4. SAFETY AND CRASH ANALYSIS

I-395 within the study area is characterized by recurring congestion during peak commuter periods that extends for several hours during the morning and evening peak periods. This congestion creates the potential for crashes, especially rear end and sideswipe crashes. The safety and crash analysis portion of this study identifies and evaluates safety trends and hotspots based on historical crash data along I-395.

The available methods and tools for evaluating roadway safety can be separated into two categories: qualitative and quantitative. Qualitative methods for evaluating roadway safety typically include an evaluation of historical crash data and traffic volumes to review crash trends and rates. Quantitative methods for evaluating roadway safety are based not only on historic crash data and traffic volumes, but also take into account the geometric features of a roadway. The *Highway Safety Manual* (HSM), published in 2010, introduced a quantitative approach to evaluating roadway safety. Prior to the development of the HSM, safety analysis techniques largely focused on a review of crash history and qualitative assessments of the historic data. It should be noted that the predictive crash methods detailed in the HSM are not applicable to reversible lane facilities such as the I-395 HOV lanes; therefore, the quantitative safety analysis focuses on a review of available crash modification factors (CMFs).

4.1 QUALITATIVE SAFETY ANALYSIS

Crash data along northbound (NB) and southbound (SB) I-395 from approximately 0.45 mile south of Edsall Road to the 14th Street Bridges across the Potomac River was reviewed for a four-year period from January 1, 2012 through December 31, 2015. Crash data was obtained from the VDOT Tableau-Crash Analysis Tool (T-CAT). The crash data includes crashes that were reported in the general purpose and HOV/HOT lanes as well as the ramps serving I-395. Using the latitude and longitude information from each crash, the crash data was converted to a shapefile to geospatially depict the location of each crash.

4.1.1 I-395 General Purpose and HOV/HOT Lane Crashes

A total of 2,622 crashes were reported along both the I-395 general purpose and HOV/HOT lanes within the crash study area during the four-year crash study period including 1,461 (56 percent) rear end crashes, 413 (16 percent) fixed object crashes, 382 (15 percent) sideswipe crashes, and 290 (11 percent) angle crashes. It should be noted that for the purposes of this study, crashes reported in the northbound and southbound travel directions in the HOV/HOT lanes are summarized separately although they occur within the same roadway facility for the majority of the study limits.

It should be noted that the I-395 HOV lanes south of the Turkeycock Run Interchange were expanded from two to three lanes and converted to HOT lanes during the crash study period. The HOV lanes were officially converted to HOT lanes on December 14, 2014 and tolling began on December 29, 2014. A review of the total number crashes from the southern crash study limits to the Turkeycock Run Interchange does not suggest there was a significant change in the number of reported crashes following the conversion of the HOV lanes to HOT lanes (14 crashes per year were reported during 2012 through 2014 and 17 crashes were reported during 2015). Although there was an increase in the number of crashes during the “after” period, typically a minimum of two years of crash data (and preferably five years) should be reviewed before conclusions regarding safety conditions are made. Therefore, this study does not further compare crashes

before and after the conversion to HOT lanes from the southern study limit to the Turkeycock Run Interchange.

Table 4-1 summarizes the crashes by collision type, severity, surface condition, weather condition, year, and time interval. As shown, 657 crashes (25 percent) resulted in a total of 960 personal injuries and two crashes resulted in three fatalities. One fatal crash occurred on Wednesday, December 19, 2012 at 4:45 AM within the northbound I-395 general purpose lanes in the vicinity of the on-ramp from eastbound Little River Turnpike/Duke Street. This crash resulted in one fatality. Another fatal crash occurred on Thursday, April 9, 2015 at 10:00 PM within the HOV/HOT lanes approximately 450 feet north of Little River Turnpike/Duke Street and involved a vehicle traveling northbound in the HOV lanes when the lanes were operating in a southbound direction. This crash resulted in two fatalities. Of the 2,622 total crashes, 416 (16 percent) crashes occurred on wet/ice/snow-covered roadways and 397 (15 percent) crashes occurred during adverse weather conditions (i.e., rain, snow, etc.).

During the study period, there were approximately 131, 117, 25, and 11 crashes per mile reported in the northbound general purpose, southbound general purpose, northbound HOV/HOT, and southbound HOV/HOT lanes, respectively. The number of crashes per year by facility is shown in **Figure 4-1.** As shown, the number of crashes per year increased approximately 12 percent in 2013 compared to 2012, remained approximately the same in 2014 (compared to 2013), and increased by approximately 14 percent in 2015 compared to 2013 or 2014, which suggests an upward trend in reported crashes. Further review of the crash data indicates that there was a high number of crashes (22 crashes) reported on snow-covered roadways during 2014, including 9 crashes that occurred on March 17, 2014 (St. Patrick's Day), 4 crashes that occurred on February 13, 2014, and 4 crashes that occurred on February 25, 2014. Of these 22 reported crashes, 14 occurred in the northbound HOV/HOT lanes. The number of crashes reported between 12 PM and 3 PM increased by approximately 38 percent in 2013 (compared to 2012), by approximately 29 percent in 2014 (compared to 2013), and by approximately 15 percent in 2015 (compared to 2014).

Figure 4-2 summarizes weekday (i.e., Monday - Friday) crashes by time of day. Seventy-eight percent of all reported crashes occurred on weekdays. As shown, 30 percent of all weekday crashes occurred during the AM peak period from 6:00 AM to 11:00 AM and 40 percent of all weekday crashes occurred during the PM peak period between 2:00 PM and 8:00 PM. The HOV lanes operate in the northbound direction between 2:30 AM and 11:00 AM with HOV-3 restrictions from 6:00 AM to 9:00 AM. The HOV lanes operate in the southbound direction from 1:00 PM to 12:00 AM with HOV-3 restrictions from 3:30 PM to 6:00 PM. During time periods without HOV-3 restrictions, all vehicles are permitted to use the HOV lanes. During time periods immediately preceding and following the HOV-3 restrictions, traffic volumes in the HOV lanes increase, creating the potential for congestion-related crashes. Crashes were reviewed for the 15-minute intervals during the one-hour preceding the HOV-3 restriction time periods through the two hours following the HOV-3 restriction period (see **Figures 4-3 and 4-4**) to determine the impact on the number of reported crashes. Northbound I-395 crashes were reviewed for the morning peak period and southbound I-395 crashes were reviewed for the evening peak period.

As shown, there is an increase in the number of crashes in the northbound HOV/HOT lanes from 5:30 – 6:00 AM (i.e., the time period preceding the AM peak HOV-3 restriction period), which is followed by a decrease in crashes from 6:15 – 6:30 AM. Following the HOV-3 restriction period, there is an increase in crashes in the northbound HOV/HOT lanes from 9:15 – 9:30 AM and 9:45 – 10:00 AM. A total of 34

crashes were reported in the northbound HOV/HOT lanes from 9:15 - 10:15 AM, which represents the highest number of crashes during a one-hour interval throughout the day and is 113 percent greater than the number of crashes reported in the northbound HOV/HOT lanes from 8:00 – 9:00 AM (i.e., the last hour of the AM peak HOV-3 restriction period).

A total of 14 crashes were reported in the southbound HOV/HOT lanes from 6:30 – 7:30 PM, which represents the highest number of crashes during a one-hour interval throughout the day and is 75 percent greater than the number of crashes reported in the southbound HOV/HOT lanes from 5:00 – 6:00 PM (i.e., the last hour of the PM peak HOV-3 restriction period). Furthermore, five crashes were reported in the southbound HOV/HOT lanes from 3:15 – 3:30 PM during the 15-minute period immediately preceding the PM peak HOV-3 restriction period. Three of these five crashes occurred south of Eads Street near the ramp from the southbound HOV lanes to the general purpose lanes. These historical crash trends suggest that there is a degradation of safety within the HOV lanes during the time period preceding and following the AM and PM peak HOV-3 restriction periods.

Table 4-1: I-395 Crash Summary

Crash Type		Number of Crashes[2]				Total Crashes	% of Total Crashes
		NB General Purpose Lanes	NB HOV/HOT[1] Lanes	SB General Purpose Lanes	SB HOV/HOT[1] Lanes		
Collision Type	Rear End	722	128	579	32	**1,461**	**55.7%**
	Sideswipe	186	30	147	19	**382**	**14.6%**
	Angle	146	26	112	6	**290**	**11.1%**
	Fixed Object	131	40	208	34	**413**	**15.7%**
	Other	22	11	35	8	**76**	**2.9%**
Crash Severity	Fatal Injury	0	0	1	1	**2**	**0.1%**
	Ambulatory Injury	26	5	33	3	**67**	**2.5%**
	Visible Injury	208	43	196	19	**466**	**17.8%**
	Non-Visible Injury	65	11	42	6	**124**	**4.7%**
	Property Damage Only	908	176	809	70	**1,963**	**74.9%**
Surface Condition	Dry	1,042	201	888	75	**2,206**	**84.1%**
	Wet	139	25	178	19	**361**	**13.8%**
	Snowy/Icy/Slush	25	9	15	5	**54**	**2.1%**
	Other	1	0	0	0	**1**	**0.0%**
Weather Condition	No Adverse Conditions (Clear/Cloudy)	1,053	200	897	75	**2,225**	**84.9%**
	Rain/Mist	124	26	170	19	**339**	**12.9%**
	Snow/Sleet/Hail	28	9	13	4	**54**	**2.1%**
	Fog	2	0	1	0	**3**	**0.1%**
	Other	0	0	0	1	**1**	**0.0%**
Year of Crash	2012	284	33	230	34	**581**	**22.2%**
	2013	318	51	266	16	**651**	**24.8%**
	2014	275	85	270	20	**650**	**24.8%**
	2015	330	66	315	29	**740**	**28.2%**
Time	12 AM - 3 AM	46	8	79	6	**139**	**5.3%**
	3 AM - 6 AM	62	28	82	4	**176**	**6.7%**
	6 AM - 9 AM	316	54	83	9	**462**	**17.6%**
	9 AM - 12 PM	167	61	93	8	**329**	**12.6%**
	12 PM - 3 PM	173	29	126	14	**342**	**13.0%**
	3 PM - 6 PM	221	28	280	23	**552**	**21.1%**
	6 PM - 9 PM	140	18	194	26	**378**	**14.4%**
	9 PM - 12 AM	82	9	144	9	**244**	**9.3%**
Total Crashes by Facility		**1,207**	**235**	**1,081**	**99**	**2,622**	**-**
Crashes per Mile (9.25 total miles)		**130.5**	**25.4**	**116.9**	**10.7**	**283.5**	**-**

[1] HOV/HOT = High Occupancy Vehicle/High Occupancy Toll lanes which include both the reversible I-395 HOV/HOT lanes and the northern section of the I-395 HOV lanes with dedicated travel lanes for each direction

[2] Crash study period consists of January 1, 2012 through December 31, 2015

Figure 4-1: Crashes by Year by Facility

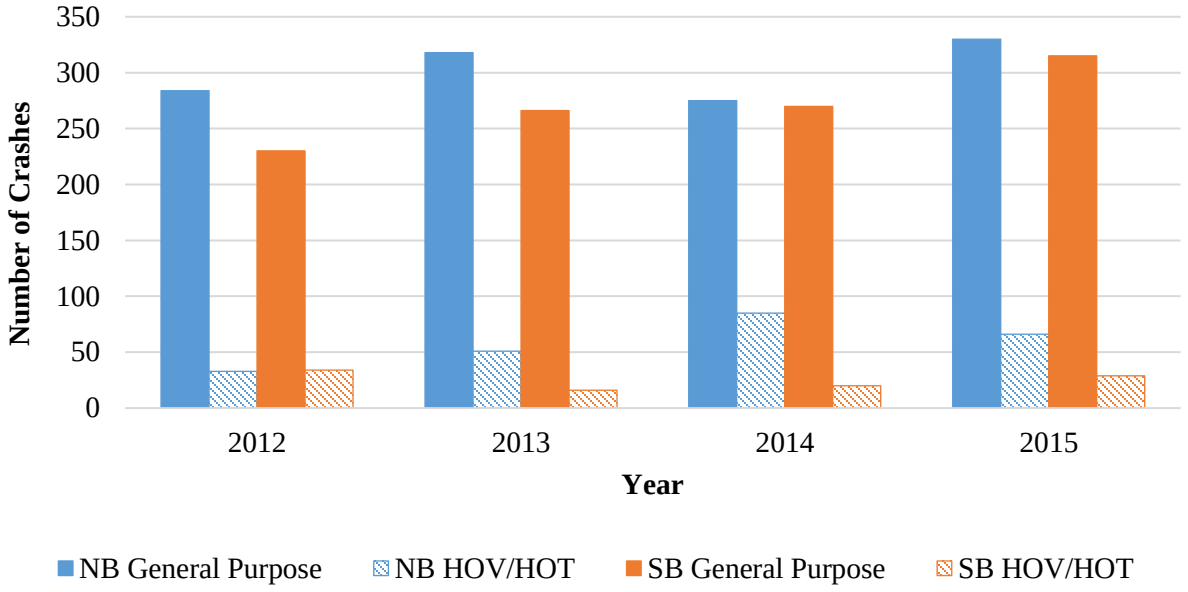


Figure 4-2: Weekday (Monday – Friday) Crashes by Time of Day (2012 – 2015)

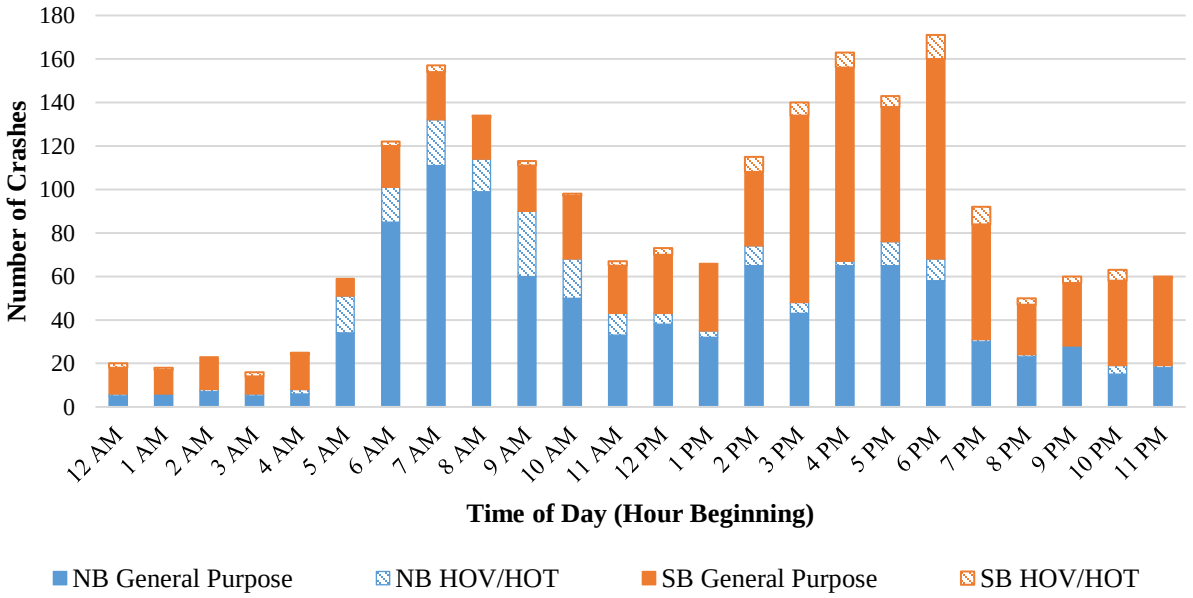


Figure 4-3: Crashes by 15-Minute Time Period Intervals (2012 – 2015) – 5:00 AM to 11:00 AM Northbound I-395 Crashes

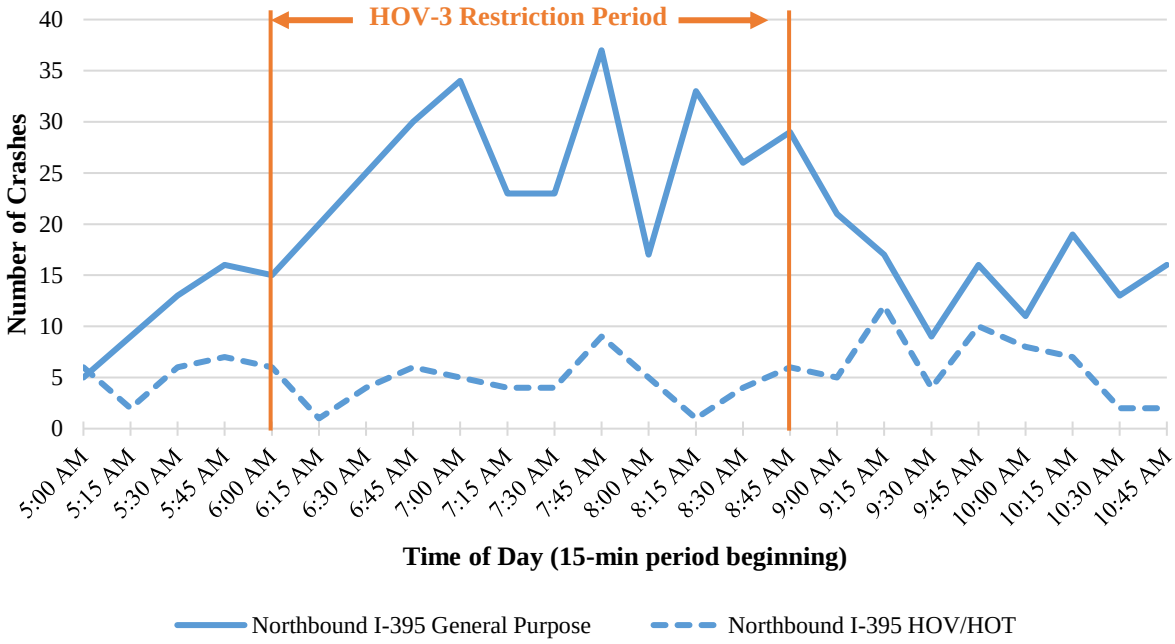
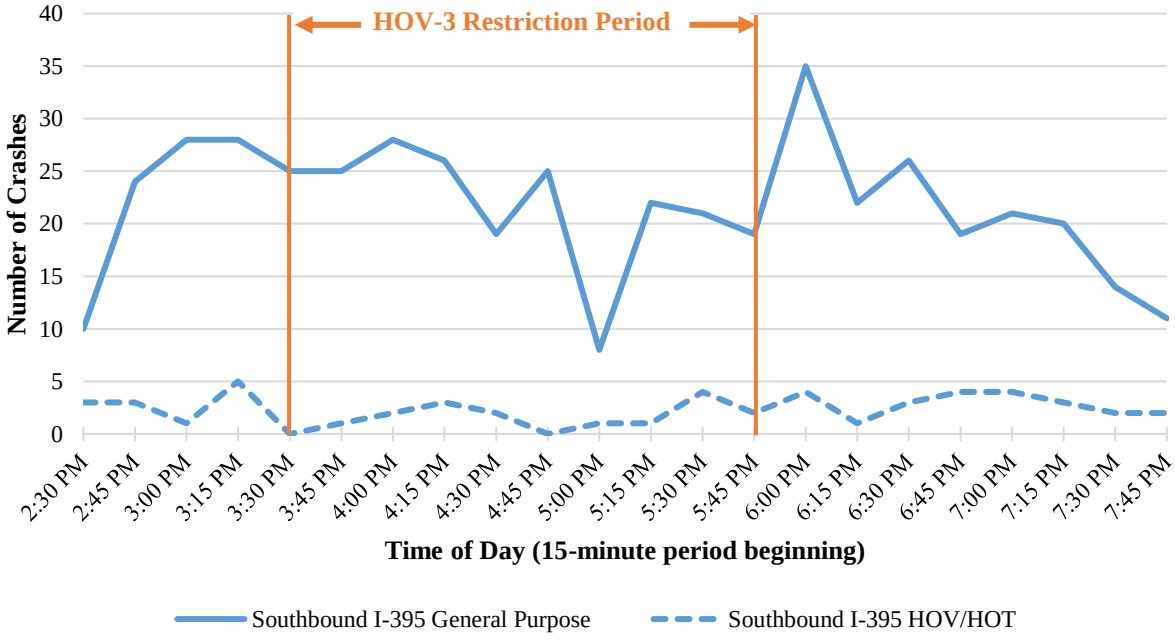


Figure 4-4: Crashes by 15-Minute Time Period Intervals (2012 – 2015) – 2:30 PM to 8:00 PM Southbound I-395 Crashes



To further analyze the crash data and identify crash trends, the study corridor was separated into 37 segments, each covering a 0.25-mile roadway segment. Quarter-mile points were established at consistent locations along all four I-395 facilities (northbound general purpose, southbound general purpose, northbound HOV/HOT, southbound HOV/HOT) and are generally based on the VDOT-published Linear Referencing System (LRS), Release 14.1. All crashes reported along I-395 were associated with a specific 0.25-mile point based on geospatial data. For example, crashes associated with mile point 3.25 represent the roadway segment from mile point 3.125 to 3.375. Crashes within the general purpose and HOV/HOT travel lanes are summarized using crash frequency histograms in 0.25-mile segments by crash type in **Figures 4-5 and 4-6, respectively.** These figures are also included in **Appendix E** with similar figures showing the crash frequency by crash severity and time of day.

Figure 4-5: Crash Severity by Crash Type – General Purpose Lanes (Sheet 1 of 5)

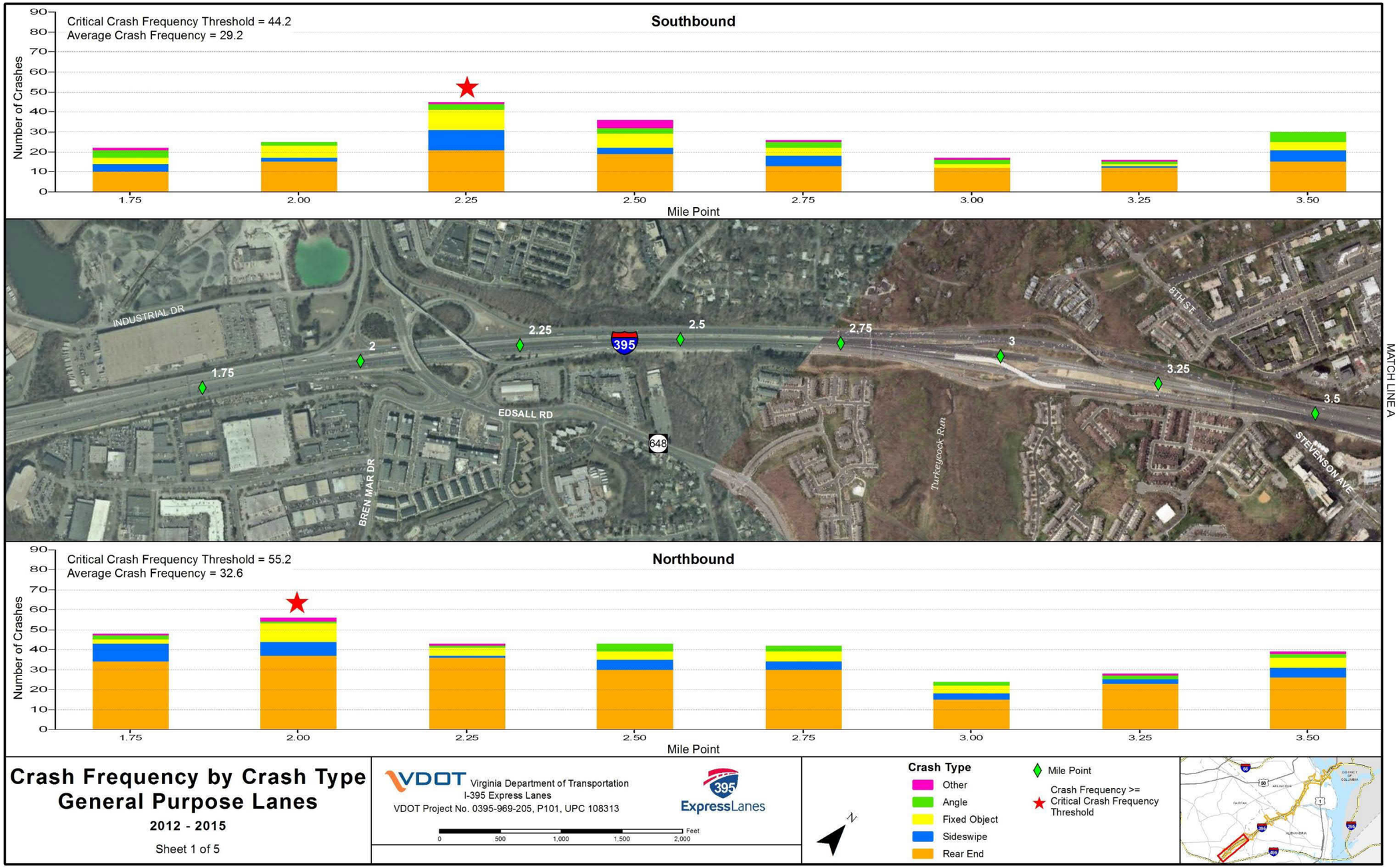


Figure 4-5: Crash Severity by Crash Type – General Purpose Lanes (Sheet 2 of 5)

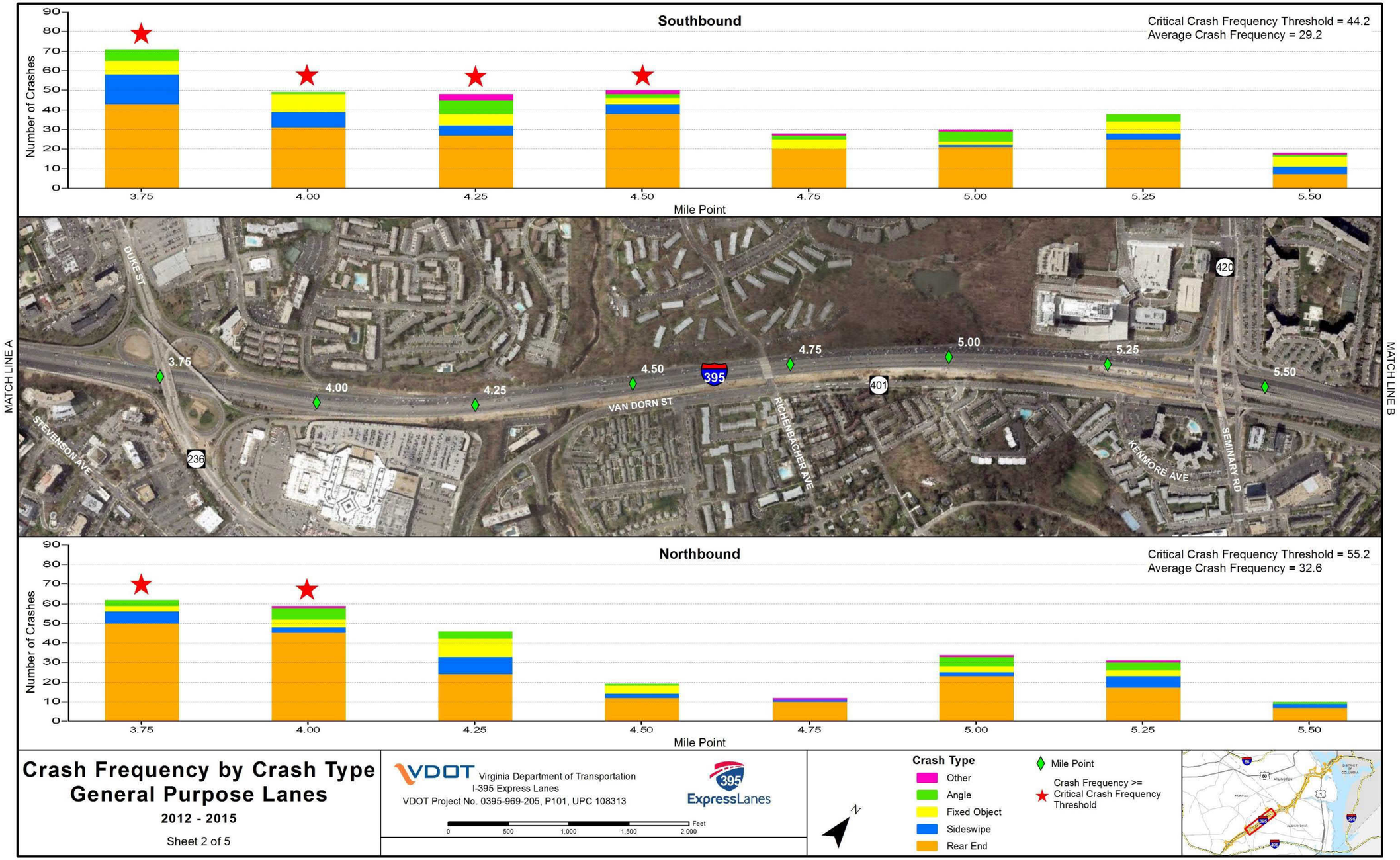


Figure 4-5: Crash Severity by Crash Type – General Purpose Lanes (Sheet 3 of 5)

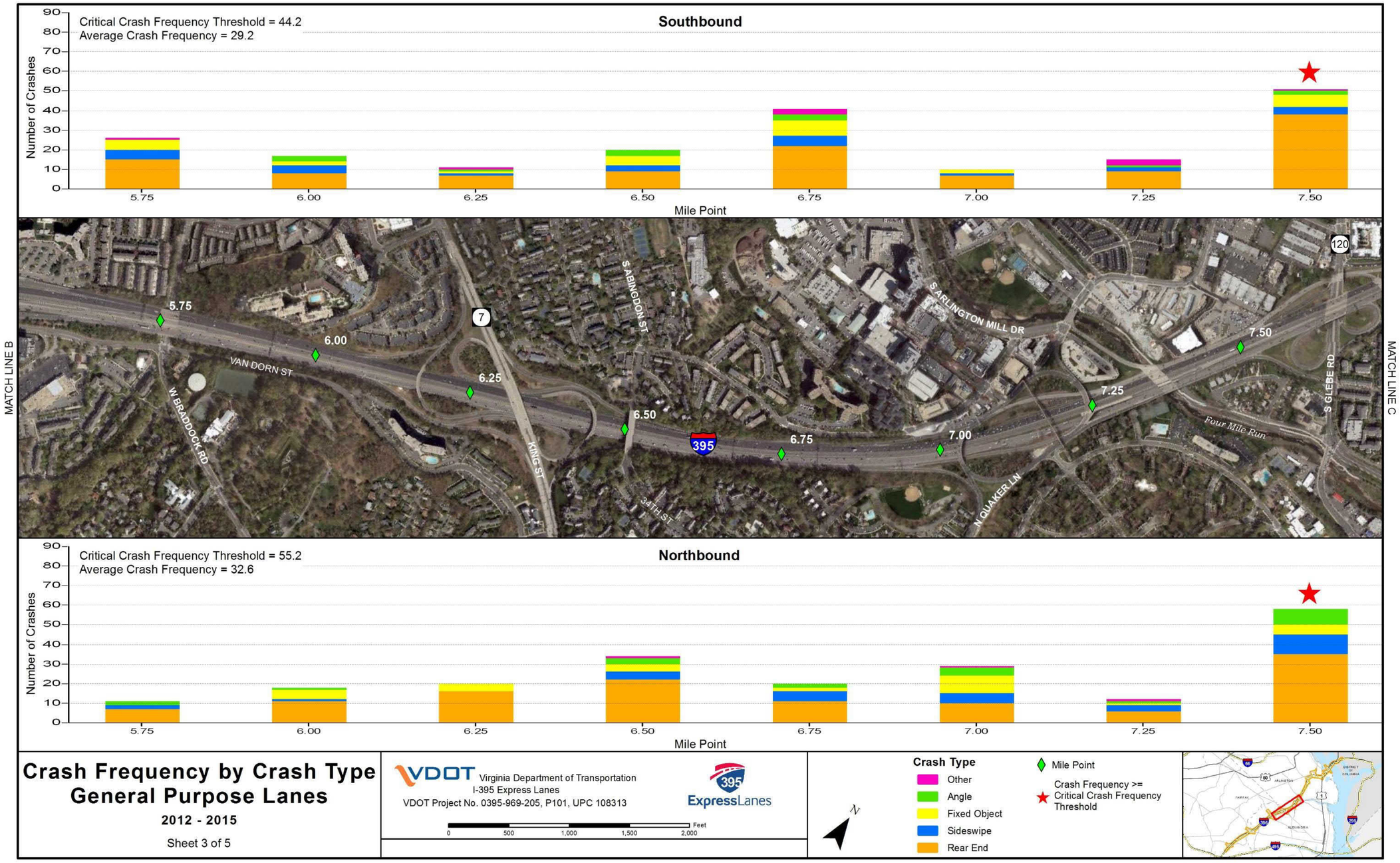


Figure 4-5: Crash Severity by Crash Type – General Purpose Lanes (Sheet 4 of 5)

Figure 4-5: Crash Severity by Crash Type – General Purpose Lanes (Sheet 5 of 5)

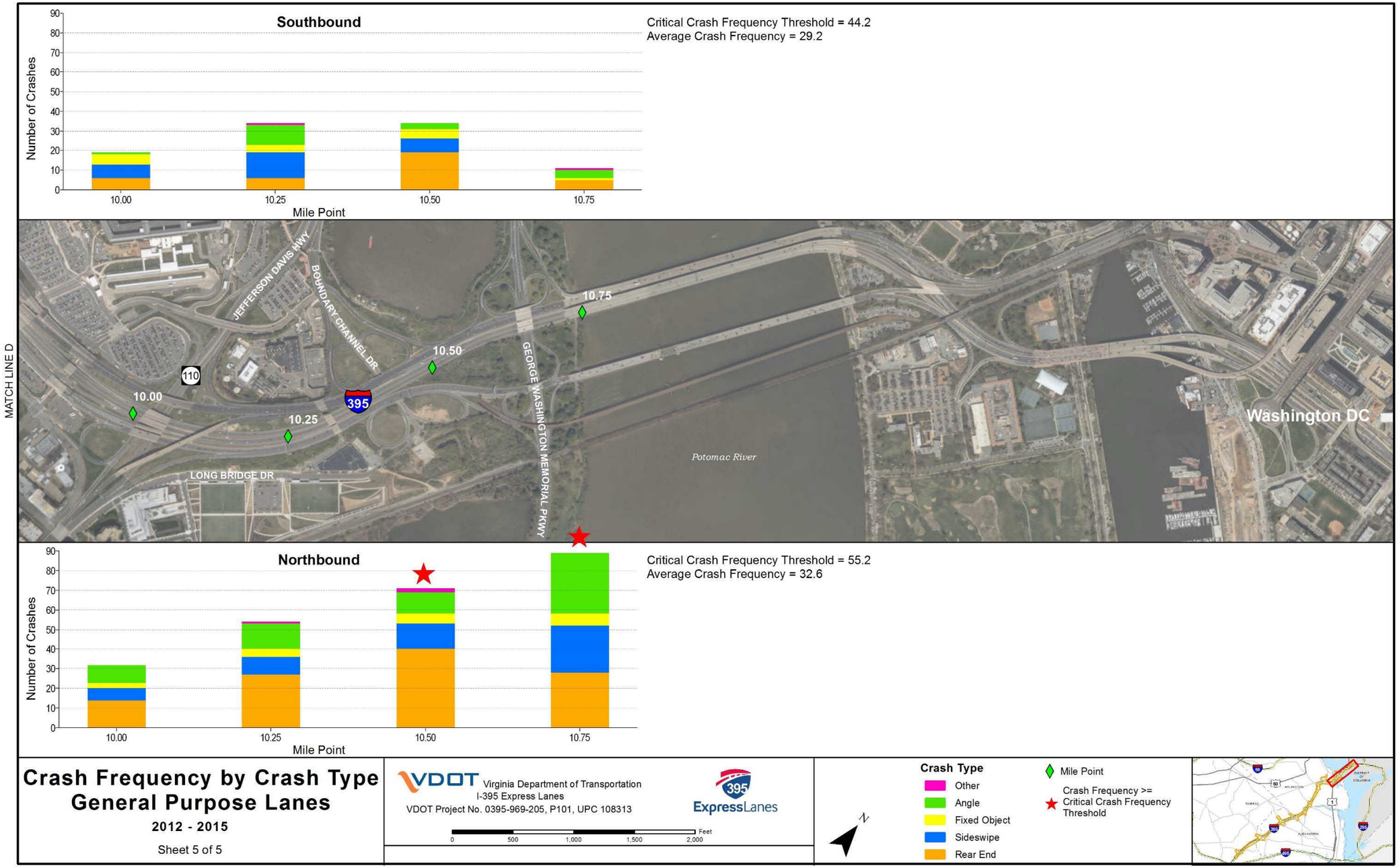


Figure 4-6: Crash Severity by Crash Type – HOV/HOT Lanes (Sheet 1 of 5)

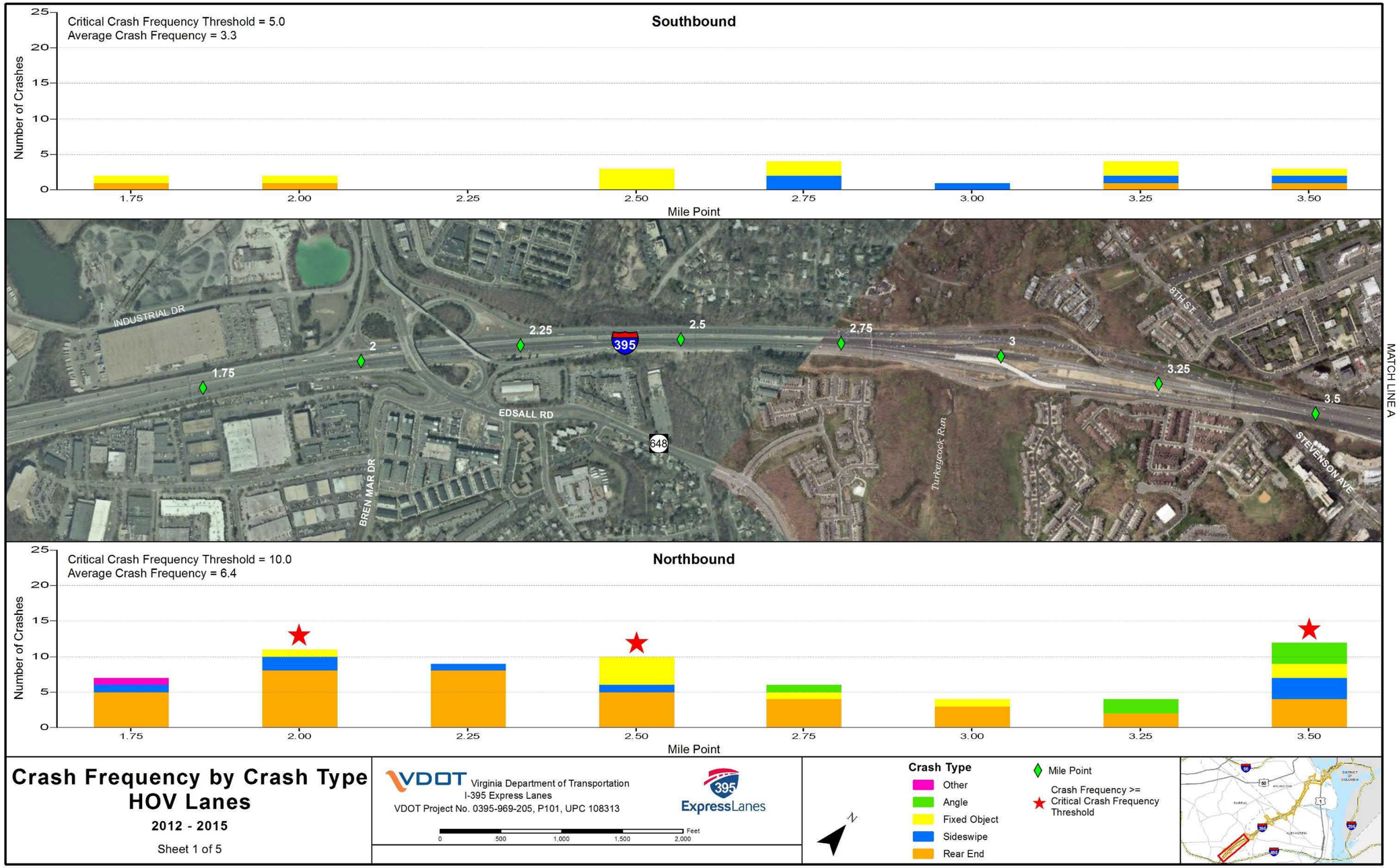


Figure 4-6: Crash Severity by Crash Type – HOV/HOT Lanes (Sheet 2 of 5)

Figure 4-6: Crash Severity by Crash Type – HOV/HOT Lanes (Sheet 3 of 5)

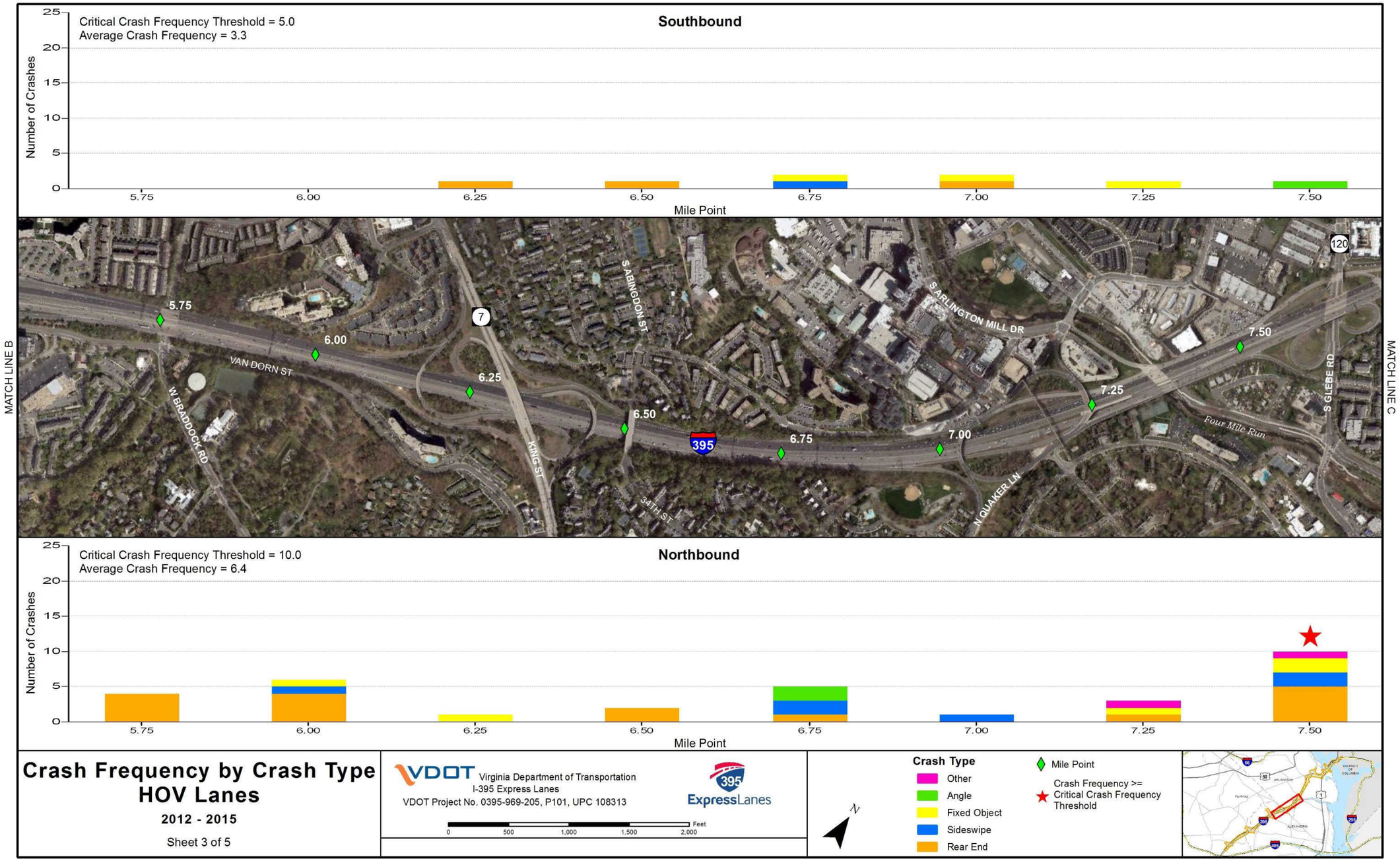


Figure 4-6: Crash Severity by Crash Type – HOV/HOT Lanes (Sheet 4 of 5)

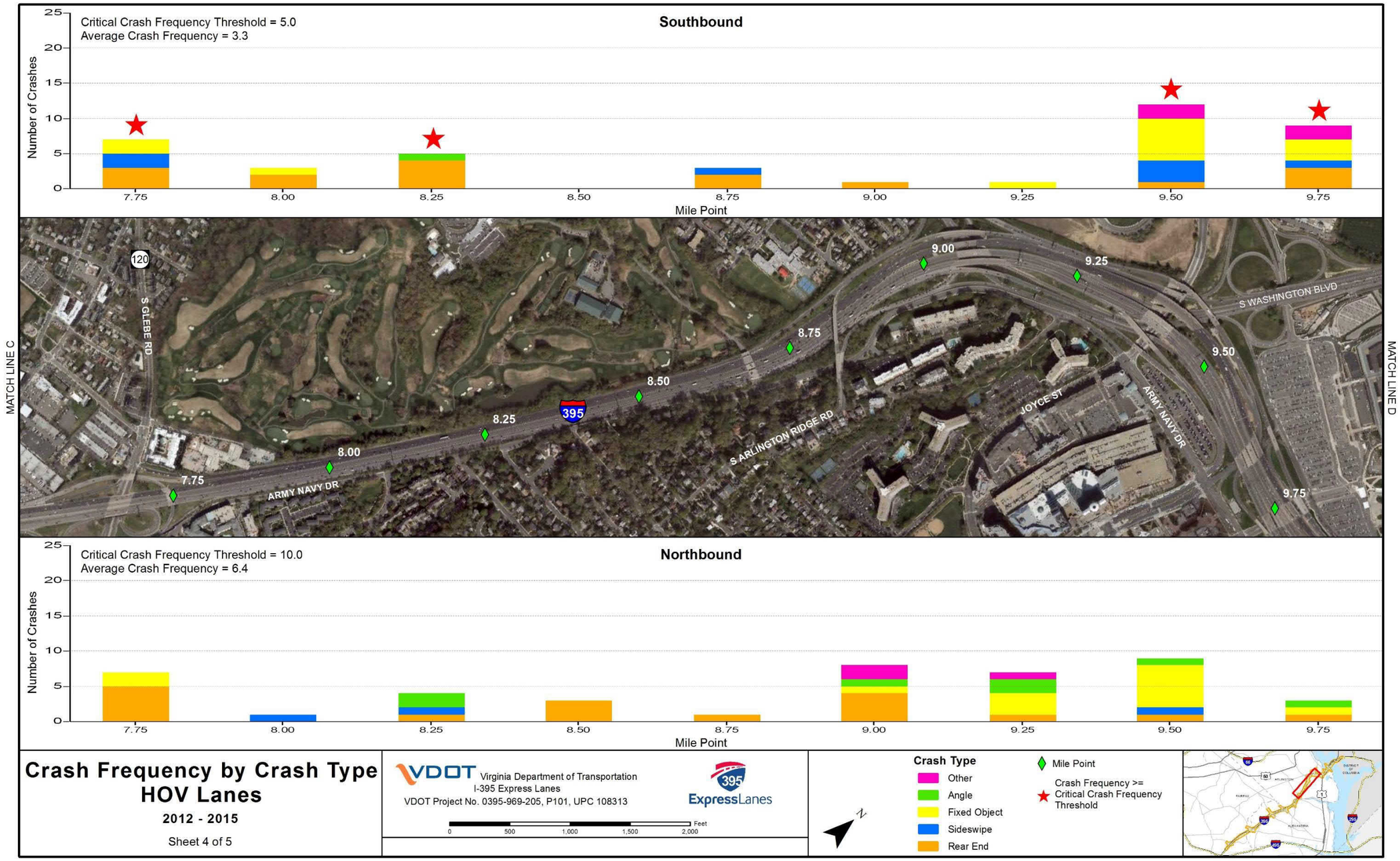
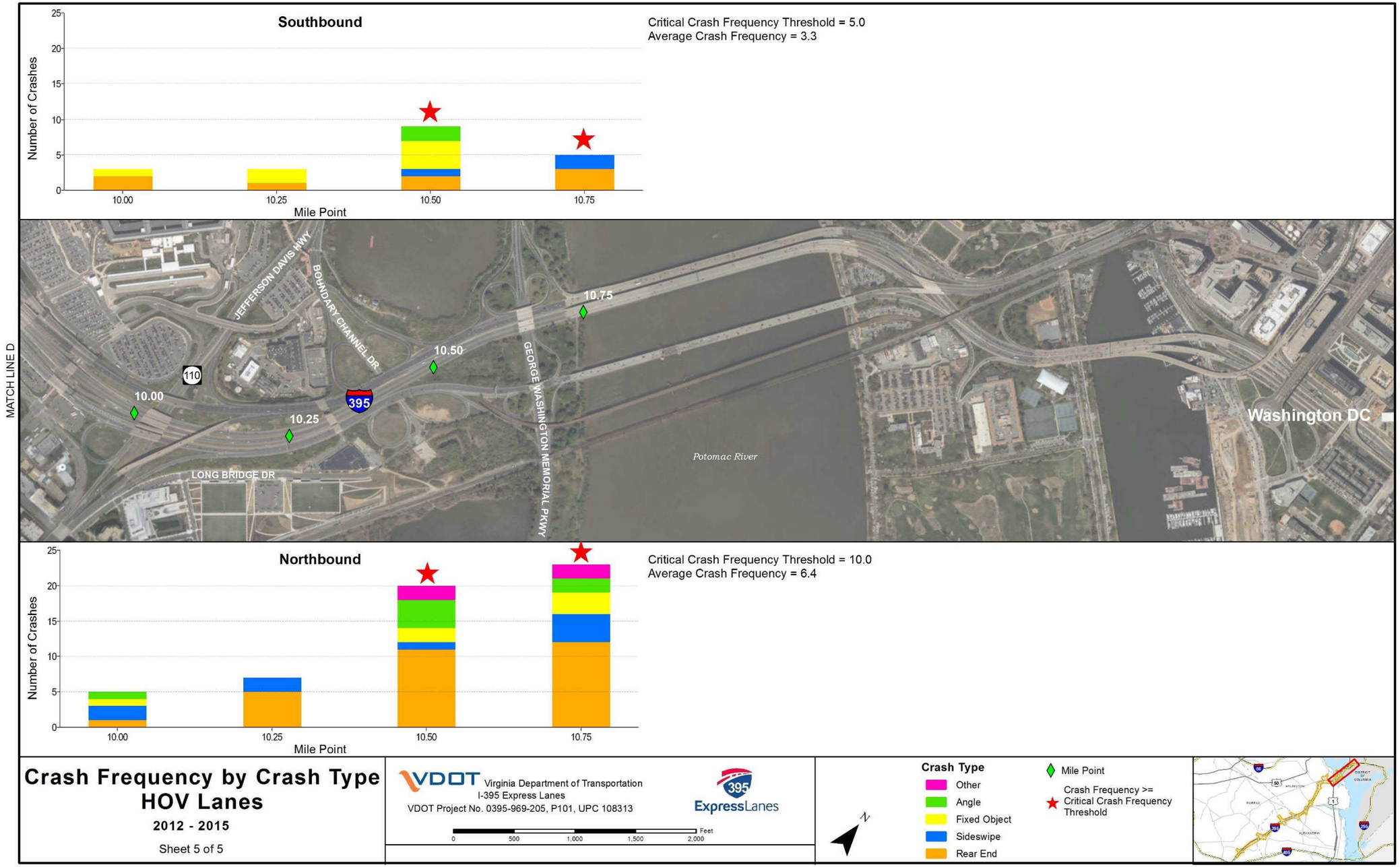


Figure 4-6: Crash Severity by Crash Type – HOV/HOT Lanes (Sheet 5 of 5)



Crash rates per 100 million vehicle miles traveled were calculated for the four I-395 facilities for each 0.25-mile segment and are summarized in **Table 4-2** and **Figures 4-7 and 4-8** for both total crashes and injuries.

Calculated crash rates were compared to VDOT's annually-published statewide average interstate, statewide average urban interstate, and Northern Virginia interstate crash rates. The calculated crash rates were compared to the average of the 2012 through 2014 crash rates, which represent three of the four years included in the crash study period. Of the 148 total 0.25-mile segments analyzed (37 per facility), 63 (43 percent) segments have a total crash rate greater than the statewide average interstate crash rate, statewide average urban interstate crash rate, and Northern Virginia crash rate. Eleven (7 percent) segments have a total crash rate greater than both the statewide average urban interstate and statewide average interstate crash rates, but have a rate lower than the Northern Virginia interstate average crash rate. Eight (5 percent) segments have a total crash rate greater than the statewide interstate average crash rate, but have a rate lower than both the Northern Virginia interstate average and statewide average interstate crash rates.

Calculated injury rates were compared to VDOT's annually-published statewide average interstate, statewide average urban interstate, and Northern Virginia interstate injury rates. At the time of this study, statewide crash rates for calendar year 2015 were not available; therefore, the calculated crash rates were compared to the average of the 2012 through 2014 crash rates. Of the 148 total quarter-mile segments analyzed (37 per facility), 48 (32 percent) segments have an injury rate greater than the statewide average interstate injury rate, statewide average urban interstate injury rate, and Northern Virginia interstate injury rate. Twelve (8 percent) segments have an injury rate greater than both the statewide average interstate and statewide average urban interstate, but have a rate lower than the Northern Virginia interstate average injury rate. Ten (7 percent) segments have an injury rate greater than the statewide average interstate injury rate, but have a rate lower than both the Northern Virginia interstate average and statewide average interstate injury rates.

The overall crash rate in the northbound general purpose, southbound general purpose, and northbound HOV/HOT facilities is greater than the statewide average interstate crash rate, statewide average urban interstate crash rate, and Northern Virginia crash rate. The overall corridor crash rate for the southbound HOV/HOT lanes is lower than all three average crash rates.

Fatality rates were not calculated for each segment due to the relatively low number of reported fatal crashes during the study period (three fatalities were reported during the four-year study period).

Critical crash locations (or crash "hot spots") were identified along the corridor using two different methods, both of which used an 85th-percentile measurement to define the critical crash threshold. Separate thresholds were calculated for each of the four facilities (i.e., northbound general purpose, southbound general purpose, northbound HOV/HOT, and southbound HOV/HOT). The first method reviewed the crash frequency (i.e., number of crashes) and the second method reviewed the total crash rates (i.e., crashes per 100 million vehicle miles traveled) as described below:

- **Crash Frequency** - The critical crash locations identified using the crash frequency methodology are summarized in **Table 4-3 and Figures 4-5 and 4-6**. As shown, the 85th-percentile crash frequency for the northbound general purpose, southbound general purpose, northbound

HOV/HOT, and southbound HOV/HOT facilities are 55, 44, 10, and 5 crashes per 0.25-mile segment, respectively.

- **Crash Rate per 100 Million VMT** – The critical crash locations identified using the crash rate are summarized in **Table 4-4** and are indicated with shading in **Table 4-2**. As show, the 85th-percentile crash rates for the northbound general purpose, southbound general purpose, northbound HOV/HOT, and southbound HOV/HOT facilities are 188, 161, 181, and 68 crashes per 100 million vehicle miles traveled, respectively.

A comparison of the critical crash locations identified through both the crash frequency and crash rate methodologies indicates similar results. The northbound general purpose lanes have critical crash locations near the Edsall Road Interchange, Little River Turnpike/Duke Street Interchange, Glebe Road Interchange, and approaching the Potomac River in the vicinity of the Boundary Channel Drive and George Washington Memorial Parkway. The southbound general purpose lanes have critical crash locations near the Edsall Road Interchange, approaching the Little River Turnpike/Duke Street Interchange, near the Glebe Road Interchange, and near the Washington Boulevard (south) Interchange. Critical crash locations within the northbound HOV/HOT lanes were identified south of and north of Edsall Road, between the Turkeycock Run Interchange and Little River Turnpike/Duke Street, south of Seminary Road, south of Glebe Road, near the northern terminus of the reversible HOV lanes, and north and south of George Washington Memorial Parkway. Critical crash locations within the southbound HOV/HOT lanes were identified south of and north of the Turkeycock Run Interchange, north of Glebe Road, in the vicinity of the Eads Street on-ramp and approaching the ramp from the HOV lanes to the southbound general purpose lanes), near Boundary Channel Drive (approaching the exit from the HOV lanes to the southbound general purpose lanes), and at George Washington Memorial Parkway.

Table 4-2: Crash and Injury Rate (per 100 million VMT) Comparison by Quarter-Mile Segment

MP	Reference Interchange / Cross Street	I-395 Total Crash Rate by Facility[1] (2012 – 2015 Crashes)				I-395 Injury Rate by Facility (2012 – 2015 Crashes)			
		Statewide Average Total Crash Rates[2]: Interstate = 68 Urban Interstate = 81 Northern Virginia Interstate = 97				Statewide Average Injury Rates[2]: Interstate = 30 Urban Interstate = 37 Northern Virginia Interstate = 41			
		NB GP	NB HOV/ HOT	SB GP	SB HOV/ HOT	NB GP	NB HOV/ HOT	SB GP	SB HOV/ HOT
1.75		146	131	65	36	64	75	27	0
2.00	Edsall Road	192	206	80	36	76	56	80	0
2.25		166	169	149	0	39	94	43	0
2.50		146	188	117	54	68	113	55	18
2.75		143	123	93	72	41	0	21	72
3.00	Turkeycock Run Interchange	85	104	59	24	39	0	31	0
3.25		95	78	54	102	41	59	27	26
3.50		132	235	109	44	74	59	51	44
3.75	Duke Street	234	157	263	59	102	39	93	59
4.00		250	117	188	44	42	39	38	15
4.25		154	98	161	15	63	39	30	0
4.50		63	59	167	0	20	0	60	0
4.75	Sanger Avenue	40	20	94	0	23	20	20	0
5.00		114	157	100	0	60	0	30	0
5.25	Seminary Road	122	196	152	15	35	59	88	0
5.50		39	18	72	27	20	18	28	0
5.75	W. Braddock Road	35	73	94	0	0	0	18	0
6.00	King Street Interchange	58	109	59	0	19	36	38	0
6.25		73	18	41	14	18	0	22	0
6.50		109	36	77	14	16	0	35	0
6.75		60	91	137	27	6	0	41	0
7.00		95	18	36	27	49	0	7	41
7.25		39	54	61	14	20	36	16	14
7.50	Glebe Road Interchange	175	171	229	13	78	0	67	13
7.75		94	120	130	88	33	17	45	63
8.00		48	17	107	38	19	34	48	0
8.25		42	68	106	63	10	17	10	100
8.50		67	51	96	0	19	17	34	0
8.75		91	17	161	38	49	0	37	0
9.00	Washington Boulevard	60	137	247	13	8	103	84	0
9.25		64	152	102	15	19	65	20	0
9.50		85	211	115	198	30	94	23	17
9.75	Fern Street	128	90	79	134	52	30	18	30
10.00	Jefferson Davis Highway	181	130	114	48	45	52	36	0
10.25		217	57	118	43	84	49	38	0
10.50		284	164	133	88	104	25	47	79
10.75	Potomac River	270	188	34	35	130	114	34	21
Overall Corridor		**119**	**109**	**113**	**39**	**29**	**44**	**37**	**39**

[1] Critical crash locations identified based on the crash rate (i.e., crashes per 100 million vehicle miles traveled) are indicated with shading
[2] Average of the 2012, 2013 to 2014 crash rates published annually by VDOT's Traffic Engineering Division

Figure 4-7: Total Crash Rate Summary by Mile Point

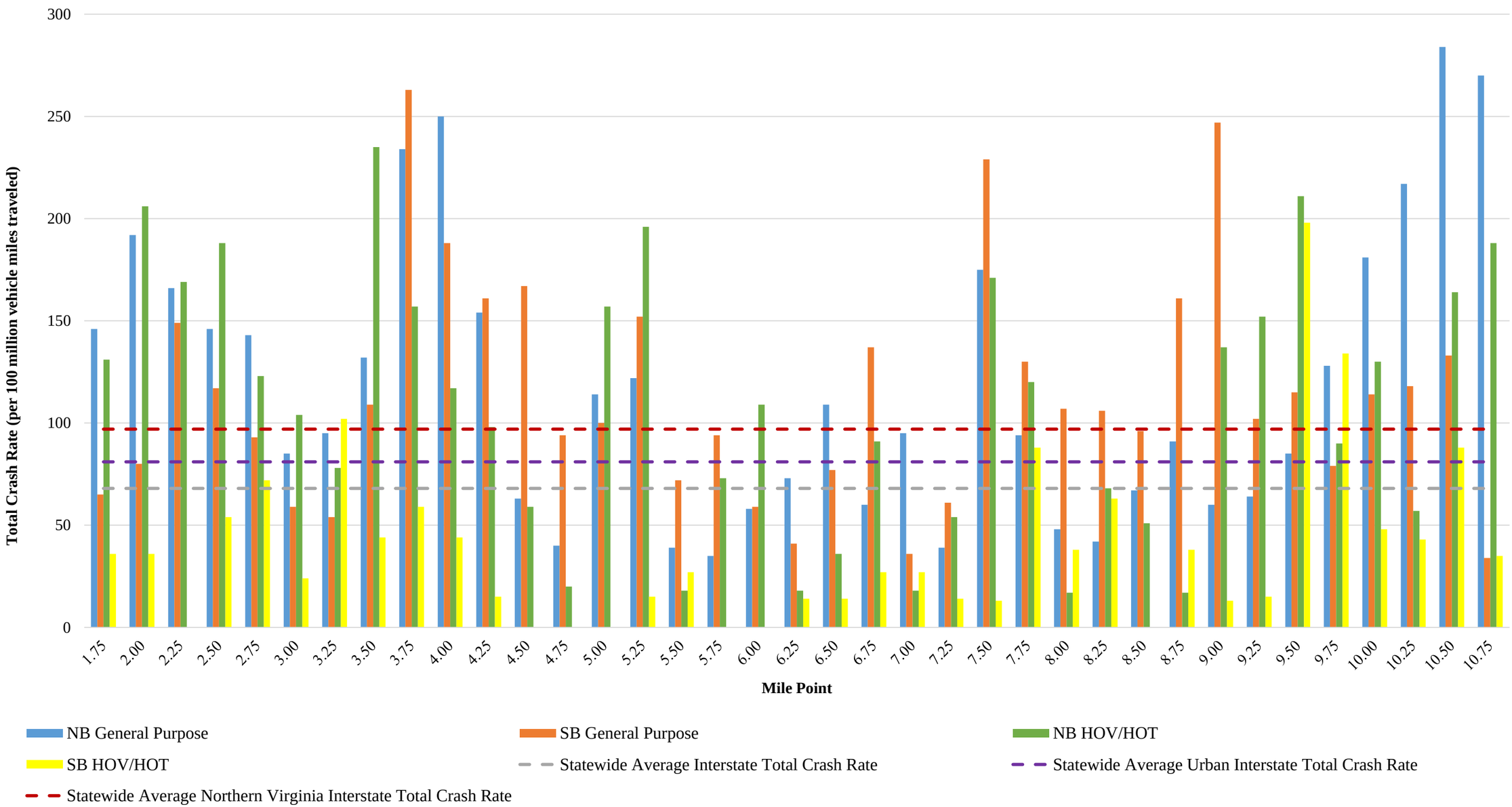


Figure 4-8: Total Injury Rate Summary by Mile Point

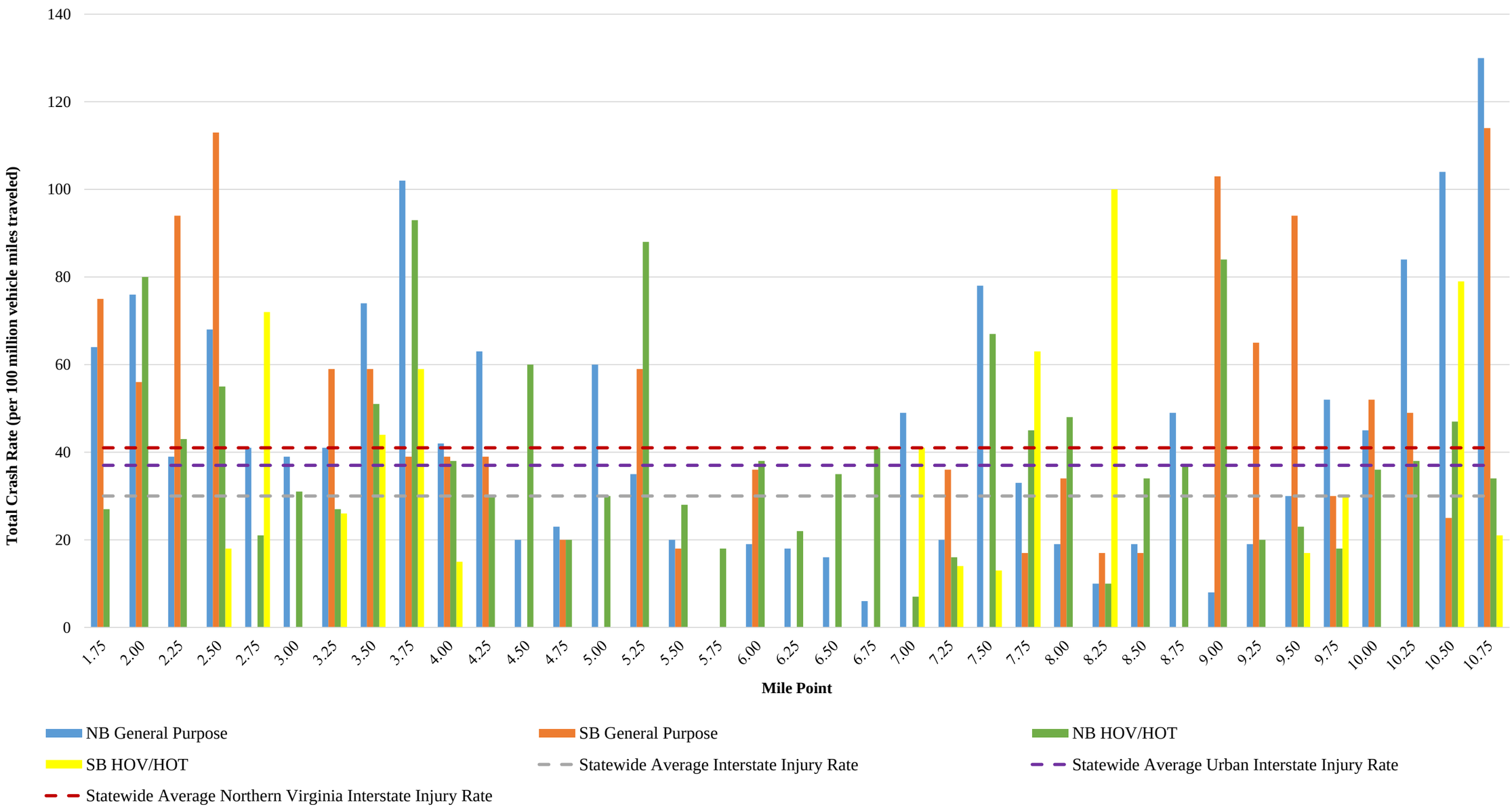


Table 4-3: I-395 Critical Crash Locations based on Crash Frequency

I-395 Facility	Average Crash Frequency (crashes per 0.25-mile segment)	85th-Percentile Critical Crash Frequency (crashes per 0.25-mile segment)	Locations with Crash Frequency ≥ 85th-Percentile Critical Crash Frequency
NB General Purpose	32.6	55.2	• MP 2.00: South of Edsall Rd • MP 3.75: Duke St • MP 4.00: North of Duke St • MP 7.5: South of Glebe Rd • MP 10.50: Boundary Channel Drive to George Washington Memorial Pkwy • MP 10.75: George Washington Memorial Pkwy to Potomac River
SB General Purpose	29.2	44.2	• MP 2.25: North of Edsall Rd • MP 3.75: Duke St • MP 4.00: North of Duke St • MP 4.25: In Vicinity of Off-Ramp to Duke St • MP 4.50: South of Sanger Ave • MP 7.50: South of Glebe Rd
NB HOV/ HOT	6.4	10.0	• MP 2.00: South of Edsall Rd • MP 2.50: Between Edsall Rd and Turkeycock Run • MP 3.50: South of Duke St • MP 5.25: South of Seminary Rd • MP 7.50: South of Glebe Road • MP 10.50: Boundary Channel Drive to George Washington Memorial Pkwy • MP 10.75: George Washington Memorial Pkwy to Potomac River
SB HOV/ HOT	3.3	5.0	• MP 7.75: North of Glebe Rd • MP 8.25: Between Glebe Rd and Arlington Ridge Rd • MP 9.50: Joyce St to Hayes St • MP 9.75: Hayes St to Eads St • MP 10.50: Boundary Channel Drive to George Washington Memorial Pkwy • MP 10.75: George Washington Memorial Pkwy to Potomac River

Table 4-4: I-395 Critical Crash Locations based on Crash Rate

I-395 Facility	Average Crash Rate (crashes per 100 million VMT[1] per 0.25-mile segment)	85th-Percentile Critical Crash Rate (crashes per 100 million VMT[1] per 0.25-mile segment)	Locations with Crash Frequency ≥ 85th-Percentile Critical Crash Rate
NB General Purpose	118.9	187.9	• MP 2.00: South of Edsall Rd • MP 3.75: Duke St • MP 4.00: North of Duke St • MP 10.25: South of Boundary Channel Drive • MP 10.50: Boundary Channel Drive to George Washington Memorial Pkwy • MP 10.75: George Washington Memorial Pkwy to Potomac River
SB General Purpose	113.5	161.0	• MP 3.75: Duke St • MP 4.00: North of Duke St • MP 4.25: In Vicinity of Off-Ramp to Duke St • MP 4.50: South of Richenbacher Ave • MP 7.50: South of Glebe Rd • MP 8.75: South of Arlington Ridge Rd • MP 9.00: South of Washington Blvd
NB HOV/ HOT	108.9	181.1	• MP 2.00: South of Edsall Rd • MP 2.50: Between Edsall Rd and Turkeycock Run • MP 3.50: South of Duke St • MP 5.25: South of Seminary Rd • MP 9.50: Joyce St to Hayes St • MP 10.75: George Washington Memorial Pkwy to Potomac River
SB HOV/ HOT	38.8	68.3	• MP 2.75: South of Turkeycock Run • MP 3.25: North of Turkeycock Run • MP 7.75: North of Glebe Rd • MP 9.50: Joyce St to Hayes St • MP 9.75: Hayes St to Eads St • MP 10.50: Boundary Channel Drive to George Washington Memorial Pkwy

[1] VMT = Vehicle Miles Traveled

4.1.2 I-395 Ramp Crashes

Crashes reported along the I-395 ramps within the study area were analyzed separately from crashes reported within the general purpose and HOV/HOT lanes. Ramp crashes were identified based on the roadway data fields included in VDOT's crash data, specifically the route number. A total of 325 crashes were reported on the I-395 ramps within the study area, including 127 (39 percent) rear end crashes, 100 (31 percent) fixed object crashes, and 47 (14 percent) angle crashes. A summary of the number of crashes for each ramp by crash severity is shown in **Table 4-5**. As shown, 99 (30 percent) crashes resulted in personal injuries and one crash resulted in a fatality. The fatal crash occurred on Thursday, August 16, 2012 at approximately 2:30 AM along the southbound off-ramp to westbound Duke Street (Exit 3B). The fatal crash involved an impaired driver.

Of the 325 total reported ramp crashes, 57 (18 percent) crashes occurred on wet/snow/ice-covered roadways. The northbound I-395 off-ramp to southbound Glebe Road (Exit 7A) had the highest number of reported crashes during the study period with 31 crashes (8 crashes per year). The majority of these crashes occurred in the vicinity of the first horizontal curve after departing the northbound general purpose travel lanes. One crash was reported at both the northbound and southbound HOV lane exit ramps to Eads Street during the study period. Three crashes were reported on the ramp from the HOV lanes to the general purpose lanes located south of Eads Street.

Table 4-5: I-395 Ramp Crash Frequency Summary (January 2012 – December 2015)

Facility	Ramp	Fatal Crashes	Injury Crashes	Property Damage Only Crashes	Total
NB General Purpose	NB GP Frontage Road at Seminary Rd	0	13	17	30
	NB GP Exit 2A	0	11	12	23
	NB GP Exit 2B	0	1	2	3
	NB GP to NB HOV at Turkeycock Run	0	0	2	2
	NB GP Exit 3A	0	1	4	5
	NB GP Exit 3B	0	3	5	8
	NB GP Exit 5A	0	0	2	2
	NB GP Exit 5B	0	3	1	4
	NB GP Exit 6A	0	4	4	8
	NB GP Exit 6B	0	1	2	3
	NB GP Exit 7A	0	9	22	31
	NB GP Exit 7B	0	8	4	12
	NB GP Exit 8A	0	2	8	10
	NB GP Exit 8B	0	3	7	10
	NB GP Exit 8C	0	2	7	9
	SB Route 110 to NB GP	0	0	1	1
	NB GP Exit 10A	0	2	2	4
	NB GP Exit 10B	0	1	0	1
	NB GP Exit 10C	0	4	11	15
NB HOV	NB HOV to S. Eads St	0	0	1	1
SB General Purpose	SB GP Exit 4	0	8	20	28
	SB GP Frontage Rd at Glebe Rd	0	10	20	30
	SB GP Exit 2A	0	0	2	2
	SB GP Exit 2B	0	0	1	1
	SB GP to SB HOV at Turkeycock Run	0	0	4	4
	SB GP Exit 3A	0	2	3	5
	SB GP Exit 3B	1	1	17	19
	SB GP Exit 5A	0	1	5	6
	SB GP Exit 5B	0	1	2	3
	SB GP Exit 6A	0	2	5	7
	SB GP Exit 6B	0	0	1	1
	SB GP Exit 7	0	4	9	13
	SB GP Exit 8A	0	0	5	5
	SB GP Exit 8B	0	1	5	6
	SB GP Exit 8C	0	0	2	2
	SB GP Exit 9	0	0	2	2
	SB GP Exit 10A	0	1	1	2
	SB GP Exit 10C	0	0	3	3
SB HOV	SB HOV to SB GP near northern terminus of reversible HOV lanes	0	0	3	3
	SB HOV to S. Eads St	0	0	1	1
	TOTAL	**1**	**99**	**225**	**325**

4.2 QUANTITATIVE SAFETY ANALYSIS

AASHTO's *Highway Safety Manual* (HSM), published in 2010, presents a variety of quantitative methods for estimating crash frequency or severity for various facility types. In 2014, a supplement for the HSM was released which includes two new chapters to estimate crash frequency for both freeways and ramps. There are two tools available for implementing the predictive method of the HSM for freeway facilities - the Interactive Highway Safety Design Model (IHSDM) and Enhanced Interchange Safety Analysis Tool (ISATe). The Traffic Operations Analysis Tool Selection Matrix included in **Appendix D** of the Traffic Operations and Safety Analysis Manual (TOSAM), Version 1.0 (VDOT TOSAM, 2015) specifies the use of the IHSDM or ISATe; however, according to Chapter 18 of the HSM and the ISATe Users Manual, "the predictive method for freeways does not account for the influence of reversible lanes." Also, a freeway segment is defined as "a length of freeway consisting of several through lanes with a constant cross section providing two directions of travel in which the opposing travel lanes are physically separated by a median." These statements indicate that the IHSDM and ISATe tools are not applicable to the reversible HOV facility located between the I-395 northbound and southbound general purpose lanes where the majority of physical improvements are located. A quantitative HSM analysis of the I-395 general purpose lanes could be performed using the IHSDM or ISATe; however, since minimal physical modifications are proposed to the general purpose lanes, the analysis would provide little benefit in terms of informing decision making and selection of a preferred alternative.

Therefore, the quantitative safety analysis focuses on the review of available crash modification factors (CMFs) and their application to the conversion from two HOV lanes to three HOT lanes and improvements to the Eads Street Interchange.

4.2.1 HOV Lane Conversion from Two to Three Lanes

The Build Alternative would convert the two existing reversible HOV lanes to HOT lanes and construct an additional HOT lane between Turkeycock Run and Eads Street near the Pentagon. The additional HOT lane would be constructed along the existing roadway alignment of the existing HOV lanes between the northbound and southbound I-395 general purpose lanes by reducing the travel lane width from 12-feet to 11-feet and reducing the shoulder widths. The additional travel lane has the potential to increase safety by increasing capacity and, thus, reducing congestion which is frequently a contributing factor in crashes. However, the Build Alternative also requires design exceptions and waivers that have the potential to decrease safety and increase the potential for crashes.

The *Crash Modification Factors Clearinghouse* is a web-based comprehensive listing of available crash modification factors (CMF) including both those included and not included in the HSM. A CMF is a multiplicative factor used to compute the expected number of crashes after implementing a given countermeasure at a specific site. CMFs with higher reliability are typically included in the HSM. Based on a review of the *Crash Modification Factors Clearinghouse* and the HSM, a CMF does not currently exist for converting a two-lane reversible HOV facility to a three-lane reversible HOV/HOT facility. Although no CMF is available, the additional roadway capacity would reduce the potential for congestion-related rear end and sideswipe crashes in both the general purpose and HOV lanes.

A summary of individual design elements that may contribute to safety along I-395 within the study limits is discussed below. Many of the design elements are not quantifiable in terms of their impacts on safety.

Where quantifiable benefits cannot be documented, a qualitative discussion of the safety impacts is provided. CMFs discussed below are primarily outlined in Chapter 18 of the HSM which does not account for reversible lanes and are based on two-direction freeway segments (see discussion above). Furthermore, CMFs are developed assuming a facility operates in the same direction at all times. The proposed I-395 Express Lanes would be reversible, single-direction travel lanes; therefore, the CMFs are applied with the intention of identifying the relative safety of various design elements and are not intended to predict the frequency of future crashes. For these reasons, caution should be used when applying the methodologies of the HSM (including CMFs) to the Build Alternative.

- The two existing 12-foot HOV lanes would be reduced to three 11-foot HOT lanes. Chapter 18 of the HSM, provides a CMF to describe the relationship between lane width and predicted crash frequency for freeway segments. Based on this, the predicted crash frequency for multi-vehicle and single-vehicle crashes of all severities may increase by approximately 4 percent or less than one crash per year.

- The inside shoulder width for travel in the northbound direction of the HOV lanes would be decreased to 2 feet to accommodate the additional HOT lane. Currently, a 10-foot inside shoulder (minimum) is provided on both sides of the HOV lanes. Chapter 18 of the HSM provides a CMF to describe the relationship between inside shoulder width and predicted crash frequency for freeway segments. The CMF is applicable to all crash types of all severities. Based on this, reducing the inside shoulder may increase crash frequency for northbound fatal and injury crashes by approximately 15 percent or 1.0 crashes per year and increase crash frequency for northbound property damage only crashes by approximately 13 percent or 3.5 crashes per year.

- The outside shoulder width for travel in the southbound direction of the HOV lanes would be decreased to 2 feet to accommodate the additional HOT lane. Currently, a 10-foot outside shoulder (minimum) is provided on both sides of the HOV lanes. Chapter 18 of the HSM provides a CMF to describe the relationship between outside shoulder width and predicted crash frequency for freeway segments. The CMF is applicable to single-vehicle crashes only of all severities. Based on this, reducing the outside shoulder may increase the frequency of single-vehicle, southbound fatal and injury crashes by approximately 92 percent or 1.6 crashes per year and increase the frequency of single-vehicle, southbound property damage only crashes by approximately 64 percent or 2.5 crashes per year.

- Currently, a double-faced guardrail is generally provided on both sides of the HOV lanes between Turkeycock Run and approximately Shirlington Road to separate the HOV lanes from the general purpose lanes. As part of the proposed improvements, the existing double-faced guardrail would be replaced with concrete barrier. There is currently no CMF for the conversion of existing median barrier from double-faced guardrail to concrete barrier. FHWA identifies three basic categories of median barriers: rigid barrier systems (e.g., concrete barrier), semi-rigid barrier systems (e.g., guardrail), and flexible barrier systems (e.g., high-tension cable). Per FHWA, concrete barriers "have proven to be highly effective in locations with high traffic volumes and high speeds" (USDOT FHWA, 2015). Additionally, the need for little to no maintenance following a crash with a concrete barrier as compared to guardrail is likely to reduce the vulnerability of subsequent crashes that could occur prior to addressing the maintenance need. It should be noted that the HSM

includes a CMF for the *presence* of a median barrier; however, it is not applicable to the Build Alternative.

- Traffic Management System (TMS) elements would include a suite of closed circuit television cameras (CCTV) providing full video coverage of the Express Lanes to the Express Lanes Operations Center, microwave vehicle detectors to monitor traffic flow, and a Lane Use Management System (LUMS) consisting of lane use arrows above each lane. The LUMS would provide advance notice of any closures or breakdowns to approaching motorists and would include variable speed limit signs, advising motorists of the desired speed based on downstream traffic conditions. Per the CMF Clearinghouse, installing variable speed limit signs has a CMF of 0.92. Based on this, installing variable speed limit signs may decrease all crashes by 8 percent or approximately 4 crashes per year. No CMFs are available for the other TMS elements; however, installation of these devices would improve the Express Lanes operators' ability to remotely detect and visually verify reported incidents and congestions levels. This would lead to more rapid response to and clearing of incidents. The TMS including the LUMS would enable the Express Lanes operators to provide more reliable information to motorists in the Express Lanes, which reduces the potential for secondary crashes.

Table 4-6 summarizes the relevant CMFs (lane width, inside shoulder width, outside shoulder width) discussed above. The CMFs were applied to the northbound and southbound HOV/HOT lanes from Turkeycock Run to Eads Street and the existing four-year crash study period to calculate the predicted crash frequency per year for each element. However, as previously noted, the results are intended to identify relationships between design elements and safety but are not intended to predict the frequency of future crashes due to the limitations of the HSM for this situation.

According to Chapter 3 of the HSM, there is limited understanding of the interrelationships between various countermeasures; therefore, it is difficult to quantify the impacts of multiple CMFs. One proposed method of quantifying multiple CMFs is to multiply the CMFs together; however, this assumes that the countermeasures are independent of each other. Many of the CMFs shown in **Table 4-6** address similar crash types and could be considered dependent; therefore, quantifying the combined impact of all the project elements was not pursued. As noted above, although many of the elements of the project that would provide safety benefits including the additional of a third travel lane, the TMS, and the installation of concrete median barrier are likely to reduce the potential for crashes, their benefits are not quantifiable with CMFs. Therefore, the potential increase in crashes due to the reduction of typical section elements (i.e., lane width and shoulder width) may be offset by these other design elements in addition to the improvements at the Eads Street Interchange as discussed in **Section 4.2.2.**

Table 4-6: Predicted Crash Frequency/CMF Summary for I-395 HOV Lanes from Turkeycock Run to Eads Street

Design Element	Crash Type[1] (Severity)	CMF[2]	Applicable Facility	Existing Crash Frequency[3] (crashes/yr)	Predicted Crash Frequency[2] (crashes/yr)
Lane Width[4] Reduce from 12 to 11 feet	MV; SV (fatal and injury)	1.038	NB & SB HOV	12.3	12.7 (+0.4)
Inside Shoulder Width[5] Reduce from 10 to 2 feet	MV; SV (fatal and injury)	1.148	NB HOV	7.3	8.3 (+1.0)
	MV; SV (PDO)	1.130		27.0	30.5 (+3.5)
Outside Shoulder Width[6] Reduce from 10 to 2 feet	SV (fatal and injury)	1.924	SB HOV	1.8	3.4 (+1.6)
	SV (PDO)	1.635		4.0	6.5 (+2.5)
Install Variable Speed Limit Signs[7]	MV; SV (all severities)	0.920	NB & SB HOV	51.3	47.2 (-4.1)

[1] MV = Multiple Vehicle Crashes; SV = Single Vehicle Crashes; PDO = Property Damage Only
[2] CMFs found in Chapter 18 of the HSM do not account for reversible, one-directional lanes (e.g., I-395 Express Lanes); therefore, the results are intended to identify relationships between design elements and safety and are not indented to predict the frequency of future crashes
[3] Four-year crash study period from January 1, 2012 through December 31, 2015 from Turkeycock Run to Eads Street
[4] Source: *Highway Safety Manual* Equation 18-25
[5] Source: *Highway Safety Manual* Equation 18-26
[6] Source: *Highway Safety Manual* Equation 18-35
[7] Source: CMF Clearinghouse – CMF ID 3340

4.2.2 Eads Street Interchange

Several alternatives were considered at the Eads Street Interchange as discussed in the ***Alternatives Technical Report*** (VDOT, 2016). The Dual Reversible Ramps concept would increase capacity to and from Eads Street by dividing traffic between two ramps - one for traffic traveling to and from the Pentagon and one for traffic traveling to and from Army Navy Drive. Another key element of the Eads Street Interchange improvements is the removal of the ramp from the southbound I-395 HOV lanes to the southbound I-395 general purpose lanes located just south of the Eads Street Interchange. Currently, there is a weave condition between the on-ramp from Eads Street and the off-ramp to the general purpose lanes.

Based on a review of crash data, this location has the highest crash rate reported during the four-year study period with a crash rate of 134 to 198 crashes per 100 million VMT compared to the average corridor-wide rate of 39 crashes per 100 million VMT within the southbound HOV/HOT lanes. Of the 68 crashes reported within the southbound HOV lanes from Turkeycock Run to Eads Street, 21 (31 percent) crashes occurred at this location. Three additional crashes were reported on this ramp. Removal of this ramp would eliminate the weave condition and reduce the potential for crashes in this area. Additionally, increasing the capacity of the on and off-ramps serving the Eads Street Interchange would reduce the potential for congested-related crashes at the Eads Street Interchange. Based on a review of the crash data, two crashes were reported on the Eads Street ramps to/from the HOV lanes. There are no available CMFs that are applicable to the specific interchange configuration proposed at Eads Street due to the atypical configuration of the reversible ramps; however, additional geometric elements of the improvements at the Eads Street

Interchange and their implications on safety would be further documented in the Interchange Modification Report.

5. FUTURE CONDITIONS

Future traffic conditions for the 2040 design year were evaluated for both No Build and Build conditions. This section summarizes the methodology used to develop the 2040 design year traffic volume forecasts and the results of the traffic analysis for both No Build and Build conditions. In addition, traffic conditions, in the vicinity of the Eads Street Interchange were evaluated for year 2020 interim year conditions due to the proposed interim improvements located within the Pentagon South Parking lot as described in **Section 5.5.3**.

5.1 NO BUILD PROJECTS

The traffic forecasts and analysis for the No Build conditions include all projects funded through construction in VDOT's Fiscal Year (FY) 2016-2021 Six-Year Improvement Program (SYIP) and the Metropolitan Washington Council of Governments (MWCOG) Constrained Long-Range Transportation Plan (CLRP) for the National Capital Region. **Table 5-1** summarizes the No Build projects in the vicinity of the study area. The corridor-specific No Build projects are discussed in more detail below:

5.1.1 I-395 HOV / Transit Ramp at Seminary Road

This project includes the construction of a south-facing ramp between the I-395 HOV lanes and the third level of the Seminary Road Interchange that provides access for HOV and transit vehicles along I-395 to the south of the interchange. The HOV ramp is reversible and permits northbound traffic to exit to Seminary Road in the morning hours and permits traffic from Seminary Road to access the southbound I-395 HOV lanes in the afternoon and evening hours. The ramp was opened to traffic in January 2016. Additional project information is located at: http://www.virginiadot.org/projects/northernvirginia/i-395_hov-transit_ramp.asp (accessed 7/25/16).

5.1.2 12th Street Extension

This public-private project involves the construction of 12th Street between S. Eads Street and S. Fern Street to accommodate two-way traffic. Traffic signal upgrades are planned at the intersections of 12th Street with S. Eads Street and with S. Fern Street. The project is currently under construction by private developers and the street will be turned over to Arlington County once complete. Additional project information is located at: https://projects.arlingtonva.us/projects/12th-street-south-extension/ (accessed 7/25/16).

5.1.3 I-395 4th Lane South Widening – Duke Street to Edsall Road

This project involves the construction of a fourth lane along southbound I-395 to provide one additional through lane from north of Duke Street to south of Edsall Road. Work will include interchange modifications at both Edsall Road and Duke Street to accommodate the additional through lane and to reduce weaving issues along southbound I-395. At the Duke Street / Little River Turnpike Interchange, the loop ramp serving southbound I-395 to eastbound Duke Street traffic will be removed and replaced with a traffic signal. At the Edsall Road Interchange, the loop ramp serving westbound Edsall Road to southbound I-395 traffic will be removed and replaced with a traffic signal. The project is currently in design and will be advertised and constructed concurrently with the I-395 Express Lanes project. Additional project information is located at: http://www.virginiadot.org/projects/northernvirginia/i-395_south_-_duke_to_edsall.asp (accessed 7/25/16).

Table 5-1: No Build Improvements

Project/Study	Description	Completion Date
I-395 HOV / Transit Ramp at Seminary Road [1]	Construction of a south-facing ramp to and from the HOV lanes to the top level of the Seminary Road Interchange that provides additional access for HOV and transit	Jan 2016
12th Street Extension [2]	Construct 12th Street between S. Eads Street and S. Fern Street	2016
I-395 4th Lane South Widening – Duke Street to Edsall Road	Widening of southbound I-395 to provide one additional through lane from north of Duke Street to south of Edsall Road	2019
Seminary Road and Beauregard Street Ellipse	Modification of the intersection to an ellipse design to eliminate weaving issues on westbound Seminary Road and increase capacity	2020
Boundary Channel Drive Interchange	Interchange modifications to improve operations and reduce weaving along southbound I-395 including constructing two roundabouts, providing connections to Long Bridge Drive and US Route 1, and multi-modal improvements	Summer 2021
Army Navy Drive Complete Streets [3]	Multi-modal improvements along Army Navy Drive between South Joyce Street and 12th Street including constructing a dedicated bicycle facility and improving transit accommodations	2021
Arlington National Cemetery Southern Expansion Project and Associated Roadway Realignment	Interchange improvements to remove the NW and SW ramps and conversion to a diamond configuration to increase the contiguous area of Arlington National Cemetery	TBD [4]
Pentagon South Parking Lot Improvements	Reconfiguration of the South Parking Lot as part of the Pentagon Master Plan	TBD [5]

[1] Not included in base year conditions due to recent opening of the HOV ramp and adjustment period required for full utilization of the ramp
[2] Not included in the CLRP, but currently under construction
[3] Not included in the CLRP; however, funding for the project was included in the approved Arlington County 2015-2024 CIP
[4] Sponsoring agencies are planning to incorporate this project into 2017 CLRP; anticipate completion between 2020 and 2040
[5] The South Parking Lot Improvements associated with the Pentagon Master Plan will be completed following construction of the interim improvements to the South Parking Lot that are incorporated into the I-395 Express Lanes Extension

5.1.4 Seminary Road and Beauregard Street Ellipse

This project involves modifications to the existing Seminary Road at Beauregard Street intersection to an ellipse design to eliminate weaving issues along westbound Seminary Road and to increase capacity of the intersection. The existing intersection will be shifted slightly to the south to accommodate eastbound Beauregard Street. A new signalized intersection with Seminary Road to the north will accommodate westbound Beauregard Street. Left-turning vehicles along Seminary Road will be directed into the ellipse to access Beauregard Street. Additional signalized access will be provided for the South Tower Apartments. The project is included in the CLRP and currently scheduled to be complete in 2020. Additional project information is located at:

https://www.alexandriava.gov/uploadedFiles/BeauregardPlanTransportationAnalysisFinal.pdf (accessed 7/25/16).

5.1.5 Boundary Channel Drive Interchange

This project involves modifications to the existing I-395 and Boundary Channel Drive Interchange to improve operations and reduce weaving along southbound I-395. The project will include construction of two single-lane roundabouts at the I-395 ramp termini with Boundary Channel Drive. Additionally, connections to Long Bridge Park Drive and US Route 1 will be constructed and multi-modal improvements will be incorporated. An Interchange Modification Report (IMR) is currently being prepared by Arlington County and the project is scheduled to be completed in 2021. Additional project information is located at: https://projects.arlingtonva.us/projects/boundary-channel-drive-interchange/ (accessed 7/25/16).

5.1.6 Army Navy Drive Complete Streets

This project includes the construction of multi-modal improvements along Army Navy Drive between S. Joyce Street and 12th Street and will include a dedicated bicycle facility and improved transit accommodations. Funding for the project was included in the approved Arlington County 2015-2024 Capital Improvement Program (CIP). Preliminary engineering is underway with construction anticipated to begin in 2019 and project completion in 2021. Additional project information is located at: http://www.crystalcity.org/area/transformation/army-navy-drive-complete-streets-project (accessed 7/25/16).

5.1.7 Arlington National Cemetery Southern Expansion Project and Associated Roadway Realignment

This project includes modifications to the Washington Boulevard at Columbia Pike (East) Interchange and the realignment of Columbia Pike from S. Joyce Street to the west to increase the contiguous acreage of Arlington National Cemetery. The interchange modifications include the removal of the northwest and southwest loop ramps and converting the interchange to a partial diamond configuration. Southbound Washington Boulevard will access Columbia Pike at a new signalized intersection and access from Columbia Pike to southbound Washington Boulevard will also be provided at the new signal. Columbia Pike will be realigned to the south of its current location.

Arlington National Cemetery, the lead agency for the project, has been working with Arlington County and VDOT to pursue to the roadway modifications and land exchange agreement. The U.S. Army Corps of Engineers is preparing an Environmental Assessment for the project. The project is not included in the CLRP; however, sponsoring agencies are planning to incorporate this project into 2017 CLRP. Additional project information is located at: http://www.nao.usace.army.mil/Missions/Military-Construction/ANCSouthernExpansion/ (accessed 7/25/16).

5.1.8 Pentagon Master Plan South Parking Lot Improvements

The 2015 Master Plan Update for the Pentagon Reservation establishes a long-term vision for the Pentagon and surrounding facilities and includes a reconfiguration of the Pentagon South Parking Lot as shown in **Figure 5-1** (WHS, 2015). The Pentagon Reservation, including the Pentagon Transit Center, accommodates more than 23,000 employees and commuters using the transit center traveling to and from

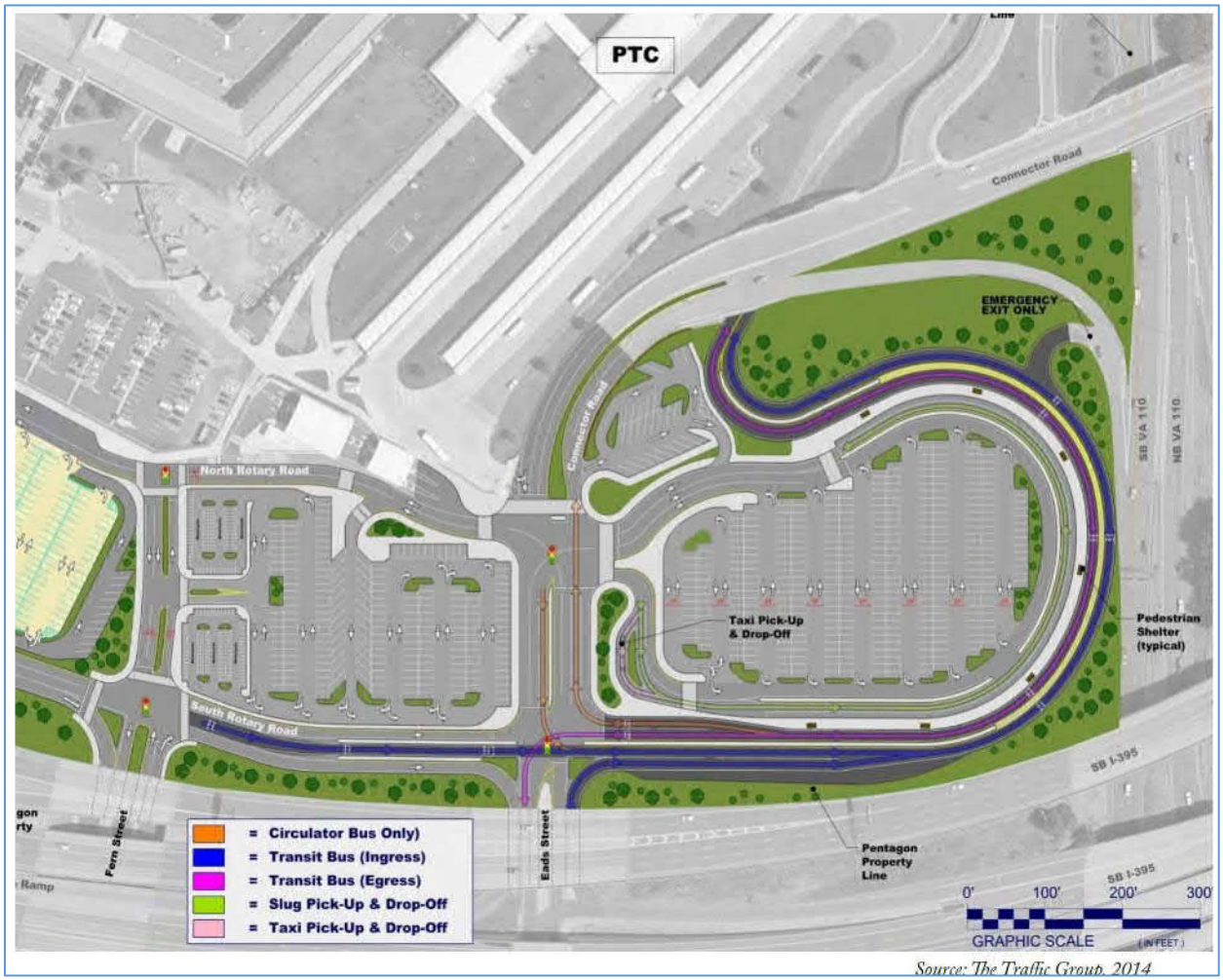
the site every day. Modifications to the Eads Street Interchange have the potential to affect traffic circulation at the Pentagon Reservation.

As shown in **Figure 5-1**, the South Parking Lot improvements include the following major components:

- Direct access to the Pentagon Transit Center via a dedicated two-way bus loop that circulates on the eastern perimeter of the South Parking Lot. Transit vehicles will be separated from passenger vehicles and substantial pedestrian conflicts along North Rotary Road.
- Traffic signalization at the Eads Street at South Rotary Road and Eads Street at North Rotary Road intersections. These signals will be coordinated to provide smooth traffic flow and would be coordinated with the signals along Eads Street at the I-395 HOT ramps and Army Navy Drive.
- A dedicated ridesharing (slugging) area within the bus loop to accommodate the substantial ridesharing that occurs within this portion of the South Parking Lot.
- A fourth lane along EB South Rotary Road approaching Eads Street that will be used to access the future HOT lanes.

The exact timing of the implementation of the proposed South Parking Lot Improvements is not known at this time and is dependent on federal approvals and funding availability. As such, VDOT and 95 Express have collaborated with Pentagon staff to develop an interim improvement for the South Parking Lot (see **Section 3.3.2.3**) that is consistent with the longer term Master Plan improvements and would allow the Eads Street Interchange to operate effectively until the ultimate improvements are implemented.

Figure 5-1: Pentagon Master Plan South Parking Lot Improvements



Source: The Traffic Group, 2014

5.2 LAND USE AND SOCIOECONOMIC TRENDS

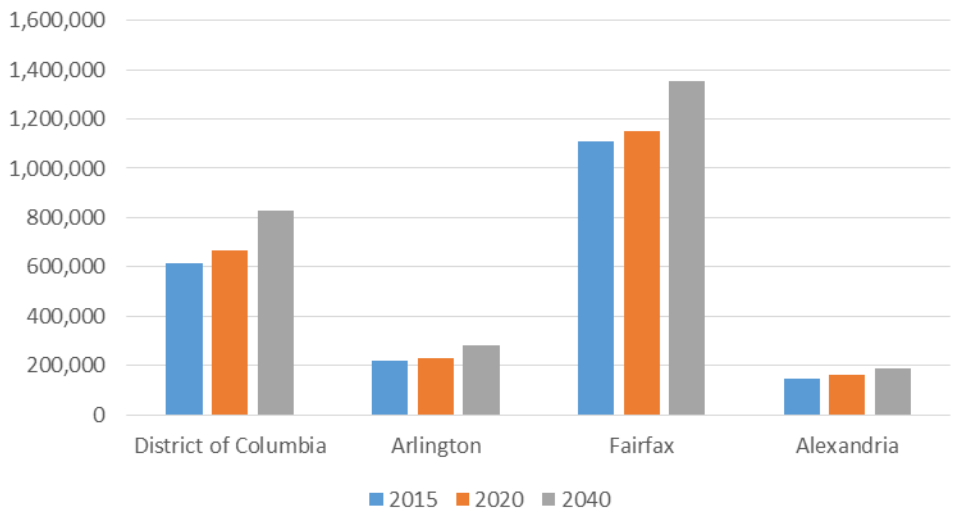
Between 2015 and 2040, the region is expected to increase the number of households by three quarters of a million people and increase the total employment by 1.4 million (see **Table 5-2**). More specific to the I-395 study corridor, the localities within the traffic study area include the District of Columbia, Arlington, Fairfax and Alexandria. Within this portion of the region, the growth in population, households and employment is nearly one third of the regional growth between 2015 and 2040.

Table 5-2: MWCOG Demographic Inputs (Source: MWCOG version 2.3.57a)

Year	Households	Population	Total Employment	Industrial	Retail	Office	Other
2015	2,632,300	6,910,868	4,095,480	454,363	750,599	2,039,077	851,441
2020	2,807,126	7,331,949	4,397,669	482,531	803,002	2,213,105	899,031
2040	3,357,575	8,598,702	5,504,157	604,039	994,432	2,810,914	1,094,772

The change in population among the four areas that are included in the traffic study area is shown in **Figure 5-2**. Within the study area, Fairfax has the largest population with nearly 53% of the total 2.1 million in 2015. The total population growth among the four areas is 550,000, increasing it to over 2.6 million by 2040. The District of Columbia is expected to have the largest growth as a percentage of the 2015 population, increasing 35% from 616,000 to 830,000 by 2040.

Figure 5-2: Population Growth by County / City within Traffic Study Area



Household changes between 2015 and 2040 are shown below in **Figure 5-3**. As with population, Fairfax has the most households within the area with a total number of households in 2015 of just over 400,000. All areas within the study area increase in number of households by roughly 30% over the 2015 to 2040 period.

Figure 5-3: Household Growth by County / City within Traffic Study Area

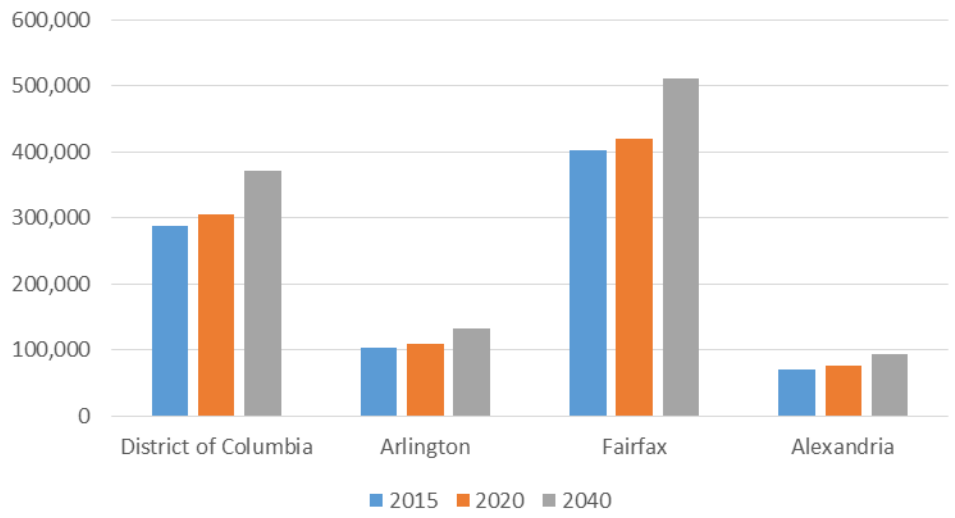
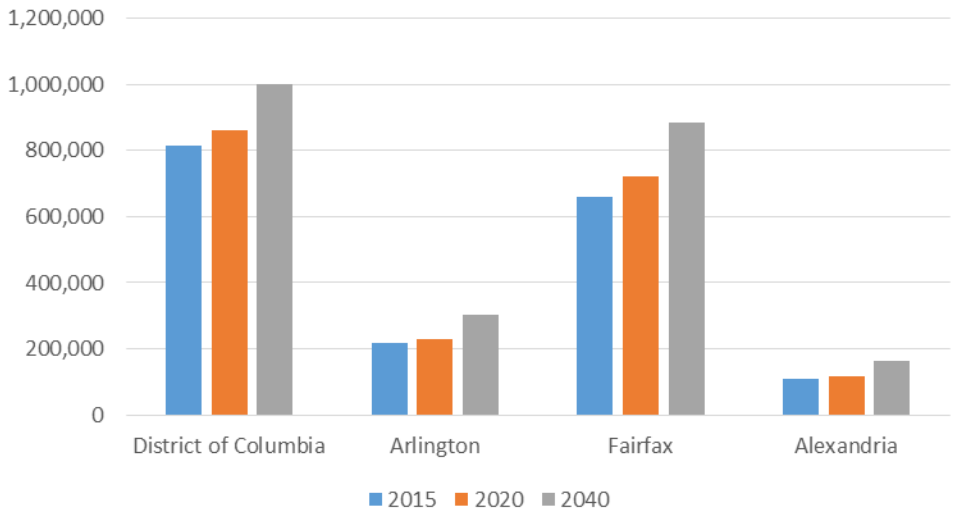


Figure 5-4 displays the growth in total employment in the traffic study area. With respect to employment, the District of Columbia has the highest employment followed by Fairfax. By 2040, the largest growth in employment is within Fairfax, but as a percentage growth, Alexandria is expected to have a 50% increase in employment.

Figure 5-4: Employment Growth by County / City within Traffic Study Area



In the broader scope, looking at all likely users of the corridor, nine localities are identified. The total population, household and employment for 2015, 2020 and 2040 are shown in **Tables 5-3 through 5-5.**

The relative size of each jurisdiction relative to the entire region stays consistent through the forecast years as Fairfax is the largest population area and the majority of the employment is in the District and Fairfax areas.

Table 5-3: Forecasted Population by Jurisdiction

Jurisdiction	2015	2020	2040
Alexandria	145,761	160,668	188,961
Arlington	219,030	229,367	279,715
District of Columbia	616,552	667,271	830,387
Fairfax	1,111,263	1,149,129	1,351,416
Falls Church	13,069	14,169	17,269
Prince William	425,930	468,523	551,501
Stafford	145,519	165,644	246,651
Fredericksburg	22,978	24,260	30,019
Spotsylvania	107,132	118,738	154,521
Total	**2,807,234**	**2,997,769**	**3,650,440**

Table 5-4: Forecasted Households by Jurisdiction

Jurisdiction	2015	2020	2040
Alexandria	71,202	77,352	93,188
Arlington	104,317	109,394	133,319
District of Columbia	287,112	305,550	370,758
Fairfax	402,885	420,328	510,212
Falls Church	5,504	6,204	7,904
Prince William	140,046	156,008	186,086
Stafford	49,673	57,533	87,670
Fredericksburg	10,239	10,969	13,739
Spotsylvania	37,503	42,153	55,567
Total	**1,108,481**	**1,185,491**	**1,458,443**

Table 5-5: Forecasted Employment by Jurisdiction

Jurisdiction	2015	2020	2040
Alexandria	108,712	115,060	163,401
Arlington	219,152	228,897	301,281
District of Columbia	814,952	861,809	1,001,809
Fairfax	661,038	722,083	886,765
Falls Church	12,000	14,300	18,300
Prince William	132,664	151,486	235,360
Stafford	52,681	58,399	84,159
Fredericksburg	35,586	39,662	54,819
Spotsylvania	43,173	46,219	61,356
Total	**2,079,958**	**2,237,915**	**2,807,250**

5.3 FORECASTING METHODOLOGY AND VALIDATION

To provide consistency with the regional planning efforts, the MWCOG Travel Demand Forecasting Model, Version 2.3 Build 57a (adopted on October 21, 2015), also known as the Version 2.3.57a Travel Model was used as the basis for the development traffic forecasts. Models exist for the following years: 2015, 2017, 2020, 2025, 2030, and 2040. The MWCOG Model utilizes a four step trip-based model framework with feedback between traffic assignment and distribution. Memoranda summarizing the travel demand model methodology, calibration, and validation are contained in **Appendices F and G**, respectively. The forecasting methodology was consistent with FHWA's *Interim Guidance on the Application of Travel and Land Use Forecasting in NEPA publication* (USDOT FHWA, 2010).

Model Validation: Prior to using the model for further analysis, the 2015 model network was reviewed for consistency with field conditions, including link coding and number of lanes. The model was validated to ensure reasonable volumes across a set of cutlines and corridors defined to capture the movements in the region.

Time of Day Assignment Model (MWCOG Post Processor): A review of the MWCOG Model periods and I-395 HOV lane operations showed an inconsistency that impacted the overall model calibration and use of the model for project-level forecasts and inputs into the operations models. Specifically, the time periods of operation of the HOV facility do not align well with the MWCOG Model Periods.

Based on the difference between the MWCOG Model periods and the actual I-395 HOV operations, a post process to the MWCOG Model was developed that further disaggregated the MWCOG trip tables to improve the alignment of periods between the model and actual operations as well as improving toll evaluations.

The Post Processor was used to develop the 2015 (existing conditions) and 2040 (No Build and Build) inputs to the operational analysis model as well as provide input to the environmental studies including the air and noise analysis. The MWCOG Model was first run to provide consistency with regional forecasts.

The output of the MWCOG Model was then input to the MWCOG Post Processor to develop the demand matrices used in the VISUM models.

VISUM Model Development: The base year VISUM models (see **Section 2.5.1)** were modified to reflect future committed projects (see **Section 5.1**) to generate the 2040 No Build VISUM models. Signal timings were adjusted to accommodate significant changes in future travel patterns and traffic flows. This was not intended to be a detailed development of signal timings, but to provide the basic operations of the signals that are able to manage future traffic demand. The outputs of the MWCOG Post Processor as described above were used to generate growth rates that were then applied to the base year VISUM matrices to generate the 2040 No Build and Build scenario forecasts.

The future No Build models were then modified to reflect the proposed Build Alternative as discussed in **Section 3.3**.

5.4 FUTURE TRAFFIC VOLUMES

5.4.1 Overview of MWCOG Post Processor Forecasts

Using the I-395 Post Processor the results of the 2040 Build and 2040 No Build scenario were compared to assess the daily impacts of the project on the study area network. As expected, the HOV/HOT lanes in the corridor show an increase in traffic consistent with the increase in capacity of the two HOV lanes to three HOT lanes from Turkeycock Run to Eads Street. The daily difference in volumes on the general purpose lanes is less than a 5% change. The benefit to the general purpose lanes with the reassignment of traffic to the Express Lanes is mitigated by new traffic entering the I-395 corridor as a preferred route and thus maintaining traffic levels near those of the no build scenario.

A review of volume differences between No Build and Build conditions along the arterial system serving I-395 does not show evidence of systematic diversion from the corridor in response to the conversion of the two existing HOV lanes to three HOT lanes. Additionally, the arterial network benefits from increased traffic being drawn to the I-395 facility with some arterials showing improved conditions with lower daily volumes. Based on a review of the daily volume difference along Seminary Road and Shirlington Road / Quaker Lane, the two current access points to the HOV lanes in the southern portion of the study area, daily traffic volumes change by less than 5 percent.

At the north end of the study area in the vicinity of the Eads Street Interchange, there is some reallocation of traffic observed in the MWCOG network with alternative routes being taken as a result of the revised access points associated with the modifications to the Eads Street Interchange.

The following sections describe the daily and peak hour traffic volume changes for both No Build and Build conditions in more detail.

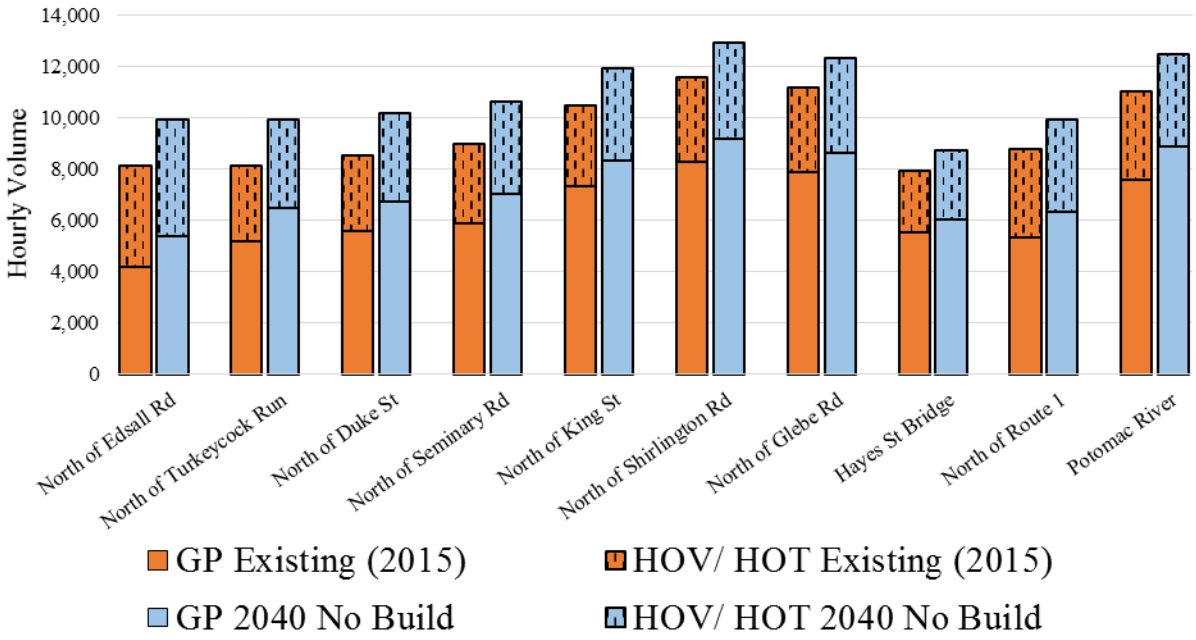
5.4.2 2040 No Build Peak Hour Traffic Volumes

Existing (2015) and 2040 No Build peak hour traffic volumes for northbound and southbound I-395 for both the general purpose and HOV/HOT lanes are summarized in **Figures 5-5 and 5-6**, respectively.

As shown in **Figure 5-5**, in the AM peak hour, northbound I-395 general purpose traffic volumes increase by 900 to 1,300 vehicles per hour between existing and 2040 No Build conditions from north of Edsall Road to north of Shirlington Road. From north of Glebe Road to the Hayes Street bridge (located between Washington Boulevard and Eads Street), traffic volumes increase by 500 to 700 vehicles. North of Route 1 and at the Potomac River crossing, traffic volumes increase by 1,000 to 1,300 vehicles.

Northbound traffic volumes in the HOV/HOT lanes increase by approximately 600 vehicles between Edsall Road and Turkeycock Run and by 300 to 500 vehicles between Turkeycock Run and Hayes Street (located south of Eads Street). North of Route 1, traffic volumes in the HOV lanes increase by approximately 150 vehicles.

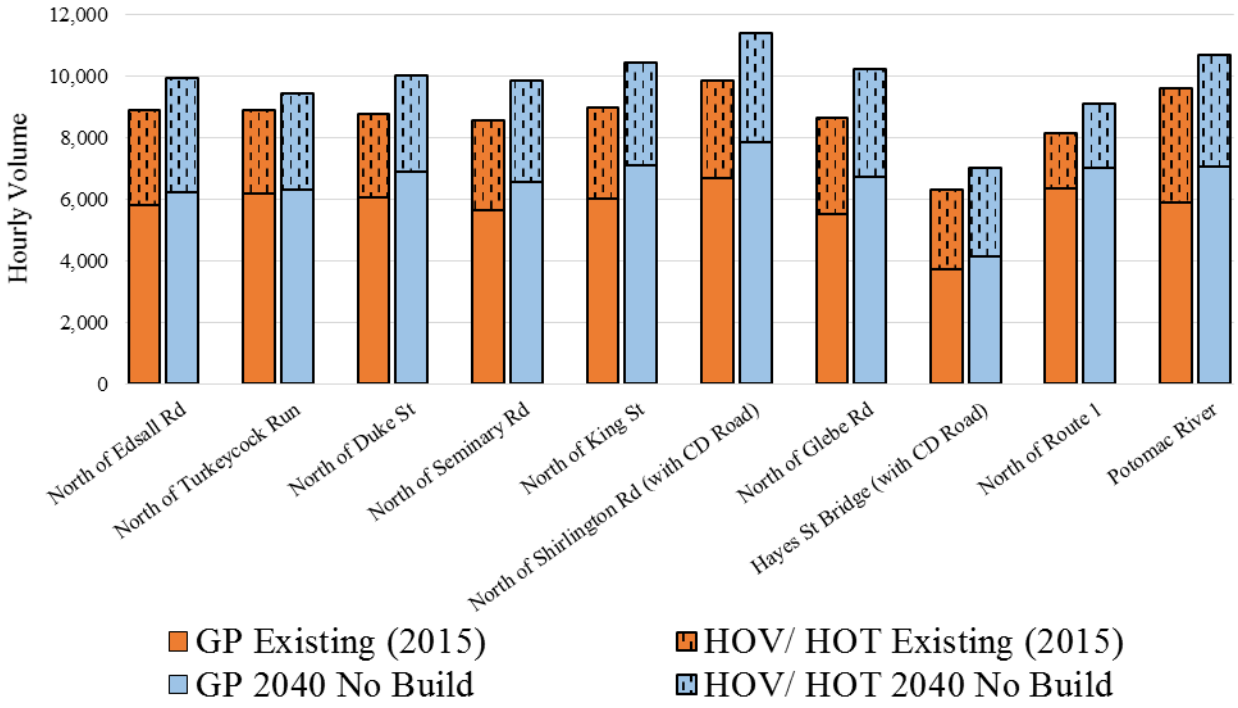
Figure 5-5: Existing (2015) and 2040 No Build AM Peak Hour – Northbound I-395



As shown in **Figure 5-6**, in the PM peak hour, southbound I-395 general purpose traffic volumes increase by 850 to 1,200 vehicles between existing and 2040 No Build conditions from north of Duke Street to north of Glebe Road. Between Turkeycock Run and Duke Street, traffic volume increases are less (approximately 150 vehicles) due to the I-395 4th Lane South Widening – Duke Street to Edsall Road project which relocates southbound traffic entering from Little River Turnpike and Duke Street to a collector-distributor road. From the Hayes Street bridge to north of Route 1, traffic volumes increase by approximately 400 to 700 vehicles. At the Potomac River crossing, traffic volumes increase by approximately 1,100 vehicles.

Southbound traffic volumes in the HOV/HOT lanes increase by approximately 600 vehicles between Edsall Road and Turkeycock Run and by 350 to 400 vehicles from Turkeycock Run to north of Glebe Road. Between Hayes Street (located south of Eads Street) and north of Route 1, traffic volumes in the HOV lanes increase by 250 to 300 vehicles.

Figure 5-6: Existing (2015) and 2040 No Build PM Peak Hour – Southbound I-395



Figures 5-7a through 5-7e depict the balanced peak hour traffic volumes along both the I-395 mainline and ramps for 2040 No Build conditions. AM and PM peak hour intersection traffic volumes for 2040 No Build conditions are included in **Appendix H**.

Figure 5-7a: 2040 No Build Peak Hour Traffic Volumes

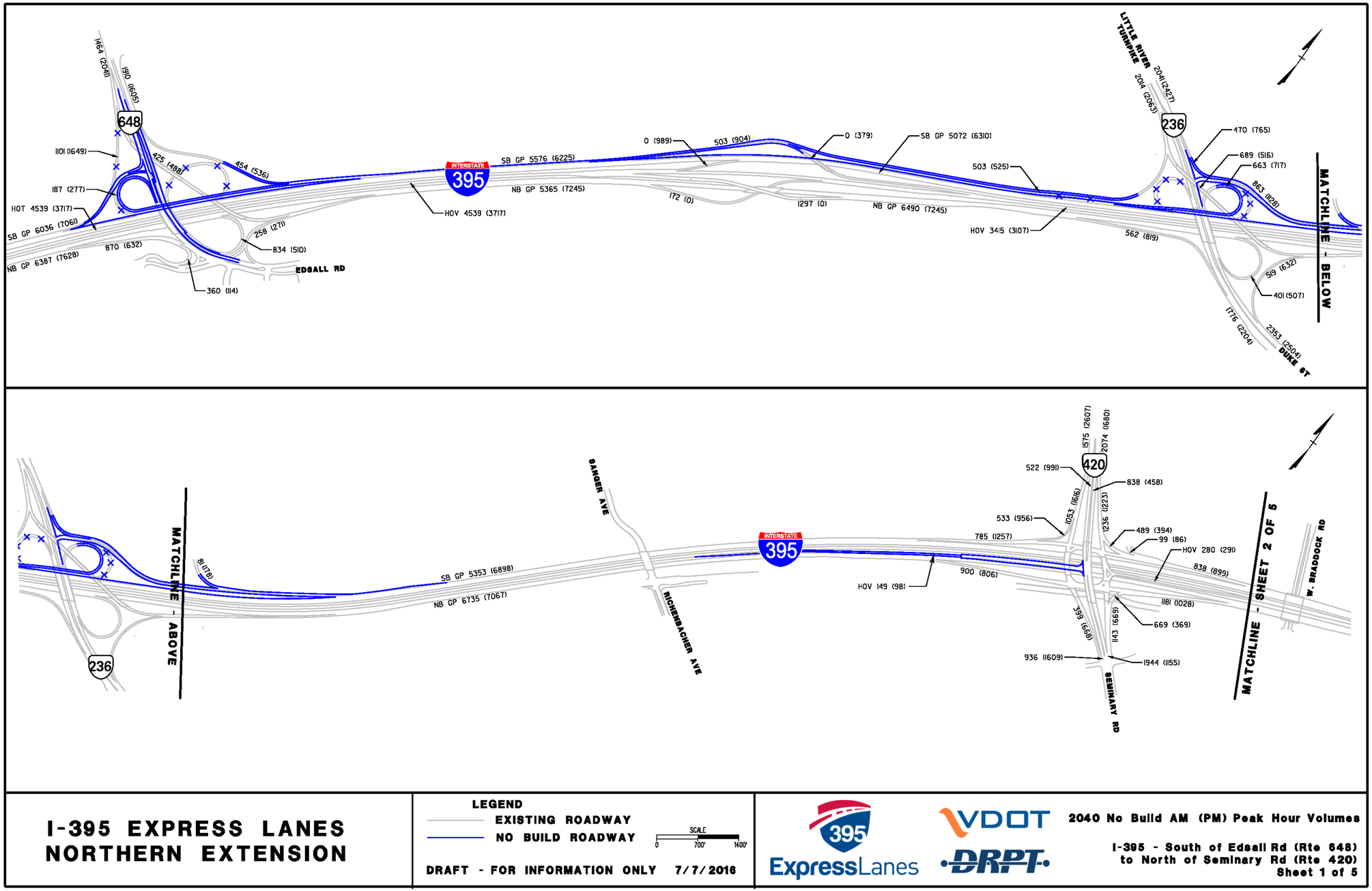


Figure 5-7b: 2040 No Build Peak Hour Traffic Volumes

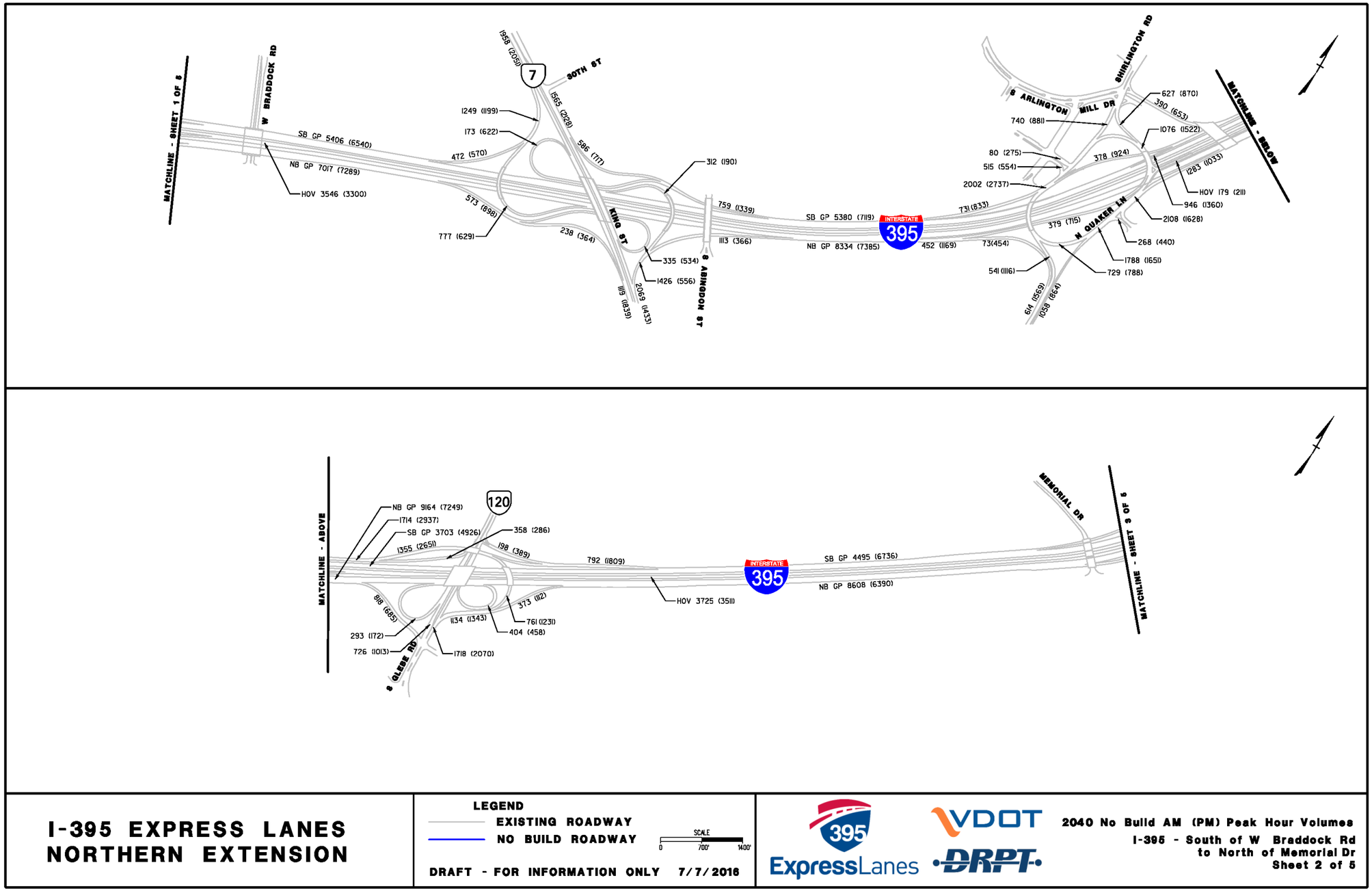


Figure 5-7c: 2040 No Build Peak Hour Traffic Volumes

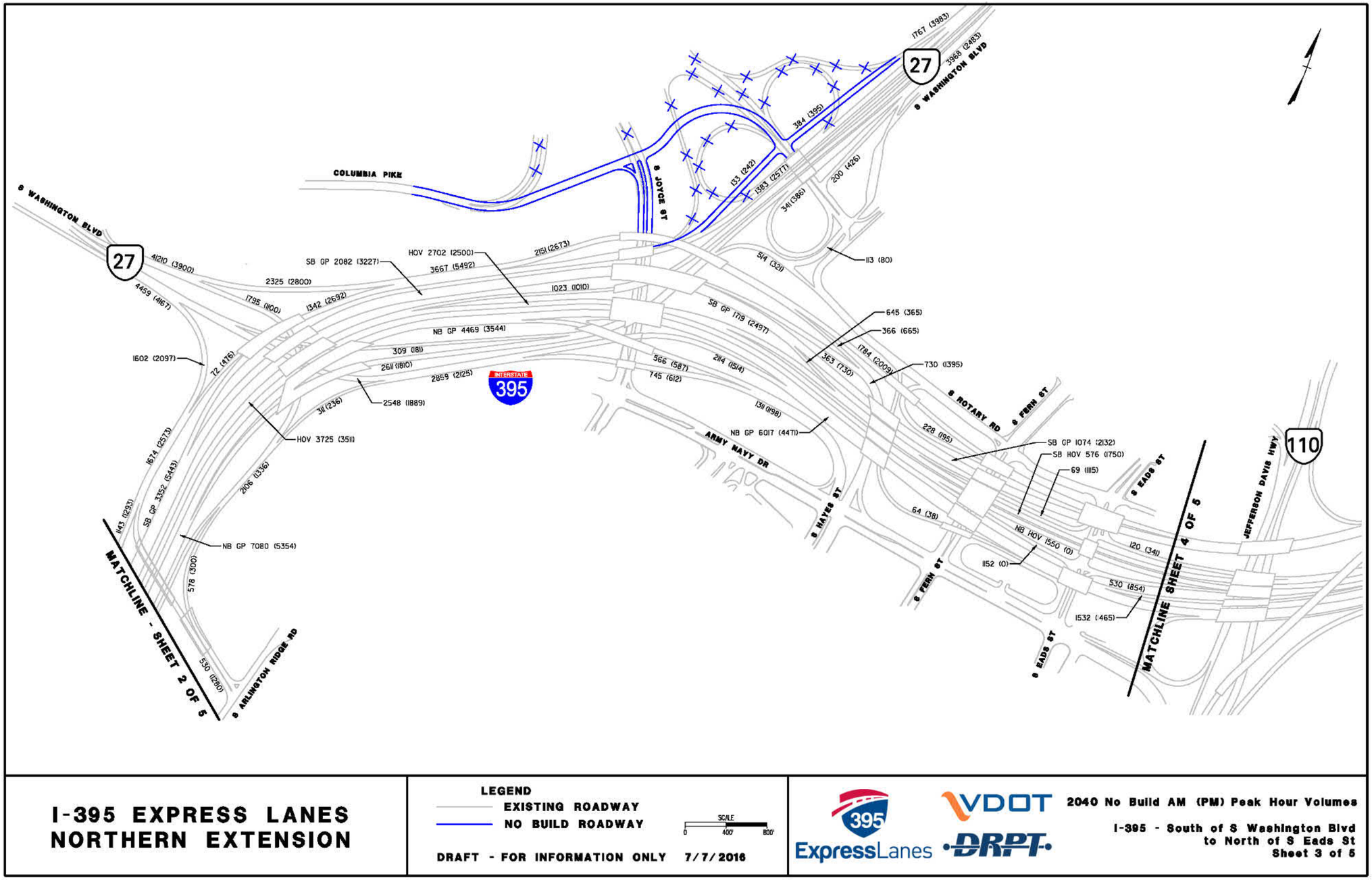
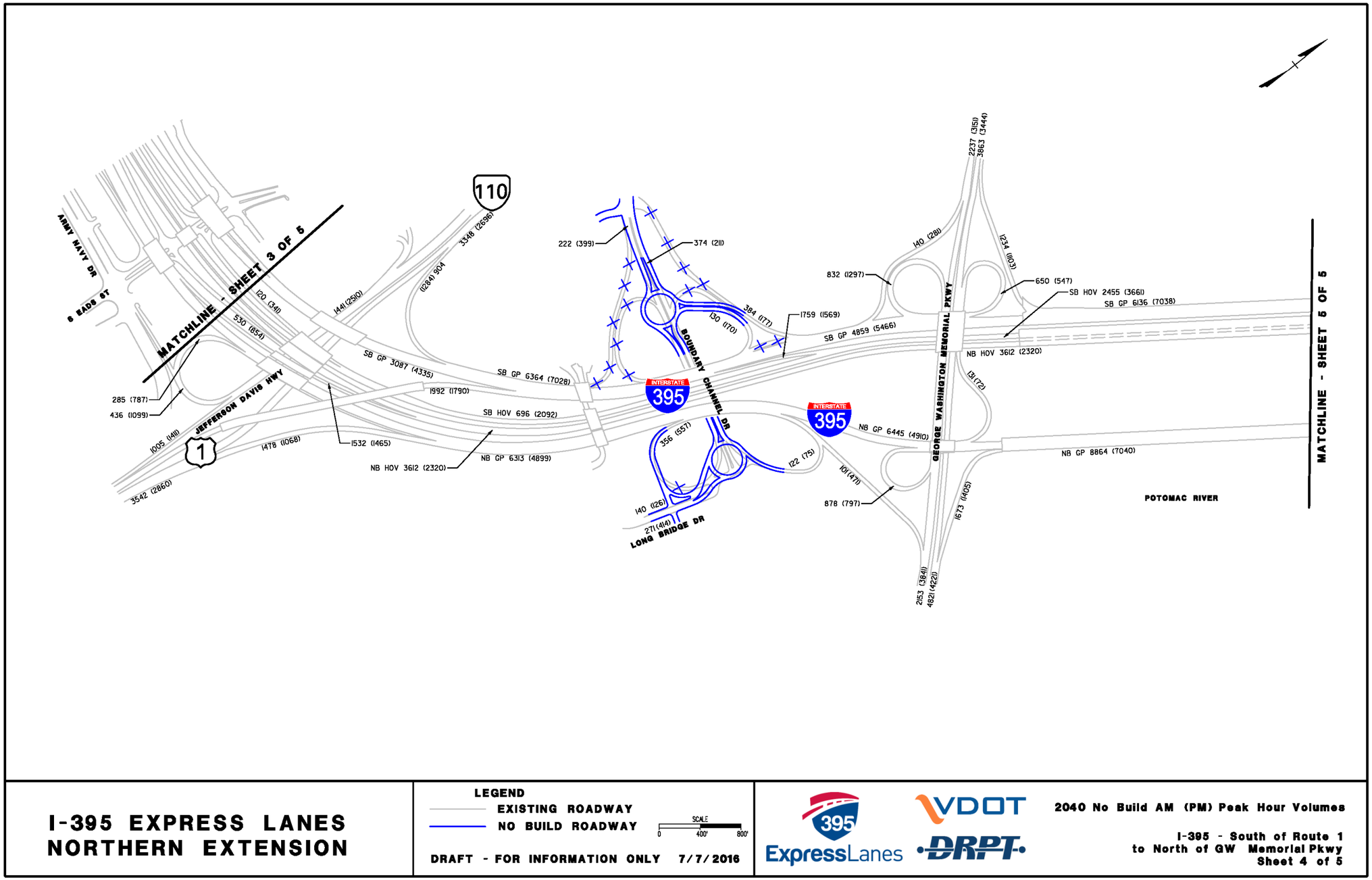


Figure 5-7d: 2040 No Build Peak Hour Traffic Volumes



I-395 EXPRESS LANES NORTHERN EXTENSION

LEGEND
EXISTING ROADWAY
NO BUILD ROADWAY
SCALE 0 400' 800'

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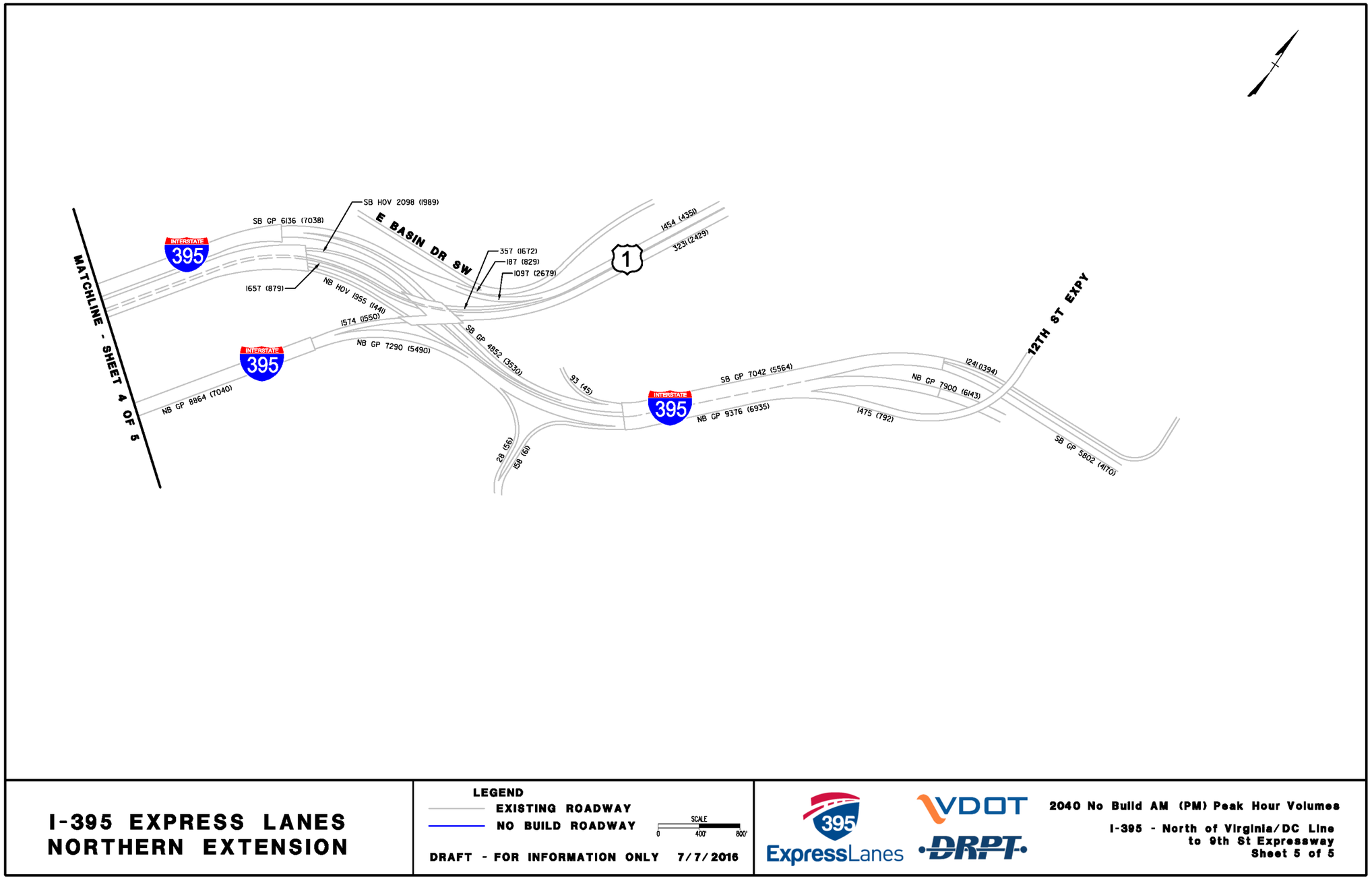
2040 No Build AM (PM) Peak Hour Volumes

I-395 - South of Route 1 to North of GW Memorial Pkwy
Sheet 4 of 5

Figure 5-7e: 2040 No Build Peak Hour Traffic Volumes



I-395 EXPRESS LANES NORTHERN EXTENSION

LEGEND
EXISTING ROADWAY
NO BUILD ROADWAY
SCALE 0 400' 800'

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395 ExpressLanes VDOT DRPT

2040 No Build AM (PM) Peak Hour Volumes
I-395 - North of Virginia/DC Line to 9th St Expressway
Sheet 5 of 5

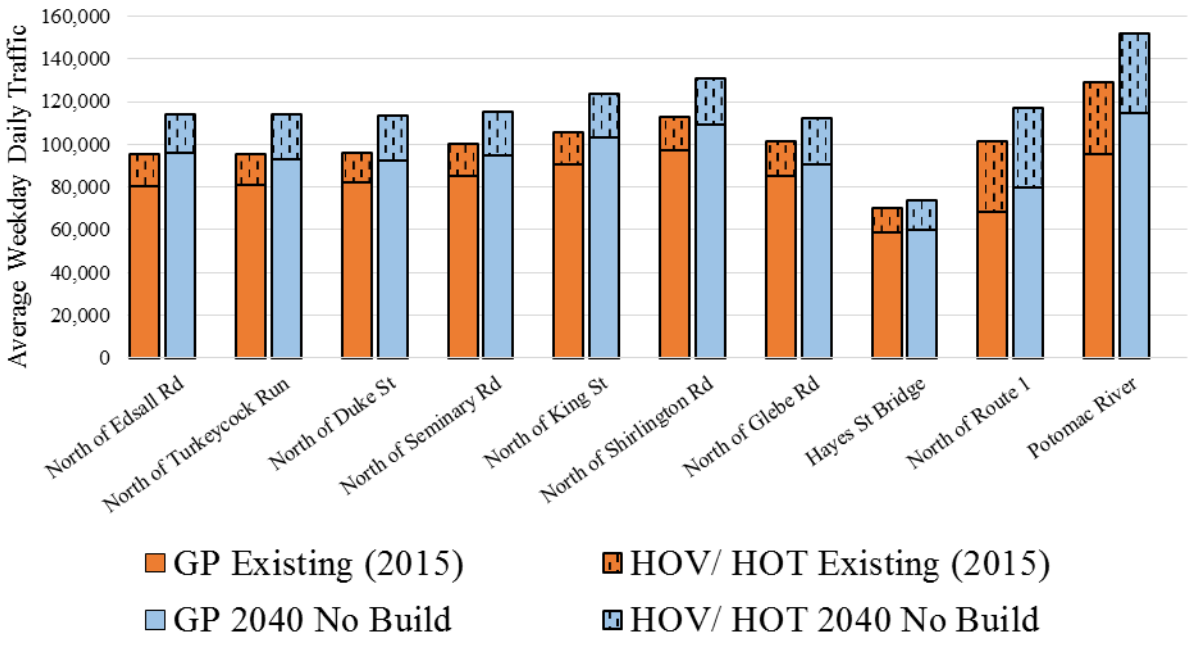
5.4.3 2040 No Build Weekday Daily Traffic Volumes

Existing (2015) and 2040 No Build weekday daily traffic volumes for northbound and southbound I-395 for both the general purpose and HOV/HOT lanes are summarized in **Figures 5-8 and 5-9**, respectively.

As shown in **Figure 5-8**, northbound I-395 general purpose weekday daily traffic volumes increase by approximately 10,000 to 15,000 vehicles (12% to 19% increase) between existing and 2040 No Build conditions from north of Edsall Road to north of Shirlington Road. From north of Glebe Road to the Hayes Street bridge (located between Washington Boulevard and Eads Street), traffic volumes increase by 1,000 to 5,000 vehicles (2% to 6% increase). North of Route 1 and at the Potomac River crossing, traffic volumes increase by 12,000 to 19,000 vehicles (17% to 20% increase).

Northbound weekday daily traffic volumes in the HOV/HOT lanes increase by approximately 3,500 vehicles between Edsall Road and Turkeycock Run (24% increase) and by 5,000 to 7,000 vehicles between Turkeycock Run and north of Glebe Road (36% to 51% increase). North of Route 1, traffic volumes in the HOV lanes increase by approximately 4,000 vehicles (11% increase). The higher growth rates within the HOV/HOT lanes compared to the general purpose lanes can be attributed to the available capacity in the HOV/HOT lanes compared to the general purpose lanes.

Figure 5-8: Existing (2015) and 2040 No Build Weekday Daily Traffic Volumes – Northbound I-395



As shown in **Figure 5-9**, southbound I-395 general purpose weekday daily traffic volumes increase by approximately 11,000 to 14,000 vehicles (13% to 16% increase) between existing and 2040 No Build conditions from north of Edsall Road to north of Shirlington Road with one exception. Between Turkeycock Run and Duke Street, traffic volume increases are 3,000 vehicles (approximately 4%) due to the I-395 4th Lane South Widening – Duke Street to Edsall Road project which relocates southbound traffic entering from Little River Turnpike and Duke Street to a collector-distributor road. From north of Glebe Road to the Hayes Street bridge (located between Washington Boulevard and Eads Street), traffic volumes increase by 3,000 to 8,000 vehicles (6% to 10% increase). North of Route 1 and at the Potomac River crossing, traffic volumes increase by 14,000 to 16,000 vehicles (15 to 17% increase).

Southbound weekday daily traffic volumes in the HOV/HOT lanes increase by approximately 3,500 vehicles between Edsall Road and Turkeycock Run (23% increase) and by 3,000 to 5,000 vehicles between Turkeycock Run and Hayes Street (16% to 29% increase). From north of Route 1 to the Potomac River, traffic volumes in the HOV lanes increase by 2,000 to 5,000 vehicles (12% to 14% increase). The higher growth rates within the HOV/HOT lanes compared to the general purpose lanes at the south end of the corridor can be attributed to the available capacity in the HOV/HOT lanes compared to the general purpose lanes.

Figure 5-9: Existing (2015) and 2040 No Build Weekday Daily Traffic Volumes – Southbound I-395

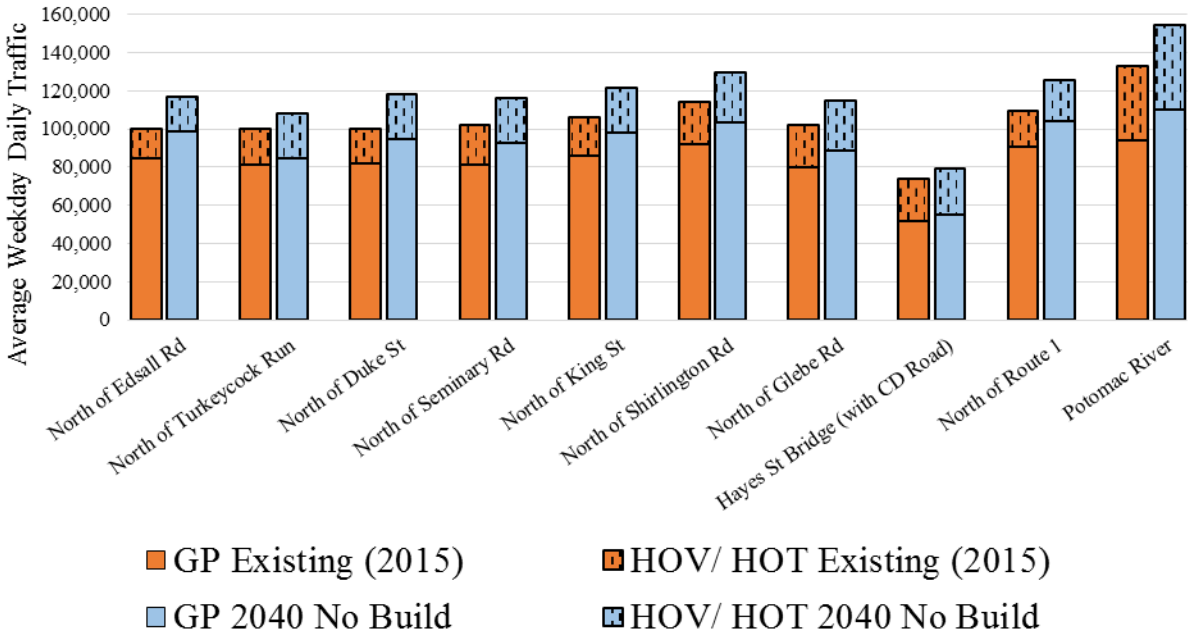


Figure 5-10a: 2040 No Build Weekday Daily Traffic Volumes

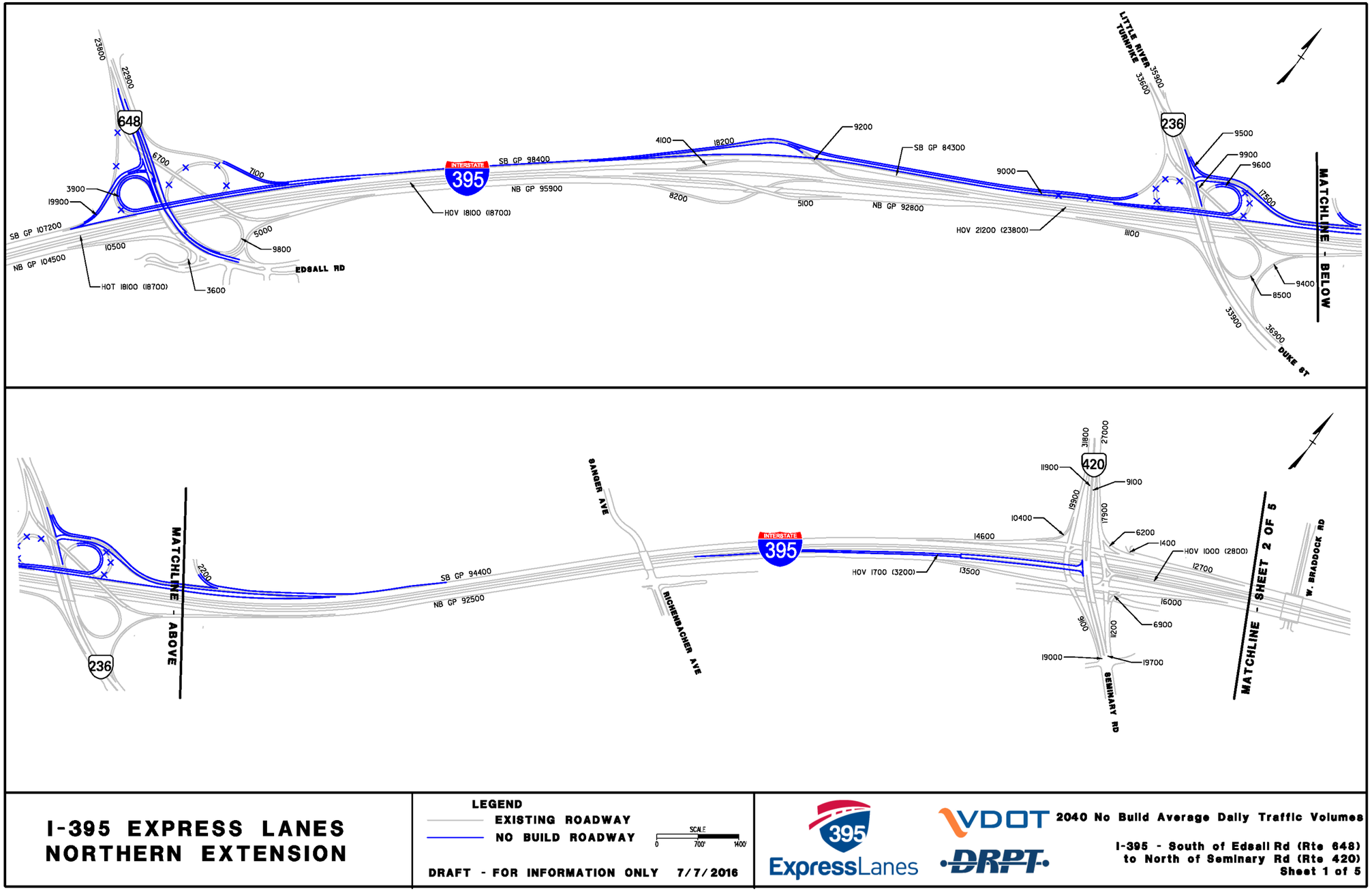
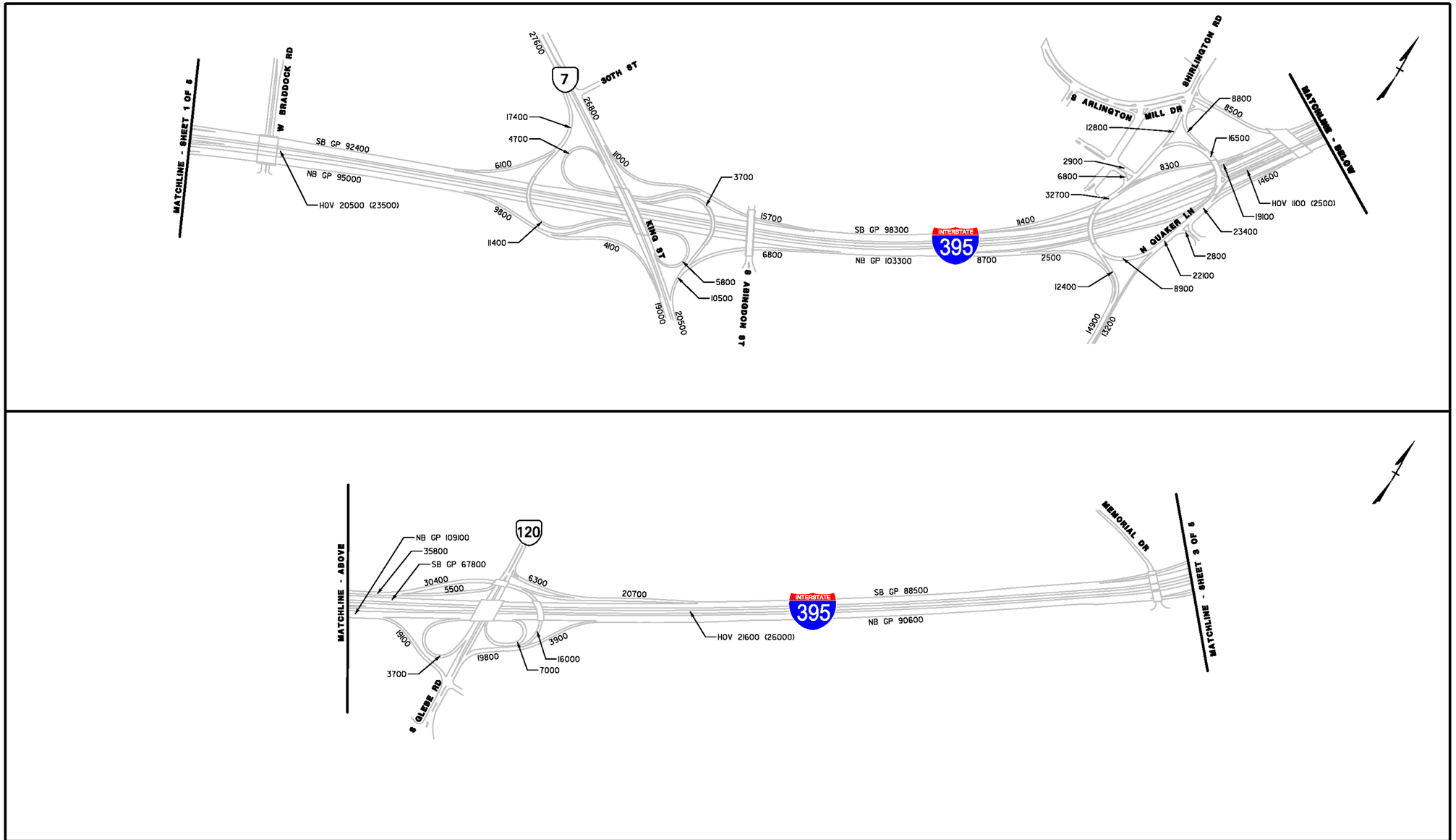


Figure 5-10b: 2040 No Build Weekday Daily Traffic Volumes



I-395 EXPRESS LANES NORTHERN EXTENSION

LEGEND
EXISTING ROADWAY
NO BUILD ROADWAY
SCALE 0 700' 1400'

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395 ExpressLanes VDOT DRPT

2040 No Build Average Daily Traffic Volumes
I-395 - South of W Braddock Rd to North of Memorial Dr
Sheet 2 of 5

Figure 5-10c: 2040 No Build Weekday Daily Traffic Volumes

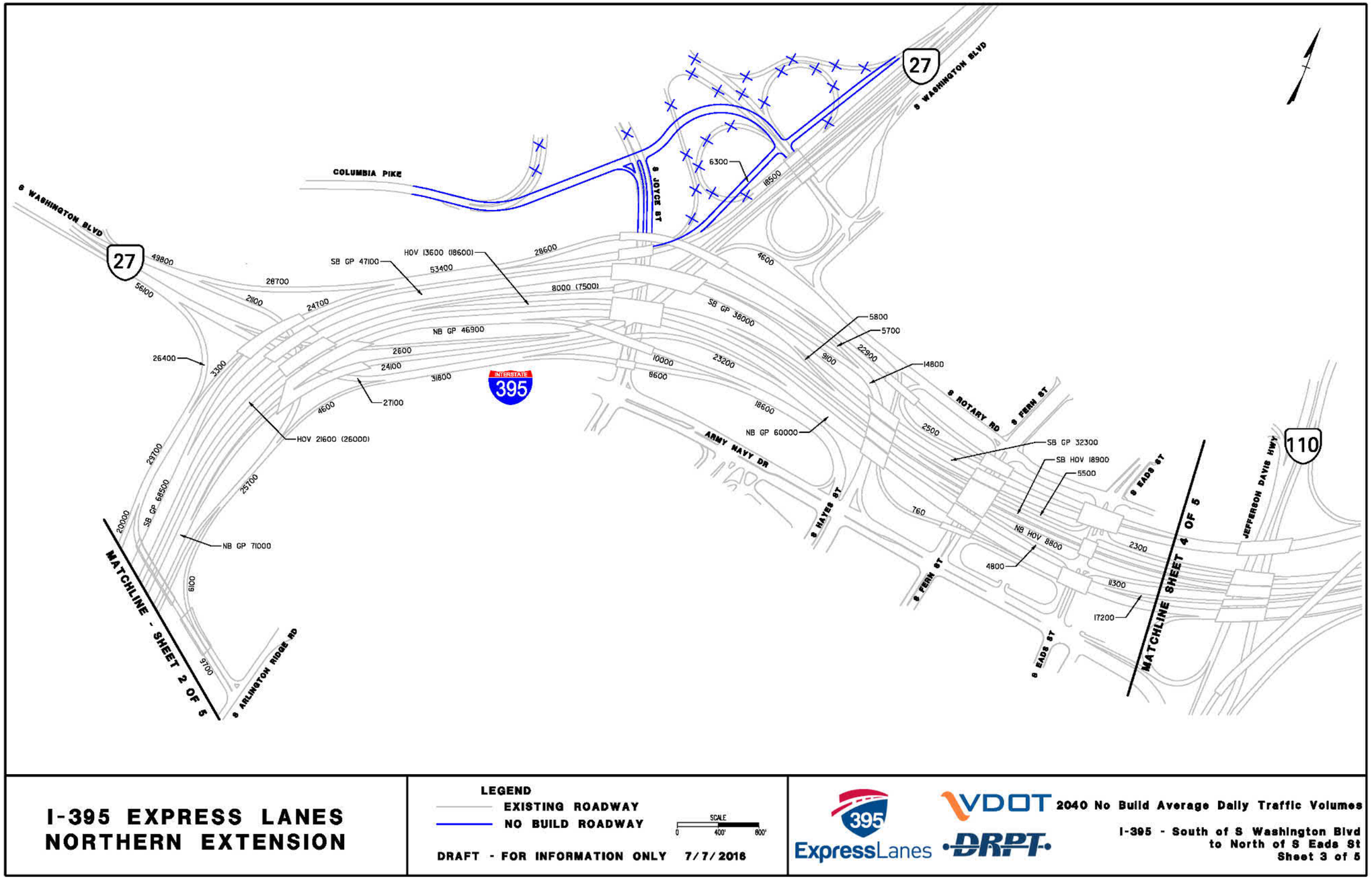


Figure 5-10d: 2040 No Build Weekday Daily Traffic Volumes

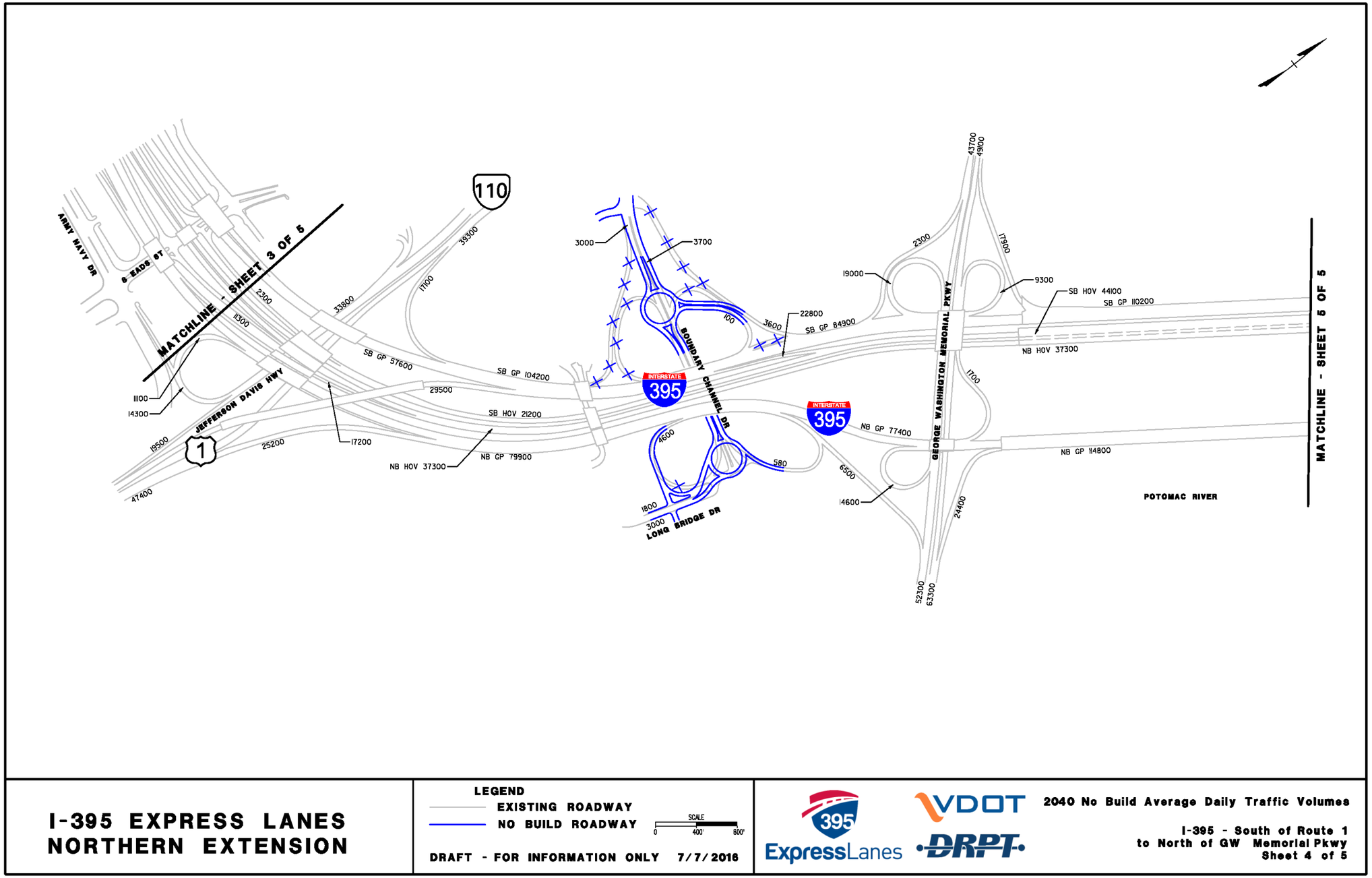
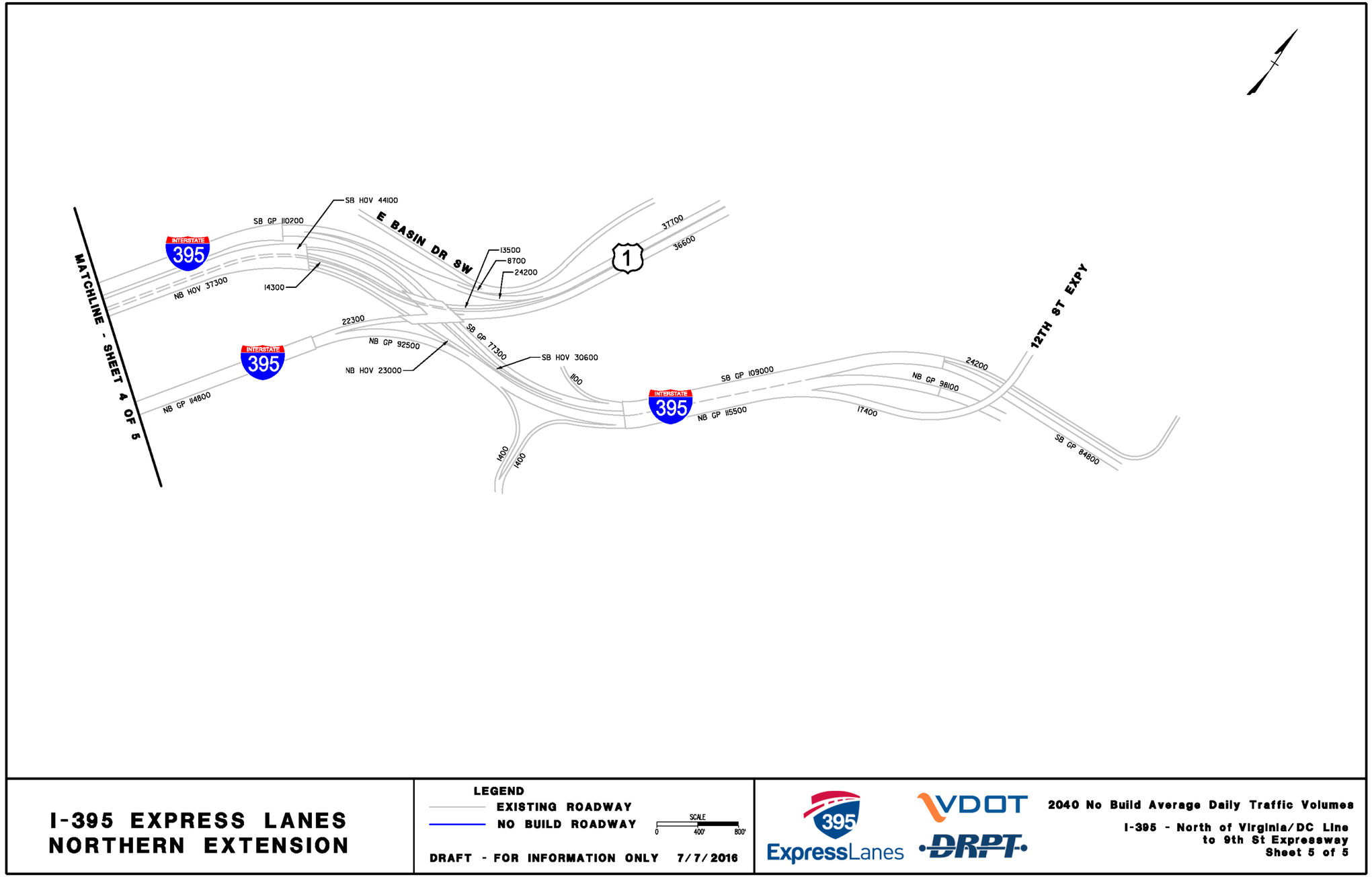


Figure 5-10e: 2040 No Build Weekday Daily Traffic Volumes



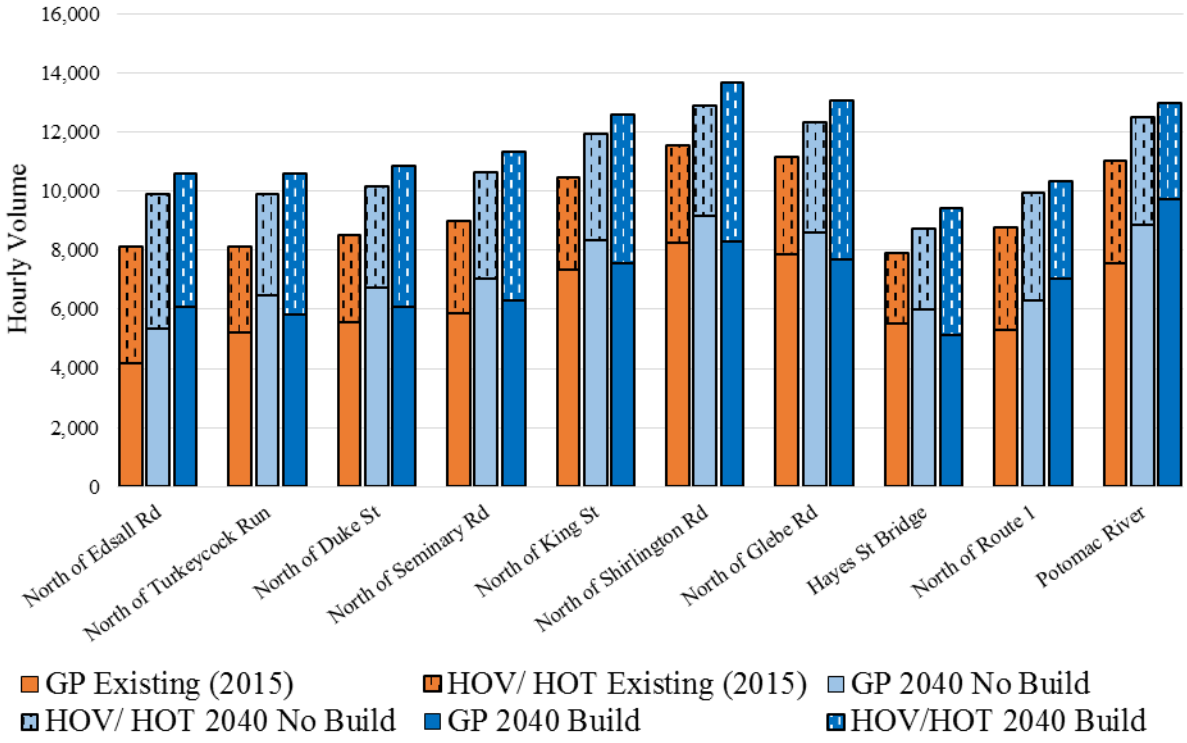
5.4.4 2040 Build Peak Hour Traffic Volumes

Existing (2015), 2040 No Build, and 2040 Build peak hour traffic volumes for northbound and southbound I-395 for both the general purpose and HOV/HOT lanes are summarized in **Figures 5-11 and 5-12,** respectively. AM and PM peak hour intersection traffic volumes for 2040 Build conditions are included in **Appendix J**.

As shown in **Figure 5-11**, in the AM peak hour, northbound I-395 general purpose traffic volumes decrease by 600 to 900 vehicles per hour between 2040 No Build and 2040 Build conditions from north of Turkeycock Run to the Hayes Street bridge. From north of Route 1 to the Potomac River, traffic volumes increase by 700 to 800 vehicles due to the shifting of traffic from the HOV/HOT lanes to the general purpose lanes in this area.

Northbound traffic volumes in the HOV/HOT lanes increase by 1,400 to 1,700 vehicles between Turkeycock Run and the Hayes Street bridge. North of Route 1, traffic volumes in the HOV lanes decrease by approximately 350 vehicles primarily due to the reduction in volumes entering the HOV lanes at the ramp from the general purpose lanes and HOV/HOT lanes located north of Eads Street.

Figure 5-11: Existing (2015), 2040 No Build and 2040 Build AM Peak Hour - Northbound I-395



As shown in **Figure 5-12**, southbound I-395 general purpose traffic volumes decrease by 400 to 1,100 vehicles per hour between 2040 No Build and 2040 Build conditions from north of Turkeycock Run to the Hayes Street bridge. North of Route 1 traffic volumes decrease by approximately 300 vehicles and there is no change in volumes between no build and build conditions at the Potomac River.

Southbound traffic volumes in the HOV/HOT lanes increase by 400 and 1,200 vehicles from Turkeycock Run to north of Glebe Road with higher increases at the northern end of this segment. At the Hayes Street bridge, traffic volumes increase by approximately 700 vehicles, and from North of Route 1 to the Potomac River, traffic volumes increase by 100 vehicles or less.

Figure 5-12: Existing (2015), 2040 No Build and 2040 Build PM Peak Hour - Southbound I-395

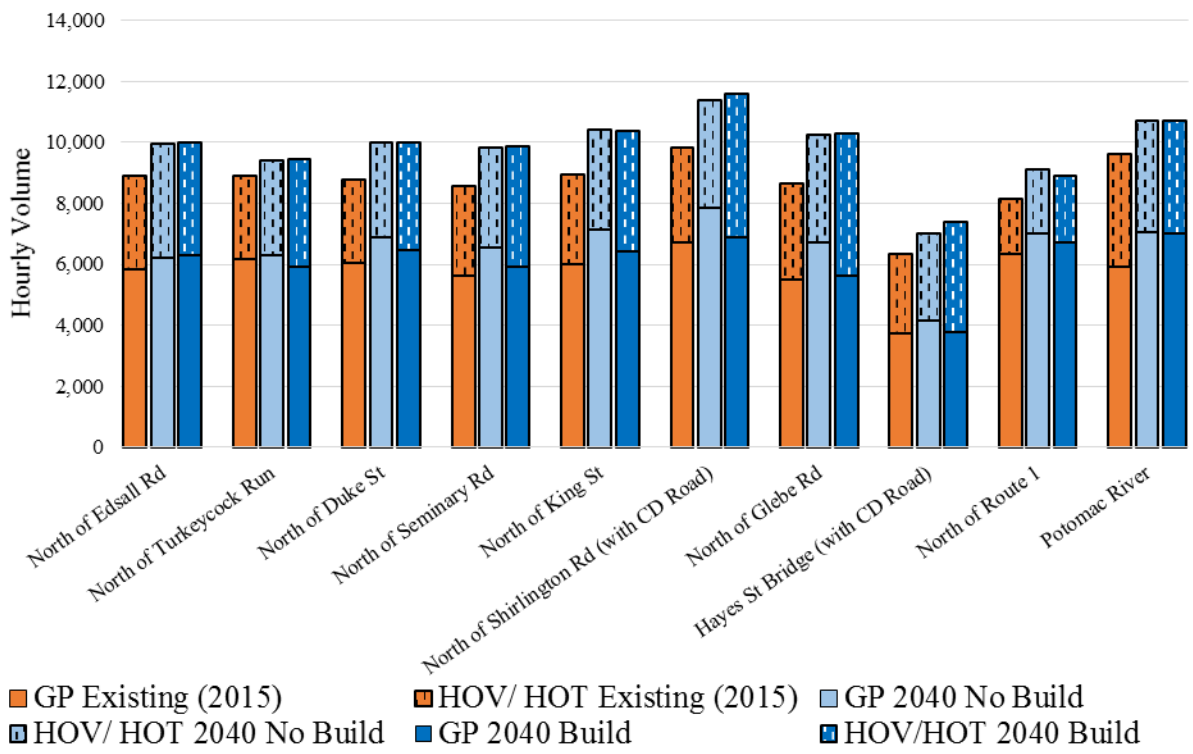


Figure 5-13a: 2040 Build Peak Hour Traffic Volumes

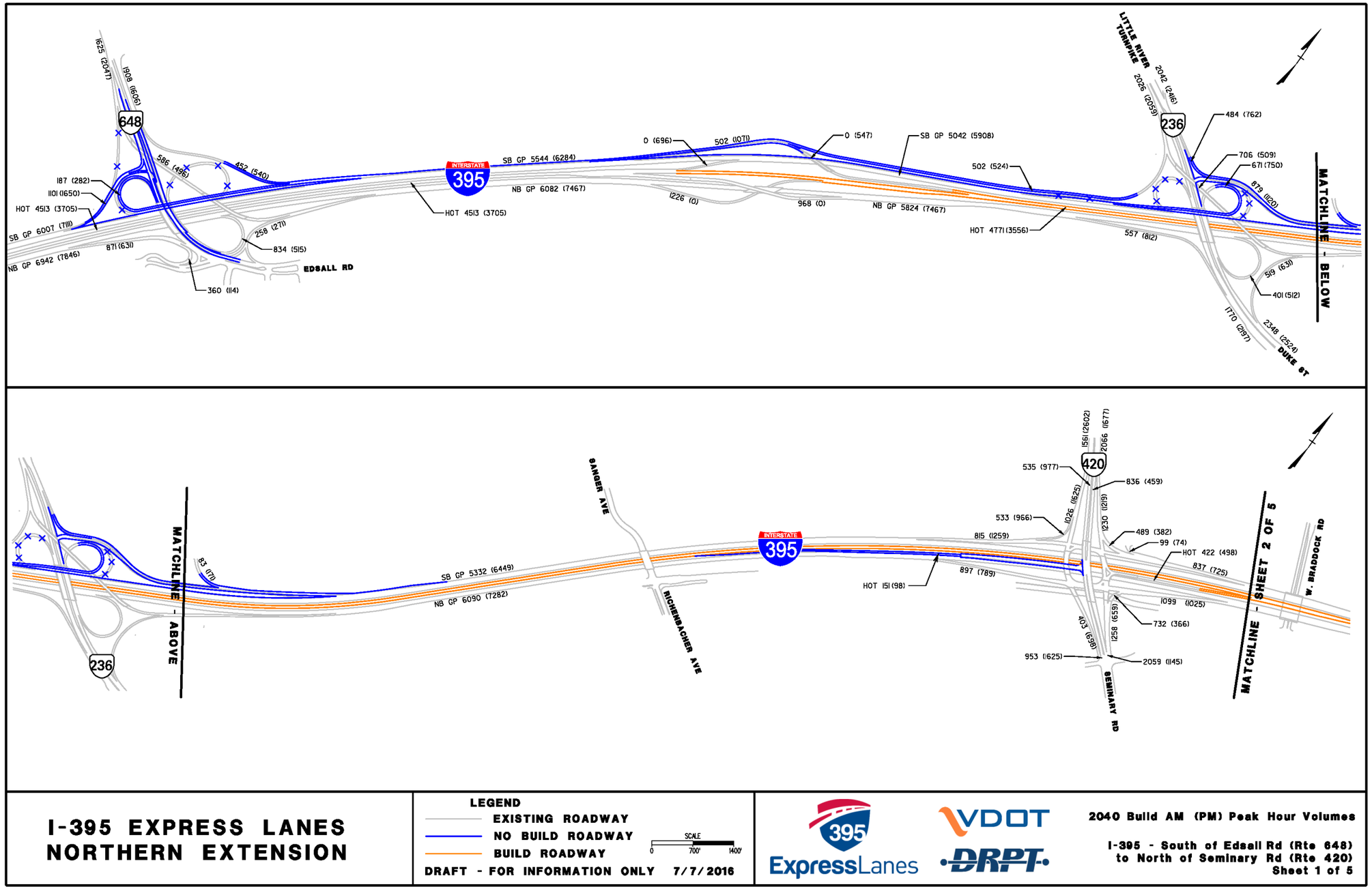


Figure 5-13b: 2040 Build Peak Hour Traffic Volumes

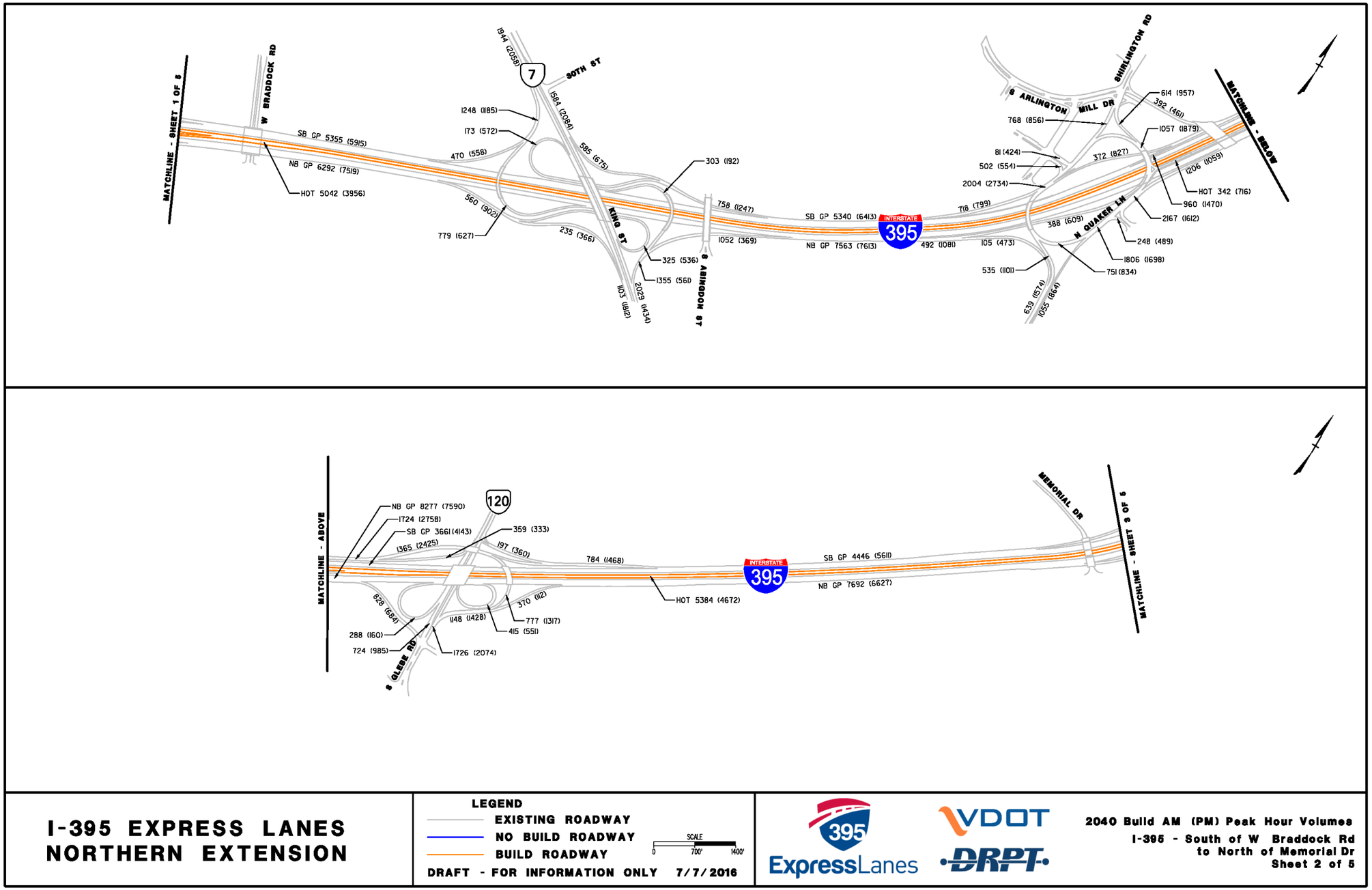


Figure 5-13c: 2040 Build Peak Hour Traffic Volumes

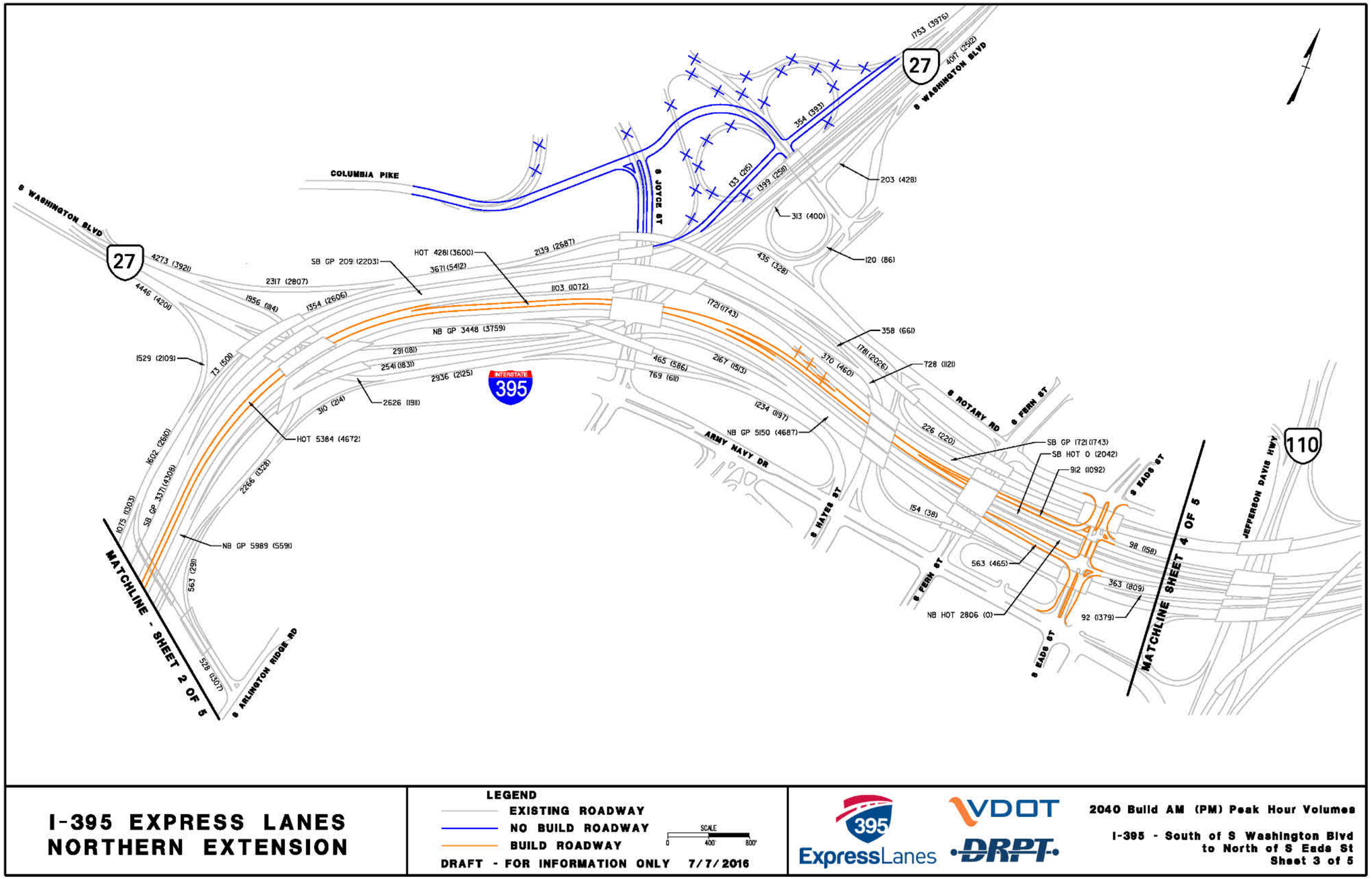
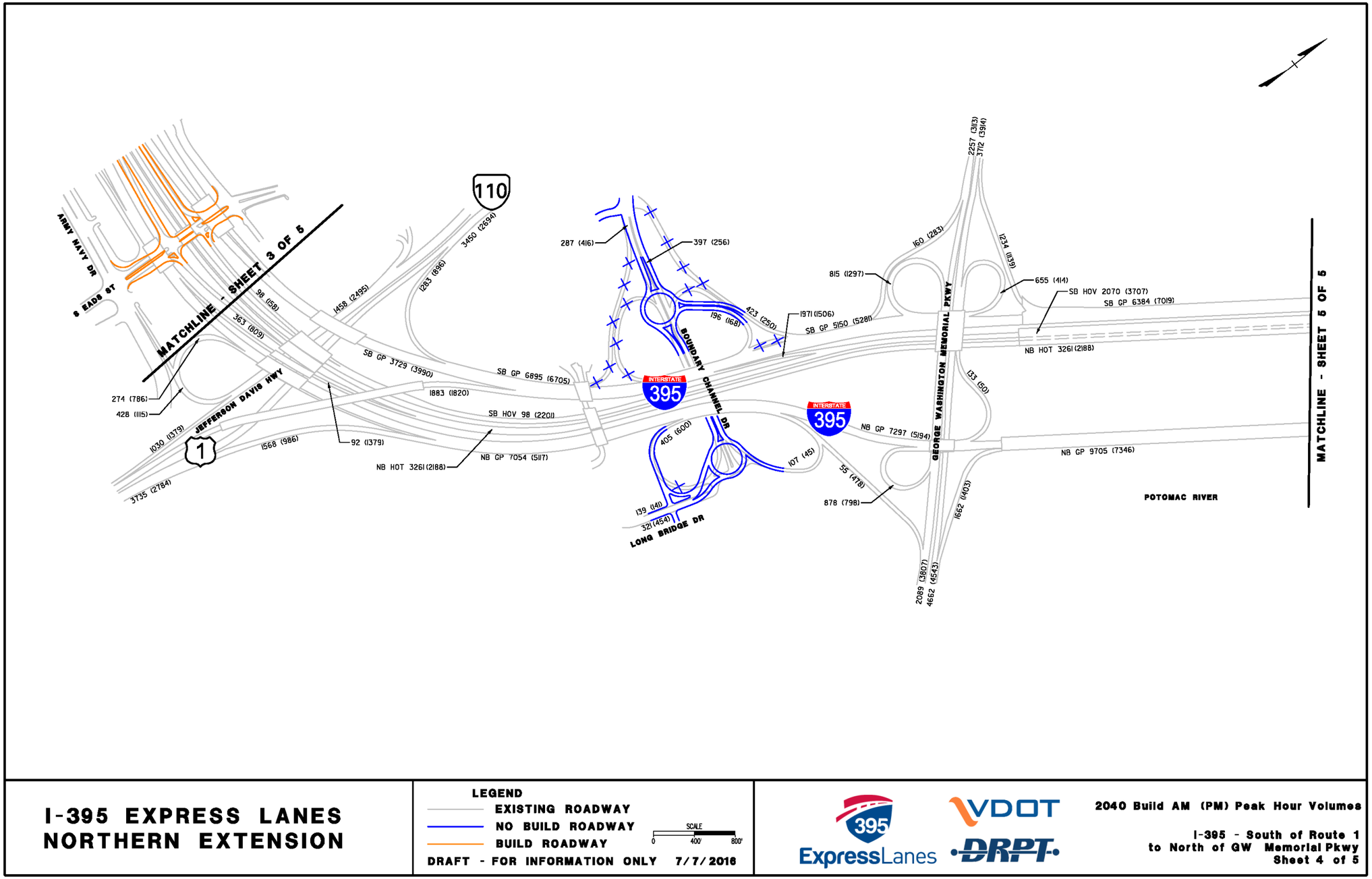


Figure 5-13d: 2040 Build Peak Hour Traffic Volumes



I-395 EXPRESS LANES NORTHERN EXTENSION

LEGEND
- EXISTING ROADWAY
- NO BUILD ROADWAY
- BUILD ROADWAY

SCALE 0 400' 800'

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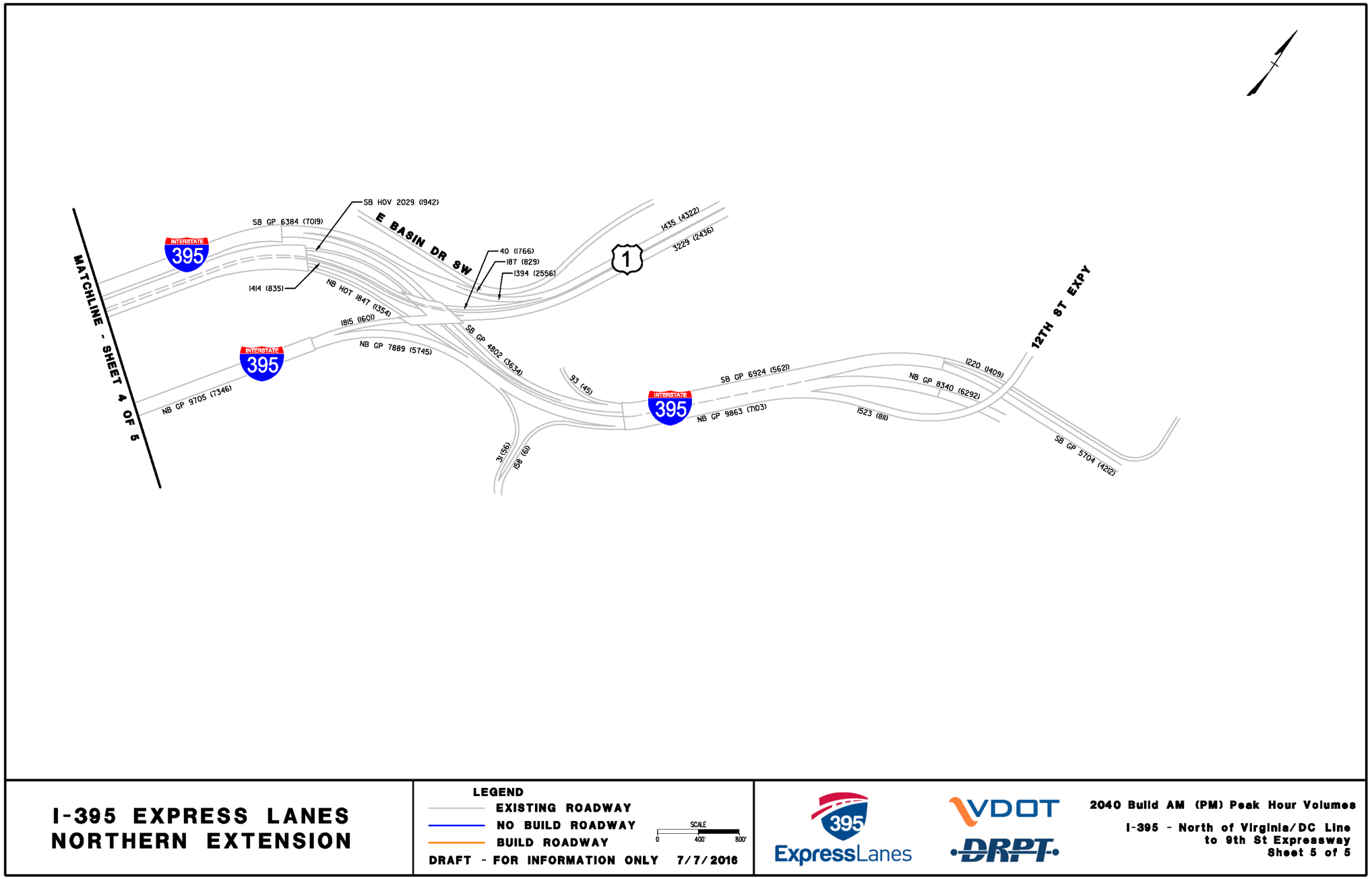
395 ExpressLanes VDOT DRPT

2040 Build AM (PM) Peak Hour Volumes

I-395 - South of Route 1 to North of GW Memorial Pkwy
Sheet 4 of 5

Figure 5-13e: 2040 Build Peak Hour Traffic Volumes



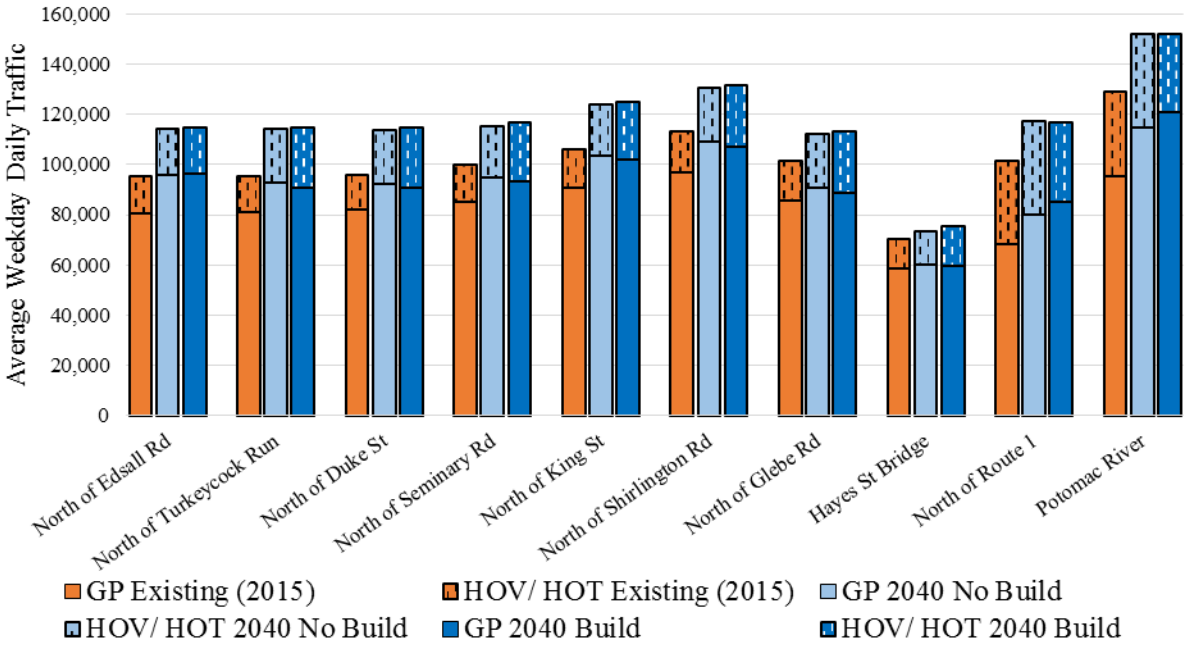
5.4.5 2040 Build Weekday Daily Traffic Volumes

Existing (2015), 2040 No Build, and 2040 Build weekday daily traffic volumes for northbound and southbound I-395 for both the general purpose and HOV/HOT lanes are summarized in **Figures 5-14 and 5-15**, respectively.

As shown in **Figure 5-14**, overall daily traffic volume changes between the combined general purpose lanes and HOV/HOT lanes are less than 2 percent along northbound I-395 between No Build and Build conditions. Northbound I-395 general purpose traffic volumes decrease by 1,500 to 2,200 vehicles between No Build and Build conditions from north of Turkeycock Run to north of Glebe Road. Traffic volumes on the Hayes Street bridge decrease by 500 vehicles. From north of Route 1 to the Potomac River and crossing the Potomac River, traffic volumes increase by 5,300 vehicles and 5,900 vehicles, respectively due to the shifting of traffic from the HOV lanes to the general purpose lanes in this area.

Northbound traffic volumes in the HOV/HOT lanes increase by 2,000 to 3,000 vehicles between Turkeycock Run and the Hayes Street bridge. North of Route 1, traffic volumes in the HOV lanes decrease by approximately 6,000 vehicles primarily due to the reduction in volumes entering the HOV lanes at the ramp from the general purpose lanes and HOV lanes located north of Eads Street.

Figure 5-14: Existing (2015), 2040 No Build Weekday and 2040 Build Daily Traffic Volumes – Northbound I-395



As shown in **Figure 5-15**, overall daily traffic volumes changes between the combined general purpose lanes and HOV/HOT lanes are less than 2 percent along southbound I-395 between No Build and Build conditions, similar to the northbound trends. Combined general purpose and HOV/HOT lane traffic volumes increase by 700 to 1,300 vehicles between No Build conditions and Build conditions from north of Turkeycock Run to north of Glebe Road. From the Hayes Street bridge to the Potomac River, daily traffic volume changes are less than 300 vehicles.

Figure 5-15: Existing (2015), 2040 No Build Weekday and 2040 Build Daily Traffic Volumes – Southbound I-395

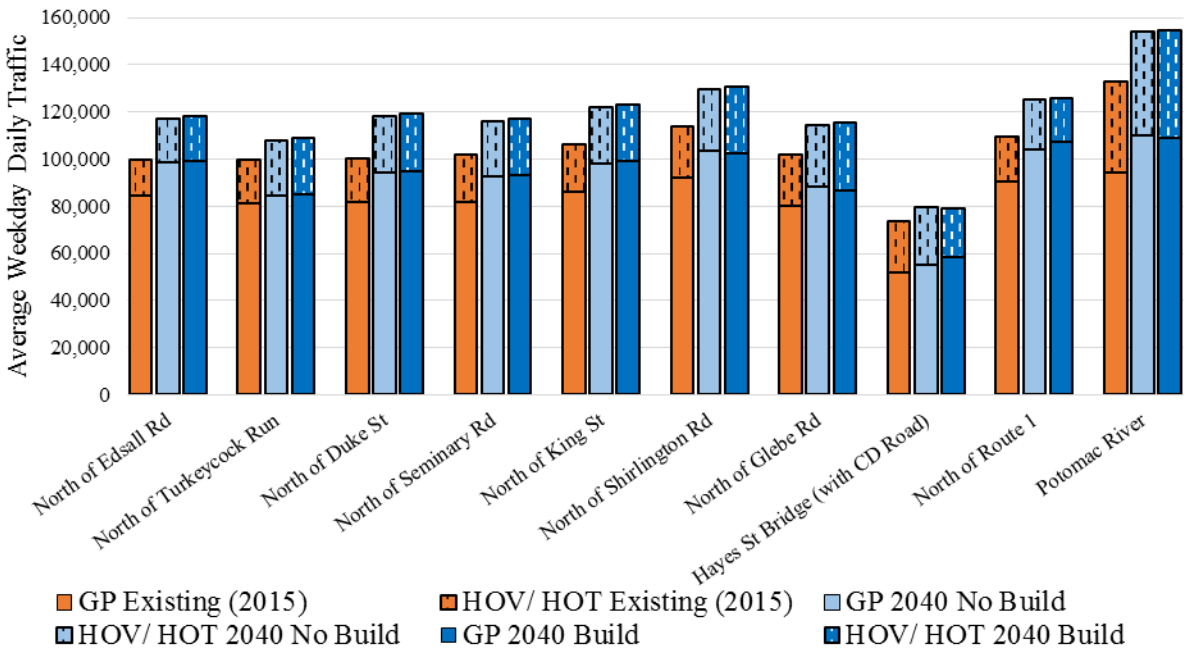


Figure 5-16a: 2040 Build Weekday Daily Traffic Volumes

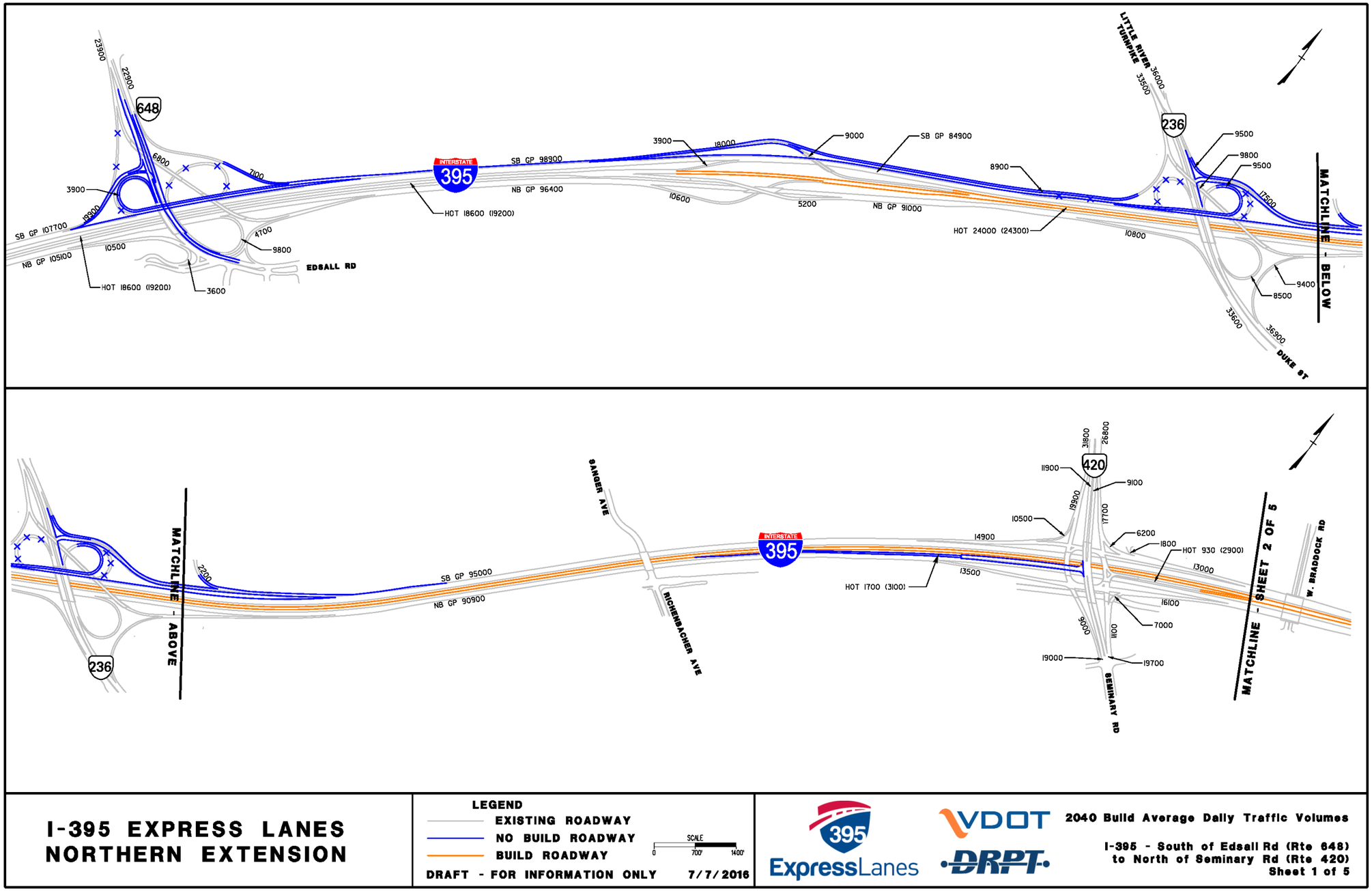
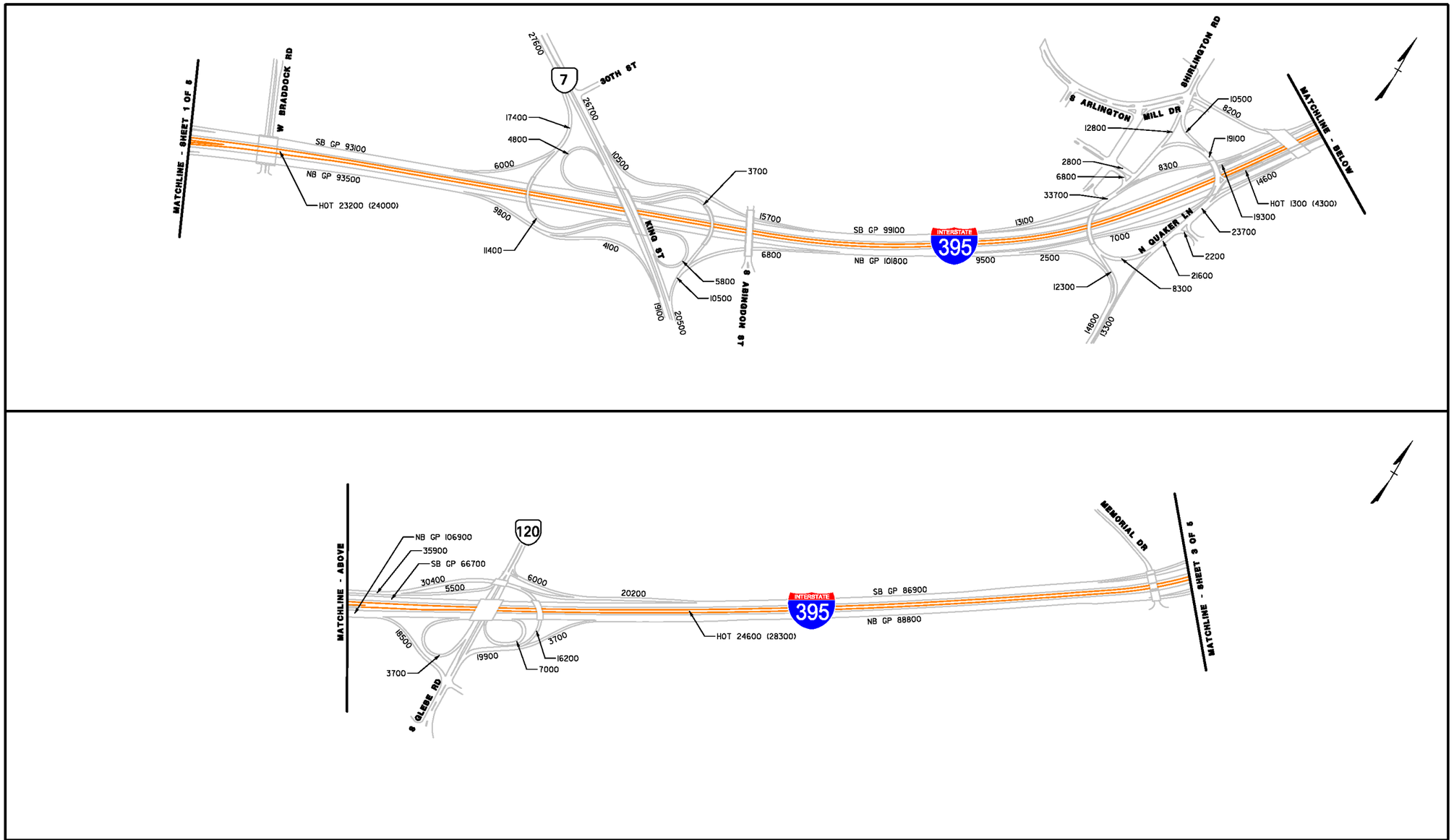


Figure 5-16b: 2040 Build Weekday Daily Traffic Volumes



I-395 EXPRESS LANES NORTHERN EXTENSION

LEGEND
- EXISTING ROADWAY
- NO BUILD ROADWAY
- BUILD ROADWAY

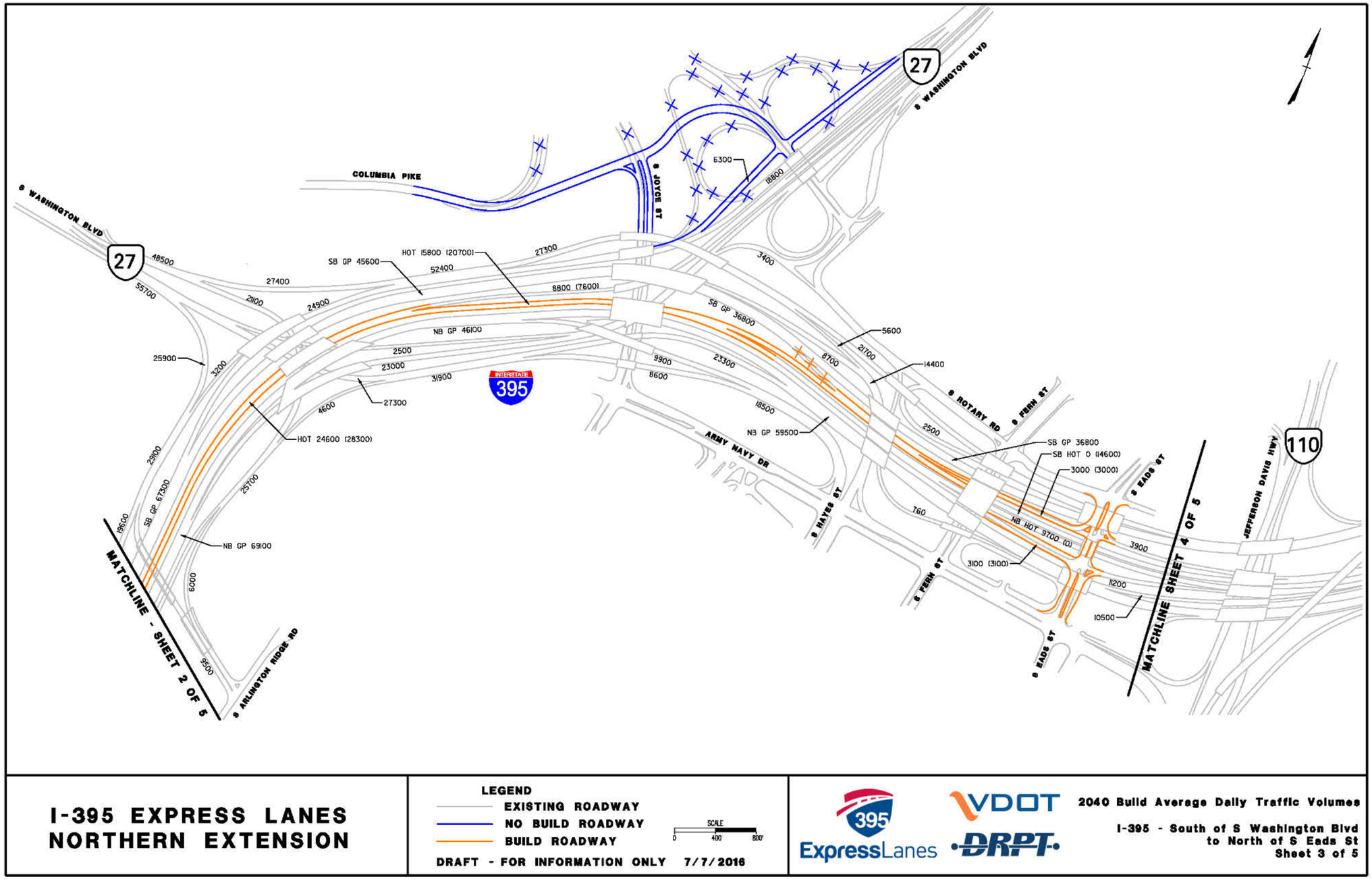
SCALE 0 700' 1400'

DRAFT - FOR INFORMATION ONLY 7/7/2016

395 ExpressLanes VDOT DRPT

2040 Build Average Daily Traffic Volumes
I-395 - South of W Braddock Rd to North of Memorial Dr
Sheet 2 of 5

Figure 5-16c: 2040 Build Weekday Daily Traffic Volumes



I-395 EXPRESS LANES NORTHERN EXTENSION

LEGEND
- EXISTING ROADWAY
- NO BUILD ROADWAY
- BUILD ROADWAY

SCALE 0 400 800'

DRAFT - FOR INFORMATION ONLY 7/7/2016

395 ExpressLanes VDOT DRPT

2040 Build Average Daily Traffic Volumes

I-395 - South of S Washington Blvd to North of S Eads St
Sheet 3 of 5

Figure 5-16d: 2040 Build Weekday Daily Traffic Volumes

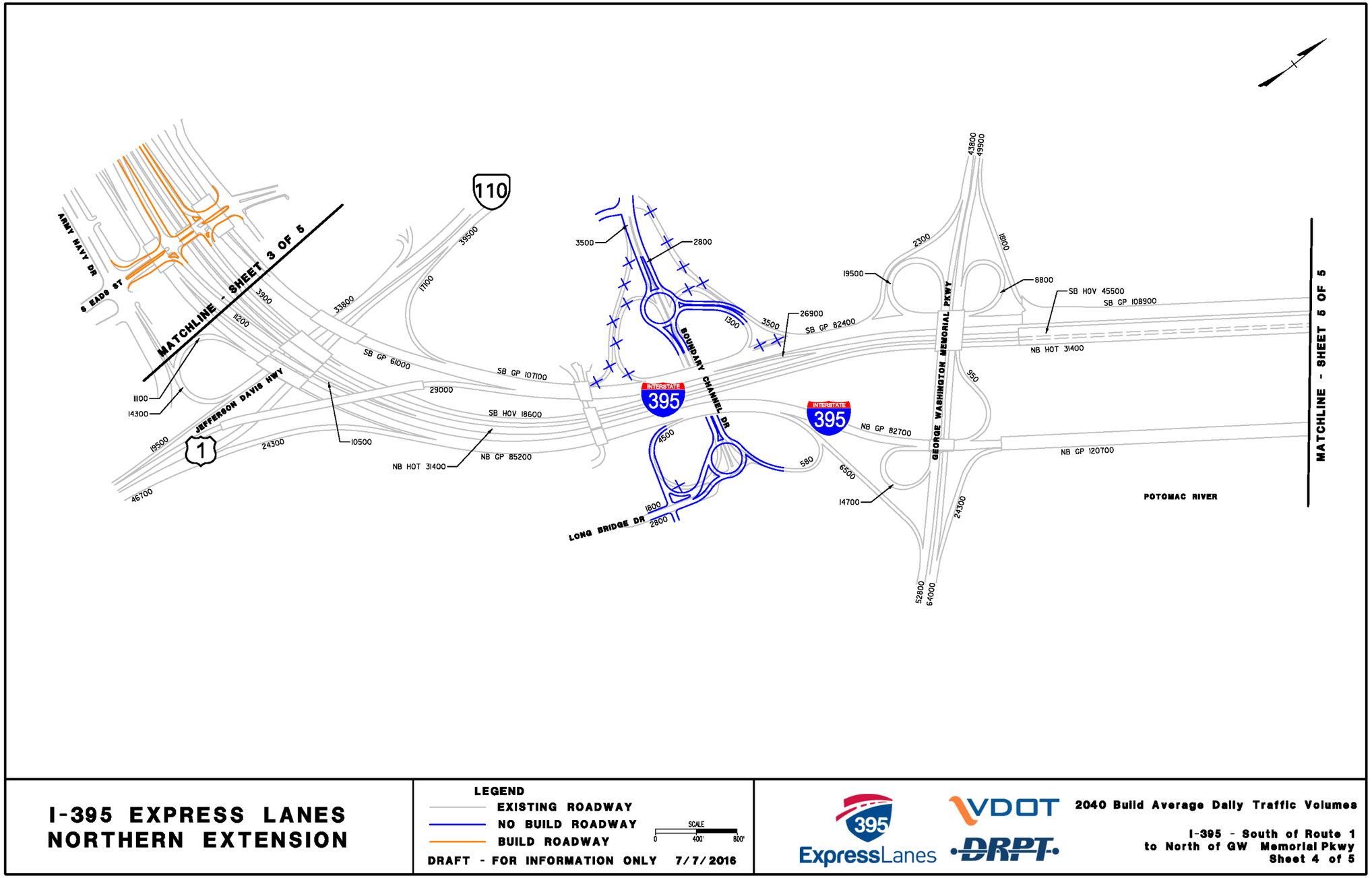
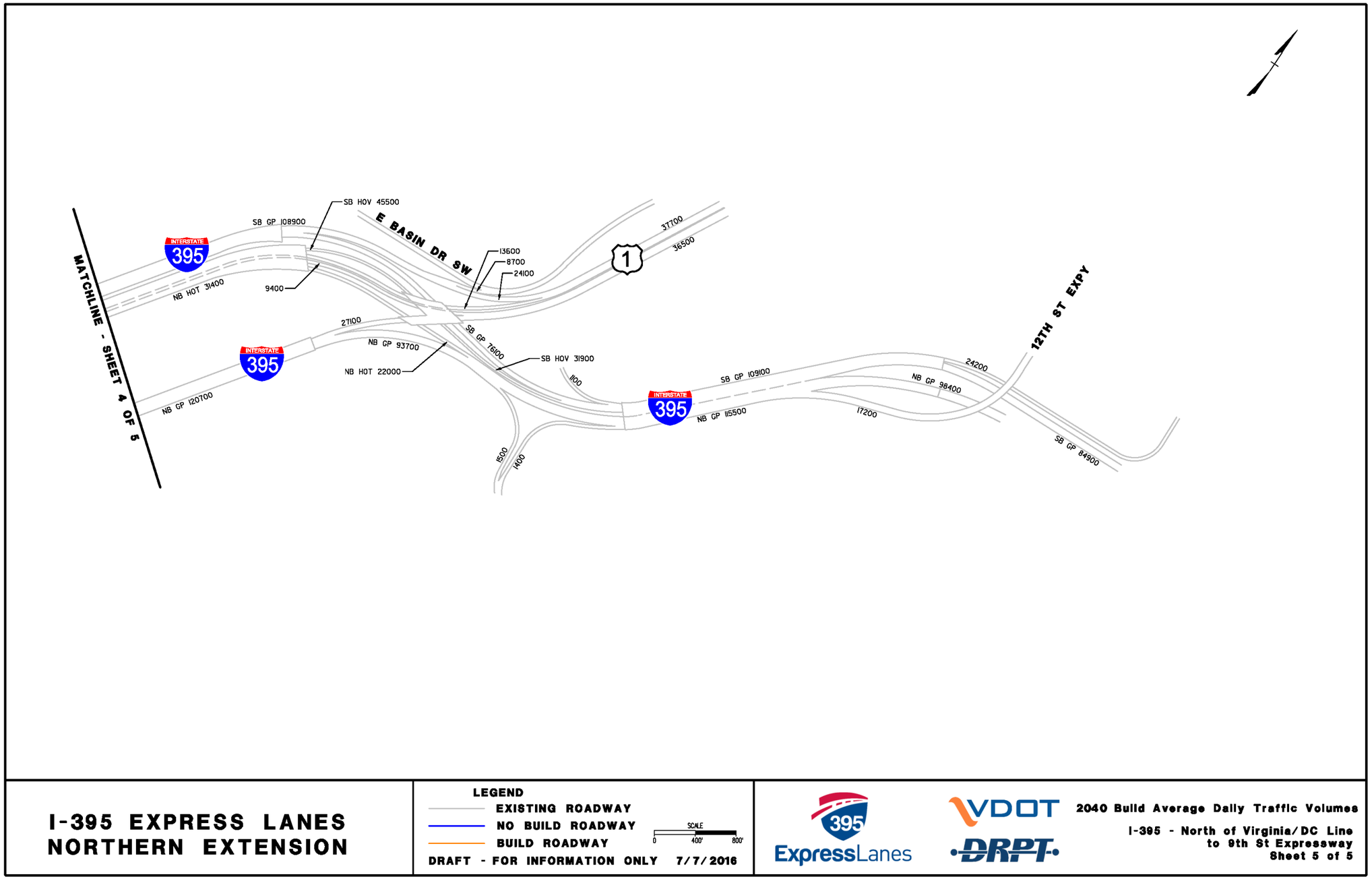


Figure 5-16e: 2040 Build Weekday Daily Traffic Volumes



I-395 EXPRESS LANES
NORTHERN EXTENSION

LEGEND
EXISTING ROADWAY
NO BUILD ROADWAY
BUILD ROADWAY
SCALE 0 400' 800'
DRAFT - FOR INFORMATION ONLY 7/7/2016

395 ExpressLanes
VDOT
DRPT

2040 Build Average Daily Traffic Volumes
I-395 - North of Virginia/DC Line to 9th St Expressway
Sheet 5 of 5

5.5 FUTURE TRAFFIC OPERATIONS

The base year (2015) VISSIM mesoscopic models for both the AM and PM peak periods were modified to reflect the committed No Build projects as discussed in **Section 5.1** to create a 2040 No Build conditions model. The 2040 Build conditions model was then created by incorporating the proposed Build Alternative for the I-395 Express Lanes.

5.5.1 Freeway Operations

5.5.1.1 Travel Times and Speeds

A comparison of corridor travel times for existing conditions, 2040 No Build conditions, and 2040 Build conditions is summarized in **Figures 5-17 through 5-18** for the peak travel direction (i.e., northbound in the AM peak period and southbound in the PM peak period) for each of the four analysis hours. **Figures 5-19 through 5-20** summarize travel times for the northbound and southbound I-395 general purpose and HOV/HOT lanes for each of the four analysis hours during the AM and PM peak periods by segment along the corridor. Travel times for each segment and cumulative travel times are shown. **Figures 5-21 through 5-24** summarize the travel speeds by segment along the corridor for existing conditions, No Build conditions, and Build conditions. Figures depicting the No Build and Build freeway segment average speeds and densities from the VISSIM mesoscopic models for the northbound and southbound I-395 general purpose and HOV lanes for each of the eight analysis periods are included **Appendix I and K**, respectively.

<u>No Build Conditions</u>

AM Peak Period – Northbound General Purpose Lanes (Peak Direction)

Under 2040 No Build conditions, travel times along the northbound I-395 general purpose lanes increase by 10 to 19 minutes compared to existing conditions in the AM peak period with the largest increases of 18 to 19 minutes occurring between 8 AM and 10 AM. A large portion of the travel time increase (average of 5 minutes over the four peak hours) occurs south of the Turkeycock Run Interchange. This is a result of the congestion and queuing along northbound I-395 extending farther to the south during peak hours. The average travel time increase of 4 minutes over the four peak hours between Washington Boulevard and Route 1 are due to further increases in traffic volumes in this portion of the corridor which is already operating over capacity during peak hours.

Similar trends are observed when reviewing the speed data along the corridor. Speeds decrease in the segment south of Turkeycock Run. The duration of low travel speeds and over-capacity conditions between Seminary Road and Washington Boulevard increases from approximately 2 to 3 hours to the entire four-hour study period causing congestion to extend beyond the southern study limits throughout the four hours.

AM Peak Period – Northbound HOV/HOT Lanes (Peak Direction)

Travel times from 6 to 7 AM remain approximately the same in the northbound HOV/HOT lanes when comparing existing to No Build conditions. From 7 AM to 10 AM, travel times increase by 1.5 to 5 minutes with the highest increases from 8 AM to 9 AM. Travel times increase south of Turkeycock Run as northbound motorists in the HOT lanes attempt to exit to the general purpose lanes at Turkeycock Run and encounter greater congestion in the general purpose lanes compared to existing conditions. Travel times

also increase between Eads Street and 14th Street in the District as a result of higher traffic volumes and congestion levels in this section where the HOV lanes are open to travel by all motorists.

AM Peak Period – Southbound General Purpose Lanes (Off-Peak Direction)

Travel times along the I-395 general purpose lanes increase by 1 to 2 minutes in the southbound off-peak direction between existing conditions and 2040 No Build Conditions with the largest increases in delays and reductions in speeds occurring exiting the District and approaching the George Washington Memorial Parkway.

AM Peak Period – Southbound HOV Lanes (Off-Peak Direction)

Travel times increase by less than 30 seconds in the southbound off-peak direction of the HOV lanes between existing conditions and 2040 No Build Conditions. From 8 AM to 9 AM, travel delays increase and speeds increase along the southbound HOV lanes approaching the exit to the general purpose lanes within the Boundary Channel Drive Interchange due to higher congestion levels in the general purpose lanes.

PM Peak Period – Southbound General Purpose Lanes (Peak Direction)

Under 2040 No Build conditions, travel times along the southbound I-395 general purpose lanes increase by 10 to 19 minutes compared to exiting conditions in the PM peak period with the largest increases of 18 to 19 minutes occurring between 5 PM and 7 PM. Travel times increase incrementally throughout the study limits, with the largest travel times increases occurring in the middle portion of the corridor (Washington Boulevard to King Street) in the earliest hour of the four-hour analysis period and the largest travel time increases occurring in the northern and middle portions of the corridor (10th Street bridge to Shirlington Road) between 4 PM and 7 PM. Travel times decrease by 1 to 2 minutes from Duke Street to Turkeycock Run as a result of the addition of a fourth lane in this area as part of the No Build conditions.

Similar trends are observed when comparing the existing to No Build conditions speed data along the corridor. Travel speeds decrease from north of Duke Street through the northern study limits due to increased traffic volumes and resulting congestion. Travel speeds increase from just north of Duke Street to north of Turkeycock Run as a result of the addition of a fourth lane in this area as part of the No Build conditions.

PM Peak Period – Southbound HOV/HOT Lanes (Peak Direction)

Travel times from 3 PM to 7 PM remain approximately the same in the southbound HOV/HOT lanes when comparing existing to No Build conditions. Delay increases of approximately 15 seconds occur from 5 PM to 6 PM in the vicinity of the Boundary Channel Drive Interchange approaching the ramp from the HOV lanes to the general purpose lanes.

PM Peak Period – Northbound General Purpose Lanes (Off-Peak Direction)

Travel times along the I-395 general purpose lanes increase by 5 to 7 minutes in the northbound off-peak direction of the general purpose lanes between existing conditions and 2040 No Build Conditions with the majority of the travel time increases (over 97%) and reductions in speeds occurring between Route 1 and

the northern study limits. This is due to the increase in the reverse commute pattern toward the District in the PM peak period.

PM Peak Period – Northbound HOV Lanes (Off-Peak Direction)

Travel times and speeds remain approximately the same in the northbound HOV/HOT lanes when comparing existing to No Build conditions.

Build Conditions

AM Peak Period – Northbound General Purpose Lanes (Peak Direction)

Under 2040 Build conditions, travel times along the northbound I-395 general purpose lanes decrease by 10 to 11 minutes from 8 AM to 10 AM when compared to 2040 No Build conditions. Travel times increase by up to 2 minutes between Route 1 and the north end of the study area due to higher traffic volumes in the general purpose lanes in this section of the study area compared to No Build conditions.

Similar trends are observed when reviewing the speed data along the corridor. Speeds increase from an average of 18 MPH to 23 MPH from south of Turkeycock Run to Washington Boulevard with the largest speed increases occurring from 8 AM to 10 AM. From Washington Boulevard to the north end of the study area, travel speeds decrease to an average of 14 MPH with the largest reduction in speeds occurring from 8 AM to 9 AM.

AM Peak Period – Northbound HOV/HOT Lanes (Peak Direction)

Travel times from 6 AM to 7 AM remain approximately the same in the northbound HOV/HOT lanes when comparing No Build to Build conditions. From 7 AM to 10 AM, travel times decrease by 1 to 6 minutes with the highest decreases from 8 AM to 9 AM. From 7 AM to 9 AM, travel times decrease by 1 to 1.5 minutes south of Turkeycock Run as there are fewer northbound motorists in the HOT lanes attempting to exit to the general purpose lanes and encountering lower congestion levels in the general purpose lanes compared to No Build conditions. Travel times also decrease by approximately 1 minute from 7 AM to 8 AM and 9 AM to 10 AM and approximately 4 minutes from 8 to 9 AM between Eads Street and 14th Street in the District as a result in lower traffic volumes and congestion levels in this section compared to No Build conditions.

AM Peak Period – Southbound General Purpose Lanes (Off-Peak Direction)

Travel times along the I-395 southbound general purpose lanes remain the same when comparing 2040 No Build to Build conditions with less than a 5 second change in travel times.

AM Peak Period – Southbound HOV Lanes (Off-Peak Direction)

Travel times along the I-395 HOV lanes decrease by less than 30 seconds in the southbound off-peak direction of the HOV lanes between 2040 No Build and Build conditions.

PM Peak Period – Southbound General Purpose Lanes (Peak Direction)

Under 2040 Build conditions, travel times along the southbound I-395 general purpose lanes decrease by 6 to 16 minutes between 3 PM and 6 PM and increase by approximately 1.5 minutes between 6 PM and 7 PM compared to No Build conditions with the highest decrease of 16 minutes occurring between 4 PM and 5 PM. Travel times decrease incrementally from the northern study limits to approximately Glebe Road from 3 PM to 6 PM with an average of 11 minutes of travel time savings over the three hours. From south of Glebe Road to the southern study limits, overall travel times decrease by less than 30 seconds with increases in travel times on some segments due to more traffic accessing this area during the earlier portion of the peak period.

Similar trends are observed when comparing the No Build to Build conditions speed data along the corridor. Travel speeds generally increase north of Glebe Road and remain the same or decrease south of Glebe Road due to higher volumes accessing the southern portion of the study area as result of reduced congestion in the northern portion of the study area.

PM Peak Period – Southbound HOV/HOT Lanes (Peak Direction)

Travel times from 3 PM to 5 PM and 6 PM to 7 PM remain approximately the same in the southbound HOV/HOT lanes when comparing 2040 No Build to Build conditions. Delay increases of approximately 30 seconds occur from 5 PM to 6 PM between 14th Street and the exit from the HOV lanes to the general purpose lanes due to heavier congestion in the general purpose lanes. Corresponding speeds in this area reduce by approximately 8 miles per hour between No Build and Build conditions.

PM Peak Period – Northbound General Purpose Lanes (Off-Peak Direction)

Travel times along the I-395 general purpose lanes increase by 1.5 to 2 minutes in the northbound off-peak direction between 2040 No Build and Build conditions with the majority of the travel time increases (over 96%) and reductions in speeds occurring between Washington Boulevard and the northern study limits. This is due to higher traffic volumes and resulting congestion in the general purpose lanes in this section of the study area compared to No Build conditions.

PM Peak Period – Northbound HOV Lanes (Off-Peak Direction)

Travel times and speeds remain approximately the same in the northbound HOV/HOT lanes when comparing No Build to Build conditions.

Figure 5-17: Northbound Overall Travel Time Summary - AM Peak Period

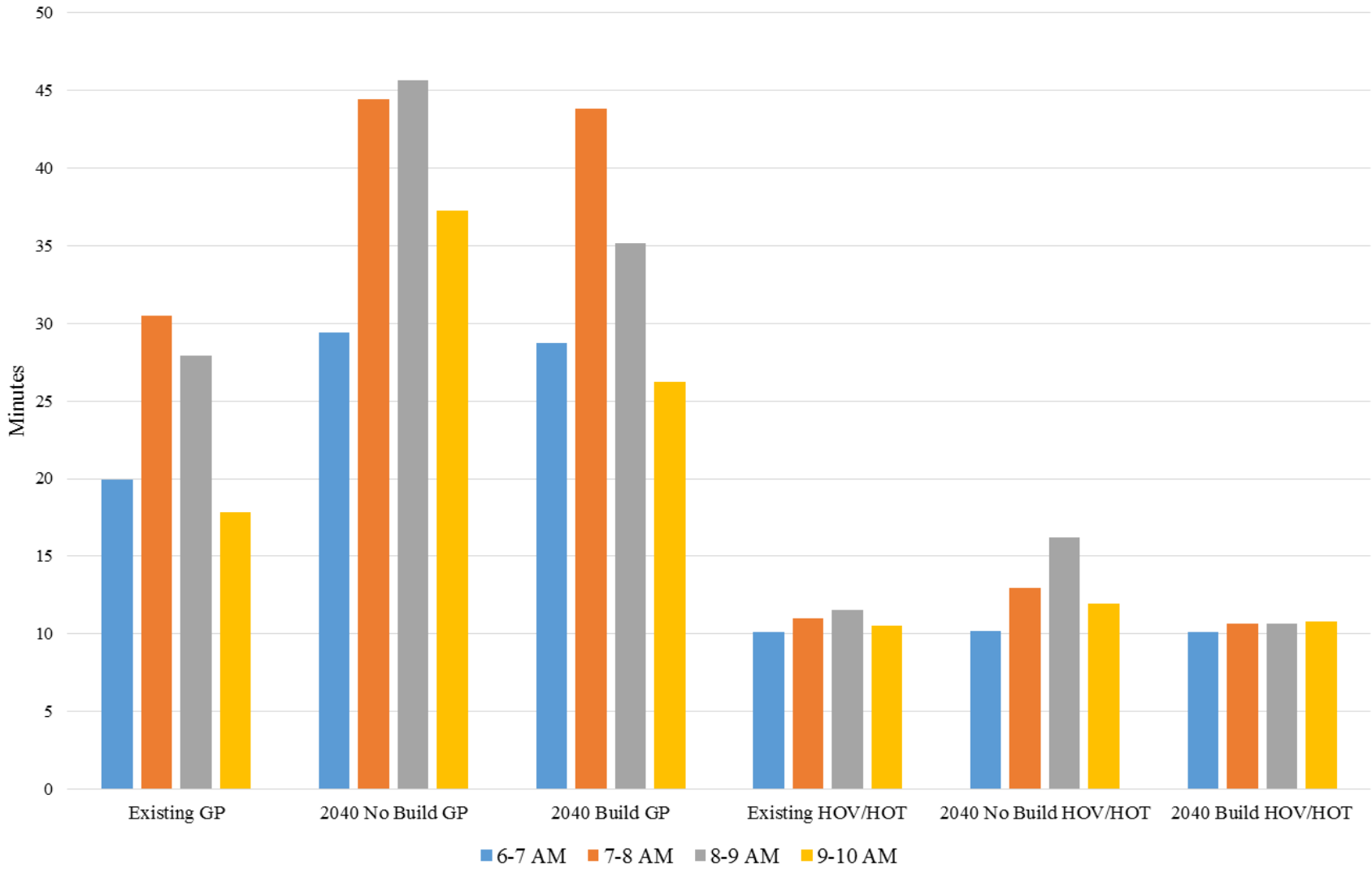


Figure 5-18: Southbound Overall Travel Time Summary - PM Peak Period

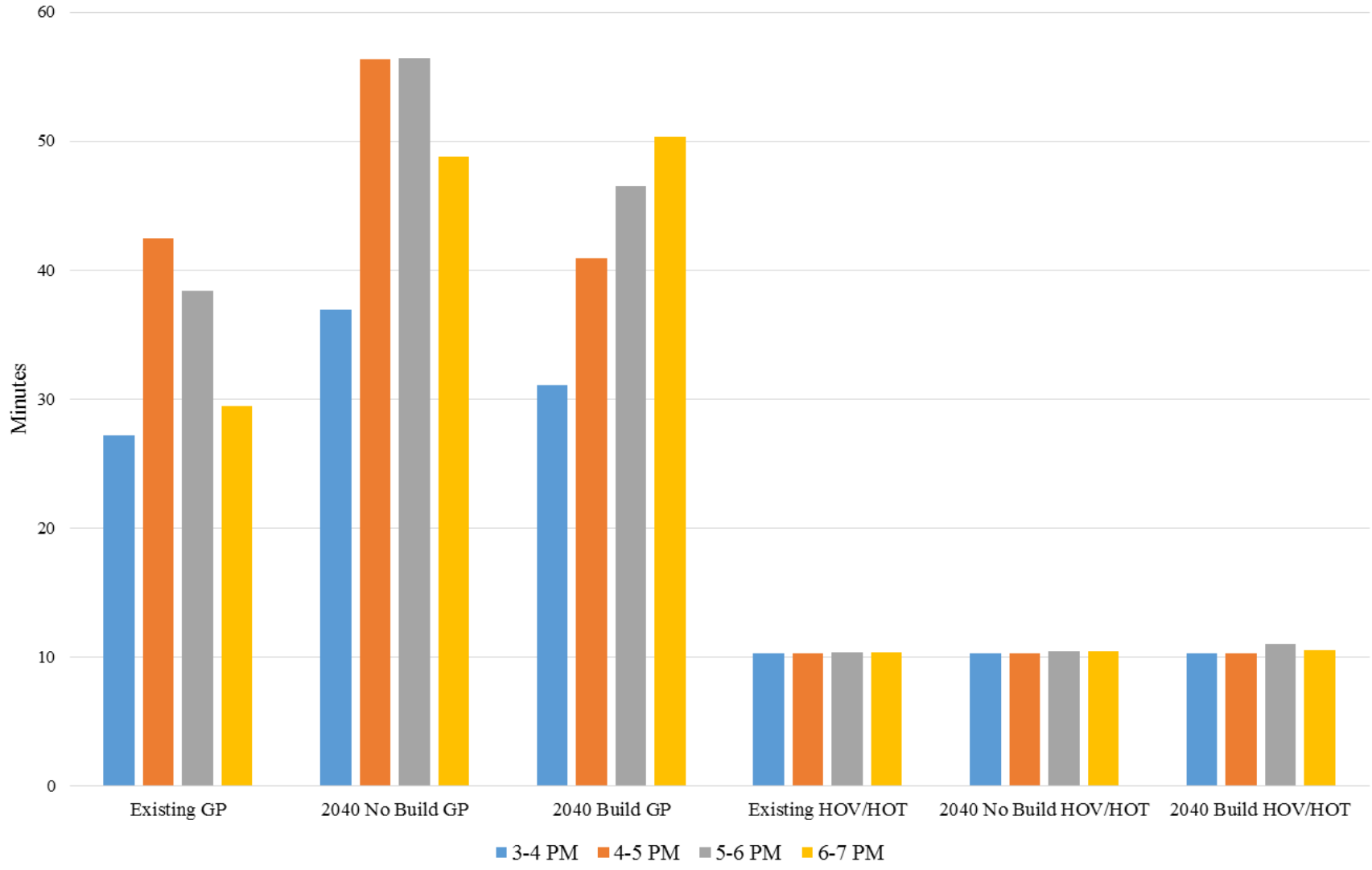


Figure 5-19a: AM Peak Period (6 – 7 AM) Travel Times

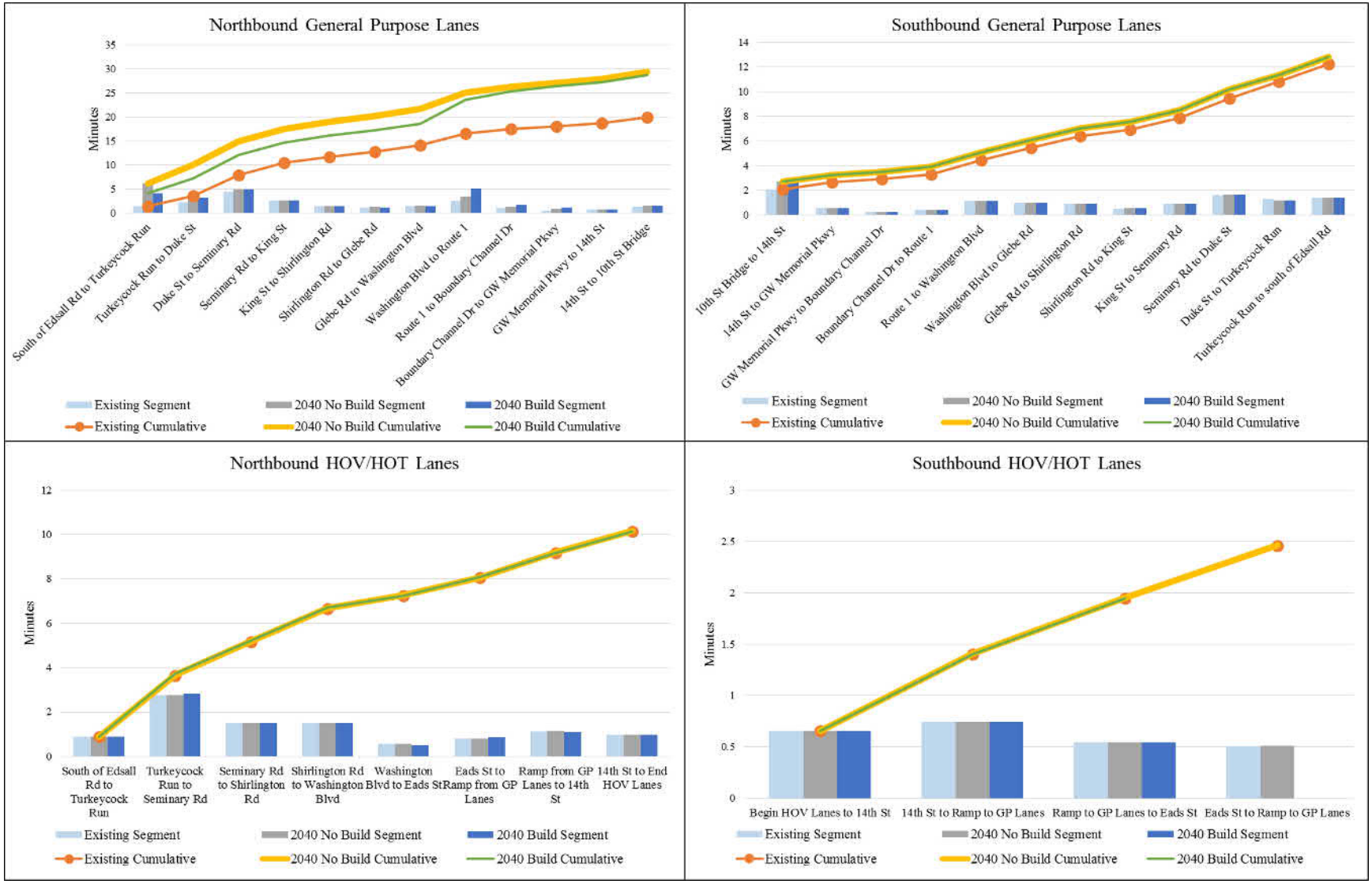


Figure 5-19b: AM Peak Period (7 – 8 AM) Travel Times

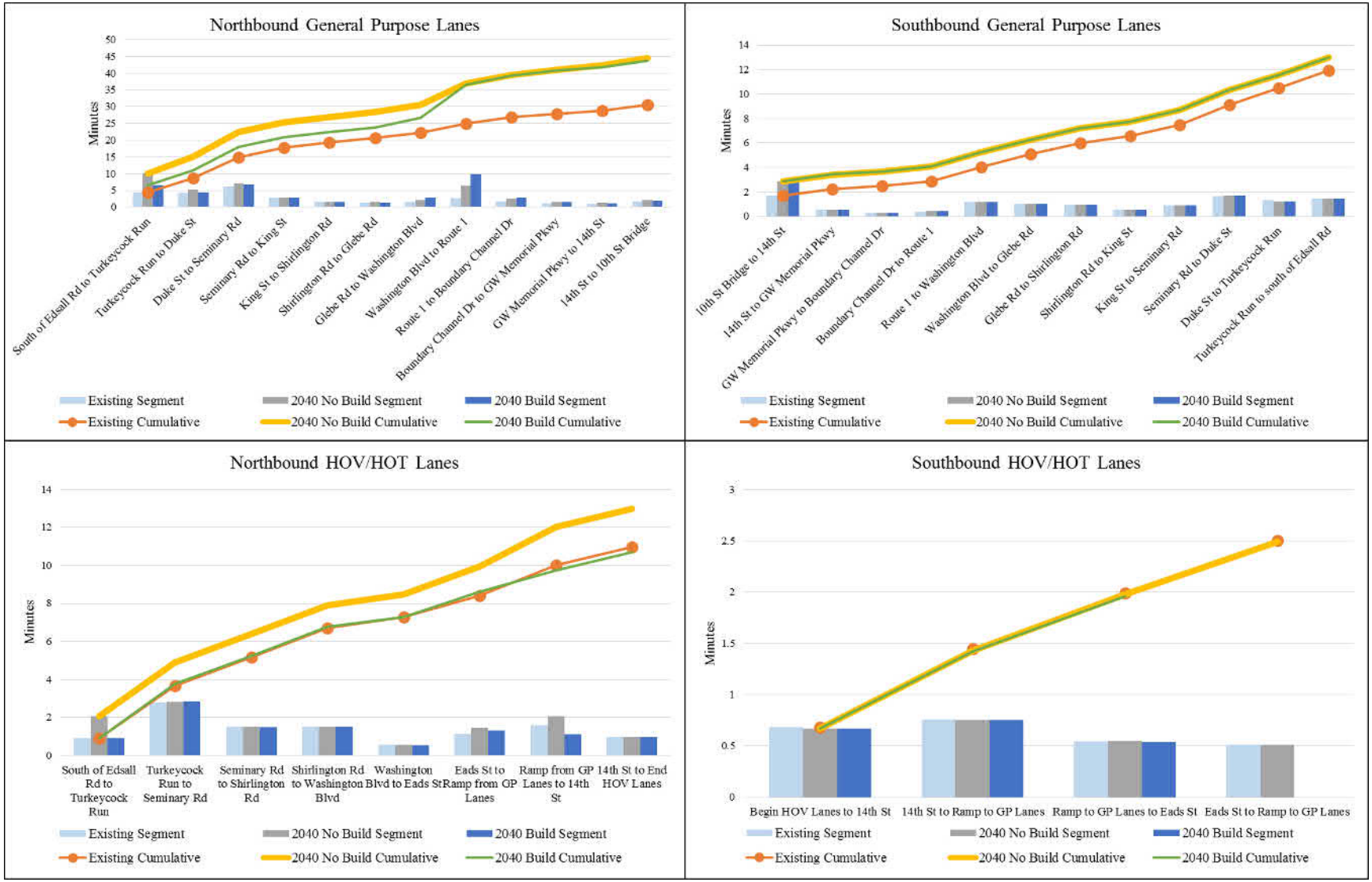


Figure 5-19c: AM Peak Period (8 – 9 AM) Travel Times

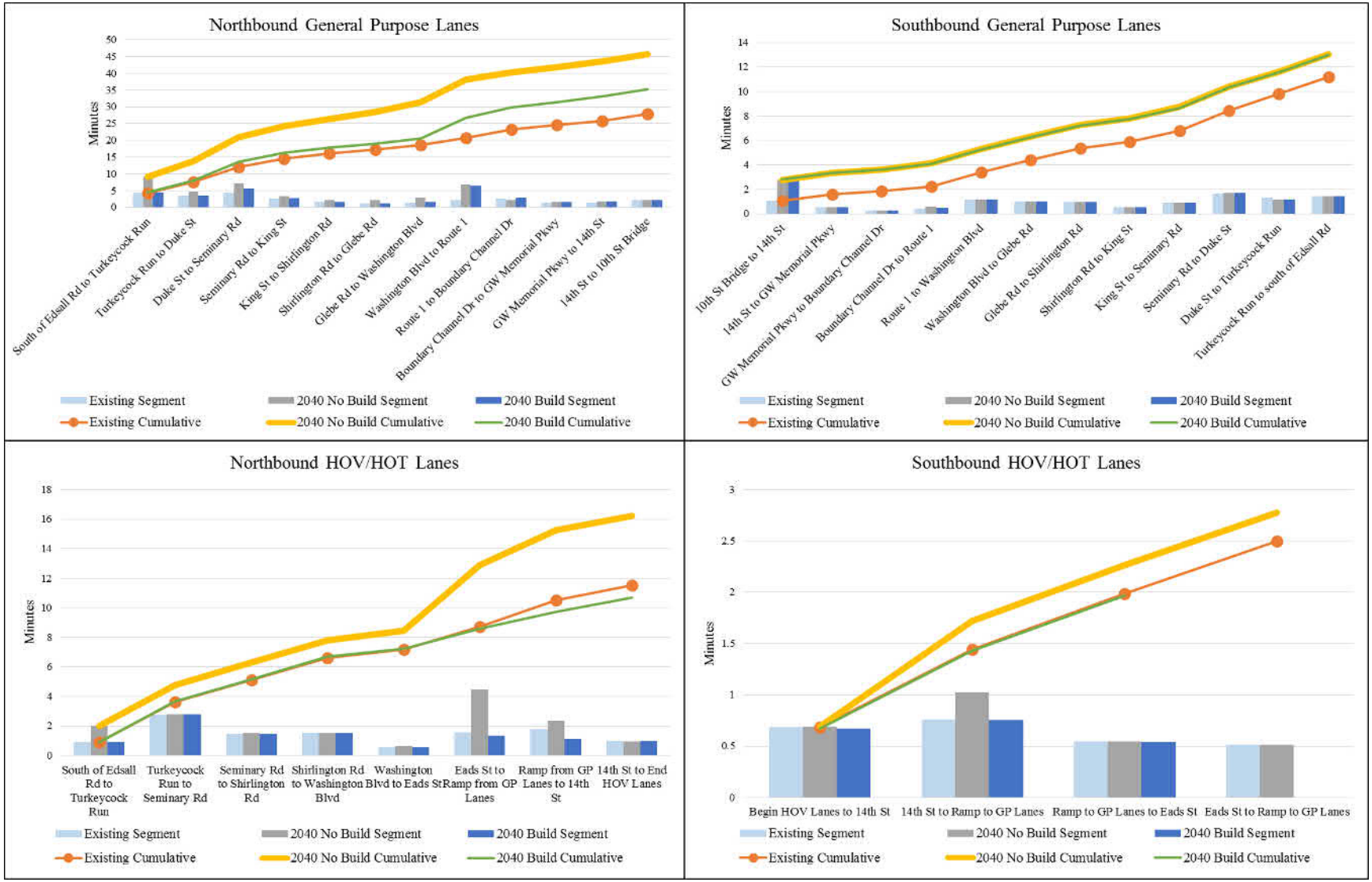


Figure 5-19d: AM Peak Period (9 – 10 AM) Travel Times

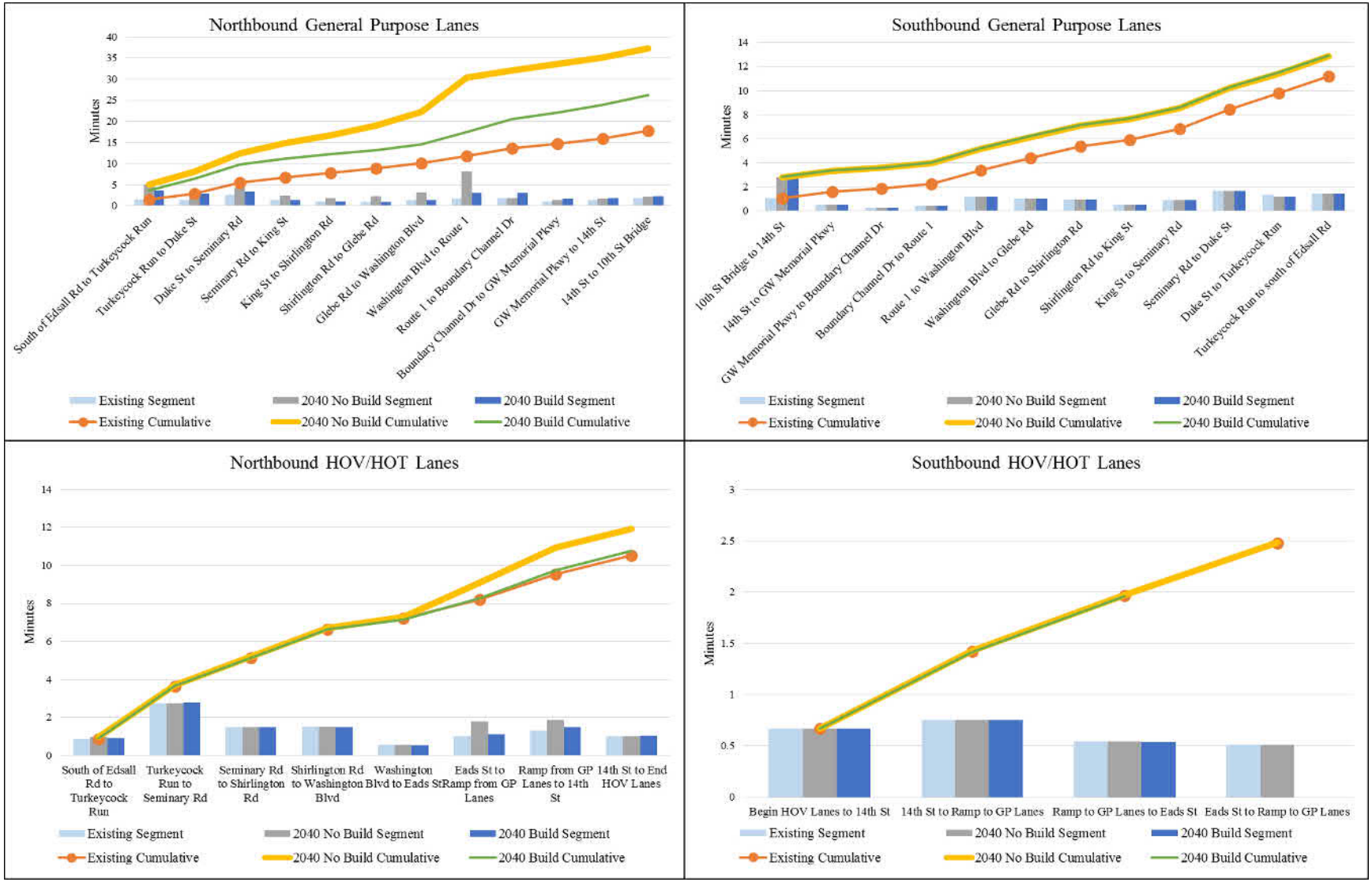


Figure 5-20a: PM Peak Period (3 – 4 PM) Travel Times

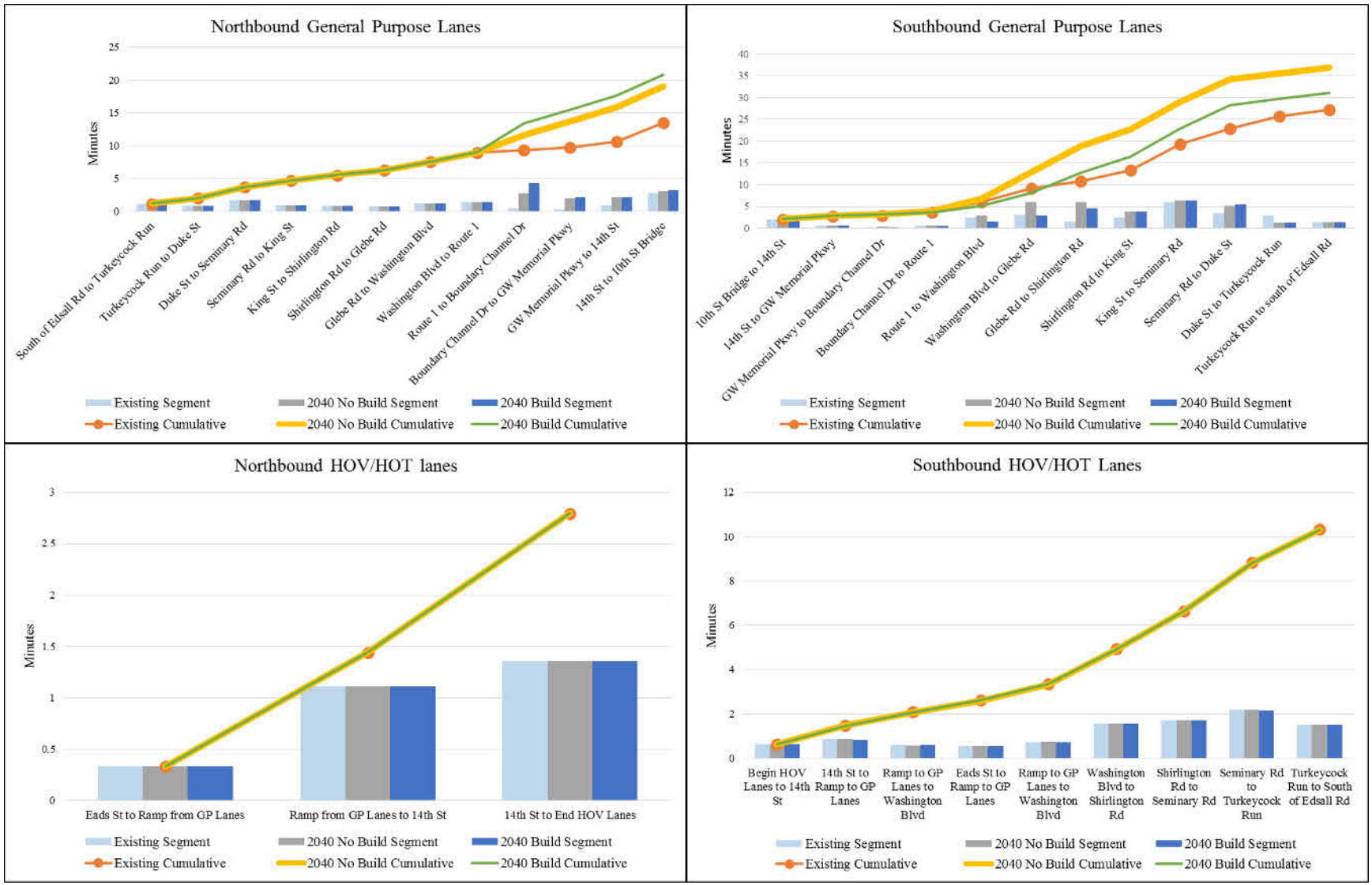


Figure 5-20b: PM Peak Period (4 – 5 PM) Travel Times

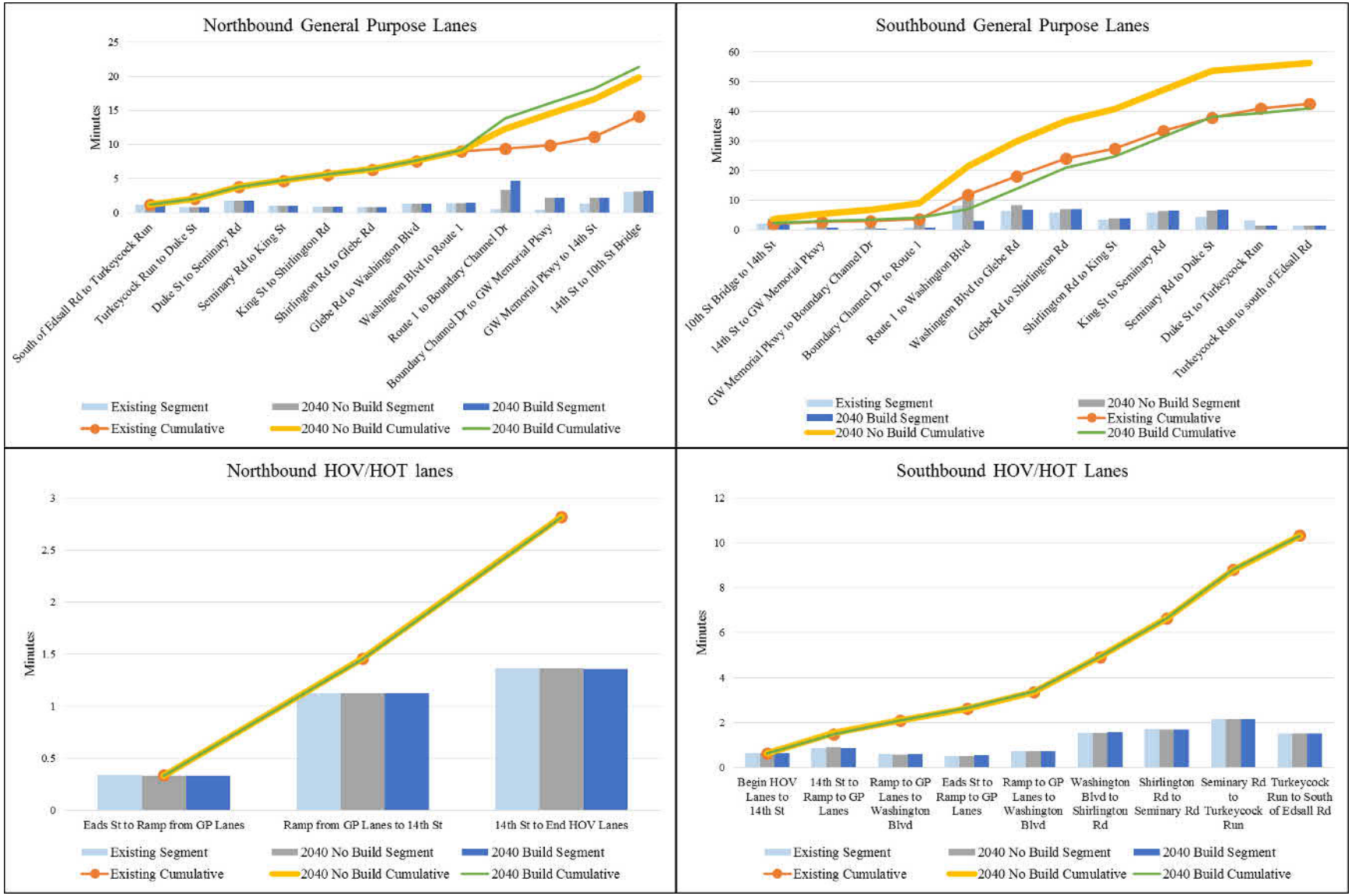


Figure 5-20c: PM Peak Period (5 – 6 PM) Travel Times

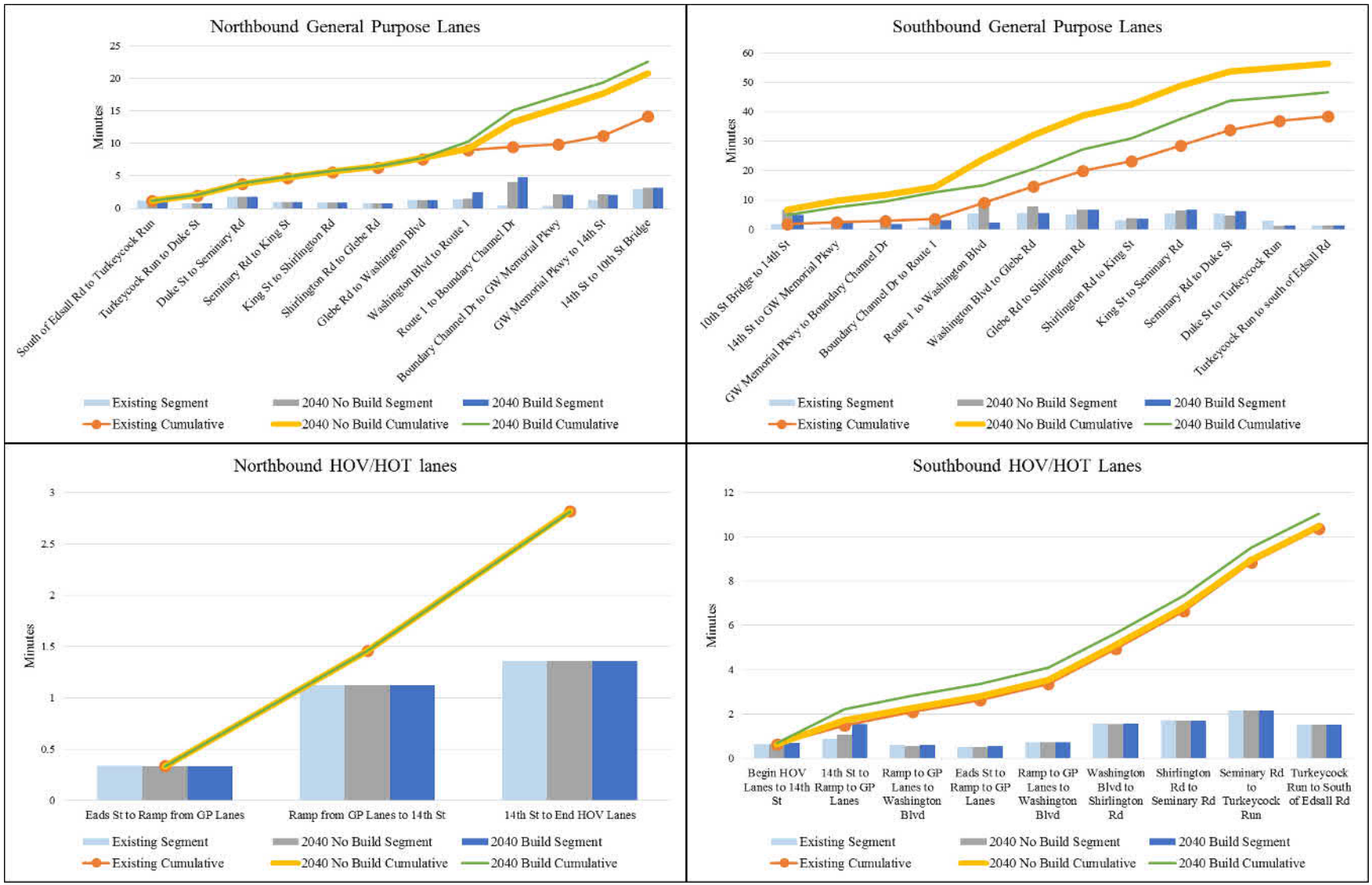


Figure 5-20d: PM Peak Period (6 – 7 PM) Travel Times

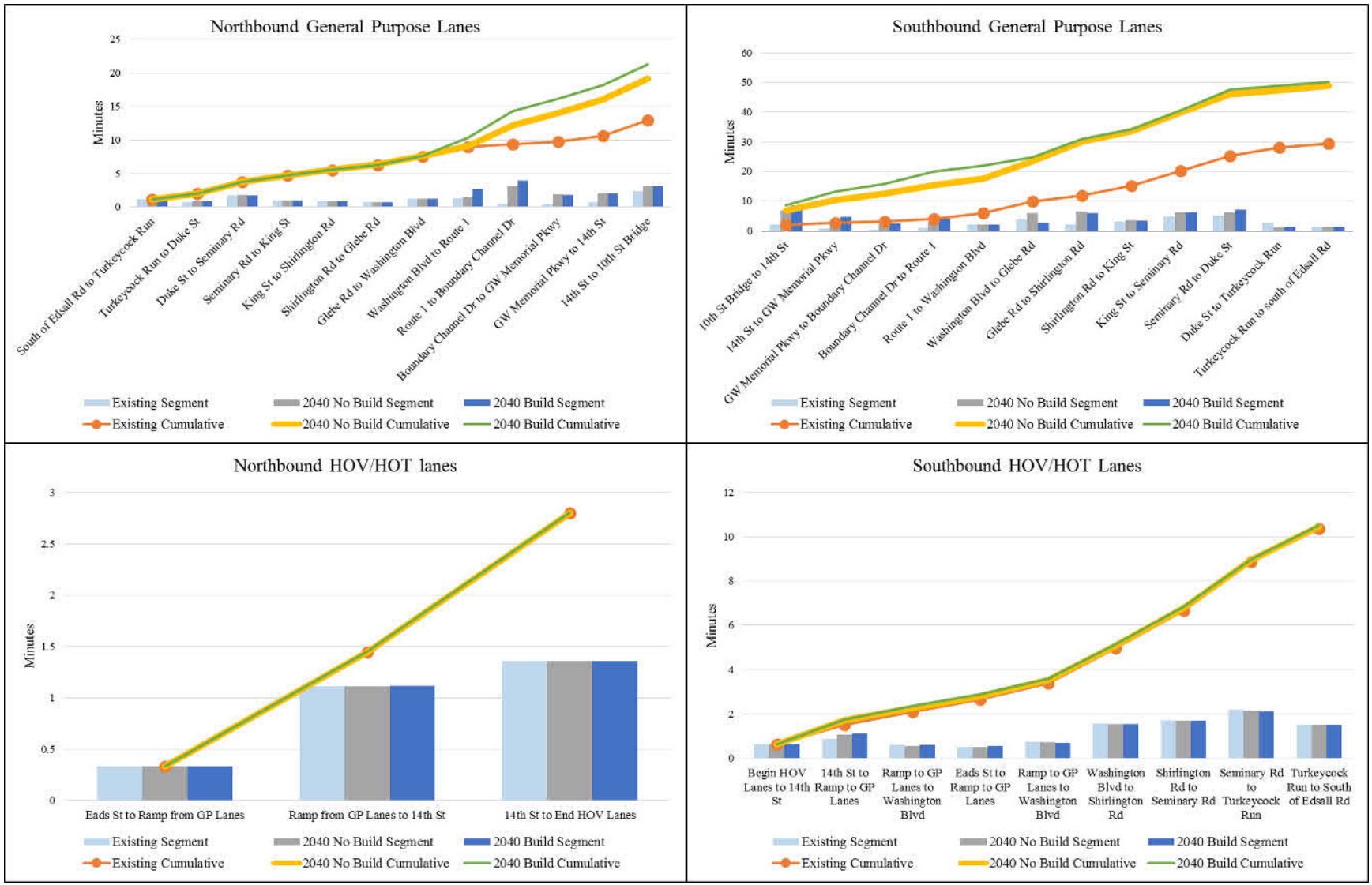


Figure 5-21a: AM Peak Period Speed Comparison – Northbound General Purpose Lanes

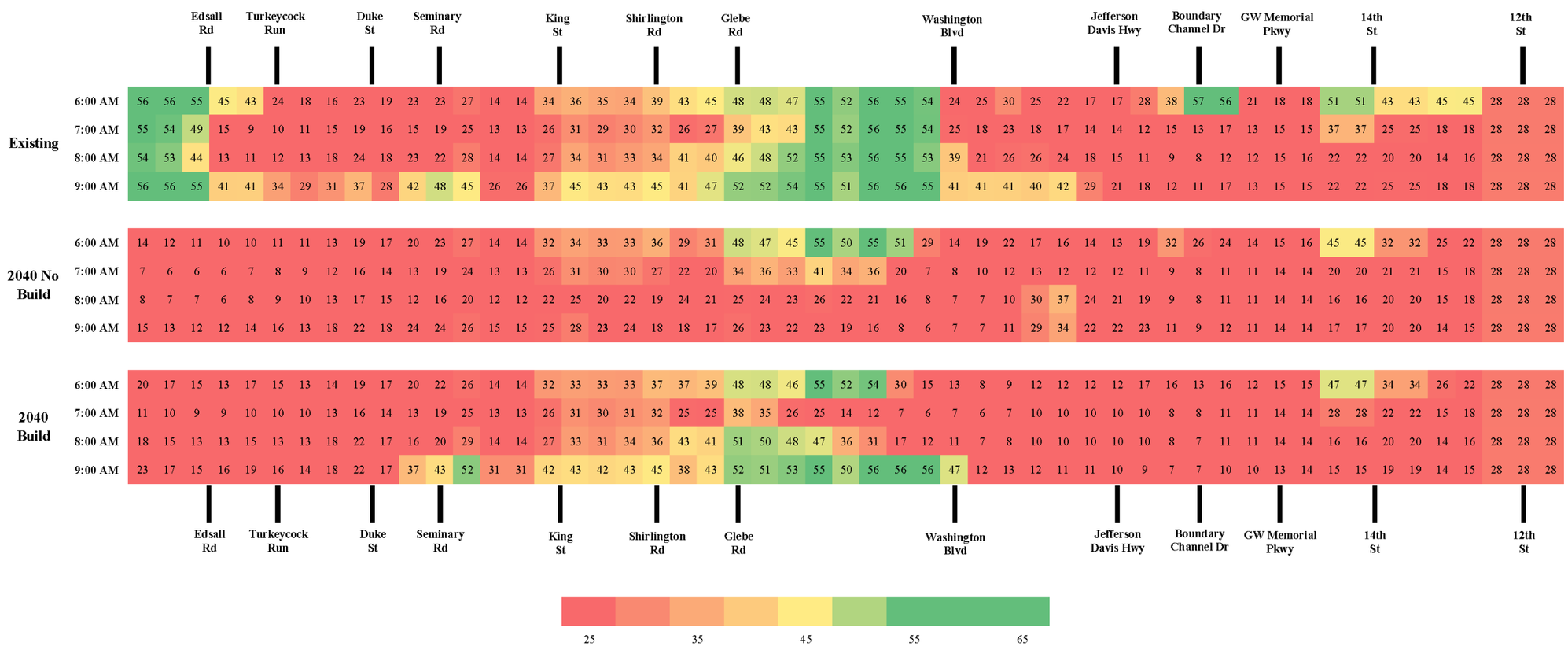


Figure 5-21b: AM Peak Period Speed Comparison – Southbound General Purpose Lanes

		Edsall Rd						Turkeycock Run						Duke St						Seminary Rd						King St			Shirlington Rd	Glebe Rd					Washington Blvd					Jefferson Davis Hwy			Boundary Channel Dr			GW Memorial Pkwy			14th St		12th St	
Existing	6:00 AM	55	54	55	55	54	54	55	55	55	57	56	55	55	55	57	57	58	55	58	57	58	58	55	55	56	56	56	58	58	57	63	63	56	56	56	56	55	52	53	48	48	48	48	49	48	49	47	48	22	21	17	25
	7:00 AM	55	54	54	54	54	54	55	55	54	57	53	55	55	53	57	57	58	53	57	57	57	58	54	55	55	56	55	58	58	54	62	63	56	56	56	56	50	52	53	47	48	48	48	48	48	48	47	48	28	28	26	27
	8:00 AM	55	54	55	55	54	54	55	55	54	57	54	55	55	54	57	57	58	54	57	57	57	58	55	55	55	56	55	58	58	56	62	63	56	56	56	57	53	50	53	47	48	48	48	48	48	48	48	48	43	36	44	48
	9:00 AM	56	55	55	55	54	54	55	55	55	57	56	55	55	55	57	57	58	55	57	57	57	58	55	55	56	56	56	58	58	56	62	63	56	56	56	56	55	51	53	47	48	46	48	49	48	49	48	48	42	36	45	48
2040 No Build	6:00 AM	55	55	55	55	55	55	52	54	58	58	58	55	56	56	56	56	56	55	58	57	57	58	55	55	55	56	55	58	58	56	63	63	56	56	55	56	55	53	53	49	47	47	48	49	48	49	47	48	21	19	15	13
	7:00 AM	55	55	55	55	55	55	52	54	58	58	58	55	56	56	56	56	56	55	58	56	57	58	54	55	55	56	55	58	58	52	62	63	56	56	56	56	52	53	53	48	47	47	48	49	48	48	47	48	21	20	16	11
	8:00 AM	55	55	55	55	55	55	53	54	58	58	58	55	56	56	56	56	56	55	58	56	57	58	55	55	55	56	55	58	58	55	62	63	56	56	56	57	50	51	51	38	23	23	38	47	47	48	48	48	21	21	16	11
	9:00 AM	55	55	55	55	55	55	53	54	58	58	58	55	57	57	57	57	57	56	58	57	57	58	55	55	55	56	55	58	58	55	62	63	56	56	56	56	54	52	52	48	43	43	48	48	48	48	48	48	21	20	16	12
2040 Build	6:00 AM	55	55	55	55	55	55	52	54	58	58	58	55	56	56	56	56	56	55	58	57	57	58	55	55	55	56	56	58	58	57	63	63	56	56	55	56	55	53	53	49	47	47	48	49	48	49	47	48	21	19	14	13
	7:00 AM	55	55	55	55	55	55	52	54	58	58	58	55	56	56	56	56	56	55	58	56	57	58	54	55	55	56	55	58	58	56	62	63	56	56	56	56	52	52	52	48	47	47	48	48	48	48	47	48	21	20	16	11
	8:00 AM	55	55	55	55	55	55	53	54	58	58	58	55	56	56	56	56	56	55	58	56	57	58	55	55	55	56	55	58	58	55	62	63	56	56	56	57	51	52	52	43	35	35	45	47	47	48	47	48	21	20	16	11
	9:00 AM	55	55	55	55	55	55	53	54	58	58	58	55	57	57	57	57	57	55	58	57	57	58	55	55	55	56	55	58	58	54	62	63	56	56	56	56	54	52	52	48	42	42	48	48	48	48	47	48	21	20	15	11

25 35 45 55 65

Figure 5-22: AM Peak Period Speed Comparison – HOV/HOT Lanes

Northbound HOV/HOT Lanes

Turkeycock Run | Seminary Rd | Shirlington Rd | Washington Blvd | Eads St | 14th St

Existing	6:00 AM	68	68	67	68	68	68	67	67	67	68	68	62	64	65	54	54	51	56	24	54	32	42	28
	7:00 AM	68	67	66	68	68	68	67	67	67	67	67	61	64	65	55	55	51	55	18	42	16	30	28
	8:00 AM	69	68	67	68	68	68	68	68	68	68	68	63	64	65	55	55	53	46	12	25	12	26	28
	9:00 AM	69	69	69	68	68	68	67	67	67	68	68	62	64	65	55	55	53	56	20	41	21	36	27
2040 No Build	6:00 AM	68	65	68	68	68	68	67	67	67	68	68	61	64	65	54	54	51	56	26	55	34	41	28
	7:00 AM	30	28	66	67	67	67	65	65	65	66	67	60	64	64	54	54	51	44	13	22	14	23	28
	8:00 AM	31	28	67	68	68	68	66	66	66	67	68	62	64	64	52	52	32	8	7	7	10	20	28
	9:00 AM	63	64	68	68	68	68	67	67	67	68	68	62	64	65	55	55	53	53	22	19	8	26	27
2040 Build	6:00 AM	68	68	68	68	68	68	65	65	65	67	68	61	64	64	60	60	55	52	12	53	56	44	28
	7:00 AM	68	67	68	68	68	67	65	65	65	67	68	59	64	63	59	59	52	27	9	49	55	42	28
	8:00 AM	68	68	68	68	68	68	66	66	66	68	68	59	64	64	58	58	46	25	9	49	54	43	28
	9:00 AM	69	69	69	69	69	68	67	67	67	69	68	62	64	65	60	60	55	52	15	38	20	32	26

Turkeycock Run | Seminary Rd | Shirlington Rd | Washington Blvd | Eads St | 14th St

25 35 45 55 65

Southbound HOV/HOT Lanes

Eads St | Boundary Channel Dr | 14th St

Existing	6:00 AM	58	55	48	48	48	48	40
	7:00 AM	57	54	48	48	45	48	39
	8:00 AM	57	54	48	47	47	47	39
	9:00 AM	58	54	48	48	47	48	40
2040 No Build	6:00 AM	58	54	48	48	48	48	40
	7:00 AM	57	54	47	47	47	48	40
	8:00 AM	57	54	48	48	27	36	39
	9:00 AM	58	54	48	48	47	48	40
2040 Build	6:00 AM			48	48	47	48	40
	7:00 AM			48	48	47	48	40
	8:00 AM			48	48	44	48	40
	9:00 AM			48	48	47	48	40

Eads St | Boundary Channel Dr | 14th St

25 35 45 55 65

Figure 5-23a: PM Peak Period Speed Comparison – Northbound General Purpose Lanes

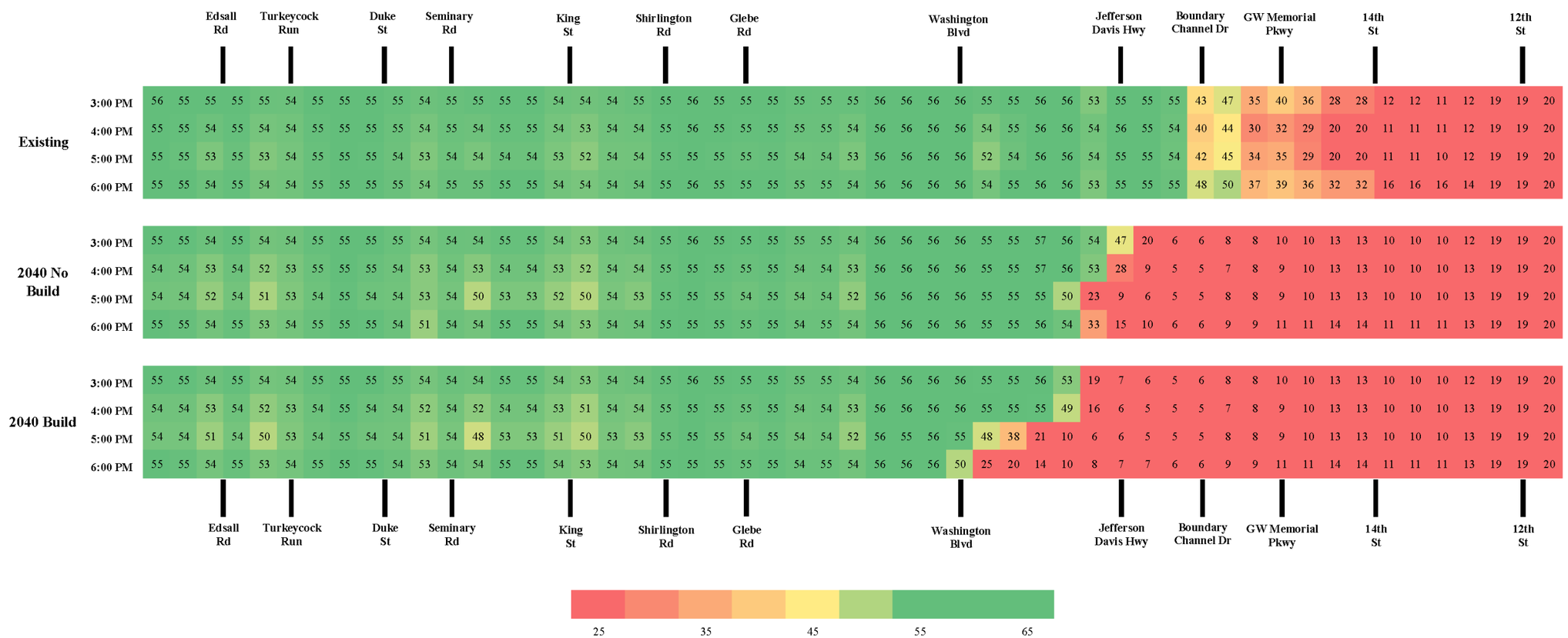


Figure 5-23b: PM Peak Period Speed Comparison – Southbound General Purpose Lanes

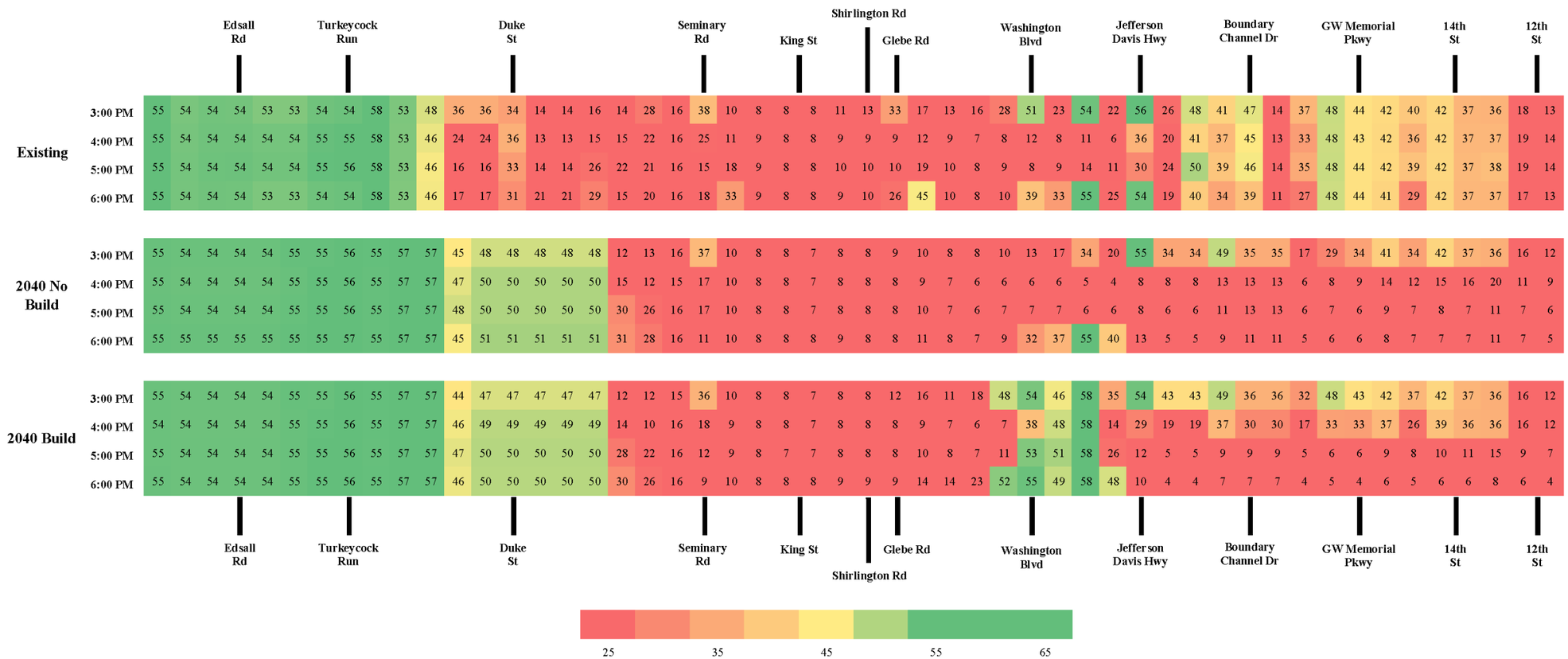


Figure 5-24: PM Peak Period Speed Comparison – HOV/HOT Lanes

Northbound HOV/HOT Lanes

		Eads St			14th St
Existing	3:00 PM	58	56	43	43	20
	4:00 PM	58	55	43	42	20
	5:00 PM	58	55	43	42	20
	6:00 PM	58	56	43	42	20
2040 No Build	3:00 PM	58	56	43	43	20
	4:00 PM	58	55	43	42	20
	5:00 PM	58	55	43	42	20
	6:00 PM	58	56	43	42	20
2040 Build	3:00 PM	58	56	43	42	20
	4:00 PM	58	55	43	42	20
	5:00 PM	58	55	43	42	20
	6:00 PM	58	56	43	42	20

Eads St — 14th St

25 35 45 55 65

Southbound HOV/HOT Lanes

		Turkeycock Run					Seminary Rd			Shirlington Rd			Washington Blvd			Eads St		Boundary Channel Dr			14th St	
Existing	3:00 PM	66	66	66	66	64	64	64	64	64	64	52	52	55	55	54	52	43	43	43	42	42
	4:00 PM	65	65	65	65	64	64	64	64	64	65	52	53	55	55	55	53	43	43	43	42	42
	5:00 PM	65	65	65	65	64	64	64	64	64	64	52	52	55	55	53	53	43	43	43	42	42
	6:00 PM	65	66	66	66	64	64	64	64	64	64	52	52	55	55	53	52	43	43	42	42	41
2040 No Build	3:00 PM	66	66	66	66	64	61	64	64	64	64	52	52	55	55	53	52	45	45	43	42	42
	4:00 PM	65	65	65	66	64	63	65	65	65	65	52	53	55	55	54	52	46	46	39	40	42
	5:00 PM	65	65	65	65	64	63	65	65	65	65	52	53	55	55	55	53	46	46	29	33	42
	6:00 PM	65	66	65	66	65	64	65	65	65	65	53	53	55	55	56	53	46	46	27	34	42
2040 Build	3:00 PM	65	66	66	62	64	61	65	65	65	65	52	51	54	56	55	52	42	43	44	43	42
	4:00 PM	65	65	66	66	64	62	65	65	65	65	52	51	55	55	55	52	43	43	43	42	42
	5:00 PM	65	65	65	66	64	63	65	65	65	65	52	51	55	55	55	52	43	43	21	24	39
	6:00 PM	65	65	66	66	65	64	65	65	65	65	52	52	55	57	56	53	43	43	22	33	42

Turkeycock Run — Seminary Rd — Shirlington Rd — Washington Blvd — Eads St — Boundary Channel Dr — 14th St

25 35 45 55 65

5.5.1.2 Person Throughput

In addition to traditional measures of effectiveness typically used to measure the benefits of a project including traffic volumes, travel times, speeds, and density, person throughput is a valuable measure that can be used to document the effectiveness of the I-395 Express Lanes project. Person throughput is the number of travelers passing through a corridor at a given point for all modes of travel.

Traffic volumes by vehicle class were extracted from the VISSIM mesoscopic model and used as the basis for the calculation of the person throughput in both the general purpose and HOV/HOT lanes. Vehicle occupancy for each vehicle class was based on the vehicle occupancy data collected as part of the *2014 Performance of High-Occupancy Vehicle Facilities on Freeway in the Washington Region* (NCRTPB, 2015) report (see **Section 2.4.2**).

Figures 5-25 and 5-26 summarize the person throughput along the corridor for existing conditions, No Build conditions, and Build conditions in the peak direction at two locations along the corridor – north of Turkeycock Run and north of Glebe Road for the four-hour analysis periods during the AM and PM peak periods (i.e., 6 AM to 10 AM and 3 PM to 7 PM).

As shown in **Figure 5-25**, there is a 3 to 4 percent increase in person trips between existing conditions and 2040 No Build conditions along I-395 in the northbound AM peak travel direction. When comparing No Build to Build conditions, there is an 8 to 11 percent increase in person trips equating to moving 6,000 to 6,350 more persons during the morning peak period north of Glebe Road and north of Turkeycock Run, respectively.

As shown in **Figure 5-26**, there is a 4 and 16 percent decrease in person trips between existing conditions and 2040 No Build conditions along I-395 in the southbound PM peak travel direction north of Turkeycock Run and north of Glebe Road, respectively. This is due to the northern portion of the study area being severely over capacity and approaching “jam density” throughout the duration of the four-hour peak period which causes a decrease in both traffic flow rates and person throughput. Jam density refers to high traffic densities with stopped traffic flow. When comparing No Build to Build conditions there is a 14 to 26 percent increase in person trips equating to moving 7,250 to 13,300 more persons during the evening peak period north of Turkeycock Run and north of Glebe Road, respectively.

Figure 5-25: Northbound AM Peak Period Person Throughput Comparison

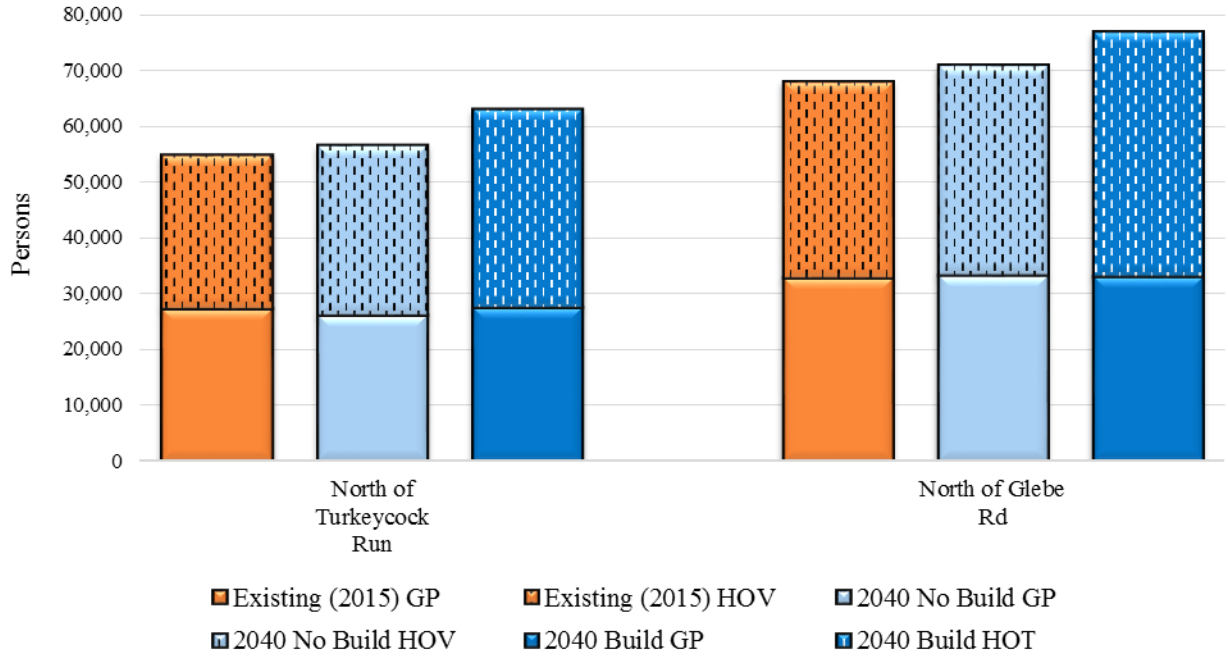
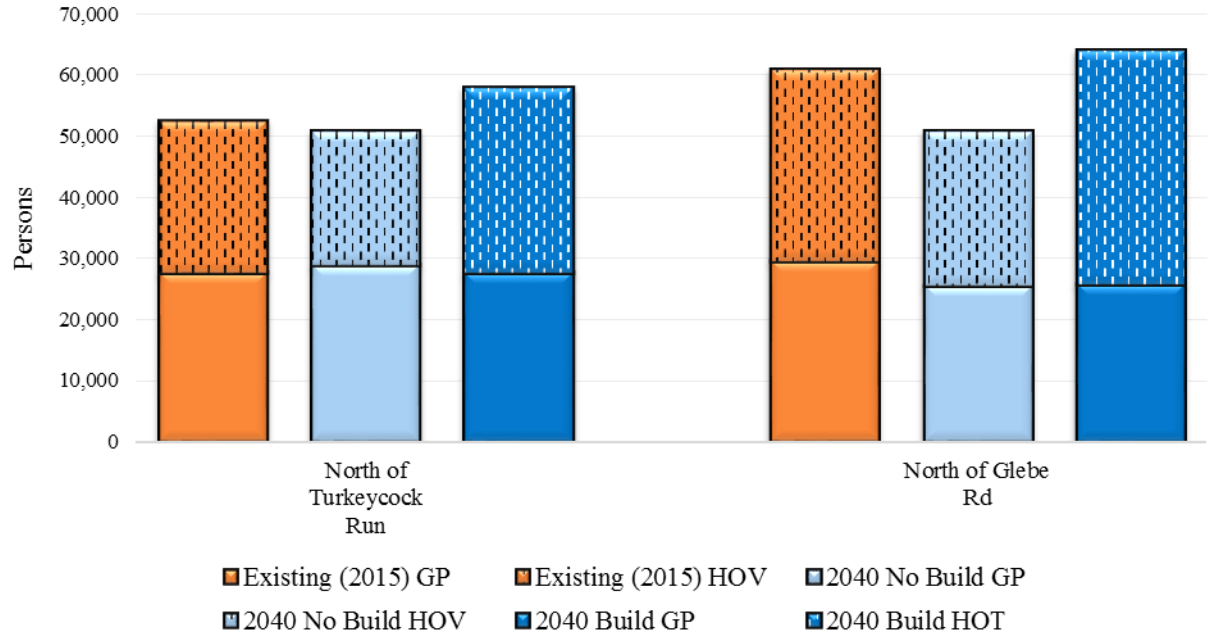


Figure 5-26: Southbound PM Peak Period Person Throughput Comparison



5.5.2 Arterial Operations

Similar to existing conditions, intersection traffic analysis was performed at signalized and unsignalized intersections along the I-395 study corridor for both 2040 No Build and Build conditions. Standard methodologies described in the Highway Capacity Manual (HCM) were utilized, using the software package *Synchro Version 9* (Build 907, Revision 6). Reported Measures of Effectiveness (MOEs) from Synchro were developed by applying HCM methodologies to the analysis outputs for both signalized and unsignalized intersections. The HCM methodology was also applied to roundabout analysis performed using *Sidra Intersection 7.0*. Existing traffic signal timings for signalized intersections were modified as required to accommodate changing traffic patterns under No Build and Build conditions.

It should be noted that the HCM-based *Synchro* software does not take into account the interactions between closely spaced intersections and that delays associated with queue interactions may result in higher delay values than reported. The HCM methodology also does not take into account downstream congestion constraints, for example on-ramps to I-395 that may spill back onto the arterial network at some intersections during peak periods. The development of a VISSIM model to support the Interchange Modification Report for both the I-395 freeway facility and the arterial network serving I-395 will further examine and document operations along the arterial network serving I-395.

Table 5-5 depicts level of service (LOS) for both signalized and unsignalized intersections for the AM and PM peak hours for both No Build and Build conditions. Similar to existing conditions, the majority (80 percent) of the intersections operate at LOS C or better during both the AM and PM peak periods. This can be primarily attributed to congestion along I-395 metering traffic flow entering the arterials intersecting the corridor that further degrades in the future compared to existing conditions.

Forty-four of the 55 intersections (80 percent) operate at LOS C or better under both No Build and Build conditions. Based on a comparison of LOS for No Build and Build conditions, there are two intersections that have a LOS degradation to D or worse in one or more peak periods as discussed below. The remaining 53 of 55 intersections have LOS C or better operations under both No Build and Build conditions or no change/improved LOS when comparing No Build and Build conditions.

Martha Custis Road at Gunston Road: This unsignalized intersection operates under four-way stop control and is located just east of the Shirlington Road Interchange. In the PM peak hour, traffic volumes along eastbound Gunston Road from the Shirlington Road Rotary increase by approximately 11% in the 2040 Build scenario, compared to 2040 No Build scenario. This increase in traffic volume results in an increase in eastbound approach delays of approximately 10 seconds and an LOS degradation from D to E. The operation of this intersection in conjunction with the Shirlington Road Rotary (see discussion below) will be evaluated in more detail as part of the Interchange Modification Report.

Army Navy Drive at Eads Street: This signalized intersection is located just south of the Eads Street Interchange with the I-395 HOV lanes. In the PM peak hour, the LOS degrades from C to D and is discussed in more detail in **Section 5.5.3**.

Shirlington Road Rotary at North-facing HOV/HOT ramp: The Shirlington Road / Quaker Lane Interchange with I-395 includes a north-facing ramp serving the HOV lanes. Due to the limitations of the HCM methodology to analyze the rotary interchange at Shirlington Road, a separate analysis using a subsection of the larger VISSIM microscopic network that is under development as part of the Interchange

Modification Report was prepared for the PM peak period from 3 PM to 7 PM for the 2040 Build scenario. The analysis was performed to analyze the operation of the future HOT ramp junction at the rotary in relation to the weave section on the north side of the rotary between the HOT ramp and the exit from the rotary to Shirlington Road.

During the PM peak hour, the forecasted ramp volume from the southbound I-395 HOV (future HOT) lanes increases by approximately 500 vehicles per hour when comparing 2040 No Build to 2040 Build conditions; however, it should be noted that this is partially offset by a reduction of approximately 300 vehicles exiting the two general purpose off-ramps resulting in an overall net increase in volumes exiting the southbound I-395 general purpose and HOT lanes of approximately 12% compared to the overall volume exiting I-395 southbound under No Build conditions. The results from this VISSIM analysis indicate that the HOT lane ramp approach to the Shirlington rotary would operate at LOS C with an average delay of approximately 20 seconds.

Table 5-5: 2040 No Build and Build Conditions Intersection LOS and Delay Summary

Intersection Number	Intersection Name	2040 No Build Conditions					2040 Build Conditions				
		Intersection Control	AM Peak Hour (7-8 AM)		PM Peak Hour (5-6 PM)		Intersection Control	AM Peak Hour (7-8 AM)		PM Peak Hour (5-6 PM)	
			Avg Delay (sec)	LOS	Avg Delay (sec)	LOS		Avg Delay (sec)	LOS	Avg Delay (sec)	LOS
1	Edsall Rd at Cherokee Ave	Signalized	12.6	B	18.8	B	Signalized	12.6	B	18.8	B
2	Edsall Rd at Bren Mar Dr	Signalized	24.9	C	23.6	C	Signalized	24.7	C	23.0	C
3	Edsall Rd at Bloomfield Dr	Signalized	23.3	C	9.2	A	Signalized	23.3	C	9.4	A
101	Edsall Rd at I-95 SB On Ramp	Signalized	4.8	A	7.9	A	Signalized	4.8	A	7.9	A
4	Little River Turnpike at Beauregard St	Signalized	63.5	E	76.2	E	Signalized	63.3	E	76.2	E
5	Little River Turnpike at Oasis Dr	Signalized	9.6	A	13.0	B	Signalized	9.6	A	12.9	B
102	Little River Turnpike at I-395 SB Off Ramp	Signalized	14.9	B	12.7	B	Signalized	14.9	B	12.5	B
6	Duke St at S Walker St	Signalized	27.2	C	31.4	C	Signalized	26.7	C	31.4	C
8	Seminary Rd at Mark Center Dr	Signalized	29.3	C	27.1	C	Signalized	29.4	C	24.5	C
104	Ramp to Beauregard St W at Beauregard St WB	Signalized	31.4	C	24.1	C	Signalized	31.4	C	32.8	C
105	Beauregard St WB at South Tower	Signalized	23.1	C	26.8	C	Signalized	23.3	C	26.8	C
106	Beauregard St EB at South Tower	Signalized	23.4	C	32.6	C	Signalized	23.9	C	26.0	C
107	Ramp to Beauregard St EB & Beauregard St EB	Signalized	10.9	B	17.3	B	Signalized	10.9	B	12.1	B
9	EB Seminary Rd at SB I-395 ramps	Signalized	25.3	C	21.1	C	Signalized	22.3	C	20.8	C
10	WB Seminary Rd at SB I-395 ramps	Signalized	12.9	B	18.4	B	Signalized	13.6	B	12.7	B
11	EB Seminary Rd at NB I-395 ramps	Signalized	43.4	D	31.6	C	Signalized	43.3	D	32.6	C
12	WB Seminary Rd at NB I-395 ramps	Signalized	22.6	C	16.0	B	Signalized	30.1	C	15.6	B
13	WB Seminary Rd at I-395 HOV Ramp	Unsignalized	-[1]	-[1]	13.9	B (WB R)	Unsignalized	-[1]	-[1]	14.0	B (WB R)
103	Seminary Rd at Beauregard St WB	Signalized	23.2	C	27.3	C	Signalized	23.2	C	29.5	C
108	Seminary Rd at Beauregard St EB	Signalized	35.3	D	36.2	D	Signalized	34.9	C	36.2	D
109	Seminary Rd at I-395 HOV ramp	Signalized	15.3	B	0.8	A	Signalized	15.8	B	0.8	A
14	Seminary Rd at Kenmore Ave	Unsignalized	17.7	C (WB R)	16.0	C (EB R)	Unsignalized	22.2	C (WB R)	16.1	C (EB R)
15	Seminary Rd at Library Ln	Signalized	13.1	B	11.1	B	Signalized	13.7	B	11.1	B
16	King St at Park Center Dr	Signalized	23.9	C	30.9	C	Signalized	23.8	C	31.3	C
17	King St at 30th St	Unsignalized	13.6	B (WB R)	16.2	C (WB R)	Unsignalized	13.6	B (WB R)	16.0	C (WB R)
18	King St at Menokin Dr	Signalized	20.1	C	11.8	B	Signalized	20.1	C	11.8	B
19	S Shirlington Rd at S Arlington Mill Dr/ Four Mile Run Tr	Signalized	37.8	D	53.1	D	Signalized	38.2	D	49.3	D
22	S Shirlington Rd at Campbell Ave	Signalized	17.1	B	17.1	B	Signalized	17.2	B	17.3	B
27	Martha Custis Dr at Gunston Rd	Unsignalized	21.9	C (WB LTR)	29.3	D (EB LTR)	Unsignalized	23.3	C (WB LTR)	39.9	E (EB LTR)
30	N Quaker Ln at Preston Rd	Signalized	28.1	C	31.3	C	Signalized	27.3	C	31.1	C
31	S Glebe Rd at 24th Rd S (north)	Signalized	28.7	C	22.9	C	Signalized	28.6	C	22.0	C
32	S Glebe Rd at 24th Rd S (south)	Signalized	21.3	C	19.6	B	Signalized	21.4	C	19.7	B
33	S Glebe Rd at SB I-395 off-ramp	Signalized	1.9	A	24.6	C	Signalized	2.0	A	24.7	C
34	S Glebe Rd at NB I-395 off-ramp	Signalized	32.9	C	40.3	D	Signalized	32.9	C	39.0	D
36	Columbia Pike at Southgate Rd/S Joyce St	Signalized	20.2	C	18.0	B	Signalized	13.6	B	18.1	B
37	Columbia Pike at Rotary Rd	Unsignalized	16.5	C (NB L)	16.5	C (NB L)	Unsignalized	16.7	C (NB L)	16.3	C (NB L)
110	Columbia Pike at Southgate Rd/S Joyce St (Relocated)	Signalized	20.2	C	18.0	B	Signalized	13.6	B	18.1	B
111	Columbia Pike at Interchange Ramps	Signalized	18.0	B	16.7	B	Signalized	16.9	B	16.4	B
38	Army Navy Dr at S Joyce St	Signalized	29.7	C	24.0	C	Signalized	29.0	C	24.2	C
39	Army Navy Dr at parking lot/garage	Signalized	14.0	B	16.9	B	Signalized	15.6	B	23.8	C
40	Army Navy Dr at S Hayes St	Signalized	28.0	C	34.3	C	Signalized	23.4	C	34.4	C
41	Army Navy Dr at S Fern St	Signalized	24.2	C	24.1	C	Signalized	30.9	C	27.2	C
42	S Eads St at I-395 SB HOV Ramps	Unsignalized	42.5	E (WB L)	14.4	B (WB L)	Unsignalized	37.2	D	7.9	A
43	S Eads St at I-395 NB HOV Ramps	Unsignalized	-[2]	F (SB TL)	133.6	F (SB TL)	Unsignalized	28.6	C	14.0	B
44	Army Navy Dr at S Eads St	Signalized	27.8	C	29.9	C	Signalized	22.6	C	37.9	D
45	S Eads St at 12th St S	Signalized	15.6	B	13.7	B	Signalized	16.9	B	14.4	B
46	Army Navy Dr at 12th St S	Unsignalized	26.0	D (SB L)	24.6	C (SB L)	Unsignalized	31.3	D (SB L)	23.3	C (SB L)
47	12th St S at S Clark Pl/ Long Bridge Dr	Signalized	16.4	B	19.4	B	Signalized	16.7	B	23.2	C
51	S Fern St at North Rotary Rd	Signalized	10.4	B	10.9	B	Signalized	10.7	B	15.9	B
52	S Fern St at South Rotary Rd	Signalized	33.0	C	23.1	C	Signalized	34.7	C	27.0	C
53	S Eads St at North Rotary Rd	Signalized	28.3	C	22.0	C	Signalized	29.2	C	23.1	C
54	S Eads St at South Rotary Rd	Signalized	48.2	D	41.6	D	Signalized	23.4	C	35.3	D
55	Connector Rd at Boundary Channel Dr	Unsignalized	24.4	C (NB L)	18.0	C (NB L)	Unsignalized	23.8	C (NB L)	21.8	C (NB L)
113	Boundary Channel Dr West Roundabout	Roundabout	5.1	A	5.1	A	Roundabout	5.6	A	5.3	A
114	Boundary Channel Dr East Roundabout	Roundabout	4.0	A	4.5	A	Roundabout	5.0	A	4.7	A

Notes: 1: Intersection does not utilize signal, stop, or yield control during this time period, therefore no results given
2: Delays exceed Highway Capacity Manual methodology, therefore no results given
3: Movements shown in parenthesis for unsignalized intersections are for the worst case approach at the intersection

5.5.3 Eads Street Interchange

Traffic operations at the Eads Street Interchange were evaluated for both 2020 and 2040 No Build and Build conditions as discussed below. Year 2020 interim conditions were evaluated due to the proposed interim improvements associated with the Pentagon South Parking Lot.

2040 No Build and Build Conditions

As discussed in **Section 5.1.8**, it is assumed that improvements to the Pentagon South Parking Lot associated with the Pentagon Master Plan would be implemented prior to the 2040 design year and therefore these improvements were assumed to be in place for both 2040 No Build and Build Conditions. Under 2040 No Build Conditions, the two I-395 HOV ramp terminals would continue to operate the same as existing conditions with stop-controlled approaches. Under 2040 No Build conditions, overall delays and congestion are expected to increase moderately compared to existing conditions; however, due to the conversion of Fern Street to two-way between North Rotary Road and South Rotary Road associated with the South Parking Lot improvements, traffic volumes are reduced along Eads Street providing some relief to traffic operations at the two I-395 HOV ramp terminals.

Under 2040 Build conditions, as discussed in **Section 3.2.2**, the two HOT ramp terminals would be signalized at their intersections with Eads Street as follows:

- **Eads Street at South I-395 HOT ramps (southern intersection):** In the AM peak hour, the northbound I-395 HOT off-ramp would include two right-turn lanes onto Eads Street southbound serving Army Navy Drive and the Pentagon City area. In the PM peak hour, the traffic direction for the northbound I-395 HOT off-ramp would be reversed to permit traffic to enter the HOT lanes in the southbound direction. The southbound Eads Street approach would be widening into the median to accommodate a left-turn and through lane. The northbound Eads Street approach would be widened to provide a left-turn lane, a through lane, and a right-turn lane. The northbound left-turn from Eads Street provides a new access point to the HOT lanes and would be accommodated only during the PM peak period due to the reversible nature of the ramp. Access would be prohibited by gates during other periods. The configuration of the on-ramp from Eads Street to the northbound HOV lanes would not be changed.

- **Eads Street at North I-395 HOT ramps (northern intersection):** In the AM peak hour, on-ramp that currently accommodate traffic from Eads Street to the southbound I-395 HOV lanes, would be reversed to accommodate northbound I-395 HOT traffic destined for the Pentagon. The ramp would include two left-turn lanes onto northbound Eads Street. In the PM peak hour, the traffic direction for the ramp would be reversed to permit traffic to enter the I-395 southbound HOT lanes. The southbound I-395 HOV off-ramp would be widened to provide a dedicated left-turn lane and right turn lane approaching Eads Street. The southbound Eads Street approach would be modified to provide a right-turn lane, a shared through/right-turn lane and a right-turn lane. The two right-turn lanes are channelized and become free-flowing right turns to the ramp to the southbound I-395 HOT lanes. The northbound Eads Street approach would be widened to accommodate two through lanes.

The installation of traffic signals and expansion of capacity on the I-395 HOT ramps under Build conditions would improve traffic operations and allow for the smooth progression of traffic between the intersections proposed within the Pentagon South Parking Lot and the two new signals at the I-395 HOT ramp terminals. These signals would also be coordinated with the existing traffic signal at the Eads Street at Army Navy Drive intersection.

During the AM peak period, the two existing lanes (one left-turn lane and one right-turn lane) on the I-395 HOV ramp approaching Eads Street would be increased to four lanes (two left-turn lanes and two right-turn lanes) under Build Conditions doubling the turning capacity approaching Eads Street and reducing the potential for queues extending to the northbound I-395 HOT lanes. Separating traffic destined for the Pentagon and Army Navy Drive reduces the number of conflict points at the two ramp signals and greatly simplifies traffic signal operations by reducing the number of signal phases. The double left turn from the northbound I-395 HOT ramp toward the Pentagon would be coordinated with the northbound Eads Street approach to South Rotary Road and subsequently the northbound Eads Street approach to North Rotary Road allowing for a free-flowing operation of this heavy movement during the AM peak period. Similarly, the heavy right turn from the northbound I-395 HOT ramp toward Army Navy Drive would be coordinated with the southbound Eads Street approach to Army Navy Drive to minimize the potential for queuing between these two intersections. Additionally, reduced congestion along the northbound I-395 HOT lanes approaching the northern terminus of the HOT lanes facility would improve operations at the southern I-395 HOT ramps intersection compared to No Build conditions due to the spillback from the northbound I-395 HOV lanes that currently extends down the ramp to Eads Street. As shown in Table 5-5, LOS at the five signalized intersections along Eads Street between Army Navy Drive and North Rotary Road are expected to operate at LOS D or better during the AM peak hour.

During the PM peak period, the high traffic volumes along eastbound South Rotary Road and southbound Eads Street would be signal-controlled as motorists exit the Pentagon Reservation toward the southbound I-395 HOT lanes and make a double right turn to the southbound on-ramp. At the southern I-395 HOT ramps intersection, the new northbound Eads Street left-turn movement to southbound I-395 ramp would be signalized and operate at part of a two-phase signal accommodating northbound and southbound Eads Street left turns concurrently and northbound and southbound Eads Street through traffic. It should be noted that under current conditions, based on a review of the travel patterns within the Pentagon South Parking lot, motorists in the Pentagon City area and points along Army Navy Drive travel north along Fern Street and make a right turn onto eastbound South Rotary Road to access the southbound I-395 HOV lanes. Providing this ramp would eliminate this traffic from entering the Pentagon Reservation during the heavy traffic periods and reduce traffic along Fern Street which is the designated pedestrian route crossing I-395 and entering the Pentagon Reservation. This new access point would also reduce traffic on the eastbound South Rotary Road approach to Eads Street. As shown in **Table 5-5**, LOS at the five signalized intersections along Eads Street between Army Navy Drive and North Rotary Road are expected to operate at LOS D or better during the PM peak hour. It should be noted that Eads Street at Army Navy Drive would experience higher traffic volumes under Build Conditions compared to No Build conditions due to the new access point to the HOT lanes. In the PM peak hour, traffic volumes for the eastbound left turn from Army Navy Drive to Eads Street increase by approximately 12%, and the northbound through volume along Eads Street increases by approximately 53% in the 2040 Build scenario compared to the 2040 No Build scenario. This increase in traffic volume results in an increase to overall intersection delays by approximately 8 seconds and a LOS degradation from C to D.

Another key feature of the Eads Street Interchange concept is the removal of the ramp from the southbound I-395 HOV lanes to the SB I-395 general purpose lanes. This would eliminate a weave condition along the southbound I-395 HOV lanes and eliminate a merge condition along the southbound I-395 general purpose lanes in an area with a high density of access points. Access to the southbound I-395 general purpose lanes would be provided via Hayes Street/Army Navy Drive, Washington Boulevard/Columbia Pike, and Boundary Channel Drive instead of the current ramp. Based on a review of LOS changes at these other locations, the revised access would not result in a degradation of LOS.

2020 No Build and Build Conditions (Interim Conditions)

As noted in **Section 3.3.2.3**, the timing of the improvements to the Pentagon South Parking Lot is unknown at this time; however, some improvements to the South Parking Lot are required in order to provide a smooth transition between the improvements planned at the Eads Street Interchange and within the Pentagon Reservation. The interim improvements include the following key features:

- Direct access to the Pentagon Transit Center via a dedicated two-way bus loop that circulates on the eastern perimeter of the South Parking Lot. Access to the bus loop is provided on the east leg of the Eads Street at South Rotary Road intersection. Transit vehicles would be separated from passenger vehicles and substantial pedestrian conflicts along North Rotary Road.

- Traffic signalization at the Eads Street at South Rotary Road intersection. The eastbound South Rotary Road intersection would be widened to provide a second eastbound right-turn lane providing four total lanes approaching the Eads Street intersection. The second right-turn lane would be open to traffic during the PM period when the I-395 HOT lanes are operating in a southbound direction. During other periods, gates would prohibit traffic from entering the rightmost right-turn lane. The northbound Eads Street approach to South Rotary Road would be widened to provide two through lanes and a separate right-turn lane serving buses entering the new bus loop discussed above.

- Traffic signalization at the Eads Street at North Rotary Road intersection and removal of the north leg of the intersection serving the Pentagon Transit Center. The South and North Rotary signals would be coordinated with the signals along Eads Street at the I-395 HOT ramps and Army Navy Drive. A signalized pedestrian crossing would be provided on the east leg of the intersection.

- A dedicated ridesharing (slugging) area within the bus loop to accommodate the substantial ridesharing that occurs within this portion of the South Parking Lot. The existing slug area along Fern Street would remain in its current location under the interim conditions.

As shown in **Table 5-6**, the five signalized intersections along Eads Street between Army Navy Drive and North Rotary Road are expected to operate at LOS D or better during both the AM and PM peak hours under Build conditions. Similar to the discussion of 2040 No Build compared to 2040 Build conditions above, traffic operations at the two I-395 HOT ramp terminals would improve due to the added capacity on the ramp approaches to Eads Street and the reduction of conflict points at the two intersections. Within the Pentagon South Parking Lot, traffic operations would improve by providing predictable traffic flow and signal progression between the I-395 HOT lanes ramp signals and the North and South Rotary Road signals. Pedestrian operations and safety would be greatly improved at the Eads Street at North Rotary Road intersection by eliminating the north leg of the intersection and conflicts between buses exiting the PTC

and pedestrians currently crossing on the north leg of the intersection. Another key advantage of the interim improvements is that it is compatible with the Pentagon's ongoing Bus Pilot Program whereby buses exiting the Pentagon are directed to Connector Road from 7 AM to 9 AM rather than traveling southbound on Eads Street.

Figure 5-27: Pentagon South Parking Lot Interim Improvements

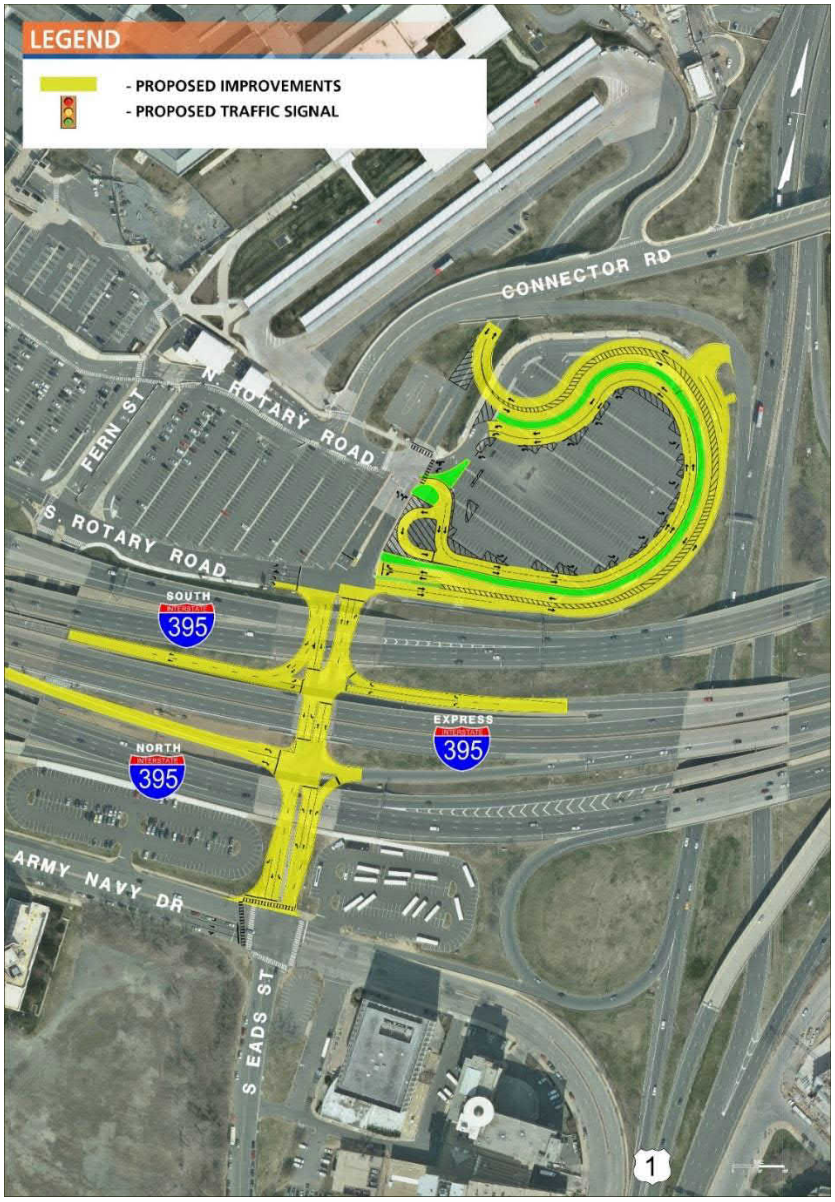


Table 5-6: 2020 No Build and Build Conditions Intersection LOS and Delay Summary – Eads Street Interchange

Intersection Number	Intersection Name	2020 No Build Conditions					2020 Build Conditions				
		Intersection Control	AM Peak Hour (7-8 AM)		PM Peak Hour (5-6 PM)		Intersection Control	AM Peak Hour (7-8 AM)		PM Peak Hour (5-6 PM)	
			Avg Delay (sec)	LOS	Avg Delay (sec)	LOS		Avg Delay (sec)	LOS	Avg Delay (sec)	LOS
42	S Eads St at I-395 SB HOV Ramps	Unsignalized	39.2	E (WB L)	13.8	B (WB L)	Signalized	37.1	D	7.8	A
43	S Eads St at I-395 NB HOV Ramps	Unsignalized	-[1]	F (SB TL)	131.5	F (SB TL)	Signalized	29.2	C	14.5	B
44	Army Navy Dr at S Eads St	Signalized	28.8	C	32.3	C	Signalized	25.0	C	33.2	C
53	S Eads St at North Rotary Rd	Unsignalized	-[2]	-[2]	-[2]	-[2]	Signalized	13.5	B	28.2	C
54	S Eads St at South Rotary Rd	Unsignalized	-[2]	-[2]	-[2]	-[2]	Signalized	27.2	C	32.4	C

Notes: 1: Delays exceed Highway Capacity Manual methodology, therefore no results given
2: Intersection control configuration not accomodated by the Highway Capacity Manual, therefore no results given
3: Movements shown in parenthesis for unsignalized intersections are for the worst case approach at the intersection

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