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How’s That Diet Working: Performance of Virginia Road Diets

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In 2018, the Virginia Department of Transportation (VDOT) initiated this study to improve its understanding of past road diets in Virginia. Of interest were how road diets have been analyzed, how their performance has been quantified, how other states and localities have optimized their practices relating to road diets (e.g., public participation processes), and which Virginia localities—including those that maintain their own roads—have recently implemented road diets. In addition, VDOT's Transportation and Mobility Planning Division (TMPD) requested an analysis of recently completed road diets on VDOT-maintained roadways in Fairfax County, Virginia, to determine their effectiveness in order to provide planners with data that could be useful in public participation processes across Virginia.

The purpose of this study was (1) to compile an inventory of road diets completed in Virginia since 2010, and (2) to analyze a selection of road diets completed in Fairfax County in the last 5 years to determine if they are working as intended. The scope was limited to lane-removal projects (i.e., road diets), excluding lane-narrowing projects (i.e., lane diets). Safety analyses (e.g., crash analyses) were outside the scope of the study but could be included in future efforts. The study tasks included (1) reviewing existing literature including before-after studies of road diets, case analyses, modeling and simulation studies, guidance, and performance measures; (2) developing an inventory of Virginia road diets; and (3) collecting data and analyzing operational effects of recent road diets in Fairfax County.

The study found that road diets have been incorporated into broader concepts and initiatives such as complete streets, bikeway selection, bicycle networks, context-sensitive design, and tactical urbanism and the literature has continued to document their effectiveness. Virginia localities reported generally positive views about their road diet projects. A working inventory developed in this study represents approximately 39 miles of Virginia road diets across 66 projects. Although most studies reported by localities were conducted before road diets and data from those studies were generally unavailable, survey respondents reported that road diets did not generally create traffic congestion problems and that, in their opinions, most road diets had met their primary goals. The Fairfax County road diets studied did not result in practically significant changes in mean speeds; one indicated that the road diet might have reduced unsafe behavior by people walking and biking. Additional research on topics such as crash modification factors or the application of new data sources to road diets would be beneficial.

The study recommends that TMPD maintain a statewide inventory of completed road diets and of candidate segments for future road diets. This could inform decision-making in the VDOT resurfacing program by having an easily accessible inventory of comparable past projects and potential future ones. TMPD should also develop guidance for road diets including processes for evaluating the feasibility of a road diet on a VDOT-maintained road, stakeholder and/or public participation, implementation, and evaluation. In addition, TMPD should work with VDOT districts to facilitate the implementation of road diets through the resurfacing program. To gauge interest in developing crash modification factors for specific road diet types, VDOT's Northern Virginia District should prepare a new research problem statement for presentation and discussion with the Virginia Transportation Research Council's Traffic and Safety Research Advisory Committee.

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FINAL REPORT

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In Cooperation with the U.S. Department of Transportation
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Virginia Transportation Research Council
(A partnership of the Virginia Department of Transportation
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ABSTRACT

In 2018, the Virginia Department of Transportation (VDOT) initiated this study to improve its understanding of past road diets in Virginia. Of interest were how road diets have been analyzed, how their performance has been quantified, how other states and localities have optimized their practices relating to road diets (e.g., public participation processes), and which Virginia localities—including those that maintain their own roads—have recently implemented road diets. In addition, VDOT's Transportation and Mobility Planning Division (TMPD) requested an analysis of recently completed road diets on VDOT-maintained roadways in Fairfax County, Virginia, to determine their effectiveness in order to provide planners with data that could be useful in public participation processes across Virginia.

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The study found that road diets have been incorporated into broader concepts and initiatives such as complete streets, bikeway selection, bicycle networks, context-sensitive design, and tactical urbanism and the literature has continued to document their effectiveness. Virginia localities reported generally positive views about their road diet projects. A working inventory developed in this study represents approximately 39 miles of Virginia road diets across 66 projects. Although most studies reported by localities were conducted before road diets and data from those studies were generally unavailable, survey respondents reported that road diets did not generally create traffic congestion problems and that, in their opinions, most road diets had met their primary goals. The Fairfax County road diets studied did not result in practically significant changes in mean speeds; one indicated that the road diet might have reduced unsafe behavior by people walking and biking. Additional research on topics such as crash modification factors or the application of new data sources to road diets would be beneficial.

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FINAL REPORT

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INTRODUCTION

When road construction boomed in the mid-1900s, the focus was on providing maximum automobile capacity as traffic volumes grew exponentially (Knapp et al., 2014). One solution to alleviate congestion was to expand existing two-lane roads to four-lane undivided roadways. A tradeoff from the capacity increase was a compromise in safety, with increased conflicts between left-lane through traffic and left-turning vehicles; streets with this cross-section have a higher rate of such crashes compared to other roadway cross-sections (Persaud et al., 2008). In addition, these road designs often lack bicycle and pedestrian accommodations, which increases the risk of crashes involving non-motorized traffic, which is a growing percentage of road users (Schroeder and Wilbur, 2013). Pedestrian deaths per 100 pedestrian-involved crashes rose from 2010 through 2015; from 2009 through 2016, the largest increases in pedestrian fatalities occurred in urban areas, on arterials, at non-intersection locations, and in dark conditions (Hu and Cicchino, 2018). The bicycle commute mode share in Virginia increased 89% from 2006 to 2017 (League of American Bicyclists, 2018). To help reduce conflicts, the road diet is one countermeasure receiving increased interest. In 2012, the Federal Highway Administration (FHWA) added road diets to its list of proven safety countermeasures (FHWA, 2019).

A typical "four to three" (hereinafter "4-3") road diet converts a four-lane undivided roadway to a street with one general purpose lane in each direction, a center two-way left-turn lane, and bicycle lanes (Figure 1). By completion of a road diet on such facilities in conjunction with planned resurfacing or restriping activities, safety and multimodal improvements can be delivered for only the incremental cost of additional signs and markings, sometimes accomplished at no additional cost to the roadway agency (FHWA, 2017). Road diets have also been performed on streets with many different before-after cross-sections, such as a five-lane street to a three-lane street with buffered bike lanes (Figure 2); a four-lane street to a two-lane street with dedicated left-turn lanes and buffered bike lanes; or a four-lane boulevard with a median to a two-lane boulevard with a median and on-street parking. Road diets may also be known as roadway or street reconfigurations, rechannelizations, or reallocations (Sanders et al., 2019). A lane diet is a related term referring to the narrowing rather than removal of travel lanes to accommodate bicycle lanes, turn lanes, parking lanes, or traffic calming elements.

Figure 1. Before (Left) and After (Right) Photographs of a 2009 Road Diet in Fairfax County, Virginia

Figure 2. After Photograph of a 2016 Road Diet With Buffered Bike Lanes in Fairfax County, Virginia

In 2018, the Virginia Department of Transportation (VDOT) initiated this study to improve its understanding of past road diets in the state in preparation for developing guidance for road diets in Virginia. Of interest were how road diets have been analyzed, how their performance has been quantified, how other states and localities had optimized their practices relating to road diets (e.g., public participation processes), and which Virginia localities had recently implemented road diets.

Prior to a 2017 legislative change (*Code of Virginia* § 33.2-319), cities and towns receiving state maintenance payments for roads were sometimes hesitant to complete road diets, because such projects could lead to reduced funding because of the funding formula's definition of "moving-lanes," which excluded bicycle lanes and center turn lanes (Dudley, 2015). The legislative revision explicitly allowed conversion of moving-lanes to bicycle lanes with no loss of funding, with some limits that no localities had reached as of summer 2019; this may have added momentum for local road diet projects. The *Code of Virginia* requires that an engineering study be conducted to ensure that the street's level of service (LOS) will not be reduced or that the roadway network's overall capacity will remain adequate. This requirement applies only to cities and towns receiving state maintenance payments for roads.

VDOT's Pedestrian Safety Action Plan (VDOT, 2018) recommended creating road diet and lane width reduction guidelines. Although there was no specific state-level guidance for road diets as of 2018, standard practice in VDOT's Northern Virginia District was to analyze two key indicators when determining a road diet's feasibility: (1) average daily traffic (ADT) (typically an upper ADT threshold was 15,000 to 20,000), and (2) lane utilization at signalized intersections. In addition, road diets could support several of the guiding principles in the statewide long-range multimodal plan, including ensuring safety, security, and resiliency; efficiently delivering programs; and improving coordination between transportation and land use. Goals and objectives related to safety, healthy and sustainable communities, reducing vehicle miles traveled, and increasing the number of trips traveled by active transportation are also relevant (Office of Intermodal Planning and Investment, 2015). An economical approach to reliable multi-modality is a central component of the road diet concept. That is, most road diets involve only signs and eradication and replacement of pavement markings, which are relatively low-cost items compared to other construction activities such as relocating curbs or building a shared-use path.

Two road diets have been completed and analyzed in Reston, Virginia, on Lawyers Road and Soapstone Drive (both VDOT roadways). The 2009 Lawyers Road project involved transforming a 2-mile segment of four-lane undivided roadway into a three-lane roadway with a two-way left-turn lane and bike lanes (a typical 4-3 road diet). The project was initially aimed at addressing crashes in the left through lanes and was met with concerns about increased congestion and the addition of bike lanes. After implementation, studies found that there was a 70% reduction in crashes and travel times remained the same. In a post-implementation survey, 47% of respondents indicated that they bicycled on the road more often than before and 69% indicated that the road seemed safer (FHWA, 2015).

After that initial success, another road diet was implemented in 2011 along a 2-mile segment of Soapstone Drive with the goals of improving safety for bicyclists and pedestrians and reducing crashes. In this case, the roadway cross-section varied; the first segment was a typical 4-3 road diet, the second was a 4-3 road diet with on-street parking, and the third was a lane diet where 18-ft lanes were restriped to 12 ft with bike lanes. The addition of bike lanes along all segments improved bicycle network connectivity to area parks and recreational trails and to the new bike lanes along Lawyers Road. Post-implementation analysis of the Soapstone Drive project indicated a 70% reduction in crashes (FHWA, 2015). These examples support the argument that when applied appropriately, road diets are an effective strategy to create safer streets for motorized and non-motorized traffic without substantially increasing congestion or travel times.

Several more road diets were implemented in Fairfax County in subsequent years, and through the combined efforts of the county and VDOT, dozens of lane-miles of bicycle facilities were added through road diets and lane diets (Dittberner, 2016). Figure 3 shows bike lane mileage added in VDOT's Northern Virginia District through the repaving process (via both road diets and lane diets) from 2015 through 2019. These facilities had not been studied to determine how well the intended goals had been achieved. Other road diets have occurred elsewhere in Virginia in recent years, such as a 1.4-mile portion of Main Street in the Town of Amherst in 2017. The exact number of these is unknown, as is whether they have been studied/evaluated.

VDOT's Transportation and Mobility Planning Division (TMPD) requested an analysis of road diets including those in Fairfax County to determine their effectiveness in order to provide evidence to the public in support of future road diet endeavors across Virginia.

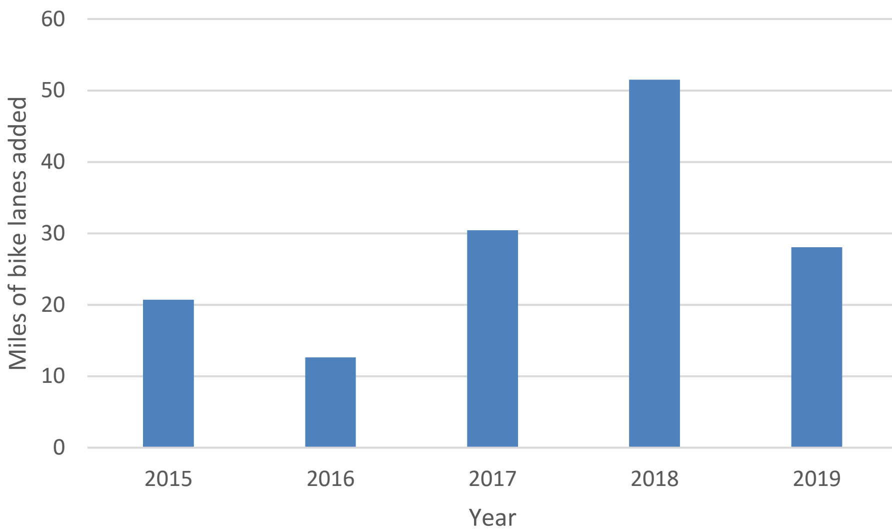


Figure 3. Yearly Bike Lane Mileage Added in VDOT's Northern Virginia District Through the Repaving Process From 2015 Through 2019

PURPOSE AND SCOPE

The purpose of this study was to compile an inventory of road diets completed in Virginia since 2010 and analyze a selection of road diets completed in Fairfax County in the last 5 years to determine if they are working as intended. The scope was limited to lane-removal projects (i.e., road diets) and excluded lane-narrowing projects (i.e., lane diets). Safety analyses (e.g., crash analysis and development of crash modification factors [CMFs]) were outside the scope of this study but could be included in future efforts.

METHODS

Five tasks were undertaken to accomplish the study objectives:

1. Conduct a literature review.
2. Conduct an inventory of Virginia road diets.
3. Collect data on some recent road diets in Fairfax County.
4. Analyze operational effects of those recent road diets in Fairfax County.
5. Develop conclusions and recommendations.

Conducting the Literature Review

A review of the literature was undertaken to obtain relevant information regarding road diet studies completed within the past 10 years in the United States. Upon finding that studies before 2014 were summarized in the *Road Diet Informational Guide* (Knapp et al., 2014), the researchers limited the primary focus to studies published from 2014 to 2019. Of particular interest were methods used to analyze road diets and performance measurement criteria.

The 2014 *Road Diet Informational Guide* provided some methods for consideration in performing and analyzing road diets but did not set any standards. It also included a comprehensive literature review of studies available before 2014. To augment this, the VDOT Research Library conducted a focused search for U.S. and Canadian studies published in 2014 and later using subscription databases and freely accessible search tools (Ernest and Winter, 2019). Researchers synthesized those studies to provide a snapshot of work related to road diets approximately 5 years after the publication of the *Road Diet Informational Guide.*

Conducting an Inventory of Virginia Road Diets

This task involved compiling an inventory of road diets completed in Virginia since 2010. Having an inventory of road diet projects around the state can enable planners and designers of new road diets to identify past projects with similar contexts (rural/suburban/urban, traffic volumes, etc.) and to learn about specific implementation details and lessons learned. To achieve this objective, a survey was distributed to Virginia localities (cities, counties, and towns) with the following goals:

1. Identify the locations of and motivations for road diet projects.

2. Document roadway geometric characteristics before and after implementation.

3. Document results from studies (if performed).

4. Ascertain opinions on effectiveness in terms of operations and safety (including feedback from the public, if available).

5. Record lessons learned.

To obtain a more complete inventory of locality road diet installations, surveys were also distributed separately to all nine VDOT districts. The results of these surveys were combined with information from other sources (e.g., in-person comments at meetings, news articles, personal observations, etc.) to create a working inventory of Virginia road diets. Each locality with at least one road diet was then asked to confirm its listing(s); in some cases, this resulted in additional information than what a locality provided in the initial survey.

Development and Testing of the Survey Instrument

The survey was constructed in Google Forms. To enable follow-up questions, the first page of the survey collected contact information including name, locality or VDOT district, email, title, and telephone number. An initial version of the survey included questions about both road diets and lane diets. A locality that had completed both road diets and lane diets pilot-tested this version of the survey and advised researchers that the inclusion of lane diets complicated matters and would require further research and time, possibly leading potential participants to forego completing the survey. Because the primary focus of this study was road diets, the final survey was revised to include only those types of roadway reconfiguration projects. The remainder of this section discusses the final version of the survey.

Following the contact information page, an introduction was provided with the following language and figure:

> This survey will ask about road diets in your locality/VDOT district. A road diet involves removing one or more travel lanes and reconfiguring the roadway to add elements such as turn lanes, bicycle lanes, and/or on-street parking. Road diets can have many configurations, and a common one is shown below (Figure 4).

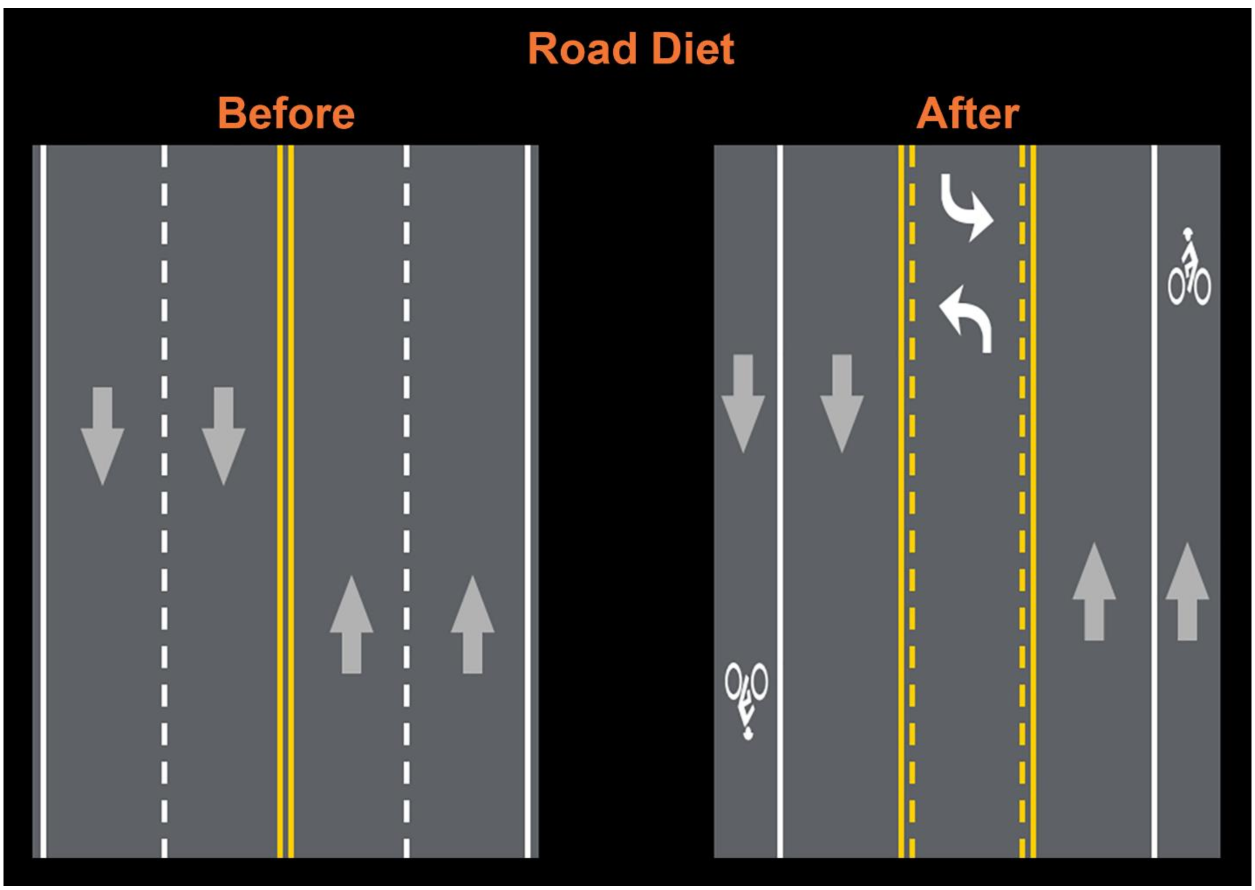


Figure 4. Example of a 4-Lane to 3-Lane Conversion Road Diet Presented to Survey Respondents

The survey included general questions for all respondents and additional questions for localities and VDOT districts that had implemented road diets. Based on answers to questions, skip logic (also known as “conditional branching” or “branch logic”) was formulated, allowing a path through the survey that varied based on a respondent's answers.

General Questions for All Respondents

The following questions were intended for each locality/VDOT district to answer:

- Since 2010, how many road diets have been constructed in your district/locality/jurisdiction?

- Do you have any road diet projects that are not yet complete, but are planned or underway? (Please tell us about any road diet projects that are planned or underway.)

- Before 2017, language in the *Code of Virginia* reduced roadway maintenance payments to cities and towns after road diet projects (because such payments were based on vehicular lane miles). The General Assembly modified that language in 2017 to allow for road diets without a reduction in maintenance payments. Were you aware of this legislative change?
    - (*if yes*) Did this legislative change affect your jurisdiction's decisions regarding road diets?

Additional Questions for Localities/VDOT Districts That Reported Implementing Road Diets

Prior to development of the survey, it was understood that some localities and VDOT districts had implemented more than one road diet. For the purpose of keeping the survey relatively short, questions were asked about each road diet up to a limit of five road diets. Localities that reported implementing more than five road diets were notified that the research team would follow up with them for information about additional road diets. The following information was sought for each road diet:

- Roadway name and extents

- Year completed

- Brief description of the project

- What were the primary reasons for implementing this road diet? (Improving safety, accommodating bicycle travel, providing on-street parking, other)

- In your opinion, how well did the project meet the primary goals you selected? Describe any lessons learned.

- Have you received any public feedback on the project?

- (if yes) Has the majority of the feedback been positive, negative, or mixed (equally positive and negative)?

- Was a study performed BEFORE constructing the project?

- Was an evaluation performed AFTER the project's completion?

Conducting the Survey

When the survey was distributed, the objective was to provide an opportunity for input from every locality and VDOT district in Virginia. To meet this objective, the first step was to obtain or develop a list of initial contacts, including a telephone number and email address, for each VDOT district and locality (i.e., city, county, or town). VDOT's Local Assistance Division provided an initial list of email addresses for county administrators and city and town managers, and the researchers reviewed locality websites to obtain appropriate contacts (e.g., in departments of planning, transportation, economic development, public works, or parks and recreation). In cases where specific department listings were not found, the contact points remained the administrators and managers. The list of initial contacts was populated for all 95 counties, 38 cities, and 113 of 190 towns (some of Virginia's towns are very small and had not had contact with VDOT's Local Assistance Division or lacked email addresses). For VDOT districts, primary points of contact were obtained from VDOT's Traffic Engineering Division website for each district: Northern Virginia, Fredericksburg, Culpeper, Richmond, Lynchburg, Bristol, Hampton Roads, Salem, and Staunton. In most cases, the points of contact were the district traffic engineers; in the Northern Virginia and Hampton Roads districts, contacts were a transportation engineer and an assistant district traffic engineer, respectively.

For surveying localities, it was anticipated that a survey instrument distributed solely by email would have a low response rate; therefore, telephone calls were made to every contact. If a direct connection was made (telephone was answered), an introduction to the project was given followed by the question of who would be the most appropriate person to complete the survey for the organization. In most cases, the initial contact was the appropriate person. If not, he or she provided another contact's telephone number and email address, and the process was repeated. In cases where the contact person did not answer the telephone (approximately 50% of the time), a message was left on voicemail. Immediately after discussing the project and introducing the survey with each contact (either directly or by voicemail), the researcher sent a link to the survey via email. For VDOT districts, emails were sent with the survey attached. Follow-up emails to localities and VDOT districts were sent if responses were not received within 2 weeks.

Collecting Data on Recent Road Diets in Fairfax County

The installation of four road diets in Fairfax County was coordinated with the paving season (summer and early fall) in 2017 and 2018. Sites and data collection methods are discussed here.

Site Descriptions

Bluemont Way

Bluemont Way (State Route 7199) is an urban major collector with a posted speed limit of 30 mph that runs in a general east/west direction. Its link length from Town Center Parkway (western terminus) to Reston Parkway (eastern terminus) is 0.43 miles. The facility is rated as having an LOS A and carries an annual average daily traffic (AADT) of approximately 7,800 vehicles per day (vpd). The road diet replaced a four-lane typical section with a three-lane typical section including dedicated left-turn lanes and buffered bike lanes (Figure 5). It was completed in the summer of 2018 and spans 0.31 miles from Town Center Parkway to Democracy Drive.

Figure 5. Before (Left) and After (Right) Photographs of Road Diet on Bluemont Way

Colts Neck Road

Colts Neck Road (State Route 4701) is classified as an urban major collector with a posted speed limit of 35 mph that runs in a general northeast/southwest direction. Its link length from Sunrise Valley Drive (northeast terminus) to Reston Parkway (southwest terminus) is 1.41 miles. The facility is rated as having an LOS A and carries an AADT of approximately 8,700 vpd. The road diet was completed in the fall of 2017 and spans 0.85 miles from Glade Drive to Sunrise Valley Drive. The road diet replaced a four-lane typical section with a three-lane typical section including a two-way left-turn lane and bike lanes between Glade Drive and South Lakes Drive (0.6 miles, Figure 6). Two northbound lanes were retained for part of the 0.25-mile segment between South Lakes Drive and Sunrise Valley Drive (Figure 7).

Figure 6. Before (Left) and After (Right) Photographs of Road Diet on Colts Neck Road, Southern Segment

Figure 7. Before (Left) and After (Right) Photographs of Road Diet on Colts Neck Road, Northern Segment

Post Forest Drive

Post Forest Drive (State Route 7435) is classified as an urban major collector with a posted speed limit of 35 mph that runs in a general east/west direction. Its link length from West Ox Road (western terminus) to Government Center Parkway (eastern terminus) is 0.58 miles. The facility is rated as having an LOS A from West Ox Road to Legato Road and an LOS C from Legato Road to Government Center Parkway. It carries an AADT of approximately 9,350 vpd. The road width varied, and the road diet completed in the summer of 2018 also had varying cross-sections. The western segment was converted from two westbound lanes, one eastbound lane, and a two-way left-turn lane to one lane in each direction, dedicated left-turn lanes, and a westbound buffered bike lane (Figure 8). The wider eastern segment included buffered bike lanes in both directions after the road diet.

Figure 8. Before (Left) and After (Right) Photographs of Road Diet on Post Forest Drive

Ridge Top Road

Ridge Top Road (State Route 7224) is an urban minor collector with a posted speed limit of 35 mph that runs in a general north/south direction. Its link length from Lee Highway (southern terminus) to Random Hills Road (northern terminus) is 0.51 miles. The facility is rated as having an LOS A and carries an AADT of approximately 4,650 vpd. The road diet was completed in the summer of 2018. The road diet replaced a four-lane typical section with a three-lane typical section including dedicated left-turn lanes and buffered bike lanes between Random Hills Road and Government Center Parkway (Figure 9). The wider segment between Government Center Parkway and Lee Highway had varying before-after cross-sections; the road diet added buffered bike lanes on this segment and retained on-street parking where it had existed previously (Figure 10).

Figure 9. Before (Left) and After (Right) Photographs of Road Diet on Ridge Top Road Between Random Hills Road and Government Center Parkway

Figure 10. Before (Left) and After (Right) Photographs of Road Diet on Ridge Top Road Between Government Center Parkway and Lee Highway

Data Collection

Road diet installations occurred in the summer of 2018 with the exception of Colts Neck Road where installation occurred in the fall of 2017. Prior to the road diet installations, a VDOT traffic data contractor collected motor vehicle volume and speed data with pneumatic tube counters on the dates shown in the "Before Period" column in Table 1. Accounting for potential seasonal variations in traffic patterns, data were collected during similar dates in the after period approximately 1 year later, as shown in the table. (The one exception was Colts Neck Road, where before data were collected in mid- to late July and after data were collected in early June.) Data collection days were selected to capture typical weekday (Tuesday through Thursday) and weekend traffic patterns, avoiding holidays and special events. Generally, 8 to 10 days of data were obtained at each location; data for Mondays, Fridays, and days with rain were discarded. Data quality was verified at each site, and if the quality was deemed poor, additional days of data were collected. This was the case at Colts Neck Road, where additional days of data were collected to replace data for the days exhibiting poor quality data (i.e., abnormal volumes and/or speeds). Speed data were provided in 5-mph bins.

Intuitively, ideal data collection locations would be at the midpoint of each roadway and/or segment; however, actual locations were determined based on field observations of traffic with an objective of capturing free-flow vehicle movements. The last column in Table 1 shows the number of data collection locations on each road.

Table 1. Motor Vehicle Volume and Speed Data Collection Dates

Road Diet	Before Period	After Period	No. of Locations
Bluemont Way	4/26/2018 to 5/4/2018	4/22/2019 to 5/1/2019	1
Colts Neck Road	7/17/2017 to 7/26/2017	5/30/2018 to 6/8/2018[a]	2
Post Forest Drive	5/7/2018 to 5/15/2018	4/22/2019 to 5/1/2019	1
Ridge Top Road	5/7/2018 to 5/15/2018	4/22/2019 to 5/1/2019	2

[a] Additional after data collection days: 6/15/2018 to 6/19/2018.

For Colts Neck Road and Ridge Top Road, data were collected at two locations to account for potential traffic pattern changes from intersecting roads. Data were collected at one location along both Bluemont Way and Post Forest Drive; the latter had two segments, but it was determined in the field that tubes could be deployed safely only on the segment between West Ox Road and Legato Road. An aerial view of Bluemont Way is shown in Figure 11, with the green marker showing the data collection location. Aerial views of data collection locations for Colts Neck Road, Post Forest Drive, and Ridge Top Road are shown in Appendix B.

At each data collection site, schematics provided traffic directionality and pneumatic tube spacing and dimensions. Figure 12 shows the before and after road diet installation pneumatic tube schematic for Bluemont Way. Schematics for Colts Neck Road, Post Forest Drive, and Ridge Top Road are shown in Appendix C.

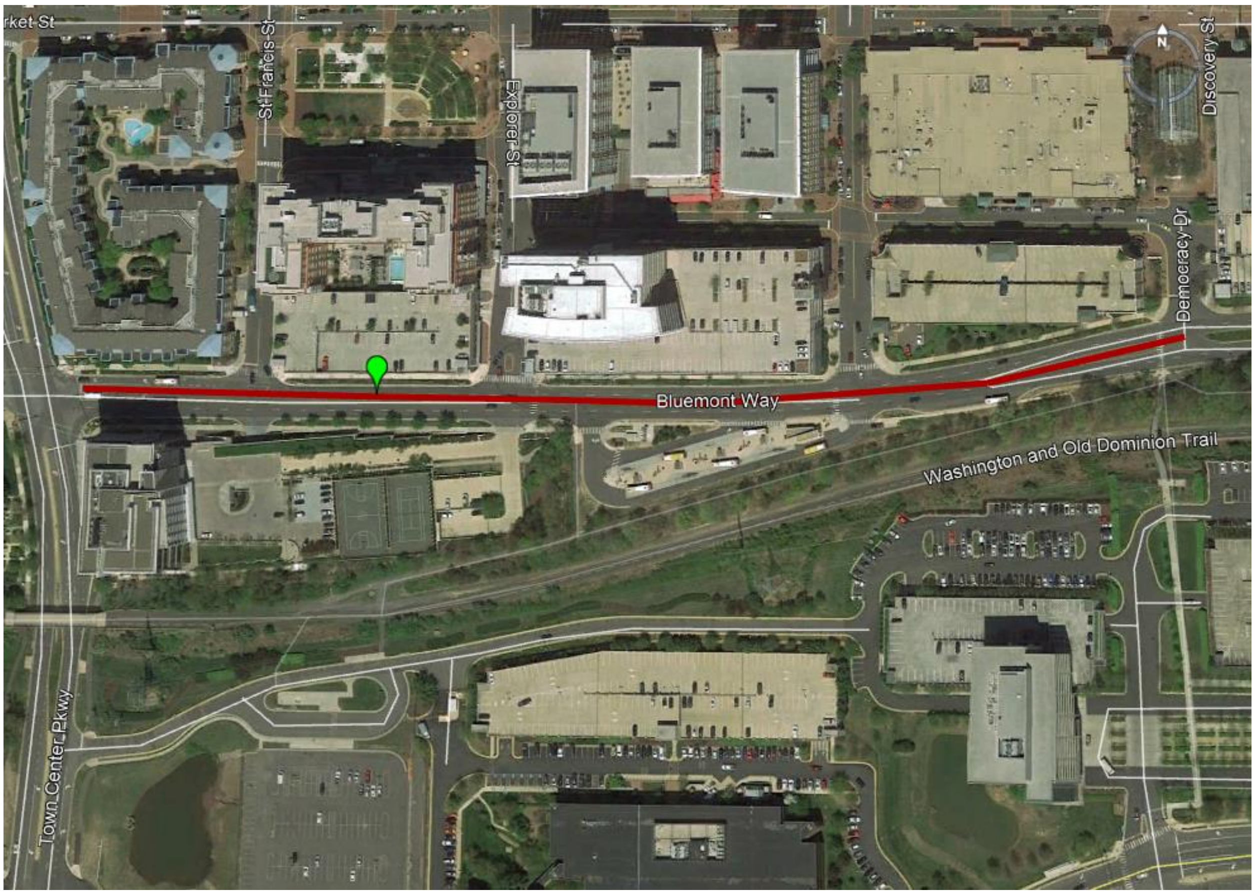


Figure 11. Aerial View of Bluemont Way Road Diet Site, Surrounding Land Use Context, and Data Collection Location. The green marker shows the data collection location. Map data ©2018 Google.

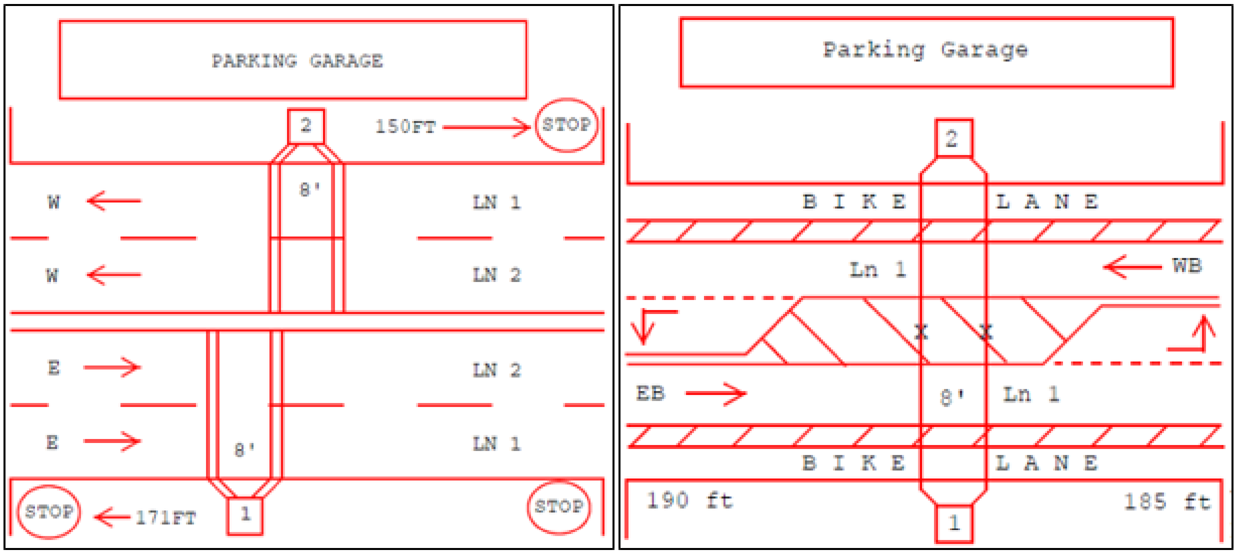


Figure 12. Schematics of Bluemont Way Data Collection Locations Before (Left) and After (Right) Road Diet. Images provided by The Traffic Group, Inc. Reprinted with permission.

Bicycle and Pedestrian Volume Data Collection

To investigate the value of examining bicycle and pedestrian volumes before and after a road diet, short-duration roadway videos were obtained at two sites on one of the road diet streets: Colts Neck Road. Data were collected for 7 days to encompass a 3-day Tuesday through Thursday period plus a weekend both before and after the road diet. As shown in Table 2, the video data collection dates were at similar times of the year with comparable low and high temperatures, but rain occurred during several of the after counts. Day 3 (Thursday before) had some missing video footage and was re-filmed as Day 7 the following Thursday. Dates for manual data reduction were selected as described here.

The two sites represent two segments of Colts Neck Road, but there were discrepancies regarding where contractors placed the cameras in the before and after cases. For the segment between Sunrise Valley Drive and South Lakes Drive, the camera was placed at South Lakes Drive in the before case and at Royal Fern Court (approximately 400 ft north of South Lakes Drive) in the after case. For the segment between South Lakes Drive and Glade Drive, the camera was placed at 2264 Hunters Woods Plaza in the before case and at Winterthur Lane (approximately 550 ft north of 2264 Hunters Woods Plaza) in the after case. For motor vehicle traffic monitoring, these small differences would likely be insignificant in terms of the resulting vehicular volumes, but because of the more granular nature of walking and, to a lesser extent, bicycling activity, they could have introduced substantial error in the results. For this reason and because of relatively low volumes and few before and after cases, the analysis of bicycle and pedestrian volume data was limited to visualizations and high-level discussion of the data rather than statistical analysis.

Table 2. Video Data Collection Dates and Weather Conditions for Colts Neck Road

Case	Day No.	Date	Day of Week	Rain (in)[a]	Low Temperature	High Temperature
Before	**1**[b]	**June 6, 2017**	**Tuesday**	None	59 °F	77 °F
	2	**June 7, 2017**	**Wednesday**	None	53 °F	69 °F
	3[c]	June 8, 2017	Thursday	None	50 °F	75 °F
	4	June 9, 2017	Friday	None	52 °F	80 °F
	5	**June 10, 2017**	**Saturday**	None	60 °F	87 °F
	6	June 11, 2017	Sunday	None	64 °F	91 °F
	7	June 15, 2017	Thursday	None	69 °F	85 °F
After	8	May 31, 2018	Thursday	2.4 (5-7 p.m.)	68 °F	83 °F
	9	June 1, 2018	Friday	0.1 (11 p.m.)	69 °F	88 °F
	10	**June 2, 2018**	**Saturday**	1.2 (6 p.m.)	69 °F	82 °F
	11	June 3, 2018	Sunday	0.8 (daytime)	56 °F	71 °F
	12	June 4, 2018	Monday	None	56 °F	79 °F
	13	**June 5, 2018**	**Tuesday**	None	52 °F	80 °F
	14	**June 6, 2018**	**Wednesday**	None	59 °F	74 °F

[a] Precipitation and temperature data were obtained from Weather Underground using the Washington Dulles International weather station.
[b] Dates selected for manual data reduction are in boldface type.
[c] Date had missing data (1 hr at one site and 10 hr at the other site).

Analyzing Operational Effects of Road Diets

Motor Vehicles

Volume and Speed

The pneumatic tube counters placed at each site before and after road diet construction provided motor vehicle count and speed data in 15-minute bins for each lane. An example of the raw output from the counters in the before period on Bluemont Way eastbound is shown in Table 3 (values shown are the sum of both lanes). Upon completion of both before and after data collection, the data were reviewed for the purposes of analyzing data integrity and constructing volume and speed profiles. Constructing volume profiles served two purposes: (1) identifying peak flows for use when analyzing after data, and (2) creating baseline traffic volume profiles so that systematic differences in traffic characteristics could be examined over the study period.

An example of a volume profile created from weekday before data eastbound at Bluemont Way is shown in Figure 13, wherein the 15-minute data in the "All Speeds" column in Table 3 were summed per hour to provide an hourly volume. If there were two travel lanes in each direction (as was typically the case in the before period), the 15-minute count data were summed for both lanes to obtain an hourly directional volume. Hourly volumes were then averaged for weekdays using Tuesday, Wednesday, and Thursday data and for weekends using Saturday and Sunday data. Comparing data from each direction provided information on peak hourly flows. For example, the morning peak flow on Bluemont Way was in the eastbound direction from 7:00 a.m. to 10:00 a.m. Similar volume profiles were constructed for the westbound lanes.

Table 3. Example Motor Vehicle Speed Classification Output (Number of Vehicles per Speed Bin) for a Single Lane, Bluemont Way, Eastbound

Time	<5 mph[a]	10 mph	15 mph	20 mph	25 mph	30 mph	35 mph	40 mph	45 mph	50 mph	All Speeds
7:00[b]	0	0	0	0	7	36	17	2	1	0	63
7:15	0	0	0	5	15	25	18	3	0	0	66
7:30	0	1	1	4	14	41	18	2	0	0	81
7:45	0	0	1	5	19	49	30	3	1	0	108
8:00	0	0	1	3	15	48	35	5	1	0	108
8:15	0	0	1	5	23	61	30	4	1	0	125
8:30	0	0	0	4	20	65	32	8	1	0	130
8:45	0	0	0	9	26	75	35	7	0	0	152
9:00	0	1	2	4	20	69	26	6	0	0	128
9:15	1	1	2	3	34	46	31	5	1	0	124
9:30	0	0	0	1	8	32	38	7	1	0	87
9:45	0	0	0	4	24	38	27	9	0	1	103

[a] Speed bin headings are the maximum speed for 5-mph bins, exclusive of that speed. For example, 2 vehicles traveling at 25.0 mph and 29.9 mph would both be counted in the 30-mph bin.
[b] Times shown are start times for 15-minute bins.

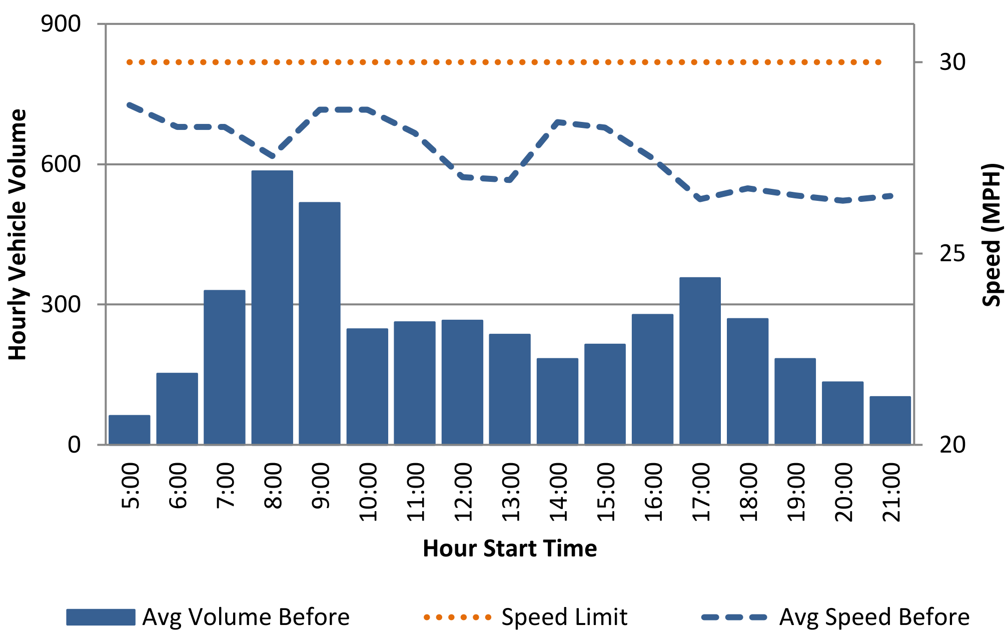


Figure 13. Average Volume and Speed Profiles, Weekday Data Before Road Diet, Bluemont Way, Eastbound

Figure 13 also shows the before period eastbound speed profile for Bluemont Way. To find an average speed over each 15-minute time period, bin data were extrapolated into discrete mean bin data points. For example, in Table 3, during the time period 7:00-7:15 and the speed bin of 30 mph, there were 36 vehicles recorded. This dataset was expanded from 1 data point to 36 data points with an associated speed of 27.5 mph per data point, since the 30-mph bin includes all vehicles traveling at least 25 mph but less than 30 mph. This process created larger datasets and allowed for more robust statistical comparisons of mean speeds. The data “expansion” procedure was performed for each data collection day and for the before and after cases. To obtain average speeds over a time period interval, the number of vehicles per speed bin was multiplied by the average bin speed, summed over the range of speed bins, and then divided by the total number of vehicles. For example, for the 7:00-7:15 time period in Table 3, the following calculation was performed to obtain average speed:

$$\frac{7*22.5+36*27.5+17*32.5+2*37.5+1*42.5}{63}=28.9\text{ mph}$$

Once the average speed was determined for each 15-minute time period, the values were averaged per hour to obtain average hourly speeds. Python scripts were developed to repeat the calculations for all sites in the before and after data collection periods, and graphical visualizations of speed and volume profiles were developed for comparison purposes.

Statistical Testing

Statistical testing was performed to analyze changes in average traffic speed and the proportion of speeders all day (5 a.m. to 10 p.m.); during an average weekday period (using Tuesday, Wednesday, and Thursday data) during morning peak hours (7 a.m. to 10 a.m.); and during the afternoon peak hours (4 p.m. to 7 p.m.). Additional testing was performed for an average weekend period using Saturday and Sunday data all day (5 a.m. to 10 p.m.) and during midday peak hours (11 a.m. to 5 p.m.). Based on an analysis of the traffic volume profiles, weekday and weekend peak periods were found to be consistent across all locations.

Hypothesis Testing for Difference in Mean Speed. Large-sample tests for the difference between two means were used to determine if there was a statistically significant difference in the average speed observed before and after the road diet installations. This testing procedure was performed for all locations and day periods. The null hypothesis that there is no difference at a 95% confidence interval ($p \leq 0.05$) and whether to reject or fail to reject it was calculated as follows:

$$z=\frac{(\bar{X}-\bar{Y})-\Delta_0}{\sqrt{\frac{\sigma_X^2}{n_x}+\frac{\sigma_Y^2}{n_Y}}}$$

$$H_0: \mu_X-\mu_Y=0$$

$$H_1: \mu_X-\mu_Y\neq 0$$

where

μ_X = population mean speed (before)
μ_Y = population mean speed (after)
σ_X^2 = sample variance (before)
σ_Y^2 = sample variance (after)
z = z-test statistic
$\bar{X}$ = sample mean speed (before)
$\bar{Y}$ = sample mean speed (after)
n_x = sample size (before)

n_Y = sample size (after).

Hypothesis Testing for the Difference Between Two Proportions. Statistical tests were conducted to determine the significance of changes in speeding behavior before and after road diet installations at all locations. The proportions of speeders at least 5 mph and at least 10 mph over the speed limit were analyzed for all locations and day periods, and, at a 95% confidence level ($p \leq 0.05$), whether to reject or fail to reject the null hypothesis that the proportion of speeders was unchanged was calculated as follows:

$$z = \frac{(\hat{p}_x - \hat{p}_y)}{\sqrt{\hat{p}(1-\hat{p})\left(\frac{1}{n_X} + \frac{1}{n_Y}\right)}}$$

$$\hat{p}_X = \frac{X}{n_X}, \qquad \hat{p}_Y = \frac{Y}{n_Y}, \qquad \hat{p} = \frac{X+Y}{n_X + n_Y}$$

$$H_0: \widehat{\boldsymbol{p}_x} - \widehat{\boldsymbol{p}_y} = 0$$

$$H_1: \widehat{\boldsymbol{p}_x} - \widehat{\boldsymbol{p}_y} \neq 0$$

where

$\hat{p}_x$ = proportion of speeders (before)
$\hat{p}_y$ = proportion of speeders (after)
n_x = sample size (before)
n_Y = sample size (after)
X =number of speeders (before)
Y =number of speeders (after)
$\hat{p}$ = pooled proportion
z = z-test statistic.

Bicycle and Pedestrian Volumes

To obtain bicycle and pedestrian counts from the videos, automated video analysis (Miovision) was considered but ultimately not pursued because of its disproportionately high cost compared to its role in the overall research study. Instead, two parallel avenues were pursued for obtaining bicycle and pedestrian counts from the video footage. Videos were shared with researchers developing computer vision systems, both to help refine the technology and to see if reasonably accurate count data could be obtained. This approach was ultimately unsuccessful for the purposes of this study, so manual video reduction was performed for selected dates and times.

Obtaining Counts From Computer Vision Technology

Videos of before and after footage were shared with researchers at the Robotics Institute at Carnegie Mellon University (CMU) who were refining an automated process with human verification to obtain automobile, bicycle, and pedestrian counts. At the time, the algorithms were claimed to have 95% accuracy, and all counts were human-verified, which was also the plan for the Virginia Transportation Research Council (VTRC) data. There were no requirements for video quality, and a 2-week timeframe was expected to allow for manual verification.

Still images from videos were annotated to indicate detection and trajectory zones for the analysis. Although this study required only screenline counts, CMU's algorithm was set up to conduct turning movement counts for bicyclists and to tally pedestrians in multiple detection zones. As shown in Figure 14, pedestrian detection zones were drawn for pedestrians in the crosswalk, on the sidewalk, and in the street adjacent to the sidewalk. Bicycle detection zones were also drawn for bicyclists on the sidewalk; zones drawn in the street were to be used for bicycle turning movement counts.

This dataset was significantly longer than what the algorithm had analyzed in the past. This resulted in the realization that 100% human verification would be too time-consuming; at the same time, necessary adjustments to the algorithm required manual review and re-training in order to attempt to reach 95% accuracy, at an additional time cost. For one day, the poor/blurry image quality made the data not usable; camera resolution was lower than CMU had expected; and low light levels made data for nighttime hours difficult or impossible to process.

After several months, a sample of results from one day's footage was provided. Manual review by VTRC researchers indicated several accuracy issues and also found that the pedestrian detection zones resulted in a pedestrian being counted multiple times, complicating the conversion to screenline counts. Bicycle counts included only turning movements and not bicyclists on the sidewalk. Explanations for the accuracy issues included a software bug, changing lighting conditions, and expenditure of CMU staff time optimizing the auto counts rather than the bicycle and pedestrian counts. In part as a result of this experience, CMU began working on a new machine learning system that could address some of the limitations encountered.

Figure 14. Proposed Pedestrian Detection Zones (Left) and Bicycle Trajectory Zones (Right) for One Camera Angle

The approach was later revised to include manual review to obtain 95% accuracy for only a subset of hours (3 hours during the PM peak on Tuesdays and Wednesdays). When after several more months that analysis had not been completed, the VTRC researchers made the decision to perform manual data reduction on a subset of the videos rather than continue to pursue the use of automated algorithms. Although it was not successful in analyzing this dataset, computer vision is an ongoing area of computational development that may be of value in future studies, especially if technologists and researchers can address the issues encountered and lessons learned in this study.

Manual Data Reduction

Manual data reduction was performed using VLC Media Player software and Excel for two weekdays and one weekend day in both the before and after cases. Tuesday and Wednesday were selected as the weekdays to avoid potentially atypical volume patterns of Mondays or Fridays and to avoid the rainy Thursday after count. For these days, afternoon and evening hours were reviewed: 3 p.m. to 10 p.m. Saturday was selected as the weekend day; although the after Saturday had a slightly higher rainfall total than the after Sunday, the former had a brief period of rain around 6 p.m., but the latter's rainfall was spread throughout the day. An afternoon and evening period of 1 p.m. to 10 p.m. was reviewed for the Saturdays.

The following rules were used for manual data reduction, which used 15-minute bins. Cars, buses, motorcycles, or motorized scooters with seats were not counted. People in wheelchairs or strollers were counted along with other pedestrians and joggers. People on tricycles, bicycles, tandem bikes, and in bike trailers were counted as bicyclists. This location did not have a substantial amount of people using other low-speed conveyances (e.g., stand-up scooters, rollerblades, skateboards, hoverboards, etc.), but any such vehicles were tallied as bicycles. All users were tallied as they crossed a predetermined screenline. To enable analysis of user positioning (i.e., whether bicyclists were riding in the street and in the proper direction and whether pedestrians were walking on the sidewalk), bicyclists were classified by direction, location (in street or on the sidewalk), and whether riding with adjacent traffic (in the same direction as cars) or against traffic. Pedestrians were classified by location (in street or on sidewalk). Charts were developed to visualize the data.

RESULTS AND DISCUSSION

Literature Review

Literature review results are organized into summaries in the following general categories:

- the *Road Diet Informational Guide*
- studies before 2014 not included in the *Road Diet Informational Guide*
- before-after studies of road diets published from 2014 through 2019

- other publications from 2014 through 2019, such as case analyses, modeling and simulation studies, guidance, and performance measures related to road diets.

Tabular summaries are presented for studies and other publications published from 2014 through 2019 for ease in comparing their methods, findings, limitations, and recommendations.

The *Road Diet Informational Guide*

The *Road Diet Informational Guide* provided a comprehensive baseline of considerations from research and practice to support the decision-making process regarding road diets, including feasibility, design, and evaluation (Knapp et al., 2014). It contained an overview of studies conducted prior to 2014 along with details in an appendix and also provided context and history regarding the prevalence of four-lane undivided roadways. It summarized studies from eight states and with widely varying methods that ranged from simple before-after analysis without controls to advanced statistical techniques. It also summarized the results of interviews conducted with agencies that had implemented road diets.

Treatment sites from studies summarized in the *Road Diet Informational Guide* had ADT levels from 2,000 to 26,000 and total crash reductions of 19% to 47%. Other key findings included that safety benefits may diminish as traffic volumes increase and that motor vehicle speed reductions of 3 to 5 mph are likely, along with improved speed harmony (i.e., lower variability in speeds). Greater reductions in speed were apparent on corridors with higher traffic volumes. Studies supported the intuitive conclusion that road diets can be relatively low cost if performed along with reconstruction or repaving.

The *Road Diet Informational Guide* recommended road diets for addressing safety problems including rear-end crashes with left-turning traffic, sideswipe crashes, left-turn crashes because of negative offset left turns, and bicycle and pedestrian crashes. CMFs as high as 47% were provided for small town sites with low traffic volumes. For suburban corridors in larger cities, a lower CMF of 19% was provided, with a mid-range CMF of 29% suitable for other sites. Similarly, road diets can address certain operational problems, including delays from left-turning traffic, side street delays at unsignalized intersections, bicycle delay because of shared lanes with vehicles or sidewalk use, and other issues such as lack of bicycle and pedestrian facilities, unappealing aesthetic conditions, and vehicle speeds that discourage pedestrian activity. Automobile LOS begins to decline at two-way peak hour volumes above 1,750 vehicles per hour, but signal timing optimization can mitigate some declines. Streets with transit routes should be assessed for potential operational effects of transit stops before a road diet is implemented.

Studies Before 2014 Not Included in the *Road Diet Informational Guide*

Two studies bear mentioning that were published prior to the *Road Diet Informational Guide* but not included therein. Persaud et al. (2010) compared two methods for before-after road safety evaluations: the empirical Bayes and fully Bayesian approaches. The dataset was that of a study (Pawlovich et al., 2006) that was included in the *Road Diet Informational Guide* and consisted of 15 road diets (mainly 4-3 road diets) and 15 control sites in Iowa. Persaud et al.

added a 296-site reference group and produced various models with crash reduction rates of 47% to 55% (over all crash sites, not per mile). The study found that the empirical Bayes and fully Bayesian results were comparable. A recommendation was to consider fully Bayesian analysis when the reference group is not large enough to calibrate safety performance functions in an empirical Bayes approach or if the distribution of crash counts does not follow the negative binomial distribution.

Vergis and Niemeier (2012) focused on public opinions of a road diet in Davis, California, based on a 2011 citywide household survey prior to construction. Substantial opposition caused the project to be implemented as a trial rather than a permanent road diet. The study found that public opinion influences the consideration and implementation of projects and whether they are deemed successful. Project support in the survey was correlated with levels of perceived safety and comfort, bicycle usage frequency, and expectation of side-street congestion. It was also correlated with attendance at public outreach meetings, among other factors, suggesting that jurisdictions can address residents' concerns by providing the types of information they value. Further research was suggested on the relationship between public opinion and information sources.

Before-After Studies, 2014-2019

Tables 4 and 5 summarize before-after studies published from 2014 through 2019, after publication of the *Road Diet Informational Guide*. Studies shown in Table 4 were of road projects that used the term "road diets." Studies shown in Table 5 concerned projects that had various names: complete streets (Anderson and Searfoss, 2015; Yu et al., 2018); traffic calming (New York City Department of Transportation, 2014a); protected bicycle lanes (New York City Department of Transportation, 2014b); and roadway reallocation projects (Figliozzi and Glick, 2017). Each of the studies in Table 5 contained at least one project that could be termed a road diet (i.e., at least one travel lane was converted to a different roadway feature).

All of the studies found generally positive results but used different methods and performance measures. Auto-oriented measures included volumes, travel times, speeds, crashes, and cut-through traffic; one study used bus transit data to quantify both auto and transit operations. Volume was the most common performance measure for bicycle and pedestrian modes, and crashes and injuries were used in one study. Economic measures included retail sales, employment, number of businesses, property values, and private investment. Not studying effects on parallel or neighborhood streets was a limitation in a few studies; the one study with extensive data collection on such streets (Nixon et al., 2017) still found it difficult to detect significant effects.

Table 4. Before-After Road Diet Studies, 2014-2019

Citation: Title	Study Focus; Region; Data Year; Methods	Findings	Limitations; Recommendations
Gudz et al. (2016): When a Diet Prompts a Gain: Impact of a Road Diet on Bicycling in Davis, California	Before-after study of road diet effects on pedestrian and bicyclist volumes and auto travel times; Davis, California; 2013-2014; t-tests	Every intersection within the treatment corridor had a statistically significant increase in the number of bicyclists, averaging 243%, with increased gender parity; there were no statistically significant changes in pedestrian volumes. No evidence was found of increased auto travel times.	The number of after observations was lower than planned because a major construction project affected traffic patterns, preventing data collection. Auto travel time runs used signs as start/end points, one of which was moved slightly during the reconfiguration. Parallel streets and impacts to business and bus operations were not studied.
Ntonifor and Chavis (2017): Valuation of the Impacts of Road Diet Implementation: Wilson Boulevard Road Diet, Arlington County Virginia	Before-after analysis of auto volumes, speeds, travel times, crashes, and cut-through traffic, plus bicycle and pedestrian volumes; Arlington, Virginia; 2014-2015; simple comparisons, F-tests, and t-tests	Project objectives were more or less met; study was inconclusive regarding whether residents' claim of spillover cut-through traffic on neighborhood streets was supported by the data.	Study had a very short after period and no control streets. A more detailed study was recommended to confirm whether neighborhood streets were negatively affected.
Nixon et al. (2017): Designing Road Diet Evaluations: Lessons Learned from San Jose's Lincoln Avenue Road Diet	Comprehensive before-after evaluation with recommendations for how to design road diet evaluations; San Jose, California; 2014-2016; analysis of speeds and volumes including a power analysis	Despite extensive data collection (45 locations for a single road diet), 2 days before and 2 days after, more days would have been useful; in most cases, the power analysis found that the changes in traffic volume or number of speeders were too small given the small sample size to detect significant effects.	Look at data by time-of-day and aggregated across time, number of speeders (5 mph+ and 10 mph+ above limit), and impacts at individual locations and across locations. Use citywide data to compare a road diet area with volume/speed changes outside the area, and present findings as counts and percentages; use graphics to emphasize changes between pre- and post- (not just before and after values).
FHWA (2018): Toolbox of Pedestrian Countermeasures and Their Potential Effectiveness	Presents crash modification factors (CMFs) for pedestrian countermeasures for all, left-turn, and pedestrian crash types; refers to data and methods from Pawlovich et al. (2006) and Persaud et al. (2010)	CMFs for road diets, pedestrian crash type: 0.81 for an urban area and 0.53 for a suburban area	Both were given a 4 star rating of 5 for quality of the CMF based on the underlying studies

Table 5. Before-After Studies of Complete Streets, Protected Bicycle Lane, and Roadway Reallocation Projects, 2014-2019

Citation: Title	Study Focus; Region; Data Year; Methods	Findings	Limitations; Recommendations
New York City Department of Transportation (2014a): 4th Avenue, Sunset Park Traffic Calming	Image-heavy presentation of analysis of a 2012 road diet; New York, New York; 2006-2014; before-after metrics for safety, mobility, and economic vitality and quality of life	Reductions in total crashes (12%), pedestrian injuries (29%), and speeding (38%). Unchanged traffic volumes, slightly improved peak travel times, increased pedestrian volumes.	One-year after analysis period may be too short for drawing generalizations, especially regarding pedestrian fatalities (0 after implementation, but previous 6 years each had 0, 1, or 2).
New York City Department of Transportation (2014b): Protected Bicycle Lanes in NYC	Image-heavy presentation of analysis of 12 protected bike lane projects at least 3 years old, typically lane reconfigurations but more than just restriping; New York, New York; 2007-2014; before-after metrics for safety, mobility, and economic vitality and quality of life	Crashes with injuries were reduced 17%, bicyclist injuries had a minor decrease whereas bicycle volumes dramatically increased, travel speeds remained steady, treatment sites saw a greater increase in retail sales	Findings are not necessarily transferrable to typical road diets, but the document may represent a model for evaluating projects on multiple scales and for presenting results.
Anderson and Searfoss (2015): Safer Streets, Stronger Economies: Complete Streets Project Outcomes From Across the Country	Compilation of 37 projects with before-after data on transportation and economic performance submitted by local departments of transportation; 31 cities in 18 states; years not always shown but likely pre-2014; crashes, volumes, costs, employment, number of businesses, property values, and private investment	Complete Streets projects tend to improve safety and increase biking and walking and can inexpensively achieve transportation goals and economic gains.	More data that are non-anecdotal would be required for a conclusive determination that Complete Streets projects produce economic gains. Before-and-after data were scarce and collected with different methods. Many of the projects described are included in other sources and the *Road Diet Informational Guide.*
Figliozzi and Glick (2017): Evaluation of Roadway Reallocation Projects: Analysis of Before-and-After Travel Speeds and Congestion Utilizing High-Resolution Bus Transit Data	Method for evaluating transit operations and speed and queue length before road diets using high-resolution transit datasets; 2 case studies in Portland, Oregon; 2015-2016; flagged significant changes using confidence intervals for changes in transit speeds and travel times after removing the influence of bus stops from the dataset	High-resolution transit data from automatic vehicle location systems are often freely available and can help in evaluating speed and queue length. The proposed methods are broadly applicable and allow analysts to consider transit operations.	Did not address general questions about effectiveness of road diets. Case study 1 was a lane diet (no lane removal). High-resolution transit datasets require a lot of data processing, a barrier that may decrease over time as analytic tools improve.
Yu et al. (2018): Assessing the Economic Benefits and Resilience of Complete Streets in Orlando, FL: A Natural Experimental Design Approach	Natural experiment exploring the economic benefits on single-family property values along a Complete Street project before and after the 2001-2002 resurfacing and before and after the 2007-2011 housing market crash; Edgewater Dr., Orlando, Florida; 2000-2011; propensity score matching	On average, single-family homes exposed to Complete Streets had 8.2% higher home value appreciation during the housing boom and 4.3% higher home value resilience during the housing market downturn than controls.	Complete Streets can contribute to increased housing values during a boom and to housing value resilience during a recession.

Other Publications, 2014-2019

Tables 6 through 8 summarize other publications from 2014 through 2019. Table 6 includes case analyses of road diets, three of which are high-level qualitative assessments from Minnesota. The 24 other case studies from nine states included in *Road Diet Case Studies* (FHWA, 2015) were developed alongside the *Road Diet Informational Guide* and are also high-level summaries, some with quantitative data. The 24 case studies focused on various aspects of road diets, including the following:

- suitability analysis of all four-lane roads
- demonstration projects and simulations to look at tradeoffs and feasibility
- traffic congestion and capacity, signal operations, and transit operations
- motorist safety, crashes, aggressive driving, and speeding
- bicycle safety, mobility, connectivity, and ridership
- pedestrian safety
- multimodal LOS
- livability and economic development
- community input, public outreach, and public perceptions.

Results were generally described as positive (FHWA, 2015).

Table 7 presents four studies concerning the modeling and simulation of road diets, two of which (Le Vine, 2017; Noland, 2017a) were responses to a third (Noland et al., 2015). The fourth study included road diets as one geometric design option that a comprehensive sustainability model was able to analyze. Noland et al. (2015) and Zhang et al. (2015) provided contrasting approaches to modeling road diets, with the former focusing on estimating the most likely and highest order benefits (crash reductions) and costs (travel time increases) and the latter attempting to model those items alongside several other categories of performance measures.

The items in Table 8 comprise guidance for practitioners regarding road diets and related processes for planning, design, and performance evaluation. Some of these (e.g., Stamatiadis and Kirk, 2014, and Noland, 2017b) could have been categorized alongside studies concerning modeling of road diets (i.e., in Table 7) but were instead placed in this group because the analysis they contained was performed for the purpose of developing operations-based guidelines or policy recommendations. The operations-based guidelines highlighted the importance of considering side street traffic volumes and signalized intersections along with volumes on the proposed road diet street in evaluating the suitability of a road diet. Noland (2017b) used a cost-benefit analysis to support the argument that detailed engineering analysis is unnecessary for many road diet projects, especially in cases where a study would cost more than constructing the road diet itself. Other publications in this group addressed the role of interim design and tactical urbanism (i.e., the use of low-cost materials to make temporary or permanent changes); the roadway resurfacing planning and design process; measures for evaluating complete streets; and the creation of bikeways through reallocating road space.

Table 6. Road Diet Case Studies, 2014-2019

Citation: Title	Focus; Region; Data Year; Methods	Findings	Limitations; Recommendations
FHWA (2015): Road Diet Case Studies	Case studies of 24 U.S. road diets; Michigan, Illinois, California, Virginia, Iowa, Nevada, New York, Washington, and Indiana; various years; case studies	Various positive outcomes in safety, operations, and quality of life measures. Low cost if completed in conjunction with reconstruction or resurfacing projects.	Many case studies include elements not consistent with the Manual on Uniform Traffic Control Devices (MUTCD).
Cebe (2016): An Evaluation of "Road Diet" Projects on Five Lane and Larger Roadways	Six completed and 2 proposed road diets on roads with 5 to 9 lanes before; South Carolina, California, Oregon, Washington, DC, North Carolina, and Texas; various years; case studies	Projects that added or improved bike lanes and counted bikes found increases in bicycle volumes. Crash data were inconclusive. Vehicular operations were minimally impacted.	Further research is needed to determine which design treatments and corridor conditions lead to which safety and operational improvements. Volume-based guidelines are less clear for road diets on 5-lane roads than for 4-3 road diets.
Minnesota Department of Transportation (2018a): Road Diet Case Study: Highway 29 in Parkers Prairie	High-level case analysis of a 2016 road diet on a street through a small town; Parkers Prairie, Minnesota; 2015-2018; qualitative summary of change	Street is safer and more attractive with improved stormwater management. Crashes were reduced, with a lower rate of injury and property damage crashes.	Numerical crash reduction not provided; no quantitative data for volumes of motor vehicles, bicycles, or pedestrians. Reconstruction allowed for more substantial bicycle, pedestrian, and livability improvements than a mill and overlay would have allowed.
Minnesota Department of Transportation (2018b): Road Diet Case Study: Highway 65/South Broadway Avenue in Albert Lea	High-level case analysis of a 2015 road diet on a downtown street; Albert Lea, Minnesota; 2009-2018; qualitative summary of change	Crashes were reduced, and average vehicle speeds dropped slightly. May have contributed to broader community-wide outcomes such as increased biking and walking.	Same as Minnesota Department of Transportation (2018a).
Minnesota Department of Transportation (2018c): Road Diet Case Study: Highway 78/Lake Avenue in Battle Lake	High-level case analysis of a 2014 road diet on the main street of a small town; Battle Lake, Minnesota; 2013-2018; qualitative summary of change	Reconstruction of the state highway/main street improved conditions for biking, walking, and stormwater. Crashes were reduced, and pedestrian visibility was increased.	Same as Minnesota Department of Transportation (2018a).

Table 7. Studies Modeling and Simulating Road Diets, 2014-2019

Citation: Title	Focus; Region; Data Year; Methods	Findings	Limitations; Recommendations
Noland et al. (2015): Costs and Benefits of a Road Diet Conversion	Cost-benefit evaluation of a proposed road diet project; New Brunswick, New Jersey; 2012; VISSIM micro-simulation and benefit-cost analysis of multiple scenarios	Benefits (the value of statistical lives saved based on expected crash reductions) exceed costs (travel time costs based on increased delay) over a 20-year period.	Did not collect speed data. Assumptions could be inaccurate (e.g., one scenario required assuming an 8% traffic volume reduction in order to maintain operations). Other costs and benefits may exist that were not accounted for. [Le Vine (2017) is a critique of this study.]
Zhang et al. (2015): MOSAIC: Model of Sustainability and Integrated Corridors Phase 3: Comprehensive Model Calibration and Validation and Additional Model Enhancement	Quantitative evaluation of sustainability indicators for corridor improvements; road diets are one of the tool's 3 geometric improvement options; Maryland; no data year; development of a model	Performance measures address the categories of mobility, safety, socioeconomic effects, natural resources, energy and emissions, and benefit-cost ratio.	Integration within a state highway department's GIS environment allows the tool to be used to support decision-making processes.
Le Vine (2017): How Overwhelming Is the Evidence in Favor of Road Diets? A Note on the Cost-Benefit Methodology Proposed by Noland et al. (2015)	Critique of how Noland et al. (2015) specified benefits and costs and interpreted public opinion regarding a proposed road diet; New Brunswick, New Jersey (see Noland et al., 2015)	Crash reduction benefits were estimated improperly; increases in crash exposure on parallel routes were ignored; traffic volume assumptions were unjustified; costs of increased emissions were not quantified; and public opinion was improperly represented.	The cost-benefit method used by Noland et al. (2015) does not represent good practice and does not show that the benefits exceed the costs. Planners should be more "timid" when performing and reporting cost-benefit analyses, rather than less timid as was suggested by the authors of the original study.
Noland (2017a): A Rejoinder to the Critique of "Costs and Benefits of a Road Diet Conversion"	Rebuttal to Le Vine (2017), which critiqued Noland et al. (2015); New Brunswick, New Jersey (see Noland et al., 2015)	Not analyzing off-peak traffic conditions is common practice; there could have been off-peak benefits, not just costs. Volume assumptions were reasonable. Traffic might have diverted to other time periods or not have been generated; even if it diverted to parallel streets, back-of-the-envelope calculations do not change original findings.	Future simulation work should make use of newer tools to simulate 2-way turning lanes and should include varied crash reduction factors. Regulations should be changed that require costly upgrades over quick restriping projects that can achieve meaningful crash reductions. Status quo traffic engineering approaches are time-consuming and biased toward maintaining free-flowing traffic.

Table 8. Guidance and Performance Measures Related to Road Diets, 2014-2019

Citation: Title	Focus; Region; Data Year; Methods	Findings	Limitations; Recommendations
Stamatiadis and Kirk (2014): Simulation-Based Guidelines for Road "Diets"	Guidelines for considering road diets based on traffic operations; no region or data; microsimulation and linear regression	Side street volumes matter, and road diets can work on roadways with volumes up to 23,000 vehicles per day.	Includes a figure with road diet suitability based on main and side street traffic volumes and signalized intersections and a flow chart for road diet evaluations
Nielson et al. (2015): Engineering Interim Design and Tactical Urbanism: From Cost-Effective, Quick Improvements to Powerful Public Outreach Tools	Overview of engineering considerations for interim design (several months to several years) and tactical urbanism (a few hours to a few days) projects; three California sites; 2014; case studies	One case study illustrated a 1-day effort to install a 2-block parking-protected bike lane by removing 1 lane on a 5-lane street (Telegraph Ave. in Oakland) to demonstrate traffic operations.	No before/after data on the case studies described. Interim design and tactical urbanism can help obtain buy-in from decision makers, address safety needs, and achieve community goals.
FHWA (2016): Incorporating On-Road Bicycle Networks Into Resurfacing Projects	Methods and considerations for adding bicycle facilities with repaving projects; Wisconsin, California, Kansas, and Virginia; various years; case studies and local focus groups, interviews, and peer exchanges	Outlines typical roadway resurfacing planning and design process and bikeway selection decision points	Considering bikeways earlier in the resurfacing process provides more time for design and public participation. A minimum 2-year timeframe is recommended.
Hui et al. (2017): Measuring the Completeness of Complete Streets	Considers performance standards for how streets serve mobility, environmental, and place functions; no region or data	The Complete Streets design concept lacks quantitative guidance, and no framework was found in the literature for evaluating the completeness of a complete street.	Does not directly mention road diets but discusses "the right-of-way allocation problem." Measures should recognize street functions in terms of mobility, environment, and place and should be context-sensitive.
Noland (2017b): Evaluating Potential Road Diets: The Benefits of Avoiding Detailed Engineering Analysis	Uses assumptions for the value of a statistical life and travel time costs to perform a cost-benefit analysis of whether delay costs of a road diet will outweigh safety benefits; New Jersey; year unclear; cost-benefit analysis	Argues that detailed conceptual studies can be more expensive than actual roadway restriping work and cause unnecessary project delay	There are other (non-quantifiable) benefits besides those that were considered. Cost-benefit analysis can help screen and prioritize projects and avoid more costly analysis in favor of actually completing projects.
Schultheiss et al. (2019): Bikeway Selection Guide	Guidance for practitioners to select bikeway types while considering tradeoffs; compilation of research and engineering judgment	Includes removing travel lanes through a road diet as one of several options for reallocating roadway space	Primarily directs readers to the *Road Diet Informational Guide*. Also notes that some streets may have other elements that can be reorganized to create bikeways without removing travel lanes.

Inventory of Virginia Road Diets

From the 246 surveys that were distributed to localities, 105 responses were received, for a total response rate of 43%. The response rates for cities (38 distributed, 19 received), counties (95 distributed, 43 received), and towns (113 distributed, 43 received) were 50%, 45%, and 38%, respectively. Table 9 shows each of the localities that responded to the survey categorized by locality type. All nine VDOT districts responded to the survey, and district responses on planned or implemented road diets were allocated to the appropriate towns or counties based on locations provided.

Table 9. Cities, Counties, and Towns That Responded to the Survey

Cities That Responded to Survey	Counties That Responded to Survey	Towns That Responded to Survey
Buena Vista	Alleghany	Abingdon
Charlottesville	Amelia	Altavista
Colonial Heights	Appomattox	Amherst
Danville	Augusta	Appalachia
Emporia	Bath	Appomattox
Franklin	Bedford	Berryville
Fredericksburg	Botetourt	Blackstone
Harrisonburg	Campbell	Boones Mill
Lexington	Charlotte	Bridgewater
Lynchburg	Clarke	Chase City
Manassas	Culpeper	Chincoteague
Martinsville	Cumberland	Culpeper
Norton	Fairfax	Damascus
Poquoson	Fluvanna	Fincastle
Richmond	Gloucester	Floyd
Roanoke	Goochland	Glen Lyn
Salem	Grayson	Gordonsville
Suffolk	Greensville	Gretna
Williamsburg	Henry	Hurt
	Highland	Independence
	Isle of Wight	Kilmarnock
	James City	La Crosse
	King and Queen	Leesburg
	King George	Luray
	Loudoun	Mount Jackson
	Mecklenburg	New Market
	Nelson	Nickelsville
	New Kent	Occoquan
	Northampton	Orange
	Page	Rural Retreat
	Patrick	Scottsville
	Pittsylvania	South Hill
	Powhatan	Stanley
	Prince George	Stephens City
	Roanoke	Tangier
	Rockbridge	Urbanna
	Shenandoah	Vienna
	York	Vinton
		Warrenton
		Wise
		Woodstock

Responses to General Questions for All Respondents

Since 2010, how many road diets have been constructed in your locality/jurisdiction?

Thirteen percent of respondents (15 of 113) indicated constructing road diets since 2010. These localities and VDOT districts included the following:

- City of Danville
- City of Richmond
- City of Roanoke
- City of Salem
- City of Williamsburg
- County of Fairfax
- County of Loudoun
- Town of Altavista
- Town of Amherst
- Town of Blacksburg
- Town of Culpeper
- Northern Virginia District (County of Fairfax)
- Fredericksburg District (County of Mathews)
- Culpeper District (County of Albemarle)
- Lynchburg District (Town of Altavista).

As indicated by the information within parentheses, road diet locations provided by the Northern Virginia and Lynchburg districts correspond to the road diet locations provided by the County of Fairfax and Town of Altavista, respectively.

Do you have any road diet projects that are not yet complete, but are planned or underway? (Please tell us about any road diet projects that are planned or underway.)

Table 10 lists 29 localities where projects were reportedly planned or underway. In addition to localities listed in the table, the Town of Vinton and Shenandoah County provided commentary about potential projects that were in pre-planning stages:

- *Town of Vinton*: We hope to apply for [a] grant for Gus Nicks Boulevard/Washington Avenue Corridor Improvement Project by implementing [the] road diet concept.

- *Shenandoah County*: We are in the preliminary phases of discussing bike lanes in the county. Most of our county is 2 lane highway and unpaved surfaces. Our first step would be an initial study to identify where bike lanes and turn lanes would be appropriate.

Table 10. Localities With Road Diets Planned or Underway

Locality	Road Diets Planned or Underway (Responses as Submitted)
City of Danville	Being studied . . . Westover Drive 4 lanes to 2 with bike lanes
City of Fredericksburg	Lafayette Boulevard is being studied to determine if a planned 4-lane divided road is necessary or if we can scale that back to repurposing the existing road width
City of Harrisonburg	Applied for funding in 2018, Smart Scale for University Blvd and Evelyn Byrd Ave. These roads connect JMU with a regional commercial area
City of Lexington	North Main Street smart scale project (VDOT awarded and construction scheduled for 2022) will take a two lane entryway with on-street parallel parking on both sides and a narrow sidewalk on one side to a two lane street with bike lanes in each direction and a much wider sidewalk on one side (basically through all of VMI)
City of Lynchburg	Campbell Avenue
City of Manassas	Grant Avenue project from Lee Avenue to Wellington Road
City of Martinsville	Two Smartscale applications include road diets.
City of Richmond	13 lane miles of diets have been designed or are in design and anticipated for construction in FY19 and FY20. All are for adding separated bike lanes.
City of Roanoke	Several corridors under consideration for road diets as we look to the future.
City of Salem	More phases of Downtown improvements.
City of Williamsburg	Capitol Landing Road from Bypass Road to Merrimac Trail
County of Accomack	Route 179 [Market St] from Town of Onley to Town of Onancock
County of Alleghany	Reduction of current 4 lane section reduced to two lanes with addition of bicycle/pedestrian lanes both directions
County of Fairfax	Ridge Top Rd. from Lee Hwy. to Random Hills Rd.; Legato Rd. from West Ox Rd. to Fair Lakes Pkwy.; Forum Rd. from Lee Hwy. to Government Center Pkwy.; Post Forest Dr. from Government Center Pkwy. to West Ox Rd
County of Fluvanna	VDOT installation of a couple new traffic circles. No locally funded projects.
County of Henrico*	Hilliard Rd
County of Loudoun	Augusta Drive and Davis Drive
Town of Blacksburg	In the study phase for two possible road diet projects on Patrick Henry Drive and on North Main Street
Town of Culpeper	Sperryville Pike
Town of Gordonsville	Route 15 north of town
Town of Independence	[No response entered]
Town of Lorton*	Lorton Station Blvd from Pohick Rd. to Lorton Rd
Town of Luray	A four lane section of East Main Street might be a good candidate for combined bike and pedestrian additions. We are considering it now, but could use some help.
Town of Montross*	Route 3 from Porter Ln to 1000 ft east of Ashbury Rd
Town of Scottsville	Redevelopment planning for a vacant factory site in town could involve road diets to calm traffic and promote bike/ped activity. Traffic studies have not yet launched, but a comprehensive plan and small area plan process is nearly complete.
Town of South Hill	Raleigh Avenue extension from Hwy 47 to Parker Park is still on our wish list for construction when funding becomes available. This will be two lane local road and we would love to have wide shoulders to accommodate cyclists.
Town of Warrenton	Broadview Avenue with Smartscale funding is being reconfigured for safety reasons.
Town of Warsaw*	Route 360 form 1100 ft west of Washington Ave to Route 3
Town of Woodstock	SmartScale application being processed for vehicular improvements on Route 42 between Main Street and Hisey Avenue; SmartScale application being processed for bicycle/pedestrian improvements on Water Street.

* Locations from VDOT District Survey.

Before 2017, language in the Code of Virginia reduced roadway maintenance payments to cities and towns after road diet projects (because such payments were based on vehicular lane miles). The General Assembly modified that language in 2017 to allow for road diets without a reduction in maintenance payments. Were you aware of this legislative change?

Twenty-seven percent of respondents (32 of 113; 1 respondent did not answer this question) indicated that they were aware of the legislative change in the *Code of Virginia*.

Did this legislative change affect your jurisdiction's decisions regarding road diets?

Of the 32 respondents who indicated awareness of the 2017 legislative change, 24 respondents (75%) reported no change to their decisions regarding road diets. The following eight localities (25%) indicated that this change resulted in the implementation or planning of more road diets:

- City of Danville
- City of Lynchburg
- City of Harrisonburg
- City of Richmond
- City of Williamsburg
- County of Fairfax
- Town of Blacksburg
- Town of Luray.

Responses to Additional Questions for Localities/VDOT Districts That Reported Implementing Road Diets

Respondents reported that road diets have been installed in 13 localities (5 cities, 4 counties, and 4 towns) since 2010. Table 11 shows the number of road diet projects within each locality. Specific details about each road diet based on the survey questions are provided in Appendix A.

Table 11. Number of Road Diets in Each Locality

Locality	No. of Road Diets
City of Danville	1
City of Richmond	5 or more
City of Roanoke	4
City of Salem	1
City of Williamsburg	1
County of Albemarle	1
County of Fairfax	5 or more
County of Loudoun	1
County of Mathews	1
Town of Amherst	1
Town of Altavista	1
Town of Blacksburg	2
Town of Culpeper	1

Reported years of construction for these road diets are shown in Figure 15. Ten road diets were constructed in 2018, and three each in years 2014, 2016, and 2017.

Figure 16 shows the reported types of roadway conversions in terms of the number of general purpose travel lanes before and after. The majority of conversions were of the 4-3 type. Three types could not be determined with the information provided by the respondents; see Appendix A for specific responses.

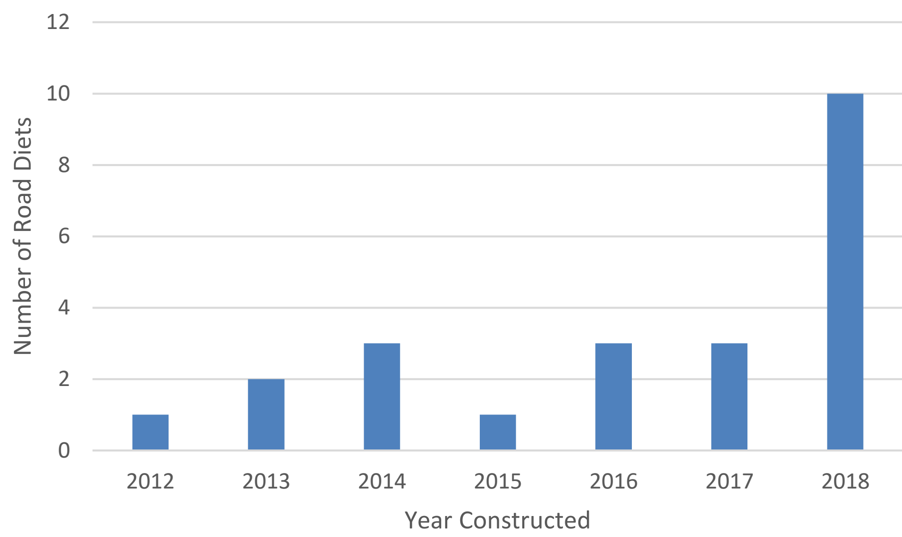


Figure 15. Year Road Diets Were Constructed

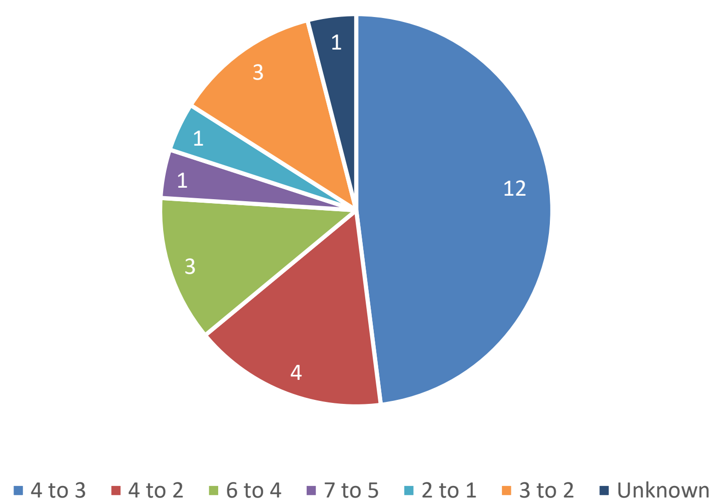


Figure 16. Type of Roadway Conversion

What were the primary reasons for implementing this road diet? (Improving safety, accommodating bicycle travel, providing on-street parking, other)

This question allowed multiple responses. As shown in Figure 17, the majority of localities implemented road diets to accommodate bicycle travel (18 responses) and/or to improve safety (15 responses). Providing on-street parking had the lowest number of responses (4).

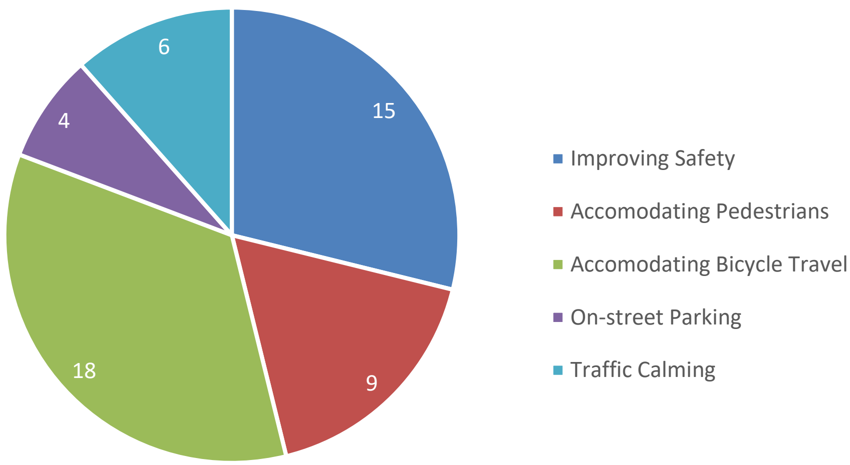


Figure 17. Primary Reasons for Implementing Road Diet

In your opinion, how well did the project meet the primary goals you selected? Describe any lessons learned.

A large majority of respondents indicated that the road diets met the primary goals of the project (Figure 18; see also Figure 17). Of the 25 road diet installations, 72% of respondents (18 of 25) indicated that the project met the goals. Three road diet installations had either just been completed or were nearing completion, so opinions could not be provided on this question. Three projects in the City of Richmond had mixed results in terms of meeting the goals: two projects had bike lanes with challenging termini, one of those projects also received complaints about cars being driven in the bike lanes, and a two-way cycletrack project had issues including delay and increased bike exposure (i.e., conflict points). Lessons learned from these Richmond projects are shown in Table A10 in Appendix A. Information on meeting objectives and lessons learned from other road diet projects are provided in Tables A2, A4, A6, and A8.

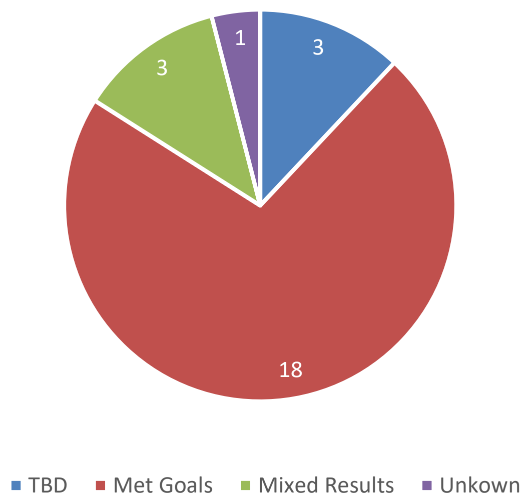


Figure 18. Survey Responses to Whether the Road Diet Met Goals

Have you received any public feedback on the project? If yes, has the majority of the feedback been positive, negative, or mixed (equally positive and negative)?

Of the 25 road diets implemented since 2010, 72% (18 of 25) incurred public feedback. Of that feedback, 50% (9 of 18) of the road diets received positive feedback. Nine road diets (50%) received mixed feedback, and no locality indicated that the majority of the feedback on road diets was negative.

Was a study performed BEFORE constructing the project? Was an evaluation performed AFTER the project's completion?

Table 12 shows that the majority of studies (11) were conducted on roadways before the road diet implementation, and few studies (3) were completed afterward. The cities of Richmond and Roanoke were the two localities reporting both before and after studies for specific road diet projects. Some respondents did not know if studies had been performed in the before period (2 respondents) or after period (5 respondents).

Follow-up contacts were made with respondents who had indicated that studies were performed. After further discussion, limited or no information was received for before studies of road diet locations in the cities of Salem and Richmond and the Town of Blacksburg. The City of Salem indicated that its study was part of a more comprehensive downtown plan that involved parking studies and surveys and that recommended converting downtown alleys into "shared streets" accommodating both pedestrians and slow-speed vehicles. The City of Richmond indicated that manual and automated counts were conducted and that crashes were monitored but the data were not available. Data from the Town of Blacksburg studies were also not available.

Table 12. Before and After Road Diet Studies

Studies	Yes	No	Don't know
Before	11	12	2
After	3	17	5

Fairfax County provided data on two studies; one was conducted on Colts Neck Road, which is included in this report's road diet evaluation. Two localities indicated studies were performed after road diets, including one road diet in the City of Roanoke and two road diet locations in the City of Richmond. As was the case in the before period, data from the City of Richmond were not available. The City of Roanoke was the only locality to provide data on its after evaluation.

Table 13 shows the types of evaluations each locality reported performing for each road diet. With the exception of the Elm Avenue road diet in the City of Roanoke, all studies were conducted in the before period, with road diet implementation recommended based on the results of the studies. The City of Roanoke's study used INRIX data and showed a 5% to 10% reduction in travel time after the implementation of the road diet. City staff noted that improved signal coordination along the corridor was deemed a factor for this improved travel time, which occurred despite a reduction in the number of travel lanes. As shown in Table 13, the majority of the studies involved motor vehicle counts, crash counts, and field observations (11, 10, and 8 locations, respectively). Intersection turning movement counts, LOS analyses, and speeds were studied at 7, 6, and 5 locations, respectively. Pedestrian and bicycle counts, parking analyses, travel time, and travel forecasts were analyzed at the fewest number of locations.

Table 13. Reported Elements of Evaluations of Road Diets

Locality	**Road Diet**	**Field Observations[a]**	**Crash Counts**	**Motor Vehicle Counts**	**Intersection Turning Counts**	**Pedestrian Counts**	**Bicycle Counts**	**Level of Service (Delay)**	**Speed Analysis**	**Parking Analysis**	**Travel Time Analysis**	**Traffic Forecasting**
Town of Culpeper	U.S. 522 (Sperryville Pike)		x	x								
City of Danville	Main St	x	x	x	x			x				x
Town of Altavista	Main St		x	x	x							
Loudoun County	Davis Dr.[b]	x	x	x	x	x		x	x	x		
	Maple Leaf Pl./Jennings Dr.	x	x	x	x	x	x	x	x			
	Augusta Dr.[b]	x	x	x	x	x	x	x	x			
	George Washington Blvd.	x	x	x								
	Oakgrove Rd.[b]	x	x	x	x			x				x
	Defender Dr.	x	x	x	x			x				x
Fairfax County	South Lakes Dr.	x	x	x					x			
City of Roanoke	Elm Ave.[c]			x					x		x	

[a] Field observations documented roadway conditions, lighting, pedestrian facilities, sight distance, etc.
[b] Planned projects.
[c] Before and after studies.

In addition to the study information provided by survey respondents, the Hampton Roads Transportation Planning Organization provided a report (Case, 2018) that it created to assist localities with identifying roadways that are candidates for road diets. The report included a database of roadways for each locality comprising existing four-lane undivided segments with ADTs less than 12,500 vpd and listing existing cross-section types, segment lengths, AADT, and crash history and rates. Additional observations included in the database included bicycle and pedestrian facilities, nearby bus routes, and land use information. The analysis identified 72 candidate locations from 13 localities. The localities and the number of candidate locations in each were as follows:

- Chesapeake, 11
- Franklin, 1
- Gloucester, 1
- Hampton, 14
- James City, 2
- Newport News, 8
- Norfolk, 8
- Poquoson, 1
- Portsmouth, 15
- Suffolk, 2
- Virginia Beach, 5
- Williamsburg, 2
- York, 2.

Working Inventory of Virginia Road Diets

Table 14 is a working compilation of completed road diets in Virginia based on survey responses and other sources (e.g., in-person comments at meetings, news articles, personal observations, communications subsequent to the locality survey, etc.). Although it is likely not comprehensive, it represents approximately 39 miles of road diets across 66 projects and could be a starting point should VDOT wish to maintain such an inventory. In addition to information shown in the table (length, approximate limits, predominant before and after cross-sections, and implementation year), VDOT could add data such as AADT, roadway width, functional classification, etc.

Table 14. Working Inventory of Virginia Road Diets

Locality: Roadway	Length (mi)	Approximate Limits		Predominant Cross Section(s)[a]		Year
		From	To	Before	After	
City of Alexandria: King St.	1.1	Kenwood Ave.	Janneys Ln.	AAAA	BuATABu	2016
City of Alexandria: Seminary Rd.	0.9	N. Howard St.	N. Quaker Ln.	AAAA	BuATABu	2019
City of Charlottesville: Monticello Ave.	0.4	Ridge St.	6th St.	AAMAA	PBAMABP	2001[b]
City of Danville: W Main / Main St.	0.4	Stewart St.	Holbrook Ave.	AAAA	BATAB, BAABP	2018
City of Norfolk: 35th St.	0.4	Colley Ave.	Colonial Ave.	PATAP	PABuBuAP	2016
City of Norfolk: Colley Ave.	0.3	21st St.	28th St.	AAMAA, PAAMAAP	BuAMABu, BuPAMAPBu	2016
City of Norfolk: E Ocean View Ave.	1.6	Capeview Ave.	19th Bay St.	AAAA	BuATABu	2018
City of Norfolk: Lafayette Blvd.	0.6	Tidewater Dr.	Cromwell Rd.	AATAA, PAAAAP	PBAMAB, PBATAB	2017
City of Norfolk: Llewelyn Ave.	1.6	35th St.	Virginia Beach Blvd.	AAA, AAAA, PAAA, AAMAA	BAB, BATAB, PBATAB, BuAMABu	2016
City of Norfolk: Olney Rd.	0.3	Virginia Beach Blvd.	Colonial Ave.	AAMAA	BuAMABu	2016
City of Richmond: Brookland Pkwy.	0.8	Brook Rd.	Hermitage Rd.	PAAMAAP	PBuAMABuP	2014
City of Richmond: Franklin St.	0.9	Belvidere St.	9th St.	[c]	[c]	2018
City of Richmond: Manchester Bridge/S. 9th St.	0.7	E. Cary St.	Bridge on- and off-ramps	AAAMAAAA	BuAAAMAAABu	2015
City of Richmond: MLK Bridge (Leigh St. Viaduct)	0.6	N. 10th St.	Mosby St.	AAAMAAA	BuAAMAABu	2014
City of Richmond: Oliver Hill Way/N. 18th St.	0.7	Fairfield Way	Venable St.	[d]	[d]	2014
City of Roanoke: 13th St. SW	0.4	Cleveland St.	Salem Ave.	ATA	BAAB	2016
City of Roanoke: 5th St. NW	0.2	Shenandoah Ave. NW	Gilmer Ave. NW	AAAA	PBAABP	2017
City of Roanoke: Elm Ave.	0.5	Franklin Rd.	8th St. SW	AAA	BAAB	2018
City of Roanoke: Memorial Ave. SW	0.5	Winborne St. SW	13th St. SW	AAAA	BAABP	2003
City of Roanoke: Main St. SW (Winona Bridge)	0.2	Winona Ave. SW	Elm Ave.	AAAA	BAAB	2008[b]
City of Roanoke: Williamson Rd.	0.9	Angell Ave. NW	Hershberger Rd. NW	AAAAT	AAMAA	2005
City of Roanoke: McClanahan St.	0.5	Jefferson St.	Franklin Rd.	PAAP, AAAP	PBAAB, BAAB	2016
City of Williamsburg: Second St.	0.4	Page St.	City limits	AAAA	BATAB	2018
County of Albemarle: Whitewood Rd.	0.2	Hydraulic Rd.	Oak Forest Dr.	ATAT, TAAT	BATAB	2019
County of Arlington: Four Mile Run Dr.	0.4	Columba Pike	S. George Mason Dr.	PAMAA	PAMAP	2008[b]
County of Arlington: Lorcom Ln.	0.2	N. Fillmore St.	Nellie Custis Dr.	AAABP	PBAABP	2011[b]

Locality: Roadway	Length (mi)	Approximate Limits		Predominant Cross Section(s)[a]		Year
		From	To	Before	After	
County of Arlington: N. Sycamore St.	0.6	Williamsburg Blvd.	24th St. N.	PAAMAAP, PBAAAABP	PBAMABP	2015[b], 2018[b]
County of Arlington: S. Eads St.	0.2	12th St.	15th St.	AAAAP	BuATAPBu	2015
County of Arlington: S. Eads St.	0.4	15th St.	23rd St.	PAAAAP	BuPATAPBu, BuPATABu	2015
County of Arlington: Wilson Blvd.	0.7	N. Edison St.	N. Manchester St.	AAAA	BATAB	2015
County of Arlington: Wilson Blvd.	0.1	N. Manchester St.	N. Larrimore St.	AAMAA	BuAMAA	2017
County of Fairfax: Armistead Rd.	0.2	Lorton Rd.	Richmond Hwy.	AAAA	BuATABu	2018
County of Fairfax: Bluemont Way	0.3	Town Center Pkwy.	Democracy Dr.	AAAA	BuATABu	2018
County of Fairfax: Colts Neck Rd.	0.8	Glade Dr.	Sunrise Valley Dr.	AAAA	BATAB	2017
County of Fairfax: Commerce St.	0.5	Old Keene Mill Rd.	Amherst Ave.	AATAA	BuATABu	2017
County of Fairfax: Courthouse Rd.	0.3	Oakton Plantation Ln.	Fariba Ct.	AAA	PBAAB, BAAB	2014
County of Fairfax: Fountain Dr.	0.4	Baron Cameron Ave.	New Dominion Pkwy.	AAAA	BuATABu	2018
County of Fairfax: Fullerton Rd.	0.2	Yarnwood Ct.	Boston Blvd.	AAAA	BuATABu	2019
County of Fairfax: Greensboro Dr.	0.5	Solutions Dr.	Spring Hill Rd.	AAAA	BATAB	2015
County of Fairfax: Kidwell Dr./Towers Crescent Dr.	0.5	Leesburg Pike	Gallows Branch Rd.	AAAA	BATAB, BuAABu	2019
County of Fairfax: Kingstowne Village Pkwy.	1.3	Beulah Rd.	Hayfield Dr.	AAAA	BATAB	2015
County of Fairfax: Lawyers Rd.	2.0	Fox Mill Rd.	Myrtle Ln.	AAAA	BATAB	2009
County of Fairfax: New Braddock Rd.	0.4	Store House Dr.	Centrewood Dr.	PAMAA	PBAMTAB, PBAMABP	2019
County of Fairfax: Oak St.	0.1	Gallows Rd.	Arden St	AAAA	BATAB	2013
County of Fairfax: Park Run Dr.	0.4	Tysons Blvd.	Jones Branch Dr.	PAAAAP, AATAA	PBATABP, BAATAB	2015
County of Fairfax: Pleasant Valley Rd.	1.6	Lee Hwy.	Saddle Downs Pl.	AAAA, AATA	BuATA	2015
County of Fairfax: Pleasant Valley Rd.	0.3	Lafayette Center Dr.	Pleasant Valley Rd.	AAAA	ATAA	2012
County of Fairfax: Pole Rd.	0.9	Jeff Todd Way	Leaf Rd.	AAAA	ATA	2009
County of Fairfax: Post Forest Dr.	0.6	West Ox Rd.	Government Center Pkwy.	AATA, AATAA	BuATA, BuATABu	2018
County of Fairfax: Post Forest Dr.	0.4	West Ox Rd.	Legato Rd.	AAAA	ATAA	2008
County of Fairfax: Ridge Top Rd.	0.5	Random Hills Rd.	Lee Hwy.	AAAA, AATAAP	BuATABu, BuATABuP	2018
County of Fairfax: River Birch Rd.	0.7	Sunrise Valley Dr.	Dulles Technology Dr.	AAAA	PBAABP	2013

Locality: Roadway	Length (mi)	Approximate Limits		Predominant Cross Section(s)[a]		Year
		From	To	Before	After	
County of Fairfax: Soapstone Dr.	1.5	Lawyers Rd.	Sunrise Valley Dr.	PAAAAP, AAAA	PBATABP, BATAB	2011
County of Fairfax: South Lakes Dr. (eastern)	0.4	Ridge Heights Rd.	Twin Branches Rd.	AAMAA	BuAMABu	2018
County of Fairfax: South Lakes Dr. (western)	0.9	Colts Neck Rd.	Soapstone Dr.	AAMAA	BuAMABu	2018
County of Fairfax: Sunset Hills Rd.	0.2	Michael Faraday Dr.	W&OD Trail crossing	AAAA	ATA	2009
County of Fairfax: Walker Ln.	0.5	Franconia Springfield Pkwy.	Beulah St.	AAMAA	BuAMABu	2019
County of Fairfax: Westbranch Dr.	0.3	Westpark Dr.	Jones Branch Dr.	AATAA	BuATABu	2015
County of Loudoun: George Washington Blvd.	0.6	Loudoun County Pkwy.	Bridgefield Way	AAATMAAA	BuAATMAABu	2016
County of Loudoun: W. Poplar Rd.	0.6	S. Sterling Blvd.	S. Greenthorn Ave.	PAAP (2-way)	PA (1-way)	2019
County of Mathews: General Puller Hwy.	0.5	Regent Rd.	Twiggs Ferry Rd.	AAAA	ATA	2013
County of Prince William: Horner Rd.	0.3	Millwood Dr.	Marumsco Dr.	AAAA	ATAA	1990s
Town of Altavista: Main St.	0.7	Pittsylvania Ave.	Hughes Ave.	AAAA	ATA	2017
Town of Amherst: Main St.	1.2	Richmond Hwy.	Arthur Ct.	PATAP	PBAABP	2017
Town of Blacksburg: College Ave.	0.2	Otey St.	N Main St.	PAAP	PAS	2013
Town of Blacksburg: Main St.	0.4	College Ave.	Prices Fork Rd.	AAAA	SATAS	2012

[a] Cross-section abbreviations: A (automobile/general purpose travel lane), B (standard bicycle lane), Bu (buffered or separated bicycle lane), P (parking lane), T (1-way or 2-way left-turn lane), M (median), S (new or widened sidewalk or plaza)

[b] Dates estimated but not confirmed.

[c] 4-lane, 1-way street with 2 off-peak parking lanes (4-lane in AM peak) converted to the following cross-section: a 2-way separated bike lane, floating parking (AM peak travel lane), single travel lane, dedicated parking lane

[d] Mostly a 1-way pair, with each street converted from AAA to BuAA; one block was AAAMAAA and converted to BuAAMAABu.

Motor Vehicles

Volumes and Speeds

Data collected at each location were provided in daily 24-hour summary and 15-minute bin formats. Summary data were helpful in providing a daily snapshot of vehicle volumes and percentile speeds, mean speeds, and standard deviations for each day of data collection. Example before and after daily data summaries for Bluemont Way (posted speed limit of 30 mph) are shown in Tables 15 and 16, respectively (daily summary tables for all other locations are shown in Appendix D).

Table 15. Bluemont Way Motor Vehicle Volume and Speed Summary, Before Road Diet

Date	Day of Week	Travel Direction	Total Vehicles	15th Percentile Speed (mph)	50th Percentile Speed (mph)	85th Percentile Speed (mph)	Mean Speed (mph)	Standard Deviation (mph)
4/28/2018	Sat	EB	2979	21.8	27.1	32.5	27.1	5.0
		WB	3555	21.8	27.7	33.8	27.8	5.5
4/29/2018	Sun	EB	2360	22.7	27.8	33.3	28.0	4.9
		WB	2749	21.8	28.0	34.0	28.0	5.6
5/1/2018	Tues	EB	4520	22.3	27.5	33.0	27.6	5.0
		WB	4142	22.1	27.8	34.0	28.1	5.6
5/2/2018	Wed	EB	4507	22.2	27.5	33.1	27.6	5.1
		WB	4112	22.4	28.1	34.1	28.4	5.4
5/3/2018	Thurs	EB	4527	22.2	27.7	33.2	27.7	5.1
		WB	4130	22.3	28.1	34.1	28.3	5.5

EB = eastbound; WB = westbound.

Table 16. Bluemont Way Motor Vehicle Volume and Speed Summary, After Road Diet

Date	Day of Week	Travel Direction	Total Vehicles	15th Percentile Speed (mph)	50th Percentile Speed (mph)	85th Percentile Speed (mph)	Mean Speed (mph)	Standard Deviation (mph)
4/23/2019	Tues	EB	4299	22.6	27.7	33.1	27.8	4.7
		WB	3898	23.5	28.4	33.8	28.6	4.8
4/24/2019	Wed	EB	4297	23.0	28.0	33.3	28.1	4.8
		WB	3797	22.7	28.1	33.7	28.3	5.2
4/25/2019	Thurs	EB	4497	22.7	27.7	32.9	27.8	4.7
		WB	4097	23.3	28.5	34.0	28.7	5.1
4/27/2019	Sat	EB	3017	23.0	28.1	33.5	28.3	5.0
		WB	3101	23.1	28.5	34.1	28.7	5.2
4/28/2019	Sun	EB	2298	23.8	28.5	34.1	28.9	4.8
		WB	2642	23.5	28.6	34.1	28.9	5.0
4/30/2019	Tues	EB	4327	22.7	27.8	33.1	27.91	4.7
		WB	3911	23.3	28.4	34.0	28.6	5.1

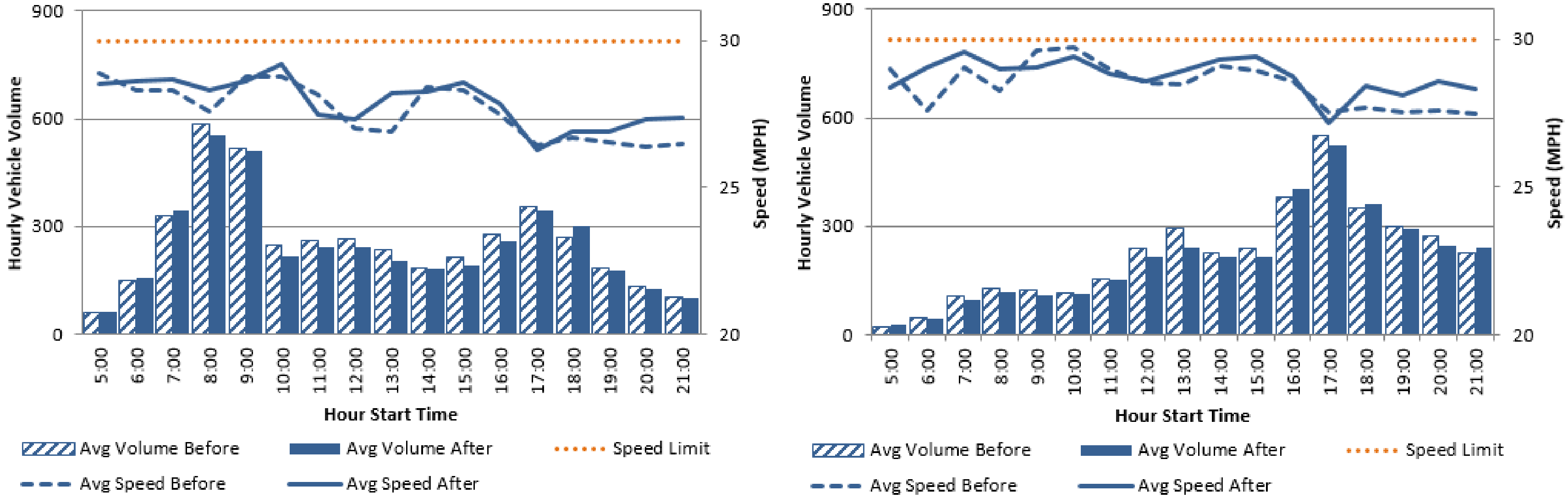
EB = eastbound; WB = westbound.

Data collection days shown in each table correspond to full-day data used in all analyses (i.e., Tuesday, Wednesday, Thursday, Saturday, and Sunday data, as described in the "Methods" section). For example, in the before period on Bluemont Way, data were collected from 4/26/2018 to 5/4/2018; however, a full day's worth of data were not collected on 4/26, so that day's data were discarded along with data collected on Fridays and Mondays (4/27, 4/30, and 5/4). A comparison of the before and after data showed that 85th percentile and mean speeds increased on this street after the road diet installation. For example, in the before period on Saturday in the westbound direction, the 85th percentile and mean speeds were 33.8 and 27.8 mph, respectively. In the after period, on Saturday in the westbound direction, the 85th percentile and mean speeds were 34.1 and 28.7 mph, respectively.

Although summary information is helpful for a daily snapshot of average speeds, to enable visual comparisons of hourly before and after speed and volume data, extrapolation of 15-minute bin data was performed as discussed in the "Methods" section. Figures 19a and 19b show the eastbound and westbound (respectively) before and after weekday volume and speed profiles for Bluemont Way from 5 a.m. to 10 p.m. Volumes in the before and after periods were relatively consistent, with an eastbound AM peak direction and a westbound PM peak direction. Before and after speed profiles were also similar, varying ±1 mph. To allow visualization of speed data further, speed distribution histograms are shown in Figures 20a and 20b for each peak direction in the before and after periods, respectively (morning peak hours were from 7 a.m. to 10 a.m., and afternoon peak hours were from 4 p.m. to 7 p.m.). In both the before and after periods and in both directions, the highest percentage of vehicles were found to be traveling in the 25-29 mph speed bin. In both directions, the speed trendline is skewed more to the right in the after condition, indicating higher average speeds. In the westbound p.m. histogram, the speed trendline for the before condition has a slightly wider skew, indicating a higher percentage of both low- and high-end speeds before the changes and a slightly more uniform speed distribution after.

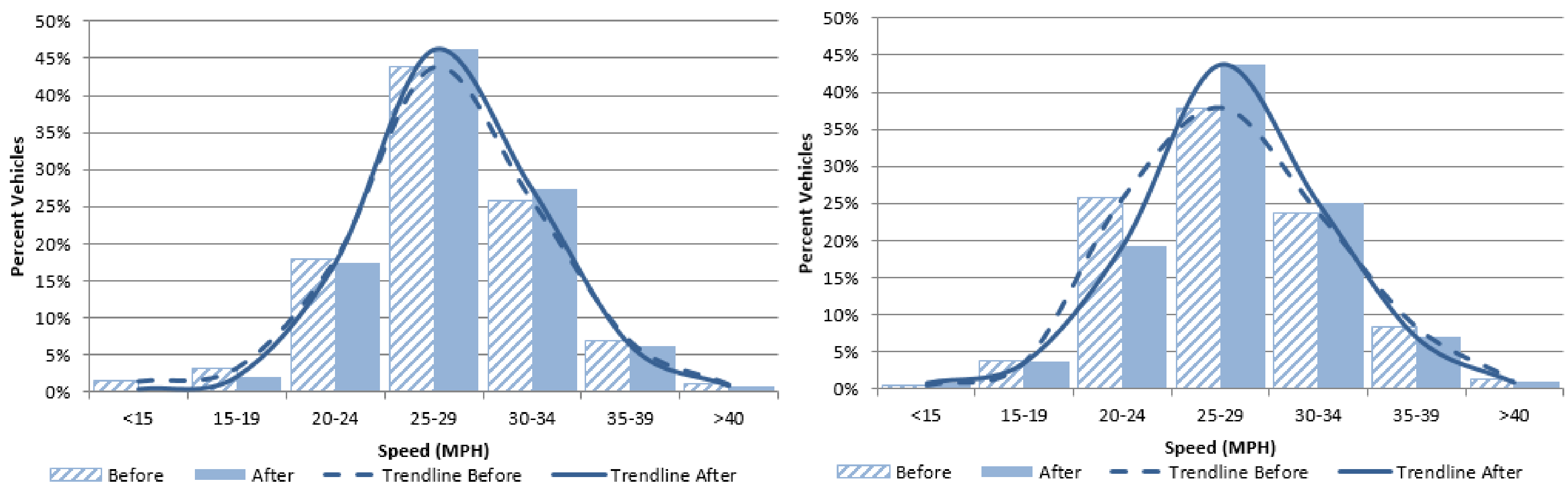
Similar volume and speed profiles and speed distribution histograms were created for average weekend data. As was the case with average weekday data, volume profiles in the before and after periods eastbound and westbound (shown in Figures 21a and 21b, respectively) remained relatively consistent for this site, and speed profiles followed similar trends, with consistently higher speeds in the after period. Speed distribution histograms in the before and after periods eastbound and westbound are shown in Figures 22a and 22b, respectively, for the midday peak period (11 a.m. to 5 p.m.). The plots show a larger percentage of higher end speeds compared to the before data, with curves skewed more to the right in the after period.

Speed and volume profiles and speed distribution histograms for average weekday and weekend data at the other study locations are shown in Appendix E. As previously discussed, creating profiles and histograms help in visualizing the data; however, they do not provide a quantitative means to analyze differences in the data. Therefore, the next step was to determine if the differences in average speeds were statistically different in the before and after periods.



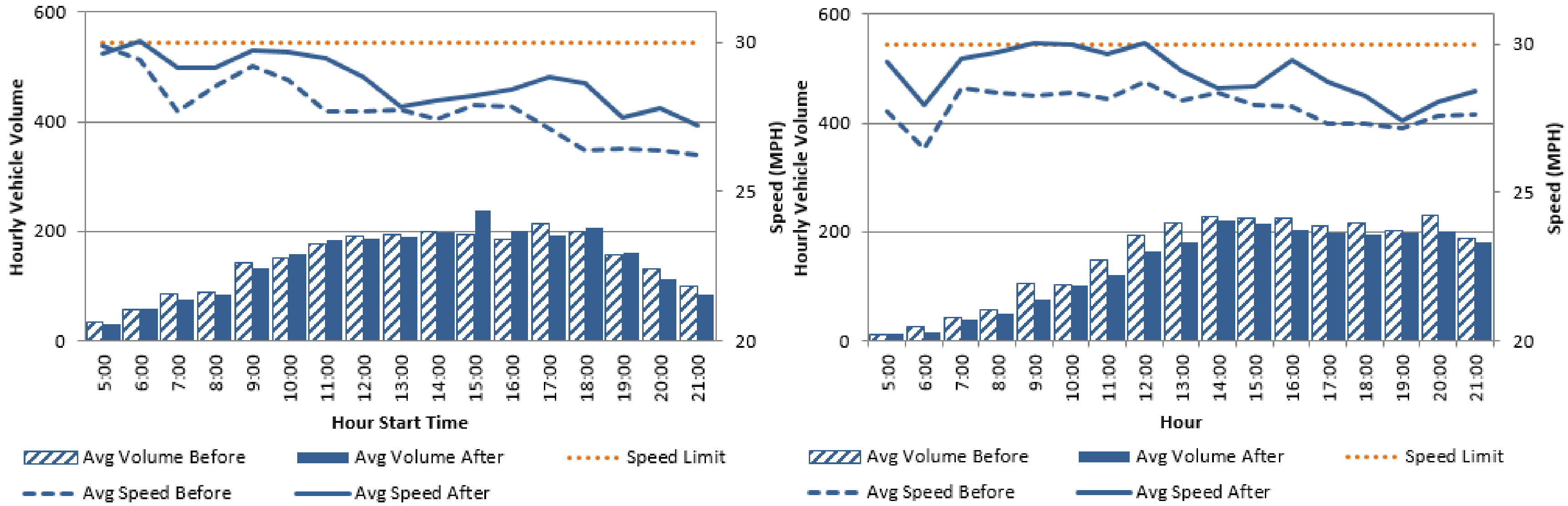
(a) (b)

Figure 19. Eastbound (a) and Westbound (b) Before and After Weekday Volume and Speed Profiles for Bluemont Way



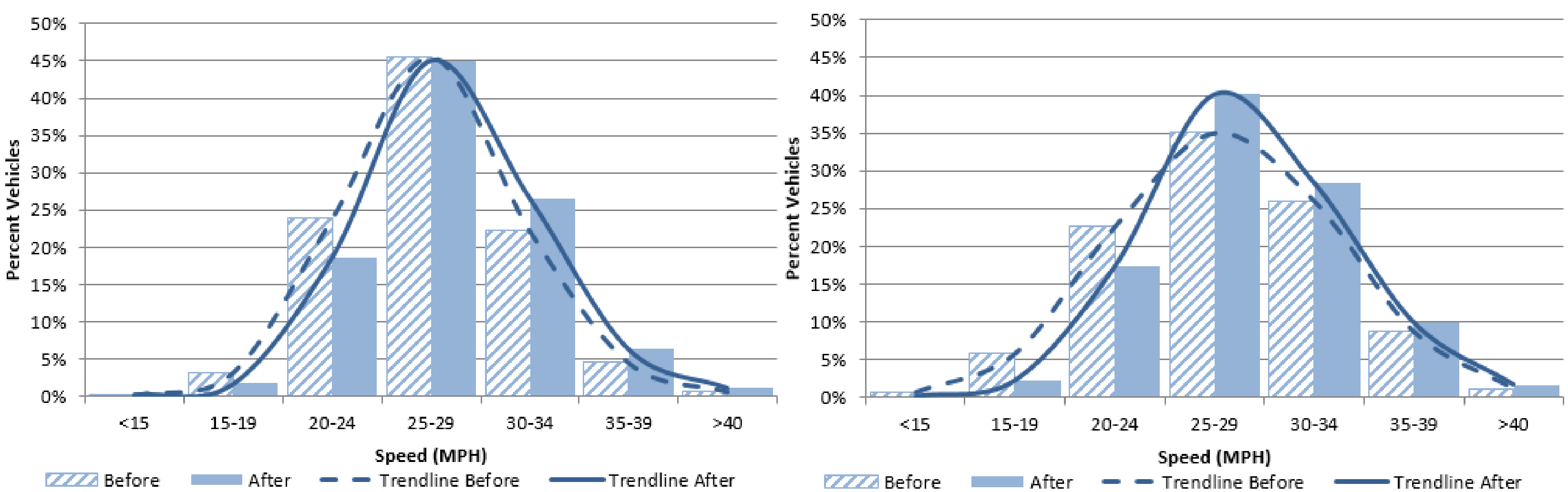
(a) (b)

Figure 20. Eastbound a.m. (a) and Westbound p.m. (b) Weekday Before and After Speed Distribution Histograms for Bluemont Way



(a) (b)

Figure 21. Eastbound (a) and Westbound (b) Before and After Weekend Volume and Speed Profiles for Bluemont Way



(a) (b)

Figure 22. Eastbound (a) and Westbound (b) Weekend Midday Before and After Speed Distribution Histograms for Bluemont Way

Statistical Testing

In accordance with the procedures described in the “Methods” section, hypothesis testing was conducted to identify statistically significant differences in mean speed and differences between two proportions (for vehicles traveling ≥5 mph and ≥10 mph over the speed limit). The results of the analysis are provided in tables that show day of week (weekday or weekend); direction of travel (eastbound/westbound or northbound/southbound); time of day (all day, weekday AM peak period, weekday PM peak period, and weekend midday period); and before and after data of total volume, mean speed, and number of 5+ and 10+ mph speeders. In all cases, the all day period was 5 a.m. to 10 p.m.; the weekday AM peak period was 7 a.m. to 10 a.m.; the weekday PM peak period was 4 p.m. to 7 p.m.; and the weekend midday period was 11 a.m. to 5 p.m.

Bluemont Way. Table 17 shows the results for Bluemont Way, where data were collected at one location both before and after road diet installation. At this site, in all cases of day of week, direction of travel, and time of day, mean speeds in the after period were higher than in the before period, all of which were statistically significant except for the weekday eastbound AM peak period and weekday westbound PM peak period. The number of speeders at 5+ mph over the speed limit was higher in the before period in all cases, with the weekday westbound PM peak and weekend eastbound all day and midday peak periods showing statistically significant differences. Interestingly, although not statistically significant differences, the number of higher-end speeders (those traveling 10+ mph over the speed limit) was higher in the before period for all weekday cases yet higher in the after period for all weekend cases. Such higher-end speeders are of particular concern when considering crash risks, especially risks to vulnerable road users.

Table 17. Results of Statistical Testing for Bluemont Way

Day of Week	Direction of Travel	Time of Day	Volume[a]		Mean Speed (mph)		5+ Speeders[b]		10+ Speeders[c]	
			Before	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**
Weekday	EB	All Day	4372	4207	27.7	27.9*	288	251	46	36
		AM Peak	1429	1407	28.2	28.5	112	97	15	10
	WB	All Day	3782	3619	28.2	28.5*	386	310*	65	49
		PM Peak	1282	1290	27.9	28.0	107	91	16	12
Weekend	EB	All Day	2503	2497	27.6	28.6*	153	216*	30	32
		Midday	1358	1387	27.6	28.5*	71	105*	9	16
	WB	All Day	2623	2374	27.9	28.8*	233	244	27	35
		Midday	1446	1306	28.0	29.1*	140	152	14	22

EB = eastbound; WB = westbound.
[a] Vehicles traveling within a speed range of 5 to 50 mph, averaged across weekday or weekend data collection days.
[b] Vehicles traveling ≥5 mph over the speed limit, averaged across weekday or weekend data collection days.
[c] Vehicles traveling ≥10 mph over the speed limit, averaged across weekday or weekend data collection days.
* Statistically significant difference from the before period at $\alpha = 0.05$.

Colts Neck Road. Tables 18 and 19 show the results for Colts Neck Road, where data were collected at two locations both before and after road diet installation. At Site 1 (Table 18) where data were collected between Hunters Woods Plaza and Winterthur Lane, for all weekday cases of direction of travel and time of day, mean speeds in the after period were lower than in the before period, and the differences were all statistically significant. Similarly, the numbers of speeders in the after period at both 5+ and 10+ mph over the speed limit were lower in the after period, and all differences were statistically significant. During the weekend, mean speeds were statistically significantly higher in the after period for the northbound direction, both all day and during the midday peak. The number of high-end speeders (10+ mph over the speed limit) was higher in the before period for all weekend cases, but the differences were not statistically significant.

At Site 2 (Table 19) where data were collected between Royal Fern Court and Sunrise Valley Drive, mean speeds were statistically significantly higher in all after cases except weekend northbound periods. A statistically significant increase in 5+ speeders occurred in the after period in all weekday northbound and weekend southbound cases, whereas a significant decrease in 5+ speeders occurred in the after period during the PM peak period in the southbound direction.

Table 18. Results of Statistical Testing for Colts Neck Road Between Hunters Woods Plaza and Winterthur Lane

Day of Week	Direction of Travel	Time of Day	Volume[a]		Mean Speed (mph)		5+ Speeders[b]		10+ Speeders[c]	
			Before	After	Before	After	Before	After	Before	After
Weekday	NB	All Day	4933	4851	34.8	33.2*	865	434*	196	58*
		AM Peak	1533	1522	37.2	34.3*	477	199*	121	24*
	SB	All Day	4791	4571	37.1	35.4*	1384	818*	261	104*
		PM Peak	1630	1591	37.9	36.1*	553	300*	117	36*
Weekend	NB	All Day	3321	3203	32.9	33.3*	288	295	50	45
		Midday	1788	1684	33.1	33.9*	160	178	27	22
	SB	All Day	3352	3134	36.0	35.9	722	660	120	87
		Midday	1828	1636	36.4	36.4	429	387	76	55

NB = northbound; SB = southbound.
[a] Vehicles traveling within a speed range of 10 to 55 mph, averaged across weekday or weekend data collection days.
[b] Vehicles traveling ≥5 mph over the speed limit, averaged across weekday or weekend data collection days.
[c] Vehicles traveling ≥10 mph over the speed limit, averaged across weekday or weekend data collection days.
* Statistically significant difference from the before period at $\alpha = 0.05$.

Table 19. Results of Statistical Testing for Colts Neck Road Between Royal Fern Court and Sunrise Valley Drive

Day of Week	Direction of Travel	Time of Day	Volume[a]		Mean Speed (mph)		5+ Speeders[b]		10+ Speeders[c]	
			Before	After	Before	After	Before	After	Before	After
Weekday	NB	All Day	2976	2846	32.8	34.0*	232	263*	36	31
		AM Peak	1313	1236	31.5	34.2*	81	109*	15	9
	SB	All Day	4096	3969	33.9	32.5*	288	281	34	25
		PM Peak	1627	1554	34.4	30.7*	127	73*	14	6
Weekend	NB	All Day	1354	1191	32.9	32.6	83	77	11	8
		Midday	691	651	33.2	33.0	46	38	6	4
	SB	All Day	2255	2210	32.8	33.5*	101	174*	11	22*
		Midday	1254	1166	33.0	33.6*	65	92*	8	12

NB = northbound; SB = southbound.

[a] Vehicles traveling within a speed range of 10 to 55 mph, averaged across weekday or weekend data collection days.

[b] Vehicles traveling ≥5mph over the speed limit, averaged across weekday or weekend data collection days.

[c] Vehicles traveling ≥1 mph over the speed limit, averaged across weekday or weekend data collection days.

* Statistically significant difference from the before period at $\alpha = 0.05$.

Post Forest Drive. Table 20 shows the results for Post Forest Drive, where data were collected at one location both before and after road diet installation. At this site, there were statistically significant increases in mean speeds and the number of 5+ and 10+ speeders in all cases for the after period.

Table 20. Results of Statistical Testing for Post Forest Drive

Day of Week	Direction of Travel	Time of Day	Volume[a]		Mean Speed (mph)		5+ Speeders[b]		10+ Speeders[c]	
			Before	After	Before	After	Before	After	Before	After
Weekday	EB	All Day	4993	4891	34.6	36.1*	447	854*	42	105*
		AM Peak	1352	1345	35.0	36.1*	138	256*	12	30*
	WB	All Day	4576	4404	38.1	39.4*	1627	2024*	318	486*
		PM Peak	1284	1236	38.0	39.1*	444	555*	85	115*
Weekend	EB	All Day	2871	3423	34.4	36.5*	254	653*	29	88*
		Midday	1663	1942	34.8	36.8*	168	387*	20	44*
	WB	All Day	2964	2941	38.1	40.1*	1047	1488*	210	397*
		Midday	1709	1704	38.6	40.4*	671	907*	137	246*

EB = eastbound; WB = westbound.

[a] Vehicles traveling within a speed range of 10 to 55 mph, averaged across weekday or weekend data collection days.

[b] Vehicles traveling ≥5 mph over the speed limit, averaged across weekday or weekend data collection days.

[c] Vehicles traveling ≥10 mph over the speed limit, averaged across weekday or weekend data collection days.

* Statistically significant difference from the before period at $\alpha = 0.05$.

Ridge Top Road. Tables 21 and 22 show the results for Ridge Top Road, where data were collected at two locations both before and after road diet installation. At Site 1 (Table 21) where data were collected between Government Center Parkway and Random Hills Road, with the exception of weekday northbound, the after period showed statistically significant increases in mean speed in all cases. Statistically significant increases in the number of 5+ speeders also occurred in all weekend after period cases. Similarly, with the exception of the weekend northbound all day period, statistically significant increases in the number of 10+ speeders occurred in all after period weekend cases. At Site 2 (Table 22) where data were collected between Lee Highway and Government Center Parkway, with the exception of the PM peak period, mean speeds were statistically significantly higher in all after cases in the southbound direction.

Table 21. Results of Statistical Testing for Ridge Top Road Between Government Center Parkway and Random Hills Road

Day of Week	Direction of Travel	Time of Day	Volume[a]		Mean Speed (mph)		5+ Speeders[b]		10+ Speeders[c]	
			Before	After	Before	After	Before	After	Before	After
Weekday	NB	All Day	1388	1304	32.2	32.7	163	200*	26	36
		AM Peak	351	321	32.7	33.5	46	56	8	8
	SB	All Day	1679	1585	31.8	32.7*	138	151	20	23
		PM Peak	556	525	31.9	32.7*	51	49	6	5
Weekend	NB	All Day	1060	993	33.4	34.1*	141	191*	29	40
		Midday	574	546	33.5	34.6*	78	120*	12	24*
	SB	All Day	1224	1077	32.6	34.2*	108	146*	15	26*
		Midday	680	617	32.7	34.5*	58	91*	8	17*

NB = northbound; SB = southbound.
[a] Vehicles traveling within a speed range of 10 to 55 mph, averaged across weekday or weekend data collection days.
[b] Vehicles traveling ≥5 mph over the speed limit, averaged across weekday or weekend data collection days.
[c] Vehicles traveling ≥10 mph over the speed limit, averaged across weekday or weekend data collection days.
* Statistically significant difference from the before period at $\alpha = 0.05$.

Table 22. Results of Statistical Testing for Ridge Top Road Between Lee Highway and Government Center Parkway

Day of Week	Direction of Travel	Time of Day	Volume[a]		Mean Speed (mph)		5+ Speeders[b]		10+ Speeders[c]	
			Before	After	Before	After	Before	After	Before	After
Weekday	NB	All Day	2466	2624	27.3	27.3	25	22	2	2
		AM Peak	564	584	27.6	28.0	7	5	1	0
	SB	All Day	2017	1985	28.1	28.6*	32	37	4	3
		PM Peak	612	608	28.8	29.3	12	12	1	0
Weekend	NB	All Day	1990	2133	27.5	27.3	19	24	0	1
		Midday	1070	1171	27.9	27.8	11	17	0	1
	SB	All Day	1833	1621	28.1	28.8*	19	25	2	3
		Midday	1052	956	28.4	28.9*	11	10	1	1

NB = northbound; SB = southbound.
[a] Vehicles traveling within a speed range of 10 to 55 mph, averaged across weekday or weekend data collection days.
[b] Vehicles traveling ≥5 mph over the speed limit, averaged across weekday or weekend data collection days.
[c] Vehicles traveling ≥10 mph over the speed limit, averaged across weekday or weekend data collection days.
* Statistically significant difference from the before period at $\alpha = 0.05$.

Discussion

Table 23 shows a simple visualization of differences in mean speed and the number of 5+ and 10+ speeders for weekday and weekend peak periods. A shaded cell indicates whether a particular metric was higher in the before case or the after case, and asterisks indicate statistically significant differences.

Table 23. Summary Visualization of Peak Period Speed Differences for All Sites

Roadway	Day of Week	Travel Direction	Before			After		
			µS	+5	+10	µS	+5	+10
Bluemont Way	Weekday	EB						
		WB						
	Weekend	EB				*	*	
		WB				*		
Colts Neck Road (Site 1)	Weekday	NB	*	*	*			
		SB	*	*	*			
	Weekend	NB				*		
		SB	---			---		
Colts Neck Road (Site 2)	Weekday	NB				*	*	
		SB				*	*	
	Weekend	NB						
		SB				*	*	*
Post Forest Drive	Weekday	EB				*	*	*
		WB				*	*	*
	Weekend	EB				*	*	*
		WB				*	*	*
Ridge Top Road (Site 1)	Weekday	NB			---			---
		SB				*		
	Weekend	NB				*	*	*
		SB				*	*	*
Ridge Top Road (Site 2)	Weekday	NB						
		SB		---			---	
	Weekend	NB						
		SB			---	*		---

µS = mean speed; +5 = number of vehicles traveling ≥5 mph; +10 = number of vehicles traveling ≥10 mph; EB = eastbound; WB = westbound; NB = northbound; SB = southbound; shaded cell = higher value; unshaded cell = lower value; * = statistically significant difference at α = 0.05; --- = no difference.

Table 24 visualizes the same metrics for weekday and weekend all day periods. A shaded cell indicates whether a particular metric was higher in the before case or the after case, and asterisks indicate statistically significant differences.

Public comments in advance of road diet projects sometimes indicate concerns that the reconfigured roadways will be unable to handle vehicular traffic or that motorist travel speeds will be slowed unnecessarily. The volume and speed data from these sites suggest that this was not the case. The results indicate that there were no major changes in motor vehicle volumes at any site. All sites had modest traffic volumes (AADTs between 4,500 and 10,000), substantially lower than the traffic volumes of some road diets studied in the literature. Additional analysis of higher volume road diets in Virginia could be useful.

Changes in motor vehicle speed were more varied. Mean speeds changed at some sites and in some time periods but were not consistently higher or lower. Several of the changes were statistically significant because of the large sample size but not practically significant (e.g., in Table 17, the increase in weekday eastbound all day mean speed from 27.7 mph to 27.9 mph was statistically significant despite representing a very small and not practically significant change). Because speed data were provided in 5-mph increments (i.e., analysis was conducted using the midpoint of each 5-mph speed bin), a change in mean speed of less than 3 mph was assumed not to be practically significant.

Table 24. Summary Visualization of All Day Period Speed Differences for All Sites

Roadway	Day of Week	Travel Direction	Before			After		
			µS	+5	+10	µS	+5	+10
Bluemont Way	Weekday	EB				*		
		WB				*		
	Weekend	EB				*		
		WB				*		
Colts Neck Road (Site 1)	Weekday	NB	*	*	*			
		SB	*	*	*			
	Weekend	NB	*					
		SB						
Colts Neck Road (Site 2)	Weekday	NB				*	*	
		SB	*					
	Weekend	NB						
		SB				*	*	*
Post Forest Drive	Weekday	EB				*	*	*
		WB				*	*	*
	Weekend	EB				*	*	*
		WB				*	*	*
Ridge Top Road (Site 1)	Weekday	NB				*	*	
		SB				*		
	Weekend	NB				*	*	
		SB				*	*	*
Ridge Top Road (Site 2)	Weekday	NB			---			---
		SB				*		
	Weekend	NB						
		SB				*		

µS = mean speed; +5 = number of vehicles traveling ≥5 mph; +10 = number of vehicles traveling ≥10 mph; EB = eastbound; WB = westbound; NB = northbound; SB = southbound; shaded cell = higher value; unshaded cell = lower value; * = statistically significant difference at $\alpha = 0.05$; --- = no difference.

Under this assumption, no time periods across all sites had a practically significant increase in mean speed (Tables 17 through 22). One time period in one direction at one site—the southbound weekday afternoon peak period on Colts Neck Road between Royal Fern Court and Sunrise Valley Drive—had a practically significant decrease in mean speed (Table 19). Thus, on the whole, despite findings of statistical significance, the streets examined in this study did not exhibit practically significant changes in mean speeds after road diets.

There are, however, several possible reasons why mean speeds might rise slightly after a road diet; none of these explanations was specifically tested in this study. First, the lane reconfiguration intentionally provides dedicated space for vehicles that might have slowed through vehicles before the change, such as left-turning traffic and bicycles. Second, all of these road diets were accomplished through VDOT's resurfacing program, meaning that the roadway surface before the change was in relatively poor condition; the smoother ride surface and fresh pavement markings after repaving might lead to increased speeds. The center turn lane and, for some sites, painted bike lane buffer may also increase driver comfort by providing more separation between opposing directions of traffic and between motor vehicles and bicyclists, possibly inducing higher speeds.

High-end speeding was measured in two bins representing the numbers of speeders at least 5 mph and at least 10 mph over the speed limit. With regard to the 5+ bin, there was no statistically significant change in 23 time periods; a statistically significant increase in 19 time periods, 8 of which were on Post Forest Drive and 5 of which were at Ridge Top Road Site 1; and a statistically significant decrease in 6 time periods. With regard to the 10+ bin, there was a statistically significant decrease at Colts Neck Road Site 1 for all weekday time periods in both directions and a statistically significant increase at Colts Neck Road Site 2 (weekend southbound all day period), Post Forest Drive (all time periods), and Ridge Top Road Site 1 (weekend all day southbound and weekend midday in both directions).

Two site-specific observations were as follows:

1. All four weekday time periods at Colts Neck Road Site 1 had fairly large decreases in both 5+ speeders (41% to 58% fewer) and 10+ speeders (60% to 80% fewer), but none of its weekend time periods had statistically significant changes in either category.

2. There were no statistically significant changes in the numbers of speeders at Ridge Top Road Site 2. Mean speeds were lower than at Ridge Top Road Site 1, and volumes of speeders were very low in both the before and after cases, possibly because of the segment's relatively short width, topography, and/or the proximity of bus stops to the counting site.

Other studies have recommended looking at network effects beyond a road diet corridor itself. This study did not do so, but depending on the goals of a road diet, this could be an important analysis step. Big data solutions such as StreetLight Data may offer one way to estimate network-level volume changes through low-cost desktop analysis. For road diets where safety is a main objective, examining before-after crashes would be valuable, although where crashes are rare, finding a statistically significant change over a short time period may be unlikely.

Safety analyses (e.g., crash analysis and development of CMFs) were outside the scope of this study but could be useful. Although CMFs for traditional 4-3 road diets were found in the literature for varying land use contexts (e.g., Knapp et al., 2014), there may be a need to develop CMFs for before and after configurations that are less traditional but not uncommon in Virginia. For example, Table 14 included several sites where a four-lane median-divided roadway was reconfigured to a two-lane median-divided roadway with buffered or separated bicycle lanes.

Bicycle and Pedestrian Volumes

Figures 23 and 24 show total average weekday bicycle and pedestrian volumes for the time period analyzed, before and after the changes, for the two sites. Figures 25 and 26 present each day's total bicycle and pedestrian volumes by hour of the day. Figures 27 and 28 illustrate user positioning, with the smaller pie chart in each pair providing a breakdown of users who were not using the facilities as intended, including bicyclists traveling against traffic or on the sidewalk and pedestrians walking in the street.

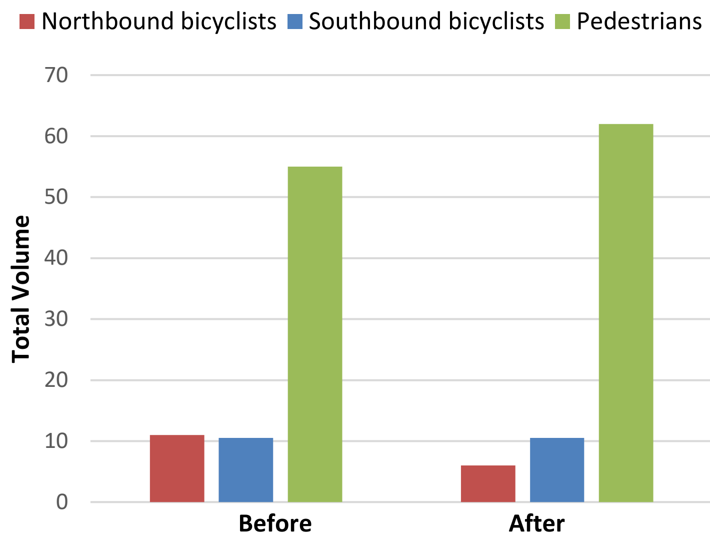


Figure 23. Total Average Weekday (Tuesday and Wednesday) Bicycle and Pedestrian Volumes From 3 p.m. to 10 p.m., Colts Neck Road Between Sunrise Valley Drive and South Lakes Drive, Before and After Road Diet

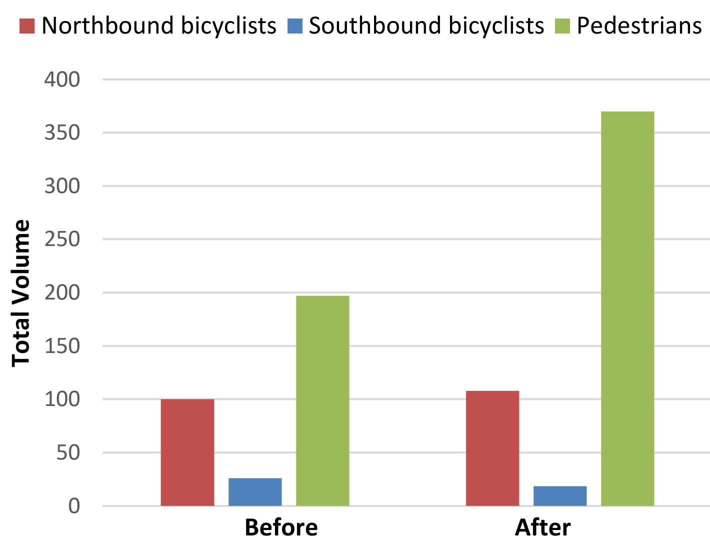


Figure 24. Total Average Weekday (Tuesday and Wednesday) Bicycle and Pedestrian Volumes From 3 p.m. to 10 p.m., Colts Neck Road Between South Lakes Drive and Glade Drive, Before and After Road Diet

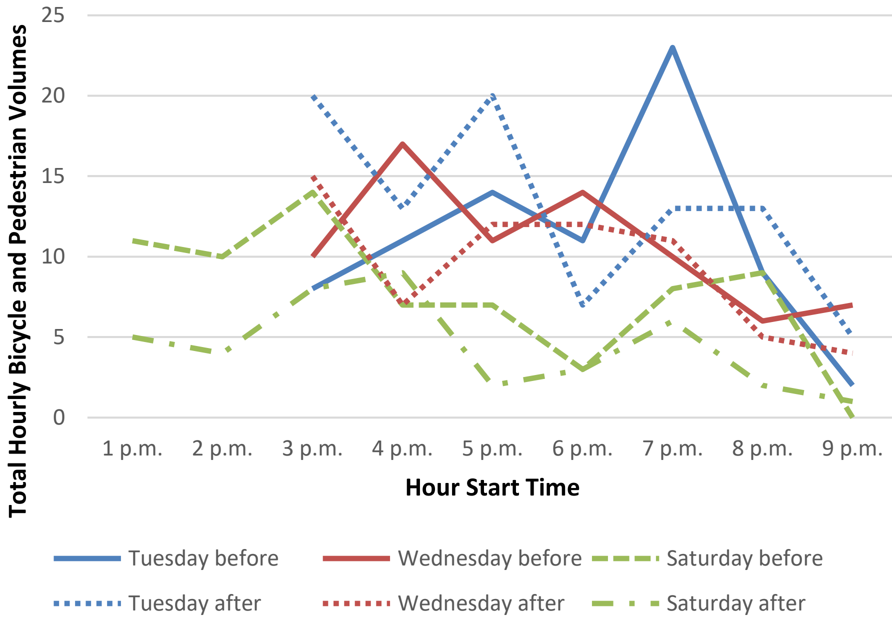


Figure 25. Total Hourly Bicycle and Pedestrian Volumes, Colts Neck Road Between Sunrise Valley Drive and South Lakes Drive, Before and After Road Diet

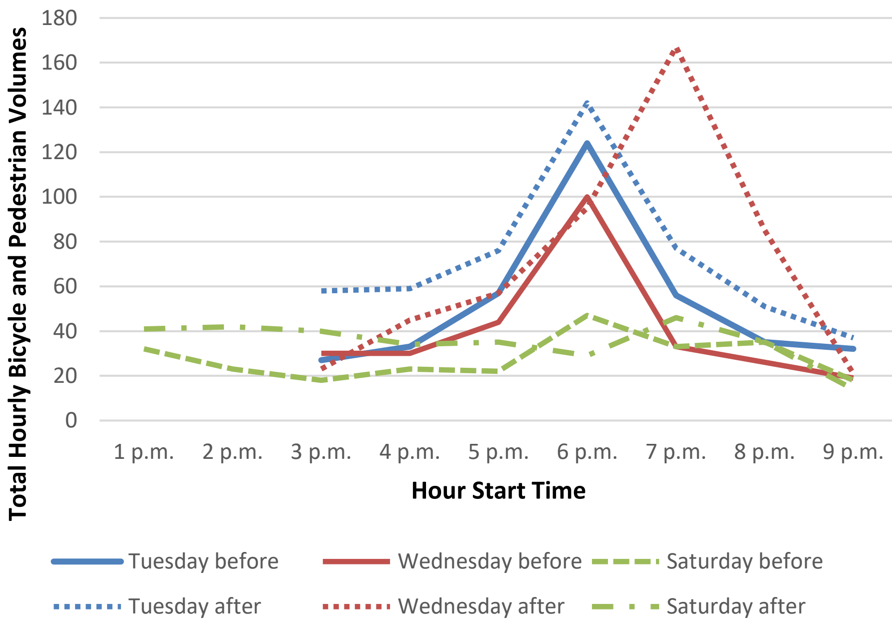


Figure 26. Total Hourly Bicycle and Pedestrian Volumes, Colts Neck Road Between South Lakes Drive and Glade Drive, Before and After Road Diet

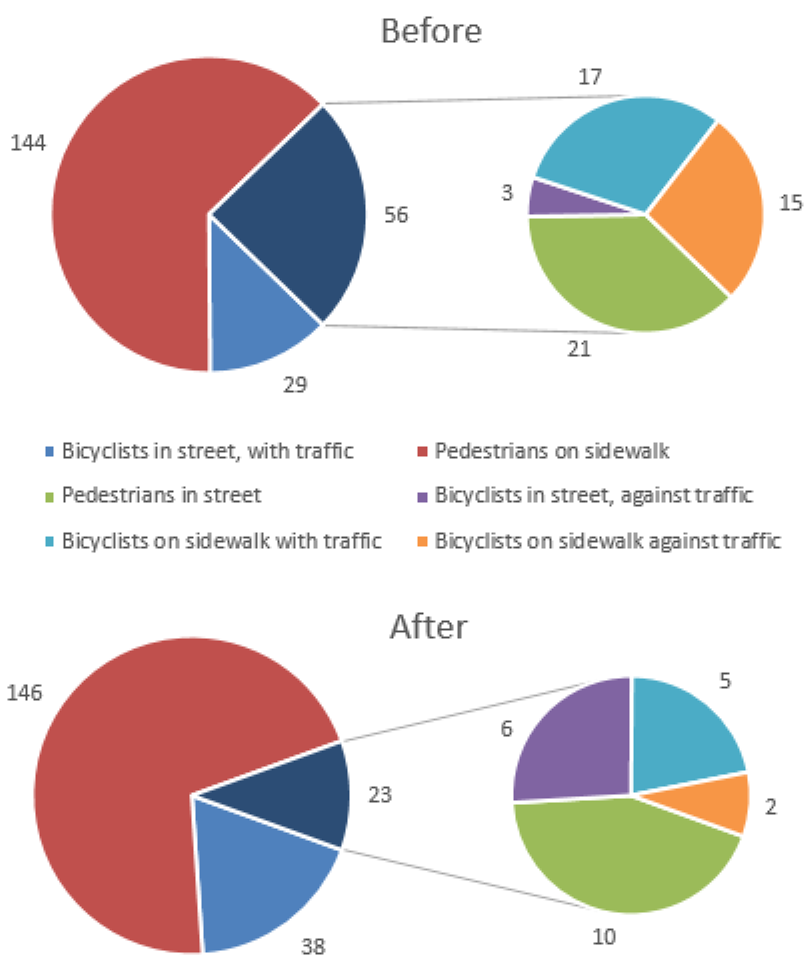


Figure 27. User Positioning, Colts Neck Road Between Sunrise Valley Drive and South Lakes Drive, Before (Top) and After (Bottom) Road Diet

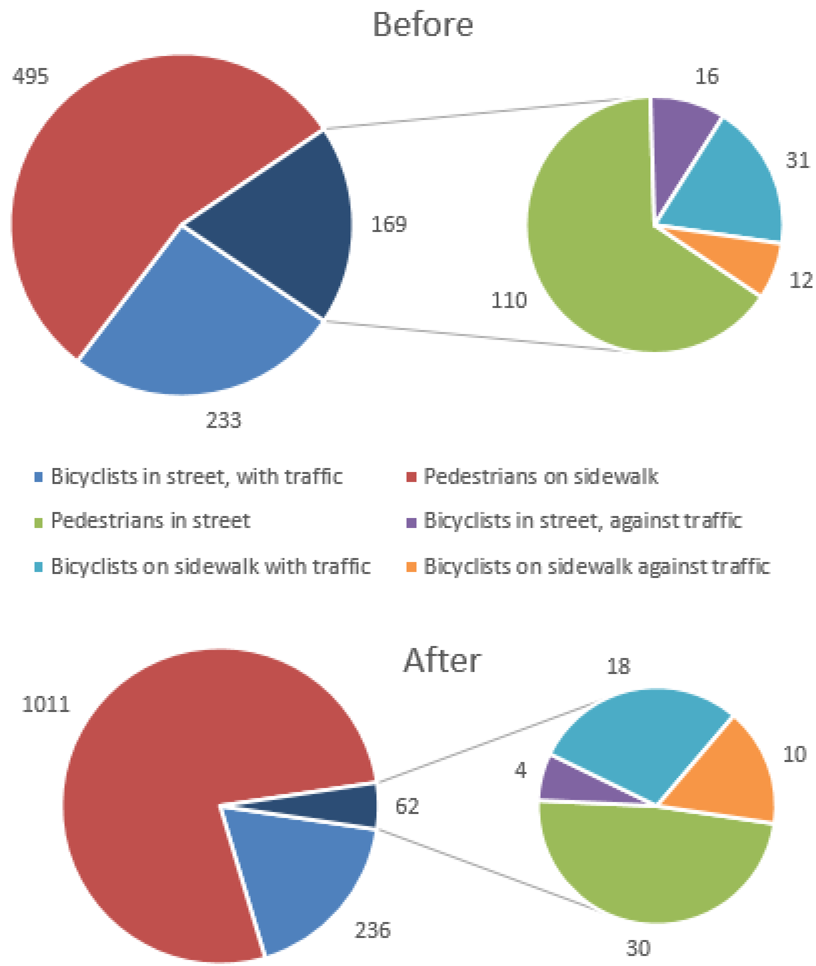


Figure 28. User Positioning, Colts Neck Road Between South Lakes Drive and Glade Drive, Before (Top) and After (Bottom) Road Diet

Discussion

For the two sites analyzed along Colts Neck Road, bicycle volume changes were minimal. About twice as many pedestrians were observed after the road diet as before the road diet at the site with higher levels of walking and biking activity, a street segment leading up to the Hunters Woods Plaza Shopping Center. Although this held true for all 3 days of the week that were sampled, the difference in camera placement may have contributed to the difference in volumes.

Northbound bicycle volumes on the segment between South Lakes Drive and Glade Drive were higher than southbound volumes (Figure 24) because of weekday evening group rides that were observed both before and after the road diet. These resulted in 15-minute periods with more than 50 northbound bicyclists, which also affected the hourly volumes shown in Figure 26.

Other minor issues affecting volumes and/or the data at both sites included a 3-minute gap in footage in the 2:00 p.m. hour on the Saturday of the before count and a roughly 30-minute period of rain around 4:45 p.m. on the Saturday of the after count. In addition, very poor visibility was noted after 9:30 p.m. on the Saturday of the after count on the segment between South Lakes Drive and Glade Drive.

Inconsistent camera placement may have also played a role in another apparent difference between before and after conditions, although it was observed at both sites. After the road diet, larger proportions of bicyclists and pedestrians appeared to be using facilities as intended (i.e., biking in the street in the same direction as traffic and walking on the sidewalk) than before (Figures 27 and 28). Put another way, there were apparent reductions in some combination of wrong-way and sidewalk bicycling—which could be explained by the addition of bicycle lanes with pavement markings, which both provide a clear space for bicycling and indicate the appropriate travel direction—along with pedestrians walking in the street. The apparent reduction in pedestrians in the street in Figure 28 is likely attributable largely to the camera placement: the screenline in the before condition was near a marked crosswalk, and pedestrians crossing diagonally near the crosswalk (but outside it) were counted as being in the street if they had not reached the curb when they crossed the screenline; the screenline in the after condition was not as close to a marked crosswalk. At the same time, it is likely that at least some of the reduction in bicyclists using the sidewalk at both sites was due to the addition of bicycle lanes through the road diet.

Another potential metric could be comfort or stress levels for walking and biking, rather than solely nonmotorized user volumes, especially for road diets where the goal is to improve the walking or biking environment and not necessarily the volumes. This can be done using scoring systems such as level of traffic stress, before-after user surveys, or emerging virtual reality methods involving simulated street environments.

CONCLUSIONS

- *Road diets take many different forms.* The typical 4-3 conversion remains the most common, but other designs have emerged to match existing conditions and contexts better. Some streets that have undergone road diets have had a second round of redesign proposed, such as Fourth Avenue in New York City (New York City Department of Transportation, 2017), or implemented.

- *Studies have used many different methods and performance measures to evaluate road diets.* Sometimes this evaluation was in the form of before-after studies; other times, models or simulations were used to evaluate a proposed road diet beforehand. In addition to the common performance measures related to safety and multimodal traffic volumes and operations, some studies have considered environmental, economic, and other effects.

- *Road diets have been incorporated into broader concepts and initiatives such as complete streets, bikeway selection, bicycle networks, context-sensitive design, and tactical urbanism. Some projects that could be classified as road diets have not used that term.*

- *Road diets still work.* The literature has continued to document their effectiveness in terms of many of the performance measures noted previously.

- *Virginia survey respondents had generally positive views about their road diet projects.* Although most studies reported by localities were conducted only before road diets and data from those studies were generally unavailable, localities reported that road diets did not generally create traffic congestion problems. Most survey respondents indicated that, in their opinions, road diets had met the primary goals of the projects. Most respondents had also received public feedback, all of which was either mostly positive or mixed.

- *The Fairfax County road diets studied did not result in practically significant changes in mean speeds.* Mean speeds changed for some time periods in some directions at some sites but were neither consistently higher nor lower. Only one site had a practically significant change in mean speed of more than 3 mph, a decrease that occurred in one direction during one time period.

- *Road diets may reduce unsafe behavior by people walking and biking.* Although volume changes for pedestrians and bicyclists were not consistent, larger proportions of bicyclists and pedestrians appeared to be using facilities as intended (i.e., biking in the street in the same direction as traffic and walking on the sidewalk) after the road diet than before.

- *A working inventory represents approximately 39 miles of Virginia road diets across 66 projects.* This inventory can be used as a foundation for future planning and research studies.

- *Additional research would be beneficial.* Having an inventory of Virginia road diets may facilitate the development of CMFs that are specific to Virginia or specific to a configuration with less published research than the typical 4-3 conversion (e.g., converting a 5-lane cross-section to a 3-lane cross-section with buffered bike lanes). Another possibility could be evaluating new data sources (e.g., StreetLight Data) and their application to road diets.

- *Planning for road diets routinely on VDOT roadways—i.e., as safety countermeasures under appropriate conditions—rather than only when requested by a county or town could yield benefits in terms of safety and multimodal connectivity.*

RECOMMENDATIONS

1. *VDOT's TMPD should maintain a statewide inventory of road diets and of candidate road diet segments.* This could inform decision-making in the VDOT resurfacing program by having an easily accessible inventory of comparable past projects and potential future projects. Additional data collection and analyses could be conducted for such inventoried road diets.

2. *VDOT's TMPD should develop guidance for road diets.* Such guidance should include processes for evaluating the feasibility of a road diet on a VDOT-maintained road,

stakeholder and/or public participation, implementation, and evaluation. Evaluation could be tailored to the context (e.g., although one metric for a repaving program could be the quantity repaved in miles, metrics for road diets accomplished through repaving might include indicators of traffic operations/congestion, miles of bike lanes added, level of traffic stress for bicyclists, and/or corridor-level commercial business receipts).

3. *VDOT's TMPD should work with VDOT district maintenance staff to ensure that road diets can be implemented through the resurfacing program.* When a road is already being resurfaced, the cost of restriping is negligible compared to the cost of restoring preexisting markings. In cases where a road diet requires funding beyond what is available in the maintenance program, TMPD may be able to apply other funding sources.

4. *VDOT's Northern Virginia District Traffic Engineering should work with VTRC to develop a research problem statement regarding CMFs for road diets.* This would be presented at a future meeting of a VTRC research advisory committee, likely the Traffic and Safety Research Advisory Committee.

IMPLEMENTATION AND BENEFITS

Implementation

Some early implementation actions have already occurred to begin institutionalizing road diets in VDOT's routine practices. These and future implementation steps are as follows.

With regard to Recommendation 1, the working statewide inventory of road diets presented in this report can be digitized and adapted as needed. For candidate road diets, the VDOT TMPD's Multimodal Programs Section has created a GIS tool to flag road segments with at least four lanes and ADTs under 20,000. By summer 2020, the Multimodal Programs Section will determine a format for the inventory of existing and candidate road diets (e.g., tabular, interactive map, booklet, etc.) and an update schedule. VTRC could provide technical assistance for these initiatives as needed.

With regard to Recommendation 2, VDOT's TMPD began developing roadway reconfiguration guidelines in 2019 with several purposes including increasing consistency across districts. It established a working group in winter 2020 to guide implementation efforts. By spring 2020, the TMPD's Multimodal Programs Section will either incorporate elements of this report in the final guidelines or identify possible revisions to the guidelines based on this study. Some studies and examples in this report could be used to help VDOT tell effective stories during the public involvement process. The TMPD may also seek to collect additional data—such as bicycle counts, traffic speeds, and aerial imagery—before and after future road diets, and VTRC could provide technical assistance with data analysis. VDOT's Local Assistance Division could then promote the guidelines to localities; those with VDOT-maintained roads would need to follow these guidelines, and those with locally maintained roads could still use the guidelines as a resource.

With regard to Recommendation 3, VDOT's TMPD has offered on-call consultant assistance to Districts for developing restriping plans, one cost associated with road diets that is not encountered when replacing pavement markings in kind during resurfacing. Such assistance could also come from district planning or engineering divisions. The Virginia Department of Rail and Public Transportation has an existing data source that could be used in restriping plans: a GIS layer of bus routes and stops. In 2019, as part of implementing its Pedestrian Safety Action Plan (VDOT, 2018), VDOT's Traffic Engineering Division began developing an Instructional and Informational Memorandum (I&IM) that is expected to consider road diets in a broader context of no- and low-cost safety improvements that can be made as part of routine resurfacing. By fall 2020, the TMPD's Multimodal Programs Section will assess the status of existing efforts (statewide inventory, roadway reconfiguration guidelines, I&IMs, etc.) and identify next steps, resource requirements, or additional research needed to implement road diets regularly through the resurfacing program. One relevant national research effort through the National Cooperative Highway Research Program, NCHRP Project 15-78, is expected to begin in 2020 to develop a guidebook for urban and suburban roadway cross-sectional reallocation (Transportation Research Board, 2019). The project will result in a guidebook and decision-making framework for reallocating space on existing roads in projects such as road diets; in the future, VDOT could adopt these products or use them to revise VDOT practices.

With regard to Recommendation 4, the district traffic engineer for VDOT's Northern Virginia District will work with VTRC to develop a research problem statement for the fall 2020 meeting of VTRC's Traffic and Safety Research Advisory Committee. This could include scanning recent literature and the working inventory of Virginia road diets to identify types of road diets for which CMFs are nonexistent or questionable. Assuming there is indeed a gap that new research could fill, either in the Northern Virginia District or statewide, the district traffic engineer will submit the research problem statement by December 2020.

Benefits

The primary benefits of implementing the recommendations are improved safety and multimodal connectivity at relatively low marginal costs. The benefits of implementing each recommendation can be described as follows:

The primary benefits of implementing Recommendation 1 are improved decision-making and support of future research (e.g., research to develop CMFs). An inventory of existing road diets would enable safety studies and would create a foundation for future research. An inventory of candidate road diet sites would streamline the application of guidance as noted in Recommendation 1.

The primary benefits of implementing Recommendation 2 are improved decision-making and a more consistent use of best practices throughout VDOT for evaluating the feasibility of a road diet, conducting an effective public participation process, implementing the changes, and evaluating the effects.

Recommendation 3 would use the recommended inventory and guidance to enable VDOT districts to implement road diets more regularly through routine resurfacing efforts. The benefits of doing so would depend on the volume of road diet projects and on site-specific conditions for each one, but such benefits would likely fall into one or more of the following categories based on the literature:

- *safety benefits,* such as total crash reductions of 19% to 47% (Knapp et al., 2014), exceeding delay costs (Noland et al., 2015)

- *improved nonmotorized connectivity or comfort,* such as increased volumes of bicyclists and pedestrians (Anderson and Searfoss, 2015; Cebe, 2016; Gudz et al., 2016; New York City Department of Transportation, 2014a, 2014b)

- *livability benefits,* such as reduced speeding and reduced pedestrian injury crashes (FHWA, 2015; New York City Department of Transportation, 2014a)

- *economic development benefits,* such as increases in retail sales (New York City Department of Transportation, 2014b) or increases or stability in home values (Yu et al., 2018).

In addition, localities surveyed for this study said that their road diets typically met their objectives, which can be viewed as a qualitative assessment of the benefits of past projects in Virginia.

The primary benefits of implementing Recommendation 4 would depend on the resulting research. VDOT has used the results of older road diets such as the 2009 Lawyers Road project to estimate crash reductions from road diets, but there may be benefits from developing CMFs based on more recent road diets and/or those with other before and after configurations. Development of CMFs could result in an improved estimation of safety benefits for certain types of road diets.

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APPENDIX A

ROAD DIET DETAILS IN EACH LOCALITY

Localities With One Road Diet

Table A1. Roadway and Study Information for Localities With One Road Diet

Locality	Roadway	Type	Year	Study	
				Before	After
City of Danville	West Main / Main from Stewart Street to Holbrook Street	4-2[a]	2018	Yes	No
City of Salem	Downtown Salem includes road diet elements throughout on Main Street and College Avenue[b]	---	---	Yes	U
City of Williamsburg	Second Street from Page Street to city limits	4-3[c]	2018	No	No
County of Albemarle	Whitewood Road from Hydraulic Road to Oak Forest Drive	4-3[d]	2019	No	No
County of Loudoun	George Washington Blvd etween Loudoun County Parkway and Riverside Parkway	6-4[e]	2016	Yes	No
County of Mathews	General Puller Highway from Regent Road to Twiggs Ferry Road	4-3[f]	2013	No	No
Town of Altavista	Main Street from Pittsylvania Avenue to just north of Lola Avenue	4-3[f]	2017	Yes	No
Town of Amherst	Main Street corridor	4-3[c]	---[g]	U	U
Town of Culpeper	Sperryville Pike from Blue Ridge Avenue to Colonel Jameson Boulevard	4-3[h]	2019	Yes	No

U = unknown; --- = no answer provided.
[a] 4-lane converted to 2-lane plus bike lanes and turn lanes or on-street parking.
[b] Downtown redevelopment, including streetscaping and placemaking (unclear if lane removal had occurred).
[c] 4-lane conversion to 2-lane plus a center turn lane and bike lanes.
[d] Converted 2 through lanes and 2 right-turn lanes to 2 through lanes / center 2-way left-turn lane with bike lanes.
[e] 6-lane divided converted to 4-lane with turn lane and bike lanes. Installed rectangular rapid flashing beacon at 1 intersection to improve pedestrian crossing.
[f] 4-lane converted to 3-lane with center turn lane and 2- to 3-ft shoulders.
[g] Although the survey respondent indicated that the Town of Amherst road diet was a 4-3 type and did not provide the year, VDOT's Lynchburg District advised that it occurred in 2017 and converted a 3-lane road to a 2-lane road with bike lanes.
[h] 4-lane converted to 3-lane plus 1 planted median and 1 bike lane.

Table A2. Additional Survey Information From Localities With One Road Diet

Locality	Reasons for Implementing Road Diet	Met Objectives? Lessons Learned	Feedback
City of Danville	Improving safety, accommodating bicycle travel, providing on-street parking, sowing down cars	It met the goals.	Mixed
City of Salem	Creating a sense of place, providing for on-sidewalk pedestrian uses	Project is underway, but we think it'll turn out pretty great.	Positive
City of Williamsburg	Improving safety, accommodating bicycle travel	Very well. Much easier to make left turns and for peds to cross the street.	Mixed
County of Albemarle	Improving safety, accommodating bicycle travel, better allocation of turn lanes	Just recently constructed, too soon to evaluate.	Mixed
County of Loudoun	Improving safety	Very well. No lessons learned.	Positive
County of Mathews	Improving safety	Unknown	Mixed
Town of Altavista	Improving safety	The goal of improving safety was met.	Mixed
Town of Amherst	Improving safety, accommodating bicycle travel	It has helped increase safety for walkers and bikers.	Mixed
Town of Culpeper	Improving safety	The project actually will be completed in 2019. TBD.	Positive

Locality With Two Road Diets

Table A3. Roadway and Study Information From the Town of Blacksburg

Locality	Roadway	Type	Year	Study	
				Before	After
Town of Blacksburg	College Avenue	2-1[a]	2013	Yes	U
	Main Street from College Avenue to Prices Fork Road	4-3[b]	2012	Yes	U

U = unknown.
[a] 2-lane with 2 sides of on-street parking converted to 1-lane 1-way with 1 side of on-street parking and wider sidewalks/plaza.
[b] 4-lane converted to 2-lane plus a center turn lane and wider sidewalks.

Table A4. Additional Survey Information From the Town of Blacksburg

Roadway	Reasons for Implementing	Met Objectives? Lessons Learned	Feedback
College Avenue	Improving safety and implementation of Downtown Master Plan creating a pedestrian promenade, urban park, and streetscape	Very well. The area is home to vibrant pedestrian activity and outdoor dining and public plaza space.	Positive
Main Street from College Avenue to Prices Fork Road	Improving safety and implementation of Downtown Master Plan for improved public plazas and streetscape	Very well.	Positive

Locality With Four Road Diets

Table A5. Roadway and Study Information From the City of Roanoke

Locality	Roadway	Type	Year	Study Before	Study After
City of Roanoke	13th Street SW from Wasena Terrace to Salem Avenue	3-2[a]	2016	U	U
	Elm Avenue from Franklin Road to 8th Street SW	3-2[b]	2018	Yes	Yes
	McClanahan Street from Jefferson Street to Franklin Road	3-2[c]	2016	No	No
	5th Street NW from Shenandoah to Gilmer	4-3[d]	2017	No	No

U = unknown.
[a] Removed travel lane to provide bike lanes and some parking.
[b] Removed 1 travel/parking lane and added bike lanes in 2 directions.
[c] Reduction in number of travel lanes to provide bicycle lanes.
[d] Removed 1 travel lane and added bicycle lanes in 2 directions.

Table A6. Additional Survey Information From the City of Roanoke

Roadway	Reasons for Implementing Road Diet	Met Objectives? Lessons Learned	Feedback
13th Street SW from Wasena Terrace to Salem Avenue	Accommodating bicycle travel, providing on-street parking, reducing length of pedestrian crossings	Met the goals. Minimal vehicular traffic impact. Big improvement for bicyclists and pedestrians.	Positive
Elm Avenue from Franklin Road to 8th Street SW	Accommodating bicycle travel, enhancing pedestrian crossings	Very well. Public input process was essential to success.	Positive
McClanahan Street from Jefferson Street to Franklin Road	Accommodating bicycle travel, enhancing pedestrian crossings	Very well. Minimal impact to traffic.	None
5th Street NW from Shenandoah to Gilmer	Accommodating bicycle travel, providing on-street parking, removing excess lane capacity	Very well.	None

Localities With Five or More Road Diets

Table A7. Roadway and Study Information From the County of Fairfax

Locality	Roadway	Type	Year	Study Before	Study After
County of Fairfax	Fountain Drive from Baron Cameron Avenue to New Dominion Parkway	4-3[a]	2018	No	No
	Bluemont Way from Town Center Parkway to Democracy Drive	4-3[a]	2018	No	No
	South Lakes Drive from Colts Neck Road to Soapstone Drive and from Ridge Heights to Twin Branches Road	4-2[b]	2018	Yes	No
	Colts Neck Road from Sunrise Valley Drive to Glade Drive	4-3[a]	2017	Yes	No
	Armistead Road from Lorton Road to Richmond Highway	4-3[a]	2018	No	No

[a] 4-lane converted to 3-lane with left-turn lanes and bike lanes or buffered bike lanes.
[b] 4-lane divided converted to 2-lane divided with buffered bike lanes.

Table A8. Additional Survey Information From the County of Fairfax

Roadway	Reasons for Implementing Road Diet	Met Objectives? Lessons Learned	Feedback
Fountain Drive from Baron Cameron Avenue to New Dominion Parkway	Improving safety, accommodating bicycle travel, calming traffic, improving pedestrian safety (crossings)	Road diet works smoothly, as expected.	None
Bluemont Way from Town Center Parkway to Democracy Drive	Improving safety (especially for pedestrians), accommodating bicycle travel	Significantly improves pedestrian comfort and safety.	None
South Lakes Drive from Colts Neck Road to Soapstone Drive and from Ridge Heights to Twin Branches Road	Improving safety, accommodating bicycle travel, calming traffic, improving pedestrian safety and comfort	Yes, all project goals were achieved. Lessons learned: provide new traffic pattern warning signage during construction, narrow the buffer enough to discourage driving in it (either wider bike lane or wider shy line at median). Additional enforcement of new traffic pattern needed after implementation. Public had more difficulty understanding concept than traditional road diet.	Yes (Mixed)
Colts Neck Road from Sunrise Valley Drive to Glade Drive	Improving safety, accommodating bicycle travel, improving pedestrian safety and comfort, calming traffic	Works as expected.	None
Armistead Road from Lorton Road and Richmond Highway	Accommodating bicycle travel	Project provided bike lanes.	None

Table A9. Roadway and Study Information From the City of Richmond

Locality	Roadway	Type	Year	Study	
				Before	After
City of Richmond	MLK Bridge (Leigh Viaduct), N. 10th Street to Mosby Street	6-4[a]	2014	No	No
	Oliver Hill Way / N. 18th Street from Fairfield Way to Venable Street	6-4[b]	2014	No	No
	Manchester Bridge / S. 9th Street, from E. Cary Street to bridge on/off-ramps	7-5[c]	2015	No	No
	Franklin Street Cycletrack	4-2[d]	2018	Yes	Yes
	Brookland Parkway, from Brook Road to Hermitage Road	4-2[e]	2014	No	Yes

[a] 6-lane, median-divided bridge over I-95 reduced to 4-lane with buffered bike lanes.
[b] 6-lane 1-way couplet/median-divided roadway (2 1-ways converge into divided 2-way) reduced to 4-lane with buffered bike lanes.
[c] 7-lane (3 north, 4 south) median-divided bridge reduced to 2 and 3 lanes, respectively, and buffered bike lanes.
[d] 4-lane, 1-way street with 2 off-peak parking lanes (4-lane in AM peak) converted to the following cross-section: a 2-way separated bike lane, floating parking (AM peak travel lane), single travel lane, dedicated parking lane.
[e] Median-divided 4-lane with curbside parking (substandard width) converted to 2 travel lanes with buffered bike lanes and parking.

Table A10. Additional Survey Information From the City of Richmond

Roadway	Reasons for Implementing Road Diet	Met Objectives? Lessons Learned	Feedback
MLK Bridge (Leigh Viaduct), N. 10th Street to Mosby Street	Improving safety, accommodating bicycle travel, reducing speeds because of excess capacity inducing high speeds	Noticeably slower speeds, increased bike traffic in roadway instead of pedestrian walkway. Some people bike against traffic. If congested drivers will sometimes drive in the bike lane to bypass traffic.	Yes (positive)
Oliver Hill Way / N. 18th Street from Fairfield Way to Venable Street	Accommodating bicycle travel	Modest improvement. Terminates at I-95 off-ramp, which is most challenging location for bicyclists, limiting the value. Also located in post-industrial area with minimal trip generators but fills part of a gap in the bike network. Will be reconstructed with redevelopment of the corridor.	Yes (mixed)
Manchester Bridge / S. 9th Street, from E. Cary Street to bridge on/off-ramps	Improving safety, accommodating bicycle travel	Mixed results. Southern ramp access lacks bike lanes, requiring shared lane condition, which limits safety and utility benefits for bicyclists. However made crossing the bridge considerably more comfortable with less exposure to riding in a high-speed shared roadway (45+ mph speeds typical). Greater benefits on the two blocks of surface streets (9th from bridge to Cary St), reducing exposure at turn lanes.	Yes (positive)
Franklin Street Cycletrack	Accommodating bicycle travel	Well with some challenges. Speeds are slower and more consistent with 25 mph posted limit. Single travel lane can see delay with drivers parking or large commercial vehicles having to proceed more slowly between two parking lanes. Two-way bike lane introduces some exposure that may need to be addressed via future countermeasures. Had to add parking "L's" at limits of parking in the floating lane to communicate the limits of parking to correspond with curbside signage.	Yes (mixed)
Brookland Parkway, from Brook Road to Hermitage Road	Accommodating bicycle travel, providing on-street parking, speed management	Mixed. Bike usage has been modest but increased. Speeds were modestly reduced and parking is easier since the substandard parking lane (6 ft) can now accommodate parking without risk of sideswipes. We receive complaints of people driving in the bike lanes and the lanes terminate before the major intersection end points to provide intersection capacity, reducing utility of the bike lanes.	Yes (mixed)

APPENDIX B

DATA COLLECTION SITE AERIAL VIEWS

Figure B1. Aerial View of Colts Neck Road Diet Site, Surrounding Land Use Context, and Data Collection Locations. The green markers show the data collection locations. Map data ©2018 Google.

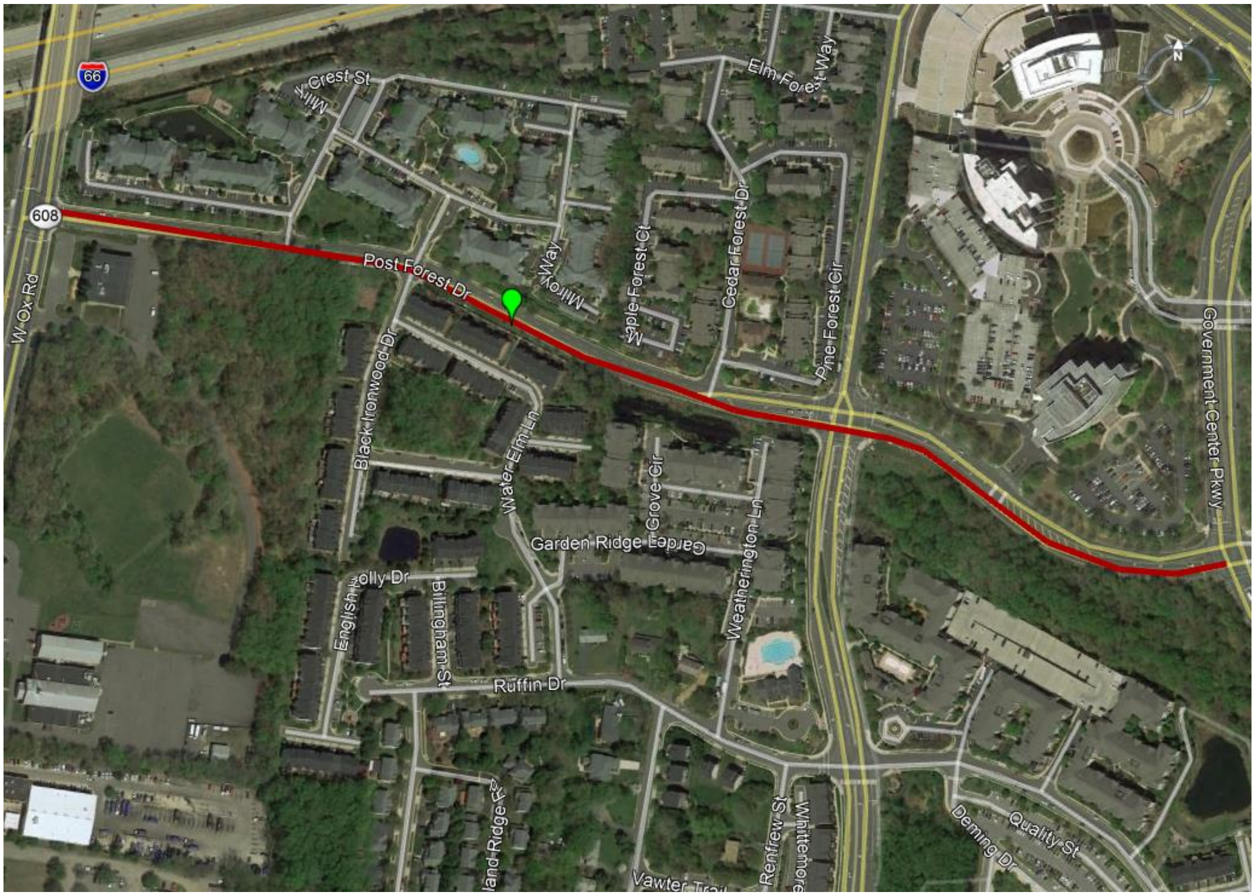


Figure B2. Aerial View of Post Forest Drive Diet Site, Surrounding Land Use Context, and Data Collection Location. The green marker shows the data collection location. Map data ©2018 Google.

Figure B3. Aerial View of Ridge Top Road Diet Site, Surrounding Land Use Context, and Data Collection Location. The green markers show the data collection locations. Map data ©2018 Google.

APPENDIX C

DATA COLLECTION SCHEMATICS

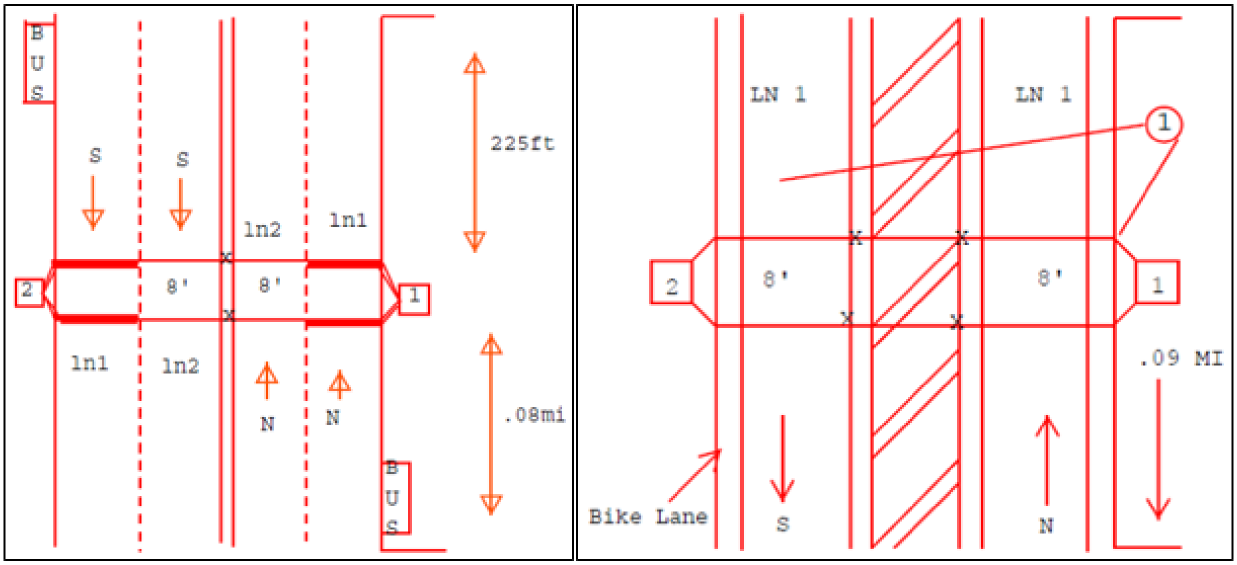


Figure C1. Schematics of Colts Neck Road Site 1 Data Collection Locations Before (Left) and After (Right) Road Diet. Images provided by The Traffic Group, Inc. Reprinted with permission.

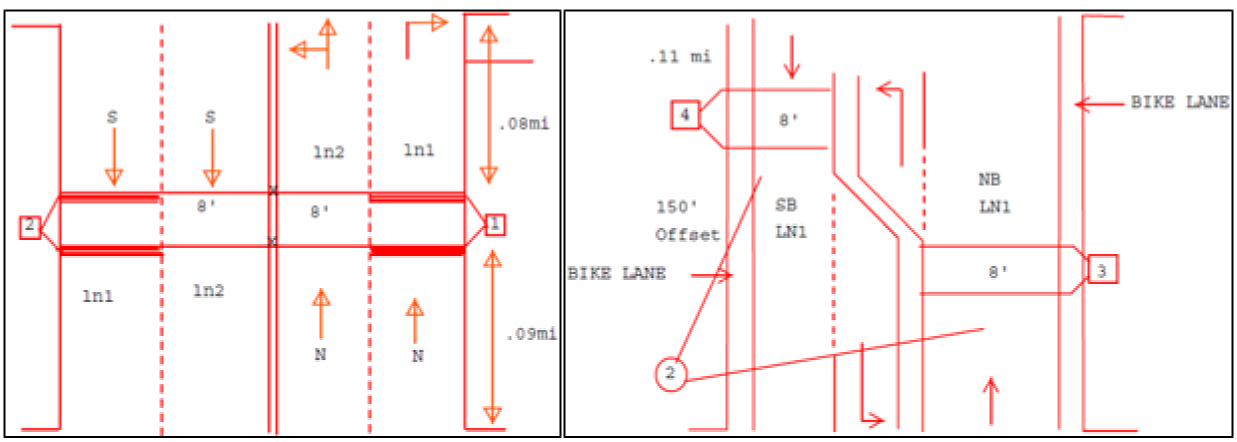


Figure C2. Schematics of Colts Neck Road Site 2 Data Collection Locations Before (Left) and After (Right) Road Diet. Images provided by The Traffic Group, Inc. Reprinted with permission.

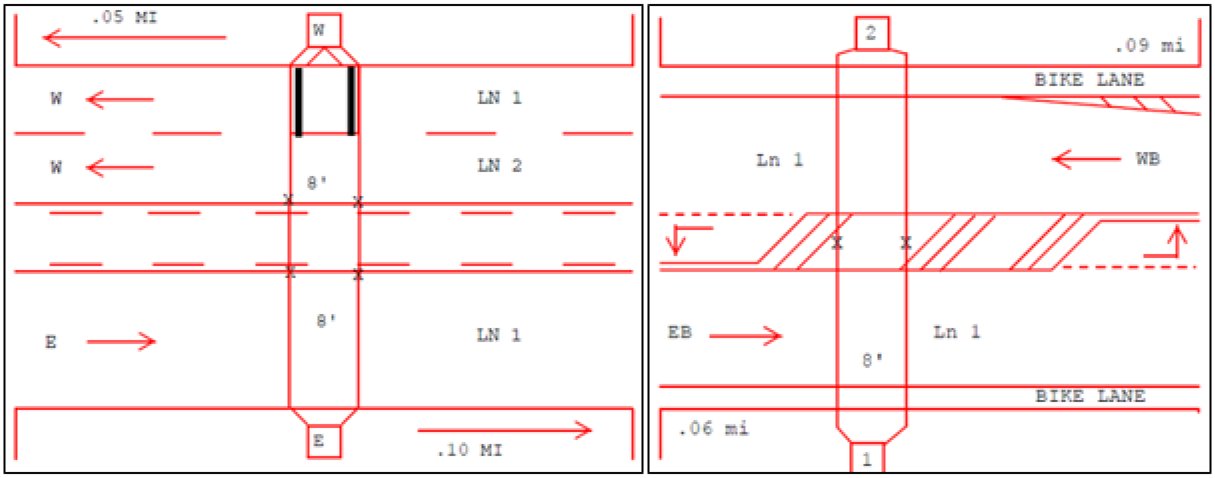


Figure C3. Schematics of Post Forest Drive Data Collection Locations Before (Left) and After (Right) Road Diet. Images provided by The Traffic Group, Inc. Reprinted with permission.

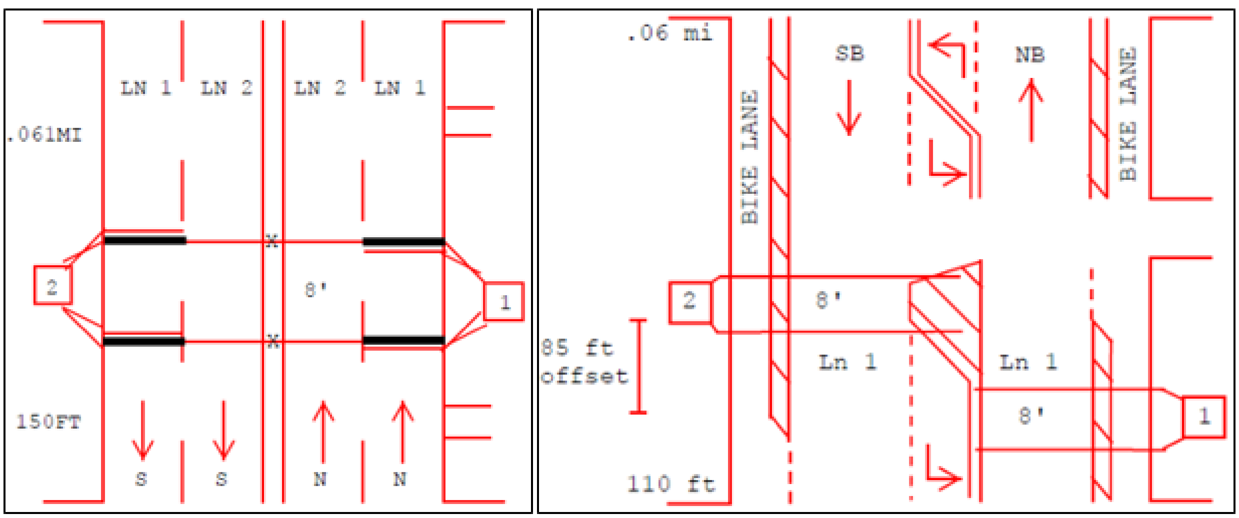


Figure C4. Schematics of Ridge Top Road Site 1 Data Collection Locations Before (Left) and After (Right) Road Diet. Images provided by The Traffic Group, Inc. Reprinted with permission.

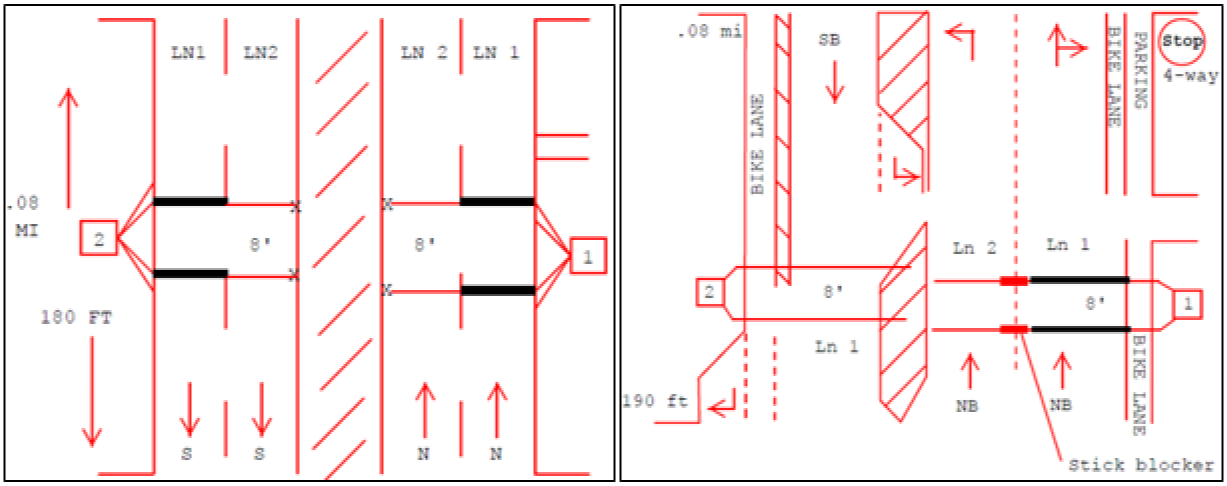


Figure C5. Schematics of Ridge Top Road Site 2 Data Collection Locations Before (Left) and After (Right) Road Diet. Images provided by The Traffic Group, Inc. Reprinted with permission.

APPENDIX D

DATA COLLECTION DAILY SUMMARIES

Table D1. Colts Neck Road Site 1 Motor Vehicle Volume and Speed Summary, Before Road Diet

Date	Day of Week	Travel Direction	Total Vehicles	15th Percentile Speed (mph)	50th Percentile Speed (mph)	85th Percentile Speed (mph)	Mean Speed (mph)	Standard Deviation (mph)
7/18/2017	Tues	NB	5164	28.7	34.6	40.6	34.6	5.8
		SB	5194	31.2	37.3	42.9	36.9	5.6
7/19/2017	Wed	NB	5320	28.9	34.9	41.4	34.9	6.0
		SB	5053	31.2	37.5	43.2	37.2	5.7
7/20/2017	Thurs	NB	5127	28.2	34.3	40.5	34.3	6.1
		SB	4895	31.1	37.2	43.0	37.0	5.8
7/22/2017	Sat	NB	3737	27.0	32.9	38.8	33.0	5.6
		SB	3754	30.5	36.3	41.8	36.0	5.5
7/23/2017	Sun	NB	3481	26.7	32.5	38.5	32.6	5.5
		SB	3427	30.3	36.3	41.6	35.8	5.6
7/25/2017	Tues	NB	5209	27.9	34.4	40.7	34.5	6.3
		SB	4963	31.0	37.1	42.6	36.7	5.6

NB = northbound; SB = southbound.

Table D2. Colts Neck Road Site 1 Motor Vehicle Volume and Speed Summary, After Road Diet

Date	Day of Week	Travel Direction	Total Vehicles	15th Percentile Speed (mph)	50th Percentile Speed (mph)	85th Percentile Speed (mph)	Mean Speed (mph)	Standard Deviation (mph)
6/5/2018	Tues	NB	5026	26.9	33.5	39.1	33.1	6.1
		SB	4820	30.2	36.2	40.9	35.6	5.4
6/6/2018	Wed	NB	5291	27.2	33.5	39.1	33.3	5.8
		SB	4815	29.7	35.9	39.1	35.2	6.2
6/7/2018	Thurs	NB	5009	26.9	33.1	38.7	32.8	5.7
		SB	4636	30.0	36.0	40.8	35.3	5.8
6/16/2018	Sat	NB	3715	27.3	33.5	39.2	33.5	5.7
		SB	3621	30.3	36.5	41.7	36.0	5.7
6/17/2018	Sun	NB	4462	28.6	34.3	39.5	34.2	5.3
		SB	4256	30.5	36.7	41.6	36.1	5.5

NB = northbound; SB = southbound.

Table D3. Colts Neck Road Site 2 Motor Vehicle Volume and Speed Summary, Before Road Diet

Date	Day of Week	Travel Direction	Total Vehicles	15th Percentile Speed (mph)	50th Percentile Speed (mph)	85th Percentile Speed (mph)	Mean Speed (mph)	Standard Deviation (mph)
7/18/2017	Tues	NB	3108	27.3	33.1	38.6	32.8	5.6
		SB	4486	29.5	33.8	38.8	33.7	4.7
7/19/2017	Wed	NB	3176	26.7	32.7	34.4	32.5	6.1
		SB	4467	29.7	33.9	38.8	33.7	4.7
7/20/2017	Thurs	NB	3057	27.1	33.2	38.8	33.0	5.9
		SB	4242	29.4	33.8	38.8	33.6	4.7
7/22/2017	Sat	NB	1553	27.7	33.0	38.5	33.1	4.9
		SB	2732	28.2	33.0	38.0	32.0	4.6
7/23/2017	Sun	NB	1413	27.2	32.8	38.1	32.7	5.1
		SB	2370	27.4	32.5	37.6	31.1	4.6
7/25/2017	Tues	NB	3127	26.4	32.7	38.5	32.0	6.3
		SB	4383	28.8	33.6	38.6	33.2	4.7

NB = northbound; SB = southbound.

Table D4. Colts Neck Road Site 2 Motor Vehicle Volume and Speed Summary, After Road Diet

Date	Day of Week	Travel Direction	Total Vehicles	15th Percentile Speed (mph)	50th Percentile Speed (mph)	85th Percentile Speed (mph)	Mean Speed (mph)	Standard Deviation (mph)
6/2/2018	Sat	NB	1499	26.8	32.8	38.4	32.5	5.7
		SB	2759	27.7	33.1	38.6	33.1	5.1
6/3/2018	Sun	NB	1119	26.5	32.8	38.3	32.4	5.7
		SB	2212	27.7	33.2	38.5	33.2	4.9
6/5/2018	Tues	NB	2973	29.0	34.3	39.2	34.1	5.3
		SB	4292	26.0	32.6	38.2	31.9	6.6
6/6/2018	Wed	NB	3000	28.6	34.1	39.2	33.9	5.5
		SB	4243	26.3	32.9	38.7	32.3	6.7
6/7/2018	Thurs	NB	2895	28.5	33.9	39.0	33.7	5.5
		SB	4232	27.0	33.1	38.6	32.8	5.8
6/16/2018	Sat	NB	n/c	n/c	n/c	n/c	n/c	n/c
		SB	2711	28.6	33.8	39.1	34.0	5.0
6/17/2018	Sun	NB	n/c	n/c	n/c	n/c	n/c	n/c
		SB	2434	28.2	33.5	38.9	33.6	5.0

NB = northbound; SB = southbound; n/c = not collected.

Table D5. Post Forest Drive Motor Vehicle Volume and Speed Summary, Before Road Diet

Date	Day of Week	Travel Direction	Total Vehicles	15th Percentile Speed (mph)	50th Percentile Speed (mph)	85th Percentile Speed (mph)	Mean Speed (mph)	Standard Deviation (mph)
5/8/2018	Tues	EB	5232	30.3	34.7	39.3	34.7	4.6
		WB	4771	32.8	38.4	43.7	38.3	5.3
5/9/2018	Wed	EB	5284	30.4	34.7	39.2	34.7	4.5
		WB	4922	32.9	38.4	43.8	38.4	5.3
5/10/2018	Thurs	EB	5116	30.1	34.2	39.0	34.3	4.6
		WB	4654	32.2	32.2	37.9	37.8	5.4
5/12/2018	Sat	EB	3323	30.2	34.3	39.2	34.4	4.6
		WB	3518	32.7	38.4	43.8	38.4	5.2
5/13/2018	Sun	EB	4527	30.0	34.2	39.0	34.3	4.7
		WB	2949	32.1	37.7	43.4	37.8	5.2

EB = eastbound; WB = westbound.

Table D6. Post Forest Drive Motor Vehicle Volume and Speed Summary, After Road Diet

Date	Day of Week	Travel Direction	Total Vehicles	15th Percentile Speed (mph)	50th Percentile Speed (mph)	85th Percentile Speed (mph)	Mean Speed (mph)	Standard Deviation (mph)
4/23/2019	Tues	EB	5081	31.1	36.2	41.0	36.1	4.8
		WB	4452	34.5	39.5	44.5	39.5	5.2
4/24/2019	Wed	EB	5084	31.2	36.2	40.8	36.1	4.7
		WB	4684	34.3	39.3	44.4	39.2	5.3
4/25/2019	Thurs	EB	5155	31.1	36.1	40.6	36.0	4.6
		WB	4728	34.5	39.6	44.5	39.4	5.3
4/27/2019	Sat	EB	4457	31.5	36.6	41.3	36.5	4.6
		WB	3499	35.2	39.9	44.7	40.0	4.8
4/28/2019	Sun	EB	2992	31.5	36.6	41.1	36.5	4.6
		WB	2939	35.4	40.1	44.9	40.2	4.8
4/30/2019	Tues	EB	5154	31.1	36.3	40.8	36.1	4.7
		WB	4576	34.9	39.5	44.5	39.5	5.1

EB = eastbound; WB = westbound.

Table D7. Ridge Top Road Site 1 Motor Vehicle Volume and Speed Summary, Before Road Diet

Date	Day of Week	Travel Direction	Total Vehicles	15th Percentile Speed (mph)	50th Percentile Speed (mph)	85th Percentile Speed (mph)	Mean Speed (mph)	Standard Deviation (mph)
5/8/2018	Tues	NB	1415	24.3	32.6	39.5	32.3	7.0
		SB	1761	25.4	32.0	38.4	31.8	6.4
5/9/2018	Wed	NB	1490	24.9	32.8	39.6	32.5	6.8
		SB	1803	25.3	32.0	38.7	31.8	6.6
5/10/2018	Thurs	NB	1418	23.6	31.8	38.9	31.6	6.8
		SB	1713	25.0	31.6	38.2	31.4	6.4
5/12/2018	Sat	NB	1193	26.3	34.2	39.9	33.7	6.7
		SB	1412	26.1	32.8	38.8	32.6	6.1
5/13/2018	Sun	NB	1031	25.5	33.2	39.3	32.8	6.4
		SB	1263	26.2	32.5	38.6	32.4	5.8

NB = northbound; SB = southbound.

Table D8. Ridge Top Road Site 1 Motor Vehicle Volume and Speed Summary, After Road Diet

Date	Day of Week	Travel Direction	Total Vehicles	15th Percentile Speed (mph)	50th Percentile Speed (mph)	85th Percentile Speed (mph)	Mean Speed (mph)	Standard Deviation (mph)
4/23/2019	Tues	NB	1387	23.4	34.0	41.0	33.0	7.6
		SB	1681	26.5	33.2	39.1	32.9	6.1
4/24/2019	Wed	NB	1369	23.3	33.6	40.0	32.7	7.6
		SB	1641	26.0	32.7	38.7	32.5	6.2
4/25/2019	Thurs	NB	1349	23.4	33.3	39.5	32.4	7.2
		SB	1652	26.2	32.8	38.8	32.5	6.1
4/27/2019	Sat	NB	1160	25.3	35.0	41.6	34.1	7.2
		SB	1193	28.1	34.0	39.9	34.2	5.8
4/28/2019	Sun	NB	966	24.6	34.8	40.9	33.7	7.3
		SB	1156	27.9	33.8	40.9	33.9	5.7
4/30/2019	Tue	NB	1300	22.9	33.2	40.4	32.4	7.7
		SB	1650	26.3	32.9	39.1	32.7	6.3

NB = northbound; SB = southbound.

Table D9. Ridge Top Road Site 2 Motor Vehicle Volume and Speed Summary, Before Road Diet

Date	Day of Week	Travel Direction	Total Vehicles	15th Percentile Speed (mph)	50th Percentile Speed (mph)	85th Percentile Speed (mph)	Mean Speed (mph)	Standard Deviation (mph)
5/8/2018	Tues	NB	2679	19.4	27.8	33.8	27.1	6.5
		SB	2155	20.9	28.2	34.4	27.9	6.4
5/9/2018	Wed	NB	2599	19.5	28.0	34.2	27.4	6.7
		SB	2028	21.2	28.3	34.4	28.0	6.2
5/10/2018	Thurs	NB	2711	19.6	28.5	34.1	27.6	6.7
		SB	2311	21.2	28.5	34.5	28.1	6.3
5/12/2018	Sat	NB	2296	18.8	27.7	34.1	27.1	6.7
		SB	2031	21.2	28.3	34.1	28.0	5.9
5/13/2018	Sun	NB	2460	19.0	27.8	34.0	27.1	6.7
		SB	2143	21.0	27.9	34.0	27.7	6.1

NB = northbound; SB = southbound.

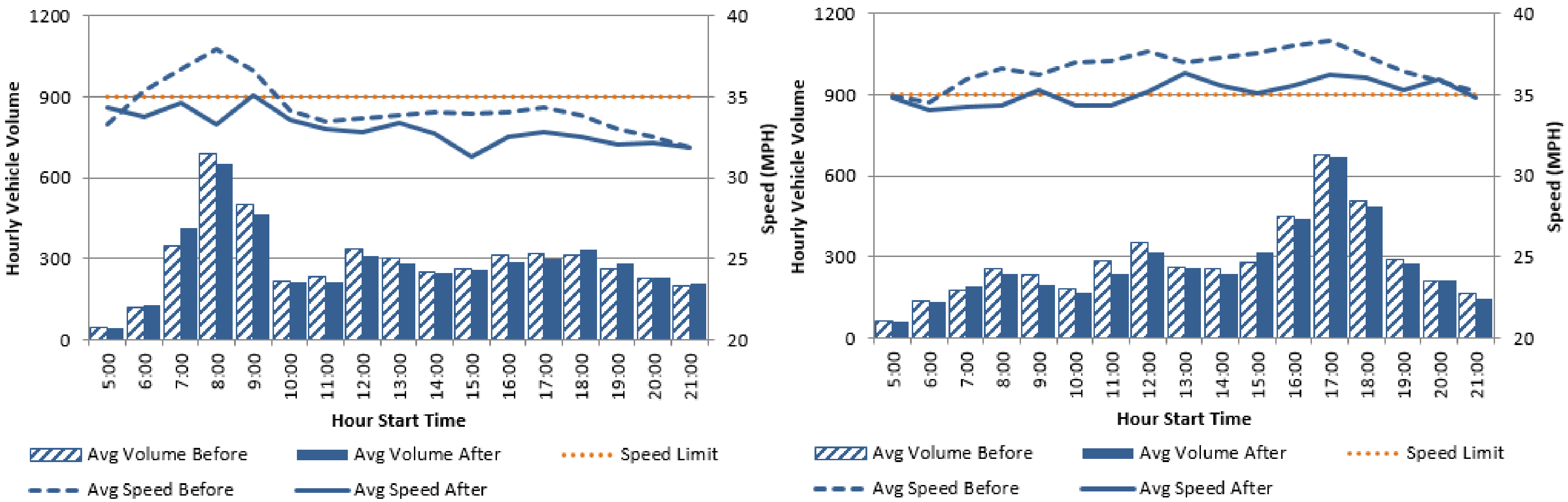
Table D10. Ridge Top Road Site 2 Motor Vehicle Volume and Speed Summary, After Road Diet

Date	Day of Week	Travel Direction	Total Vehicles	15th Percentile Speed (mph)	50th Percentile Speed (mph)	85th Percentile Speed (mph)	Mean Speed (mph)	Standard Deviation (mph)
4/23/2019	Tues	NB	2788	19.9	27.9	33.9	27.3	6.4
		SB	2065	21.5	29.1	34.8	28.6	6.3
4/24/2019	Wed	NB	2827	19.1	27.7	33.6	27.0	6.5
		SB	2046	21.5	29.0	34.9	28.5	6.5
4/25/2019	Thurs	NB	2777	19.2	27.5	33.7	26.9	6.5
		SB	2108	21.3	28.7	34.4	28.2	6.3
4/27/2019	Sat	NB	2569	19.2	27.7	33.8	27.1	6.5
		SB	1773	22.2	28.9	34.5	28.6	5.8
4/28/2019	Sun	NB	2094	19.3	27.6	33.9	27.0	6.5
		SB	1713	22.1	29.1	34.7	28.8	5.8
4/30/2019	Tues	NB	2744	19.7	27.8	33.9	27.2	6.5
		SB	2114	21.7	29.0	34.6	28.5	6.1

NB = northbound; SB = southbound.

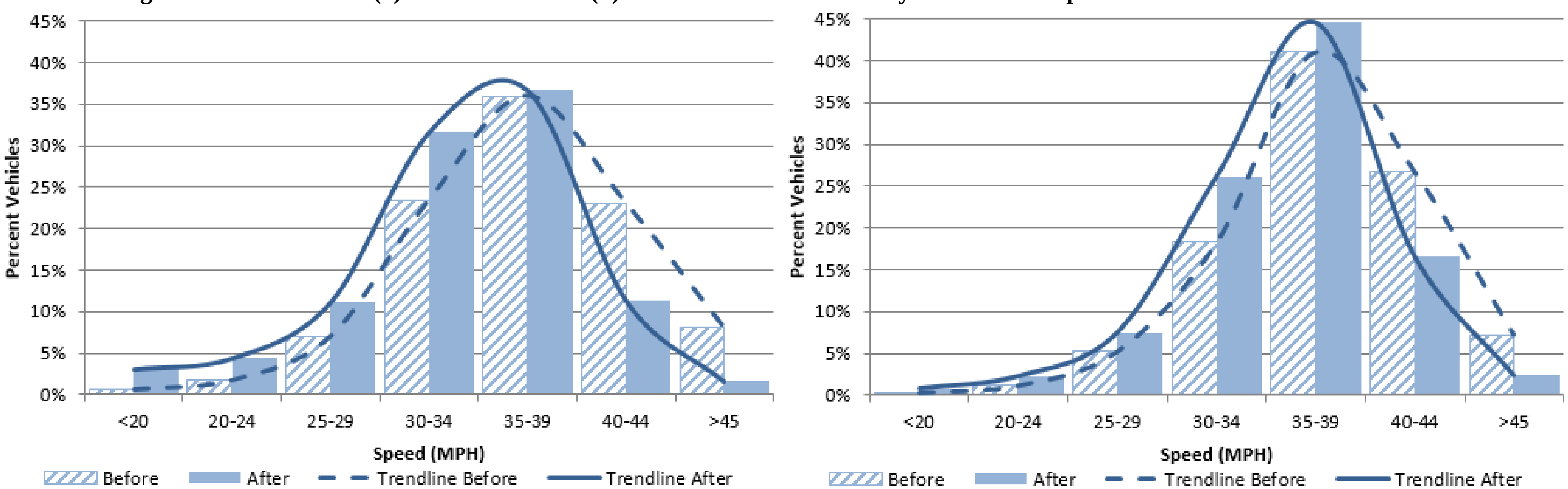
APPENDIX E

SPEED AND VOLUME PROFILES AND SPEED DISTRIBUTION HISTOGRAMS



(a) (b)

Figure E1. Northbound (a) and Southbound (b) Before and After Weekday Volume and Speed Profiles for Colts Neck Road Site 1



(a) (b)

Figure E2. Northbound a.m. (a) and Southbound p.m. (b) Weekday Before and After Speed Distribution Histograms for Colts Neck Road Site 1

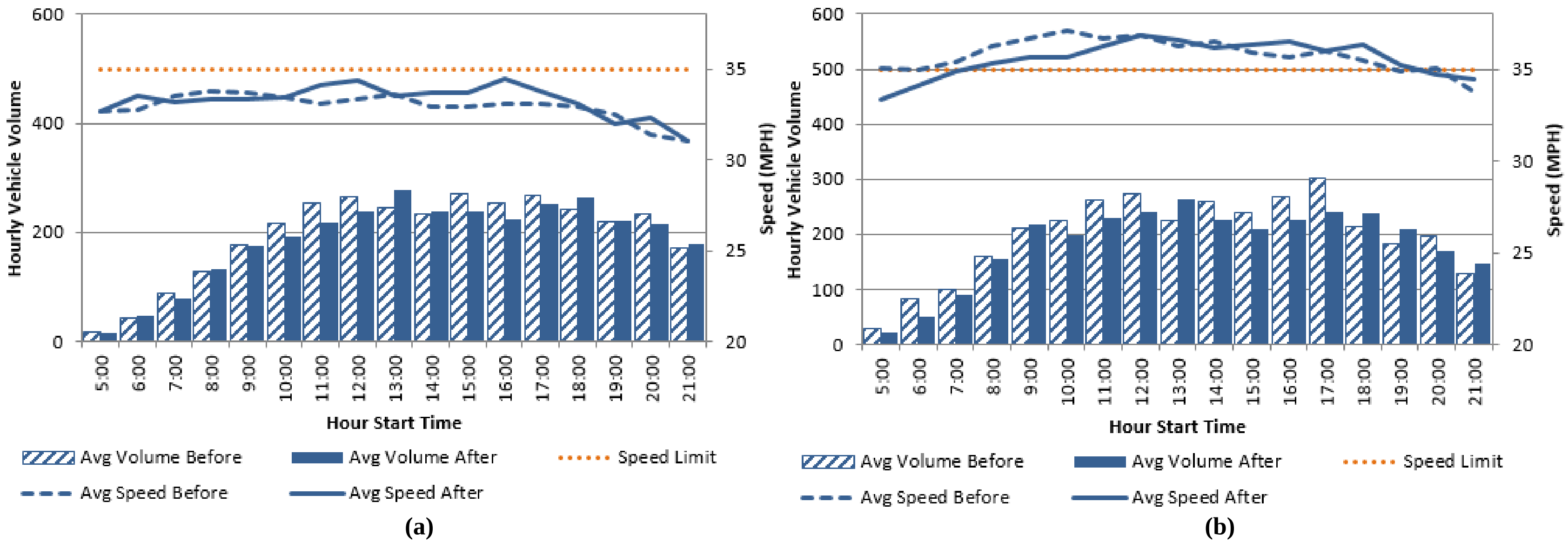


Figure E3. Northbound (a) and Southbound (b) Before and After Weekend Volume and Speed Profiles for Colts Neck Road Site 1

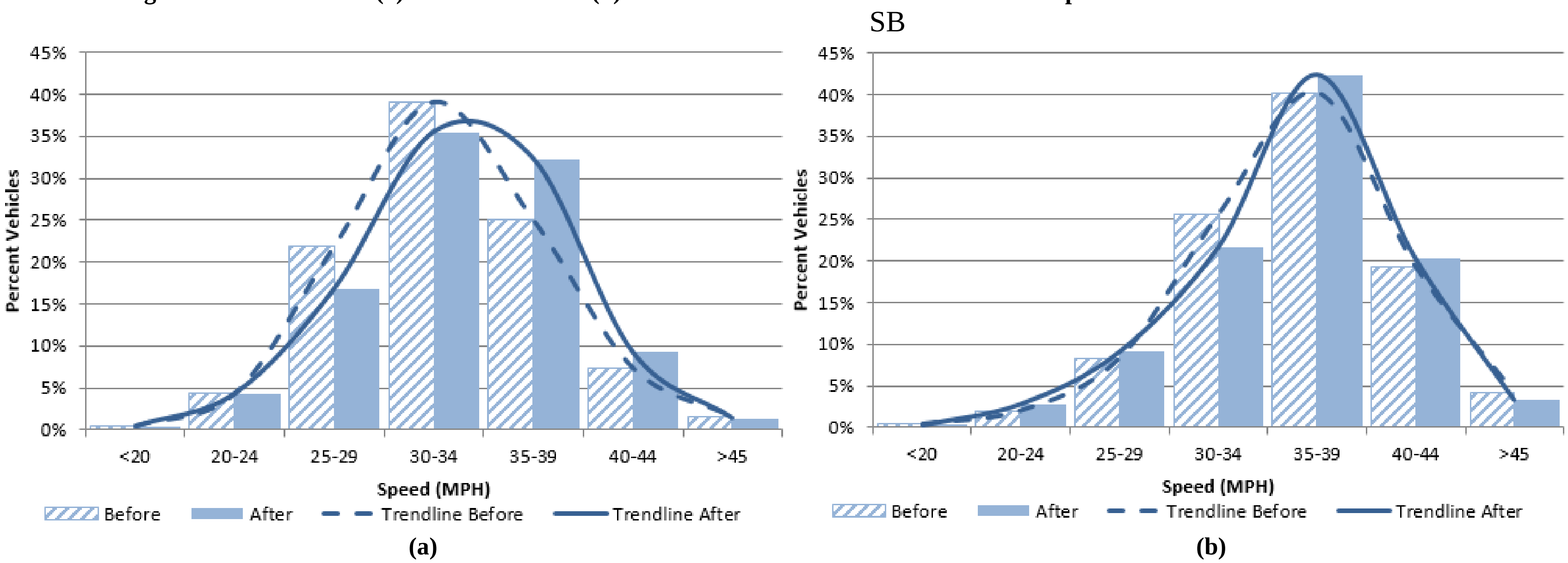
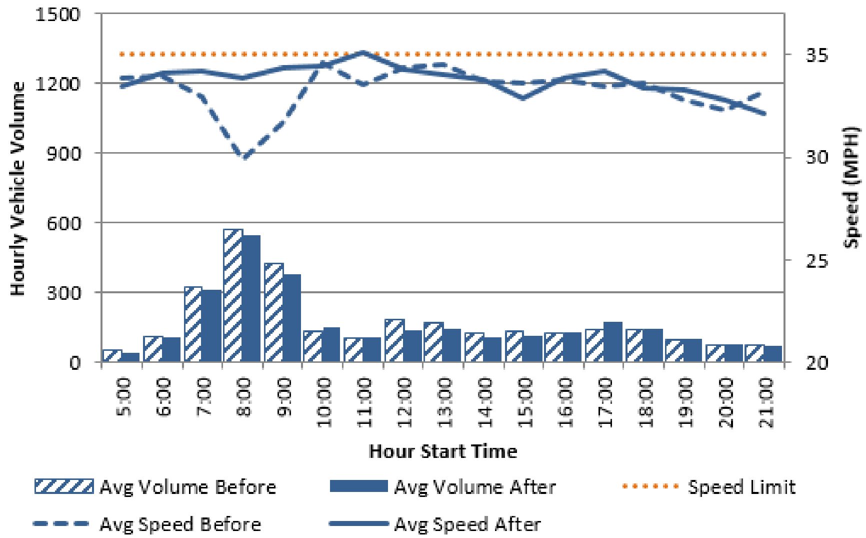
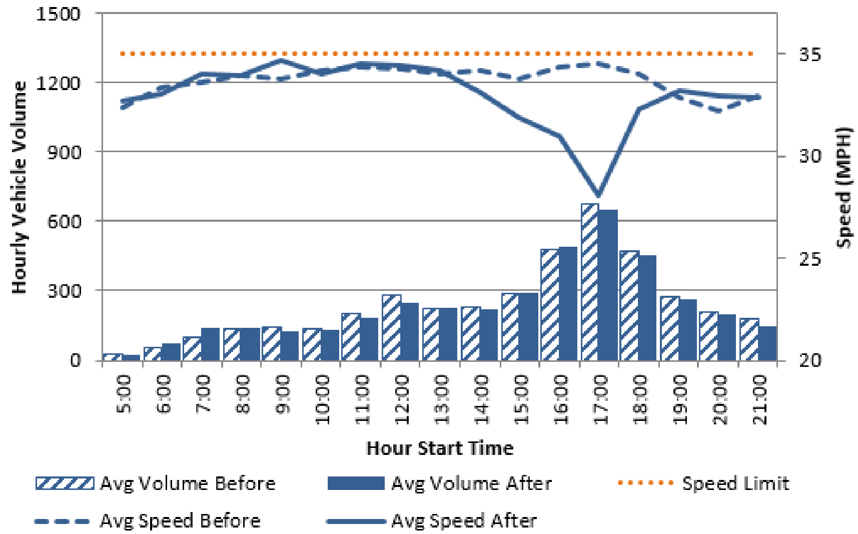


Figure E4. Northbound (a) and Southbound (b) Before Weekend Midday Speed Distribution Histograms for Colts Neck Road Site 1

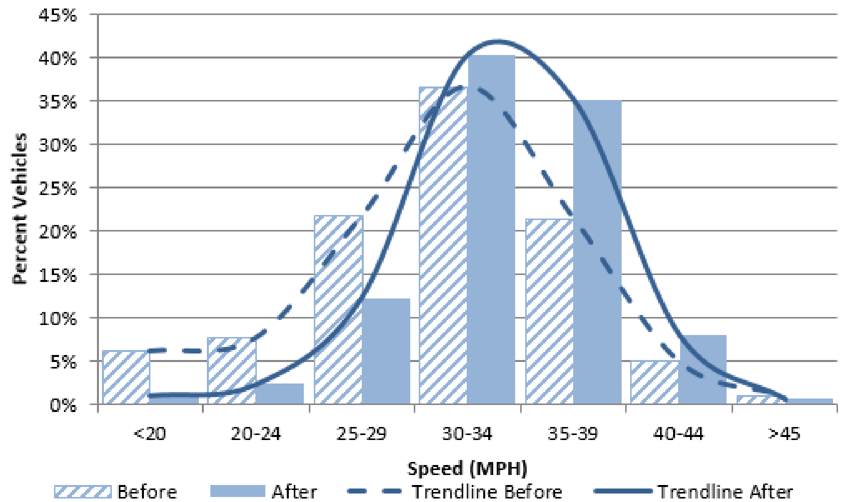


(a)

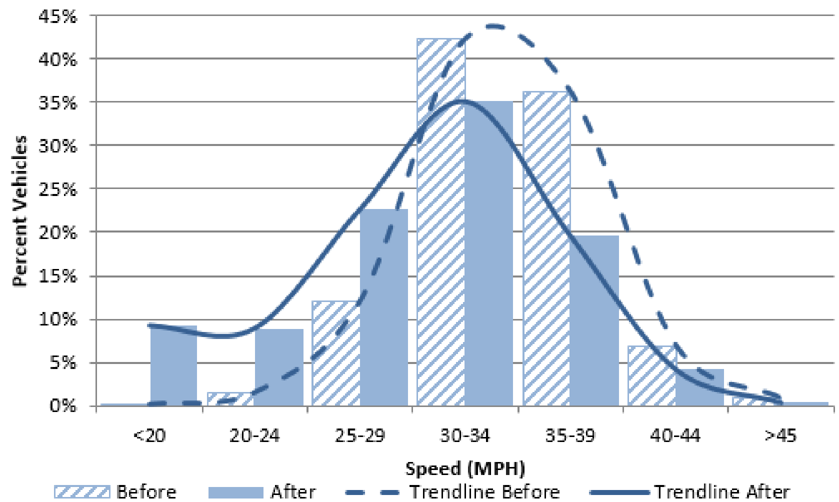


(b)

Figure E5. Northbound (a) and Southbound (b) Before and After Weekday Volume and Speed Profiles for Colts Neck Road Site 2

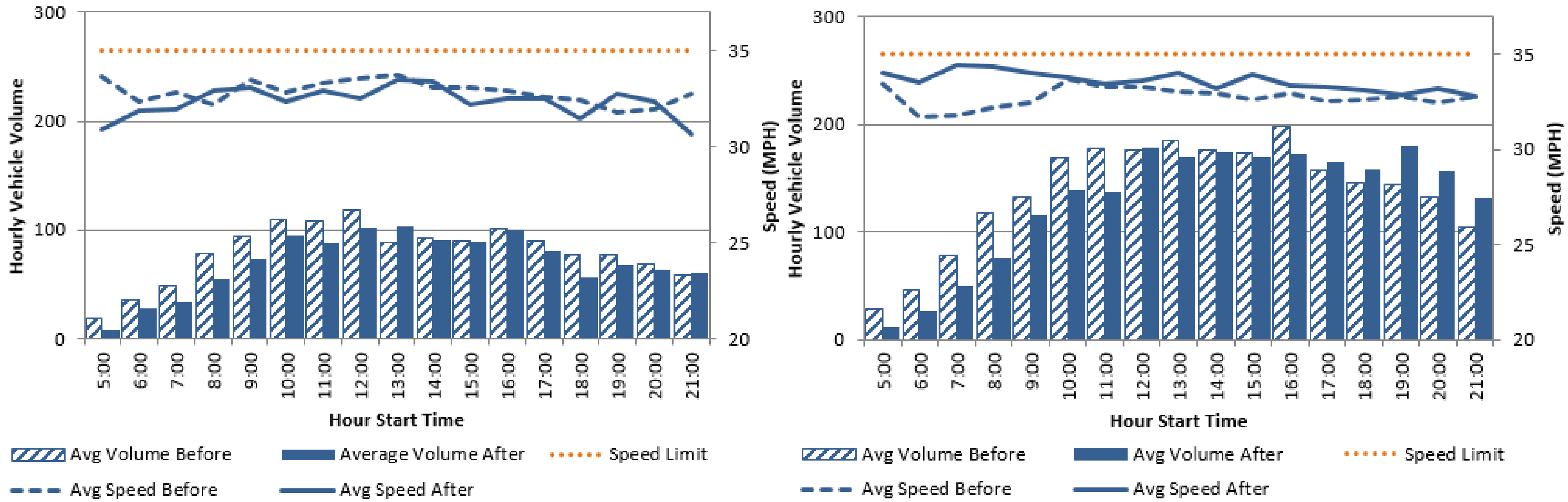


(a)



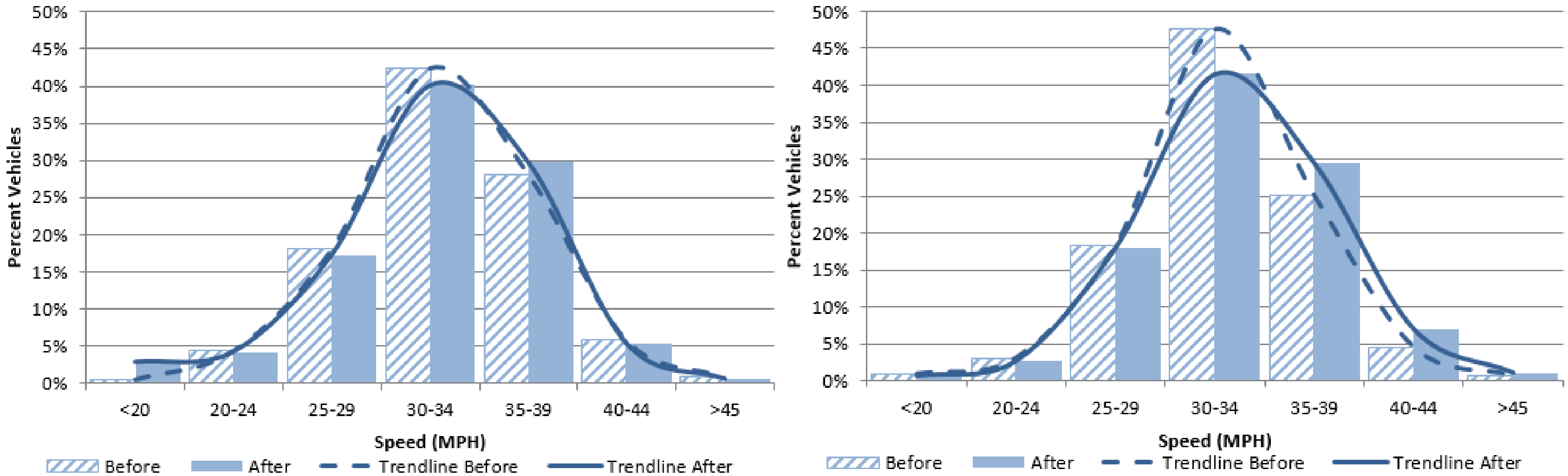
(b)

Figure E6. Northbound a.m. (a) and Southbound p.m. (b) Weekday Before and After Speed Distribution Histograms for Colts Neck Road Site 2



(a) (b)

Figure E7. Northbound (a) and Southbound (b) Before and After Weekend Volume and Speed Profiles for Colts Neck Road Site 2



(a) (b)

Figure E8. Northbound (a) and Southbound (b) Weekend Midday Speed Distribution Histograms for Colts Neck Road Site 2

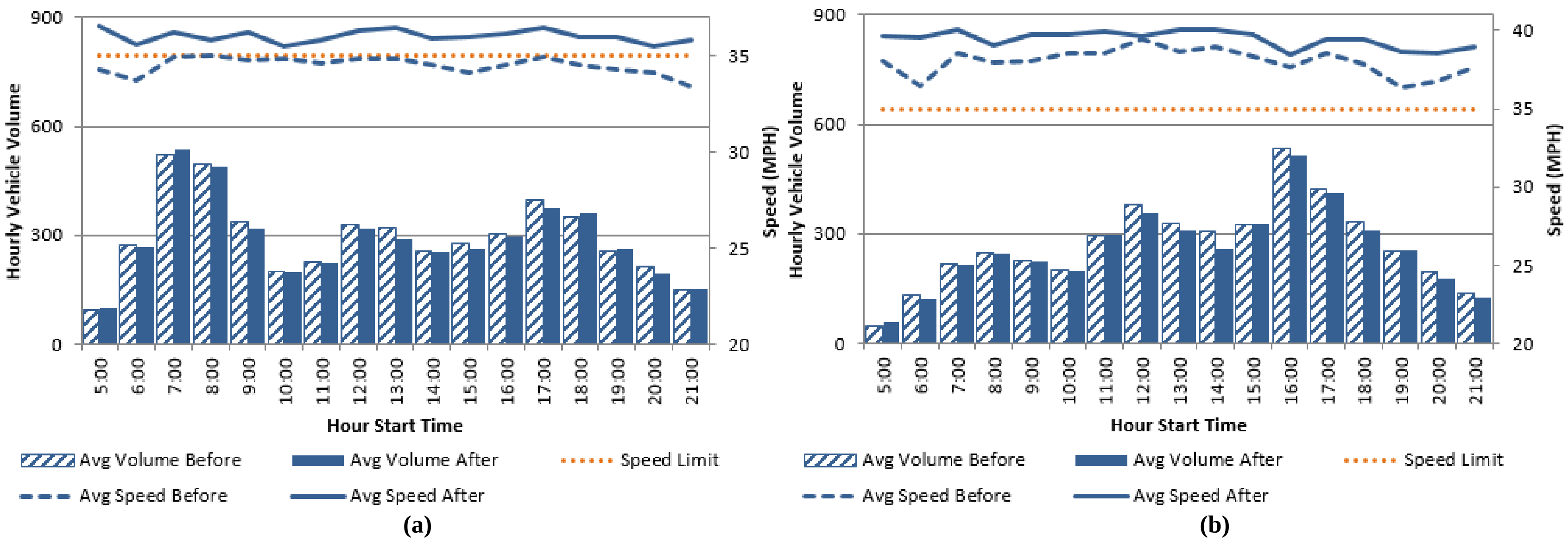


Figure E9. Eastbound (a) and Westbound (b) Before and After Weekday Volume and Speed Profiles for Post Forest Drive

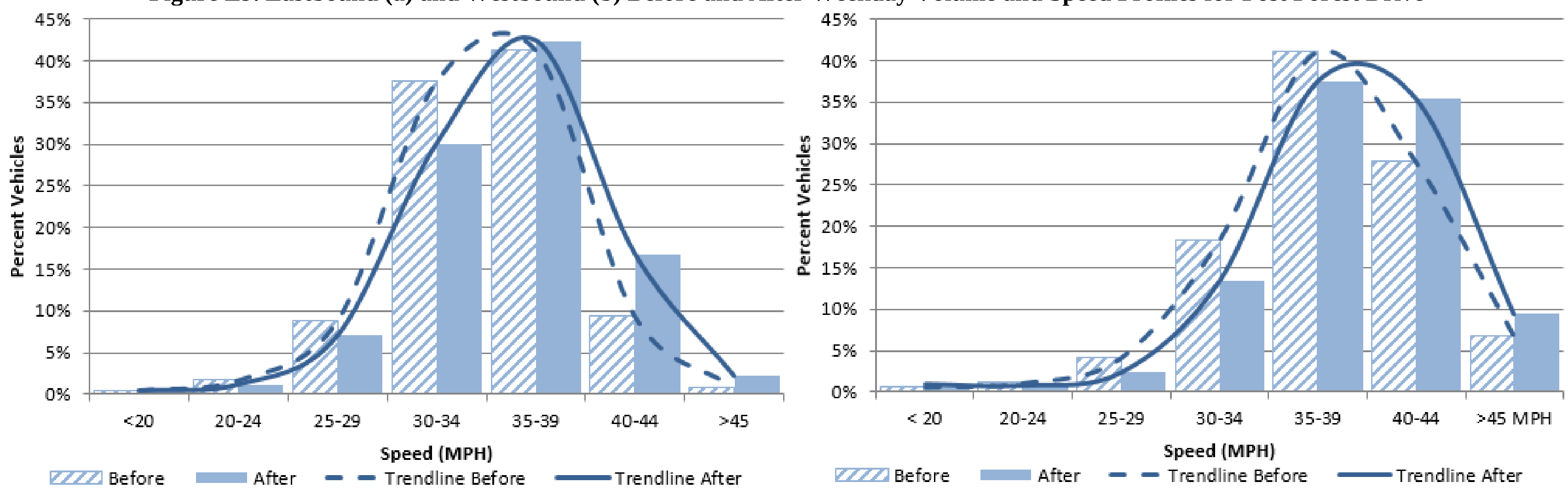
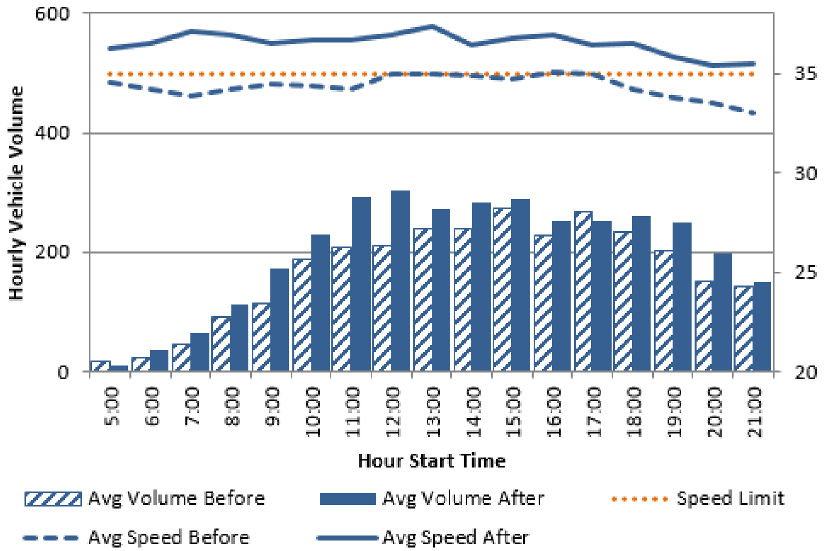
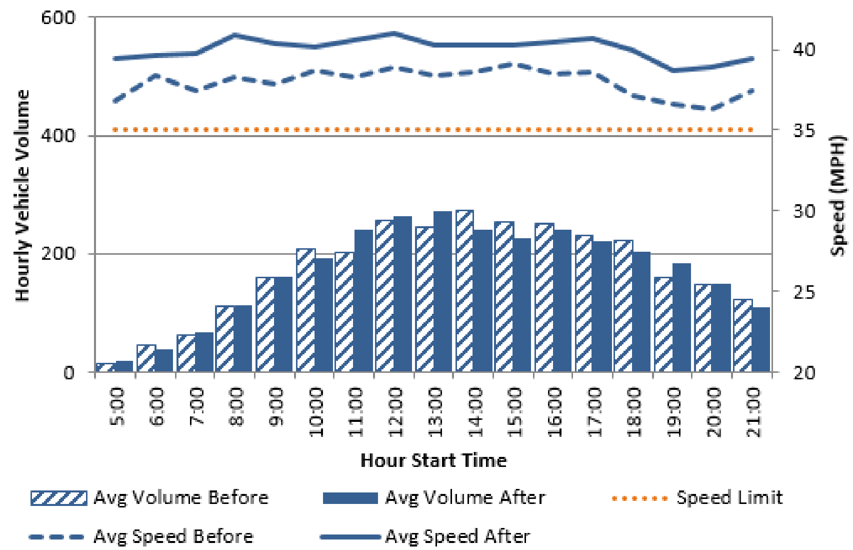


Figure E10. Eastbound a.m. (a) and Westbound p.m. (b) Weekday Before and After Speed Distribution Histograms for Post Forest Drive

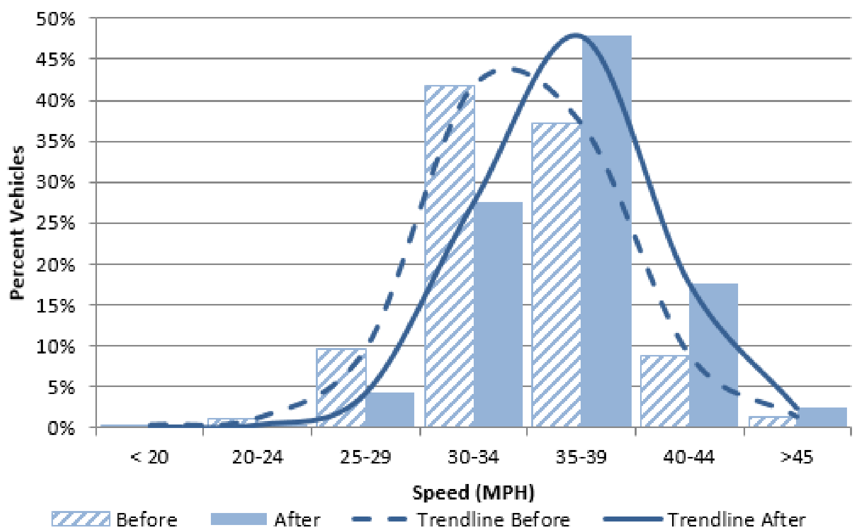


(a)

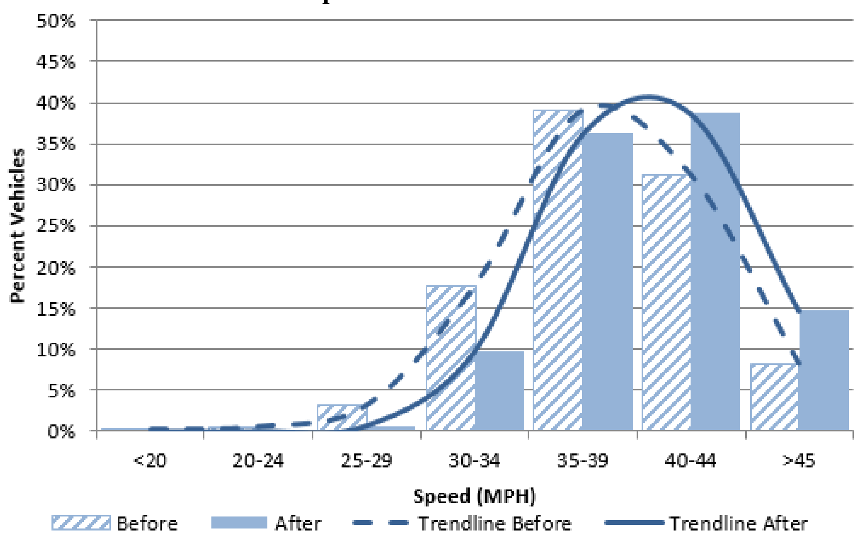


(b)

Figure E11. Eastbound (a) and Westbound (b) Before and After Weekend Volume and Speed Profiles for Post Forest Drive

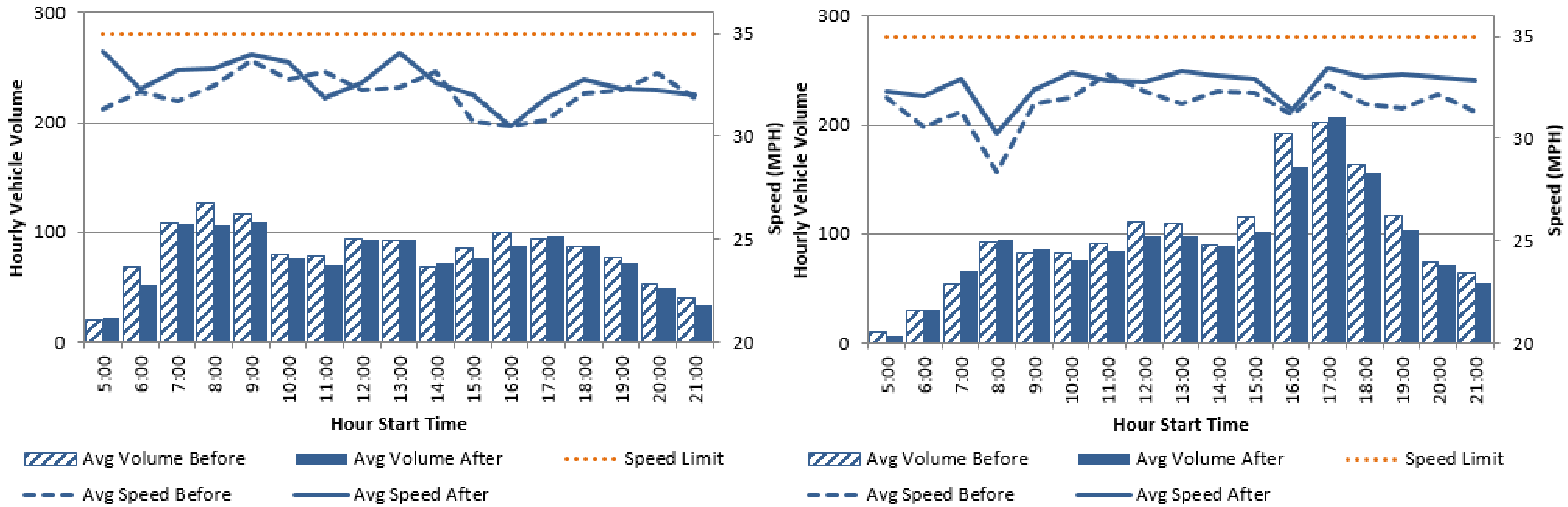


(a)



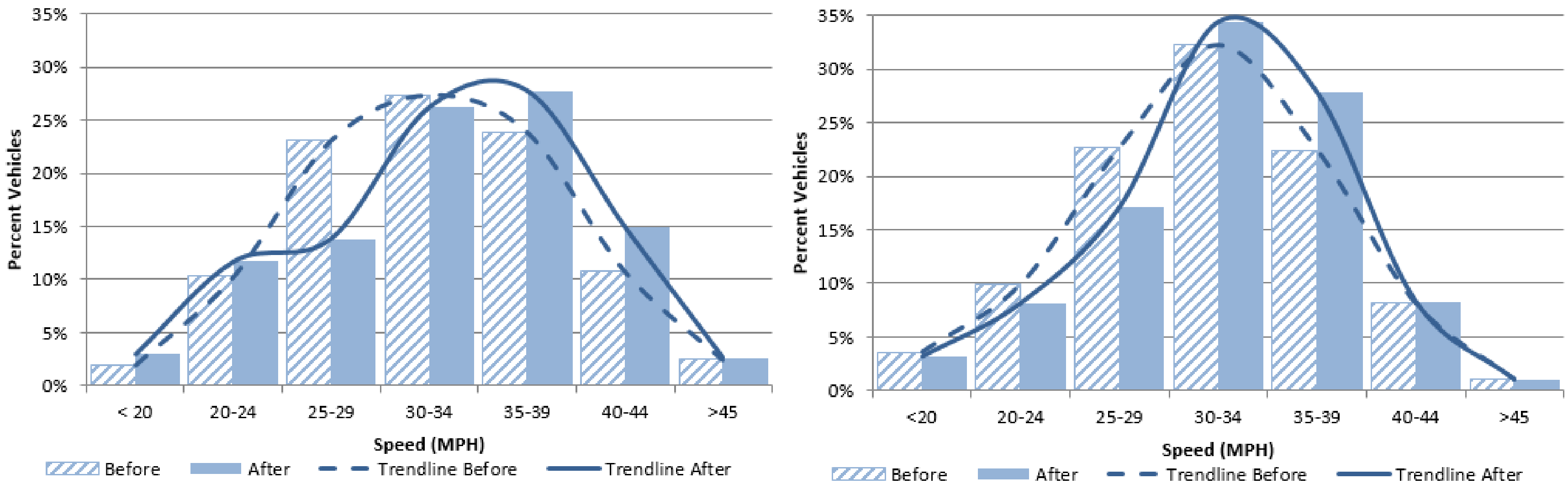
(b)

Figure E12. Eastbound (a) and Westbound (b) Weekend Midday Before and After Speed Distribution Histograms for Post Forest Drive



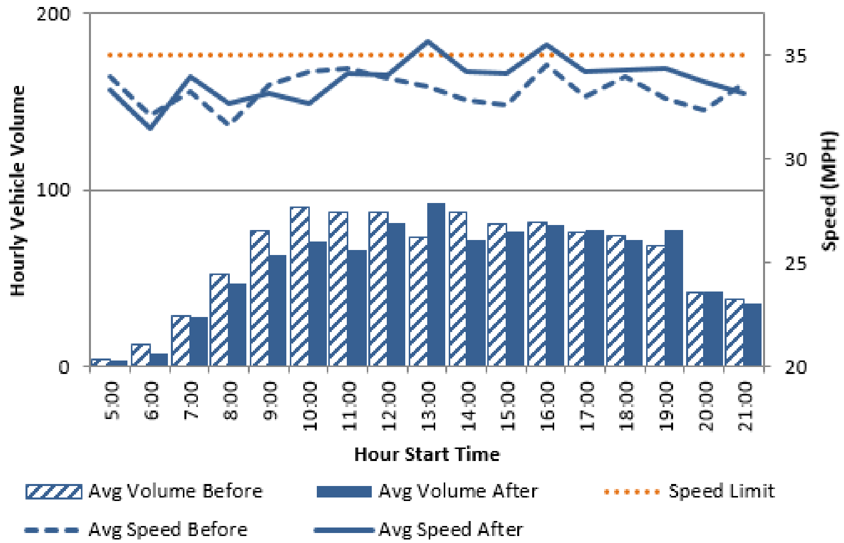
(a) (b)

Figure E13. Northbound (a) and Southbound (b) Before and After Weekday Volume and Speed Profiles for Ridge Top Road Site 1

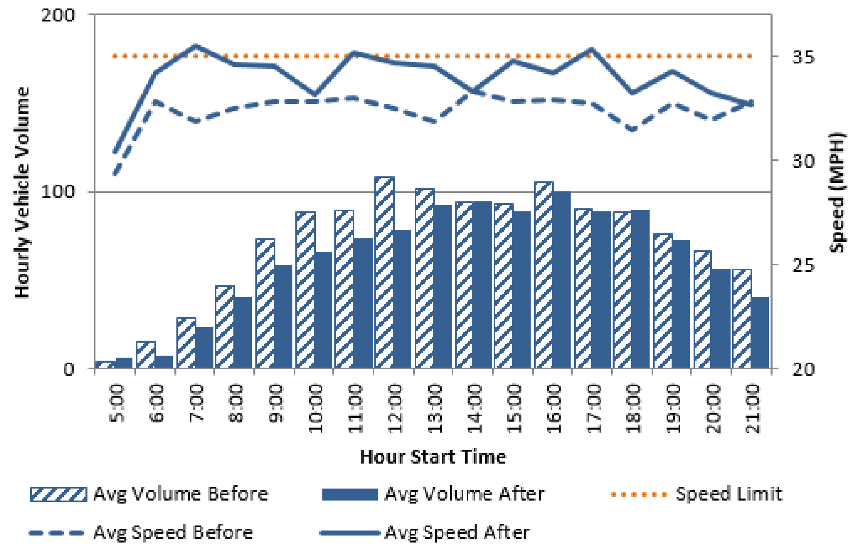


(a) (b)

Figure E14. Northbound a.m. (a) and Southbound p.m. (b) Weekday Before and After Speed Distribution Histograms for Ridge Top Road Site 1

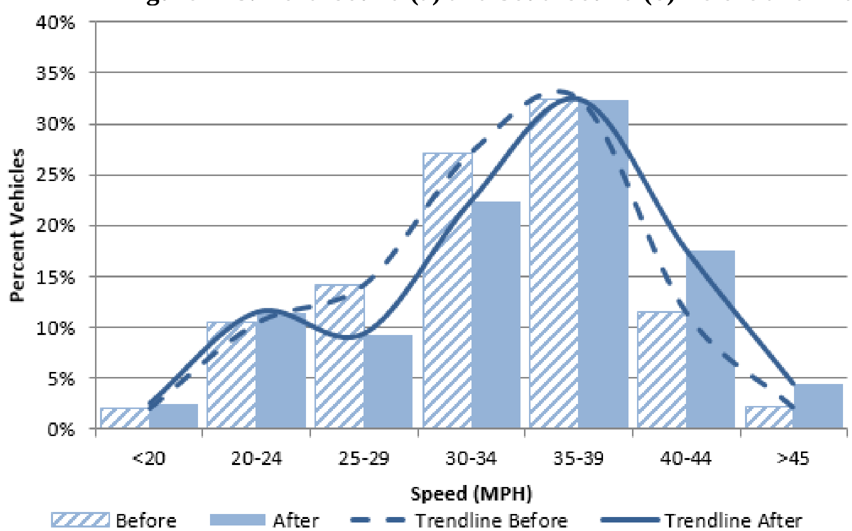


(a)

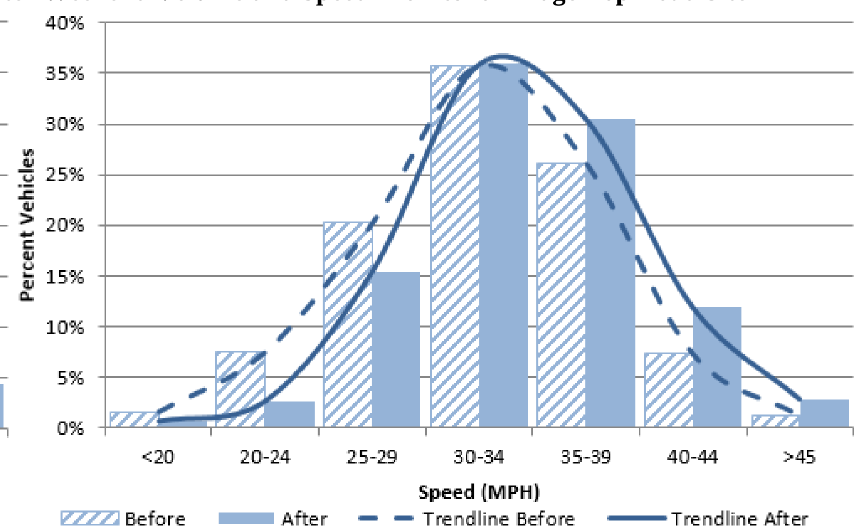


(b)

Figure E15. Northbound (a) and Southbound (b) Before and After Weekend Volume and Speed Profiles for Ridge Top Road Site 1



(a)



(b)

Figure E16. Northbound (a) and Southbound (b) Weekend Midday Before and After Speed Distribution Histograms for Ridge Top Road Site 1

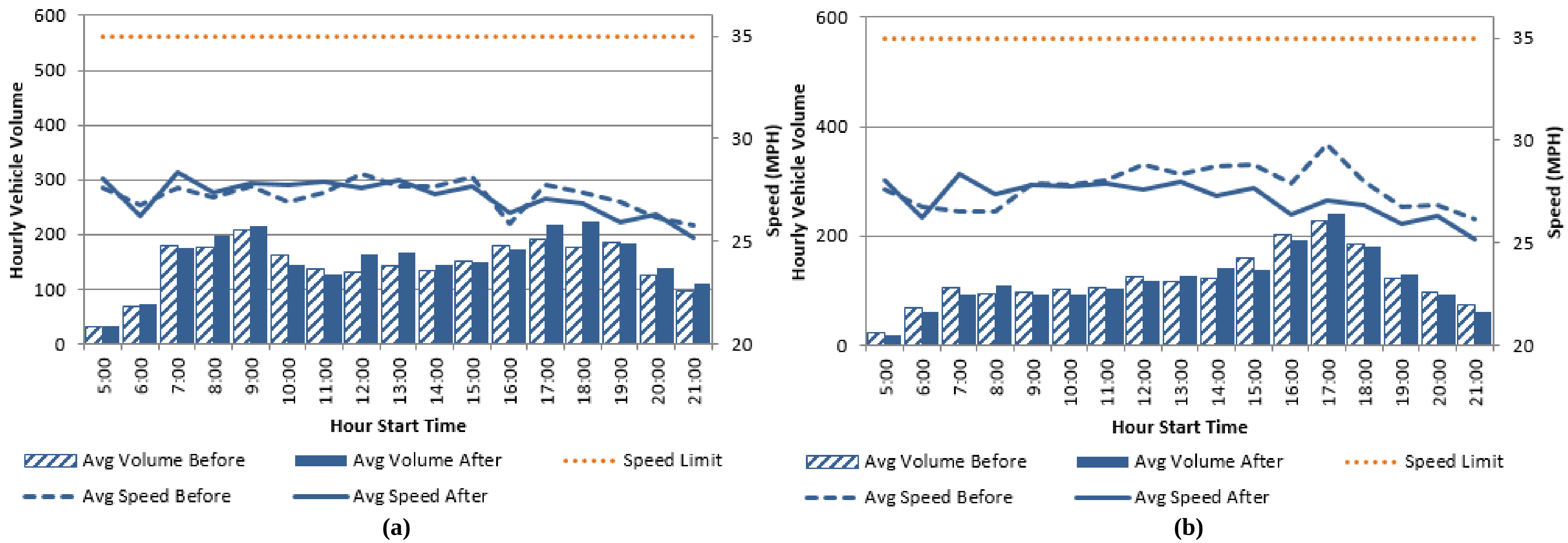


Figure E17. Northbound (a) and Southbound (b) Before and After Weekday Volume and Speed Profiles for Ridge Top Road Site 2

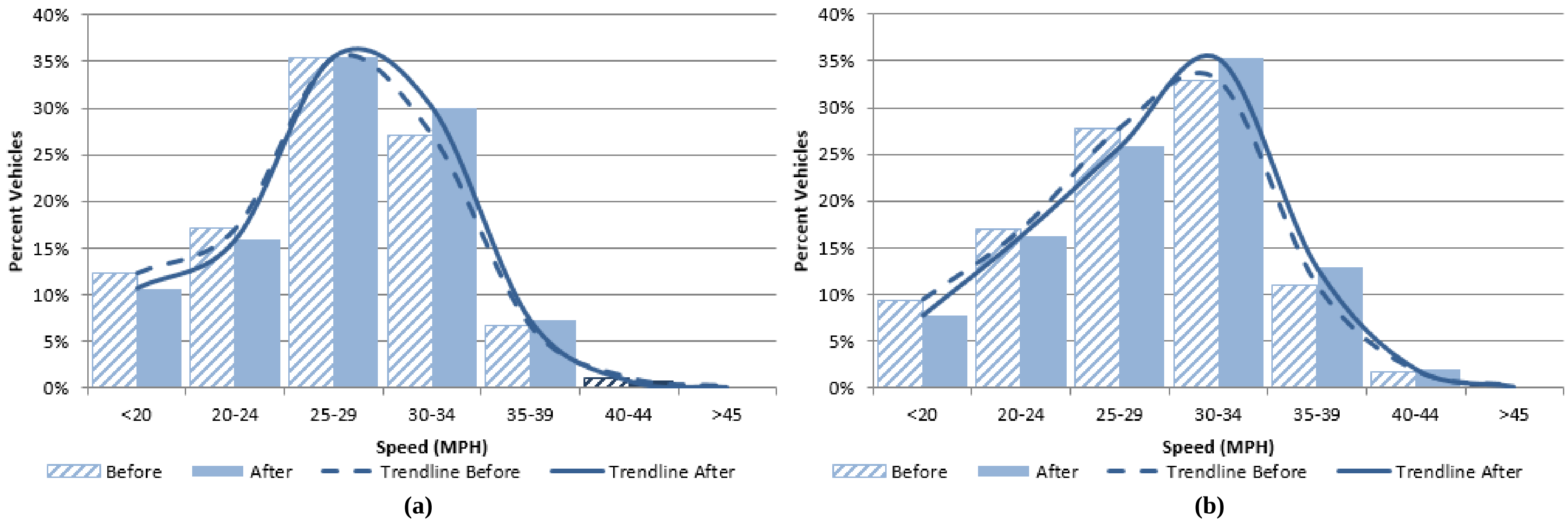
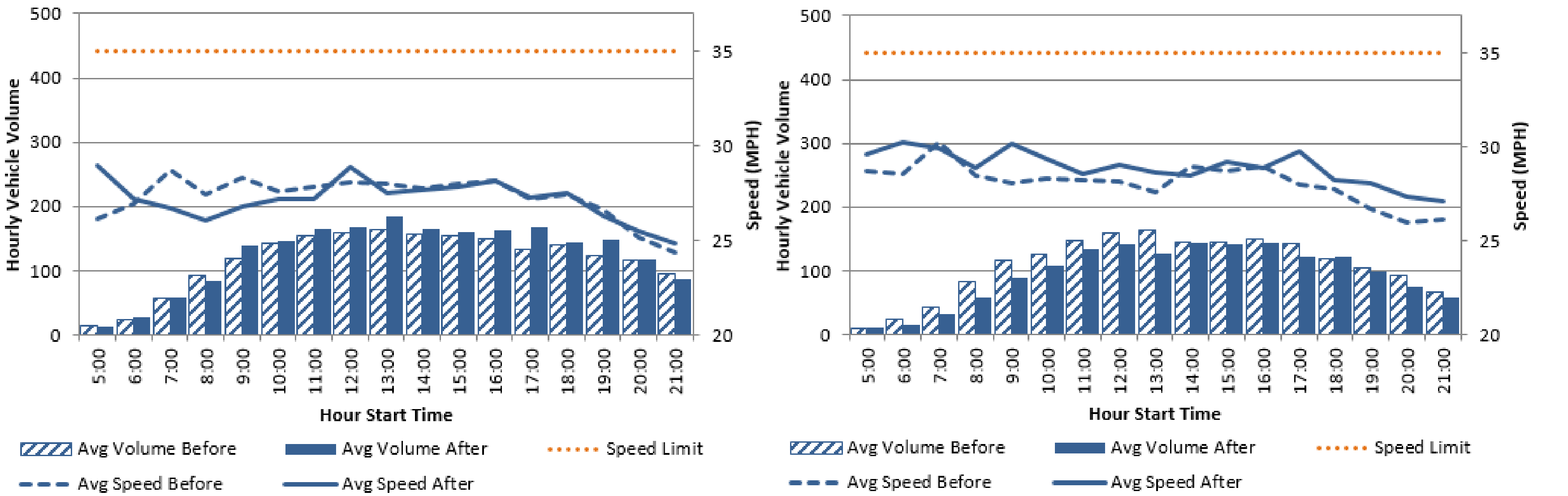
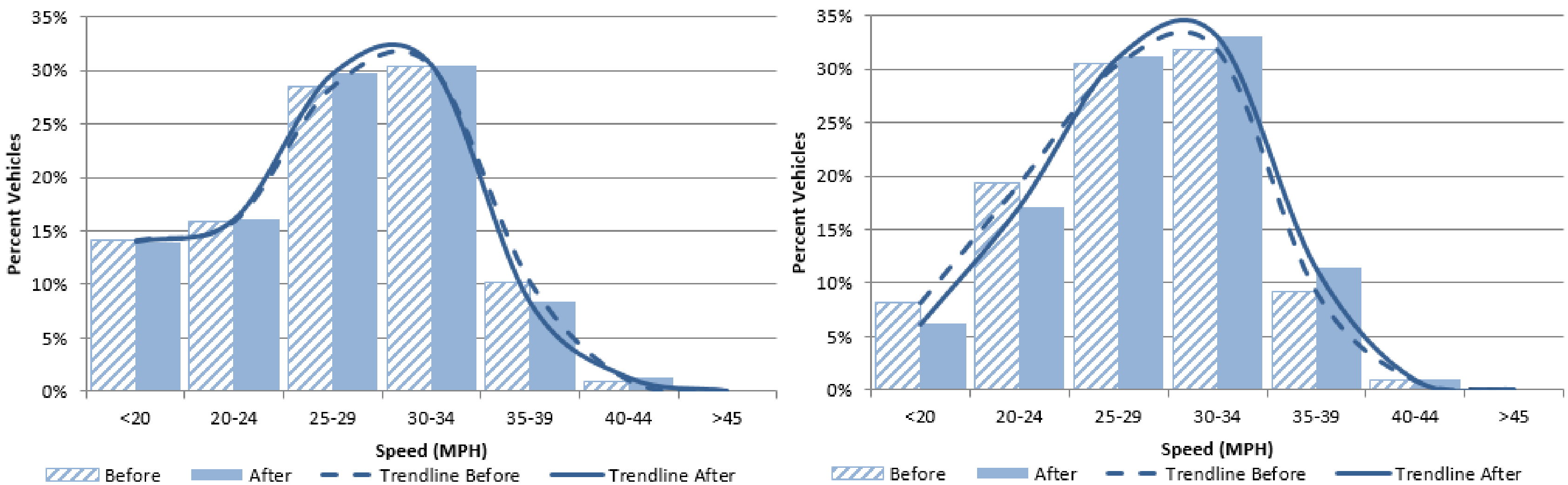


Figure E18. Northbound a.m. (a) and Southbound p.m. (b) Weekday Before and After Speed Distribution Histograms for Ridge Top Road Site 2



(a) (b)

Figure E19. Northbound (a) and Southbound (b) Before and After Weekend Volume and Speed Profiles for Ridge Top Road Site 2



(a) (b)

Figure E20. Northbound (a) and Southbound (b) Weekend Midday Before and After Speed Distribution Histograms for Ridge Top Road Site