Exhibit B

HUNTON ANDREWS KURTH LLP ON BEHALF OF
TOLL ROAD INVESTORS PARTNERSHIP II, L.P.

# THE DULLES GREENWAY

## USER BENEFIT AND TOLL ELASTICITY STUDY

FINAL REPORT

DECEMBER 20, 2019

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# 1 PROJECT BACKGROUND

## 1.1 REPORT BACKGROUND AND PURPOSE

WSP was engaged by Hunton Andrews Kurth LLP on behalf of Toll Road Investors Partnership II, L.P. (hereafter TRIP II or Client) to provide an overview of the user benefits of the Dulles Greenway (or "the Greenway") as it relates to toll rates on the project and the impact on traffic from those tolls (the "Report"). The Report provides an assessment of existing conditions for the Greenway, a benefit-cost analysis, and an econometric model to forecast the potential benefits and traffic on the Greenway in the future.

The State Corporation Commission (SCC) is vested with regulatory authority over many business and economic interests in Virginia, including setting rates charged by utilities. Under Section 56-542 of the Virginia Highways Corporation Act of 1988, the SCC establishes the maximum chargeable toll rates on the Greenway. The test for determining these rates are that any toll:

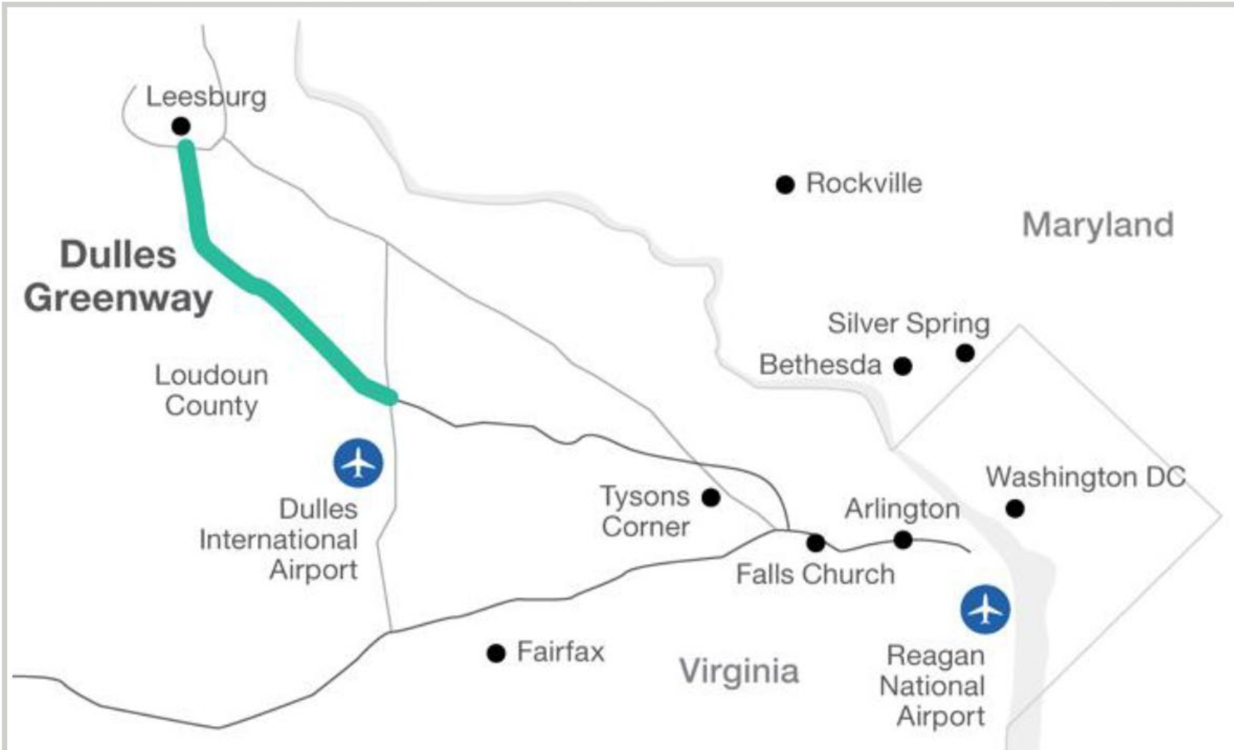
i. Is reasonable to the user in relation to the benefit obtained;
ii. Will not materially discourage use of the roadway by the public; and
iii. Will provide the operator with no more than a reasonable rate of return as determined by the SCC.

This report is intended to provide information to support an assessment under tests (i) and (ii).

## 1.2 DESCRIPTION OF THE DULLES GREENWAY

The Dulles Greenway is a 14-mile limited access highway that connects Washington Dulles International Airport at its eastern end with Leesburg, Virginia at its western end (*See* **Figure 1.1**). Privately owned since its opening in 1995, the Greenway provides a non-stop alternative to commuters and travelers in Loudoun County. As one of two limited-access highways in central Loudoun county, the Dulles Greenway provides east-west access between the fast-growing Virginia municipalities of Leesburg, Ashburn and their environs with the core of the Washington metro area, including Washington D.C., Tyson's Corner, and Dulles International Airport (IAD). The Greenway provides direct access to the Dulles Toll Road (DTR), which runs from I-66 in Falls Church to IAD.

**Figure 1.1: Map of The Dulles Greenway and DTR**




Source: Atlas Arteria, Half Year Results Investor Presentation (June 2019).

The Dulles Greenway is a six-lane separated highway (three lanes per direction) with eight interchanges between Leesburg Bypass and the Greenway Toll Plaza, about 1.5 miles west of the DTR interchange. Along with the DTR, the Greenway is signed Virginia State Route 267. The Greenway is open to both personal vehicles (PVs) and Commercial Vehicles (CVs), with differing toll rates depending on the number of axles, as described in **Section 2.1**. The Greenway is open and collects tolls 24 hours a day, 7 days a week. The Greenway has undergone a number of improvements over the last 15 years, including:

- Widening at the mainline toll plaza;
- 6.5-mile mainline widening between Route 15 and Claiborne Parkway;
- Interchange improvements on the eastern end of the Greenway;
- Construction of two new interchanges at the western end of the Dulles Greenway;
- Construction of a direct access ramp from the Greenway to IAD;
- Eastbound ramp widening/improvement to connection between the Greenway and the DTR (future Improvement); and
- Westbound-to-south exit ramp improvements to Leesburg Bypass (future improvement).

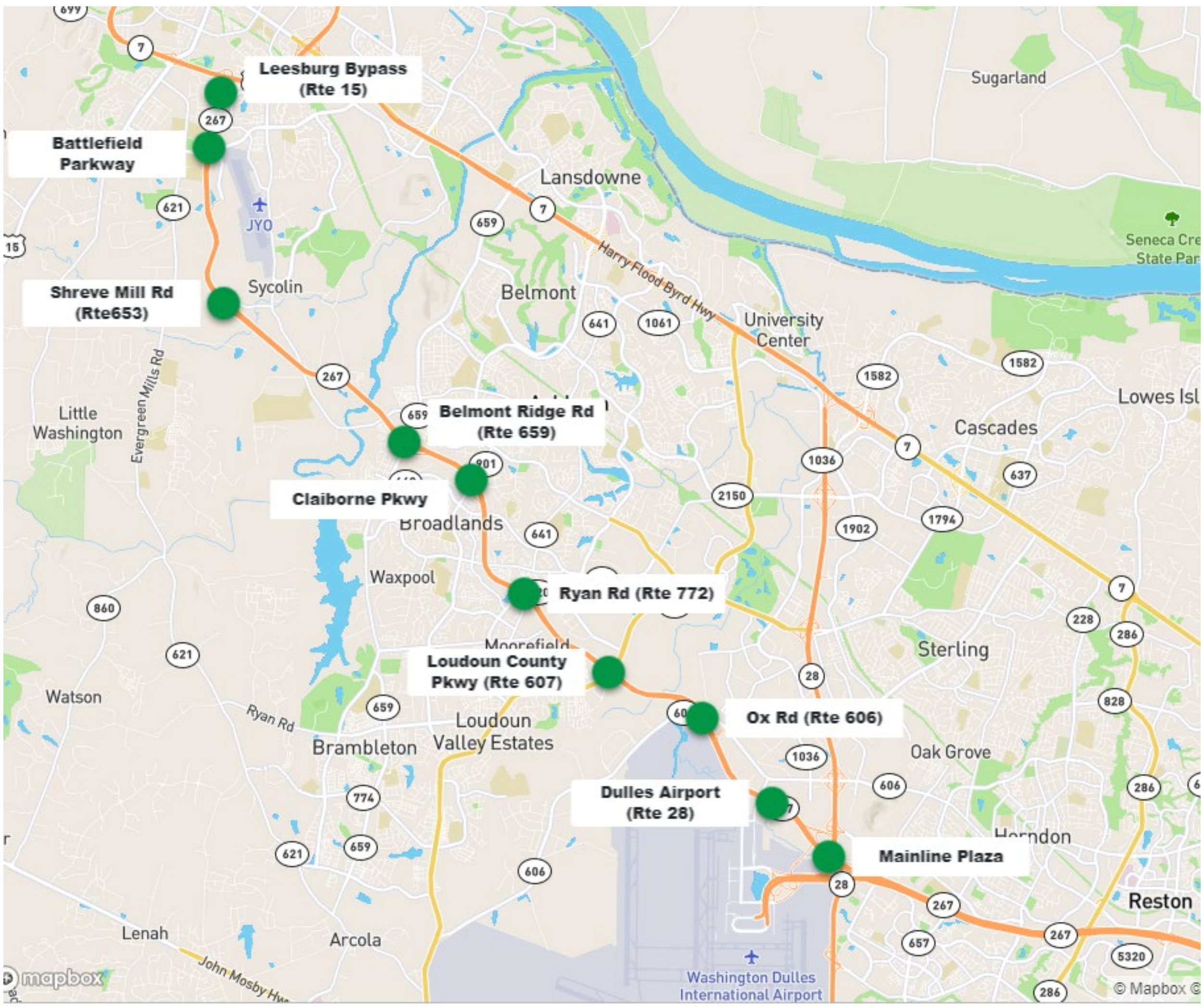
The Greenway was developed by TRIP II, a private toll road company that currently operates and maintains the Greenway. TRIP II, through its Certificate of Authority, has the right to collect tolls on the Greenway until 2056, whereby the road will transfer to the Commonwealth of Virginia at no cost to the Commonwealth.

# 2 EXISTING CONDITIONS

## 2.1 CURRENT TOLL RATES

The Dulles Greenway has a varied toll schedule depending on the type of vehicle, time of day, origin and destination, and payment method. During weekdays, a peak-hour congestion toll is applied between the hours of 6:30 AM – 9:00 AM in the eastbound direction and 4:00 PM – 6:30 PM in the westbound direction. A three-axle vehicle is tolled at about twice the rate of two-axle vehicle. Vehicles with more than three axles are charged the three-axle toll plus half of the two-axle toll for each additional axle. It is also worth noting that each vehicle class pays a standard toll rate regardless of the distance travelled and those tolls are paid asymmetrically, meaning that they are paid upon entry when travelling in the westbound direction and upon exit when travelling in the eastbound direction.

**Figure 2.1: The Dulles Greenway Entrances Map**




Source: Dulles Greenway, MapBox

In both directions, any trip that begins or ends at one of the eastern points of the Greenway pays the same toll. The two-axle toll is currently $4.75 during non-peak hours and $5.80 during peak hours, translating to $0.34 and $0.41 per mile, respectively, for a through trip on the Greenway. For three-axle vehicles, the toll is $9.60 during non-peak hours and $11.55 during peak hours, or $0.69 and $0.83 per mile, respectively. The toll schedule is shown in **Tables 2.1 and 2.2** for two-and-three-axle vehicles, respectively. For trips that both originate and end at points west of Loudoun County Parkway, the schedule varies depending on type of payment.

**Figure 2.2** displays the history of average toll rate per transaction for cars and for three-axle vehicles. The average is displayed on a monthly basis. The level includes variation in the length of trips and any annual applicable annual adjustment in the toll rate schedule.

The Greenway provides a discount for E-ZPass, the sole electronic toll collector (ETC) provider, which accounted for 95% of the peak-hour transactions and 92% of the off-peak transactions in 2005. This rate gradually reduced over the later years, down to 89% for peak-hour and 85% for off-peak hour in 2018 (See **Figure 2.3**). There are no tolls for trips between Battlefield Parkway and Leesburg Bypass.

**Table 2.1: Current Two-Axle Toll Schedule**

| Greenway Toll Plaza | Cash/Credit Card | | ETC | |
|---|---|---|---|---|
| | Peak | Off Peak | Peak | Off Peak |
| **Eastern Points:** Mainline Plaza/ Dulles Airport/ Ox Rd./ Loudoun County Pkwy | $5.80 | $4.75 | $5.80 | $4.75 |
| **Central Points:** Ryan Rd./ Claiborne Pkwy/ Belmont Ridge Rd./ | $5.10 | $4.05 | $4.65 | $3.55 |
| **Shreve Mill Road** | $3.60 | $3.60 | $3.10 | $3.10 |
| **Western Points:** Battlefield Pkwy/ Leesburg Bypass (Rte. 15) | $0.00 | $0.00 | $0.00 | $0.00 |

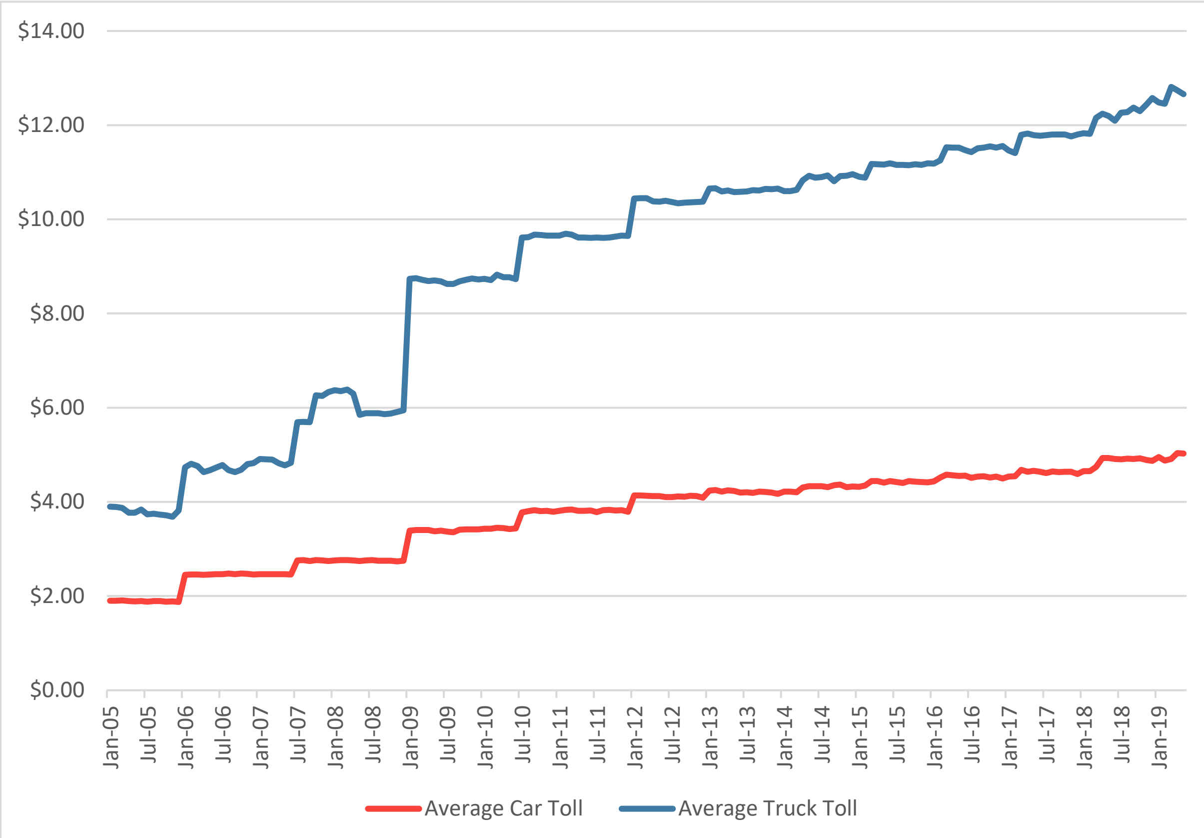
Source: Dulles Greenway

**Table 2.2: Current Three-Axle Toll Schedule**

| Greenway Toll Plaza | Cash/Credit Card | | ETC | |
|---|---|---|---|---|
| | Peak | Off Peak | Peak | Off Peak |
| **Eastern Points:** Mainline Plaza/ Dulles Airport/ Ox Rd./ Loudoun County Pkwy | $11.55 | $9.60 | $11.55 | $9.60 |
| **Central Points:** Ryan Rd./ Claiborne Pkwy/ Belmont Ridge Rd./ | $10.20 | $8.15 | $9.15 | $7.05 |
| **Shreve Mill Road** | $7.15 | $7.15 | $6.15 | $6.15 |
| **Western Points:** Battlefield Pkwy/ Leesburg Bypass (Rte. 15) | $0.00 | $0.00 | $0.00 | $0.00 |

Source: Dulles Greenway

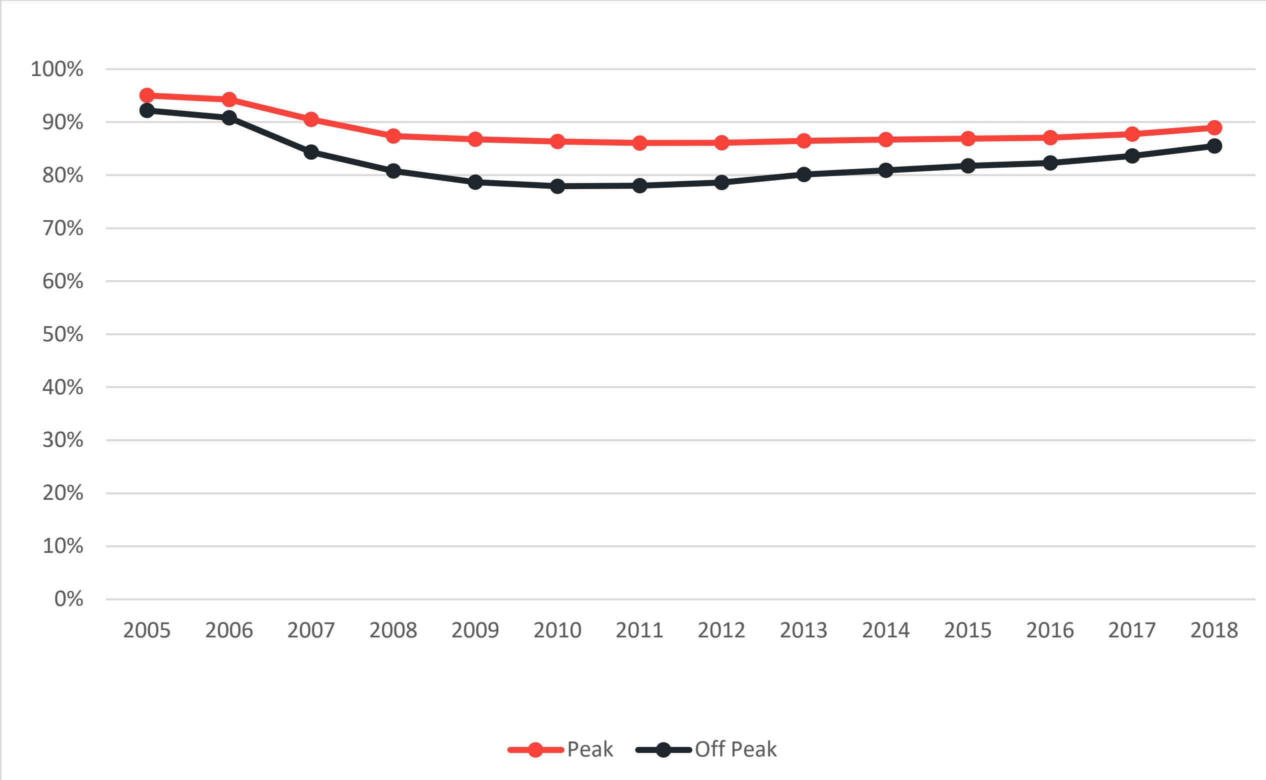
**Figure 2.2: Monthly Average Toll on the Dulles Greenway[1]**




Source: WSP analysis of Dulles Greenway data, 2019

[1] Average toll price is calculated on the revenue traffic, which is approximately 98% of all trips made on the corridor. This figure, and the transaction counts used in the econometric analysis, is based on revenue generating traffic, which excludes toll-exempt traffic and violations.

**Figure 2.3: Electronic Toll Collection Usage Rates on the Dulles Greenway by Year**




Source: WSP analysis of Dulles Greenway data, 2019

## 2.2 CURRENT TRAFFIC TRENDS

WSP analyzed recent traffic trends on the Greenway, including historical growth over the last 14 years, time of day and day of week variation in traffic patterns, seasonal traffic patterns, use by vehicle class, and trends at the tolled entry and exit points.

**Daily Traffic and Growth:** The historic growth in traffic is considered by analyzing the growth in average annual daily traffic (AADT), or the average number of vehicles traveling on the roadway in either direction over the course of a single day. Revenue-generating AADT[2], which accounts for 98% of AADT, decreased from over 59,000 in 2005 to 46,000 in 2010. From 2010 to 2017, AADT on the corridor gradually increased to over 50,000 before dropping back down to 47,500 in 2018. The AADT and compounded annual growth rates are shown in **Table 2.3.**

[2] AADT shown here is based on average annual daily revenue traffic, which is approximately 98% of all trips made on the corridor. This figure, and the transaction counts used in the econometric analysis, is based on revenue generating traffic, which excludes toll-exempt traffic and violations.

**Table 2.3: Revenue-Generating AADT on the Dulles Greenway**

| YEAR | MAINLINE | RT 606 | RT 772 | CLAIBORNE PKWY | RT 659 | RT 607 | SHREVE MILL RD | TOTAL |
|---|---|---|---|---|---|---|---|---|
| 2005 | 51,444 | 4,938 | 893 | 1,491 | 1,071 | 928 | - | 60,766 |
| 2006 | 48,572 | 4,413 | 880 | 1,447 | 926 | 940 | | 57,177 |
| 2007 | 46,450 | 4,082 | 947 | 1,482 | 845 | 1,009 | | 54,815 |
| 2008 | 43,877 | 3,901 | 998 | 1,421 | 838 | 972 | 28 | 52,035 |
| 2009 | 41,343 | 3,622 | 958 | 1,286 | 821 | 871 | 47 | 48,948 |
| 2010 | 40,419 | 3,403 | 893 | 941 | 740 | 759 | 45 | 47,200 |
| 2011 | 39,752 | 3,201 | 869 | 845 | 716 | 717 | 54 | 46,155 |
| 2012 | 40,004 | 3,070 | 854 | 776 | 697 | 712 | 52 | 46,167 |
| 2013 | 40,420 | 3,100 | 928 | 774 | 773 | 734 | 73 | 46,803 |
| 2014 | 41,484 | 3,217 | 976 | 797 | 842 | 745 | 77 | 48,139 |
| 2015 | 43,451 | 3,555 | 1,081 | 835 | 891 | 801 | 90 | 50,704 |
| 2016 | 44,663 | 4,157 | 1,195 | 876 | 973 | 879 | 110 | 52,853 |
| 2017 | 43,557 | 4,152 | 1,319 | 936 | 1,028 | 961 | 138 | 52,091 |
| 2018 | 41,311 | 3,422 | 1,215 | 912 | 1,009 | 959 | 103 | 48,932 |
| 2019 | 40,020 | 3,179 | 1,174 | 879 | 992 | 879 | 131 | 47,255 |
| 2005-2011 CAGR | -4.21% | -6.97% | -0.45% | -9.03% | -6.49% | -4.20% | NA | -4.48% |
| 2011-2018 CAGR | 0.55% | 0.96% | 4.90% | 1.09% | 5.03% | 4.23% | 9.70% | 0.84% |

Source: WSP analysis of Dulles Greenway data, 2019

**Figure 2.4** shows the monthly transaction growth in percentage from 2005 to 2019 by gantry. Traffic counts by gantry in May 2019 was used as a comparison benchmark for the prior months, starting from January 2005. Transactions at the mainline have decreased on average 1.7% per year from 2015 to 2018, while transactions on Route 606 and Claiborne decreased by annual rates of 2.7% and 3.7% respectively during the same time period. On the other hand, transactions on the Route 607, Route 659 and Route 772 ramps have gradually increased by 0.1%, 0.2% and 2.4% respectively. Shreve Mill ramp, which opened in 2008, which corresponds to the zero transactions in the chart, has experienced strong, steady growth with a compound annual growth rate (CAGR) above 10% since 2010.

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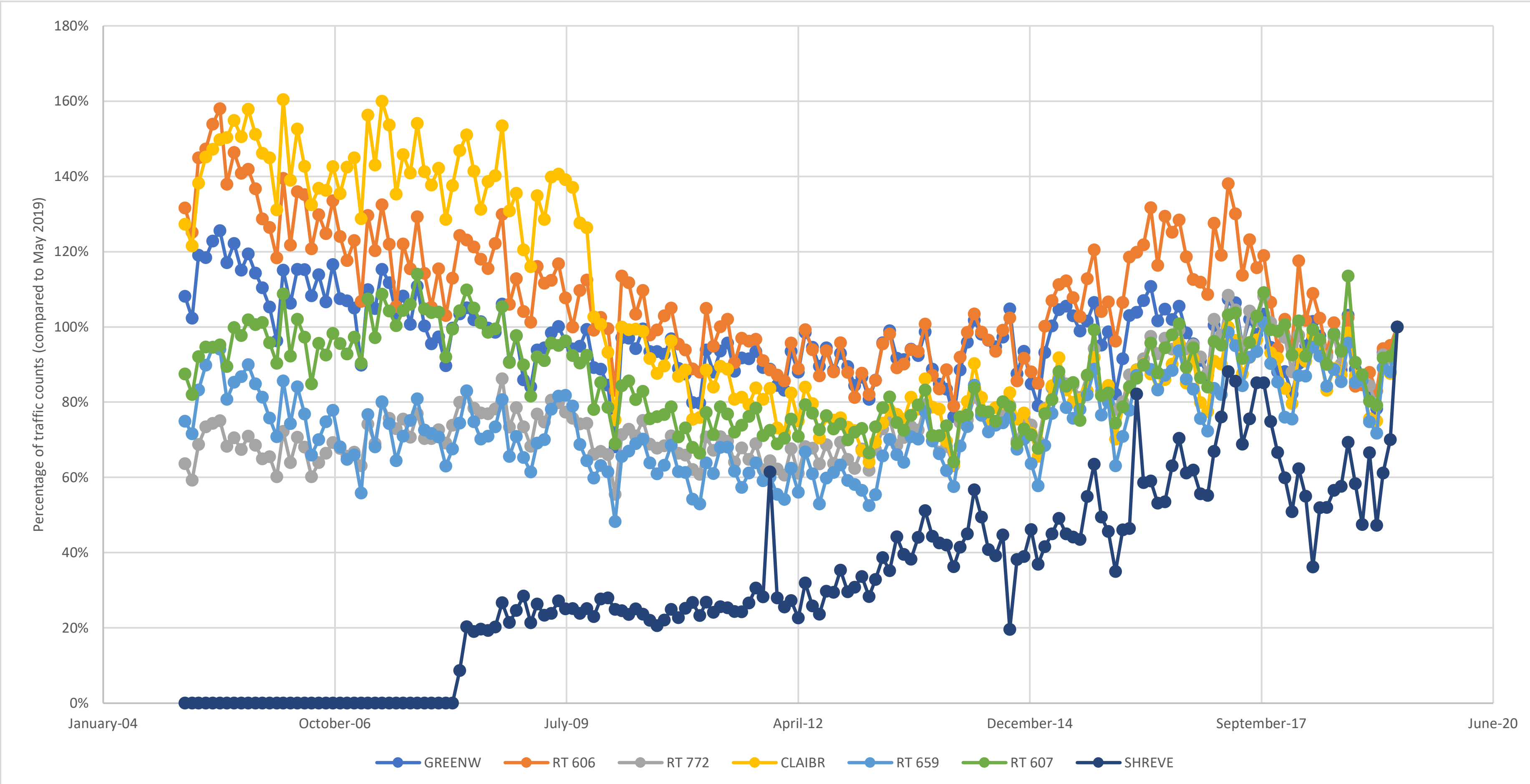
**Figure 2.4: Transaction Trends by Ramp (January 2005 to May 2019)**[3]




Source: WSP analysis of Dulles Greenway data, 2019

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[3] This chart represents transactions that generate revenues, excluding toll-exempt vehicles and violations.

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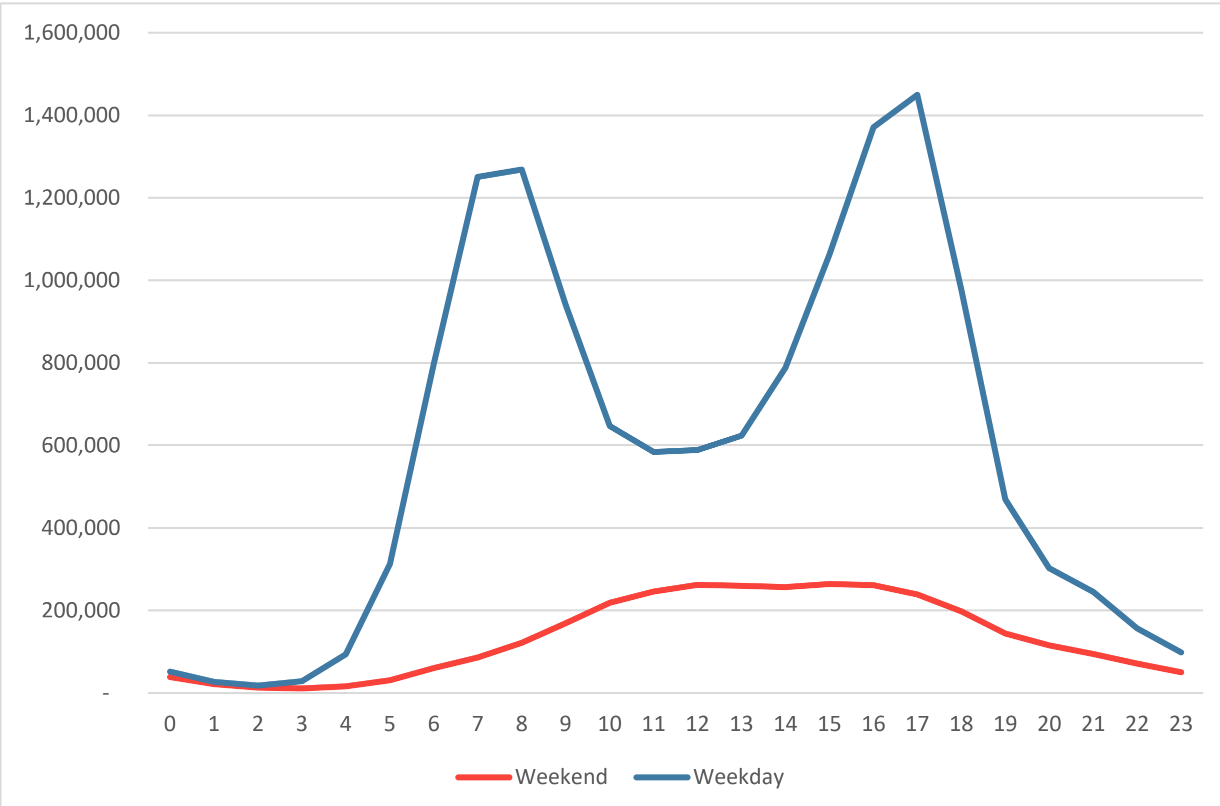
**Time of Day and Day of Week: Figure 2.5** shows variations in time of day travel and day of week travel for the year 2018. There are clear peak patterns during peak hours on the Greenway during the weekdays; the traffic on the Greenway is heaviest from 6AM to 9AM, and 4PM to 7PM. On the other hand, there is no clear peak pattern during weekend travels, as trips build up gradually throughout the day.

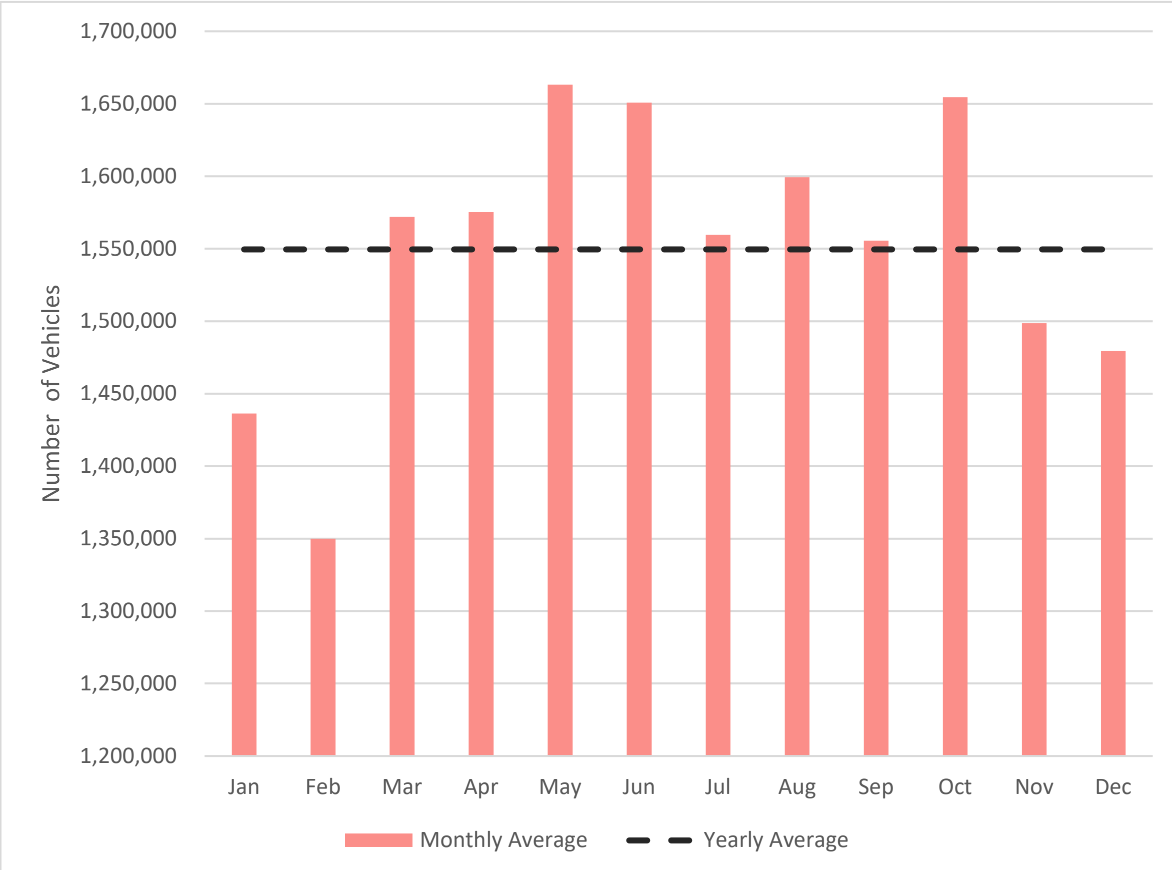
**Figure 2.5: Total Number of Auto Vehicles by Time of Day and Day of Week in 2018**




Source: WSP analysis of Dulles Greenway data, 2019.

**Month of Year: Figure 2.6** shows variations in traffic by the month of the year, for all years from 2005 to 2018. The dashed line represents the yearly average. There is a clear seasonal pattern for traffic on the Greenway, as the number of trips is substantially higher in the spring/summer months of March through June compared to the fall/winter months of November through February.

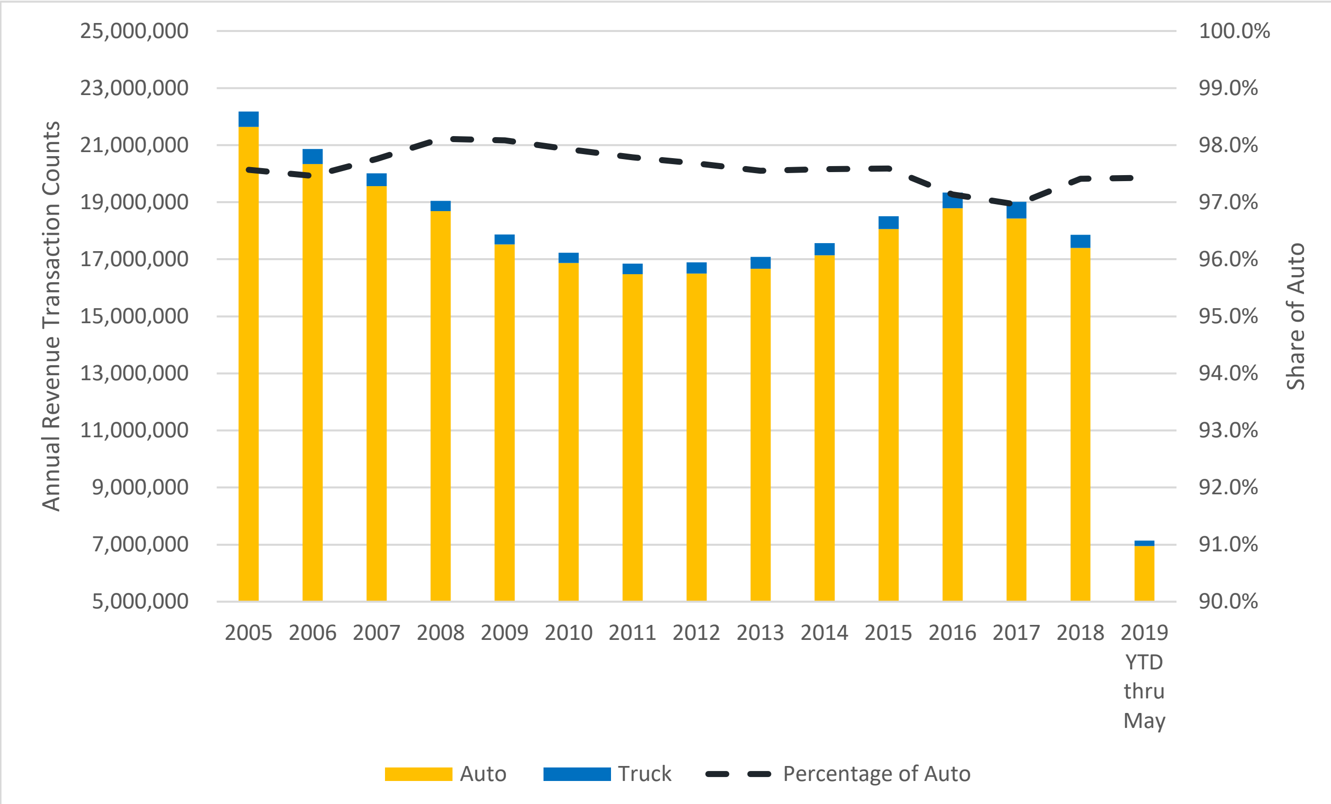
**Figure 2.6: Average Monthly Transactions on DG, 2005 - 2018**




Source: WSP analysis of Dulles Greenway data, 2019.

**Vehicle Class: Figure 2.7** shows the distribution in traffic by vehicle class. As noted in **Section 2.1**, tolls are dependent on the number of axles a vehicle has, with a three-axle vehicle incurring approximately double the toll as a two-axle personal vehicle (PV). Two-axle vehicles make up the majority of the trips on the Greenway, averaging at approximately 97.6% of all vehicles traveling.

**Figure 2.7: Share of Vehicle Types on the Dulles Greenway**




Source: WSP analysis of Dulles Greenway data, 2019.

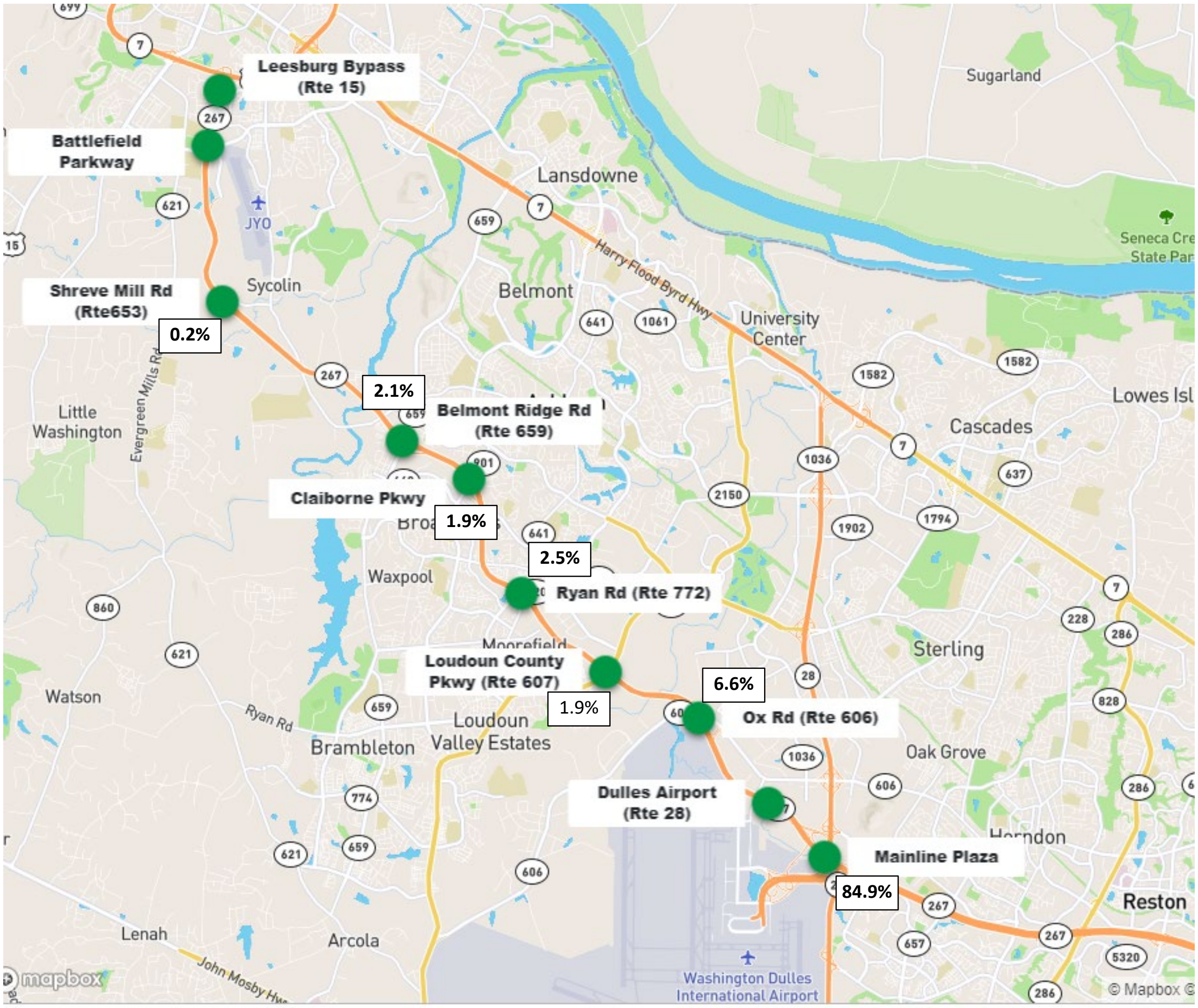
**Gantry Use:** For a more complete view of traffic trends on the Greenway, WSP reviewed the locations where traffic enters and exits the Greenway. Approximately 86% of the eastbound trips and 85% of the westbound trips on the Greenway are going through the mainline gantry. In 2018, 74% of all eastbound trips through the mainline gantry continued on the Dulles Toll Road (DTR), with a similar proportion of all the westbound trips through the mainline gantry coming from the DTR. Approximately 7.5% of traffic entered the Greenway via the Route 606 gantry in 2005, and this figure has decreased to 6.4% through May 2019. Claiborne had the third highest share of traffic entering the highway with 2.5% of total transactions in 2005, compared to 1.6% at Route 659, 1.5% at Route 607 and 1.5% at Route 772. However, from January through May in 2019, Claiborne's share of transaction has dropped to 1.9% of all total transaction, lower than the 2.5% figure of Route 772 and 2.1% of Route 659, and only higher than the 1.8% share of transactions at Route 607. Despite its fast growth, Shreve Mill ramp only accounts for 0.3% of all traffic entering the Greenway in 2019.

**Table 2.4: Share of Transactions by Gantry on Dulles Greenway**

| | MAINLINE | RT 606 | RT 772 | CLAIBORNE PKWY | RT 659 | RT 607 | SHREVE MILL RD |
|---|---|---|---|---|---|---|---|
| 2005 | 85.4% | 7.5% | 1.5% | 2.5% | 1.6% | 1.5% | |
| 2006 | 85.6% | 7.2% | 1.5% | 2.6% | 1.5% | 1.6% | |
| 2007 | 85.2% | 7.0% | 1.7% | 2.7% | 1.5% | 1.8% | |
| 2008 | 84.6% | 7.3% | 1.9% | 2.7% | 1.6% | 1.8% | 0.1% |
| 2009 | 84.8% | 7.1% | 2.0% | 2.6% | 1.7% | 1.8% | 0.1% |
| 2010 | 85.9% | 6.9% | 1.9% | 2.0% | 1.6% | 1.6% | 0.1% |
| 2011 | 86.4% | 6.7% | 1.9% | 1.8% | 1.5% | 1.5% | 0.1% |
| 2012 | 87.0% | 6.3% | 1.8% | 1.7% | 1.5% | 1.5% | 0.1% |
| 2013 | 86.7% | 6.3% | 2.0% | 1.7% | 1.6% | 1.5% | 0.2% |
| 2014 | 86.6% | 6.4% | 2.0% | 1.7% | 1.7% | 1.5% | 0.2% |
| 2015 | 86.0% | 6.7% | 2.1% | 1.7% | 1.7% | 1.5% | 0.2% |
| 2016 | 85.1% | 7.3% | 2.2% | 1.7% | 1.8% | 1.6% | 0.2% |
| 2017 | 84.2% | 7.4% | 2.5% | 1.8% | 2.0% | 1.8% | 0.3% |
| 2018 | 84.9% | 6.6% | 2.5% | 1.9% | 2.1% | 1.9% | 0.2% |
| 2019 YTD thru May | 85.1% | 6.4% | 2.5% | 1.9% | 2.1% | 1.8% | 0.3% |

Source: WSP analysis of Dulles Greenway data, 2019

Figure 2.8: Share of Transactions by Gantry on Dulles Greenway (2018)

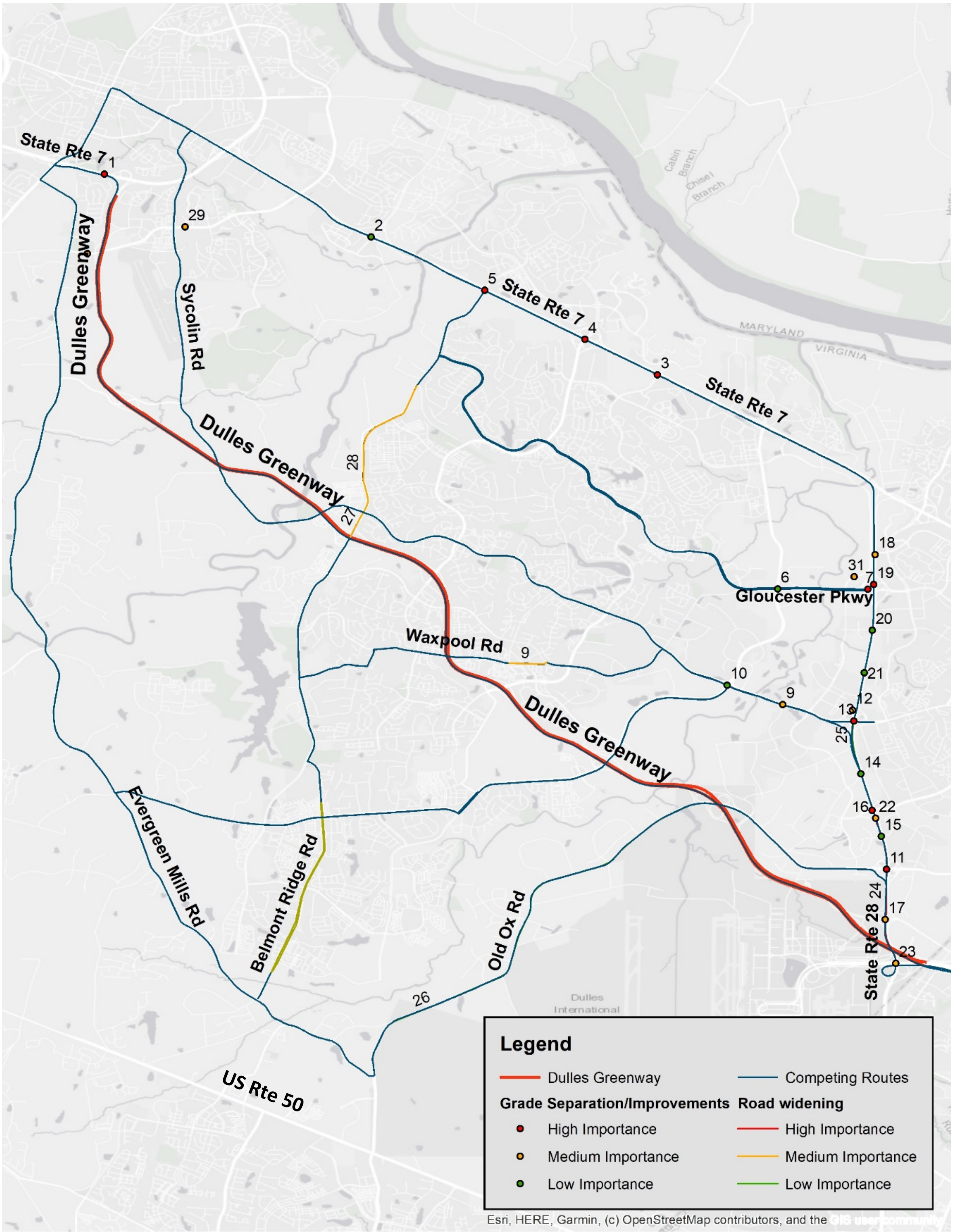



Source: Dulles Greenway, Mapbox

## 2.3 ALTERNATIVE ROUTES

The Dulles Greenway, along with the Dulles Toll Road, provides direct access from Loudoun County to the core of the Washington metro area. Two other highways, Route 50 to the south and Route 7 to the north, provide un-tolled competing east-west access between the core metro area and Loudoun County and regions west. In addition to these major routes, WSP analyzed local routes that provide alternatives to travelers within Loudoun County. **Figure 2.9** provides a visual presentation of the locations of the local alternative routes, in respect to the Dulles Greenway (in red). **Table 2.5** provides a listing of the key routes and **Table 2.6** provides the details for recent improvements that have improved their service. **Figure 2.10** provides a visual presentation of these improvements on Route 7 and Route 28 along with the traffic counts of revenue transactions on the Greenway that were used as inputs for the econometric models.

**Figure 2.9: Alternative Routes**




Source: WSP

**Table 2.5: Key Alternative Routes to the Dulles Greenway**

| ROUTE | DESCRIPTION |
|---|---|
| Alternative 1 | State Rte 7 and State Rte 28 |
| Alternative 2 | Sycolin Road, Ashburn Farm Parkway, Waxpool Road |
| Alternative 3 | Evergreen Mills Road, Ryan Road, Loudoun County Parkway |
| Alternative 4 | Evergreen Mills Road, Ryan Road, Old Ox Road |

Source: WSP, in consultation with Dulles Greenway.

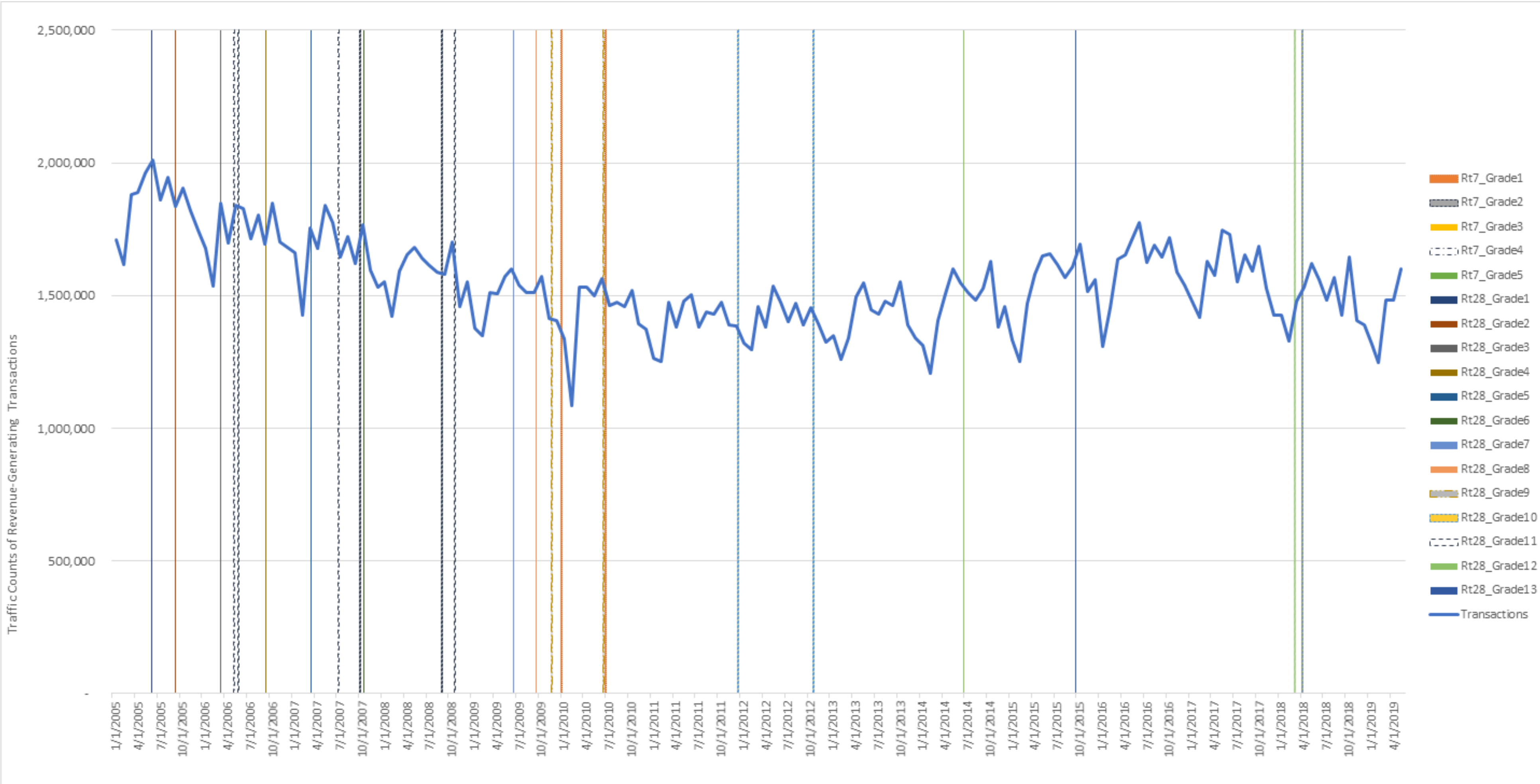
**Table 2.6: Important Improvements to Alternative Routes Since the Opening to Traffic in 1995**

| NUMBER | ROADWAY | IMPROVEMENTS AND DATES |
|---|---|---|
| 1 | Route 7 | Grade separation, at Loudoun Co Pkwy intersection, between 12/2009 and 8/2010 |
| 2 | Route 7 | Grade separation, at River Creek Pkwy intersection, between 9/2007 and 10/2008 |
| 3 | Route 7 | Grade separation, at Ashburn Village Blvd intersection, between 4/2016 and 4/2018; DG knows as 6/2018 so using 4/2018 |
| 4 | Route 7 | Grade separation, at Claiborne Pkwy intersection, between 4/2006 and 9/2007 |
| 5 | Route 7 | Grade separation, at Belmont Ridge, on 3/20/2018 (appears on satellite imagery between 4/2016 and 4/2018) |
| 6 | Gloucester Pkwy. | Gloucester Parkway completed to Loudoun County Pkwy between 10/2008 and 12/2009 |
| 7 | Gloucester Pkwy. | Gloucester Parkway completed to Rt 28 between 4/2016 and 4/2018; 8/2016, according to DG |
| 8 | Waxpool Rd. | Widened between 10/2012 and 10/2014 between Ashburn Rd and Faulkner Pkwy |
| 9 | Waxpool Rd. | Intersection improvements at Broderick Drive and Pacific Blvd 3/2018 |
| 10 | Waxpool Rd. | Intersection improvements at Loudoun Co Pkwy 1/2019 |
| 11 | Route 28 | Interchange at Old Ox Rd/Rt 606 grade-separated 5/2005 |
| 12 | Route 28 | Interchange at Commercial Drive grade-separated 6/2005 |
| 13 | Route 28 | Interchange at Waxpool Rd grade-separated 9/2005 |
| 14 | Route 28 | Interchange at Relocation Dr grade-separated 3/2006 |
| 15 | Route 28 | Interchange at Republic Dr/Holiday Dr grade-separated 9/2006 |

| NUMBER | ROADWAY | IMPROVEMENTS AND DATES |
|---|---|---|
| 16 | Route 28 | Interchange at Sterling Blvd grade-separated 3/2007 |
| 17 | Route 28 | Interchange at Innovation Ave grade-separated 10/2007 |
| 18 | Route 28 | Interchange at Dulles Center Blvd grade-separated 6/2009 |
| 19 | Route 28 | Interchange at Nokes Blvd grade-separated between 10/2008 and 10/2009; 9/2009 according to DG |
| 20 | Route 28 | Interchange at Severn Way grade-separated between 12/2009 and 8/2010 |
| 21 | Route 28 | Interchange at Warp Drive grade-separated between 11/2011 and 10/2012 |
| 22 | Route 28 | Interchange at Shaw Road/Severn Road/Relocation Dr grade-separated between 4/2006 and 10/2008 |
| 23 | Route 28 | Widening of bridges over Dulles Toll Road 6/2014 |
| 24 | Route 28 | Widening to four lanes southbound from Sterling Blvd to DTR 9/2015 |
| 25 | Route 28 | Widening to four lanes southbound b/w Waxpool Rd and Rt 50; and northbound b/w McLearen Road and DTR 6/2017 |
| 26 | Old Ox Road (Rt 606) | Widening between the Dulles Greenway and Loudoun County Pkway, complete July 2018 |
| 27 | Belmont Ridge | Widening south of Hay Rd between 8/2010 and 4/2011 |
| 28 | Belmont Ridge | Widening north of Hay Rd not done as of July 2018; assumed for January 2019 |
| 29 | Battlefield Parkway | Built in stages 9/2007 to 8/2010 |
| 30 | Battlefield Parkway | Widening from Evergreen Mills Rd to the Dulles Greenway in Spring 2018 (Appears partially complete in 4/2018; assumed to open gradually from 1/2018 to 7/2018) |
| 31 | Pacific Blvd. | Expansion from Nokes Blvd to Russel Branch Pkwy; widening from Severn Way to Nokes Blvd 9/2016 |
| 32 | Sycolin Road | Road Pavement (2009) |
| 33 | Sycolin Road | Road widening (summer 2018) |

Source: Satellite imagery, VDOT's website, Loudoun County's website .

**Figure 2.10: Monthly Revenue Transactions and Dates of Important Improvements to Route 7 and Route 28 (Alternative 1)**




Source: WSP analysis of data provided by Dulles Greenway

### 2.3.1 ROUTE 7 AND ROUTE 28

Route 7, signed the Harry Byrd Parkway in Loudoun County, is a 72-mile primary state highway from Alexandria in the east to Winchester in the west. In Fairfax County, Route 7 intersects with the Dulles Toll Road near Tyson's Corner and proceeds west, reaching Leesburg before continuing to Winchester. In Loudoun County, Route 7 is located 5 miles north of the Greenway and runs parallel to the Greenway for approximately 12.5 miles. Route 7 has approximately three lanes per direction and features both at-grade and grade-separated intersections throughout its length in Loudoun County.

Route 28 is a 49 mile north-south state highway that runs from Fauquier County in the south to Route 7 in the north. In Loudoun County, Route 28 forms the eastern boundary of IAD and runs another 6 miles north to its terminus at Route 7. It is a grade-separated highway with three lanes in each direction for its entire length in Loudoun County. Route 28 provides ramp access to both the DTR and the Greenway, with the ramp location before the Mainline Toll Plaza.

Route 28 is a highly trafficked highway in eastern Loudoun County and provides direct access to the airport from points north and south, including Route 7 and Route 50. There have been a number of recent improvements that have varying degrees of impact to the Greenway. Most of these improvements involve the grade-separation of interchanges. Those that are near the Greenway include the interchange at Nokes Boulevard, completed in September 2009. Over the past five years, Route 28 has been widened to four lanes southbound from Sterling Boulevard to the DTR in September 2015, improving the capacity of the roadway between Route 7 and the IAD. The bridges over the DTR were widened as well in June 2014.

As described further in **Table 2.6** and shown in the satellite imagery of **Figure 2.11 and 2.12**, Route 7 and Route 28 have been improved in recent years with grade separations, significantly increasing throughput and travel speed on both roadways. As such, these improvements have made Route 7 and Route 28 the highest-speed diversion for trips avoiding the Greenway between Leesburg and the DTR.

**Figure 2.11: Aerial images of Route 7 in 2003 (top) and Route 7 in 2018 (bottom)**

Source: Google Earth

**Figure 2.12: Aerial Images of Route 28 in 2005 (left) and Route 28 in 2018 (right)**

Source: Google Earth

### 2.3.2 GLOUCESTER PARKWAY

Gloucester Parkway is a roughly 5 mile median-separated parkway that runs parallel to the Dulles Greenway between Route 28 in the east to Route 659 in the west. Gloucester Parkway is located about 2.5 miles north of the Greenway, about halfway between the Greenway and Route 7. The parkway provides local access to much of the residential development that has grown in recent years in Ashburn. The first section of Gloucester Parkway was completed between 10/2008 and 12/2009 between Route 28 and Loudoun County Parkway. A significant expansion was completed in August 2016 that extended the road to its current western endpoint at Route 659. The addition of this roadway has added significant capacity for east-west travel in the corridor.

### 2.3.3 WAXPOOL ROAD

Waxpool Road is a Virginia Secondary State Highway/Road that runs mostly east-west from Farmwell Road in Ashburn to Belmont Ridge Road in Waxpool. It bisects the Greenway between the Ryan Road and Claiborne Parkway intersections and serves mostly commercial and office facilities in the east and residential subdivisions in the west. The largest improvement to Waxpool Road in recent years was its widening between Ashburn Road and Faulkner Parkway between 10/12 and 10/14, northwest of the Greenway. This stretch of road serves mostly denser apartment residences near the Ryan Road intersection.

### 2.3.4 SYCOLIN ROAD

Sycolin Road is a six-mile long Virginia Secondary State Highway/Road that is approximately parallel to the Dulles Greenway, with the two roads located within a mile of each other. It runs from E Market Street in Leesburg to Belmont Ridge Road in Ashburn, crossing the Dulles Greenway twice, but there are no ramps connecting the two roads at either crossing. It has either one or two lanes per direction, and the land uses surrounding it are generally rural or low-density suburban. Sycolin Road provides a lower-speed but direct diversion around the western section of the Dulles Greenway, and was partially widened in the summer of 2018.

### 2.3.5 OLD OX ROAD (RT. 606)

Old Ox Road is a Virginia Secondary State Highway/Road that lines the IAD perimeter from Loudoun County Parkway in the west until the Fairfax County line. The 7.5-mile road crosses over the Greenway just north of the IAD, and serves as the first intersection after the Mainline Toll Plaza. Given its proximity to the IAD and state highways, Old Ox Road serves a variety of uses, including parking access for Airport users and employees, dense and single-family developments, and mixed-use developments with retail, restaurant, and working space. Of particular note are the number of large supply, warehousing, and other storage-based facilities that line or directly connect to Old Ox Road on both sides of the Greenway.

Old Ox Road was widened on its western end between the Dulles Greenway and Loudoun County, expanding its capacity for the continued high growth of mixed-use facilities in the area.

### 2.3.6 BELMONT RIDGE ROAD

Belmont Ridge Road is a 9 mile north-south Virginia Secondary State Highway/Road that goes from Evergreen Mills Road in the south, near Route 50, to Route 7 in the north. In the northern end of Belmont Ridge Road, it intersects with the Dulles Greenway. The road is mostly a median-separated two-lane per direction roadway with a number of residential and commercial facilities. Near the Greenway, Belmont Ridge was widened south of Hay Rd between August 2010 and April 2011 to a two-lane per direction roadway. Further widening to two-lane per direction was recently completed between Hay Road and Gloucester Parkway in December 2018. Belmont Ridge now has consistent capacity improvements between the Greenway and Route 7.

### 2.3.7 BATTLEFIELD PARKWAY

Battlefield Parkway is a Virginia Secondary State Highway/Road making a ring to the south and east of Leesburg, starting and ending off of Route 15. The Parkway roughly parallels the US-15 Leesburg Bypass, about 1 mile on the exterior. Battlefield Parkway is a relatively new road, built in stages between September 2007 and August 2010. Since then, there has been a widening project between Evergreen Mills Road and the Dulles Greenway in 2018, extending from two to three-lane per direction within that section.

Battlefield Parkway intersects and shares interchanges with a number of roads that lead into Leesburg, including the Greenway, Sycolin Road, and Route 7. Because of the residential and commercial growth in the Leesburg area, Battlefield Parkway directly connects a number of new suburban developments. There is currently not much commercial land use on the road, but the parkway provides connections to other roadways that have significant commercial uses.

### 2.3.8 PACIFIC BOULEVARD

Pacific Boulevard is a north-south road that generally parallels Route 28 between Old Ox Road, just north of the Dulles Greenway, to Route 7, where it changes names to Russell Branch Parkway. Originally ending at Nokes Boulevard, Pacific Boulevard was widened and extended to add capacity in the growing commercial and industrial development in Eastern Loudoun County. Much of these businesses, like those that Old Ox Road serves, are in storage and warehousing industry. Northern Pacific Boulevard is more residential, with some retail developments as well.

## 2.4 SPEED CONDITIONS ON GREENWAY AND ALTERNATIVE ROUTES

The Dulles Greenway operates at consistent free flow speeds near or above the posted speed limit throughout much of the day. The alternative routes are more congested, particularly during peak periods and operate at speeds often substantially below posted limits, which are in many cases lower than on the Dulles Greenway. **Figures 2.13** and **2.15** provide an indication of speeds by roadway segment along the Greenway and comparable section of the alternative routes. As a comparison to speed limits, **Figures 2.14 and 2.16** include the ratio of speed-to-speed limit, which provides a summary of congestion on various roadways throughout the day.

**Figure 2.13: Speed Conditions by Hour - Eastbound**

| **Dulles Greeenway** | | Early | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | Evening |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| E1 | US 15 to Battlefield Pkwy | 64 | 64 | 64 | 63 | 63 | 62 | 62 | 61 | 62 | 62 | 62 | 61 | 61 | 61 | 61 | 59 |
| E2 | Battlefield Pkwy to Shreve Mill Rd | 68 | 70 | 70 | 69 | 68 | 67 | 67 | 67 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 64 |
| E3 | Shreve Mill Rd to Belmont Ridge Road | 69 | 70 | 70 | 70 | 69 | 68 | 68 | 68 | 67 | 67 | 67 | 67 | 67 | 67 | 66 | 65 |
| E4 | Belmont Ridge Rd to Claiborne Pkwy | 70 | 71 | 71 | 71 | 70 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 68 | 68 | 68 | 66 |
| E5 | Claiborne Pkwy to Ryan Rd | 69 | 70 | 70 | 70 | 69 | 68 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 66 | 65 |
| E6 | Ryan Rd to Loudoun County Pkwy | 68 | 69 | 69 | 68 | 68 | 66 | 65 | 64 | 64 | 64 | 65 | 66 | 66 | 65 | 65 | 63 |
| E7 | Loudoun County Pkwy to Ox Rd | 66 | 67 | 65 | 62 | 66 | 65 | 64 | 63 | 63 | 62 | 63 | 64 | 64 | 64 | 63 | 61 |
| E8 | Ox Rd to Mainline Plaza | 61 | 61 | 55 | 44 | 58 | 60 | 59 | 59 | 59 | 58 | 59 | 60 | 60 | 60 | 59 | 56 |
| E9 | Mainline Plaza to Sunrise Valley DR | 57 | 57 | 40 | 30 | 50 | 54 | 55 | 55 | 54 | 54 | 55 | 56 | 56 | 56 | 55 | 53 |

| **Alternative 1 (SR 7 / SR 28)** | | Early | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | Evening |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| E1 | US 15 to Battlefield Pkwy | 42 | 28 | 22 | 24 | 29 | 28 | 28 | 26 | 27 | 32 | 33 | 33 | 32 | 35 | 38 | 39 |
| E2 | Battlefield Pkwy to River Creek Pkwy | 49 | 45 | 43 | 43 | 43 | 42 | 42 | 42 | 42 | 43 | 43 | 43 | 42 | 43 | 43 | 43 |
| E3 | River Creek Pkwy to Belmont Ridge Road | 60 | 56 | 51 | 53 | 53 | 54 | 55 | 55 | 55 | 56 | 56 | 57 | 56 | 56 | 56 | 56 |
| E4 | Belmont Ridge Rd to Claiborne Pkwy | 61 | 56 | 35 | 42 | 55 | 57 | 57 | 57 | 57 | 58 | 58 | 58 | 58 | 58 | 58 | 57 |
| E5 | Claiborne Pkwy to Ashburn Village Blvd | 61 | 48 | 25 | 27 | 47 | 57 | 58 | 58 | 58 | 58 | 57 | 57 | 57 | 58 | 58 | 58 |
| E6 | Ashburn Vill Blvd to Loudoun County Pkwy | 56 | 47 | 37 | 38 | 42 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 43 | 46 | 47 | 50 |
| E7 | Loudoun County Pkwy to SR 28 | 59 | 55 | 50 | 51 | 53 | 55 | 55 | 54 | 54 | 54 | 54 | 53 | 52 | 54 | 55 | 55 |
| E8 | SR 28 @ Old Ox Rd | 61 | 61 | 55 | 49 | 59 | 61 | 61 | 61 | 61 | 60 | 60 | 60 | 60 | 60 | 60 | 59 |
| E9 | Old Ox Rd to DTR @ Sunrise Valley DR | 51 | 45 | 35 | 30 | 41 | 49 | 50 | 50 | 50 | 49 | 50 | 49 | 49 | 50 | 51 | 50 |

| **Alternative 2 (SR 640 / SR 628 / SR 28)** | | Early | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | Evening |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| E1 | US 15 to Battlefield Pkwy | 33 | 33 | 30 | 29 | 31 | 31 | 31 | 30 | 30 | 30 | 29 | 28 | 27 | 29 | 31 | 31 |
| E2 | Battlefield Pkwy to Shreve Mill Rd | 37 | 35 | 34 | 34 | 32 | 32 | 32 | 32 | 32 | 32 | 34 | 34 | 34 | 35 | 36 | 37 |
| E3 | Shreve Mill Rd to Belmont Ridge Road | 40 | 37 | 37 | 36 | 36 | 37 | 36 | 37 | 36 | 37 | 35 | 38 | 38 | 39 | 39 | 40 |
| E4 | Belmont Ridge Rd to Claiborne Pkwy | 37 | 38 | 34 | 36 | 36 | 36 | 36 | 36 | 36 | 35 | 35 | 35 | 35 | 36 | 36 | 36 |
| E5 | Claiborne Pkwy to Ryan Rd | 36 | 35 | 32 | 31 | 31 | 32 | 31 | 31 | 31 | 31 | 31 | 30 | 30 | 30 | 31 | 32 |
| E6 | Ryan Rd to Loudoun County Pkwy | 38 | 33 | 23 | 20 | 29 | 33 | 32 | 30 | 30 | 29 | 29 | 28 | 27 | 29 | 31 | 35 |
| E7 | Loudoun County Pkwy to SR 28 | 39 | 38 | 34 | 32 | 32 | 33 | 33 | 32 | 32 | 30 | 31 | 31 | 31 | 31 | 33 | 35 |
| E8 | SR 28 @ Old Ox Rd | 59 | 58 | 47 | 38 | 55 | 59 | 59 | 59 | 58 | 58 | 58 | 58 | 57 | 58 | 59 | 58 |
| E9 | Old Ox Rd to DTR @ Sunrise Valley DR | 51 | 45 | 35 | 30 | 41 | 49 | 50 | 50 | 50 | 49 | 50 | 49 | 49 | 50 | 51 | 50 |

| **Alternative 3 ( Evergreen Mills Rd / Old Ox Rd)** | | Early | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | Evening |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| E1 | US 15 to Battlefield Pkwy | 31 | 28 | 23 | 21 | 23 | 26 | 26 | 26 | 25 | 25 | 24 | 22 | 23 | 26 | 28 | 30 |
| E2 | Battlefield Pkwy to Shreve Mill Rd | 44 | 43 | 40 | 38 | 39 | 40 | 41 | 41 | 41 | 40 | 40 | 37 | 40 | 40 | 41 | 41 |
| E3 | Shreve Mill Rd to The Woods Rd | 53 | 51 | 48 | 48 | 48 | 48 | 49 | 48 | 48 | 47 | 48 | 48 | 49 | 49 | 50 | 50 |
| E4 | The Woods Rd to Reservior Rd | 49 | 47 | 46 | 45 | 43 | 41 | 42 | 42 | 42 | 42 | 44 | 44 | 44 | 45 | 46 | 46 |
| E5 | Reservoir Rd to Ryan Rd | 50 | 47 | 45 | 45 | 43 | 40 | 40 | 40 | 41 | 41 | 45 | 46 | 46 | 47 | 47 | 48 |
| E6 | Ryan Rd to Somerset Crossing Rd | 43 | 40 | 37 | 35 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 37 | 38 | 40 |
| E7 | Somerset Cross Rd to Loudoun County Pkwy | 37 | 31 | 28 | 29 | 30 | 31 | 31 | 31 | 31 | 30 | 30 | 29 | 28 | 30 | 32 | 34 |
| E8 | Loudoun County Pkwy to SR 28 @ Old Ox Rd | 48 | 45 | 39 | 35 | 41 | 42 | 42 | 42 | 42 | 42 | 43 | 43 | 42 | 44 | 46 | 46 |
| E9 | Old Ox Rd to DTR @ Sunrise Valley DR | 50 | 44 | 34 | 29 | 40 | 48 | 49 | 49 | 49 | 48 | 49 | 48 | 48 | 50 | 50 | 49 |

| **Alternative 4 (Evergreen Mills Rd / Ryan Rd)** | | Early | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | Evening |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| E1 | US 15 to Battlefield Pkwy | 31 | 28 | 23 | 21 | 23 | 26 | 26 | 26 | 25 | 25 | 24 | 22 | 23 | 26 | 28 | 30 |
| E2 | Battlefield Pkwy to Shreve Mill Rd | 44 | 43 | 40 | 38 | 39 | 40 | 41 | 41 | 41 | 40 | 40 | 37 | 40 | 40 | 41 | 41 |
| E3 | Shreve Mill Rd to The Woods Rd | 53 | 51 | 48 | 48 | 48 | 48 | 49 | 48 | 48 | 47 | 48 | 48 | 49 | 49 | 50 | 50 |
| E4 | The Woods Rd to Reservior Rd | 49 | 47 | 46 | 45 | 43 | 41 | 42 | 42 | 42 | 42 | 44 | 44 | 44 | 45 | 46 | 46 |
| E5 | Reservoir Rd to Ryan Rd | 47 | 44 | 42 | 41 | 40 | 37 | 38 | 38 | 38 | 38 | 41 | 42 | 42 | 43 | 44 | 45 |
| E6 | Ryan Rd & Evergreen Mills to Ryan & LCP | 41 | 39 | 35 | 35 | 37 | 38 | 38 | 38 | 38 | 37 | 37 | 36 | 36 | 36 | 36 | 37 |
| E7 | Ryan & LCP to Waxpool Rd | 40 | 36 | 31 | 30 | 32 | 36 | 36 | 36 | 36 | 36 | 36 | 35 | 34 | 35 | 36 | 37 |
| E8 | LCP & Waxpool to SR 28 | 41 | 39 | 35 | 33 | 33 | 34 | 34 | 33 | 33 | 31 | 32 | 32 | 32 | 33 | 34 | 37 |
| E9 | SR 28 @ Waxpool to DTR | 54 | 50 | 39 | 33 | 46 | 53 | 53 | 53 | 53 | 52 | 53 | 52 | 52 | 53 | 54 | 53 |

Source: TomTom GPS Data (2019).

## Figure 2.14: Speed-to-Speed Limit Ratios in Select Roadways by Hour - Eastbound

| **Dulles Greeenway** | | Early | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | Evening |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| E1 | US 15 to Battlefield Pkwy | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 |
| E2 | Battlefield Pkwy to Shreve Mill Rd | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| E3 | Shreve Mill Rd to Belmont Ridge Road | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| E4 | Belmont Ridge Rd to Claiborne Pkwy | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.0 | 1.0 |
| E5 | Claiborne Pkwy to Ryan Rd | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| E6 | Ryan Rd to Loudoun County Pkwy | 1.0 | 1.1 | 1.1 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| E7 | Loudoun County Pkwy to Ox Rd | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 0.9 |
| E8 | Ox Rd to Mainline Plaza | 0.9 | 0.9 | 0.9 | 0.7 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 |
| E9 | Mainline Plaza to Sunrise Valley DR | 0.9 | 0.9 | 0.6 | 0.5 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.9 | 0.9 | 0.9 | 0.8 | 0.8 |

| **Alternative 1 (SR 7 / SR 28)** | | Early | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | Evening |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| E1 | US 15 to Battlefield Pkwy | 0.8 | 0.5 | 0.4 | 0.4 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.7 | 0.7 |
| E2 | Battlefield Pkwy to River Creek Pkwy | 0.9 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 |
| E3 | River Creek Pkwy to Belmont Ridge Road | 1.1 | 1.0 | 0.9 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| E4 | Belmont Ridge Rd to Claiborne Pkwy | 1.1 | 1.0 | 0.6 | 0.8 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.1 | 1.1 | 1.0 | 1.1 | 1.1 | 1.0 |
| E5 | Claiborne Pkwy to Ashburn Village Blvd | 1.1 | 0.9 | 0.5 | 0.5 | 0.8 | 1.0 | 1.0 | 1.0 | 1.1 | 1.0 | 1.0 | 1.0 | 1.0 | 1.1 | 1.1 | 1.0 |
| E6 | Ashburn Vill Blvd to Loudoun County Pkwy | 1.0 | 0.8 | 0.7 | 0.7 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.9 | 0.9 |
| E7 | Loudoun County Pkwy to SR 28 | 1.1 | 1.0 | 0.9 | 0.9 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 0.9 | 1.0 | 1.0 | 1.0 |
| E8 | SR 28 @ Old Ox Rd | 1.1 | 1.1 | 1.0 | 0.9 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 |
| E9 | Old Ox Rd to DTR @ Sunrise Valley DR | 0.9 | 0.8 | 0.6 | 0.5 | 0.7 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 |

| **Alternative 2 (SR 640 / SR 628 / SR 28)** | | Early | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | Evening |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| E1 | US 15 to Battlefield Pkwy | 1.0 | 0.9 | 0.9 | 0.8 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.8 | 0.8 | 0.8 | 0.8 | 0.9 | 0.9 |
| E2 | Battlefield Pkwy to Shreve Mill Rd | 1.1 | 1.0 | 1.0 | 1.0 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.1 |
| E3 | Shreve Mill Rd to Belmont Ridge Road | 1.0 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 1.0 | 0.9 | 1.0 | 1.0 | 1.0 |
| E4 | Belmont Ridge Rd to Claiborne Pkwy | 0.9 | 0.9 | 0.8 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 |
| E5 | Claiborne Pkwy to Ryan Rd | 0.7 | 0.7 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |
| E6 | Ryan Rd to Loudoun County Pkwy | 0.8 | 0.7 | 0.5 | 0.4 | 0.6 | 0.7 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.5 | 0.6 | 0.6 | 0.7 |
| E7 | Loudoun County Pkwy to SR 28 | 0.8 | 0.8 | 0.7 | 0.6 | 0.6 | 0.7 | 0.7 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.7 | 0.7 |
| E8 | SR 28 @ Old Ox Rd | 1.1 | 1.1 | 0.8 | 0.7 | 1.0 | 1.1 | 1.1 | 1.1 | 1.1 | 1.0 | 1.1 | 1.1 | 1.0 | 1.0 | 1.1 | 1.1 |
| E9 | Old Ox Rd to DTR @ Sunrise Valley DR | 0.9 | 0.8 | 0.6 | 0.5 | 0.7 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 |

| **Alternative 3 ( Evergreen Mills Rd / Old Ox Rd)** | | Early | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | Evening |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| E1 | US 15 to Battlefield Pkwy | 1.3 | 1.1 | 0.9 | 0.8 | 0.9 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 0.9 | 0.9 | 1.0 | 1.1 | 1.2 |
| E2 | Battlefield Pkwy to Shreve Mill Rd | 1.0 | 1.0 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.8 | 0.9 | 0.9 | 0.9 | 0.9 |
| E3 | Shreve Mill Rd to The Woods Rd | 1.1 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 0.9 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| E4 | The Woods Rd to Reservior Rd | 0.9 | 0.9 | 0.8 | 0.8 | 0.8 | 0.7 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 |
| E5 | Reservoir Rd to Ryan Rd | 0.9 | 0.9 | 0.8 | 0.8 | 0.8 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.8 | 0.8 | 0.8 | 0.9 | 0.9 | 0.9 |
| E6 | Ryan Rd to Somerset Crossing Rd | 0.8 | 0.7 | 0.7 | 0.6 | 0.6 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.6 | 0.6 | 0.7 | 0.7 | 0.7 |
| E7 | Somerset Cross Rd to Loudoun County Pkwy | 0.7 | 0.6 | 0.5 | 0.5 | 0.5 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.5 | 0.5 | 0.5 | 0.6 | 0.6 | 0.6 |
| E8 | Loudoun County Pkwy to SR 28 @ Old Ox Rd | 0.9 | 0.8 | 0.7 | 0.6 | 0.7 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 |
| E9 | Old Ox Rd to DTR @ Sunrise Valley DR | 0.9 | 0.8 | 0.6 | 0.5 | 0.7 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 |

| **Alternative 4 (Evergreen Mills Rd / Ryan Rd)** | | Early | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | Evening |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| E1 | US 15 to Battlefield Pkwy | 1.3 | 1.1 | 0.9 | 0.8 | 0.9 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 0.9 | 0.9 | 1.0 | 1.1 | 1.2 |
| E2 | Battlefield Pkwy to Shreve Mill Rd | 1.0 | 1.0 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.8 | 0.9 | 0.9 | 0.9 | 0.9 |
| E3 | Shreve Mill Rd to The Woods Rd | 1.1 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 0.9 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| E4 | The Woods Rd to Reservior Rd | 0.9 | 0.9 | 0.8 | 0.8 | 0.8 | 0.7 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 |
| E5 | Reservoir Rd to Ryan Rd | 0.9 | 0.8 | 0.8 | 0.8 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 |
| E6 | Ryan Rd & Evergreen Mills to Ryan & LCP | 1.0 | 1.0 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 |
| E7 | Ryan & LCP to Waxpool Rd | 1.0 | 0.9 | 0.8 | 0.7 | 0.8 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 |
| E8 | LCP & Waxpool to SR 28 | 1.0 | 1.0 | 0.9 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.9 |
| E9 | SR 28 @ Waxpool to DTR | 1.0 | 0.9 | 0.7 | 0.6 | 0.8 | 1.0 | 1.0 | 1.0 | 1.0 | 0.9 | 1.0 | 1.0 | 0.9 | 1.0 | 1.0 | 1.0 |

Source: TomTom GPS Data (2019).

## Figure 2.15: Speed Conditions by Hour -Westbound

| **Dulles Greenway** | | Early | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | Evening |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W1 | Sunrise Valley Dr to Mainline Plaza | 58 | 59 | 59 | 58 | 58 | 58 | 59 | 59 | 59 | 59 | 58 | 53 | 52 | 55 | 59 | 58 |
| W2 | Mainline Plaza to Old Ox Rd | 55 | 55 | 55 | 56 | 56 | 56 | 57 | 57 | 57 | 58 | 60 | 59 | 59 | 60 | 60 | 57 |
| W3 | Old Ox Rd to Loudoun County Pkwy | 60 | 61 | 61 | 61 | 61 | 61 | 62 | 63 | 63 | 65 | 66 | 65 | 63 | 64 | 65 | 62 |
| W4 | Loudoun County Pkwy to Ryan Rd | 61 | 63 | 62 | 62 | 62 | 62 | 63 | 64 | 65 | 66 | 67 | 66 | 64 | 65 | 66 | 63 |
| W5 | Ryan Rd to Claiborne Pkwy | 64 | 65 | 65 | 65 | 65 | 65 | 66 | 66 | 67 | 68 | 69 | 68 | 67 | 67 | 67 | 65 |
| W6 | Claiborne Pkwy to Belmont Ridge Rd | 66 | 67 | 67 | 67 | 67 | 68 | 68 | 69 | 69 | 70 | 70 | 70 | 69 | 69 | 69 | 67 |
| W7 | Belmont Ridge Rd to Shreve Mill Rd | 66 | 67 | 68 | 68 | 68 | 68 | 68 | 69 | 69 | 70 | 70 | 70 | 70 | 70 | 69 | 67 |
| W8 | Shreve Mill Rd to Battlefield Pkwy | 66 | 67 | 67 | 67 | 67 | 67 | 68 | 68 | 68 | 69 | 69 | 68 | 68 | 69 | 68 | 67 |
| W9 | Battlefield Pkwy to US 15 | 55 | 56 | 56 | 56 | 56 | 56 | 56 | 57 | 57 | 52 | 30 | 17 | 19 | 37 | 56 | 55 |

| **Alternative 1 (SR 7 / SR 28)** | | Early | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | Evening |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W1 | Sunrise Valley Dr to Old Ox Rd @ SR28 | 50 | 50 | 51 | 50 | 49 | 49 | 49 | 49 | 48 | 47 | 42 | 26 | 23 | 28 | 48 | 49 |
| W2 | SR 28 @ Old Ox Rd | 59 | 61 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 59 | 57 | 53 | 50 | 53 | 59 | 59 |
| W3 | SR 28 to Loudoun County Pkwy | 58 | 60 | 58 | 57 | 58 | 58 | 58 | 57 | 56 | 53 | 39 | 35 | 31 | 43 | 55 | 57 |
| W4 | Loudoun County Pkwy to Ashburn Vill Blvd | 55 | 52 | 46 | 45 | 45 | 45 | 43 | 42 | 40 | 37 | 32 | 32 | 31 | 36 | 43 | 50 |
| W5 | Asburn Village Blvd to Claiborne Pkwy | 58 | 59 | 57 | 56 | 56 | 56 | 56 | 56 | 55 | 52 | 51 | 51 | 51 | 52 | 55 | 56 |
| W6 | Claiborne Pkwy to Belmont Ridge Rd | 57 | 60 | 60 | 58 | 58 | 57 | 57 | 56 | 54 | 50 | 53 | 51 | 53 | 54 | 57 | 56 |
| W7 | Belmont Ridge Rd to River Creek Rd | 58 | 61 | 60 | 60 | 59 | 58 | 58 | 58 | 57 | 55 | 48 | 43 | 49 | 54 | 58 | 58 |
| W8 | River Creek Rd to Battlefield Pkwy | 51 | 51 | 47 | 45 | 46 | 42 | 39 | 33 | 31 | 25 | 16 | 15 | 19 | 29 | 40 | 46 |
| W9 | Battlefield Pkwy to US 15 | 46 | 43 | 42 | 41 | 40 | 38 | 37 | 35 | 36 | 38 | 30 | 22 | 21 | 31 | 41 | 42 |

| **Alternative 3 ( Evergreen Mills Rd / Old Ox Rd)** | | Early | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | Evening |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W1 | DTR @ Sunrise Valley Dr to Old Ox Rd | 47 | 47 | 47 | 46 | 46 | 46 | 46 | 46 | 45 | 44 | 40 | 26 | 23 | 29 | 45 | 47 |
| W2 | Old Ox Rd to Loudoun County Pkwy | 46 | 42 | 41 | 40 | 41 | 41 | 40 | 40 | 40 | 41 | 42 | 40 | 36 | 41 | 45 | 46 |
| W3 | Loudoun County Pkwy to Somerset Cross Rd | 38 | 35 | 34 | 32 | 33 | 34 | 34 | 34 | 34 | 34 | 34 | 33 | 32 | 34 | 35 | 36 |
| W4 | Somerset Crossing Rd to Ryan Rd | 44 | 42 | 40 | 39 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 41 | 42 | 43 |
| W5 | Ryan Rd to Reservoir Rd | 45 | 43 | 38 | 40 | 39 | 39 | 39 | 39 | 39 | 39 | 38 | 41 | 41 | 42 | 43 | 43 |
| W6 | Reservoir Rd to The Woods Rd | 42 | 40 | 37 | 39 | 39 | 39 | 39 | 40 | 40 | 40 | 40 | 40 | 40 | 42 | 44 | 44 |
| W7 | The Woods Rd to Shreve Mill Rd | 52 | 52 | 47 | 47 | 48 | 48 | 49 | 48 | 49 | 48 | 48 | 49 | 49 | 50 | 51 | 50 |
| W8 | Shreve Mill Rd to Battlefield Pkwy | 45 | 44 | 41 | 36 | 39 | 42 | 42 | 42 | 43 | 42 | 40 | 32 | 39 | 39 | 42 | 43 |
| W9 | Battlefield Pkwy to US 15 | 30 | 28 | 25 | 23 | 25 | 26 | 26 | 27 | 27 | 26 | 23 | 19 | 21 | 26 | 27 | 29 |

| **Alternative 4 (Evergreen Mills Rd / Ryan Rd)** | | Early | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | Evening |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W1 | DTR @ Sunrise Valley Dr to SR 28 @ Waxpool | 54 | 54 | 54 | 53 | 53 | 53 | 53 | 53 | 52 | 51 | 46 | 36 | 33 | 37 | 51 | 53 |
| W2 | SR 28 to LCP & Waxpool | 38 | 35 | 32 | 30 | 31 | 34 | 32 | 31 | 30 | 30 | 30 | 27 | 24 | 28 | 31 | 35 |
| W3 | LCP & Waxpool to Ryan Rd | 40 | 38 | 37 | 36 | 36 | 37 | 37 | 37 | 37 | 36 | 36 | 33 | 29 | 33 | 37 | 38 |
| W4 | Ryan & LCP to Evergreen Mills Rd | 39 | 38 | 36 | 35 | 36 | 37 | 37 | 37 | 37 | 37 | 37 | 35 | 34 | 35 | 36 | 37 |
| W5 | Evergreen Mills & Ryan to Reservoir Rd | 46 | 45 | 40 | 42 | 41 | 41 | 41 | 41 | 41 | 41 | 40 | 42 | 43 | 44 | 45 | 45 |
| W6 | Reservoir Rd to The Woods Rd | 42 | 40 | 37 | 39 | 39 | 39 | 39 | 40 | 40 | 40 | 40 | 40 | 40 | 42 | 44 | 44 |
| W7 | The Woods Rd to Shreve Mill Rd | 52 | 52 | 47 | 47 | 48 | 48 | 49 | 48 | 49 | 48 | 48 | 49 | 49 | 50 | 51 | 50 |
| W8 | Shreve Mill Rd to Battlefield Pkwy | 47 | 46 | 43 | 37 | 41 | 44 | 44 | 44 | 45 | 43 | 41 | 33 | 41 | 41 | 44 | 44 |
| W9 | Battlefield Pkwy to US 15 | 30 | 27 | 24 | 22 | 24 | 25 | 26 | 26 | 26 | 25 | 22 | 18 | 20 | 25 | 27 | 28 |

Source: TomTom GPS Data (2019).

## Figure 2.16: Speed-to-Speed Limit Ratios in Select Roadways by Hour - Westbound

| Dulles Greeenway | | Early | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | Evening |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W1 | Sunrise Valley Dr to Mainline Plaza | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.8 | 0.8 | 0.8 | 0.9 | 0.9 |
| W2 | Mainline Plaza to Old Ox Rd | 0.8 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 |
| W3 | Old Ox Rd to Loudoun County Pkwy | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 0.9 |
| W4 | Loudoun County Pkwy to Ryan Rd | 0.9 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| W5 | Ryan Rd to Claiborne Pkwy | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.1 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| W6 | Claiborne Pkwy to Belmont Ridge Rd | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.0 |
| W7 | Belmont Ridge Rd to Shreve Mill Rd | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.0 |
| W8 | Shreve Mill Rd to Battlefield Pkwy | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.1 | 1.1 | 1.1 | 1.1 | 1.0 | 1.1 | 1.1 | 1.0 |
| W9 | Battlefield Pkwy to US 15 | 0.8 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.8 | 0.5 | 0.3 | 0.3 | 0.6 | 0.9 | 0.9 |

| Alternative 1 (SR 7 / SR 28) | | Early | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | Evening |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W1 | Sunrise Valley Dr to Old Ox Rd @ SR28 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.8 | 0.5 | 0.4 | 0.5 | 0.9 | 0.9 |
| W2 | SR 28 @ Old Ox Rd | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.0 | 1.0 | 0.9 | 1.0 | 1.1 | 1.1 |
| W3 | SR 28 to Loudoun County Pkwy | 1.1 | 1.1 | 1.1 | 1.0 | 1.0 | 1.1 | 1.1 | 1.0 | 1.0 | 1.0 | 0.7 | 0.6 | 0.6 | 0.8 | 1.0 | 1.0 |
| W4 | Loudoun County Pkwy to Ashburn Vill Blvd | 1.0 | 0.9 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.7 | 0.7 | 0.6 | 0.6 | 0.6 | 0.6 | 0.8 | 0.9 |
| W5 | Asburn Village Blvd to Claiborne Pkwy | 1.0 | 1.1 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 0.9 | 0.9 | 0.9 | 1.0 | 1.0 | 1.0 |
| W6 | Claiborne Pkwy to Belmont Ridge Rd | 1.0 | 1.1 | 1.1 | 1.1 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 0.9 | 1.0 | 0.9 | 1.0 | 1.0 | 1.0 | 1.0 |
| W7 | Belmont Ridge Rd to River Creek Rd | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.0 | 1.0 | 1.0 | 0.9 | 0.8 | 0.9 | 1.0 | 1.0 | 1.0 |
| W8 | River Creek Rd to Battlefield Pkwy | 0.9 | 0.9 | 0.9 | 0.8 | 0.8 | 0.8 | 0.7 | 0.6 | 0.6 | 0.5 | 0.3 | 0.3 | 0.3 | 0.5 | 0.7 | 0.8 |
| W9 | Battlefield Pkwy to US 15 | 0.8 | 0.8 | 0.8 | 0.7 | 0.7 | 0.7 | 0.7 | 0.6 | 0.7 | 0.7 | 0.6 | 0.4 | 0.4 | 0.6 | 0.7 | 0.8 |

| Alternative 2 (SR 640 / SR 628 / SR 28) | | Early | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | Evening |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W1 | Sunrise Valley Dr to Old Ox Rd @ SR28 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.8 | 0.9 | 0.9 | 0.8 | 0.8 | 0.7 | 0.4 | 0.4 | 0.5 | 0.8 | 0.9 |
| W2 | SR 28 @ Old Ox Rd | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 0.9 | 0.8 | 0.7 | 0.8 | 1.0 | 1.0 |
| W3 | SR 28 to Loudoun County Pkwy | 0.7 | 0.6 | 0.6 | 0.5 | 0.5 | 0.6 | 0.6 | 0.5 | 0.5 | 0.5 | 0.6 | 0.5 | 0.5 | 0.5 | 0.6 | 0.6 |
| W4 | Loudoun County Pkwy to Ashburn Rd | 0.8 | 0.7 | 0.6 | 0.6 | 0.6 | 0.7 | 0.7 | 0.6 | 0.6 | 0.7 | 0.7 | 0.7 | 0.6 | 0.6 | 0.7 | 0.7 |
| W5 | Ashburn Rd to Claiborne Pkwy | 0.8 | 0.8 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 |
| W6 | Claiborne Pkwy to Belmont Ridge Rd | 0.9 | 0.9 | 0.7 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.7 | 0.8 | 0.7 | 0.7 | 0.8 | 0.8 | 0.8 |
| W7 | Belmont Ridge Rd to Shreve Mill Rd | 1.0 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 1.0 |
| W8 | Shreve Mill Rd to Battlefield Pkwy | 1.1 | 1.0 | 1.0 | 1.0 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.8 | 1.0 | 1.0 | 1.1 |
| W9 | Battlefield Pkwy to US 15 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.7 | 0.7 | 0.8 | 0.8 | 0.8 |

| Alternative 3 ( Evergreen Mills Rd / Old Ox Rd) | | Early | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | Evening |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W1 | DTR @ Sunrise Valley Dr to Old Ox Rd | 0.9 | 0.8 | 0.9 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.7 | 0.5 | 0.4 | 0.5 | 0.8 | 0.8 |
| W2 | Old Ox Rd to Loudoun County Pkwy | 0.8 | 0.8 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.8 | 0.7 | 0.7 | 0.8 | 0.8 | 0.8 |
| W3 | Loudoun County Pkwy to Somerset Cross Rd | 0.7 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.7 |
| W4 | Somerset Crossing Rd to Ryan Rd | 0.8 | 0.8 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.8 | 0.8 |
| W5 | Ryan Rd to Reservoir Rd | 0.8 | 0.8 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.8 | 0.8 | 0.8 |
| W6 | Reservoir Rd to The Woods Rd | 0.8 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.8 | 0.8 | 0.8 |
| W7 | The Woods Rd to Shreve Mill Rd | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 |
| W8 | Shreve Mill Rd to Battlefield Pkwy | 1.0 | 1.0 | 0.9 | 0.8 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.7 | 0.9 | 0.9 | 0.9 | 0.9 |
| W9 | Battlefield Pkwy to US 15 | 1.2 | 1.1 | 1.0 | 0.9 | 1.0 | 1.0 | 1.0 | 1.1 | 1.1 | 1.0 | 0.9 | 0.7 | 0.8 | 1.0 | 1.1 | 1.1 |

| Alternative 4 (Evergreen Mills Rd / Ryan Rd) | | Early | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | Evening |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W1 | DTR @ Sunrise Valley Dr to SR 28 @ Waxpool | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 0.9 | 0.9 | 0.8 | 0.6 | 0.6 | 0.7 | 0.9 | 1.0 |
| W2 | SR 28 to LCP & Waxpool | 1.0 | 0.9 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.7 | 0.8 | 0.7 | 0.7 | 0.6 | 0.7 | 0.8 | 0.9 |
| W3 | LCP & Waxpool to Ryan Rd | 1.0 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.8 | 0.7 | 0.8 | 0.9 | 1.0 |
| W4 | Ryan & LCP to Evergreen Mills Rd | 1.0 | 1.0 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 |
| W5 | Evergreen Mills & Ryan to Reservoir Rd | 0.8 | 0.8 | 0.7 | 0.8 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 |
| W6 | Reservoir Rd to The Woods Rd | 0.8 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.8 | 0.8 | 0.8 |
| W7 | The Woods Rd to Shreve Mill Rd | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 |
| W8 | Shreve Mill Rd to Battlefield Pkwy | 1.0 | 1.0 | 1.0 | 0.8 | 0.9 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 0.9 | 0.7 | 0.9 | 0.9 | 1.0 | 1.0 |
| W9 | Battlefield Pkwy to US 15 | 1.2 | 1.1 | 1.0 | 0.9 | 1.0 | 1.0 | 1.0 | 1.0 | 1.1 | 1.0 | 0.9 | 0.7 | 0.8 | 1.0 | 1.1 | 1.1 |

Source: TomTom GPS Data (2019).

# 3 SOCIOECONOMIC CONDITIONS

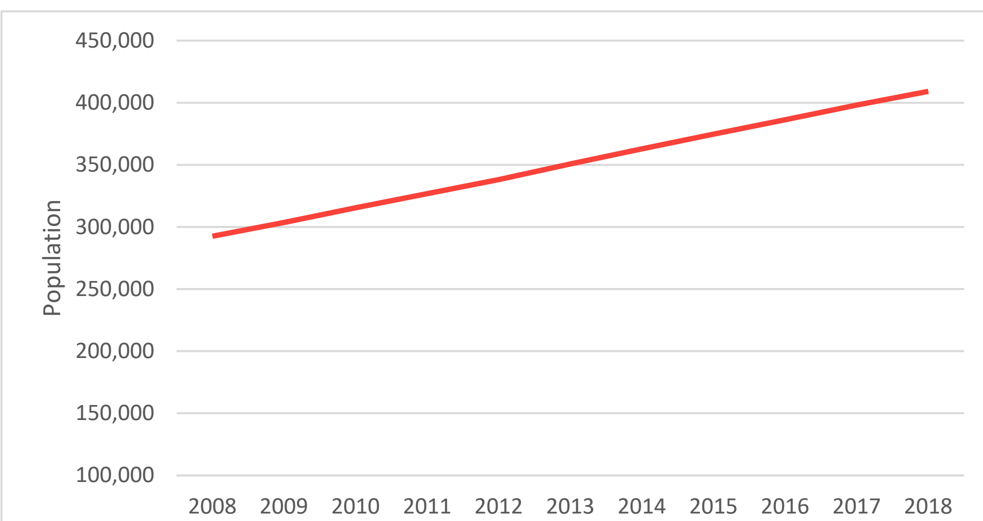
## 3.1 TRENDS IN SOCIOECONOMIC VARIABLES

This section provides background on socioeconomic variables that influence traffic levels on the Greenway and are inputs into the econometric model. Included are recent trends in the population and real per capita income in Loudoun County, as well as the real transportation and warehousing income in the region, which includes Loudoun, Fairfax, Arlington, and Washington, D.C. All estimates are derived from data provided by Woods & Poole, a well-regarded demographics data source commonly used for studies of this kind. Additionally, this section provides some insight into general land use trends in Loudoun County related to residential and commercial growth.

### *3.1.1 POPULATION*

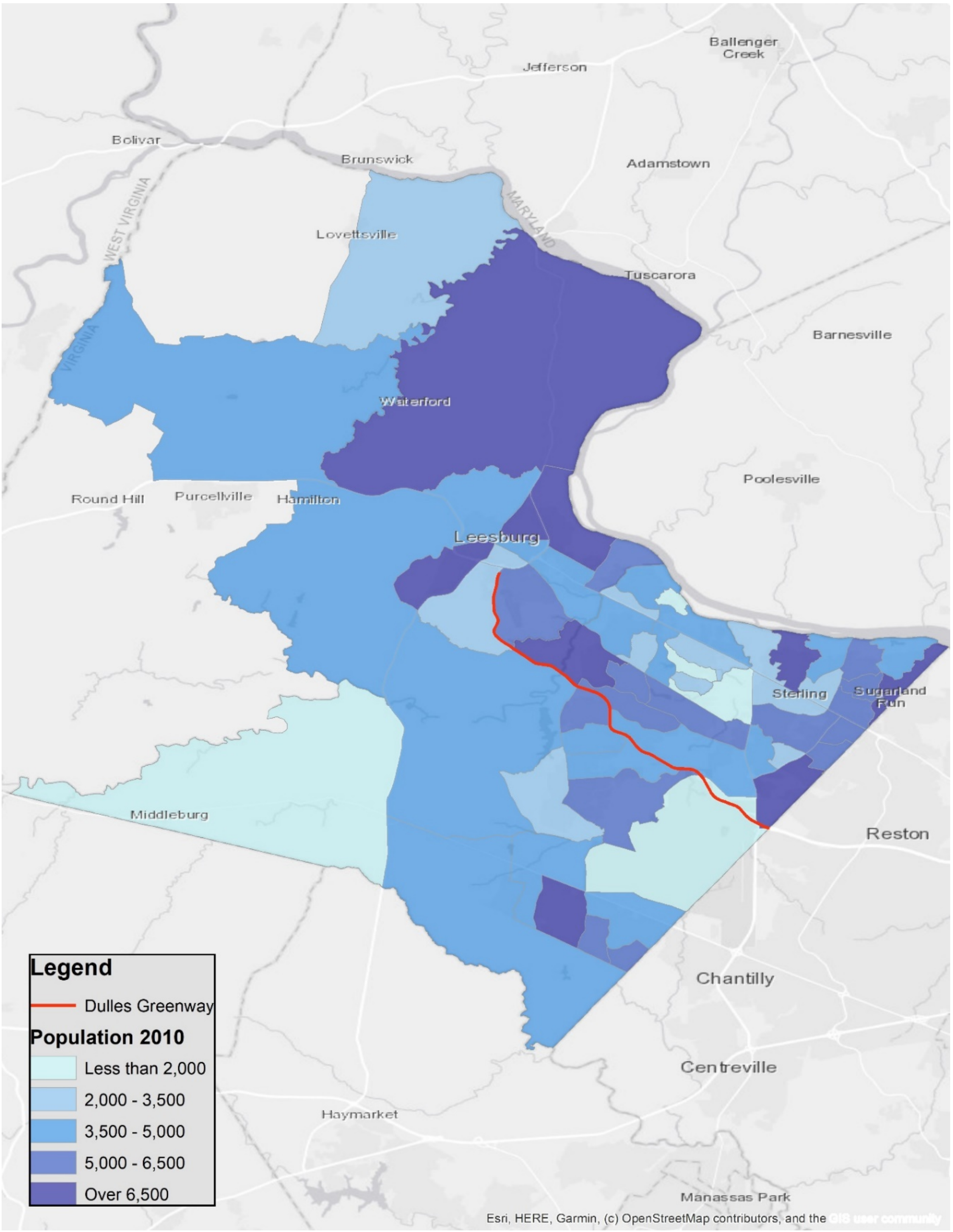
Loudoun County is one of the fastest growing counties in the Commonwealth of Virginia. In 2018, Loudoun County had an estimated population of 406,850. The compound annual growth rate (CAGR) for Loudoun County population from 2008 to 2018 is 3.4%, over four times the USA population CAGR and just under four times the Virginia rate. This growth remained steady over the 10-year period, with Loudoun County gaining about 12,000 residents each year on average. This steady growth followed years of extremely high population growth in the 1990's and early 2000's, when year-over-year growth rates were over 10%. The population is in line with large housing developments that are growing near the Dulles Greenway, indicating that this population growth is taking place within areas where the Greenway is competitive. **Figure 3.2** shows the population by census tracts in Loudoun County along the Dulles Greenway corridor in 2010 and 2017, and the population change in percentage during this period. As demonstrated in the econometric analysis of Chapter 5 of this Report, the population growth metric correlates significantly to traffic growth on the region's roads. This conclusion is further supported by the fact that the number of vehicles per household has remained roughly the same over the past 7 years, as shown in **Figure 3.3**, lending support to the direct relationship between population and regional vehicular travel.

**Figure 3.1: Loudoun County Population, 2008-2018**

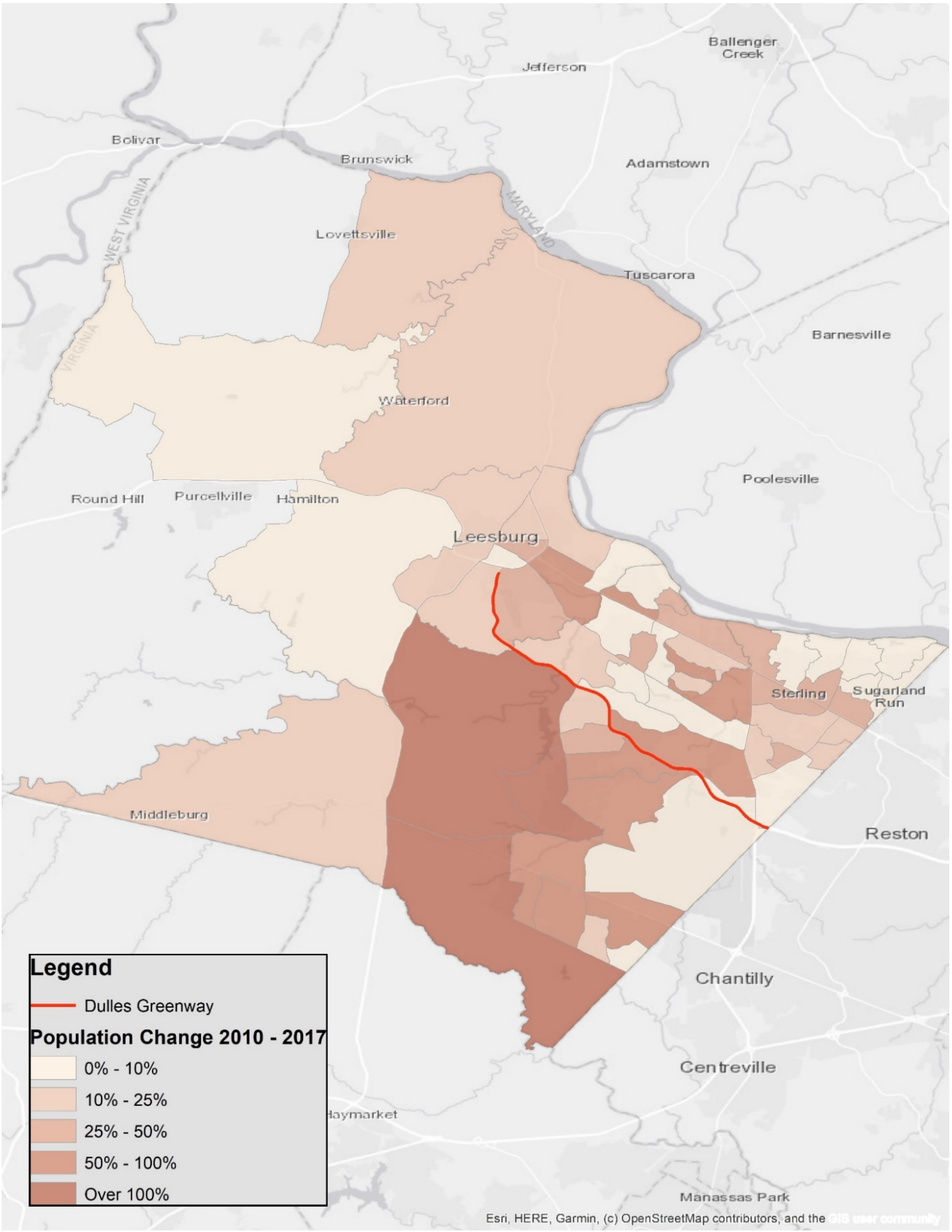



Source: Woods & Poole

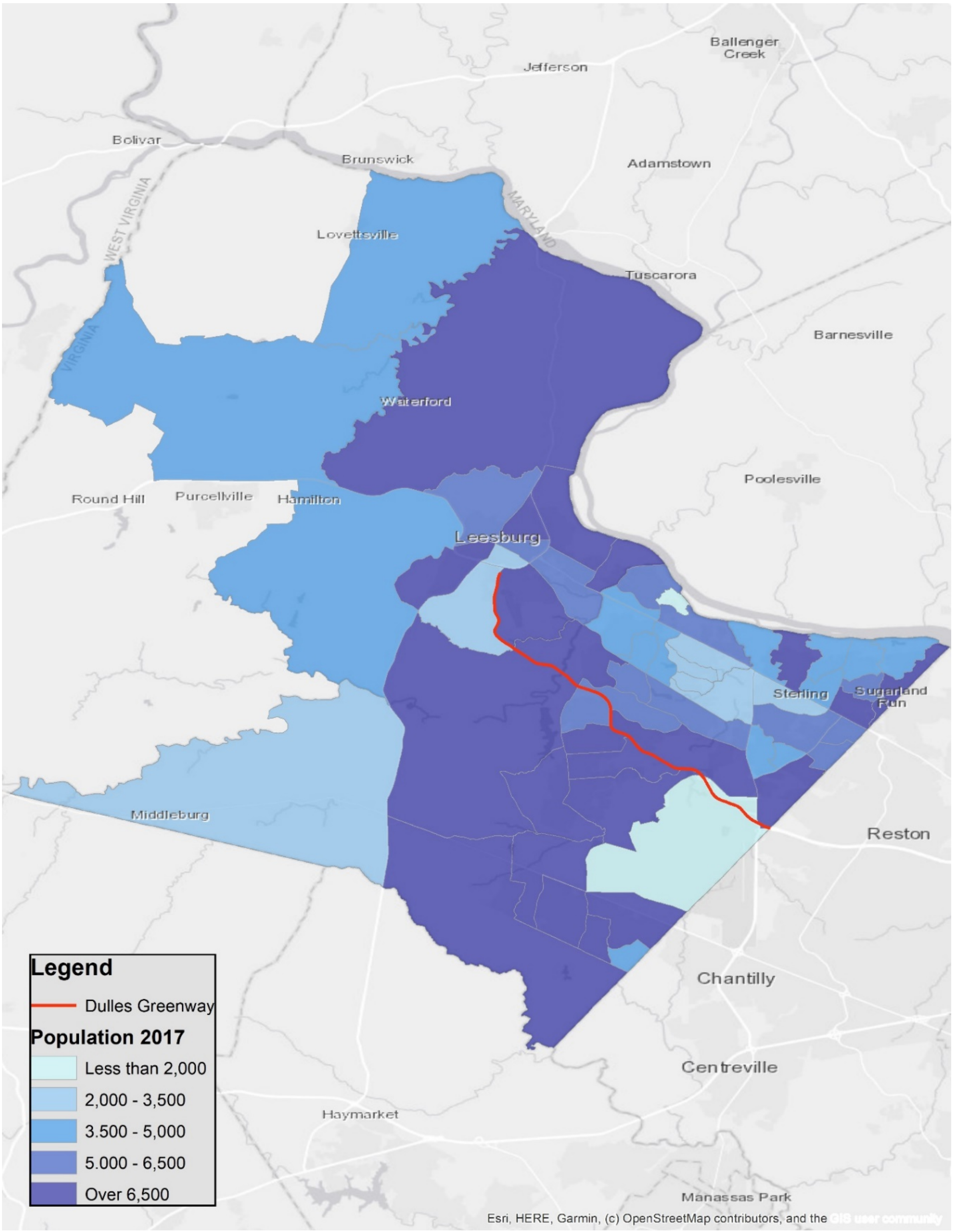
**Figure 3.2: Population by Census Tract in Loudoun County in proximity to Dulles Greenway, 2010-2017**




Source: U.S. Census Data.

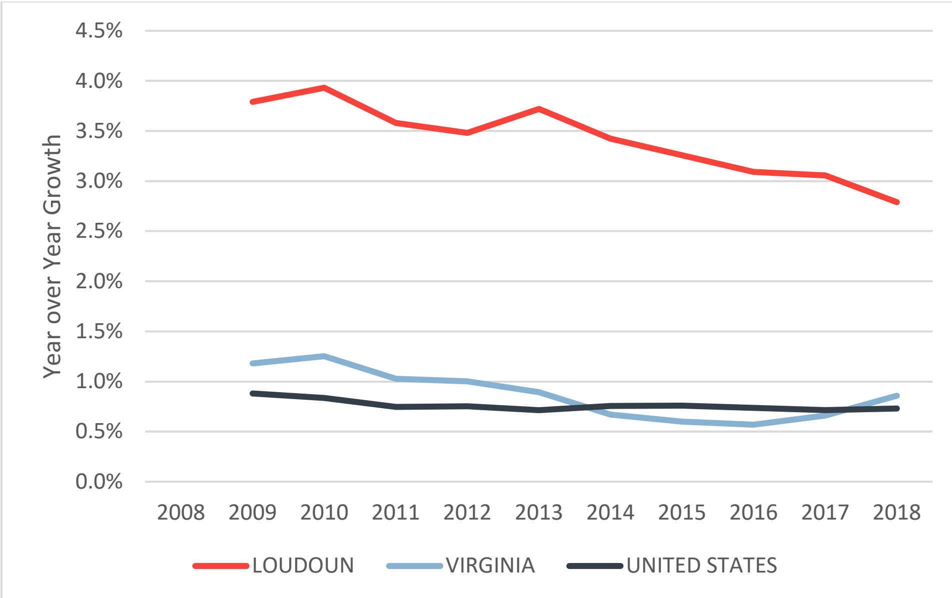



Source: U.S. Census Data.



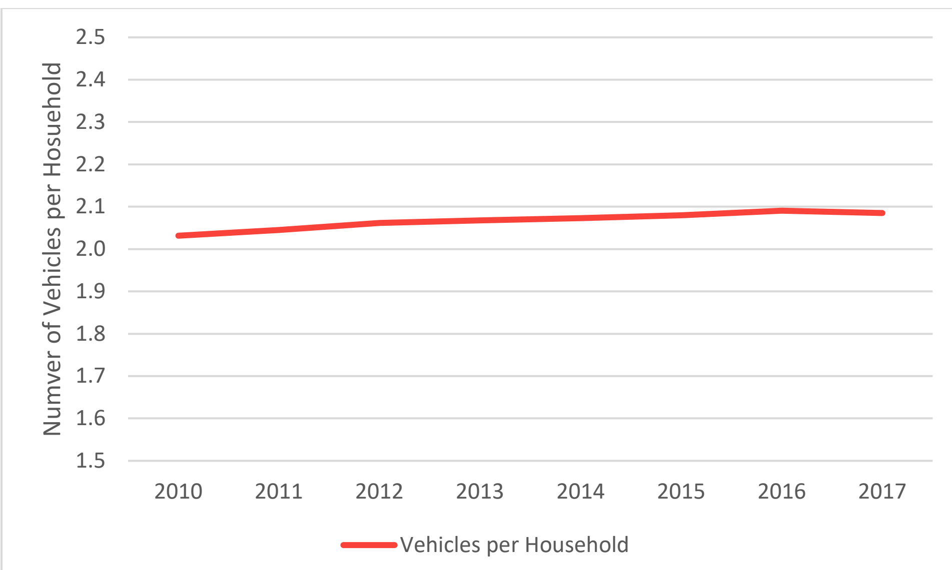

Source: U.S. Census Data.

**Figure 3.3: Annual Population Growth**




Source: Woods & Poole

**Figure 3.4: Average Vehicle Ownership per Household in Loudoun County**

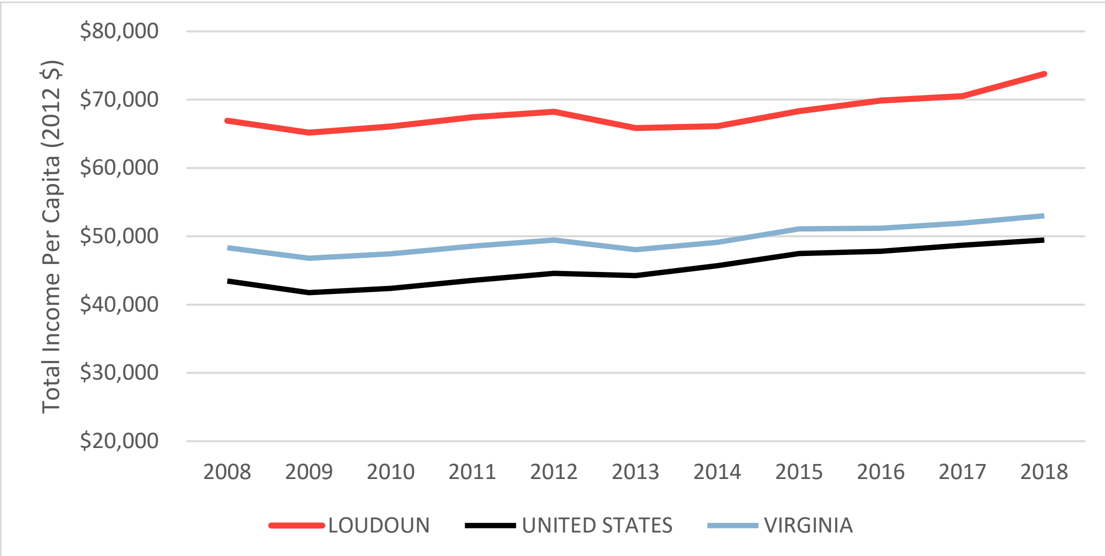



Source: U.S. Census Bureau, ACS 5-year Estimates (2013-2017 5-year estimates)

## 3.1.2 PER CAPITA INCOME

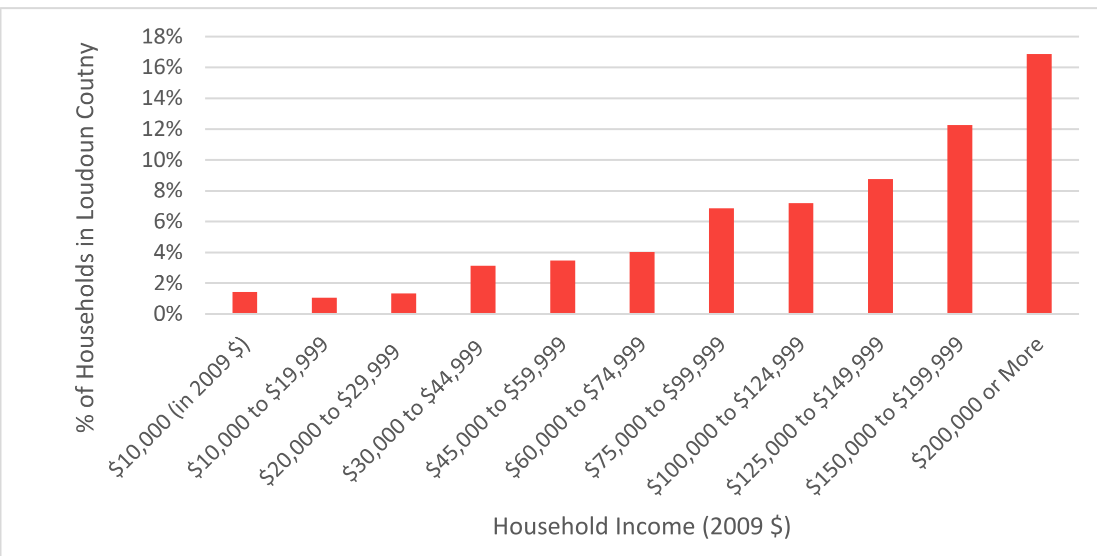
Total income per capita is a good measure of the relative growth in wealth. Per capita income in Loudoun County is, like most of Northern Virginia, much higher than the state average and the national average as a whole. In 2018, the real per capita income (in 2012 dollars) was $73,776, about 40% higher than the Virginia average and almost 50% higher than the United States average, as shown in **Figure 3.5.** Loudoun has the third-highest income by county in the state, behind Arlington and Fairfax counties. A higher per capita income results in a higher value of travel time savings and reliability, which correlates to a greater willingness to pay tolls, as demonstrated in Chapter 5's econometric analysis. **Figure 3.6** shows the distribution of household income in Loudoun County, showing a much higher share of homes in higher income brackets.

**Figure 3.5: Total Real Income per Capita (2012 $)**




Source: Woods & Poole

Figure 3.6: Distribution of Household Income in Loudoun County

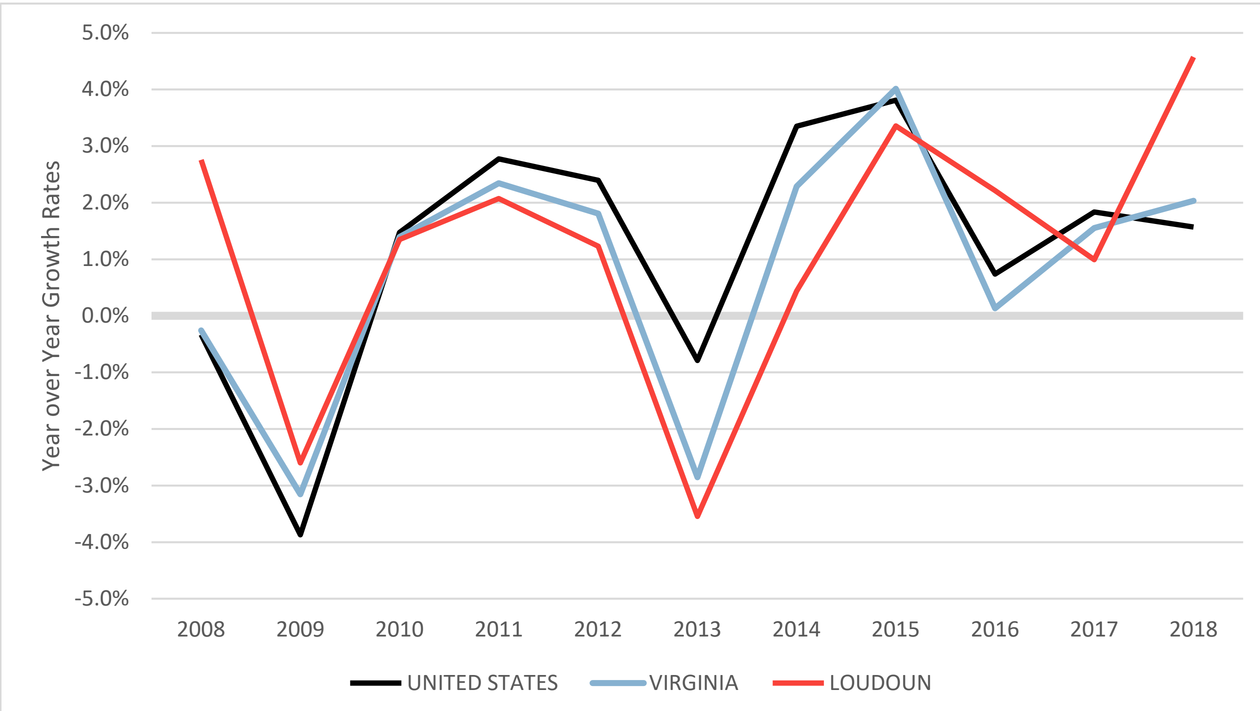



Source: Woods & Poole

When comparing recent growth trends for real income, Loudoun County has generally followed national and statewide patterns. During the height of the recession in 2009, Loudoun County lost about 2.6% real income from 2008, before rising to 1.3% growth the next year. The one exception was in 2008, when income had grown 2.8% compared to 2007, while Virginia and the U.S. as a whole saw real income losses between 2007 and 2008. This delay in impacts from the recession is most likely due to the fact that the Washington metropolitan area is quite different from the more representative economies of the Commonwealth and nation as a whole. Loudoun County saw a noticeable jump in per-capita income between 2017 and 2018 of close to 5%, while national and statewide trends stabilized around 1.5-2%.

Because of the high income per capita and number of households that earn well above the national median, standard guidance on the willingness to pay tolls indicates that the value of time for most of Loudoun County residents is relatively high.

**Figure 3.7: Growth in Real Income per Capita**



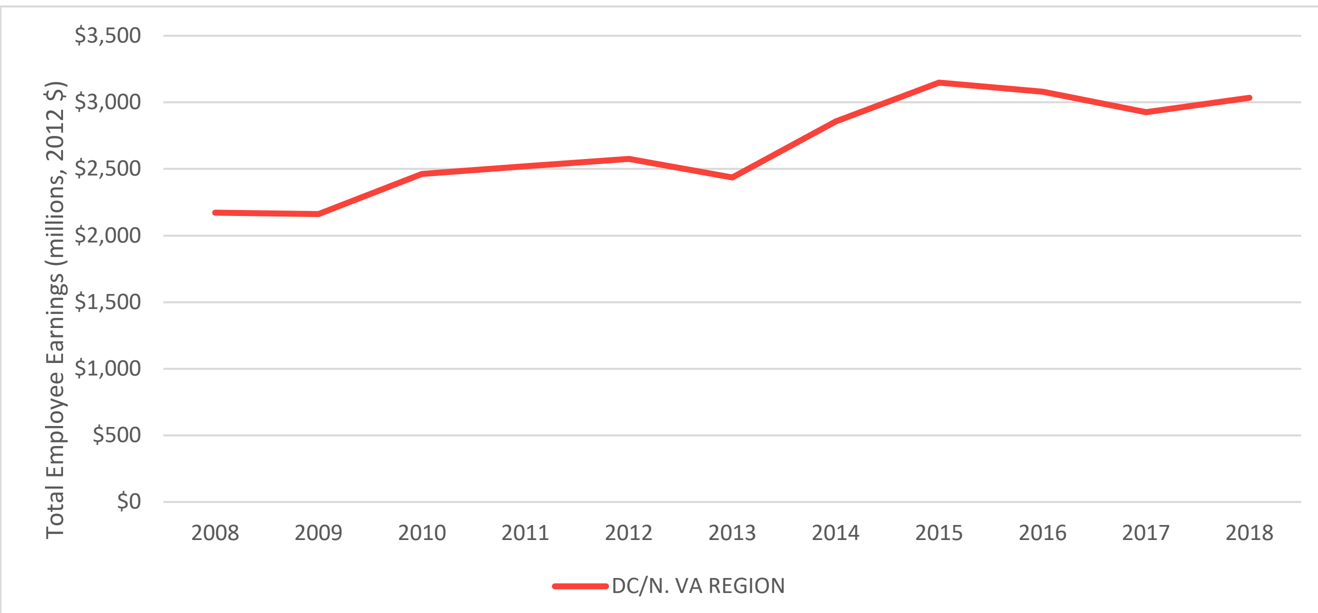

Source: Woods & Poole

### *3.1.3 REGIONAL INCOME AND TRANSPORTATION AND WAREHOUSE SECTORS*

As detailed in Section 3.2 below, the Dulles Greenway is in a corridor with significantly expanding storage and warehousing facilities. This variable, when compared to others that had been tested as part of the econometric model, had higher influence on Greenway traffic. This is most likely due to the fact that the Greenway was developed around land that has been conducive to warehouse and storage facilities. Greenfield land, major highways with access to multiple major metro areas, and proximity to IAD all contribute to this growing sector. To measure this, WSP reviewed real income growth in the transportation and warehouse sectors, provided by Woods & Poole. In order to gauge the industry's presence in the region as a whole, WSP looked at real earnings in the region, including Loudoun, Fairfax, and Arlington counties, as well as Washington D.C.

In 2018, the Washington-Northern Virginia region had real employee total earnings at just over $3 billion dollars in the transportation and warehouse sector. Overall, the real income had a CAGR of 3.4% from 2008 to 2018. This compares similarly to the CAGR of total earnings for Virginia and the U.S. as a whole, which had CAGRs of 2.9% and 3.5, respectively.

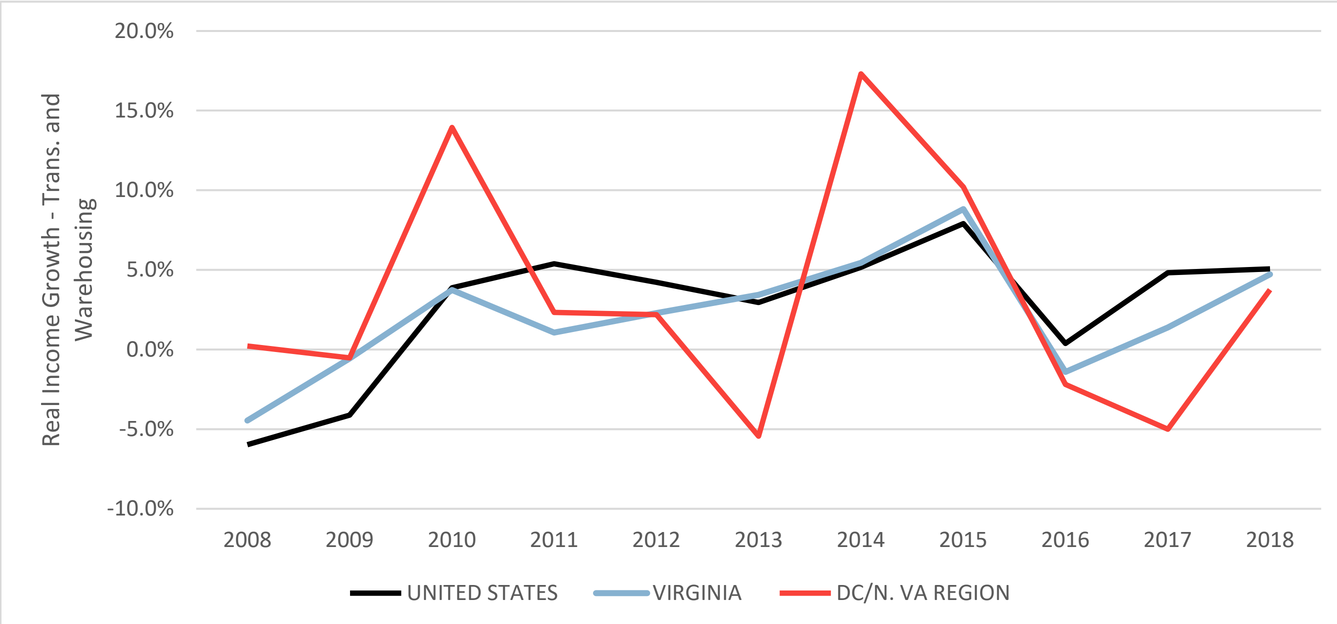
**Figure 3.8: Total Employee Real Earnings in the Transportation and Warehouse Sector**




Source: Woods & Poole

Year over year, total real earnings has had significant variation in the DC region. After the recession, the transportation and warehousing industry saw total earnings rise by almost 10%, only to drop to a 5% reduction by 2013. This was followed by a large rise in 2014 of almost 17%, culminating in a drop of around 5% in 2017. While the degree to which real income growth rises and falls year-over-year is significant compared to the state and nation as a whole, the growth trajectory follows roughly a similar pattern across the industry. This significance indicates that the transportation and warehouse sector is of significant importance to the local economy.

**Figure 3.9: Total Employee Real Earnings in the Transportation and Warehouse Sector**




Source: Woods & Poole

## 3.2 LOCAL LAND USE AND DEVELOPMENT

Loudoun County's growth can be traced back to the opening of IAD in the early 1960's. Since then, significant greenfield and agricultural land has been developed both north and west of the airport. Much of this land has become large residential developments, with planned communities in Ashburn, Sterling, and other communities expanding the Washington D.C. suburban area. According to the U.S. Census Bureau, the number of housing units in Loudoun County has increased from about 7,000 in 1960 to over 100,000 in 2010.[4] Much of this growth has come in the form of single-family developments scattered throughout Loudoun County, but mostly concentrated in the eastern half. Near major roadways and highways, such continued growth has spurned condo developments and other densifying developments. This is true especially off the Greenway, where growth near intersections like Ryan Road or Old Ox Road has been occurring for many years.

[4] Government of Loudoun County, "Loudoun County Housing Units – 2017 Estimate" https://www.loudoun.gov/DocumentCenter/View/120297/Housing-Units---Historic-and-2017-Estimate-Series-PDF?bidId=

**Figure 3.10: Existing and Future Residential Development near the Dulles Greenway**


Source: Google Maps, 2018

Of special note for regional traffic more generally, is the number of warehousing, storage, and tech firms that have been moving to the area because of the historic availability of relatively large amounts of land, access to a major international airport and the nation's capital. According to Loudoun Virginia Economic Development, Loudoun County is the world's largest concentration of data centers, with over 13 million square feet of operating facilities and another 4.5 million in development as of 2018. These data centers serve the likes of major tech firms that have offices in the area, such as Google[5], Verizon[6], and Amazon. While data centers tend to have lower employment ratios than other growing industries, their presence around eastern Loudoun County is currently extensive and continues to grow.

Because of its proximity, a number of cargo, warehousing, and supply storage facilities operate on the outskirts of Dulles International Airport. In 2016, Dulles moved over 250,000 tons of cargo.[7] Major facilities off Old Ox Road, Pacific Boulevard, Route 28, Loudoun County Parkway and Waxpool Road are home to a number of industrial parks with wholesale supply

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[5] Loudoun Virginia Economic Development, "Google Confirms $1.2 billion Loudoun Investment," June 11, 2019 https://biz.loudoun.gov/2019/06/11/google-loudoun-billion/

[6] Loudoun Virginia Economic Development, "Major Employers" (Verizon is ranked 4th, and is the top private employer) https://biz.loudoun.gov/information-center/major-employers/

[7] Loudoun Virginia Economic Development, "Transportation" https://biz.loudoun.gov/site-selection/transportation/

companies, cargo and freight forwarders, and other logistics-based companies. These new developments are important to the Greenway because of the cargo and commuter traffic they generate; the econometric model shows that these facilities are directly driving truck traffic growth on the Greenway, as discussed further in Chapter 5.

**Figure 3.11: Warehouse Developments North of Dulles Airport**


Source: Google Maps, 2018

# 4 BENEFITS TO USERS

## 4.1 INTRODUCTION

Users of the Greenway benefit from time savings, reliability, reduced operating costs, and safety that the toll road offers when compared to the alternative routes. This chapter provides a quantitative and qualitative evaluation of those benefits. The analysis is performed on a per trip basis that incorporates data on the average vehicle occupancy per trip.

## 4.2 OVERVIEW OF METHODOLOGY

The benefit assessment was conducted by WSP in keeping with the guidance of the U.S. Department of Transportation for the conduct of benefit cost evaluations and other best practices in user benefit analysis for surface transportation facilities.[8] The guidance on methods and assumptions is cited throughout this chapter where individual aspects of the analysis are discussed.

Several classes of users were considered to ensure proper representation of how users may value time based on their trip purpose or class of vehicle.

- Personal and Commuting
- Business
- Airport Access/Egress
- Trucks

The analysis also involved the identification of several performance measures and input assumptions. These measures include the following.

- Travel Time and Reliability Benefits
  - Monetary Value of Travel Time Savings (VTTS)
  - Monetary Value of Reliability (VOR)
  - Travel time savings for travelers on the Greenway with respect to alternative routes
  - Buffer time savings (increased reliability) for travelers on the Greenway with respect to alternative routes
- Vehicle Operating Cost Savings
  - Fuel consumption by speed of travel
  - Reduced fuel consumption and cost per mile
  - Other variable operating costs per mile
  - Fixed operating costs per mile
- Safety Benefits
  - Crash rate history for the Dulles Greenway and Commonwealth of Virginia
  - Crash unit costs values
  - Crash cost savings for travelers on the Greenway with respect to alternative routes

The basis for each measure and steps in the calculation are detailed in the sections below.

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[8] U.S. Department of Transportation*, Benefit-Cost Analysis Guidance for Discretionary Grant Programs*, 2018. (USDOT 2018)

## 4.3 MARKET SEGMENTS

Guidance on the development of highway user benefit assessments suggests the analysis be conducted on the basis of user market segments to ensure that variations in user behavior and preferences are appropriately considered in the evaluation.[9] The four primary market segments of the Dulles Greenway are outlined below.

**Table 4.1: Dulles Greenway User Classes**

| USER CLASS | DESCRIPTION | PROPORTION OF TRANSACTIONS |
|---|---|---|
| Personal and Commuting | Trips by private motor vehicles to and from work and to and from other personal activities such as school, shopping, service providers, medical care, and similar trip purposes. | 67.9% |
| Business | Trips taken by private motor vehicles during the course of official business for private industry or government. Examples include travel by employees or self-employed individuals to visit clients, or to make deliveries or pick-ups. Because these activities occur "on-the-clock" during the business day with expenses typically reimbursed by employers or considered a the cost of doing business, this user class may have different preference for valuation of travel time or route choice. | 22.1% |
| Airport Access/Egress | In the Dulles Greenway Corridor, a proportion of travelers are using the roadway to make trips to and from IAD. This class of travelers may have different preference for valuation of travel time and route choice because of the importance of on-time arrival. | 7.4% |
| Trucks | The Dulles Greenway vehicle Classes 2 through 4 (i.e. vehicles with 3 or more axles) are evaluated separately to account for the higher applicable toll rates and differences in the value of travel time savings and route choice related to the increased expenses and requirements in the operation of heavy vehicles. | 2.6% |
| **Total** | | **100.0%** |

Source: WSP

While the Dulles Greenway does not have the ability to track customers or transactions based on trip purpose, the proportion of transactions by market segment has been based on the following information.

[9] U.S. Department of Transportation, *Benefit-Cost Analysis Guidance for Discretionary Grant Programs*, 2018. (USDOT 2018)

- Personal commuting and business travel is based on the proportion of home-based work trips and home based shopping and other trips (personal and commuting) along with other non-home based trip purposes (business trips) observed in the National Capital Region Transportation Planning Board travel demand model, which includes Fairfax and Loudoun counties and surrounding areas.[10]
- Airport access and egress is based on observed daily traffic counts (collected for a single week annually and extrapolated to represent annual conditions by traffic engineer Dewberry Engineers, Inc. on behalf of the Greenway) at entry and exit ramps on the Greenway for the Dulles Access Road as a proportion of total daily Greenway traffic as reported by the Dulles Greenway.
- Truck trip proportion is based on Class 2 through 4 (i.e. vehicles with 3 or more axles) transactions as a proportion of total transactions in 2018 data obtained from the Dulles Greenway.

## 4.4 TRAVEL TIME AND RELIABILITY BENEFITS

Time savings and reliability of travel time are important benefits the Greenway affords users. With differences in posted speeds and congested travel times, the Greenway offers consistent travel time savings with respect to the alternative routes (see **table 2.5**) at every time of day. This section outlines assumptions for the monetary valuation of travel time savings and reliability, and the latest estimates of the magnitude of travel times savings that the Greenway provides to customers.

### *4.4.1 VALUE OF TRAVEL TIME SAVINGS*

The monetary value of travel time savings (VTTS) is an important assumption in the estimation of user benefits for surface transportation facilities. This measure indicates the dollar value that travelers can be assumed to consider when evaluating travel time savings and route choice. The measure is based on generally observed behavior and is linked to income, wages, and related measures, dependent on the purpose of the trip. The basis for the assumption for each market segment considered in this evaluation is outlined below.

**PERSONAL AND COMMUTE TRIPS**

In keeping with USDOT Guidance, VTTS for personal and commute trips is estimated from median annual household income converted into an hourly value. (USDOT 2018). To provide a measure reflecting the prevailing income characteristics of Greenway users, WSP established the median household income for Loudoun and Fairfax counties as these are the major residential and business activity centers in the vicinity of the Greenway. Data from the latest U.S. Census Bureau American Community Survey (2017) is provided in **Table 4.2**, below.

[10] Metropolitan Washington Council of Governments, Calibration Report for the TPB Travel Demand Model v. 2.3, 2012. (TPB 2012)

**Table 4.2: Median Annual Household Income and Median Income per Hour**

| HOUSEHOLD LOCATION | NUMBER OF HOUSEHOLDS | WEIGHT | MEDIAN ANNUAL HOUSEHOLD INCOME (2017 $) | MEDIAN HOURLY HOUSEHOLD INCOME (2017 $) |
|---|---|---|---|---|
| Loudoun County | 121,299 | 24% | $129,588 | $62.30 |
| Fairfax County | 393,380 | 76% | $117,515 | $56.50 |
| Total / Weighted Average | **514,679** | **100%** | **$120,360** | **$57.87** |

Source: Analysis by WSP of U.S. Census Bureau data, 2019. Note: Median Hourly Income = Median Annual Household Income / 2,080 hours; weights and weighted average are based on each county's share of the total number of households in Loudoun and Fairfax counties.

The steps in the calculation of value of time based on study area household income is shown below in **Table 4.3**. The recommended value for personal and commute trips is 50 percent of the median hourly income based on 2,080 hours per year (USDOT 2018). Values have been adjusted from 2017 to 2019 values based on observed inflation rates.[11] Adjustments are also made for estimated vehicle occupancy for home-based work trips.[12]

**Table 4.3: Calculation of VOT per Vehicle (Personal and Commuting Trips)**

| MEASURE | | VALUE | NOTES |
|---|---|---|---|
| a) | Median Annual Household Income (2017 $) | $120,360 | Weighted average household income per hour as noted in Table 4.2, above |
| b) | Hours | 2,080 | Annual work hours |
| c) | Median Hourly Household Income (2017 $) | $57.87 | a / b |
| d) | CPI Adjustment 2017 to 2019 | 1.0457 | CPI – U.S. all urban consumers (Bureau of Labor Statistics 2019) |
| e) | Median Hourly Income (2019 $) | $60.51 | c x d |
| f) | VOT Recommended Value (@ 50% of median hourly income) | $30.26 | Valued at 50% of median income per hour as recommended in USDOT Guidance. (USDOT 2018) |
| g) | Vehicle Occupancy | 1.06 | MWCOG average auto occupancy for home-based work trips. (TPB 2012). |
| h) | VTTS per Vehicle | **$32.07** | f x h |

Source: Analysis by WSP, 2019.

[11] U.S. Bureau of Labor Statistics, Consumer Price Index for All U.S. Urban Consumers (CPI).

[12] TPB 2012.

### BUSINESS TRIPS

Business trips are made while travelers are "on-the-clock" for travel to and from business meetings, client visits, or related activities and so are valued in accordance with the regional median hourly wage in keeping with established guidance (USDOT 2018). This measure is based on median hourly wage data rather than an hourly measure of household income. Specific steps in the calculation are outlined below.

**Table 4.4: Calculation of VOT per Vehicle (Business Trips)**

| MEASURE | VALUE | NOTES |
|---|---|---|
| a) Median Hourly Income (2018 $) | $26.29 | Median hourly wage, all occupations, Washington-Arlington-Alexandria, DC-VA-MD-WV metropolitan statistical area (Bureau of Labor Statistics 2019). |
| b) CPI Adj 2018 to 2019 | 1.0165 | CPI – U.S. all urban consumers (Bureau of Labor Statistics 2019). |
| c) Median Hourly Income (2019 $) | $26.72 | a x b |
| d) Adjustment for Benefits | 1.4880 | Employer costs for employee compensation (Bureau of Labor Statistics 2019). |
| e) Full Median Hourly Income (2019 $) | $39.76 | c x d |
| f) VOT Recommended Value<br>(@ 100% of median hourly income) | $39.76 | Valued at 100% of median income per hour as recommended in guidance (USDOT 2019). |
| g) Vehicle Occupancy | 1.11 | MWCOG average auto occupancy for non-home-based work trips (TPB 2012). |
| h) VTTS per Vehicle | **$44.13** | f x h |

Source: Analysis by WSP, 2019.

### AIRPORT ACCESS/EGRESS TRIPS

Trips to and from IAD are assumed to have a higher value of time than typical commute and personal trips. This is based on observations in studies and surveys of airport access-egress trips, which indicate that airport travel is valued based on the increased importance of on-time arrival and the higher overall value of a long-distance trip made on airline for personal or business reasons. These studies indicate that airport access-egress trips are generally valued at 1.35x typical personal or commute trips.[13]

**Table 4.5: Calculation of VOT per Vehicle (Airport Access/Egress Trips)**

| MEASURE | VALUE | NOTES |
|---|---|---|
| a) VOT per Vehicle (Personal and Commuting Trips) | **$32.07** | See Row H in Table 4.3, above. |
| b) Increased value for airport access/egress | 1.35 | TRB 2016. |
| c) Median Hourly Income (2019 $) | **$43.29** | a x b |

Source: Analysis by WSP, 2019.

[13] Transportation Research Board Paper 16-4101, *Measuring Air Carrier Passengers Values of Time by Trip Component*, 2016 (TRB 2016).

### TRUCK TRIPS

The recommended process for establishing the VTTS for truck trips is based on the non-fuel operating costs of heavy vehicles used for commercial trips. These costs include the average wages and benefits of the driver to provide a comprehensive measure of operations cost.[14] WSP identified the components of these costs from the latest available national survey of commercial vehicle operators published by the American Transportation Research Institute. [15]

**Table 4.6: Average Non-Fuel Marginal Costs per Mile (Truck Operations)**

| COST CATEGORY | COST PER MILE (2017 $) |
|---|---|
| ***Vehicle-based*** | |
| Truck/Trailer Lease or Purchase Payments | $0.26 |
| Repair & Maintenance | $0.17 |
| Truck Insurance Premiums | $0.08 |
| Permits and Licenses | $0.02 |
| Tires | $0.04 |
| ***Driver-based*** | |
| Driver Wages | $0.56 |
| Driver Benefits | $0.17 |
| **TOTAL:** | **$1.30** |

Source: American Transportation Research Institute, An Analysis of the Operational Costs of Trucking: 2018 Update.

Specifics steps in the calculation of VTTS for Truck trips are outlined below. The base operating costs are transformed to hourly basis by accounting for average vehicle speeds, and values are adjusted to 2019 basis.

**Table 4.7: Calculation of VOT per Vehicle (Truck Trips)**

| MEASURE | VALUE | NOTES |
|---|---|---|
| a) Operating Costs per Mile (2017 $) | $1.30 | Non-Fuel operating cost per mile as outlined in Table 1.6, above. |
| b) Average Speed (mph) | 56.34 | Metropolitan Washington, D.C. average truck speeds from Bureau of Transportation Statistics, Freight Facts and Figures, 2017. |
| c) Non-Fuel Operating Costs per Hour (2017 $) | $73.02 | a x b |
| d) CPI Adjustment 2017 to 2019 | 1.0457 | CPI – U.S. all urban consumers, Bureau of Labor Statistics, 2019 |
| e) VTTS per Vehicle | **$76.35** | c x d |

Source: Analysis by WSP, 2019.

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14 Texas Transportation Institute, *Value of Delay Time for Use in Mobility Monitoring Efforts*, 2017 (TTI, 2017).

15 American Transportation Research Institute, *An Analysis of the Operational Costs of Trucking: 2018 Update* (ATRI 2018).

#### VALUE OF TRAVEL TIME SAVINGS BY MARKET SEGMENT

The VTTS for each market segment considered in the Dulles Greenway user benefit evaluation is summarized in the table below.

**Table 4.8: Summary of VTTS ($ per hour) per Trip Type**

| TRIP TYPE | VTTS (2019 $/HOUR) |
|---|---|
| Personal and Commute Trips | $32.07 |
| Business Trips | $44.13 |
| Airport Access / Egress Trips | $43.29 |
| Truck Trips | $76.35 |

Source: Analysis by WSP, 2019.

### 4.4.2 VALUE OF RELIABILITY

While the value of travel time savings is critical to understanding the benefits of a transportation option, so too is travel time reliability, which refers to the predictability and variation of travel times over multiple trips. So even if the average travel time savings is not significant, a user can receive significant benefit by not having to plan for significant variations from the average travel time due to unreliability. The Federal Highway Administration has recommended the measurement and valuation of trip reliability as a factor in measuring the value of existing or planned highway resources. The performance measures used by WSP in this analysis are outlined below.

#### PERFORMANCE MEASURES FOR TRAVEL TIME RELIABILITY

Average travel time on a highway route, even when calculated separately for peak and off-peak times of day, does not tell the full story of the distribution of likely travel times and the reliability of a trip, given variations in recurring and non-recurring delay. The Federal Highway Administration indicates that travelers who require certainty in arrival times, take these variations into accounts, planning trips according a perception of the worst-case travel time rather than an average or typical journey time. With this in mind, the agency recommends several performance measures to better understand variations in typical travel times and the ultimate level of reliability in a trip.[16]

— Free-Flow Travel Time: The time it would take to traverse a route with no delay due to congestion or incidents.

— Average (Mean) Travel Time: The observed mean in a distribution of observed travel times along a particular route.

— Planning Time: The 95$^{th}$ percentile travel time in a distribution of observed travel times along a particular route. For a higher degree of precision, a long time series of observations is recommended.

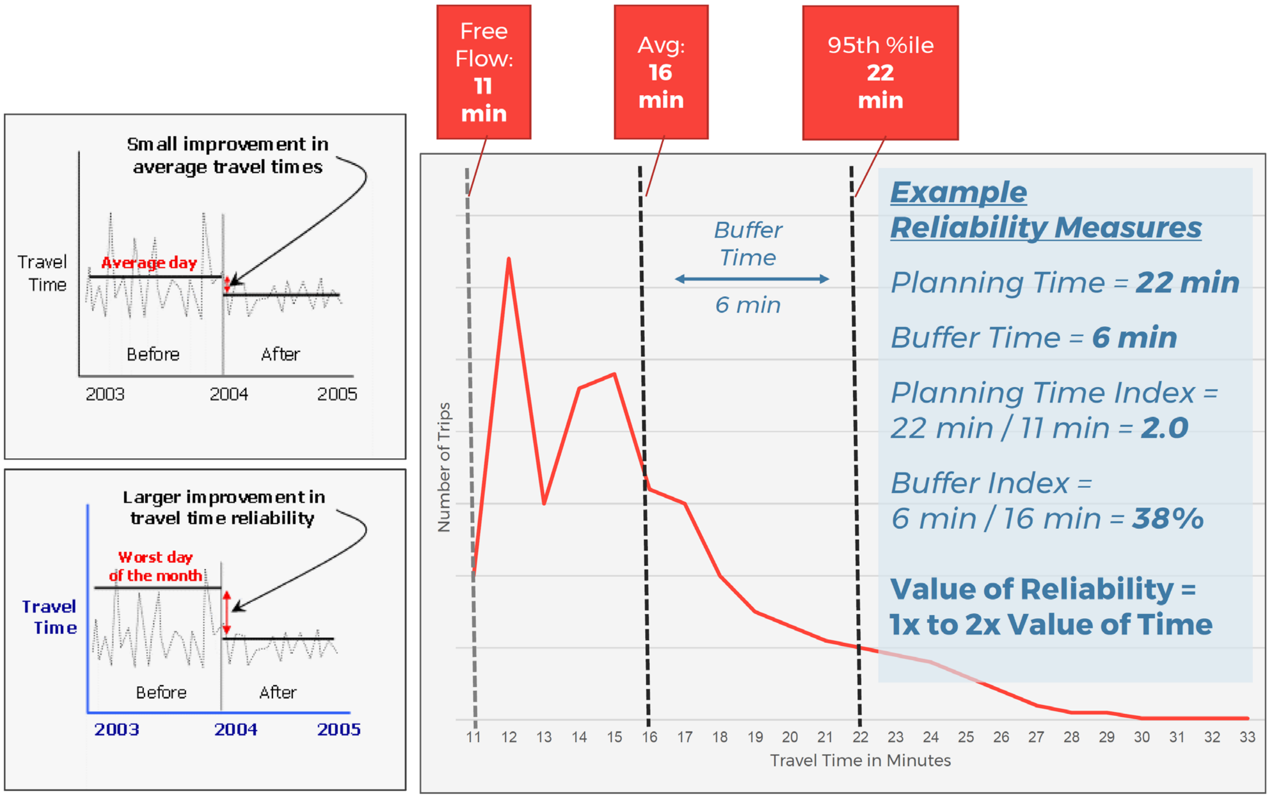
— Planning Time Index: The ratio of the Planning Time to Free Flow Time. A planning time index of 2.0 would indicate a traveler would need to budget twice the uncongested travel time to be confident of on-time arrival

— Buffer Time: The difference between the Planning Time and the Average Time. This is a measure of the number of additional minutes a traveler would need to budget for a trip to be confident of on-time arrival.

[16] Federal Highway Administration, *Travel Time Reliability: Making It There On-Time, All the Time*, 2017 (FHWA 2017).

**Figure 4.1** provides an illustration of these measures. The figure shows how a small improvement in average travel time attributable to new highway capacity can be accompanied by a greater increase in reliability.

**Figure 4.1: Travel Time Reliability Performance Measure Examples**




Source: Federal Highway Administration, Travel Time Reliability: Making It There On-Time, All the Time, 2017

### MONETARY VALUE OF REDUCED BUFFER TIME (VALUE OF RELIABILITY)

The literature on travel time reliability indicates that highway travelers value the certainty of on-time arrival or the reduction in buffer time more highly than the value of travel time savings itself. This bonus for value of reliability (VOR) has been found to vary from 1.0x to 3.0x the base VTTS,[17] with studies of commute trips averaging 10 miles suggesting the value of 1.5x .[18] For the purposes of this analysis, therefore, a VOR at 1.5x the level of VTTS for each market segment Is assumed. This value sits at the center of a wide range of study findings and is consistent with the value observed for commute trips of a distance similar the length of the Greenway.[19]

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[17] Strategic Highway Research Program Synthesis Report, *Workshop on the Value of Travel Time Reliability*, 2012.

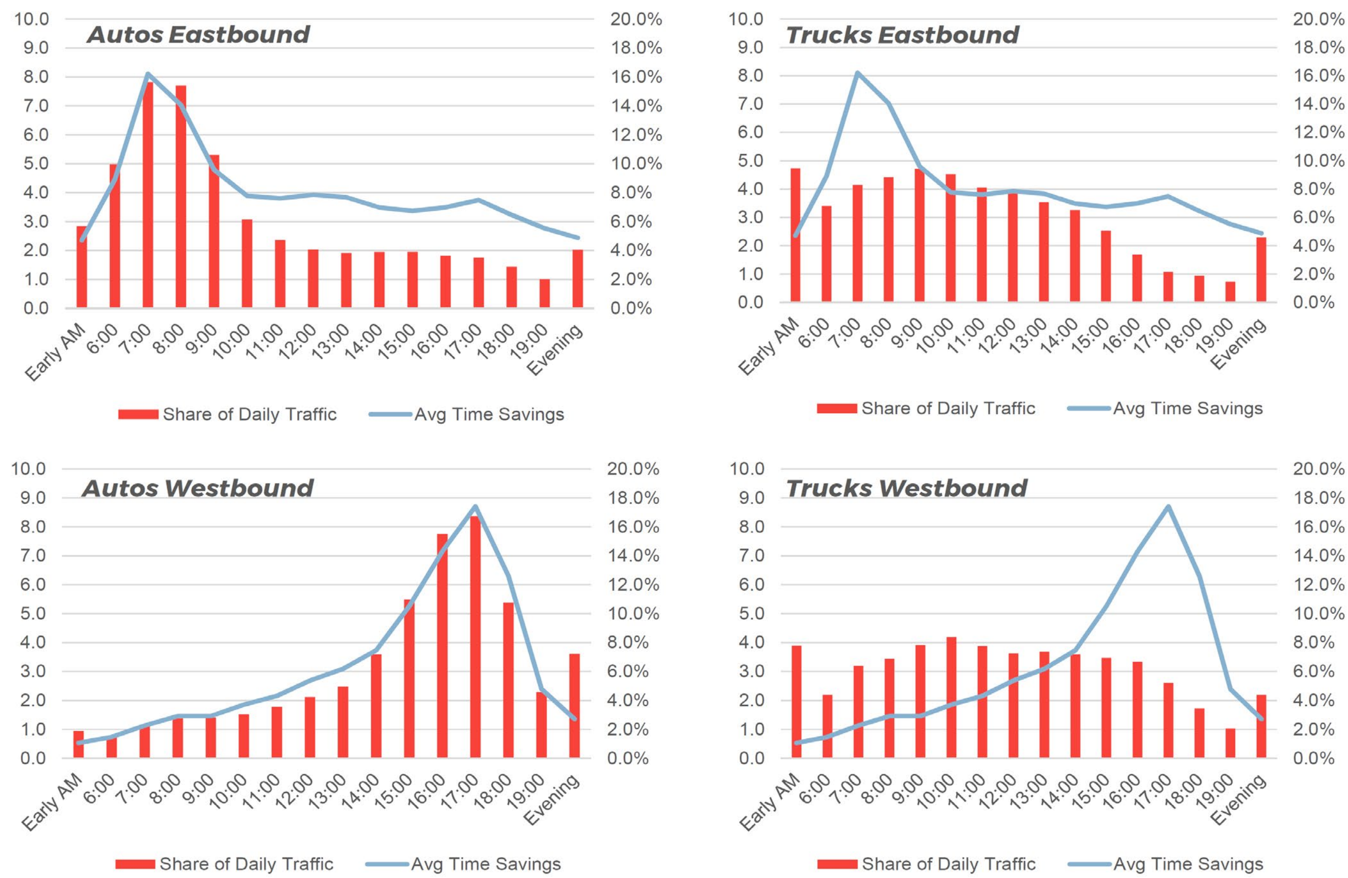
[18] Strategic Highway Research Program 2 Report CO4, *Improving Our Understanding of How Highway Congestion and Pricing Affect Travel Demand*, 2013.

[19] Strategic Highway Research Program Synthesis Report, *Workshop on the Value of Travel Time Reliability*, 2012; Strategic Highway Research Program, *Value of Travel Time Reliability in Transportation Decision Making,* 2014.

## 4.4.3 *TRAVEL TIME SAVINGS AND RELIABILITY BENEFITS FOR DULLES GREENWAY USERS*

With higher free flow speeds, lower levels of congestion, and lower incidence of recurrent and non-recurrent delays, the Dulles Greenway provides benefits in travel times savings and reliability to users at all times of day. WSP quantified these benefits through an examination of travel time data for July 2018 through June 2019 obtained from TomTom International BV.[20] The travel time savings provided by the Greenway with respect to Alternative 1 vary by hour and typically range from 2 to 3 minutes during off-peak hours and off-peak direction of travel to 5 to 8 minutes during peak periods in the peak direction of flow. The comparison is being made to Alternative 1 because it is the primary, free alternative route that effectively serves the same areas as the Greenway and receives significant usage.

**Figure 4.2: Travel Time Savings (DG vs Alt 1) and Share of Total Traffic (DG) by Time of Day, Autos and Trucks**




Source: Analysis by WSP of travel time data obtained from TomTom, and Dulles Greenway transactions counts, 2019.

**Figure 4.2**, above shows the average daily travel time savings for the Greenway versus Alternative 1 for a full-distance trip. The travel time savings are displayed in minutes along with the share of total daily trips for autos and for trucks. The data plots indicate that for auto trips, there is a close correspondence between the hours in which most trips occur and the hours in which the highest level of travel time savings is observed. The data also shows the peak direction of flow for auto trips is Eastbound in the morning hours and Westbound in the evening hours, typically of commute trips flowing from suburban

[20] Dulles Greenway, Travel time data from subscription service provided by TomTom International BV for July 1, 2018 through June 30, 2019 (TomTom 2019). This data is collected from TomTom GPS devices being used by drivers on the relevant routes that are then aggregated and anonymized for the purposes of traffic analysis.

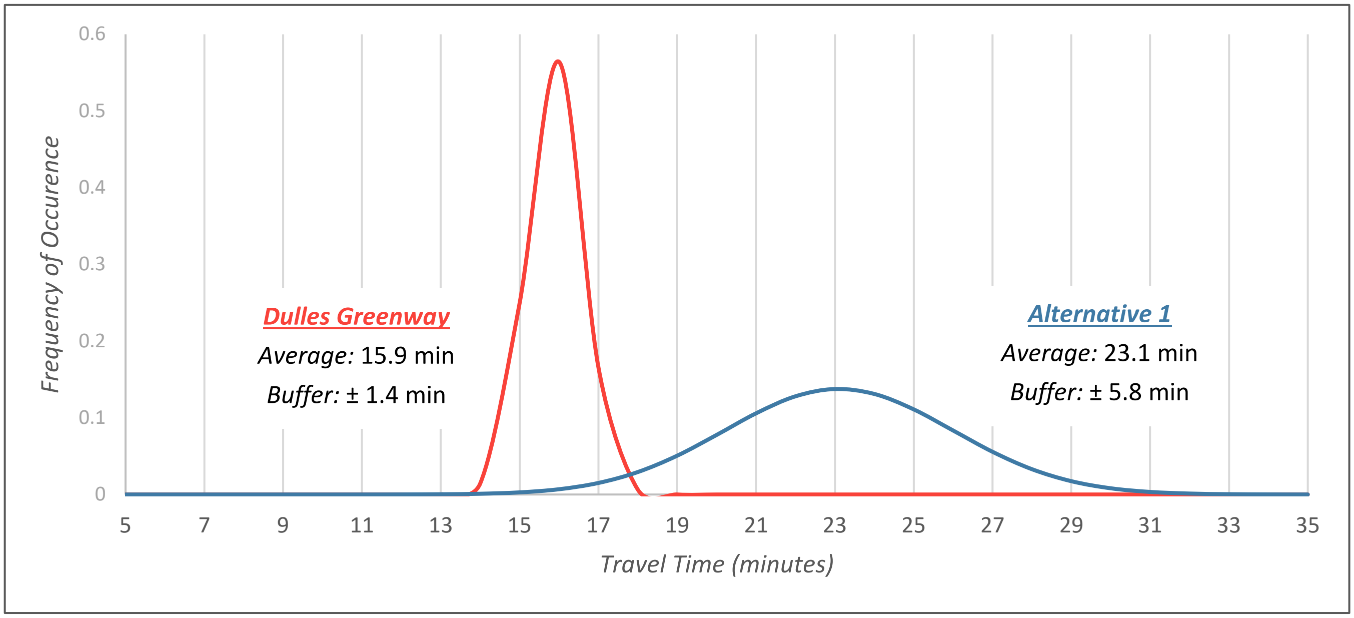
residential centers in Loudoun County and employment centers in Fairfax and further East in Arlington and the District of Columbia.

The pattern for trucks indicates no similar correspondence between the proportion of daily trips by hour and travel time savings indicating that timing of truck trips may be governed by departure and arrival time considerations that differ markedly from auto trips and are centered in the midday period in each direction of travel.

As noted above, reliability benefits are associated with variation in buffer times between routes. To calculate the buffer times for the Dulles Greenway and the alternative routes, WSP analyzed the travel time data (TomTom 2019) which provides mean, median, and standard deviation of travel times by segment on the Dulles Greenway and the alternative routes for the entire year from July 1, 2018 through June 30, 2019. The buffer time was estimated by comparing the total travel time for 2 standard deviations to the mean travel time for each route.

**Figure 4.3**, below, provides an illustration of the variation in travel times for the Greenway and Alternative 1. The Greenway displays a relatively tight distribution that typically varies no more than 1.4 minutes around a mean of 15 minutes for a typical peak period (AM and PM peaks combined). Alternative 1 displays a much wider variation in travel times varying by nearly 6 minutes around a peak period average of 23 minutes.

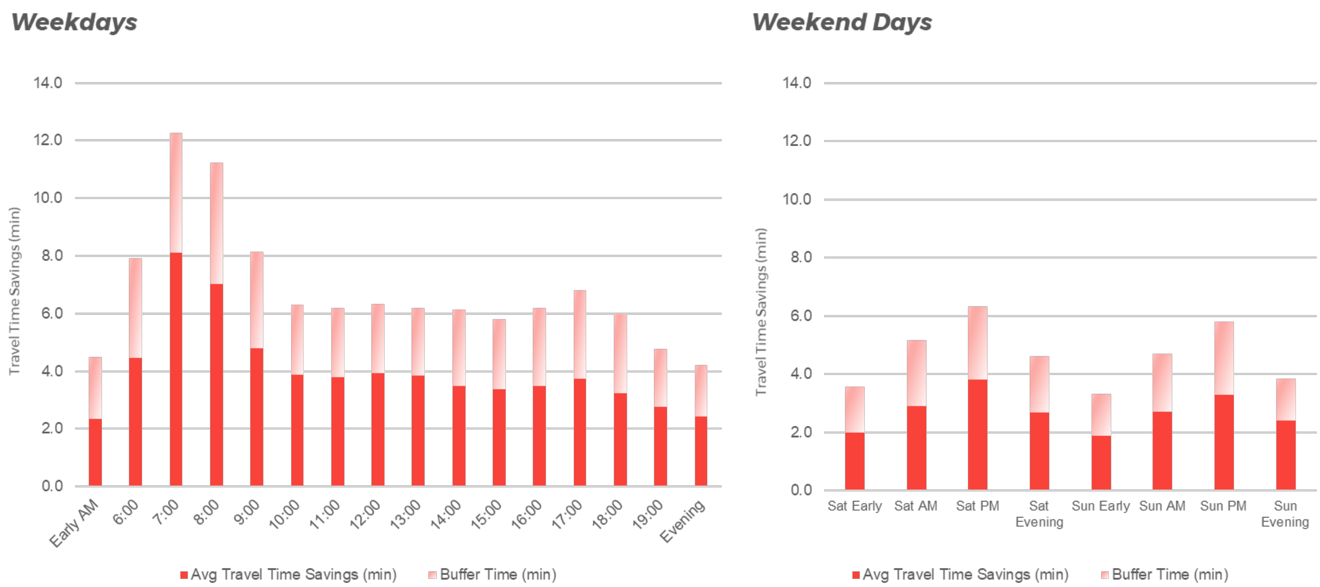
**Figure 4.3: Example Travel Time Distributions, Dulles Greenway vs. Alt 1, Weekday Peak Hours**




Source: Analysis by WSP of travel time data obtained from TomTom, 2019.

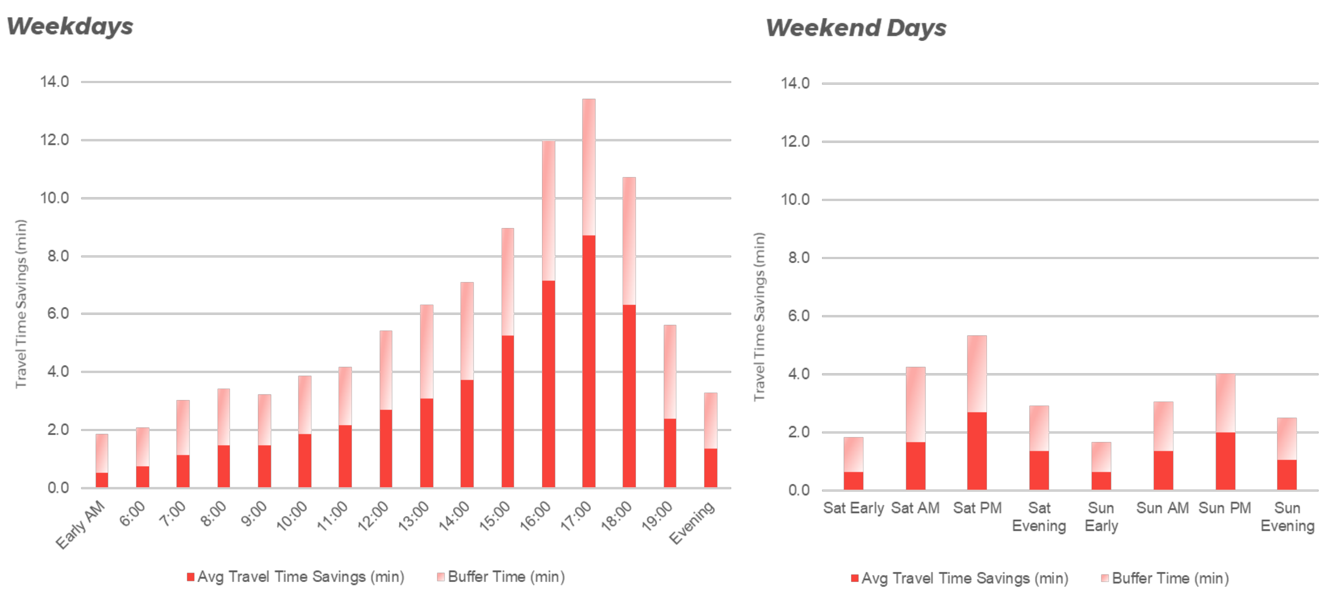
The buffer time savings (95th percentile travel time savings) by hour during weekdays and by period on weekends are shown below in **Figure 4.4 and 4.5**, below, along with the average travel time savings for the Greenway versus Alternative 1.

**Figure 4.4: Difference in Full Route Travel Time by Time of Day, Dulles Greenway vs. Alternative 1, Eastbound**




Source: Analysis by WSP of travel time data obtained from TomTom, 2019.

**Figure 4.5: Difference in Full Route Travel Time by Time of Day, Dulles Greenway vs. Alternative 1, Westbound**




Source: Analysis by WSP of travel time data obtained from TomTom, 2019.

To provide the basis for travel time and reliability estimates by time period, WSP aggregate the hourly observations by calculating average travel time savings weighted by the number of transactions by hour in each time period. The findings are detailed in the tables below.

**Table 4.9: Trip-Weighted Travel Time Savings and Buffer Time Savings *(in minutes)*, Dulles Greenway vs. Alternative 1, Autos**

| TIME OF DAY | DULLES GREENWAY TRAVEL TIME | ALT 1 TRAVEL TIME | **TRAVEL TIME SAVINGS** | DULLES GREENWAY BUFFER TIME | ALT 1 BUFFER TIME | **BUFFER TIME SAVINGS** |
|---|---|---|---|---|---|---|
| Weekday Peak | 15.9 | 23.1 | **7.2** | 1.4 | 5.8 | **4.4** |
| Weekday Off-Peak | 13.9 | 17.1 | **3.2** | 1.3 | 3.9 | **2.6** |
| Weekend Peak | 13.7 | 16.9 | **3.3** | 0.9 | 3.5 | **2.6** |
| Weekend Off-Peak | 13.8 | 16.0 | **2.2** | 0.9 | 3.0 | **2.1** |

Source: Analysis by WSP, 2019.

**Table 4.10: Trip-Weighted Travel Time Savings and Buffer Time Savings *(in minutes)*, Dulles Greenway vs. Alternative 1, Trucks**

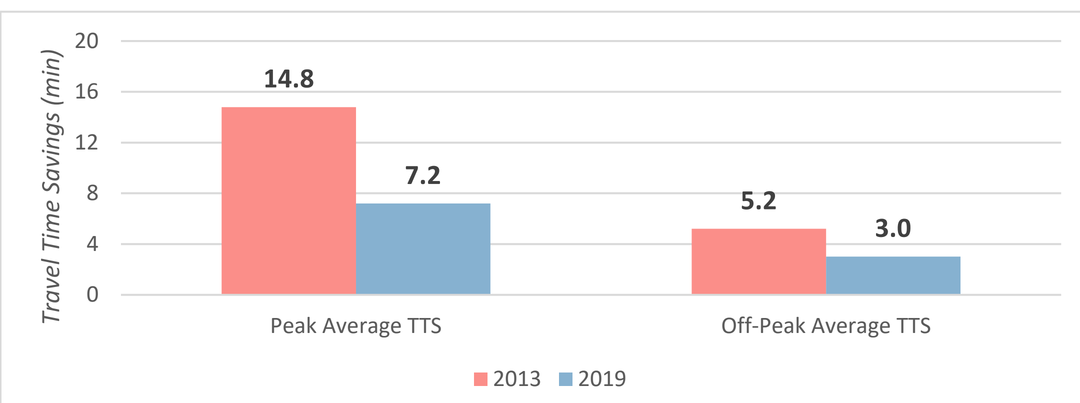
| TIME OF DAY | DULLES GREENWAY TRAVEL TIME | ALT 1 TRAVEL TIME | **TRAVEL TIME SAVINGS** | DULLES GREENWAY BUFFER TIME | ALT 1 BUFFER TIME | **BUFFER TIME SAVINGS** |
|---|---|---|---|---|---|---|
| Weekday Peak | 15.6 | 22.6 | **7.0** | 1.4 | 5.7 | **4.3** |
| Weekday Off-Peak | 13.9 | 16.8 | **2.8** | 1.3 | 3.7 | **2.4** |
| Weekend Peak | 13.7 | 16.9 | **3.2** | 0.9 | 3.5 | **2.6** |
| Weekend Off-Peak | 13.9 | 15.9 | **2.0** | 0.9 | 3.0 | **2.1** |

Source: Analysis by WSP, 2019.

## *4.4.4 CHANGES IN TRAVEL TIME SAVINGS OVER TIME*

Travel time savings between the Dulles Greenway and Alternative 1 (Routes 7 and 28) have decreased substantially over time as at-grade signalized intersections on this alternative route have been removed and replaced with overpasses.

**Figure 4.6: Estimated Difference in Travel Time Savings (DG vs. Alt 1), 2013 to 2019**




Source: 2013 data from TRIP II/AECOM; 2019 data from analysis by WSP of travel time data obtained from TomTom

## 4.4.5 MONETARY VALUE OF TRAVEL TIME SAVINGS AND RELIABILITY TO USERS

WSP has estimated the VTTS and the VOR in 2019 based on the valuation input assumptions outlined in **Sections 4.4.1 and 4.4.2** along with the travel time and reliability parameters presented in **Section 4.4.3.**

**Table 4.11: Dulles Greenway Time and Reliability Savings when compared to Alternative 1**

| MARKET SEGMENT | VTTS (2019 $ / HR /TRIP) | VOR (2019 $ / HR /TRIP) | TIME SAVINGS (MIN) | RELIABILITY SAVINGS (MIN) | TIME SAVINGS (2019 $) | RELIABILITY SAVINGS (2019 $) | TOTAL VALUE OF TRAVEL TIME SAVINGS (2019 $) |
|---|---|---|---|---|---|---|---|
| **Weekday Peak** | | | | | | | |
| Personal and Commuting | $32.07 | $48.11 | 7.2 | 4.4 | $3.85 | $3.49 | **$7.34** |
| Business | $44.13 | $66.20 | 7.2 | 4.4 | $5.29 | $4.81 | **$10.10** |
| Airport Access/Egress | $43.29 | $64.94 | 7.2 | 4.4 | $5.19 | $4.72 | **$9.91** |
| Trucks | $76.35 | $114.53 | 7.0 | 4.3 | $8.92 | $8.15 | **$17.07** |
| **Off-Peak (All Other Times and Directions)** | | | | | | | |
| Personal and Commuting | $32.07 | $48.11 | 3.0 | 2.6 | $1.62 | $2.05 | **$3.67** |
| Business | $44.13 | $66.20 | 3.0 | 2.6 | $2.23 | $2.82 | **$5.05** |
| Airport Access/Egress | $43.29 | $64.94 | 3.0 | 2.6 | $2.18 | $2.77 | **$4.95** |
| Trucks | $76.35 | $114.53 | 2.8 | 2.4 | $3.51 | $4.52 | **$8.03** |

Source: Analysis by WSP, 2019.

## 4.4.6 CONSIDERATION OF OTHER ALTERNATIVE ROUTES (ALTERNATIVES 2, 3, AND 4)

As noted in **Section 4.4.3**, above, Alternative 1, which runs along Routes 7 and 28, provides the main alternative route to the Dulles Greenway. Although it operates at a slower speed and higher travel time with respect to the Greenway at all times of day, Alternative 1 is more competitive with the Greenway in terms of travel time and overall distance than Alternatives 2, 3 or 4.

Alternatives 2, 3, and 4 may be the logical alternative route for some travelers, however, based on the location of their origin and destination or preference for a local secondary road over an arterial highway.

The Dulles Greenway maintains a program of collecting periodic traffic counts on the alternative routes to provide an indication of the volumes at several screenline locations that can be compared to segments of the Greenway. Screenlines are designed to measure traffic at locations that are comparable across routes. Screenline B, which is located on the Greenway between Belmont Ridge Road and Claiborne Road interchanges provides a central location for comparison of the alternative routes. **Figure 4.7**, below shows the location of the traffic count locations (with B2 being the Greenway location, B1 being the location on Alternative 1 on SR 7, B3 for Alternative 2 on Sycolin Road, and B4 for Alternatives 3 and 4 on Evergreen Mills Road.

**Figure 4.7: Location of Traffic Count Stations – Screenline B**


Source: Dulles Greenway, 2018

**Table 4.12: Traffic Counts and Share of Total Volume at Screenline Location B, 2018**

| LOCATION/ROUTE | AVERAGE DAILY TRAFFIC COUNT | SHARE OF TOTAL TRAFFIC | SHARE BY ALTERNATIVE ROUTE |
|---|---|---|---|
| B2 – Dulles Greenway | 25,987 | 18.9% | - |
| B1 – Alternative 1 | 89,494 | 65.0% | 80.1% |
| B3 – Alternative 2 | 11,377 | 8.3% | 10.2% |
| B4 – Alternative 3/4 | 10,812 | 7.9% | 9.7% |

Source: Analysis by WSP of Dulles Greenway data, 2019.

As shown in **Table 4.12**, above, Alternative 1 carries 80.1% of the alternative route traffic at Screenline B with Alternatives 2 and 3/4 carrying the remainder. This indicates that it would be appropriate to consider the travel time savings that the Greenway provides with respect to Alternative 2, 3, and 4, in addition to Alternative 1, as it is possible that all routes carry a proportion of traffic seeking an alternative to the Greenway.

To provide an indication of the travel time savings on the full range of alternative routes, WSP developed a Composite Alternative with the performance on each route weighted by the share of traffic indicated in **Table 4.12**. The speed and travel time performance measures for the Composite Alternative are shown in **Tables 4.13 through 4.15**, below.

**Table 4.13: Composite Route Weighted Average Speed and Distance**

| MEASURE | ALTERNATIVE 1 | ALTERNATIVE 2 | ALTERNATIVE 3 AND 4 | **COMPOSITE ALTERNATIVE** |
|---|---|---|---|---|
| Traffic Share | 80% | 10% | 10% | 100% |
| Peak Average Speed (mph) | 37.6 | 29.7 | 23.0 | **35.4** |
| Off-Peak Average Speed (mph) | 50.1 | 34.6 | 26.3 | **46.2** |
| WE Peak Average Speed (mph) | 50.5 | 35.8 | 27.8 | **46.7** |
| WE OP Average Speed (mph) | 53.5 | 36.9 | 28.4 | **49.3** |
| Distance (miles) | 14.2 | 14.8 | 21.8 | **15.1** |

Source: Analysis by WSP of Dulles Greenway data and TomTom data, 2019.

**Table 4.14: Composite Route Weighted Average Travel Time Savings (TTS)**

| MEASURE | ALTERNATIVE 1 | ALTERNATIVE 2 | ALTERNATIVE 3 AND 4 | **COMPOSITE ALTERNATIVE** |
|---|---|---|---|---|
| Traffic Share | 80% | 10% | 10% | 100% |
| Peak Average TTS (min) | 7.2 | 13.5 | 22.0 | **9.3** |
| Off-Peak Average TTS (min) | 3.2 | 11.2 | 19.1 | **5.6** |
| WE Peak Average TTS (min) | 3.0 | 10.5 | 17.5 | **5.2** |
| WE OP Average TTS (min) | 2.0 | 9.7 | 16.6 | **4.3** |

Source: Analysis by WSP of Dulles Greenway data and TomTom data, 2019.

**Table 4.15: Composite Route Weighted Average Travel Time Savings (TTS)**

| MEASURE | ALTERNATIVE 1 | ALTERNATIVE 2 | ALTERNATIVE 3 AND 4 | **COMPOSITE ALTERNATIVE** |
|---|---|---|---|---|
| Traffic Share | 80% | 10% | 10% | 100% |
| Peak Average TTS (min) | 2.6 | 3.2 | 6.7 | **3.1** |
| Off-Peak Average TTS (min) | 2.0 | 2.9 | 5.5 | **2.4** |
| WE Peak Average TTS (min) | 1.9 | 2.6 | 4.7 | **2.3** |
| WE OP Average TTS (min) | 1.7 | 2.8 | 4.3 | **2.1** |

Source: Analysis by WSP of Dulles Greenway data and TomTom data, 2019.

Utilizing the estimates outlined above, WSP estimated measures of the monetary value of travel time savings and reliability for a total value of travel times savings for the Composite Alternative Route.

**Table 4.16: Dulles Greenway Time and Reliability Savings when compared to Composite Alternative**

| MARKET SEGMENT | VTTS (2019 $ / HR /TRIP) | VOR (2019 $ / HR /TRIP) | TIME SAVINGS (MIN) | RELIABILITY SAVINGS (MIN) | TIME SAVINGS (2019 $) | RELIABILITY SAVINGS (2019 $) | TOTAL VALUE OF TRAVEL TIME SAVINGS (2019 $) |
|---|---|---|---|---|---|---|---|
| **Peak** | | | | | | | |
| Personal and Commuting | $32.07 | $48.11 | 9.3 | 4.5 | $4.98 | $3.59 | **$8.56** |
| Business | $44.13 | $66.20 | 9.3 | 4.5 | $6.85 | $4.94 | **$11.79** |
| Airport Access/Egress | $43.29 | $64.94 | 9.3 | 4.5 | $6.72 | $4.84 | **$11.56** |
| Trucks | $76.35 | $114.53 | 9.1 | 4.4 | $11.61 | $8.40 | **$20.01** |
| **Off-Peak** | | | | | | | |
| Personal and Commuting | $32.07 | $48.11 | 5.4 | 2.9 | $2.87 | $2.29 | **$5.15** |
| Business | $44.13 | $66.20 | 5.4 | 2.9 | $3.95 | $3.15 | **$7.09** |
| Airport Access/Egress | $43.29 | $64.94 | 5.4 | 2.9 | $3.87 | $3.09 | **$6.96** |
| Trucks | $76.35 | $114.53 | 5.2 | 2.7 | $6.59 | $5.18 | **$11.77** |

Source: Analysis by WSP, 2019.

When compared to the values for Alternative 1 (see **Table 4.9**), the Dulles Greenway provides approximately 26% higher travel time savings in the peak and 57% travel time savings in the off-peak with respect to the Composite Alternative. The value of overall travel time and reliability savings is 22% higher in peak and 50% higher in off-peak for Greenway vs. Composite as compared to Greenway vs. Alternative 1.

For the discussion of other benefit cost performance measures (i.e., vehicle operating costs and safety benefits) outlined below, WSP included estimates for the Dulles Greenway with respect to Alternative 1 and the Composite Alternative.

## 4.5 VEHICLE OPERATING COST SAVINGS

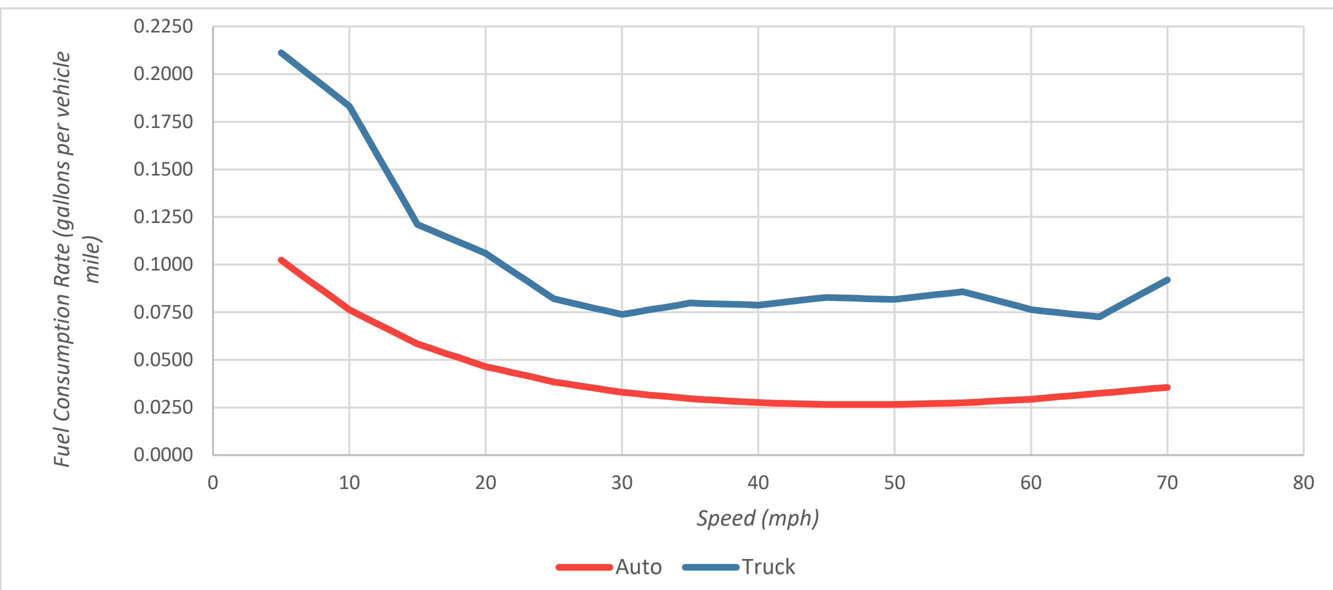
Another key element in the benefit to users that is provided by the Dulles Greenway is the savings in vehicle operating cost related to the reliably lower travel times and higher speeds on the Greenway in comparison to the alternative routess. This section outlines the key assumptions and methods used by WSP to estimate the operating cost savings.

### *4.5.1 FUEL CONSUMPTION AND COST*

The consumption of vehicle fuel varies by vehicle type and speed. This is of particular importance in the evaluation of vehicle operating costs between the Dulles Greenway and the alternative routes, as they operate at differing speed profiles, especially during peak periods, as noted in **Section 4.4**, above.

The rate of fuel consumption by vehicle type and speed of travel is derived from data maintained for the State of California cost-benefit model for mobile-source emissions, which is a commonly accepted industry standard used to analyze transportation projects of this kind across the country.[21]

**Figure 4.8: Fuel Consumption (gal/VMT) by Vehicle Type and Speed of Travel (mph)**




Source: California Life-Cycle Benefit/Cost Analysis Model (Cal-B/C) version 6.2, 2017.

[21] California Life-Cycle Benefit/Cost Analysis Model (Cal-B/C) version 6.2, 2017 (CalBC 2017).

The calculation of fuel costs from the consumption data is based on average retail fuel prices for gasoline and diesel in the region observed at the time of this analysis as published by the U.S. Energy Information Administration.[22] **Table 4.17**, below, shows the fuel cost assumption for autos and trucks.

**Table 4.17: Fuel Price Assumptions (2019 $ per Gallon)**

| VEHICLE / FUEL TYPE | FUEL COST (AS OF JULY 29, 2019) |
|---|---|
| Autos (regular gasoline pump price average) | $2.79 |
| Trucks (on-highway diesel pump price average) | $3.25 |

Source: U.S. Energy Information Administration (Central Atlantic Region), 2019

## *4.5.2 OTHER VARIABLE VEHICLE OPERATING COSTS*

There are other elements of vehicle operating costs that vary by distance and that can be affected by the type of highway facility on which travel takes place. These non-fuel operating costs include repair and maintenance related to vehicle equipment and tire wear. Assumptions for the value of these costs are derived from standard industry sources and are displayed in the tables below.[23]

**Table 4.18: Non-Fuel Variable Operating Costs (2019 $ per mile), Autos**

| EXPENSE TYPE | COST |
|---|---|
| Tires and Wear | $0.08 |

Source: AAA Average Personal Auto Costs, 2018

**Table 4.19: Non-Fuel Variable Operating Costs (2019 $ per mile), Trucks**

| EXPENSE TYPE | COST |
|---|---|
| Repair and Maintenance | $0.17 |
| Tires | $0.04 |
| **TOTAL:** | **$0.21** |

Source: American Transportation Research Institute, An Analysis of the Operational Costs of Trucking: 2018 Update.

[22] U.S. Energy Information Administration (Central Atlantic Region), 2019

[23] AAA Average Personal Auto Costs, 2018 (AAA 2018), and ATRI 2019.

### 4.5.3 FIXED VEHICLE OPERATING COSTS

Fixed costs for the operation of motor vehicles estimated on a per-mile basis for vehicle travel are also included in the calculation.[24] Values and sources are as specified in the tables below, which are the same for the Greenway and all alternatives.

**Table 4.20: Non-Fuel Fixed Operating Costs (2019 $ per mile), Autos**

| EXPENSE TYPE | COST |
|---|---|
| Fixed Costs | $0.40 |

Source: AAA Average Personal Auto Costs, 2018

**Table 4.21: Non-Fuel Fixed Operating Costs (2019 $ per mile), Trucks**

| EXPENSE TYPE | COST |
|---|---|
| Truck/Trailer Lease or Purchase | $0.28 |
| Insurance Premiums | $0.08 |
| Permits and Licenses | $0.02 |
| Driver Wages | $0.58 |
| Driver Benefits | $0.18 |
| **TOTAL:** | **$1.14** |

Source: American Transportation Research Institute, An Analysis of the Operational Costs of Trucking: 2018 Update.

### 4.5.4 OPERATING COST SAVINGS FOR DULLES GREENWAY USERS

The total operating costs savings for the Dulles Greenway with respect to Alternative 1 and the Composite Alternative are based on relative differences in speed and travel distance on the routes. The steps in estimation include the following.

- Differences in speed by route are calculated from the travel time data (TomTom 2019).
- Based on the speed profile for vehicle type and speed, fuel consumption per mile is estimated for each route. Fuel consumption varies by speed as shown in **Figure 4.8.**
- Per mile costs for variable and fixed costs are also identified
- Costs are added to estimate a total cost per mile for each route, separately for autos and trucks.
- Per mile costs are multiplied by route distance for the Greenway, Alternative 1, and the Composite Alternative.
- The savings for the Greenway is estimated by comparing costs with Alternative 1 and the Composite Alternative.

[24] Fixed costs include insurance, license and registration fees, permits, taxes, depreciation and finance charges.

**Table 4.22 and 4.23**, below displays the assumptions and calculation steps noted above.

**Table 4.22: Dulles Greenway Time and Reliability Savings when compared to Alternative 1**

| ROUTE | SPEED (MPH) | FUEL CONSUMPTION (GAL/MI) | | FUEL COST PER MILE | | VARIABLE COSTS PER MILE | | FIXED COSTS PER MILE | | TOTAL COST PER MILE | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | AUTO | TRUCK | AUTO | TRUCK | AUTO | TRUCK | AUTO | TRUCK | AUTO | TRUCK |
| **Peak** | | | | | | | | | | | |
| Dulles Greenway | 55.3 | 0.028 | 0.086 | $0.08 | $0.28 | $0.08 | $0.21 | $0.40 | $1.14 | $0.56 | $1.63 |
| Alternative 1 | 37.6 | 0.029 | 0.079 | $0.11 | $0.36 | $0.12 | $0.30 | $0.40 | $1.14 | $0.63 | $1.80 |
| Composite Alternative | 35.4 | 0.030 | 0.080 | $0.12 | $0.36 | $0.12 | $0.30 | $0.40 | $1.14 | $0.64 | $1.80 |
| **Off-Peak** | | | | | | | | | | | |
| Dulles Greenway | 62.4 | 0.031 | 0.075 | $0.09 | $0.24 | $0.08 | $0.21 | $0.40 | $1.14 | $0.57 | $1.60 |
| Alternative 1 | 50.6 | 0.027 | 0.082 | $0.10 | $0.37 | $0.12 | $0.30 | $0.40 | $1.14 | $0.62 | $1.81 |
| Composite Alternative | 46.7 | 0.027 | 0.083 | $0.10 | $0.38 | $0.12 | $0.30 | $0.40 | $1.14 | $0.62 | $1.82 |

Source: Analysis by WSP, 2019.

**Table 4.23: TOTAL OPERATING COST DIFFERENCE PER TRIP**

| ROUTE | DISTANCE (MI) | PER TRIP COST | | **SAVINGS PER GREENWAY TRIP** | |
|---|---|---|---|---|---|
| | | Auto | Truck | Auto | Truck |
| **Peak** | | | | | |
| Dulles Greenway | 14.44 | $8.14 | $23.59 | | |
| Alternative 1 | 14.24 | $9.02 | $25.66 | **$0.87** | **$2.07** |
| Composite Alternative | 15.06 | $9.58 | $27.17 | **$1.44** | **$3.58** |
| **Off-Peak** | | | | | |
| Dulles Greenway | 14.44 | $8.27 | $23.08 | | |
| Alternative 1 | 14.24 | $8.89 | $25.81 | **$0.63** | **$2.73** |
| Composite Alternative | 15.06 | $9.40 | $27.35 | **$1.14** | **$4.27** |

Source: Analysis by WSP, 2019.

Overall, the vehicle operating cost savings for the Greenway are estimated to range from $0.56 in off-peak to $0.89 peak for autos with respect to Alternative 1, and $1.10 to $1.49 respectively for the Composite Alternative. Truck operating costs savings are higher as noted above.

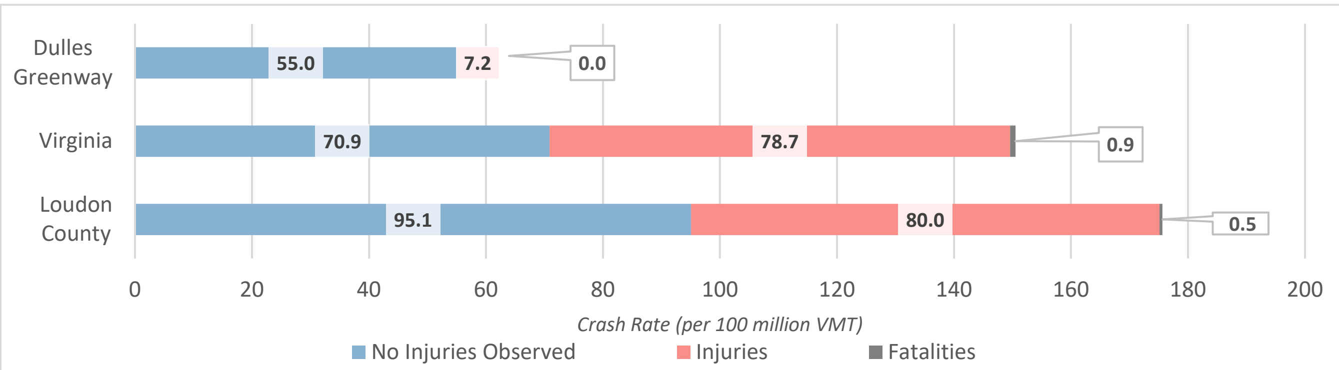
## 4.6 SAFETY BENEFITS

Data on the incidence of motor vehicle crashes on the Dulles Greenway indicates that it provides a measurable benefit in safety over the alternative routes. This section establishes the magnitude of that benefit and the monetary value to users.

### *4.6.1 MOTOR VEHICLE CRASH RATES*

The Dulles Greenway maintains statistics on the incidence of crashes on the facility which are classified by those involving injuries, fatalities, or property damage only. The Commonwealth of Virginia also maintains similar annual statistics on crash rates for all primary and secondary roadways in the state as a whole and crashes in individual counties. **Figure 4.9** below displays the rate of motor vehicle crashes in the last five years per 100 million vehicle miles traveled (VMT). The chart illustrates the difference in rates between the Greenway, Virginia as a whole, and all primary and secondary routes in Loudoun County (including the Dulles Greenway).

**Figure 4.9: Crash Rates: Incidence of Motor Vehicle Crashes by Severity per 100 million VMT, Five-Year Average**




Source: Analysis by WSPfrom data obtained from the Dulles Greenway and the Virginia Department of Motor Vehicles, 2019.

The data which is the basis for the crash rates displayed above are presented in the tables below. The five most recent years of available data are referenced: Greenway (2014-2018) and Loudoun and Commonwealth (2013-2017).

**Table 4.24: Dulles Greenway Motor Vehicle Crashes by Year and Type, and Estimated Crash Rates**

| YEAR | CRASHES WITH NO OBSERVED INJURY | CRASHES WITH INJURIES | CRASHES WITH FATALITIES | ANNUAL VMT *(IN MILLIONS)* |
|---|---|---|---|---|
| 2014 | 75 | 13 | 0 | 163.4 |
| 2015 | 85 | 10 | 0 | 167.5 |
| 2016 | 94 | 11 | 0 | 173.0 |
| 2017 | 105 | 15 | 0 | 173.7 |
| 2018 | 102 | 11 | 0 | 160.6 |
| **TOTAL**: | 461 | 60 | 0 | 838.2 |

| Rate per 100 million in VMT: | 55.0 | 7.2 | 0.0 | - |
|---|---|---|---|---|

Source: Analysis by WSP of data supplied by Dulles Greenway/TRIP II, 2019.

**Table 4.25: Commonwealth of Virginia Motor Vehicle Crashes by Year and Type, and Estimated Crash Rates**

| YEAR | CRASHES WITH NO OBSERVED INJURY | CRASHES WITH INJURIES | CRASHES WITH FATALITIES | ANNUAL VMT *(IN MILLIONS)* |
|---|---|---|---|---|
| 2013 | 55,908 | 65,114 | 741 | 80,258 |
| 2014 | 56,198 | 63,384 | 700 | 80,985 |
| 2015 | 60,018 | 65,029 | 753 | 82,970 |
| 2016 | 60,472 | 67,292 | 761 | 84,278 |
| 2017 | 61,226 | 65,306 | 843 | 85,964 |
| **TOTAL**: | 293,822 | 326,125 | 3,798 | 414,455 |
| | | | | |
| ***Rate per 100 million in VMT:*** | **70.9** | **78.7** | **0.9** | **-** |

Source: Commonwealth of Virginia Department of Motor Vehicles, 2017 Virginia Crash Facts.

**Table 4.26: Loudoun County Motor Vehicle Crashes by Year and Type, and Estimated Crash Rates**

| YEAR | CRASHES WITH NO OBSERVED INJURY | CRASHES WITH INJURIES | CRASHES WITH FATALITIES | ANNUAL VMT *(IN MILLIONS)* |
|---|---|---|---|---|
| 2013 | 2,269 | 1,917 | 13 | 2,536 |
| 2014 | 2,158 | 2,123 | 12 | 2,588 |
| 2015 | 2,681 | 2,143 | 11 | 2,598 |
| 2016 | 2,632 | 2,289 | 12 | 2,676 |
| 2017 | 2,794 | 2,081 | 22 | 2,785 |
| **TOTAL**: | 12,534 | 10,553 | 70 | 13,183 |
| | | | | |

| | | | | |
|---|---|---|---|---|
| ***Rate per 100 million in VMT:*** | **95.1** | **80.0** | **0.5** | **-** |

Source: Analysis by WSP of Comm. of Virginia Department of Motor Vehicles, Crash Data, 2019; VDOT Annual VMT Publications.

### 4.6.2 MONETARY VALUE OF MOTOR VEHICLE CRASHES

The monetary value of motor vehicle crashes is established by reference to guidance on direct costs associated with property damage and medical care. These costs are commonly referred to as the economic valuation of motor vehicle crashes. A more complete measure of the costs associated with crashes includes the opportunity cost of lost wages, reduced productivity and enjoyment associated with crashes involving injury and loss of life. This is commonly referred to as a comprehensive valuation and is based on accepted accounting of the value of a statistical life. With its more complete accounting of direct and indirect costs, the comprehensive valuation is inclusive of and substantially higher than the economic valuation. The comprehensive approach has become the standard recommendation of USDOT for transportation cost benefit studies as discussed below.

The economic and comprehensive valuations are presented in **Table 4.27**, below as available from two commonly referenced sources: the National Safety Council and the USDOT. These costs are based on the costs to each individual involved in a crash (per person costs) based on the severity of the crash on the KABCO scale outlined in the table. The National Safety Council average economic cost in column 1 only considers direct out of pocket costs such as medical care and property damage, while columns two and three include a more comprehensive valuation that takes into account opportunity cost and reduced productivity. Differences between the comprehensive valuations recommended by National Safety Council and USDOT are not apparent from the documentation provided but are most likely based on differences in the estimation of the total value of a statistical life.

**Table 4.27: Valuation Options: Cost per Person Involved in a Motor Vehicle Crash by Severity**

| SEVERITY | AVERAGE ECONOMIC COST – NATIONAL SAFETY COUNCIL (2017 $) | AVERAGE COMPREHENSIVE COST – NATIONAL SAFETY COUNCIL (2017 $) | USDOT DISCRETIONARY GRANT BCA GUIDANCE COMPREHENSIVE COST (2018 $) |
|---|---|---|---|
| Death (K) | $1,615,000 | $10,662,200 | $9,600,000 |
| Disabling (A) | $93,800 | $1,155,000 | $459,100 |
| Evident (B) | $27,100 | $318,000 | $125,000 |
| Possible (C) | $22,300 | $147,000 | $63,900 |
| No injury observed (O) | $11,900 | $48,700 | $3,200 |

Source: National Safety Council, Guide to Calculating Cost of Motor Vehicle Injuries 2018, Benefit Cost Analysis Guidance for Discretionary Grant Programs, 2018.

It should be noted that the USDOT Guidance recommends a comprehensive approach to crash valuation on a per person basis.[25] For the purposes of this analysis WSP used the USDOT recommended values adjusted to crash unit values as noted below.

The table above shows the cost per person involved in a crash of varying magnitude, however, in order to adequately assess the cost per crash, one needs to consider the average number of people per crash. FHWA has analyzed this, and has provided the below comprehensive costs per crash, which are comparable to the USDOT figures but are expressed in 2016 dollar terms.[26] The table below provides an update to 2019 values per CPI.

**Table 4.28: Recommended Valuation of Comprehensive Cost per Crash by Severity**

| SEVERITY | RECOMMENDED CRASH UNIT COST (2016 $) | CPI ADJUSTMENT (2016-2019)[27] | RECOMMENDED CRASH UNIT COST (2019 $) |
|---|---|---|---|
| Death (K) | $11,295,400 | 1.063 | $12,004,239 |
| Disabling (A) | $655,000 | 1.063 | $696,104 |
| Evident (B) | $198,500 | 1.063 | $210,957 |
| Possible (C) | $125,600 | 1.063 | $133,482 |
| No injury observed (O) | $11,900 | 1.063 | $12,647 |

Source: Federal Highway Administration, Crash Costs for Highway Safety Analysis, 2018.

The commonly accepted KABCO scale provides the full level of detail for reporting on crash severity. The data available to WSP for this analysis aggregates the crashes involving injury. To provide an equivalent aggregation for the crash unit costs WSP refers to the share of crashes noted in FHWA 2018 and outlined in the Table below.

**Table 4.29: Estimated Share of Total Crashes and Crashes with Injuries**

| SEVERITY | SHARE OF CRASHES | SHARE OF INJURY CRASHES |
|---|---|---|
| Death (K) | 0.15% | - |
| Disabling (A) | 0.76% | 6.08% |
| Evident (B) | 8.74% | 69.64% |
| Possible (C) | 3.81% | 30.36% |
| No injury observed (O) | 86.53% | - |

[25] USDOT 2018.

[26] Federal Highway Administration, *Crash Costs for Highway Safety Analysis*, 2018 (FHWA 2018).

[27] U.S. Bureau of Labor Statistics, Consumer Price Index for All U.S. Urban Consumers (CPI).

Source: Federal Highway Administration, Crash Costs for Highway Safety Analysis, 2018.

With the share of crashes involving injury identified by level of severity, WSP developed a weighted average cost for the aggregation of crashes involving injury. The final assumption for crash unit valuation used in this evaluation are presented in the table below.

**Table 4.30: Assumed Crash Cost Valuation**

| SEVERITY | COST PER CRASH (2019 $) |
|---|---|
| Crash with no observed injury (O) | $12,647 |
| Injury Crash (Weighted ABC) | $229,781 |
| Fatal Crash (K) | $12,004,239 |

Source: Analysis by WSP of Federal Highway Administration, Crash Costs for Highway Safety Analysis, 2018.

### 4.6.3 SAFETY BENEFITS FOR DULLES GREENWAY USERS

By applying the monetary valuation for each crash to the crash rates for the Greenway and the alternative routes, WSP determined a per trip savings in crash costs for travel on the Greenway. This estimate includes the following steps and assumptions.

- Comprehensive crash unit costs for crashes with no observed injury, crashes with injury, and fatal crashes are estimated through the process outlined in **Section 4.6.2**, above.
- These values are multiplied by crash rates identified in **Section 4.6.1**, above to estimate a total cost for the Greenway and alternative routes. For the alternative routes WSP assumed the average crash rates for the Commonwealth of Virginia as a whole to be representative of the crash rates on those routes. This assumption matches that employed in previous analyses prepared by the Greenway.
- The annual VMT for the Greenway is used to convert the total cost per 100 million VMT to a cost per trip on the Greenway.
- The difference between the per trip crash on the Greenway versus the alternative routes is calculated.

**Table 4.31: Savings in Avoided Crash Costs, Dulles Greenway vs. Alternative Routes**

| SEVERITY | COST PER CRASH (2019 $) | CRASHES PER 100 MILLION IN VMT GREENWAY | CRASHES PER 100 MILLION IN VMT ALTERNATIVE ROUTES | COST PER 100 MILLION IN VMT GREENWAY | COST PER 100 MILLION IN VMT ALTERNATIVE ROUTES |
|---|---|---|---|---|---|
| Crash with no observed injury (O) | $12,647 | 55.00 | 70.9 | $695,559 | $896,576 |
| Injury Crash (Weighted ABC) | $229,781 | 7.16 | 78.7 | $1,644,820 | $18,080,928 |
| Fatal Crash (K) | $12,004,239 | 0.00 | 0.92 | $0 | $11,000,494 |
| **TOTAL:** | | 62.16 | 150.5 | $2,340,379 | $29,977,998 |
| | | | | | |
| | | | ***Cost per Trip:*** | $0.34 | $4.35 |
| | | | ***Savings Per Trip for Greenway Users:*** | $4.01 | - |

Source: Analysis by WSP, 2019.

The application of the methods and assumptions outlined above yield and estimate crash cost of $0.34 per trip on the Greenway and $4.35 on the alternative routes. This is reflective of the substantial differences in the rate of crashes with injuries and crashes with fatalities on the Greenway versus the overall Commonwealth average.

## 4.7 ESTIMATE OF TOTAL BENEFITS TO USERS

Total benefits to users of the Dulles Greenway are comprised of the monetary value of direct travel times savings, the reduction in buffer time (reliability savings), reduction in vehicle operating costs, and the overall value in avoided crash cost expenses (safety benefits). This section provides a summary of the overall benefit to users from a full-length trip perspective for the Greenway versus Alternative 1, and the Greenway versus the Composite Alternative. Also provided is a discussion on the benefits to users making shorter distance trips on the Greenway.

### *4.7.1 TOTAL BENEFITS FOR USERS, GREENWAY WITH REPSECT TO ALTERNATIVE 1*

A summary of the estimated total user benefits is provided in Table 4.32 for each market segment for the peak and off-peak travel periods. This estimate is based on a comparison of the Dulles Greenway to Alternative 1. The analysis identifies total benefits that range from $8.30 to $14.79 for auto trips depending on the time of day and $14.77 to $23.15 for truck trips.

**Table 4.32: Total Monetary Benefit to Users per Trip by Market Segment and Savings Type, DG vs Alt 1 (2019 $)**

| MARKET SEGMENT | TIME SAVINGS | RELIABILITY SAVINGS | VEHICLE OPERATING COST SAVINGS | CRASH COST SAVINGS | **TOTAL BENEFIT** |
|---|---|---|---|---|---|
| **Peak** | | | | | |
| Personal and Commuting | $3.85 | $3.49 | $0.87 | $4.01 | **$12.22** |
| Business | $5.29 | $4.81 | $0.87 | $4.01 | **$14.98** |
| Airport Access/Egress | $5.19 | $4.72 | $0.87 | $4.01 | **$14.79** |
| Trucks | $8.92 | $8.15 | $2.07 | $4.01 | **$23.15** |
| **Off-Peak** | | | | | |
| Personal and Commuting | $1.62 | $2.05 | $0.63 | $4.01 | **$8.30** |
| Business | $2.23 | $2.82 | $0.63 | $4.01 | **$9.68** |
| Airport Access/Egress | $2.18 | $2.77 | $0.63 | $4.01 | **$9.59** |
| Trucks | $3.51 | $4.52 | $2.73 | $4.01 | **$14.77** |

Source: Analysis by WSP, 2019.

Because users of the Dulles Greenway choose to pay a toll for each trip they make on the facility, it can be expected that these customers perceive a total benefit per trip that is equal to or higher than the toll expense incurred. WSP's enumeration of the individual benefits indicates that Greenway customers accrue quantifiable benefits which are uniformly greater than the toll rate. **Table 4.33** displays the total estimated benefits outlined above against the full trip toll cost to calculate a total net benefit and a Benefit-Cost Ratio (BCR). The peak and off-peak estimates are combined into an all-day estimate based on the share of trips (transactions) by period. The evaluation indicates that auto customers receive a net benefit that ranges generally from $4.50 to $6.40 for all times of day combined, a ratio of benefit to toll cost of 1.9 to 2.2, depending on trip type. For trucks the net benefit is estimated at $8.55 in the peak and $2.62 in the off-peak for an all-day average of $3.67, a BCR of 1.3. For context, in 2013 AECOM reported net benefits between $1.13 and $7.49 for all trips during off-peak and peak hours, for a BCR between 1.3 and 2.5, respectively. Truck trips received a benefit between -$1.30 and $7.51, with a weighted average BCR of 1.2.

Weighting the net benefits by transactions to develop a total estimate for all trip types WSP concluded that net benefits for all users amount to $5.05 per trip a BCR of 2.0, overall. This is slightly higher than the overall AECOM BCR, which was 1.7.

**Table 4.33: Total Monetary Benefit to Users per Trip by Market Segment and Savings Type, DG vs Alt 1 (2019 $)**

| MARKET SEGMENT | SHARE OF TRIPS | TOTAL BENEFIT | TOLL COST | NET BENEFIT | BCR |
|---|---|---|---|---|---|
| **Peak** | | | | | |
| Personal and Commuting | 23.2% | $12.22 | $5.80 | $6.42 | 2.1 |
| Business | 7.6% | $14.98 | $5.80 | $9.18 | 2.6 |
| Airport Access/Egress | 2.5% | $14.79 | $5.80 | $8.99 | 2.5 |
| Trucks | 0.5% | $23.15 | $14.60 | $8.55 | 1.6 |
| *Weighted Average:* | **33.8%** | **$13.18** | **$5.92** | **$7.26** | **2.2** |
| **Off-Peak** | | | | | |
| Personal and Commuting | 44.7% | $8.30 | $4.75 | $3.55 | 1.7 |
| Business | 14.6% | $9.68 | $4.75 | $4.93 | 2.0 |
| Airport Access/Egress | 4.9% | $9.59 | $4.75 | $4.84 | 2.0 |
| Trucks | 2.1% | $14.77 | $12.15 | $2.62 | 1.2 |

| MARKET SEGMENT | SHARE OF TRIPS | TOTAL BENEFIT | TOLL COST | NET BENEFIT | BCR |
|---|---|---|---|---|---|
| *Weighted Average:* | **66.2%** | **$8.91** | **$4.99** | **$3.92** | **1.8** |
| **All Day** | | | | | |
| Personal and Commuting | 67.9% | $9.64 | $5.11 | $4.53 | 1.9 |
| Business | 22.1% | $11.49 | $5.11 | $6.38 | 2.2 |
| Airport Access/Egress | 7.4% | $11.36 | $5.11 | $6.26 | 2.2 |
| Trucks | 2.6% | $16.25 | $12.58 | $3.67 | 1.3 |
| *Weighted Average:* | **100.0%** | **$10.35** | **$5.30** | **$5.05** | **2.0** |

Source: Analysis by WSP, 2019.

### 4.7.2 TOTAL BENEFITS FOR USERS, GREENWAY WITH REPSECT TO THE COMPOSITE ALTERNATIVE

When the Greenway is compared to the Composite Alternative, the overall level of benefits is substantially higher than those seen when the Greenway is compared solely to Alternative 1. Total benefits for auto trips ranges from $10.30 to $17.23 depending on the trip purpose and time of day. Truck benefits are estimated at $20.05 per trip in the off-peak and $27.60 for the peak hours and direction of travel.

Overall, when compared to the Composite Alternative, the BCR ranges from 2.3 to 2.7 for the auto user market segments and 1.7 for trucks. Weighted by the number of transactions in each segment, the overall BCR is 2.4.

**Table 4.34: Total Monetary Benefit to Users per Trip by Market Segment and Savings Type, DG vs Composite Alt (2019 $)**

| MARKET SEGMENT | TIME SAVINGS | RELIABILITY SAVINGS | VEHICLE OPERATING COST SAVINGS | CRASH COST SAVINGS | **TOTAL BENEFIT** |
|---|---|---|---|---|---|
| **Peak** | | | | | |
| Personal and Commuting | $4.98 | $3.59 | $1.44 | $4.01 | **$14.01** |
| Business | $6.85 | $4.94 | $1.44 | $4.01 | **$17.23** |
| Airport Access/Egress | $6.72 | $4.84 | $1.44 | $4.01 | **$17.01** |
| Trucks | $11.61 | $8.40 | $3.58 | $4.01 | **$27.60** |
| **Off-Peak** | | | | | |
| Personal and Commuting | $2.87 | $2.29 | $1.14 | $4.01 | **$10.30** |
| Business | $3.95 | $3.15 | $1.14 | $4.01 | **$12.24** |
| Airport Access/Egress | $3.87 | $3.09 | $1.14 | $4.01 | **$12.10** |

| MARKET SEGMENT | TIME SAVINGS | RELIABILITY SAVINGS | VEHICLE OPERATING COST SAVINGS | CRASH COST SAVINGS | **TOTAL BENEFIT** |
|---|---|---|---|---|---|
| Trucks | $6.59 | $5.18 | $4.27 | $4.01 | **$20.05** |

Source: Analysis by WSP, 2019.

**Table 4.35: Total Monetary Benefit to Users per Trip by Market Segment and Savings Type, DG vs Composite Alt (2019 $)**

| MARKET SEGMENT | SHARE OF TRIPS | TOTAL BENEFIT | TOLL COST | NET BENEFIT | BCR |
|---|---|---|---|---|---|
| **Peak** | | | | | |
| Personal and Commuting | 23.2% | $14.01 | $5.80 | $8.21 | 2.4 |
| Business | 7.6% | $17.23 | $5.80 | $11.43 | 3.0 |
| Airport Access/Egress | 2.5% | $17.01 | $5.80 | $11.21 | 2.9 |
| Trucks | 0.5% | $27.60 | $14.60 | $13.00 | 1.9 |
| *Weighted Average:* | **33.8%** | **$15.14** | **$5.92** | **$9.22** | **2.6** |
| **Off-Peak** | | | | | |
| Personal and Commuting | 44.7% | $10.30 | $4.75 | $5.55 | 2.2 |
| Business | 14.6% | $12.24 | $4.75 | $7.49 | 2.6 |
| Airport Access/Egress | 4.9% | $12.10 | $4.75 | $7.35 | 2.5 |
| Trucks | 2.1% | $20.05 | $12.15 | $7.90 | 1.6 |
| *Weighted Average:* | **66.2%** | **$11.17** | **$4.99** | **$6.18** | **2.2** |
| **All Day** | | | | | |
| Personal and Commuting | 67.9% | $11.57 | $5.11 | $6.46 | 2.3 |
| Business | 22.1% | $13.94 | $5.11 | $8.83 | 2.7 |
| Airport Access/Egress | 7.4% | $13.78 | $5.11 | $8.67 | 2.7 |
| Trucks | 2.6% | $21.38 | $12.58 | $8.80 | 1.7 |
| *Weighted Average:* | **100.0%** | **$12.51** | **$5.30** | **$7.21** | **2.4** |

Source: Analysis by WSP, 2019.

### 4.7.3 CONSIDERATION OF BENEFITS FOR USERS MAKING SHORTER-DISTANCE TRIPS

In keeping with the evaluation conducted for the Dulles Greenway for previous toll rate adjustment requests, WSP has provided an estimate of total benefits based on full-length trips on the Greenway and the alternative routes as outlined in the sections above. WSP recognized, however, that a certain proportion of users make partial-length trips on the Greenway or alternatives depending on their route preference and/or origin-destination. The toll rate paid by these customers may not be proportional to trip-length, however, due to the structure of toll rates applicable at the Mainline toll plaza and the individual gantries at entry and exit ramps further west on the Greenway.

To calculate an estimate of the average toll based on entry and exit patterns, WSP conducted a review of the 2018 traffic counts and related analysis conducted by traffic engineer Dewberry Engineers, Inc. on behalf of the Greenway. **Tables 4.36** and **4.37**, below show estimated average daily volumes by entry and exit location. The tables illustrate that over 42,000 users daily pass through the Mainline Plaza in the eastbound and westbound directions, with a large majority of those users originating from or destined to Leesburg Bypass or other exits at the western end of the Dulles Greenway.

## Table 4.36: Estimated Average Daily Volumes by Entry and Exit Ramp, Eastbound, 2018

| ON/OFF | Leesburg Bypass (Rte 7) | Battlefield Parkway | Shreve Mill Rd | Belmont Ridge Road (Rte 659) | Claiborne Parkway (Rte 901) | Ryan Road (Rte 772/2020) | Loudoun County Pkwy (Rte 607) | Old Ox Road (Rte 606) | Mainline Plaza | |
|---|---|---|---|---|---|---|---|---|---|---|
| Leesburg Bypass (Rte 7) | - | 4,281 | 60 | 439 | 399 | 490 | 381 | 1,074 | 9,995 | 17,118 |
| Battlefield Parkway | - | - | 8 | 61 | 55 | 68 | 53 | 148 | 1,681 | 2,074 |
| Shreve Mill Rd | - | - | - | 25 | 22 | 27 | 21 | 60 | 681 | 836 |
| Belmont Ridge Road (Rte 659) | - | - | - | - | 47 | 58 | 45 | 128 | 1,469 | 1,747 |
| Claiborne Parkway (Rte 901) | - | - | - | - | - | 88 | 68 | 193 | 2,249 | 2,599 |
| Ryan Road (Rte 772/2020) | - | - | - | - | - | - | 71 | 199 | 2,341 | 2,611 |
| Loudoun County Pkwy (Rte 607) | - | - | - | - | - | - | - | 391 | 4,629 | 5,020 |
| Old Ox Road (Rte 606) | - | - | - | - | - | - | - | - | 2,648 | 2,648 |
| Mainline Plaza | - | - | - | - | - | - | - | - | - | |
| | | | | | | | | | | |
| | | 4,281 | 68 | 524 | 524 | 731 | 639 | 2,193 | 25,693 | |

Source: Analysis by WSP of Greenway Traffic Operations Report, Dewberry, 2018.

## Table 4.37: Estimated Average Daily Volumes by Entry and Exit Ramp, Westbound, 2018

| ON/OFF | Mainline Plaza | Old Ox Road (Rte 606) | Loudoun County Pkwy (Rte 607) | Ryan Road (Rte 772/2020) | Claiborne Parkway (Rte 901) | Belmont Ridge Road (Rte 659) | Shreve Mill Rd | Battlefield Parkway | Leesburg Bypass (Rte 7) | |
|---|---|---|---|---|---|---|---|---|---|---|
| Mainline Plaza | - | 2,677 | 3,885 | 2,848 | 1,931 | 1,629 | 800 | 2,927 | 10,361 | 27,059 |
| Old Ox Road (Rte 606) | - | - | 348 | 255 | 173 | 146 | 72 | 262 | 988 | 2,243 |
| Loudoun County Pkwy (Rte 607) | - | - | - | 87 | 59 | 50 | 24 | 89 | 357 | 665 |
| Ryan Road (Rte 772/2020) | - | - | - | - | 73 | 61 | 30 | 110 | 459 | 734 |
| Claiborne Parkway (Rte 901) | - | - | - | - | - | 47 | 23 | 84 | 359 | 513 |
| Belmont Ridge Road (Rte 659) | - | - | - | - | - | - | 31 | 115 | 496 | 643 |
| Shreve Mill Rd | - | - | - | - | - | - | - | 17 | 74 | 91 |
| Battlefield Parkway | - | - | - | - | - | - | - | - | 4,133 | 4,133 |
| Leesburg Bypass (Rte 7) | - | - | - | - | - | - | - | - | - | |
| | | | | | | | | | | |
| | | 2,677 | 4,233 | 3,190 | 2,235 | 1,933 | 981 | 3,605 | 17,227 | |

Source: Analysis by WSP of Greenway Traffic Operations Report, Dewberry, 2018.

The evaluation of the volumes at entry and exit points allows for the calculation of the benefits for trips and the corresponding toll cost for each entry and exit pairing. This calculation has the following key features.

- It is an aggregate estimate of toll costs and benefits for trips of various lengths (between each pair of possible entry and exit points).
- Toll costs are based on the estimated weighted average daily toll rate accounting for proportion of peak and off-peak toll traffic and proportion of traffic by vehicle class.
- Benefits are based on the estimated all-day weighted average of benefits per trip from the previous analysis (see table 4.35, above).
- The Composite Alternative Route was chosen because trips of varying lengths and origin-destination points may consider a route other than Alternative 1 as the competitive alternative to the Dulles Greenway.
- The calculation was prepared for each on-and-off trip pair and then summarized by trip length. Trips between on and off points where there is no toll assessed are summarized separately, as it is not possible to calculate a cost benefit ratio for trips with zero cost.

WSP conducted the evaluation using the following steps.

- Entry and exit patterns from the 2018 Dewberry traffic count report (DG Operations Report) were analyzed to create an estimate of the number of daily trips entering and exiting at ramp locations as shown in **Tables 4.36** and **4.37**, above.
- To determine the average toll applicable to each of the trip pairs, the daily average toll (weighted by proportion of peak and off-peak traffic by class) of $5.30 (see bottom row of **Table 4.35**, above) was assumed for full length trips and reduced for shorter length trips based on the current toll schedule by ramp.
- To determine the average benefit applicable to each of the trip pairs, the daily average total benefit per trip (weighted by proportion of peak and off-peak traffic by trip purpose) of $12.51 (see bottom row of **Table 4.35**) was assumed for full length trips and reduced for shorter length trip proportionally by the distance traveled. The average benefit estimate is inclusive of all travel time, reliability, operating cost and safety benefits, and is based on travel on the Dulles Greenway with respect to the Composite Alternative, as a variety of alternative routes are used by trips of varying lengths.
- A net benefit estimate for each trip pair was calculated by subtracting the toll cost from the estimated benefit.
- A summary by trip length categories (e.g., <2 miles, 2-4 miles) was also prepared with no-toll segments shown separately.
- Overall net benefit is $2.46 in EB direction and $2.68 WB direction when calculated in this manner.

Calculations and results are presented in **Tables 4.38** and **4.39** by entry and exit pair and then summarized by distance in **Tables 4.40** and **4.41**, below.

**Table 4.38: Estimated Benefits with Respect to Toll Costs Per Trip by Entry and Exit Point, Eastbound**

| Entry Point | Exit Point | AADT | Distance | Distance Category | Total Benefit | Toll Cost | Net Benefit | BCR |
|---|---|---|---|---|---|---|---|---|
| Leesburg Bypass (Rte 7) | Battlefield Parkway | 4,281 | 1.0 | x | $0.95 | $0.00 | $0.95 | N/A |
| Leesburg Bypass (Rte 7) | Shreve Mill Rd | 60 | 2.9 | b | $2.69 | $4.02 | ($1.32) | 0.7 |
| Leesburg Bypass (Rte 7) | Belmont Ridge Road (Rte 659) | 439 | 5.6 | c | $5.21 | $4.52 | $0.69 | 1.2 |
| Leesburg Bypass (Rte 7) | Claiborne Parkway (Rte 901) | 399 | 6.5 | c | $6.08 | $4.52 | $1.56 | 1.3 |
| Leesburg Bypass (Rte 7) | Ryan Road (Rte 772/2020) | 490 | 8.2 | d | $7.62 | $4.52 | $3.10 | 1.7 |
| Leesburg Bypass (Rte 7) | Loudoun County Pkwy (Rte 607) | 381 | 9.5 | e | $8.88 | $5.30 | $3.58 | 1.7 |
| Leesburg Bypass (Rte 7) | Old Ox Road (Rte 606) | 1,074 | 10.8 | e | $10.03 | $5.30 | $4.73 | 1.9 |
| Leesburg Bypass (Rte 7) | Mainline Plaza | 9,995 | 13.4 | f | $12.51 | $5.30 | $7.21 | 2.4 |
| Battlefield Parkway | Shreve Mill Rd | 8 | 1.9 | a | $1.74 | $4.02 | ($2.28) | 0.4 |
| Battlefield Parkway | Belmont Ridge Road (Rte 659) | 61 | 4.6 | b | $4.26 | $4.52 | ($0.26) | 0.9 |
| Battlefield Parkway | Claiborne Parkway (Rte 901) | 55 | 5.5 | c | $5.13 | $4.52 | $0.61 | 1.1 |
| Battlefield Parkway | Ryan Road (Rte 772/2020) | 68 | 7.2 | d | $6.67 | $4.52 | $2.14 | 1.5 |
| Battlefield Parkway | Loudoun County Pkwy (Rte 607) | 53 | 8.5 | d | $7.93 | $5.30 | $2.63 | 1.5 |
| Battlefield Parkway | Old Ox Road (Rte 606) | 148 | 9.7 | e | $9.08 | $5.30 | $3.78 | 1.7 |
| Battlefield Parkway | Mainline Plaza | 1,681 | 12.4 | f | $11.56 | $5.30 | $6.26 | 2.2 |
| Shreve Mill Rd | Belmont Ridge Road (Rte 659) | 25 | 2.7 | b | $2.52 | $4.52 | ($2.00) | 0.6 |
| Shreve Mill Rd | Claiborne Parkway (Rte 901) | 22 | 3.6 | b | $3.38 | $4.52 | ($1.14) | 0.7 |
| Shreve Mill Rd | Ryan Road (Rte 772/2020) | 27 | 5.3 | c | $4.92 | $4.52 | $0.40 | 1.1 |
| Shreve Mill Rd | Loudoun County Pkwy (Rte 607) | 21 | 6.6 | c | $6.19 | $5.30 | $0.89 | 1.2 |
| Shreve Mill Rd | Old Ox Road (Rte 606) | 60 | 7.9 | d | $7.34 | $5.30 | $2.03 | 1.4 |
| Shreve Mill Rd | Mainline Plaza | 681 | 10.5 | e | $9.82 | $5.30 | $4.51 | 1.9 |
| Belmont Ridge Road (Rte 659) | Claiborne Parkway (Rte 901) | 47 | 0.9 | a | $0.87 | $4.52 | ($3.65) | 0.2 |
| Belmont Ridge Road (Rte 659) | Ryan Road (Rte 772/2020) | 58 | 2.6 | b | $2.41 | $4.52 | ($2.12) | 0.5 |
| Belmont Ridge Road (Rte 659) | Loudoun County Pkwy (Rte 607) | 45 | 3.9 | b | $3.67 | $5.30 | ($1.63) | 0.7 |
| Belmont Ridge Road (Rte 659) | Old Ox Road (Rte 606) | 128 | 5.2 | c | $4.82 | $5.30 | ($0.48) | 0.9 |
| Belmont Ridge Road (Rte 659) | Mainline Plaza | 1,469 | 7.8 | d | $7.30 | $5.30 | $2.00 | 1.4 |
| Claiborne Parkway (Rte 901) | Ryan Road (Rte 772/2020) | 88 | 1.7 | a | $1.54 | $4.52 | ($2.98) | 0.3 |
| Claiborne Parkway (Rte 901) | Loudoun County Pkwy (Rte 607) | 68 | 3.0 | b | $2.81 | $5.30 | ($2.50) | 0.5 |
| Claiborne Parkway (Rte 901) | Old Ox Road (Rte 606) | 193 | 4.2 | b | $3.95 | $5.30 | ($1.35) | 0.7 |
| Claiborne Parkway (Rte 901) | Mainline Plaza | 2,249 | 6.9 | c | $6.43 | $5.30 | $1.13 | 1.2 |
| Ryan Road (Rte 772/2020) | Loudoun County Pkwy (Rte 607) | 71 | 1.4 | a | $1.27 | $5.30 | ($4.03) | 0.2 |
| Ryan Road (Rte 772/2020) | Old Ox Road (Rte 606) | 199 | 2.6 | b | $2.41 | $5.30 | ($2.89) | 0.5 |
| Ryan Road (Rte 772/2020) | Mainline Plaza | 2,341 | 5.3 | c | $4.89 | $5.30 | ($0.41) | 0.9 |
| Loudoun County Pkwy (Rte 607) | Old Ox Road (Rte 606) | 391 | 1.2 | a | $1.15 | $5.30 | ($4.16) | 0.2 |
| Loudoun County Pkwy (Rte 607) | Mainline Plaza | 4,629 | 3.9 | b | $3.63 | $5.30 | ($1.68) | 0.7 |
| Old Ox Road (Rte 606) | Mainline Plaza | 2,648 | 2.7 | b | $2.48 | $5.30 | ($2.82) | 0.5 |
| | | 34,653 | 7.6 | | $7.06 | $4.60 | $2.46 | 1.5 |

Source: Analysis by WSP, 2019.

**Table 4.39: Estimated Benefits with Respect to Toll Costs Per Trip by Entry and Exit Point, Westbound**

| Entry Point | Exit Point | AADT | Distance | Distance Category | Total Benefit | Toll Cost | Net Benefit | BCR |
|---|---|---|---|---|---|---|---|---|
| Mainline Plaza | Old Ox Road (Rte 606) | 2,677 | 2.7 | b | $2.48 | $5.30 | ($2.82) | 0.5 |
| Mainline Plaza | Loudoun County Pkwy (Rte 607) | 3,885 | 3.9 | b | $3.63 | $5.30 | ($1.68) | 0.7 |
| Mainline Plaza | Ryan Road (Rte 772/2020) | 2,848 | 5.3 | c | $4.89 | $5.30 | ($0.41) | 0.9 |
| Mainline Plaza | Claiborne Parkway (Rte 901) | 1,931 | 6.9 | c | $6.43 | $5.30 | $1.13 | 1.2 |
| Mainline Plaza | Belmont Ridge Road (Rte 659) | 1,629 | 7.8 | d | $7.30 | $5.30 | $2.00 | 1.4 |
| Mainline Plaza | Shreve Mill Rd | 800 | 10.5 | e | $9.82 | $5.30 | $4.51 | 1.9 |
| Mainline Plaza | Battlefield Parkway | 2,927 | 12.4 | f | $11.56 | $5.30 | $6.26 | 2.2 |
| Mainline Plaza | Leesburg Bypass (Rte 7) | 10,361 | 13.4 | f | $12.51 | $5.30 | $7.21 | 2.4 |
| Old Ox Road (Rte 606) | Loudoun County Pkwy (Rte 607) | 348 | 1.2 | a | $1.15 | $5.30 | ($4.16) | 0.2 |
| Old Ox Road (Rte 606) | Ryan Road (Rte 772/2020) | 255 | 2.6 | b | $2.41 | $5.30 | ($2.89) | 0.5 |
| Old Ox Road (Rte 606) | Claiborne Parkway (Rte 901) | 173 | 4.2 | b | $3.95 | $5.30 | ($1.35) | 0.7 |
| Old Ox Road (Rte 606) | Belmont Ridge Road (Rte 659) | 146 | 5.2 | c | $4.82 | $5.30 | ($0.48) | 0.9 |
| Old Ox Road (Rte 606) | Shreve Mill Rd | 72 | 7.9 | d | $7.34 | $5.30 | $2.03 | 1.4 |
| Old Ox Road (Rte 606) | Battlefield Parkway | 262 | 9.7 | e | $9.08 | $5.30 | $3.78 | 1.7 |
| Old Ox Road (Rte 606) | Leesburg Bypass (Rte 7) | 988 | 10.8 | e | $10.03 | $5.30 | $4.73 | 1.9 |
| Loudoun County Pkwy (Rte 607) | Ryan Road (Rte 772/2020) | 87 | 1.4 | a | $1.27 | $5.30 | ($4.03) | 0.2 |
| Loudoun County Pkwy (Rte 607) | Claiborne Parkway (Rte 901) | 59 | 3.0 | b | $2.81 | $5.30 | ($2.50) | 0.5 |
| Loudoun County Pkwy (Rte 607) | Belmont Ridge Road (Rte 659) | 50 | 3.9 | b | $3.67 | $5.30 | ($1.63) | 0.7 |
| Loudoun County Pkwy (Rte 607) | Shreve Mill Rd | 24 | 6.6 | c | $6.19 | $5.30 | $0.89 | 1.2 |
| Loudoun County Pkwy (Rte 607) | Battlefield Parkway | 89 | 8.5 | d | $7.93 | $5.30 | $2.63 | 1.5 |
| Loudoun County Pkwy (Rte 607) | Leesburg Bypass (Rte 7) | 357 | 9.5 | e | $8.88 | $5.30 | $3.58 | 1.7 |
| Ryan Road (Rte 772/2020) | Claiborne Parkway (Rte 901) | 73 | 1.7 | a | $1.54 | $4.52 | ($2.98) | 0.3 |
| Ryan Road (Rte 772/2020) | Belmont Ridge Road (Rte 659) | 61 | 2.6 | b | $2.41 | $4.52 | ($2.12) | 0.5 |
| Ryan Road (Rte 772/2020) | Shreve Mill Rd | 30 | 5.3 | c | $4.92 | $4.52 | $0.40 | 1.1 |
| Ryan Road (Rte 772/2020) | Battlefield Parkway | 110 | 7.2 | d | $6.67 | $4.52 | $2.14 | 1.5 |
| Ryan Road (Rte 772/2020) | Leesburg Bypass (Rte 7) | 459 | 8.2 | d | $7.62 | $4.52 | $3.10 | 1.7 |
| Claiborne Parkway (Rte 901) | Belmont Ridge Road (Rte 659) | 47 | 0.9 | a | $0.87 | $4.52 | ($3.65) | 0.2 |
| Claiborne Parkway (Rte 901) | Shreve Mill Rd | 23 | 3.6 | b | $3.38 | $4.52 | ($1.14) | 0.7 |
| Claiborne Parkway (Rte 901) | Battlefield Parkway | 84 | 5.5 | c | $5.13 | $4.52 | $0.61 | 1.1 |
| Claiborne Parkway (Rte 901) | Leesburg Bypass (Rte 7) | 359 | 6.5 | c | $6.08 | $4.52 | $1.56 | 1.3 |
| Belmont Ridge Road (Rte 659) | Shreve Mill Rd | 31 | 2.7 | b | $2.52 | $4.52 | ($2.00) | 0.6 |
| Belmont Ridge Road (Rte 659) | Battlefield Parkway | 115 | 4.6 | b | $4.26 | $4.52 | ($0.26) | 0.9 |
| Belmont Ridge Road (Rte 659) | Leesburg Bypass (Rte 7) | 496 | 5.6 | c | $5.21 | $4.52 | $0.69 | 1.2 |
| Shreve Mill Rd | Battlefield Parkway | 17 | 1.9 | a | $1.74 | $4.02 | ($2.28) | 0.4 |
| Shreve Mill Rd | Leesburg Bypass (Rte 7) | 74 | 2.9 | b | $2.69 | $4.02 | ($1.32) | 0.7 |
| Battlefield Parkway | Leesburg Bypass (Rte 7) | 4,133 | 1.0 | x | $0.95 | $0.00 | $0.95 | N/A |
| | | 36,081 | 7.9 | | $7.34 | $4.65 | $2.68 | 1.6 |

Source: Analysis by WSP, 2019.

**Table 4.40: Estimated Net Benefit, Summary by Distance, Eastbound**

| Distance Category (miles) | | AADT | Weighted Avg Benefit | Weighted Avg Cost | Net Benefit | BCR |
|---|---|---|---|---|---|---|
| x | No Toll | 4,281 | $0.95 | $0.00 | $0.95 | N/A |
| a | <2 mi | 606 | $1.20 | $5.11 | ($3.91) | 0.2 |
| b | 2 to 4 | 8,008 | $3.20 | $5.28 | ($2.07) | 0.6 |
| c | 4 to 6 | 5,660 | $5.62 | $5.18 | $0.44 | 1.1 |
| d | 6 to 8 | 2,139 | $7.37 | $5.10 | $2.27 | 1.4 |
| e | 8 to 10 | 2,284 | $9.71 | $5.30 | $4.41 | 1.8 |
| f | 10 to 13 | 11,676 | $12.37 | $5.30 | $7.07 | 2.3 |
| | *All traffic:* | | $7.06 | $4.60 | $2.46 | 1.5 |
| | *All tolled traffic:* | | $7.92 | $5.25 | $2.67 | 1.5 |

Source: Analysis by WSP, 2019.

**Table 4.41: Estimated Net Benefit, Summary by Distance, Westbound**

| Distance Category (miles) | | AADT | Weighted Avg Benefit | Weighted Avg Cost | Net Benefit | BCR |
|---|---|---|---|---|---|---|
| x | No Toll | 4,133 | $0.95 | $0.00 | $0.95 | N/A |
| a | <2 | 571 | $1.21 | $5.10 | ($3.89) | 0.2 |
| b | 2 to 4 | 7,403 | $3.16 | $5.27 | ($2.11) | 0.6 |
| c | 4 to 6 | 5,919 | $5.50 | $5.17 | $0.33 | 1.1 |
| d | 6 to 8 | 2,360 | $7.36 | $5.11 | $2.24 | 1.4 |
| e | 8 to 10 | 2,407 | $9.69 | $5.30 | $4.38 | 1.8 |
| f | 10 to 13 | 13,288 | $12.30 | $5.30 | $7.00 | 2.3 |
| | *All traffic:* | | $7.34 | $4.65 | $2.68 | 1.6 |
| | *All tolled traffic:* | | $8.16 | $5.25 | $2.91 | 1.6 |

Source: Analysis by WSP, 2019.

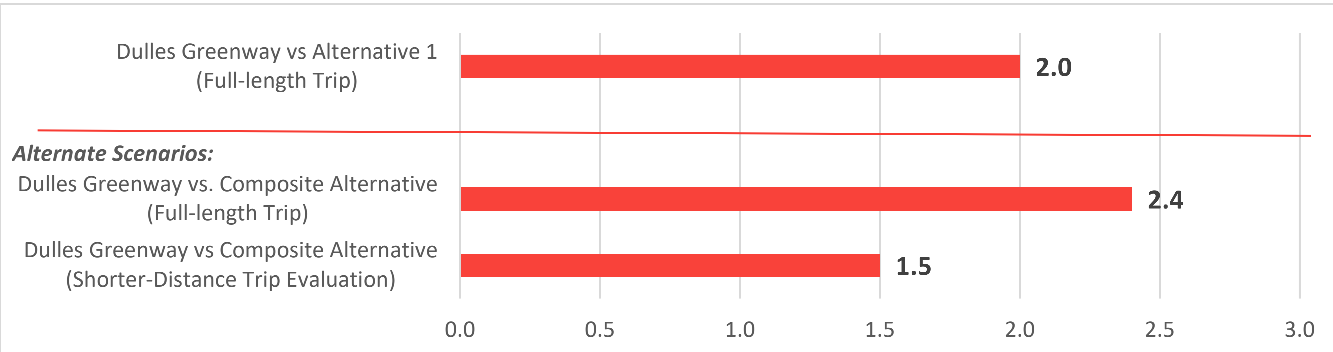
The tables show that over 4,000 daily trips in each direction entering or exiting at Battlefield Parkway derive a small benefit for the 1-mile trip on the Dulles Greenway without paying a toll. There are over 8,000 travelers in each direction using the Greenway for trips between 1 and 4 miles in length that are paying a toll. These trips generally show a negative net benefit based on the identified quantitative benefits as the average toll cost exceeds the quantified benefit for trips in this range of distances. In both the eastbound and westbound directions, trips between 4 and 6 miles in length break even with respect to toll costs and benefits. Trips greater than 6 miles in length show a positive net benefit (BCR >1.0). Over 67% of daily trips (approximately 24,000 in each direction) cover a distance that yields a positive net benefit. Overall, through this method, WSP estimated an average trip-length of 8-miles (trip-weighted average) with a net benefit (trip-weighted average) of between $2.46 and $2.68 and a BCR of 1.5 to 1.6.

### 4.7.4 CONCLUSION

Based on the analysis of user benefits and toll costs outlined above, Dulles Greenway users received benefits in excess of the toll costs with a BCR of 2.0.

Additional estimates based on alternate scenarios (Dulles Greenway vs. Composite Alternative and an evaluation of shorter distance trips) also yield benefits in excess of the applicable toll charges.

**Figure 4.10: Benefit-Cost Ratio (BCR) Summary**




Source: Analysis by WSP, 2019.

# 5 TOLL ELASTICITY EVALUATION

## 5.1 INTRODUCTION

This chapter provides a review of Dulles Greenway toll rates and usage over time. This information is relevant to the second test the SCC considers for a toll application: that any change in the toll rate will not materially discourage use of the roadway by the public.

The micro-economic principle of price elasticity of demand is the key element of this evaluation. This principle indicates that demand for a good or service is often influenced by the price charged for use of that good or service. The extent of influence of price on demand is typically, but not necessarily, negative and can vary widely depending on the circumstances. In cases where demand falls in a greater proportion to an increase in the price, the demand response to price is highly elastic. When the demand falls less than proportionally to the price, for example when demand drops by 5% in response to a price rise of 10%, that demand is relatively inelastic.

To characterize price elasticity of demand on the Dulles Greenway, WSP evaluated the extent to which the average number of transactions has changed in response to previous toll price changes. Because factors other than toll price are also likely to influence the level of demand in any given month or year, it is important to isolate the effect of price from the effects of other factors through statistical analysis. These other factors include general economic conditions, fuel prices, weather, special events, and conditions on alternative routes. WSP utilized econometric regression analysis, a standard practice in traffic and revenue analysis, to determine the elasticity of demand to price while controlling for the effect of these other factors. The analysis included the following features, which are described in detail in the remainder of the chapter:

— A time series of monthly transaction totals for each Dulles Greenway toll collection point from January 2005 through December 2019 was assembled as the dependent variable. The transaction data excluded non-revenue transactions (toll-exempt traffic and violations) to focus on the factors influencing only paying traffic.
— Corresponding monthly data for several independent variables including socioeconomic indicators, fuel prices, Dulles Greenway toll rates, Dulles Toll Road toll rates, and other factors were also assembled.
— A weighted fixed-effects panel regression structure was employed to account for the longitudinal differences in the transaction levels at the mainline and ramp toll collection points that may be correlated separately with independent variables.
— Separate models for autos and trucks to account for expected differences in the factors influencing demand were developed.
— Separate models by time-of-day and day-of-week (i.e., weekday peak, weekday off-peak, and weekend all-day for autos; weekday and weekend days for trucks) were also developed to account for differences in toll rates and the factors influencing demand. Peak travel times represent transactions in only the peak direction of flow (eastbound in AM, westbound in PM) to correspond with peak period toll pricing.

Through this analysis WSP found that toll rate increases on the Dulles Greenway are just one factor contributing to increases and decreases in traffic on the facility observed over the past 14 years. Other factors, such as capacity improvements and removal of signals on alternative routes, and toll rate increases on the Dulles Toll Road have had more substantial negative impact on use of the Greenway.

The sections below outline the steps WSP took to assemble data, implement the regression analysis, and evaluate the findings. This process included several important steps, including:

— Assembly of the data for the dependent variable and a range of potential independent variables,
— Determining the appropriate form and structure of the models,
— Testing relevant independent variables and model specifications, and
— Documenting findings.

## 5.2 ASSEMBLY OF THE DATA

To provide a base of inputs for the statistical evaluation, WSP assembled a dataset for both the dependent variable and a range of independent variables to be tested for their significance in explaining variation in the dependent variable over time.

The dependent variable in the econometric analysis is the total number of monthly revenue transactions at each of the toll collection points on the Dulles Greenway with detail for peak and off-peak time periods, weekdays and weekend days, and vehicle class. Non-revenue transactions, including violations, were excluded from the evaluation. WSP assembled a time-series of monthly transaction totals by direction of travel, hour of day, day of week, and vehicle class at each of the toll collection points from daily transaction reports provided by TRIP II. These transaction reports covered a period from January 2005 through May 2019, providing 173 months of observations for each toll collection point, vehicle class, and time period. This dataset constitutes a substantial history of operation of the Dulles Greenway and covers a period that includes regular toll changes, a wide variety of socio-economic conditions, and improvements on alternative routes.

The independent variables obtained by WSP in the study are as follows.

**Socioeconomic variables** – Toll elasticity evaluations often include consideration of local area population, employment, income, industrial output, and other socioeconomic indicators as factors that influence travel demand. To support model development and testing, WSP obtained a wide range of these indicators from third-party socioeconomic data vendor Woods & Poole Economics. For autos, the models shown below include as predictive variables the population of Loudoun County, and real income per capita in Loudoun County. For trucks, the socioeconomic predictive variable is real total earnings in the transportation and warehousing sectors in the region, which includes Loudoun County, Fairfax County, Arlington County, and Washington, DC. In the development and testing of these final models, WSP tested other combinations of socioeconomic input variables such as population in both Fairfax and Loudoun counties, employment in Fairfax County and Loudoun County, real gross regional product in Loudoun County, and the population of Virginia, but found the chosen variables to result in the models that most conform to the objectives listed in **Section 5.4**, and as a result create the model that is the most accurate predictor of how the usage of the Greenway will be impacted by future changes in the key variables listed here.

**Fuel prices** – Toll prices are not the only cost of travel that can influence toll road demand. For autos, the price of gasoline is included in the model as it was found to be a statistically significant factor in demand. The price of diesel fuel was not found to impact truck demand for the Greenway. A time-series of monthly gasoline prices was obtained from the U.S. Energy Information Administration for the period of 2005 through 2018. Real dollar values were used by WSP, so as to focus the evaluation on real price changes not changes influenced by variations in inflation.

**Special events** – To promote an accurate understanding of toll elasticity it is important to control for the effect of special events that could provide a one-time effect on traffic separate and apart from other cost and socioeconomic factors. For autos, a dummy variable[28] notes the occurrence of Hurricane Sandy, whereas for trucks the construction of the Silver Line in the Greenway alignment was found to have a statistically significant impact on travel patterns. Other events considered, such as government shutdowns, did not result in statistically significant and correctly-signed coefficients, and therefore are not considered as part of the econometric analyses that determined the elasticities shown in this chapter.

**Weather** – For autos, the impact of monthly rainfall and snowfall were included as statistically significant independent variables; however, for trucks, only rainfall was found to have a statistically significant impact. WSP obtained weather variables through data published by the National Oceanic and Atmospheric Administration.

[28] In regression analysis, a dummy variable is used to mark the time bounds of non-quantitative events. For example, for Hurricane Sandy, the dummy variable has a value of 1 for the month that the hurricane occurred, and a value of 0 for all other months. This allows the regression to estimate the impact of the hurricane, knowing that there is only one specific month in which the event occurred. For some events, such as the Silver Line construction, the dummy variable can take a value of 1 for multiple months. For other events, such as government shutdowns, the dummy variable can take values between 0 and 1 in months where there was a shutdown that didn't cover the entire month.

**Tolls** – For autos, the tolls on both the Greenway and the Dulles Toll Road were found to have an impact on travel demand, whereas for trucks, only the Greenway toll was found to have a significant impact. Toll change history for the Dulles Greenway and Dulles Toll Road from 2005 through 2018 were provided by TRIP II. Tolls were included in the model in real terms to focus the evaluation on real price changes rather than changes influenced by variations in inflation.

**Seasonality** – The models are operationalized on monthly transactions, and as such, dummy variables were included to represent each month. As expected, wintertime travel is lower than other seasons; for simplicity, these variables and their coefficients are not shown in the summary tables below; however, they were factored into the analysis for all model runs.

**Competing route improvements** – WSP considered a list of 31 improvements made to other routes in Loudoun County that may have drawn traffic from the Greenway as a result of lowered travel times. Throughout the analysis, WSP found that improvements to Route 7 and Route 28 had a greater impact to Greenway demand than other improvements. As such, two variables were included in the models shown below, one of which counts the number of grade separations on Route 7 and Route 28, and the second of which counts all other improvements made to the competing routes. The variables increase from zero at the beginning of the data series, increasing by one in each month that a competing improvement opened for traffic. For some improvements where precise opening dates were unknown, satellite imagery was used to determine a window for the opening, and the variable was increased gradually such that it had increased by one by the end of the window.

## 5.3 MODEL STRUCTURE

The primary location for toll collection on the Dulles Greenway is the mainline plaza which accounts for over 80 percent of transactions. A complete understanding of toll elasticity requires, however, inclusion of the ramp toll collection points to account for the toll prices applicable to trips that do not cover the full distance of the facility. To properly incorporate these locations into the evaluation, WSP developed a weighted fixed effects panel structure for the regression analysis. The choice of a fixed effects panel regression – as opposed to a regression in which the dependent variable is a sum of all transactions – allowed WSP to consider that each gantry holds unique information about the factors influencing traffic counts and how they change through time. The addition of weighting into the panel regression allows WSP to acknowledge that travel on the Greenway is primarily driven by trips crossing the mainline gantry – in this way, the resulting coefficients are not unduly influenced by traveler behavior on ramps with significantly smaller traffic counts. As such, the mainline gantry is included in the regression with the highest weight, and all other ramps are included with lower weights.[29]

WSP tested alternate structures for the regression analysis, including ordinary least squares models with the mainline plaza and other ramp locations as dependent variables but found that the panel structure provided a more efficient and comprehensive approach to incorporating the full range of data and also provided a higher level of performance with regard to statistical measures for goodness of fit, variable significance, and collinearity.

## 5.4 MODEL TESTING AND SPECIFICATION

Following identification of the panel model structure as the most appropriate to provide a comprehensive evaluation of toll elasticity, WSP also conducted tests to identify independent variables most relevant for inclusion in the model. The overall goal is to find statistically significant relationships between each of the independent variables and the dependent variable while adhering to a reasonable economic theory as to why the independent variables influence variation in the dependent

[29] The mainline gantry is included with weight 1.0. Most ramps are included with weight 0.5. The Shreve Mill ramp, due to its very low usage, is included with weight 0.05. These weights allow WSP to meaningfully consider each ramp in the regression analysis by allocating a greater weight to each ramp than would be the case if the weights chosen were proportional to the usage of each ramp.

variable. This avoids spurious regressions, where it is possible to find relationships between two variables by happenstance when no such economic relationship exists in fact.

To guide the testing, WSP established three criteria for evaluating the inclusion of variables in the final model specifications. WSP considers these criteria to be consistent with best practices for toll price elasticity analysis and econometric forecasting. The criteria are as follows.

— Coefficients should have a logical sign and a magnitude broadly consistent with benchmarks seen in the literature or evaluation of comparable facilities.
— Descriptive statistics for each individual variable should indicate it has significant explanatory power with respect to variation in the dependent variable and that descriptive statistics for the overall model should indicate that the model has a good fit to the historical dataset for the dependent variable.
— The overall model should provide as detailed a distinction as possible with regard to toll elasticity, and the impact of special events and improvements to competing routes.

Because the structure of the regression is based on log transformation of the data, the coefficient for each variable in the analysis is the elasticity of Greenway usage (i.e., transactions) to that variable. A high-magnitude coefficient indicates that Greenway usage is very sensitive to the predictive variable, and a low-magnitude coefficient indicates that Greenway usage is insensitive to the predictive variable. For key variables, such as tolls, gas prices, network improvements, and socioeconomic predictors, WSP required that the resulting coefficients have a sensible magnitude – in particular, that the resulting coefficient fall within the range WSP observed during evaluation of other similar toll road corridors. Furthermore, WSP ensured that the implied relationship between the predictive variables and Greenway usage is of the correct direction – that usage goes up with higher socioeconomic values, for example, and down with higher tolls or higher gas prices—movements that are logical and supported by observations on other facilities.

To evaluate the extent to which each individual variable is statistically significant with respect to the dependent variable, WSP utilized the t-statistic as a descriptor of how clear the impact of the variable is on Greenway usage. A high-magnitude t-statistic means that the variable clearly had an impact on Greenway usage, whereas a low-magnitude t-statistic indicates that it was challenging for the model to tell apart the impact of the variable from the random noise occurring in Greenway demand. A t-statistic higher in magnitude than two roughly indicates that the variable clearly influenced Greenway demand. The t-statistics are also translated into p-values – a p-value of 0.05 indicates that given the levels of noise observed in the predictive variables and Greenway demand, there is a 5% chance that the resulting coefficient is an artifact of random variation rather than a true relationship between the variable and Greenway demand. The 5% threshold is commonly used to denote the statistical significance of a coefficients; as shown in **Table 5.2**, most key variable have associated p-values below 5%.

Our assessment of various independent variables with regard to the three goals listed above led to the model formulations listed in **Section 5.5**. Other independent variables that were not chosen for inclusion in the model as a result of this process are shown in **Table 5.1**. This table shows the historical correlation between the various possible independent socioeconomic variables. As shown, the historical correlation between various socioeconomic variables is generally high, and as such the variables included in the chosen econometric models reflect similar socioeconomic trends to the highly-correlated variables left out. In general, all values above 0.80 reflect a high level of correlation between two possible predictive variables, indicating that they have similar growth trends through time. The negative correlations between the socioeconomic variables indicate, for example, that while the relationship is weak, gas prices have tended to fall as the economy grows, and vice versa.

The chosen models were subjected to various confirmatory tests to ensure that they are a reasonable reflection of the relationship between predictive variables and historical traffic levels. A key component of this integrity testing is **Figure 5.1** and **Figure 5.4**, which show the close correspondence between historical traffic counts, and the model's prediction of traffic counts for each month.

The table below shows the correlations between the independent variables considered. When variables are highly correlated with one another, the statistical models can have difficulty distinguishing between the impacts of those two variables on the independent variable. (For instance, it may be hard to tell whether rises in diesel or gas prices impact demand; in truth a factor common to both gas and diesel prices may be the underlying factor.) This phenomenon is referred to as multicollinearity, and is a well-known challenge when employing regression analysis. For this reason, econometric models typically avoid using multiple highly correlated independent variables at the same time in the same model.

**Table 5.1: Correlation Table for Socioeconomic Independent Variables Considered**

| **Full Name** | **Type** | **Abbreviation** | Lo Pop | Lo Emp | Lo Inc | Fa Emp | FaLo Emp | Diesel | Gas | Compete | Cl Pop | VA Pop | Reg Emp | Lo Const |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Loudoun Co population | Continuous | Lo Pop | | 0.99 | 0.88 | 0.97 | 0.98 | -0.26 | -0.36 | 0.98 | 0.96 | 0.99 | 0.99 | 0.92 |
| Loudoun Co employment | Continuous | Lo Emp | 0.99 | | 0.88 | 0.99 | 1.00 | -0.33 | -0.43 | 0.95 | 0.96 | 0.97 | 1.00 | 0.94 |
| Loudoun Co income per capita | Continuous | Lo Inc | 0.88 | 0.88 | | 0.90 | 0.89 | -0.11 | -0.23 | 0.92 | 0.94 | 0.88 | 0.88 | 0.93 |
| Fairfax Co employment | Continuous | Fa Emp | 0.97 | 0.99 | 0.90 | | 1.00 | -0.30 | -0.41 | 0.94 | 0.97 | 0.95 | 0.99 | 0.96 |
| Fairfax Co and Loudoun Co employment | Continuous | FaLo Emp | 0.98 | 1.00 | 0.89 | 1.00 | | -0.31 | -0.42 | 0.94 | 0.97 | 0.96 | 1.00 | 0.95 |
| Diesel price, Atlantic region, real | Continuous | Diesel | -0.26 | -0.33 | -0.11 | -0.30 | -0.31 | | 0.95 | -0.15 | -0.12 | -0.19 | -0.31 | -0.30 |
| Gas price, Atlantic region, real | Continuous | Gas | -0.36 | -0.43 | -0.23 | -0.41 | -0.42 | 0.95 | | -0.27 | -0.24 | -0.30 | -0.42 | -0.41 |
| Number of competing route improvements | Dummy | Compete | 0.98 | 0.95 | 0.92 | 0.94 | 0.94 | -0.15 | -0.27 | | 0.96 | 0.98 | 0.95 | 0.91 |
| Clarke Co population | Continuous | Cl Pop | 0.96 | 0.96 | 0.94 | 0.97 | 0.97 | -0.12 | -0.24 | 0.96 | | 0.96 | 0.96 | 0.95 |
| Virginia population | Continuous | VA Pop | 0.99 | 0.97 | 0.88 | 0.95 | 0.96 | -0.19 | -0.30 | 0.98 | 0.96 | | 0.97 | 0.89 |
| Regional employment (DC, Fairfax Co, Arlington Co, Loudoun Co) | Continuous | Reg Emp | 0.99 | 1.00 | 0.88 | 0.99 | 1.00 | -0.31 | -0.42 | 0.95 | 0.96 | 0.97 | | 0.95 |
| Loudoun Co construction income | Continuous | Lo Const | 0.92 | 0.94 | 0.93 | 0.96 | 0.95 | -0.30 | -0.41 | 0.91 | 0.95 | 0.89 | 0.95 | |

Source: Analysis by WSP, 2019.

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## 5.5 STATISTICAL ANALYSIS RESULTS

In order to provide a more granular understanding of traveler behavior, WSP built three models for autos (representing the peak weekday period, the off-peak weekday period, and the weekend period), and two models for trucks (representing weekdays and weekends). The structure of the models and a summary of the findings of the evaluation is summarized below.

### *5.5.1 ECONOMETRIC MODEL FOR AUTOS*

**Table 5.2** shows the econometric model results for autos.

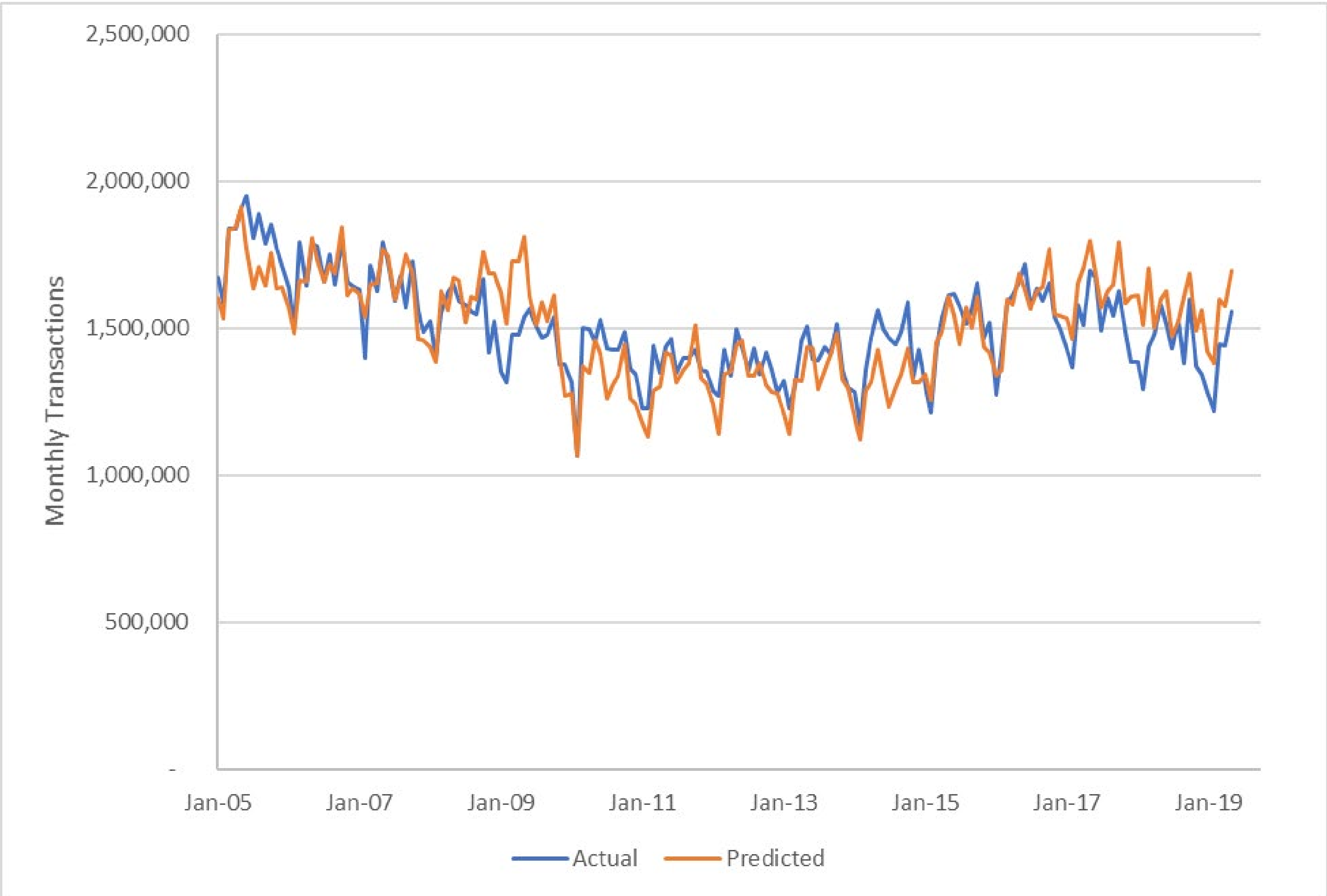
**Table 5.2: Econometric Model Results for Auto Usage of the Greenway**

| Independent Variable | Weekday Peak | | | Weekday Off-Peak | | | Weekend | | |
|---|---|---|---|---|---|---|---|---|---|
| | Coef. | SE | t-statistic | Coef. | SE | t-statistic | Coef. | SE | t-statistic |
| Loudoun Population (%) | 1.85 | 0.38 | 4.88*** | 2.00 | 0.30 | 6.56*** | 1.77 | 0.35 | 4.99*** |
| Loudoun Real Income (%) | 0.43 | 0.31 | 1.40 | 1.45 | 0.22 | 6.74*** | 1.54 | 0.25 | 6.17*** |
| Real Gas Price (%) | -0.13 | 0.03 | -3.89*** | -0.17 | 0.03 | -6.47*** | -0.20 | 0.03 | -6.64*** |
| Rainfall (in.) | -0.00029 | 0.00024 | -1.23 | -0.00021 | 0.00018 | -1.15 | -0.00019 | 0.00022 | -0.86 |
| Snowfall (in.) | -0.00446 | 0.00105 | -4.23*** | -0.00203 | 0.00084 | -2.41* | -0.00277 | 0.00098 | -2.84** |
| DTR Toll (%) | -0.21 | 0.05 | -3.99*** | -0.11 | 0.04 | -2.61** | -0.05 | 0.05 | -0.95 |
| Greenway Toll (%) | -0.28 | 0.06 | -4.96*** | -0.23 | 0.06 | -3.95*** | -0.06 | 0.07 | -0.84 |
| Hurricane Sandy | -0.025 | 0.066 | -0.38 | -0.061 | 0.053 | -1.16 | -0.193 | 0.061 | -3.18** |
| Rt 7/28 Improvements | -0.038 | 0.008 | -5.03*** | -0.066 | 0.006 | -12.00*** | -0.064 | 0.006 | -10.15*** |
| Other Improvements | -0.017 | 0.005 | -3.12** | -0.001 | 0.005 | -0.19 | -0.007 | 0.006 | -1.26 |
| Model Fit ($R^2$) | 0.98 | | | 0.99 | | | 0.83 | | |
| Effective $R^2$ All Times | 0.98 | | | | | | | | |

Source: Analysis by WSP, 2019. Notes: In the table above, the stars represent the degree to which the coefficients are statistically significantly different from zero – * represents a p-value of 0.05, ** represents a p-value of 0.01, and *** represents a p-value of 0.001. A higher-magnitude t-statistic is related to a lower-magnitude p-value, and a result which is more statistically significantly different from zero. The dependent variable was log-transformed in the regression, as were the independent variables marked with (%) in the table above. The $R^2$ statistic shown here is calculated via a traditional definition of $R^2$ – as the share of variance in the dependent variable described by the model. The variance in the dependent variable is the total sum squared difference to the mean (SST), whereas the unexplained component is the sum squared of residuals (SSR). The SE refers to the standard error; it is equivalent to the coefficient divided by the t-statistic. It provides an indication of the precision of the coefficient – that is, a high SE indicates that the coefficient is difficult to estimate precisely, whereas a low SE indicates that the coefficient is likely to have been estimated precisely.

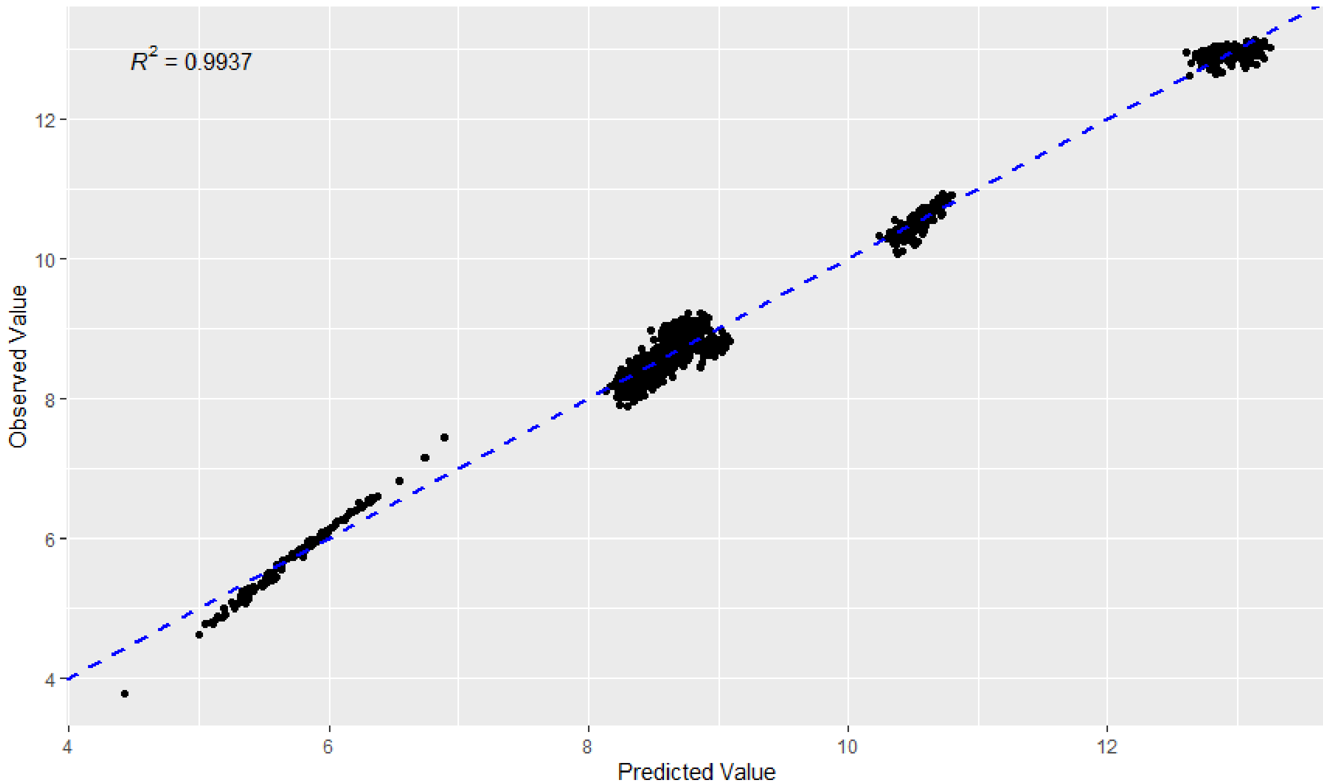
**Figure 5.1** shows the historical time series alongside the transaction counts predicted by the econometric model outlined in the table above. As shown, the econometric model performs well in replicated historical trends. **Figure 5.2** shows the relationship between actual monthly transaction counts and the monthly transaction counts predicted by the econometric model, as split by entry/exit ramp. As shown, the relationship between the observed and predicted values is very strong, with an $R^2$ of 0.9937 – an $R^2$ of 0 would indicate no correlation, whereas an $R^2$ of 1 indicates a perfect relationship. Similar figures are included in the appendices for the other four models (auto off-peak, auto weekend, truck weekday, truck weekend) – they show similarly strong relationships between observed and predicted values.

**Figure 5.1: Comparison of Historical and Predicted Monthly Usage, Autos**




Source: Analysis by WSP, 2019.

**Figure 5.2: Comparison of Historical and Predicted Monthly Usage, by Gantry, Autos, Weekday Peak**




Source: Analysis by WSP, 2019.

## 5.5.2 COMMENTARY ON MODEL COEFFICIENTS, AUTOS

All included variables have reasonable magnitude and correctly signed coefficients, and WSP have included all considered categories of variables that exhibit reasonable coefficients and add value to the model. In this section, WSP comments on the coefficients found for each of the key variables.

**Socioeconomic variables** – The coefficients on the socioeconomic variables are in reasonable ranges, indicating that as population or incomes per capita grow in Loudoun County, demand for Greenway travel increases. Notably, travel in the off-peak times and weekend times is significantly more sensitive to per capita incomes than travel at peak times – given that a greater proportion of these non-peak trips are discretionary, this is as expected. WSP found that a 10% increase in per capita incomes in Loudoun County increases peak Greenway trips by approximately 4%, whereas non-peak trips increase by approximately 15%.

**Fuel prices** – As with income per capita, non-peak trips are more elastic to changes in gas prices. A 10% increase in gas prices causes a 1.3% drop in peak travel on the Greenway, whereas off-peak weekday trips fall by 1.7% and weekend trips fall by 2.0%.

**Weather** – As expected, significant rainfall and snowfall dampen travel demand for autos. Notably, although Hurricane Sandy impacted travel at all times of day, it had a particularly stark impact on weekend travel.

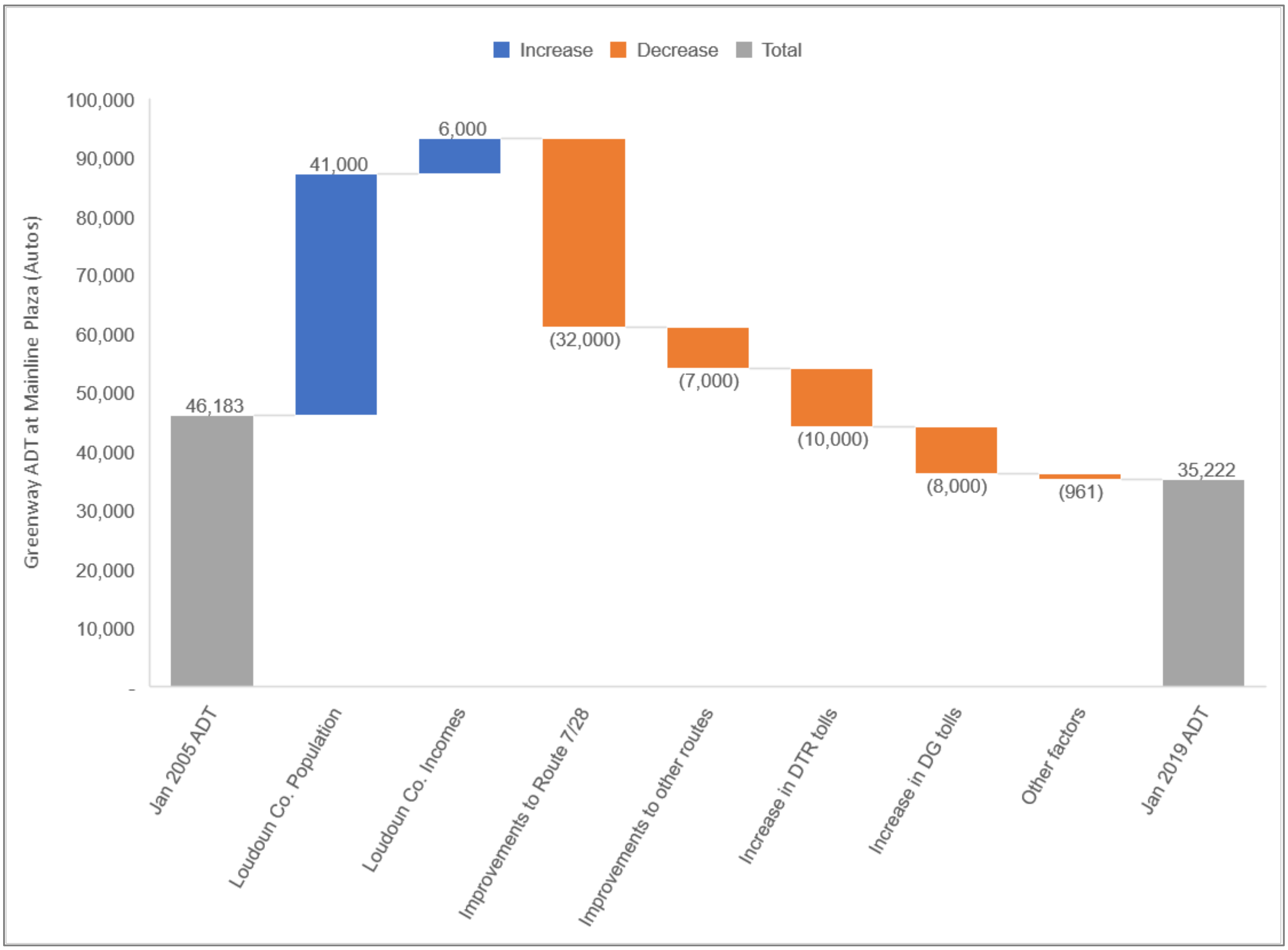
**Tolls on the Greenway –** WSP found that travelers are most sensitive to tolls on the Greenway at peak times and are least sensitive on weekends. In general, the toll elasticities are significantly higher than -1, indicating that current tolls are significantly below revenue-maximizing levels. At peak times, WSP found a 10% increase in tolls leading to a 2.8% reduction in usage (and thus a 6.9% increase in revenues). Travelers show even less sensitivity to tolls at non-peak times, with a 10% increase in tolls leading to a 2.3% reduction in usage at weekday off-peak times, and an 0.6% reduction in usage on weekends. Weighted by the number of transactions in each time period, the toll elasticity is -0.21.

**Tolls on the Dulles Toll Road –** Similar to Greenway tolls, travelers are most sensitive to increases in Dulles Toll Road tolls at peak times. A 10% increase in Dulles Toll Road tolls reduces travel demand for the Greenway by 2.1% at peak times, 1.1% at weekday off-peak times, and 0.5% on weekends. As expected, tolls on the Greenway are more determinant of Greenway travel demand than Dulles Toll Road tolls, but both have an independent impact.

**Competing route improvements –** The analysis reveals the disproportionate and significant impact on Greenway demand caused by grade separation improvements made to Route 7 and Route 28. Each grade separation results in a drop of Greenway traffic between 3.8% for the peak period and 6.6% for the weekday off-peak period. Improvements made to other competing routes (of which there were 11 in the 2005-2018 study period) each result in a 1.7% drop in Greenway demand at peak times, and smaller drops at non-peak times.

An aggregate demonstration of how the variables described in this section combine to explain usage trends on the Greenway between 2005 and 2019 is shown in **Figure 5.3**. The figure is shown for the peak period and demonstrates the significant impact of both the socioeconomic indicators as well as the improvements made to Route 7 and Route 28. This illustrates that in the peak period, the increase in the Greenway tolls constitutes 14% of the overall effect of factors contributing to decline in traffic.

**Figure 5.3: Factors Contributing to Observed Change in Greenway ADT (Mainline Plaza), Based on Peak Period Model for Autos**




Source: Analysis by WSP, 2019. Notes: Based on Greenway peak period, revenue-generating auto ADT at Mainline plaza only. Changes in gas prices, rainfall, and snowfall are grouped into the "Other" category on this figure for clarity since the impacts due to these three factors are comparatively small.

### 5.5.3 ECONOMETRIC MODEL FOR TRUCKS

**Table 5.3** shows the econometric model results for trucks.

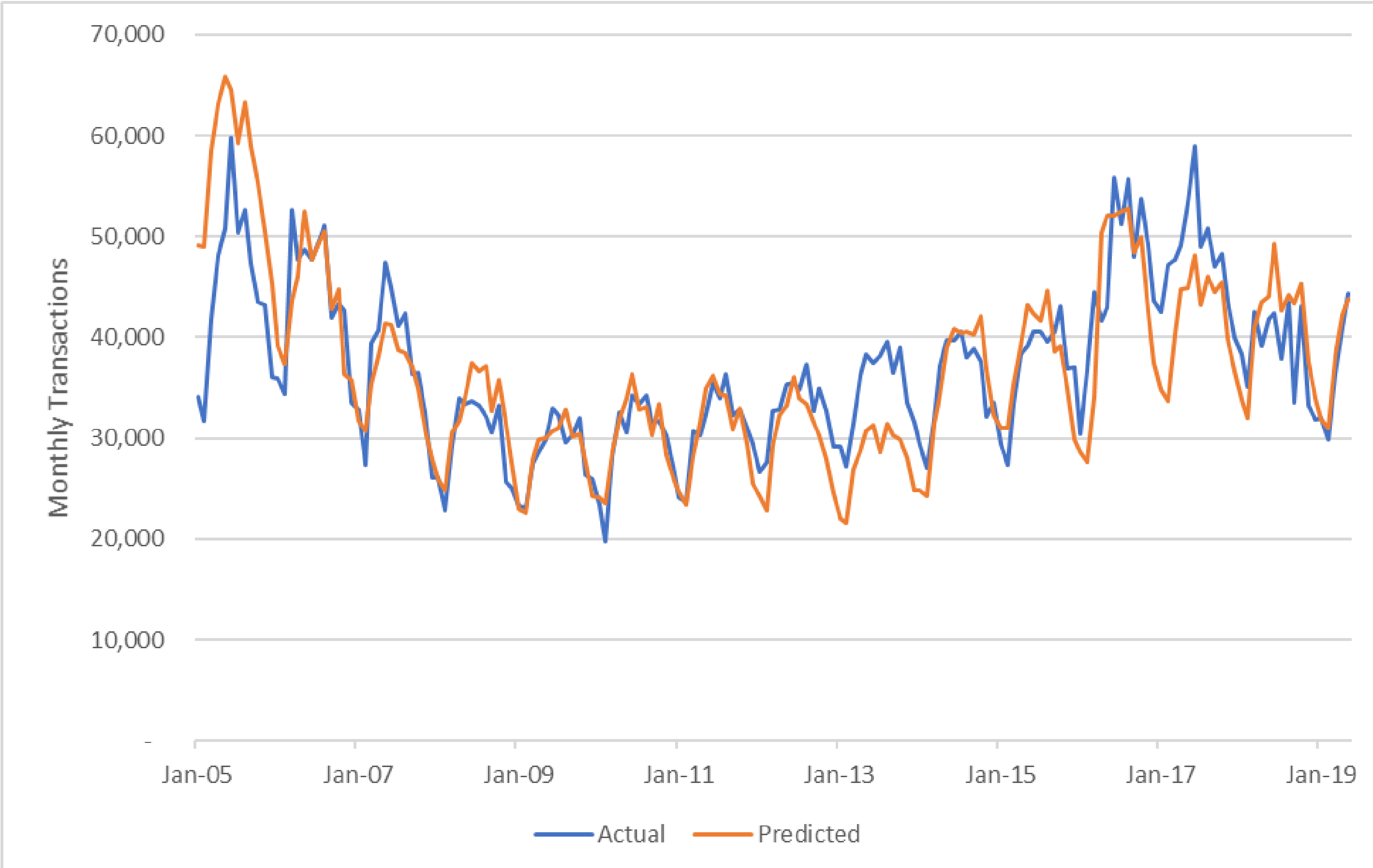
**Table 5.3: Econometric Model Results for Truck Usage of the Greenway**

| Independent Variable | Weekday | | | Weekend | | |
|---|---|---|---|---|---|---|
| | Coef. | SE | t-statistic | Coef. | SE | t-statistic |
| Regional Real Transportation and Warehousing Earnings (%) | 1.38 | 0.11 | 12.78*** | 0.60 | 0.12 | 4.83*** |
| Silver Line Construction | 0.23 | 0.03 | 6.95*** | 0.24 | 0.03 | 6.98*** |
| Rainfall (in.) | -0.00106 | 0.00038 | -2.76** | -0.00029 | 0.00054 | -0.54 |
| Greenway Toll (%) | -0.22 | 0.07 | -2.94** | -0.38 | 0.04 | -8.72*** |
| Rt 7/28 Improvements | -0.028 | 0.006 | -4.57** | --- | | --- |
| Other Improvements | -0.006 | 0.010 | -0.60 | --- | | --- |
| Model Fit ($R^2$) | 0.76 | | | 0.98 | | |
| Effective $R^2$ All Times | 0.79 | | | | | |

Source: Analysis by WSP, 2019. Notes: In the table above, the stars represent the degree to which the coefficients are statistically significantly different from zero – * represents a p-value of 0.05, ** represents a p-value of 0.01, and *** represents a p-value of 0.001. A higher-magnitude t-statistic is related to a lower-magnitude p-value, and a result which is more statistically significantly different from zero. The dependent variable was log-transformed in the regression, as were the independent variables marked with (%) in the table above. The $R^2$ statistic shown here is calculated via a traditional definition of $R^2$ – as the share of variance in the dependent variable described by the model. The variance in the dependent variable is the total sum squared difference to the mean (SST), whereas the unexplained component is the sum squared of residuals (SSR). The SE refers to the standard error; it is equivalent to the coefficient divided by the t-statistic. It provides an indication of the precision of the coefficient – that is, a high SE indicates that the coefficient is difficult to estimate precisely, whereas a low SE indicates that the coefficient is likely to have been estimated precisely.

**Figure 5.4** shows the historical time series alongside the transaction counts predicted by the econometric model outlined in the table above. As shown, the econometric model performs well in replicated historical trends.

**Figure 5.4: Comparison of Historical and Predicted Monthly Transactions, Trucks**




Source: Analysis by WSP, 2019.

## 5.5.4 COMMENTARY ON MODEL COEFFICIENTS, TRUCKS

All included variables have reasonable magnitude and correctly signed coefficients, and WSP included all considered categories of variables that exhibit reasonable coefficients and add value to the model. In this section, WSP comments on the coefficients found for each of the key variables.

**Socioeconomic variables** – The coefficients on the socioeconomic variables are in reasonable ranges, indicating that as the total real earnings in the regional transportation and warehousing sector increase, demand for Greenway travel grows. WSP found that a 10% increase in real regional transportation and warehousing income increases weekday Greenway trips by approximately 14%, whereas weekend trips increase by approximately 6%.

**Weather** – Significant rainfall dampens travel demand for trucks. Beyond what is already accounted for in the seasonality dummy variables, snowfall and Hurricane Sandy do not appear to impact travel demand for trucks on the Greenway.

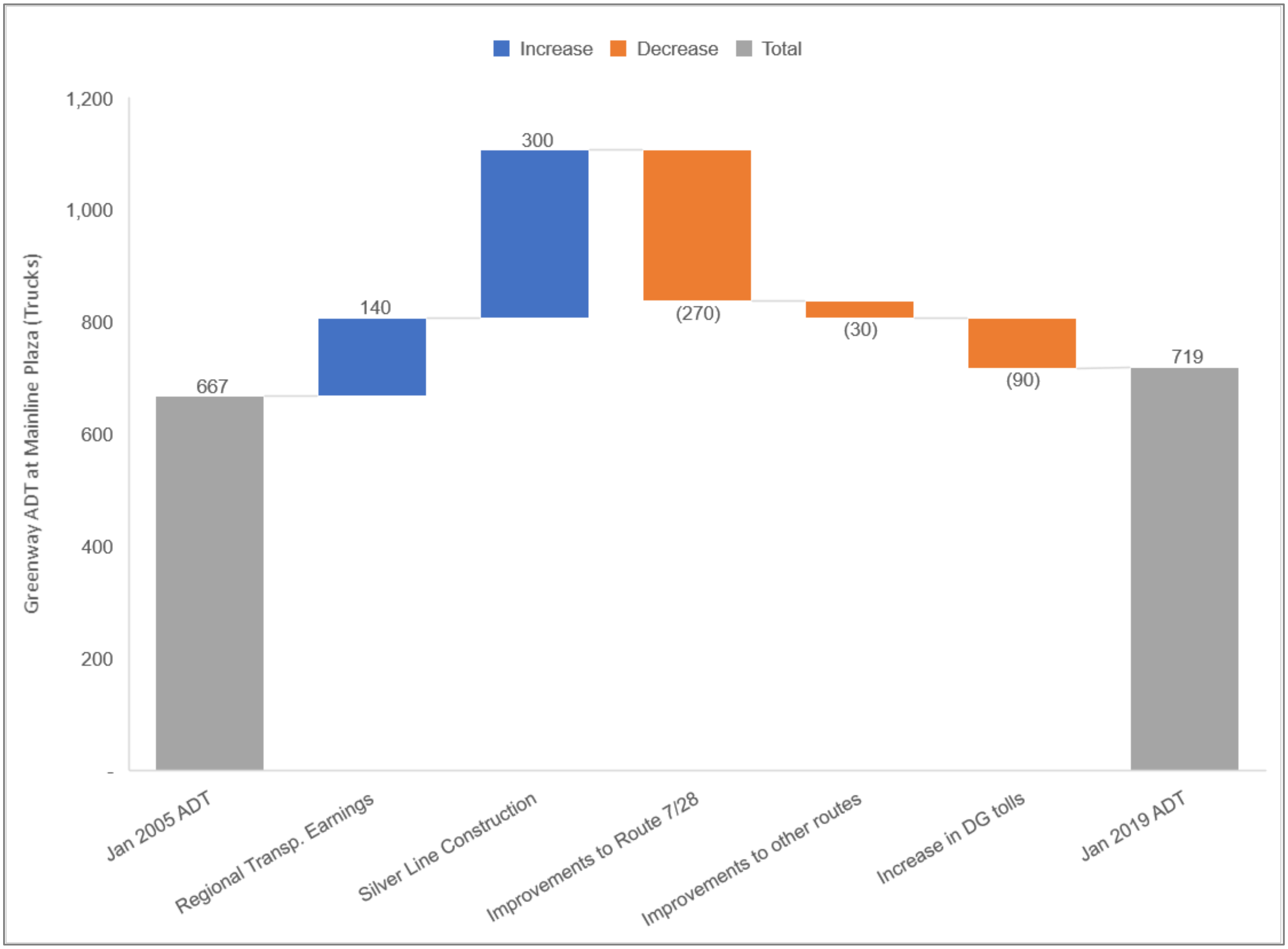
**Silver Line construction** – The construction of the Silver Line within the Greenway alignment caused an increase in truck traffic as trucks involved in the construction project used the Greenway to access their job sites. As shown, this construction project had a significant impact on both weekdays and weekends, increasing truck traffic by 23% and 24% respectively for the duration of construction.

**Tolls on the Greenway –** In general, the toll elasticities for trucks are significantly higher than -1, indicating that current tolls are significantly below revenue-maximizing levels. On weekdays, WSP found a 10% increase in tolls leading to a 2.2% reduction in usage (and thus a 7.6% increase in revenues). Travelers show more sensitivity to toll on weekends, with a 10% increase in tolls leading to a 3.8% reduction in usage (and thus a 5.8% increase in revenues). Weighted by the number of transactions in each time period, the toll elasticity is -0.23.

**Competing route improvements –** The analysis reveals the disproportionate and significant impact on Greenway truck demand caused by grade separation improvements made to Route 7 and Route 28. Each grade separation results in a drop of 2.8% to Greenway truck traffic on weekdays. Improvements made to other competing routes (of which there were 11 in the 2005-2019 study period) each result in a 0.6% drop in Greenway truck demand on weekdays. No impact is observed to weekend demand for trucks due to these improvements to competing routes.

An aggregate demonstration of how the variables above combine to explain usage trends for trucks on the Greenway between 2005 and 2019 is shown in **Figure 5.5**. The figure is shown for average weekday truck volumes and demonstrates the important impact of both the socioeconomic indicators as well as the improvements made to Route 7 and Route 28. This illustrates that for weekdays, the increase in Greenway tolls constitutes 61% of the overall effect of factors contributing to decline in truck traffic, although the overall transaction volume and revenue amounts involved are small with respect those overall for the Dulles Greenway.

**Figure 5.5: Factors Contributing to Observed Change in Greenway ADT (Mainline Plaza), Based on Weekday Model for Trucks**




Source: Analysis by WSP, 2019. Notes: Based on Greenway peak period, revenue-generating truck ADT at Mainline plaza only.

## 5.6 CONCLUSION

The econometric analysis described in this chapter revealed that auto and truck travel demand on the Greenway are differentiated by time-of-day, and that travel demand is significantly determined by socioeconomic indicators, weather, fuel prices, tolls, seasonality, special events, and improvements to competing routes. In the process of creating the models shown in this chapter, WSP included predictive variables that have reasonable magnitude and correctly signed coefficients, and WSP included all considered categories of variables that exhibit reasonable coefficients and add value to the model.

With regard to the elasticity of travel demand to tolls charge on the Greenway, WSP found that elasticities range from -0.06 (for autos on weekends) to -0.38 (for trucks on weekends). When aggregated to a combined measure weighted by traffic, the overall elasticity is -0.21– showing that user demand is relatively inelastic to toll increases.

# 6 LIMITATIONS

This Report is based upon information provided to WSP by TRIP II, information obtained from proprietary data purchased from third-party data sources, or from publicly available information or sources gathered by WSP in the course of evaluations of the Project. WSP provides no assurance as to the accuracy of any such third-party information and bears no responsibility for the results of any actions taken on the basis of the third-party information contained in the Report. The data used in the Report was current as of the date of the Report and may not now represent current conditions. WSP makes no representations or warranty that the information in the Report is sufficient to provide all the information, evaluations and analyses necessary to satisfy the entire due diligence needs of a user of the Report.

Certain forward-looking statements are based upon interpretations or assessments of best available information at the time of writing.  Actual events may differ from those assumed, and events are subject to change. Findings are time-sensitive and relevant only to current conditions at the time of writing. Factors influencing the accuracy and completeness of the forward-looking statements may exist that are outside of the purview of WSP. Certain assumptions regarding past performance may not be indicative of future trends, which may affect actual future performance and market demand, so actual results are uncertain and may vary significantly from any projections developed as part of this Report.

This Report assumes no major recession or significant economic restructuring will occur which could substantially reduce trip-making and traffic in the region or alter travel patterns in the future.

This Report assumes no natural disasters will occur that could significantly alter travel patterns throughout the area served by the Dulles Greenway.

This Report assumes no local, regional, or national emergency will arise which would abnormally restrict Dulles Greenway operations, use of the facility or connectivity to other roadway, or the use of motor vehicles, or other modes of travel, for regional travel.

Any significant departure from these basic assumptions could materially affect the conclusions of this Report. Assumptions regarding economic growth, competitive position of alternative routes, monetization of benefits, and external factors affecting overall travel demand are subject to uncertainty going forward and may prove inconsistent with the findings of this Report.

As noted herein, WSP has relied on information developed by third parties regarding regional traffic patterns, travel times, past performance and future outlook for economic indicators, and monetization of benefits.  Changes from these assumptions could produce results that differ from those contained in this report. Please see our disclaimer on the page following the cover for more information.

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# APPENDIX

# A ECONOMETRIC MODEL TESTS

# 8 APPENDIX A: ECONOMETRIC MODEL TESTS

**Figure 8.1: Comparison of Historical and Predicted Monthly Usage, by Gantry, Autos, Weekday Peak**

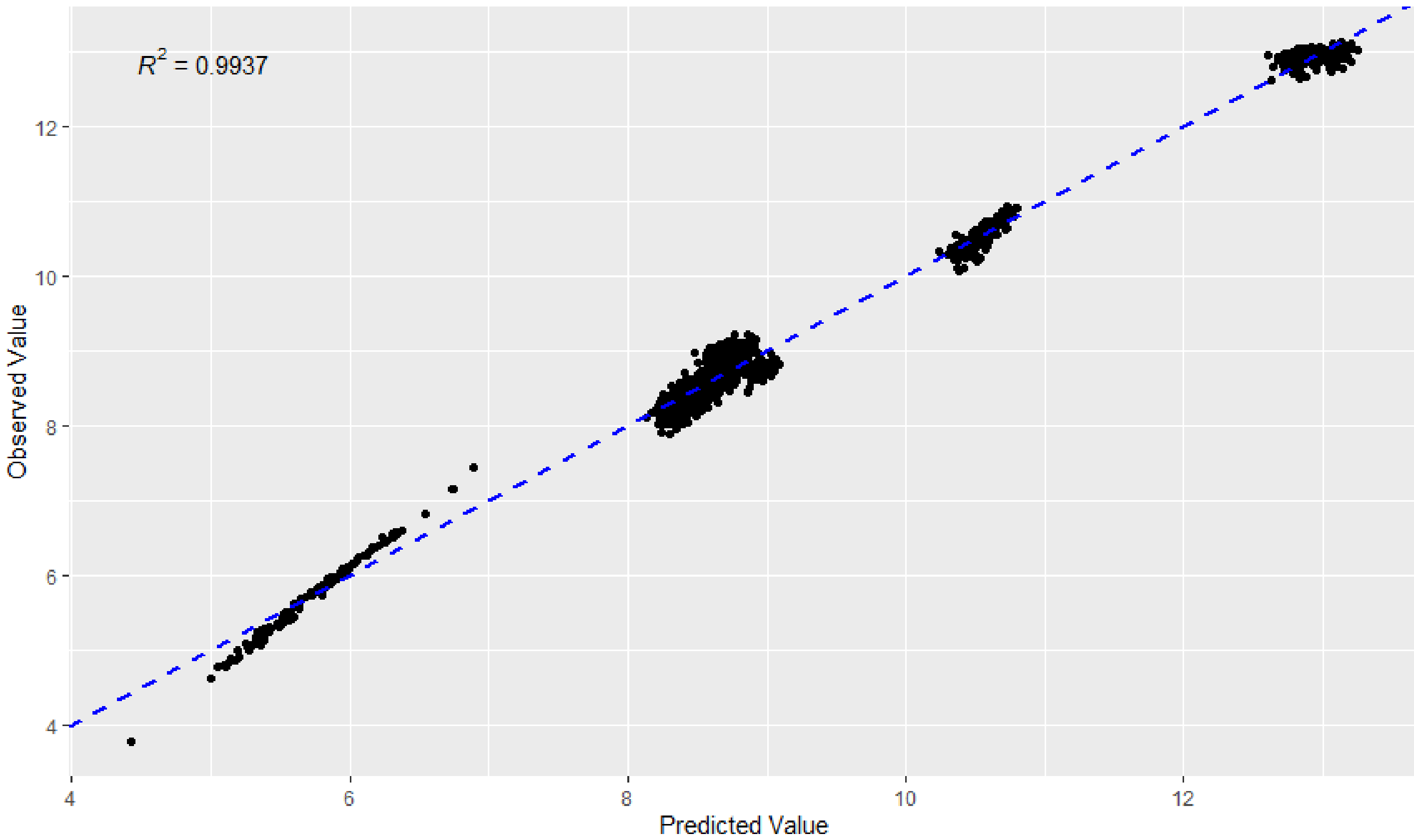

**Figure 8.2: Comparison of Historical and Predicted Monthly Usage, by Gantry, Autos, Weekend**

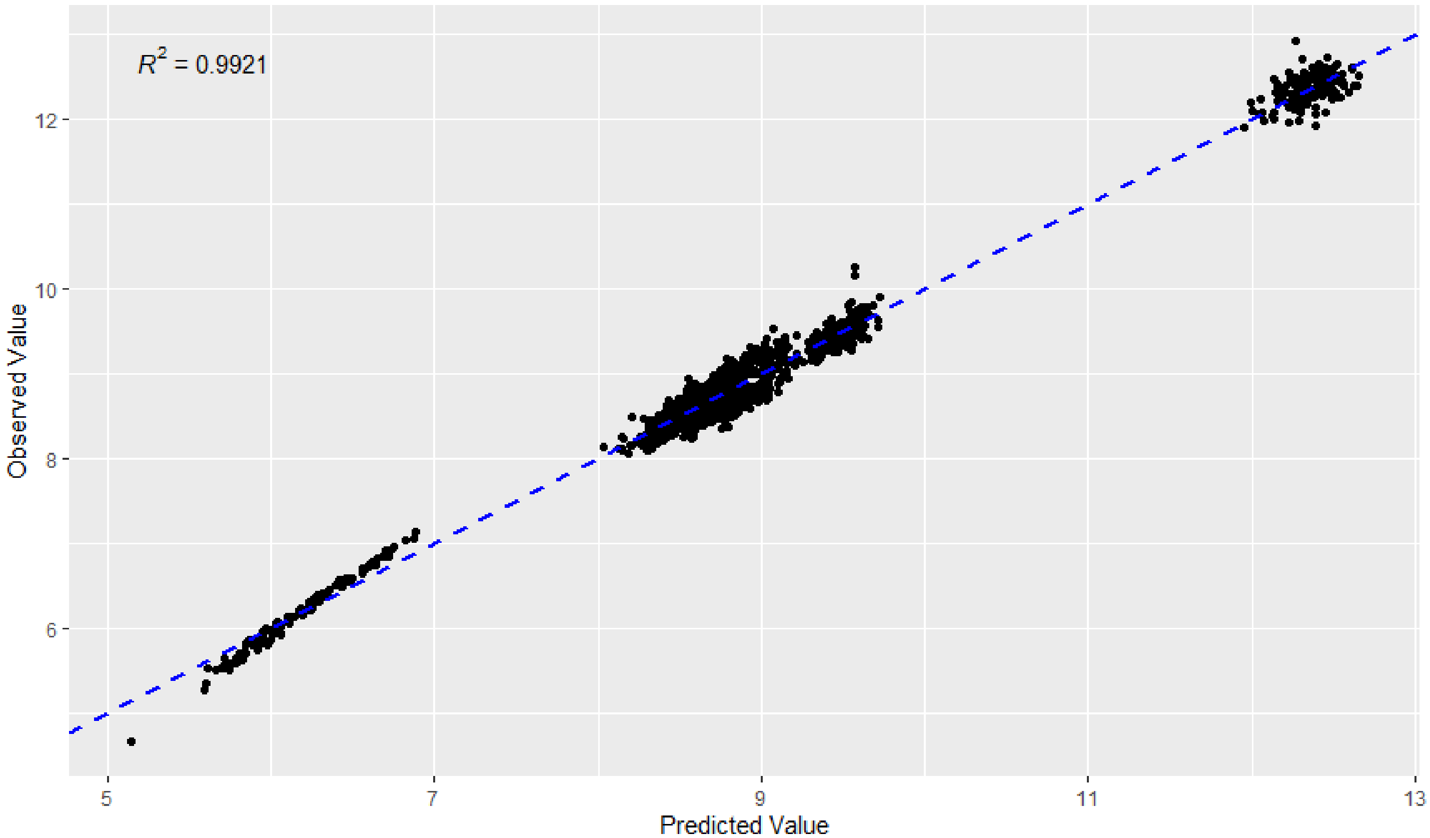

**Figure 8.3: Comparison of Historical and Predicted Monthly Usage, by Gantry, Autos, Weekday Off-Peak**

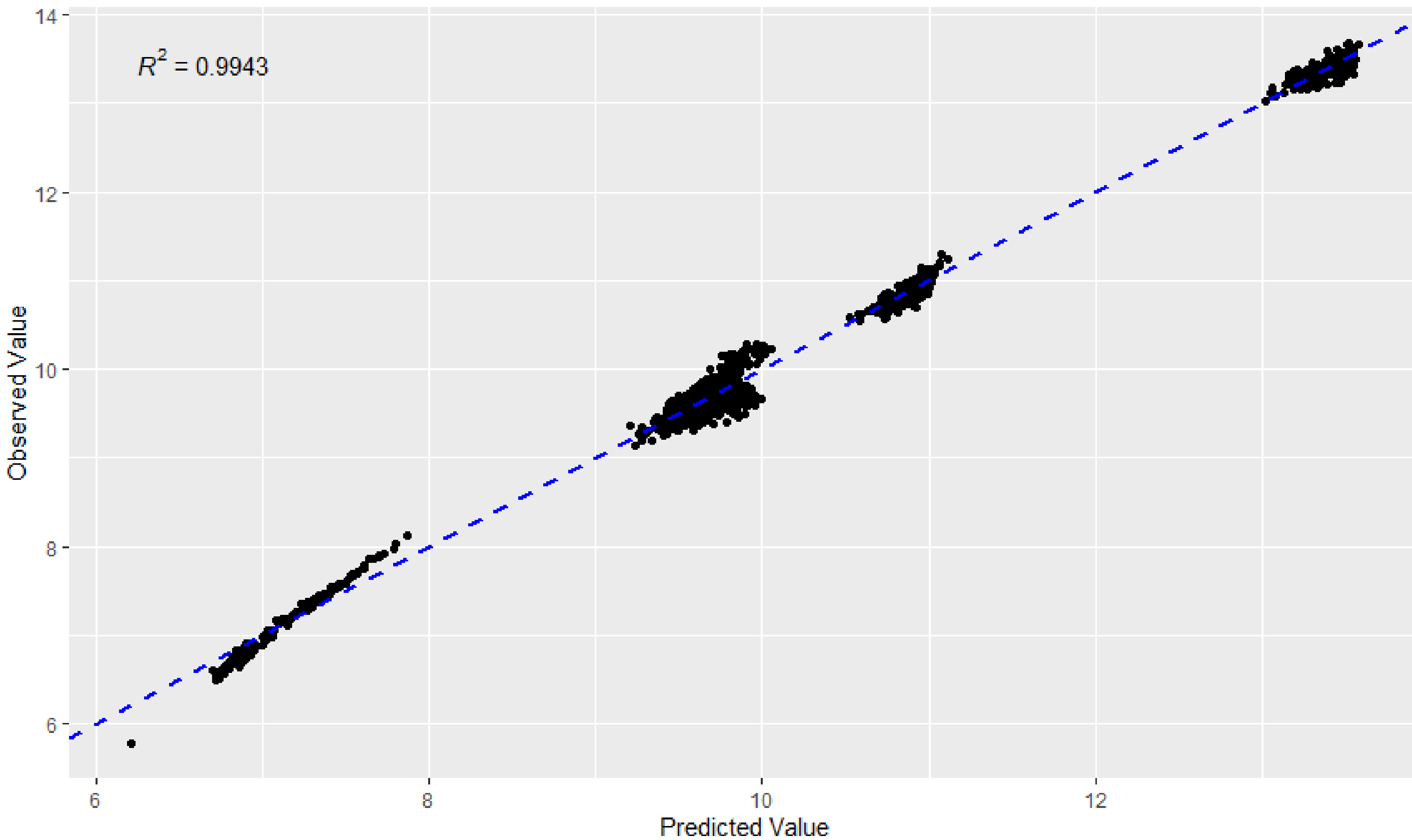

**Figure 8.4: Comparison of Historical and Predicted Monthly Usage, by Gantry, Trucks, Weekday**

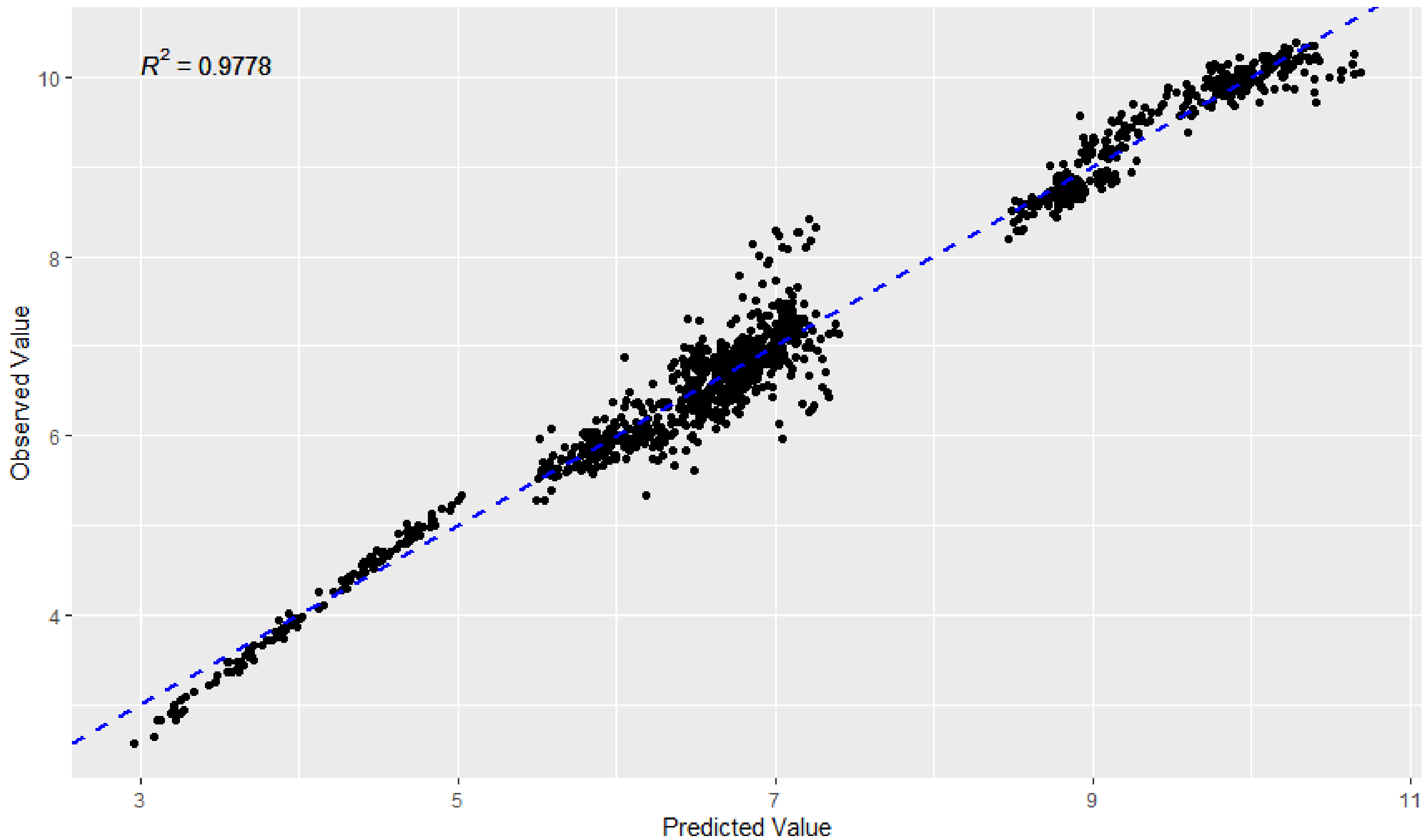

**Figure 8.5: Comparison of Historical and Predicted Monthly Usage, by Gantry, Trucks, Weekend**