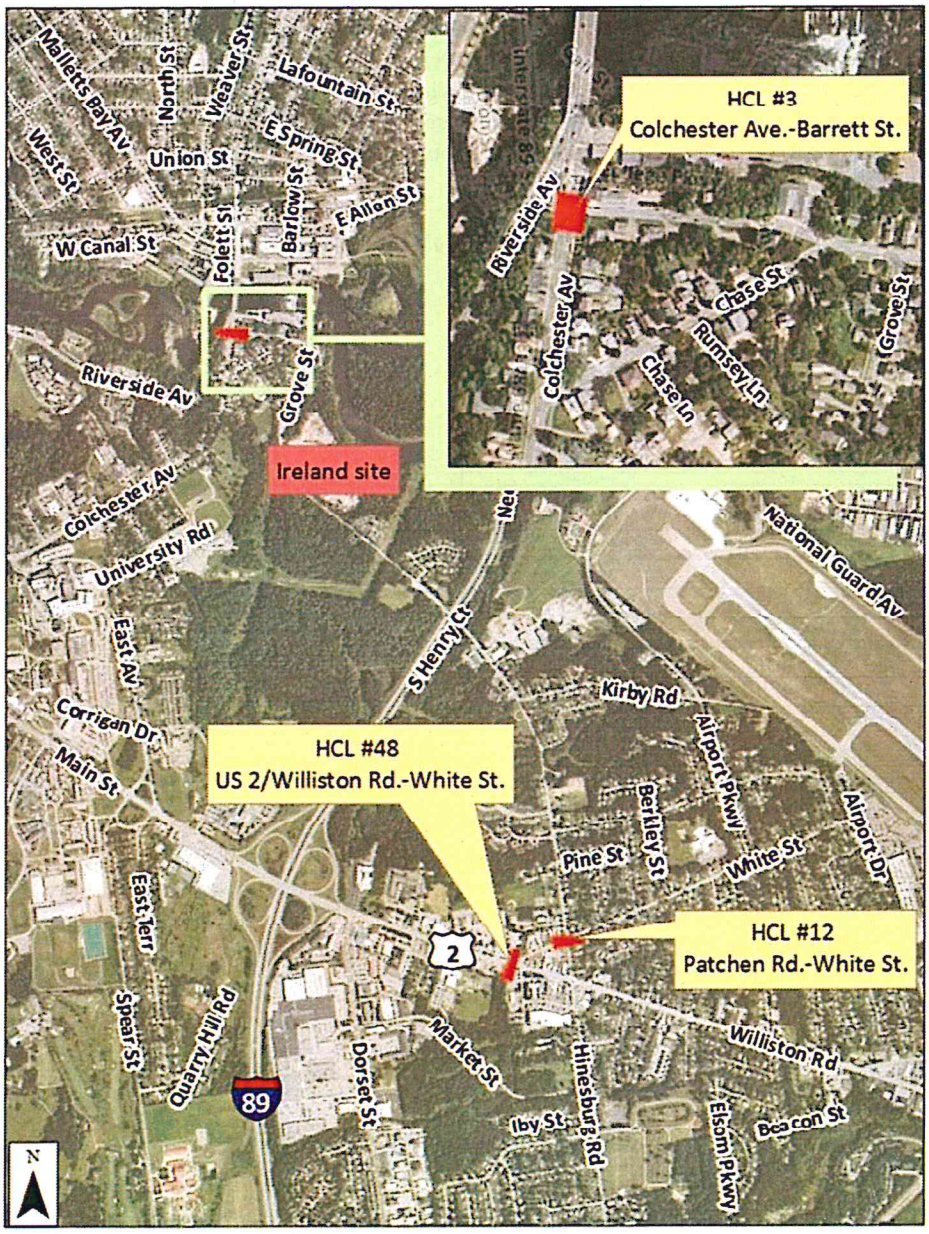
1. It must have at least 5 crashes over a 5-year period
2. The Actual Crash Rate must exceed the Critical Crash Rate.

Figure 18 presents the location of the three designated HCLs within the project study area. These include the Colchester Avenue/Barrett Street intersection, the Patchen Road/White Street intersection, and the US 2/White Street intersection. Figure 18 also presents each HCL's rank in the entire VTrans HCL listing, which currently includes 124 HCL intersections statewide.

During the 5 year period of HCL designation (from 2006-2010), there were 15 crashes reported along the entire length of Grove Street in Burlington, and 44 crashes reported along the entire length of Patchen Road in South Burlington. However, aside from the Patchen Road/White Street intersection, no other HCL locations exist along Grove Street or Patchen Road. During this same period there were a total 4 crashes reported in the area of the proposed site access location.[1]

[1] The area of influence of the site access intersections is assumed to be within the design stopping sight distance of either access location (155' for a 25 mph roadway).

Figure 18: 2006-2010 HCLs



7.1 Riverside Avenue/Colchester Avenue/Barrett Street

This intersection is the third highest ranked HCL intersection in the state. Out of the 41 reportable crashes cited in the VTrans HCL report, nine involved injuries and the rest were property damage only; there were no fatalities.

In considering this intersection, we broadened our investigation to include crashes at the entire Colchester Avenue/Riverside Avenue triangle, within which there were 88 crashes reported in this same 5 year period. Of these 88 crashes, 13 crashes (15%) resulted in 18 injuries. No crashes resulted in any fatalities.

Weather does not appear to be a factor in crashes as shown in Figure 19 and Figure 21. Most crashes were rear-ends, although there were 17 same direction sideswipes (19%) and 11 left-turn and through conflicts (13%) (Figure 20). After inattention and unknown factors, circumstances that contributed to crashes included disregard for traffic control elements, failure to yield right of way, and following too closely. Following too closely may be the primary cause of the 44 rear end collisions (50%); the same direction sideswipes and left-turn/through conflicts may be attributed to the failure to yield right of way and disregard for traffic control.

Figure 19: Crash Details for the Colchester Ave/Riverside Ave/Barrett St Triangle

Type	Head-On	5
	Left-Turn and Through	11
	Single Vehicle Crash	3
	Through Movement Broadside	2
	Rear End	44
	Same Direction Sideswipe	17
	Other	6
	Total	**88**

Weather	Clear/Cloudy	61
	Rain	6
	Snow	12
	Sleet/Hail	1
	Unknown	8
	Total	**88**

Contributing Circumstances	Disregarded traffic signs, signals, road markings	8
	Operating vehicle in erratic, reckless, careless, negligent, or aggressive manner	4
	Driving too fast for conditions	6
	Failure to keep in proper lane	4
	Followed too closely	8
	Failed to yield right of way	8
	Made an improper turn	4
	Other improper action	5
	Inattention	27
	Operating defective equipment	3
	Visibility obstructed	4
	Swerving or avoiding due to wind, slippery surface, vehicle, object, non-motorist in roadway etc	3
	Under the influence of medication/drugs/alcohol	1
	Unknown	18

Figure 20: Types of Crashes at the Colchester Ave/Riverside Ave/Barrett St Triangle

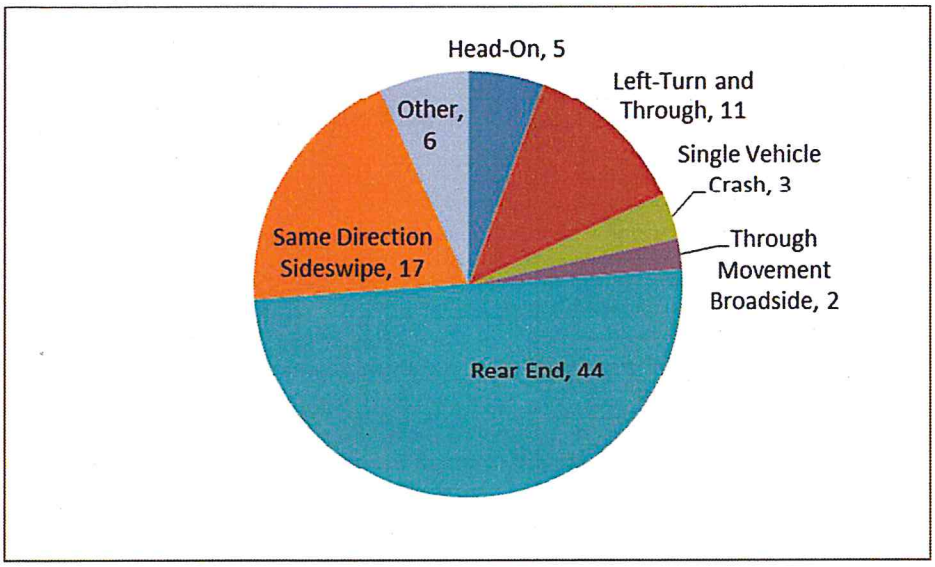
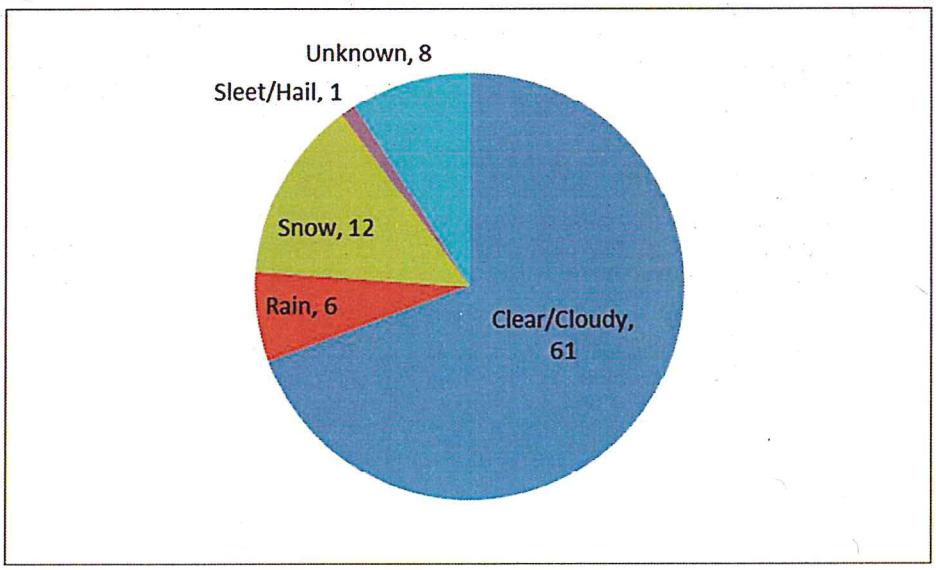


Figure 21: Weather Conditions during Crashes at the Colchester Ave/Riverside Ave/Barrett St Triangle



7.2 Patchen Road/White Street

This intersection is the twelfth highest ranked HCL intersection in the state. Out of the 40 reportable crashes cited in the VTrans HCL report, 6 involved injuries (15%) and the rest were property damage only; there were no fatalities.

Weather does not appear to be a factor in crashes as shown in Figure 22 and Figure 24. Many crashes were rear-ends, although there were 6 through-movement broadsides (15%) and 5 left-turn and through conflicts (13%) (Figure 23). Failure to yield right of way contributed to 10 crashes (25%) and could certainly be the reason there were so many through-movement broadside crashes. However, red-light running ("disregard for traffic signs, etc.") was only cited as a contributing circumstance in one crash.

Figure 22: Crash Details for the Patchen Road/White Street Intersection

Type	Head-On	2
	Left-Turn and Through	5
	Single Vehicle Crash	2
	Through Movement Broadside	6
	Rear End	20
	Same Direction Sideswipe	1
	Other	4
	Total	**40**

Weather	Clear/Cloudy	34
	Rain	2
	Snow	1
	Unknown	3
	Total	**40**

Contributing Circumstances	Disregarded traffic signs, signals, road markings	1
	Inattention	12
	Driving too fast for conditions	2
	Failure to keep in proper lane	2
	Followed too closely	6
	Failed to yield right of way	10
	Made an improper turn	2
	Other improper action	2
	Under the influence of medication/drugs/alcohol	2
	Unknown	4

Figure 23: Types of Crashes at the Patchen Road/White St Intersection

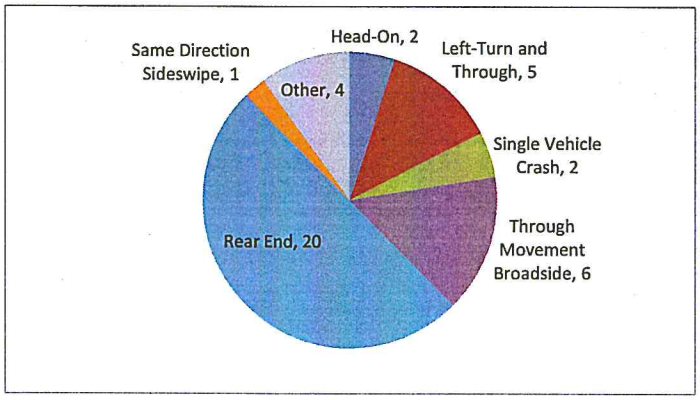
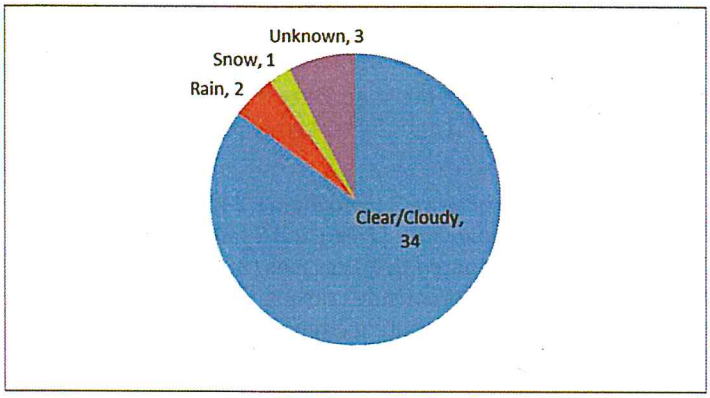


Figure 24: Weather Conditions during Crashes at the Patchen Road-White St Intersection



7.3 US 2/White Street

This intersection is the 48th highest ranked HCL intersection in the state. Out of the 62 reportable crashes cited in the VTrans HCL report, 4 involved injuries (7%) and the rest were property damage only; there were no fatalities.

Weather does not appear to be a factor in crashes as shown in Figure 25 and Figure 27. Most crashes were rear-ends, although there were 12 same direction sideswipes (19%), (Figure 26). After inattention, following too closely was the most frequently cited circumstance that contributed to crashes. It would easily be suspected that "failure to keep in proper lane" would be the primary reason for 12 same direction sideswipes (19%), but this was only cited in four crashes, so "inattention" may be the reason for these.

Figure 25: Crash Details for the US 2/White Street Intersection

	Left-Turn and Through	6
	Single Vehicle Crash	1
	Through Movement Broadside	3
	Rear End	33
	Same Direction Sideswipe	12
	Other	7
	Total	**62**

Weather	Clear/Cloudy	48
	Rain	10
	Sleet/Hail	2
	Unknown	2
	Total	**62**

Contributing Circumstances	Disregarded traffic signs, signals, road markings	1
	Operating vehicle in erratic, reckless, careless, negligent, or aggressive manner	3
	Failure to keep in proper lane	4
	Followed too closely	20
	Failed to yield right of way	12
	Made an improper turn	3
	Other improper action	4
	Inattention	26
	Visibility obstructed	3
	Swerving or avoiding due to wind, slippery surface, vehicle, object, non-motorist in roadway etc	3
	Under the influence of medication/drugs/alcohol	1
	Unknown	6

Figure 26: Types of Crashes at the US2/ White St Intersection

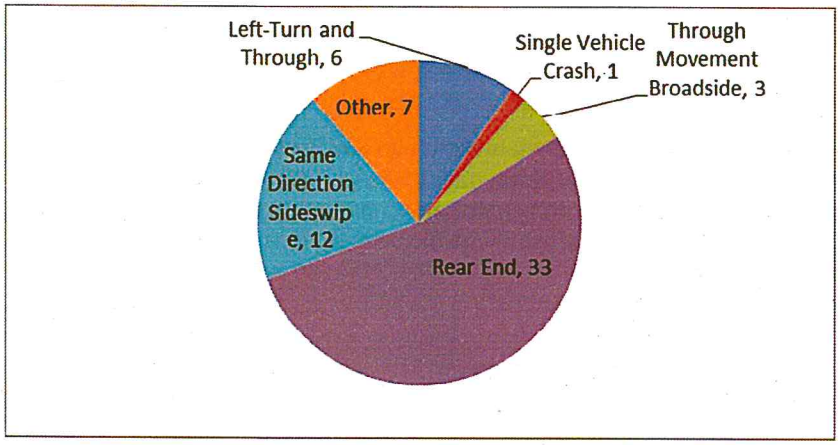
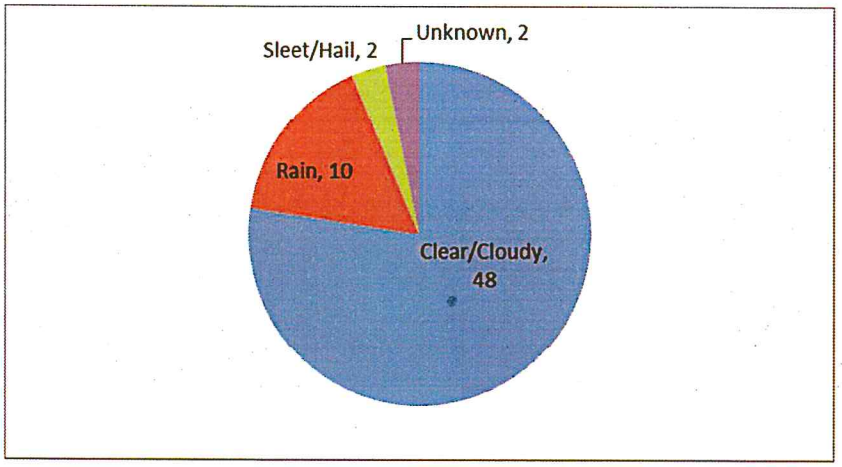


Figure 27: Weather Conditions during Crashes at the US2/Williston Road-White St Intersection



7.4 Sight Distance Assessment

As defined in the 2011 publication *A Policy on Geometric Design of Highways and Streets*, from the American Association of State Highway and Transportation Officials (AASHTO), sight distance is the "the length of roadway ahead that is visible to the driver."[1] Sight distances of sufficient length are necessary at all points along a roadway to ensure vehicles can safely stop or avoid colliding with potential obstructions or other vehicles on the roadway.

Standard practice in assessing intersection safety and operations involves measuring two separate sight distances – **stopping sight distance** and **intersection sight distance.**

7.4.1.1 Stopping Sight Distance

Stopping sight distance is the visible distance along a roadway between an advancing motorist and a potential obstacle in the roadway. It is measured from a point representing the approaching driver's eye and a point representing an obstacle in the roadway.[2] Stopping sight distances of adequate length are needed along all roadways, both at and away from intersections, so that drivers travelling at design speeds can react to potential obstacles and safely brake to avoid collisions. Design minimum stopping sight distances are calculated based on factors such as design speed, response times, and grades as reported in the *2011 Policy on Geometric Design of Highways and Streets.*[3]

At the project access, Grove Street has a posted speed limit of 25 mph and is relatively flat. The design minimum stopping sight distances at the project access is 155 feet.

Stopping sight distances both north and south of the project access were measured in the field and were found to be at least 400 feet north and south of the proposed access location, exceeding the design standard.

7.4.1.2 Intersection Sight Distance

Intersection sight distance is the distance available along the major road travelled way corresponding with the maximum visibility between an advancing motorist on the major road and an entering motorist on an intersecting minor road. It is measured between a point representing the advancing driver's eye above the major road and the entering driver's eye above the intersecting road.[4]

The *2011 Policy on Geometric Design of Highways and Streets* states that the available intersection sight distance should be at least equal to the required stopping sight distance along the major road, which in this case equals 155 feet.

> *"Sight distance is also provided at intersections to allow the drivers of stopped vehicles a sufficient view of the intersecting highway to decide when to enter the intersecting highway or to cross it. If the available sight distance for an entering or crossing vehicle is at least equal to the appropriate*

---

[1] American Association of State Highway and Transportation Officials, *A Policy on Geometric Design of Highways and Streets*, Fifth Edition (Washington D.C.: American Association of State Highway and Transportation Officials, 2011). Page 3-2.

[2] As noted in the *2011 Policy on Geometric Design of Highways and Streets (page3-14 to 3-15),* the height of the driver's eye is assumed to be 3.5' above the road surface and the height of a potential obstacle is 2.0' above the road surface.

[3] American Association of State Highway and Transportation Officials, *A Policy on Geometric Design of Highways and Streets*, Fifth Edition (Washington D.C.: American Association of State Highway and Transportation Officials, 2011). Page 3-5.

[4] As noted in the *2011 Policy on Geometric Design of Highways and Streets (page3-14 to 3-15),* the height of the driver's eye of the approaching vehicle is assumed to be 3.5' above the road surface of the major road and the height of the driver's eye of the entering vehicle is assumed to 3.5' above the minor road surface and 14.5' back from the edge of the major road travelled way. VTrans standard B-71 suggest the entering driver's eye should be measured 15' back from the edge of the major road travelled way and we have followed this practice in our measurements.

stopping sight distance for the major road, then drivers have sufficient sight distance to anticipate and avoid collisions."[1]

However, when possible it is desirable to have intersection sight distances that exceed the design minimum stopping sight distances in order to offer improved operations, such that major road traffic need not decelerate to accommodate entering traffic.

> *"However, in some cases a major-road vehicle may need to stop or slow to accommodate the maneuver by a minor road vehicle. To enhance traffic operations, intersection sight distances that exceed stopping sight distances are desirable along the major road."*[2]

Desirable target intersection sight distances are based on design speeds. For the section of Grove Street proximate to the project access, the design target intersection sight distance in either direction is 280 feet.

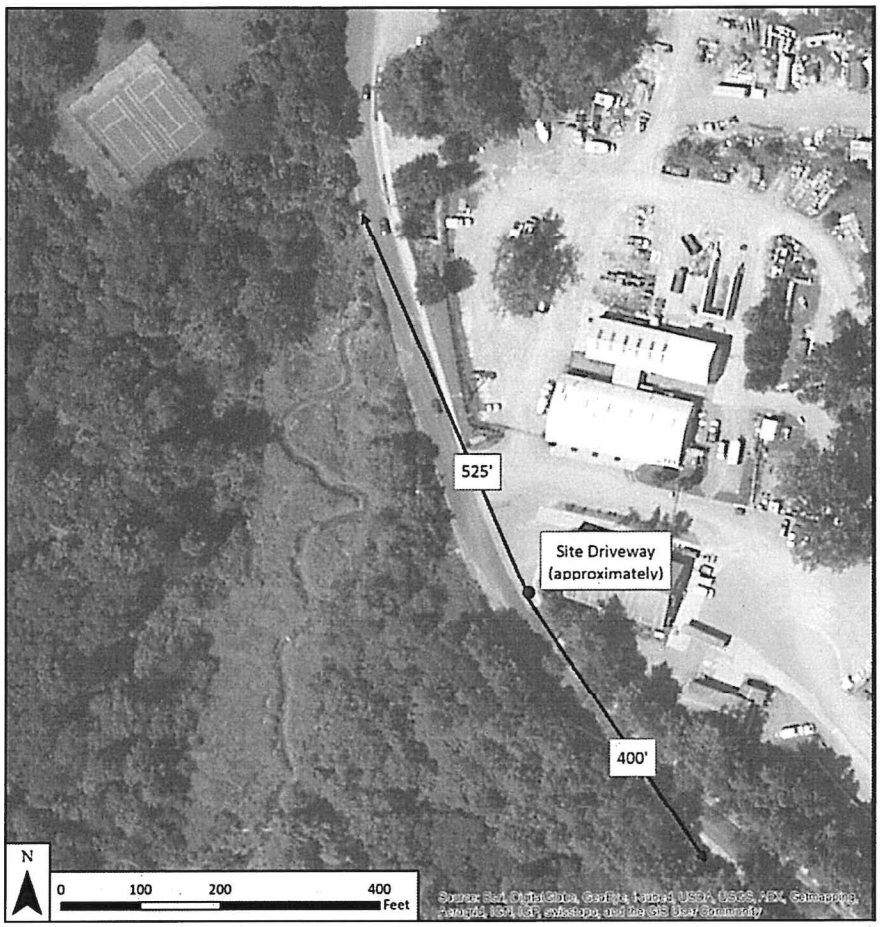
Intersection sight distances both north and south of the project access were measured in the field and were found to be at least 400 feet north and south of the proposed access location, exceeding both the design standard and desired target distance (Figure 28).

---

[1] American Association of State Highway and Transportation Officials, *A Policy on Geometric Design of Highways and Streets*, Fifth Edition (Washington D.C.: American Association of State Highway and Transportation Officials, 2011). Page 9-29

[2] American Association of State Highway and Transportation Officials, *A Policy on Geometric Design of Highways and Streets*, Fifth Edition (Washington D.C.: American Association of State Highway and Transportation Officials, 2011). Page 9-29

Figure 28: Measured Sight Distances



7.5 Turn Lane Warrant Assessment

In assessing the proposed site access, we conducted a turn lane warrant analysis to determine if projected peak hour traffic volumes are sufficient to meet warrant thresholds for construction of a dedicated left-turn lane into the site. Dedicated left-turn lanes have the safety and capacity benefits of removing left-turning traffic from the through volume traffic stream but also promote higher vehicle speeds and require increased pavement widths.

Using the scenario volumes, we conducted a left-turn lane warrant analysis at the Grove Street/Site Access intersection. Using Harmelink's methodology for unsignalized intersections, we found that volume warrants necessary for construction of a dedicated southbound left-turn lane are not met during the weekday PM peak hour at this site.

We also examined left-turn lane warrants using a second methodology developed by Kikuchi and Chakroborty (1991), which modified the Harmelink equation to correct errors in its application of queuing theory.[1] This method provided identical results to the Harmelink method.

[1] Larson, Larry & Fred L. Mannering, *Method for Prioritizing Intersection Improvements*, January 1997, Washington State Transportation Commission, Department of Transportation and U.S. Department of Transportation, Federal Highway Administration, 2 June 2003.

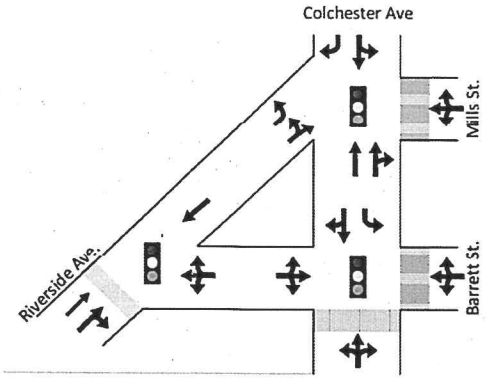
Based on this analysis we believe the proposed access configuration will effectively accommodate site generate traffic and do not recommend any additional turn lanes be constructed.

8.0 PLANNED ROADWAY IMPROVEMENTS

8.1 Colchester Avenue Corridor Plan

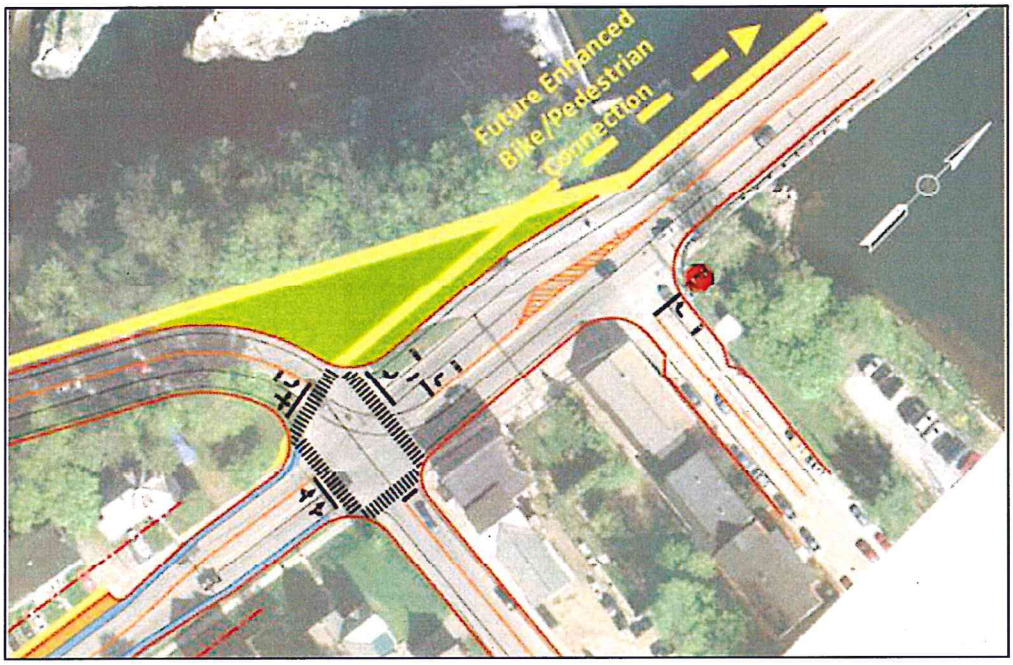
In 2011, RSG completed the *Colchester Avenue Corridor Plan* for the Chittenden County Regional Planning Commission (CCRPC).[1] This plan included recommendations for the Colchester Avenue/Riverside Avenue/Barrett Street intersection triangle, noting that the close spacing of the three traffic signals creates multiple conflict points and inefficiencies for vehicles, pedestrians, and bicyclists (Figure 29). To mitigate these issues, the Plan recommended consolidating the vehicle movements into one signalized intersection realigning Riverside Avenue to intersect Colchester Avenue directly opposite Barrett Street, and replacing the signal at Mill Street with a stop sign (Figure 30).

Figure 29: Existing Configuration at the Colchester Avenue/Riverside Avenue Triangle



[1] http://www.ccrpcvt.org/library/colchester_ave/20111219_Colchester_Ave_Corridor_Plan_Final.pdf

Figure 30: Proposed Consolidation Recommended in Colchester Avenue Corridor Plan



The Plan also recommends considering traffic calming measures for Chase Street, which is used as a cut-through for traffic between Colchester Avenue and Grove Street. Any traffic calming plan should follow the Burlington Traffic Calming and Neighborhood Enhancement Program process to gather input from neighbors and evaluate advantages and disadvantages.

8.2 Market Street Improvements

As part of the South Burlington City Center project, a new street connection is planned between Dorset Street and US 2 by connecting the existing Market Street with Midas Drive. Figure 31 presents the proposed street configuration, which includes a realignment of the US 2/White Street intersection, bringing White Street in alignment opposite Midas Drive, and construction of left-turn lanes on US 2. This configuration is intended to improve safety and operations at the intersection by eliminating the existing off-set White Street and Midas Drive approaches and by adding protected exclusive left-turn lanes on US 2. Improvements along Market Street are currently slated for fiscal year 2016 in the 2013-2016 CCRPC Transportation Improvement Program (TIP). Full improvements at the US 2/White Street intersection, are currently planned but are not yet included in the near term Transportation Improvement Program.

Figure 31: Proposed Roadway Alignment from Market Street Improvements[1]

[1] Market Street improvement layout was taken from the *South Burlington, Market Street Improvements STP 5200 (17) Revised Environmental Assessment*, VHB, May 2010.

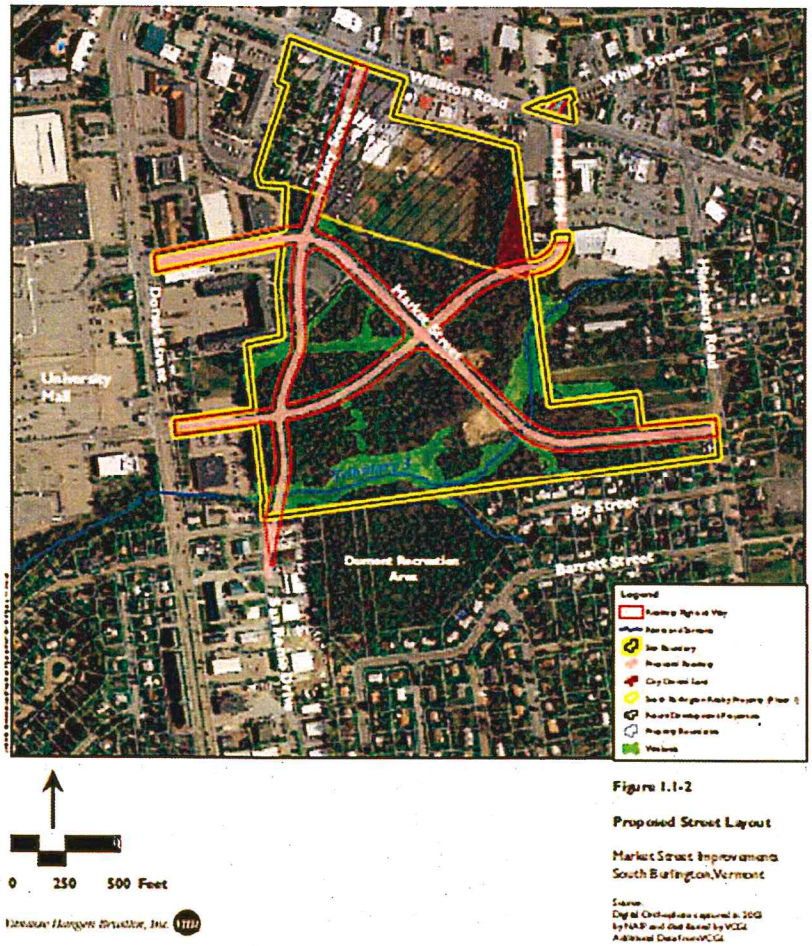


Figure 32: Recommended Pedestrian Warning Signs (MUTCD W11-2 and W16-7P)

8.3 Grove Street Traffic Calming and Pedestrian Improvements

The proposed project site plan includes reconfiguration of the site access and additional off-site roadway improvements in the area adjacent to the Grove Street/Site Access intersections. These improvements include construction of new sidewalk connections both north and south of the project site, new and repainted crosswalks, a new raised center island south of the project access, installation of a solar powered speed monitoring sign, relocation of an existing no parking sign on Grove Street south of Barrett Street, new curbing, and better designation of paved public parking. These enhancements, as proposed by O'Leary Burke Civil Associates, are presented in (Figure 33 and Figure 35).

These off-site improvements provide enhanced pedestrian connectivity between the project and existing pedestrian infrastructure in the area and improve the overall pedestrian environment in this area. They provide a critical pedestrian connection to the south by linking existing sidewalks in South Burlington with sidewalks in Burlington and Winooski. In addition to the pedestrian improvements called out below, we recommend the existing pedestrian warning signs at the north end of the paved public parking area be upgraded to new fluorescent yellow signs (W11-2) with diagonal arrows (W16-7P) indicating the crosswalk location, and that these be gate posted on either side of the crosswalk facing both northbound and southbound grove street traffic. We suggest similar signage be installed at the second crossing approximately 300 feet north of this parking area at the north end of the park.

Figure 33: Off-Site Pedestrian Improvements – South of Site

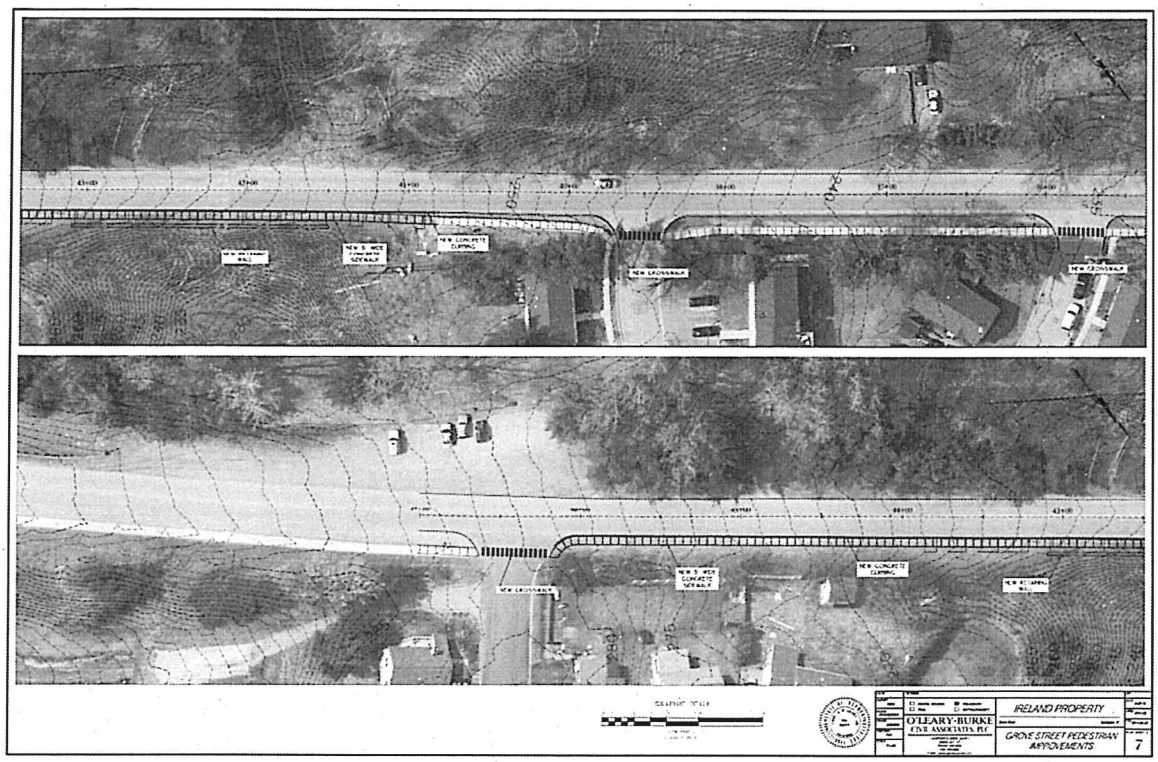


Figure 34: Off-Site Pedestrian Improvements – Adjacent to Site

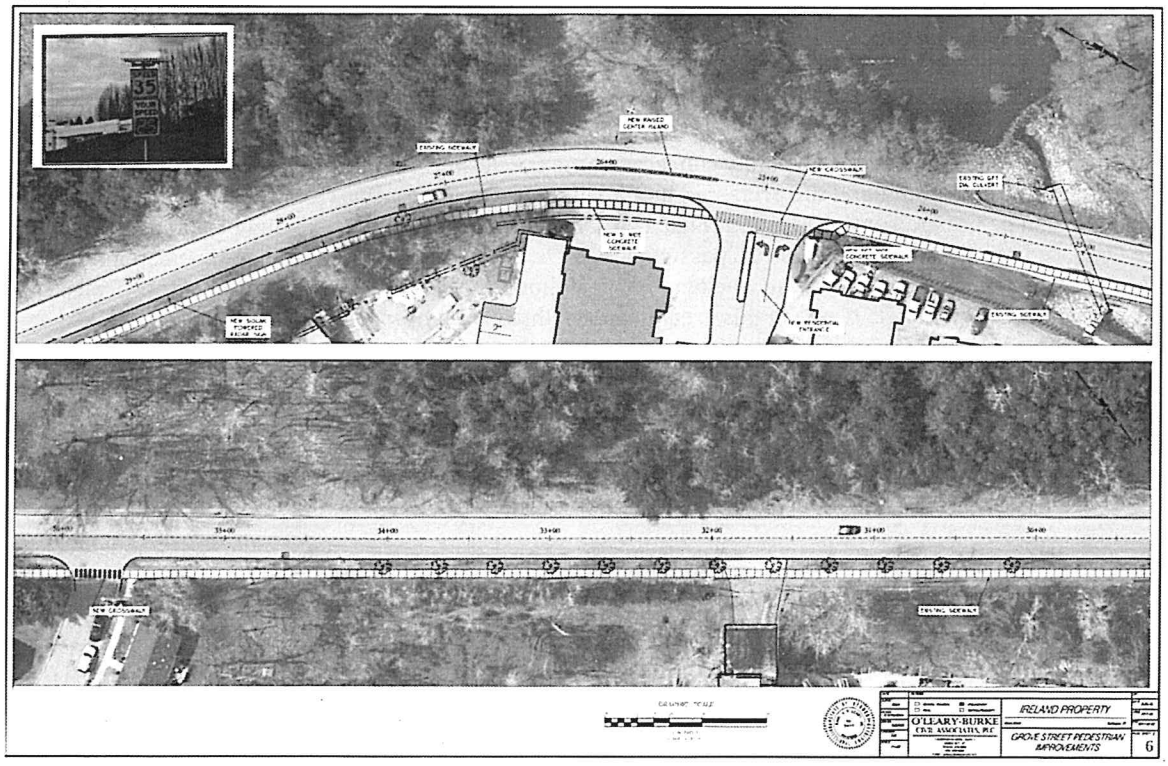
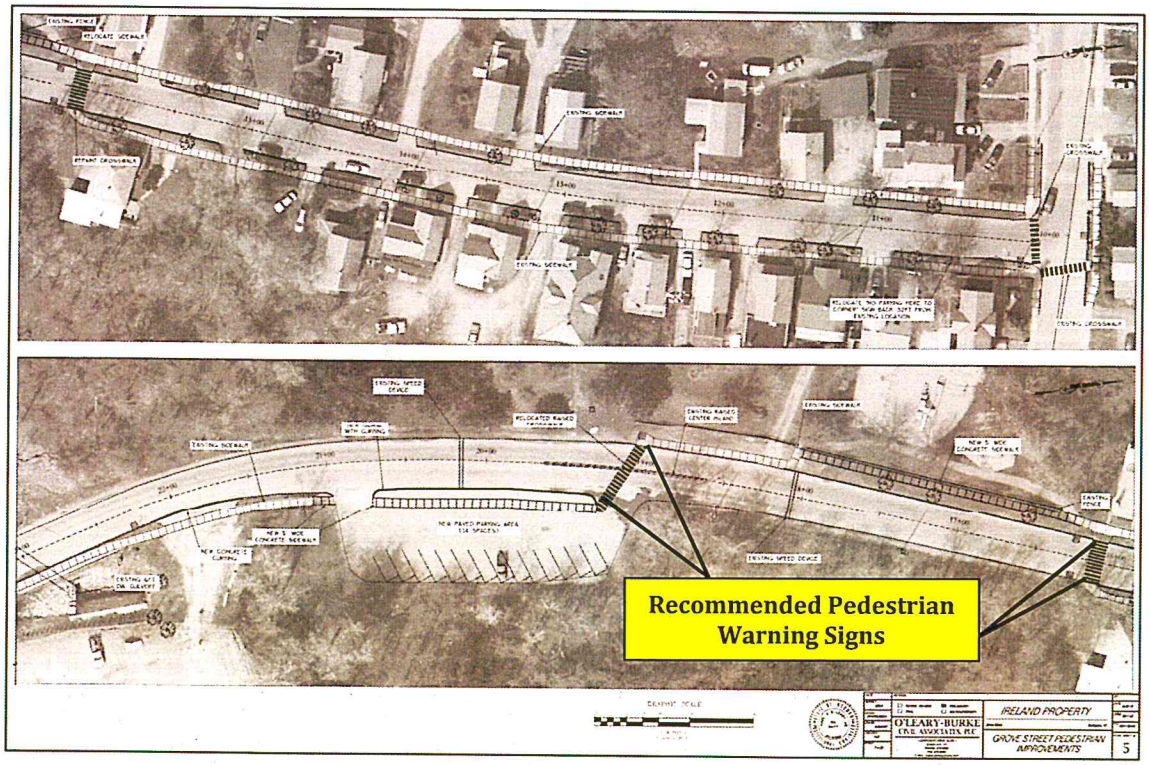


Figure 35: Off-Site Pedestrian Improvements – North of Site



9.0 RECOMMENDED MITIGATION MEASURES

9.1 Colchester Avenue/Riverside Avenue/Barrett Street

Due to the existing congestion and safety concerns at the Colchester Avenue/Riverside Avenue/Barrett Street triangle, we recommend the preferred intersection design alternative from the Colchester Avenue Corridor Plan be pursued at this location (Figure 30). However, this is a long existing problem, to which the proposed project would add only 26 passenger vehicle trips during the weekday AM peak hour and 27 passenger vehicle trips during the weekday PM peak hour. Additionally, construction of this project would reduce heavy vehicle traffic in this area by approximately 10 heavy vehicle trips per hour.[1] For cost sharing purposes, we project that construction of the Grove Street housing project will result in a net increase in traffic volumes at the Colchester Avenue/Riverside Avenue triangle of 0.36% during the AM peak hour (a net increase of 10 vehicle trips) and 0.43% during the PM peak hour (a net increase of 14 vehicle trips).[2]

[1] Additionally, some passenger vehicle trips associated with existing concrete plant staff would be eliminated with the proposed project.

[2] The December 2011 Colchester Avenue Corridor Plan, conducted by Resource Systems Group indicated an approximate project cost of $1.4 million to reconstruct the Colchester Avenue/Riverside Avenue/Barrett Street intersection triangle. Applying the peak hour percent increase in traffic associated with the proposed project (highest during the PM peak hour at 0.43%) to the estimated project cost results in a proportional project share of approximately $6,000.

9.2 US 2/White Street Intersection

The US 2/White Street intersection is currently slated for major improvements that will realign White Street opposite Midas Drive and will add left-turn lanes on US 2. These improvements are anticipated to improve overall intersection operations and safety. Improvements along Market Street are currently slated for fiscal year 2016 in the 2013-2016 CCRPC Transportation Improvement Program (TIP). Full improvements at the US 2/White Street intersection, are currently planned but are not yet included in the near term Transportation Improvement Program. The proposed project is expected to increase overall intersection volumes at this intersection by 0.41% during the weekday AM peak hour (a net increase of 10 vehicle trips) and by 0.38% during the weekday PM peak hour (a net increase of 13 vehicle trips).[1]

9.3 Patchen Road/White Street Intersection

At the Patchen Road/White Street intersection, overall LOS B is maintained during the weekday AM peak hour and overall LOS C is maintained during the weekday PM peak hour with the addition of project generated traffic. However, historic crash data indicates this area is a High Crash Location and intersection improvements here could improve overall operations and safety. Suggested Federal Highway Administration guidelines for determining if a protected left-turn phase is warranted at a signalized intersection state that if the product of the hourly left-turn volume and the hourly opposing volume exceeds 50,000, and there are more than 2 left-turn vehicles per cycle during that peak hour (or roughly more than 100 left-turns per hour) a protected left-turn phase should be considered.[2] At this intersection, both the eastbound left and westbound left turn movements exceed 100 left-turns per hour during the PM peak hour. However, the product of left-turn and opposing traffic is less than 50,000 for both approaches (~43,000 for the westbound approach and ~26,000 for the eastbound approach). The FHWA guidelines further indicate if 5 or more crashes involving left-turning vehicles occur within a 12 month period, a protected left-turn phase should also be considered. However, at this intersection there were 5 crashes involving left-turning vehicles in an entire 5 year period, rather than in any single year. While future conditions may indicate the addition of eastbound and westbound left-turn lanes and left-turn phasing is necessary, currently projected Build scenario volumes do not meet the recommended guidelines at this time. Additionally, the highest frequency crash type at this intersection was a rear-end collision, which comprised 20 of the 40 total crashes in the past 5 years of available data. Due to the high prevalence of rear-end collisions at this intersection we recommend advance intersection warning signs (MUTCD W3-3) be installed on the eastbound and westbound White Street approaches to this intersection. Similar signs currently exist on the northbound and southbound, Patchen Road approaches.

Figure 36: Recommended Warning Sign for White Street Approaches to Patchen Road/White Street Intersection

W3-3

The proposed project is expected to increase traffic volumes at the Patchen Road/White Street intersection by approximately 3% during the weekday AM and PM peak hours.

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[1] The August 2007 US 2 Corridor Study, conducted by Resource Systems Group indicated an approximate project cost of $3.94 million to reconstruct the US 2/White Street and US 2/Patchen Road intersections. Applying the peak hour percent increase in traffic associated with the proposed project (highest during the AM peak hour at 0.41%) to the estimated project cost results in a proportional project share of approximately $16,000.

[2] *Signalized Intersections: Informational Guide*, Federal Highway Administration, Publication No. FHWA-HRT-04-091, 2004. Table 118

10.0 Impact Fee Calculations

Within the City of Burlington new development projects are subject to various impact fees intended to help offset the costs associated with construction and maintenance of public infrastructure. Applying the proposed project's overall square footage of new housing (291,250 square feet) to the City's traffic impact fee calculator[1], we calculate traffic impact fees of approximately $53,600 for this project.

11.0 Conclusions and Recommended Mitigation Measures

11.1 Conclusions

9. The proposed Grove Street housing project would replace the existing SD Ireland concrete batch plant on Grove Street in Burlington, Vermont with a 247 unit apartment development.
10. Using trip generation rates presented by the Institute of Transportation Engineers (ITE) for this land use, we calculate this project would generate approximately 125 new vehicle trips during the AM peak hour (25 entering and 100 exiting) and 154 vehicle trips during the PM peak hour (100 entering and 54 exiting).
11. Removal of the existing SD Ireland concrete plant will result in a reduction of existing concrete plant traffic, including heavy vehicle and passenger car traffic, in this area. Based on average production levels and existing administrative operations at the plant, we expect this project to eliminate approximately 61 existing AM peak hour trips (41 entering and 20 exiting) and approximately 61 existing PM peak hour trips (22 entering and 39 existing) from the local roadways.
12. Long delays and Level of Service F conditions exist at the Riverside Avenue/Barrett Street and Colchester Avenue/Barrett Street intersections and at the US 2/White Street intersection, with or without the addition of site-generated traffic. Delays at all other study area intersections are projected to remain at acceptable levels and increase by fewer than 5 seconds per vehicle with the addition of project generated traffic.
13. A review of historic VTrans crash data identified three High Crash Locations within the study area at the Colchester Avenue/Barrett Street intersection, at the Patchen Road/White Street intersection, and at the US 2/White Street intersection.
14. RSG recently conducted the Colchester Avenue Corridor study as a planning document for the Chittenden County Regional Planning Commission and identified a preferred alternative for reconstructing the Colchester Avenue/Riverside Avenue intersection triangle and we recommend this improvement be pursued to improve both operations and safety in this area, with or without the proposed project.
15. At the US 2/White Street intersection, major improvements are currently planned as part of the City Center initiative and Market Street improvements project. Improvements on Market Street are currently slated for fiscal year 2016 in the 2013-2016 CCRPC Transportation Improvement Program (TIP). Full improvements at the US 2/White Street intersection, are currently planned but are not yet included in the near term Transportation Improvement Program.
16. At the Patchen Road/White Street intersection overall LOS B and LOS C conditions are maintained during the weekday AM and PM peak hours, respectively, with the addition of project generated traffic.

[1] http://www.burlingtonvt.gov/Content.aspx?id=2321

17. Using the City of Burlington's impact fee calculator, we calculate approximately $53,600 in traffic impact fees to be associated with the proposed project.
18. We have also examined the proposed site access on Grove Street and have found that stopping and corner sight distances exceed design standards in both directions.
19. We conducted a turn-lane warrant assessment and found that a dedicated left-turn lane is not warranted on Grove Street at the site access.
20. We project average vehicle delays of less than 20 seconds per vehicle for traffic exiting the site driveway and expect the access to operate safely and effectively.
21. We have examined plans for proposed off-site traffic calming and pedestrian accommodation improvements prepared by O'Leary Burke Civil Associates including new sidewalks, crosswalks, new curbing, new lighting, and a proposed solar powered speed feedback display.
22. We believe the proposed pedestrian improvements greatly enhance the existing infrastructure. The proposed sidewalk section south of the project site provides a critical pedestrian link between South Burlington and Burlington and Winooski, creating a continuous pedestrian route between these areas. Additionally, improved curbing signage and striping at crossings north of the project site will help improve pedestrian safety for all pedestrians in the area.

11.2 Recommended Mitigation Measures

23. We recommend a cost sharing allocation be paid by the developer to the City of Burlington towards eventual improvements at the Colchester Avenue/Riverside Avenue/Barrett Street intersection triangle. This area currently experiences long delays and has been identified for future improvements by the Chittenden County Regional Planning Commission c. While the proposed project does not cause this issue, we suggest the developer make a fair share contribution towards the ultimate intersection improvements based on the percent increase in peak hour traffic from the proposed project and the estimated cost of the overall improvement. Based on the larger peak hour percent increase in traffic (0.43% during the PM peak) and the estimated project cost ($1.4 million)[1], we calculate a fair share contribution of approximately $6,000.
24. We recommend a cost sharing allocation be paid by the developer to the City of South Burlington towards eventual improvements at the US 2/White Street intersection. This area currently experiences long delays and has been identified for future improvements by the Chittenden County Regional Planning Commission based on heavy use by existing traffic. While the proposed project does not cause this issue, we suggest the developer make a fair share contribution towards the ultimate intersection improvements based on the percent increase in peak hour traffic from the proposed project and the estimated cost of the overall improvement. Based on the larger peak hour percent increase in traffic (0.41% during the AM peak) and the estimated project cost ($3.94 million) [2], we calculate a fair share contribution of approximately $16,000.
25. Due to the high prevalence of rear-end collisions at the Patchen Road/White Street intersection we recommend advance intersection warning signs (MUTCD W3-3) be installed on both the eastbound and westbound, White Street, approaches to this intersection. Similar signs already exist on the northbound and southbound, Patchen Road approaches (Figure 36).

[1] The December 2011 Colchester Avenue Corridor Plan, conducted by Resource Systems Group indicated an approximate project cost of $1.4 million to reconstruct the Colchester Avenue/Riverside Avenue/Barrett Street intersection triangle.

[2] The August 2007 US 2 Corridor Study, conducted by Resource Systems Group indicated an approximate project cost of $3.94 million to reconstruct the US 2/White Street and US 2/Patchen Road intersections.

26. To enhance pedestrian connectivity and to improve pedestrian accommodations proximate to the project site, we recommend all off-site traffic calming and pedestrian enhancements identified by O'Leary Burke Civil Associates be installed prior to the first certificate of occupancy for the project.

27. In addition to the pedestrian enhancements proposed by O'Leary Burke Civil Associates we recommend the existing pedestrian warning signs at the crosswalk on Grove Street north of the paved public parking area (north of the project access) be upgraded to new fluorescent yellow warning signs (W11-2) and be accompanied by diagonal arrows indicating the crossing location (W16-7P) and that these signs be gate-posted for both northbound and southbound traffic prior to the first certificate of occupancy for the project. We recommend similar signage be installed at the second pedestrian crossing approximately 300 feet north of this parking area at the north end of the park.

28. Due to the tight turning radius for the southbound right-turn from Barrett Street onto Grove Street, we recommend the "No Parking Here To Corner" sign be relocated as indicated by O'Leary Burke Civil Associates, assuming Burlington Public Works is willing to accept the associated reduction in on-street parking.

In conclusion, we believe that if the above recommendations are followed, traffic associated with construction of the proposed Grove Street housing project will not cause unreasonable congestion or unsafe conditions on the surrounding road network.