

BROADVIEW ACCESS MANAGEMENT REVIEW

US 211/US17/29 BUS (BROADVIEW AVENUE), WARRENTON, VA

Date: August 27, 2018 Project #: 21905
To: Brandie Schaeffer, Town of Warrenton
From: Chris Tiesler, PE; Bradley Reynolds, PE; and Andy Butsick, PE

At the request of the Town of Warrenton, Kittelson & Associates, Inc. (Kittelson) performed a re-evaluation and review of Broadview Avenue access management improvements along US 211/US 17/29 BUS (Broadview Avenue) from south of Frost Avenue to south of Winchester Street in Warrenton, Virginia. The purpose of this assessment is to aid in identifying potential transportation solutions that improve corridor safety, mobility, and multi-modal operations while maintaining business access, accommodating aesthetic enhancements, and supporting economic development. Kittelson reviewed project information, reports and Preliminary Field Inspection (PFI) plans provided by the Town of Warrenton and Virginia Department of Transportation (VDOT).

Kittelson reviewed the following information, reports, and PFI plans:

- Comprehensive Plan 2000 - 2025, Town of Warrenton, June 11th, 2002
- Comprehensive Plan 2040 updates, Town of Warrenton, March 13th, 2018
- Broadview Access Management Study, VDOT, February 2013
- ADA/Access Management/Traffic Assessment Report, VDOT, April 2015
- Intersection Traffic Analysis (Broadview Avenue at Frost Avenue / Waterloo Street), VDOT, September 2015
- Smart Scale Technical Guide, August 2017
- Walkability Audit Report, September 2017
- Complete Streets Report, September 2017
- Broadview Avenue Presentation (Business Owner's Focus Group), VDOT, January 25th, 2018
- Traffic Sampling on Broadview Avenue Memorandum, Town of Warrenton, May 4th, 2018
- VDOT 30 Percent PFI Plans, VDOT, *Received April 4th, 2018*
- VDOT 30 Percent PFI Plans, VDOT, May 14th, 2018

Kittelson's re-evaluation and review of Broadview Avenue access management improvements focused on the following four (4) components:

- Intersection Improvements at Broadview Avenue and Frost Avenue / Waterloo Street
- Access Management Improvements
- Interparcel Connectivity
- Signal Warrant Review at Broadview Avenue and Gold Cup Drive

1.0 INTERSECTION IMPROVEMENTS AT BROADVIEW AVENUE AND FROST AVENUE

At Broadview Avenue and Frost Avenue / Waterloo Street intersection, the following reports, plans, or concepts were reviewed, analyzed, or developed as part of this intersection assessment:

- ADA/Access Management/Traffic Assessment Report, VDOT, April 2015
- Intersection Traffic Analysis (Broadview Avenue at Frost Avenue / Waterloo Street), VDOT, September 2015
- Walkability Audit Report, September 2017
- Complete Streets Report, September 2017
- VDOT 30 Percent PFI Plans, VDOT, May 14th, 2018
- Town of Warrenton Preferred Intersection Concept
- Partial Displaced Left-Turn Intersection Concept

The *ADA/Access Management/Traffic Assessment Report, VDOT, April 2015* and *Intersection Traffic Analysis, VDOT, September 2015* recommended to construct Alternative 2 geometric improvements to provide more safety for pedestrians and access along westbound Frost Avenue, while improving operations at the study intersection. Intersection improvements to mitigate operational deficiencies include:

- Provide signalized southbound dual right-turn lanes on Broadview Avenue.
- Provide signalized northbound dual left-turn lanes on Shirley Avenue.
- Provide pedestrian accommodations based on modified geometry.
- Install median on Broadview Avenue. Provide first median break approximately 425 feet north of intersection for northbound left-turns/U-turns.
- Install median on Shirley Avenue. Provide first median break approximately 250 feet south of intersection for Wawa and Waterloo Station Shopping Center.

The *VDOT 30 Percent PFI Plans, VDOT, May 14th, 2018* provided designs very similar to Alternative 2 geometric improvements but with the following notable modifications:

- Install median on Broadview Avenue. Provide first median break approximately 800 feet north of intersection for northbound left-turns/U-turns.
- Install median on Shirley Avenue. Provide first median break approximately 600 feet south of intersection for southbound left-turns/U-turns.

Town of Warrenton Preferred Intersection Design

In consultation with the Town of Warrenton's decision makers and staff, the Town's preferred intersection design is consistent with VDOT's recommended Alternative 2 geometric improvements to provide more safety for pedestrians and access along westbound Frost Avenue while improving operations at the study intersection, with minor access break modifications. In **Appendix A, Figures 1A**

and 1B illustrate the Town's preferred concept at Broadview Avenue at Frost Avenue. Intersection improvements to mitigate operational deficiencies include (proposed geometric modifications in **bold**):

- Provide signalized southbound dual right-turn lanes on Broadview Avenue.
- Provide signalized northbound dual left-turn lanes on Shirley Avenue.
- Provide pedestrian accommodations based on modified geometry.
- Install median on Broadview Avenue. Provide first median break approximately **400 feet north of intersection for southbound left-turns/U-turns to access Frost properties.**
- Install median on Shirley Avenue. Provide first median break approximately 250 feet south of intersection **for left-in/right-in/right-out access to Wawa. Install driveway island at Wawa to restrict left-out movement.**

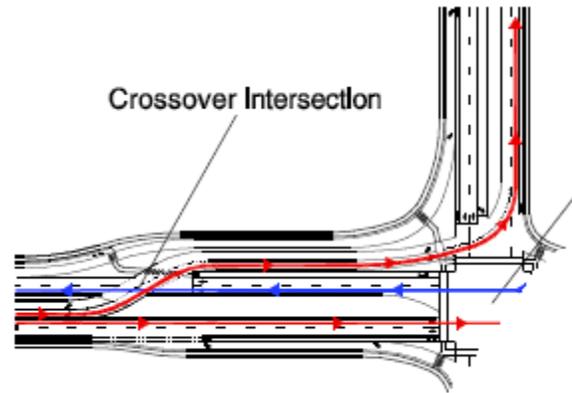
Partial Displaced Left-Turn Intersection Concept

Future traffic volumes and operations of the Broadview Avenue at Frost Avenue / Waterloo Street intersection were reviewed and re-evaluated to identify potential intersection improvements or modifications that can provide safe, efficient, and acceptable operations while maintaining access to businesses.

The VDOT Junction Screening Tool (vJuST) was utilized to screen alternative intersections to assess planning-level feasibility. Based on the initial screening using future 2040 weekday a.m., weekday p.m., and Saturday midday peak hour volumes and a review of the study area intersection, a partial displaced left-turn (DLT) intersection, also referred to as a continuous flow intersection (CFI) appeared to be a competitive improvement option from a congestion, pedestrian, and safety perspective. A DLT was previously screened out in the 2015 VDOT study.

A one-leg partial DLT intersection concept was developed to evaluate its operational feasibility, while considering its footprint, impacts to adjacent businesses, and cost. This concept relocates the Frost Avenue eastbound left-turn movements to the other side of the opposing Frost Avenue eastbound traffic flow and provides a southbound right-turn bypass lane. Crossing over the heavy eastbound left-turns allows this movement to proceed simultaneously with the through movements and eliminates the left-turn phase for this approach (or split phase), thereby reducing the number of existing signal phases. This configuration also reduces the number of conflict points from a conventional intersection, which can result in improved traffic operations and safety performance. The signal green time previously allocated for the left turns under existing conditions could be reallocated, including to accommodate pedestrian crossings.

- Partial DLT (Frost Avenue eastbound approach) – Provide signalized two-phase eastbound dual left-turns in advance of main intersection. Provide signalized dual southbound right-turns via bypass lane. Provide northbound dual left-turns. Restrict westbound left-turn or only allow permitted westbound left-turns. Realign Rappahannock Street as right-in/right-out to right-turn bypass lane. Accommodates pedestrian crossings with protected phasing.



In **Appendix A, Figure 2** illustrates the partial displaced left-turn intersection preliminary concept (illustration does not reflect analyzed geometry). **Figure 3** shows an example of a similar partial displaced left-turn intersection at Beechmont Avenue and Five Mile Road in Ohio.

Operational analysis of the future 2040 weekday a.m., weekday p.m., and Saturday midday peak hour volumes were developed for the study intersection in accordance with the Highway Capacity Manual (HCM) for signalized intersections using Synchro 9 and SimTraffic software. Overall, the DLT is projected to operate at LOS B in 2040 for the weekday a.m., weekday p.m., and Saturday peak hours with minimal queues. Comparatively, the DLT provides greatly improved operations and reduced queues over the No-Build condition and the recommended Alternative 2 from the VDOT 2015 study.

Table 1 summarizes the HCM Level of Service (LOS). **Table 2** summarizes the resulting 95th percentile queues based Synchro analysis. **Table 3** provides a general list of DLT advantages and disadvantages for consideration in reevaluation. **Appendix B** provides detailed Synchro analysis results and queuing results. **Appendix C** provides vJuST worksheet results.

Table 1. 2040 Capacity Analysis Results

Intersection	Alternative	Weekday AM Peak Hour			Weekday PM Peak Hour			Saturday Midday Peak Hour		
		LOS	Delay (sec.)	v/c	LOS	Delay (sec.)	v/c	LOS	Delay (sec.)	v/c
Broadview Avenue / Frost Avenue / Waterloo Street / W Shirley Avenue	No-Build	E	59.0	0.72	F	192.7	1.44	F	173.9	1.32
	VDOT Alternative 2 ¹	D	44.8	0.68	E	55.7	0.83	E	69.9	0.91
	Partial DLT ²	B	18.1	0.37	B	20.0	0.53	B	19.4	0.45
Frost Avenue / Eastbound DLT Crossover	Partial DLT ²	B	16.1	0.37	B	14.5	0.67	B	12.8	0.56
Broadview Avenue / Eastbound DLT Crossover	Partial DLT ²	A	7.8	0.47	A	9.9	0.85	A	9.9	0.88

¹Includes dual-SBRT lanes and dual-NBLT lanes, as outlined in September 2015 study

²Includes partial displaced left-turn intersection with dual-SBRT lanes, dual-NBLT lanes, and restricted westbound left-turns

Table 2. 2040 Peak Hour 95th Percentile Queue Lengths

Alternative	Approach	Lane Group	Storage Available (ft)	95 th Percentile Queue Length (ft)		
				AM	PM	SAT
VDOT Alternative 2	EB	L	-	496	539	808
		LT	-	481	483	755
		R	605	-	-	507
	WB	LT	290	164	355	216
		T	-	111	303	165
		R	225	64	88	111
	NB	L	500	197	504	212
		T	-	259	356	257
		R	-	226	348	234
	SB	L	250	174	202	265
		T	-	217	347	228
		R	400	-	355	206
Partial DLT	EB	L	350	102	222	275
		T	-	138	105	104
		R	605	44	8	45
	WB	T	-	41	125	60
		R	225	31	51	51
	NB	L	500	93	155	113
		TR	-	144	231	216
	SB ¹	L	250	337	332	361
		T	-	117	232	180
		R	-	-	-	

¹Cumulative SB queues between main intersection and adjacent DLT intersection

Table 3. Summary of DLT Advantages and Disadvantages*

Advantages	Disadvantages
Non-Motorized Users	
Bicycles and pedestrians can be accommodated at-grade	Pedestrians may require 2-stage crossings
Bicyclists have refuge (room for bicycle box) in making two-stage left turns	Some indirect movements may be necessary for pedestrians
	Longer pedestrian crossings
	Unique challenges for visually impaired pedestrians
Safety	
Fewer conflict points than interchanges (ramp terminals, exit/entrance ramps) and conventional intersections	Drivers may be less familiar with intersection
Lower delay and fewer stops on major street could reduce rear-end crash rates	Potential for wrong-way movements
	Issues with signal in flashing mode / going dark
Operations	
Increase in lane-by-lane capacity due to efficient 2-phase or 3-phase signal operation	Complex signal operations
Compatible with high-volume turning movements	Pedestrian crossing time and phasing may limit cycle length flexibility
More green time for major movements offers better progression when used as a corridor solution	Potential for additional user delay during off-peak periods
	No right-turn on red without bypass right-turn lane
Access Management	
Compatible with access-restricted corridors	May change ingress/egress patterns to corner businesses or development
	Medians and wide separators required
Cost and Right-of-Way Impact	
Smaller footprint than interchange	Required right of way likely larger than conventional intersection
Lower cost than interchange	More traffic signals, pavement, curbs and median/refuge islands

*Exhibit 2-6, FHWA Displaced Left Turn Intersection Informational Guide, August 2014

While a one-leg partial DLT intersection concept provides certain advantages, this alternative intersection design is not recommended for further study or implementation at this location due to the disadvantages and the ability of conventional geometric improvements to meeting desired project goals.

2.0 ACCESS MANAGEMENT IMPROVEMENTS

The *ADA/Access Management/Traffic Assessment Report, VDOT, April 2015* provided access management recommendations and indicated the proposed improvements of installing a raised median with left-turn lanes at the median openings and intersections, capacity improvements at Frost Avenue / Waterloo Street, driveway and turning movement restrictions, and improving pedestrian and bicycle accommodations will effectively improve safety along the corridor. In general, the study recommended the following:

- Installation of medians – A total of 10 median breaks within the Broadview Avenue study corridor, the same number of median breaks proposed in the *Broadview Access Management Study, VDOT, February 2013*.
- Installation of left-turn lanes.
- Turning movement restrictions.
- Driveway access restrictions.
- Improved lighting.
- Improved pedestrian and bicycle facilities – Improved sidewalk, ADA facilities, and 5' bike lanes.
- Driveway consolidation (4 driveways consolidated).
- U-turn geometry to accommodate passenger cars.
- Restrict Broadview Avenue at Gold Cup Drive / Stuyvesant Street to left-in/right-in/right-out.
- Restrict Broadview Avenue at Old Broadview Avenue / Roebing Street to left-in/right-in/right-out.
- Install marked uncontrolled pedestrian crossing between Gold Cup Drive and Stuyvesant Street intersections.
- South of Frost Avenue, median break to access Wawa and Waterloo Station Shopping Center.

Since completion of the 2015 study, VDOT's most recent 30 Percent PFI Plan is dated May 14th, 2018. This plan is similar to the 2015 study but has the following general modifications:

- A total of 9 median breaks from 10 (removal of the median break at Burger King and Frost Diner) with two median breaks no longer shown with back-to-back left-turns.
- Removed uncontrolled pedestrian crossing between Gold Cup Drive and Stuyvesant Street intersections.
- South of Frost Avenue, removed median break to access Wawa and Waterloo Station Shopping Center and extended median further south to Fox Den Antique Mall.
- Restricted all median breaks to directional left-in/right-in/right-out.

Town of Warrenton Preferred Access Management Concept

Overall, the VDOT 30% PFI Plan design approach is an appropriate traffic engineering solution to improve safety, mobility, and operations but can be in conflict with local interests and business access. The Broadview corridor includes unique challenges such as a high-volume corridor, local versus thru trips, corridor travel speeds, maintaining acceptable business access, right-of-way constraints, lack of interconnectivity, numerous driveway cuts, intersection spacing limitations, U-turn design vehicle

accommodations, bicycle accommodations, pedestrian crossing accommodations, and maintaining the Town's vision of this corridor.

In consultation with the Town of Warrenton's decision makers and staff, Kittelson has prepared an access management concept plan reflective of the Town of Warrenton's preferred concept that modifies VDOT's plan to provide a four-lane facility with landscape medians and center two-way left-turn lanes (CTWLTL) and buffered bike lanes along the Broadview Avenue corridor. This conceptual plan attempts to incorporate developed design studies and established project goals, as detailed in the ADA/Access Management/Traffic Assessment Report, VDOT, April 2015, along with the Town of Warrenton's vision for the corridor and complete street initiatives by implementing the following:

- Installation of medians and center two-way left-turn lanes – A total of approximately 8 median breaks/CTWLTL segments within the Broadview Avenue study corridor, a similar number of median breaks proposed in the *Broadview Access Management Study, VDOT, February 2013*.
- Installation of left-turn lanes.
- Turning movement restrictions.
- Driveway access restrictions.
- Installation of two segments of CTWLTL. The southern segment is approximately 650' in length from Station 128+50 to Station 134+50. The northern segment is approximately 450' in length from Station 151+00 to Station 155+50.
- Improved lighting.
- Improved pedestrian and bicycle facilities – Improved sidewalk, ADA facilities, buffered bike lanes, and on-road bike lane to sidewalk transitions.
- Install two (2) marked controlled pedestrian crossings (i.e. Pedestrian Hybrid Beacon) with median refuge islands. Install Pedestrian Hybrid Beacons between Gold Cup Drive and Stuyvesant Street intersections and at Chappel Street, approximately 900 feet apart.
- U-turn geometry to accommodate passenger cars.
- South of Frost Avenue, provide median break for left-in/right-in/right-out access to Wawa. Install driveway island at Wawa to restrict left-out movement.
- Provide median break for left-in/right-in/right-out access to Frost properties approximately 400 feet north of Frost Avenue. Align access for future cross connectivity to Sullivan Street.
- Provide left/U-turn median break approximately 700 feet north of Frost Avenue for properties in southwest quadrant of Broadview Avenue corridor.
- Maintain full movement access on Broadview Avenue at Church Street, Gold Cup Drive, and Stuyvesant Street. Monitor intersections for signal warrants and future signalization.
- Restrict Broadview Avenue at Chappel Street to left-in/right-in/right-out.
- Restrict Broadview Avenue at Old Broadview Avenue / Roebing Street to left-in/right-in/right-out.
- Reduce the posted speed limit on Broadview Avenue from 40 mph to 35 mph in the corridor study area.

In **Appendix A, Figure 1A** comparatively illustrates three (3) concepts: 1) Town of Warrenton's preferred concept, 2) VDOT's 30% PFI Plan (dated May 14th, 2018), and 3) VDOT's previous

recommended geometric improvements concept per the ADA/Access Management/Traffic Assessment Report, VDOT, April 2015, by Wallace Montgomery. **Figure 1B** illustrates the Town of Warrenton's preferred concept.

Broadview Avenue, Warrenton, VA

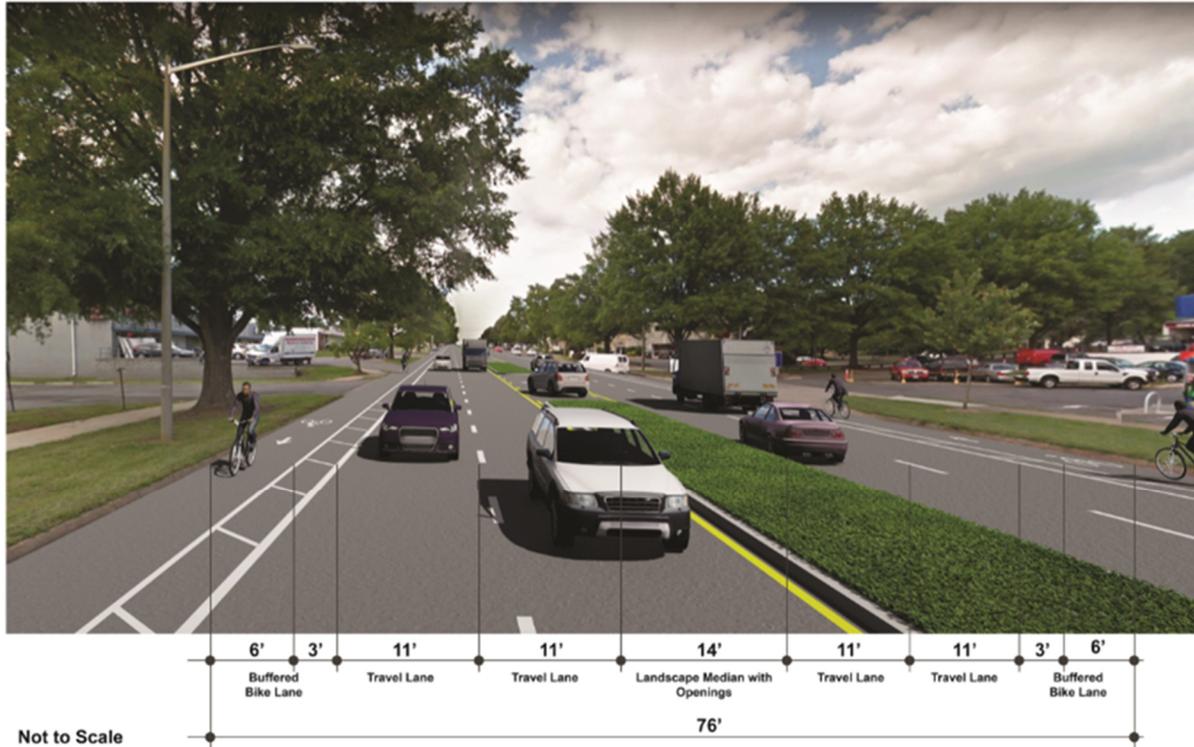


Exhibit 1. Cross-Section Concept with Landscaped Medians with Openings and Buffered Bike Lanes

Posted Speed Limit

The Town's preferred access management concept proposes a reduction in the speed limit on Broadview Avenue from 40 mph to 35 mph. Per the Complete Streets Report, September 2017, Broadview Avenue is a Boulevard Street and serves as a Gateway Street, serving as a point of transition for the way in which different modes of transportation are accommodated and to encourage a change in travel behavior. Gateway Streets provide street treatments that instill the changing context of the street from a higher speed, rural character to a slower speed, urban character where pedestrians and bicyclists can be expected.

Based on available data, per the ADA/Access Management/Traffic Assessment Report, VDOT, April 2015, a spot speed study indicated that the 85th percentile speed does not exceed the posted speed limit of 40 mph and shall be considered as both the posted and design speed for proposed improvements. A traffic sampling memo dated May 4, 2018, indicates average travel speeds on Broadview Avenue were generally 40 mph and that four of six 85% speeds were higher than 45 mph.

As part of the Town's preferred concept and vision for the corridor as a complete street Boulevard, consideration should be given to lowering the posted speed limit from 40 mph to 35 mph in the Broadview Avenue corridor study area.

Center Two-Way Left-Turn Lanes

The Town's preferred access management concept proposes two segments of center two-way left-turn lanes to maintain full movement access for multiple businesses along the corridor. To help inform the location of CTWLTL's, Broadview Avenue crash data from the ADA/Access Management/Traffic Assessment Report, VDOT, April 2015, was reviewed. Per the crash data, the majority of crashes occur at the southern end of corridor between Frost Avenue and Church Street and at the northern end of the corridor at Roebing Street and Business US 17. Therefore, in these areas of highest crash frequency, medians and channelized turn lanes are recommended. CTWLTL segments are proposed in the areas with fewer reported crashes and away from existing major signalized intersections.

Pedestrian Crossings

The Town's preferred access management concept proposes installation of two (2) marked controlled pedestrian crossings (i.e. Pedestrian Hybrid Beacon) with median refuge islands. The Pedestrian Hybrid Beacons are located between Gold Cup Drive and Stuyvesant Street intersections and at Chappel Street, approximately 900 feet apart. These crossings are intended to allow pedestrians and bicyclists to stop traffic to cross high volume arterial streets, like Broadview Avenue, where it is necessary to provide assistance to safely cross.

Maple Avenue Corridor Example

The Town of Vienna's Maple Avenue in the urban core provides a comparable example of the Town of Warrenton's vision for the Broadview Avenue corridor. While these two corridors are different, they share many similarities. Both corridors are urban principal arterials, four-lane facilities with continuous left-turn lanes and raised medians at the ends of both corridors, serve over 30,000 ADT, serve local and regional trips, serve multimodal trips, serve local businesses, serve nearby schools, have many driveway access points, have existing sidewalk, experience bicycle and pedestrian traffic, and have right-of-way constraints. Maple Avenue is different in that it is a continuous five-lane undivided section with a 30 mph speed limit, pedestrian hybrid beacons, signalized intersections throughout the corridor, and a more connected roadway network. Per the Town of Vienna's Comprehensive Plan, transportation goals include provide efficient and reliable movement for all transportation modes, manage impact of regional and local traffic, maximize safety and dependability, encourage people to walk and bicycle, reduce congestion, manage effects of regional development and travel trends. The Plan provides transportation choices for residents, employees, visitors, and firms doing business in Vienna, with a balanced multimodal transportation system to support neighborhood livability and economic development.



Exhibit 2. Maple Avenue Corridor at Washington and Old Dominion Trail, Vienna, VA

Source: Google Maps

3.0 INTERPARCEL CONNECTIVITY

Interparcel vehicular connections provide a number of benefits to drivers, businesses, and highway operations. Some of the benefits include allowing vehicles to access adjacent land uses without having to access the highway, maximizing the use of unsignalized intersections, and providing access to signalized intersections. The Broadview Avenue corridor, from south of Frost Avenue to south of Winchester Street, has poor overall interparcel connectivity with a majority of businesses not providing cross access. The following comments provide a general assessment of interparcel interconnectivity along the corridor, divided up into four segments:

- Southwest (West of Broadview Avenue between Gold Cup Drive and Frost Avenue)
 - Limited cross access, shared access, and on-site circulation.
 - Key interparcel connection opportunities between Foster's Grille and Burger King, Burger King and Auto Plus Auto Parts, and Subway to Oak View National Bank to Sherwin-Williams.
 - Barriers for enhanced interconnectivity are between Warrenton Foreign Car and El Toro, Sherwin-Williams and Murphy's Motorsports, and Rappahannock Street neighborhood.
- Southeast (East of Broadview Avenue between Stuyvesant Street and Waterloo Street)
 - Limited cross access, shared access, and on-site circulation.
 - Sullivan Street and Church Street provide additional access and roadway connectivity benefits for drivers, businesses, and highway operations.
 - Roadway connectivity, and interconnectivity, would be enhanced if Sullivan Street connected to Stuyvesant Street.
 - Key interparcel and roadway connectivity opportunities exist with the Frost properties. Evaluate opportunities to maintain access and create future connection from Broadview Avenue to Sullivan Street.
- Northwest (West of Broadview Avenue between Roebing Street and Gold Cup Drive)
 - Limited cross access, shared access, and on-site circulation.
 - Norfolk Drive and residential neighborhood provides barrier to additional roadway connectivity.
- Northeast (East of Broadview Avenue between Roebing Street and Stuyvesant Street)
 - Limited cross access, shared access, and on-site circulation.
 - Jackson Street, Stuyvesant Street, Chappell Street, and Roebing Street provide additional access and roadway connectivity benefits for drivers, businesses, and highway operations. Benefit is limited due to residential units accessing Jackson Street.

Overall, this corridor has many individual businesses with multiple driveway cuts and no or limited cross access. The existing limited roadway connectivity, high number of individual lots/driveways, and adjacent residential abutting to commercial development, make it very challenging to retrofit interparcel connectivity into the corridor without major redevelopment or access modifications. In **Appendix A**, Figure 4 illustrates interconnectivity opportunities and interconnectivity barriers for the southwest segment of the corridor and Frost Properties in the southeast segment of the corridor.

4.0 SIGNAL WARRANT REVIEW AT BROADVIEW AVENUE AND GOLD CUP DRIVE

In the *Intersection Traffic Analysis (Broadview Avenue at Frost Avenue / Waterloo Street)*, VDOT, September 2015, signal warrant analyses were performed at the following five unsignalized intersections in accordance to the 2011 Virginia Manual on Uniform Traffic Control Devices (VaMUTCD):

- Broadview Avenue at Church Street
- Broadview Avenue at Gold Cup Drive
- Broadview Avenue at Stuyvesant Street
- Broadview Avenue at Chappell Street
- Broadview Avenue at Roebing Street / Old Broadview Avenue

The Broadview Avenue at Roebing Street / Old Broadview Avenue intersection was the only location that met one signal warrant (eight-hour vehicle volume). However, this location would not meet any signal warrants if right turns were separated from the shared through and left-turn movements or the minor streets were restricted to right-turns only.

2018 Traffic Volumes at Broadview Avenue and Gold Cup Drive

Design year 2018 traffic volumes from the 2018 VDOT Signal Warrant Analysis report were used to determine whether a traffic signal is warranted at the Broadview Avenue/Gold Cup Drive intersection. **Table 4** shows the volume profile for the intersection from the VDOT study.

Table 4. Design Year 2018 Volume Profile – Broadview Avenue/Gold Cup Drive

Hour Beginning	Total Approach Volume ¹			
	Northbound (Broadview Avenue)	Southbound (Broadview Avenue)	Eastbound (Gold Cup Drive)	Westbound (Private Driveway)
6:00 AM	910	555	42	0
7:00 AM	1,192	802	53	0
8:00 AM	1,026	870	36	2
9:00 AM	941	787	36	1
10:00 AM	965	909	46	1
11:00 AM	1,118	1,054	41	2
12:00 AM	1,117	1,134	34	1
1:00 PM	991	1,108	42	0
2:00 PM	1,090	1,304	41	0
3:00 PM	1,002	1,481	33	1
4:00 PM	1,082	1,634	34	3
5:00 PM	994	1,549	50	0
6:00 PM	892	568	31	0

¹Volumes obtained from Appendix A of 2018 VDOT Signal Warrant Analysis Report

Signal warrants found in the 2009 *Manual on Uniform Traffic Control Devices (MUTCD)* are evaluated below.

Warrant 1 – Eight-Hour Vehicle Volume

Warrant 1 determines the need for a traffic signal based on conditions for each of any eight hours of an average day. Two conditions, Condition A and Condition B, can be evaluated, and the warrant is considered met if either one is met.

The eight highest hours were determined through eight-hour turning movement counts collected at Elden Street and Dulles Park Shopping Center. Mid-week, hourly traffic volumes were used for the analysis. Because the posted speed limit on Broadview is above 40 mph, the warranting volume thresholds for Warrants 1A and 1B are considered using the 70 percent thresholds (per MUTCD Section 4C.02).

Table 5 below summarizes the comparison of intersection volumes to the volume thresholds for MUTCD Warrants 1A and 1B. As shown, the major street hourly volumes exceed the Warrant 1A threshold of 420 vehicles-per-hour for all 13 hours of the study period; however, the minor street volumes do not meet the 105 vehicles-per-hour threshold during any of the hours. Similarly, the major street volumes exceed the Warrant 1B threshold of 630 vehicles-per-hour, but the minor street threshold of 53 vehicles is only met during one hour during the study period. Further, the optional thresholds for considering the combination of Conditions A and B after adequate trial or other remedial measures are not met. Therefore, the vehicular volumes at Broadview Avenue/Gold Cup Drive do not satisfy the requirements for signal Warrant 1A or Warrant 1B.

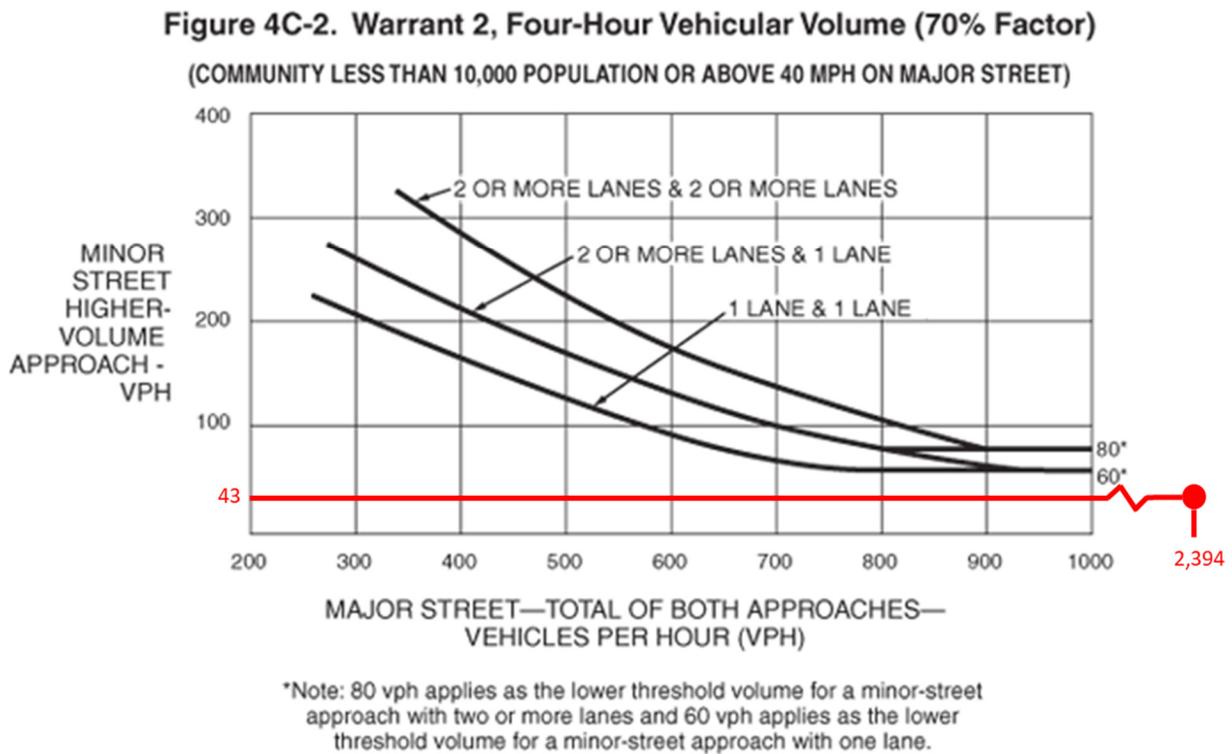
Table 5. Warrant 1A and Warrant 1B Evaluation (Eight Hour Vehicular Volume) – Broadview Avenue/Gold Cup Drive

			Warrant 1A Volume Thresholds (70%) [vph]	Warrant 1B Volume Thresholds (70%) [vph]	
			Major Street (both directions):	420	630
			Minor Street (peak direction only):	105	53
Hour Beginning	Major Street Volumes [vph] (both directions)	Minor Street Volumes [vph] (peak direction only)	Warrant 1A Met?	Warrant 1B Met?	
6:00 AM	1,465	42	No	No	
7:00 AM	1,994	53	No	Yes	
8:00 AM	1,896	36	No	No	
9:00 AM	1,728	36	No	No	
10:00 AM	1,874	46	No	No	
11:00 AM	2,172	41	No	No	
12:00 AM	2,251	34	No	No	
1:00 PM	2,099	42	No	No	
2:00 PM	2,394	41	No	No	
3:00 PM	2,483	33	No	No	
4:00 PM	2,716	34	No	No	
5:00 PM	2,543	50	No	No	
6:00 PM	1,460	31	No	No	
Total Hours Met			0	1	

Warrant 2 – Four-Hour Vehicular Volume

In accordance with the MUTCD, *Warrant 2, Four-Hour Vehicular Volume* is to be applied where the volume of intersecting traffic is the principal reason to consider installing a traffic signal. The warrant requires that any four (4) hours (i.e., the 4th highest hourly volume) on an average day plotted on the applicable curve to determine the need for a traffic signal. **Exhibit 3** shows the 4th highest hour volumes plotted on Figure 4C-1 of the MUTCD.

Exhibit 3. Warrant 2 (Four-Hour Vehicular Volume) – Broadview Avenue/Gold Cup Drive



As shown in **Exhibit 3**, the 4th highest hour volumes do not exceed the minimum thresholds and do not warrant a traffic signal.

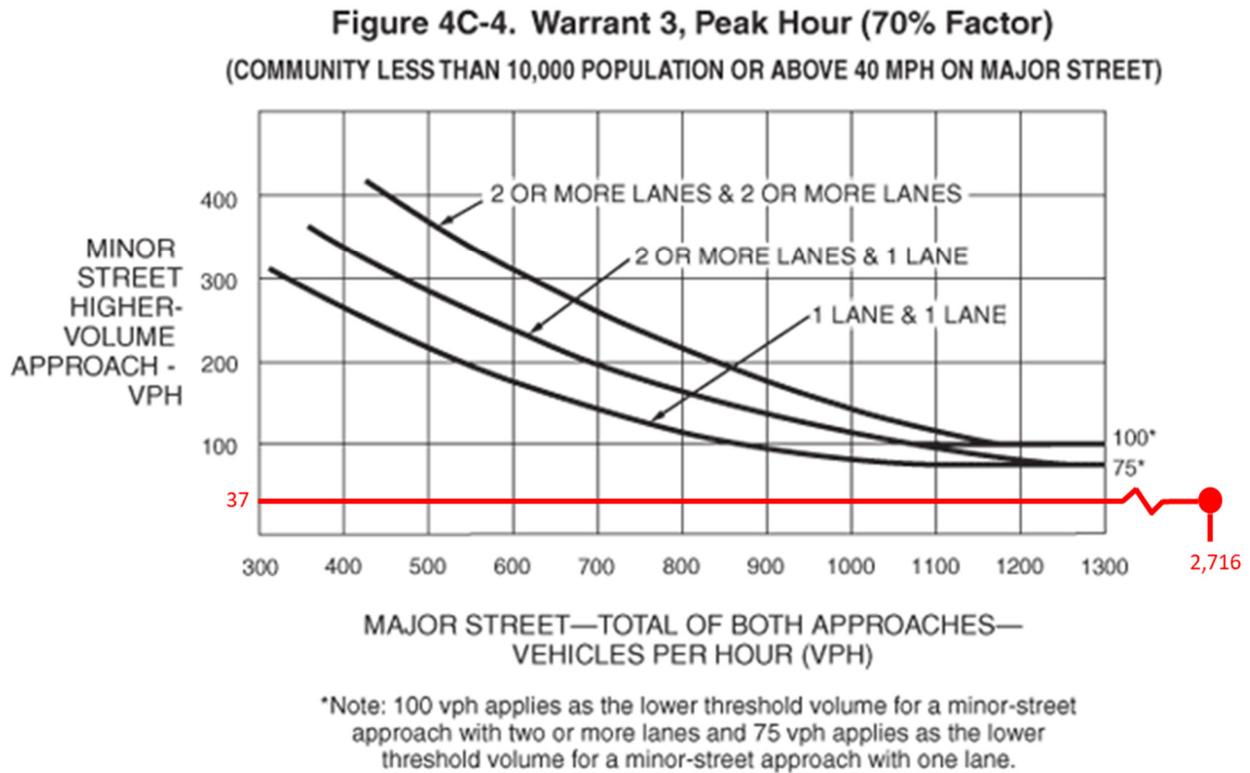
Warrant 3 – Peak Hour

Warrant 3 is intended for used at a location where traffic conditions are such that for a minimum of one hour of an average day, the minor-street traffic suffers undue delay when entering or crossing the major street.

While VDOT does not commonly apply this warrant as the primary basis for justifying a signal, its evaluation is provided as additional support of Warrants 1 and 2.

Error! Reference source not found.4 shows the peak hour volumes as plotted on Figure 4C-3 of the MUTCD.

Exhibit 4. Warrant 3 (Peak Hour Volume Volume) – Broadview Avenue/Gold Cup Drive



As shown in **Exhibit 4**, peak hour volumes do not exceed the minimum thresholds for an intersection with a one-lane minor street and do not warrant a traffic signal.

Warrant 4 – Pedestrian Volume

Warrant 4 is intended for application where the traffic volume on a major street is so heavy that pedestrians experience excessive delay in crossing the major street. Because the posted speed limit on Broadview is above 35 mph, the warranting volume thresholds for Warrant 4 are considered using the 70 percent thresholds (per MUTCD Section 4C.05).

For the 4th highest hour volume of 1,000 vehicles-per-hour on the major street, 75 pedestrians-per-hour (PPH) is required to meet the signal warrant threshold. As illustrated in the April 2015 VDOT Broadview Avenue Access Management Improvements report, only five (5) pedestrians were observed crossing Broadview Avenue at Gold Cup Drive during a single weekday. Therefore, the intersection does not meet the minimum requirements under Warrant 4 for a traffic signal.

Warrant 5 – School Crossing

Warrant 5 is intended for application where the fact that schoolchildren cross the major street is the principal reason to consider installing a traffic control signal. For the purposes of this warrant, the word "schoolchildren" includes elementary through high school students.

The nearest school in the area, Fauquier High School to the southwest is approximately 0.7 miles away, and major street crossing volumes suggest that pedestrian traffic is not influenced by the school.

Engineering judgement concludes that the intersection does not meet the requirements for Warrant 5.

Warrant 6 – Coordinated Signal System

Warrant 6 determines justification of a traffic signal where progressive movement in a coordinated system necessitates installation of traffic control where they would not otherwise be needed to maintain proper platooning of vehicles.

To help quantify the potential coordinatability of a traffic signal at the Broadview Avenue/Gold Cup Drive with the existing signals at Broadview Avenue/Lee Highway/Winchester Avenue and Broadview Avenue/Frost Avenue/West Shirley Avenue/Waterloo Street, the proprietary *coordinatability factor* (CF) in Synchro was evaluated. Based on a scale of zero to 100, the Synchro coordinatability factor is based on factors such as travel time, signal spacing, link volume, vehicle platooning, vehicle queueing, and natural cycle length. A coordinatability factor less than 20 generally indicate coordination is not desirable, while values greater than 80 indicate coordination is critical to avoid blocking issues. A coordinatability factor between those thresholds (i.e., greater than 20 and less than 80) indicates coordination may be desirable. Table 6 illustrates the coordinatability factors for the weekday a.m. and weekday p.m. peak hours at the Broadview Avenue/Gold Cup Drive intersection.

Table 6. Synchro Coordinatability Factor – Broadview Avenue/Gold Cup Drive

Analysis Period	Coordinatability Factor With:	
	Broadview Avenue/Lee Highway/Winchester Street	Broadview Avenue/ Frost Avenue/West Shirley Avenue/Waterloo Street
Weekday AM Peak Hour	31	71
Weekday PM Peak Hour	47	89

As shown, developing coordination in the southbound direction between the Broadview Avenue/Gold Cup Drive and Broadview Avenue/Frost Avenue/West Shirley Avenue/Waterloo Street intersections is desirable with regards to platooning and progressing traffic along the corridor.

Warrant 7 – Crash Experience

Warrant 7 is intended for application where the severity and frequency of crashes are the principal reasons to consider installing a traffic control signal.

Upon review of the crash data summarized in the April 2015 VDOT Broadview Avenue Access Management Improvements report, conditions do not meet the requirements for Warrant 7, Crash Experience.

Warrant 8 – Roadway Network

Warrant 8 determines justification of a traffic signal where the concentration and organization of traffic flow is encouraged on a roadway network.

To meet Warrant 8, the major street must meet at least one of the following characteristics:

- It is part of the street or highway system that serves as the principal roadway network for through traffic flow.
- It includes rural or suburban highways outside, entering, or traversing a city.
- It appears as a major route on an official plan, such as a major street plan in an urban area traffic and transportation study.

Gold Cup Drive, classified as a local roadway, does not meet these requirements. As such, the intersection does not meet Warrant 8.

Warrant 9 – Intersection Near a Grade Crossing

In accordance with the MUTCD, Warrant 9 is intended for use at a location where none of the conditions described in the other eight traffic signal warrants are met, but the proximity to the intersection of a grade crossing on an intersection approach controlled by a STOP or YIELD sign is the principal reason to consider installing a traffic control signal.

These conditions are not present in areas immediately surrounding the Broadview Avenue/Gold Cup Drive intersection; the intersection does not meet the requirements for Warrant 9.

Traffic Signal Considerations

While a traffic signal may not be warranted at Gold Cup Drive or other individual intersection locations, these intersections should continue to be monitored for signal warrants and potential signalization. Additional benefits of considering traffic signals at select locations along the Broadview Avenue corridor include:

- Traffic progression – While traffic signals are not installed to control speed, two or more adjacent traffic signals can be coordinated as a system to progress traffic at a posted or desired speed. For these types of signal systems, it is counterproductive to exceed the speed limit.
- Traffic gaps – Traffic signals create gaps in traffic that allow for downstream minor street turning movements or major street left-turns or U-turns. With a projected AADT of approximately 40,000 in 2040, gaps in traffic will be increasingly difficult to find and navigate safely.
- Traffic weaving – In an access management scenario, traffic signals create gaps in traffic that should allow for safer and more efficient cross weaving maneuvers.
- U-turns – In an access management scenario, traffic signals may be necessary to safely accommodate the U-turn of a design vehicle.
- Signal Phasing – Two-phase and three-phase signals along a corridor can operate efficiently and in relatively close proximity while providing corridor mobility, safety, progression, and multimodal accommodations.
- Pedestrians and bicycles crossings – Traffic signals can have the added benefit of providing protected pedestrian and bicycle crossings at full movement, directional left-turn, or U-turn intersections.

5.0 SUMMARY AND CONCLUSION

Kittelson's re-evaluation and review of Broadview Avenue access management improvements along US 211/US 17/29 BUS (Broadview Avenue) from south of Frost Avenue to south of Winchester Street in Warrenton, Virginia provides the following summary and conclusion.

Intersection Improvements at Broadview Avenue and Frost Avenue / Waterloo Street

The Town's preferred intersection design is consistent with VDOT's recommended Alternative 2 geometric improvements to provide more safety for pedestrians and access along westbound Frost Avenue while improving operations at the study intersection. Intersection improvements to mitigate operational deficiencies include (proposed geometric modifications in **bold**):

- Provide signalized southbound dual right-turn lanes on Broadview Avenue;
- Provide signalized northbound dual left-turn lanes on Shirley Avenue;
- Provide pedestrian accommodations based on modified geometry;
- Install median on Broadview Avenue. Provide first median break approximately **400 feet north of intersection for southbound left-turns/U-turns to access Frost properties.**

- Install median on Shirley Avenue. Provide first median break approximately 250 feet south of intersection **for left-in/right-in/right-out access to Wawa. Install driveway island at Wawa to restrict left-out movement.**

Access Management Improvements

In coordination with the Town of Warrenton, Kittelson has prepared an access management concept plan that modifies VDOT's plan to provide a four-lane facility with landscape medians and center two-way left-turn lanes (CTWLTL) and buffered bike lanes along the Broadview Avenue corridor. The Town's preferred access management concept attempts to incorporate developed design studies and established project goals, as detailed in the ADA/Access Management/Traffic Assessment Report, VDOT, April 2015, along with the Town of Warrenton's vision for the corridor and complete street initiatives. Notable differences in the Town's preferred concept versus VDOT's 30 Percent PFI Plan include center two-way left turn lanes in two sections, pedestrian crossings, buffered bike lanes, modified median breaks and restricted driveway access, and consideration of a reduced posted speed limit. Additional concept details are listed in **Section 2**. This concept references the Town of Vienna's Maple Avenue as a comparable example of the Town of Warrenton's vision for the Broadview Avenue corridor.

In **Appendix A, Figure 1A** comparatively illustrates three (3) concepts: 1) Town of Warrenton's preferred concept, 2) VDOT's 30% PFI Plan (dated May 14th, 2018), and 3) VDOT's previous recommended geometric improvements concept per the ADA/Access Management/Traffic Assessment Report, VDOT, April 2015, by Wallace Montgomery. **Figure 1B** illustrates the Town of Warrenton's preferred concept.

Interparcel Connectivity

Overall, this corridor has many individual businesses with multiple driveway cuts and no or limited cross access. The existing limited roadway connectivity, high number of individual lots/driveways, and adjacent residential abutting to commercial development, make it very challenging to retrofit interparcel connectivity into the corridor without major redevelopment or access modifications. In **Appendix A, Figure 4** illustrates interconnectivity opportunities and interconnectivity barriers for the southwest segment of the corridor and Frost Properties in the southeast segment of the corridor.

Signal Warrant Review at Broadview Avenue and Gold Cup Drive

While a traffic signal may not be warranted at Gold Cup Drive or the other four intersection locations evaluated, these intersections should continue to be monitored for signal warrants and potential signalization.

In conclusion, this re-evaluation and review provides a comparison of similar designs and the Town of Warrenton's preferred concepts for VDOT's consideration in the design of the Broadview Avenue corridor project.