Development of Texas On-road Mobile 2023 Air Emissions Reporting Requirements (AERR) Emissions Inventory

FINAL REPORT

Prepared for the Texas Commission on Environmental Quality (TCEQ)

December 2024

Texas A&M Transportation Institute

Texas A&M Transportation Institute

FINAL REPORT

Grant No: 582-21-10369
TCEQ PGA 582-21-10369-020
Task 6.2: Final Report

DATE: December 19, 2024

TO: Mogwai Turner
Texas Commission on Environmental Quality (TCEQ)

COPY TO: Amy Fountain
TCEQ

FROM: Jianbang Du, Ph.D.
Tao Li, Ph.D.
Camilo Jurado
Minjie Xu, Ph.D.
Guo Quan Lim, Ph.D.
Neha Alluri
Chaoyi Gu, P.E.
Madhusudhan Venugopal, P.E.
Texas A&M Transportation Institute

ABSTRACT: This project aimed to develop a set of updated statewide emissions inventories (EIs) for all on-road and off-network source categories in Texas. These EIs are needed to fulfill the federal 2023 Air Emissions Reporting Requirements (AERR) and to support state implementation plan development. Controlled and uncontrolled emissions estimates of criteria air pollutants and their precursors, along with select hazardous air pollutants species were developed using the latest available data. Vehicle activity data were estimated using the latest available datasets from the Texas Department of Transportation (TxDOT) and the Texas Department of Motor Vehicles (TxDMV) and supplemented by travel demand models from local Metropolitan Planning Organizations (MPOs), if available.

The latest version of the Environmental Protection Agency’s (EPA's) Motor Vehicles Emissions Simulator (MOVES4) model was utilized.

FOR MORE INFORMATION:

Madhusudhan Venugopal, P.E.
Air Quality and Environmental Division
972.994.2213
m-venugopal@tti.tamu.edu

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

The State of Texas is required to submit periodic emissions inventories and U.S. Environmental Protection Agency (EPA) Motor Vehicle Emissions Simulator (MOVES) county database files (CDBs) under the Air Emissions Reporting Requirements (AERR) to support the EPA's comprehensive three-year cycle National Emissions Inventory (NEI). The Texas A&M Transportation Institute (TTI) produced the requisite on-road mobile source portion of the 2023 periodic emissions inventory (EI) and EI CDBs for all 254 Texas counties. TTI developed summer work weekday and winter work weekday (El Paso only) emissions inventory estimates of CO_2, criteria air pollutants (CAPs), and CAP precursors, as well as annual EI estimates of CO_2, CAPs, CAP precursors, and hazardous air pollutants (HAPs) as summarized in Table 1.

Table 1. 2023 AERR Emissions Inventories.

Area	Emissions Inventory Type[1]	Pollutants
All 254 Texas Counties	Annual	CAPs, CAPs precursors, and HAPS
All 254 Texas Counties	Summer Weekday	CAPs and CAPs precursors
El Paso County	Winter Weekday	CAPs and CAPs precursors

[1] "Annual" represents the calendar year totals for all counties. "Summer" represents June, July, and August. "Winter" represents January, February, and December. "Weekday" represents the average Monday through Friday.

The work also included the preparation of inputs for the Texas Commission on Environmental Quality's (TCEQ) Road Dust Calculator necessary to develop a statewide 2023 calendar year EI. The inputs can be used in the Road Dust Calculator to produce both summer weekday and annual road dust EIs for each county in Texas.

The general methodology was consistent with the process TTI used to produce the 2017 and 2020 AERRs, as well as county-level on-road inventories and inventory mode CDBs, with a change in the annual emissions calculation process. Seasonal weekday inventories were estimated using the detailed hourly link (roadway segment)-based method. CDBs for MOVES annual inventory mode runs were prepared using local input data (from the weekday EI activity data and various conversion factors) and some default input data. Annual EIs were produced from MOVES inventory mode runs using the local, annual inventory mode CDBs[1]. The seasonal weekday emission rates and annual inventory-mode runs were performed using the EPA's latest MOVES4 model.

[1] Computation of 2020 annual EIs using MOVES inventory mode is a change from previous TTI 2017 (and earlier) annual EI analyses in which TTI employed the summer weekday EI annualization process to produce the annual EIs.

To estimate the seasonal weekday county-level inventories the hourly, MOVES rates-per-activity, detailed link-based inventory method was used with the latest available data, models, methods, and procedures. One of two vehicle miles of travel (VMT) activity bases were used, depending on data source availability. For counties in areas where regional travel demand model (TDM) data were available, TDM roadway network link data was the basis of VMT activity estimates. For counties not included in an area TDM, the virtual link-based method was used. The virtual link method uses Highway Performance Monitoring System (HPMS) data from the Texas Department of Transportation (TxDOT) as the basis of VMT activity.

The hourly and 24-hour EIs were estimated by MOVES source use type (SUT) and fuel type combination (SUT/fuel type or vehicle type), and by roadway class which includes an off-network category. The inventoried vehicle fleet included the predominant gasoline-, diesel-, and electricity-powered vehicles, as depicted in Table 2, with other alternative fuels, compressed natural gas (CNG) and ethanol (E85), treated as *de minimis*.

Table 2. MOVES SUT and Fuel Type Combinations.

SUT ID	SUT Description	SUT/FT Abbreviation[1]
11	Motorcycle	MC_Gas
21	Passenger Car	PC_Gas, PC_Diesel, PC_Electricity
31	Passenger Truck	PT_Gas, PT_Diesel, PT_Electricity
32	Light Commercial Truck	LCT_Gas, LCT_Diesel, LCT_Electricity
41	Other Buses	OBus_Gas, OBus_Diesel, OBus_Electricity
42	Transit Bus	TBus_Gas, TBus_Diesel, TBus_Electricity
43	School Bus	SBus_Gas, SBus_Diesel, SBus_Electricity
51	Refuse Truck	RT_Gas, RT_Diesel, RT_Electricity
52	Single Unit Short-Haul Truck	SUShT_Gas, SUShT_Diesel, SUSht_Electricity
53	Single Unit Long-Haul Truck	SULhT_Gas, SULhT_Diesel, SULhT_Electricity
54	Motor Home	MH_Gas, MH_Diesel, MH_Electricity
61	Combination Short-Haul Truck	CShT_Gas, CShT_Diesel, CShT_Electricity
62	Combination Long-Haul Truck	CLhT_Diesel, CLhT_Electricity

[1] The SUT/fuel type, or vehicle type, labels are the combined SUT abbreviation and fuel type names separated by an underscore (e.g., MC_Gas, RT_Diesel, and SBus_Gas are motorcycles, diesel-powered refuse trucks, and gasoline-powered school buses, respectively).

A source-classification-code (SCC)- based 24-hour inventory summary was also produced. This EI analysis was performed for all Texas counties by the eight areas shown in Table 3. Table 3 provides the counties or number of counties included in each of the eight areas and their activity basis (TDM or HPMS).

Table 3. Areas, Counties, and Activity Basis for 2023 AERR Inventories.

Area[1]	Counties	Activity Basis
1. Austin	Bastrop, Burnet, Caldwell, Hays, Travis, Williamson	TDM
2. Beaumont-Port Arthur	Jefferson, Hardin, and Orange	TDM
3. Dallas-Fort Worth	Collin, Denton, Dallas, Ellis, Hood, Hunt, Johnson, Kaufman, Parker, Rockwall, Tarrant, Wise	TDM
4. El Paso[2]	El Paso	TDM
5. Houston-Galveston-Brazoria	Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, Waller	TDM
6. San Antonio	Bexar, Comal, Guadalupe, Kendall, Wilson	TDM
7. Tyler-Longview-Marshall	Gregg, Smith, Harrison, Rusk, Upshur	TDM HPMS
8. Remainder of Texas	214 Counties	HPMS
Totals by Activity Basis	37	TDM
	217	HPMS

[1] The 40 counties listed as (1) through (7) were modeled using county-level emission rates, whereas the remaining 214 counties (8) were modeled using the statewide inventory methodology, which produces emission rate estimates by county groups.
[2] El Paso is the only county for which a winter weekday inventory was produced.

The TDM and HPMS data were post-processed to estimate hourly, directional, link-level VMT, and operational speeds for the emission calculations. The hourly off-network activity factors were estimated for the off-network emission calculations using estimates of vehicle operating hours (also known as vehicle hours traveled or VHT), vehicle type populations, combination long-haul truck hotelling, and other data. These off-network activity factors are off-network idling (ONI) hours, source hours parked (SHP), starts, and source hours extended idling (SHEI) and auxiliary power unit (APU) hours—where SHEI and APU are components of hotelling hours for combination long-haul trucks. Post-processing was performed using MOVES input, output, and default data to produce the off-network evaporative emission rates in terms of mass/SHP (currently not directly provided by MOVES). These post-processed emission rates were compiled with the other rates produced directly by MOVES emission rate mode runs yielding final emission rate look-up tables with all rates in terms of mass per vehicle activity unit (i.e., mass/mile, mass/SHP, mass/start, mass/ONI hour, mass/SHEI, mass/APU hour).

The final rates were combined with their corresponding activity estimates in the seasonal weekday emissions calculations. Roadway-based rates were selected from the rate tables by hour, link speed, and road type for the roadway link-level hourly emissions calculations, and off-network category rates were selected by hour for the off-network hourly emissions calculations.

A set of MOVES inventory mode CDBs was developed for producing annual emissions inventories consistent with the local data and with EPA's specifications for MOVES on-road input data submittals for the 2023 NEI. The resulting annual emissions output from MOVES was formatted similarly to the 24-hour summer weekday link-based emissions output (i.e., two tab-delimited summary files, one with standard MOVES category labeling, and one based on SCCs). The SCC-based 24-hour seasonal weekday and annual inventory summaries were converted to an Extensible Markup Language (XML) format suitable for uploading to the TCEQ's Texas Air Emissions Repository (TexAER) and/or EPA's Emissions Inventory System (EIS).

The inventories were produced using utilities developed by TTI to process on-road vehicle activity (TDM link-based or HPMS roadway-based), off-network vehicle activity, and SUT/fuel type emission rate data into spatially and temporally detailed emission estimates for use in air quality modeling, as well as various other needed reporting aggregations and formats. EPA's Technical Guidance[2] was the primary technical reference used for guidance on appropriate inputs and use of MOVES.

This analysis included both summer weekday and annual emission estimates for volatile organic compounds (VOC), carbon monoxide (CO), oxides of nitrogen (NO_X), sulfur dioxide (SO_2), ammonia (NH_3), carbon dioxide (CO_2), particulate matter with an aerodynamic diameter equal to or less than 2.5 microns ($PM_{2.5}$), and particulate matter with an aerodynamic diameter equal to or less than 10 microns (PM_{10}); and annual estimates for HAPs, which include six priority mobile source air toxics (MSATs: benzene, methyl tertiary-butyl ether (not in MOVES), 1,3-butadiene, formaldehyde, acetaldehyde, acrolein) and the additional on-road mobile source air toxic pollutants included in the MOVES database (gaseous hydrocarbons, metals, dioxin/furans, and polycyclic aromatic hydrocarbons). Emission summaries by the on-road emissions processes available in MOVES were included (refueling emissions processes were excluded).

Table 4, Table 5, Table 6, and Table 7 summarize the 2023 estimates of summer weekday and winter weekday 24-hour CAPs and CO_2 emissions, annual CAPs and CO_2 emissions, and annual HAPs emissions, for all of the counties in Texas. Summer and winter (El Paso Only) weekday VMT, speed, and annual VMT estimates are also included.

The detailed emissions inventory results in a tab-delimited file format (by pollutant and emissions process, for each vehicle type and roadway category) were provided in electronic form as described in Appendix B.

[2] EPA. 2023. *MOVES4 Technical Guidance: Using MOVES to Prepare Emission Inventories for State Implementation Plans and Transportation Conformity*, EPA-420-B-23-009, Office of Transportation and Air Quality. August 2023.

Table 4. 2023 Summer Weekday Emissions by Area (Tons/Day).

Area	County	VMT	Speed[1]	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[2]	$PM_{2.5}$[2]
Austin (AUS) Metropolitan Planning Area (MPA)	Bastrop	3,581,875	41.7	1.05	20.25	1.99	1,917	0.01	0.20	0.23	0.06
	Burnet	2,496,430	40.1	0.61	12.68	1.36	1,306	0.01	0.13	0.17	0.04
	Caldwell	1,796,638	49.2	0.47	10.36	1.01	964	0.01	0.10	0.09	0.03
	Hays	7,391,542	39.4	1.74	34.51	3.33	3,745	0.03	0.37	0.45	0.12
	Travis	32,714,342	36.4	6.50	134.45	13.38	16,849	0.13	1.64	2.22	0.55
	Williamson	16,749,985	41.5	3.39	68.99	6.95	8,519	0.07	0.80	0.99	0.27
	Area Total	**64,730,812**	**41.4**	**13.77**	**281.23**	**28.01**	**33,301**	**0.26**	**3.23**	**4.14**	**1.07**
Beaumont-Port Arthur (BPA) MPA	Hardin	1,712,909	32.5	0.46	9.50	1.06	1,024	0.01	0.09	0.16	0.04
	Jefferson	7,785,138	33.8	1.85	43.42	5.04	4,814	0.04	0.45	0.72	0.19
	Orange	3,302,212	30.4	0.69	17.10	2.46	2,169	0.02	0.19	0.33	0.08
	Area Total	**12,800,260**	**32.2**	**3.00**	**70.02**	**8.56**	**8,007**	**0.06**	**0.73**	**1.21**	**0.31**
Dallas-Fort Worth (DFW) MPA	Collin	27,617,832	35.9	4.81	94.12	9.69	14,083	0.08	1.36	1.92	0.43
	Dallas	76,529,884	38.3	14.13	292.74	28.80	38,953	0.22	4.07	4.86	1.13
	Denton	22,914,615	36.9	4.45	79.51	9.09	11,879	0.07	1.13	1.58	0.36
	Ellis	8,333,162	46.6	1.35	28.91	4.09	4,339	0.03	0.41	0.43	0.13
	Hood	1,596,858	41.4	0.48	7.68	0.80	844	0.01	0.08	0.10	0.03
	Hunt	4,077,258	47.8	0.86	18.82	2.27	2,264	0.02	0.22	0.21	0.07
	Johnson	5,437,885	41.9	1.22	22.42	2.92	2,999	0.02	0.29	0.34	0.10
	Kaufman	6,120,028	47.8	0.93	20.74	3.10	3,229	0.02	0.30	0.31	0.09
	Parker	5,818,627	43.0	1.08	21.25	3.61	3,298	0.02	0.30	0.36	0.10
	Rockwall	3,563,596	36.9	0.59	12.60	1.66	1,891	0.01	0.18	0.25	0.06
	Tarrant	57,541,499	37.2	11.05	217.00	22.52	29,694	0.17	3.03	3.90	0.89
	Wise	3,395,742	46.0	0.72	15.55	1.98	1,800	0.01	0.18	0.18	0.05
	Area Total	**222,946,987**	**41.6**	**41.68**	**831.33**	**90.54**	**115,273**	**0.67**	**11.54**	**14.44**	**3.44**
El Paso MPA	El Paso	18,013,139	39.6	5.20	79.41	12.08	10,093	0.05	1.01	1.24	0.34

Area	County	VMT	Speed[1]	VOC	CO	NO_x	CO_2	SO_2	NH_3	PM_{10}[2]	$PM_{2.5}$[2]
Houston-Galveston-Brazoria (HGB) MPA	Brazoria	8,934,448	44.4	2.16	34.90	3.79	4,522	0.03	0.43	0.48	0.14
	Chambers	3,686,331	56.4	0.44	11.49	1.99	2,034	0.01	0.17	0.14	0.05
	Fort Bend	15,684,927	41.0	3.99	62.81	6.73	8,158	0.05	0.76	0.98	0.26
	Galveston	7,446,107	41.8	1.89	31.04	3.08	3,852	0.02	0.36	0.45	0.12
	Harris	125,327,606	41.2	25.70	506.06	53.13	65,060	0.37	6.34	7.65	1.98
	Liberty	2,979,541	50.6	0.81	14.46	1.48	1,557	0.01	0.15	0.13	0.04
	Montgomery	18,245,780	42.6	3.97	67.85	7.83	9,277	0.05	0.87	1.06	0.28
	Waller	2,917,224	52.0	0.53	12.21	1.42	1,481	0.01	0.14	0.12	0.04
	Area Total	**185,221,964**	**46.3**	**39.49**	**740.82**	**79.44**	**95,941**	**0.55**	**9.23**	**11.02**	**2.92**
San Antonio (SAN) MPA	Bexar	50,684,850	27.0	14.95	310.53	26.75	30,042	0.24	3.03	5.13	1.14
	Comal	6,784,042	31.5	1.68	36.14	3.58	3,788	0.03	0.37	0.60	0.14
	Guadalupe	5,227,375	33.8	1.53	30.61	3.16	3,055	0.02	0.29	0.44	0.11
	Kendall	1,773,995	34.9	0.54	9.51	1.01	989	0.01	0.09	0.14	0.04
	Wilson	1,350,797	37.4	0.46	8.07	0.82	749	0.01	0.07	0.11	0.03
	Area Total	**65,821,060**	**32.9**	**19.16**	**394.86**	**35.32**	**38,623**	**0.31**	**3.86**	**6.41**	**1.46**
Tyler-Longview-Marshall (TLM) MPA	Gregg	4,183,839	33.8	1.10	24.60	2.58	2,442	0.02	0.24	0.38	0.09
	Harrison[3]	3,516,520	49.2	0.72	16.80	2.26	2,039	0.01	0.19	0.18	0.06
	Rusk[3]	1,686,672	44.5	0.49	9.24	0.96	901	0.01	0.09	0.10	0.03
	Smith	8,044,288	32.9	2.21	49.22	5.16	4,790	0.04	0.48	0.74	0.18
	Upshur[3]	1,351,827	44.1	0.38	7.02	0.76	713	0.01	0.07	0.08	0.02
	Area Total	**18,783,146**	**40.9**	**4.90**	**106.89**	**11.72**	**10,886**	**0.08**	**1.07**	**1.48**	**0.40**
Other Texas Counties	214 counties[3]	287,565,821	46.6	66.74	1,406.75	178.83	158,351	1.14	15.04	17.61	5.23
Statewide Total	**254 counties**	**875,883,189**	**40.2**	**193.94**	**3,911.31**	**444.50**	**470,475**	**3.12**	**45.71**	**57.55**	**15.17**

[1] Miles-per-hour, aggregated by county.
[2] Particulate matter (PM) estimates are MOVES-based only (i.e., no re-suspended dust from roadways was included).
[3] An HPMS-based methodology was used for these counties. A TDM-based methodology was used for all other counties.

Table 5. 2023 Winter Weekday Emissions by Area (Tons/Day).

Area	County	VMT	Speed[1]	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[2]	$PM_{2.5}$[2]
El Paso MPA	El Paso	19,950,074	38.30	4.32	64.62	13.25	10,177	0.05	1.07	1.44	0.39

[1] Miles-per-hour.
[2] PM estimates are MOVES-based only (i.e., no re-suspended dust from roadways was included).

Table 6. 2023 Annual Emissions by Area (Tons/Year).

Area	County	VMT	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[1]	$PM_{2.5}$[1]
AUS MPA	Bastrop	1,238,893,443	279.41	5,012.19	596.12	616,528	3.69	66.86	62.88	18.22
	Burnet	863,460,456	167.82	3,173.69	412.81	420,418	2.30	44.78	47.20	12.99
	Caldwell	621,418,693	129.04	2,626.06	319.34	318,615	1.86	34.01	27.09	8.82
	Hays	2,556,574,807	461.54	8,836.48	1,000.30	1,208,761	7.37	126.72	126.85	33.73
	Travis	11,315,193,585	1,731.41	33,599.28	4,034.26	5,376,405	33.11	558.82	629.29	154.91
	Williamson	5,793,458,540	908.83	17,266.39	2,163.75	2,761,149	16.76	276.87	291.64	76.91
	Area Total	**22,388,999,527**	**3,678.05**	**70,514.10**	**8,526.57**	**10,701,877**	**65.09**	**1,108.06**	**1,184.95**	**305.59**
BPA MPA	Hardin	599,770,844	120.52	2,257.08	320.22	321,767	2.01	31.65	44.07	11.21
	Jefferson	2,725,947,420	496.67	10,571.49	1,599.55	1,540,554	9.40	152.03	202.45	53.20
	Orange	1,156,262,281	188.50	4,213.59	789.18	677,256	4.04	63.62	88.47	23.99
	Area Total	**4,481,980,546**	**805.69**	**17,042.17**	**2,708.95**	**2,539,577**	**15.45**	**247.29**	**335.00**	**88.40**
DFW MPA	Collin	9,405,246,148	1,516.51	26,013.75	3,370.39	4,501,189	25.79	457.07	557.02	131.43
	Dallas	26,062,234,772	4,441.84	80,883.85	9,977.01	12,531,740	72.04	1,379.78	1,414.55	351.89
	Denton	7,803,569,257	1,384.59	22,116.42	3,131.05	3,795,567	21.50	380.88	453.18	112.42
	Ellis	2,837,858,434	431.48	8,297.22	1,421.22	1,430,686	8.25	142.12	126.65	39.65
	Hood	540,444,477	146.33	2,098.91	270.12	272,442	1.62	27.50	29.59	8.39
	Hunt	1,413,886,490	275.24	5,385.20	837.26	761,229	4.31	77.03	62.80	21.32
	Johnson	1,840,412,929	377.68	6,071.24	1,000.68	967,997	5.57	96.88	98.95	29.56
	Kaufman	2,084,174,866	300.86	5,887.99	1,111.10	1,066,347	6.06	103.05	90.92	29.61
	Parker	1,969,272,580	343.73	5,885.74	1,268.90	1,071,961	5.98	99.58	104.39	32.91
	Rockwall	1,213,581,867	186.95	3,405.85	568.00	603,688	3.58	58.55	70.82	18.47
	Tarrant	19,474,496,022	3,412.01	59,338.71	7,626.32	9,428,803	54.21	1,014.93	1,124.73	273.40
	Wise	1,149,264,314	228.76	4,218.88	695.66	586,109	3.40	59.73	54.39	17.05
	Area Total	**75,794,442,160**	**13,045.97**	**229,603.75**	**31,277.70**	**37,017,759**	**212.33**	**3,897.09**	**4,187.98**	**1,066.09**

Area	County	VMT	VOC	CO	NO_x	CO_2	SO_2	NH_3	PM_{10}[1]	$PM_{2.5}$[1]
El Paso MPA	El Paso	6,554,855,838	1,651.09	24,165.05	4,262.50	3,521,782	17.34	366.47	390.19	114.04
HGB MPA	Brazoria	3,093,114,745	581.68	9,013.95	1,200.66	1,490,578	7.81	152.09	149.49	40.95
	Chambers	1,290,760,198	127.73	3,219.74	733.78	695,925	3.33	59.94	44.93	17.55
	Fort Bend	5,430,138,804	1,051.73	16,005.70	2,149.47	2,668,520	14.00	265.26	297.56	77.19
	Galveston	2,577,851,073	504.08	7,759.54	981.24	1,257,726	6.62	128.14	137.01	35.67
	Harris	43,388,551,369	6,962.10	128,189.36	17,129.35	21,246,291	111.77	2,219.35	2,322.33	600.02
	Liberty	1,043,279,738	216.00	3,798.32	485.45	522,135	2.69	54.87	42.17	13.56
	Montgomery	6,316,701,363	1,075.89	17,388.89	2,531.28	3,035,430	15.86	303.23	320.05	85.86
	Waller	1,009,945,029	154.07	3,347.94	492.58	496,506	2.54	51.22	36.84	12.51
	Area Total	**64,150,342,322**	**10,673.26**	**188,723.44**	**25,703.81**	**31,413,111**	**164.63**	**3,234.10**	**3,350.39**	**883.31**
SAN MPA	Bexar	17,472,957,025	3,842.32	73,672.95	7,768.57	9,128,069	56.97	984.13	1,372.21	307.98
	Comal	2,338,712,250	443.97	8,654.55	1,079.32	1,174,036	7.21	121.59	161.39	38.19
	Guadalupe	1,802,072,127	401.91	7,430.54	974.18	960,795	5.74	97.57	119.96	31.41
	Kendall	611,562,725	143.79	2,330.05	306.45	311,713	1.72	31.21	38.61	10.02
	Wilson	465,669,745	118.75	1,928.96	241.57	238,992	1.43	24.71	29.23	7.85
	Area Total	**22,690,973,873**	**4,950.73**	**94,017.05**	**10,370.09**	**11,813,605**	**73.06**	**1,259.22**	**1,721.41**	**395.46**
TLM MPA	Gregg	1,416,514,502	291.50	5,860.61	789.61	761,456	4.58	79.91	105.69	26.57
	Harrison	1,179,864,341	199.47	4,373.30	787.46	665,855	3.67	64.69	54.30	19.29
	Rusk	571,053,969	129.04	2,267.33	301.18	289,262	1.73	30.62	29.20	8.73
	Smith	2,723,538,619	577.63	11,622.88	1,570.47	1,472,738	8.88	156.42	201.16	51.26
	Upshur	453,565,337	101.33	1,733.19	234.19	227,463	1.36	24.29	22.96	6.89
	Area Total	**6,344,536,771**	**1,298.97**	**25,857.32**	**3,682.91**	**3,416,773**	**20.22**	**355.92**	**413.30**	**112.74**
Other Texas Counties	214 counties	98,996,721,164	18,459.37	369,087.60	58,227.82	52,207,313	301.67	5,228.74	5,260.84	1,599.99
Statewide Total	**254 counties**	301,402,852,201	54,563.13	1,019,010.48	144,760.35	152,631,797	869.79	15,696.89	16,844.06	4,565.62

[1] PM estimates are MOVES-based only (i.e., no re-suspended dust from roadways was included).

Table 7. 2023 Annual HAPS Emissions by Area (Tons/Year).

Area	County	Benz[1]	Form	Acet	1,3-But	Acrol	OGH	PAH	Metal	Dio/Fur	DPM +DEOG[2]
AUS MPA	Bastrop	5.11	2.24	2.08	0.58	0.19	65.16	0.43	0.007	1.11E-07	39.95
	Burnet	3.03	1.46	1.33	0.37	0.12	38.79	0.27	0.005	7.71E-08	28.68
	Caldwell	2.34	1.13	1.00	0.26	0.09	29.86	0.21	0.003	5.51E-08	19.44
	Hays	8.69	3.74	3.48	0.96	0.32	106.98	0.71	0.014	2.30E-07	68.81
	Travis	32.15	14.51	13.20	3.51	1.24	398.02	2.73	0.062	1.02E-06	301.24
	Williamson	16.90	7.75	7.18	1.90	0.67	207.82	1.45	0.032	5.19E-07	154.02
	Area Total	**68.22**	**30.84**	**28.27**	**7.58**	**2.63**	**846.63**	**5.80**	**0.123**	**2.01E-06**	**612.14**
BPA MPA	Hardin	2.41	1.13	1.00	0.23	0.09	27.53	0.20	0.003	5.50E-08	26.36
	Jefferson	9.70	5.43	4.41	0.90	0.44	111.92	0.92	0.015	2.46E-07	132.64
	Orange	3.58	2.70	2.00	0.33	0.22	40.92	0.42	0.007	1.04E-07	66.34
	Area Total	**15.70**	**9.26**	**7.41**	**1.47**	**0.76**	**180.37**	**1.55**	**0.025**	**4.05E-07**	**225.34**
DFW MPA	Collin	24.14	12.41	12.46	3.80	1.06	347.15	2.36	0.052	8.60E-07	256.31
	Dallas	67.11	37.45	34.99	10.24	3.06	1,025.15	6.93	0.146	2.39E-06	701.85
	Denton	21.69	11.45	11.54	3.51	0.98	316.70	2.16	0.043	7.10E-07	233.19
	Ellis	7.99	4.61	3.96	0.92	0.39	96.70	0.80	0.016	2.52E-07	94.25
	Hood	2.77	1.02	1.10	0.34	0.09	34.19	0.21	0.003	4.91E-08	18.09
	Hunt	5.13	2.88	2.46	0.59	0.24	62.35	0.50	0.008	1.26E-07	51.97
	Johnson	6.89	3.35	3.11	0.82	0.29	86.52	0.62	0.010	1.65E-07	68.23
	Kaufman	5.53	3.69	3.03	0.64	0.31	66.13	0.61	0.012	1.84E-07	76.22
	Parker	6.26	4.25	3.54	0.75	0.36	75.40	0.70	0.011	1.74E-07	88.66
	Rockwall	3.53	2.00	1.75	0.41	0.17	41.64	0.34	0.007	1.09E-07	43.66
	Tarrant	51.73	27.88	26.71	7.94	2.30	787.93	5.21	0.110	1.80E-06	561.83
	Wise	4.28	2.64	2.22	0.50	0.22	51.02	0.44	0.006	1.04E-07	46.62
	Area Total	**207.06**	**113.64**	**106.88**	**30.48**	**9.48**	**2,990.88**	**20.88**	**0.424**	**6.93E-06**	**2,240.88**

Area	County	Benz[1]	Form	Acet	1,3-But	Acrol	OGH	PAH	Metal	Dio/Fur	DPM +DEOG[2]
El Paso MPA	El Paso	31.23	14.61	13.03	3.49	1.23	379.06	2.67	0.037	5.96E-07	269.41
HGB MPA	Brazoria	8.27	4.63	4.50	1.34	0.39	134.55	0.86	0.017	2.83E-07	86.99
	Chambers	1.94	2.39	1.72	0.28	0.19	25.94	0.35	0.007	1.13E-07	49.36
	Fort Bend	14.99	8.34	8.22	2.43	0.71	242.30	1.55	0.030	4.97E-07	166.61
	Galveston	7.13	3.84	3.79	1.15	0.32	116.83	0.72	0.014	2.36E-07	74.72
	Harris	99.71	63.96	56.56	14.93	5.19	1,593.04	11.25	0.244	3.98E-06	1,319.59
	Liberty	3.11	1.91	1.76	0.50	0.16	49.89	0.34	0.006	9.56E-08	31.50
	Montgomery	15.77	9.64	9.04	2.52	0.80	245.95	1.73	0.035	5.77E-07	189.51
	Waller	2.27	1.94	1.51	0.34	0.15	34.19	0.31	0.006	9.14E-08	32.72
	Area Total	**153.19**	**96.64**	**87.11**	**23.48**	**7.92**	**2,442.68**	**17.12**	**0.360**	**5.88E-06**	**1,951.00**
SAN MPA	Bexar	70.84	31.12	27.81	7.55	2.59	894.81	5.85	0.099	1.63E-06	625.66
	Comal	8.30	4.15	3.58	0.89	0.34	101.73	0.74	0.013	2.17E-07	83.66
	Guadalupe	7.30	3.74	3.22	0.81	0.31	92.17	0.67	0.010	1.65E-07	72.63
	Kendall	2.52	1.19	1.11	0.31	0.10	33.27	0.22	0.003	5.60E-08	22.24
	Wilson	2.19	0.90	0.86	0.25	0.08	27.72	0.17	0.003	4.24E-08	17.09
	Area Total	**91.15**	**41.10**	**36.58**	**9.81**	**3.42**	**1,149.71**	**7.65**	**0.128**	**2.11E-06**	**821.29**
TLM MPA	Gregg	5.55	2.79	2.45	0.61	0.23	66.66	0.50	0.008	1.31E-07	63.22
	Harrison	3.68	2.61	2.04	0.41	0.21	43.85	0.42	0.007	1.04E-07	49.71
	Rusk	2.38	1.10	1.00	0.27	0.09	29.87	0.20	0.003	5.23E-08	19.80
	Smith	10.96	5.68	4.87	1.20	0.47	131.76	1.01	0.015	2.51E-07	123.69
	Upshur	1.92	0.86	0.81	0.22	0.07	23.46	0.16	0.003	4.16E-08	15.08
	Area Total	**24.50**	**13.05**	**11.17**	**2.72**	**1.08**	**295.60**	**2.30**	**0.036**	**5.80E-07**	**271.50**
Other Texas Counties	214 counties	420.86	330.87	249.58	46.45	26.42	4,671.48	53.19	0.997	1.58E-05	6,303.97
Statewide Total	**254 counties**	**1,011.89**	**649.99**	**540.04**	**125.48**	**52.94**	**12,956.40**	**111.15**	**2.130**	**3.43E-05**	**12,695.51**

[1] Abbreviation from left: Benzene, Formaldehyde, Acetaldehyde, 1.3-Butadiene, Other Gaseous Hydrocarbon HAPs (Toluene, Xylene, 2,2,4-Trimethylpentane, Hexane, Ethyl Benzene, Styrene, Propionaldehyde), Polycyclic Aromatic Hydrocarbons (16 PAHs), Metal Compounds (Arsenic, Chromium, Manganese, Mercury, Nickel), Dioxins and Furans (17), and diesel particulate matter and diesel exhaust organic gases (represented as total of diesel fleet exhaust VOC and exhaust PM_{10}).

[2] Note that the DPM+DEOG emissions estimates are not exclusive of the other tabulated fleetwide HAPs emissions estimates.

1 INTRODUCTION

The Texas Commission on Environmental Quality (TCEQ) works with local planning districts, the Texas Department of Transportation (TxDOT), and the Texas A&M Transportation Institute (TTI) to provide on-road mobile source emissions inventories of air pollutants. TxDOT typically funds transportation conformity determinations required under 40 Code of Federal Regulations (CFR) Part 93. The TCEQ funds mobile source inventory work in support of federal Clean Air Act (CAA) requirements, such as the attainment of the National Ambient Air Quality Standards (NAAQS), as well as the control of hazardous air pollutants (HAPs).

Under the U.S. Environmental Protection Agency's (EPA) Air Emissions Reporting Requirements (AERR), the state of Texas is required to prepare and submit a comprehensive statewide periodic emissions inventory (EI) and provide EPA Motor Vehicle Emissions Simulator (MOVES) county database files (CDBs) to support the EPA's National Emissions Inventory (NEI) every three years. The three-year cycle inventory year for this work was 2023 and is due to the EPA by January 15, 2025[3].

This report describes work conducted by TTI on behalf of the TCEQ and details how TTI produced the Texas 2023 on-road mobile source triennial (periodic) EIs and CDBs according to AERR requirements. The work involved the development of 2023 mobile source model inputs for MOVES and emission estimates for criteria air pollutants (CAPs), CAP precursors, and HAPs. The on-road mobile CDBs and inventories prepared under this work incorporated recently collected data for the calendar year 2023 and used the latest version of the MOVES model. The work also included preparation of requisite vehicle miles of travel (VMT) inputs for the TCEQ's Texas Road Dust Calculator necessary to develop a statewide 2023 calendar year emissions inventory. The work was conducted in accordance with the associated TCEQ-approved pre-analysis plan.

1.1 OBJECTIVE

The purpose of this document is to describe the methods and data used to develop the 2023 year EIs and CDBs for all 254 Texas counties. TTI developed for summer work weekday and winter work weekday (El Paso only) (together referred to as daily EIs) inventory estimates of CAPs and CAP precursors, and annual EI estimates of CAPs, CAP

[3] More information available in the *2023 NEI Plan: Final, July 2023* document. Available at: https://www.epa.gov/system/files/documents/2023-05/2023_NEI_Plan_draft_May2023.pdf.

precursors, and HAPs. The objective also included providing the requisite VMT inputs for the TCEQ's Texas Road Dust Calculator for the statewide 2023 EI.

For this statewide AERR, TTI used travel demand model (TDM) network link-based VMT for the counties in the seven areas with current TDMs listed in Table 3 and used Highway Performance Monitoring System (HPMS)-based VMT for counties not included in a TDM.

The methods used to calculate the daily and annual EIs are an extension of historically-consistent traffic activity and emission rate methods developed by TTI. The emissions inventory calculations described in this document were based on an hourly, link-level analysis that uses the outputs of the regional TDM or HPMS, as well as other local data sources (e.g., seasonal, day type, and hourly travel factors, vehicle population data, and environmental inputs) consistent with the region, and MOVES default inputs. This report details the data sources, methods, and annual and seasonal weekday combinations used to define each EI developed for this project.

EIs were developed using the latest version of the EPA's on-road emissions inventory software—MOVES4. MOVES4 was released (and replaced the MOVES4 version of the software) in August 2023 (initially as MOVES4.0.0) and was updated in January 2024 (MOVES4.0.1). The EI methods described in this document have been developed to incorporate the latest information on on-road mobile source emissions and methods outlined in the associated EPA guidance for conducting MOVES4-based EIs. Using the TDM VMT data and HPMS VMT data developed during this project, TTI also produced updated Texas-specific activity input where needed for the year 2023. The data was specifically formatted for use with the Texas Road Dust Calculator for all 254 counties.

This project involved the development of electronic deliverables that were post-processed from each county EI into formats described below.

- Tabular summaries of activity and emissions by county based on MOVES source use types.
- Tabular summaries of activity and emissions by county based on the EPA's Source Classification Codes (SCCs).
- MOVES CDBs, MOVES run specification (MRS) files, and utilities are used to process the data files for the MOVES runs.
- Emissions inventory files and CDBs are formatted and ready for upload to the EPA's Emissions Inventory System (EIS).
- Input files for use in the Texas Road Dust Calculator for all 254 Texas counties.

1.2 Summary of Modeling Methodology

The EIs were calculated using a detailed MOVES rates-per-activity estimation method based on the areas described in Table 1. This approach calculates on-network emissions for each link defined by the regional TDM or HPMS outputs and formats results as needed for subsequent uses. The TTI rates-per-activity estimation method was performed using four basic steps as described below.

- **Step 1 – Estimate Emission Rates:** MOVES4 was used to estimate regional emission rates (or factors) relevant to the analysis area. The rates were calculated based on local inputs to MOVES such as temperature and humidity, fuel formulation, etc. The MOVES emission rates are post-processed with TTI utilities into the form needed for external emissions calculations.
- **Step 2 – Estimate Traffic Activity:** The local HPMS and TDM data were processed to derive 24 hourly VMT and speed estimates for all virtual HPMS links and TDM links (as well as for added TDM intrazonal links). Processing involved using HPMS-based 2023 EI scenario VMT control totals for scaling base link-VMT to reflect the EI seasonal weekday VMT. Seasonal and daily adjustment and hourly allocation factors based on local automatic traffic recorder (ATR) traffic count data were used to process the HPMS and TDM data. After on-network activity was estimated, off-network activity was calculated using outputs from the processed HPMS and TDM data, vehicle population data, and MOVES default inputs. The traffic activity was processed to replicate the operating conditions for each county EI.
- **Step 3 – Develop Seasonal Emissions:** The seasonal weekday emission rates calculated in Step 1 were multiplied by the on- and off-network activity calculated in Step 2. This yielded emission estimates in units of mass calculated at a spatial scale of each link (on-network) or county (off-network) for each hour of the day.
- **Step 4 – Develop Annual Emissions**: The summer weekday on- and off-network activity were used in the development of annual activity which in turn was used, along with seasonal fuels and monthly meteorology and other input data needed, to develop the county-level CDBs used in the annual inventory runs using MOVES.
- **Step 5 – Post-Process EI Outputs:** Outputs for each pollutant were post-processed into a variety of formats and electronic deliverables for reporting purposes and downstream air quality planning.

Subsequent sections of this report describe these basic steps in more detail.

1.3 Emissions Inventory Scope

TTI developed and produced the Texas 2023 on-road mobile source triennial EIs and CDBs for all 254 counties according to the AERR requirements and the pre-analysis plan, as approved by the TCEQ. The following six subsections (Emissions Inventory Parameters; Source Use Types, Activity, and Pollutant Processes; Pollutants Modeled; Emission Rate (MOVES) Input Data; Traffic Activity Input Data; and Emissions Inventory Outputs) provide detailed lists of the scope of criteria used for the preparation of the emissions inventory products.

Emissions Inventory Parameters:

- Emissions inventories were developed to model the following emissions parameters:
- Analysis year—2023.
- Summer work weekday (Monday through Friday) emissions statewide for all 254 counties. Adjusted the average annual weekday to the average for summer months.
- Winter work weekday (Monday through Friday) emissions for El Paso County. Adjust the average annual weekday to the average for winter months.
- Annual emissions (calendar year totals for all counties) statewide for all 254 counties.
- These emissions inventories were estimated by combining traffic activity estimates for each county and each daily (summer work weekday and winter work weekday) or annual EI as described above. The final EIs were calculated by multiplying the activity rate scenarios by the corresponding emission rates.

Source Use Types, Activity, and Pollutant Processes:

- *Source use types (SUT) and fuel types* modeled—the various combinations of these are referred to as *vehicle types* as described in Table 8.
- *Traffic activity modeled*: VMT, vehicle starts, hotelling hours (classified by auxiliary power unit [APU], engine on, engine off), source hours parked, off-network idling.
- *Vehicle-based emission processes modeled*: running exhaust; crankcase running exhaust; start exhaust; crankcase start exhaust; extended idle exhaust; crankcase

extended idle exhaust; auxiliary power exhaust; evaporative permeation; evaporative fuel vapor venting; evaporative liquid leaks; brakewear; and tirewear.

Table 8. MOVES SUT/Fuel Types (Vehicle Types).

SUT ID	SUT Description	SUT/FT Abbreviation[1]
11	Motorcycle	MC_Gas
21	Passenger Car	PC_Gas, PC_Diesel, PC_Electricity
31	Passenger Truck	PT_Gas, PT_Diesel, PT_Electricity
32	Light Commercial Truck	LCT_Gas, LCT_Diesel, LCT_Electricity
41	Other Buses	OBus_Gas, OBus_Diesel, OBus_Electricity
42	Transit Bus	TBus_Gas, TBus_Diesel, TBus_Electricity
43	School Bus	SBus_Gas, SBus_Diesel, SBus_Electricity
51	Refuse Truck	RT_Gas, RT_Diesel, RT_Electricity
52	Single Unit Short-Haul Truck	SUShT_Gas, SUShT_Diesel, SUSht_Electricity
53	Single Unit Long-Haul Truck	SULhT_Gas, SULhT_Diesel, SULhT_Electricity
54	Motor Home	MH_Gas, MH_Diesel, MH_Electricity
61	Combination Short-Haul Truck	CShT_Gas, CShT_Diesel, CShT_Electricity
62	Combination Long-Haul Truck	CLhT_Diesel, CLhT_Electricity

[1]MOVES fuel type IDs are 1 for gasoline, 2 for diesel, and 9 for electricity.

Pollutants Modeled:

- *CAPs and CAP precursors* for the daily and the annual emissions inventories—the CAP precursors include volatile organic compounds (VOC), carbon monoxide (CO), nitrogen oxides (NO_X), sulfur dioxide (SO_2), ammonia (NH_3), carbon dioxide (CO_2), particulate matter with an aerodynamic diameter equal to or less than 2.5 microns ($PM_{2.5}$), and particulate matter with an aerodynamic diameter of equal to or less than 10 microns (PM_{10}).
- *HAPs* for annual emissions inventories—HAPs include six priority mobile source air toxics (MSATs: benzene, methyl tertiary-butyl ether, 1,3-butadiene, formaldehyde, acetaldehyde, acrolein) and the additional on-road mobile source air toxic pollutants included in the MOVES database (gaseous hydrocarbons, metals, dioxin/furans, and polycyclic aromatic hydrocarbons) which includes all 21 MSATs listed in the EPA's 2001 MSAT rule.

Emission Rate (MOVES) Input Data:

- *Emission rates:* EPA's latest mobile source emission rate model—MOVES4.0.1 (herein abbreviated to MOVES). The latest version of the model upon commencement of this work was released in January 2024. MOVES installation suites were downloaded from the following link: https://www.epa.gov/moves/latest-version-motor-vehicle-emission-simulator-moves [4]

- *Local meteorologic data*: 2023 climate inputs (temperature, humidity, barometric pressure).
- *Local fuel formulation input data:*
    - Consistent with TCEQ 2023 Summer Fuel Field Study conducted by Eastern Research Group (ERG) under contract to TCEQ, available at https://www.tceq.texas.gov/downloads/air-quality/research/reports/on-road/5822343388010-20240227-2023-summer-fuel-field-study.pdf.
    - MOVES individual fuel parameter inputs were used to model the Low Reid Vapor Pressure (RVP) gasoline control strategy for applicable counties, consistent with Sections 114.301-114.309 of TCEQ rules.[5]
    - Modeled reformulated gasoline for the HGB area and the four DFW counties—Collin, Dallas, Denton, and Tarrant.
    - Modeled the effects of the oxygenated fuel program for El Paso.
- *Inspection and maintenance (I/M) program information*: Modeled I/M programs currently administered in the Austin-Round Rock, DFW, HGB, and El Paso areas.
- *Federal motor vehicle control programs (FMVCP)*: Modeled the effects of all FMVCP in Texas, as incorporated by default in MOVES.

Traffic Activity Input Data:

- Validated TDM link-based VMT for the analysis year 2023 for the seven areas with current TDMs listed in Table 3 and HPMS-based VMT for counties not included in a TDM.
- Texas Department of Transportation (TxDOT) traffic count data (latest available 2023) to derive seasonal, day type, and hour-of-day traffic patterns.

[4] Note that the daily inventories were produced earlier in the project than the annual inventories. MOVES4.0.1 released in January 2024 was used to develop the emission rates for both the daily and the annual inventories.

[5] Code of Federal Regulations, Title 40 – Protection of the Environment, Part 80 – Regulation of Fuels and Fuel Additives, Section 27 – Controls and Prohibitions on Gasoline Volatility.

- HPMS data for deriving HPMS adjustment factors and historical year county VMT control totals.
- Base hotelling hours data sourced from TTI's study.[6]
- MOVES default hotelling mode distributions.
- MOVES default for the number of vehicle starts per local vehicle type population estimates.
- Vehicle population data: End of year 2021 vehicle registrations and age class data classified by source use and fuel type provided by the Texas Department of Motor Vehicles (TxDMV) with VMT-based scaling factors for estimating 2023.
- For local fleet VMT mix:
  - TxDOT traffic classification data.
  - TxDMV vehicle registration data.
  - DFW clean city electric vehicle data.
  - MOVES default data as needed.

Emissions Inventory Products:

- County-level activity and control program tables are sufficient for the CDBs to be used in MOVES inventory mode.
- A document listing all submitted files and detailing file naming conventions.
- MOVES CDBs, MOVES run spec files, and MySQL files are used to process data files for MOVES rates mode runs used in the daily, link- and virtual link-based EIs.
- All pertinent data relating to task activities.
- Two standard sets of activity and inventory summary files: one based upon MOVES SUTs and one based upon the EPA's SCCs.
- TexAER-ready formatted inventory files.[7]

[6] Heavy-Duty Vehicle Idle Activity Study Final Report, prepared by TTI for TCEQ, July 2019.

[7] The EPA requires 2023 emissions inventory data to be reported through the Central Data Exchange (CDX) system. TTI provided inventory summary data in a loadable format compatible with the EPA's EIS and the TCEQ's Texas Air Emissions Repository (TexAER). The format was based upon the most recent

- Inventory files are formatted and ready for uploading to the EPA's EIS.
- CDBs are formatted and ready for uploading to the EPA's EIS.

1.4 Report Structure

The remainder of this report provides a detailed description of the methods used to estimate the daily and annual EI products outlined in the summarized scope. The subsequent chapters broadly follow the simplified analysis steps reported in Section 1.2.

- Section 2—Estimating Traffic Activity—details the data and calculations used to calculate regional on-network and off-network traffic activity.
- Section 3—Estimating Weekday Emission Rates—details the calculation of emission rates via MOVES and subsequent rate modifications.
- Section 4—Developing Emissions Inventories—details the methods used to calculate regional emissions for the summer weekday and annual emissions inventories.
- Section 5—Texas Road Dust Calculator Input Development—details the process, inputs, and considerations used to prepare the Texas Road Dust Calculator input tables.
- Section 6—Quality Assurance—details the internal review and quality assurance/quality control (QA/QC) procedures, including independent verification and reasonableness checks.

version of the EPA's NEI format with the Consolidated Emissions Reporting Schema (CERS) written in Extensible Markup Language (XML). The loadable inventory files were based on SCCs compatible with the 2023 NEI code list.

2 ESTIMATING TRAFFIC ACTIVITY

On-network and off-network activity are required to estimate mobile source emissions. TTI uses a method that calculates on-network daily emissions using VMT by hour and direction for each link in a TDM or each virtual link in a county HPMS data set. Off-network daily emissions are calculated using county-level, hourly estimates of activity measures, including off-network idling (ONI) hours, source hours parked (SHP), starts, source hours extended idling (SHEI), and APU hours. Annual roadway-based activity is estimated at a more aggregate level (i.e., not a the link-level). Both on- and off-network activity (and emissions) are produced for each of the on-road fleet vehicle types. This section describes the methods used to develop on- and off-network activity for the summer weekday and annual estimations.

2.1 VEHICLE TYPE VMT MIX

VMT mix is a major input to the MOVES link-based emissions estimation process. It is an estimate of the fraction of on-road fleet VMT attributable to each SUT by fuel type and is used to subdivide the total VMT estimate on each link into VMT by vehicle type. These hourly VMT estimates by vehicle type are combined with the appropriate emissions factors in the link-emissions calculations. A form of VMT mix is also a major input for estimating vehicle type populations needed in the off-network emissions estimation process.

Since the VMT mix can vary by time-of-day impacting the emissions totals, the TTI VMT mix procedure produces VMT mix by time period. Time period VMT mix (by MOVES roadway type and vehicle type) consists of four time periods: morning rush hour (AM peak), mid-day, evening rush hour (PM peak), and overnight.

TxDOT district-level, time period, and Weekday, Friday, Saturday, and Sunday VMT mix (for gasoline-powered, diesel-powered, and electricity-powered vehicles) are estimated by the four MOVES road-type categories using the methodology characterizing VMT by vehicle type for a region (or district) as follows. Figure 1 shows the simplified process flow chart of the SUT VMT mix procedure before the subdivision of the estimated SUT proportions by fuel type. To accommodate MOVES4 changes, the procedure has been updated to manage MOVES4 requirements about the SUT/FT combinations. The procedural approach is to modify certain vehicle categories and fuel combinations to allow the immediate use of MOVES4.

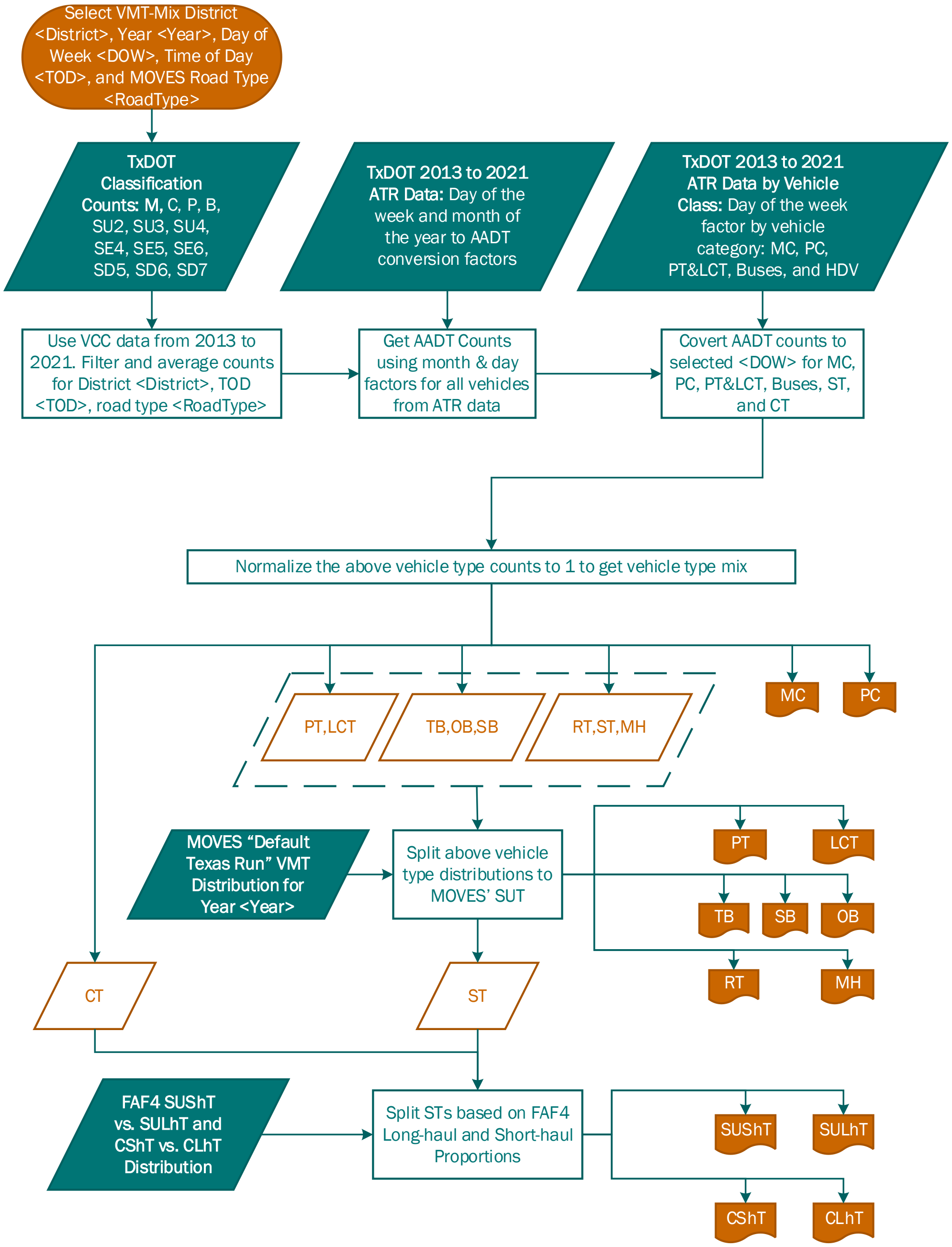


Figure 1. Simplified Overview of the VMT Mix Process Prior to Subdivision by Fuel Type.

The modified procedure characterizes VMT by vehicle type for a region or district as described below:

1. Develop county-level customized Alternate Vehicle Fuel and Technology (AVFT) table for MOVES4 using TxDMV Registration Data and dfwcleancities online database[8] for better estimation of local electric vehicles.
2. Conduct MOVES county-level inventory runs using customized AVFT and default values. Aggregate the VMT by SUT and fuel type at the district level.
3. TxDOT Classification Counts – Data files of standard TxDOT vehicle classification data assembled and used for determining the in-use road fleet mix.
4. TxDOT ATR Data – Data files of TxDOT ATR data assembled and used to allocate VMT by season and day of the week.
5. Day of Week (DOW) Factors by Urban Area/TxDOT District – Seasonal day-of-week factors from TxDOT ATR data used to allocate VMT by season and day-of-week by urban area/TxDOT district.
6. Convert TxDOT Classification Counts into MOVES SUT:

- Split vehicle classes 1 (motorcycles [M]) and 2 (passenger vehicles [C]) count into motorcycle and passenger cars directly based on their vehicle classification counts.
- Split vehicle class 3 (two-axle, four-tire single-unit trucks [P]) counts into passenger trucks and light commercial trucks using district-level VMT distribution by the corresponding SUTs.
- Split vehicle class 4 (buses [B]) counts into other buses, transit buses, and school buses using MOVES4 district-level VMT by the corresponding SUTs.
- Split vehicle classes 5 (six-tire, two-axle single-unit vehicles [SU2]), 6 (three-axle single-unit vehicles [SU3]), and 7 (four or more axle single-unit vehicles [SU4]) into single-unit trucks, single-unit trucks, mobile homes, and refuse trucks using MOVES4 district-level VMT by the corresponding SUTs.
- Split vehicle classes 8 (three or four-axle single-trailer vehicles [SE4]), 9 (five- axle single-trailer vehicles [SE5]), 10 (six or more axle single-trailer vehicles [SE6]), 11 (five or less axle multi-trailer vehicles [SD5]), 12 (six axle multi-trailer vehicles [SD6]), and 13 (seven or more axle multi-trailer vehicles [SD7]) into combination short-haul trucks and combination long-haul trucks and split single-unit trucks into

[8] Dfwcleancities online database: https://www.dfwcleancities.org/.

single-unit short-haul trucks and single-unit long-haul trucks using assignment results from registration data.

7. Estimate fractions of fuel types for each MOVES SUT using its district-level VMT by fuel types and apply the fuel type fractions to each SUT.

   - To account for the Texas-specific EV population, the 2021 vehicle registration data was utilized to develop an EV adjustment factor at the county-level by comparing the actual EV count to the MOVES4 default. This adjustment factor was applied to the market share of electric passenger cars, passenger trucks, and light commercial trucks of all model years in the *samplevehiclepopulation* table. Then, the market share of all other fuel types but gasoline, diesel, and electricity in the *samplevehiclepopulation* table was set to zero.

8. Produce VMT mix – Output file of MOVES SUTs and fuel types by region, analysis year, day type, and time period.

Using the same data sets and a similar procedure, aggregate (i.e., all road-type categories), 24-hour, TxDOT district-level weekday vehicle type VMT mixes (used in the vehicle population estimation) are also produced. To ensure general applicability and consistency across all study areas, all VMT mixes are developed in five-year increments beginning with the year 2005 and applied to the analysis years based on the pattern shown in Table 9.

Table 9. VMT Mix Year/Analysis Year Correlations.

VMT Mix Year	Analysis Years
2005	2003 through 2007
2010	2008 through 2012
2015	2013 through 2017
2020	2018 through 2022
2025	2023 through 2027
2030	2028 through 2032
2035	2033 through 2037
…	…

2.2 Seasonal Weekday Activity

This section describes the methods used to estimate the daily (summer work weekday and winter work weekday [El Paso only]) activity used in the EI.

2.2.1 Vehicle Miles of Travel

The hourly, link-based emissions process requires VMT estimates by hour and direction for each link in the TDM or each HPMS-based virtual link method. TDM VMT was adjusted to be consistent with HPMS and to reflect estimated traffic activity patterns characteristic of the typical seasonal day type scenarios (i.e., 2023 summer work weekday for all counties and winter work weekday for El Paso) needed. Operational (congested) link speed estimates corresponding to these traffic conditions were also required. All calculations were conducted using TTI's EI utility suite (see Appendix A).

2.2.1.1 Data Sources

Three major traffic data sources were utilized for developing the VMT estimates and VMT adjustment and allocation factors for the AERR. These were ATR counts, HPMS VMT estimates, and TDM estimates. The first two are collected and developed regularly by TxDOT as part of the larger HPMS data collection program. If applicable, U.S. Census and Texas State Data Center (TSDC) county population statistics and projections were also used to develop VMT forecasts along with the traffic data. TDM VMT estimates were derived from the TDMs prepared by each of the associated metropolitan areas.

HPMS VMT estimates were developed based on ATR data collected according to a statistical sampling procedure specified by the Federal Highway Administration (FHWA) designed to estimate VMT. TxDOT compiles and reports Texas HPMS data in its annual Roadway Inventory Functional Classification Record (RIFCREC) reports. A wide range of traffic data is collected under the HPMS program; however, the focus for this application was specifically the VMT, centerline miles, and lane miles estimates. The HPMS roadway data were categorized by seven roadway functional classifications and four area types.

TDM directional link VMT and speeds were calculated using the latest available TDM link data, trip data, and zonal radii data sets extracted from the TDMs. Since intrazonal VMT is not accounted for in the TDMs, the intrazonal VMT was estimated using the TDM trip matrix and zonal radii data. HPMS VMT estimates[9] were used to adjust the total TDM-based VMT for consistency with HPMS.

Seasonal and day-type factors derived from local ATR data were used to translate the traffic activity represented by the TDM or HPMS to those defined for each emissions scenario. These seasonal and day-type factors were estimated using ATR data collected from 2013 through 2022. TxDOT collects ATR vehicle counts at selected locations continuously throughout Texas. These counts are available by season, month, and day type, as well as on an annual average daily traffic (AADT) basis. Since they are continuous, they are well suited for making seasonal, day-of-week, and time-of-day comparisons (i.e., adjustment factors), even though there may be relatively few ATR data collection locations in any area.

2.2.1.2 VMT Adjustments

The following sections describe the steps TTI used to transform TDM-based and HPMS-based VMT estimates to the hourly VMT estimates required for the 2023 summer weekday and winter weekday emissions analysis. The total VMT was adjusted for HPMS consistency (applicable to TDM-based estimates) and to represent the activity for each seasonal weekday scenario. For this 2023 AERR, which by definition is a historical year (i.e., HPMS VMT data exists for the year), county-level VMT control totals were used to develop VMT adjustment factors.

VMT Adjustment Factor

To estimate the HPMS-consistent link VMT, county-level VMT control totals were used to develop county-level VMT adjustment factors. The VMT control totals are calculated using two key components: the analysis year county-level HPMS AADT VMT acquired from TxDOT and the AADT-to-seasonal weekday adjustment factors.

The AADT-to-seasonal weekday adjustment factors were developed for each county using aggregated TxDOT district ATR data for the years 2013 through 2022. These factors were calculated by dividing the seasonal weekday average traffic count by the AADT count. Appendix C provides the TxDOT district AADT-to-seasonal weekday adjustment factors used in developing the VMT control totals.

[9] HPMS VMT estimates are based on traffic count data collected according to a statistical sampling procedure specified by the FHWA. The EPA and FHWA have endorsed HPMS as the appropriate source of VMT and require that VMT used to construct on-road mobile source emissions estimates be consistent with that reported through HPMS.

The VMT control totals were calculated by multiplying the HPMS AADT VMT for each county by the seasonal weekday adjustment factors. To develop the county-level VMT adjustment factors, the county's control totals were then divided by the county total VMT from the TDM (TDM assignment VMT plus intrazonal VMT estimate) or the HPMS VMT for virtual link counties. For each link, the volume was multiplied by the corresponding county-level VMT adjustment factor. The adjusted link volumes were then multiplied by the associated link lengths for virtual links (centered lane miles) to produce the analysis year link-level, HPMS consistent, seasonal weekday VMT estimates. For TDM counties this same adjustment was also applied to the intrazonal VMT.

Seasonal Weekday Adjustment Factors

Seasonal weekday adjustment factors were used to adjust the virtual link VMT, and the TDM and estimated intrazonal VMT estimates. The seasonal adjustment factors were developed using aggregated ATR data for the years 2013 through 2022. These factors were calculated using local ATR data by dividing the average seasonal weekday traffic counts by the average non-summer weekday (ANSWT) traffic counts, or divided by the AADT counts in the HPMS (virtual link) VMT or the HPMS-adjusted historical TDM VMT.

Appendix C provides the seasonal adjustment factors for each county.

Hourly Travel Factors

Season and day-type-specific hourly travel factors were used to distribute the HPMS virtual link VMT, TDM link, and intrazonal VMT to each hour of the day. These hourly travel factors were developed using multi-year (2013 through 2022) aggregated ATR station data for each region[10]. For TDM counties, to maintain VMT proportions within each of the four time of day (TOD) TDM assignment periods, the 24 hourly fractions were normalized within each TOD period. For virtual link counties, the 24 hourly allocation factors sum to 1.0 (i.e., no time-of-day period normalization of hourly fractions for virtual link counties). Within each time period, the normalized hourly allocation factors were then multiplied by the seasonally adjusted total volume on each link to allocate the link volumes to each hour of the TOD period. Application of this procedure for each of the TDM's four TOD periods produced the set of 24 hourly volumes. These adjusted, hourly link volumes were then multiplied by their respective link lengths to estimate the link level hourly VMT for each inventory scenario. These adjustment and allocation factors were also similarly

[10] For TDMs, the region is the counties covered by the TDM and for HPMS counties, it is the associated TxDOT district.

multiplied by the estimated intrazonal VMT to produce the final hourly-adjusted VMT for each scenario.

Hourly travel factors are provided in Appendix E.

2.2.1.3 Link Speeds

On-network emission factors are based on the congested (or operational) speed for each link. For counties where a TDM is available (i.e., Dallas-Fort Worth, Houston-Galveston-Brazoria, etc.), the area-specific speed model in the TDM was used. For the rest of the counties (i.e., HPMS-based virtual link areas) the virtual link speed model was used. The methods are described below:

i. Bureau of Public Roads Link Speed Model

To estimate link operational (congested) speeds for Austin, Beaumont-Port Arthur, El Paso, San Antonio, and Tyler-Longview-Marshall, the speed model (i.e., the Bureau of Public Roads [BPR] Speed Model) built into their TDMs is used. The BPR speed model is formulated as a polynomial function with respect to the ratio of traffic volume to capacity. The BPR speed model was used to estimate the hourly, directional, congested speed for each link, except for the TDM centroid connectors and added intrazonal links. The speed readings of centroid connectors are the model free-flow speed (FFS). The speeds of intrazonal links are calculated as the average speeds of all centroid connectors in the same TAZ. The congested speed formula is:

$$Congested\ Speed\ = \frac{LEN}{(FFT * \left(1 + \alpha \times \left(\frac{V}{C}\right)^{\beta}\right))/60}$$

Where

LEN is the length of the link,

FFT is the directional link free-flow travel time (in minutes),

V is the directional link traffic flow,

C is the directional link capacity,

α and β are model parameters.

To calculate the hourly, directional, congested speed:

- The link length and directional link free-flow speeds in the travel model were directly used to calculate the FFT,

- the directional hourly link flow *V* was estimated by distributing the TOD link flow among each hour in the TOD using corresponding normalized hourly factors for the TOD,
- the directional hourly link capacity *C* was estimated by evenly distributing the TOD capacity among each hour within the TOD, and
- the model parameters α and β associated with each link in the travel model were directly used.

ii. Houston Speed Model

The operational speeds for each link of the Houston-Galveston-Brazoria TDM, excluding centroid connectors and the special intrazonal links, were calculated using the Houston speed model. The Houston speed model calculates these speeds using the travel model speed, speed factors (consisting of a free-flow speed factor and level of service [LOS] E speed factor), and a volume-to-capacity (V/C) ratio-based speed reduction factor (SRF) associated with each link.

The speed factors were used to convert the link-level travel model (input) speed to a free-flow speed and a LOS E speed (i.e., the application of these factors results in two speeds). The free-flow speed factors (grouped by functional class and area type) were calculated by dividing the distance-weighted free-flow speed by the distance-weighted input speed for each functional class/area type combination. The distance-weighted free-flow speeds were calculated using output from the detailed speed model used by Houston-Galveston Area Council (H-GAC) in the travel model development process (as provided by H-GAC) with link volumes set to 0 (i.e., V/C = 0). The LOS E speed factors were calculated in a similar manner (distance-weighted LOS E speed divided by distance-weighted input speed) using the detailed speed model output with link volumes set equal to capacity (i.e., V/C = 1). Appendix F shows the speed factors of the network functional class and the functional group relationship.

The link-specific V/C ratio was calculated as the time period (hourly) volume divided by the time period capacity. The V/C ratio is expressed as:

$$v/c\ ratio = V_h/C_h$$

Where:

Vh = the hourly link volume (travel model × HPMS factor × seasonal adjustment factor × hourly time period factor; Weekend profile factor for Saturday and Sunday [not applicable]); and

Ch = the hourly link capacity (travel model capacity × hourly capacity factor). Appendix F shows the hourly capacity factors.

After the V/C ratio was calculated, the link-specific SRF was determined using the V/C ratio, the link-specific SRF area type, the link-specific SRF functional class, and the SRFs. The SRFs are for V/C ratios of 0 to 1 in 0.05 increments (i.e., 0, 0.05, 0.10, …, 0.95, 1.0). Appendix F shows these SRFs. The link-specific SRF was calculated using linear interpolation. For V/C ratios greater than 1.0, an SRF is not required.

The speed model (for V/C ratios from 0.00 to 1.00) is expressed as:

$$S_{v/c} = S_{0.0} - SRF_{\frac{v}{c}} \times (S_{0.0} - S_{1.0})$$

Where:

$S_{V/C}$ = estimated directional speed for the forecast V/C ratio on the link in the given direction;

$S_{0.0}$ = estimated free-flow speed for the V/C ratio equal to 0.0;

$S_{1.0}$ = estimated LOS E speed for the V/C ratio equal to 1.0; and

$SRF_{V/C}$ = SRF for the V/C ratio on the link. The V/C ratio can be 0.0 to 1.0.

For V/C ratios greater than 1.0 and less than 1.5, the following speed model extension was used:

$$S_{v/c} = S_{1.0} \times \left(\frac{1.15}{1.0 + (0.15 \times (v/c)^4)}\right)$$

Where:

$S_{v/c}$ = estimated directional speed for the forecast V/C ratio on the link in the given direction;

$S_{1.0}$ = estimated LOS E speed for the V/C ratio equal to 1.0; and

v/c = the forecast V/C ratio on the link. The V/C ratio can be 1.0 to 1.5.

For V/C ratios greater than 1.5, the speed was calculated using the previous speed model extension, except the V/C ratio was set to 1.5.

These speed models were applied to all functional classes aside from centroid connector and intrazonal functional classes. For these functional classes, capacity data were not used. The centroid connector travel model input speeds were used as the centroid connector operational speed estimates. Operational speeds for the intrazonal functional class were estimated by zone as the average of the zone's centroid connector speeds.

The hourly and 24-hour speed (VMT/VHT) summaries by county and road type were provided electronically to TCEQ (see Appendix B).

iii. DFW Speed Model from NCTCOG's AQ report

For the Dallas-Fort Worth area, the operational speeds for each link, excluding centroid connectors and the special intrazonal links, were calculated using the DFW speed model provided in its AQ report[11]. The DFW speed model calculates these speeds using the free-flow travel speed, delay factors (consisting of delay constants and nonrecurring factors), and a volume-to-capacity (V/C) ratio.

The congested speed was calculated using the following formula:

$$Congested\ Speed\ = \frac{60*LEN}{(FFT+(unitDelay*Len)*(1+NonRecFactor))},$$

$$unitDelay = \min\,(delay, CConst),$$

$$delay = AConst * \exp\,(BConst * V/C),$$

Where

LEN is the length of the link,

FFT is the directional link free-flow travel time (in minutes),

V is the directional link traffic flow,

C is the directional link capacity,

$AConst, BConst$, $CConst$, and $NonRecFactor$ are model parameters whose values depend on link functional class.

iv. Virtual Link Speed Model

The virtual link speed model was applied to the 217 Texas counties that are not included in a TDM. There are three critical parameters for estimating operational speeds on virtual links: hourly lane capacity, free-flow speed, and hourly volume by direction. The hourly lane capacity is the maximum flow past a given point on a roadway, which varies by road type (or functional classification). The free-flow speed is the maximum speed at which

[11] https://www.nctcog.org/getmedia/fcbb560e-798b-47a0-8baa-ccbe285dbfed/2023-Conformity_Document_Final_Updated.pdf

traffic will move along a given roadway if there are no impediments (e.g., congestion, bad weather). The hourly volume by direction is the hourly link VMT by direction (discussed in the previous section) divided by the link's centerline miles.

The virtual link speed model was applied to estimate a link's directional, time-of-day congested speed. This speed model involves both the estimated free-flow speed and estimated directional delay as a function of volume and capacity for the link and time period (i.e., hour). The speed model was applied to each link for each hour and direction. Development of the hourly lane capacities and free-flow speeds input to the speed model is discussed first, followed by the estimation of congested speeds (including the model delay and congested speed equations).

Capacities and Free-Flow Speeds

The capacities and free-flow speeds used in the virtual link speed model procedure were based on the Highway Capacity Manual (HCM). For HPMS functional classifications 1 and 2 (Interstate and Freeway), both capacities and free-flow speeds were consistent with HCM guidance (HCM Chapters 13 and 30). The capacity (2,400 passenger cars per hour per lane [pcphpl]) and free-flow speed (70 mph) for four-lane freeways were used for all interstates and rural freeways. A free-flow speed of 65 mph and capacity of 2,300 pcphpl were used for small urban and urban freeways (HCM Exhibits 13-3 and 30-2).

The only adjustment applied to these two highest-level roadways is for the impact of heavy trucks on capacity (which is measured in passenger car equivalents). Table 10 shows the capacities for Interstates and Freeways based on the VMT mix (discussed in Section 2.1 of this report) for these roads in the three area types (procedure discussed next), and HCM-designated passenger car equivalents (1.5 per HCM Exhibit 23-8).

Table 10. Adjusted Interstate and Freeway Flow Rate (pcphpl) by Area Type.

Area Type	Ideal Flow	HDV[1]	Factor	Adjusted Flow
Rural	2,400	0.2832	0.8760	2,102
Small Urban	2,400	0.1140	0.9461	2,271
Urban	2,400	0.0616	0.9701	2,328
Rural	2,300	NA	NA	NA
Small Urban	2,300	0.1140	0.9461	2,176
Urban	2,300	0.0616	0.9701	2,231

[1] Heavy-duty vehicle.

HPMS functional classifications 3, 4, 5, 6, and 7 (Principal Arterial, Minor Arterial, Major Collector, Minor Collector, and Local) are interrupted flow facilities (i.e., they have traffic control devices). The capacities of these interrupted flow facilities are estimated as a function of adjusted flow and available green time (per HPMS Appendix N, Equation 20):

$$C_{ap} = Sat \times (gr/c)$$

Where:

C_{ap} = capacity of lane group, vehicles per hour (vph);

Sat = saturation flow rate of lane group, vehicles per hour of effective green time (vphg); and

gr/c = effective green ratio for the lane group.

The saturation flow rate (Sat) is the flow in vph that could be accommodated by the lane group assuming that the green phase is always available to the lane group (i.e., green ratio = 1.0). Calculation of the adjusted saturation flow rate begins with the ideal saturation flow rate (HCM Exhibit 10-12) of 1,900 pcphpl, which is adjusted to reflect deviation from ideal conditions. The saturation flow rate is adjusted using the following logic (from HCM equation 16-4, with parameter estimates consistent with HCM Exhibit 16-7 and Chapter 10):

$$S = fw \times fhv \times fg \times fbb \times fa \times flu \times frt \times flt \times flpb \times frpb$$

Where:

S = saturation flow rate adjustment factor;

fw = lane width factor (NA, 12-foot lane for all area types assumed);

fhv = heavy vehicle adjustment factor (based on area type VMT mix);

fg = approach grade factor (NA, level terrain assumed);

fp = parking lane adjustment (NA, unusual for rural or small urban areas, inappropriate for urban areas given HPMS aggregation);

fbb = bus blocking factor (NA, negligible per area type VMT mix);

fa = area type adjustment (NA, since the default of 0.9 is for urban area central business districts and urban is more broadly defined in HPMS);

flu = lane utilization adjustment (NA, data unavailable in HPMS);

frt = right turn adjustment factor (exclusive lanes for urban areas, 90 percent shared lane for right turns for rural areas, midpoint for small urban areas);

flt = left turn adjustment factor (exclusive lanes for urban areas, 90 percent shared left-turn lanes for rural areas, midpoint for small urban areas).

flpb = left turn pedestrian-bike adjustment (NA, no significant pedestrian-bike activity on average); and

frpb = right turn pedestrian-bike adjustment (NA, no significant pedestrian-bike activity).

Table 11 shows the saturation flow rate adjustment factors used for the three different area types. Unitary factors (i.e., factors whose value is 1 for all area types, or which are otherwise not applicable) for parameters fw, fg, fp, fbb fa, flu, flpb, and frpb are not shown.

Table 11. Saturation Flow Rate Adjustment Factors by Area Type

Area Type	fhv	Frt	flt	Factor
Rural	0.8918	0.9850	0.9950	0.8740
Small Urban	0.9380	0.9175	0.9725	0.8369
Urban	0.9661	0.8500	0.9500	0.7801

Table 12 shows the adjusted saturation flow rate (expressed in pcphpl) for all interrupted flow facilities (i.e., signalized streets, not Interstate or Freeway) for the three area types.

Table 12. Adjusted Saturation Flow Rate (pcphpl) by Area Type.

Area Type	Ideal Flow	Adjustment Factor	Adjusted Saturation Flow
Rural	1,900	0.8740	1,661
Small Urban	1,900	0.8369	1,590
Urban	1,900	0.7801	1,482

Table 13 shows the effective green ratios used for different functional classes and area types. Since the virtual link procedure is highly aggregated, individual green ratio calculations are not meaningful. Instead, assuming a hierarchical interface of classifications, ratios of adjacent roadway functional category group AADT were used to estimate effective green ratios. The ratio of AADT between the two highest categories of arterials scaled to a hypothetical 0.5 balance, is used for Arterials. The ratio of the highest category of Collector AADT to the lowest category of Arterial AADT is used for Collectors, again scaled to a hypothetical 0.5 balance. Locals are the default values recommended in the HPMS procedures (HPMS Appendix N). The overall approach is based on, and consistent with, HPMS guidance.

Table 13. Estimated Effective Green Ratios (gr/c) by Area Type

Area Type	Arterials	Collectors	Locals
Rural	0.613	0.448	0.400
Small Urban	0.600	0.487	0.400
Urban	0.508	0.478	0.400

Note that Interstates and Freeways are uninterrupted flow facilities, i.e., they have no traffic control devices and therefore do not require green ratios. For this calculation, area-type definitions are made at the county level and are based on U.S. Census criteria. Table 14 shows the hourly lane capacities by functional class and area type.

Table 14. Hourly Lane Capacities (vehicles per hour per lane [vphpl]) by Roadway Functional Classification

Area Type	Interstate	Freeway	Arterials	Collectors	Local
Rural	2,102	2,102	1,018	744	664
Small Urban	2,271	2,176	954	774	636
Urban	2,328	2,231	753	708	593

The free-flow speed for rural and urban Interstates, Freeways, and Arterials is consistent with HCM guidance (HCM Chapter 10, especially Exhibit 10-5), with appropriate modifications for the aggregation inherent in the virtual link procedure. Minor Collectors and Locals are grouped. In recognition of the aggregation inherent in the process, a lower limit of 30 mph is set on free-flow speed. Free-flow speeds are provided for each of the three area types and seven roadway functional classifications (i.e., 21 HPMS virtual links). Table 15 shows the free-flow speeds.

Table 15. Hourly Lane Capacities (vehicles per hour per lane [vphpl]) by Roadway Functional Classification

Area Type	Interstate	Freeway	Arterials	Collectors
Rural	2,102	2,102	1,018	744
Small Urban	2,271	2,176	954	774
Urban	2,328	2,231	753	708

The free-flow speed for rural and urban Interstates, Freeways, and Arterials is consistent with HCM guidance (HCM Chapter 10, especially Exhibit 10-5), with appropriate

modifications for the aggregation inherent in the virtual link procedure. Minor Collectors and Locals are grouped. In recognition of the aggregation inherent in the process, a lower limit of 30 mph is set on free-flow speed. Free-flow speeds are provided for each of the three area types and seven roadway functional classifications (i.e., 21 HPMS virtual links). Table 16 shows the free-flow speeds.

Table 16. Free-Flow Speeds (mph) by HPMS Roadway Functional Classification.

HPMS Area Type	Interstate	Freeway	Other Principal Arterial	Minor Arterial	Major Collector	Minor Collector and Local
Rural	70	70	60	50	40	30
Small Urban	70	60	50	40	35	30
Urban	70	60	40	35	30	30

Estimation of Congested Speeds

The estimation of congested speeds is a two-step process. The first step is the v/c ratio calculation. The second step is the application of the congested speed model to estimate the congested speed.

V/C ratios are generated for each combination of time period (hour), roadway functional classification, area type, and direction using the hourly lane capacities and VMT. The calculations for this procedure are:

- Volume: hourly VMT by direction (discussed in the previous section) is divided by centerline miles, yielding volume for each hour. This procedure was performed for each virtual link (i.e., roadway functional classification and area type combination);

- Capacity: lane miles are divided by centerline miles to produce lanes. Lanes are multiplied by the hourly lane capacities (i.e., adjusted saturation flows) generated by the process described previously, producing hourly capacities. This procedure was performed for each virtual link. (Capacity is the same for each hour and each direction.); and

- V/C ratios: the speed model uses the hourly volumes and capacities to produce hourly, directional v/c ratios for each roadway functional classification and area type combination. These v/c ratios are used to calculate hourly, directional congestion-related delay, and congested speeds (as described in the next section) by functional classification and area type combination.

- The congested speed model calculates the delay on the link and then applies this delay to the link free-flow speed to calculate the link operational congested speed estimate. The volume/delay equation is:

$$Delay = Min\ [Ae^{B(v/c)}, M]$$

Where:

Delay	=	congestion delay (in minutes/mile);
A and *B*	=	volume/delay equation coefficients;
M	=	maximum minutes of delay per mile; and
V/C	=	time-of-day directional v/c ratio.

There are two sets of delay model parameters A, B, and M, as shown in Table 17 —one set for high-capacity facilities and one set for low-capacity facilities. The HPMS high-capacity facilities are the Interstate and Freeway classifications.

Table 17. Volume/Delay Equation Parameters

Facility Category	A	B	M
High-Capacity Facilities (> 3,400 vph one way, e.g., Interstates and Freeways)	0.015	3.5	1.0
Low-Capacity Facilities (<=3,400 vph, e.g., Arterials, Collectors and Locals)	0.050	3.0	2.0

Given the estimated directional delay (in minutes/mile) and the estimated free-flow speed, the directional congested speed is calculated as follows:

$$Congestion\ Speed = \frac{60}{\frac{60}{freeflow\ Speed} + \ Delay}$$

For each daily inventory, this model was applied to each link, based on functional class and area type, for each hour and each direction. The hourly and 24-hour speed summaries (time period VMT/time period VHT) by county and road type were included with the detailed inventory data provided (see inventory data file descriptions in Appendix B).

Estimation of link-level VMT

The directional hourly link-level VMT is calculated as follows:

$$VMT_h = V_h * LEN$$

Where

V_h is the hourly directional link volume (after applying VMT adjustment factors),

LEN is the length of the link.

The TDM for the Dallas-Fort Worth area includes specific TOD periods that span half-hour intervals, such as the AM peak period from 6:30 to 9:00 AM. To compute the directional hourly link-level VMT, the VMT for each half-hour interval is first calculated. These half-hour VMT values are then aggregated to obtain the directional hourly link-level VMT. For instance, the VMT from 6:00 to 7:00 AM is determined by combining the VMT from the 6:00-6:30 and 6:30-7:00 intervals.

2.2.2 Off-Network

To estimate the off-network (or parked vehicle) emissions using the rates per activity (i.e., rate per ONI hour, rate per SHP, per start, per SHEI, and per APU hour), county-level estimates of ONI hours and SHP, starts, SHEI, and APU hours are required by hour and vehicle type for each inventory scenario. (SHEI and APU hours are for diesel combination long-haul trucks only.) One of the main components of the SHP and starts off-network activity estimation is the analysis of year county-level vehicle population.

The county-level vehicle population estimates and the estimates of county-level ONI hours, SHP, starts, and SHEI and APU hours by hour and vehicle type were developed using TTI's emission calculation utilities, available in Appendix A.

Vehicle Populations

The county-level vehicle population estimates for the 2023 inventory scenario year were calculated using the inventory scenario year county-level 2021 end-year TxDMV vehicle registrations and the assigned aggregate VMT mix (see Appendix D). The vehicle population estimation process assumes that all non-long-haul SUT category populations for a county are represented in the county vehicle registration data. This process also estimates the long-haul category populations as an expansion of the county registrations. There are three main steps in the vehicle population estimation process: registration data category aggregation, calculation of the vehicle type population factors, and estimation of the county-level vehicle population by vehicle type.

1. The first step in the vehicle estimation process is the registration data category aggregation. The inventory scenario year vehicle registrations were aggregated for each county into five categories. Table 18 shows these five categories.

Table 18. Registration Data Categories.

Registration Data Category	Vehicle Registration Aggregation
1	Motorcycles
2	Passenger Cars (PC)
3	Trucks ≤ 8.5 K gross vehicle weight rating (GVWR) (pounds)
4	Trucks > 8.5 and ≤ 19.5 K GVWR
5	Trucks > 19.5 K GVWR

2. The second step is calculating the vehicle type population factors. Using the assigned aggregate VMT mix, population factors were calculated for each vehicle type. For the non-long-haul SUT categories, the population factors were calculated by dividing the vehicle type VMT mix fraction by the summed total of the VMT mix fractions in its associated vehicle registration data category. For example, the LCT_Diesel population factor using the VMT mix is LCT_Diesel/(PT_Gas + PT_Diesel + PT_Electricity+ LCT_Gas + LCT_Diesel + LCT_Electricity). For the long-haul SUTs, the vehicle type population factors were calculated by taking the ratio of the long-haul and short-haul VMT mix values. For example, the SULhT_Gas population factor using SUT mix fractions is SULhT_Gas/SUShT_Gas. Table 19 shows the vehicle registration aggregations and their associated MOVES SUT/fuel types.

Table 19. TxDMV Vehicle Registration Aggregations and Associated Vehicle Types for Estimating Vehicle Populations.

Vehicle Registration[1] Aggregation	Associated Vehicle Type[2]
Motorcycles	MC_Gas
Passenger Cars (PC)	PC_Gas; PC_Diesel; PC_Electricity
Trucks ≤ 8.5 K GVWR (pounds)	PT_Gas; PT_Diesel; PT_Electricity LCT_Gas; LCT_Diesel; LCT_ Electricity
Trucks > 8.5 and ≤ 19.5 K GVWR	RT_Gas; RT_Diesel; RT_ Electricity SUShT_Gas; SUShT_Diesel; SUShT_ Electricity MH_Gas; MH_Diesel; MH_ Electricity Obus_Gas; Obus_Diesel; Obus_ Electricity TBus_Gas; TBus_Diesel; TBus_ Electricity SBus_Gas; SBus_Diesel; SBus_ Electricity
Trucks > 19.5 K GVWR	CShT_Gas; CShT_Diesel; CShT_ Electricity
NA[1]	SULhT_Gas; SULhT_Diesel; SULhT_ Electricity CLhT_Gas; CLhT_Diesel; CShT_ Electricity

[1] The four long-haul SUT/fuel type populations are estimated using a long-haul-to-short-haul weekday SUT VMT mix ratio applied to the short-haul SUT population estimate.
[2] The year-end TxDMV county registrations data extracts were used (i.e., the data consists of 1—light-duty cars, trucks, and motorcycles; 2—heavy-duty diesel trucks; and 3—heavy-duty gasoline trucks) for estimating the vehicle populations.

3. The third step is the estimation of the county-level vehicle type population. The non-long-haul vehicle type populations were estimated by applying their vehicle type population factors to the appropriate registration data category. For the CLhT_Gas type, the vehicle population was set to zero. For the remaining long-haul SUT/fuel types (SULhT_Gas, SULhT_Diesel, SULhT_Electricity, CLhT_Diesel, and CLhT_Electricity), the vehicle populations were calculated as the product of the corresponding short-haul category vehicle population and the associated long-haul population factor (e.g., SULhT_Gas vehicle population = SUShT_Gas vehicle population × [SULhT_Gas SUT mix fraction/ SUShT_Gas SUT mix fraction]).

The VMT mix data used in these calculations was the TxDOT district-level, 24-hour weekday VMT mix described in more detail in the "Development of Vehicle Type VMT Mix" section and included in Appendix D. The methods above yielded end-of-year 2021 vehicle population data for each of the vehicle types modeled in the EIs.

Analysis year vehicle type populations were then calculated by applying a vehicle types population growth factor (VPGF). The VPGF was calculated using county-level HPMS-reported total VMT for the registration data year (2021) and the 2023 analysis year.

$$VPGF = Analysis\ Year\ VMT\ /\ Registration\ Year\ VMT$$

ONI Hours

One of the activity measures needed to estimate the off-network emissions is the new activity type with MOVES3, which was inherited in MOVES4, from off-network idling activity. ONI hours are not related to combination truck hours of hotelling activity. ONI is an idling activity that occurs while a vehicle is idling in a parking lot, drive-through, or driveway while waiting to pick up passengers or loading/unloading cargo. ONI applies to all MOVES source types. Emissions are calculated by multiplying the emission rates (exhaust running emissions for MOVES roadType ID “1”, or “off-network”) with the corresponding hours of ONI.

TTI estimates ONI hours activity factors (or SHI off-network) following the MOVES methodology, by employing key MOVES defaults derived from telematics data, in combination with local network link-level activity estimates. This is accomplished using the formula that calculates ONI[12] as a function of the:

- Total idle fraction (TIF) (MOVES default derived from telematics data), or total idling hours on and off-network divided by total SHO (on network plus ONI hours): $TIF = (SHI_{network} + ONI) / (SHO_{network} + ONI)$,
- $SHO_{network}$ (from local link VMT and speeds), and
- SHI on the network ($SHI_{network}$). $SHI_{network}$ is calculated using the MOVES default road idle fractions (RIF) applied to local $SHO_{network}$ (VMT/speed) at the link level.

The equation for calculating ONI Hours is:

$$ONI\ Hours = (SHO_{network} \times TIF - SHI_{network})/(1 - TIF)$$

SHP

The second activity measure needed to estimate the off-network emissions using the mass per activity emissions rates is county-level estimates of SHP by the hour and vehicle type for each inventory scenario. For each inventory scenario and hour, the county-level SHP for each vehicle type was calculated by taking the difference between its total available hours minus its SHO. Since this calculation was performed at the hourly level, the total available hours by vehicle type is the same as the analysis year vehicle population. The SHO was calculated using the inventory scenario link VMT and speeds and the TxDOT district-level vehicle type VMT mixes by MOVES road-type category (see the “Development of Vehicle Type VMT Mix” section for more details). The ONI hours

[12] Population and Activity of Onroad Vehicles in MOVES4 (pdf) (August 2023, EPA-420-R-23-005)

estimated in the previous step are then subtracted from the SHP to produce the adjusted SHP used in the analysis.

Appendix G details county-level SHP and adjusted SHP by hour and vehicle type for each analysis year and inventory scenario. Hourly summaries were provided electronically to TCEQ; see Appendix B for electronic data descriptions.

Starts

Engine starts were based on the MOVES rates runs starts per vehicle output, and the local, county vehicle type population estimates. The starts were calculated as the product of starts/vehicle from MOVES, and the county vehicle type population estimates. This was performed by county and hour for each MOVES day type. The starts per vehicle were calculated using MOVES with data on the age distribution and fuel fractions of the local fleet. TTI used local age distributions and fuelfractions inputs to MOVES combined with MOVES default parameters (startsageadjustment, startsmonthadjust [three-month seasonal average], and startspervehicle) to produce hourly starts per vehicle output representative of the seasonal weekday. The MOVES output provided the seasonal weekday starts per vehicle.

For each hour of the day, the MOVES starts per vehicle data were multiplied by the local vehicle type population estimates to produce the total number of starts by vehicle type per hour.

The starts per vehicle data were used with constant vehicle type populations (i.e., vehicle type populations were assumed to be constant throughout the calendar year).

Hotelling: SHEI and APU Hours

The remaining activity measures needed to estimate the off-network emissions using the mass per activity emissions rates are the hourly, county-level heavy-duty diesel truck (SUT 62, FT 2 [CLhT_Diesel]) emissions-producing hotelling activity factors (i.e., truck main engine idling and diesel APU use). During hotelling, the truck's main engine is assumed to be in idling mode or its diesel auxiliary power unit is in use, or it is using electricity power or no power. For each inventory scenario, hotelling hours were first estimated, followed by an estimation of the SHEI and diesel APU hours components of hotelling hours. The hotelling hours for heavy-duty diesel and electricity trucks (SUT 62, FT 9 [CLhT_Electricity]) were calculated. The discussion and associated emission calculation procedures, though, are only applicable to CLhT_Diesel vehicles, unless noted otherwise, since electric vehicles don't produce idling or APU emissions.

The hotelling activity estimates were based on information from a TCEQ extended idling study, which produced 2017 winter weekday extended idling estimates for each Texas county. Hotelling scaling factors were applied to the base 2017 winter weekday hotelling values from the study to estimate the 24-hour hotelling for 2023 inventory scenarios. Hotelling hourly factors were then applied to allocate the 24-hour hotelling to each hour of the day. To ensure valid hourly hotelling values were used in the emissions estimation, the hourly hotelling hours were compared to the CLhT_Diesel and CLhT_Electricity hourly SHP (i.e., hourly hotelling values cannot exceed the hourly SHP values). SHEI and APU hours factors were then applied to the hotelling hours to produce the hourly SHEI and APU hours of activity. This procedure was repeated for each inventory scenario.

The SHEI and APU hours activity distribution fractions were each first multiplied by the travel distribution (model year operating mode activity fraction multiplied by the associated model year travel fraction). The product of the SHEI fractions and travel fractions were then summed to produce the total SHEI fraction, and the same process was performed for APU hours to produce the total APU hours fraction. (The sum of the SHEI and APU hours fractions subtracted from 1.0 results in the remaining fraction of hotelling hours, consisting of the electricity power or no power in use modes.)

Hotelling Scaling Factors

To estimate the county-level 24-hour hotelling by inventory scenario, county-level hotelling scaling factors were developed. These scaling factors were produced using the county-level base 2017 winter weekday link-level VMT and speeds, the TxDOT district-level base weekday vehicle type VMT mix (by MOVES road type), the county-level inventory scenario link-level VMT and speeds, and the TxDOT district-level inventory scenario vehicle type VMT mix (by MOVES road type). The 2017 winter weekday link-level VMT and speeds were developed similarly to the 2023 period, day-type link-level VMT and speed data except using a 2017 winter weekday VMT control total. Except for the 2017 hotelling base year, for which the 2015 VMT mixes were used, the vehicle type VMT mixes were the same VMT mixes used to estimate emissions in the emissions estimation process.

For each link in the 2017 winter weekday link-level VMT and speeds, the link VMT was allocated to CLhT_Diesel using the base weekday vehicle type VMT mix. This VMT allocation was performed for each link and hour in the 2017 winter weekday link-level VMT and speeds, with the individual link VMT aggregated by hour to produce the CLhT_Diesel hourly and 24-hour 2017 winter weekday VMT. Using a similar allocation process, the inventory scenario CLhT_Diesel hourly and 24-hour VMT were calculated using the inventory scenario link-level VMT and speeds and the inventory vehicle type VMT mix. The county-level 24-hour hotelling scaling factors by inventory scenario were calculated by dividing the CLhT_Diesel 24-hour 2023 inventory scenario weekday VMT by the CLhT_Diesel 24-hour 2017 winter weekday VMT.

Hotelling Hourly Factors

Hotelling hourly factors for each inventory scenario were used to allocate county-level, 24-hour, hotelling hours to each hour of the day. These hotelling hourly factors were calculated as the inverse of the inventory scenario hourly VHT fractions. The hourly VHT fractions were first calculated using the hourly VHT from the SHP estimation process (VHT = SHO). The inverses of these hourly VHT fractions were calculated and then normalized across all hours to produce the county-level, hotelling hours hourly distribution. This procedure was performed for each inventory scenario.

Hotelling by Hour Estimation

The initial inventory scenario hotelling by hour was calculated by multiplying the 24-hour 2017 winter weekday hotelling hours by the inventory scenario hotelling scaling factor and by the inventory scenario hotelling hourly factors. A comparison was then made between hourly hotelling and hourly SHP for the scenario. For each hour where the inventory scenario initial hotelling hours were greater than the SHP, the final hotelling hours estimate was set equal to the SHP; otherwise, the initial hotelling hours estimate was set as the final value. All calculations (scaling factors, hotelling hourly factors, and hotelling by hour calculations) were performed by county for each inventory scenario.

SHEI and APU Hours Estimation

The hourly, county-level, hotelling estimates for each inventory scenario were then factored to produce the SHEI and APU hours activity components using aggregate extended idle mode and aggregate APU mode fractions. For each hour, the inventory scenario hotelling hours were multiplied by the SHEI fraction to calculate the hourly SHEI and by the APU fraction to calculate the hourly APU hours.

The aggregate SHEI and the APU fractions were estimated using model year travel fractions (based on source type age distribution and relative mileage accumulation rates used in the MOVES runs) and the MOVES default hotelling operating mode distributions shown in Table 20. The associated travel fractions were applied to the appropriate extended idle and APU operating mode fractions (of the hotelling operating mode distribution) by model year and summed within each mode to estimate the aggregate (across model years) individual SHEI and APU fractions. (The sum of the resulting SHEI and APU fractions, when subtracted from 1.0, leaves the portion of hotelling hours in which trucks were either using electric power or using no power.)

Table 20. Hotelling Activity Distributions by Operating Mode and Model Year

Fuel Type ID	Begin Model Year ID	End Model Year ID	Extended Idling (ID = 200)	Hotelling Diesel APU (ID = 201)	Hotelling Shore Power (plug-in) (ID = 203)	Hotelling Battery or All Engines/ Accessories Off (ID = 204)
2	1960	2009	0.80	0.00	0.00	0.20
2	2010	2020	0.73	0.07	0.00	0.20
2	2021	2023	0.48	0.24	0.00	0.28
2	2024	2026	0.40	0.32	0.00	0.28
2	2027	2060	0.36	0.32	0.00	0.32
3	1960	2020	0.80	0.00	0.00	0.20
3	2021	2026	0.72	0.00	0.00	0.28
3	2027	2060	0.68	0.00	0.00	0.32
9	1960	2060	0.00	0.00	0.80	0.20

2.3 Annual Activity

To estimate the annual emissions and build the annual MOVES inventory mode databases consistently, the summer weekday activity was converted to annual activity based on the MOVES calculation procedures to a format suitable for use with the MOVES inventory mode. Annual off-network activity estimate procedures for VMT, ONI hours, SHP, starts, and hotelling hours are described in the following sections.

2.3.1 Vehicle Miles of Travel

The MOVES calculation procedure for VMT allocates annual VMT by the MOVES-defined HPMS vehicle types to summer weekday VMT by HPMS vehicle type using month VMT fractions, day VMT fractions, number of days in the month, and the number of days in the period for the day VMT fraction. The formula for the MOVES VMT allocation procedure is:

$$SWkdVMT_{HPMSVtype} = AVMT_{HPMSVtype} \times monthFract_{Month} \times \frac{\frac{dayFract_{Month,DayType}}{\frac{noOfDays}{7}}}{noOfRealDays}$$

Where:

$SWkdVMT_{HPMSVtype}$	= summer weekday VMT by HPMS vehicle type;
$AVMT_{HPMSVtype}$	= annual VMT by HPMS vehicle type;
$monthFract_{Month}$	= month VMT fraction for the desired month;
$dayFract_{Month,DayType}$	= day VMT fraction for the desired day type (weekday or weekend day by month);
$noOfDays$	= number of days in the desired month; and
$noOfRealDays$	= number of days in the desired day type (5 for weekdays, 2 for weekend days).

Since the objective was to estimate the annual VMT from the summer weekday VMT, the formula from the MOVES VMT allocation procedure can be transformed to calculate the annual VMT from the summer weekday VMT by reversing the calculations. The formula for calculating the annual VMT by HPMS vehicle type from the summer weekday VMT is:

$$AVMT_{HPMSVtype} = SWkdVMT_{HPMSVtype} \times noOfRealDays \times \frac{\frac{noOfDays}{7}}{\frac{dayFract_{Month,DayType}}{monthFract_{Month}}}$$

The number of days in the day type (noOfRealDays) and the number of days in the month (noOfDays) were determined by the seasonal inventory scenario being analyzed. Since the inventories were for summer (July) weekdays, the number of days in the day type was set to 5 and the number of days in the month was set to 31. Day VMT fractions and month VMT fractions were developed by the TxDOT district using aggregated ATR data (years 2013-2022). See Appendix C for the day VMT fractions and the month VMT fractions. By county, this calculation procedure was applied to the summer weekday VMT for each HPMS vehicle type and saved for use in building the annual MOVES inventory mode databases.

2.3.2 Off-Network

Annual off-network activity estimate procedures for ONI hours, SHP, starts, and hotelling hours are described in the following sections.

Vehicle Population

Vehicle population data were used to estimate SHP and vehicle starts off-network activity. The vehicle populations were estimated similarly to seasonal activity.

Off-Network Idling

TTI estimated off-network idling using the MOVES inventory mode process. MOVES default data was used for the county-level TotalIdleFraction input table to indicate the total time spent idling as a fraction of source hours operating by source type, model year range, month, and day type. TotalIdleFraction was processed to reflect annual weekday and weekend activity. MOVES internally calculated the off-network idling hours for inventory mode. Idle time while hotelling for long-haul combination trucks (SUT 62) is not included in this estimate and is discussed in the next section. All off-network idling calculations were performed at the county level.

Hotelling Hours

The annual hotelling hours were calculated using similar logic and input parameters as the annual VMT procedure. The annual hotelling hours were redistributed to each month and day type to calculate the monthly weekday hotelling hours and the monthly weekend hotelling hours. The monthly weekday hotelling hours and the monthly weekend hotelling hours were each summed to produce the annual weekday hotelling hours and annual weekend hotelling hours. Next, the annual weekday hotelling hours were divided by the number of annual weekdays to calculate annual weekday hotelling hours per day. Similarly, the annual weekend hotelling hours were divided by the number of annual weekend days to calculate annual weekend hotelling hours per day. The annual weekday hotelling hours per day and annual weekend hotelling hours per day were converted to the proper format for use with the MOVES inventory mode databases (hotelling hours per day by day type).

The following formulas were used to calculate the annual hotelling hours, annualization factors, weekday hotelling hours per day, and weekend hotelling hours per day.

- **Step 1** – Summer weekday hotelling hours per day to annual hotelling hours:

$$\begin{aligned}&Annual\ Hotelling\ Hours\\&= swkd\ Hotelling\ Hours\ per\ day\ \times Annualization\ Factor_{swkd\ to\ Annual}\\&= \frac{swkd\ Hotelling\ Hours\ \times 31\ \times 5/7}{dayVMTfraction_{monthID=7,dayID=5} \times monthVMTfraction_{monthID=7}}\end{aligned}$$

$$\begin{aligned}Annualization\ Factors_{swkd\ to\ Annual} &= \frac{Annual\ Hotelling\ Hours}{swkd\ Hotelling\ Hours}\\&= \frac{31\ \times 5/7}{dayVMTfraction_{monthID=7,dayID=5} \times monthVMTfraction_{monthID=7}}\end{aligned}$$

- **Step 2** – Annual hotelling hours to annual weekday hotelling hours and annual weekend hotelling hours (based on the same algorithm used in Step 1):

$$Annual\ Weekday\ Hotelling\ Hours = \sum_{i\ from\ 1\ to\ 12} Annual\ Hotelling\ Hours \times dayVMTfraction_{monthID=i,dayID=5} \times monthVMTfraction_{monthID=i}$$

$$Annual\ Weekned\ Hotelling\ Hours = \sum_{i\ from\ 1\ to\ 12} Annual\ Hotelling\ Hours \times dayVMTfraction_{monthID=i,dayID=2} \times monthVMTfraction_{monthID=i}$$

- **Step 3** – Hotelling hours per day for weekdays and hotelling hours per day for weekends:

$$Annual\ Weekday\ Hotelling\ Hours\ per\ day = Annual\ Weekday\ Hotelling\ Hours/(365\ \times 5/7)$$

$$Annual\ Weekend\ Hotelling\ Hours\ per\ day = Annual\ Weekday\ Hotelling\ Hours/(365\ \times 2/7)$$

Where:

swkd = summer weekday.

i = monthID (1 through 12).

The hotelling annualization factor was then calculated by dividing the county's total hotelling hours by the county's total summer weekday hotelling hours. This hotelling annualization factor was used for annualizing the SHEI and APU hours activity in the emissions annualization process. Appendix J shows the annual hotelling hours, summer weekday hotelling hours, and annualization factors for each county.

3 ESTIMATING WEEKDAY EMISSION RATES

This section describes the development of the emission rates for each CAP and CO_2 for the seasonal weekday EIs. The emission rates were calculated using EPA's MOVES4 emission factor model parameterized using local and default data. The resulting MOVES4 emission rates were then post-processed using the TTI utilities to yield the emission rates used to calculate total, seasonal weekday emissions for each county (summer for all counties plus winter for El Paso County). The emission rates were developed based on the methods and procedures shown in Appendix A, with updated as needed to accommodate MOVES4 and EPA's Technical Guidance[13] applicable to MOVES4 inventory development.

The following sections describe the (seasonal) weekday emission rate development process. In a few places (e.g., on fuels and meteorological inputs) additional information is provided on inputs used later in the process for developing MOVES inventory mode county inputs database (CDB) inputs needed for the production of the annual EIs.

3.1 PROCESS OVERVIEW

The general process involves setting up and executing MOVES emissions rates mode runs to produce the emissions and activity data needed for the development of on-road mobile source, county-level emissions rates, for an average seasonal weekday. For the initial post-processing step following the MOVES emission rates mode run, TTI uses an on-road rates look-up table post-processor utility to convert the mass/vehicle evaporative rates to mass/SHP and to compile all the needed rates into look-up tables. Using this process, on-road rates look-up tables are produced from each set of MOVES runs, in the form needed for input to the external inventory calculations utility.

The weekday EIs were based on two EI methods: one for TDM region counties that uses county-level emission rates for 37 metropolitan area counties (3 in TLM area use HPMS method) and the other statewide virtual link method that uses county group level emission rates (by 34 groups) for the 217 other counties. These 217 counties are listed in Table 21.

[13] EPA. 2023. *MOVES4 Technical Guidance: Using MOVES to Prepare Emission Inventories for State Implementation Plans and Transportation Conformity*, EPA-420-B-23-011, Office of Transportation and Air Quality. August 2023.

Table 21. The 34 County Groups and the Counties Included

Group County	Counties Included
Anderson	Anderson, Cherokee, Henderson, Van Zandt, Wood
Andrews	Andrews, Crane, Ector, Loving, Martin, Midland, Pecos, Reeves, Terrell, Upton, Ward, Winkler
Angelina	Angelina, Houston, Nacogdoches, Polk, Sabine, San Augustine, San Jacinto, Shelby, Trinity
Aransas	Aransas, Bee, Goliad, Karnes, Live Oak, Nueces, Refugio, San Patricio
Archer	Archer, Baylor, Clay, Montague, Throckmorton, Wichita, Wilbarger, Young
Armstrong	Armstrong, Carson, Dallam, Deaf Smith, Gray, Hansford, Hartley, Hemphill, Hutchinson, Lipscomb, Moore, Ochiltree, Oldham, Potter, Randall, Roberts, Sherman
Atascosa	Atascosa
Austin	Austin, Calhoun, Colorado, De Witt, Fayette, Gonzales, Jackson, Lavaca, Matagorda, Victoria, Wharton
Bailey	Bailey, Castro, Cochran, Crosby, Dawson, Floyd, Gaines, Garza, Hale, Hockley, Lamb, Lubbock, Lynn, Parmer, Swisher, Terry, Yoakum
Bandera	Bandera, Frio, Kerr, Medina, Uvalde
Bell	Bell, Bosque, Coryell, Falls, Hill, Limestone, McLennan
Blanco	Blanco, Gillespie, Llano, Mason
Borden	Borden, Callahan, Fisher, Haskell, Howard, Jones, Kent, Mitchell, Nolan, Scurry, Shackelford, Stonewall, Taylor
Bowie	Bowie, Camp, Cass, Marion, Morris, Panola, Titus
Brazos	Brazos, Burleson, Freestone, Grimes, Leon, Madison, Milam, Robertson, Walker, Washington
Brewster	Brewster, Culberson, Jeff Davis, Presidio
Briscoe	Briscoe, Childress, Collingsworth, Cottle, Dickens, Donley, Foard, Hall, Hardeman, King, Knox, Motley, Wheeler
Brooks	Brooks, Cameron, Hidalgo, Jim Hogg, Kenedy, Starr, Willacy
Brown	Brown, Coleman, Comanche, Eastland, Lampasas, McCulloch, Mills, San Saba, Stephens
Coke	Coke, Concho, Crockett, Edwards, Glasscock, Irion, Kimble, Menard, Reagan, Real, Runnels, Schleicher, Sterling, Sutton, Tom Green
Cooke	Cooke
Delta	Delta, Fannin, Franklin, Grayson, Hopkins, Lamar, Rains, Red River
Dimmit	Dimmit, Kinney, La Salle, Maverick, Val Verde, Webb, Zavala
Duval	Duval
Erath	Erath, Jack, Palo Pinto
Hamilton	Hamilton
Hudspeth	Hudspeth
Jasper	Jasper, Newton, Tyler
Jim Wells	Jim Wells, Kleberg
Lee	Lee
McMullen	McMullen
Navarro	Navarro
Somervell	Somervell
Zapata	Zapata

The county grouping scheme was based on prior statewide on-road mobile source inventory modeling projects. The county groups were delineated by the intersecting boundaries of geographic data aggregations (or area coverages) for input parameters based on local data, regulations, or conditions. Fleet input (age distributions based on TxDMV vehicle registration data) and meteorological input parameters are at the TxDOT district level (25 districts); fuel formulations and fuel supply inputs are at the MOVES Texas fuel regions (or Texas fuel policy jurisdictions) level. The county Federal Information Processing System (FIPS) code of the first county (alphanumerically) in each county group was used as the MOVES countyID input value for the MOVES runs and represents all of the counties in the group.

Emission rates were developed for the 2023 summer and winter (for El Paso only) weekdays. These emission rates were then used with the corresponding traffic activity estimates (corresponding to county and season) to calculate the full EI.

For the external inventory calculations, the method requires that all rates be in terms of mass per unit of activity, as opposed to particular off-network rates of mass per vehicle, which is the only output option available for off-network "parked vehicle" evaporative emissions output by MOVES. Table 22 defines the rates produced for the external inventory calculations relative to traffic activity measures.

Table 22. Emission Rates by MOVES Emissions Process and Activity Factor.

Emissions Process	Activity[1]	Emission Rates[2]
Running Exhaust	VMT	mass/mile (mass/mi)
Crankcase Running Exhaust	VMT	mass/mi
Brake Wear	VMT	mass/mi
Tire Wear	VMT	mass/mi
Start Exhaust	Starts	mass/start
Crankcase Start Exhaust	Starts	mass/start
Extended Idle Exhaust	SHEI	mass/hour
Crankcase Extended Idle Exhaust	SHEI	mass/hour
Auxiliary Power Exhaust	APU Hours	mass/hour
Running exhaust (1) – Road Type 1 off-network	ONI Hours	mass/hour
Evaporative Permeation Evaporative Fuel Vapor Venting Evaporative Fuel Leaks	VMT, SHP	mass/mi, mass/hour

[1] VMT, ONI hours, SHP, vehicle starts, and the SHEI and APU hours components of hotelling are the basic activity factors. SHEI and APU hours are for combination long-haul trucks only.

[2] All mass per activity rates shown are available in MOVES rate mode table output except for mass/hour associated with SHP, which is produced using the TTI rates post-processing utility.

The MOVES model is equipped with default modeling values for the range of conditions that affect emissions factors. MOVES defaults may be replaced by alternate input data sets that better reflect local scenario conditions, where available and consistent with the methodology. Local data were developed to reflect county weather conditions, regional seasonal (summer) fuel properties, and county vehicle age distributions.

For the activity input data to MOVES, the MOVES defaults are generally used, which is basic to the emissions rates method (i.e., inventory scenario emission rates produced via post-processing were externally multiplied by the actual local VMT and off-network activity estimates, detailed in previous sections, to calculate emissions external to MOVES). Where local data is required, MOVES default data are replaced with local data using the MRS and MOVES CDBs. The MRS files, CDBs, and MOVES default database provide the input data tailored for each local scenario model run.

MOVES set-ups and runs were executed and the results were post-processed to produce the county-level, seasonal weekday, activity-based emission rates of the desired pollutants and processes. The emission rates were estimated by speed (for miles-based rates), process, hour, MOVES road type (road type 1 for off-network), SUT, and fuel type. The following sections describe the emission rates estimation process used for setting up the MOVES RunSpec files and CDBs, executing MOVES emissions rate mode runs, and post-processing.

3.2 MOVES Run Specification Input Files

The MOVES Run Specification (MRS) is a file (in XML format) that defines the place, time, road categories, vehicle and fuel types, pollutants and emissions processes, and the overall scale and level of output detail for the modeling scenario. TTI created an MRS for one county and season using the MOVES graphical user interface (GUI), then converted the MRS to a template and used it as a base from which to build all the required MRS files. Table 23 describes the MRS selections used, followed by sections describing the input data used per selection.

Table 23. MRS Selections by MOVES GUI Navigation Panel.

Navigation Panel	Detail Panel	Selection
Scale[1]	Model; Domain/Scale; Calculation Type	On-Road; County; Emission Rates
Time Spans[1]	Time Aggregation Level;	Hour;
	Years – Months – Days – Hours	***<2023>***[1] - July – Weekday - All

Navigation Panel	Detail Panel	Selection
Geographic Bounds[1]	States; Counties; Selections	Texas - ***<COUNTY>***;[1] ***<TX COUNTY SELECTION>***
Onroad Vehicles[2]	T/Fuel Combinations: 1 – Gasoline, 2 – Diesel, 3 – Compressed natural gas (CNG), 5 – E85 (85% ethanol-15% gasoline blend), 9 – Electricity	SUT — Fuel Types Motorcycle: 1 - - - - Passenger Car: 1 2 - - 9 Passenger Truck: 1 2 - - 9 Light Commercial Truck: 1 2 - - 9 Other Buses: 1 2 3 - 9 Transit Bus: 1 2 3 - 9 School Bus: 1 2 3 - 9 Refuse Truck: 1 2 3 - 9 Single Unit Short-Haul Truck: 1 2 3 - 9 Single Unit Long-Haul Truck: 1 2 3 - 9 Motor Home: 1 2 3 - 9 Combination Short-Haul Truck: 1 2 3 - 9 Combination Long-Haul Truck: - 2 - - 9
Road Type	Selected Road Types	Off-Network – Rural Restricted Access – Rural Unrestricted Access – Urban Restricted Access – Urban Unrestricted Access
Pollutants[3] and Processes	VOC; CO; NO_X; SO_2; NH_3; Atmospheric CO_2; $PM_{2.5}$: Total Exhaust, Brakewear, and Tirewear; PM_{10}: Total Exhaust, Brakewear, Tirewear, and the MOVES HAPs	Dependent on pollutants: Running Exhaust, Start Exhaust, Extended Idle Exhaust, Auxiliary Power Exhaust, Crankcase Running Exhaust, Crankcase Start Exhaust, Crankcase Extended Idle Exhaust, Evap Permeation, Fuel Vapor Venting, Fuel Leaks; Brakewear, Tirewear
General Output	Output Database; Units; Activity	***<MOVES OUTPUT DATABASE NAME>***;[1] Grams, KiloJoules, Miles; Hotelling Hours, Population, Starts (not adjustable, pre-selected)
Output Emissions Detail	Always; For All Vehicles/Equipment; On Road	Time: Hour – Location: Link – Pollutant; Fuel Type, Emissions Process; Road Type, Source Use Type
Advanced Features	Aggregation and Data Handling	Only the "clear BaseRateOutput after rate calculations" box is checked

[1] Limited to one county per County Scale run. County Federal Information Processing Standards (FIPS) code, year, and season/day type labels were included in the MRS file and output database names. For county group runs, the first county alphabetically in each group was used as the group representative for each MOVES run.
[2] Although MOVES requires all fuel types to be included in MRSs, only gasoline, diesel, and electricity were modeled.
[3] Prerequisite pollutants that were needed to model the reported pollutants are not shown.

3.2.1 Scale

The MOVES Domain/Scale "County" was selected as is required for SIP inventory estimates. The MOVES Calculation Type "Emissions Rates" was selected for MOVES to produce the emissions rates with speed bin indexing needed in the emission rate look-up tables.

3.2.2 Time Span

The Time Spans parameters were specified to provide the most detail available, which is the hourly aggregation level, for all hours of the day, for the selected year, month, and day type. One analysis year (2023), “Months” (July for all counties and January for El Paso County), and “Days” (Weekdays) selection were made per run.

3.2.3 Geographic Bounds

Per the MOVES County Scale, only one county was selected per run. For county group runs, the first county alphabetically in each group was used as the group representative for each MOVES run.

3.2.4 On-Road Vehicles and Road Type

The local VMT mixes developed for the study include the SUT/fuel type combinations modeled with MOVES, namely, gasoline, diesel, and electric vehicle types. The VMT mixes specify the vehicle fleet as the gasoline, diesel, and electric SUTs designated as “on-road vehicles” selections in Table 23. These SUT/fuel type combinations were selected in all the MRSs. All other SUT/fuel type combinations available in MOVES were also selected as required by MOVES, but only gasoline and diesel were modeled. Fuel type output was controlled through adjustments to the MOVES default fuel engine fractions via the MOVES Alternate Vehicle and Fuel Technology (AVFT) table (discussed later). All five MOVES road-type categories were selected.

3.2.5 Pollutants and Processes

In addition to the pollutants defined by the scope of the inventory, MOVES requires that additional pollutants be selected for “chained” pollutants (i.e., pollutants that are calculated as a function of another MOVES pollutant). Of the pollutants listed for the inventory, the following additional pollutants were selected, as required by the model, due to chaining: non-methane hydrocarbons and total gaseous hydrocarbons (for VOC); TEC (for CO_2); and Composite – NonECPM (non-elemental carbon) for Primary Exhaust $PM_{2.5}$ - Total. All of the associated on-road processes available by the selected pollutants were included.

3.2.6 General Output

The output units were grams, kilojoules, and miles. The activity categories were pre-set by MOVES rates mode (and not adjustable) for inclusion in the output database. The selected output detail level was by hour, link (in MOVES rates mode "link" is the combination of county, road type, and speed bin), pollutant, process, road type, SUT, and fuel type.

The MOVES model produces results at different aggregation levels that may be specified in the MRS. The detailed, hourly, HPMS virtual link-based inventory method required MOVES weekday day type rates at the following MOVES output detail level:

- Up to 13 source types (i.e., vehicle types).
- Up to five fuel types.
- Up to five road types (four actual MOVES road categories and off-network).
- Each of the 24 hours in a day.
- 16-speed bins (only included in miles-based rate tables).
- Up to 156 pollutants.
- Up to 14 on-road processes.

The vehicle fleet was modeled as powered only by the predominant on-road fuels of gasoline, diesel, and electricity (alternate fuels were considered de minimis). The five road type categories in MOVES are Off-Network (not a road type, this category is for parked vehicle activity), Rural Restricted Access, Rural Unrestricted Access, Urban Restricted Access, and Urban Unrestricted Access. The rates for each of the actual four MOVES road types are indexed by the 16 MOVES speed bin average speeds: 2.5, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, and 75 mph.

3.3 MOVES County Input Databases

The locality-specific input data for the county scale runs were entered through the CDB.

MOVES CDBs were created for each county in the seven metropolitan areas and the 34 county group representative counties for the rest of Texas for the weekday emission rate runs. The CDBs were populated with local input data (such as local fleet age distributions, fuel formulations, and meteorological conditions) as well as MOVES defaults.

TTI developed procedures to build and check CDBs for each emissions scenario. The basic procedure was to write a MySQL script to produce one CDB and convert it to a template from which all of the CDB scripts were built. The scripts were then run in batch mode to produce all CDBs for the analysis.

Data for populating the CDBs were first prepared in the form of text files and/or MySQL databases (e.g., for local fuels, and weather data), and some values were provided directly in the CDB builder MySQL script. Any default data used were selected from the MOVES default database, movesdb20240104. After running the scripts to produce the CDBs, the CDBs were checked to verify that all CDB tables were built and populated as intended.

Table 24 provides an outline and brief description of the CDBs, followed by a discussion of the development of the local data and the defaults contained therein. Unless otherwise stated, the CDB table data applies to all counties (including the counties representing county groups) used in the analysis.

Table 24. CDB Input Tables.

Table	Data Source	Notes
auditlog	An empty table was used (Flag if no IM coverage)	Table for MOVES to determine if the imcoverage table is required
avft	Local /defaults	Set for Texas modeling assumptions, i.e., gasoline and diesel only, but also including default flex fuel vehicle fractions which were set to 100% gasoline use via the fuelusagefraction table
avgspeeddistribution	MOVES default	Driving time fractions by speed bin for each source type, road type, day type, hour
County	local	Identifies the county, barometric pressure (TxDOT district level for county group CDBs), high or low altitude, and whether the county is an MSA or non-MSA county
dayvmtfraction	MOVES default	Weekend and weekday period VMT fractions by month for each source type and road type
fuelformulation	Local /defaults	Gasoline and diesel formulations by fuel region based on Texas regional survey data and defaults as needed, with MOVES default CNG, E85, and electricity as required to run MOVES4.
fuelsupply	Local /defaults	Market shares of fuel formulations are set to reflect Texas modeling assumptions of gasoline, diesel, and electricity only, although all MOVES default fuels are included as required to run MOVES (i.e., CNG and E85 are included but are not used as specified in the AVFT and fuel usage configurations)
fuelusagefraction	MOVES default (except usage for fueltype 5 = 0)	Flex-fuel vehicle fuel type usage, set for Texas modeling assumptions, i.e., flex-fuel vehicles operate totally on gasoline.
hotellingactivitydistribution	MOVES default	Allocation of hotelling to four operating modes by zone (e.g., county) and model year group

Table	Data Source	Notes
hourvmtfraction	MOVES default	Hourly VMT fractions for each source type, road type, day type
hpmsvtypeyear	MOVES default	National, annual VMT by HPMS vehicle type
imcoverage	local	Empty for non-I/M counties, or includes I/M program modeling parameters characterizing the local program applicable to the county, to include updated compliance factors based on TCEQ area-specific I/M program statistics
monthvmtfraction	MOVES default (3-month average)	Month VMT fractions by source type
roadtypedistribution	MOVES default	Source type VMT fractions by MOVES road type
sourcetypeagedistribution	local/default (actual analysis year default)	Distribution by 31 age categories for each source type, based on the latest available county vehicle registrations, and MOVES defaults where needed (i.e., for buses, refuse trucks, motor homes)
sourcetypeyear	MOVES default	National source type populations
startsageadjustment	MOVES default	Starts by vehicle age within each source type, relative to the number of starts at age 0 (lower frequency of starts with age)
startshourfraction	MOVES default	Average hourly allocation of starts by source type and day type
startsmonthadjust	MOVES default (3-month average)	Average monthly multiplicative adjustment to startspervehicleperday
startsopmodedistribution	MOVES default	Distribution of engine start soak times by source type, age, day type, hour
startsperdaypervehicle	MOVES default	Average starts per day by source type and day type
state	MOVES default	Identifies the state and idle region
totalidlefraction	MOVES default (3-month average)	The ratio of total source hours idling (SHEI) and total source hours operating (SHO) for each source type by month, day type, idle region, county type (Metropolitan Statistical Area [MSA] or non-MSA)
year	MOVES default	Designates analysis year as the base year (i.e., activity inputs supplied, not forecast by MOVES)
zone	MOVES default (set alloc factors = 1)	SHO geographic allocation factors, set to 1.0 for county scale runs
zonemonthhour	local	Provides zone hourly temperatures and relative humidity by month using month ID 7 (July) to represent the summer season (populated with local June through August averages)
zoneroadtype	MOVES default (set alloc factors = 1)	National road type VMT allocation factors to county road type VMT set to 1.0 for county scale runs

[1] These 13 empty tables not shown were also included: hotellingagefraction, hotellinghourfraction, hotellinghoursperday, hotellingmonthadjust, hpmsvtypeday, idledayadjust, idlemodelyeargrouping, idlemonthadjust, onroadretrofit, sourcetypedayvmt, sourcetypeyearvmt, starts, and startsperday.

3.3.1 Year, State, and County Inputs

The year, state, and county tables were populated with data defining the analysis year, state, and county of the run.

The yearID field of the "year" table was populated with the analysis year value, and the year was set as a base year (to specify that certain user-input fleet and activity data were to be used, rather than forecast by MOVES during the model runs). As part of designating the appropriate fuel supply for the modeling run, the fuelyearID in the year table was also set to the analysis year.

StateID "48" (Texas) and idleregionID "102" (southern region which includes Texas) were included in the state table. In addition to identifying the county of analysis and other county information, the county table contains barometric pressure (discussed further with other meteorological inputs) and altitude information.

3.3.2 Activity and Vehicle Population Inputs

The following activity and vehicle population input parameters under the methodology mostly use the MOVES defaults. The data tables are: hourvmtfraction, dayvmtfraction, monthvmtfraction, hpmsvtypeyear, roadtypedistribution, avgspeeddistribution, sourcetypeyear, startsperdaypervehicle, startshourfraction, startsmonthadjust, startsageadjustment, startssopmodedistribution, totalidelfraction, and hotellingactivitydistribution. Data for all these tables were selected and inserted from the MOVES default database. In the case of the startsmonthadjust and totalidlefraction, which vary by month, the MOVES default data were averaged for each three-month seasonal period (same for MOVES default monthvmtfraction, for consistency).

The zone and zoneroadtype tables contain zonal sub-allocation activity factors. For county scale analyses, the county is equal to the zone; therefore these allocation factors were set to 1.0. The MOVES default value was used for the fuelusagefraction except that the usage for fueltype 5 was set to zero.

3.3.3 Age Distributions and Fuel Engine Fractions Inputs

The locality-specific vehicle age and fuel type fractions by model year inputs to MOVES under the SIP regional-level inventory procedures consist of county-level age distributions and statewide gasoline, diesel, and electricity fractions (termed fuel engine fractions in MOVES). The age distributions and fuel engine fractions inputs were calculated and written to text files in preparation for loading the data into the appropriate CDB input tables: the sourcetypeagedistribution table for age distributions, and the avft table for fuel engine fractions. TTI's process utility was used to produce local sourcetypeagedistribution and avft inputs to MOVES in the required formats, and MySQL scripts were used to populate the CDB input tables.

The age distributions and fuel engine fractions were based on TxDMV 2021 year-end county registration data and MOVES model defaults, where needed. The fuel engine fractions were developed consistent with the local VMT mix estimate (i.e., the local fuel engine fractions estimates reflect no CNG vehicles, E-85 fuel type is counted as gasoline, and no gasoline transit buses, consistent with the VMT mix). For light-duty electricity fuel vehicles, the MOVES default values were adjusted by the Texas local district-level EV fractions based on the MOVES default. Locality-specific SUT age distributions were produced based on the TxDMV county vehicle registration category aggregations, consistent with the vehicle registration category aggregations of the VMT mix. Appendix F includes the age distributions and fuel engine fractions summaries.

Table 25 summarizes the data sources and aggregation levels used to estimate the local sourcetypeagedistribution and AVFT inputs to MOVES (summarized in Appendix I).

Table 25. Sources and Aggregations for Age Distributions and Fuel Fractions.

SUT Name	SUT ID	TxDMV Category[1] Aggregations for Age Distributions and Fuel/Engine Fractions	Geographic Aggregation for Age Distributions[2]	Geographic Aggregation for Fuel/Engine Fractions[3]
Motorcycle	11	Motorcycles	County or TxDOT district	NA – 100% gasoline, no Fuel/Engine Fractions
Passenger Car	21	Passenger Cars	County or TxDOT district	MOVES default[2] with district-level local EV adjustment[5]
Passenger Truck	31	Total Trucks<=8500	County or TxDOT district	MOVES default[2] with district-level local EV adjustment[5]
Light Commercial Truck	32	Total Trucks<=8500	County or TxDOT district	MOVES default[2] with district-level local EV adjustment[5]
Single-Unit Short-Haul Truck	52	>8500+ >10000+ >14000+>16000	Region or TxDOT district	Texas Statewide
Single-Unit Long-Haul Truck	53	>8500+ >10000+ >14000+>16000	Texas Statewide	Texas Statewide
Refuse Truck	51	MOVES default[4]	MOVES default[4]	MOVES default[4]
Motor Home	54	MOVES default[4]	MOVES default[4]	MOVES default[4]
Other Buses	41	MOVES default[4]	MOVES default[4]	MOVES default[4]
Transit Bus[2]	42	MOVES default[4]	MOVES default[4]	MOVES default[4]
School Bus	43	MOVES default[4]	MOVES default[4]	MOVES default[4]
Combination Short-Haul Truck	61	>19500+ >26000+ >33000+ >60000	Region or TxDOT district	Texas Statewide

SUT Name	SUT ID	TxDMV Category[1] Aggregations for Age Distributions and Fuel/Engine Fractions	Geographic Aggregation for Age Distributions[2]	Geographic Aggregation for Fuel/Engine Fractions[3]
Combination Long-Haul Truck	62	>19500+ >26000+ >33000+ >60000	Texas Statewide	MOVES default[4] without CNG

[1] TxDMV year-end 2018 (latest available, used for all years) county vehicle registration data were used for developing local inputs (weights are gross vehicle weight ratings in units of pounds). The MOVES model default age distributions were from the movesdb20240104 database.

[2] County and region aggregations were used for individual counties in the metropolitan regions. TxDOT district aggregations were used for the county group modeling.

[3] MOVES fuel engine fraction defaults (for gasoline, diesel, E85 capability) were used for light-duty SUTs (with E85 use set to zero in the fuelusagefraction table). MOVES default fuel engine fractions were taken from the movesdb20240104 sample vehicle population table.

[4] MOVES default values consistent with the analysis year.

[5] The local district-level EV adjustment is only done on the 2018 registration-based AVFT table.

3.3.4 Meteorological Inputs

Unlike in the previous AERR efforts, meteorological inputs were not provided by the TCEQ; instead, they were prepared by the TTI study team. These meteorological inputs for 2023 are included in MOVES zonemonthhour (hourly temperature and relative humidity) and county (barometric pressure) database table formats in databases used in building MOVES CDBs. In the zonemonthhour table, the zone is equal to the county.

The two primary data sources utilized were the National Oceanic and Atmospheric Administration's (NOAA's) annual meteorological data (available at https://www.ncei.noaa.gov/data/global-hourly/) as well as the TCEQ's Texas Air Monitoring Information System (TAMIS) annual meteorological data (available at: https://www17.tceq.texas.gov/tamis/index.cfm?fuseaction=home.welcome). The former contained 217 monitoring stations throughout Texas and the Gulf of Mexico, most of which are located at airports, while the latter contained ambient data collected from 174 air quality monitoring stations in Texas, most of which are located in metropolitan areas.

Most of the TAMIS stations measure temperature, with only a few also measuring relative humidity and/or barometric pressure, whereas most of the NOAA stations measure ambient temperature, dew point temperature, and barometric pressure. The TTI study team calculated hourly relative humidity values from the NOAA data using both ambient temperature and dew point temperature. Then, the hourly data of individual stations in the database was aggregated into the required temporal (monthly or seasonally) and regional (county, district, nonattainment region, etc.) resolution by taking the averages of the data. For districts with missing or incomplete data, their data was replaced entirely by the average of corresponding data from adjacent districts, whereas for counties with missing or incomplete data, their data was replaced entirely by the corresponding data of the districts they are located in.[14]

The prepared seasonal meteorological or MET data in MOVES input table formats for the 2023 AERR are stored in two databases: "*_mvs4_2023met_seasonal_254counties_tceq*" and "*_mvs4_2023met_seasonal_26district_254counties_tceq*" with the former used for the TDM counties and latter used for the county groups (25 TxDOT districts with El Paso district being split into two time zones). For the seasonal average temperature and relative humidity values in the zonemonthhour table, the seasons are winter (months 12, 1, and 2), spring (months 3, 4, and 5), summer (months 6, 7, and 8), fall (months 9, 10, and 11), represented by monthids 1, 4, 7, and 10, respectively. Information on barometric pressure is available in averages by season (county_winter, county_spring, county_summer, and county_fall tables) as well as annual averages (county_ann table).

See Appendix J for temperatures, relative humidity, and barometric pressure input value summaries.

3.3.5 Fuels Inputs

This section provides details on the development of the fuel formulation and fuel supply inputs (of the MOVES fuelformulation and fuelsupply database tables) used for the seasonal weekday emission rate analyses. Details are also provided on the additional fuel formulation inputs needed for the annual EI mode CDBs used in the annual emissions analysis detailed in a later section.

Overview and Assumptions

TTI used various data sources to produce the best available Texas summer and winter fuel formulation inputs to MOVES. Four MOVES fuels input tables must be consistent between the fuel types in the scope of the inventory analysis. These are:

- AVFT (source type population fuel type distributions by model year).
- fuelformulation (fuel properties for each fuel subtype supplied in the study area).
- fuelsupply (market shares of each fuel sub-type formulation).
- fuelusagefraction (flex fuel vehicle fuel type usage).

[14] The methodology utilized by the TTI study team to fill in the missing or incomplete data at the county of district level is consistent with TCEQ's methodology.

The fuel types in the scope of the inventory analysis were gasoline, diesel, and electricity, with alternative fuels assumed to have an insignificant impact. Thus the AVFT model year fuel fractions were normalized for only gasoline, diesel, and flex-fuel vehicles (i.e., vehicles with the capability to be powered by gasoline or E85 [a blend of 85 percent ethanol and 15 percent gasoline, by volume]). Since the analysis scope was gasoline and diesel, flex-fuel vehicle fuel usage was set to 100 percent gasoline (via the fuelusagefraction table). With gasoline, diesel, and electricity set by the AVFT and fuelusagefraction tables, the fuelformulation and fuelsupply table's gasoline and diesel fuel properties and market shares were then specified.

Texas Fuel Type Details

The Texas MOVES4 fuels inputs consist of:

- gasohol (gasoline blended with roughly 10 percent ethanol - for conventional gasoline [CG] and reformulated gasoline [RFG] - fuelsubtypeID 12) and
- biodiesel (BD) (ultra-low sulfur diesel [ULSD] - in Texas blended with roughly 5 percent BD - fuelsubtypeid 21).
- The alternative fuels available in MOVES4 were treated as negligible and excluded from the analysis (via the use of the MOVES AVFT, fuelusagefraction tables, and fuelfraction inputs). Since MOVES4 requires all (5) available fuel types in the model to be included in the fuelformulation and fuelsupply inputs, the MOVES4 default fuelformulations for the following—each with 1.0 market shares in the fuel supply—were included in the CDBs.[15]
- CNG (fuelsubtypeid 30),
- E85 (ethanol - blended with roughly 15 percent gasoline - fuelsubtypeid 51), and
- electricity (fuelsubtypeid 90).

Data Sources

The local data include historical and current, latest available retail outlet seasonal fuel surveys of gasoline and diesel fuel, and annual, estimated state-level fuels sales statistics including summaries from which to estimate BD volumes relative to petroleum diesel sales volumes and gasoline sales estimates by the three grades (regular, mid-grade,

[15] TTI inserted these alternative fuel formulations and supplies, and the updated AVFT fuel fractions [i.e., gasoline, diesel, and flex fuel types only], and set flex fuel vehicles to 100 percent gasoline use in the fuelusagefraction table, via CDB builder scripts.

premium). Survey data consists of TCEQ statewide summer gasoline and diesel retail outlet sampling surveys. The TCEQ survey data applicable to FY2024 TCEQ inventories includes the 2017, 2020, and 2023 summer season statewide surveys. TTI uses the TCEQ E10 conventional gasoline data processed by MOVES fuel regions for non-RFG regions and produces statewide diesel sample averages (sulfur content) assumed for all counties, supplemented with BD volume content estimates based on the Energy Information Administration's (EIA's) the then-latest available 2021 State Energy Data System (SEDS) fuel consumption data for Texas. For RFG regions, the latest available 2020 EPA estimated fuel characteristics were applied.

General Procedure

The fuel formulation development procedures were performed by six MOVES fuel regions for Texas. In general, the sample data were aggregated and averaged by fuel grade within each MOVES fuel region (e.g., consistent with Texas fuel regulation jurisdictions and distribution networks), then weighted into gasoline composite averages using relative sales volumes by grade (results of this procedure were available directly from the TCEQ 2023 survey summary for the summer season). For the MOVES RFG region, TTI developed separate RFG formulation estimates for the DFW and HGB RFG counties for the summer seasons. For the seasonal weekday analyses, the winter season was only required for El Paso (fuelRegionID = 370010000).

The application of summer and winter fuel formulations in the seasonal weekday emission rates was via month ID where MOVES month IDs 1 and 7 (January and July) were used to represent winter and summer seasons. For the annual emissions analysis the fuel formulations were input by month (or month ID, where 1, 2, 3… is January, February, March…) as follows:

- Summer fuel formulations: month IDs 5, 6, 7, 8, and 9;
- Winter fuel formulations: month IDs 1, 2, 3, 11, and 12;
- Shoulder fuel formulations: month IDs 4, 10[16]

The fuel inputs to MOVES were supplied in the CDB fuelsupply and fuelformulation tables. The local fuel supply for each county, year, and month (or season) consisted of one gasoline and one diesel formulation (with the exception of the other MOVES default alternative fuels required to run MOVES). Each gasoline and diesel formulation market share in the fuel supply was therefore 1.0.

[16] MOVES defaults were applied for shoulder months.

Fuel Formulations

Table 26 and Table 27 provide the gasoline fuel formulations for the summer and winter months, used for the 2023 analysis year.

Table 26. Summer 2023 Gasoline Fuel Formulation Input Estimates by Region.

MOVES Fuel Formulation Field[1, 2]	Units	R1	R2	R3	R4	R4	R5	R6
fuelFormulationID	-	2371	2372	2373	2378	2379	2375	2376
fuelSubtypeID[2]	-	12	12	12	12	12	12	12
RVP	psi	9.17	7.62	7.11	7.09	7.15	7.61	8.71
sulfurLevel	ppm	11.62	14.08	9.39	9.58	9.98	15.87	21.08
ETOHVolume	vol.%	9.88	9.70	9.89	9.56	9.56	9.78	9.77
MTBEVolume	vol.%	0	0	0	0	0	0	0
ETBEVolume	vol.%	0	0	0	0	0	0	0
TAMEVolume	vol.%	0	0	0	0	0	0	0
aromaticContent	vol.%	25.54	28.39	27.10	16.98	16.92	30.45	22.52
olefinContent	vol.%	10.27	9.35	5.62	10.08	10.24	5.18	17.14
benzeneContent	vol.%	0.69	0.59	1.07	0.37	0.41	0.79	0.43
e200	vap.%	60.21	50.25	45.96	46.96	48.20	54.45	58.73
e300	vap.%	85.76	84.40	85.80	85.00	84.92	84.75	89.32
volToWtPercentOxy	vol.%	0.3653	0.3653	0.3653	0.3653	0.3653	0.3653	0.3653
BioDieselEsterVolume		\N	\N	\N	\N	\N	\N	\N
CetaneIndex		\N	\N	\N	\N	\N	\N	\N
PAHContent		\N	\N	\N	\N	\N	\N	\N
T50	deg. F	178.68	199.01	207.76	210.48	206.36	190.43	181.69
T90	deg. F	316.15	322.32	315.98	325.10	326.70	320.73	299.95

[1] The fuel region labels and associated MOVES fuel region IDs are defined as:

Label	fuelregionid	Counties	Description
R1	300000000	132	Federal 9.0 RVP limit (RVP waiver available for E10)
R2	178010000	95	State 7.8 RVP limit (no available RVP waiver)
R3	370010000	1	El Paso 7.0 RVP (no RVP waiver)
R4	1370011000	12	RFG (ID 2378 is DFW; ID 2379 is HGB)
R5	178000000	3	Federal 7.8 RVP limit (RVP waiver available for E10)
R6	100000000	11	Same as R1, except a different distribution network (per EPA Office of Transportation and Air Quality [OTAQ]).

[2] Fuel subtype ID 12 is E10 gasoline (either CG or RFG with a nominal 10 percent by volume ethanol content).

Table 27. Winter 2023 Gasoline Fuel Formulation Input Estimates by Region.

MOVES Fuel Formulation Field[1, 2]	Units	R1	R2	R3	R4	R4	R5	R6
fuelFormulationID	-	2311	2312	2311	2318	2319	2312	2312
fuelSubtypeID	-	12	12	12	12	12	12	12
RVP	psi	11.50	12.50	11.50	12.30	12.30	12.50	12.50
sulfurLevel	ppm	8.12	8.12	8.12	10.85	8.24	8.12	8.12
ETOHVolume	vol.%	10.00	10.00	10.00	10.00	10.00	10.00	10.00
MTBEVolume	vol.%	0	0	0	0	0	0	0
ETBEVolume	vol.%	0	0	0	0	0	0	0
TAMEVolume	vol.%	0	0	0	0	0	0	0
aromaticContent	vol.%	20.63	18.27	20.63	16.43	14.08	18.27	18.27
olefinContent	vol.%	9.39	7.93	9.39	9.16	8.40	7.93	7.93
benzeneContent	vol.%	0.62	0.86	0.62	0.47	0.43	0.86	0.86
e200	vap.%	50.01	52.97	50.01	59.80	59.87	52.97	52.97
e300	vap.%	85.73	86.20	85.73	86.60	87.94	86.20	86.20
volToWtPercentOxy	vol.%	0.3653	0.3653	0.3653	0.3653	0.3653	0.3653	0.3653
BioDieselEsterVolume		\N	\N	\N	\N	\N	\N	\N
CetaneIndex		\N	\N	\N	\N	\N	\N	\N
PAHContent		\N	\N	\N	\N	\N	\N	\N
T50	deg. F	198.83	182.05	198.83	155.38	153.99	182.05	182.05
T90	deg. F	318.17	316.20	318.17	317.91	312.04	316.20	316.20

[1] The fuel region labels and associated MOVES fuel region IDs are defined as:

Label	fuelregionid	Counties	Description
R1	300000000	132	Federal 9.0 RVP limit (RVP waiver available for E10)
R2	178010000	95	State 7.8 RVP limit (no available RVP waiver)
R3	370010000	1	El Paso 7.0 RVP (no RVP waiver)
R4	1370011000	12	RFG (ID 2318 is DFW; ID 2319 is HGB)
R5	178000000	3	Federal 7.8 RVP limit (RVP waiver available for E10)
R6	100000000	11	Same as R1, except a different distribution network (per OTAQ).

[2] Fuel subtype ID 12 is E10 gasoline (either CG or RFG with a nominal 10 percent by volume ethanol content).

Table 28 provides the diesel formulations used. Although Cetane Index and PAHContent are also diesel property fields of the fuelformulation table, they are not currently enabled for use in MOVES.

Table 28. 2023 Statewide Diesel Fuel Formulation Input Estimates.

MOVES Fuel Formulation Field	Units	2023
fuelFormulationID	-	30236
fuelSubtypeID	-	21
RVP	psi	0
sulfurLevel	ppm	5.91
ETOHVolume	vol.%	0
MTBEVolume	vol.%	0
ETBEVolume	vol.%	0
TAMEVolume	vol.%	0
aromaticContent	vol.%	0
olefinContent	vol.%	0
benzeneContent	vol.%	0
e200	vap.%	0
e300	vap.%	0
volToWtPercentOxy	vol.%	0
BioDieselEsterVolume		2.82
CetaneIndex		\N
PAHContent		\N
T50	deg. F	0
T90	deg. F	0

The MOVES fuelsupply table fields include:

- fuelRegionID (MOVES fuel region ID).
- fuelYearID (the year in which the fuel supply occurs – same as the analysis year).
- monthGroupID (1 [January] through 12 [December] – for this analysis summer and winter seasons are respectively represented by IDs 7 and 1).
- fuelFormulationID (ID of the fuelformulation for the specified fuelRegionID, fuelYearID, and monthGroupID).
- marketShare (a market share value from 0 to 1.0 for the specified fuelformulationID that must sum to 1.0 for each fuel type).

The fuelsupply table marketshare field values for each fuelformulationID is 1.0 since there is only one fuel subtype in the supply for each fuel type.

3.3.6 I/M Inputs

To model a local I/M program design, it must be defined by source type using MOVES I/M coverage parameters, entered in the MOVES imcoverage table. The appropriate internal MOVES I/M factors for modeling a local I/M program are designated in a model run by the local program input data in the imcoverage table.[17]

MOVES adjusts emissions (Hydrocarbons [HC], CO, and NO_X) at the source-type level to incorporate the benefits of the local I/M program design defined using the MOVES imcoverage table parameters. TTI previously produced a comprehensive set of MOVES imcoverage records for Texas I/M counties to use in place of MOVES defaults. An I/M program is required in 17 Texas counties of the Austin, DFW, El Paso, and Houston areas (see Table 29 notes for a list of the counties).

TTI produced the local I/M coverage input parameters to represent Texas I/M program designs as specified in the Texas I/M SIP and Texas rules. The I/M program requires annual emissions testing of gasoline vehicles within a 2-through-24-year vehicle age coverage window (excluding motorcycles, military tactical vehicles, diesel-powered vehicles, and antique vehicles). The vehicle model years input to MOVES corresponding to this age coverage window were calculated by subtracting “2” and “24” from the analysis year (2023), resulting in 1999 through 2021 model years subject to testing. The PC, PT, and LCT SUTs were modeled for exhaust and evaporative I/M tests including a gas cap integrity test and On-Board Diagnostics (OBD) exhaust and evaporative tests. The updated latest available 2022 I/M program data coverage compliance factors were provided by TCEQ on May 10, 2024.

Table 29 and associated notes describe MOVES imcoverage records developed by TTI in consultation with TCEQ for all 17 Texas I/M counties, for the 2023 analysis year. For additional I/M program details, see the current I/M SIP and/or pertinent Texas Administrative Code.[18]

[17] In general, MOVES produces a local I/M program effect as an adjustment to the model’s internal reference I/M program effect (i.e., represented as the “standard I/M difference” in the pair of MOVES emission rates [I/M – No I/M], which are specific to vehicle regulatory class categories of which the source types are composed). MOVES contains a large set of “I/M factors” by source type (in the imfactor table) computed specifically for adjusting the MOVES standard I/M difference to reflect the effects of various local I/M program design alternatives.

[18] Revision to the State Implementation Plan Mobile Source Strategies, Inspection and Maintenance State Implementation Plan Revision, TCEQ, adopted February 12, 2014.

Table 29. MOVES I/M Coverage Inputs for Annual Inspections of Gasoline Vehicles, 2023 Analysis Year, All 17 Texas I/M Counties.

yearID	begModelYearID	endModelYearID	testStandardsID[1]	Sourcetypeid[2]
2023	1999	2021	51 (Exh OBD)	21 (PC), 31 (PT), and 32 (LCT)
2023	1999	2021	45 (Evp Cap, OBD)	21 (PC), 31 (PT), and 32 (LCT)

[1] The model processes/pollutants affected are starts and running exhaust HC, CO, NO_X, and tank vapor venting HC.

[2] Source type compliance factor field input values were updated and provided by TCEQ for this analysis (May 10, 2024). The I/M county MOVES compliance factors by I/M area for 2022 and later, in percent, are:

DFW: PC – 94.00; PT – 91.39; LCT – 72.35.
HGB: PC – 94.00; PT – 91.39; LCT – 72.35.
Austin: PC – 94.00; PT – 91.39; LCT – 72.35.
El Paso: PC – 94.00; PT – 91.39; LCT – 72.35.

Note: I/M counties by area are Austin: Travis and Williamson; DFW: Dallas, Tarrant, Collin, Denton, Ellis, Johnson, Kaufman, Parker, and Rockwall; El Paso: El Paso; HGB: Harris, Brazoria, Fort Bend, Galveston, and Montgomery.

3.3.7 Control Programs Modeling

Table 30 shows the modeling approaches used for the emissions control strategies.

Table 30. Emissions Control Strategies and Modeling Approaches.

Control Strategy	Approach
Federal Motor Vehicle Control Program Standards	**MOVES defaults**.
Federal Heavy-Duty Diesel Engines Rebuild and 2004 Pull-Ahead Programs (to Mitigate NO_X Off-Cycle Effects)	**MOVES defaults**.
CG Properties	**Local input to MOVES consistent with regulatory standards** – summer based on TCEQ's 2023 survey data; for winter, MOVES defaults in the absence of local data.
RFG Properties	**Local input to MOVES consistent with regulatory standards** – based on EPA summer and winter 2020 RFG compliance survey data for Dallas and Houston areas; and MOVES default winter RVP.
Diesel Sulfur	**Local input to MOVES** – statewide average based on TCEQ's 2023 diesel fuel survey (summer 2023).
I/M Program	**Local input to MOVES** – For I/M counties, available MOVES I/M coverage parameters for I/M vehicles, consistent with current program descriptions and latest I/M modeling protocols, to include latest I/M area-specific MOVES compliance factor inputs provided by TCEQ based on the latest (2022) I/M program statistics.
Federal On-board Refueling Vapor Recovery Program	**MOVES defaults**.
Federal Stage II Gasoline Vapor Recovery Program	**Not applicable** – refueling emissions not modeled.

3.4 Checks and Runs

After completing the input data preparation, the CDBs were checked to verify that all tables were in the appropriate CDBs and that the tables were populated with data as intended. The MOVES RunSpecs were executed in batches using the MOVES commandline tool. After completion, TTI verified that the MOVES runs were error-free (i.e., checked all run log text files for errors and warnings and compared record counts in each rate table between output databases).

3.5 Post-Processing

Each MOVES output database was post-processed for on-road mobile emission rates to produce the on-road rate tables input to the inventory calculations. The following post-processing procedures were performed on the MOVES output database.

On-Road Mobile Emission Rates

This Rates Calc utility module calculated the mass/SHP off-network evaporative process rates using data from the CDB, the MOVES default database, and the MOVES rateperprofile and ratepervehicle emission rate output. The utility also copied the mass/mile, mass/start, and mass/hour rates along with the units into emission rate tables. The utility created the look-up tables ttirateperdistance (which also includes the rateperhour rates for off-network idling), ttirateperstart, ttirateperhour (for SHEI and APU hours), and ttiratepershp.

See Appendix A for more information on the TTI MOVES on-road emission rate calculation and adjustment utilities.

The resulting hourly on-road emission rates were input to emissions utilities to calculate and summarize the separate on-road mobile source seasonal weekday inventories for each county.

4 DEVELOPING EMISSIONS INVENTORIES

This section describes the methods used to calculate the seasonal weekday link-based EIs using the TTI EI utilities (with MOVES emission rates) and the annual EIs using MOVES in inventory mode. The methods for developing the annual CDBs for the EPA's NEI application are discussed in this section as well.

4.1 Seasonal Weekday Emissions Inventories

TTI calculated the hourly, seasonal weekday, and on-road mobile EIs by county (TDM link-based and HPMS virtual link-based) using the TTI EI utilities.

The VMT-based emissions calculations used link-based VMT and congested speeds to estimate link-level emissions. The off-network emissions calculations used county-based off-network activity (ONI hours, SHP, starts, SHEI, and APU hours) to estimate county-level emissions.

The hourly roadway-link-based and off-network emissions for the seasonal weekday EIs were calculated using the TTI EI utility inputs:

- County of inventory – from study area counties list, including county FIPS, link data county code, TxDOT district ID, county group FIPS, county type flag (MSA or non-MSA);
- Vehicle type VMT mix – time period TxDOT district-level VMT mix by MOVES roadway type;
- Time period designation – the time-of-day (AM peak, mid-day, PM peak, overnight) VMT mix to hour-of-day associations;
- HPMS (virtual-link) roadway-based activity – link-specific, hourly, directional, operational VMT and speed estimates as developed by the TTI EI utility to include: HPMS area-type code, HPMS functional class code, county number, HPMS area-type and functional-class combination code, HPMS centerline miles, congested speed, and VMT;
- TDM roadway-based activity – link (and intrazonal link)-specific, hourly, directional, operational VMT and speed estimates as developed by the EI utility to include A node, B node, county number, TDM road type (functional class) code, link length, congested (operational) speed, VMT, and TDM area type code;

- HPMS road type designations – HPMS road type and area type codes to MOVES road type codes (and to VMT mix road type, and rates road type codes);
- TDM road type designations – TDM road type and area type codes to MOVES road type codes (and to VMT mix road type, and rates road type codes);
- Off-network activity – county ONI hours, SHP, starts, SHEI, and APU hours by vehicle type and hour;
- Pollutant/process/units list for emissions;
- Roadway-based emission factors – MOVES-based, county-level by pollutant, process, hour, average speed, MOVES road type, SUT, and fuel type; and
- Off-network (parked vehicle) emission factors – MOVES-based, county-level by pollutant, process, hour, SUT, and fuel type.
- The TTI EI utilities produced emissions outputs aggregated by county, hour, road functional class, road area type, vehicle type, pollutant, pollutant process, and link for on-network emissions; and county, hour, road functional class, vehicle type, pollutant, and pollutant process for off-network emissions. These outputs were then post-processed to produce electronic files in the specified formats for submission to the TCEQ sponsor.

A summary of EIs for the seasonal weekday CAPs and CAP precursors by metropolitan area and county is provided in Appendix K.

4.1.1 Roadway-based Emissions Calculations

County information was identified (e.g., county group ID, county ID, TxDOT district) and inputs were selected for the inventory calculations based on these IDs.

The VMT-based emissions were calculated for each hour using the time-period, TxDOT district-level vehicle type VMT mix, the link VMT and speeds estimates, the MOVES-based on-network emission factors, and the link road type/area type-to-MOVES road type designations. For each link, the link was assigned a MOVES road type based on the link's road type and area type. The link VMT was distributed to each vehicle type using the VMT mix from the appropriate time period based on the link's designated MOVES road type. The AM peak, mid-day, PM peak, and overnight VMT mixes were applied by hour according to the local area time periods designation file which assigns each hour of the day to one of the four periods.

The emission factors by the hour for each vehicle type were selected based on the designated hour of the link file, the link's designated MOVES road type, and the link speed. For link speeds falling between MOVES speed bin average speeds, emission factors were interpolated from the bounding speeds. For link speeds falling outside of the MOVES speed range (less than 2.5 mph and greater than 75 mph), the emission factors for the associated bounding speeds were used. The mass per mile rates were multiplied by the link vehicle type VMT producing the link-level emissions estimates. This was performed for each hour of the day.

4.1.2 Off-Network Emissions Calculations

The hourly off-network emissions were calculated at the county level by multiplying the hourly MOVES-based vehicle type off-network emission factors by the appropriate county-level hourly vehicle type off-network activity, which was determined by the pollutant process and associated emission rate table. For selecting the ONI emission rate from the rate per distance table, the road type column was used (i.e., to look up rates with road-type ID "1" for off-network). The off-network emissions calculations used off-network activity (ONI hours, SHP, starts, SHEI, and APU hours) to estimate hourly county-level emissions.

4.1.3 Output

The following output files were formatted from the raw EI output data tables.

- A tab-delimited MOVES SUT-based summary output file consisting of one header section followed by hourly and 24-hour totals data blocks of on-road activity and emissions (in units of pounds). Hourly and 24-hour total summaries are by road type and vehicle type of VMT, VHT, speed (VMT/VHT), pollutant totals, and pollutant process totals (with the "off-network" category listed as the last road type preceding the TOTALS row in each data block), and with starts, ONI hours, SHP, SHEI, and APU activity rows last in the activity data block for each time period; and

- A tab-delimited SCC-based summary output file that contains the 24-hour totals of VMT and emissions (in units of pounds) using inventory data aggregations, SCCs, and pollutant codes consistent with the EPA's 2020 NEI.

The seasonal weekday SUT-based EIs consisted of the standard MOVES CAPs and CAP precursors by MOVES pollutant IDs listed in Table 31 (before coding and particular MOVES pollutant aggregations needed for the NEI).

Table 31. CAPs and CAP Precursors Included in the Inventories

Pollutant ID	Pollutant Name
2	CO
3	NO_X
30	NH_3
31	SO_2
87	VOC
90	Atmospheric CO_2
100	Primary Exhaust PM_{10} – Total
106	Primary PM_{10} – Brakewear Particulate
107	Primary PM_{10} – Tirewear Particulate
110	Primary Exhaust $PM_{2.5}$ – Total
116	Primary $PM_{2.5}$ – Brakewear Particulate
117	Primary $PM_{2.5}$ – Tirewear Particulate

See Appendix A for further details on the utilities and Appendix B for descriptions of the emissions inventory electronic data files provided.

4.2 Annual Emissions Inventories

The MOVES CDBs used to produce summer weekday emission rates for the link-based inventory analyses were designed only for use in MOVES rates mode runs. For the annual emissions, the MOVES CDBs TTI developed for the EPA's 2023 NEI project were also used in MOVES runs performed in inventory mode to produce the 2023 AERR annual emissions estimates for each Texas county.

The summaries of 2023 annual CAPs, CAP precursors, and HAPs by metropolitan area and county are provided in Appendix L.

4.2.1 MOVES Inventory Mode Inputs and CDBs

The sources for the MOVES inventory mode input data sets used to produce the CDBs for each Texas county for the 2023 AERR annual EIs (and EPA's NEI) consisted of data from the link-based inventory analysis supplemented with other needed data. Data for the annual analysis were from the daily EI MOVES rates inputs, link-based activity outputs and off-network activity outputs, and particular MOVES defaults or modified MOVES defaults consistent with the local inventories, supplemented with other data as needed for the annual analysis and described in previous sections. TTI used the EI utilities to process the data into the MOVES4 inventory mode inputs for the annual runs. The utility accesses the data sources, performs the needed processing of data into MOVES input form, and organizes the resulting MOVES input files in folders by county, year, period, and day type, for populating the CDBs.

Table 32 lists the 26 input tables produced and the sources of the data. The inventory CDBs include the same 21 MOVES tables used in the HPMS virtual link-based inventory analysis rates mode CDBs, plus five additional tables (hotellinghours, sourcetypeage, starts, monthofanyyear, and dayofanyweek). The data source categories were:

- Rates CDBs (mainly local data directly from the HPMS virtual link-based inventory analysis rates CDBs).
- MOVESactivityInputBuild utility output (for activity inputs built from the pertinent HPMS virtual link-based inventory data).
- VehiclePopulationBuild utility output (for vehicle population estimates).
- Adjusted MOVES defaults (for activity allocation factors modified as needed to produce daily output from daily activity input, and for sourcetypeage table relativeMAR adjustments to produce VMT proportions between HPMS vehicle categories that more closely reflect the local VMT Mix).

Table 32. MOVES Annual Inventory Mode CDBs and Data Sources.

Table	Data Source
Avft	Rates CDB
avgspeeddistribution	MOVESactivityInputBuild utility output
county	Rates CDB
countyyear	Rates CDB
dayvmtfraction	MOVES default with dayVMTFraction = 1 (dayID = 5) and dayVMTFraction = 0 (dayID = 2)
fuelsupply	Rates CDB for summer and winter months, MOVES default for shoulder months
fuelformulation	Rates CDB
hotellingactivitydistribution	Rates CDB
hotellinghours	MOVESactivityInputBuild utility output
hourvmtfraction	MOVESactivityInputBuild utility output
hpmsvtypeyear	MOVESactivityInputBuild utility output
imcoverage	Rates CDB
monthvmtfraction	Rates CDB with monthVMTFraction = 1 (monthID = 7) and monthVMTFraction = 0 (monthID <> 7)
roadtype	MOVESactivityInputBuild utility output
roadtypedistribution	MOVESactivityInputBuild utility output

Table	Data Source
sourcetypeage	MOVESactivityInputBuild utility output - MOVES default with relativeMAR adjusted for VMT Mix (travel fractions calculated using relativeMAR adjusted to match 24-hour VMT from link-level inventory)
sourcetypeagedistribution	Rates CDB
sourcetypeyear	VehiclePopulationBuild utility output
starts	MOVESactivityInputBuild utility output
state	Rates CDB
Year	Rates CDB
zone	Rates CDB
zonemonthhour	Rates CDB
zoneroadtype	Rates CDB
monthofanyyear	MOVES default with noOfDay = 7
dayofanyweek	MOVES default with noOfRealDays = 1

Additional details on most of these MOVES input tables may be found in the MOVES4 inventory development guidance and MOVES technical information at EPA's MOVES model website. Appendix A describes the TTI EI utilities and Appendix B describes the files provided.

4.2.2 Emissions Calculations

The annual emissions were calculated using MOVES with the annual MRSs by county and the associated annual inventory mode CDBs. See Appendix B for a description of the files provided.

4.2.3 Output

Similarly to the daily EI analysis, the following output files were produced by post-processing the MOVES annual EI output.

- A tab-delimited MOVES SUT-based summary output file consisting of one header section followed by calendar year totals data blocks of on-road activity and emissions (in units of pounds). Year total summaries are by road type and vehicle type of VMT, VHT, speed (VMT/VHT), pollutant totals, and pollutant process totals (with the "off-network" category listed as the last road type preceding the TOTALS row in each data block), and with starts, ONI hours, SHP, SHEI, and APU activity rows last in the activity data block; and

- A tab-delimited SCC-based summary output file that contains the calendar year totals of VMT and emissions (in units of pounds) using inventory data aggregations, SCCs, and pollutant codes consistent with the EPA's 2023 NEI.

These files were further processed by the TTI EI utility to produce the various inventory extracts and summaries including those coded, aggregated, and formatted (i.e., in XML) for uploading to EPA's EIS and the TCEQ's TxAER.

The CAPs and CAPs precursors included in the annual EIs are listed in Table 31 and the HAPs included are listed in Table 33 (before particular MOVES pollutant aggregations and coding needed for the NEI).

Table 33. HAPs Included in Annual Inventories.

Category[1]	MOVES Pollutant ID[2]	Pollutant Name[2]	NEI Pollutant Code
Gaseous HC	20	Benzene	71432
	24	1,3-Butadiene	106990
	25	Formaldehyde	50000
	26	Acetaldehyde	75070
	27	Acrolein	107028
	40	2,2,4-Trimethylpentane	540841
	41	Ethyl Benzene	100414
	42	Hexane	110543
	43	Propionaldehyde	123386
	44	Styrene	100425
	45	Toluene	108883
	46	Xylene	1330207
Polycyclic Aromatic HC (PAH)	170 (Gas); 70 (PM)	Acenaphthene	83329
	171 (Gas); 71 (PM)	Acenaphthylene	208968
	172 (Gas); 72 (PM)	Anthracene	120127
	173 (Gas); 73 (PM)	Benz(a)anthracene	56553
	174 (Gas); 74 (PM)	Benzo(a)pyrene	50328
	175 (Gas); 75 (PM)	Benzo(b)fluoranthene	205992
	176 (Gas); 76 (PM)	Benzo(g,h,i)perylene	191242
	177 (Gas); 77 (PM)	Benzo(k)fluoranthene	207089
	178 (Gas); 78 (PM)	Chrysene	218019
	168 (Gas); 68 (PM)	Dibenzo(a,h)anthracene	53703
	169 (Gas); 69 (PM)	Fluoranthene	206440
	181 (Gas); 81 (PM)	Fluorene	86737
	182 (Gas); 82 (PM)	Indeno(1,2,3,c,d)pyrene	193395

Category[1]	MOVES Pollutant ID[2]	Pollutant Name[2]	NEI Pollutant Code
	185 (Gas); 23 (PM)	Naphthalene	91203
	183 (Gas); 83 (PM)	Phenanthrene	85018
	184 (Gas); 84 (PM)	Pyrene	129000
Metal	60	Mercury Elemental Gaseous	7439976
	61	Mercury Divalent Gaseous	7439976
	62	Mercury Particulate	7439976
	63	Arsenic Compounds	7440382
	65	Chromium 6+	7440473
	66	Manganese Compounds	7439965
	67	Nickel Compounds	7440020
Dioxin/Furan	130	1,2,3,7,8,9-Hexachlorodibenzo-p-Dioxin	19408743
	131	Octachlorodibenzo-p-dioxin	3268879
	132	1,2,3,4,6,7,8-Heptachlorodibenzo-p-Dioxin	35822469
	133	Octachlorodibenzofuran	39001020
	134	1,2,3,4,7,8-Hexachlorodibenzo-p-Dioxin	39227286
	135	1,2,3,7,8-Pentachlorodibenzo-p-Dioxin	40321764
	136	2,3,7,8-Tetrachlorodibenzofuran	51207319
	137	1,2,3,4,7,8,9-Heptachlorodibenzofuran	55673897
	138	2,3,4,7,8-Pentachlorodibenzofuran	57117314
	139	1,2,3,7,8-Pentachlorodibenzofuran	57117416
	140	1,2,3,6,7,8-Hexachlorodibenzofuran	57117449
	141	1,2,3,6,7,8-Hexachlorodibenzo-p-Dioxin	57653857
	142	2,3,7,8-Tetrachlorodibenzo-p-Dioxin	1746016
	143	2,3,4,6,7,8-Hexachlorodibenzofuran	60851345
	144	1,2,3,4,6,7,8-Heptachlorodibenzofuran	67562394
	145	1,2,3,4,7,8-Hexachlorodibenzofuran	70648269
	146	1,2,3,7,8,9-Hexachlorodibenzofuran	72918219

[1] MOVES models two groups of metal emissions, those used for air quality modeling, and metals due to their known toxicity (i.e., the seven metal species in this table) (See Section 2.3 in *Air Toxic Emissions from On-Road Vehicles in MOVES3*, EPA, November 2020). The other metals (e.g., iron, aluminum) were not estimated separately as HAPs, but were, by default, included in the aggregate exhaust $PM_{2.5}$ estimates.

See the electronic data submittal description (Appendix B) for further details on conversions, coding, and files provided for uploading to TxAER and EIS.

4.3 Reporting for TexAER and EIS

TTI converted the county-level seasonal weekday (CAPs and CAP precursors) annual emissions (CAPs, CAP precursors, and HAPs) and activity results to a format compatible with uploading to the TCEQ's TexAER and EPA's EIS based on the EPA's EIS NEI CERS XML format, which uses EPA's EIS inventory data codes. Particular MOVES pollutants required aggregation and re-coding for EIS compatibility (i.e., combining gas and particle PAHs; combining the three mercury compounds; and combining PM from exhaust, brakewear, and tirewear). The resulting XML file and output summary of SCC-labeled inventory and activity data in tab-delimited text files for each county are included in the XML file creation process. All these files were included in the electronic data submittal with additional descriptive information.

5 TEXAS ROAD DUST CALCULATOR INPUT DEVELOPMENT

Estimates of road dust PM from vehicles driving on paved and unpaved roads are relatively large compared to the direct exhaust, brakewear, and tirewear estimates from vehicles driving on these roads. The EPA has developed a paved and unpaved roads calculator tool for the NEI that uses on-road mobile VMT activity data. TTI developed the Microsoft Excel "Texas Road Dust Calculator" to produce EIs of road dust PM, using VMT activity inputs consistent with the on-road mobile source EIs. The road dust calculator estimates the road dust emissions at the county level.

TTI developed inputs for use in the TCEQ Texas Road Dust Calculator for the statewide 254 counties for the 2023 analysis year using the current TDM-link and HPMS-virtual link activity data described for the statewide, on-road mobile source direct vehicle emissions inventories. Inputs were developed as described in TTI's August 2020 *Revised Final Technical Report Area Source Texas Calculator for Paved and Unpaved Roads* prepared for the TCEQ.

5.1 Data Used to Develop Input Files

The Texas road dust calculator includes Texas-specific activity input and was designed to accommodate input parameter changes, as may be needed. The following steps were performed to produce the VMT, centerline miles, traffic volumes, and speed inputs to the calculator (referred to as HPMS and TDM Staging Inputs):

5.1.1 HPMS Staging Inputs

The 2023 analysis year HPMS total AADT VMT and unpaved AADT VMT for the 217 HPMS counties were formatted, and processed into road dust calculator input form, by the 14 FHWA roadway types, consistent with the TxDOT county HPMS Staging Inputs format.

- Paved AADT VMT and centerline miles were calculated.
- Paved and unpaved summer weekday (SWKD) VMT were calculated using the latest TxDOT district-level summer weekday factors.
- AADT and SWKD traffic volumes were calculated (for paved road emission factors).

- For roadway types with unpaved segments, 24-hour average speed estimates were added (from the HPMS-based county 2023 AERR SWKD on-road mobile source inventories activity data).

5.2 Estimating Road Dust Emissions

Once the development of the road dust inputs was complete, the data was organized into a format specified for input into the Texas road dust calculator for the road dust inventory calculations. For simplicity, TTI placed the updated input tables directly into a 2023 version of the Texas road dust inventory calculator as an electronic deliverable. Installing the updated tables directly into the calculator allowed TTI to confirm that the files worked properly.

The TCEQ road dust inventory calculator input files and the updated Texas road dust calculator were provided as electronic data in Appendix M. A summary of the Texas statewide PM_{10} and $PM_{2.5}$ emissions generated from road dust is presented in Table 34. Compared to the 2020 AERR values, paved PM_{10} and $PM_{2.5}$ emissions remained relatively constant (slight decrease of 0.4%) whereas the unpaved emissions fell by 11.8%.

Table 34. SWKD and Annual VMT and Road Dust PM Emissions from Paved and Unpaved Roads

Period	Parameter	Paved	Unpaved	Total	Units
SWKD	VMT	879,001,566	5,327,526	884,329,091	miles
	PM_{10}	240.1	1,655.6	1,895.8	Tons
	$PM_{2.5}$	60.0	164.9	224.9	Tons
Annual	VMT	299,432,657,782	1,820,814,496	301,253,472,278	miles
	PM_{10}	82,300.1	573,128.0	655,428.1	Tons
	$PM_{2.5}$	20,575.0	57,076.7	77,651.7	Tons

6 QUALITY ASSURANCE

Analyses and results were subjected to appropriate internal review and QA/QC procedures, including independent verification and reasonableness checks. All work was completed consistent with applicable elements of the American Society for Quality, American National Standard Institute (ASQ/ANSI): E4:2014: Quality Management Systems for Environmental Information and Technology Programs – Requirements with Guidance for Use, February 2014, and the TCEQ Quality Management Plan.

The Quality Assurance Project Plans (QAPP) category and project type most closely matching the intended use of this analysis are QAPP Category II (for important, highly visible Agency projects involving areas such as supporting the development of environmental regulations or standards) and Modeling for NAAQS Compliance. Internal review and quality control measures consistent with the QA category and project type-specific requirements provided in Guidance for Quality Assurance Project Plans for Modeling, EPA QA/G-5M,[19] along with appropriate audits or assessments of data and reporting of findings, were employed. These include but are not limited to the elements outlined, per EPA Requirements for Quality Assurance Project Plans (EPA QA/R-5),[20] in the following description.

6.1 PROJECT MANAGEMENT

The definition and background of the problem addressed by this project, the project/task description, and project documents and records are as described in the Purpose and Background section of the Grant Activity Description (GAD). No special training or certification was required. The TTI project manager ensured project personnel used the most current, approved version of the QAPP by approving the pre-analysis plan.

The objective was to produce emissions inventories of the quality level required for air quality modeling, according to the guidance and methods documents as referenced, and in consultation with the TCEQ project manager.

Basic criteria were used to assure the acceptable quality of the product, to include:

- The product met the purpose of the emissions analysis;
- The full extent of the modeling domain was included;

[19] PDF available at: https://www.epa.gov/sites/production/files/2015-06/documents/g5m-final.pdf.
[20] PDF available at: https://www.epa.gov/sites/production/files/2016-06/documents/r5-final_0.pdf.

- Agreed methods, models, tools, and data were used;
- The output data sets were produced in the required formats;
- Any deficiencies found (as discussed in Section 6.5) were corrected; and
- Aggregate results were comparable with available, similarly produced emissions estimates.

6.2 Measurement and Data Acquisition

Note that no sampling of data was involved in the emissions inventory development; thus, only existing data (non-direct measurements) were used for this project.

The data needed for project implementation was for the development of emission rate and emissions inventory model inputs and adjustment factors and the development of the activity inputs for both internal (relatively aggregate) and external (detailed, link-level) emissions calculations. Existing data acquired from various organizations (e.g., TxDOT, MPOs, TCEQ, EPA) was reviewed by TTI for suitability, and in most cases was previously QA'd by the providing agency. These data sets may include HPMS data (from TxDOT's RIFCREC report); regional travel demand model data; speed model data; vehicle registration data; ATR data; vehicle classification count data; meteorological data; fuels data; MOVES emissions model data; extended idling activity data; and vehicle I/M program design data.

Any significant problems found during review, verification, and/or validation (see QA criteria and methods discussed in Section 6.5) were corrected, and the QA procedure was repeated until satisfied. No significant problems were found.

6.3 Data Management

Project staff used the same electronic project folder structure on each workstation. As various scripts, inputs, and outputs were developed in the process, data were shared within the team for crosschecking. To perform the MOVES model runs, a computer cluster (multiple computers) configuration or individual workstation configuration was used. After input data were QA'd, data sets were backed up and stored in compressed files.

After the final product was completed, all the project data archives were compiled on USB 3.0-compatible external hard drive storage media and/or a shared folder using a secure file-sharing website as agreed upon by the TCEQ project manager. A complete archive of the project data is kept by TTI (including the computer models and emissions inventory development utilities used in the process). The electronic data submittal package (containing the project deliverables as listed in Appendix B) was produced along with the data description (and copied to a shared folder or external hard drive) and delivered to TCEQ.

6.4 Assessment and Oversight

The following assessments were performed.

- Verified that the overall scope was met (i.e., consistent with the intended purpose, for specified temporal resolution and geographic coverage, for specified sources, pollutants, and emissions processes).
- Checked that input data was prepared according to the plan; and
- Checked that correct output data was produced. Records were kept of the checks performed.

In the case of any inconsistency or deficiency found, the issue was directly communicated to the responsible staff for correction (or outside agency staff involved, if any). After any correction, QA checks were repeated to ensure the additional work resulted in the intended result and were noted in the QA record.

Any major problems were reported to the project manager and communicated to the project team as needed, as well as when various data elements passed QA checks and were ready for the next steps. The project manager ensured all of the QA checks performed were compiled and maintained in the project archives.

In addition, technical systems audits were performed. Audits of data quality at the requisite 25 percent level were performed for any data produced as part of this study. QA findings were reported in both the draft and the final reports.

6.5 Data Validation

Erroneous or improper inputs at any point during the emissions inventory development process may produce inaccurate emissions estimates. The TTI project team performed QA checks at each step of the analysis to ensure data quality.

The criteria for passing quality checks are summarized in the following guidelines. These QA guidelines were used to ensure the development of emissions inventories that were as accurate as possible and met the requirements of TCEQ's intended use.

As previously stated, TTI verified the overall scope of the emissions analysis to include:

- Purpose (i.e., needed for AERR reporting purposes).
- Modeling domain (e.g., analysis years, geographic coverage, seasonal periods, days, sources, pollutants).
- Methods, models, and data (e.g., default versus local input data sources).
- Procedures, tools, and required emissions output data sets.

TTI performed checks on input data, model execution, and output, as follows:

- Input data preparation:
  - Verify the basis of input data sets against the PGA and GAD: Actual historical or latest available data, validated model, expected values or regulated limits, regulatory program design, model defaults, surrogates, professional judgment; check aggregation levels;
  - Data development: Depending on the procedure and input data set, calculations may be verified (e.g., re-calculated independently and compared with originally prepared values – if spot-checking a series of results, including extremes and intermediate values);
  - Completeness: Verify that input data sets are within the required dimensions and that all required fields are populated and properly coded or labeled;
  - Format: Verify that formats are within required specifications if any (e.g., field positions, data types and formats, and file formats);
- Check for the successful completion of model executions:
  - Verify that the correct specifications are prepared for each analysis in the inputs (e.g., by year, season); and
  - Verify that each utility or model run script includes the correct modeling specifications (e.g., commands, input values, input and output file paths, and output options) for the application per the applicable guide.
- Check for the successful completion of modeling parameter generations:

  - Verify that the correct number of each type of output file was produced by the model or utility;
  - Check for any unusual output file sizes;
  - Search output for warnings and errors (e.g., model execution logs that contain error and warning records); and
  - Check the summary information provided in the output files for any unusual results.
- Perform further checks for consistency, completeness, and reasonability of data output from model or utility applications:
  - Verify that fleet mix distribution factors produced or used sum to 1.0, as appropriate (e.g., hourly travel factors within a time period, proportion of travel by vehicle categories on a given roadway category);
  - Verify that the required data fields are present, populated, and properly coded or labeled; verify that data and file formats are within specifications;
  - Verify that any activity and emissions adjustments were performed as intended (e.g., seasonal activity factor, emissions control program adjustment);
  - Verify if the hierarchy is applied appropriately (i.e., local data are preferred and used versus other data sets);
  - For datasets prepared with temporal or geographic variation (e.g., activity distributions between weekends/weekdays, vehicle mix, or average speeds between road types or time periods), compare and note whether directional differences are as expected;
  - Check for consistency between data sets (e.g., compare detailed spatially and temporally disaggregated activity estimates [e.g., link VMT] to original aggregate totals, activity total summaries between utility applications [e.g., link-VMT producer and emissions calculator], and input hourly distributions versus hourly summaries from the link activity output data);
  - Calculate county, 24-hour, aggregate emissions rates (from aggregate VMT and emissions output) and compare the rates between counties examining the results for outliers while assessing the reasonability of any relative and directional differences (e.g., qualify based on activity distributions by road type and speed, mix of vehicles by road type, meteorological variation, control

program coverage). Compare the results to results from previous emissions analyses if available; and

- Calculate county, and 24-hour aggregate rates by vehicle class and compare between vehicle classes. Examine the results for consistent patterns.

Any additional data products required for the emissions analysis were subjected to the appropriate QA checks previously listed. Any issues found needing resolution were corrected, and appropriate QA checks were performed until satisfied, ensuring the project results met the TCEQ requirements, i.e., as outlined in the GAD and QAPP.

7 REFERENCES

1. EPA. 2020. *MOVES4 Technical Guidance: Using MOVES to Prepare Emission Inventories for State Implementation Plans and Transportation Conformity,* EPA-420-B-20-052, Office of Transportation and Air Quality. November 2020.

2. TTI, 2009. *Methodologies for Conversion of Data Sets for MOVES Model Compatibility*. Texas A&M Transportation Institute, August 2009, ftp://amdaftp.tceq.texas.gov/pub/Mobile_EI/MOVES/VMT_Mix/MOVES_VMT_Mix_Methodology.pdf.

3. *2020 Summer Fuel Field Study, Final*. Eastern Research Group, September 2020, https://www.tceq.texas.gov/assets/public/implementation/air/am/contracts/reports/mob/5822011094002-20200909-erg-2020SummerFuelFieldStudy.pdf.

4. *MOVES Source Use Type and VMT Mix for Conformity Analysis* (TxDOT Air Quality/Conformity IAC-A - TTI Task 409480-0843: Maintain, Update and Enhance Traffic Activity Estimation and Forecasting Methods), Texas Department of Transportation, Austin, TX. October 2017.

5. EPA. 2015. *Motor Vehicle Emission Simulator (MOVES), User Guide for MOVES2014a*, EPA420-B-15-095, Assessment and Standards Division, Office of Transportation and Air Quality. November 2015.

6. *Revision to the State Implementation Plan Mobile Source Strategies, Inspection and Maintenance State Implementation Plan Revision*, TCEQ, adopted February 12, 2014.

7. EPA. 2002. *Guidance for Quality Assurance Project Plans (QAPP's) for Modeling*, EPA QA/G-5M, EPA/240/R-02/007, Office of Environmental Information. December 2002. Available at: https://www.epa.gov/sites/production/files/2015-06/documents/g5m-final.pdf.

8. EPA. 2001. *EPA Requirements for Quality Assurance Project Plans*, EPA QA/R-5, EPA/240/B-01/003, Office of Environmental Information. March 2001. Available at: https://www.epa.gov/sites/production/files/2016-06/documents/r5-final_0.pdf.

9. *Development of 2014 On-road Mobile Source Annual, Summer Weekday, and Winter Work Weekday Emissions Inventories for Specified Areas: El Paso Area*, TTI, August 2015.

10. *MOVES2014a Software Design Reference Manual, U.S. EPA Office of Transportation and Air Quality*, EPA-420-B-15-096, November 2015, https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100NNKC.txt.

11. *MOVES2014a User Interface Reference Manual*, U.S. EPA Office of Transportation and Air Quality, EPA-420-B-16-085, November 2016, https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100Q3C1.pdf.

12. *MOVES2014 User Interface Reference Manual Appendix: MOVES2014b*, EPA-420-B-18-038, August 2018, https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100V7ER.pdf.

13. Up*date of On-Road Inventory Development Methodologies for MOVES2014, Texas A&M Transportation Institute*, December 2014, ftp://amdaftp.tceq.texas.gov/EI/onroad/mvs14_utilities/MOVES2014_Utilities_Report_Final_December_2014.pdf.

14. *Heavy-Duty Vehicle Idle Activity Study, Final Report*. Texas A&M Transportation Institute, Environment and Air Quality Division. July 2019. https://www.tceq.texas.gov/assets/public/implementation/air/am/contracts/reports/mob/582177430806-20190722-TTI-HeavyDutyIdleActivityStudyFinal.pdf.

15. Air Emissions Reporting Requirement. 40 C.F.R. Part 51 2015.

16. EPA. 1992. Procedures for Emission Inventory Preparation, Volume IV: Mobile Sources, EPA 42o-R-92-009, Office of Air Quality Planning and Standards.

17. EPA. 2001. Memorandum: Texas Low Emission Diesel (LED) Fuel Benefits. To Karl Edlund, EPA, Region VI, from Robert Larson, EPA, Office of Transportation and Air Quality (OTAQ), National Vehicle and Fuel Emissions Laboratory at Ann Arbor, Michigan. September 27, 2001.

18. EPA. 2009. Emission Inventory System Implementation Plan, Appendix 2, CERS and Examples, available at https://www.epa.gov/air-emissions-inventories/2008-national-emissions-inventory-nei-documentation-draft.

19. EPA. 2009. Emission Inventory System Implementation Plan, Section 5, Submitting XML Data to the EIS, available at https://www.epa.gov/air-emissions-inventories/2008-national-emissions-inventory-nei-documentation-draft.

20. EPA. 2009. Emission Inventory System Implementation Plan, Appendix 6, Reporting Code Tables, available at https://www.epa.gov/air-emissions-inventories/2008-national-emissions-inventory-nei-documentation-draft.

21. EPA. 2009. Emissions Inventory System Exchange: Flow Configuration Document, Version 1.2b, available at https://www.epa.gov/sites/production/files/2014-07/documents/configuration.pdf.

22. EPA. 2015. MOVES2014 and MOVES2014a Technical Guidance: Using MOVES to Prepare Emission Inventories for State Implementation Plans and Transportation Conformity, EPA-420-B-15-093, Transportation and Regional Programs Division, Office of Transportation and Air Quality. November 2015.

23. EPA. 2017. Emissions Inventory Guidance for Implementation of Ozone and Particulate Matter National Ambient Air Quality Standards (NAAQS) and Regional Haze Regulations, EPA-454/B-17-002, Issued By: Office of Air Quality Planning and Standards, Air Quality Assessment Division, U.S. Environmental Protection Agency, Research Triangle Park, NC 27711. May 2017.

24. EPA. 2017. National Emissions Inventory (NEI) Documentation, available at https://www.epa.gov/air-emissions-inventories/2017-national-emissions-inventory-nei-documentation.

25. EPA. 2020. National Emissions Inventory (NEI) Documentation, available at https://www.epa.gov/air-emissions-inventories/2020-national-emissions-inventory-nei-documentation.

26. ERG. 2017. 2017 Summer Fuel Field Study. Final Report. Eastern Research Group, Inc. August 31, 2017, available at https://www.tceq.texas.gov/assets/public/implementation/air/am/contracts/reports/ei/582177149010-20170831-ergi-2017SummerFuelFieldStuday.pdf.

27. Texas A&M Transportation Institute. 2016. TTI Emissions Inventory Estimation Utilities Using MOVES: MOVES2014aUTL User's Guide. August 2016.

28. U.S. Environmental Protection Agency, 2020 National Emission Inventory (NEI) https://www.epa.gov/air-emissions-inventories/2020-national-emissions-inventory-nei-documentation.

29. 2020, *Area Source Texas Calculator for Paved and Unpaved Roads*, Revised Final Technical Report, August 2020.

APPENDIX A: EMISSIONS UTILITIES FOR MOVES-BASED EMISSIONS INVENTORIES (ELECTRONIC ONLY)

This appendix is available separately in an electronic format (e.g., .docx, .xlsx, .pdf, .txt, .zip, or other format.) and can be provided upon request.

APPENDIX B: ELECTRONIC DATA SUBMITTAL DESCRIPTION (ELECTRONIC ONLY)

This appendix is available separately in an electronic format (e.g., .docx, .xlsx, .pdf, .txt, .zip, or other format.) and can be provided upon request.

APPENDIX C: COUNTY VMT SEASONAL WEEKDAY ADJUSTMENT FACTORS (ELECTRONIC ONLY)

This appendix is available separately in an electronic format (e.g., .docx, .xlsx, .pdf, .txt, .zip, or other format.) and can be provided upon request.

APPENDIX D: TXDOT DISTRICT AGGREGATE WEEKDAY VMT MIX (ELECTRONIC ONLY)

This appendix is available separately in an electronic format (e.g., .docx, .xlsx, .pdf, .txt, .zip, or other format.) and can be provided upon request.

APPENDIX E: TXDOT DISTRICT HOURLY TRAVEL FACTORS (ELECTRONIC ONLY)

This appendix is available separately in an electronic format (e.g., .docx, .xlsx, .pdf, .txt, .zip, or other format.) and can be provided upon request.

APPENDIX F: HOUSTON SPEED MODEL CAPACITY FACTORS, SPEED FACTORS, AND SPEED REDUCTION FACTORS

Capacity Factors

Time of Day Assignment	Capacity Factor[1]
AM Peak	0.3333333
Mid-Day	0.1666667
PM Peak	0.2500000
Overnight	0.0909091

[1] To obtain hourly capacities, a single capacity factor for each time-of-day assignment is used for all area types and functional classes.

Free-Flow (V/C=0) Speed Factors for the Houston/Galveston Speed Model.

Functional Class Code	Functional Class Description	Area Type Code	Area Type Description	Distance Weighted Input Speeds[1]	Distance Weighted Free-Flow Speeds[2]	Free-Flow Speed Factor[3]
1	Urban Interstate	1	CBD	50.85	56.40	1.10906
1	Urban Interstate	2	Urban	52.55	61.40	1.16842
2	Urban Other Freeway	1	CBD	NA	58.00	1.21154
2	Urban Other Freeway	2	Urban	52.00	63.00	1.21154
3	Toll Road	1	CBD	NA	34.50	0.62652
3	Toll Road	2	Urban	57.58	36.08	0.62652
3	Toll Road	3	Urban Fringe	61.69	36.14	0.58577
3	Toll Road	4	Suburban	64.34	37.99	0.59040
3	Toll Road	5	Rural	59.13	38.43	0.64991
4	Ramp	1	CBD	28.62	35.13	1.22734
4	Ramp	2	Urban	40.06	36.26	0.90509
4	Ramp	3	Urban Fringe	43.22	38.52	0.89119
4	Ramp	4	Suburban	44.82	45.71	1.01987
4	Ramp	5	Rural	55.16	52.11	0.94478
5	Urban Principal Arterial	1	CBD	24.72	26.52	1.07262
5	Urban Principal Arterial	2	Urban	35.78	29.69	0.82974
6	Urban Other Arterial	1	CBD	22.00	24.64	1.11996
6	Urban Other Arterial	2	Urban	34.57	27.31	0.79001
7	Urban Collector	1	CBD	20.94	24.17	1.15413
7	Urban Collector	2	Urban	35.36	25.78	0.72901
10	Rural Interstate	3	Urban Fringe	57.84	61.40	1.06152
10	Rural Interstate	4	Suburban	59.15	67.20	1.13613
10	Rural Interstate	5	Rural	62.00	68.57	1.10599
11	Rural Other Freeway	3	Urban Fringe	62.00	63.00	1.01613
11	Rural Other Freeway	4	Suburban	62.00	69.00	1.11290
11	Rural Other Freeway	5	Rural	64.00	71.00	1.10938
12	Rural Principal Arterial	3	Urban Fringe	40.23	33.75	0.83890
12	Rural Principal Arterial	4	Suburban	46.12	42.48	0.92125
12	Rural Principal Arterial	5	Rural	60.00	55.53	0.92536
13	Rural Other Arterial	3	Urban Fringe	39.05	30.51	0.78131
13	Rural Other Arterial	4	Suburban	43.03	39.85	0.92612
13	Rural Other Arterial	5	Rural	53.97	54.07	1.00194
14	Rural Major Collector	3	Urban Fringe	38.00	27.76	0.73061
14	Rural Major Collector	4	Suburban	41.00	49.22	1.20059
14	Rural Major Collector	5	Rural	53.00	54.06	1.02009

Functional Class Code	Functional Class Description	Area Type Code	Area Type Description	Distance Weighted Input Speeds[1]	Distance Weighted Free-Flow Speeds[2]	Free-Flow Speed Factor[3]
15	Rural Collector	3	Urban Fringe	36.00	24.07	0.66864
15	Rural Collector	4	Suburban	40.00	35.58	0.88938
15	Rural Collector	5	Rural	49.00	49.86	1.01762

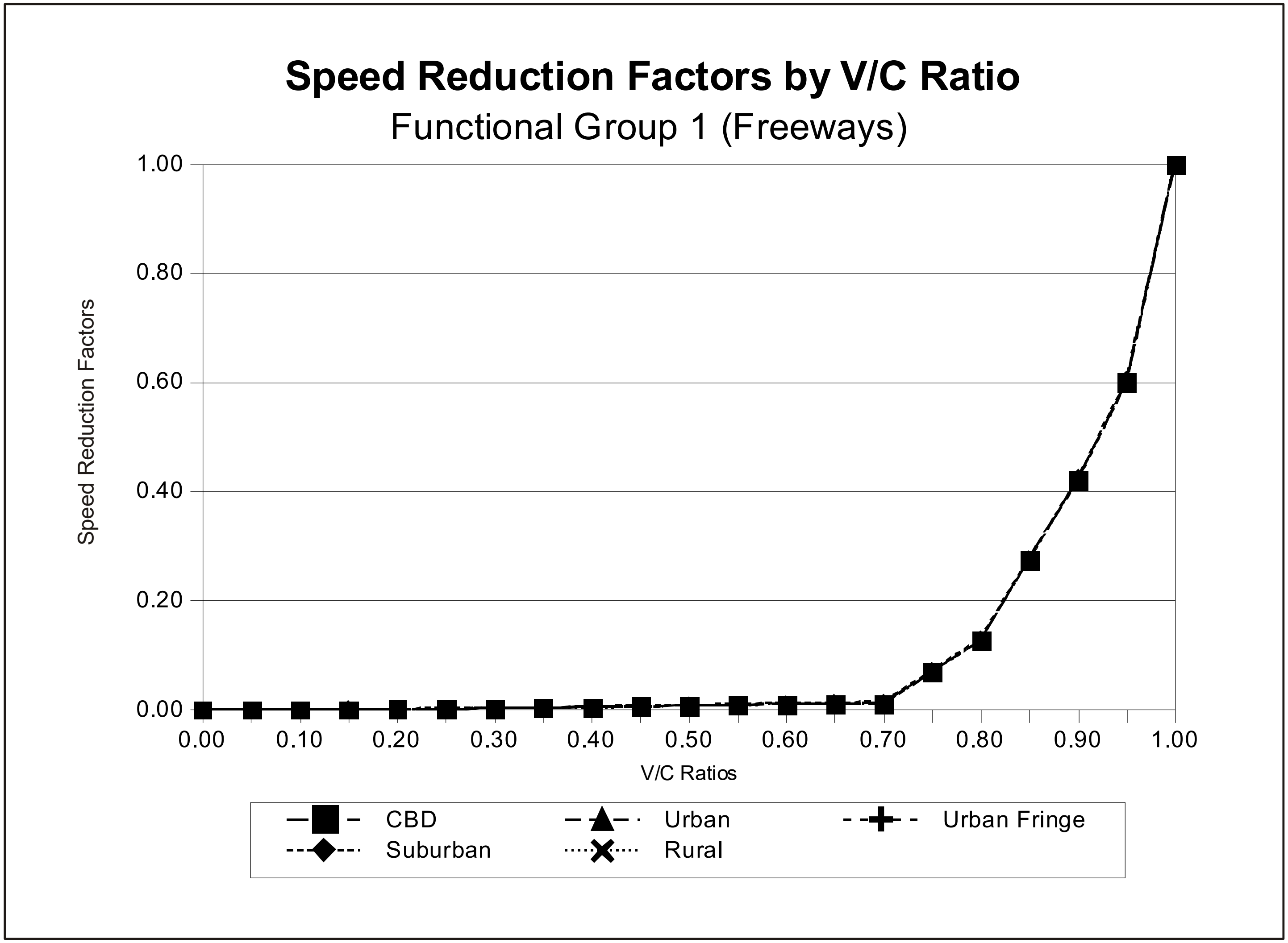
[1] Based on 2012 TDM data
[2] Calculated from detailed speed model runs by H-GAC with link volumes set to 0 (v/c = 0).
[3] When input speeds are not available, speed factors are taken from the nearest area type.

LOS E (V/C=1) Speed Factors for the Houston/Galveston Speed Model.

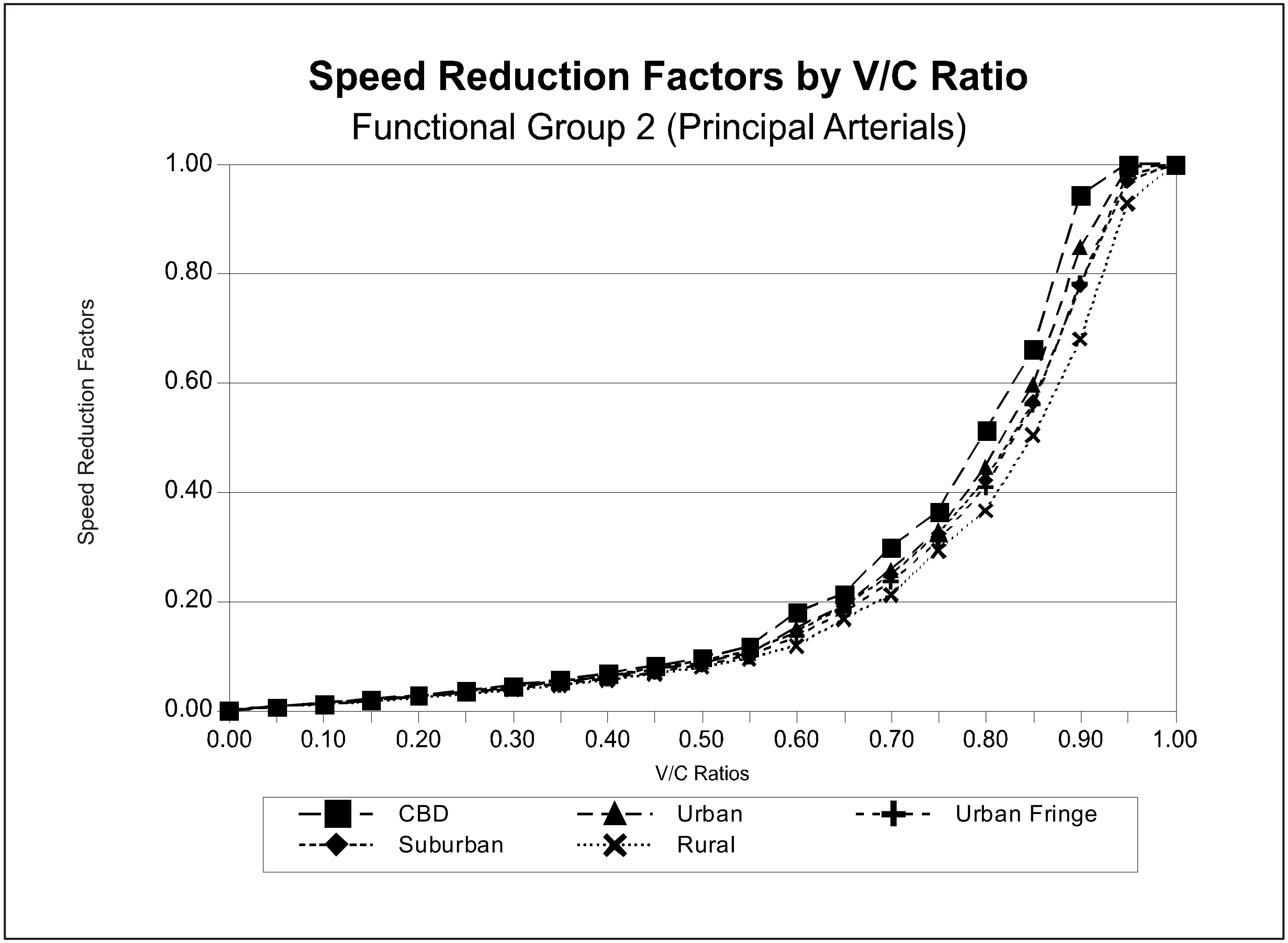
Functional Class Code	Functional Class Description	Area Type Code	Area Type Description	Distance Weighted Input Speeds[1]	Distance Weighted LOS E Speeds [2]	LOS Speed Factor[3]
1	Urban Interstate	1	CBD	50.85	34.35	0.67549
1	Urban Interstate	2	Urban	52.55	34.35	0.65370
2	Urban Other Freeway	1	CBD	N/A	35.00	0.67308
2	Urban Other Freeway	2	Urban	52.00	35.00	0.67308
3	Toll Road	1	CBD	N/A	24.77	0.43011
3	Toll Road	2	Urban	57.58	24.77	0.43011
3	Toll Road	3	Urban Fringe	61.69	26.52	0.42983
3	Toll Road	4	Suburban	64.34	29.54	0.45920
3	Toll Road	5	Rural	59.13	29.70	0.50229
4	Ramp	1	CBD	28.62	31.68	1.10692
4	Ramp	2	Urban	40.06	30.03	0.74952
4	Ramp	3	Urban Fringe	43.22	33.24	0.76908
4	Ramp	4	Suburban	44.82	41.22	0.91979
4	Ramp	5	Rural	55.16	49.01	0.88861
5	Urban Principal Arterial	1	CBD	24.72	22.13	0.89529
5	Urban Principal Arterial	2	Urban	35.78	24.44	0.68294
6	Urban Other Arterial	1	CBD	22.00	20.80	0.94565
6	Urban Other Arterial	2	Urban	34.57	22.76	0.65833
7	Urban Collector	1	CBD	20.94	20.06	0.95782
7	Urban Collector	2	Urban	35.36	21.23	0.60033
10	Rural Interstate	3	Urban Fringe	57.84	39.25	0.67860
10	Rural Interstate	4	Suburban	59.15	49.08	0.82973
10	Rural Interstate	5	Rural	62.00	49.08	0.79157
11	Rural Other Freeway	3	Urban Fringe	62.00	40.00	0.64516
11	Rural Other Freeway	4	Suburban	62.00	50.00	0.80645
11	Rural Other Freeway	5	Rural	64.00	50.00	0.78125
12	Rural Principal Arterial	3	Urban Fringe	40.23	27.30	0.67871

Functional Class Code	Functional Class Description	Area Type Code	Area Type Description	Distance Weighted Input Speeds[1]	Distance Weighted LOS E Speeds [2]	LOS Speed Factor[3]
12	Rural Principal Arterial	4	Suburban	46.12	32.64	0.70784
12	Rural Principal Arterial	5	Rural	60.00	38.32	0.63858
13	Rural Other Arterial	3	Urban Fringe	39.05	24.81	0.63540
13	Rural Other Arterial	4	Suburban	43.03	30.15	0.70070
13	Rural Other Arterial	5	Rural	53.97	38.46	0.71270
14	Rural Major Collector	3	Urban Fringe	38.00	22.22	0.58465
14	Rural Major Collector	4	Suburban	41.00	34.09	0.83151
14	Rural Major Collector	5	Rural	53.00	36.83	0.69499
15	Rural Collector	3	Urban Fringe	36.00	19.74	0.54845
15	Rural Collector	4	Suburban	40.00	26.40	0.65994
15	Rural Collector	5	Rural	49.00	34.33	0.70057

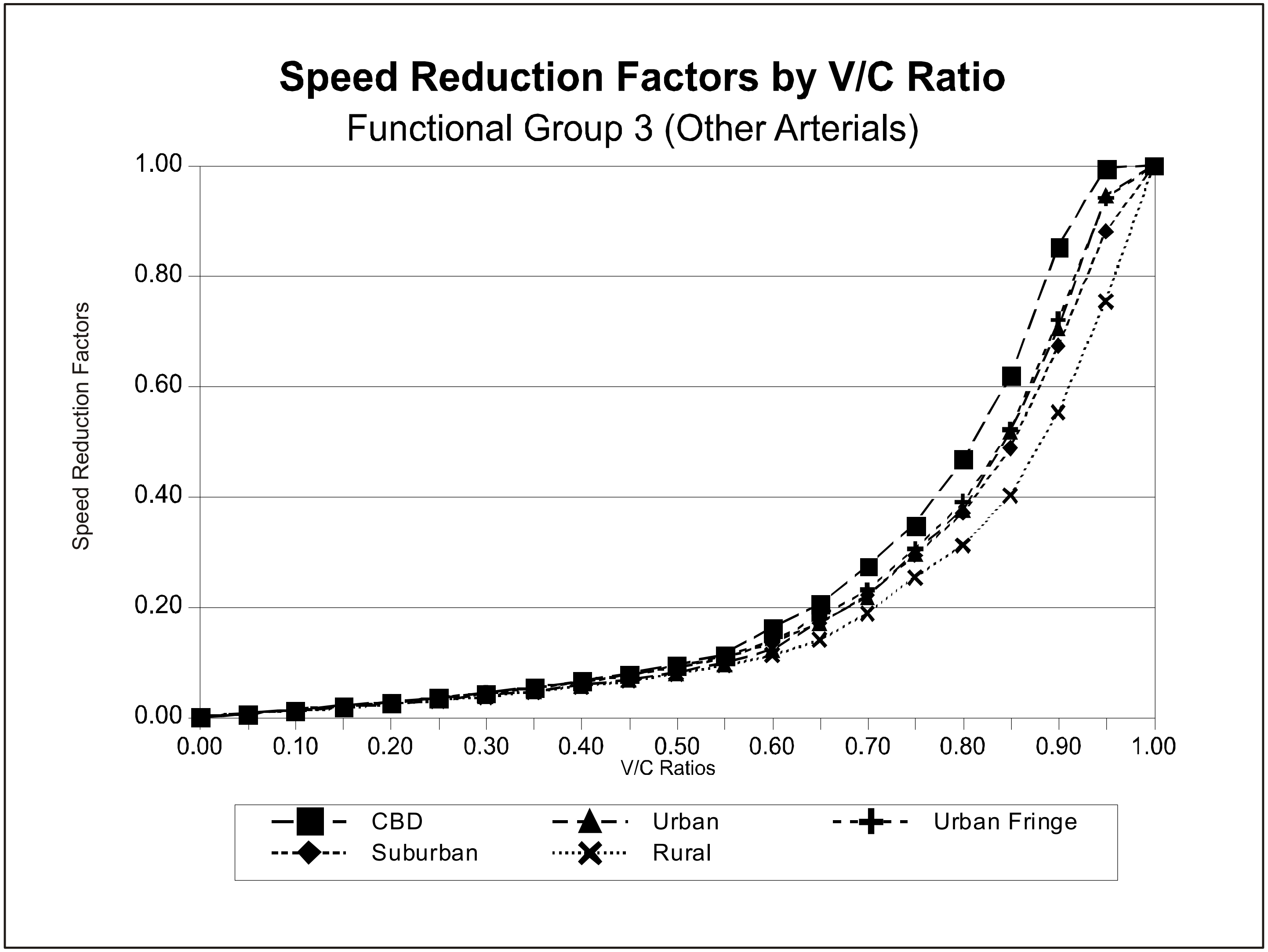
[1] Based on 2012 TDM data.
[2] Calculated from detailed speed model runs by H-GAC with link volumes set to capacity 0 (v/c = 0).
[3] When input speeds are not available, speed factors are taken from the nearest area type.



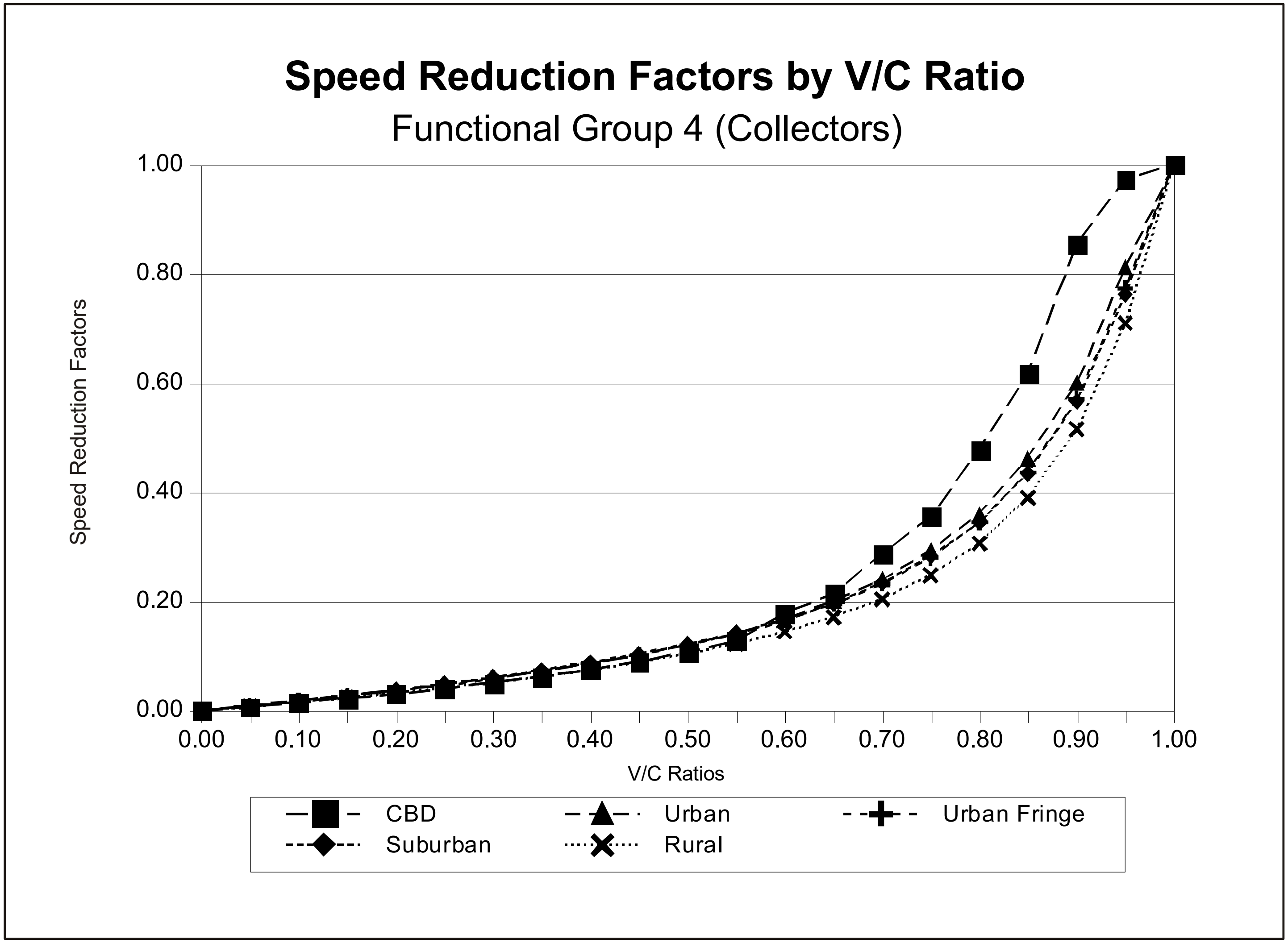
Freeway Speed Reduction Factors by V/C Ratio.



Principal Arterial Speed Reduction Factors by V/C Ratio.



Other Arterial Speed Reduction Factors by V/C Ratio.



Collector Speed Reduction Factors by V/C Ratio.

Functional Classification to Functional Group Relationship for the Application of Speed Reduction Factors.

Functional Group	Corresponding Network Functional Classifications
Freeways, Interstates	1. Urban Interstate Freeways
	2. Urban Other Freeways
	3. Toll Roads
	10. Rural Interstate Freeways
	11. Rural Other Freeways
Principal Arterials	5. Urban Principal Arterials
	12. Rural Principal Arterials
Other Arterials, Major Collectors	6. Urban Other Arterials
	13. Rural Other Arterials
	14. Rural Major Collectors
Collectors	4. Ramps
	7. Urban Collectors
	15. Rural Collectors

APPENDIX G: VEHICLE POPULATION ESTIMATES AND 24-HOUR ONI HOURS, SHP, STARTS, SHEI, AND APU HOURS SUMMARIES (ELECTRONIC ONLY)

This appendix is available separately in an electronic format (e.g., .docx, .xlsx, .pdf, .txt, .zip, or other format.) and can be provided upon request.

APPENDIX H: INDIVIDUAL COUNTIES AND TEXAS COUNTY GROUPS FOR THE EMISSION FACTOR ANALYSIS

Individual Counties and Texas County Groups for the Emission Factor Analysis

74 Counties	Group_CountyName	Group_FIPS	Rates_ID	#of Counties
1	Harrison	48203	TLM48203	1
2	Upshur	48459	TLM48459	1
3	Burnet	48053	AUS48053	1
4	Bastrop	48021	AUS48021	1
5	Caldwell	48055	AUS48055	1
6	Hays	48209	AUS48209	1
7	Travis	48453	AUS48453	1
8	Williamson	48491	AUS48491	1
9	Chambers	48071	HGB48071	1
10	Liberty	48291	HGB48291	1
11	Hardin	48199	BPA48199	1
12	Jefferson	48245	BPA48245	1
13	Orange	48361	BPA48361	1
14	Ellis	48139	DFW48139	1
15	Kaufman	48257	DFW48257	1
16	Rockwall	48397	DFW48397	1
17	Collin	48085	DFW48085	1
18	Dallas	48113	DFW48113	1
19	Denton	48121	DFW48121	1
20	El Paso	48141	ELP48141	1
21	Hood	48221	DFW48221	1
22	Johnson	48251	DFW48251	1
23	Parker	48367	DFW48367	1
24	Wise	48497	DFW48497	1
25	Tarrant	48439	DFW48439	1
26	Brazoria	48039	HGB48039	1
27	Fort Bend	48157	HGB48157	1
28	Galveston	48167	HGB48167	1
29	Harris	48201	HGB48201	1
30	Montgomery	48339	HGB48339	1
31	Waller	48473	HGB48473	1
32	Hunt	48231	DFW48231	1
33	Kendall	48259	SAN48259	1
34	Bexar	48029	SAN48029	1
35	Comal	48091	SAN48091	1

74 Counties	Group_CountyName	Group_FIPS	Rates_ID	#of Counties
36	Guadalupe	48187	SAN48187	1
37	Wilson	48493	SAN48493	1
38	Gregg	48183	TLM48183	1
39	Rusk	48401	TLM48401	1
40	Smith	48423	TLM48423	1
41	Borden	48033	D0148033	13
42	Armstrong	48011	D0248011	17
43	Bowie	48037	D0348037	7
44	Blanco	48031	D0448031	4
45	Lee	48287	D0448287	1
46	Jasper	48241	D0548241	3
47	Brown	48049	D0648049	9
48	Brazos	48041	D0748041	10
49	Briscoe	48045	D0848045	13
50	Aransas	48007	D0948007	8
51	Jim Wells	48249	D0948249	2
52	Navarro	48349	D1048349	1
53	Brewster	48043	D1148043	4
54	Hudspeth	48229	D1148229	1
55	Erath	48143	D1248143	3
56	Somervell	48425	D1248425	1
57	Dimmit	48127	D1448127	7
58	Duval	48131	D1448131	1
59	Bailey	48017	D1548017	17
60	Angelina	48005	D1648005	9
61	Andrews	48003	D1748003	12
62	Delta	48119	D1848119	8
63	Zapata	48505	D1948505	1
64	Brooks	48047	D1948047	7
65	Coke	48081	D2048081	15
66	Bandera	48019	D2148019	5
67	Atascosa	48013	D2148013	1
68	McMullen	48311	D2148311	1
69	Anderson	48001	D2248001	5
70	Hamilton	48193	D2348193	1
71	Bell	48027	D2348027	7
72	Archer	48009	D2448009	8
73	Cooke	48097	D2448097	1
74	Austin	48015	D2548015	11

APPENDIX I: SOURCE TYPE AGE AND FUEL ENGINE FRACTIONS INPUTS TO MOVES (ELECTRONIC ONLY)

This appendix is available separately in an electronic format (e.g., .docx, .xlsx, .pdf, .txt, .zip, or other format.) and can be provided upon request.

APPENDIX J: METEOROLOGICAL INPUTS TO MOVES (ELECTRONIC ONLY)

This appendix is available separately in an electronic format (e.g., .docx, .xlsx, .pdf, .txt, .zip, or other format.) and can be provided upon request.

APPENDIX K: SEASONAL WEEKDAY ON-ROAD EMISSIONS

Texas Statewide 2023 Summer Season Weekday On-Road Mobile Source Emissions – MOVES4 (Tons/Day).

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[1]	$PM_{2.5}$[1]
All Texas Counties	193.94	3,911.31	444.50	470,475	3.12	45.71	57.55	15.17

[1] PM emissions are total, direct vehicle emissions (exhaust, brakewear, and tirewear). No re-suspended dust from roadways was included.

El Paso MPA 2023 Winter Season Weekday On-Road Mobile Source Emissions – MOVES4 (Tons/Day).

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[1]	$PM_{2.5}$[1]
El Paso	4.32	64.62	13.25	10,177	0.05	1.07	1.44	0.39

[1] PM emissions are total, direct vehicle emissions (exhaust, brakewear, and tirewear). No re-suspended dust from roadways was included.

AUS MPA 2023 Summer Season Weekday On-Road Mobile Source Emissions – MOVES4 (Tons/Day).

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[1]	$PM_{2.5}$[1]
Bastrop	1.05	20.25	1.99	1,917	0.01	0.20	0.23	0.06
Burnet	0.61	12.68	1.36	1,306	0.01	0.13	0.17	0.04
Caldwell	0.47	10.36	1.01	964	0.01	0.10	0.09	0.03
Hays	1.74	34.51	3.33	3,745	0.03	0.37	0.45	0.12
Travis	6.50	134.45	13.38	16,849	0.13	1.64	2.22	0.55
Williamson	3.39	68.99	6.95	8,519	0.07	0.80	0.99	0.27
Area Total	**13.77**	**281.23**	**28.01**	**33,301**	**0.26**	**3.23**	**4.14**	**1.07**

[1] PM emissions are total, direct vehicle emissions (exhaust, brakewear, and tirewear). No re-suspended dust from roadways was included.

BPA MPA 2023 Summer Season Weekday On-Road Mobile Source Emissions – MOVES4 (Tons/Day).

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[1]	$PM_{2.5}$[1]
Hardin	0.46	9.50	1.06	1,024	0.01	0.09	0.16	0.04
Jefferson	1.85	43.42	5.04	4,814	0.04	0.45	0.72	0.19
Orange	0.69	17.10	2.46	2,169	0.02	0.19	0.33	0.08
Area Total	**3.00**	**70.02**	**8.56**	**8,007**	**0.06**	**0.73**	**1.21**	**0.31**

[1] PM emissions are total, direct vehicle emissions (exhaust, brakewear, and tirewear). No re-suspended dust from roadways was included.

DFW MPA 2023 Summer Season Weekday On-Road Mobile Source Emissions – MOVES4 (Tons/Day).

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[1]	$PM_{2.5}$[1]
Collin	4.81	94.12	9.69	14,083	0.08	1.36	1.92	0.43
Dallas	14.13	292.74	28.80	38,953	0.22	4.07	4.86	1.13
Denton	4.45	79.51	9.09	11,879	0.07	1.13	1.58	0.36
Ellis	1.35	28.91	4.09	4,339	0.03	0.41	0.43	0.13
Hood	0.48	7.68	0.80	844	0.01	0.08	0.10	0.03
Hunt	0.86	18.82	2.27	2,264	0.02	0.22	0.21	0.07
Johnson	1.22	22.42	2.92	2,999	0.02	0.29	0.34	0.10
Kaufman	0.93	20.74	3.10	3,229	0.02	0.30	0.31	0.09
Parker	1.08	21.25	3.61	3,298	0.02	0.30	0.36	0.10
Rockwall	0.59	12.60	1.66	1,891	0.01	0.18	0.25	0.06
Tarrant	11.05	217.00	22.52	29,694	0.17	3.03	3.90	0.89
Wise	0.72	15.55	1.98	1,800	0.01	0.18	0.18	0.05
Area Total	**41.68**	**831.33**	**90.54**	**115,273**	**0.67**	**11.54**	**14.44**	**3.44**

[1] PM emissions are total, direct vehicle emissions (exhaust, brakewear, and tirewear). No re-suspended dust from roadways was included.

El Paso MPA 2023 Summer Season Weekday On-Road Mobile Source Emissions – MOVES4 (Tons/Day).

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[1]	$PM_{2.5}$[1]
El Paso	5.20	79.41	12.08	10,093	0.05	1.01	1.24	0.34

[1] PM emissions are total, direct vehicle emissions (exhaust, brakewear, and tirewear). No re-suspended dust from roadways was included.

HGB MPA 2023 Summer Season Weekday On-Road Mobile Source Emissions – MOVES4 (Tons/Day).

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[1]	$PM_{2.5}$[1]
Brazoria	2.16	34.90	3.79	4,522	0.03	0.43	0.48	0.14
Chambers	0.44	11.49	1.99	2,034	0.01	0.17	0.14	0.05
Fort Bend	3.99	62.81	6.73	8,158	0.05	0.76	0.98	0.26
Galveston	1.89	31.04	3.08	3,852	0.02	0.36	0.45	0.12
Harris	25.70	506.06	53.13	65,060	0.37	6.34	7.65	1.98
Liberty	0.81	14.46	1.48	1,557	0.01	0.15	0.13	0.04
Montgomery	3.97	67.85	7.83	9,277	0.05	0.87	1.06	0.28
Waller	0.53	12.21	1.42	1,481	0.01	0.14	0.12	0.04
Area Total	**39.49**	**740.82**	**79.44**	**95,941**	**0.55**	**9.23**	**11.02**	**2.92**

[1] PM emissions are total, direct vehicle emissions (exhaust, brakewear, and tirewear). No re-suspended dust from roadways was included.

SAN MPA 2023 Summer Season Weekday On-Road Mobile Source Emissions – MOVES4 (Tons/Day).

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[1]	$PM_{2.5}$[1]
Bexar	14.95	310.53	26.75	30,042	0.24	3.03	5.13	1.14
Comal	1.68	36.14	3.58	3,788	0.03	0.37	0.60	0.14
Guadalupe	1.53	30.61	3.16	3,055	0.02	0.29	0.44	0.11
Kendall	0.54	9.51	1.01	989	0.01	0.09	0.14	0.04
Wilson	0.46	8.07	0.82	749	0.01	0.07	0.11	0.03
Area Total	**19.16**	**394.86**	**35.32**	**38,623**	**0.31**	**3.86**	**6.41**	**1.46**

[1] PM emissions are total, direct vehicle emissions (exhaust, brakewear, and tirewear). No re-suspended dust from roadways was included.

TLM MPA 2023 Summer Season Weekday On-Road Mobile Source Emissions – MOVES4 (Tons/Day).

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[1]	$PM_{2.5}$[2]
Gregg	1.10	24.60	2.58	2,442	0.02	0.24	0.38	0.09
Harrison[3]	0.72	16.80	2.26	2,039	0.01	0.19	0.18	0.06
Rusk[3]	0.49	9.24	0.96	901	0.01	0.09	0.10	0.03
Smith	2.21	49.22	5.16	4,790	0.04	0.48	0.74	0.18
Upshur[3]	0.38	7.02	0.76	713	0.01	0.07	0.08	0.02
Area Total	**4.90**	**106.89**	**11.72**	**10,886**	**0.08**	**1.07**	**1.48**	**0.40**

[1] PM emissions are total, direct vehicle emissions (exhaust, brakewear, and tirewear). No re-suspended dust from roadways was included.
[2] An HPMS-based methodology was used for these counties. A TDM-based methodology was used for Gregg and Smith Counties.

All Other Counties in Texas (VLink)[1] 2023 Summer Season Weekday On-Road Mobile Source Emissions – MOVES4 (Tons/Day).

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[2]	$PM_{2.5}$[2]
Anderson	0.43	8.24	0.89	820	0.01	0.08	0.10	0.03
Andrews	0.16	4.47	0.75	636	0.00	0.06	0.08	0.02
Angelina	0.71	13.71	1.72	1,465	0.01	0.14	0.18	0.05
Aransas	0.19	4.00	0.31	378	0.00	0.04	0.05	0.01
Archer	0.10	2.33	0.27	245	0.00	0.02	0.03	0.01
Armstrong	0.04	1.52	0.27	243	0.00	0.02	0.02	0.01
Atascosa	0.43	10.20	1.28	1,261	0.01	0.12	0.11	0.04
Austin	0.36	8.49	0.89	906	0.01	0.09	0.08	0.03
Bailey	0.05	1.21	0.16	147	0.00	0.01	0.02	0.00
Bandera	0.17	2.57	0.28	261	0.00	0.02	0.03	0.01
Baylor	0.04	1.20	0.13	136	0.00	0.01	0.01	0.00
Bee	0.17	3.88	0.40	442	0.00	0.04	0.05	0.01
Bell	3.30	61.46	7.20	6,745	0.05	0.64	0.77	0.23

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[2]	$PM_{2.5}$[2]
Blanco	0.15	3.62	0.47	452	0.00	0.04	0.04	0.01
Borden	0.01	0.32	0.04	37	0.00	0.00	0.00	0.00
Bosque	0.19	3.50	0.43	374	0.00	0.03	0.04	0.01
Bowie	0.82	18.62	2.34	2,181	0.02	0.21	0.21	0.07
Brazos	1.64	31.58	3.67	3,245	0.02	0.31	0.45	0.13
Brewster	0.09	1.58	0.25	172	0.00	0.02	0.02	0.01
Briscoe	0.02	0.34	0.06	38	0.00	0.00	0.01	0.00
Brooks	0.09	3.07	0.33	363	0.00	0.04	0.03	0.01
Brown	0.38	6.36	0.77	601	0.00	0.06	0.07	0.02
Burleson	0.20	4.48	0.54	504	0.00	0.05	0.05	0.02
Calhoun	0.15	3.25	0.33	313	0.00	0.03	0.04	0.01
Callahan	0.16	4.55	0.71	635	0.00	0.06	0.05	0.02
Cameron	3.09	56.90	5.50	5,360	0.06	0.53	0.69	0.18
Camp	0.12	2.06	0.25	199	0.00	0.02	0.02	0.01
Carson	0.10	3.31	0.60	526	0.00	0.05	0.04	0.01
Cass	0.28	5.48	0.63	557	0.00	0.06	0.06	0.02
Castro	0.06	1.44	0.20	172	0.00	0.02	0.02	0.01
Cherokee	0.46	8.56	0.91	843	0.01	0.08	0.10	0.03
Childress	0.09	2.26	0.52	301	0.00	0.03	0.03	0.01
Clay	0.13	3.78	0.47	455	0.00	0.05	0.04	0.01
Cochran	0.02	0.55	0.08	65	0.00	0.01	0.01	0.00
Coke	0.04	0.94	0.12	106	0.00	0.01	0.01	0.00
Coleman	0.10	2.24	0.24	228	0.00	0.02	0.02	0.01
Collingsworth	0.03	0.52	0.09	57	0.00	0.01	0.01	0.00
Colorado	0.31	9.62	1.17	1,134	0.01	0.11	0.09	0.03
Comanche	0.16	3.08	0.34	291	0.00	0.03	0.03	0.01
Concho	0.04	1.17	0.13	142	0.00	0.01	0.01	0.00
Cooke	0.46	10.41	1.38	1,208	0.01	0.12	0.11	0.04
Coryell	0.55	8.93	0.96	883	0.01	0.08	0.11	0.03
Cottle	0.02	0.38	0.06	44	0.00	0.00	0.01	0.00
Crane	0.05	1.38	0.22	205	0.00	0.02	0.02	0.01
Crockett	0.07	2.65	0.34	317	0.00	0.03	0.02	0.01
Crosby	0.05	0.96	0.14	119	0.00	0.01	0.01	0.00
Culberson	0.09	2.82	1.14	621	0.00	0.04	0.04	0.02
Dallam	0.08	2.14	0.38	294	0.00	0.03	0.03	0.01
Dawson	0.10	2.56	0.32	327	0.00	0.03	0.03	0.01
Deaf Smith	0.17	2.98	0.52	356	0.00	0.03	0.04	0.01
Delta	0.06	1.18	0.12	119	0.00	0.01	0.01	0.00
De Witt	0.16	3.73	0.37	371	0.00	0.04	0.05	0.01

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[2]	$PM_{2.5}$[2]
Dickens	0.02	0.56	0.09	67	0.00	0.01	0.01	0.00
Dimmit	0.13	3.25	0.42	371	0.00	0.04	0.04	0.01
Donley	0.08	2.70	0.64	388	0.00	0.03	0.03	0.01
Duval	0.09	2.06	0.28	234	0.00	0.02	0.03	0.01
Eastland	0.27	7.27	1.06	806	0.01	0.08	0.06	0.02
Ector	1.28	24.18	3.23	2,821	0.02	0.26	0.36	0.09
Edwards	0.02	0.55	0.06	56	0.00	0.01	0.01	0.00
Erath	0.33	7.32	0.85	840	0.01	0.08	0.09	0.03
Falls	0.18	4.34	0.58	543	0.00	0.05	0.05	0.02
Fannin	0.36	6.64	0.70	626	0.00	0.06	0.08	0.02
Fayette	0.36	10.17	1.11	1,143	0.01	0.11	0.10	0.03
Fisher	0.04	0.95	0.11	103	0.00	0.01	0.01	0.00
Floyd	0.05	0.97	0.13	109	0.00	0.01	0.01	0.00
Foard	0.02	0.37	0.07	42	0.00	0.00	0.01	0.00
Franklin	0.13	2.93	0.50	381	0.00	0.03	0.03	0.01
Freestone	0.26	7.55	1.20	1,034	0.01	0.09	0.08	0.03
Frio	0.19	6.08	0.95	842	0.01	0.08	0.06	0.02
Gaines	0.19	4.29	0.59	520	0.00	0.05	0.06	0.02
Garza	0.05	1.83	0.25	261	0.00	0.03	0.02	0.01
Gillespie	0.24	4.65	0.50	528	0.00	0.05	0.05	0.02
Glasscock	0.05	1.77	0.19	206	0.00	0.02	0.02	0.01
Goliad	0.06	1.78	0.23	232	0.00	0.02	0.02	0.01
Gonzales	0.24	7.48	0.78	846	0.01	0.08	0.07	0.02
Gray	0.19	3.59	0.68	469	0.00	0.04	0.04	0.02
Grayson	1.41	27.85	3.09	2,883	0.02	0.28	0.33	0.10
Grimes	0.34	7.50	0.89	834	0.01	0.08	0.10	0.03
Hale	0.21	4.64	0.65	574	0.00	0.06	0.05	0.02
Hall	0.05	1.34	0.25	177	0.00	0.02	0.02	0.01
Hamilton	0.10	2.02	0.26	230	0.00	0.02	0.02	0.01
Hansford	0.05	0.90	0.16	106	0.00	0.01	0.02	0.00
Hardeman	0.06	1.88	0.41	254	0.00	0.02	0.02	0.01
Hartley	0.07	2.19	0.38	315	0.00	0.03	0.03	0.01
Haskell	0.05	1.20	0.14	136	0.00	0.01	0.01	0.00
Hemphill	0.04	0.71	0.13	89	0.00	0.01	0.01	0.00
Henderson	0.82	14.20	1.46	1,348	0.01	0.13	0.16	0.05
Hidalgo	6.27	117.17	11.97	10,881	0.12	1.07	1.58	0.39
Hill	0.55	14.05	2.89	2,130	0.01	0.18	0.17	0.07
Hockley	0.17	3.57	0.46	407	0.00	0.04	0.05	0.01
Hopkins	0.42	9.55	1.44	1,200	0.01	0.11	0.10	0.04

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[2]	$PM_{2.5}$[2]
Houston	0.21	4.25	0.56	459	0.00	0.04	0.05	0.02
Howard	0.29	7.04	1.22	976	0.01	0.09	0.09	0.03
Hudspeth	0.14	5.00	1.92	1,222	0.01	0.09	0.07	0.04
Hutchinson	0.16	2.38	0.35	246	0.00	0.02	0.03	0.01
Irion	0.03	1.03	0.11	122	0.00	0.01	0.01	0.00
Jack	0.08	1.86	0.22	210	0.00	0.02	0.02	0.01
Jackson	0.16	4.92	0.57	534	0.00	0.05	0.06	0.02
Jasper	0.30	6.77	0.66	723	0.01	0.07	0.08	0.02
Jeff Davis	0.03	0.71	0.18	124	0.00	0.01	0.01	0.00
Jim Hogg	0.04	0.79	0.07	76	0.00	0.01	0.01	0.00
Jim Wells	0.26	6.46	0.75	795	0.01	0.07	0.08	0.02
Jones	0.13	2.74	0.32	301	0.00	0.03	0.03	0.01
Karnes	0.14	3.84	0.50	484	0.00	0.04	0.06	0.02
Kenedy	0.04	1.97	0.21	255	0.00	0.03	0.02	0.01
Kent	0.01	0.26	0.03	29	0.00	0.00	0.00	0.00
Kerr	0.44	8.19	0.88	901	0.01	0.09	0.09	0.03
Kimble	0.10	3.26	0.63	407	0.00	0.04	0.03	0.01
King	0.01	0.38	0.06	51	0.00	0.01	0.00	0.00
Kinney	0.04	1.00	0.12	123	0.00	0.01	0.01	0.00
Kleberg	0.21	4.92	0.59	580	0.01	0.05	0.06	0.02
Knox	0.04	0.86	0.15	99	0.00	0.01	0.01	0.00
Lamar	0.48	9.11	0.99	878	0.01	0.09	0.10	0.03
Lamb	0.11	2.39	0.31	288	0.00	0.03	0.03	0.01
Lampasas	0.24	4.43	0.50	435	0.00	0.04	0.05	0.01
La Salle	0.15	5.21	1.45	945	0.00	0.07	0.06	0.03
Lavaca	0.20	3.86	0.39	360	0.00	0.04	0.05	0.01
Lee	0.17	3.92	0.44	465	0.00	0.04	0.04	0.01
Leon	0.25	7.48	1.11	1,023	0.01	0.09	0.08	0.03
Limestone	0.22	4.36	0.54	456	0.00	0.04	0.06	0.02
Lipscomb	0.03	0.56	0.10	65	0.00	0.01	0.01	0.00
Live Oak	0.18	6.93	1.22	1,094	0.01	0.09	0.08	0.03
Llano	0.21	3.69	0.39	387	0.00	0.04	0.05	0.01
Loving	0.03	1.60	0.28	235	0.00	0.02	0.04	0.01
Lubbock	2.03	38.83	4.56	4,117	0.03	0.42	0.56	0.15
Lynn	0.06	1.80	0.24	243	0.00	0.02	0.02	0.01
McCulloch	0.11	2.02	0.24	193	0.00	0.02	0.02	0.01
McLennan	0.79	40.95	5.51	5,428	0.04	0.51	0.59	0.17
McMullen	0.06	1.19	0.16	136	0.00	0.01	0.02	0.00
Madison	0.11	4.64	0.67	663	0.00	0.06	0.05	0.02

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[2]	$PM_{2.5}$[2]
Marion	0.27	2.72	0.29	204	0.00	0.02	0.02	0.01
Martin	0.40	5.73	0.84	715	0.00	0.06	0.07	0.02
Mason	0.05	0.92	0.10	102	0.00	0.01	0.01	0.00
Matagorda	1.33	10.46	1.03	594	0.00	0.05	0.08	0.03
Maverick	0.12	6.28	0.79	740	0.00	0.07	0.10	0.02
Medina	0.44	8.50	1.11	992	0.01	0.09	0.09	0.03
Menard	0.03	0.80	0.09	92	0.00	0.01	0.01	0.00
Midland	1.46	29.44	4.16	3,549	0.02	0.33	0.44	0.12
Milam	0.25	5.10	0.62	549	0.00	0.05	0.06	0.02
Mills	0.07	1.51	0.16	152	0.00	0.02	0.02	0.00
Mitchell	0.08	2.82	0.46	422	0.00	0.04	0.03	0.01
Montague	0.23	4.74	0.60	500	0.00	0.05	0.05	0.02
Moore	0.19	3.36	0.59	407	0.00	0.04	0.05	0.02
Morris	0.12	2.58	0.36	320	0.00	0.03	0.03	0.01
Motley	0.02	0.31	0.05	35	0.00	0.00	0.00	0.00
Nacogdoches	0.55	10.96	1.42	1,181	0.01	0.11	0.14	0.04
Navarro	0.44	10.91	1.42	1,416	0.01	0.13	0.12	0.04
Newton	0.11	2.41	0.23	254	0.00	0.02	0.03	0.01
Nolan	0.17	4.91	0.95	725	0.00	0.07	0.05	0.02
Nueces	2.05	48.97	3.63	5,007	0.04	0.50	0.57	0.15
Ochiltree	0.10	1.72	0.31	198	0.00	0.02	0.03	0.01
Oldham	0.06	2.82	0.53	481	0.00	0.05	0.03	0.01
Palo Pinto	0.27	6.00	0.97	814	0.00	0.07	0.07	0.02
Panola	0.27	6.26	0.75	665	0.00	0.07	0.07	0.02
Parmer	0.08	1.87	0.26	242	0.00	0.02	0.02	0.01
Pecos	0.18	5.44	1.15	850	0.01	0.07	0.07	0.02
Polk	0.53	10.59	1.42	1,178	0.01	0.11	0.12	0.04
Potter	1.00	19.05	3.70	2,474	0.01	0.23	0.28	0.09
Presidio	0.06	1.06	0.17	126	0.00	0.01	0.01	0.00
Rains	0.13	2.37	0.26	228	0.00	0.02	0.03	0.01
Randall	1.12	17.11	2.64	1,910	0.01	0.18	0.25	0.08
Reagan	0.07	1.80	0.21	195	0.00	0.02	0.02	0.01
Real	0.04	0.64	0.07	62	0.00	0.01	0.01	0.00
Red River	0.13	2.66	0.28	269	0.00	0.03	0.03	0.01
Reeves	0.19	7.07	1.29	1,116	0.01	0.10	0.10	0.03
Refugio	0.09	3.43	0.46	488	0.00	0.04	0.05	0.01
Roberts	0.01	0.38	0.07	54	0.00	0.01	0.01	0.00
Robertson	0.20	4.81	0.60	556	0.00	0.05	0.06	0.02
Runnels	0.10	2.07	0.23	222	0.00	0.02	0.02	0.01

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[2]	$PM_{2.5}$[2]
Sabine	0.11	1.90	0.23	189	0.00	0.02	0.02	0.01
San Augustine	0.08	1.71	0.21	184	0.00	0.02	0.02	0.01
San Jacinto	0.27	5.33	0.67	589	0.00	0.06	0.07	0.02
San Patricio	0.52	13.17	1.36	1,553	0.01	0.15	0.16	0.05
San Saba	0.06	1.27	0.14	120	0.00	0.01	0.01	0.00
Schleicher	0.02	0.54	0.06	59	0.00	0.01	0.01	0.00
Scurry	0.16	3.50	0.52	423	0.00	0.04	0.05	0.01
Shackelford	0.03	0.76	0.09	84	0.00	0.01	0.01	0.00
Shelby	0.26	4.90	0.61	514	0.00	0.05	0.06	0.02
Sherman	0.04	1.16	0.22	175	0.00	0.02	0.02	0.01
Somervell	0.09	1.67	0.19	178	0.00	0.02	0.02	0.01
Starr	0.49	8.24	0.80	735	0.01	0.07	0.09	0.02
Stephens	0.08	1.55	0.18	149	0.00	0.01	0.02	0.01
Sterling	0.03	1.05	0.13	130	0.00	0.01	0.01	0.00
Stonewall	0.02	0.37	0.04	41	0.00	0.00	0.00	0.00
Sutton	0.07	2.68	0.27	324	0.00	0.03	0.02	0.01
Swisher	0.07	1.91	0.32	268	0.00	0.03	0.02	0.01
Taylor	1.18	20.95	4.14	2,775	0.02	0.24	0.37	0.11
Terrell	0.01	0.35	0.06	55	0.00	0.00	0.00	0.00
Terry	0.10	2.55	0.34	326	0.00	0.03	0.03	0.01
Throckmorton	0.01	0.37	0.04	39	0.00	0.00	0.00	0.00
Titus	0.30	6.74	0.84	800	0.01	0.08	0.07	0.02
Tom Green	0.92	15.16	1.54	1,424	0.01	0.14	0.19	0.05
Trinity	0.15	2.60	0.32	269	0.00	0.03	0.03	0.01
Tyler	0.17	3.41	0.33	352	0.00	0.03	0.04	0.01
Upton	0.05	1.50	0.26	225	0.00	0.02	0.03	0.01
Uvalde	0.19	3.90	0.41	417	0.00	0.04	0.05	0.01
Val Verde	0.41	5.69	0.63	518	0.00	0.05	0.06	0.02
Van Zandt	0.61	14.97	1.46	1,477	0.01	0.16	0.14	0.04
Victoria	0.68	15.37	1.65	1,543	0.01	0.15	0.19	0.06
Walker	0.54	13.66	1.96	1,720	0.01	0.16	0.15	0.05
Ward	0.16	5.47	0.98	854	0.01	0.08	0.07	0.02
Washington	0.36	8.24	0.99	919	0.01	0.09	0.10	0.03
Webb	2.11	37.83	5.09	3,832	0.02	0.35	0.49	0.14
Wharton	0.37	9.49	1.03	983	0.01	0.10	0.11	0.03
Wheeler	0.08	2.54	0.51	367	0.00	0.03	0.03	0.01
Wichita	1.00	17.30	2.22	1,813	0.01	0.17	0.21	0.06
Wilbarger	0.13	3.45	0.41	395	0.00	0.04	0.04	0.01
Willacy	0.16	3.42	0.35	352	0.00	0.03	0.04	0.01

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[2]	$PM_{2.5}$[2]
Winkler	0.09	2.84	0.46	406	0.00	0.04	0.05	0.01
Wood	0.44	7.25	0.75	669	0.01	0.07	0.09	0.03
Yoakum	0.09	1.94	0.27	225	0.00	0.02	0.03	0.01
Young	0.18	2.85	0.33	270	0.00	0.03	0.03	0.01
Zapata	0.10	1.95	0.18	186	0.00	0.02	0.02	0.01
Zavala	0.10	2.43	0.30	280	0.00	0.03	0.03	0.01
All Counties[1]	**66.74**	**1,406.75**	**178.83**	**158,351**	**1.14**	**15.04**	**17.61**	**5.23**

[1] This table includes all Texas counties outside the areas comprised of the 39 counties of the Austin, BPA, DFW, El Paso, HGB, San Antonio, and TLM metropolitan planning areas. An HPMS-based methodology was used for these counties.

[2] PM emissions are total, direct vehicle emissions (exhaust, brakewear, and tirewear). No re-suspended dust from roadways was included.

APPENDIX L: ANNUAL ON-ROAD MOBILE SOURCE EMISSIONS

Texas 2023 Annual On-Road Mobile Source Emissions – MOVES4 (Tons/Year).

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[1]	$PM_{2.5}$[1]
All Texas Counties	58,108.93	1,244,849.98	196,846.72	198,099,265	1,102.74	20,123.81	17,810.25	5,447.77

[1] PM emissions are total, direct vehicle emissions (exhaust, brakewear, and tirewear). No re-suspended dust from roadways was included.

AUS MPA 2023 Annual On-Road Mobile Source Emissions – MOVES4 (Tons/Year).

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[1]	$PM_{2.5}$[1]
Bastrop	279.41	5,012.19	596.12	616,528	3.69	66.86	62.88	18.22
Burnet	167.82	3,173.69	412.81	420,418	2.30	44.78	47.20	12.99
Caldwell	129.04	2,626.06	319.34	318,615	1.86	34.01	27.09	8.82
Hays	461.54	8,836.48	1,000.30	1,208,761	7.37	126.72	126.85	33.73
Travis	1,731.41	33,599.28	4,034.26	5,376,405	33.11	558.82	629.29	154.91
Williamson	908.83	17,266.39	2,163.75	2,761,149	16.76	276.87	291.64	76.91
Area Total	**3,678.05**	**70,514.10**	**8,526.57**	**10,701,877**	**65.09**	**1,108.06**	**1,184.95**	**305.59**

[1] PM emissions are total, direct vehicle emissions (exhaust, brakewear, and tirewear). No re-suspended dust from roadways was included.

BPA MPA 2023 Annual On-Road Mobile Source Emissions - MOVES4 (Tons/Year).

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[1]	$PM_{2.5}$[1]
Hardin	120.52	2,257.08	320.22	321,767	2.01	31.65	44.07	11.21
Jefferson	496.67	10,571.49	1,599.55	1,540,554	9.40	152.03	202.45	53.20
Orange	188.50	4,213.59	789.18	677,256	4.04	63.62	88.47	23.99
Area Total	**805.69**	**17,042.17**	**2,708.95**	**2,539,577**	**15.45**	**247.29**	**335.00**	**88.40**

[1] PM emissions are total, direct vehicle emissions (exhaust, brakewear, and tirewear). No re-suspended dust from roadways was included.

DFW MPA 2023 Annual On-Road Mobile Source Emissions – MOVES4 (Tons/Year).

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[1]	$PM_{2.5}$[1]
Collin	1,516.51	26,013.75	3,370.39	4,501,189	25.79	457.07	557.02	131.43
Dallas	4,441.84	80,883.85	9,977.01	12,531,740	72.04	1,379.78	1,414.55	351.89
Denton	1,384.59	22,116.42	3,131.05	3,795,567	21.50	380.88	453.18	112.42
Ellis	431.48	8,297.22	1,421.22	1,430,686	8.25	142.12	126.65	39.65
Hood	146.33	2,098.91	270.12	272,442	1.62	27.50	29.59	8.39
Hunt	275.24	5,385.20	837.26	761,229	4.31	77.03	62.80	21.32
Johnson	377.68	6,071.24	1,000.68	967,997	5.57	96.88	98.95	29.56
Kaufman	300.86	5,887.99	1,111.10	1,066,347	6.06	103.05	90.92	29.61
Parker	343.73	5,885.74	1,268.90	1,071,961	5.98	99.58	104.39	32.91
Rockwall	186.95	3,405.85	568.00	603,688	3.58	58.55	70.82	18.47
Tarrant	3,412.01	59,338.71	7,626.32	9,428,803	54.21	1,014.93	1,124.73	273.40
Wise	228.76	4,218.88	695.66	586,109	3.40	59.73	54.39	17.05
Area Total	**13,045.97**	**229,603.75**	**31,277.70**	**37,017,759**	**212.33**	**3,897.09**	**4,187.98**	**1,066.09**

[1] PM emissions are total, direct vehicle emissions (exhaust, brakewear, and tirewear). No re-suspended dust from roadways was included.

El Paso MPA 2023 Annual On-Road Mobile Source Emissions – MOVES4 (Tons/Year).

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[1]	$PM_{2.5}$[1]
El Paso	1,651.09	24,165.05	4,262.50	3,521,782	17.34	366.47	390.19	114.04

[1] PM emissions are total, direct vehicle emissions (exhaust, brakewear, and tirewear). No re-suspended dust from roadways was included.

HGB MPA 2023 Annual On-Road Mobile Source Emissions – MOVES4 (Tons/Year).

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[1]	$PM_{2.5}$[1]
Brazoria	581.68	9,013.95	1,200.66	1,490,578	7.81	152.09	149.49	40.95
Chambers	127.73	3,219.74	733.78	695,925	3.33	59.94	44.93	17.55
Fort Bend	1,051.73	16,005.70	2,149.47	2,668,520	14.00	265.26	297.56	77.19
Galveston	504.08	7,759.54	981.24	1,257,726	6.62	128.14	137.01	35.67
Harris	6,962.10	128,189.36	17,129.35	21,246,291	111.77	2,219.35	2,322.33	600.02
Liberty	216.00	3,798.32	485.45	522,135	2.69	54.87	42.17	13.56
Montgomery	1,075.89	17,388.89	2,531.28	3,035,430	15.86	303.23	320.05	85.86
Waller	154.07	3,347.94	492.58	496,506	2.54	51.22	36.84	12.51
Area Total	**10,673.26**	**188,723.44**	**25,703.81**	**31,413,111**	**164.63**	**3,234.10**	**3,350.39**	**883.31**

[1] PM emissions are total, direct vehicle emissions (exhaust, brakewear, and tirewear). No re-suspended dust from roadways was included.

SAN MPA 2023 Annual On-Road Mobile Source Emissions – MOVES4 (Tons/Year).

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[1]	$PM_{2.5}$[1]
Bexar	3,842.32	73,672.95	7,768.57	9,128,069	56.97	984.13	1,372.21	307.98
Comal	443.97	8,654.55	1,079.32	1,174,036	7.21	121.59	161.39	38.19
Guadalupe	401.91	7,430.54	974.18	960,795	5.74	97.57	119.96	31.41
Kendall	143.79	2,330.05	306.45	311,713	1.72	31.21	38.61	10.02
Wilson	118.75	1,928.96	241.57	238,992	1.43	24.71	29.23	7.85
Area Total	**4,950.73**	**94,017.05**	**10,370.09**	**11,813,605**	**73.06**	**1,259.22**	**1,721.41**	**395.46**

[1] PM emissions are total, direct vehicle emissions (exhaust, brakewear, and tirewear). No re-suspended dust from roadways was included.

TLM MPA 2023 Annual On-Road Mobile Source Emissions - MOVES4 (Tons/Year).

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[1]	$PM_{2.5}$[1]
Gregg	291.50	5,860.61	789.61	761,456	4.58	79.91	105.69	26.57
Harrison[2]	199.47	4,373.30	787.46	665,855	3.67	64.69	54.30	19.29
Rusk[2]	129.04	2,267.33	301.18	289,262	1.73	30.62	29.20	8.73
Smith	577.63	11,622.88	1,570.47	1,472,738	8.88	156.42	201.16	51.26
Upshur[2]	101.33	1,733.19	234.19	227,463	1.36	24.29	22.96	6.89
Area Total	**1,298.97**	**25,857.32**	**3,682.91**	**3,416,773**	**20.22**	**355.92**	**413.30**	**112.74**

[1] PM emissions are total, direct vehicle emissions (exhaust, brakewear, tirewear). No re-suspended dust from roadways was included.
[2] An HPMS-based methodology was used for these counties. A TDM-based methodology was used for Gregg and Smith Counties.

All Other Counties in Texas (VLink)[1] 2023 Annual On-Road Mobile Source Emissions - MOVES4 (Tons/Year).

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[2]	$PM_{2.5}$[2]
Anderson	113.42	2,030.53	274.75	263,585.98	1.57	27.75	27.59	8.25
Andrews	48.61	1,159.66	233.03	203,144.82	1.07	19.09	21.40	6.26
Angelina	192.19	3,530.13	578.97	498,572.59	2.79	49.65	57.33	17.05
Aransas	48.22	909.49	82.02	111,963.02	0.71	11.92	14.33	3.43
Archer	28.96	585.13	83.20	79,343.34	0.43	8.49	8.28	2.46
Armstrong	14.13	453.02	97.29	82,136.09	0.42	8.32	6.32	2.31
Atascosa	120.03	2,823.69	422.64	421,515.65	2.42	41.17	33.76	11.22
Austin	100.15	2,396.93	307.11	317,428.55	1.89	33.03	26.02	8.67
Bailey	15.70	322.51	49.66	48,111.99	0.26	5.07	4.75	1.43
Bandera	44.53	637.63	84.56	85,104.05	0.46	8.46	8.13	2.50
Baylor	12.25	316.30	42.95	44,826.04	0.25	4.86	3.43	1.14
Bee	46.09	909.73	119.06	132,849.05	0.79	13.13	12.81	3.77
Bell	864.29	15,670.38	2,327.28	2,203,735.11	12.79	219.70	230.97	68.47

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[2]	$PM_{2.5}$[2]
Blanco	43.04	950.41	154.10	148,651.08	0.80	14.57	12.82	4.02
Borden	2.70	82.78	11.69	12,147.35	0.07	1.31	1.36	0.36
Bosque	48.40	860.03	130.91	120,317.28	0.70	11.88	12.35	3.84
Bowie	226.12	4,795.25	805.36	708,781.18	3.99	70.54	62.01	20.57
Brazos	437.27	8,111.56	1,208.72	1,099,340.56	6.36	110.26	139.61	38.32
Brewster	26.63	428.84	80.19	60,101.33	0.31	5.97	7.06	2.09
Briscoe	4.46	85.60	17.87	11,955.57	0.06	1.20	1.46	0.51
Brooks	26.68	887.88	110.89	123,470.80	0.92	13.21	9.79	3.03
Brown	101.50	1,595.41	238.95	195,810.89	1.06	20.52	22.06	6.80
Burleson	54.29	1,163.14	174.79	170,773.99	0.99	17.26	15.96	5.05
Calhoun	41.62	872.53	105.83	108,458.07	0.65	11.24	12.85	3.65
Callahan	48.52	1,333.49	249.78	215,252.84	1.12	21.26	14.00	5.39
Cameron	822.26	14,950.07	1,657.24	1,799,211.48	13.37	190.63	213.94	55.44
Camp	32.07	491.33	71.42	62,627.78	0.37	6.50	6.44	1.98
Carson	32.18	1,019.55	213.87	178,224.40	0.91	17.89	11.94	4.76
Cass	74.80	1,345.18	199.67	177,410.42	1.05	18.63	17.76	5.43
Castro	18.45	373.40	62.23	55,564.05	0.30	5.76	6.20	1.80
Cherokee	119.72	2,104.40	281.57	270,644.07	1.61	28.49	27.66	8.37
Childress	27.49	626.98	183.10	98,118.63	0.50	9.18	7.87	3.50
Clay	38.43	1,017.88	159.35	150,146.56	0.81	15.92	12.05	4.02
Cochran	6.66	141.50	23.59	20,855.18	0.11	2.17	2.51	0.71
Coke	11.64	244.04	37.11	34,517.39	0.19	3.62	3.11	0.98
Coleman	27.20	571.92	76.41	74,049.40	0.41	8.10	6.53	2.12
Collingsworth	7.41	130.57	29.88	17,995.05	0.09	1.77	2.26	0.79
Colorado	92.35	2,908.80	436.61	403,544.15	2.35	40.74	26.81	10.26
Comanche	43.63	782.71	99.83	94,081.61	0.52	10.18	9.20	2.89
Concho	10.64	316.62	43.44	46,641.39	0.26	4.99	3.89	1.21
Cooke	127.83	2,822.40	462.19	403,427.41	2.32	41.13	33.39	11.49
Coryell	141.28	2,203.42	291.31	285,049.87	1.70	29.13	32.20	9.22
Cottle	4.70	96.35	20.24	13,999.38	0.07	1.41	1.57	0.57
Crane	14.46	367.34	69.30	66,291.86	0.35	6.22	5.85	1.84
Crockett	22.82	766.89	120.29	105,373.11	0.59	11.29	7.18	2.49
Crosby	13.37	257.01	44.79	39,114.14	0.21	4.00	3.35	1.12
Culberson	32.81	885.19	447.12	224,876.55	0.97	16.66	14.48	7.21
Dallam	25.70	601.90	126.64	97,636.14	0.50	9.87	9.73	3.17
Dawson	28.91	698.89	104.47	108,282.18	0.59	11.47	9.59	2.95
Deaf Smith	49.82	823.09	170.71	117,985.85	0.61	11.68	12.76	4.18
Delta	15.40	298.27	39.38	38,882.46	0.23	4.17	3.66	1.16

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}^2	$PM_{2.5}^2$
DeWitt	43.81	978.53	121.41	127,057.04	0.76	13.34	13.55	3.99
Dickens	7.00	147.24	29.14	21,481.74	0.11	2.19	2.08	0.79
Dimmit	36.37	844.45	133.13	121,351.74	0.63	12.08	11.75	3.54
Donley	27.63	773.49	231.84	127,082.44	0.64	11.88	9.79	4.39
Duval	25.73	529.37	87.85	76,330.93	0.52	7.49	7.16	2.21
Eastland	81.76	2,109.31	365.94	268,504.38	1.46	28.12	17.18	6.92
Ector	357.01	6,155.35	973.45	901,104.13	4.92	88.47	106.09	28.59
Edwards	6.42	134.16	17.31	17,823.21	0.10	1.92	2.16	0.58
Erath	91.35	1,808.88	271.94	270,608.17	1.44	27.29	26.36	7.77
Falls	48.61	1,128.80	187.28	178,413.20	1.01	17.35	15.43	5.15
Fannin	96.38	1,643.14	219.52	203,681.85	1.21	21.77	22.58	6.74
Fayette	104.38	2,905.45	400.84	401,853.77	2.37	41.55	32.01	10.91
Fisher	11.27	242.33	32.82	33,494.74	0.19	3.58	3.70	1.02
Floyd	14.75	248.26	40.00	35,273.98	0.19	3.63	3.91	1.17
Foard	4.71	93.37	20.41	13,228.08	0.07	1.32	1.63	0.57
Franklin	37.35	793.12	180.96	128,199.88	0.68	11.76	10.21	3.98
Freestone	76.87	2,153.56	445.54	359,923.07	1.97	33.99	24.83	9.83
Frio	59.74	1,784.91	341.49	284,941.77	1.48	26.91	19.23	7.31
Gaines	54.45	1,161.65	184.41	170,081.17	0.92	17.71	17.11	5.11
Garza	16.62	515.05	85.50	86,814.34	0.47	9.10	6.67	2.21
Gillespie	64.78	1,157.55	161.23	173,355.01	0.93	17.35	16.37	4.87
Glasscock	14.24	466.60	60.07	66,822.34	0.37	7.23	6.87	1.90
Goliad	17.36	431.98	66.61	69,747.03	0.40	6.60	6.47	2.03
Gonzales	71.62	2,192.83	279.87	298,428.91	1.76	31.07	23.05	7.82
Gray	55.51	1,011.58	232.61	157,148.43	0.80	15.33	13.54	5.08
Grayson	386.93	7,108.14	1,035.31	950,378.76	5.55	99.20	97.39	30.11
Grimes	90.99	1,948.81	292.17	282,705.62	1.63	28.52	28.53	8.68
Hale	61.95	1,258.29	216.16	190,105.76	1.01	19.53	16.91	5.51
Hall	14.13	366.28	84.58	57,198.95	0.30	5.70	5.08	2.03
Hamilton	26.38	504.04	83.31	74,436.99	0.39	7.33	6.77	2.23
Hansford	14.61	236.96	48.29	34,273.57	0.18	3.40	4.15	1.31
Hardeman	20.73	521.42	143.76	82,654.62	0.42	7.91	7.00	2.97
Hartley	23.65	617.63	128.46	104,691.59	0.54	10.63	9.70	3.26
Haskell	13.88	315.64	44.75	44,858.07	0.25	4.77	4.04	1.21
Hemphill	11.55	196.64	41.04	29,241.52	0.15	2.87	2.91	1.01
Henderson	214.03	3,432.35	447.85	432,032.54	2.58	45.61	46.87	13.88
Hidalgo	1,731.01	30,507.77	3,639.66	3,622,983.97	26.74	379.63	485.10	121.22
Hill	160.45	3,985.43	1,015.03	715,896.00	3.72	61.50	51.18	21.19

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}^2	$PM_{2.5}^2$
Hockley	49.13	929.17	142.45	132,315.97	0.72	13.89	14.95	4.28
Hopkins	118.88	2,623.95	514.23	406,159.52	2.21	38.81	31.62	11.99
Houston	57.08	1,085.23	185.15	154,362.84	0.86	15.30	16.02	5.09
Howard	86.56	1,978.73	424.21	330,183.05	1.68	31.18	27.30	9.59
Hudspeth	50.39	1,690.35	737.64	447,577.58	1.92	33.60	24.64	13.14
Hutchinson	45.70	625.34	109.34	80,684.38	0.42	8.16	10.20	3.12
Irion	10.06	277.79	35.64	40,021.37	0.22	4.32	3.29	1.02
Jack	22.60	460.20	66.17	67,188.70	0.36	6.84	6.37	1.90
Jackson	47.62	1,336.17	201.77	184,615.90	1.09	18.97	18.31	5.67
Jasper	81.54	1,698.23	211.25	238,573.86	1.42	24.78	23.40	6.77
Jeff Davis	8.56	212.21	66.20	44,274.76	0.20	3.72	3.68	1.43
Jim Hogg	10.08	199.67	22.68	25,041.70	0.19	2.71	2.63	0.72
Jim Wells	73.04	1,595.27	221.03	240,431.71	1.79	23.59	22.78	6.62
Jones	37.13	708.20	100.30	99,065.82	0.54	10.40	9.85	2.90
Karnes	36.99	911.65	145.95	144,801.11	0.83	13.68	14.86	4.48
Kenedy	11.83	603.50	74.56	87,893.90	0.65	9.45	5.87	1.95
Kent	2.74	66.93	9.00	9,423.46	0.05	1.01	1.07	0.29
Kerr	119.09	2,107.99	292.44	298,861.95	1.61	30.05	26.52	8.28
Kimble	35.17	997.28	228.30	137,120.76	0.74	13.36	8.29	3.53
King	3.11	104.10	21.49	16,676.72	0.09	1.71	1.43	0.56
Kinney	9.95	270.09	40.14	40,873.92	0.21	4.08	2.98	1.02
Kleberg	56.80	1,179.68	182.08	174,193.59	1.30	17.05	17.56	5.03
Knox	11.58	224.05	47.19	31,824.79	0.17	3.18	3.15	1.20
Lamar	128.46	2,281.67	321.49	288,616.77	1.72	30.90	31.26	9.37
Lamb	31.15	633.94	99.65	94,457.08	0.51	9.87	9.30	2.81
Lampasas	63.99	1,119.44	153.83	141,360.49	0.77	15.16	14.61	4.52
La Salle	51.62	1,627.37	529.48	322,151.95	1.46	25.28	19.38	9.54
Lavaca	51.91	983.26	120.20	122,019.39	0.73	12.77	13.32	3.93
Lee	47.15	1,004.64	136.13	152,488.58	0.90	15.28	12.99	4.00
Leon	72.51	2,198.18	405.68	357,962.50	1.97	34.23	24.31	9.46
Limestone	57.11	1,060.69	159.65	145,925.47	0.85	14.55	17.00	4.94
Lipscomb	8.83	147.76	31.08	21,252.13	0.11	2.10	2.68	0.83
Live Oak	53.75	1,893.11	406.91	339,914.48	1.86	29.72	21.47	8.90
Llano	56.71	898.65	120.64	124,569.81	0.68	12.49	14.66	3.98
Loving	7.20	366.72	20.80	50,632.16	0.31	5.83	6.70	1.26
Lubbock	579.80	10,160.45	1,436.47	1,343,710.36	7.43	143.15	169.86	45.01
Lynn	18.51	495.79	79.80	80,553.16	0.43	8.44	6.61	2.14
McCulloch	30.19	503.80	74.40	62,679.63	0.34	6.69	5.45	1.87

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[2]	$PM_{2.5}$[2]
McLennan	246.97	11,014.40	1,919.79	1,787,944.31	10.22	177.56	177.29	52.71
McMullen	15.95	303.76	51.29	44,308.01	0.31	4.34	4.56	1.35
Madison	34.64	1,383.81	247.59	232,015.52	1.28	22.47	15.98	6.02
Marion	66.71	626.37	79.10	63,757.47	0.37	6.38	6.56	2.26
Martin	106.08	1,476.42	256.72	230,095.94	1.20	21.10	19.14	6.69
Mason	13.72	231.25	30.65	33,092.94	0.18	3.29	3.13	0.94
Matagorda	315.86	2,317.38	254.13	193,638.12	1.17	18.60	23.44	7.95
Maverick	38.29	1,639.45	268.54	240,708.95	1.27	24.54	29.53	7.61
Medina	122.89	2,281.08	371.19	329,465.54	1.74	31.77	27.60	9.22
Menard	8.51	209.69	27.97	29,734.31	0.17	3.19	2.94	0.86
Midland	418.58	7,551.68	1,246.77	1,131,852.42	6.15	110.34	128.43	35.37
Milam	67.88	1,315.95	207.63	187,016.53	1.08	18.69	18.03	5.70
Mills	18.08	387.20	50.86	49,249.36	0.27	5.38	4.58	1.45
Mitchell	26.29	845.08	164.85	143,924.16	0.74	13.96	9.06	3.58
Montague	64.53	1,221.36	198.44	164,244.08	0.88	16.92	15.08	4.95
Moore	55.70	907.95	197.31	134,905.86	0.69	13.29	13.75	4.71
Morris	32.83	662.86	121.48	103,930.15	0.57	10.04	8.11	2.99
Motley	4.36	79.47	16.05	11,127.48	0.06	1.12	1.27	0.46
Nacogdoches	149.19	2,763.70	483.09	399,979.16	2.23	39.75	45.01	13.69
Navarro	120.61	2,961.65	479.33	469,624.42	2.67	45.48	36.09	12.17
Newton	28.26	594.88	72.99	82,678.25	0.49	8.60	8.90	2.46
Nolan	53.43	1,470.11	339.93	247,466.25	1.26	23.15	17.26	6.72
Nueces	531.22	11,760.07	1,024.41	1,499,648.32	9.55	159.30	156.00	39.53
Ochiltree	28.36	447.00	99.94	64,450.75	0.33	6.40	8.27	2.59
Oldham	22.87	917.84	195.19	164,437.92	0.83	16.44	9.08	4.04
Palo Pinto	76.24	1,570.14	332.17	267,375.05	1.34	24.39	21.79	7.76
Panola	75.69	1,574.04	246.48	213,165.06	1.25	22.27	20.10	6.29
Parmer	22.33	507.88	86.31	79,571.52	0.43	8.23	6.75	2.21
Pecos	56.28	1,545.11	394.83	277,853.56	1.42	24.77	20.56	7.58
Polk	146.63	2,747.04	483.12	399,618.10	2.23	39.47	38.02	12.67
Potter	298.56	5,378.65	1,288.06	827,652.79	4.18	79.66	87.63	29.14
Presidio	17.93	292.89	56.46	44,397.05	0.22	4.30	3.85	1.35
Rains	35.73	591.33	82.05	74,620.55	0.44	7.89	7.32	2.35
Randall	317.55	4,592.06	847.42	628,934.27	3.25	62.89	75.39	23.46
Reagan	19.96	464.81	66.30	62,948.38	0.35	6.66	6.78	1.92
Real	9.64	157.26	19.87	19,786.10	0.11	2.10	2.27	0.64
Red River	33.94	671.65	89.63	88,099.10	0.52	9.45	8.47	2.65
Reeves	61.83	1,980.84	436.98	362,872.71	1.89	33.62	29.81	9.84

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[2]	$PM_{2.5}$[2]
Refugio	24.99	862.24	142.79	148,527.27	0.85	14.01	12.82	4.14
Roberts	4.16	107.50	23.03	17,825.07	0.09	1.78	1.80	0.59
Robertson	54.76	1,261.21	201.65	189,269.93	1.09	19.01	17.16	5.52
Runnels	26.63	535.57	69.63	72,169.80	0.40	7.69	6.89	2.06
Sabine	28.15	470.10	71.05	62,922.85	0.36	6.34	6.77	2.10
San Augustine	22.11	434.39	68.30	62,039.60	0.35	6.25	5.93	1.93
San Jacinto	71.88	1,364.78	218.98	198,246.60	1.11	19.78	19.17	6.26
San Patricio	138.92	3,222.05	407.67	470,167.07	2.81	46.37	43.92	12.91
San Saba	17.29	317.77	41.88	38,609.18	0.21	4.19	3.90	1.20
Schleicher	6.73	140.92	17.79	19,225.48	0.11	2.06	1.72	0.53
Scurry	44.84	914.37	171.65	140,549.38	0.74	13.99	14.37	4.40
Shackelford	9.02	194.43	27.33	27,335.17	0.15	2.91	2.75	0.79
Shelby	69.02	1,235.10	198.29	172,986.16	0.97	17.31	17.47	5.59
Sherman	11.71	335.76	75.91	58,330.65	0.30	5.83	5.06	1.77
Somervell	22.89	403.48	56.21	56,595.01	0.33	5.75	5.80	1.68
Starr	130.96	2,095.30	240.63	248,380.84	1.83	25.99	30.04	7.85
Stephens	22.82	394.73	56.22	48,518.97	0.26	5.14	5.41	1.65
Sterling	9.49	291.50	42.63	43,363.43	0.24	4.60	3.12	1.05
Stonewall	4.38	96.25	13.32	13,580.88	0.07	1.45	1.36	0.39
Sutton	21.84	807.32	93.41	108,722.67	0.62	12.11	5.75	2.13
Swisher	20.36	547.66	111.29	89,041.49	0.46	8.87	7.09	2.47
Taylor	331.64	5,592.87	1,351.83	929,782.09	4.61	82.60	112.51	34.66
Terrell	3.62	95.54	20.44	17,866.45	0.09	1.63	1.29	0.46
Terry	29.43	695.07	113.54	107,830.06	0.58	11.29	9.82	3.03
Throckmorton	3.99	92.62	13.02	12,724.82	0.07	1.38	1.34	0.39
Titus	81.56	1,744.13	283.10	260,529.44	1.46	25.87	22.01	7.48
Tom Green	250.92	3,854.80	461.62	461,978.97	2.62	49.58	57.88	15.47
Trinity	38.27	643.46	100.22	89,477.02	0.50	8.99	9.36	2.97
Tyler	45.24	847.60	100.61	115,177.76	0.69	11.94	11.10	3.26
Upton	13.67	388.15	78.71	71,250.19	0.37	6.69	7.82	2.23
Uvalde	52.09	985.62	127.88	136,612.57	0.74	13.94	13.98	3.97
Val Verde	102.99	1,367.21	191.78	168,050.60	0.89	16.81	18.30	5.32
Van Zandt	167.48	3,987.76	471.53	477,810.94	2.98	53.41	39.20	12.48
Victoria	190.30	4,086.29	562.00	533,646.71	3.18	55.04	60.37	17.65
Walker	154.32	3,898.91	701.45	599,422.59	3.34	57.47	48.77	17.10
Ward	52.04	1,572.54	328.47	279,395.21	1.46	26.00	21.31	7.31
Washington	99.72	2,191.16	326.07	314,280.22	1.82	31.74	32.34	9.68

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[2]	$PM_{2.5}$[2]
Webb	569.18	9,716.07	1,567.16	1,250,114.67	6.50	120.85	146.20	41.33
Wharton	106.31	2,516.67	352.14	338,631.87	2.01	35.11	35.38	10.67
Wheeler	26.26	742.92	177.86	120,407.62	0.60	11.52	8.07	3.64
Wichita	270.92	4,492.67	730.57	597,478.76	3.18	60.96	63.61	19.71
Wilbarger	38.67	913.93	142.01	130,741.44	0.71	13.83	11.69	3.72
Willacy	42.95	938.49	109.97	118,977.25	0.87	12.43	11.05	3.25
Winkler	27.57	734.19	141.71	128,541.54	0.68	12.20	15.13	4.17
Wood	111.53	1,721.91	222.59	212,134.49	1.27	22.36	23.70	7.00
Yoakum	25.84	497.59	82.17	72,339.55	0.39	7.50	8.65	2.46
Young	47.49	702.15	98.77	87,636.76	0.47	9.12	9.76	2.94
Zapata	27.97	523.71	57.24	63,005.36	0.35	6.71	5.99	1.74
Zavala	27.97	637.67	98.46	92,272.16	0.48	9.15	7.97	2.53
All Counties[1]	18,459.37	369,087.60	58,227.82	52,207,313.43	301.67	5,228.74	5,260.84	1,599.99

[1] This table includes all Texas counties outside the areas comprised of the 39 counties of the Austin, BPA, DFW, El Paso, HGB, San Antonio, and TLM metropolitan planning areas. An HPMS-based methodology was used for these counties.

[2] PM emissions are total, direct vehicle emissions (exhaust, brakewear, and tirewear). No re-suspended dust from roadways was included.

APPENDIX M: ROAD DUST CALCULATOR INPUT (ELECTRONIC ONLY)

This appendix includes four spreadsheets on the input for the Texas road dust calculator. It is available electronically only.