



MOBILITY ASSESSMENT REPORT APPENDIX

FEBRUARY 2017

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Appendix A – Roadway Mobility Metrics

Congestion information contained in the Roadway Mobility Metrics section of the 2017 MAR is derived from [Inrix's](#) Smart Driver Network. INRIX is an international transportation consulting firm that has been retained by the [I-95 Corridor Coalition](#) to “acquire travel times and speeds using probe technology for both freeways and arterials...to present a comprehensive picture of traffic flow.” The Smart Driver Network allows for the anonymous collection of data from GPS enabled devices from cars, trucks, taxis and many other types of vehicles. A recent study conducted by the University of Maryland on behalf of the I-95 Corridor Coalition found that INRIX consistently delivers real-time traffic information accurate within 2 mph of actual speeds under all conditions (weather, events, and holidays)¹. Montgomery County Planning is a member of the I-95 Corridor Coalition and has access to current and historical vehicle probe data throughout the region.

Planners accessed Inrix data for individual corridors analyzed in the 2017 MAR via the Center for Advanced Transportation Technology Laboratory's (CATT) Vehicle Probe Project Suite (VPPS). The CATT lab is a User-Focused R&D Laboratory at The University of Maryland and is authorized by the I-95 Corridor Coalition to serve and distribute data and analytics provided by Inrix and other data providers to member jurisdictions. Archived speed data was downloaded using VPPS's Massive Data Downloader application in 15 minute increments between collected between April 1, 2015 and May 31, 2015, and again between September 1, 2015 and October 31, 2015. This is an expanded timeframe over the 2013 MAR which only utilized data from the month of October.

¹Inrix. (2015, April 14). The World's Largest Independent Traffic Data Validation. Retrieved from <http://inrix.com/blog/2015/04/i-95-corridor-coalition-vpp-data-validation-summary-report/>

Inrix data is organized by Traffic Message Channel Codes (TMCs). TMCs are 9-character codes that uniquely identify a specific directional segment of roadway. TMC codes for each policy area grouping were identified using geographical information systems (GIS) and downloaded as separate files for further analysis. Information contained in the raw tables downloaded from the VPPS include the TMC, time stamp, measured speed, average speed, reference speed, and travel time in minutes (Table 1).

TABLE 1: EXTRACT OF RAW INRIX SPEED DATA DOWNLOADED FROM VPPS

TMC Code	Time Stamp	Speed	Average Speed	Reference Speed	Travel Time
110+05843	4/7/2015 4:00:00 PM	22.1	21	25	2.14
110+05843	4/7/2015 4:15:00 PM	22.51	21	25	2.1
110+05843	4/7/2015 4:30:00 PM	19.64	21	25	2.41

The following definitions are provided by the VPPS².

Speed - The current estimated harmonic mean speed for the roadway segment in miles per hour.

Travel Time - Time it will take to drive along the roadway segment (Distance Traveled / Speed).

Reference Speed - The calculated "free flow" mean speed for the roadway segment in miles per hour. This attribute is calculated based upon the 85th-percentile point of the observed speeds on that segment for all time periods, which establishes a reliable proxy for the speed of traffic at free-flow for that segment.

² The Center for Advanced Transportation Technology Laboratory. (2016, 12 30). Vehicle Probe Project Suite. Retrieved from Data Types: <https://vpp.ritis.org/suite/help/#data-types>

Historic Average Speed — The historical average speed for the roadway segment for that hour of the day and day of the week in miles per hour.

The speed tables for each policy area grouping were downloaded and imported into a database management system (DBMS) where queries were performed to summarize congestion along selected corridors. For each timestamp in the raw speed tables, planners calculated the free flow travel time, travel time index (TTI), and percent congested. Below are the queries that were used to calculate each variable:

Free Flow Travel Time - (Length of TMC Segment (in miles)/Reference Speed (miles per hour)) * 60

Travel Time Index (TTI) – Travel Time (minutes)/Free Flow Travel Time. If this value is less than one, TTI is set to one.

Percent Congested - TTI - 1

These derived values were then summarized by road name, travel period (a.m. peak, p.m. peak, and off peak), and hour of day for inclusion in the 2017 MAR. Congestion values per time period were also summarized by TMCs and imported into GIS for visual display of congestion in each policy area grouping. Planners relied on existing analytical tools provided by the VPPS to summarize 2011 and 2015 speed and planning time index (PTI) data for policy area groupings and the county.

TABLE 2: TOP 50 ANALYZED CORRIDORS RANKED ACCORDING TO THEIR CONGESTION

Ranking	Corridor	Direction	Congestion	Policy Area Grouping	Peak
1	MD-27	Southbound	100%	Clarksburg	AM Peak
2	Colesville Road	Southbound	100%	Silver Spring CBD, Silver Spring/Takoma	PM Peak
3	MD-185	Southbound	78%	Bethesda, Chevy Chase	AM Peak
4	Georgia Ave	Northbound	77%	Silver Spring CBD, Silver Spring/Takoma	PM Peak
5	MD-650	Northbound	76%	Silver Spring CBD, Silver Spring/Takoma	PM Peak
6	MD-185	Northbound	74%	Bethesda, Chevy Chase	PM Peak
7	MD-355	Northbound	74%	Bethesda, Chevy Chase	PM Peak
8	US-29	Southbound	73%	Fairland, White Oak & Cloverly	AM Peak
9	MD-355	Southbound	72%	Bethesda, Chevy Chase	PM Peak
10	MD-187	Southbound	67%	North Bethesda	PM Peak
11	MD-410	Westbound	66%	Bethesda, Chevy Chase	AM Peak
12	MD-185	Southbound	66%	Wheaton CBD, Wheaton/Kensington, Glenmont	AM Peak
13	MD-185	Northbound	65%	Aspen Hill & Olney	PM Peak
14	MD-547	Eastbound	65%	Wheaton CBD, Wheaton/Kensington, Glenmont	PM Peak
15	US-29	Southbound	64%	Wheaton CBD, Wheaton/Kensington, Glenmont	AM Peak
16	US-29	Northbound	64%	Wheaton CBD, Wheaton/Kensington, Glenmont	PM Peak
17	MD-390/16TH ST	Southbound	61%	Silver Spring CBD, Silver Spring/Takoma	PM Peak
18	Randolph Rd	Eastbound	61%	North Bethesda	PM Peak

Ranking	Corridor	Direction	Congestion	Policy Area Grouping	Peak
19	MD-28	Westbound	59%	Aspen Hill & Olney	AM Peak
20	US-29	Northbound	59%	Rural East	PM Peak
21	MD-187	Northbound	58%	Bethesda, Chevy Chase	PM Peak
22	MD-190	Eastbound	57%	Rural West	AM Peak
23	MD-586	Eastbound	57%	Wheaton CBD, Wheaton/Kensington, Glenmont	PM Peak
24	MD-187	Northbound	56%	North Bethesda	PM Peak
25	MD-410	Eastbound	55%	Bethesda, Chevy Chase	PM Peak
26	MD-355	Southbound	55%	Bethesda, Chevy Chase	AM Peak
27	MD-586	Westbound	55%	Wheaton CBD, Wheaton/Kensington, Glenmont	PM Peak
28	MD-117	Eastbound	55%	Gaithersburg, R & D Village, North Potomac, Montgomery Village	PM Peak
29	Montrose Rd	Westbound	55%	Potomac	PM Peak
30	MD-193	Westbound	55%	Silver Spring CBD, Silver Spring/Takoma	PM Peak
31	Colesville Road	Northbound	54%	Silver Spring CBD, Silver Spring/Takoma	AM Peak
32	MD-28	Eastbound	54%	Rockville City, Rockville Town Center, Shady Grove, Derwood	PM Peak
33	MD-190	Eastbound	54%	Bethesda, Chevy Chase	AM Peak
34	MD-586	Westbound	54%	Rockville City, Rockville Town Center, Shady Grove, Derwood	AM Peak
35	MD-193	Westbound	53%	Wheaton CBD, Wheaton/Kensington, Glenmont	AM Peak
36	MD-193	Eastbound	53%	Silver Spring CBD, Silver Spring/Takoma	PM Peak
37	MD-355	Northbound	53%	Germantown East, Germantown West, Germantown Town Center	PM Peak
38	Colesville Road	Northbound	52%	Silver Spring CBD, Silver Spring/Takoma	PM Peak
39	MD-390/16TH ST	Southbound	51%	Silver Spring CBD, Silver Spring/Takoma	AM Peak
40	MD-117	Westbound	50%	Gaithersburg, R & D Village, North Potomac, Montgomery Village	PM Peak
41	MD-355	Northbound	50%	Gaithersburg, R & D Village, North Potomac, Montgomery Village	PM Peak
42	MD-187	Southbound	50%	North Bethesda	AM Peak
43	MD-28	Eastbound	50%	Aspen Hill & Olney	PM Peak
44	Great Seneca Hwy	Northbound	49%	Gaithersburg, R & D Village, North Potomac, Montgomery Village	PM Peak
45	Randolph Rd	Westbound	49%	North Bethesda	PM Peak
46	MD-586	Eastbound	49%	Wheaton CBD, Wheaton/Kensington, Glenmont	AM Peak
47	MD-586	Westbound	49%	Wheaton CBD, Wheaton/Kensington, Glenmont	AM Peak
48	MD-355	Southbound	48%	Rockville City, Rockville Town Center, Shady Grove, Derwood	PM Peak
49	MD-650	Southbound	48%	Fairland, White Oak & Cloverly	AM Peak

Ranking	Corridor	Direction	Congestion	Policy Area Grouping	Peak
50	MD-410	Westbound	47%	Bethesda, Chevy Chase	PM Peak

Appendix B – Intersection Mobility Metrics

Overall Intersection Ranking

Historical intersection counts at signalized intersections are maintained in a database management system (DBMS). Intersections are evaluated according to their critical lane volume (CLV) as a means to determine adequacy and if additional and more detailed analysis is necessary. The 2013 LATR Guidelines specify the methodology contractors should follow when calculating CLV from observed turning movements when submitting traffic impact studies. In summary, the CLV is the highest

through movement volumes plus the opposing left hand turns for each signal phase (the critical volume for that phase) and compares this to a theoretical capacity which varies policy area to policy area

The factors impacting the CLV calculation are lane use, lane configuration, and signal phasing (concurrent versus split). Other factors such as approach capacity and delay, signal timing, geometrics, and left turn phasing are not considered. Below is a list of 50 signalized intersections in the planning department's database ordered according to their most recent CLV calculation. Prior CLV values are also included and its ranking in each of the last three mobility reports.

TABLE 3: TOP 50 INTERSECTIONS RANKED BY CLV

Ranking				Intersection Name	Previous MAR Count Date	Previous MAR CLV	Current Count Date	Current CLV	CLV Standard	Policy Area
2016	2013	2011	2009							
1	1	4	2	Rockville Pike at W Cedar Lane	11/6/2013	1957	9/16/2015	1868	1600	Bethesda/Chevy Chase
2	5	3	*3	Shady Grove Road at Choke Cherry Lane	5/19/2010	1853	5/19/2010	1853	1500	Rockville City
3	14	17	4	Connecticut Avenue at Plyers Mill Road	6/1/2011	1710	4/8/2014	1829	1600	Kensington/Wheaton
4	21	8	9	Connecticut Avenue at Jones Bridge Road/Kensington Parkway	2/29/2012	1672	2/4/2015	1827	1600	Bethesda/Chevy Chase
5	9	62	16	Frederick Avenue at Montgomery Village Avenue	4/25/2012	1795	10/23/2014	1818	1425	Gaithersburg City
6	171	175	169	Snouffer School Road at Centerway Road	4/19/2012	1342	11/5/2014	1816	1425	Montgomery Village/Airpark
7	195	198	191	W Montgomery Avenue at W Gude Drive	9/18/2007	1304	3/13/2014	1799	1500	Rockville City

³ * No intersection count was available at the time of the MAR publication

Ranking				Intersection Name	Previous MAR Count Date	Previous MAR CLV	Current Count Date	Current CLV	CLV Standard	Policy Area
2016	2013	2011	2009							
8	8	7	28	Great Seneca Hwy at Muddy Branch Road	1/4/2011	1800	4/25/2013	1791	1425	Gaithersburg City
9	70	74	167	Great Seneca Hwy (MD 119) at Sam Eig Hwy	2/3/2009	1515	2/25/2014	1779	1450	R&D Village
10	25	5	5	Georgia Avenue at Norbeck Road	9/11/2012	1656	10/29/2015	1778	1475	Aspen Hill
11	16	14	73	University Boulevard at Piney Branch Road	1/22/2009	1703	10/7/2015	1774	1600	Silver Spring/Takoma Park
12	*	*	*	New Hampshire Avenue (MD 650) at I-495 WB Off Ramps	*	*	1/22/2015	1770	1475	White Oak
13	10	142	135	Rockville Pike at First St/Wootton Parkway	5/24/2011	1768	5/24/2011	1768	1800	Rockville Town Center
14	359	336	124	Georgia Avenue at Veirs Mill Road	2/22/2012	1096	10/15/2014	1766	1800	Wheaton CBD
15	26	106	27	Frederick Road at Shady Grove Road	3/15/2011	1647	10/1/2014	1765	1800	Shady Grove Metro Station
16	128	138	81	Cherry Hill Road at Broadbitch Drive/Calverton Boulevard	2/11/2011	1406	5/27/2015	1747	1475	White Oak
17	11	9	11	E Gude Drive at Crabbs Branch/Cecil	3/24/2009	1742	3/24/2009	1742	1475	Derwood
18	38	37	39	Columbia Pike at Greencastle Road	11/15/2006	1607	2/19/2014	1738	1475	Fairland/Colesville
19	27	25	29	Colesville Road at Dale Drive	2/26/2009	1645	10/29/2015	1736	1600	Silver Spring/Takoma Park
20	40	114	113	Great Seneca Hwy at Quince Orchard Road	4/25/2012	1602	1/21/2015	1731	1425	Gaithersburg City
21	12	11	8	Veirs Mill Road at Twinbrook Parkway	6/3/2010	1721	6/3/2010	1721	1550	North Bethesda
22	13	40	44	First St at Baltimore Road	6/6/2012	1718	6/6/2012	1718	1800	Rockville Town Center
23	4	2	*	Darnestown Road at Riffle Ford Road	3/12/2009	1898	9/10/2015	1715	1450	North Potomac
24	15	13	15	Shady Grove Road at Epsilon/Tupelo	2/11/2009	1704	2/11/2009	1704	1475	Derwood
25	*	*	*	Georgia Avenue (MD 97) at Georgia Avenue/Emory Church Road	*	*	12/17/2014	1700	1450	Olney

Ranking				Intersection Name	Previous MAR Count Date	Previous MAR CLV	Current Count Date	Current CLV	CLV Standard	Policy Area
2016	2013	2011	2009							
26	*	*	*	River Road at I-495 ramp	*	*	5/27/2015	1681	1450	Potomac
27	311	197	190	W Montgomery Avenue (MD.28) at Research Boulevard	10/9/2012	1148	6/23/2015	1666	1500	Rockville City
28	*	*	*	Georgia Avenue (MD 97) at I-495 EB Off/On Ramp to/from 97 SB/On Ramp from 97 NB	*	*	6/26/2014	1656	1600	Silver Spring/Takoma Park
29	99	45	48	New Hampshire Avenue at Oakview Drive	5/23/2012	1454	2/18/2014	1654	1600	Silver Spring/Takoma Park
30	94	103	104	Seven Locks Road at Bradley Boulevard	3/17/2009	1460	10/15/2015	1651	1450	Potomac
31	28	26	1	Shady Grove Road at Midcounty Hwy	11/18/2010	1644	11/18/2010	1644	1475	Derwood
32	29	*	*	Clopper Road at Waring Station Road	6/2/2011	1636	6/2/2011	1636	1425	Germantown West
33	146	153	146	New Hampshire Avenue at Adelphi Road/Dilston Road	9/10/2008	1373	1/29/2015	1626	1600	Silver Spring/Takoma Park
34	44	122	57	Norbeck Road at Bauer Drive	10/18/2011	1586	1/22/2015	1626	1475	Aspen Hill
35	33	32	36	Colesville Road at Sligo Creek Parkway/St Andrews Way	3/6/2008	1624	3/6/2008	1624	1600	Silver Spring/Takoma Park
36	36	35	*	Aspen Hill Road at Arctic Avenue	11/6/2008	1609	11/6/2008	1609	1475	Aspen Hill
37	68	78	72	Columbia Pike at Milestone/Stewart	2/23/2011	1516	7/8/2014	1600	1475	Fairland/Colesville
38	547	545	522	MD 124 at Airpark Road	2/19/2009	827	9/1/2015	1595	1425	Montgomery Village/Airpark
39	42	43	46	Democracy Boulevard at Falls Road/S Glen Road	4/1/2009	1594	4/1/2009	1594	1450	Potomac
40	6	15	17	Connecticut Avenue at East West Hwy	11/6/2013	1848	2/6/2014	1586	1600	Bethesda/Chevy Chase
41	45	10	3	Randolph Road at New Hampshire Avenue	5/15/2012	1580	5/15/2012	1580	1475	Fairland/Colesville

Ranking				Intersection Name	Previous MAR Count Date	Previous MAR CLV	Current Count Date	Current CLV	CLV Standard	Policy Area
2016	2013	2011	2009							
42	130	206	86	Rockville Pike (MD 355) at Strathmore Avenue (MD 547)	9/14/2011	1405	9/18/2014	1580	1550	North Bethesda
43	46	48	54	Layhill Road at Ednor Road/Norwood Road	4/27/2010	1579	4/27/2010	1579	1450	Olney
44	47	49	51	River Road at I-495 (E)	3/10/2009	1579	3/10/2009	1579	1600	Bethesda/Chevy Chase
45	*	*	*	Old Georgetown Road at Ryland Drive	*	*	9/2/2015	1577	1600	Bethesda/Chevy Chase
46	49	50	55	East West Hwy at Jones Mill Road/Beach Drive	3/5/2009	1574	3/5/2009	1574	1600	Bethesda/Chevy Chase
47	50	51	58	Colesville Road at Franklin Avenue	2/3/2009	1571	2/3/2009	1571	1600	Silver Spring/Takoma Park
48	39	27	31	Old Georgetown Road at Tuckerman Lane	9/13/2011	1604	2/17/2016	1568	1550	North Bethesda
49	52	53	59	Muddy Branch Road at Diamondback Drive	10/9/2007	1563	10/9/2007	1563	1425	Gaithersburg City
50	88	64	91	Columbia Pike at Blackburn Road	12/6/2006	1484	9/18/2014	1559	1475	Fairland/Colesville

Bottlenecks

Bottlenecks are introduced in this version of the MAR. According to RITIS, “bottleneck conditions are determined by comparing the current reported speed to the reference speed for each segment of road. If the reported speed falls below 60% of the reference, the road segment is flagged as a potential bottleneck. If the reported speed stays below 60 percent for five minutes, the segment is confirmed as a bottleneck location”⁴. Once a bottleneck is confirmed, adjacent road segments meeting the same condition are consolidated to form the “bottleneck” queue. The ranking of the bottlenecks is determined by an “impact factor” calculated by RITIS. The impact factor is a product of the average duration of the queue, the average maximum length of the queue, and

the number of occurrences within the specified timeframe (March 1, 2015 – May 31, 2015). Below are the top 50 bottlenecks in Montgomery County as determined by RITIS’ impact factor.

As part of the bottleneck analysis, the MAR includes the average excess time spent in each bottleneck during peak periods. Excess time for the top bottlenecks was calculated using the following steps:

1. Calculate the difference between the measured travel time and free flow travel time for each 15-minute time increment using speed data from the VPPS.
2. Average the results from step one grouped by TMC segment and time period (a.m. peak, p.m. peak, and off-peak).

⁴ Center for Advanced Transportation Technology Laboratory. (2016, December 14). Vehicle Probe Project Suite. Retrieved from Bottlenecks: <https://vpp.ritis.org/suite/help/#bottlenecks>

3. Identify the TMC segments that approximate each bottleneck's extent represented as its average max length per RITIS' analysis.
4. Add together the average excess time for each TMC segment per time period that comprises the bottleneck's extent as identified in step three.

The following definitions are provided by the VPPS with regards to the bottleneck ranking table⁵:

Rank - The ranked position of the location according to the current table ordering (Impact by default).

Impact - Average duration (in minutes) * average max length * number of occurrences.

Average max length - The average maximum length, in miles, of queues formed by congestion originating at the location.

Average duration (minutes) - The average duration of bottlenecks occurring at this location.

Total duration - The total amount of time congestion was identified at the location

Occurrences – The number of bottlenecks flagged at the location during the time period being analyzed.

All Events/Incidents - The number of traffic events and incidents that occurred within the space of the bottleneck at any time during the time period being analyzed.

TABLE 4: BOTTLENECK RANKING FOR MARCH 1ST TO MAY 31, 2015

Rank	Location	Direction	Impact factor	Average max length (miles)	Average duration	Occurrences	All Events/Incidents
1	MD-355 N @ 1ST ST/WOOTTON PKWY	Northbound	73,776.29	2.27	51 m	638	23
2	MD-650 N @ POWDER MILL RD	Northbound	72,782.87	0.89	1 h 28 m	932	5
3	MD-190 E @ WESTERN AVE	Eastbound	58,650.18	1.34	1 h 19 m	552	4
4	MD-650 N @ US-29/COLUMBIA PIKE	Northbound	58,223.16	1.78	1 h 41 m	323	2
5	MD-185 S @ MD-191/BRADLEY LN	Southbound	42,582.24	1.77	1 h 20 m	301	9
6	MD-355 S @ WESTERN AVE	Southbound	40,778.04	0.8	1 h 14 m	687	2
7	US-29 N @ MD-516/FRANKLIN AVE	Northbound	39,047.50	0.81	1 h 27 m	551	0
8	MD-355 S @ MD-547/STRATHMORE AVE	Southbound	36,715.01	1.56	44 m	535	9
9	MD-185 N @ I-495	Northbound	33,629.59	1.03	1 h 06 m	496	16
10	MD-355 S @ MD-28/VEIRS MILL RD/E JEFFERSON ST	Southbound	32,503.14	1.01	56 m	576	6
11	MD-355 S @ MD-191/BRADLEY LN	Southbound	31,057.34	0.88	1 h 09 m	509	26

⁵ Center for Advanced Transportation Technology Laboratory. (2016, December 14). Vehicle Probe Project Suite. Retrieved from Bottlenecks: <https://vpp.ritis.org/suite/help/#bottlenecks>

Rank	Location	Direction	Impact factor	Average max length (miles)	Average duration	Occurrences	All Events/Incidents
12	MD-97 N @ RANDOLPH RD	Northbound	30,137.52	0.58	49 m	1062	21
13	MD-355 S @ GRAFTON ST	Southbound	29,606.43	1.63	2 h 25 m	125	26
14	MD-190 W @ DORSET AVE	Westbound	28,184.74	0.93	56 m	541	40
15	US-29 N @ OLD COLUMBIA RD	Northbound	28,172.00	4.24	2 h 03 m	54	7
16	MD-355 N @ CHRISTOPHER AVE	Northbound	28,047.91	0.58	56 m	869	0
17	US-29 S @ I-495	Southbound	27,799.22	1.18	1 h 00 m	394	8
18	MD-190 W @ MD-191/BRADLEY BLVD	Westbound	26,181.52	2.25	1 h 05 m	179	2
19	MD-355 S @ GROSVENOR LN	Southbound	25,811.42	1.44	44 m	408	1
20	MD-97 N @ I-495/CAPITAL BELTWAY	Northbound	25,564.42	0.48	1 h 02 m	858	3
21	SHADY GROVE RD S @ I-270	Southbound	25,441.61	0.84	38 m	793	0
22	CLARA BARTON PKWY E @ CANAL RD	Eastbound	25,108.33	3.3	2 h 21 m	54	0
23	MD-97 N @ MD-108/OLNEY SANDY SPRING RD	Northbound	25,001.29	0.57	41 m	1062	8
24	MD-117 E @ BARNESVILLE RD	Eastbound	23,975.66	3.69	1 h 43 m	63	0
25	TURKEY FOOT RD S @ TRAVILAH RD	Southbound	22,816.76	1.02	2 h 21 m	158	0
26	RANDOLPH RD W @ MD-355/ROCKVILLE PIKE	Westbound	22,601.77	0.54	53 m	789	0
27	MD-190 W @ I-495	Westbound	22,381.45	0.81	52 m	529	2
28	MD-410 W @ MD-355/WISCONSIN AVE	Westbound	21,864.31	0.78	57 m	493	5
29	MD-191 E @ MD-185/CONNECTICUT AVE	Eastbound	21,579.17	0.71	1 h 01 m	500	0
30	MD-118 N @ RIFFLE FORD RD	Northbound	21,495.92	2.87	1 h 44 m	72	0
31	MD-185 S @ MD-410/EAST WEST HWY	Southbound	20,996.08	0.58	43 m	835	3
32	MD-97 S @ HEWITT AVE	Southbound	20,800.02	0.66	1 h 06 m	474	3
33	MD-355 S @ CHESTNUT ST	Southbound	20,491.85	0.89	1 h 49 m	211	4
34	MD-355 N @ CEDAR LN	Northbound	20,400.38	0.61	55 m	608	8
35	US-29 N @ MD-650/NEW HAMPSHIRE AVE	Northbound	19,728.72	1.83	53 m	203	3
36	GREAT SENECA HWY N @ MD-117/CLOPPER RD	Northbound	19,603.05	1.18	1 h 19 m	210	0
37	MD-121 S @ DARNESTOWN RD	Southbound	19,155.36	3.26	3 h 16 m	30	0
38	MD-355 N @ I-495	Northbound	19,020.51	1.26	1 h 24 m	180	10
39	MD-187 S @ I-495/CAPITAL BELTWAY	Southbound	18,818.66	0.5	48 m	784	2
40	MD-190 W @ MD-189/FALLS RD	Westbound	18,770.16	0.77	1 h 04 m	379	0

Rank	Location	Direction	Impact factor	Average max length (miles)	Average duration	Occurrences	All Events/Incidents
41	MD-185 N @ JONES BRIDGE RD	Northbound	18,711.36	0.63	44 m	672	4
42	SHADY GROVE RD N @ MD-115/MUNCASTER MILL RD	Northbound	18,556.12	0.47	35 m	1130	0
43	MD-355 S @ 1ST ST/WOOTTON PKWY	Southbound	18,242.80	0.64	42 m	680	3
44	CLARA BARTON PKWY E @ MACARTHUR BLVD (BETHESDA)	Eastbound	18,177.15	0.7	1 h 22 m	316	0
45	RANDOLPH RD E @ PARKLAWN DR	Eastbound	17,955.14	0.47	52 m	734	0
46	SHADY GROVE RD N @ I-370	Northbound	17,928.74	0.53	35 m	974	0
47	SEVEN LOCKS RD N @ TUCKERMAN LN	Northbound	17,607.32	0.59	48 m	624	0
48	US-29 N @ FAIRLAND RD	Northbound	17,469.64	0.38	37 m	1231	0
49	MD-124 N @ MD-355/N FREDERICK AVE	Northbound	17,301.47	0.37	46 m	1011	0
50	MD-28 E @ BEL PRE RD	Eastbound	17,032.87	1.07	37 m	432	1

Appendix C – Pedestrian and Bicycle Mobility

Pedestrian and Bicycle Counts

Pedestrian and bicycle heat maps were derived from the latest counts in the intersection database. The Kernel Density function was utilized to create a magnitude per unit area surface from each intersection point's observed pedestrian or bicycle count. Below are the most recent top 50 pedestrian and bicycle counts currently in the intersection database.

Bicycle Accessibility

The bicycle accessibility analysis created two continuous surfaces representing the relative opportunity to engage in commercial and retail activities via biking. Two accessibility surfaces were created to differentiate between the ability to access activities via an all stress network and a low stress network. To accomplish this analysis, the following steps were performed:

1. A .5 X .5 mile grid of points that covers Montgomery County was created (Figure 1).
2. A subset of parcels was extracted that represents commercial and retail establishments including banks, shopping centers, libraries, museums, and restaurants (Figure 1).
3. GIS was used to calculate the network distance between a grid point and each retail/commercial parcel within 3 miles (Figure 2). This process was repeated for each .5-mile grid point to create an origin destination matrix for each grid point and retail/commercial parcel combination. This entire step was conducted using an all stress network (excluding interstates) and a low stress network. A total of 86,490 trip combinations were found along the all stress network and 5,121 trip combinations were found to exist along the low stress network.
4. For each grid point, the conventional Hansen accessibility formula based on the gravity model was calculated:

a. $A_i = \sum_{j=1}^n d_j e^{-t_{ij}}$ where,

A_i = Accessibility index for grid point j .

d_j = parcel attractiveness (square feet)

t_{ij} = the network travel distance to reach parcel j from grid point i

5. The Inverse Distance Weighted (IDW) Technique was used to derive two continuous accessibility surfaces from the discrete values calculated in the previous step for each grid point.
6. The two surfaces were compared to determine changes in accessibility between an all stress and low stress bicycle network. Changes were summarized by policy area.

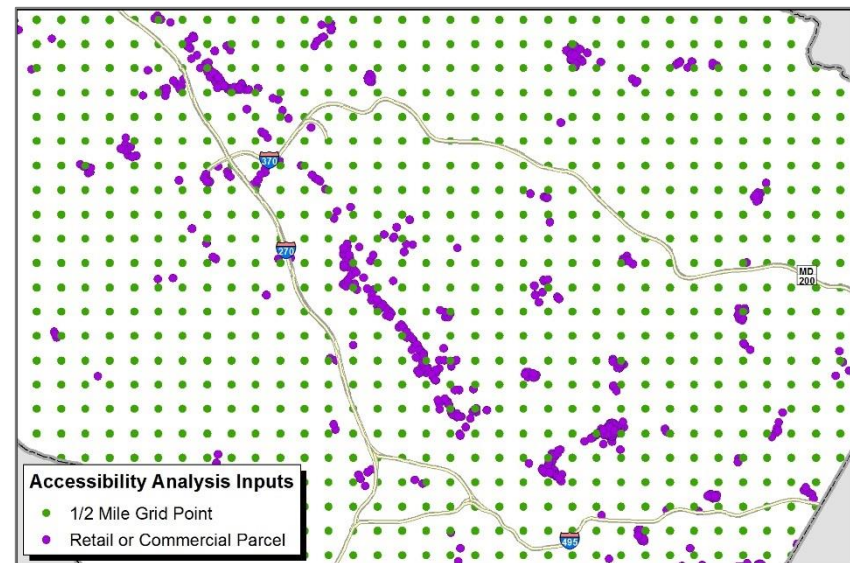


FIGURE 1: BICYCLE ACCESSIBILITY INPUTS



FIGURE 2: EXAMPLE OF GRID POINT AND PARCEL CONNECTIVITY ON A LOW STRESS BICYCLE NETWORK

TABLE 5: TOP 50 PEDESTRIAN COUNTS OBSERVED BETWEEN 6:30 A.M. TO 10 A.M. AND 4 P.M TO 7 P.M.

Rank	Intersection	Count Date	Observed Pedestrians
1	Colesville Rd at 2nd Ave/Wayne Ave	9/10/2014	6097
2	Wisconsin Ave at East-West Hwy/Old Georgetown Rd	5/10/2016	4124
3	MD 355 at Elm St/Waverly St	5/10/2016	3570
4	Wisconsin Ave at Montgomery Ln/Montgomery Ave	5/10/2016	3570
5	Colesville Rd at Georgia Ave	9/15/2015	3525
6	Rockville Pike at Marinelli Rd	4/16/2015	3147
7	Old Georgetown Rd at Commerce Ln/Edgemoor Ln	9/10/2015	3114
8	East-West Hwy at Blair Park Plz/NOAA	9/1/2015	2916
9	Woodmont Ave at Hampden Ln	5/10/2016	2859
10	Old Georgetown Rd at Woodmont Ave	9/10/2015	2650
11	Woodmont Ave at Bethesda Ave	5/10/2016	2592
12	Woodmont Ave at Elm St	5/10/2016	2506
13	Rockville Pike at South Dr/Southwood Rd	7/1/2014	2307
14	Colesville Rd at Fenton St	9/1/2015	1751

Rank	Intersection	Count Date	Observed Pedestrians
15	East-West Hwy at Waverly St	5/10/2016	1679
16	Hungerford Dr at Middle Ln/Park Rd	9/17/2014	1622
17	Wisconsin Ave at Cheltenham Dr	9/17/2014	1495
18	MD 355 at Halpine Rd	9/30/2014	1287
19	Georgia Ave at Forest Glen Rd	10/20/2015	1284
20	Arlington Rd at Elm St	5/10/2016	1259
21	Wisconsin Ave at Bethesda Ave/Willow Ln	5/10/2016	1256
22	University Blvd at Piney Branch Rd	10/7/2015	1213
23	East-West Hwy at 16th St	8/13/2015	1213
24	Randolph Rd at Veirs Mill Rd	10/21/2014	1121
25	East West Hwy at Newell/Blair Mill Rd	3/11/2015	960
26	Wisconsin Ave at Leland St/Woodmont Ave	5/10/2016	834
27	Rockville Pike at Monroe Pl/Church St	9/16/2014	812
28	Georgia Ave at University Blvd	10/16/2014	793
29	Piney Branch Rd at Flower Ave	10/20/2015	747
30	New Hampshire Ave at Lockwood Dr	6/5/2014	711
31	Colesville Rd at University Blvd (E)	9/29/2015	653
32	Colesville Rd at Spring St	7/15/2015	630
33	Rockville Pike at Twinbrook Pkwy/Rollins Ave	10/6/2015	624
34	Colesville Rd at University Blvd (W)	9/29/2015	610
35	Piney Branch Rd at Barron St	3/19/2014	567
36	Georgia Ave at Spring St	6/10/2014	550
37	Layhill Rd at Glenallen Ave	10/21/2015	526
38	Rockville Pike at Old Georgetown Rd	4/1/2015	525
39	Frederick Ave at Education Blvd	12/4/2013	492
40	Old Georgetown Rd at Auburn St	9/10/2015	487
41	Ethan Allen Ave (MD 410) at Carroll Ave	1/28/2015	485
42	MD 355 at Frederick Ave	10/9/2014	474
43	Montgomery Ln at Pearl St	1/19/2016	465
44	University Blvd at Veirs Mill Rd	4/2/2015	456
45	MD 355 at Woodmont Ave	9/17/2014	450

Rank	Intersection	Count Date	Observed Pedestrians
46	Georgia Ave at Connecticut Ave	9/3/2014	448
47	Carroll Ave (MD 195) at Tulip Ave	9/23/2014	434
48	Century Blvd at Crystal Rock Dr	11/6/2014	432
49	Philadelphia Ave (MD 410) at Carroll Ave	2/10/2015	432
50	Old Georgetown Rd at Executive Blvd	9/17/2015	425

TABLE 6: TOP 50 BICYCLE COUNTS OBSERVED BETWEEN 6:30 A.M. TO 10 A.M. AND 4 P.M TO 7 P.M

Rank	Intersection	Count Date	Observed Bicyclists
1	Woodmont Ave at Bethesda Ave	5/10/2016	375
2	Wisconsin Ave at Leland St/Woodmont Ave	5/10/2016	355
3	Connecticut Ave at Chevy Chase Lake Dr	10/6/2015	239
4	Woodmont Ave at Elm St	5/10/2016	178
5	Old Georgetown Rd at South Dr/Greentree Rd	7/21/2015	141
6	Woodmont Ave at Hampden Ln	5/10/2016	133
7	MD 355 at Elm St/Waverly St	5/10/2016	93
8	Connecticut Ave at Manor Rd	10/7/2015	85
9	Wisconsin Ave at Montgomery Ln/Montgomery Ave	5/10/2016	83
10	Wisconsin Ave at East-West Hwy/Old Georgetown Rd	5/10/2016	78
11	Rockville Pike at W Cedar Ln	9/16/2015	77
12	Bradley Blvd at Wilson Ln	3/9/2016	64
13	Colesville Rd at Georgia Ave	9/15/2015	54
14	Old Georgetown Rd at Auburn St	9/10/2015	53
15	Wisconsin Ave at Bethesda/Willow	5/10/2016	51
16	Old Georgetown Rd at Commerce Ln/Edgemoor Ln	9/10/2015	51
17	University Blvd at Piney Branch Rd	10/7/2015	47
18	Old Georgetown Rd at Battery Ln	9/10/2015	45
19	Old Georgetown Rd at Woodmont Ave	9/10/2015	44
20	River Rd at Willard Ln/Greenway Dr	10/28/2014	42
21	East-West Hwy at Waverly St	5/10/2016	37
22	Colesville Rd at Spring St	7/15/2015	37
23	Little Falls Pkwy at Hillandale Rd	5/28/2014	36

Rank	Intersection	Count Date	Observed Bicyclists
24	River Rd at Brookside Dr/Ridgefield Rd	10/16/2014	35
25	Arlington Rd at Elm St	5/10/2016	34
26	Bradley Blvd at Hill/Leland St	7/16/2015	34
27	Bradley Blvd at Burdette Rd	4/19/2016	33
28	Seminary Rd at 2nd Ave/Linden Ln	9/29/2015	31
29	Georgia Ave at Columbia Blvd/Seminary Ln	10/8/2015	31
30	Boiling Brook Pkwy at Rocking Horse Rd	9/16/2015	30
31	Bradley Blvd at Fernwood Rd	4/19/2016	29
32	Old Georgetown Rd at Lone Oak	4/19/2016	28
33	Father Hurley Blvd at Crystal Rock Dr	11/20/2014	28
34	Little Falls Pkwy at Dorset Ave	5/28/2014	27
35	Piney Branch Rd at Flower Ave	10/20/2015	25
36	Gude Dr at Dover Rd	5/6/2015	25
37	Colesville Rd at University Blvd (W)	9/29/2015	25
38	Georgia Ave at August Dr	10/29/2015	25
39	Old Georgetown Rd at Executive Blvd	9/17/2015	25
40	Germantown Rd at Clopper Rd	7/28/2015	24
41	Massachusetts Ave at Westbard Ave	10/14/2014	23
42	Rockville Pike at E Jefferson/Veirs Mill Rd	10/14/2015	23
43	Olney-Sandy Sprg Rd at Prince Philip D	6/24/2015	22
44	MD 355 at Edmondston Dr	1/5/2016	22
45	Tower Oaks Blvd at I-270 Interchange	10/21/2015	21
46	Montrose Rd at Seven Locks Rd	9/29/2015	20
47	Nicholson Ln at Nebel St	9/16/2015	20
48	E Gude Dr at Calhoun Dr	6/3/2015	20
49	East-West Hwy at 16th St	8/13/2015	20
50	W Diamond Ave at Perry Pkwy	10/8/2015	19

Appendix D – Public Transportation

The bus coverage and frequency analysis utilized the “Yay, transit!” suite of tools⁶. These tools integrate General Transit Feed Specification (GTFS) datasets with GIS network analysis tools. GTFS is a standardized data format for storing transit information including routes and schedules. The “Count Trips in Polygon Buffers” tool was used to create the coverage maps categorized by trip frequency. The tool “generates polygon service areas around the stops in your transit system and counts the number of transit trips available in those areas during a time window”⁷. If two or more bus stops occur within the specified distance of one another, trips are not double counted.

The “service area” derived around each bus stop is based on a specified *network* distance (in this case 1/3 mile). Network distance is different than Euclidean distance (straight-line) because it measures the distance along the road network (or any other type of specified network) as opposed to the shortest path between two points. Although Euclidean distance is easy to calculate and requires no additional data, it can lead to misguided conclusions (Figure 3). Once the “Count Trips in Polygon Buffers” tool was run for both Ride-On and Metro Bus routes, the two resulting surfaces were combined to get a bus frequency coverage surface for both systems. The area of each frequency category is then summarized in each census block and policy area.

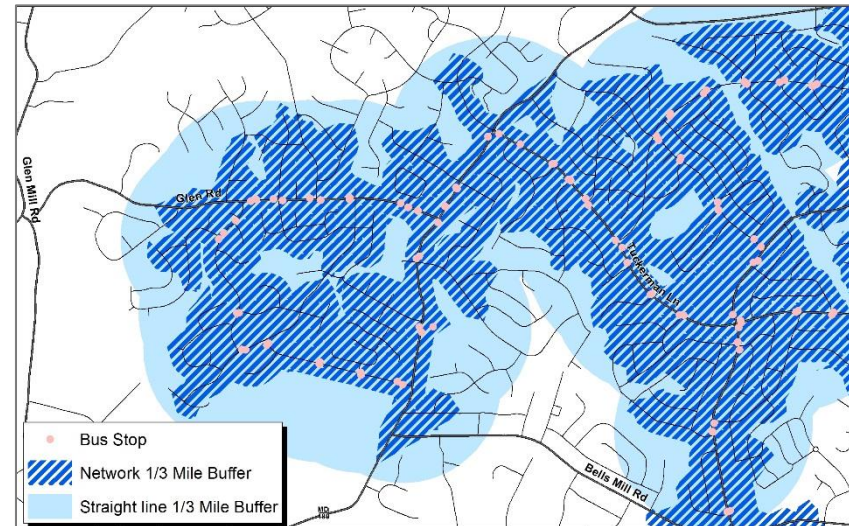


FIGURE 3: COMPARISON OF NETWORK AND EUCLIDEAN BUFFERS AROUND BUS STOPS

⁶ Morang, M. (2016, January 6). Yay, transit! Retrieved from Using GTFS Data in ArcGIS Network Analyst: <http://transit.melindamorang.com/>

⁷ Morang, M. (2016, 1 11). Better Bus Buffers User's Guide. Retrieved from http://transit.melindamorang.com/UsersGuides/BetterBusBuffers/BetterBusBuffers_UsersGuide.html#CountTripsInPolygonBuffersAroundStops



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