Memorandum

To: *Jeff Folden, Dusty Holcombe, James Wise*

From: *Ron Davis, Mark Feldman*

Date: *January 31, 2020*

Subject: *FINAL I-495 & I-270 Managed Lanes Toll Rate Ranges*
CONFIDENTIAL, PREDECISIONAL, DELIBERATIVE

This technical memorandum includes estimated toll rate ranges for the I-495 and I-270 managed lanes project. The intent is to facilitate discussion of the toll rates and other related factors with the Maryland Traffic Relief partners project team in advance of recommending toll rate ranges for approval by the Maryland Transportation Authority board.

The dynamic toll rates charged on the I-495 and I-270 managed lanes are expected to fluctuate due to several different factors, including:

- Long term (due to corridor traffic growth and changes in willingness to pay over time)
- Month to month (seasonality)
- Day to day (different days of the week)
- Hour to hour (times of day, peak vs off-peak)
- Within the hour (peak hour factor)
- Other unique extreme events such as storms, major entertainment events, or political events

The traffic and revenue (T&R) modeling, which calibrates to and predicts average traffic conditions, addresses some of the above factors. Long term variability is addressed by running the traffic model in different future model years. Hour to hour variability is addressed by running the model in multiple time periods. However, the other factors above must be considered outside of the T&R modeling results when considering potential toll rate ranges.

This memo includes the toll rate ranges from the T&R model results and analysis of the other factors using existing data from the I-495 express lanes in Virginia. The maximum per-mile toll for the I-495 and I-270 managed lanes is then estimated using the T&R model results and the other factors.

Traffic and Revenue Forecasting Model Results

The toll rates used in the T&R forecasts presented in the *I-495 and I-270 Phase 1 Priced Managed Lanes Comprehensive Traffic and Revenue Study* report, dated 11/4/2019, represent rates on an

average weekday. This is consistent with the study methodology of using the MWCOG Travel Demand Model and calibrating the model's current year outputs to existing traffic and travel conditions on an average weekday. **Table 1** shows the estimated revenue maximizing per-mile toll rates in 2025 and 2045 (under equity assumptions) in the northbound direction near the American Legion Bridge in two model time periods: 4-6 PM and 6-7 PM.

Table 1 – Equity Case Average Weekday Per Mile Toll Rates from Model Results for Toll Gantry with Highest Toll Rates in Highest Charging Time Period and Direction[1]

Vehicle Type	Payment Type	Multiplier vs. 2-axle ETC	2025 Per-Mile Toll (2019$)		2045 Per-Mile Toll (2019$)	
			4-6 PM	6-7 PM	4-6 PM	6-7 PM
Passenger Car (2-axle)	ETC	1.0	$2.15	$2.25	$3.70	$3.40
Motorcycle[2]		0.5	1.10	1.15	1.85	1.70
3-axle Light		1.5	3.20	3.40	5.55	5.10
3-axle Heavy		2.0	4.30	4.50	7.40	6.80
4-axle Light		2.5	5.40	5.65	9.25	8.50
4-axle Heavy		3.0	6.45	6.75	11.10	10.20
5-axle		6.0	12.90	13.50	22.20	20.40
6+-axle		7.5	16.15	16.90	27.75	25.50
Passenger Car (2-axle)	Unregistered Video	1.0	3.20	3.40	5.55	5.10
Motorcycle[2]		0.5	1.60	1.70	2.80	2.55
3-axle Light		1.5	4.85	5.05	8.35	7.65
3-axle Heavy		2.0	6.45	6.75	11.10	10.20
4-axle Light		2.5	8.05	8.45	13.90	12.75
4-axle Heavy		3.0	9.65	10.15	16.65	15.30
5-axle		6.0	19.35	20.25	33.30	30.60
6+-axle		7.5	24.20	25.30	41.65	38.25

[1]Does not include the impact of any ramp up factors; For toll gantry 1 (near American Legion Bridge) referring to Tables 7-2 and 7-4 in the 11/4/2019 Comprehensive Traffic and Revenue Study

[2]Alternatives that include HOV3+ free travel on the managed lanes also assume motorcycles would also travel for free

Rates shown in **Table 1** represent the location, direction, and times of day where per mile tolls were the highest on Phase 1 of the project, between the George Washington Parkway on I-495 and I-370 on I-270.[1] Passenger car ETC tolls in **Table 1** are consistent with Tables 7-2 and 7-4 in the 11/4/2019 report. For video payment, a multiplier of 1.5 was assumed, and for trucks multipliers consistent with those used by MDTA on the I-95 Express Toll Lanes in Baltimore are assumed. Classifications shown in **Table 1** include the "Toll Modernization" changes approved

[1] Tolls were slightly higher from 6-7 PM in 2025, but slightly higher from 4-6 PM in 2045, so both are included

by MDTA in November 2019. These changes are expected to take effect in calendar year 2020. Rates are rounded to the nearest 5 cents per mile and are shown in constant 2019 dollars.

Virginia I-495 Express Lanes Data

Hourly Data

CDM Smith has been signed up through the Transurban website (expresslanes.com) to receive emails which indicate the end to end tolls charged on the existing Virginia I-495 express lanes in each direction. The data is received one or two times per hour in the weekday peak periods, between the hours of 7-10 AM (three hours) and 4-7 PM (three hours), on each weekday. This data is the source in this memo for measuring toll rate variability by month (seasonality), day to day variability, and variability due to other extreme events. It is not possible to use this data set to measure variability within the hour, because the email updates are only sent one or two times per hour.

The data described above is from October 2014 to December 2019, beginning about two years after the express lanes began tolling on November 17, 2012. Prior to the calculations of seasonal and day to day variability around an average, we normalized the toll data for changing trends in toll rates over the five years. These changes can be due to many factors including traffic growth, changes in willingness to pay, ramp-up, and better connectivity to other regional facilities including the I-95 express lanes which began tolling on December 29, 2014.

Figures 1 and **2** show time series scatterplots of the per mile toll rates charged in the southbound direction from 4-5 PM and in the northbound direction from 7-8 AM, respectively. Similar scatterplots were also generated for the other peak hours (5-6 and 6-7 PM southbound and 8-9 AM and 9-10 AM northbound). The mileage assumed for the express lanes to calculate the per mile toll was 10.3 miles. This corresponds to the shortest distance trip possible on the facility that can be traveled when paying the full-length toll, from the slip ramps just north of the Dulles interchange to the slip ramps just east of the Braddock Road interchange.

Figures 1 and **2** show that tolls on the express lanes have been increasing steadily over the past 5 years, with higher increases in the southbound direction. One exception is the southbound direction tolls showed a different trend in the first half of 2017. One theory for this different trend is that the tolling algorithm may have been modified around this time. The scatterplots for the other hours in the southbound direction exhibited the same anomalous 2017 tolls, whereas in the northbound scatterplots, 2017 was consistent with other years. To prevent 2017 toll rates from distorting results, the 2017 data was removed from the analysis.

The slope of the trendlines in **Figures 1** and **2** was used to normalize the data to January 1st, 2020. **Figures 3** and **4** show the result of this adjustment for the example hours. Similar adjustments for the other hours were also performed. The normalized data was analyzed for seasonality and day to day variability which are discussed in later sections of this memo.

Figure 1 – Virginia I-495 Express Lane Average Weekday End to End Per Mile Tolls from October 2014 to December 2019, Southbound 4-5 PM

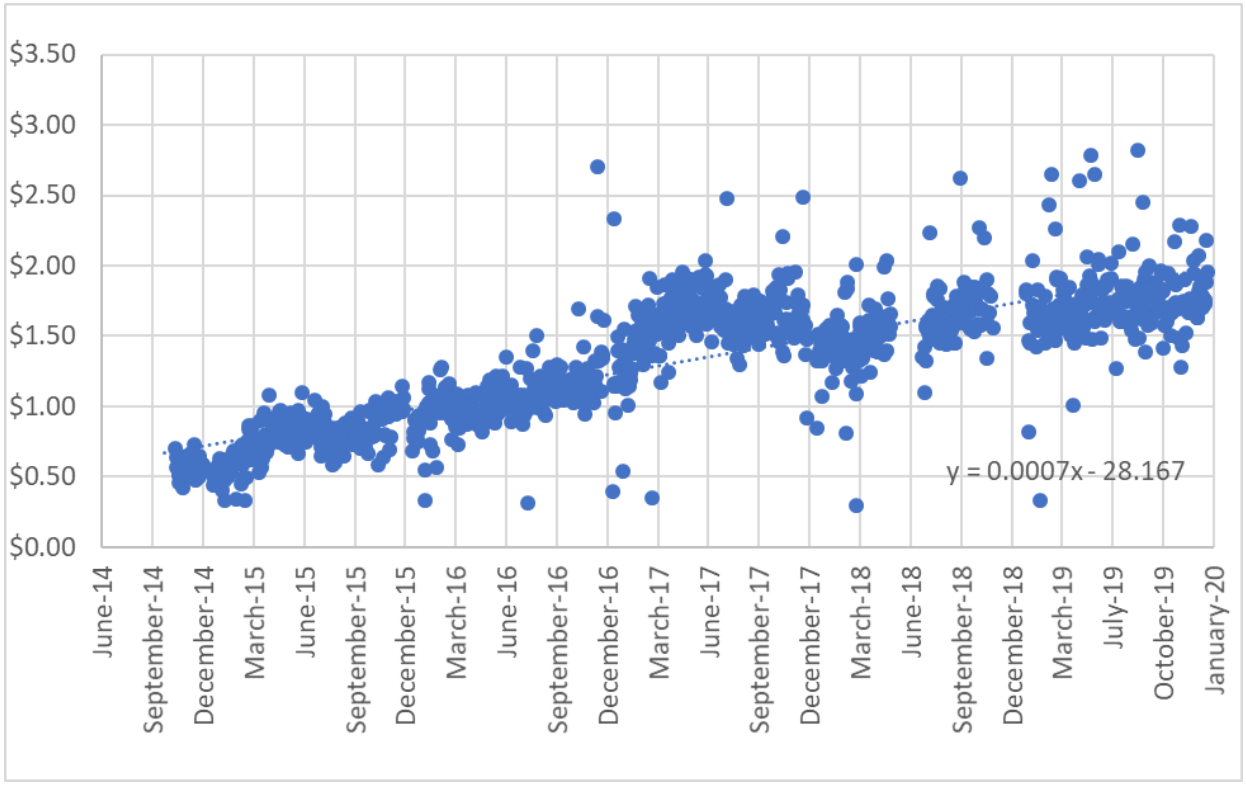


Figure 2 – Virginia I-495 Express Lane Average Weekday End to End Per Mile Tolls From October 2014 to December 2019, Northbound 7-8 AM

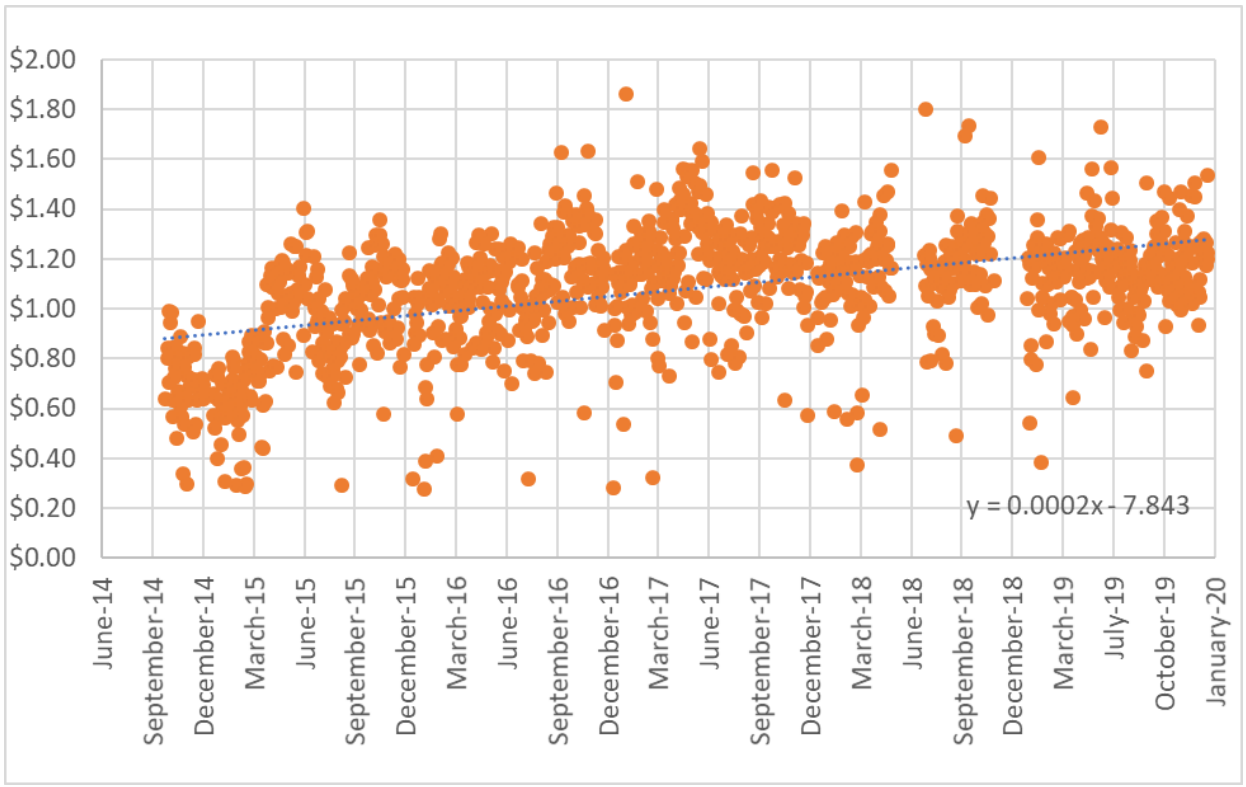


Figure 3 – Virginia I-495 Express Lane Average Weekday End to End Tolls
From October 2014 to Dec 2019, Southbound 4-5 PM, Adjusted for Long-Term Trend

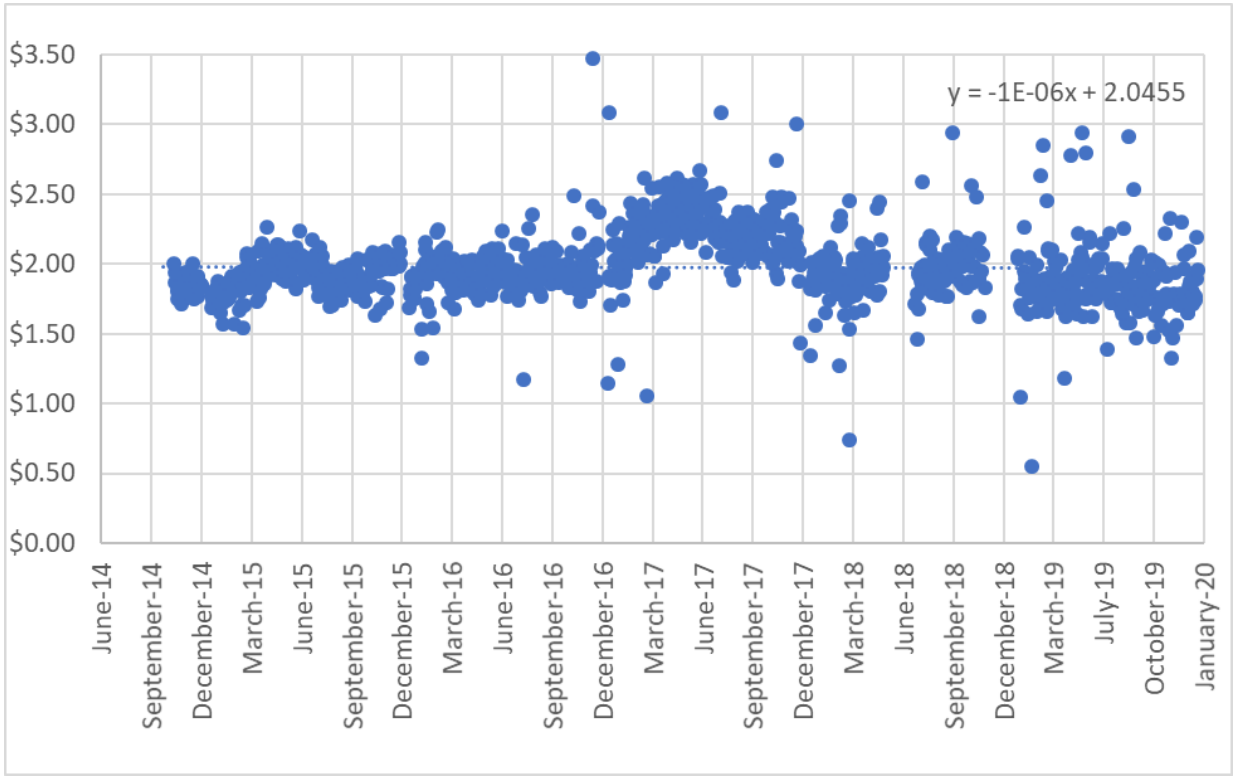
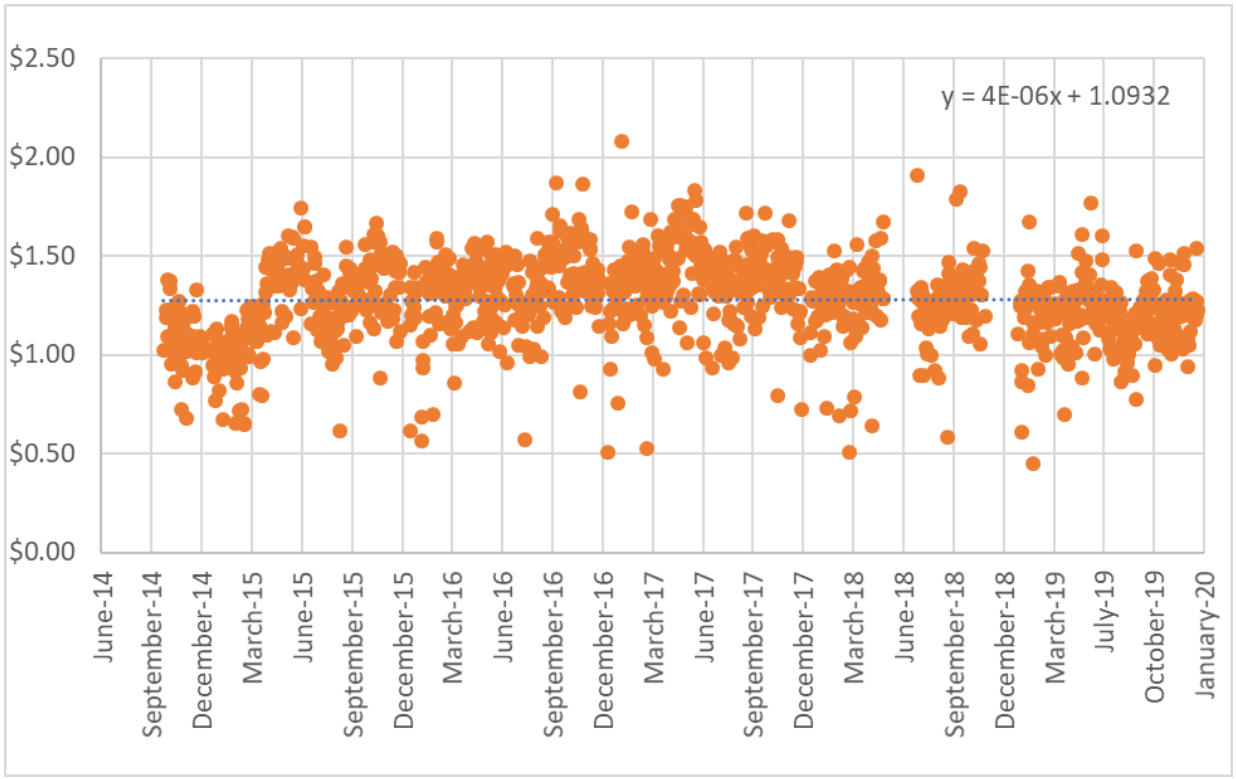


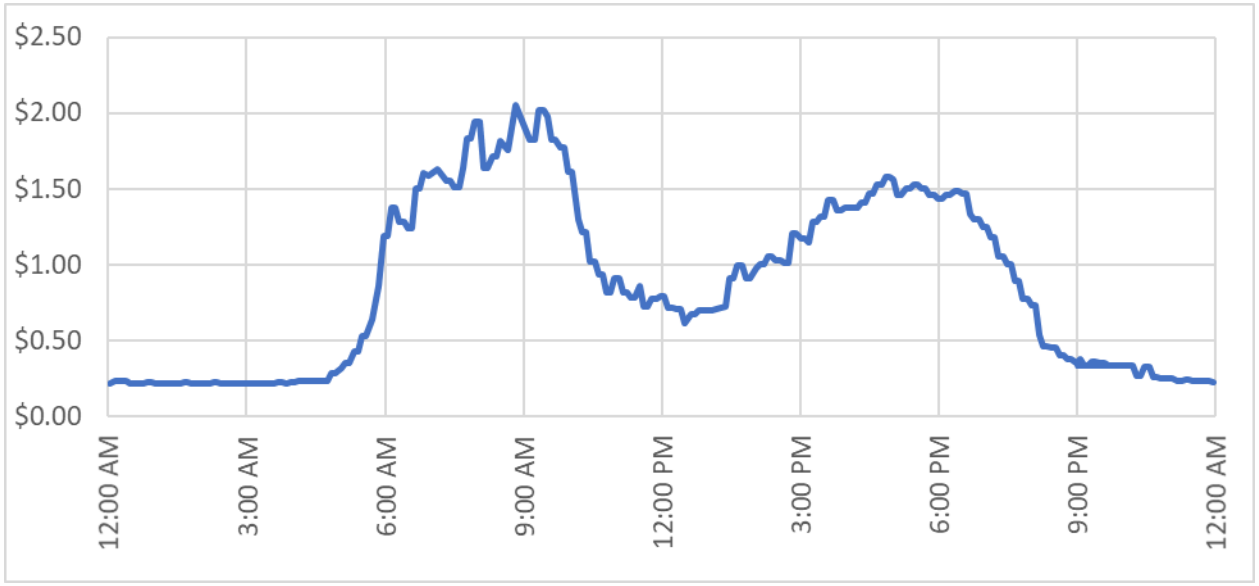
Figure 4 – Virginia I-495 Express Lane Average End to End Tolls
From October 2014 to December 2019, Northbound 7-8 AM, Adjusted for Long-Term Trend



Five Minute Data

In mid-December 2019, CDM Smith began collecting data from the VA Express Lanes website at five-minute intervals using the "Map your trip" feature, to observe variability within the hour. **Figure 5** presents an example of this data on an example day, December 19th for northbound end to end trips. This data was collected in each direction for each weekday from December 16th, 2019 to January 14th, 2020, excluding holidays. This data was used to analyze the variability of toll rates within an hour as described in a later section of this memo.

Figure 5 – VA Express Lane Example Average Five-Minute Data
Dec 19, 2019 Northbound End-to-End Toll



Toll Rate Variability by Month (Seasonality)

Using the Virginia I-495 express lane trend-adjusted data, the average tolls charged in each month were divided by the average tolls charged over the entire five year period. These ratios were the "seasonality factors"; we computed this factor for each of the six hours represented in the data in each month from October 2014 to December 2019. These factors can be multiplied by average annual weekday toll rates to estimate toll rates that could be expected in different months of the year.

After grouping all the January factors together, all the February factors, etc., we then used standard statistical techniques to develop 90 percent confidence ranges for these seasonality factors, accounting for the sample sizes, means and standard deviations. A 90 percent confidence range was considered appropriate when evaluating the seasonality factors due to inherent uncertainty in the seasonality analysis process.

Table 2 shows the seasonality factors for each month, representing the ratio of average trend-adjusted tolls charged in that month to average trend-adjusted tolls charged over the entire five-year period (excluding 2017 for reasons discussed previously).

Table 2 – Seasonality Factors in VA I-495 Express Lane Toll Data

Month	Factor	90% Confidence Range	
		Lower Bound	Upper Bound
Jan	0.90	0.87	0.93
Feb	0.97	0.94	1.00
Mar	0.97	0.95	0.99
Apr	1.01	0.98	1.04
May	1.04	1.03	1.06
Jun	1.06	1.03	1.08
Jul	1.01	0.99	1.03
Aug	0.94	0.92	0.97
Sep	1.03	1.01	1.05
Oct	1.02	1.00	1.04
Nov	1.02	0.99	1.05
Dec	1.05	1.01	1.09
Maximum	**1.06**	**1.03**	**1.09**

CDM Smith believes some level of conservatism is appropriate, and recommends applying a factor of 1.09 to account for seasonality. This represents the maximum factor in the 90 percent confidence range for any month.

Toll Rate Variability Day to Day

With the same trend-adjusted data, the day-to-day variability was measured by computing a ratio of toll charged for each day to the average toll of the entire five-year period. **Table 3** presents percentiles of these ratios, for each hour and direction. It also includes data for the two-hour period of 4-6 PM in the southbound direction, one of the highest-tolled periods in the travel demand model (along with 6-7 PM) as noted earlier in this memo. Note that the southbound direction on the Virginia I-495 Express Lanes experiences the highest toll rates while the northbound direction in the Maryland project (as shown in **Table 1**) is estimated to have the highest toll rates.

Table 3 – Percentiles, Ratio of Toll Charged / Average Toll Oct 2014-Dec 2019

Percentile	Northbound			Southbound			
	7-8 AM	8-9 AM	9-10 AM	4-5 PM	5-6 PM	4-6 PM	6-7 PM
75th	1.10	1.10	1.13	1.04	1.04	**1.04**	**1.06**
90th	1.19	1.19	1.24	1.10	1.11	**1.10**	**1.16**
95th	1.24	1.22	1.32	1.13	1.20	**1.16**	**1.29**
99th	1.34	1.30	1.55	1.34	1.37	**1.36**	**1.54**
100th	1.53	1.61	1.97	1.81	1.74	**1.81**	**1.85**

A few examples of the way to interpret **Table 3** are as follows:

- 25 percent of all tolls charged southbound from 5-6 PM were more than 4 percent higher than the average (factor of 1.04)
- 5 percent of all tolls charged northbound from 7-8 AM were more than 24 percent higher than the average (factor of 1.24)

Some notable observations from **Table 3** are:

- Ratios were highest in the third hour of each peak (6-7 PM and 9-10 AM), meaning that even though tolls were lower later in the peak, there was more variability later in the peak.
- Ratios were lowest in the southbound direction from 4-5 PM, and in general lower in the PM peak direction than the AM. Tolls were higher in the PM peak direction, meaning that congestion was more severe. Thus, at higher levels of congestion, there was less day to day variability.

In the case of day to day variability, the number of observations is much larger than the case of the seasonality factors, since each day corresponds to an observation. Thus, instead of constructing confidence intervals, we can use percentiles as shown in **Table 3** as a measure for how high tolls are likely to vary from the mean. CDM Smith initially recommends using the 99th percentile for discussion, representing occurrences of 3-4 times per year, rather than the actual maximum which represents extremely rare conditions. The 99th percentile ratio during the highest-tolled model periods (4-6 and 6-7 PM) are 1.36 and 1.54, respectively. The 100th percentile may also be considered to be an appropriate factor by the project team and can be discussed moving forward.

Toll Rate Variability Within Time Periods (Peak Hour Factor)

The average and maximum tolls charged in each of the peak hours on each day were calculated using the five-minute toll data from December 2019 to January 2020 described previously. The peak hour factor was calculated as the ratio of the maximum to the average. For this analysis, it represents the relationship between the maximum toll within an hour or time period and the average tolls estimated in the T&R analysis time periods. **Table 4** presents estimates of the peak hour factors for each hour in each direction on the VA I-495 express lanes. Due to the small sample size, a 90 percent confidence ranges for these peak hour factors was estimated.

Table 4 – Weekday Peak Hour Factors in VA I-495 Express Lanes

Direction	Time Period	Factor	90% Confidence Range	
			Lower Bound	Upper Bound
Northbound	7-8 AM	1.15	1.12	1.17
	8-9 AM	1.11	1.07	1.14
	9-10 AM	1.17	1.11	1.22
Southbound	4-5 PM	1.19	1.15	1.22
	5-6 PM	1.10	1.07	1.12
	4-6 PM	**1.23**	**1.20**	**1.27**
	6-7 PM	**1.30**	**1.24**	**1.36**

As noted earlier in this memo, one of the two travel demand model periods with the highest tolls in MD was the two-hour period from 4-6 PM. Therefore, to account for the difference between the highest and average toll in that period, we also computed a peak two-hour factor for 4-6 PM on the VA express lanes. That factor was 1.23, with its 90 percent confidence interval ranging from 1.20 to 1.27. Note that this factor covers both the variability within the peak hour and the variability between the two hours (4-5 and 5-6 PM) which make up the time period of highest congestion in the model that produced the traffic and revenue forecasts.

Due to the limited time frame of data for this analysis, we recommend using the upper ends of the 90 percent confidence interval ranges; 1.27 for 4-6 PM and 1.36 for 6-7 PM. As previously discussed, these are the time periods likely to have the highest tolls in MD.

Draft Toll Rate Ranges for Board Approval

CDM Smith's recommended factors from prior sections of this memo for the two time periods are:

- Seasonality: 1.09 (same for both time periods)
- Day to Day Variability: 1.36 for 4-6 PM, 1.54 for 6-7 PM
  These correspond to 99th percentile factors. It is recommended that the project team discuss the reasonableness of applying 100th percentile factors.
- Peak Hour (Period) Variability: 1.27 for 4-6 PM, 1.36 for 6-7 PM

Multiplying these factors together results in factors of 1.88 for 4-6 PM and 2.28 for 6-7 PM. This represents our estimate of the ratio of highest per-mile tolls to be charged at any location on the express lanes in any direction at any hour, on the busiest days of the year, barring extremely rare events. **Table 5** shows these tolls for each vehicle and payment type in 2025 and 2045 in 2019 dollars. The tolls in **Table 5** are equal to the tolls in **Table 1** multiplied by 1.88 (in the case of 4-6 PM) and 2.28 (in the case of 6-7 PM), rounded to the nearest 5 cents per mile.

It should be noted that the passenger car tolls on the existing VA I-495 express lanes reached levels approaching $3.00 per mile several times in 2018 and 2019 (as shown previously in the

scatterplots in this memo), whereas in 2014-15, per mile tolls seldom exceeded $1.00. It follows that extremely congested conditions could result in tolls as high as $5.15 per mile on the Maryland system by 2025 at the times, directions and locations of that congestion.

Table 5 – Initial Estimates of I-495 and I-270 Toll Rates for Toll Rate Setting

Vehicle Type	Payment Type	Multiplier vs. 2-axle ETC	2025 Per-Mile Toll (2019$)		2045 Per-Mile Toll (2019$)	
			4-6 PM	6-7 PM	4-6 PM	6-7 PM
Passenger Car (2-axle)	ETC	1.0	$4.05	$5.15	$6.95	$7.75
Motorcycle[1]		0.5	2.05	2.60	3.50	3.90
3-axle Light		1.5	6.00	7.75	10.45	11.65
3-axle Heavy		2.0	8.10	10.25	13.90	15.50
4-axle Light		2.5	10.15	12.90	17.40	19.40
4-axle Heavy		3.0	12.15	15.40	20.85	23.25
5-axle		6.0	24.25	30.80	41.75	46.50
6+-axle		7.5	30.35	38.55	52.15	58.15
Passenger Car (2-axle)	Unregistered Video	1.50	6.00	7.75	10.45	11.65
Motorcycle[1]		0.75	3.00	3.90	5.25	5.80
3-axle Light		2.25	9.10	11.50	15.70	17.45
3-axle Heavy		3.00	12.15	15.40	20.85	23.25
4-axle Light		3.75	15.15	19.25	26.15	29.05
4-axle Heavy		4.50	18.15	23.15	31.30	34.90
5-axle		9.00	36.40	46.15	62.60	69.75
6+-axle		11.25	45.50	57.70	78.30	87.20

[1]Alternatives that include HOV3+ free travel on the managed lanes also assume motorcycles would also travel for free

Toll Rates for Longer Trips

The rates presented in above sections of this memo in **Table 1** and **Table 5** represent the highest per-mile tolls that would be charged at any point on the project at any time of day and are thus important when considering toll rate setting. However, travelers using other portions of the project or traveling longer distances would not pay as high a toll per mile overall. This section provides some examples of estimated toll rates for longer distance trips and trips on other sections of the project during peak periods. The intent of this section is to provide context to the discussion of maximum toll rates. **Table 6** shows the estimated average tolls[2] in the two-hour peak periods for three representative longer-distance trips on the project:

- Between the George Washington (GW) Parkway and I-370 on I-495 and I-270

[2] Note that the tolls in Table 6 are from preliminary runs of the full MLS project in the Level 3 model. Forecasts from these runs have not yet been submitted in a full report.

- Between GW Parkway and I-95 on I-495
- Between I-95 and MD 5 on I-495

Peak shoulder and off-peak rates are estimated to be lower than the peak rates shown in **Table 6.**

Table 6 – Equity Case Average Weekday Passenger Car ETC 2025 Per Mile Toll Rates
Preliminary Level 3 Full Build Model Results

Trip	Distance (miles)	7 to 9 AM Average Per Mile Toll Rates (2019$)		4 to 6 PM Average Per Mile Toll Rates (2019$)	
		NB / Inner Loop	SB / Outer Loop	NB / Inner Loop	SB / Outer Loop
Between GW Parkway and I-370	12.9	0.72	1.03	1.66	0.72
Between GW Parkway and I-95	15.7	0.67	1.55	1.66	0.83
Between I-95 and MD-5	19.2	0.54	0.89	1.05	0.72

Using the methodology described earlier in this memo, the highest per-mile tolls that would likely be charged for the trips in **Table 6** can be estimated**.** The multiplicative factors would be the following:

- Seasonality: 1.09 (same as earlier in the memo)
- Day to Day Variability: 1.33 for 7-9 AM, 1.36 for 4-6 PM
- Peak Hour (Period) Variability: for 1.24 for 7-9 AM, 1.27 for 4-6 PM

Multiplying these factors together results in an overall factor of 1.76 for 7-9 AM and 1.88 for 4-6 PM. **Table 7** shows the estimates for the passenger car ETC per-mile tolls in 2025 for the trips shown in **Table 6** on the busiest days of the year, barring extremely rare events. The tolls in **Table 7** are equal to the tolls in **Table 6** multiplied by 1.76 (in the case of 7-9 AM) and 1.88 (in the case of 4-6 PM), rounded to the nearest 5 cents per mile.

Table 7 – Equity Case Weekday Passenger Car ETC 2025 Per Mile Toll Rates for Busiest Days of the Year
Preliminary Level 3 Full Build Model Results

Trip	Distance (miles)	7 to 9 AM per Mile Toll Rates (2019$)		4 to 6 PM Per Mile Toll Rates (2019$)	
		NB / Inner Loop	SB / Outer Loop	NB / Inner Loop	SB / Outer Loop
Between GW Parkway and I-370	12.9	1.30	1.95	2.90	1.35
Between GW Parkway and I-95	15.7	1.20	2.90	2.95	1.55
Between I-95 and MD-5	19.2	0.95	1.70	1.85	1.35

Disclaimer

CDM Smith used currently-accepted professional practices and procedures in the development of the traffic and revenue estimates in this report. However, as with any forecast, it should be understood that differences between forecasted and actual results may occur, as caused by events and circumstances beyond the control of the forecasters. In formulating the estimates, CDM Smith reasonably relied upon the accuracy and completeness of information provided (both written and oral) by MDOT. CDM Smith also relied upon the reasonable assurances of independent parties and is not aware of any material facts that would make such information misleading.

CDM Smith made qualitative judgments related to several key variables in the development and analysis of the traffic and revenue estimates that must be considered as a whole; therefore, selecting portions of any individual result without consideration of the intent of the whole may create a misleading or incomplete view of the results and the underlying methodologies used to obtain the results. CDM Smith gives no opinion as to the value or merit of partial information extracted from this report.

All estimates and projections reported herein are based on CDM Smith's experience and judgment and on a review of information obtained from multiple agencies, including MDOT. These estimates and projections may not be indicative of actual or future values and are therefore subject to substantial uncertainty. Future developments and economic conditions cannot be predicted with certainty, and may affect the estimates or projections expressed in this report, such that CDM Smith does not specifically guarantee or warrant any estimate or projection contained within this report.

While CDM Smith believes that the projections and other forward-looking statements contained within the report are based on reasonable assumptions as of the date of the report, such forward-looking statements involve risks and uncertainties that may cause actual results to differ materially from the results predicted. Therefore, following the date of this report, CDM Smith will take no responsibility or assume any obligation to advise of changes that may affect its assumptions contained within the report, as they pertain to socioeconomic and demographic forecasts, proposed residential or commercial land use development projects and/or potential improvements to the regional transportation network.

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