

Bowman

Memorandum

To: Mr. Casey Frazier
Sr. Real Estate Development Manager
AWS Data Center Supply Solutions

From: Michael J. Young, P.E.

Date: 3/15/2023

Re: AWS Data Center Trip Generation Assessment

As requested, Bowman has prepared a trip generation assessment to determine the weighted average trip generation rate for Amazon Web Services (AWS) Data Centers located in the Commonwealth of Virginia. This evaluation was performed in accordance with the criteria and guidelines established in the Institute of Transportation Engineers (ITE) *Trip Generation Handbook, 3rd Edition*.

Background Information

AWS develops and constructs data centers throughout the country and the Commonwealth of Virginia. The data centers developed by AWS are highly specialized and modern facilities, and the evolving design of these facilities incorporate efficient operations and automated systems.

There are several data centers planned in Virginia by AWS and, as part of the development of these sites, traffic projections need to be developed to anticipate potential impacts.

The ITE *Trip Generation Manual, 11th Edition* includes such traffic projection information for data center sites. However, the trip generation rates from the Manual were developed based on two (2) surveyed sites for daily trips, six (6) surveyed sites for AM peak hour trips, and five (5) surveyed sites for PM peak hour trips. Due to the limited number of surveyed sites, the Trip Generation Manual offers the following disclaimer for this information:

"Caution should be used when applying trip generation rates for data centers, as the database contains a small number of sites with limited data on the number of tenants and employees."

Data centers have a very small number of visitors, and the majority of trips are typically driven by employees or deliveries. Due to the technological advancements referenced above, data centers have become more efficient over time and rely on fewer on-site employees to operate.

The ITE Trip Generation Manual notes that the sites included were surveyed in the 2010s. Due to the aforementioned technological advancements, it is also likely that the traffic generation rates from the 2010s are no longer applicable to newer facilities.

Therefore, Bowman has prepared this trip generation assessment based on historical data of already established campuses with the following purposes:

1. To determine the average weekday, morning peak hour, and evening peak hour trip generation rates for a fully operational AWS Data Center. These average rates will be developed based on data from six (6) existing facilities, and will then be utilized throughout the planning process for future AWS Data Center developments in the Commonwealth of Virginia.
2. To compare these trip generation rates to the trip generation data documented in the ITE *Trip Generation Manual, 11th Edition*.

Methodology

The methodology utilized for this assessment was developed based on the criteria and guidelines included in the ITE *Trip Generation Handbook, 3rd Edition*, Chapter 9, "Use of Local Data to Estimate Trip Generation." Chapter 9 outlines the process for calculating the weighted average trip rate based on traffic data collected from existing facilities.

Chapter 9 also notes that trip generation data should be collected at a minimum of three (3) local sites, but that collecting data at five (5) or more sites is preferable. Please note that, for the purposes of this evaluation, trip generation information from six (6) existing sites was evaluated.

Site Selection

For the purposes of this assessment, traffic data was collected from six (6) existing AWS Data Center campuses, all of which are located within the Commonwealth of Virginia. The sites surveyed are similar in both size and anticipated operations as the future data centers planned in Virginia by AWS.

Additional information regarding the building square footage and number of employees at each surveyed campus is as follows:

- Campus 1: 285,000 SF / 50 Employees
- Campus 2: 600,000 SF / 100 Employees
- Campus 3: 520,000 SF / 75 Employees
- Campus 4: 310,000 SF / 50 Employees
- Campus 5: 435,000 SF / 75 Employees
- Campus 6: 725,000 SF / 160 Employees

Trip Generation Data Collection

Cumulative trip data for each campus identified above was provided by AWS for the time period of January, 2022 to January, 2023. The AWS Data Centers are all secure facilities with historical data records, and the trip data provided to Bowman was extracted from the security card readers at each campus entrance.

The data center campuses surveyed included auxiliary spaces for site maintenance and support services which do not generate additional site trips. These auxiliary spaces vary in size from campus to campus, and therefore, the square footage of these areas was not included as part of the development of the trip generation rates for the actual data center buildings.

However, all existing site trips pertinent to the overall data center operations (including the auxiliary spaces) were included in the traffic data captured and evaluated in this memorandum.

Typical vehicle and heavy vehicle information was able to be included in this dataset, as the security gates at the facilities have separate card readers for trucks vs. passenger cars.

The trip data provided to Bowman was further refined to only include the card reader information recorded on an average weekday (Tuesday, Wednesday, or Thursday). The card reader information is timestamped, and therefore, the AM and PM peak hour trips for each campus were able to be extracted from the highest one-hour period of trips from 7:00 AM – 9:00 AM (AM peak), and from 4:00 PM – 6:00 PM (PM peak).

Data Summary and Evaluation

Based on the data provided, the existing trips per day for each surveyed campus were developed as shown in **Table 1**.

Table 1. Existing Campus Trips per Day

Campus	No. of Average Weekdays Recorded Jan '22 - Jan '23	Trip Type	Total Recorded Daily Trips Jan '22 - Jan '23	Trips per Day	Total Recorded AM Peak Trips Jan '22 - Jan '23	AM Peak Hour Trips per Day	Total Recorded PM Peak Trips Jan '22 - Jan '23	PM Peak Hour Trips per Day
Campus 1	159	Car	39,272	246.99	4,360	27.42	1,583	9.96
		Truck	1,500	9.43	95	0.60	0	0.00
		TOTAL	40,772	256.43	4,455	28.02	1,583	9.96
Campus 2	159	Car	90,362	568.31	11,238	70.68	3,263	20.52
		Truck	2,026	12.74	198	1.25	7	0.04
		TOTAL	92,388	581.06	11,436	71.92	3,270	20.57
Campus 3	130	Car	41,442	318.78	5,867	45.13	1,930	14.85
		Truck	646	4.97	84	0.65	7	0.05
		TOTAL	42,088	323.75	5,951	45.78	1,937	14.90
Campus 4	159	Car	29,504	185.56	2,442	15.36	1,373	8.64
		Truck	3,984	25.06	195	1.23	60	0.38
		TOTAL	33,488	210.62	2,637	16.58	1,433	9.01
Campus 5	159	Car	45,538	286.40	6,309	39.68	1,863	11.72
		Truck	5,782	36.36	653	4.11	60	0.38
		TOTAL	51,320	322.77	6,962	43.79	1,923	12.09
Campus 6	130	Car	58,394	449.18	7,871	60.55	2,333	17.95
		Truck	2,324	17.88	285	2.19	50	0.38
		TOTAL	60,718	467.06	8,156	62.74	2,383	18.33

The campus-specific size and number of employees were then applied to these total trips to develop the average trips per 1,000 SF and the average trips per employee at each campus as shown in **Table 2**.

Table 2. Average Campus Trips per 1,000 SF and per Employee

Campus	Square Footage (SF)	No. of Employees	Trip Type	Trips per Day	Daily Trips per 1,000 SF	Daily Trips per Employee	AM Peak Hour Trips per Day	AM Peak Hour Trips per 1,000 SF	AM Peak Hour Trips per Employee	PM Peak Hour Trips per Day	PM Peak Hour Trips per 1,000 SF	PM Peak Hour Trips per Employee
Campus 1	285,000	50	Car	246.99	0.87	4.94	27.42	0.10	0.55	9.96	0.03	0.20
			Truck	9.43	0.03	0.19	0.60	0.00	0.01	0.00	0.00	0.00
			TOTAL	256.43	0.90	5.13	28.02	0.10	0.56	9.96	0.03	0.20
Campus 2	600,000	100	Car	568.31	0.95	5.68	70.68	0.12	0.71	20.52	0.03	0.21
			Truck	12.74	0.02	0.13	1.25	0.00	0.01	0.04	0.00	0.00
			TOTAL	581.06	0.97	5.81	71.92	0.12	0.72	20.57	0.03	0.21
Campus 3	520,000	75	Car	318.78	0.61	4.25	45.13	0.09	0.60	14.85	0.03	0.20
			Truck	4.97	0.01	0.07	0.65	0.00	0.01	0.05	0.00	0.00
			TOTAL	323.75	0.62	4.32	45.78	0.09	0.61	14.90	0.03	0.20
Campus 4	310,000	50	Car	185.56	0.60	3.71	15.36	0.05	0.31	8.64	0.03	0.17
			Truck	25.06	0.08	0.50	1.23	0.00	0.02	0.38	0.00	0.01
			TOTAL	210.62	0.68	4.21	16.58	0.05	0.33	9.01	0.03	0.18
Campus 5	435,000	75	Car	286.40	0.66	3.82	39.68	0.09	0.53	11.72	0.03	0.16
			Truck	36.36	0.08	0.48	4.11	0.01	0.05	0.38	0.00	0.01
			TOTAL	322.77	0.74	4.30	43.79	0.10	0.58	12.09	0.03	0.16
Campus 6	725,000	160	Car	449.18	0.62	2.81	60.55	0.08	0.38	17.95	0.02	0.11
			Truck	17.88	0.02	0.11	2.19	0.00	0.01	0.38	0.00	0.00
			TOTAL	467.06	0.64	2.92	62.74	0.09	0.39	18.33	0.03	0.11

The cumulative trip, square footage, and employee data across all six (6) campuses were then combined to develop the weighted average trip rates per the criteria in the *ITE Trip Generation Handbook, 3rd Edition*.

The weighted average trip generation rates are shown in **Table 3**.

Table 3. Weighted Average Trip Generation Rates

	Square Footage (SF)	No. of Employees	Trip Type	Trips per Day	Daily Trips per 1,000 SF	Daily Trips per Employee	AM Peak Hour Trips per Day	AM Peak Hour Trips per 1,000 SF	AM Peak Hour Trips per Employee	PM Peak Hour Trips per Day	PM Peak Hour Trips per 1,000 SF	PM Peak Hour Trips per Employee
WEIGHTED AVERAGE	2,875,000	510	Car	2055.24	0.71	4.03	258.82	0.09	0.51	83.62	0.03	0.16
			Truck	106.44	0.04	0.21	10.01	0.00	0.02	1.24	0.00	0.00
			TOTAL	2161.68	0.75	4.24	268.83	0.09	0.53	84.86	0.03	0.17

Note: Values shown represent the cumulative data from all six (6) surveyed AWS campuses.

Data Comparison with ITE Trip Generation Manual

The average projected trip generation rates for the existing data centers shown in **Table 3** were then compared with the published rates from the ITE Trip Generation Manual for data centers (Land Use 160).

The ITE Trip Generation Manual does not include any employee information, and therefore, the comparison of rates was limited to building square footage only. The average rate comparison is shown in **Table 4**.

Table 4. Average Rate Comparison – ITE Trip Generation Manual vs. Existing Campus Data

Data Source	Weekday per 1,000 SF	AM Peak Hour per 1,000 SF	PM Peak Hour per 1,000 Sf
ITE Manual	0.99	0.11	0.09
Existing Campus Data	0.75	0.09	0.03
Existing Campus % of ITE Rate	75.8%	81.8%	33.3%

As shown in **Table 4**, the site-specific campus data indicates that the average trip rates for the AWS Data Centers are lower than those included in the ITE Trip Generation Manual.

PM Peak Hour of Generator Evaluation

Based on the data provided by AWS, the PM Peak Hour (highest one-hour period from 4:00 PM – 6:00 PM) trip generation rate shown in **Table 4** is 1/3 the size of both the ITE Manual PM Peak Hour trip generation rate, and the existing campus AM Peak Hour trip generation rate.

Upon review of the data provided by AWS, this PM Peak Hour trip generation rate appears to be a result of the campus operations being more intensive during times when the surrounding roadways are not as busy (“off-peak”). Therefore, through additional coordination with VDOT, it was requested that this memorandum also evaluate the PM Peak Hour of Generator for the existing data center campuses.

Instead of only evaluating the highest one-hour period from 4:00 PM – 6:00 PM, the “PM Peak Hour of Generator” is the most trip-intensive hour of a development for any time between 12:00 PM and 12:00 AM.

The trip data for each campus was combined into 15-minute intervals for this 12:00 PM – 12:00 AM timeframe in order to determine the PM Peak Hour of Generator for each campus. The results

of this evaluation indicate that the PM Peak Hour of Generator generally falls somewhere within the timeframe of 12:30 PM to 2:15 PM depending on the campus.

The existing PM Peak Hours of Generator and associated trips per day for each surveyed campus were developed and are included in **Table 5**. The campus-specific size and number of employees were then applied to these trips per day to develop the average PM Peak Hour of Generator trips per 1,000 SF and per employee at each campus.

Table 5. PM Peak Hour of Generator Existing Campus Trips per Day, per 1,000 SF, and per Employee

Campus	No. of Average Weekdays Recorded Jan '22 - Jan '23	Observed PM Peak Hour of Generator	Square Footage (SF)	No. of Employees	Trip Type	Total Recorded PM Peak Hour of Generator Trips Jan '22 - Jan '23	PM Peak Hour of Generator Trips per Day	PM Peak Hour of Generator Trips per 1,000 SF	PM Peak Hour of Generator Trips per Employee
Campus 1	159	1:15 PM - 2:15 PM	285,000	50	Car	3,710	23.33	0.08	0.47
					Truck	229	1.44	0.01	0.03
					TOTAL	3,939	24.77	0.09	0.50
Campus 2	159	1:15 PM - 2:15 PM	600,000	100	Car	8,386	52.74	0.09	0.53
					Truck	162	1.02	0.00	0.01
					TOTAL	8,548	53.76	0.09	0.54
Campus 3	130	1:15 PM - 2:15 PM	520,000	75	Car	3,355	25.81	0.05	0.34
					Truck	62	0.48	0.00	0.01
					TOTAL	3,417	26.28	0.05	0.35
Campus 4	159	1:00 PM - 2:00 PM	310,000	50	Car	2,743	17.25	0.06	0.35
					Truck	536	3.37	0.01	0.07
					TOTAL	3,279	20.62	0.07	0.41
Campus 5	159	12:30 PM - 1:30 PM	435,000	75	Car	3,195	20.09	0.05	0.27
					Truck	524	3.30	0.01	0.04
					TOTAL	3,719	23.39	0.05	0.31
Campus 6	130	1:00 PM - 2:00 PM	725,000	160	Car	4,919	37.84	0.05	0.24
					Truck	262	2.02	0.00	0.01
					TOTAL	5,181	39.85	0.05	0.25

This information was then combined in **Table 6** to develop the weighted average PM Peak Hour of Generator trip rates per the criteria in the ITE *Trip Generation Handbook, 3rd Edition*.

Table 6. Weighted Average PM Peak Hour of Generator Trip Generation Rates

	Square Footage (SF)	No. of Employees	Trip Type	PM Peak Hour of Generator Trips per Day	PM Peak Hour of Generator Trips per 1,000 SF	PM Peak Hour of Generator Trips per Employee
WEIGHTED AVERAGE	2,875,000	510	Car	177.07	0.06	0.35
			Truck	11.62	0.00	0.02
			TOTAL	188.69	0.07	0.37

Note: Values shown represent the cumulative data from all six (6) surveyed AWS campuses.

As shown in **Table 6**, the calculated PM Peak Hour of Generator for the existing campuses currently generates an average of 0.07 trips per 1,000 SF and 0.37 trips per employee. These rates represent values that are over twice as intensive as those associated with the standard PM Peak Hour from 4:00 PM – 6:00 PM (0.03 trips per 1,000 SF and 0.17 trips per employee).

Conclusions

Based on the evaluation contained in this memorandum, the anticipated site trip rates associated with the AWS Data Centers are lower than those included in the ITE Trip Generation Manual.

The AWS rates appear to be a more appropriate estimation of future trips, as the rates from the Trip Generation Manual were developed based on a fewer number of surveyed sites. The Trip Generation Manual also only includes data from the 2010s, and the lower AWS trip generation rate is consistent with changes in the data center industry since then.

The average PM Peak Hour trip generation rate at the existing campuses is 1/3 the size of both the ITE Manual PM Peak Hour trip generation rate and the existing campus average AM Peak Hour trip generation rate. Therefore, VDOT requested an additional evaluation to determine the PM Peak Hour of Generator for the existing campuses.

Based on this evaluation, the PM Peak Hour of Generator for each campus generally falls somewhere within the timeframe of 12:30 PM to 2:15 PM, and the site trips during these timeframes are over twice as intensive as those associated with the standard PM Peak Hour from 4:00 PM – 6:00 PM.

Data centers have become more efficient and automated over this time, and typically require fewer on-site employees to operate. In coordination with VDOT, it has been determined that the square footage of each proposed campus should be used to project the anticipated site trips associated with each Data Center development.

March 15, 2023

As such, it is proposed to use the following rates throughout the planning process for future AWS Data Center developments in the Commonwealth of Virginia:

- **0.75 Daily Trips per 1,000 S.F.**
- **0.09 Morning Peak Hour Trips per 1,000 S.F.**
- **0.03 Evening Peak Hour Trips per 1,000 S.F.**