Office of INTERMODAL Planning and Investment

Northern Virginia TDM Study

Tasks 8-9: Data Analysis and Case Studies

Summary Memo

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Introduction

This report summarizes Global Positioning System (GPS) data for the Northern Virginia (NOVA) region that traces actual passenger vehicle trips within and between geographic areas called traffic analysis zones (TAZs). The report highlights areas of opportunity for reducing these trips and describes more than 15 case studies identified using the data. In developing the case studies, we relied on our team's collective knowledge, reviewed existing plans, projects and documents, and held meetings with stakeholders to solicit feedback. Each case study describes insight gained from the GPS data, existing conditions, opportunities to reduce or shorten personal vehicle trips, cost estimates of taking the recommended actions, and a description of the estimated benefits.

This work builds upon three earlier technical memos:

- General Regional Needs and Existing Approach Summary
- Assessment of Existing Local and Modal Programs and Plans
- Best Practices for Managing Transportation Demand and Improving Accessibility

The GPS data reflects upwards of 3,425,000 trips each weekday throughout the NOVA region. Of those trips, 1,760,000 (51%) are less than five miles, 819,000 (24%) are less than two miles, and 270,000 (8%) are less than one mile. Approximately 781,000 of the short trips (44%) take place during the AM or PM peak periods, when capacity needs are greatest. Of the 292 roads and corridors we evaluated, short trips account for 10% of daily traffic, on average, and upwards of 42% in some cases.

Common travel modeling and project evaluation procedures often do not fully reflect these short trips, particularly those in the lower range (1-2 miles), because they are assumed to make up a much smaller share of trips or because TAZs used in the travel models are too large to 'capture' these trips on modeled transportation networks that only carry trips traveling from one TAZ to another. Nonetheless, in such large quantities, these trips add considerably to road capacity demand, yet they also offer opportunities to improve accessibility and system performance through means other than large capacity improvements. These opportunities include conventional transportation demand management (TDM), priced parking, bicycle and pedestrian facilities, small transit enhancements, local street connections and certain changes in land use patterns, which have been shown to encourage mode shifts and reduce the frequency and length of vehicle trips. This report focuses primarily on those opportunities.

Scanning NOVA for Issues and Opportunities

The following tables and data descriptions report total daily traffic flows, estimated from observed GPS vehicle trip traces. Streetlight Data, the GPS data provider, reports relative traffic frequencies based on observed counts of GPS-enabled vehicles. The analysis presented in this memo accounts for scaling the traffic frequencies up to represent total daily traffic volumes or "flows" based on average annual daily traffic (AADT) values reported by the Virginia DOT on certain highway segments. Technical details of the scaling are provided at the end of this document. The resulting data represent only personal vehicles (commercial vehicles are filtered out).

Common pairs

The data includes personal vehicle flows for every origin-destination (O-D) pair[1] within the NOVA study region. Pairs with high flows represent opportunities to reduce personal vehicle trips through ridesharing or by converting trips to other modes, such as transit.

The highest flow between an origin and a destination, not occurring within the TAZ, is 4,658 trips during a weekday. The average flow between O-D pairs, excluding those with zero flow, is 10 trips per day. Including internal trips[2], the highest flow is 7,380 trips per day, which occur at Dulles Town Center. Table 1 lists the O-D pairs with the highest flows. The table also includes estimates of total vehicle-miles traveled and vehicle- hours traveled. The average travel distance for any given O-D pair is calculated by multiplying the straight-line distance between TAZ centroids by the average circuity (discussed below).

Circuity

For every O-D pair within the NOVA study region, the data describes average trip circuity, defined as the the straight-line distance from an origin location to a destination location divided by the estimated total travel distance[3]. This measure describes how far travelers must go out of their way during a trip, often because of poor network connectivity. Therefore, a trip circuity of 2.0 indicates that an individual traveled twice the straight line distance to reach their destination. In many cases, trip circuity (and therefore travel time and distance) can be reduced by adding street connections—including bridge crossings or streets connecting neighborhoods—and by ensuring that new developments are built around highly connected street networks.

Of the more than 150,000 O-D pairs in the NOVA region, the average weekday trip circuity is 2.0 or higher for 5,578 pairs (3.6%) and 3.0 or higher for 599 pairs (0.4%). Trips with circuities higher than 4.0 were filtered out of the data set because they tend to represent for-hire drivers and other multi-stop tours.

Table 2 details the most circuitous O-D pairs, where the flow was 65 trips per day or higher. The table also shows average trip duration and estimates of excess vehicle miles traveled and vehicle hours traveled due to circuity. These estimates assume that trip duration is proportional to circuity and that circuity may be reduced from its current value to 1.4 (corresponding with the "Manhattan distance," measured along two legs of an isosceles right triangle) through interventions like street connections. The average circuity is 1.4 or less for approximately two-thirds of O-D pairs. Further analysis of each pair is needed to determine the precise vehicle hours of travel that could be eliminated through interventions.

Short trips

As previously mentioned, O-D data describes the percentage of trips from zero to one mile in length, one to two miles, and two to five miles. These short trips represent opportunities to convert vehicle trips to walking, biking or transit. For example, many trips under two miles could realistically be made by either walking or biking—particularly if vehicle trips are circuitous and there are opportunities to improve network connectivity for bicycles and pedestrians. Many trips

[1] Defined in terms of vehicular movement from one TAZ to another
[2] Vehicles whose origin and destination are contained within a TAZ
[3] Total travel distance is estimated as the sum of straight-line distances between individual GPS pings.

under five miles could be served by transit if volumes are high enough or by bicycle if routes are safe and convenient.

Of the more than 150,000 O-D pairs in the NOVA region, more than 38,000 pairs included at least one observed trip of less than five miles in length during a typical weekday. Table 3 shows TAZs with the highest number of trips under five miles by origin. Table 4 shows the TAZs with the highest number of trips under five miles by destination. Table 5 shows the O-D pairs with the highest average circuity for short trips. We limited this analysis to pairs where there are at least 65 trips under five miles per weekday.

Selected links

Based on stakeholder input and network data including congestion, the study team selected 292 one-way network links for which GPS trace data was mined describing all of the trips passing through that link. Select link analysis focused on the prevalence of short trips and common pairs. A common pair is defined as any O-D pair that accounts for a substantial share of flow on that link. Common pairs indicate potential opportunities for transit service, shuttles, coordinated carpools or other alternatives. Short trips indicate potential opportunities to shift vehicles off of the link by changing modes, improving the connectivity of the local street network or other operational interventions.

Table 6 details the links with the highest weekday flows, where the top five O-D pairs account for at least 10% of flow or trips under five miles account for at least 10% of flow. High volume flows indicate that there may be opportunities to shift a large number of trips to other modes or routes and that there is a higher likelihood of congestion during peak periods, depending on the capacity of the roadway. Information about common pairs and short trips help explain what kind of opportunities for improvement may exist.

Table 1. Common O-D Pairs (Highest Flows, Weekday)

Rank	Orig. TAZ	Dest. TAZ	Flow (000)	Circ.	Dist. (mi)	Dur. (min)	VMT* (000)	VHT (000)
1	591	604	4.66	1.50	5.2	11	24.2	0.85
2	604	591	2.96	1.36	4.7	10	14.0	0.49
3	576	565	2.84	1.48	2.9	9	8.2	0.43
4	824	828	2.74	1.29	1.8	22	5.0	1.00
5	695	618	2.64	1.21	2.1	11	5.4	0.48
6	834	828	2.56	1.41	3.1	18	7.8	0.77
7	591	601	2.50	1.79	3.3	12	8.2	0.50
8	565	576	2.42	1.50	2.9	8	7.0	0.32
9	576	591	2.17	1.56	3.7	13	8.1	0.47
10	591	576	2.05	1.58	3.8	13	7.7	0.44
11	576	585	2.00	1.66	1.8	11	3.7	0.37
12	618	695	1.92	1.22	2.1	10	4.0	0.32
13	735	725	1.88	1.48	2.0	18	3.7	0.56
14	588	591	1.86	1.37	3.4	13	6.4	0.40
15	219	238	1.84	1.60	1.1	8	2.1	0.25
16	478	467	1.83	1.39	3.3	9	6.1	0.27
17	295	282	1.79	1.26	1.1	8	1.9	0.24
18	220	218	1.76	1.35	0.9	7	1.5	0.21
19	834	819	1.72	1.26	2.9	19	4.9	0.54
20	725	737	1.71	1.29	1.7	9	3.0	0.26
21	542	540	1.62	1.42	1.2	8	1.9	0.22
22	220	242	1.61	1.18	1.6	7	2.5	0.19
23	282	295	1.60	1.42	1.2	8	1.9	0.21
24	282	297	1.54	1.42	0.8	8	1.3	0.20
25	618	725	1.52	1.52	10.3	28	15.6	0.71
26	602	617	1.50	1.37	6.3	19	9.5	0.47
27	602	604	1.49	1.37	3.0	14	4.5	0.35
28	238	219	1.47	1.60	1.1	8	1.6	0.20
29	218	220	1.43	1.40	0.9	8	1.3	0.19
30	601	591	1.40	1.49	2.7	10	3.8	0.23
31	608	602	1.39	1.39	3.5	12	4.9	0.28
32	737	725	1.39	1.40	1.9	11	2.6	0.25
33	297	282	1.37	1.42	0.8	8	1.1	0.18
34	602	608	1.36	1.28	3.3	17	4.4	0.38
35	617	254	1.35	1.25	3.1	13	4.2	0.29
36	602	525	1.33	1.60	17.4	49	23.3	1.09
37	630	621	1.33	1.23	1.9	12	2.5	0.27
38	578	588	1.32	1.37	3.2	9	4.3	0.20
39	588	592	1.32	1.32	1.7	8	2.3	0.18
40	725	718	1.31	1.40	2.2	9	2.9	0.20
41	621	630	1.31	1.33	2.1	11	2.7	0.24
42	238	242	1.29	1.49	0.6	8	0.7	0.17
43	726	725	1.27	1.29	1.1	8	1.4	0.17
44	219	218	1.27	1.40	1.0	8	1.3	0.17
45	621	625	1.27	1.56	2.8	12	3.5	0.25
46	297	295	1.26	1.48	0.7	8	0.9	0.17
47	591	588	1.26	1.44	3.6	15	4.6	0.32
48	277	254	1.26	1.32	1.5	10	1.9	0.21
49	487	488	1.26	1.45	1.2	11	1.5	0.23
50	592	588	1.25	1.40	1.8	9	2.3	0.19

*Total vehicle miles traveled between TAZ centroids using average trip circuity

Table 1 (cont.). Common O-D Pairs (Highest Flows, Weekday)

Rank	Orig. TAZ	Dest. TAZ	Flow (000)	Circ.	Dist. (mi)	Dur. (min)	VMT* (000)	VHT (000)
51	540	542	1.25	1.40	1.2	9	1.4	0.19
52	742	487	1.25	1.48	23.7	51	29.5	1.06
53	487	576	1.24	1.71	23.9	39	29.6	0.81
54	617	615	1.24	1.38	2.6	9	3.2	0.19
55	591	602	1.23	1.31	3.7	17	4.6	0.35
56	487	326	1.22	1.53	6.9	25	8.4	0.51
57	218	219	1.22	1.37	1.0	9	1.2	0.18
58	615	617	1.21	1.38	2.5	9	3.1	0.18
59	238	218	1.19	1.30	1.4	9	1.7	0.18
60	295	297	1.19	1.58	0.8	8	0.9	0.16
61	588	554	1.19	1.80	10.9	32	12.9	0.63
62	554	588	1.19	1.77	10.7	33	12.7	0.65
63	299	319	1.18	1.36	1.4	8	1.7	0.16
64	604	601	1.18	1.38	4.6	10	5.4	0.20
65	250	260	1.18	1.32	1.2	8	1.4	0.16
66	220	238	1.17	1.39	1.8	11	2.1	0.21
67	718	725	1.14	1.36	2.1	8	2.4	0.15
68	467	478	1.14	1.40	3.4	9	3.8	0.17
69	242	238	1.13	1.59	0.6	9	0.7	0.17
70	725	618	1.13	1.51	10.2	30	11.5	0.56
71	161	174	1.11	1.51	1.5	8	1.7	0.15
72	725	726	1.10	1.23	1.1	8	1.2	0.15
73	218	242	1.10	1.34	1.8	10	2.0	0.18
74	604	576	1.09	1.28	7.5	12	8.1	0.22
75	304	41	1.08	1.29	4.3	22	4.6	0.40
76	254	266	1.08	1.63	1.6	8	1.7	0.14
77	576	487	1.07	1.74	24.3	41	26.0	0.73
78	326	487	1.07	1.49	6.7	25	7.2	0.45
79	161	158	1.07	1.29	1.4	9	1.5	0.16
80	588	578	1.06	1.38	3.2	8	3.5	0.14
81	248	254	1.06	1.53	2.3	10	2.5	0.18
82	525	602	1.05	1.72	18.7	59	19.6	1.03
83	619	621	1.04	1.37	1.9	8	2.0	0.14
84	377	120	1.04	1.32	1.3	8	1.4	0.14
85	601	576	1.04	1.40	4.4	13	4.5	0.22
86	810	828	1.04	1.45	1.8	9	1.9	0.16
87	238	220	1.04	1.42	1.8	11	1.9	0.19
88	177	192	1.03	1.48	1.5	8	1.6	0.14
89	174	178	1.02	1.36	1.4	8	1.4	0.14
90	174	161	1.02	1.48	1.5	8	1.5	0.14
91	242	220	1.01	1.43	1.9	10	1.9	0.17
92	277	294	1.00	1.29	1.9	7	1.9	0.12
93	254	248	1.00	1.53	2.3	12	2.3	0.20
94	525	540	0.99	1.44	2.0	8	1.9	0.13
95	282	301	0.99	1.26	1.4	8	1.4	0.13
96	807	810	0.98	1.49	0.9	7	0.9	0.11
97	218	238	0.98	1.37	1.5	9	1.5	0.15
98	576	588	0.97	1.34	6.0	16	5.8	0.26
99	488	487	0.97	1.52	1.2	12	1.2	0.19
100	544	525	0.97	1.46	2.9	9	2.8	0.15

*Total vehicle miles traveled between TAZ centroids using average trip circuity

Table 2. Circuitous Trips by O-D Pair (Highest Circuities, Flows ≥40, Weekday)

Rank	Orig. TAZ	Dest. TAZ	Flow	Circ.	Dur. (min)	Excess VMT*	Excess VHT*
1	602	588	511	2.42	19	1.2	94.2
2	457	457	504	2.87	18	0.0	74.4
3	588	602	367	2.48	19	1.3	66.0
4	588	10016	338	2.32	92	22.2	314.8
5	85	10015	311	2.43	37	8.0	111.1
6	121	130	297	2.77	9	1.0	22.7
7	177	604	232	2.31	14	2.4	33.0
8	559	554	196	2.69	21	2.9	35.9
9	554	559	187	2.74	24	3.1	38.4
10	540	10009	178	2.41	73	16.4	126.7
11	10013	172	178	2.52	24	4.5	39.7
12	427	423	164	2.38	8	0.5	13.0
13	482	483	146	2.35	10	1.6	14.6
14	377	304	137	2.30	37	3.5	51.8
15	592	602	135	2.35	18	2.1	24.3
16	561	554	131	2.38	19	1.3	24.4
17	708	718	131	2.31	11	0.7	14.6
18	70	89	126	2.39	12	1.4	14.8
19	172	10013	126	2.72	32	5.2	34.9
20	377	398	124	2.38	13	0.9	15.9
21	450	462	122	2.34	9	1.1	11.0
22	478	10021	122	2.88	58	24.1	57.6
23	133	118	119	2.40	6	0.6	7.0
24	10021	478	119	3.07	56	27.3	51.1
25	130	123	115	3.06	19	1.5	16.7
26	70	75	113	2.41	13	0.6	14.3
27	475	68	113	2.40	138	11.1	152.0
28	10009	576	113	2.31	60	12.4	68.6
29	130	116	97	2.73	13	1.1	10.8
30	598	10009	97	2.39	63	15.2	60.0
31	462	450	95	2.33	9	1.1	8.6
32	618	693	95	2.31	18	3.5	17.3
33	693	618	95	2.46	18	4.1	16.3
34	130	124	90	3.00	7	0.5	4.9
35	565	573	90	2.38	24	2.5	21.3
36	591	10008	90	2.52	64	11.4	53.7
37	150	10012	88	2.31	36	5.9	32.2
38	416	377	88	2.35	13	1.5	11.4
39	130	109	86	2.95	18	2.1	12.3
40	106	130	81	2.40	16	1.0	12.7
41	10021	467	81	3.19	59	33.5	35.2
42	10021	834	81	2.61	77	18.9	56.1
43	124	130	79	3.18	12	0.5	7.0
44	163	249	77	2.55	35	6.0	24.6
45	289	289	77	2.42	6	0.0	4.5
46	10021	824	74	2.52	84	18.8	58.3
47	130	106	72	2.59	14	1.2	9.2
48	482	740	72	2.62	96	18.9	62.0
49	10009	150	72	2.67	52	14.9	33.0
50	355	337	70	2.55	11	1.7	7.1

*Excess vehicle miles traveled and vehicle hours traveled, assuming trip duration is proportional to circuity and circuity may be reduced 1.4 (Manhattan distance)

Table 2 (cont.). Circuitous Trips by O-D Pair (Highest Circuities, Flows ≥40, Weekday)

Rank	Orig. TAZ	Dest. TAZ	Flow	Circ.	Dur. (min)	Excess VMT*	Excess VHT**
51	377	416	70	2.62	12	1.9	7.5
52	472	457	70	2.36	7	1.0	4.9
53	10009	598	70	2.31	54	14.0	38.4
54	740	482	68	2.45	92	16.2	59.6
55	9	130	65	2.34	31	6.4	20.3
56	287	178	65	2.46	56	11.3	35.0
57	399	381	65	2.58	19	1.2	11.3
58	560	589	65	2.78	30	6.7	16.5
59	240	240	63	2.35	8	0.0	5.0
60	10008	576	63	2.64	69	9.9	38.7
61	722	254	61	2.46	105	7.9	61.0
62	10012	145	61	2.48	38	6.6	21.9
63	47	10010	59	2.37	77	15.3	44.8
64	318	304	59	2.95	76	15.4	35.4
65	483	462	59	2.54	20	3.5	10.8
66	437	423	56	2.33	10	0.7	5.7
67	592	586	56	2.39	16	2.1	8.9
68	147	10012	54	2.37	43	7.9	23.0
69	71	67	52	2.53	10	0.5	4.8
70	138	390	52	2.56	9	0.6	4.3
71	173	218	52	2.34	32	3.7	16.6
72	397	381	52	2.67	18	1.8	8.2
73	450	451	52	2.69	10	1.3	4.5
74	567	10012	52	2.32	52	8.7	27.3
75	103	130	50	2.59	14	1.5	6.3
76	453	448	50	2.50	8	0.3	3.7
77	710	717	50	2.31	5	0.5	2.5
78	131	118	47	2.48	10	1.4	4.5
79	461	10021	47	2.35	57	17.2	26.9
80	10009	565	47	2.80	80	16.5	31.7
81	449	448	45	2.60	17	1.3	6.9
82	703	701	45	2.46	15	1.5	6.5
83	35	130	43	2.42	28	5.7	11.6
84	45	58	43	2.39	9	0.9	3.8
85	178	310	43	2.36	62	9.4	26.4
86	415	304	43	2.37	39	6.6	16.5
87	426	433	43	2.60	10	0.9	3.9
88	695	694	43	2.33	16	1.6	6.9
89	719	710	43	2.37	9	0.8	3.8
90	812	823	43	2.34	13	1.0	5.6
91	828	10021	43	2.44	74	18.5	30.4
92	10009	594	43	2.32	51	13.3	22.1
93	133	10013	41	2.58	59	14.9	21.8
94	163	232	41	2.80	32	5.2	10.9
95	467	10021	41	3.09	62	31.6	19.1
96	558	10009	41	3.06	70	22.4	21.8
97	563	10009	41	2.52	67	15.4	25.3
98	565	10009	41	2.50	66	13.0	25.1
99	567	577	41	2.51	12	1.5	4.5
100	10009	563	41	2.90	63	20.8	20.7

*Excess vehicle miles traveled and vehicle hours traveled, assuming trip duration is proportional to circuity and circuity may be reduced 1.4 (Manhattan distance)

Table 3. Short Trips by Origin (Highest Flows <5 Miles, Weekday)

		Flow (000)						Flow (000)			
Rank	TAZ	All trips	<5 mi	<2 mi	<1 mi	Rank	TAZ	All trips	<5 mi	<2 mi	<1 mi
1	10004	117.35	22.89	3.01	0.68	51	245	11.57	7.07	3.76	1.39
2	576	51.32	21.50	11.53	3.92	52	76	15.47	7.03	4.42	1.67
3	591	46.40	19.86	9.10	2.00	53	178	12.69	6.93	3.91	1.31
4	604	42.50	15.83	10.32	3.94	54	602	14.06	6.90	3.91	1.44
5	282	30.12	15.38	7.96	4.48	55	299	18.97	6.89	3.55	1.41
6	588	28.56	13.42	6.10	2.44	56	412	11.16	6.84	3.64	1.17
7	238	35.70	12.86	6.76	2.12	57	630	13.24	6.77	3.20	1.29
8	487	26.01	11.98	7.52	3.77	58	619	11.57	6.72	4.08	1.54
9	218	25.01	11.92	8.05	3.80	59	75	12.24	6.67	2.79	0.84
10	828	20.31	11.73	7.96	3.61	60	82	10.23	6.62	3.08	0.92
11	242	20.84	11.25	6.26	3.63	61	447	10.80	6.52	3.69	1.67
12	725	22.61	11.19	6.52	2.37	62	10007	14.08	6.50	4.47	2.44
13	297	20.58	11.00	6.84	3.14	63	248	10.86	6.47	3.61	1.41
14	810	27.13	10.84	7.51	3.98	64	540	20.75	6.45	3.84	1.29
15	174	19.91	10.63	5.94	2.44	65	32	13.27	6.41	4.20	1.82
16	219	23.90	10.55	6.59	3.01	66	27	12.59	6.40	3.59	1.18
17	161	19.29	10.50	6.36	2.70	67	618	13.11	6.29	3.84	1.22
18	254	16.40	9.50	4.29	1.44	68	490	14.25	6.18	2.75	1.61
19	220	24.06	9.50	5.50	1.52	69	478	13.29	6.18	2.43	0.49
20	617	20.52	9.28	4.85	1.44	70	177	17.10	6.14	1.96	1.17
21	621	21.59	9.27	4.45	1.51	71	251	11.25	6.10	3.35	1.06
22	250	14.31	9.16	5.01	1.97	72	323	14.61	6.00	2.90	1.04
23	120	17.52	8.77	4.40	2.24	73	625	11.27	5.98	2.02	0.95
24	486	15.95	8.70	5.21	1.84	74	158	10.05	5.94	2.75	1.10
25	601	11.19	8.50	3.53	0.96	75	578	10.23	5.90	3.06	1.25
26	565	18.55	8.47	5.04	2.74	76	620	10.13	5.87	2.77	1.06
27	737	25.55	8.45	3.52	1.09	77	525	11.57	5.86	2.30	0.59
28	41	17.37	8.43	4.38	1.50	78	49	9.84	5.78	2.80	0.92
29	304	15.54	8.37	4.62	2.12	79	34	10.40	5.77	2.88	0.84
30	30	24.06	8.23	4.63	2.68	80	834	11.62	5.73	3.11	1.22
31	171	14.45	8.23	3.90	1.57	81	227	15.66	5.72	3.95	1.41
32	488	15.13	8.23	4.29	1.82	82	348	10.67	5.71	3.35	1.40
33	301	18.24	8.21	4.92	0.51	83	608	11.23	5.71	3.40	1.50
34	295	33.30	8.17	1.99	1.16	84	394	18.96	5.67	3.19	1.14
35	740	13.67	8.17	4.20	2.33	85	107	12.83	5.65	3.48	1.50
36	742	14.02	8.03	3.97	1.75	86	728	21.11	5.65	2.54	0.83
37	89	15.54	7.91	2.57	0.95	87	192	9.35	5.63	2.99	1.27
38	459	16.28	7.70	4.17	1.88	88	21	11.58	5.54	2.62	1.25
39	266	23.05	7.69	2.12	0.44	89	551	13.60	5.51	3.44	1.24
40	229	15.46	7.69	4.78	3.16	90	319	12.73	5.44	2.86	1.00
41	67	16.20	7.64	3.44	1.73	91	68	12.76	5.41	1.52	0.91
42	249	15.56	7.61	4.55	1.74	92	568	9.78	5.33	2.28	0.72
43	260	17.81	7.56	3.35	0.92	93	485	10.05	5.30	2.91	1.10
44	121	14.25	7.52	4.49	1.64	94	17	12.58	5.28	3.68	1.84
45	377	14.60	7.46	4.44	1.95	95	315	9.79	5.23	2.41	0.99
46	65	12.67	7.35	3.37	1.10	96	599	8.40	5.23	3.22	1.47
47	213	16.87	7.29	3.70	1.34	97	851	34.65	5.22	0.49	0.13
48	118	16.55	7.27	3.78	2.04	98	495	11.47	5.22	2.47	0.93
49	542	11.50	7.26	4.40	1.61	99	283	8.97	5.22	3.08	1.24
50	718	16.42	7.17	3.06	1.50	100	807	8.35	5.22	2.28	0.97

Table 4. Short Trips by Destination (Highest Flows <5 Miles, Weekday)

Rank	TAZ	Flow (000) All trips	<5 mi	<2 mi	<1 mi	Rank	TAZ	Flow (000) All trips	<5 mi	<2 mi	<1 mi
1	10004	135.77	28.45	5.62	1.32	51	245	11.34	6.96	3.94	1.17
2	576	51.40	19.62	9.86	3.56	52	76	15.30	6.84	3.38	1.38
3	591	45.35	17.76	7.34	2.14	53	178	14.40	6.79	4.60	1.86
4	604	40.13	17.55	10.95	3.99	54	602	33.93	6.77	2.70	1.22
5	282	29.79	14.51	7.14	4.36	55	299	15.61	6.74	4.14	1.54
6	588	26.68	12.84	5.84	2.22	56	412	12.78	6.73	3.61	1.39
7	238	27.79	12.57	8.03	4.16	57	630	21.07	6.69	3.71	1.20
8	487	35.44	12.43	6.08	2.09	58	619	11.51	6.66	3.33	1.05
9	218	25.45	12.12	8.25	4.17	59	75	15.26	6.55	3.14	1.73
10	828	17.43	11.90	7.88	1.31	60	82	12.45	6.50	2.71	0.89
11	242	21.31	11.83	7.82	3.63	61	447	15.63	6.43	3.35	2.04
12	725	23.06	11.21	6.20	2.09	62	10007	37.67	6.42	0.94	0.25
13	297	21.64	11.09	6.23	3.74	63	248	18.75	6.38	3.14	1.25
14	810	20.84	10.94	6.01	2.53	64	540	13.35	6.32	4.03	1.65
15	174	24.79	10.67	6.33	2.64	65	32	10.43	6.30	3.01	1.32
16	219	27.47	10.52	6.94	3.49	66	27	13.28	6.27	2.72	1.06
17	161	19.42	10.34	5.81	2.54	67	618	13.11	6.18	1.53	0.92
18	254	23.10	10.31	6.12	1.98	68	490	12.35	6.18	3.77	1.46
19	220	19.25	9.92	6.44	2.97	69	478	13.90	6.07	3.60	1.41
20	617	20.60	9.75	3.86	1.34	70	177	14.63	5.97	2.98	1.09
21	621	20.58	9.65	5.51	1.59	71	251	11.48	5.90	3.18	1.07
22	250	14.85	9.46	5.07	1.87	72	323	12.75	5.85	3.33	1.11
23	120	18.60	9.44	5.13	2.25	73	625	13.28	5.85	2.58	0.54
24	486	17.29	9.35	5.36	2.40	74	158	9.58	5.83	3.33	1.53
25	601	18.01	8.69	4.02	1.05	75	578	9.95	5.82	2.89	0.88
26	565	17.35	8.67	4.66	1.54	76	620	10.43	5.81	2.87	1.05
27	737	16.53	8.65	4.34	1.41	77	525	13.49	5.74	3.18	1.22
28	41	13.99	8.52	4.04	2.12	78	49	10.94	5.69	2.96	1.15
29	304	14.98	8.50	4.31	1.57	79	34	9.11	5.66	3.25	1.32
30	30	17.53	8.44	4.29	2.14	80	834	18.18	5.61	2.52	0.53
31	171	15.46	8.22	5.15	1.73	81	227	11.72	5.61	3.34	1.17
32	488	15.57	8.21	4.54	1.82	82	348	11.48	5.58	2.76	1.18
33	301	14.39	8.09	4.49	1.83	83	608	11.81	5.58	2.56	1.12
34	295	16.64	7.90	4.91	3.47	84	394	13.41	5.57	3.46	1.16
35	740	12.28	7.87	3.45	1.31	85	107	12.49	5.49	3.55	1.82
36	742	22.85	7.86	1.96	0.46	86	728	8.89	5.44	3.35	1.43
37	89	14.82	7.81	4.74	1.75	87	192	9.96	5.42	3.14	1.36
38	459	23.40	7.80	4.38	2.64	88	21	9.59	5.41	2.50	1.07
39	266	18.77	7.56	4.52	2.12	89	551	11.30	5.37	2.47	0.86
40	229	16.41	7.55	4.92	2.47	90	319	10.44	5.31	3.18	1.16
41	67	15.64	7.51	2.36	1.02	91	68	10.99	5.29	2.01	1.00
42	249	13.50	7.51	4.08	1.89	92	568	10.57	5.19	2.14	0.56
43	260	12.70	7.49	4.06	1.92	93	485	12.41	5.16	2.74	0.93
44	121	15.37	7.44	3.75	1.72	94	17	10.03	5.11	2.32	1.00
45	377	24.03	7.24	3.02	1.03	95	315	12.46	5.10	2.81	1.21
46	65	12.28	7.20	3.33	1.07	96	599	12.32	5.07	2.72	0.72
47	213	12.36	7.14	3.62	1.50	97	851	10.57	5.05	2.50	1.08
48	118	11.51	7.14	3.25	1.03	98	495	9.16	5.05	2.35	1.04
49	542	15.41	7.10	4.13	1.66	99	283	8.99	5.02	2.37	0.98
50	718	18.33	6.97	3.69	1.53	100	807	8.70	5.00	2.23	0.96

Table 5. Short, Circuitous Trips (Highest Circuities, Flows <5 miles ≥65, Weekday)

Rank	Orig. TAZ	Dest. TAZ	<5 miles Flow	<5 miles Circ.	<2 miles Flow	<2 miles Circ.	<1 mile Flow	<1 mile Circ.
1	32	32	2,351	2.48	1,957	1.86	1,069	1.42
2	559	559	716	2.40	570	1.57	254	1.32
3	843	843	711	2.20	476	1.84	265	1.31
4	238	238	682	2.40	609	1.86	514	1.48
5	52	52	546	2.58	395	1.49	320	1.23
6	457	457	491	3.00	487	2.98	65	1.87
7	449	449	477	3.54	288	2.02	95	1.69
8	76	76	474	2.27	436	2.05	280	1.51
9	130	121	434	2.55	376	2.33	0	-
10	107	115	392	2.21	315	1.45	248	1.26
11	115	107	373	2.80	278	1.79	149	1.39
12	707	732	358	2.26	113	1.73	8	1.03
13	308	323	333	2.48	275	1.90	80	1.56
14	121	130	290	3.11	228	2.87	0	-
15	70	76	276	2.34	248	2.15	145	1.51
16	323	308	266	2.22	229	1.84	79	1.43
17	584	584	266	2.41	224	1.77	127	1.40
18	326	326	238	2.28	215	1.65	183	1.44
19	474	474	232	2.40	208	1.84	57	1.31
20	722	630	221	2.36	69	1.71	34	1.55
21	186	186	221	2.39	202	1.68	182	1.57
22	376	394	219	2.38	136	1.91	8	1.11
23	290	290	216	4.54	130	1.59	85	1.35
24	350	331	209	2.33	111	1.93	4	1.07
25	757	757	208	2.30	179	1.97	80	1.29
26	191	178	200	2.48	185	2.28	56	1.37
27	463	463	200	2.47	168	1.79	124	1.36
28	423	427	198	2.59	160	2.02	81	1.66
29	571	561	197	2.74	100	1.52	56	1.56
30	414	395	196	3.03	155	1.67	26	1.35
31	177	604	193	2.27	11	1.50	0	-
32	321	344	185	2.23	114	1.78	54	1.58
33	74	75	182	2.90	148	1.82	114	1.36
34	819	816	179	2.66	122	1.94	50	1.16
35	182	189	176	2.34	150	1.84	53	1.25
36	190	171	171	2.31	138	2.07	60	1.37
37	554	561	164	2.28	5	1.49	0	-
38	427	423	157	3.27	114	2.43	30	1.65
39	482	483	146	2.40	11	1.52	0	-
40	775	775	140	2.36	95	2.10	29	1.58
41	437	427	139	2.41	117	1.67	79	1.39
42	62	32	136	2.36	16	1.77	0	-
43	816	816	133	2.29	101	1.73	55	1.41
44	708	718	130	2.44	100	1.98	57	1.55
45	530	530	126	2.21	100	1.70	41	1.46
46	67	52	121	2.21	100	1.72	68	1.42
47	133	118	115	3.43	96	2.88	16	1.83
48	759	759	115	2.30	63	1.74	39	1.36
49	130	123	115	4.78	0	-	0	-
50	70	89	113	2.59	54	3.00	0	-

Table 5 (cont.). Short, Circuitous Trips (Highest Circuities, Flows <5 miles ≥65, Weekday)

Rank	Orig. TAZ	Dest. TAZ	<5 miles Flow	<5 miles Circ.	<2 miles Flow	<2 miles Circ.	<1 mile Flow	<1 mile Circ.
51	377	398	112	2.42	43	1.40	0	-
52	529	529	110	2.45	94	1.40	66	1.16
53	137	138	108	2.93	89	1.85	65	1.30
54	211	196	107	2.28	52	1.45	18	1.41
55	450	462	106	2.38	19	1.45	0	-
56	70	75	105	2.60	82	2.46	19	1.70
57	130	116	97	2.89	4	1.81	0	-
58	223	223	95	2.25	80	1.72	58	1.36
59	429	420	92	2.28	85	2.06	11	1.24
60	123	130	92	4.74	0	-	0	-
61	354	354	91	2.30	78	1.48	66	1.48
62	130	124	90	5.34	25	3.56	0	-
63	175	157	90	2.57	63	2.76	4	1.02
64	427	417	90	2.59	75	2.27	23	1.58
65	308	296	88	2.22	63	1.77	4	1.53
66	529	519	88	2.36	35	1.94	9	1.52
67	60	74	88	2.22	73	1.47	57	1.39
68	416	377	88	2.35	0	-	0	-
69	118	133	88	2.45	66	1.84	31	1.47
70	402	423	86	2.29	62	1.71	8	1.03
71	130	109	86	2.95	0	-	0	-
72	500	500	86	2.24	56	1.65	40	1.61
73	826	811	86	2.31	35	2.01	7	1.00
74	462	450	83	2.44	15	1.31	0	-
75	221	203	83	2.24	61	1.55	16	1.34
76	322	349	83	2.28	44	1.30	0	-
77	445	457	83	2.55	37	1.35	11	1.01
78	118	138	81	2.69	62	1.60	30	1.26
79	443	441	81	2.47	7	1.24	0	-
80	451	450	81	2.63	15	1.91	4	1.77
81	189	171	80	2.46	38	1.63	7	1.34
82	124	130	79	5.39	15	5.05	0	-
83	81	85	79	2.28	68	1.78	23	1.42
84	32	47	79	2.38	67	2.27	19	1.76
85	39	28	77	2.34	67	1.31	36	1.17
86	429	429	73	4.01	58	1.50	54	1.29
87	826	826	73	2.25	60	1.67	27	1.35
88	289	289	73	2.92	69	2.68	17	1.67
89	106	130	70	2.99	4	1.94	0	-
90	355	337	70	2.64	8	1.15	5	1.09
91	130	100	70	2.24	0	-	0	-
92	56	59	70	2.28	63	1.50	29	1.42
93	130	106	68	2.91	0	-	0	-
94	69	72	68	4.75	42	1.58	19	1.28
95	340	340	66	4.48	45	1.38	36	1.19
96	377	416	66	2.58	0	-	0	-
97	472	457	66	2.77	58	2.27	29	1.88
98	399	381	65	2.58	0	-	0	-
99	690	690	65	2.44	49	1.89	30	1.45
100	320	320	65	2.57	58	1.83	35	1.40

Table 6. Selected Links (Highest Flows, Top Five Pairs >10% or <5 Mile >10%, Weekday)

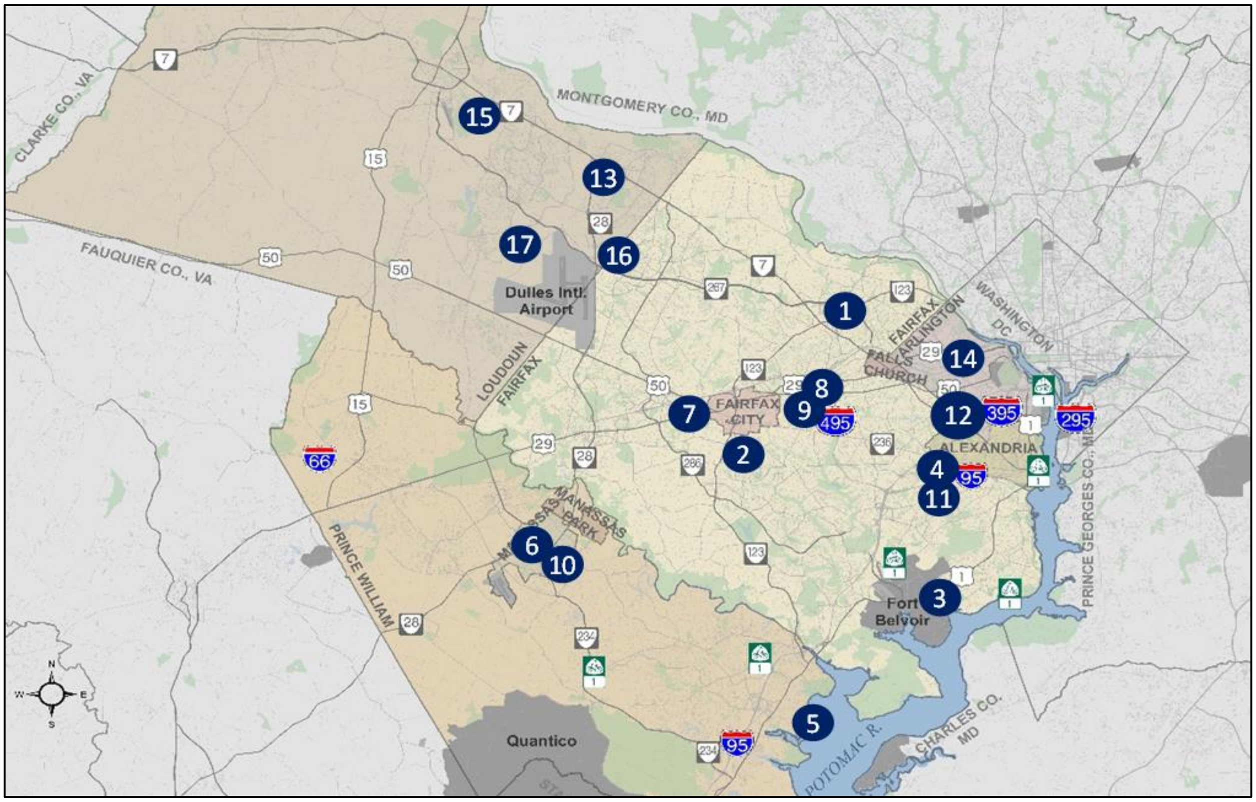
			Percent of flow						
Rank	Link ID	Flow (000)	Top O-D pair	Top five pairs	<5 mi	<2 mi	<1 mi	Link description and direction	
1	1191	156.6	6.9	10.5	0.8	0.6	0.0	I-95/I-495 (VA-613 to Eisenhower Ave Conn.)	EB
2	2191	154.0	7.0	11.6	0.8	0.6	0.0	I-95/I-495 (VA-613 to Eisenhower Ave Conn.)	WB
3	1204	139.6	7.7	11.8	0.1	0.0	0.0	I-95/I-495 (VA-241 to US-1)	EB
4	1172	136.0	9.3	15.8	0.5	0.1	0.0	I-95 (Lorton Rd to VA-286)	NB
5	1198	128.2	9.7	17.1	0.8	0.6	0.0	I-95 (VA-123 to US-1)	SB
6	1220	127.8	9.8	16.5	0.3	0.2	0.1	I-95 (US-1 to Lorton Rd)	NB
7	2220	127.6	9.7	17.4	0.4	0.3	0.1	I-95 (US-1 to Lorton Rd)	SB
8	1117	102.9	12.2	19.9	0.8	0.7	0.3	I-95 (Opitz Blvd to Prince William Pkwy)	NB
9	1028	97.1	12.8	23.3	0.8	0.3	0.1	I-95 (Joplin Rd to VA-234)	SB
10	1027	87.6	14.2	25.6	0.1	0.0	0.0	I-95 (Russell Rd to Joplin Rd)	SB
11	2027	86.0	14.6	24.2	0.3	0.2	0.1	I-95 (Russell Rd to Joplin Rd)	NB
12	2181	82.7	15.0	24.7	0.0	0.0	0.0	I-95 (VA-234 to Cardinal Dr)	NB
13	1181	81.0	15.1	26.7	0.4	0.2	0.1	I-95 (VA-234 to Cardinal Dr)	SB
14	1036	67.5	10.7	19.0	2.9	0.7	0.2	Neabsco Mills Rd (US-1 to Opitz Blvd)	SB
15	1006	47.8	10.6	25.1	0.5	0.1	0.0	VA-123 (George Wash. Pkwy to Chain Bridge)	NB
16	1049	45.0	1.6	6.0	10.2	4.4	2.0	US-50 (VA-28 to Lees Corner Rd)	EB
17	1019	40.7	2.0	7.2	10.2	3.6	1.1	US-50 (VA-609 to VA-28)	WB
18	1222	37.5	2.9	7.1	15.3	11.1	4.4	VA-7 (VA-123 to I-495)	EB
19	1013	37.5	1.3	5.1	12.0	3.8	1.0	VA-123 (VA-267 to VA-738/VA-309)	NB
20	1102	36.5	1.5	6.4	16.6	11.4	4.4	VA-7 (VA-267 to VA-123)	WB
21	2222	35.3	1.2	4.8	14.6	10.1	3.5	VA-7 (VA-123 to I-495)	WB
22	1017	34.4	3.0	10.4	13.9	7.4	1.7	VA-28 (Sudley Rd to Yorkshire Ln)	NB
23	1205	31.6	4.4	10.7	6.0	2.1	0.3	US-1 (at Gunston Rd)	NB
24	2031	30.7	2.7	10.6	0.9	0.1	0.0	VA-7 (VA-9/VA-699 to West Market St)	EB
25	1230	29.5	4.9	17.4	0.1	0.0	0.0	I-66 (Fauquier County line)	WB
26	1151	29.3	4.8	16.4	12.0	3.9	0.7	VA-606 (Evergreen Mills Rd to VA-614)	NB
27	2013	29.2	1.1	4.7	18.1	5.9	1.8	VA-123 (Dulles Toll Rd to VA-738/VA-309)	SB
28	2230	28.8	4.7	20.4	0.0	0.0	0.0	I-66 (Fauquier County line)	EB
29	2151	28.2	5.3	19.4	13.7	1.2	0.5	VA-606 (Evergreen Mills Rd to VA-614)	SB
30	1064	28.0	1.4	5.7	15.9	6.9	1.0	VA-236 (North Quaker Ln to V-241)	WB
31	1034	27.5	1.0	4.7	17.2	9.1	2.8	VA-216/VA-401 (I-95/I-495 to Edsall Rd)	NB
32	2064	26.9	1.3	5.5	17.9	7.3	1.8	VA-236 (North Quaker Ln to V-241)	EB
33	1079	26.9	3.0	11.2	10.4	2.7	0.8	US-50 (VA-606 to Tall Cedars Pkwy)	EB
34	1195	26.6	4.0	13.2	3.5	1.5	0.4	US-29 (US-15 to VA-55/VA-619)	EB
35	2205	26.5	7.6	17.3	6.1	1.8	0.4	US-1 (at Gunston Rd)	SB
36	1218	26.2	1.1	4.3	12.4	6.2	1.7	VA-286 (VA-267 to Elden St)	SB
37	1110	25.6	2.4	10.8	19.6	9.2	3.8	US-1 (Sherwood Hall Ln to South Kings Hwy)	NB
38	1022	25.1	1.2	4.1	13.5	5.9	3.1	US-50 (Barkley Dr to Gallows Rd)	WB
39	2123	23.9	3.5	7.6	12.8	3.7	0.5	US-1 (Featherstone Rd to Prince Will. Pkwy)	SB
40	1185	23.2	2.4	9.5	26.7	10.1	2.9	Sudley Rd (Sudley Manor Dr to Goodwin Dr)	NB
41	1209	22.5	1.6	6.1	15.3	7.0	1.5	VA-7 (I-495 to I-66)	EB
42	1059	22.5	7.2	18.9	5.4	0.3	0.1	Dulles Acess Rd	WB
43	1130	22.2	2.7	8.9	13.5	5.9	2.0	US-50 (I-66 to US-29)	EB
44	1123	22.1	2.5	7.4	13.7	6.7	1.4	US-1 (Featherstone Rd to Prince William Pkwy)	NB
45	1186	21.6	5.5	20.5	13.0	4.4	0.7	VA-237 (VA-236 to US-50)	SB
46	2021	21.0	2.4	8.1	28.5	13.0	4.3	VA-123 (VA-243 to Follin Lane SE)	NB
47	1074	20.9	3.7	13.5	8.0	0.4	0.0	VA-606 (Stukely Rd to VA-267)	EB
48	1039	19.9	1.5	4.7	14.5	6.9	1.8	VA-7 (I-66 to South West St)	EB
49	1021	19.8	3.8	9.2	33.8	14.3	5.7	VA-123 (VA-243 to Follin Lane SE)	SB
50	2182	19.0	4.9	12.0	11.8	2.3	0.6	US-1 (VA-234 to Cardinal Dr/Neabsco Rd)	NB

Table 6 (cont.). Selected Links (Highest Flows, Top Five Pairs >10% or <5 Mile >10%, Weekday)

Rank	Link ID	Flow (000)	Percent of flow: Top O-D pair	Top five pairs	<5 mi	<2 mi	<1 mi	Link description and direction	
51	1154	18.9	4.4	15.5	8.5	2.4	0.2	VA-28 (Linton Hall Rd to VA-234)	NB
52	1098	18.1	3.2	10.1	23.6	8.5	2.8	South Hayes St (I-395 to US-1)	SB
53	1041	18.0	2.1	8.2	26.8	15.4	5.0	VA-236 (US-29/US-50 to VA-123)	WB
54	2135	17.7	1.5	6.3	14.9	4.4	1.2	South Van Dorn St (VA-644 to I-95/I-495)	NB
55	1182	17.7	3.0	10.9	15.3	2.9	0.4	US-1 (VA-234 to Cardinal Dr/Neabsco Rd)	SB
56	1157	17.7	5.0	12.5	10.1	4.3	1.0	US-1 (Joplin Rd to VA-234)	NB
57	1135	17.6	1.8	5.5	15.4	3.3	0.6	South Van Dorn St (VA-644 to I-95/I-495)	SB
58	2039	16.4	1.1	4.1	16.4	7.4	2.1	VA-7 (I-66 to South West St)	WB
59	2125	16.4	3.1	10.2	32.1	20.4	7.4	Rosslyn-Ballston (Clarendon to Court House)	EB
60	1231	16.2	1.6	7.2	15.8	7.9	2.4	VA-120 (US-50 to N. Wilson Blvd)	NB
61	1208	16.1	10.9	31.4	29.4	7.2	1.0	Balls Ford Rd (Groveton Rd to Sudley Rd)	EB
62	1038	16.1	1.8	5.4	17.2	9.6	4.9	VA-236 (I-495 to VA-244)	WB
63	2229	15.9	4.1	13.0	0.0	0.0	0.0	US-15 (VA-661 to VA-663)	SB
64	1139	15.8	1.5	5.4	14.3	3.1	0.7	US-29 (Graham Rd to Anntoale Rd)	EB
65	1129	15.8	2.9	10.5	13.5	5.3	1.9	US-29 at VA-123)	EB
66	1125	15.7	2.1	8.3	35.6	24.7	7.7	Rosslyn-Ballston (Clarendon to Court House)	WB
67	1076	15.6	1.1	4.5	12.6	5.1	1.2	VA-120 (US-29 to North Old Dominion Dr)	SB
68	1146	15.2	3.9	12.3	21.5	4.4	1.1	VA-606 (Shaw Rd to Herndon Pkwy)	EB
69	1128	14.9	3.7	10.1	24.4	10.5	3.0	US-29 (VA-286 to US-50/VA-236)	EB
70	1043	14.8	1.3	4.8	11.5	1.6	0.2	Prince W. Pkwy (Minvl. Rd to Old Bridge Rd)	EB
71	1180	14.7	1.7	5.4	17.0	5.3	0.8	VA-7 (US-50 to VA-244)	EB
72	1047	14.6	1.7	6.7	16.4	6.8	1.9	VA-7 (I-395 to North Quaker Ln)	EB
73	2129	14.4	3.0	10.1	15.6	6.5	2.4	US-29 (at VA-123)	WB
74	2038	14.3	1.3	4.8	13.4	7.5	3.4	VA-236 (I-495 to VA-244)	EB
75	2139	14.1	1.3	5.4	17.0	3.2	0.5	US-29 (Graham Rd to Anntoale Rd)	WB
76	1126	14.1	1.7	6.6	20.9	14.4	5.3	VA-237 (Fairfax Dr) (VA-120 to 10th St N)	EB
77	2208	13.8	6.9	29.6	24.2	8.1	0.6	Balls Ford Rd (Groveton Rd to Sudley Rd)	WB
78	1115	13.7	4.8	12.9	16.4	7.4	1.0	VA-659 (VA-621 to VA-772)	SB
79	2146	13.7	2.9	11.1	18.0	3.5	0.4	VA-606 (Shaw Rd to Herndon Pkwy)	WB
80	1210	13.6	1.3	5.9	21.0	9.7	1.7	Old Dominion Dr (Chain Bridge Rd to Birch Rd)	EB
81	1081	13.3	6.8	14.6	18.1	7.4	0.8	North Quaker Ln (Seminary Rd to VA-7)	NB
82	1040	13.3	2.7	9.7	19.9	12.6	3.9	VA-123 (VA-236 to US-29/US-50)	NB
83	1192	13.3	2.0	6.9	13.0	4.9	1.7	US-1 (VA-235 to VA-235)	NB
84	2126	13.2	1.2	5.2	17.0	11.9	3.9	VA-237 (Fairfax Dr) (VA-120 to 10th St N)	WB
85	1171	12.9	4.9	12.9	0.3	0.2	0.1	US-15 (Logmill Rd to VA-600)	NB
86	2171	12.8	4.4	13.3	0.0	0.0	0.0	US-15 (Logmill Rd to VA-600)	SB
87	2073	12.6	2.1	6.2	14.1	6.4	2.3	VA-123 (Braddock Rd to VA-236)	SB
88	1073	12.5	2.8	9.6	16.4	8.5	2.4	VA-123 (Braddock Rd to VA-236)	NB
89	1178	12.4	3.5	11.5	33.4	13.2	2.9	Smoketown Rd (Prince William Pkwy to I-95)	NB
90	1052	12.4	2.2	7.2	25.3	8.7	2.1	Opitz Blvd (I-95 to US-1)	WB
91	1214	11.8	1.8	7.7	12.3	4.4	1.7	New Braddock Rd (VA-28 to Union Mill Rd)	WB
92	2157	11.8	3.0	12.4	14.2	4.5	1.1	US-1 (Joplin Rd to VA-234)	SB
93	1014	11.6	4.2	14.0	12.3	2.6	0.6	VA-659 (US-50 to VA-621)	NB
94	1119	11.5	1.5	5.4	11.4	2.4	0.8	VA-309 (Kirby Rd to North Williamsburg Blvd)	EB
95	1131	11.3	4.8	16.6	13.3	5.1	0.2	US-28 (Linton Hall Rd to VA-234)	NB
96	2137	11.3	1.6	5.6	14.6	1.5	0.0	US-29 (Clifton Rd/Stringfellow Rd to VA-286)	EB
97	2192	11.3	2.0	6.7	14.8	4.4	1.3	US-1 (VA-235 to VA-235)	SB
98	1194	11.0	3.0	12.7	3.3	0.8	0.3	VA-659 (Braddock Rd to VA-613)	NB
99	2131	10.9	4.6	12.1	11.3	2.5	0.0	US-28 (Linton Hall Rd to VA-234)	SB
100	1212	10.8	1.1	4.6	19.5	9.7	1.5	VA-120 (US-29 to I-66)	NB

Case Studies

The following case studies arise out of a thorough scan of origin, destination and route data for motor vehicles, as described above. We anticipate that local and state agencies, private transportation demand organizations and others will find other opportunities in the data as well, and we have made custom analyses available to several such stakeholders.



1. Tysons Corner
2. George Mason University
3. Fort Belvoir
4. Van Dorn Street Metro Station
5. Rippon VRE Station
6. Bull Run
7. Fairfax Center / Fair Oaks Mall
8. Merrifield
9. Inova Fairfax Hospital
10. Manassas
11. Van Dorn Street Metro Station (southern catchment area)
12. Inside the Beltway (express transit catchment area)
13. Dulles Town Center
14. Bailey’s Crossroads / Seven Corners to Ashton Heights
15. Goose Creek Crossing (Ashburn / Belmont)
16. Route 606 (northeast of Dulles)
17. Route 606 (west of Dulles)

These selected case studies illustrate how the data can be used to identify issues and opportunities, improve understanding of the conditions in each case study area, develop policies and projects to address those issues, and estimate the costs and benefits of potential solutions. Some of the selected case studies were identified using only one scan—e.g., high flows between common pairs—while several cases emerged from numerous scans. Tysons Corner, for example, is characterized by short trips, circuitous trips, high flows and major contributions to traffic on nearby selected links, including short trips. This may not be surprising to those familiar with the area, yet this O-D data can help to quantify these existing travel patterns in a way that lends itself to the development of new solutions. In many cases the data also substantiate the case for existing plan recommendations, but with greater clarity regarding the nature of needs and potential benefits.

For each case study, the study team pooled its collective knowledge; reviewed existing plans, projects and documents; and held meetings with stakeholders to solicit feedback. The case studies do not represent anywhere near the full range of opportunities in the region, nor will all of the recommended actions be viable in each case. The goal is to show how the data can be used and, hopefully, to highlight some new opportunities that have not yet been considered due to a lack of reliable data.

Each case describes a situation where relatively modest interventions – modest compared to major highway and transit capacity additions – could provide more efficient access to destinations, letting people meet their needs via shorter and/or fewer car trips. Each describes a neighborhood or area, current auto travel flows, and potential ways to reduce those flows. The following general categories describe new opportunities presented in each case study and are presented as graphic symbols to allow a quick reference to the recommendations:

	**Conventional transportation demand management (TDM), including marketing, incentives, and commuter programs to reduce single occupant vehicles.**
	**Priced parking and introduction of parking management.**
	**Bicycle infrastructure (share stations/lockers) and pedestrian pathway improvements.**

	**High frequency supplemental transit shuttle service.**
	**Introduction of new local street connections for general traffic, bicycle/pedestrian movement, transit, or other specific movements.**
	**Promote changes in land use patterns toward higher-density and mixed-use development.**

To provide perspective on the recommendations, estimates of costs and benefits were prepared. These calculations are sketch-level and are intended to provide a general sense of the potential investment level (presented as a range of costs for the 'bundle' of investment recommendations), the range of trip reductions that could reasonably be expected in light of the trip patterns in the case study, and a range of benefit values for user cost savings and carbon emission reductions. A brief summary of the costs and benefits is provided at the end of each case study. The costs include up-front capital costs and annual operating costs. Also, annualized costs were requested by stakeholders to help provide a general sense of comparison across case studies. Costs estimates are described in greater detail and annualized costs are provided in the Estimation of Costs methodology section, including the basis for annualization of costs. Additional detail on the direct up-front capital, annual operating costs and annualized costs of the recommendations are provided in the Appendix.

Importantly, not all interventions imply dollar costs. For example, parking management is assumed to be cost-neutral. This is a conservative assumption, given that parking management usually pays for itself through parking charges and reductions in the opportunity of land devoted to parking. Other costs are estimated at a conceptual, order-of-magnitude level; actual costs may vary depending on many decisions involved in developing the projects. In applying the recommendations, it's unlikely that the entire package of investments would be pursued at once. However, the recommendations as presented and costed as complete packages are assumed to be the optimum mix of supportive and complementary actions capable of achieving the benefit results reported.

It is important to note that the calculation of benefits is extremely conservative. The estimates are based on reductions of current auto travel flows – shorter or fewer car trips – resulting from the various proposed interventions. These reductions imply lower personal travel expense and lowered emissions, and they are significant. The estimates do not include other important benefits, which are difficult to calculate based on conceptual plans and available data, but which nonetheless would certainly accrue. These include:

1. Mobility benefits for motorists not directly affected by the interventions, due to reduced traffic and congestion.
2. Mobility benefits for non-drivers, who gain additional walking, biking and transit access to destinations.
3. Increasing effects of interventions in areas that are growing or densifying, as more travelers take advantage of the projects described.
4. Beneficial land use effects, as interventions spur transportation-efficient development (which in turn provides yet more users as mentioned in No. 3).

1. Tysons Corner

Tysons Corner generates many short, internal vehicle trips, which hamper regional traffic moving through the area. This pattern also indicates that travelers find it difficult to get from place to place in Tysons by walking, biking or using transit and choose to drive—adding more congestion. By improving walking conditions, local circulation and last-mile connections to Metro stations, people in Tysons would not need cars to get around—reducing short trips throughout the day and encouraging people to travel to the area by transit.

Tysons Corner is located at the intersection of I-495, Route 7 and Route 123 in Fairfax County. The area is a major retail center for the region, including two large shopping centers, which has recently begun to attract large office buildings and some residential uses. Historically, Tysons has been accessible mainly by automobile. However, the Metro Silver Line, with four stations in Tysons, opened in July 2014. An extension is planned that will run the Silver Line to Dulles International Airport and areas further west. Several Fairfax Connector bus routes and a Metrobus Major Route also serve the area. The Virginia DOT currently plans to add bicycle and pedestrian facilities along Route 123 (Chain Bridge Rd) across I-495, connecting eastern and western portions of Tysons.

Tysons is expected to grow by as many as 200,000 jobs and 100,000 residents by 2050, with 75% of development occurring within a half-mile of Metro. The Tysons comprehensive plan identifies four districts around new Silver Line Metro stations meant for dense, mixed use, transit-oriented development, with at least 20% residential uses. Areas outside of these four districts are expected to be 75% residential with a mix of office and retail uses. The plan also envisions a three-bus circulator, a highly connected street network with smaller block sizes, a full network of complete streets and bicycle facilities, and public spaces. To accommodate and manage regional travel, the plan calls for strategically placed transportation hubs, expanded local and express bus service, and the establishment of a transportation management association (TMA).[4]

Data analysis

GPS data reveals a high number of short trips beginning and ending in Tysons. It also shows that the area is a major common origin and destination for trips to and from several areas, including D.C. and Dulles.

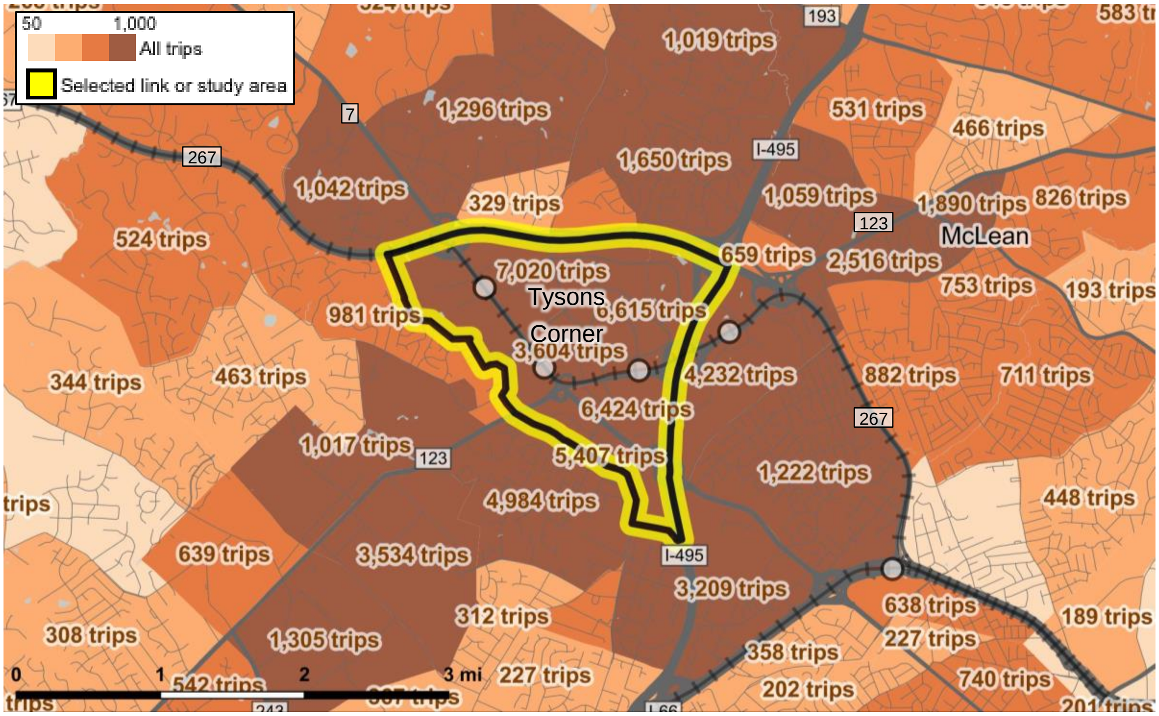
[4] http://www.fairfaxcounty.gov/tysons/comprehensiveplan/

Tysons generates approximately 234,500 personal vehicle trips per weekday, including 92,600 trips (40%) less than five miles, 52,100 (22%) less than two miles, 23,400 (10%) less than one mile, and 36,200 internal trips.

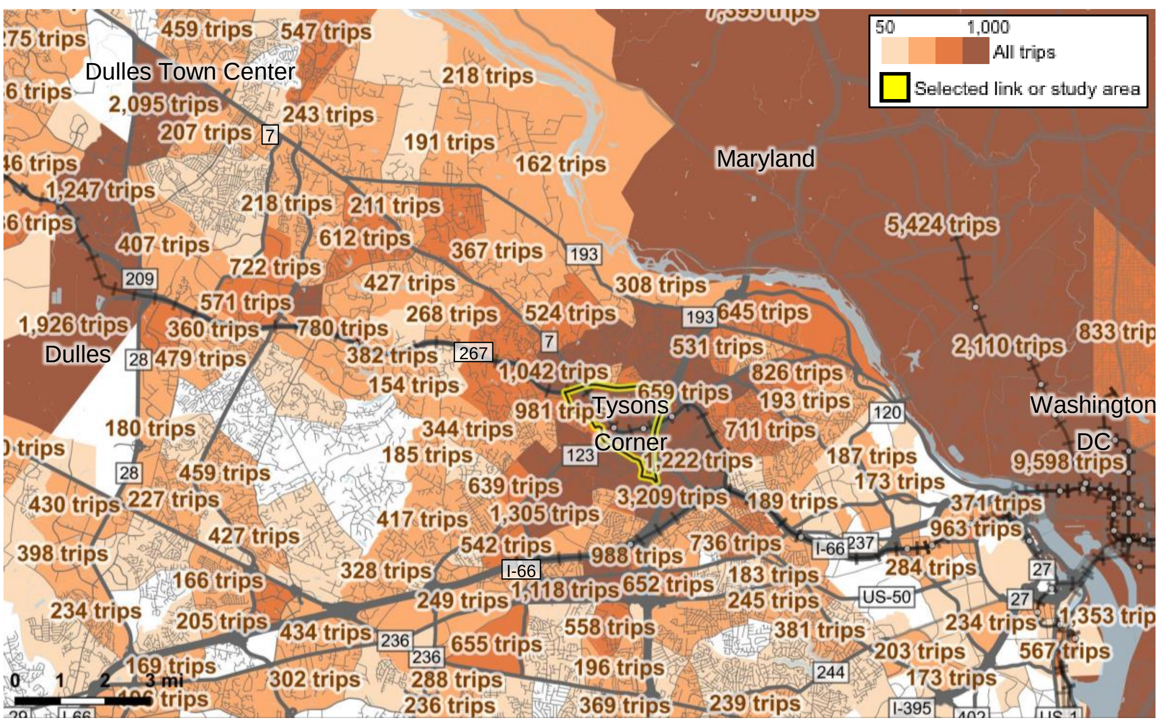
Traffic to and from Tysons also has significant impacts on nearby routes. Trips beginning in the study area during the evening produce the highest peak period flows, including:

- 2,680 trips representing 29% of traffic on VA-7 eastbound between VA-123 and I-495; 1,810 of which are less than five miles, 1,320 of which are less than two miles, and 570 of which are less than one mile (pictured below)
- 2,130 trips representing 27% of traffic on VA-7 westbound between VA-267 and VA-123; 1,480 of which are less than five miles, 1,200 of which are less than two miles, and 530 of which are less than one mile
- 2,990 trips representing 12% of traffic on I-495 northbound between VA-267 and VA-193; 110 of which are less than five miles, 70 are less than two miles, and 20 of which are less than one mile
- 1,620 trips representing 17% of traffic on VA-123 northbound between VA-267 and VA-738/VA-309; 630 of which are less than five miles and 30 of which are less than two miles
- 1,130 trips representing 17% of traffic on VA-123 southbound between VA-243 and Follin Lane Southeast; 730 of which are less than five miles and 80 of which are less than two miles
- 1,160 trips representing 8% of traffic on I-66 eastbound between VA-267 and US-29

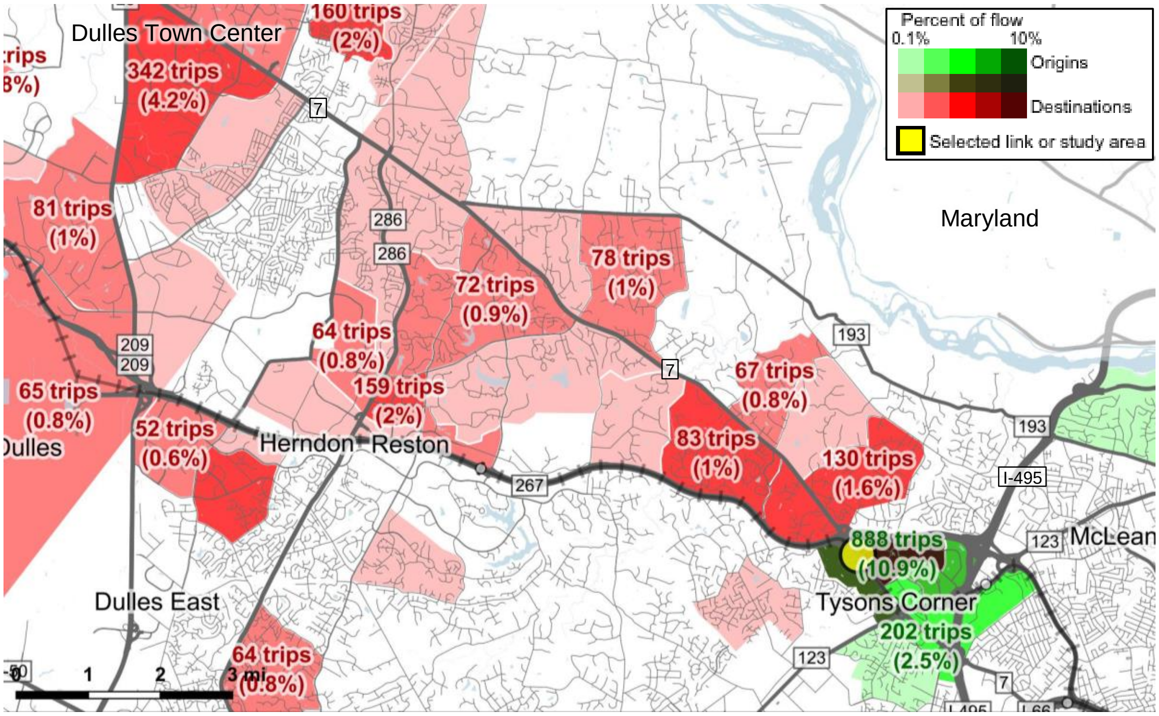
The area also generates 80,000 inter-zonal trips during the midday period, plus an additional 16,000 internal trips, 90% of which are less than two miles and 50% of which are less than one mile. The map below shows the TAZ-level trip densities for trips with either the origin or destination inside the marked area representing Tyson's Corner. The numbers inside the yellow boundary indicate trips that both start and end within Tyson's Corner.



Trips to/from Tysons Corner during weekdays (local)



Trips to/from Tysons Corner during weekdays (regional)



Trips on VA-7 eastbound during the weekday PM period

Opportunities

Primarily, Tysons should aggressively pursue and encourage dense, mixed use development, connected street networks, bicycle and pedestrian infrastructure, and an active TMA, as outlined in its comprehensive plan. This will require rigorous application of the existing Tysons Corner Urban Design Guidelines (possibly as form-based zoning codes), policies requiring developers to increase street connectivity, careful management of existing parking facilities (public and private), enforcement of parking maximums and gradual introduction of new or revised parking maximums in combination with park-once opportunities, capital investments to add street connections, and capital investments to add or improve bicycle and pedestrian facilities, including the possibility of adding a bike share program. Connections across I-495, in addition to the planned bicycle and pedestrian accommodations on Chain Bridge Road, may also be necessary.

These steps will help to reduce short trips made by personal vehicles in and around the area, while simultaneously allowing new development to occur that does not add considerably to local vehicle traffic. However, by allowing the area's employees to make short trips throughout the day, such as for lunch or meetings, without needing a personal vehicle, these steps can also encourage more commuters to travel by non-auto modes—particularly along the Silver Line—significantly reducing their impacts on traffic congestion and air quality.

Aerial view of Tysons Corner

Secondly, given that Tysons will continue to be a major employment and activity center for the region and that short, local trips by non-auto modes will be more viable, a key strategy is to continue enhancing regional transportation options to the area to capture automobile commute trips. Given the high number of trips to D.C. and Dulles, the existing and planned Silver Line will be able to handle much of that demand. However, there are also considerable daily vehicle flows from nearby locations along Route 7 (west), I-66 (west), and I-495, which could be captured by high-quality transit service or well-coordinated carpool and shuttle services.

Costs and benefits

The cost estimates include up-front capital improvements (connections) or buses (transit) and the estimated annual operating cost of transit services and TDM programs. The recommendations may also include concepts such as parking management or services provided by the private sector, and where these are assumed to be cost-neutral, they are not included in the cost estimates. Also, planned transit improvements that appear to be funded are not included in the costs, but further enhancements or incentives related to those services generally are included. See the Summary of Costs and Benefits section that follows the Case Studies for more details.

For the Tyson's Corner case study, the estimate of initial capital costs ranges from $12.4 to $13.7 million and annual operating costs are estimated at $1.8 million. Investments include:

- Full implementation of transit shuttle concepts from 2013 Tysons Circulator Study Report
- Bicycle and pedestrian infrastructure and street connections
- Local bike share
- Parking management and other TDM initiatives, some of which may be cost neutral

These actions are expected to remove an estimated 2.0 to 3.8 million personal vehicle trips per year. Up to 1 million vehicle hours are reduced from implementation of all these measures. Related benefits include personal transportation (user benefit) savings of up to $11.5 million per year and carbon emission reductions of up to 8,400 annual tons. The extremely high volumes in this area and the lack of major new physical improvements among the investments result in a high cost-effectiveness profile when viewed on an annualized basis.

2. George Mason University

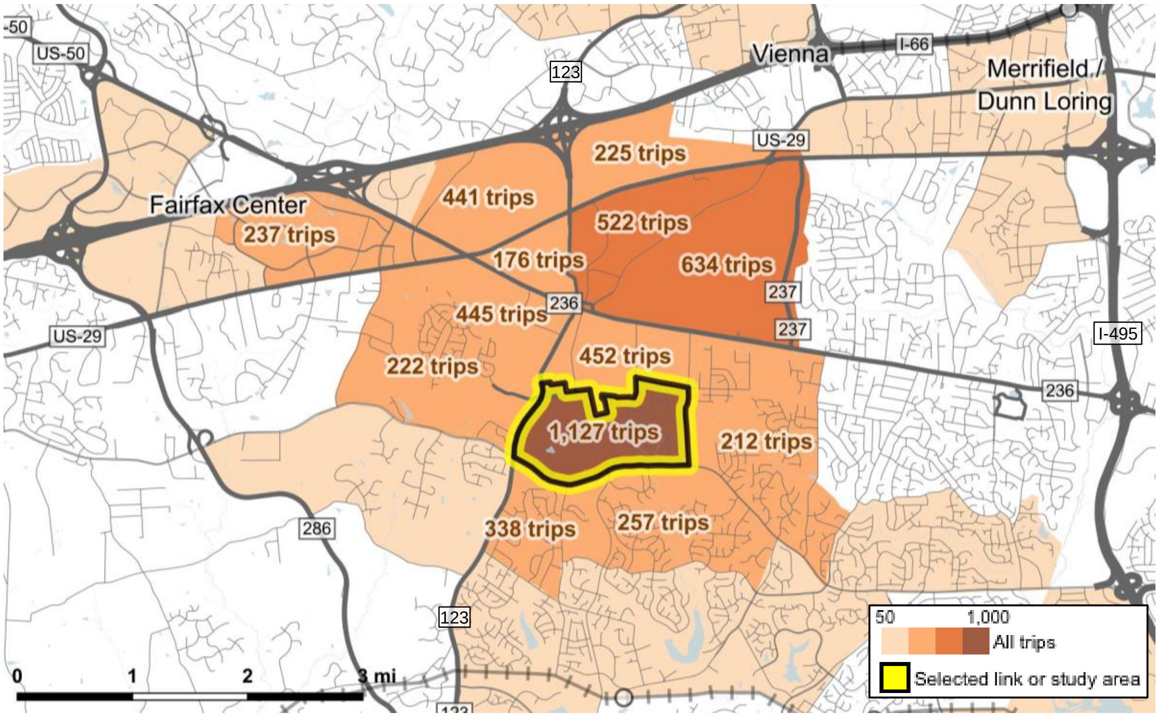
Although George Mason University serves commuters throughout the region, nearly 40 percent of car trips originate from within a few miles. This pattern indicates that students, employees and others are self-selecting into nearby neighborhoods. The campus could take advantage of that situation—reducing congestion on nearby routes and reducing costs to campus users—by working with local government to extend its active transportation network into surrounding neighborhoods, managing its parking and developing campus-oriented housing.

George Mason University has 34,000 students and operates its main campus in central Fairfax County just south of Fairfax City. While it offers housing for about 6,000 students, the majority of students as well as faculty and staff commute to campus, making it an important regional activity center. The university's transportation plan[5] focuses on demand management in large part through connections to Metro and improvements to the walkability of campus itself (while also constructing additional parking, which would tend to facilitate more traffic). The present analysis suggests a complementary approach that focuses on areas immediately around campus. Many trips to and from GMU are less than five miles, which provides an opportunity to convert car travelers to walking, biking or using transit. This figure also suggests a willingness of commuters to locate near the university, which GMU could encourage.

Data analysis

GPS data reveals that GMU generates 6,500 trips less than five miles each weekday, which accounts for 42 percent of all trips. Of those, 3,400 trips are less than two miles, 1,600 trips are less than one mile and 1,100 are internal trips.

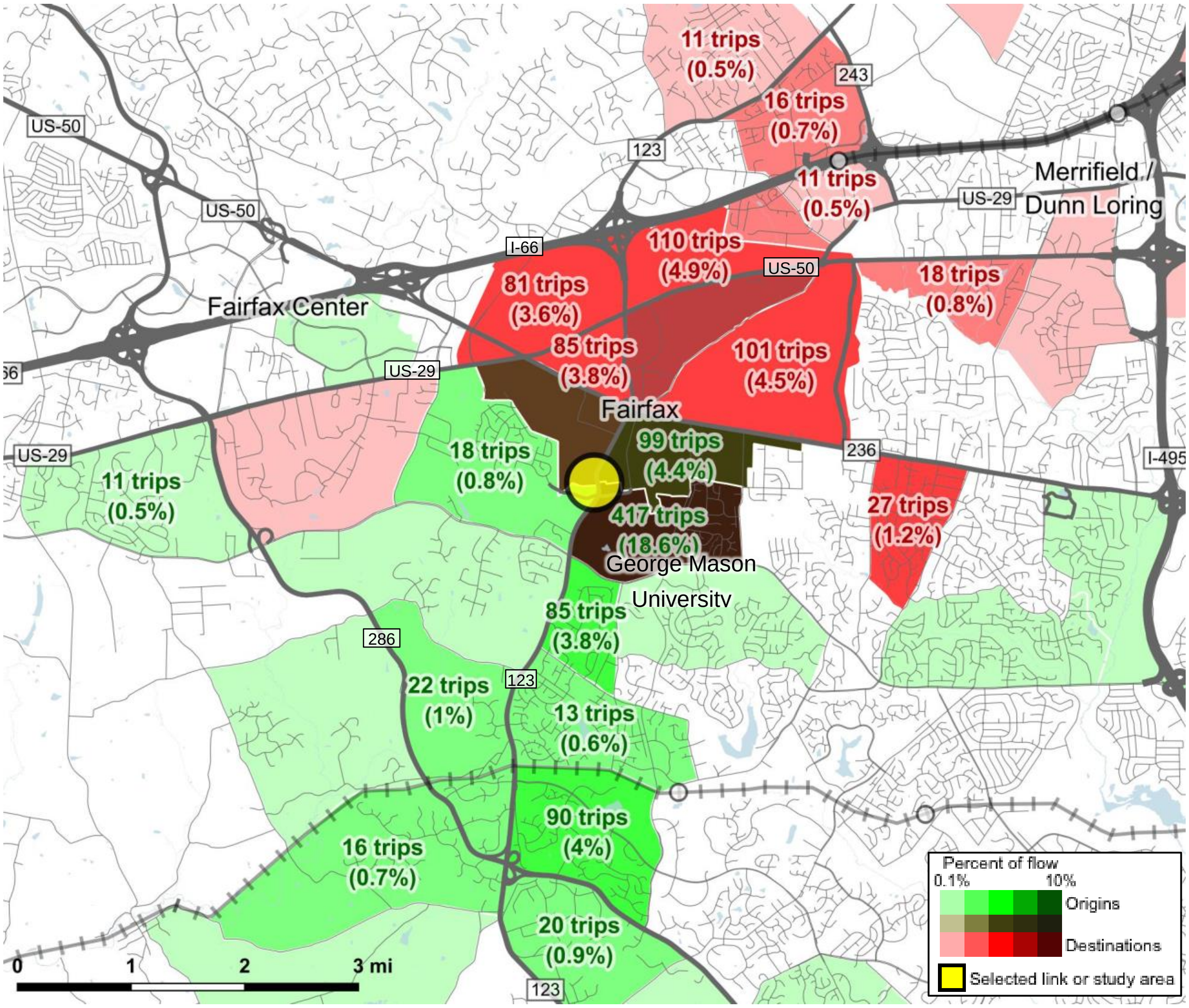
[5] http://transportation.gmu.edu/pdfs/GMU_FairfaxCampus_TransMgmtPlan_Final.pdf



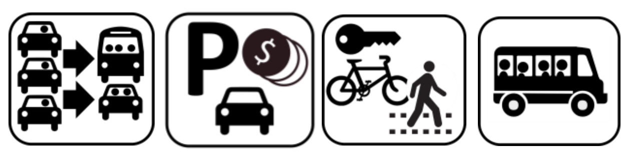
Trips to/from GMU during weekday

Traffic to and from GMU also has significant impacts on nearby routes. Trips beginning in the study area during the evening produce the highest peak period flows, including:

- 420 trips representing 19% of traffic on VA-123 northbound between Braddock Rd and VA-236; 230 of which are less than five miles and 90 of which are less than two miles



Trips on VA-123 northbound during the weekday PM period

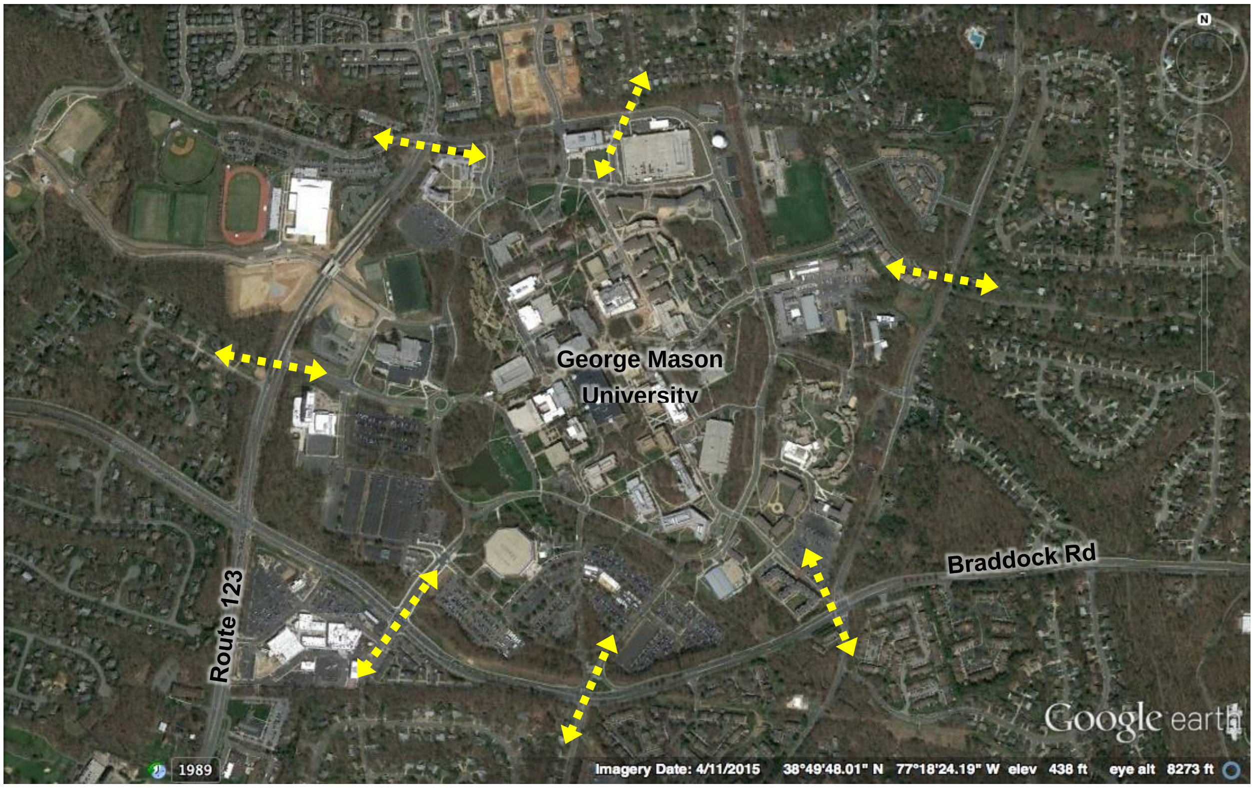


Opportunities

GMU, with its local partners, should extend its walkability analysis beyond campus borders to improve access between nearby neighborhoods and campus by foot, bike and transit. Such analysis involves treating on- and off-campus facilities as a single system, as experienced by travelers. Currently, the campus is partly ringed by large parking lots, which discourage bike and pedestrian travel. The campus plan shows no primary or secondary pedestrian routes that go beyond this ring or past campus borders, and only a handful of bikeable routes. With parking permits starting as low as $100 for a half year,[6] parking management may be an opportunity to reduce the number of parking stalls, making room for higher and better uses and improving bike and walkability. Increased parking fees during peak hours could also encourage more students

[6] http://parking.gmu.edu/PDF2016/SpringSummer20152016ParkingPermitSalesInformation.pdf

and staff to locate near campus; conversations between GMU, local land use authorities, and the development community could spur walking-oriented development. While travelers using Metro and traveling to other campuses seem well served by shuttles, GMU could also work with transit, bike share, and transportation network companies to provide non-SOV options for close-by neighborhoods.



Aerial view of George Mason University (including potential connections in yellow)

Costs and benefits

The estimated upfront capital costs of the recommendations range from $5.9 to $6.2 million. Annual Operating cost is estimated at $0.8 million. Investments include:

- Bicycle and pedestrian infrastructure and wayfinding
- A new local shuttle service providing local mobility and connections to other transit services
- Parking management and other TDM initiatives, some of which may be cost neutral

These actions are expected to remove an estimated 250,000 to 460,000 personal vehicle trips per year. Related benefits include personal transportation (user benefit) savings of up to $500,000 per year with approximately up to 82,000 less vehicle hours. The total package of solutions could potentially net a total carbon emission reduction of up to 390 annual tons.

3. Fort Belvoir

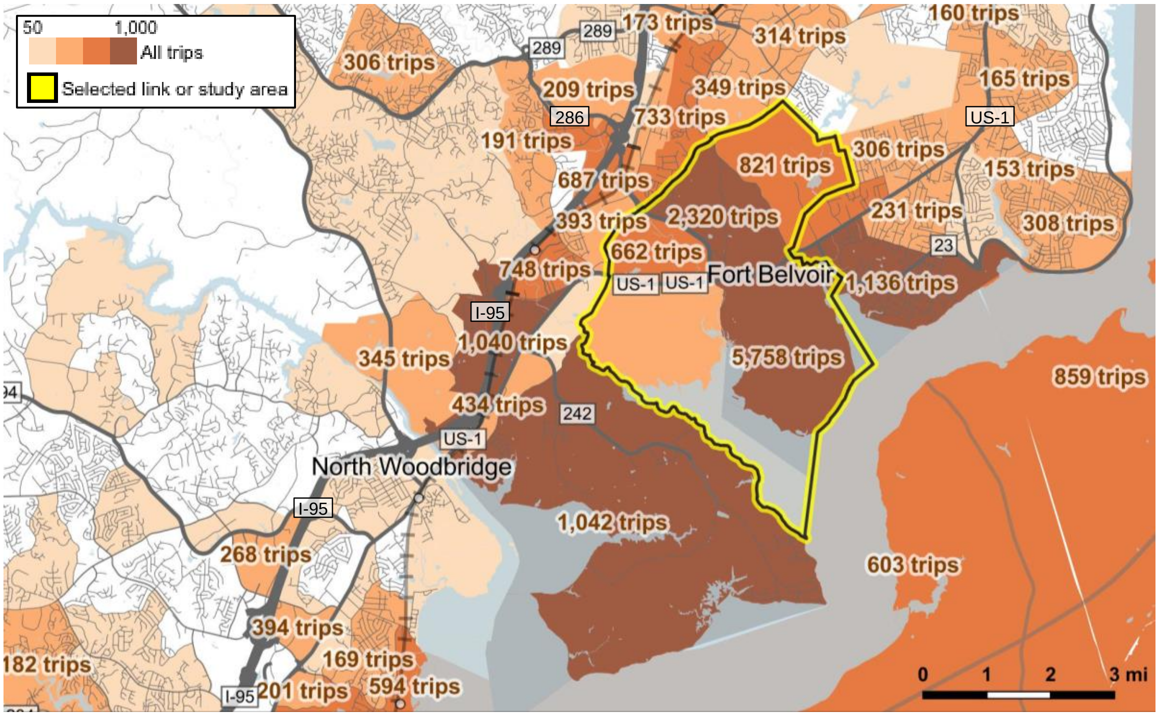
Many travelers drive to Fort Belvoir from just a few miles away each day and drive on site throughout the day, even though Army regulations only allow six spaces for every ten employees. Those travelers cause traffic to back up at the gates and along Route 1. By improving multimodal options on the post, Fort Belvoir can greatly reduce the need for a car on site. That, paired with better commuter services and TDM, could make staff more comfortable traveling to the post by non-auto modes, preventing traffic congestion from getting worse and letting the post scale back its parking over time.

Fort Belvoir experienced considerable growth as part of the Base Realignment and Closure (BRAC) process of 2005, and is expected to grow from 40,000 to 56,000 employees by 2030. As of its 2013 Commuter Survey, more than 83 percent of employees drive alone, while an additional nine percent ride in a carpool or vanpool. This traffic puts pressure on the nearby regional road network, including I-95, US-1 and Route 286, particularly at the gates to the Fort Belvoir. Moreover, our data show personal vehicles are a common mode of travel on the Fort Belvoir Main Post, accounting for approximately 10,000 trips per day.

While past efforts to improve mobility have focused on road capacity in and around Fort Belvoir, the current master plan emphasizes multimodal connections and environmental sustainability. Despite some separation of land uses, the South Post is heralded as a fairly compact, mixed-use environment with a town center. Fort Belvoir's future plans call for concentrated development, reduced parking ratios, additional bike and pedestrian facilities, and better regional transit options. With an appropriate mix of policies and strategies, our analysis suggests that there is great potential to improve on-site travel options, reducing the number of internal trips and making it easier for personnel to commute and go about their daily business without a car.

Data analysis

GPS data reveals that the Fort Belvoir Main Post generates approximately 51,100 personal vehicle trips per weekday, including 17,500 trips (34%) less than five miles, 8,000 (16%) less than two miles, 2,700 (5%) less than one mile, and 9,700 internal trips. There are common origins and destinations across the Potomac River and along the US-1/I-96 corridor to the north and south, including several TAZs with 500 to 1,000 trips each weekday. Other common origins and destinations include D.C. (580 daily trips), Tysons Corner (250 daily trips) and much of Fairfax County.



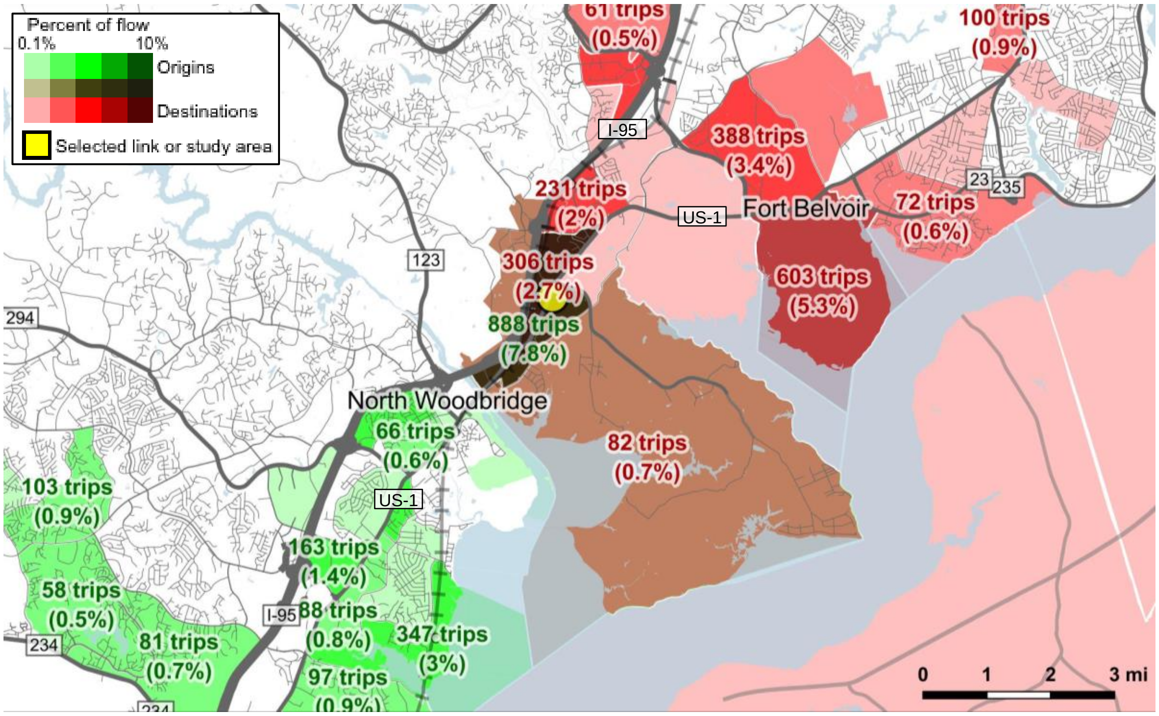
Trips to/from Fort Belvoir during weekday (local)

Traffic to and from Fort Belvoir also has significant impacts on nearby routes—particularly US-1 to the north and south. Trips ending in the study area during the morning produce the highest peak period flows, including:

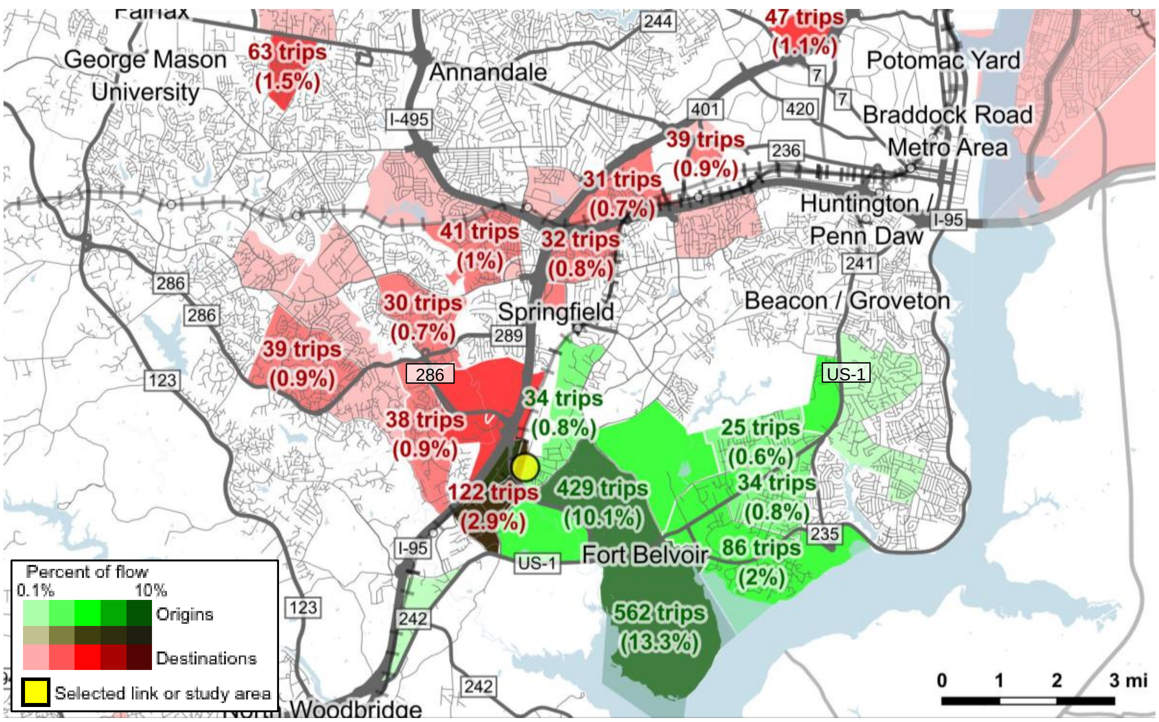
- 1,130 trips representing 10% of traffic on US-1 northbound at Gunston Rd (shown below)
- 430 trips representing 21% of traffic on US-1 southbound between VA-235 and VA-235
- 530 trips representing 8% of traffic on VA-286 southbound between Burke Lake Rd and Lee Chapel Rd

During the evening, there are also 1,210 trips from the study area on VA-286 northbound between VA-611 and I-95, representing 29% of traffic. 370 of those trips are less than five miles and 90 are less than two miles (shown below).

There are a significant number of trips within Fort Belvoir, many of which cross US-1. Within the South Post area, there are 3,400 trips per day, 84% of which are less than two miles and 39% of which are less than one mile. There are 3,300 trips made between the South Post and North Post each weekday.



Trips on US-1 northbound during the weekday AM period



Trips on VA-286 northbound during the weekday PM period

Opportunities

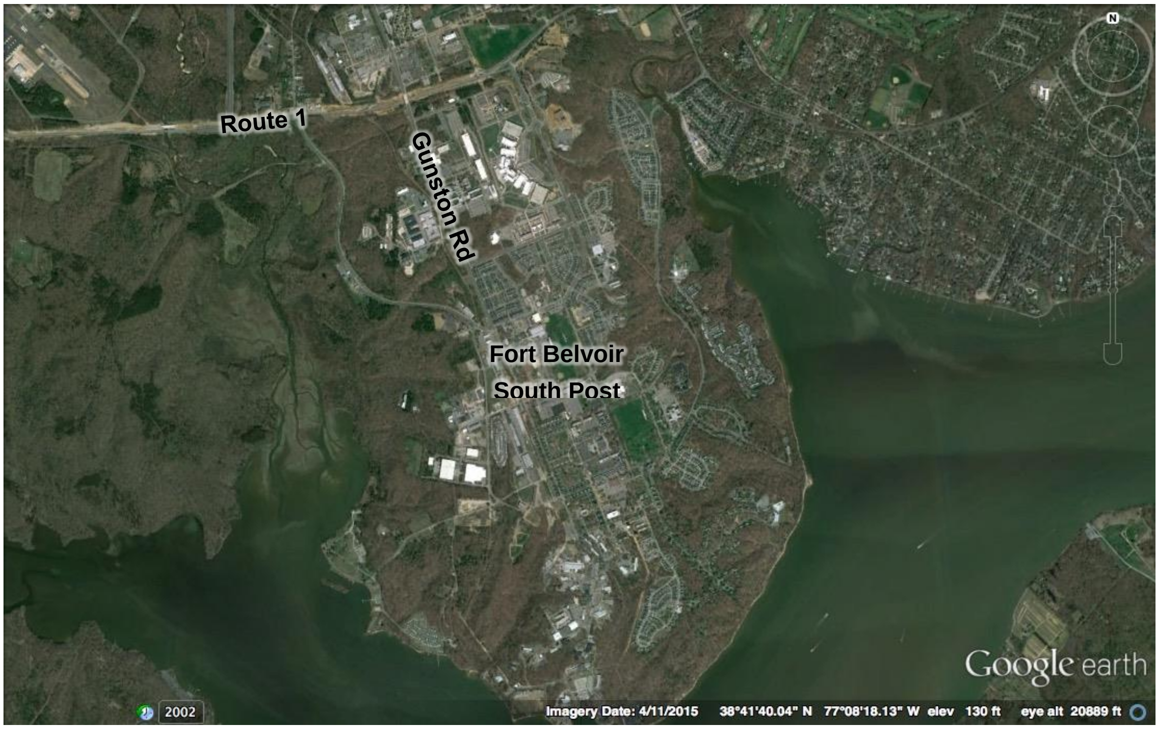
Improved transit options to and from Fort Belvoir along US-1, including possible bus rapid transit, could provide considerable new travel options for commuters, given that such a large number of trips to the post originate in nearby clusters along the corridor. These efforts should account for those trips and the potential to facilitate travel from Fort Belvoir to emerging bedroom communities.

With or without significant transit investments, however, Fort Belvoir is well positioned to improve on-site travel options, encourage commuters to reduce personal vehicle trips, and enable future growth that minimizes further traffic and environmental impacts. One critical area of focus will be adding and improving bicycle and pedestrian facilities on all future road projects, which should include safer and more frequent crossings at major roads, along with better bicycle facilities connecting across US-1 on Gunston Rd and other future crossings. These efforts could also include a focused educational campaign, targeted enforcement of motor vehicle violations, and even a bike share pilot program.

View along Gunston Rd approaching US-1 crossing

The Fort Belvoir master plan recognizes that its employees still face challenges in relying on transit to get around on the post. Several feeder bus lines serve the area, but enhanced on-site transit service and service to popular destinations could greatly reduce reliance on personal vehicles. Given the location's unique status as a self-contained campus, the Fort Belvoir

Transportation Division and the Virginia Department of Transportation should explore creative opportunities for improving transit and shuttle service. For example, interested partners might want to explore the option of launching an autonomous shuttle pilot program.



Aerial view of Fort Belvoir (South Post)

Parking management should be a key focus of Fort Belvoir's travel demand management efforts. According to recent parking inventory, Fort Belvoir provides approximately 34,000 parking spaces for its 39,000 employees, resulting in an overall parking ratio of 82 percent. However, Army guidance allows a parking ratio of only 60 percent (1.67 administrative employees per parking space and 1.5 personnel per space). Plans call for reducing those ratios by focusing future development in areas with excessive parking and managing parking demand through designated parking areas and enforcement. For a revenue-neutral option, the Transportation Division should explore the possibility of pricing the most popular parking, if not all employee parking. Another common approach to managing parking demand is to offer parking cash-outs or other incentives to employees who refuse a personal space.

Fort Belvoir's TDM coordinator should play a key role in all of these efforts, as well as any future transportation-related decisions. Other TDM efforts, such as organized ridesharing or a guaranteed ride home program, should be handled internally or else military personnel are less likely to participate. Common origins and destinations, revealed by the GPS data, could be the focus of coordinated TDM efforts such as ridesharing.

Costs and benefits

Fort Belvoir's package of investments has the estimate of initial costs ranges from $4.6 to $4.9 million and annual operating costs are estimated at $1.7 million. Investments include:

- Bicycle and pedestrian infrastructure and street connections within the base and improved bike and pedestrian connections to the base
- On-base transit shuttle
- TDM initiatives and Parking management, with the latter assumed to be cost neutral

The major transit investments on Route 1 were not included in the cost estimates. However, this case study offers a great deal of potential synergy if the Route 1 investments were made in tandem with the on-base accessibility recommendations.

These actions are expected to remove an estimated 1.1 to 1.9 million personal vehicle trips per year and up to 765,000 vehicle hours of travel. Related benefits include personal transportation (user benefit) savings of up to $16.8 million per year and carbon emission reductions of up to 12,000 annual tons. Note that the user benefits and carbon emissions are particularly high for this case study based on the assumption that the complete package of improvements could eliminate a large quantity of longer trips to the base in addition to the shorter on-base and near-base trips.

4. Van Dorn Street Metro Station

The Van Dorn Street Metro station is an important transit access point for neighborhoods immediately to the north, but those neighborhoods are cut off by a creek and rail lines. Consequently the trip data show a pattern of short but circuitous trips. South Van Dorn Street is the only connection for cars and a very poor connection for people walking or biking. An additional connection for pedestrians, bicycles and certain types of vehicles could reduce traffic to the station on South Van Dorn Street by accommodating more direct and multimodal trips, thereby reducing overall travel and congestion, while also improving non-auto safety and making Metro a more attractive option for commuters in the area.

The Van Dorn Street Metro station and nearby commercial land uses are the origin and destination for nearly 5,000 car trips each day from the Cameron Station area and other neighborhoods off of Duke Street in Alexandria. These trips are fairly short but circuitous, due to the lack of a direct connection across Backlick Run and the freight rail lines that parallel it. The findings validate the concerns raised by a VDOT Intermodal Accessibility Study[7]. Such travel is likely to be exacerbated by any future development or use of the large office building to the east of the station, which will be equally disconnected from residential and commercial areas nearby—and at a half-mile away, problematic to reach from the station without first- and last-mile planning as well.

Many of the short trips to and from the station area use congested Van Dorn Street—1,470 trips northbound each day, representing five percent of traffic—as well as other congested thoroughfares. Construction of a major roadway across Backlick Creek has been opposed by residents who are rightfully concerned that it could become yet another congested thoroughfare.

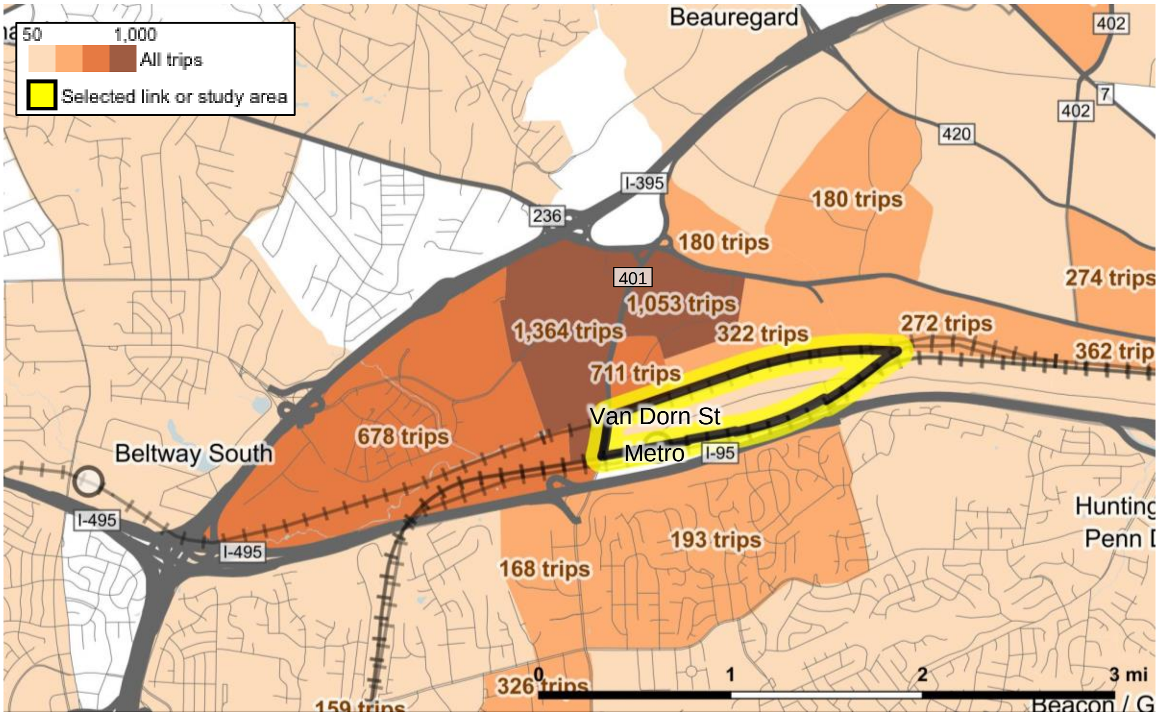
[7] http://vtrans.org/resources/reports/Van_Dorn_Metro_Station_Final.pdf

Additionally, there are significant vehicle flows from neighborhoods north of the station into D.C.—traffic that might be reduced if neighborhoods could better access the station.

View along South Van Dorn Street

Data analysis

GPS data reveals that the Van Dorn Station area generates approximately 35,600 personal vehicle trips per weekday, including 12,000 trips (34%) less than five miles, 4,200 (12%) less than two miles and 1,000 (3%) less than one mile. Among those trips are 4,100 trips to and from TAZs immediately to the north across Backlick Run and existing freight lines. Average circuities for trips to and from several of those TAZs are greater than 2.5.



Trips to/from Van Dorn Street Metro station area during weekday

Traffic from Van Dorn Street Metro station to the immediate north, south of I-395, account for 1,470 trips on South Van Dorn Street (Route 401) northbound each weekday, representing five percent of daily traffic.

Opportunities

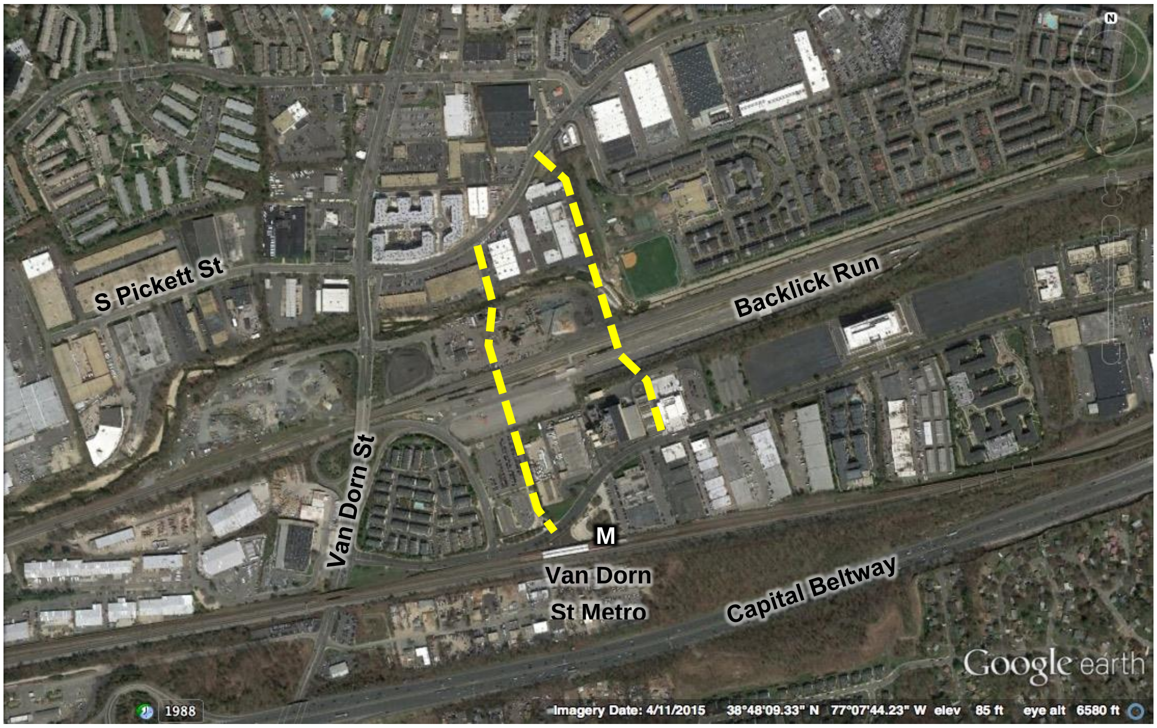
Planners have addressed the existing problem of the metro station's isolation in several studies, and these deserve consideration. Residents' concern, however, about the construction of a new, highly congested arterial across Backlick Run are valid. Solutions could include limiting new connections to pedestrians, cyclists, transit shuttles and/or taxis. Reversible, one-way car access might also serve to connect the station and neighborhoods while not permitting a flood of traffic.

Costs and benefits

For the Van Dorn Metro case study, the estimate of initial capital costs ranges from $27.7 to $38.3million and annual operating costs are estimated at $30,000. Investments focus on bicycle and pedestrian infrastructure connecting the land-locked site to nearby neighborhoods, plus a modest increase in TDM programs in the area.

These actions are estimated to remove an estimated 98,000 to 152,000 personal vehicle trips per year with an accompanying reduction of up to 24,500 vehicle hours of travel. Related benefits include personal transportation (user benefit) savings of up to $155,000 per year and carbon emission reductions of up to 113 annual tons.   It should be noted that the cost-effectiveness for these investments, is driven by a) nature of the structures involved at a relatively high cost, and

b) the smaller number (and short duration) of trips affected by the improvements which diminishes the measured benefits. Given the extreme constraints and traffic congestion on existing roads that would benefit from these trip reductions, however, these investments may have great merit.



Aerial view of Van Dorn Street station (including locations of proposed crossings in yellow)

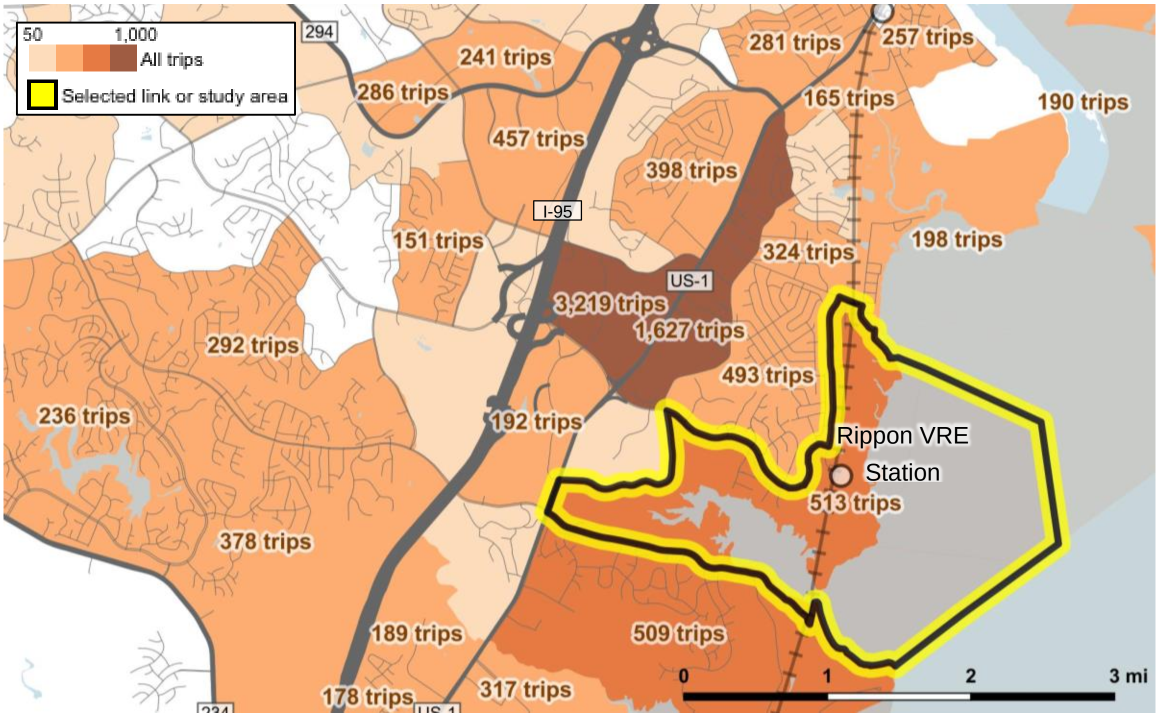
5. Rippon VRE Station

The Rippon VRE station accommodates many commuters each day, but the station is almost exclusively accessible by automobile and the road network conditions around the station are not amenable to non-auto modes. Improving bike and pedestrian conditions and adding network connections for those modes could greatly improve non-auto access to the station, improve non-auto safety and eliminate many short car trips. This has the added potential benefits of improving VRE ridership and positioning the station as an attractive site for TOD.

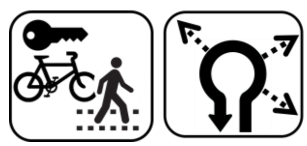
The Rippon VRE Station serves commuters along the Potomac River in southern Woodbridge, Prince William County. Data shows there are many short trips to the station from the immediately adjacent neighborhoods to the northwest and along nearby US-1. The area is suburban with a poorly connected street network, which causes circuitous car trips that feed into collector roads and makes non-automobile travel challenging. Prince William County, VRE and the Woodbridge community should work together to add small street connections, particularly for bicycles and pedestrians, and add bicycle accommodations at and near the station.

Data analysis

GPS data reveals that the Rippon VRE Station area generates 35,900 personal vehicle trips per weekday, including 13,300 trips (37%) less than five miles, 7,100 (20%) less than two miles and 800 (2%) less than one mile. Among those trips are 500 internal trips and 5,300 trips to and from TAZs immediately to the northwest.



Trips to/from Rippon VRE station area during weekday

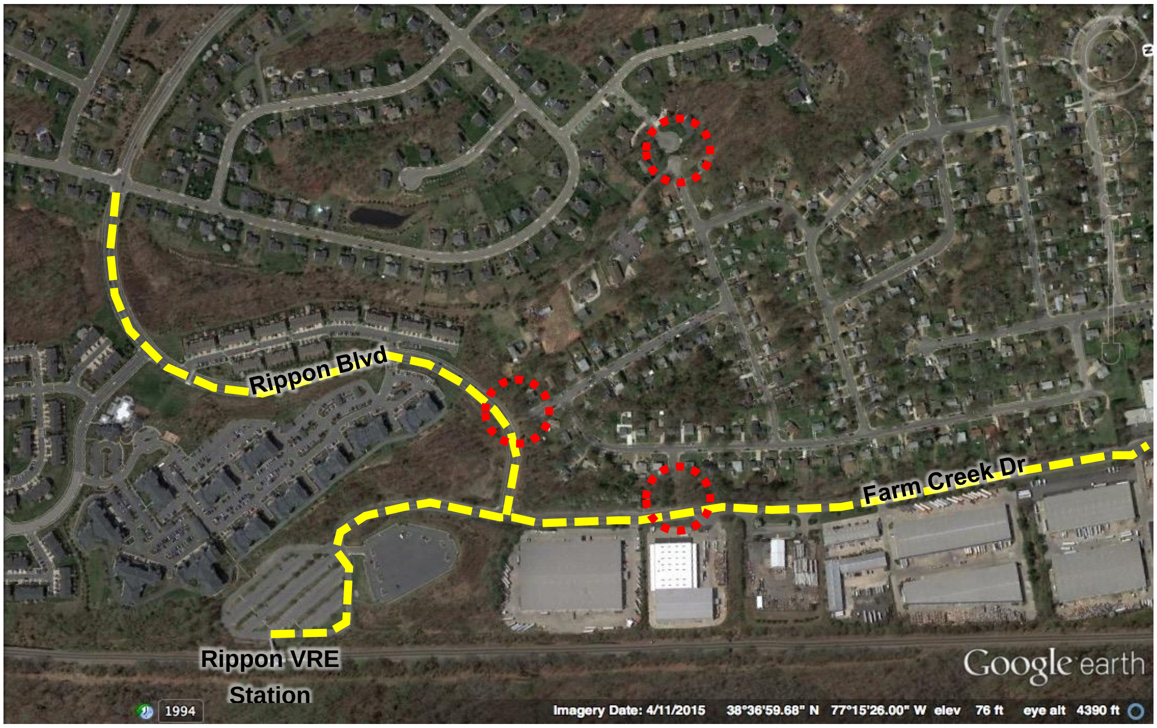


Opportunities

Many trips to and from the Rippon VRE Station are two miles or shorter, which is a reasonable distance for bicycle travel, yet the road and path network is disconnected and there are not safe bicycle facilities in most locations. There are many opportunities to create bike-suitable connections where there are cul-de-sacs and gaps in the existing network, for example: Ohio Ave to Rippon Blvd, Utah Ct to Farm Creek Drive, Decoy Court to Oregon Ave, and Big Crest Lane to the Rippon station parking lot. These connections would shorten distances for potential cyclists and let them travel mostly on low-volume residential streets, without adding unwanted vehicle traffic. Rippon Boulevard, Farm Creek Drive and Featherstone Road are the major roads feeding Rippon station from popular destinations, but they have no bicycle facilities, shoulders or shared lane markings. These roads, and other essential links in the bike network, should be fit with safe, context-appropriate bike facilities.

Adding bicycle parking and storage at the Rippon station, where there is currently very little, could also facilitate bicycle use. The county and the community might even explore the feasibility of a bike share program in the area.

The Riverside Station Apartments, immediately west of the station, signal that there is some interest in suburban-style transit-oriented development. There is potential for more mixed-use, transit-oriented development in the form of a town center (similar to the future Potomac Shores station, south of Rippon station) on land that is currently parking, open space, and industrial uses just to the north along Farm Creek Drive.



Aerial view of Rippon VRE station (including bicycle priorities in yellow and potential street connections in red)

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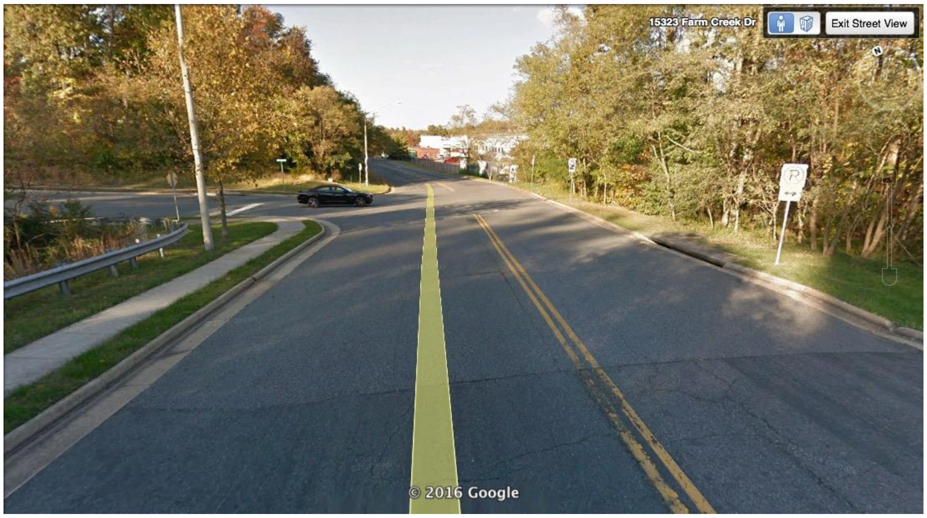


View along Farm Creek Dr at Rippon Blvd leaving Rippon station

Costs and benefits

The estimate of initial capital costs ranges from $2.7 to $3.3 million $ and annual operating costs are estimated at $7,000. Investments focus on bicycle and pedestrian improvements on-site and connecting streets and neighborhoods in the immediate surrounding area. Modest TDM program investments are also included.

These actions are expected to remove an estimated 155,000 personal vehicle trips per year and up to 36,000 less vehicle hours of travel. Related benefits include personal transportation (user benefit) savings of up to $235,000 per year and carbon emission reductions of up to 172 annual tons.

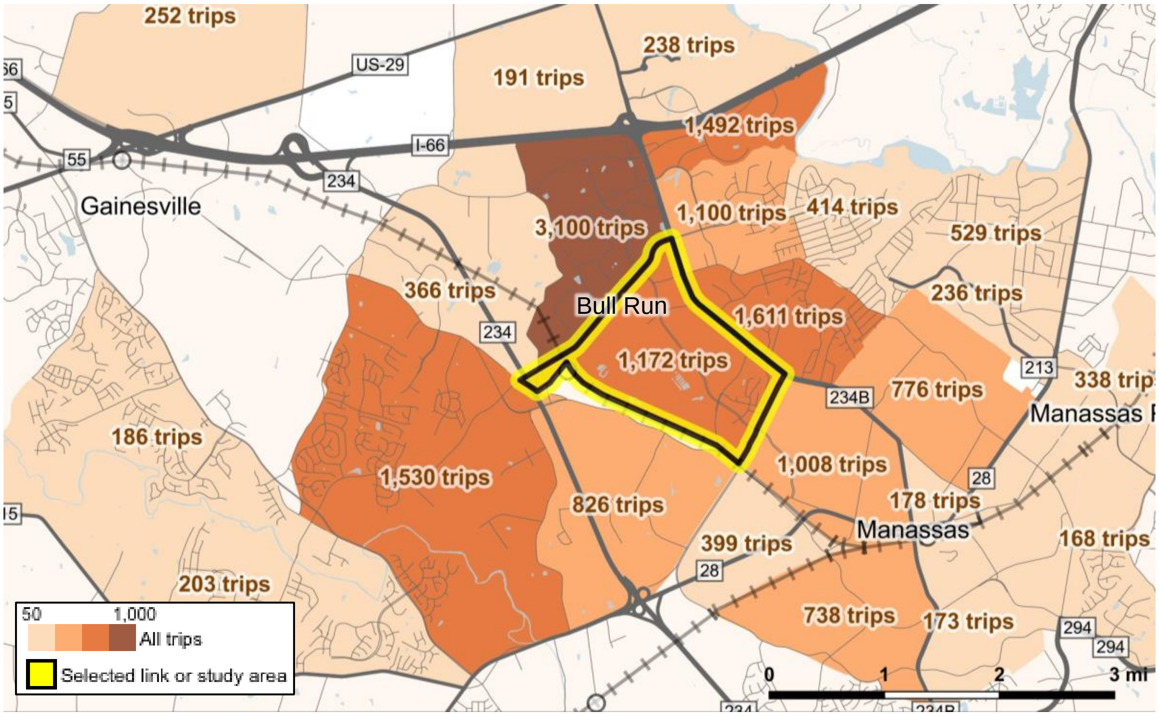
6. Bull Run

There are thousands of short vehicle trips along Ashburn Ave, which connects neighborhoods, stores and schools within 1-2 miles of each other in Bull Run, Prince William County. This indicates that people are uncomfortable walking and biking. Bike facilities along Ashburn Ave and more direct connections to surrounding land uses could serve an important local function and reduce car traffic in the area.

The Bull Run area north of Manassas in Prince William County comprises significant residential neighborhoods, a shopping mall, several schools and other land uses, including open space. As a whole it would be considered mixed use. But connections are difficult, giving rise to a large number of short vehicle trips between major developed sections. These areas abut each other, but the developed portions are separated by a quarry and open space, making distances too long to walk for most people. The gap could be covered easily on a bike, but the connecting roadway, Ashton Avenue, appears quite unfriendly to bikes. For example, local streets and driveways have been directed away from Ashton Avenue, making for fast-moving traffic, but unfriendly bike conditions and poor accessibility for the few pedestrians who might use the sidewalks there.

Data analysis

GPS data reveals 3,100 daily trips between adjacent neighborhoods in northern Bull Run and southern Bull Run. A majority of those trips are during midday (35%) and the PM peak period (35%), and flows are bidirectional, suggesting that many are short trips from work and home.



Trips to/from southern Bull Run during weekdays

Aerial view of Bull Run (including bicycle priority on Ashburn Ave in yellow)

View along Ashton Ave.

Opportunities

In the short term, develop bike lanes, a cycle track or side path along Ashton Ave to better link the developed areas – e.g. residents and schools – north of Manassas. In the medium and longer term, connect streets that now dead end short of Ashton Ave into that roadway, creating a more urban, more livable street with calmed auto traffic. As open spaces develop, likewise connect them to Ashton Ave (and to commercial centers along Sudley Rd), orienting them to this increasingly livable thoroughfare. Undeveloped land on either side of Ashton Ave is planned for future residential and commercial development, although not explicitly for mixed use. Encourage mixed use development with ground-level retail along Ashton Ave to improve walking and bicycling conditions and encourage active transportation.

Coordinated shuttles or feeder transit, Safe Routes to School Programs, and home delivery services from large retailers and restaurants offer additional opportunities to reduce short vehicle trips along the Ashton Ave corridor.

Costs and benefits

The estimate of initial capital costs ranges from $13.5 to $14.8 million. Investments in the cost estimate focus exclusively on improved bicycle and pedestrian improvements as described above and would have no annual operating costs. The additional transit and/or private sector solutions are not included in the cost estimate.

These actions are expected to remove an estimated 75,000 personal vehicle trips per year along with a reduction of up to 11,600 vehicle hours of travel. Related benefits include personal transportation (user benefit) savings of up to $44,000 per year and carbon emission reductions of up to 32 annual tons. While a high cost in relation to the anticipated benefits is projected, the added benefit of removing trips in a highly congested and constrained area could still justify the investments.

7. Fairfax Center / Fair Oaks Mall

Fairfax Center and Fair Oaks Mall, which lie at the intersection of two major highways, attract many short vehicle trips that hamper through traffic on those routes. Recent, mixed use development in the area suggests that people want to live nearby, but they are uncomfortable walking and biking to offices and major commercial areas. Fairfax County and private developers should add street connections, complete streets and other non-auto options to reduce traffic from short trips.

The Fairfax Center study area includes Fair Oaks Mall located at the intersection of U.S. 50 and I-66, Fairfax Corner South located south of I-66, Government Center, and other commercial and residential uses north of US-29. The area was built in the style of suburban shopping plazas with very large parking lots and, as such, we observe many short vehicle trips throughout the day. Plans for the area call for more compact, mixed-use development including employment and dense residential. Some of that development has already occurred nearby. Plans also call for bicycle and pedestrian improvements.[8]

The nearest Metro station—Vienna, on the Orange line—is approximately seven miles away and the area is not particularly well served by buses. However, transit improvements to the area are under consideration. The Northern Virginia Transportation Authority's TransAction 2040 plan includes an extension of the orange line through Fair Oaks to Centreville and priority bus service to Fair Oaks along U.S. 50 and U.S. 29 in its list of proposed projects through 2040.[9] However, the likelihood of an orange line extension is uncertain. A BRT alternative has also been considered.

Data analysis

GPS data reveals a high number of short, circuitous trips around Fair Oaks Mall and Fairfax Center and many short trips between the two areas, across I-66. The area generates 17,440 trips less than five miles each weekday, 9,720 trips less than two miles and 3,130 trips less than one mile, including a majority of 1,700 internal trips. Of those internal trips, 580 take place in the area around Fair Oaks Mall, 510 take place in Fairfax Center and 610 cross between the two

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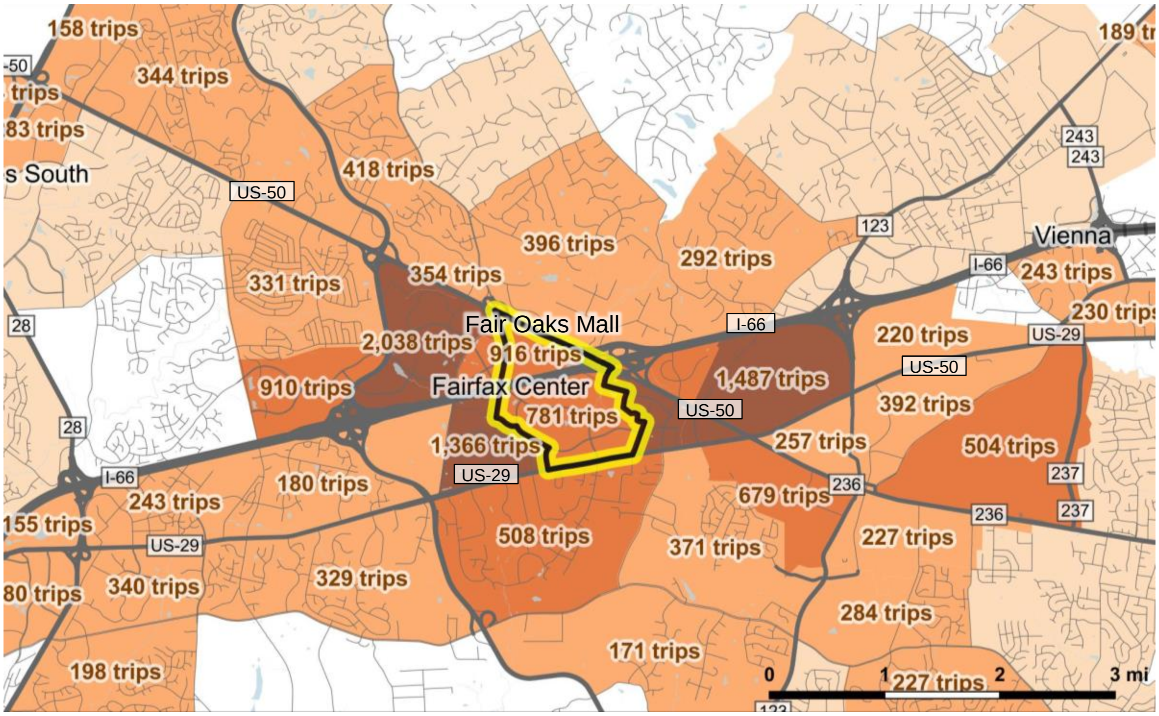
[8] http://www.fairfaxcounty.gov/dpz/comprehensiveplan/area3/fairfaxcenter.pdf

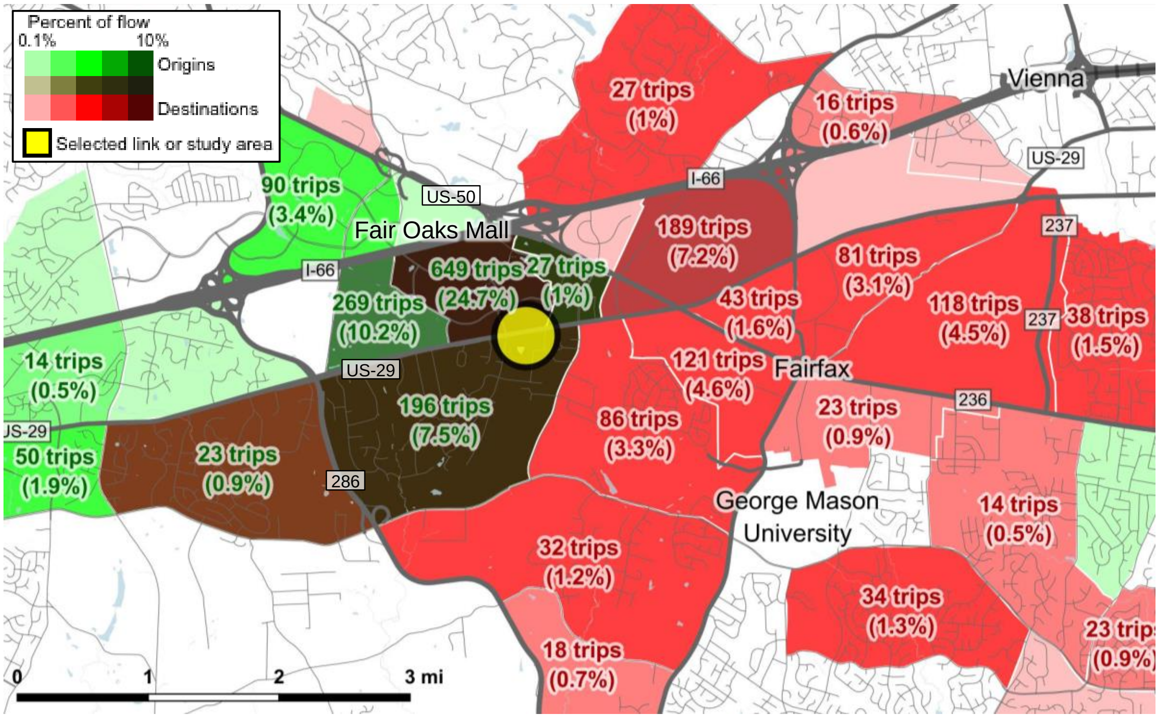
[9] http://www.thenovaauthority.org/planning-programming/transaction-2040/



Trips to/from Fair Oaks Mall and Fairfax Center during weekdays

The area also generates a large number of short trips, which have considerable impacts on nearby routes. Trips beginning in the study area during the evening produce the highest peak period flows, including:

- 660 trips representing 25% of traffic on US-29 eastbound between VA-286 and US-50/VA-236; 490 of which are less than five miles, 240 of which are less than two miles, and 70 of which are less than one mile (pictured below)
- 220 trips representing 5% of traffic on US-29 westbound between Clifton Rd/Stringfellow Rd and VA-286; 100 of which are less than five miles
- 210 trips representing 7% of traffic on US-50 eastbound between I-66 and US-29; 190 of which are less than five miles and 50 of which are less than two miles
- 300 trips representing 3% of traffic on US-50 westbound between Stringfellow Rd and VA-286
- 320 trips representing 4% of traffic on VA-236 eastbound between US-29/US-50 and VA-123; 210 of which are less that five miles and 100 of which are less than two miles



Trips on US-29 eastbound during the weekday PM period

Opportunities

Fairfax County should take advantage of the nearby compact, mixed-use development already occurring in order to transition the entire area from a primarily single use, automobile-oriented place to one that facilitates short trips by modes other than driving. This includes reconnecting the street network across large arterials and parking lots, incorporating complete street design and facilitating further infill development on disconnected parcels. Enhanced options such as ridesharing services, shuttles and transit, and on-demand delivery services can reduce the need for automobiles in meeting residents' and employees' daily needs.

Costs and benefits

The estimate of initial capital costs ranges from \$5.2 to \$6.1 million and annual operating costs are estimated at \$230,000. The improvements include inter-parcel connections and a multimodal bridge over I-66 to improve access from nearby mixed-use development, several pedestrian improvements, and one transit circulator route.

The complete set of recommendations is estimated to reduce 68,000 to 127,000 trips per year. A total reduction of up to 15,000 vehicle hours would result from the reduced trips. Associated benefits include up to \$34,000 in reduced travel costs and up to 25 tons of emissions reduction. The modest costs and large number of trips affected produce an estimated cost of \$0.33 to \$0.41 per trip reduced.

8. Merrifield

Merrifield is somewhat walkable and very close to Metro, but many people drive in the area and along the Metro corridor adding to traffic along Route 29, Route 50, I-495 and I-66. By adding complete streets, safer crossings, and other non-auto enhancements, last-mile connections to Metro could be greatly improved, making Merrifield very accessible by transit and cutting down on traffic at a busy regional crossroads.

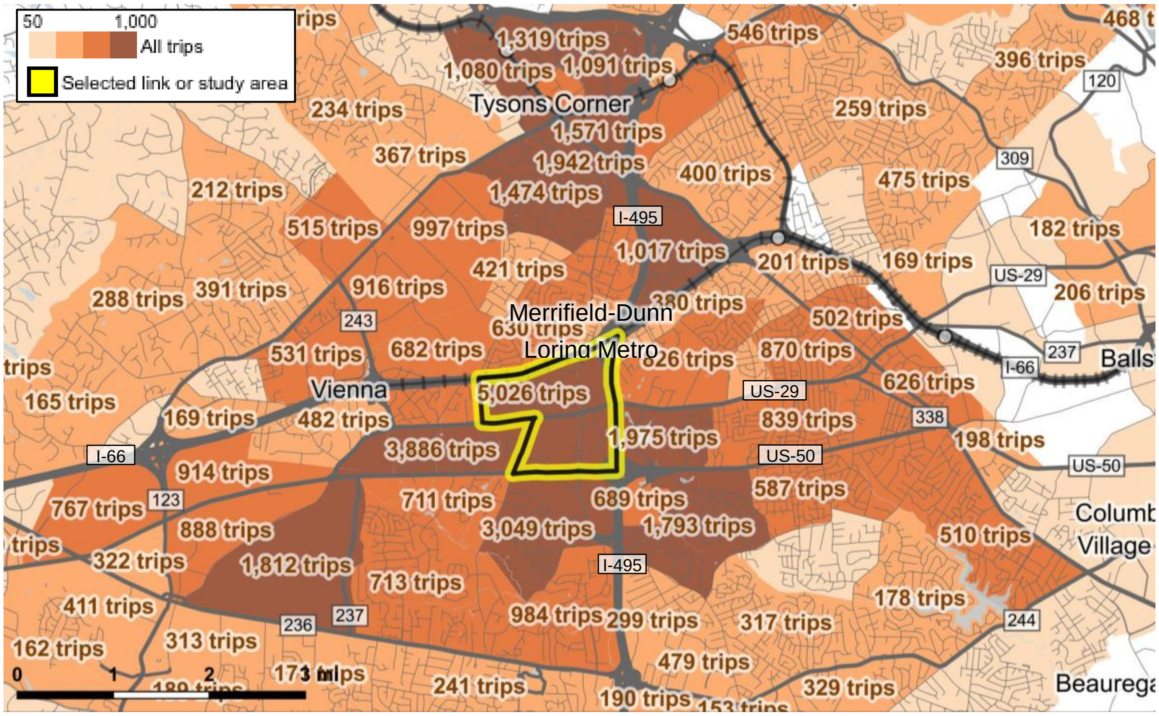
The Merrifield study area lies west of I-495 between I-66 and US-50, immediately to the south of the Dunn Loring-Merrifield Metro station on the orange line. The area has a number of policies in place encouraging compact, mixed use development, connected street networks, and reductions in automobile use. Those include the area's designation as a Commercial Revitalization Area (CRA), its street design manual and its comprehensive plan. In 2009, the Mosaic District, Merrifield's town center, was established as the county's first Community Development Authority (CDA), entitling it to public funds for infrastructure and services.[10]

These plans and programs have helped to improve street connectivity and reduce traffic congestion in and around Merrifield Town Center, increase walkability, and stimulate dense, mixed-use development. Since 2001, eight streets and 25 intersections were added. The area has also added capacity to existing roads, including Gallows Road and HOT/Express Lanes on I-495 at Route 29. Recent improvements to the Dunn Loring-Merrifield Metro station include 2,000-space parking garage, kiss-and-ride lot enhancements, improved bus bays, and bicycle and pedestrian enhancements.[11] Nonetheless, GPS data shows a large number of short trips in the area and clusters of trips to nearby areas, many of which are accessible by transit.

Data analysis

GPS data reveals that the Merrifield study area generates approximately 133,300 vehicle trips per weekday, including 60,700 trips (46%) less than five miles, 27,600 (21%) less than two miles, 14,300 (11%) less than one mile, and 13,200 internal trips. There are also 7,800 trips to/from Tysons Corner, approximately 3.5 miles to the north, 5,400 trips to/from the City of Fairfax, and 2,500 trips to/from D.C.

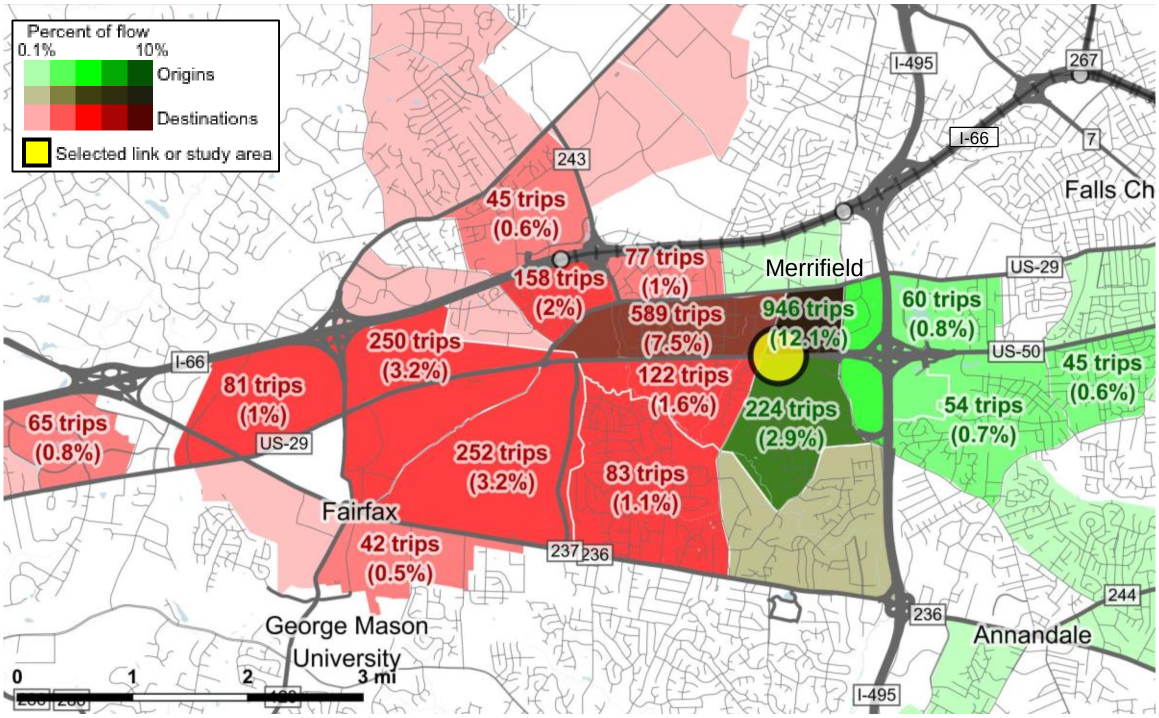
[10] http://fcrevit.org/merrifield/towncenter.htm
[11] http://www.fcrevit.org/publications/download/MerrifieldAnnualReport.pdf



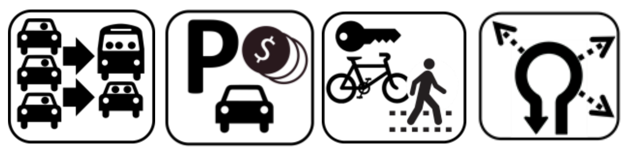
Trips to/from Merrifield during weekdays

Traffic to and from Merrifeld also has significant impacts on nearby routes—particularly US-29 and US-50. Trips beginning in the study area during the evening produce the highest peak period flows, including:

- 1,150 trips representing 15% of traffic on US-50 westbound between Barkley Dr and Gallows Rd; 1,010 of which are less than five miles, 410 of which are less than two miles, and 240 of which are less than one mile (pictured below)
- 210 trips representing 4% of traffic on US-50 eastbound between Graham Rd and VA-7
- 250 trips representing 12% of traffic on US-29 eastbound between Graham Rd and Annandale Rd; 130 of which are less than five miles
- 360 trips representing 7% of traffic on US-29 westbound at VA-123
- 770 trips representing 3% of traffic on I-495 northbound between VA-7 and I-66



Trips on US-50 westbound during the weekday PM period



Opportunities

Despite Merrifield gradually evolving into a dense, mixed-use, walkable town center, it still generates a large number of personal vehicle trips, including short trips, which add to personal transportation costs and contribute to nearby traffic congestion. Efforts to connect the local street network and improve bicycle and pedestrian infrastructure should continue, but those efforts must be paired with further transit enhancements, last-mile connections to the Merrifield-Dunn Loring Metro station, and TDM measures to ensure that travelers can make convenient, informed travel decisions. This includes parking management at local businesses and offices—most of which offer free parking in large lots and parking garages. Most businesses are still designed to be accessible primarily by automobile and there are few opportunities to park once and walk.

Mixed-use, infill development that fronts the street, with managed parking in back, will be essential for creating a walkable environment. Moreover, major roads like Lee Highway and Gallows Road, which have six to eight lanes and limited crossings, act as major obstacles for bicycle and pedestrian travel. Traffic calming, enhanced crossings, new crossings, and bike facilities can help convert short driving trips to non-auto modes.

Costs and benefits

The estimate of initial costs ranges from $4.3 to $4.6 million and annual operating costs are estimated at $270,000, with a primary focus on travel demand management through bikeshare, parking management, and enhancement of existing TDM marketing and promotion services.

Physical improvements include improving multimodal connections within mixed-use development areas and connecting these to the Metro station.

Estimated benefits include a reduction of 371,000 to 540,000 trips, up to 156,000 vehicle hours, up to $1.6 million in annual travel cost savings, and a reduction of up to 1,155 tons of carbon emissions.

9. Inova Fairfax Hospital

Inova Fairfax Hospital is a very large employer, not far from transit, but its campus is mainly accessible by automobile. Many people drive fairly short distances along existing bus and Metro lines. By improving non-auto circulation on campus, providing a better connection to transit from campus, and implementing a robust TDM program for employees, the amount of traffic generated could be greatly reduced.

Inova Fairfax Hospital, the largest hospital in Northern Virginia, presents a unique opportunity for employer-based TDM. The hospital has approximately 900 beds and handles approximately 50,000 surgeries and 140,000 emergency room visits per year.[12] Located on Gallows Road near I-495 in the city of Falls Church, it is only two miles south the Dunn Loring Metro station on the Orange Line, but it is oriented mostly towards people arriving by car. WMATA and Fairfax Connector buses stop at the campus entrance, but the bus stop is not well connected to the hospital campus. A campus shuttle serves the stop every 15 minutes. The hospital offers free parking for visits under 30 minutes and all day parking for $5.

Inova recently renovated its 11-story North Tower Building and completed the construction of a new 12-story tower for its Women's Hospital and Children's Hospital as part of multi-year expansion plan.[13,14] The hospital also plans to open new facilities on the 117-acre former ExxonMobil Fairfax Campus located less than a half-mile away across Gallows Road as early as 2016.[15] A recent traffic study recommended a new traffic signal, a new lane on Gallows Road, restriping, intersection improvements and new signal timings to accommodate campus growth.[16]

Data analysis

GPS data reveals that the hospital and its surrounding area generate approximately 23,000 vehicle trips per day, including 9,700 trips (41%) less than five miles, 5,100 (22%) less than two miles and 2,200 (9%) less than one mile, and many trips along the nearby Metro line. 10,500 of these trips occur during the midday.

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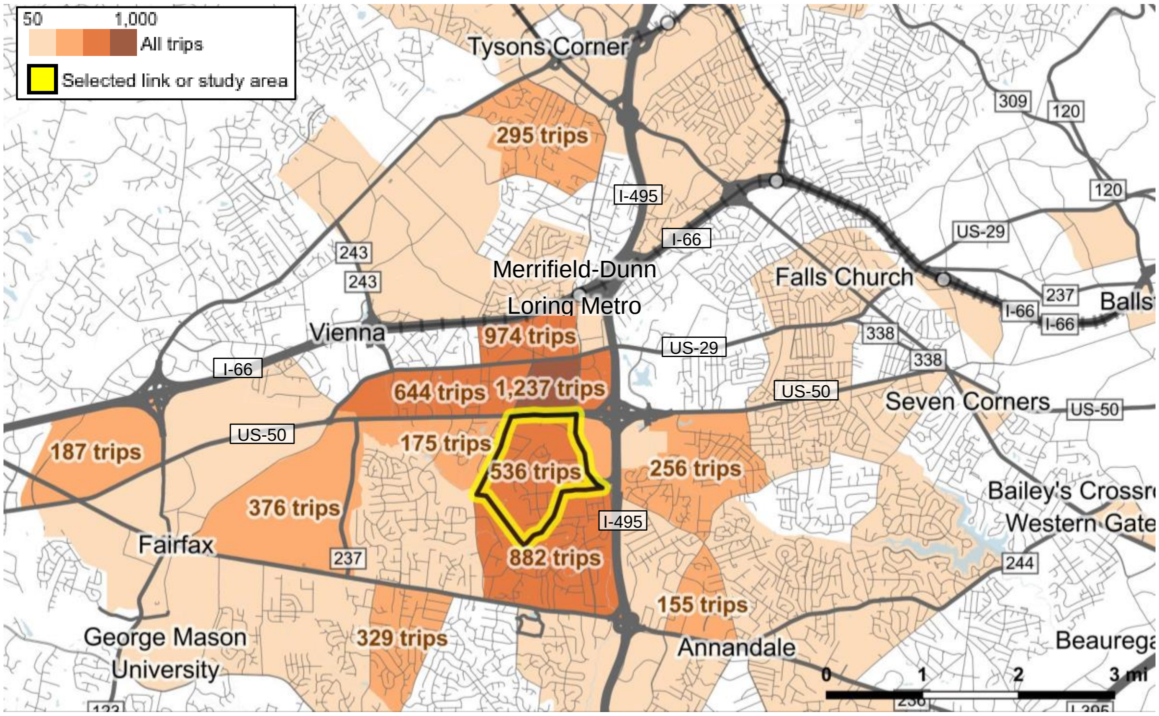
[12] http://health.usnews.com/best-hospitals/area/va/inova-fairfax-hospital-6340490
[13] http://www.healthcaredesignmagazine.com/news-item/inova-fairfax-hospital-completes-medical-campus-expansion-renovations
[14] https://www.inova.org/education/pediatric-residency/hospital-expansion
[15] http://www.bizjournals.com/washington/blog/2015/09/exclusive-inovas-vision-for-exxon-mobil-campus.html
[16] http://www.mjwells.com/projects/inova-fairfax-medical-campus



Trips to/from Inova Fairfax Hospital during weekdays

Opportunities

Inova Fairfax Hospital should initiate a comprehensive TDM program, including parking management and parking cash-out for employees. As the campus grows (including on the former ExxonMobil site), enhanced on-site options including shuttles, bicycle and pedestrian connections, shops, services and potentially a bike share system can reduce employees' need for an automobile to meet their daily needs. Improved connections to transit are also needed, given that the adjacent bus line is difficult to access and service is infrequent.

Costs and benefits

The improvements for this area focus primarily on expanded transit but also include bike/ped connections, bike share, parking management, and other employer-based TDM programs. The estimate of initial capital costs ranges from $2.5 to $2.7 million and annual operating costs estimated at $640,000.

The proposed strategies would remove an estimated 297,000 to 383,000 trips from the network, with associated benefits of up to 171,000 vehicle hours of travel eliminated. A total of up to $3.4 million in travel cost savings and a reduction of up to 2,500 tons of carbon emissions are also projected.

10. Manassas

Route 28 carries regional traffic through Manassas and provides access to some major commercial centers in Manassas, but more than half of the traffic it carries are short, local trips, which add considerably to peak period congestion. Local authorities should take advantage of opportunities to keep local vehicle traffic off of Route 28, including more mixed land uses in neighborhood areas, better biking and walking conditions, and enhanced local street connections.

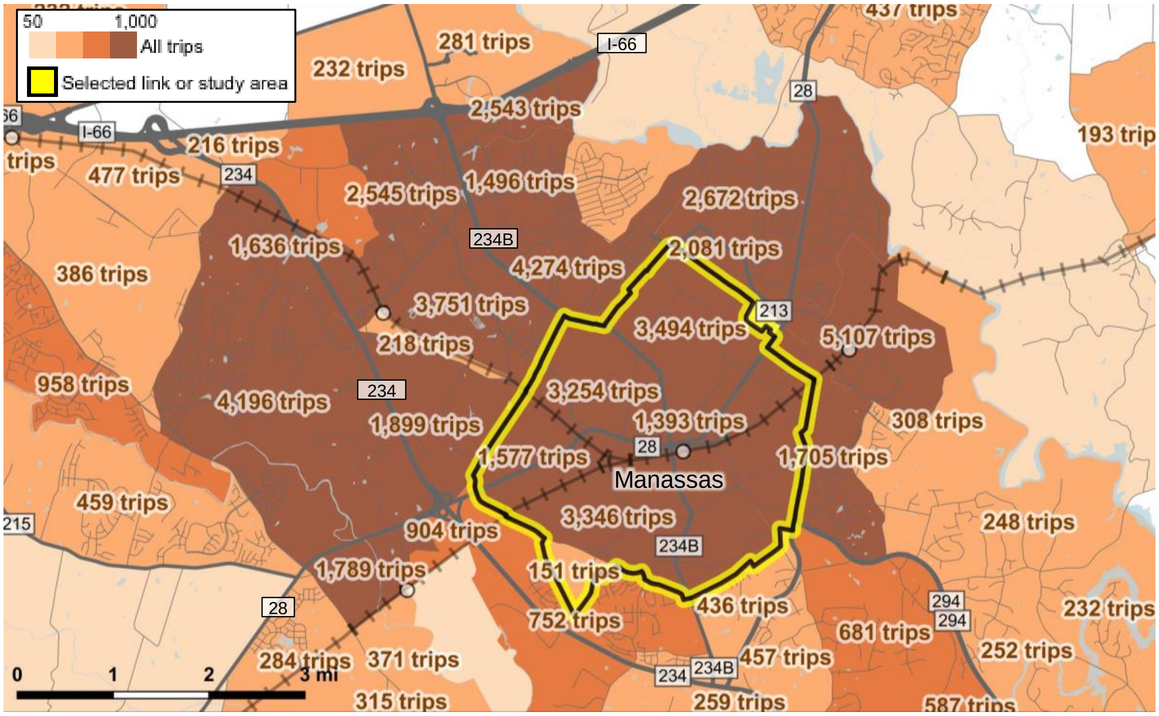
The Manassas study area includes the City of Manassas, excluding the Manassas Regional Airport and areas west of Godwin Drive. Several special districts, including Old Town at the city's center, feature historical, mixed-use development. However, most of the city's growth since the 1950s and 1960s has been concentrated along automobile-oriented commercial corridors, which serve regional demand, and detached, single-family housing, which makes up a majority of the city.

The city's comprehensive plan (2013) states: "Continuation of single-occupant automobiles as the primary form of commuting is resulting in traffic congestion during peak hours, lessening of air quality, and deterioration of the pedestrian environment as roads are expanded." Our data shows that short vehicle trips are very common in the city and account for a substantial share of traffic on its major arterials. However, the plan also calls for four road-widening projects and emphasizes that future development should be separated and buffered by land use, which could further exacerbate traffic issues. Mixed-use development with residential uses is encouraged in its downtown and special districts.[17]

Data analysis

GPS data reveals that the Manassas study area generates approximately 125,900 vehicle trips per weekday, including 53,300 trips (42%) less than five miles, 22,900 (18%) less than two miles, 6,400 (5%) less than one mile, and 19,900 internal trips.

[17] Comprehensive plan



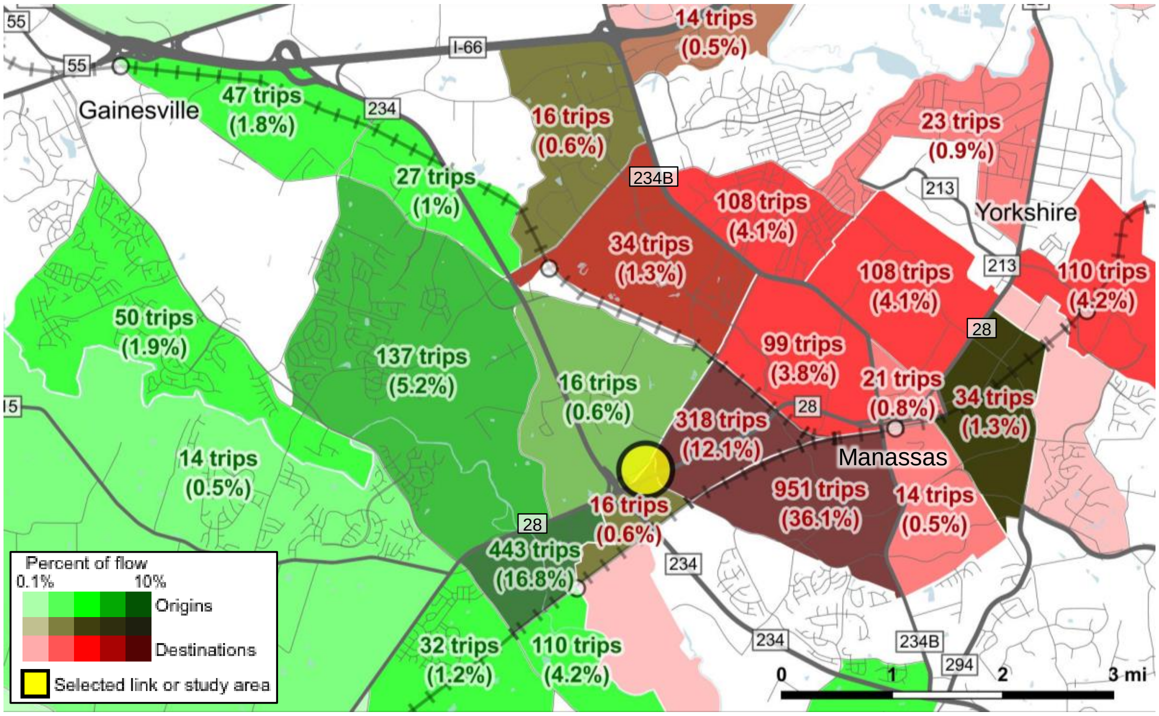
Trips to/from Manassas during weekdays

Traffic to and from Manassas, including internal trips, also has significant impacts on nearby routes—particularly on Route 28. Trips ending in the study area during the evening produce the highest peak period flows, including:

- 1,550 trips representing 59% of traffic on VA-28 eastbound between Linton Hall Rd and VA-234; 520 of which are less than five miles and 330 of which are less than two miles (pictured below)
- 440 trips representing 16% of traffic on VA-28 westbound between Wellington Rd and Grant Ave; 400 of which are less than five miles, 130 of which are less than two miles and 30 of which are less than one mile
- 560 trips representing 41% of traffic on VA-28 eastbound between Wellington Rd and Grant Ave; 330 of which are less than five miles, 100 of which are less than two miles and 40 of which are less than one mile
- 910 trips representing 62% of traffic on Wellington Rd eastbound between Goodwin Dr and VA-28; 390 of which are less than five miles and 170 of which are less than two miles
- 790 trips representing 16% of traffic on VA-234 northbound between Prince William Pkwy and Mercury Dr
- 410 trips representing 11% of traffic on VA-234 southbound between I-66 and US-29

234

Manassas



Trips on VA-28 eastbound during the weekday PM period

Opportunities

The City's existing plans call for mixed use infill development and pedestrian connections, but those will be concentrated in several special districts, including the downtown, while a majority of commercial development will be concentrated in automobile-oriented areas along major arterials, and a majority of the city's residents will live in more remote residential areas. The City, with support from the Commonwealth and Prince William County, should take steps to reduce the length and frequency of short trips by enhancing non-auto options, building complete streets, improving local street connectivity, and enabling mixed land uses in the style of existing Neighborhood Business Districts in and near all residential neighborhoods to help meet residents' daily needs. Employer-based TDM, ridesharing services and potential shuttle service should focus on areas to the immediate west of Manassas including the GMU Science and Technology Campus, Innovation Park and other offices west of Wellington Road.

Cost and benefits

This case study calls for a fairly comprehensive set of improvements, which in turn have the potential to reduce a large number of trips. The estimate of initial capital costs ranges from $7.8 to $9.4 million and annual operating costs are estimated at $360,000, consisting of numerous connections and complete street improvements as described in the Cost Summary section of the report. A new transit route is also included, as well as parking management and employer-based TDM measures.

The potential benefits are estimated to achieve a reduction of 2.4 to 4.9 million annual trips along with up to 829,000 vehicle hours, achieving related benefits of up to $7.0 million in transportation cost reductions and up to 5,100 tons of emission reductions per year.

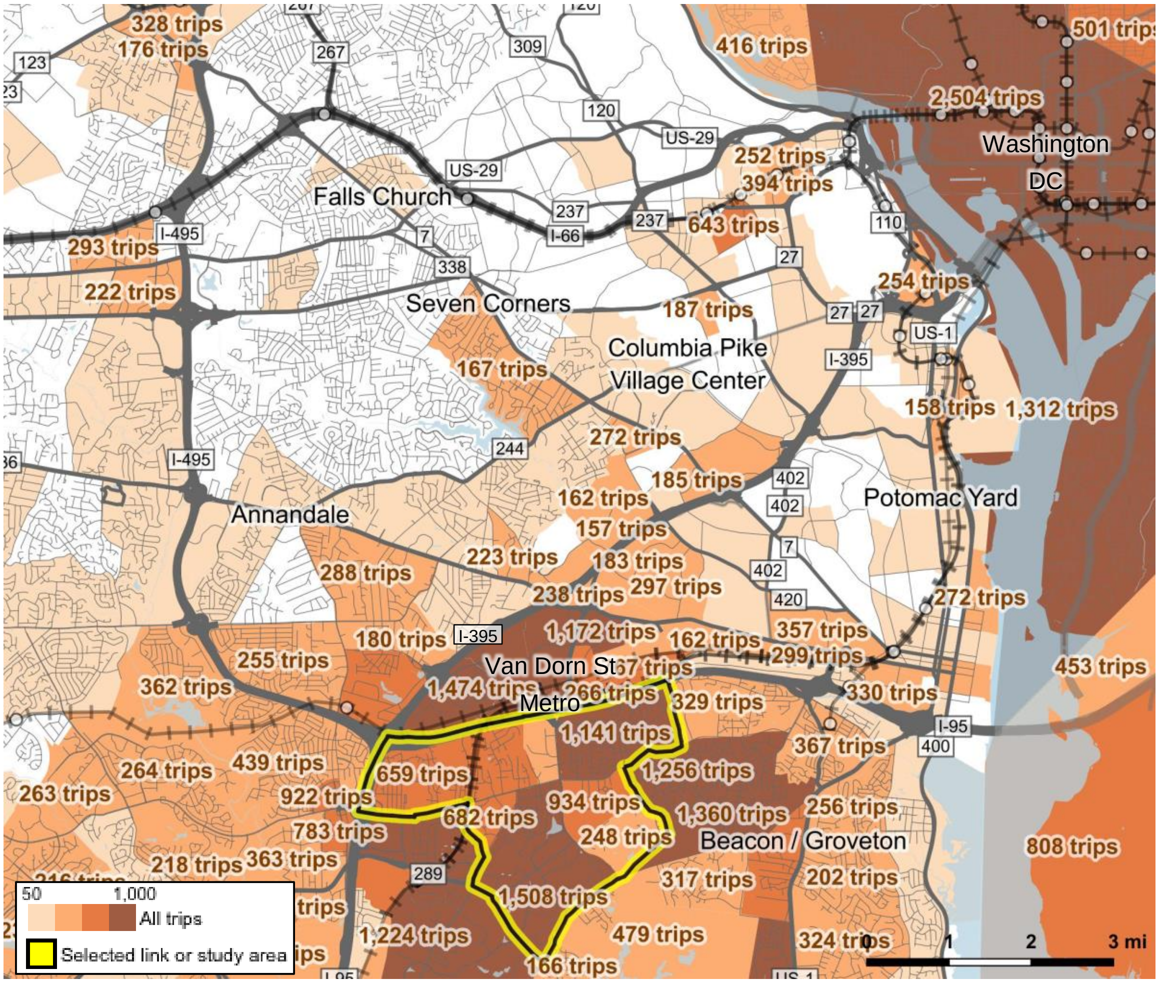
11. Van Dorn Street Metro Station (southern catchment area)

Several thousand vehicle trips are made each day between D.C. and the area just south of Van Dorn Street Metro station—bypassing the station and adding to traffic along Van Dorn Street and other routes. By adding connections across the Capital Beltway and improving non-auto access to the station, local authorities can shift more travelers to Metro and reduce traffic on nearby routes.

Alexandria and the surrounding areas of Fairfax County are fairly well served by Metro. The Van Dorn Street Metro should act as a convenient boarding location for travelers that would otherwise travel on Van Dorn Street (Route 613) and other parallel routes into DC—especially those traveling from neighborhoods just south of the station. However, GPS data reveals that many commuters drive past the station each day. There are many possible explanations for this including a lack of available parking spaces, poor connections to nearby neighborhoods and personal preferences or needs for an automobile. Given the quantity of trips passing the station, however, there are great opportunities to capture a considerable portion of trips by transit and marked benefits to doing so, particularly in terms of the impacts those trips have on road capacity.

Data analysis

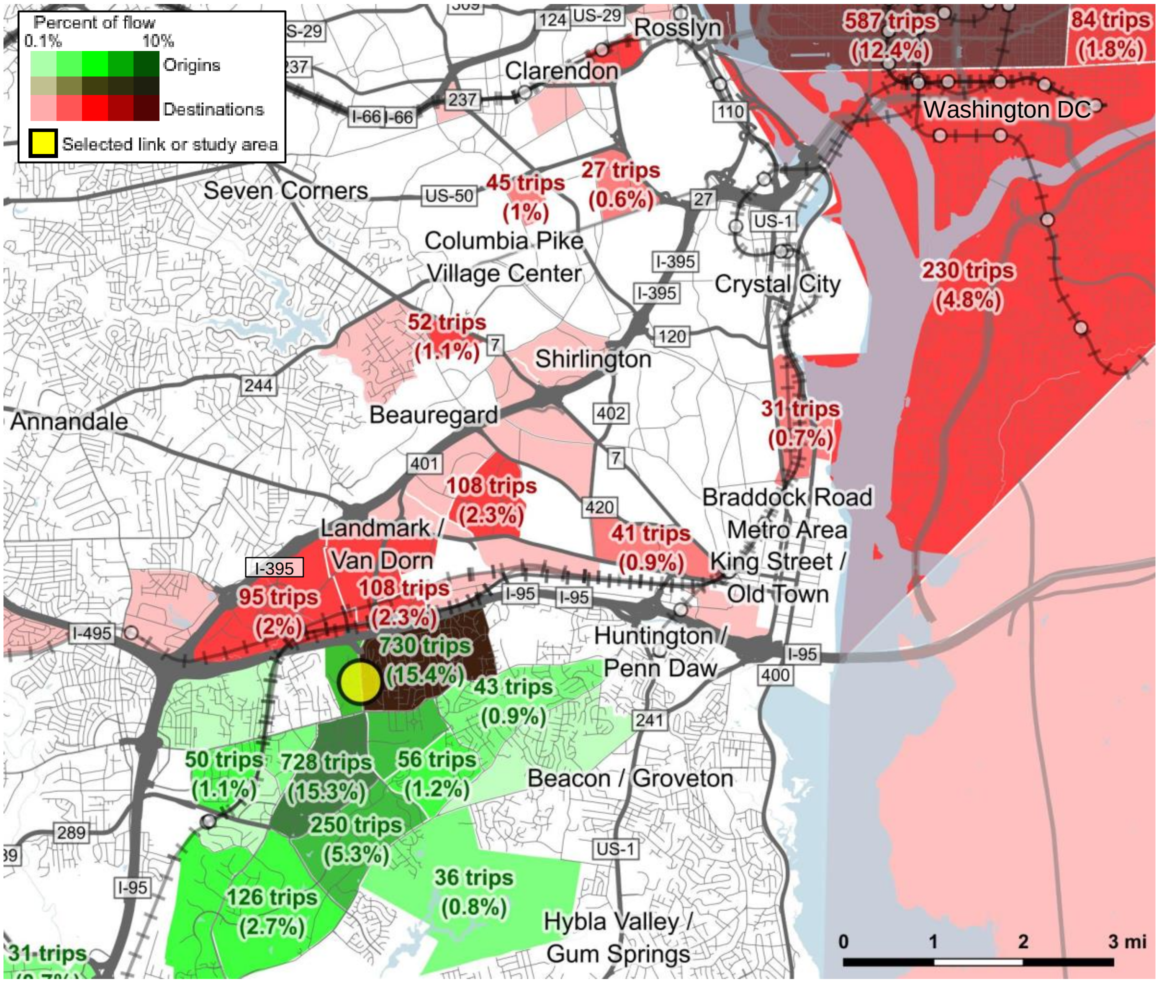
GPS data reveals approximately 2,000 to 3,000 vehicle trips between the potential transit catchment area, south of Van Dorn Street Metro station, and D.C. each weekday. Another 1,300 trips are made each day between the southern catchment area and the Van Dorn Street Metro station. These trips account for roughly 5% of the traffic on South Van Dorn St.



Trips to/from Van Dorn southern catchment area during weekdays

Traffic to and from the Van Dorn Station southern catchment area also has significant impacts on nearby routes. Trips beginning in the study area during the morning contribute the following:

- 2,130 trips representing 45% of traffic on South Van Dorn St northbound between VA-644 and I-95/I-495; 580 of which end in D.C. (pictured below)
- 1,230 trips representing 13% of traffic on VA-216/VA-401 northbound between I-95/I-495 and Edsall Rd; 440 of which end in D.C.
- 710 trips representing 3% of traffic on I-395 eastbound between VA-27 and VA-120; 590 of which end in D.C.
- 210 trips representing 10% of traffic on VA-611 northbound between Hayfield Rd and South Van Dorn St; 60 of which end in D.C.



Trips on South Van Dorn St northbound during the weekday AM period

Opportunities

The Commonwealth, Alexandria County and Fairfax County should work towards improving connections to the Van Dorn Street Metro Station across the Beltway, prioritizing bicycles, pedestrians, transit and taxis in order to avoid creating a new high traffic route. Stakeholders should also conduct a study of Metro use impediments and work to address those impediments. This could include improving feeder transit connections, adding shelters and real-time information at transit stations, and improving bicycle and pedestrian connections.

Costs and benefits

The estimate of initial capital costs ranges from $7.9 to $9.1 millionand annual operating costs are estimated at $826,000, with an emphasis on supplemental transit service and substantially improved bike/ped access via a bridge over I-495 and a tunnel under the current Metrorail tracks.

The potential trip reduction for this case study is estimated at 219,000 to 440,000 which includes elimination of up to up to 244,000 vehicle hours of travel. These trip reductions would lead to travel cost savings of up to $3.3 million per year and a reduction of up to 2,430 tons of carbon emissions.

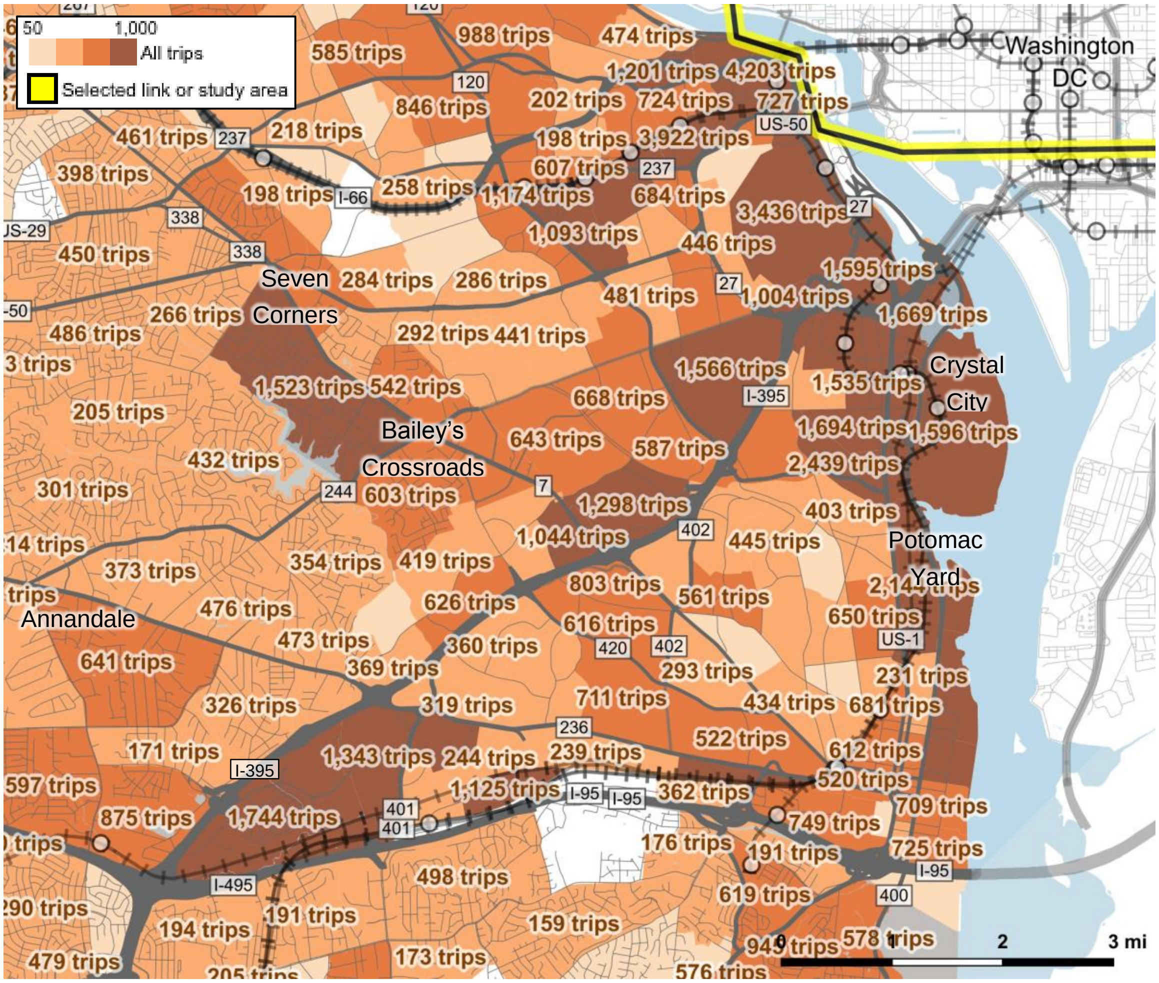
12. Inside the Beltway (express transit catchment area)

The I-395 corridor carries tens of thousands of vehicles each day between D.C. and areas inside the Capital Beltway, largely because transit service is sparse. A combination of TDM, ridesharing services and express transit service could meet a large unmet demand and reduce traffic along I-395 and nearby routes.

The area along I-395, south of D.C. and west of the Yellow and Blue Metro Lines, is not particularly well served by transit. Yet I-395 carries a large volume of travelers between D.C. and northern Virginia each day. While major transit investments are outside the scope of recommendations in this report, the GPS data enables quantification of the potential ridership that could be captured by high quality express transit along I-395, and it reveals areas that contain the highest numbers of potential riders.

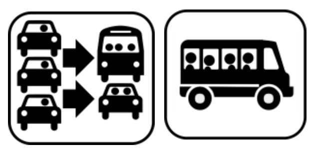
Data analysis

GPS data reveals approximately 20,000 to 30,000 trips between D.C. and areas south along the I-395 corridor. The data also reveals many trips beginning and ending within several clustered areas including just north of I-395 at Route 7, along Seminary Rd (Route 420) in Alexandria, and where I-395 meets I-95/I-495.



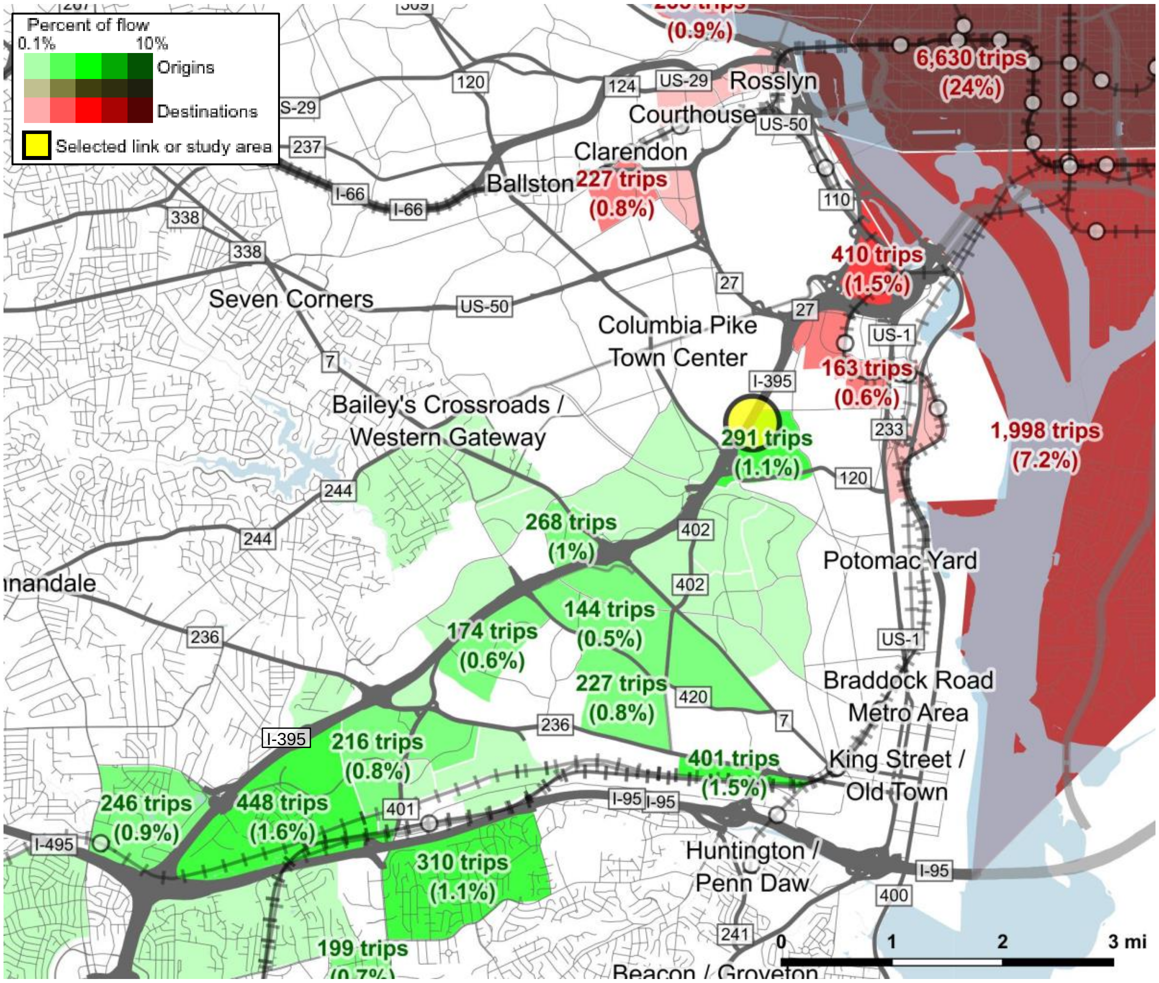
Trips to/from central D.C. during weekdays

Trips into D.C. from along the I-395 corridor also account for 3,000 to 5,000 trips on I-395 during a weekday and as much as 5% of the traffic during peak periods. Origins and destinations of trips along I-395 are shown below for the weekday morning period.



Opportunities

Trip reduction efforts along the corridor should include organized ridesharing services, additional TDM, and Safe Routes to School options. These efforts may benefit from additional GPS data related to specific highway links and analysis areas. The most valuable step, however, may be to conduct a feasibility study of high quality bus service using HOV lanes along I-395 or a robust network of connector transit to Metro. Areas generating a large number of trips to and from D.C. may be ideal locations for high-quality connector transit, park-and-ride lots, and other last-mile connections.



Trips on I-395 northbound during the weekday AM period

Costs and benefits

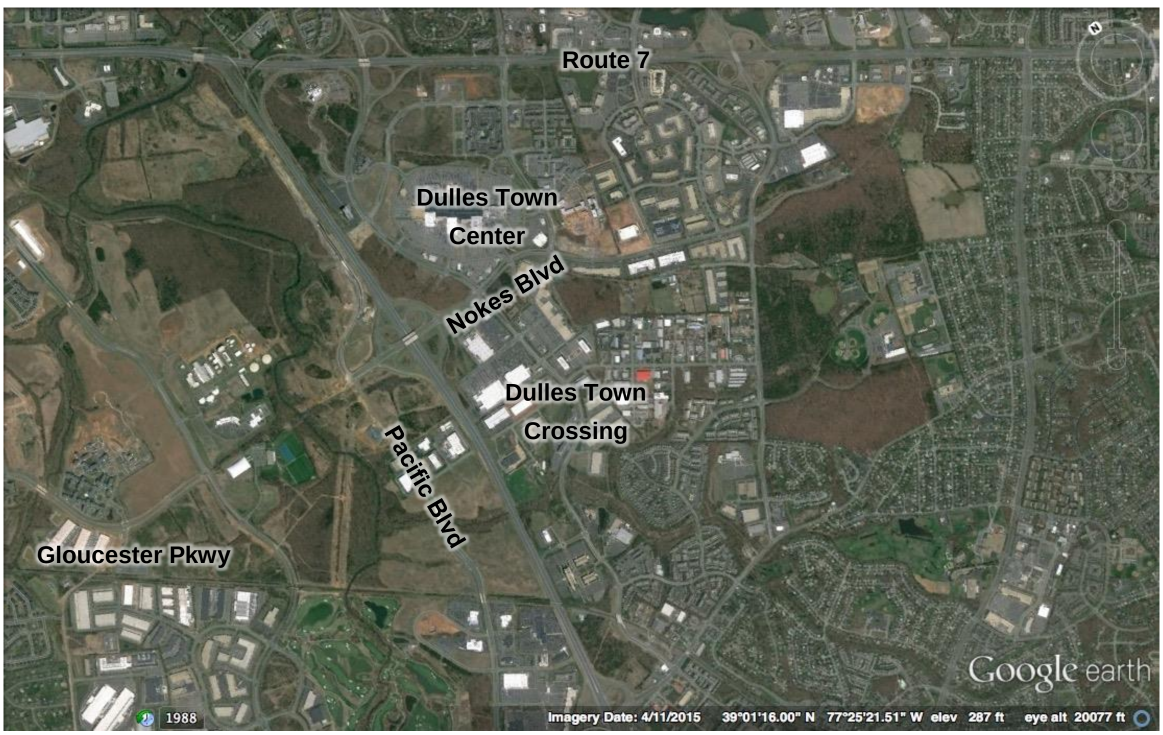
This case study focuses on transit and TDM solutions, which have an estimated annual operating costs of just over $500,000. The cost estimates include an express bus feasibility analysis and a robust TDM package.

Potential benefits are substantial, with an estimated trip reduction of 0.7 to 1.1 million annual trips along with up to 501,000 vehicle hours of travel, resulting in a travel cost savings of up to $5.3 million per year. The trip reductions would produce a reduction of up to 3,841 tons of carbon emissions.

13. Dulles Town Center

Dulles Town Center and the surrounding area generate nearly 100,000 trips each day, including 25% of the traffic on Route 7 and 15% of the traffic on Route 28. Given the large number of trips beginning and ending there, it is a natural location for a multimodal hub with ridesharing, slugging and express transit opportunities, which could greatly reduce traffic congestion along both routes and on other nearby roads. Leesburg, Dulles, Tysons Corner and D.C. are clear candidates for express transit service.

The Dulles Town Center study area includes Dulles Town Center (an enclosed shopping center in Sterling, Loudon County), Dulles Town Crossing (a large commercial plaza), and areas to the south, which contain a mix of office and commercial uses with some residential. Land uses are separated and configured around a hierarchal road network with ample parking. GPS data suggests that the area is a major termination point for east-west trips along Route 7 and north-south trips along Route 28. The Virginia DOT is currently widening portions of Route 28 south of Dulles Town Center,[18] adding a connection to Gloucester Parkway to the west,[19] and extending Pacific Boulevard from Nokes Boulevard to Richfield Way west of Route 28.[20]



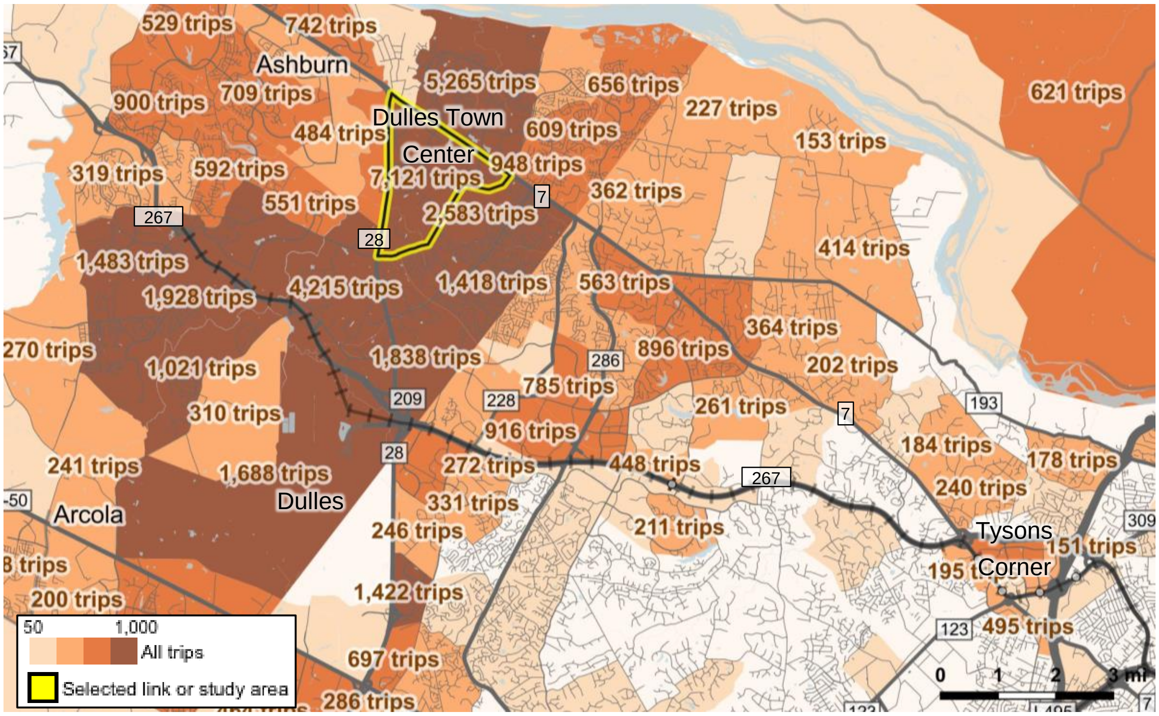
Aerial view of Dulles Town Center

Data analysis

GPS data reveals that the Dulles Town Center study area generates 97,000 vehicle trips per weekday, including 46,500 trips (48%) less than five miles, 24,000 (25%) less than two miles,

[18] http://www.virginiadot.org/projects/northernvirginia/rt_28_spot_widening.asp
[19] http://www.virginiadot.org/projects/northernvirginia/gloucester_parkway_extension.asp
[20] http://www.virginiadot.org/projects/northernvirginia/pacific_boulevard_extension.asp

8,400 (9%) less than one mile, and 10,500 internal trips. There are approximately 21,00 trips to and from Dulles Town Center along the Route 29 corridor to Dulles International Airport and the surrounding area. There are an additional 2,600 trips to and from Fairfax City, 2,000 trips to and from Tysons corner and 1,000 trips to and from central D.C.



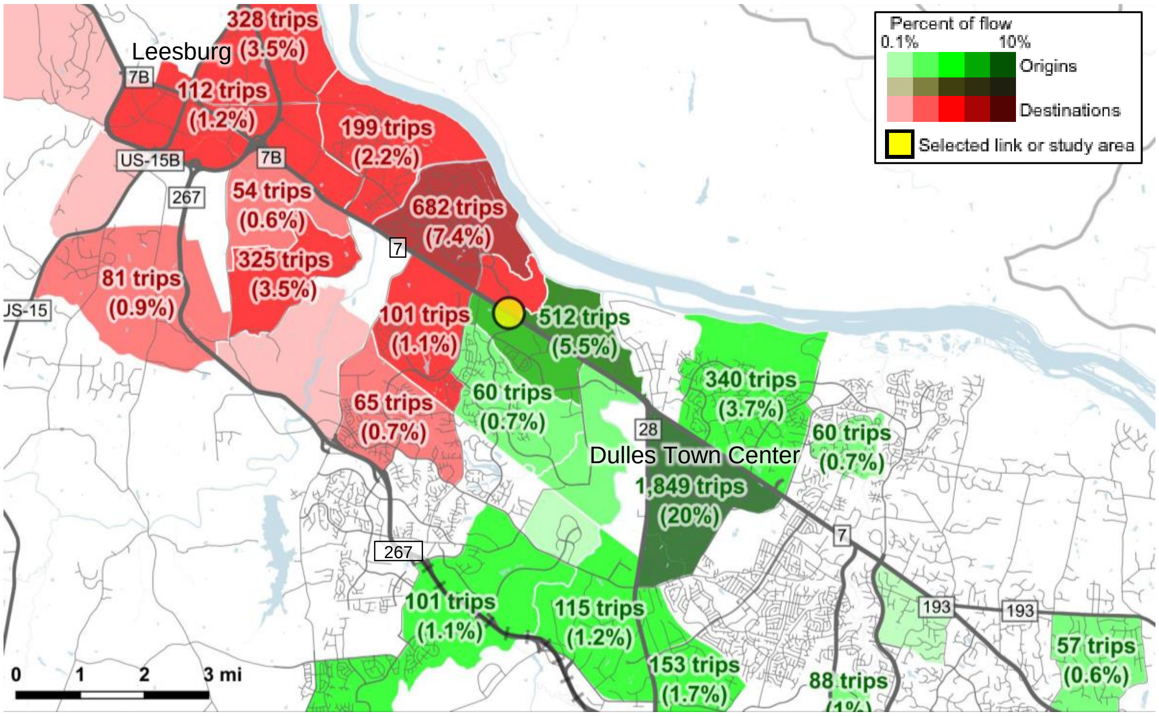
Trips to/from central Dulles Town Center during weekdays

Traffic to and from Dulles Town Center also has significant impacts on nearby routes—particularly Route 7. Trips ending in the study area during the evening produce the highest peak period flows, including:

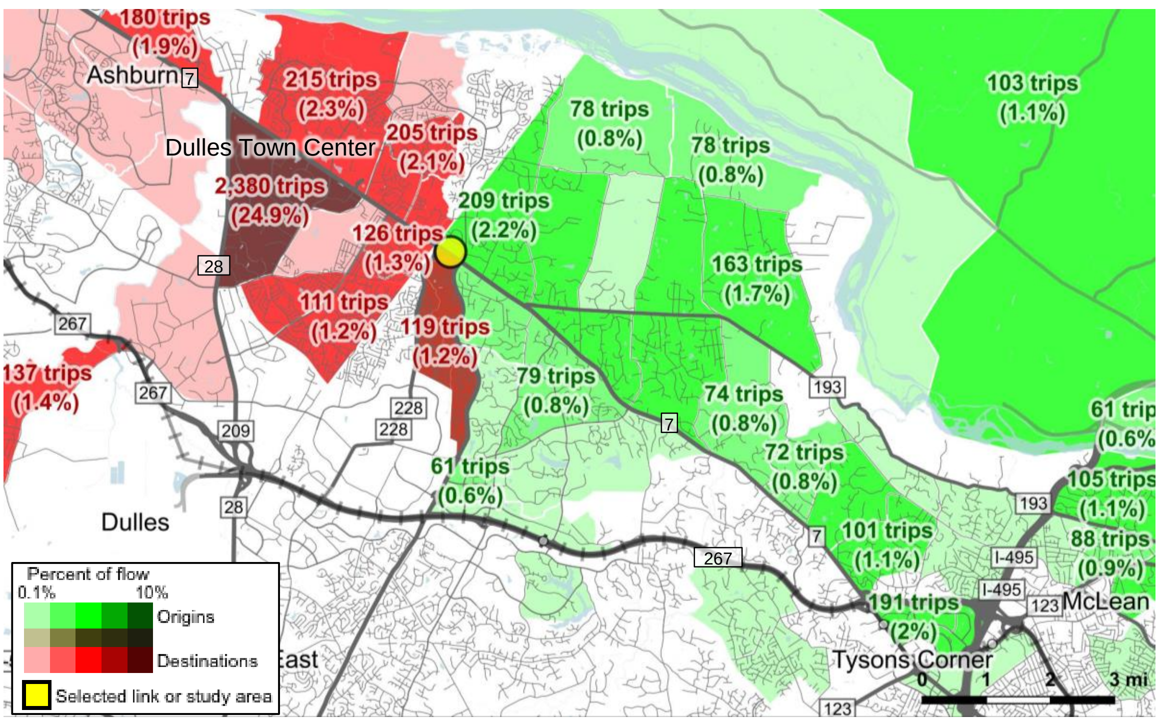
- 2,380 trips representing 25% of traffic on VA-7 westbound between Dranesville Rd and VA-286 (pictured below)
- 2,260 trips representing 25% of traffic on VA-7 westbound between VA-286 and Georgetown Pike
- 2,290 trips representing 15% of traffic on VA-28 northbound between VA-606 and VA-625
- 670 trips representing 18% of traffic on VA-193 westbound between Springvale Rd and VA-681
- 360 trips representing 10% of traffic on VA-606 westbound between Shaw Rd and Herndon Pkwy

Trips beginning in the study area during the evening produce the second highest peak period flows, including:

- 1,850 trips representing 20% of traffic on VA-7 westbound between VA-2400 and Lexington Dr (pictured below)
- 140 trips representing 8% of traffic on VA-625 westbound between VA-643 and VA-625



Trips on Route 7 westbound (east of Dulles Town Center) during the weekday PM period



Trips on Route 7 westbound (west of Dulles Town Center) during the weekday PM period

Opportunities

Given that so many trips along Route 7 and elsewhere begin or end at Dulles Town Center, the area is natural location for a multimodal hub. This hub could accommodate organized ridesharing or informal slugging and serve as a connecting point for express transit to Leesburg, Tysons Corner, D.C. and Dulles, including Silver Line Metro stations. Targeting potential transit users in the area will require careful outreach, information gathering and education. Attracting riders may require useful real-time information, accommodations for bicycles, complimentary services like daycare and guaranteed ride home, or other amenities. Over the long term, this hub could become a mixed use town center that serves many of people's daily needs. This vision is consistent with Loudoun County's plan for the area and some components have been approved but not yet constructed.

Costs and Benefits

The estimate of initial capital costs ranges from $21.2 to $26.4 million and annual operating costs are estimated at $490,000, with much of the investment focused on improved accessibility for bicycles and pedestrians via sidewalks, pedestrian signals, and inter-parcel connections joining adjacent developments. Enhanced transit service was also included in the form of express bus service.

The potential trips removed number 507,000 to 683,000 based on these opportunities. These trip reductions would yield up to 273,000 fewer vehicle hours of travel and net approximately up to $4.0 million in travel cost savings with a reduction of up to 2,884 tons of carbon emissions per year. The cost-effectiveness is expected to be moderate based on the significant infrastructure requirements and a more modest potential to reduce trips in this highly auto-oriented environment. Nevertheless, planned improvements to land use mix and design and integration of multimodal opportunities should help mitigate future increases in auto travel and congestion in this busy area.

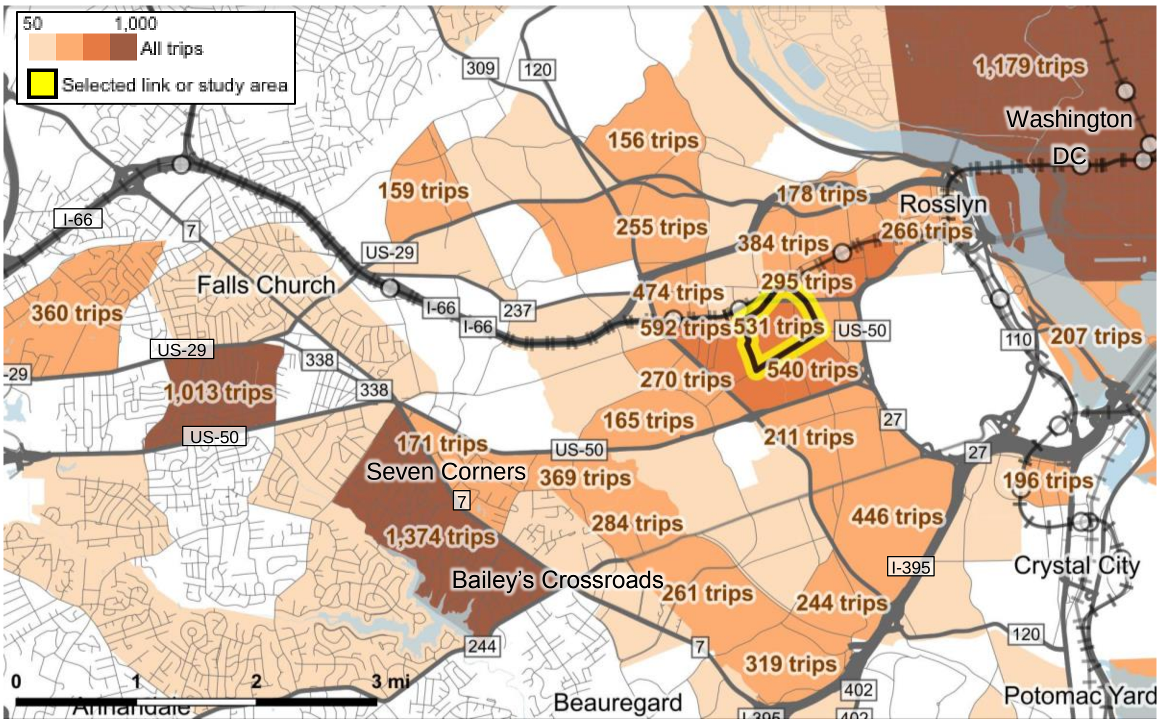
14. Bailey's Crossroads / Seven Corners to Ashton Heights

There are exceptionally high vehicle flows between certain neighborhoods in Arlington and Fairfax counties inside the Capital Beltway. The unusually high concentration of trips means there may be unique opportunities for ridesharing and shuttle or transit services, which could remove thousands of trips from Route 50 and other nearby routes. Arlington Commuter Services should study these flows and survey travelers to understand the best options.

The Ashton Heights study area in Arlington, just south of the Virginia Square and Clarendon Metro stations, includes some dense, mixed-use development around Clarendon station and mostly compact residential uses. The area generates a large number of trips each day, with origins and destinations clustered into several areas. Some of these trips are clustered along the Metro line, but others lie along Route 50, three to five miles west of Ashton Heights. Bus service along this corridor is fairly indirect and infrequent, making transit travel challenging. However, given the high number of relatively short trips along the corridor, there may be unexplored opportunities to manage demand in impactful ways.

Data analysis

GPS data reveals a high number of trips between the Ashton Heights study area and several neighborhoods three to five miles west. That includes 1,400 trips to and from a neighborhood south of Seven Corners and 1,000 trips to and from Woodley North each weekday. A majority of those trips (63% and 55%, respectively) are trips to Ashton Heights during the morning period. This suggests they are likely commute trips and that commuters may be trip-chaining on their way home in the evening. There are also more than 10,000 trips to and from other TAZs within approximately three miles of Ashton Heights, not including D.C.



Trips to/from Ashton Heights during weekdays

Opportunities

While many of the trips to common origins and destinations appear to be commute trips, a complete explanation for why there are so many trips is not entirely clear. Arlington County Commuter Services should explore these travel patterns and survey residents and employees who have reason to travel to and from these high volume origins and destinations. They may present unique opportunities for TDM, including parking management, ridesharing, guaranteed ride home and other services.

Costs and benefits

With a focus strictly on TDM strategies, the annual operating costs are estimated at $98,000, with benefits including reductions of 54,000 to 60,000 annual trips, up to 21,000 vehicle hours, up to $185,000 in annual travel costs and up to 135 fewer tons of carbon emissions.

15. Goose Creek Crossing (Ashburn / Belmont)

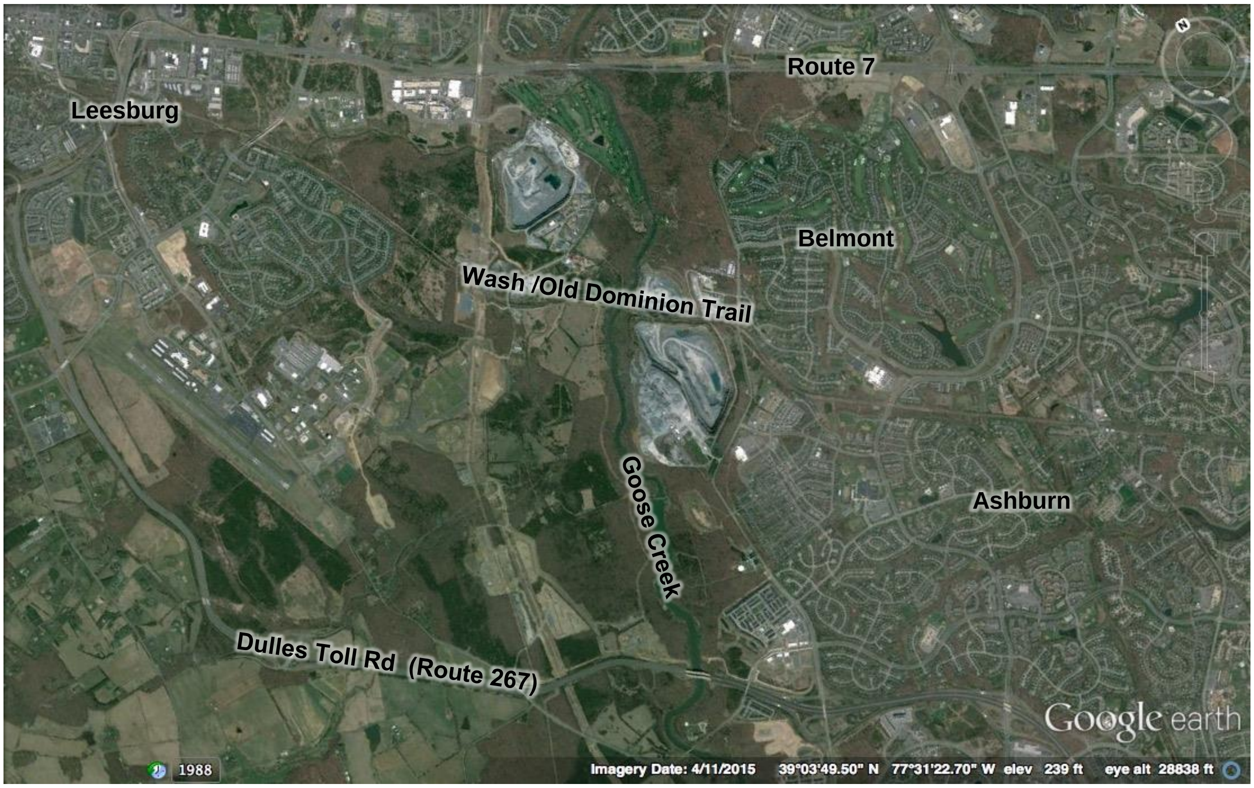
Goose Creek separates eastern Leesburg from nearby neighborhoods in Belmont and Ashburn, forcing many travelers to drive on one of several available routes including a busy segment of Route 7. By adding a local connection across the creek and improving connections to the existing Washington and Old Dominion Trail, local authorities could keep many of those trips off of busy arterials and convert some trips to walking and bicycling.

Goose Creek separates parts of Leesburg to its west and the Ashburn and Belmont neighborhoods to its east. GPS data reveals a high number of circuitous trips across Goose Creek, including more than 2,500 daily trips between the two areas described above. The only major connections across the Creek are Route 7 in the north and Route 267 (Dulles Toll Road) in the south. Route 463 (Sycolin Road) provides an alternative crossing just south of the Dulles Toll Road, while Riverside Parkway connects neighborhoods to the north of Route 7. Between those two major routes, however, there are no connections other than Washington and Old Dominion Trail.

Ashburn and Belmont, east of the creek, are mostly suburban residential areas with several schools. The street network is hierarchical and disconnected, with many cul-de-sacs. The portion of Leesburg abutting the creek to its west includes the Leesburg Executive Airport, Loudon County offices, the Loudon County Public School Transportation Center and Philip A. Bolen Memorial Park—a 405-acre regional park with sports fields. Some mixture of residential and commercial development is proposed for land along the Washington and Old Dominion Trail.

Heavy traffic and new development in the area have prompted several major road projects. Virginia DOT plans to widen VA-659 (Belmont Ridge Road), east of Goose Creek in Ashburn/Belmont, and add a bridge over the existing trail in the near future.[21] NVTA has programmed a grade-separated interchange at the intersection of Battlefield Parkway and Route 7, west of Goose Creek. A major, four-lane road connection is also planned between Crosstrail Boulevard and Kincaid Boulevard, west of Goose Creek.

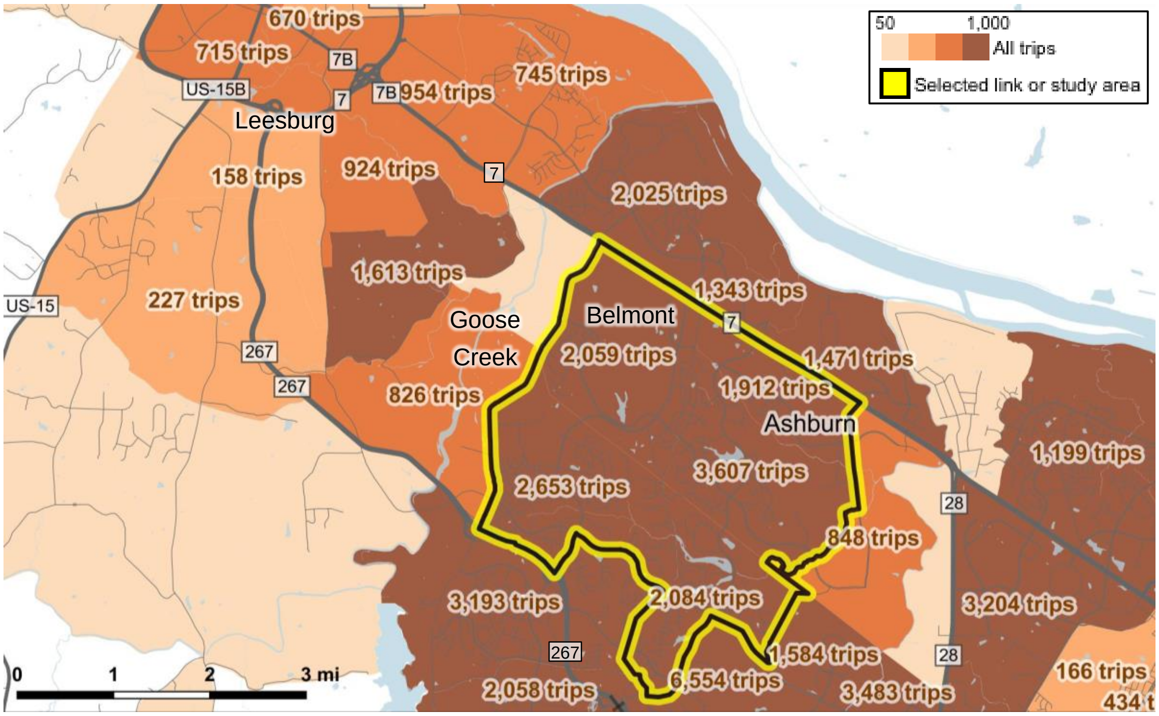
[21] http://www.virginiadot.org/projects/northernvirginia/belmont_ridge_road_widening.asp



Aerial view of Goose Creek area

Data analysis

GPS data reveals that the Ashburn/Belmont study area generates approximately 81,600 vehicle trips per weekday, including 34,300 trips (42%) less than five miles, 13,700 (17%) less than two miles, 3,900 (5%) less than one mile, and 12,000 internal trips. There are also approximately 2,500 to 3,000 trips to/from southeastern Leesburg, just across Goose Creek. These trips are highly circuitous.



Trips to/from Ashton / Belmont during weekdays

Opportunities

The high number of local trips crossing Goose Creek and the limited road options across the creek may warrant an additional road crossing or programs and policies to increase use of the existing Washington and Old Dominion Trail, including Safe Routes to School, a “bike bus” for school children, investments in bicycle and pedestrian infrastructure, road crossings and safety improvement. The study team recommends further study of travel patterns in the area to determine the best course of action to better accommodate trips across Goose Creek, if any actions are needed. New developments in Leesburg could provide opportunities to add street connections and improve connections to the trail without major public investments.

Given the high concentration of schools in the Ashburn/Belmont area, one explanation for the high number of trips may be students driving to and from school or parents dropping off children and picking them up. Similarly, residents of Ashburn/Belmont—including students and children—may be traveling across the creek to Bolen Park. In this case, many of these trips could be made by bicycling and, to a lesser extent, walking.

Possible interventions include a Safe Routes to School Program, a “bike bus” or “walking bus” for children traveling to school, and investments in bicycle and pedestrian infrastructure and safety improvements. These efforts may increase use of the existing trail across Goose Creek for transportation purposes. Additional traffic calming measures and street connections—particularly bicycle and pedestrian connections to schools—could also improve walking and bicycling conditions considerably for residents and encourage active transportation.

Costs and benefits

The estimate of initial capital costs ranges from $16.6 to $18.2 million and annual operating costs are estimated at $32,000.

The extensive improvement envisioned are anticipated to yield a reduction of up to 145,000 trips and up to 25,500 vehicle hours of travel. A total transportation cost reduction of up to $213,000 and up to 155 fewer tons of carbon emission are expected to result. The cost in comparison to benefits indicates that this extensive program of increased connectivity, while providing localized benefits, may not significantly impact travel choices to justify the investment at a regional scale.

16. Route 606 (northeast of Dulles)

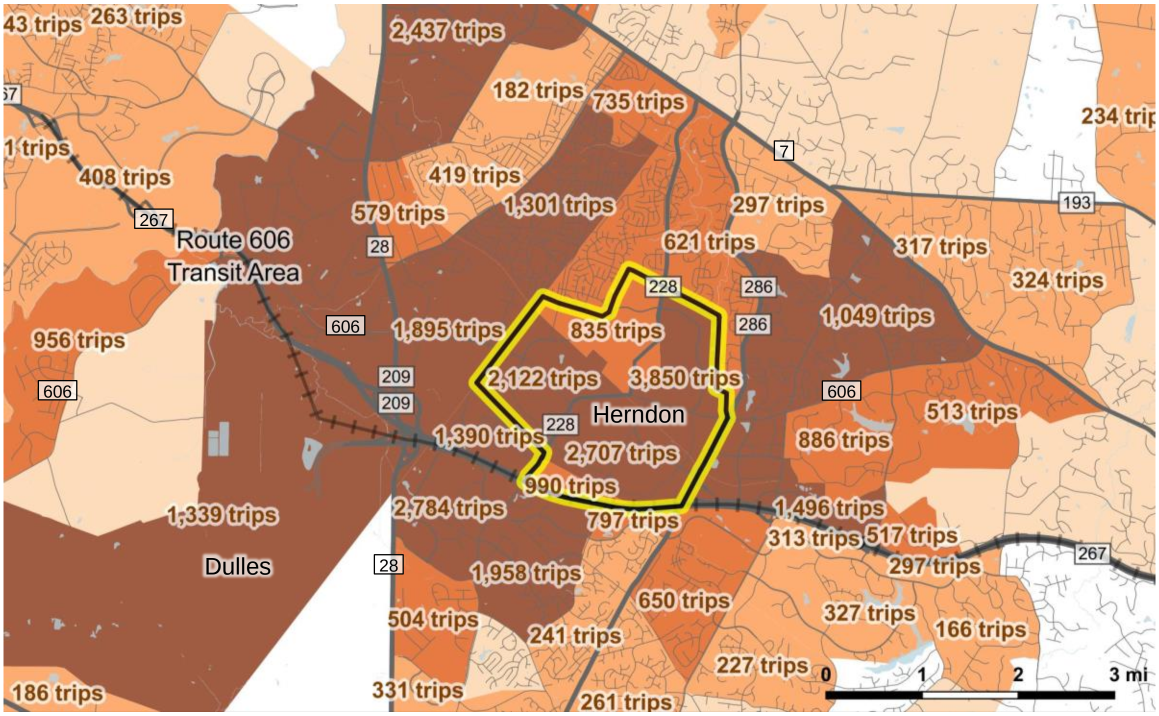
Route 606 in Herndon is congested and programmed for widening. However, upwards of one-third of the traffic is comprised of short trips that could be removed from the route by making better use of the local street network and by converting some of those trips to other modes—all while discouraging its use as an alternative to the Dulles Toll Road. This will be even more important as large developments come in west of Herndon.

The area northeast of Dulles International Airport, just outside the airport's entrance, includes the town of Herndon and several planned large, mixed-use developments—Waterside, Dulles World Center, and Innovation Center, south of the Dulles Toll Road (Route 267). These development projects will incorporate some of the strongest TDM components and vehicle trip reduction goals in Loudoun County, plus feeder transit to serve the Metro Silver Line extension. However, they will also add trips to the surrounding road network, which is already overburdened in some places. NVTA recently programmed the widening of East Elden St (Route 606), a major commercial arterial through Herndon.[22] Some roads in this area, including Route 606, also function as alternative route to the Dulles Toll Road.

Data analysis

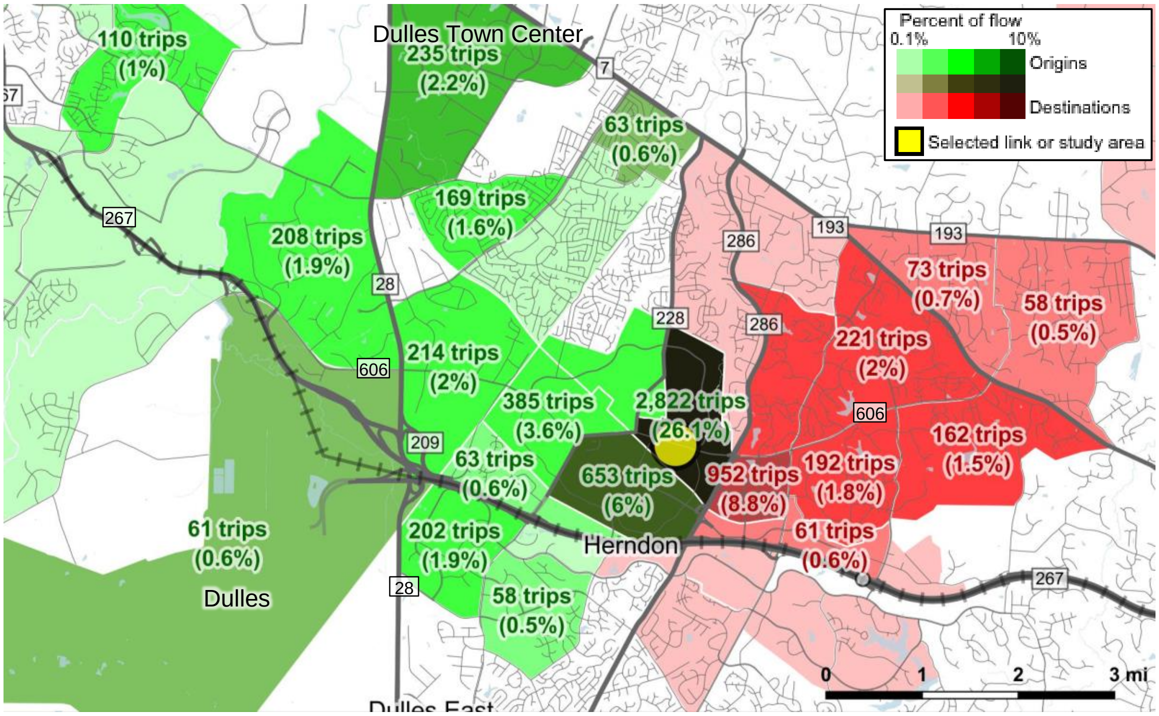
GPS data reveals that the Herndon study area generates approximately 78,700 vehicle trips per weekday, including 46,500 trips (48%) less than five miles, 24,000 (25%) less than two miles, 8,400 (9%) less than one mile, and 10,500 internal trips.

[22] http://www.thenovaauthority.org/wp-content/uploads/2015/10/Corridor-1.pdf

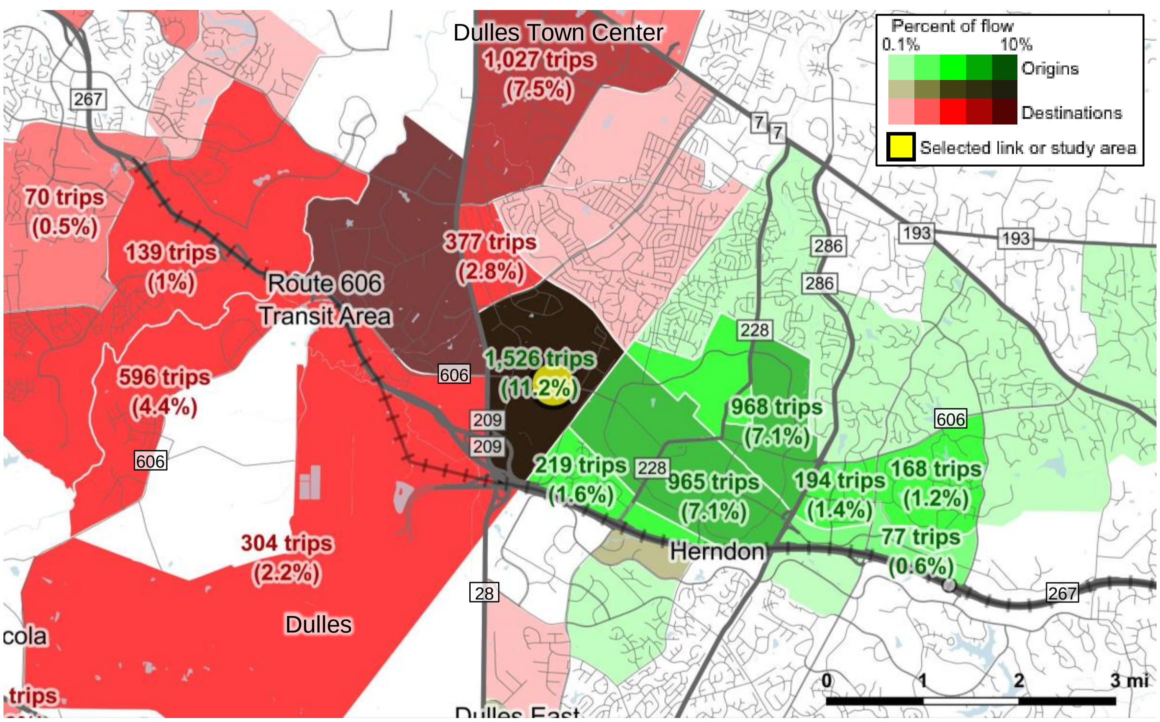


Trips to/from Herndon during weekdays

Route 606 serves as the major east-west route through Herndon and a major entry point in each direction. GPS data reveals that Old Ox Rd—Route 606 west of Herndon and north of the proposed Waterside and Dulles World Center developments—carries approximately 5,720 trips (20%) less than five miles each weekday, including 1,150 less than two miles and 220 less than one mile. East Elden St—Route 606 in eastern Herndon—carries approximately 7,310 trips (35%) less than five miles each weekday, including 3,840 less than two miles and 1,210 less than one mile.



Trips on East Elden St (Route 606) eastbound during weekdays



Trips on Old Ox Rd (Route 606) westbound during weekdays

Opportunities

As new development occurs adjacent to Route 606, new street connections should be added for bicycles and pedestrians, including connections to Herndon and the Center for Innovative Technology, to facilitate short trips without adding to demand on Route 606 on other local roads. Traffic calming and automobile diverters should be incorporated to prevent the local network from being used by those trying to avoid the Dulles Toll Road (Route 267). Proper bicycle and pedestrian facilities, paired with high quality shuttles or feeder transit, ridesharing opportunities, and home delivery services can serve residents living and working along the Route 606 corridor without adding automobile traffic.

Costs and benefits

Improvements focus on enhanced bicycle and pedestrian connections, particularly to Silver Line stations in the area, and a study of transit service feasibility, from the estimate of initial capital costs ranges from $6.7 to $8.5 million and annual operating costs are estimated at $150,000.

This package of investments is anticipated to result in a reduction of up to 172,000 vehicle trips with a corresponding reduction of up to 22,400 vehicle hours of travel. A total transportation cost reduction of up to $106,000 and up to 77 less tons of carbon emissions are also expected.

17. Route 606 (west of Dulles)

Route 606 carries traffic around the western edge of Dulles, including thousands of trips that are less than five miles, and will soon become an even busier route as developments like One Loudoun grow and once the Silver Line is extended to the area. Bicycle facilities and high-quality transit will help nearby residents reach the new Metro station and other destinations along Route 606 without adding to traffic congestion.

Loudoun County Parkway/Old Ox Road (Route 606), which loops around Dulles International Airport from north to west, is congested in both directions during peak periods. It is currently being widened from two to four lanes with bicycle and pedestrian accommodations.[23] Development along Route 606 includes one residential neighborhood and the Dulles Trade Center and Dulles Market, which are comprised of commercial and industrial uses. Loudoun County Parkway, which runs parallel to Route 606 to its west, serves residential uses and the Rock Ridge High School, but there are no vehicle connections between the two roads. A stream runs between them.

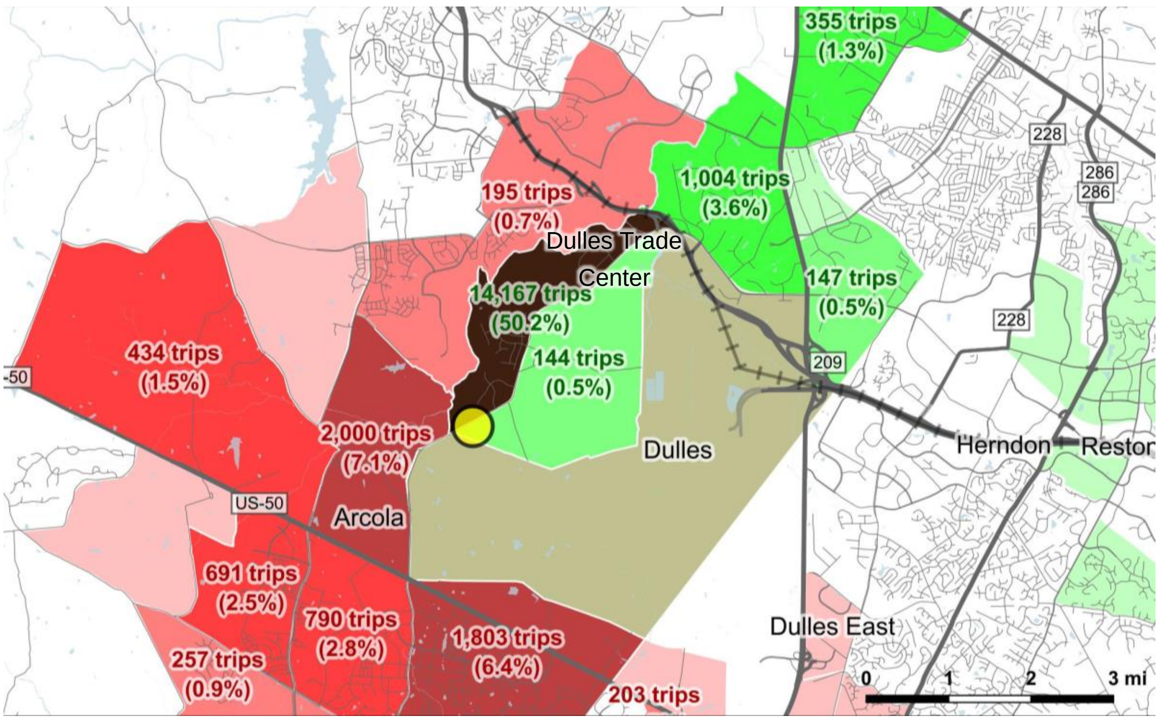
The area is currently experiencing major changes that could further impact traffic flows along the Route 606 corridor. These include the planned Metro Silver Line extension, which will add two stations west of Dulles, and the One Loudon project, which is a large, mixed-use project in northern Loudoun County, and other potential development along Route 606.

[23] http://www.virginiadot.org/projects/northernvirginia/old_ox_road_widening.asp

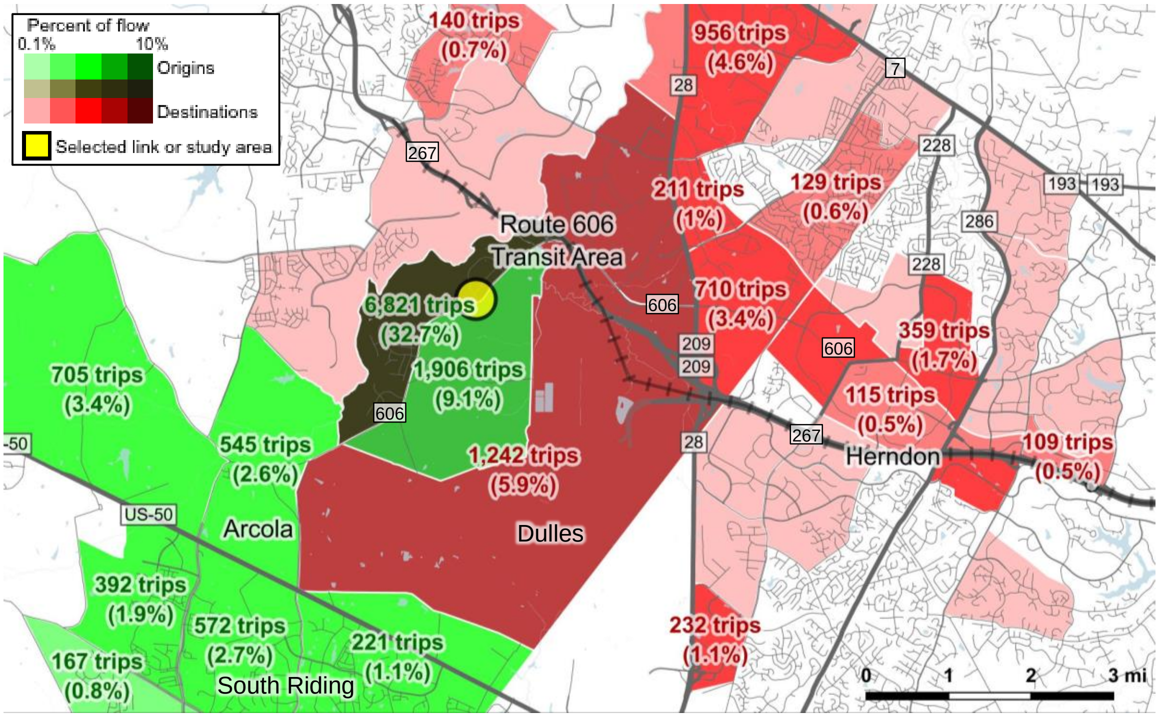
Data analysis

GPS data reveals that Route 606 south of Dulles Trade Center carries approximately 7,400 trips (13%) less than five miles each weekday, including 1,480 less than two miles and 350 less than one mile. Approximately 29,000 trips on this segment of Route 606 (50%) begin or end in the immediately adjacent area containing the Dulles Trade Center, Dulles Market and residential uses.

Route 606 near Dulles Trade Center (eastbound only) carries approximately 1,680 trips (8%) less than five miles each weekday, including 3,840 less than two miles and 1,210 less than one mile. Approximately 8,730 trips on this segment (42%) begin in the immediately adjacent area containing the Dulles Trade Center, Dulles Market and residential uses. Approximately, 1,240 trips (6%) end at Dulles International Airport.



Trips on Route 606 westbound, south of Dulles Trade Center, during weekdays



Trips on Route 606 eastbound, north of Dulles Trade Center, during weekdays

Opportunities

As future development occurs along Route 606 and Metro Silver Line extends to the Dulles North Transit Center, Route 606 should act as a multimodal corridor that can handle short trips in ways other than personal vehicles. Bicycle and pedestrian facilities are an important starting point, but additional street connections to surrounding neighborhoods may be necessary, particularly for non-auto modes. Frequent, high quality feeder transit along Route 606, targeted specifically at local residents, may help serve Metro and other local trips around Dulles. Future development should be compact, mixed-use and walkable to accommodate nearby residents without adding considerably to automobile traffic.

Costs and Benefits

The estimate of initial capital costs ranges from $8.4 to $8.9 million and annual operating costs are estimated at $710,000 to provide enhanced connections to the Route 606 corridor, which is programmed for widening and adding bike/ped facilities. Also a transit shuttle from the Dulles North Transit Center throughout the corridor and extending into South Riding is also included. This package of improvements would complete bike and ped connections between major residential areas and the major transit facilities in this part of the region.

These improvements are expected to yield a reduction of 95,000 to 178,000 trips along with up to 26,000 vehicle hours. A total transportation cost savings of up to $112,000 along with up to 82 fewer tons of carbon emission are expected outcomes.

Summary of Costs and Benefits

As reported with each case study, various strategies spanning physical improvements, new services, policies, and private initiatives offer the potential to improve travel conditions. The costs of improvements and estimated trip reduction benefits are highlighted with each case study. This section provides more detail on the improvements, assumptions and results that were developed for the study and offers insights into the components that could be singled out for specific investments. The specific assumptions underlying the connection improvements, the transit investments, and TDM programs are provided in the Estimation of Costs section that follows. Similarly, the methods and assumptions for developing the trip reductions and related benefits in terms of user cost savings and reductions in carbon emissions, are in the Estimation of Benefits section that follows.

With respect to the costs, even more detailed information is provided in the Appendix, including both up-front and annualized capital costs. Importantly, the life cycles of the various connection investments have an impact on the relationship between the capital costs and the annualized costs. Some lower up-front cost items have shorter life cycles, like bike paths, while higher up-front cost items like bridges have much longer life cycles - it is therefore possible for some lower annualized costs to be associated with higher up-front costs and vice-versa.

Tysons Corner

Connections: The recommendations for Tysons including the upgrading and/or adding pedestrian equipment at 9 signalized or unsignalized intersections within the case study area. To compliment that, a review of the NOVA Regional Bike Network study showed opportunities to provided new 10’ shared use paths along the existing corridors of Rte. 7, Rte. 123 and International Dr. Opportunities were explored to provide new crossings over I-495 and the Dulles Toll Rd., but given the developments and land-use, there were no feasible opportunities. A review of the parcels in the area yielded four potential interparcel connections. Two additional shuttle only interparcel connections were estimated with a one lane urban typical section In an effort to support the use of existing interparcel connections along Rte. 7, 7 right-in/right-out access could be closed. Finally, there were three observed locations to connect existing 5’ sidewalks.

TDM: The recommendations for Tysons include adopting a parking management association for up to 1000 currently unmanaged employee/retail spaces adjacent to existing transit. Additional local transit subsidy for up to 100 commuters and parking cash-out subsidies for up to 250 employees are envisioned to further incentivize alternate modes. A bike share system is envisioned with up to 10 stations and 100 bicycles, in addition to additional bicycle lockers at Metrorail stations with a capacity for 48 additional bicycles. Supplemental administration costs are assumed, and could be provided by the existing TYTRAN TMA that serves this area.

Transit: A robust shuttle transit system is intended to complement existing circulator service to provide increased connectivity among major development areas in Tysons Corner. The route recommendations build upon services identified in the 2013 Tysons Circulator Study Report as not fully implemented post-Silver Line debut. A total of three additional routes would provide for the complete coverage and frequency identified by the McLean, Greensboro, and Spring Hill proposed Tysons Link routes. Service would operate between 10-15 minutes, during the peak and midday (McClean is peak only). Exact routing would take advantage of new transit-only connections (Spring Hill) and function more to serve cross-Tysons trips rather than focus only on last-mile Metro connections. This could facilitate park once principles, allowing workers to reach lunch and other midday destinations without short trips to other sections of Tysons.

CASE STUDY: Tysons		
ANNUALIZED COST (2016 Dollars)		
	Low	High
OVERALL COST RANGE	**$2,690,000**	**$3,250,000**
<u>Cost Components</u>	Base Cost Estimate	Percent
Connections Recommendations	$851,000	29.6%
Transit Recommendations	$1,630,000	56.7%
TDM Recommendations	$392,000	13.6%
ANNUAL BENEFIT		
Trips Removed	1,960,000	3,782,000
Vehicle Hours Reduced		1,074,000
Transportation Cost Reduction (2016$)		$11,537,000
Emissions Reduction		8,420

George Mason

Connections: Included in the recommendations for the GMU area are multiple projects within the current GMU Transportation Master Plan. $4,250,000 worth of projects, including a wayfinding to promote mobility choices, shared use paths, metro bike route, internal shared use paths and bike shelters, were taken from the Master Plan. An additional 7 intersections or mid-block crossings were identified for new pedestrian equipment. The area was reviewed for increased interparcel connections; however, no new opportunities were observed.

Transit: Additional shuttle service to neighborhoods was envisioned for GMU and the City of Fairfax. This service is a single route, acting as a pilot to test ridership potential. Route design is intended to not replicate existing CUE, WMATA and Fairfax Connector routes, but provide alternate connections and transfer opportunities to Fairfax Boulevard by traveling via residential routes west of the City of Fairfax. The route would terminate north of the City and below I-66 in the Fairfax Village and Oakton apartment complexes. Service would operate at the peak and midday period every 15 minutes. Three shuttle vehicles would be required for this route distance (4 miles one way) and level of service.

TDM: On campus parking management would be applied at up to 500 spaces – primarily through more remote parking and improved walkability initiatives. Additionally, an extension of local transit subsidy for up to 200 commuters is included. Further marketing and promotion, via transportation events and provision of Guaranteed Ride Home benefits would assist in providing incentives for alternative mode choice. A biennial staff/student survey, with an annual cost of approx. $11,000, would be used to gauge the performance of, and adjust TDM initiatives.

CASE STUDY: GMU		
ANNUALIZED COST (2016 Dollars)		
	Low	High
OVERALL COST RANGE	**$898,000**	**$1,047,000**
Cost Components	Base Cost Estimate	Percent
Connections Recommendations	$46,000	4.8%
Transit Recommendations	$788,000	83.2%
TDM Recommendations	$114,000	12.0%
ANNUAL BENEFIT		
Trips Removed	250,000	456,000
Vehicle Hours Reduced		82,000
Transportation Cost Reduction (2016$)		$534,000
Emissions Reduction		390

Fort Belvoir

Connections: For the Ft. Belvoir study, the focus was on opportunities for bike and pedestrian improvements, not just on base but in the supporting area. Again, a review of the NOVA Regional Bike Network Study was used to determine new connections from the base to existing bike networks. Some internal mixed-use paths were included to connect more remote parts of the base with existing facilities. On-base there were 5 intersection or mid-block crossings that could benefit from new or upgraded pedestrian signal equipment.

Transit: An on-base shuttle operating in a two loop arrangement (loops north and south of US 1 overcrossing) would be restricted to on-base destinations only. The shuttle service would support park once initiatives and increase connectivity among housing and activity areas. Total loop length is 8 miles with service operating all day (7:30am – 6:30pm) at 10 minute frequencies. A total of 4 vehicles, 16 shelters, and 12 information kiosks would support this service.

TDM: On base TDM management would be adopted, including provision of up to 200 commuter transit subsidies and a bike share system comprised of 12 stations and 120 bicycles. A full time equivalent staff position would be created to support marketing, events, travel pattern surveys and an informational/real-time website on internal ride-sharing/slugging and shuttle bus locations.

CASE STUDY: Ft. Belvoir		
ANNUALIZED COST (2016 Dollars)		
	Low	High
OVERALL COST RANGE	**$1,973,000**	**$2,327,000**
Cost Component	Base Cost Estimate	Percentage
Connections Recommendations	$273,000	13.0%
Transit Recommendations	$1,059,000	50.6%
TDM Recommendations	$759,000	36.3%
ANNUAL BENEFIT		
Trips Removed	1,140,000	1,877,000
Vehicle Hours Reduced		765,000
Transportation Cost Reduction (2016$)		$16,829,000
Emissions Reduction		12,300

Van Dorn Metro

Connections: The previous Van Dorn Intermodal study provided a set of long-term recommendations that fit the identified opportunities and was therefore used in the cost estimates. A one-way reversible bridge from Pickett St. to Van Dorn Station, with accommodations for bike and peds, was included in the estimate. That project would necessitate the replacement of two existing traffic signals. Two pedestrian bridges were used to connect the Cameron Station area with new shared use paths on the opposite side of the train tracks to provide a more complete ped/bike network. New pedestrian equipment at the major employment center east of the station was included as well.

TDM: For the adjacent and surrounding residential communities, provide additional marketing/prizes and promotional support for non-automobile travel. Fractional administrative costs included, with staff provided from existing Alexandria Local Motion initiatives.

CASE STUDY: Van Dorn Metro		
ANNUALIZED COST (2016 Dollars)		
	Low	High
OVERALL COST RANGE	**$473,000**	**$627,000**
Cost Components	Base Cost Estimate	Percent
Connections Recommendations	$496,000	94.5%
Transit Recommendations	n/a	n/a
TDM Recommendations	$29,000	5.5%
ANNUAL BENEFIT		
Trips Removed	98,000	152,000
Vehicle Hours Reduced		24,500
Transportation Cost Reduction (2016$)		$155,000
Emissions Reduction		113

Rippon VRE

Connections: This case study focused on providing more accessible bike routes to the VRE, as well as completing a few street connections where there are currently cul-de-sacs. Three street connections were estimated, with the connection from Big Crest Ln to the VRE parking lot being omitted. Currently there is a set of stairs that connects the high-density residential to the parking lot and there is a significant elevation differential between the development and the parking lot. A new mid-block crossing was estimated for a residential area and bike facilities (shared use paths, wide shoulder) were provided to connect with existing networks.

TDM: Costing included the provision for small scale transportation promotional events along with 20 additional bicycle lockers to accommodate up to 40 bicycles at the station.

CASE STUDY: Rippon VRE		
ANNUALIZED COST (2016 Dollars)		
	Low	High
OVERALL COST RANGE	**$232,000**	**$308,000**
Cost Components	Base Cost Estimate	Percent
Connections Recommendations	$250,000	97.3%
Transit Recommendations	n/a	n/a
TDM Recommendations	$7,000	2.7%
ANNUAL BENEFIT		
Trips Removed		155,000
Vehicle Hours Reduced		36,000
Transportation Cost Reduction (2016$)		$235,000
Emissions Reduction		172

Bull Run

Connections: The focus was connecting existing bike and networks with new shared use paths and 4' paved shoulders. New connections to Ashton Ave. with existing dead end streets didn't appear to be feasible given access management standards or the development on the dead end streets. Only one interparcel connection opportunity was found.

CASE STUDY: Bull Run		
ANNUALIZED COST (2016 Dollars)		
	Low	High
OVERALL COST RANGE	**$1,143,000**	**$1,524,000**
Cost Components	Base Cost Estimate	Percent
Connections Recommendations	$1,270,000	100%
Transit Recommendations		n/a
TDM Recommendations		n/a
ANNUAL BENEFIT		
Trips Removed		76,000
Vehicle Hours Reduced		12,000
Transportation Cost Reduction (2016$)		$44,000
Emissions Reduction		32

Fairfax Center / Fair Oaks Mall

Connections: No opportunities were observed for new vehicles connections of arterials but there were a couple of locations to add inter-parcel connections. New shared-use facilities were estimated in an effort to better connect the existing network. A mixed use bridge was placed over I-66 to better connect the Fair Oaks Mall area and the mixed use development with surrounding medium/high density residential. Finally, there were several locations that would benefit from new or upgraded pedestrian facilities.

Transit: The recommendations and opportunities in this area include providing better short-trip connectivity among two large retail centers, separated by I-66, and allowing some local circulation with adjacent higher density development. The route envisioned is relatively short, and supports higher frequency (10 minutes) with only one vehicle. With the retail/commercial concentration in these areas, the hours of operation would be tailored around the retail peaks at midday (11:00-4:00) and evening (6:00-8:00) weekdays and aligned with store hours on weekends. Envisioned service could extend from the mall, cross I-66 on Monument Drive, and serve Fairfax Corner and terminate with convenient resident stops in the adjacent Reserve residential area. Up to four (4) Shopper/Entertainment Shuttle information kiosks and four shelters would be provided for the potential high frequency service.

CASE STUDY: Fairfax Center / Fair Oaks Mall		
ANNUALIZED COST (2016 Dollars)		
	Low	High
OVERALL COST RANGE	**$558,000**	**$700,000**
Cost Components	Base Cost Estimate	Percent
Highway Recommendations	$338,000	55.9%
Transit Recommendations	$267,000	44.1%
TDM Recommendations	n/a	n/a
ANNUAL BENEFIT		
Trips Removed	68,000	127,000
Vehicle Hours Reduced		15,000
Transportation Cost Reduction (2016$)		$34,000
Emissions Reduction		25

Merrifield /Dunn Loring

Connections: Estimates in this area focused on improving the mixed-use facilities to better serve the metro station and connect with existing facilities. The estimated improvements were developed in conjunction with estimated improvements for the Inova study area.

TDM: Opportunities presented in the recommendations include introduction of parking management for 200 priority spaces, parking cash-out and transit subsidy incentives and the introduction of a network of bike share stations to facility short-trip connectivity. Stations would be concentrated more on the western side of Gallows Road, to support employment and retail connections. A total of eight (8) stations and 60 bicycles is envisioned, with additional bicycle lockers at Metrorail and other locations to support storage of up to 24 additional bikes. It is estimated that additional support, to include transportation events, marketing/prizes, and a biennial survey would require oversight equivalent to ½ full time staff position as provided through the County's existing TDM services.

CASE STUDY: Merrifield / Dunn Loring		
ANNUALIZED COST (2016 Dollars)		
	Low	High
OVERALL COST RANGE	**$618,000**	**$778,000**
Cost Components	Base Cost Estimate	Percent
Highway Recommendations	$400,000	59.6%
Transit Recommendations	n/a	n/a
TDM Recommendations	$271,000	40.4%
ANNUAL BENEFIT		
Trips Removed	371,000	538,000
Vehicle Hours Reduced		156,000
Transportation Cost Reduction (2016$)		$1,584,000
Emissions Reduction		1,160

Inova Fairfax Hospital

Connections: As with Merrifield, there was not a substantial highway component to the case study recommendations. The efforts for this area focused on connecting existing bike/ped facilities and providing upgrade ped facilities at intersections in conjunction with the expansion of the hospital.

Transit: Additional and higher-frequency shuttle service (10 minute frequency) would connect the hospital and Exxon campus with the Dunn Loring Metro. Service would operate during peak commute times and facilitate midday travel as well. Two vehicles would be required to maintain this service and three (3) shelters, and up to five (5) information kiosks would support operations.

TDM: Targeted TDM is anticipated for the INOVA Hospital complex, with introduction of parking management for up to 150 priority spaces and additional parking cash-out for up to 1000 area employees. Commuter benefits to subsidize 50% of local transit cost and a modest four (4) station bike share network can facilitate park once travel among nearby facilities (Hospital, Medical Offices, Exxon, Willow Oaks). Up to 36 bicycles are envisioned, with additional bike locker locations providing storage for up to 12 bicycles. Additional staff resources (.25 FTE) would be used to support transportation events and commuter survey of travel habits initiatives.

CASE STUDY: Inova Fairfax Hospital		
ANNUALIZED COST (2016 Dollars)		
	Low	High
OVERALL COST RANGE	**$812,000**	**$967,000**
Cost Components	Base Cost Estimate	Percent
Highway Recommendations	$171,000	19.8%
Transit Recommendations	$518,000	60.0%
TDM Recommendations	$175,000	20.3%
ANNUAL BENEFIT		
Trips Removed	297,000	383,000
Vehicle Hours Reduced		171,000
Transportation Cost Reduction (2016$)		$3,391,000
Emissions Reduction		2,480

Manassas Area

Connections: Improvement to mixed-use facilities was centered on people getting from the outer portions of the city toward downtown where the city has called for mixed-use development. An effort was also made to improve facilities around schools since many were in close proximity to denser residential areas. While there was existing pedestrian signal equipment in the downtown area, there were several locations for improvement in the surrounding areas.

Transit: A route extending from the Manassas train station to the GMU Science and Technology Campus, Innovation Park and other offices west of Wellington Rd. would operate at 20 minute frequency during peak and midday periods. Midday service would be oriented toward connecting with lunch opportunities within the traditional urban core.
TDM: Focused upon technology employment centers west of downtown Manassas, and includes a mix of parking management and parking cash-out incentives for over 1,000 employees. Transit subsidy to cover 50% of local transit service cost would be extended to up to 200 area employees. Up to four (4) bicycle lockers would be included to facilitate last-mile travel to/from transit connections.

CASE STUDY: Manassas Area		
ANNUALIZED COST (2016 Dollars)		
	Low	High
OVERALL COST RANGE	**$1,193,000**	**$1,525,000**
Cost Components	Base Cost Estimate	Percent
Highway Recommendations	$911,000	69.9%
Transit Recommendations	$269,000	20.6%
TDM Recommendations	$124,000	9.5%
ANNUAL BENEFIT		
Trips Removed	2,350,000	4,881,000
Vehicle Hours Reduced		828,000
Transportation Cost Reduction (2016$)		$7,010,000
Emissions Reduction		5,120

Van Dorn - South

Connections: As recommended in a previous intermodal study, an improved connection along Van Dorn St. and a new connection over the Beltway were included in the estimate. The connection over the Beltway also includes a pedestrian tunnel under the current metro tracks, as called for in the intermodal study. Additional connections to existing bike facilities and pedestrian upgrades at traffic signals were included items that weren't in the intermodal study. Two shuttle only inter-parcel connections were estimated, based on a one lane urban typical, to provide better routing of the proposed shuttle service.

Transit: An additional route to supplement existing TAGS (Springfield TMA) and Fairfax Connector service, would provide additional frequency and different routing between the Franconia-Springfield Metro Station and the Van Dorn Metro Station. The route would serve Walker Lane, Kingstowne, and better serve the Rose Hill neighborhood via two new transit-only connections. Three (3) vehicles would be required to provide service at 15 minute frequency during the peak and midday. Up to 15 shelters, several of which would also benefit existing Fairfax Connector stops, are envisioned at approximately ½ mile intervals. Information kiosks at employment centers would provide real-time information.

TDM: Costing included the provision for transit subsidies for up to 250 commuters and Biennial Employee/Staff Commuter Survey. Fairfax County programs would be provided to this area.

CASE STUDY: Van Dorn - South		
ANNUALIZED COST (2016 Dollars)		
	Low	High
OVERALL COST RANGE	**$1,140,000**	**$1,365,000**
Cost Components	Base Cost Estimate	Percent
Highway Recommendations	$286,000	23.5%
Transit Recommendations	$805,000	66.3%
TDM Recommendations	$124,000	10.2%
ANNUAL BENEFIT		
Trips Removed	220,000	444,000
Vehicle Hours Reduced		244,000
Transportation Cost Reduction (2016$)		$3,330,000
Emissions Reduction		2,430

Inside the Beltway

Transit: Conduct an express bus feasibility study from communities in this area, with possible access to I-395 at Quaker Lane or Glebe Road Interchanges. Routes would traverse neighborhoods around North Ridge and may feature two morning departures per route with direct connection to Pentagon and Downtown Washington, D.C.

TDM: A robust TDM package is recommended for this area, with limited high capacity transit connections. TDM services included in the cost estimate include marketing/prizes, events, travel pattern surveys, and commuter transit subsidies. Up to ½ FTE support in promoting TDM from existing Alexandria TDM programs is anticipated.

CASE STUDY: TDM		
ANNUALIZED COST (2016 Dollars)		
	Low	High
OVERALL COST RANGE	**$482,000**	**$558,000**
Cost Components	Base Cost Estimate	Percent
Highway Recommendations	n/a	n/a
Transit Recommendations	$200,000	39.4%
TDM Recommendations	$307,000	60.6%
ANNUAL BENEFIT		
Trips Removed	700,000	1,096,000
Vehicle Hours Reduced		501,000
Transportation Cost Reduction (2016$)		$5,264,000
Emissions Reduction		3,840

Dulles Town Center

Connections: There is an ongoing project along Sterling Blvd to upgrade or install sidewalks. The estimate does not include any of that activity. Again, the focus was to connect existing and future mixed-use facilities in an effort to facilitate the idea of a multimodal hub. Several locations were identified for new or upgraded pedestrian signal equipment. There were three locations that were identified as opportunities for inter-parcel connections.

Transit: Introduction of new express bus service from Dulles area with direct service to Washington, D.C. Service would feature three (3) AM departures and PM return trips. Two shelters and one information kiosk would support the service.

CASE STUDY: Dulles Town Center		
ANNUALIZED COST (2016 Dollars)		
	Low	High
OVERALL COST RANGE	**$2,720,000**	**$3,523,000**
Cost Components	Base Cost Estimate	Percent
Highway Recommendations	$2,362,000	79.0%
Transit Recommendations	$626,000	21.0%
TDM Recommendations	n/a	n/a
ANNUAL BENEFIT		
Trips Removed	507,000	683,000
Vehicle Hours Reduced		273,000
Transportation Cost Reduction (2016$)		$3,951,000
Emissions Reduction		2,880

Bailey's Crossroads

TDM: Strategy to exploit opportunities includes parking management at up to 200 priority spaces, and parking-cash out incentives extended to up to 500 employees.

CASE STUDY: Bailey's Crossroads		
ANNUALIZED COST (2016 Dollars)		
	Low	High
OVERALL COST RANGE	**$93,000**	**$108,000**
Cost Components	Base Cost Estimate	Percent
Highway Recommendations	n/a	n/a
Transit Recommendations	n/a	n/a
TDM Recommendations	$98,000	100%
ANNUAL BENEFIT		
Trips Removed	54,000	60,000
Vehicle Hours Reduced		21,000
Transportation Cost Reduction (2016$)		$185,000
Emissions Reduction		135

Goose Creek

Connections: Currently there are projects underway to better connect arterials in the study area; therefore, no additional connections were estimated. The estimate incorporated connections to the W&OD Trail and new facilities that would complement a Safe Routes to School program. The improvements consisted of shared use paths connecting existing infrastructure, shoulder widening and pedestrian signal improvements and installations.

TDM: Costing included additions ¼ FTE to support TDM efforts from existing Loudoun TDM program, in support of transportation events and survey of travel patterns.

CASE STUDY: Goose Creek		
ANNUALIZED COST (2016 Dollars)		
	Low	High
OVERALL COST RANGE	**$1,421,000**	**$1,889,000**
Cost Components	Base Cost Estimate	Percent
Highway Recommendations	$1,545,000	98.0%
Transit Recommendations		n/a
TDM Recommendations	$32,000	2.0%
ANNUAL BENEFIT		
Trips Removed		145,000
Vehicle Hours Reduced		25,000
Transportation Cost Reduction (2016$)		$213,000
Emissions Reduction		160

Dulles Area North

Connections: The estimate tried to incorporate elements to make the area better connected for bikes and peds throughout the area. An emphasis was placed on the new Silver Line metro stations in the area. New mixed-used paths connect existing facilities and underserved areas as well as trying to provide clear and safe paths to the metro stations and areas of interest. Upgraded or new pedestrian signal equipment was estimated for several locations as well.

Transit: Cost provides for a transit service feasibility study to be conducted for the area.

CASE STUDY: Dulles Area North		
ANNUALIZED COST (2016 Dollars)		
	Low	High
OVERALL COST RANGE	**$807,000**	**$1,051,000**
Cost Components	Base Cost Estimate	Percent
Highway Recommendations	$738,000	83.1%
Transit Recommendations	$150,000	16.9%
TDM Recommendations	n/a	n/a
ANNUAL BENEFIT		
Trips Removed		172,000
Vehicle Hours Reduced		22,400
Transportation Cost Reduction (2016$)		$106,000
Emissions Reduction		77

Dulles Area West

Connections: Rte. 606 is currently being widened under a VDOT design-build project and no additional improvements were estimated in that project area. New multi-use paths were included in the estimate to connect the area south of Rte. 50 to the widened Rte. 606 as well as existing facilities. To complement the transit element in the area, additional pedestrian facilities were incorporated throughout the corridor.

Transit: Cost estimates provide for a connector shuttle service between the Dulles North Transit Center and existing/new development along VA 606. Service envisioned would include two routes as follows: (1) Shorter, seven mile route connecting from corner of US 50 and Loudoun County Parkway to the Dulles North Transit Center, with intermediate stops at existing business parks and future development. This service would operate both in the peak and at midday at 15 minute intervals to facilitate commute and lunch travel needs. (2) Route extension that would continue south of US 50 into higher-density locations around South Riding. This service would only operate during peak commuting times at 30 minute intervals and would serve to connect residents to other transit connections at North Dulles.

CASE STUDY: Dulles Area West		
ANNUALIZED COST (2016 Dollars)		
	Low	High
OVERALL COST RANGE	**$1,330,000**	**$1,633,00**
Cost Components	Base Cost Estimate	Percent
Highway Recommendations	$592,000	41.4%
Transit Recommendations	$839,000	58.6%
TDM Recommendations	n/a	n/a
ANNUAL BENEFIT		
Trips Removed	95,000	178,000
Vehicle Hours Reduced		26,000
Transportation Cost Reduction (2016$)		$112,000
Emissions Reduction		82

Methodologies

Estimation of Costs

For each case study recommendation, the following steps were utilized to translate abstract concepts into comparative cost ranges based upon the geography, market conditions, and existing services/capacity locally present that would influence the opportunities suggested. This methodology outlines a sketch-level planning approach intended to serve as a starting point for discussion of the relative cost among the various locations and opportunities they present as described in the case study summaries. The costs derived are based upon published national research, regional averages and peer experiences (if identified) at a conceptual level. The variability and uncertainty with this methodology has been captured in a cost range for various physical improvements, expanded service and administrative responsibilities required to carry out the recommendations.

This methodology incorporates the steps and components described in this section to present a cost estimate range for each case study. The steps in this process proceeded as follows:

1) Classify opportunity by Mode/Type
    a. Connections
    b. Transit
    c. TDM
    d. Other
2) Identify specific recommendations for each case study. Recommendations will conform to generalized/best practice categories as identified in the Task 4 summary report for this study.
3) Recommendations that are cost neutral are not included in the estimate. This includes recommendations that are deemed wholly private ventures, with no public subsidy/startup cost.
4) The annualized cost estimates are intended as order of magnitude sketch planning estimates for comparative purposes only.
5) Operating cost estimates include high-level assumptions of one-time start-up costs (if service is entirely new vs. extension of existing) and annualized yearly maintenance costs where identified.
6) Annual capital cost estimates do not reflect the reality of financing, bonding or other upfront cash required in the first year to procure capital improvements.
7) Determine how the recommendation will be applied (i.e. service design/model for transit; targeted market for TDM, etc.)
8) Define **operating** components that contribute to costs
    a. Use average regional costs where applicable, thereby costs remain independent of specific operator or responsible entity.

   b. Use defined or cited national practice or peer entity costs as discovered through research.
   c. Any historic costs are inflated (3% annually) to 2016 dollars.
   d. Determine the units/measures that define the cost (i.e. hours, parking spaces, etc.)
   e. Quantify the amount of units/measures that pertain to the geography of the case study, identified connections, or frequency of service envisioned.
   f. The service assumptions for transit are dictated by a physical route developed to broadly achieve the stated goals. Specific stops, or locales served can be adjusted with the route length changed accordingly. Service frequency assumed to be no more than every 20 minutes (typically 10-15 minutes) in order to be impactful in changing travel choice.
   g. Any potential revenues from recommendations that would result from a theoretical policy decision (i.e. increased fees, etc.) are not considered for offsetting costs.
   h. Final cost amount will be the sum of all components relevant to the specific case study in the quantity (units/measures) as estimated in the conceptual planning stage.
   i. Final costs presented as annual present value. No consideration for the year of implementation, duration of service, or other cash flow implications have been included.

9) Define **capital** components that contribute to costs
   a. Use procurement costs defined or cited through nation practice or peer entity costs as discovered through research
   b. Any historic costs are inflated (3% annually) to 2016 dollars.
   c. Determine the units/measures that define the cost (i.e. number of vehicles, type of facility or improvement)
   d. Quantify the amount of units/measures that pertain to the service provided or construction activity required to fulfill case study recommendations.
   e. Highway/construction improvement measures (linear or square feet, number of installations, etc.) were determined by aerial imagery and professional judgement on least impactful placement, along with VDOT guidance on typical specifications, such as urban lane width, multi-use trail/sidewalk dimensions, and bridge specification.
   f. The number of vehicles required for transit service is dictated by formula that accounts for route length, average speed for service type (local or commuter) and desired frequency of service.
   g. Determine in lifecycle for each capital improvement, cited through nation practice or peer experience.
   h. Final Costs are presented as an annualized value, spreading the total cost into each year of the anticipated lifecycle.

10) All costs and inputs have been prepared in a spreadsheet to allow for adjustments/refinement to further align service levels and capital investment with identified needs or to scale back improvements to meet a target budget.

11) Cost ranges for each case study present a low (5-10% below baseline) and high (10-20% above baseline) cost to reflect the uncertainty inherent in a sketch-level planning and cost estimating exercise. Higher percentages were used for infrastructure estimates due to an inherently higher level of uncertainty of site conditions and exact design parameters.

Cost Component Details – Connections Recommendations

Examples of Connections Cost Components

Capital Component	**How derived…**
Pedestrian crosswalk enhancements	As identified through case study mapping or where long distances between signalized intersections prompt new mid-block crossing.
Signalized intersection replacement	Additional controls and apparatus to support enhanced pedestrian accommodation.
Sidewalk/shared-use path	Estimated linear feet from aerial mapping. Sidewalks assumed for existing roadway segments with new pathways for "Charlotte-style" connectivity between adjoining parcels.
Restriping	Restriping lane widths and bicycle lanes where sufficient right-of-way width exists.
Increased roadway shoulders	Provision of additional safety buffer for bicycle/pedestrian movements where sufficient right-of-way exists.
Arterial access consolidation	Elimination and potential rerouting (access roads/connections) where multiple entry-points onto a roadway presents a hazard to bike/pedestrian movements.
Bridge (mixed-use/variable width)	Width and purpose estimated in context of surroundings, used where case study connectivity called for an overpass.
Annualized Capital Components	**Lifecycle (national/peer research)**
Traffic Signals/Crossings	20 years
Sidewalk	30 years
Share-Use Path	11 years
New Roadway Connections	15 years

Capital Component	How derived…
Arterial Access Consolidation	50 years
Bridge Connections	100 Years

Cost Component Details – TRANSIT Recommendations

Examples of Transit Cost Components

Operating Component	How derived…
Average Route Length	One-way Conceptual Route Map prepared as an overlay to existing network and utilizing any envisioned improved transit appropriate (non-residential) street connections.
Cycle Time	Time to complete one round trip, based upon average transit speeds dependent on type of service (local/express bus)
Number of Routes	Desired area of coverage/neighborhood connectivity as specified.
Service Frequency	Time between buses. High quality service envisioned as an incentive to switch travel mode is recognized as 15min. or less.
Hours of Operation	Based upon the market served and their needs, such as peak service, retail service hours (evenings/weekends), or all day service.
Capital Component	**How derived…**
Number of vehicles	Function of the number of routes, frequency and cycle time.
Vehicle Type	Higher frequency shuttle service envisioned to be provided by large hybrid vans (in service at existing TMAs, apartment communities) and commuter service envisioned provided by large over the road coaches (such as LC Transit/ PRTC).
Shelters	Standard sized, weather protected shelter assumed at route intervals (½ to 1 ½ mile) based on activity

Operating Component	How derived…
	density for shuttle service, or at new pickup locations for express/commuter service.
Information Kiosks	Real-time information, interactive schedules and/or other technology enhancements to attract ridership. Only at hubs or high volume stops/activity centers.
Annualized Capital Components	**Lifecycle (national/peer research)**
Commuter Coach	15 years
Shuttle Bus	10 years
Bus Shelter	20 years
Kiosk	8 years

Cost Component Details – TDM Recommendations

Examples of TDM Cost Components

Operating Component	How derived…
Full Time Equivalent – TDM Coordination	Estimated additional staff time (if existing TMA or TDM personnel in place) or new staff needed to administer surveys, marketing, etc. to organize, administer and promote recommendations.
Participating Commuters	Used to estimate the cost of transit subsidy at 50% of average transit fare (local or commuter based on recommendation) for workweek travel only.
Bike Share Bicycles	Ongoing maintenance cost associated with the number of bicycles included in a bike share program.
Targeted Campaigns/Activities	Varies by case study based upon the type of market and if any existing TMA/TDM outreach is occurring, and includes one or more of the following with costs based upon peer initiatives: • Sponsored Events • Marketing/Prizes • Biennial Survey
Capital Component	**How derived…**

Operating Component	How derived…
Bike Shelter Locations	Conceptual map of locations providing diversity of coverage and activity areas.
Bike Lockers	Based on existing presence and utilization of lockers at transit/activity center locations. Increases if no lockers currently present, existing lockers are fully utilized, or new stop/hub envisioned.
Signage	Peer identified costing for signage and way finding associated with providing information on newly managed parking spaces.
Annualized Capital Components	**Lifecycle (national/peer research)**
Bike Locker	20 years
Bike Share Station	20 years
Signage	5 years

Estimation of Benefits

This sketch analysis of the effects of TDM policies and actions on selected case studies comprised:

- Quantification of travel markets and characteristics associated with each case study.
- Determination of the effect of a specific policy or action on the travel behavior of the salient travel market expressed as a vehicle trip reduction factor (VTR).
- Expression of the estimated trip reduction in terms of a tangible benefits: vehicle-hours traveled, personal travel cost savings, and vehicle emissions reduction for greenhouse gases (GHG).

Travel markets associated with each case study were defined using GPS data collected for this study. This data describes the movement of primarily personal vehicles traveling from one location to another to/from and within the northern Virginia region and provides an indication as to the travel time and distance incurred for these trips. Estimation of benefits currently focuses on travel patterns observed during the average weekday (Mon-Thurs) as this includes most commuters, as these travelers are likely more responsive to TDM policies and actions. Using this information, it is possible to determine the volume, or amount, of travel to and from a case study location/area of influence as well as measures associated with travel distance and time. Particular to each case study the travel markets were defined in terms of travel distance, modal access, and whether travel was internal or external with respect to the site definition of the specific case study.

Assessment of the effectiveness of a particular TDM policy or action on the market area associated with each case study involved the determination of VTRs describing the impact of a particular policy. This study's literature search revealed several sources of information; however, when restricted to the effectiveness of a particular action that was site (case)-specific, employer-based or institutional in nature, we relied primarily on publication TCRP Report 95, Chapter 19. VTRs reflecting the defined travel markets and specific cases were applied accordingly to yield corresponding reductions in vehicle trips, vehicle-hours and vehicle-miles traveled, as a result of the application of specific policies and actions. The effect of policies and actions were assumed to be cumulative (additive) and it is noted to be a significant simplification of the analysis.

As a result of the application of VTRs in response to specific policies/actions applied to specific travel markets, tangible benefits were calculated as a result of an estimated reduction of vehicle-hours and vehicle-miles traveled (VMT).

- Vehicle-hours traveled reduction was calculated as a direct result of applying VTRs as described above
- Transportation cost reduction was calculated based on the reduction of VMT. The cost reduction rate reflects an estimate of the cost of travel to be 61.5 cents/per vehicle-mile of travel for personal vehicles in Year 2015 US dollars as reported by the Automobile Association of America. This rate reflects fuel, maintenance, tires, insurance, license and registration fees, taxes, depreciation, and finance costs.
- Vehicle emissions reduction was also based on the reduction of VMT. The emission reduction rate of 419.36 grams of pollutant per vehicle-mile traveled was based on the MOVES model reflecting April 2015 travel conditions for personal autos and trucks. The rate is expressed in "carbon dioxide equivalents", which represents the effect of a spectrum of GHG chemical components. Reductions were expressed in American short tons.

Traffic Flow Estimates

Streetlight Data reports a relative measure of traffic flow, called "traffic frequency." This measure allows users to analyze and compare data across the entire region and over the duration of the study period. However, it doesn't convey the absolute magnitude of traffic flows—e.g., the number of vehicles moving between a given origin and destination. To estimate total traffic flows, SSTI calibrated the data using average daily traffic (ADT) counts reported by the Virginia DOT along known road segments in the year 2014.

Out of the 190 unique selected links (not including bidirectional flows), ADT counts are available for 63 links in 2014. Of those, 46 links do not include parallel road segments or cross-directional flows within the analysis zone. These 46 zones are used for calibration.

For each link, the average daily traffic frequency is defined as follows:

$$ADTF = \frac{Daily\ weekend\ frequency + \ 2\ \times\ Daily\ weekday\ frequency}{3}$$

Reported ADT values represent bidirectional flows and include all motor vehicle types (personal and commercial). These values are adjusted as follows, in order to be comparable to reported traffic frequencies:

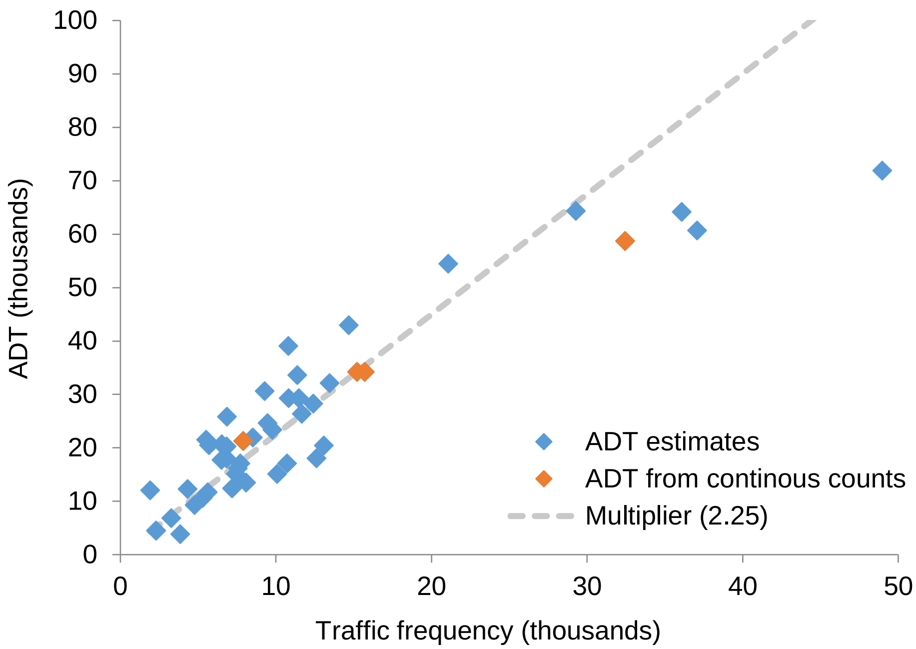
$$ADT_{adj} = 0.5 \times AADT \times 4Tire$$

4Tire = the percentage of the traffic volume made up of motorcycles, passenger cars, vans and pickup trucks. Two observations are missing values for *4Tire*, so we use the average value, 0.97.

Reported ADT values come from a variety of sources and each estimate has its own sources of error. In an effort to understand that error, we call attention (below) to four values that are based on continuous count stations and should therefore be considered the most reliable estimates of ADT.

Method 1 – Simple Multiplier

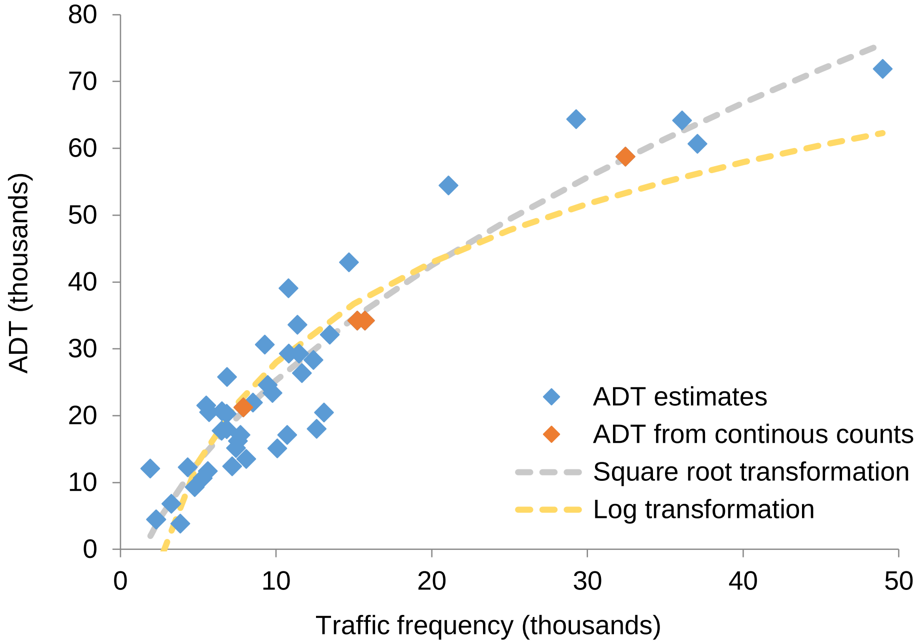
After analyzing the relationship between ADT_{adj} and $ADTF$ and the distributions of each, we determined that a multiplier of 2.25 provides reasonably consistent and reliable estimates of ADT from reported traffic frequencies. Using this method, 95 percent of estimates are within 58 to 157 percent of ADT and 50 percent of estimates are within 82 to 116 percent of ADT. The four estimates of ADT for which there are continuous traffic counts are within 84 to 125 percent of estimates.



Method 2 – Regression-Based Estimate

Although a single multiplier provides fairly reasonable of ADT from reported traffic frequencies, this method tends to overestimate traffic flows along high-volume segments. Therefore, we developed a regression-based estimate of ADT, testing two data transformations. The first model uses a log transformation of traffic frequency. This model produces an R-square of 0.81 and underestimates traffic flows along high-volume segments. The segment model uses a square root transformation of traffic frequency and produces an R-square of 0.89.

Using the second model, 95 percent of estimates are within 68 to 168 percent of ADT and 50 percent of estimates are within 84 to 121 percent of ADT. The four estimates of ADT for which there are continuous traffic counts are within 97 to 104 percent of estimates.



Reported flows

Flows reported in our final report and in delivered data products are estimated using Method 1—a single multiplier of 2.25. This determination was made for several reasons:

- Reported traffic frequencies of interest are often in the range of 1,000 or less. In these very low ranges, both regression models predict negative flows, which could be interpreted as zero flow.
- For traffic frequencies above 1,000 and below 20,000, the choice of conversion factor does not make a very large difference. We are rarely interested in frequencies above 20,000 (only six links have daily flows this high).
- Users of the data can easily convert flows back to traffic frequencies (by dividing by 2.25) and apply their own conversion functions.

APPENDIX Cost Detail

The tables that follow provide greater detail on the cost components of the case studies. All cost estimates are broad, planning level cost estimates. The up-front capital cost estimates are shown here that provided the basis for the annualized costs. Note that the relationship between up-front capital costs and annualized costs is driven by the life cycle of the investment. For example, bridges have a high up-front cost but long life cycle, while bicycle paths have a relatively small up-front cost but a short life cycle. The life-cycle costs of different capital investments are detailed in the cost methodology section.

	Tysons	George Mason University	Fort Belvoir	Fairfax Center / Fair Oaks Mall	Van Dorn - North
Cost Estimates - Connections					
COST SUBTOTALS					
Pedestrian Only					
Low	$788,000	$630,000	$420,000	$360,000	$90,000
High	$1,155,880	$910,000	$610,000	$520,000	$130,000
Bike (Pedestrian Accesible)					
Low	$7,602,056	$0	$2,578,968	$4,066,384	$4,712,960
High	$7,858,224	$0	$2,665,872	$4,663,536	$6,328,840
Roadway					
Low	$1,419,160	$0	$0	$342,860	$22,804,000
High	$2,097,200	$0	$0	$514,600	$31,752,000
TOTAL COST					
Low	$9,809,216	$4,882,060	$2,998,968	$4,769,244	$27,606,960
High	$11,111,304	$5,162,060	$3,275,872	$5,698,136	$38,210,840
ANNUALIZED TOTAL COST					
Low	$784,273	$31,500	$255,452	$305,185	$366,603
High	$850,760	$45,500	$272,852	$338,143	$495,850
Cost Estimates - TDM					
TOTAL ANNUAL COST	$ 392,000	$ 114,000	$ 759,000	$0	$ 29,000
Cost Estimates - Transit					
Total Capital Cost	$ 2,587,000	$ 997,000	$ 1,591,000	$ 411,000	$0
Annual Operating Cost	$ 1,395,000	$ 702,000	$ 927,000	$ 232,000	$0
Annualized Capital Cost	$ 235,000	$ 86,000	$ 132,000	$ 35,000	$0
TOTAL ANNUAL COST	$ 1,630,000	$ 788,000	$ 1,059,000	$ 267,000	$0
SUMMARY OF COSTS					
Initial Capital Cost - Low	$12,396,216	$5,879,060	$4,589,968	$5,180,244	$27,606,960
Initial Capital Cost - High	$13,698,304	$6,159,060	$4,866,872	$6,109,136	$38,210,840
Annual Operating Cost	$ 1,787,000	$ 816,000	$ 1,686,000	$ 232,000	$ 29,000

	Rippon VRE	Bull Run	Fairfax Center / Fair Oaks Mall	Merrifield
Cost Estimates - Connections				
COST SUBTOTALS				
Pedestrian Only				
Low	$60,000	$0	$360,000	$270,000
High	$90,000	$0	$520,000	$400,000
Bike (Pedestrian Accesible)				
Low	$2,237,284	$13,183,520	$4,066,384	$4,045,440
High	$2,627,136	$14,434,080	$4,663,536	$4,181,760
Roadway				
Low	$331,800	$243,320	$342,860	$0
High	$498,000	$365,200	$514,600	$0
TOTAL COST				
Low	$2,629,084	$13,426,840	$4,769,244	$4,315,440
High	$3,215,136	$14,799,280	$5,698,136	$4,581,760
ANNUALIZED TOTAL COST				
Low	$210,640	$1,168,905	$305,185	$381,267
High	$250,436	$1,269,627	$338,143	$400,160
Cost Estimates - TDM				
TOTAL ANNUAL COST	$ 7,000	$0	$0	$ 271,000
Cost Estimates - Transit				
Total Capital Cost	$0	$0	$ 411,000	$0
Annual Operating Cost	$0	$0	$ 232,000	$0
Annualized Capital Cost	$0	$0	$ 35,000	$0
TOTAL ANNUAL COST	$0	$0	$ 267,000	$0
SUMMARY OF COSTS				
Initial Capital Cost - Low	$2,629,084	$13,426,840	$5,180,244	$4,315,440
Initial Capital Cost - High	$3,215,136	$14,799,280	$6,109,136	$4,581,760
Annual Operating Cost	$ 7,000	$ -	$ 232,000	$ 271,000

	Inova Fairfax Hospital	Manassas Area	Van Dorn - South	Inside the Beltway
Cost Estimates - Connections				
COST SUBTOTALS				
Pedestrian Only				
Low	$360,000	$1,180,000	$240,000	$0
High	$530,000	$1,726,800	$360,000	$0
Bike (Pedestrian Accesible)				
Low	$1,533,896	$5,447,712	$6,014,036	$0
High	$1,585,584	$6,190,848	$7,012,324	$0
Roadway				
Low	$0	$718,900	$294,590	$0
High	$0	$1,079,000	$382,700	$0
TOTAL COST				
Low	$1,893,896	$7,346,612	$6,548,626	$0
High	$2,115,584	$8,996,648	$7,755,024	$0
ANNUALIZED TOTAL COST				
Low	$157,445	$728,416	$257,535	$0
High	$170,644	$910,495	$285,518	$0
Cost Estimates - TDM				
TOTAL ANNUAL COST	$ 175,000	$ 124,000	$ 124,000	$ 307,000
Cost Estimates - Transit				
Total Capital Cost	$ 587,000	$ 398,000	$ 1,297,000	$0
Annual Operating Cost	$ 463,000	$ 236,000	$ 702,000	$ 200,000
Annualized Capital Cost	$ 55,000	$ 33,000	$ 103,000	$0
TOTAL ANNUAL COST	$ 518,000	$ 269,000	$ 805,000	$ 200,000
SUMMARY OF COSTS				
Initial Capital Cost - Low	$2,480,896	$7,744,612	$7,845,626	$0
Initial Capital Cost - High	$2,702,584	$9,394,648	$9,052,024	$0
Annual Operating Cost	$ 638,000	$ 360,000	$ 826,000	$ 507,000

	Dulles Town Center	Bailey's Crossroads/ Seven Corners	Goose Creek	Dulles Area - North	Dulles Area - West
Cost Estimates - Connections					
COST SUBTOTALS					
Pedestrian Only					
Low	$720,000	$0	$810,000	$810,000	$577,000
High	$1,060,000	$0	$1,180,000	$1,190,000	$853,020
Bike (Pedestrian Accesible)					
Low	$13,358,620	$0	$15,748,348	$5,880,460	$5,899,600
High	$15,692,480	$0	$17,007,392	$7,279,840	$6,098,400
Roadway					
Low	$5,087,600	$0	$0	$0	$0
High	$7,636,000	$0	$0	$0	$0
TOTAL COST					
Low	$19,166,220	$0	$16,558,348	$6,690,460	$6,476,600
High	$24,388,480	$0	$18,187,392	$8,469,840	$6,951,420
ANNUALIZED TOTAL COST					
Low	$1,837,252	$0	$1,430,779	$584,927	$561,561
High	$2,361,640	$0	$1,544,685	$738,167	$591,667
Cost Estimates - TDM					
TOTAL ANNUAL COST	$0	$ 98,000	$ 32,000	$0	$0
Cost Estimates - Transit					
Total Capital Cost	$ 2,053,000	$0	$0	$0	$1,898,000
Annual Operating Cost	$ 490,000	$0	$0	150,000	$ 714,000
Annualized Capital Cost	$ 136,000	$0	$0	$0	$ 125,000
TOTAL ANNUAL COST	$ 626,000	$0	$0	$ 150,000	$ 839,000
SUMMARY OF COSTS					
Initial Capital Cost - Low	$21,219,220	$0	$16,558,348	$6,690,460	$8,374,600
Initial Capital Cost - High	$26,441,480	$0	$18,187,392	$8,469,840	$8,849,420
Annual Operating Cost	$ 490,000	$ 98,000	$ 32,000	$ 150,000	$ 714,000