ABSTRACT

TITLE:	Development of Dallas-Fort Worth (DFW) Area and On-Road Emissions Inventories for 2019, 2023, and 2026
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AUTHORS:	Chris Klaus Senior Program Manager Jenny Narvaez Program Manager Vivek Thimmavajjhala Transportation System Modeler Nick Van Haasen Air Quality Planner
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SOURCES OF COPIES:	Transportation Department North Central Texas Council of Governments PO Box 5888 Arlington, Texas 76005-5888 (817) 695-9240
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ABSTRACT:	The Texas Commission on Environmental Quality (TCEQ) is planning for future state implementation plan (SIP) submissions to the US Environmental Protection Agency (EPA) that will likely be required under the 2008 8-hour ozone standard of 75 parts per billion (ppb) and the 2015 8-hour ozone standard of 70 ppb. To support attainment demonstration modeling for these efforts, TCEQ is currently developing a 2019 base case ozone episode. At this time, nine of the DFW counties are expected to be reclassified as a moderate

nonattainment area for the 2015 8-hour ozone standard with an attainment date of August 3, 2024. If required, an attainment demonstration analysis would need to be based on future year emissions estimates for 2023, which represents the complete ozone season prior to the required attainment date. Ten of the DFW counties are expected to be reclassified as a severe nonattainment area for the 2008 8-hour ozone standard with an attainment date of July 20, 2027. If required, an attainment demonstration analysis would need to be based on future year emissions estimates for 2026, which represents the complete ozone season prior to the required attainment date.

The Travel Demand Model (TDM) network managed by the North Central Texas Council of Governments (NCTCOG) for the DFW area covers Collin, Dallas, Denton, Ellis, Hood, Hunt, Johnson, Kaufman, Parker, Rockwall, Tarrant, and Wise counties. Hood and Hunt counties are not classified as nonattainment under either the 70 ppb or 75 ppb standards. They are included in work under this PGA because these counties are part of the large regional domain used by the TCEQ for air quality modeling purposes. The latest available version of the EPA's Motor Vehicle Emission Simulator (MOVES) model, MOVES3 will be used for the inventory development work.

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Michael Morris, P.E.	Director of Transportation
Dan Kessler	Assistant Director of Transportation
Emily Beckham	Grants and Contract Manager
Cecilia Howard	Senior Administrative Assistant
Dan Lamers, P.E.	Senior Program Manager
Kurt Lehan	Senior Transportation Planner
Arash Mirzaei, P.E.	Senior Program Manager
Ashley Releford	Senior Grants and Contracts Coordinator
Evan Paret	Grants and Contracts Coordinator I
Francisco Torres	Data Applications Manager
Mitzi Ward	Principal Transportation Planner
Kathleen Yu	Principal Transportation System Modeler
Chris Kite	Texas Commission on Environmental Quality
Chris Owen	Texas Commission on Environmental Quality
Shantha Daniel	Texas Commission on Environmental Quality
Donna Cooper	Texas Commission on Environmental Quality

GLOSSARY OF ABBREVIATIONS

ADSIP	-	Attainment Demonstration State Implementation Plan
ASWT	-	Average School Season Weekday Traffic
ASM	-	Acceleration Simulation Mode
ATR	-	Automatic Traffic Recorder
AVFT	-	Alternative Vehicle Fuel Technology
CAAA	-	Clean Air Act Amendments
CO	-	Carbon Monoxide
CO_2	-	Carbon Dioxide
DFW	-	Dallas-Fort Worth
EPA	-	Environmental Protection Agency
ETBE	-	Ethyl Tertiary Butyl Ether
GIS System	-	Geographic Information
GISDK	-	Geographic Information System Developer Kit
H_2O	-	Water vapor
HBW	-	Home-Based Work
HNW	-	Home-Based Non-Work
HONO	-	Nitrous Acid
HOV	-	High Occupancy Vehicle
HPMS	-	Highway Performance Monitoring System
I/M	-	Inspection & Maintenance Program
MPA	-	Metropolitan Planning Area
MPO	-	Metropolitan Planning Organization
MOVES3	-	Motor Vehicle Emissions Simulator version 3
MTBE	-	Methyl Tertiary Butyl Ether
NAAQS	-	National Ambient Air Quality Standards
NCOM	-	Non-carbon Organic Matter
NCT	-	North Central Texas
NCTCOG	-	North Central Texas Council of Governments
NH_3	-	Ammonia
NH_4	-	Ammonium
NHB	-	Non-Home Based
NO	-	Nitrogen Oxide
NO_2	-	Nitrogen Dioxide
NO_3	-	Nitrate
NO_X	-	Oxides of Nitrogen
NonECPM	-	Non Elemental Carbon Particulate Matter
O_3	-	Ozone
PAH	-	Polycyclic Aromatic Hydrocarbon
ppb	-	parts per billion
PM	-	Particulate Matter
$PM_{2.5}$	-	Particulate Matter 2.5 Microns
PM_{10}	-	Particulate Matter 10 Microns
RVP	-	Reid Vapor Pressure
SIP	-	State Implementation Plan
SO_2	-	Sulfur Dioxide
SUT	-	Source Use Type
TAFT	-	Transportation Analytical Forecasting Tool
TAME	-	Tertiary Amyl Methyl Ether
TCEQ	-	Texas Commission on Environmental Quality
TOD	-	Time-of-Day
TSZ	-	Traffic Survey Zone
TTI	-	Texas A&M Transportation Institute
TxDMV	-	Texas Department of Motor Vehicles
TxDOT	-	Texas Department of Transportation
TxLED	-	Texas Low Emission Diesel
UI	-	User Interface
VHT	-	Vehicle Hours of Travel
VMT	-	Vehicle Miles of Travel
VDF	-	Volume Delay Function
VOC	-	Volatile Organic Compounds

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CHAPTER 1: INTRODUCTION

The North Central Texas Council of Governments (NCTCOG) conducted 2019, 2023, and 2026 on-road emissions inventories to support the Texas Commission on Environmental Quality's (TCEQ) efforts to develop modeling work for the Attainment Demonstration State Implementation Plan (ADSIP). These inventories will serve as base-case (2019) validation and future year (2023 and 2026) attainment demonstrations in TCEQ's photochemical modeling efforts. The successful completion of this project will ensure the TCEQ continues employing accurate and detailed on-road mobile source emission inventories, providing timely support of SIP development and overall TCEQ planning activities. The emissions inventory analysis period covers summer and school seasons within the North Central Texas (NCT) 12-county Metropolitan Planning Area (MPA): Collin, Dallas, Denton, Ellis, Hood, Hunt, Johnson, Kaufman, Parker, Rockwall, Tarrant, and Wise counties. Pollutants being evaluated are volatile organic compounds (VOC), carbon monoxide (CO), nitrogen oxide (NO), nitrogen dioxide (NO_2), nitrous acid (HONO), oxides of nitrogen (NO_X), carbon dioxide (CO_2), methane (CH_4), sulfur dioxide (SO_2), ammonia (NH_3), nitrous oxide (N_2O), particulate matter with aerodynamic diameters equal to or less than 2.5 microns ($PM_{2.5}$) - total, brake wear, tire wear, organic carbon, elemental carbon, sulfate, composite – nonECPM, and non-carbon organic matter, particulate matter with aerodynamic diameters equal to or less than 10 microns (PM_{10}) – total, brake wear, tire wear, nitrate (NO_3), ammonium (NH_4), Chloride (Cl), Sodium (Na), Potassium (K), Magnesium (Mg), Calcium (Ca), Titanium (Ti), Silicon (Si), Aluminum (Al), Iron (Fe), Aerosol H_2O (H_2O), and Non-Carbon Organic Matter (NCOM).

This report documents the methodology and results of the 2019, 2023, and 2026 On-Road Mobile Source Emissions Inventory. Chapter 1 outlines the background, purpose, scope, and modeling approach for the emissions inventory and provides a summary of the 12-county estimated emission totals.

Chapter 2 documents the procedures used to develop regional vehicle activity estimates in terms of vehicle miles of travel (VMT) and average vehicle speed. These procedures include development of adjustment factors to reflect regional conditions more accurately. Seasonal and hourly adjustment factors were applied to produce summer and school season vehicle activity, and report vehicle activity in hourly periods. Consistent with previous emissions inventory practices, a comparison was made between travel demand model VMT estimates and appropriate Highway Performance Monitoring System (HPMS) VMT, to develop HPMS adjustment factors. Also, a nonrecurring congestion adjustment was applied to account for vehicle emissions due to traffic accidents not captured in the standard four-step travel modeling process.

Chapter 3 documents the procedures used to develop the vehicle population off-network activity estimates.

Chapter 4 identifies the parameters and inputs used to develop on-road mobile source emission factors by utilizing the United States Environmental Protection Agency's (EPA) Motor Vehicle Emissions Simulator version 3 (MOVES3) model. Regionally specific calculations, procedures, MOVES3 emission factors, and adjustments are provided to better reflect regional vehicle emissions emitted. The calculations and procedures include source use type age distribution, fuel engine fractions, hourly VMT, etc. Also accounted for is low emission diesel NO_X adjustments.

Chapter 5 includes the 12-county area vehicle emission calculation flowchart.

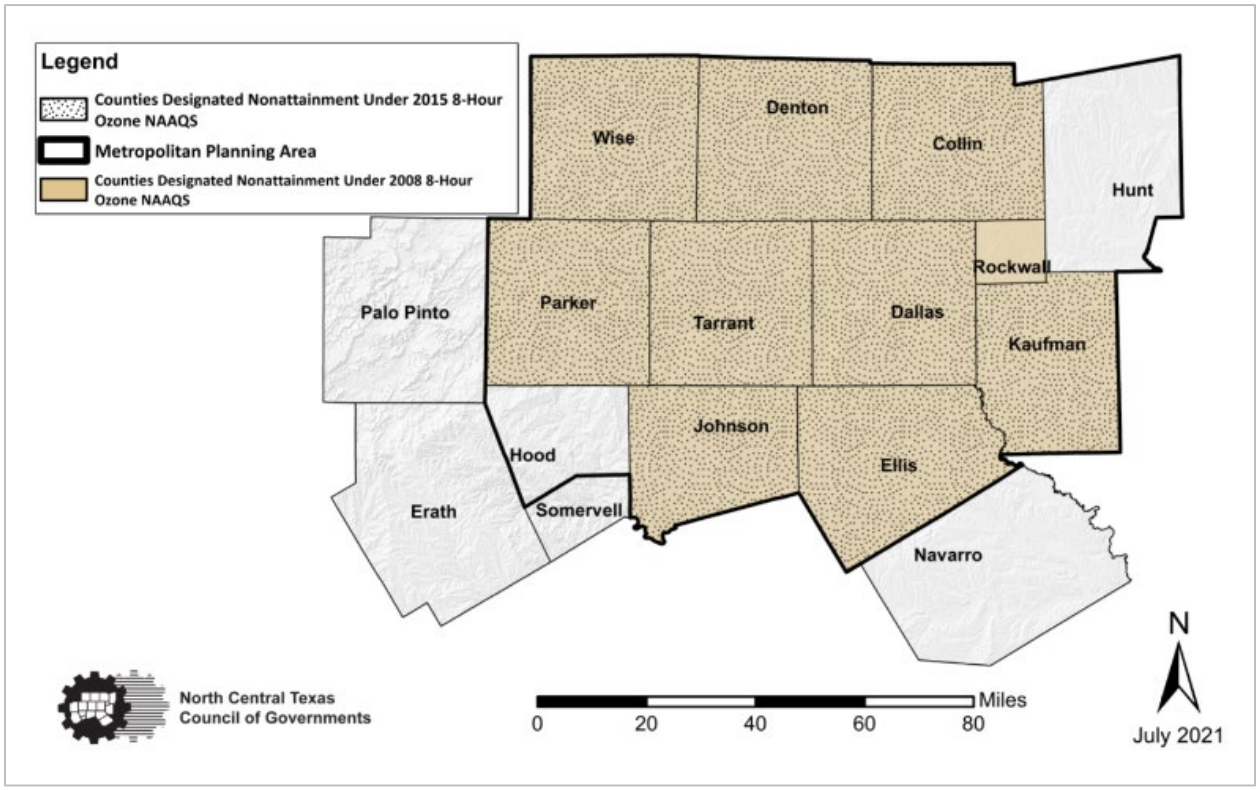
Chapter 6 documents VMT, average vehicle speed, and NO_X, VOC, CO, CO_2, NO, and NO_2 emissions by day of week and county.

The Appendix contains supplemental information referenced in this document, as well as the electronic data supporting the Dallas-Fort Worth (DFW) 2019, 2023, and 2026 On-Road Mobile Emissions Inventory.

Background

TCEQ is planning for a future SIP submission to the US EPA that may be required under both the ozone standards, the 2008 8-hour ozone standard of 75 parts per billion (ppb), and the 2015 8-hour ozone standard of 70 ppb. Under these standards, 10 counties (Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker, Rockwall, Tarrant, and Wise) and nine counties (Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker, Tarrant, and Wise) within the DFW area are classified as nonattainment respectively. Hood and Hunt counties are classified as attained but are included in this work because they are contained within the travel demand model network managed by NCTCOG. At this time, the DFW 10-county area (exhibit 1.1) is expected to be reclassified as a severe nonattainment area for the 2008 8-hour ozone standard with an attainment date of July 20, 2027. The DFW 9-county area (exhibit 1.1) is expected to be reclassified as a moderate nonattainment area for the 2015 8-hour ozone standard with an attainment date of August 3, 2024. If required, an attainment demonstration analysis would need to be based on future year emissions estimates for 2026 and 2023, representing the corresponding complete ozone seasons prior to the required attainment dates. TCEQ is currently developing a 2019 base case ozone episode. For major metropolitan areas such as DFW, on-road emission inventories need to be developed using activity data from local travel demand models.

Exhibit 1.1: DFW Nonattainment Area Map



NCTCOG applies a four-step travel demand model process using TransCAD software to forecast regional vehicle activity and utilizes the EPA's MOVES3 with a post-processing application to estimate regional mobile source emissions.

Modeling Approach

The Transportation Analytical Forecasting Tool (TAFT) is employed to estimate VMT and emissions for the 2019, 2023, and 2026 summer and school seasons. TAFT's modeling domain includes Collin, Dallas, Denton, Ellis, Hill, Hood, Hunt, Johnson, Kaufman, Parker, Rockwall, Tarrant, and Wise counties. Hill County is not part of the NCT MPA boundary; however, to capture travel from outside areas, Hill County is included in the modeling domain. The 13-county TAFT modeling domain is shown in Exhibit 1.2.

Several components of the model were updated as part of this model development. These include improvements to the following: mode-choice model; vehicle ownership model; external stations; volume-delay-function; transit assignment, and traffic assignment convergence criteria, which are discussed in Chapter 2. The final 2019, 2023, and 2026 on-road emission estimates by pollutant for summer and school day types are shown in Exhibits 1.3, 1.4, and 1.5. The appendix also contains the detailed emissions by county by pollutant by day type and time-of-day, respectively for all NCT counties modeled.

Exhibit 1.2 DFW Travel Demand Modeling Domain Map

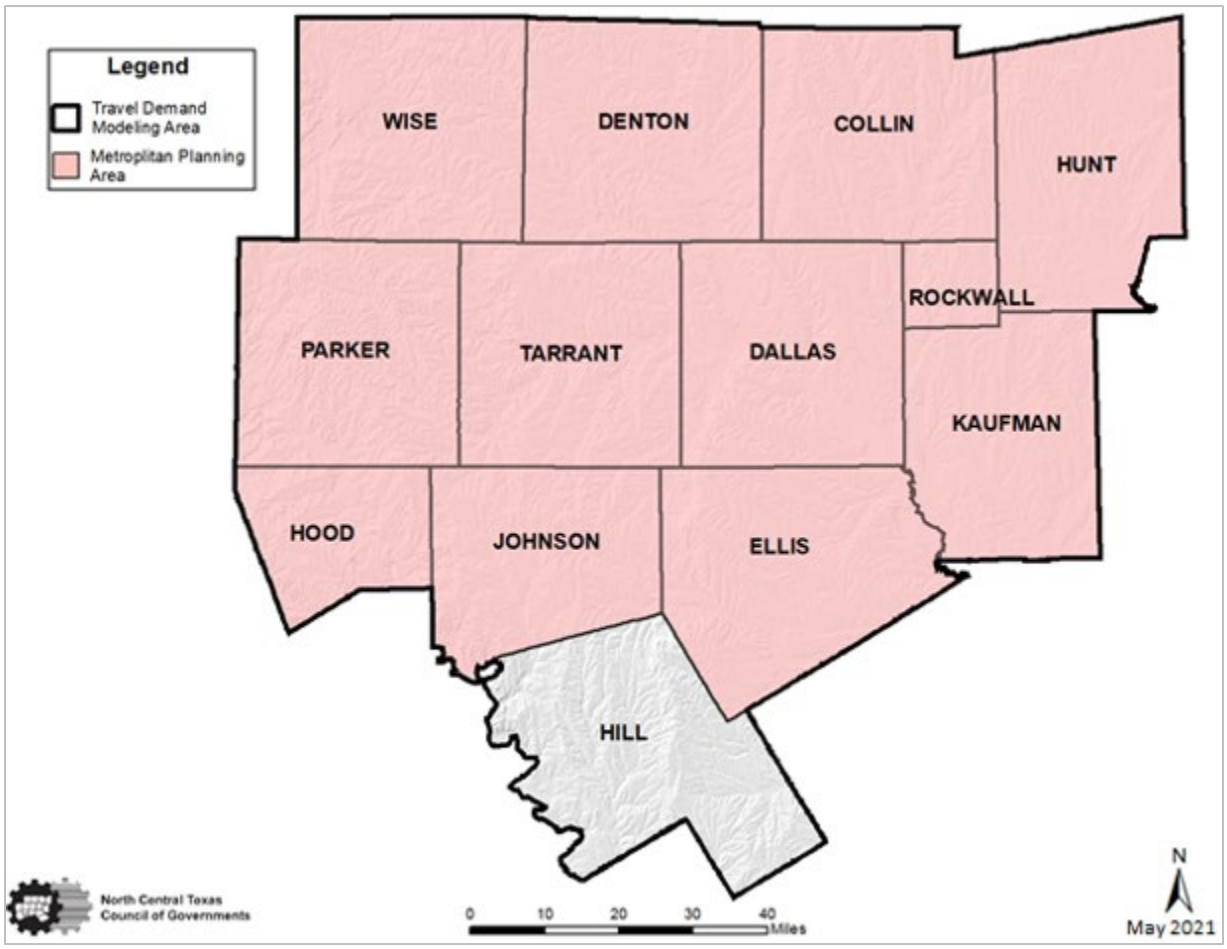


Exhibit 1.3: 2019 Emission Inventory Summary for the DFW 12-County MPA

Summer Season Total Emissions (tons per day)						
	NO_X	VOC	CO	CO_2	NO	NO_2
Midweek	107.83	50.42	972.17	117,804.75	86.26	20.71
Friday	116.84	51.91	1,055.02	128,458.46	93.44	22.47
Saturday	80.63	45.18	861.22	99,637.94	65.63	14.35
Sunday	63.95	42.21	729.16	80,665.17	52.58	10.86
School Season Total Emissions (tons per day)						
	NO_X	VOC	CO	CO_2	NO	NO_2
Midweek	105.71	49.53	953.51	115,916.12	84.53	20.33
Friday	115.86	51.23	1,044.95	127,735.59	92.59	22.35
Saturday	79.23	44.55	848.58	98,435.79	64.46	14.13
Sunday	61.95	41.43	709.16	78,641.59	50.93	10.53

Exhibit 1.4: 2023 Emission Inventory Summary for the DFW 12-County MPA

Summer Season Total Emissions (tons per day)						
	NO_X	VOC	CO	CO_2	NO	NO_2
Midweek	76.35	39.93	836.90	115,726.78	56.72	19.02
Friday	82.45	40.90	907.52	126,022.29	61.22	20.57
Saturday	54.20	35.88	738.92	97,401.69	41.33	12.43
Sunday	42.27	33.83	623.90	78,807.67	32.76	9.17
School Season Total Emissions (tons per day)						
	NO_X	VOC	CO	CO_2	NO	NO_2
Midweek	74.72	39.25	821.35	113,832.85	55.47	18.65
Friday	81.70	40.37	899.60	125,294.61	60.59	20.45
Saturday	53.17	35.40	728.45	96,187.15	40.53	12.22
Sunday	40.84	33.25	607.01	76,786.82	31.66	8.86

Exhibit 1.5: 2026 Emission Inventory Summary for the DFW 12-County MPA

Summer Season Total Emissions (tons per day)						
	NO_X	VOC	CO	CO_2	NO	NO_2
Midweek	63.67	34.29	751.49	113,792.57	44.58	18.58
Friday	68.57	35.02	814.36	123,741.71	47.96	20.06
Saturday	43.35	30.83	660.93	95,495.45	31.11	11.89
Sunday	33.29	29.21	557.14	77,259.75	24.34	8.68
School Season Total Emissions (tons per day)						
	NO_X	VOC	CO	CO_2	NO	NO_2
Midweek	62.22	33.72	737.62	111,887.40	43.53	18.19
Friday	67.89	34.57	807.45	122,990.96	47.41	19.93
Saturday	42.48	30.43	651.69	94,280.49	30.46	11.68
Sunday	32.11	28.73	542.10	75,254.61	23.47	8.38

CHAPTER 2: VEHICLE ACTIVITY ESTIMATION PROCEDURES

This chapter discusses the methodology used in estimating the vehicle activity measures influencing air quality in the North Central Texas area. These measures include the following: vehicle miles of travel (VMT) and average speed. The current Dallas-Fort Worth Transportation Analytical Forecasting Tool (TAFT) covers the 12-county Metropolitan Planning Area (MPA) of Collin, Dallas, Denton, Ellis, Hood, Hunt, Johnson, Kaufman, Parker, Rockwall, Tarrant, and Wise counties, plus Hill County. The VMT and speeds were estimated with the TAFT using a link-based methodology for each time period.

Transportation Analytical Forecasting Tool

The source of VMT estimates for the Reasonable Further Progress (RFP) Emission Inventories for the nonattainment counties is the network-based TAFT executed by the North Central Texas Council of Governments (NCTCOG) Transportation Department in the TransCAD environment. TransCAD is a Geographic Information System-based commercial travel demand software package for transportation planning. TAFT supports federally required regional transportation planning efforts for the Dallas-Fort Worth (DFW) area. Since 1974, NCTCOG has served as the Metropolitan Planning Organization (MPO) for the DFW area. The Transportation Department provides technical support and staff assistance to the Regional Transportation Council and its technical committees that comprise the MPO policy-making structure.

Multimodal Transportation Analysis Process

The forecasting technique of TAFT is based on a multi-step sequential process designed to model travel behavior and predict travel demand at regional, sub-area, or corridor levels. These steps are Trip Generation, Trip Distribution, Mode Choice, and Roadway Assignment.

The roadway network developed for the RFP Emissions Inventories contains over 40,000 unique segments constructed to replicate the transportation system of the coverage area. For this RFP inventory, the transportation network was developed for the years 2019, 2023, and 2026. Each facility link in the network has the following attributes:

- Network Node Numbers (defining the beginning and end of each link)
- Number of Operational Lanes in the AM PM Peak and Off-Peak Periods
- Functional Classification
- Divided/Undivided Roadway Code
- Type of Traffic Control at Each End of the Link
- Traffic Direction (One- or Two-Way)
- Length of Link
- Estimated Loaded Speeds in Each Period
- Speed Limit
- Traffic Survey Zone
- Tolls
- Area Type
- Free-Flow Speeds
- Hourly Capacities
- Truck Exclusion Code
- Length of Link

Every roadway segment in the network falls in one of the functional classes of centroid connectors, freeways, principal arterials, minor arterials, collectors, ramps, frontage roads, and high occupancy vehicle (HOV) lanes, rail, and managed lanes.

Household trip purposes in the TAFT are defined in one of three ways: home-based work (HBW), which includes trips from home to work or work to home; home-based non-work (HNW), which includes non-work trips beginning or ending at home; non-home based (NHB), which includes trips where home is neither the origin nor the destination. TAFT also includes non-household trips, which cover commercial trips in the region. These trips are included in the model in three vehicle classes of auto, medium trucks, and heavy trucks. Trips that are not originated and ended entirely in the region are categorized as external trips in the same three vehicle classes as commercial vehicle trips. Finally, passenger trips to commercial airports are also included as a separate trip purpose in the regional travel model.

The model process begins with an estimate of the socio-economic variables for each zone. The data is organized by transportation analysis zone (TAZ), the smallest zone size available in the TAFT. There are 5,352 TAZs in the model (5,303 internal zones plus 47 externals). The data for each TAZ includes zone centroid; number of households; population; basic, retail, and service employment, and land area. This level of detail is retained in all modeling steps.

The Trip Generation Model generates the number of weekday person trips sent to and received from each zone. The Trip Distribution Model determines the trip interaction between each zone and the rest of the zones in the MPA. The Mode Choice Model divides the person trips into two categories of transit and automobile trips. The Assignment Model loads the auto demand onto the roadway network, and the transit passenger trips onto the transit network, commonly referred to as the four-step transportation modeling process. The TAFT model application is written by NCTCOG staff in the TransCAD script language known as the Geographic Information System Developer Kit (GISDK) and integrated with a user interface developed in Microsoft Visual Basic programming language.

Trip Generation Model

The Trip Generation Model is a computer program written in GISDK script language by NCTCOG staff. The Trip Generation Model converts the population and employment data into person trip ends and outputs the total number of trips produced by and attracted to each zone by trip purpose. The 2019, 2023, and 2026 population and employment forecasts were generated with the Disaggregate Residential Allocation Model/Employment Allocation Model using travel times from the Roadway and Transit Assignment Steps consistent with current planning practice.

The trip generation step uses a cross-classification model based on various market segmentation for different trip purposes to estimate the production and attraction trips for each TAZ. The market segmentations of the household and employment are based on the American Community Survey and Census Transportation Planning Products produced by the

Census Bureau and AASHTO respectively. Trips to hospitals, universities and other educational institutions, and K-12 trips school are treated with the special models in TAFT.

Exhibit 2.1: Socioeconomic Demographic Summary for the DFW 12-County Modeling Domain

	2019	2023	2026
Population	7,555,228	8,057,240	8,433,781
Number of Households	2,693,029	2,870,206	3,003,104
Employment Types			
Basic	1,163,639	1,170,847	1,178,095
Retail	465,406	499,473	533,513
Service	3,226,360	3,433,264	3,640,131
Total Employment	4,855,405	5,103,584	5,351,739

Trip Distribution Model

The Trip Distribution Model creates the trip interaction among TAZs using production and attraction person trips estimated in the Trip Generation step. The model uses a gamma-based gravity formulation technique to estimate the zone-to-zone interchange of trips. Iterations of the gravity model are required to ensure that the estimated number of zonal trips received equals the projected number of trip attractions generated by the Trip Generation Model. Trip Distribution uses auto travel time as the representation of impedance for traveling between zone pairs. The network travel times are the results of the Traffic Assignment step, and therefore, the feedback loop is designed in TAFT for internal consistency.

Mode Choice Model

The Mode Choice Model determines the mode of travel and auto occupancy. Using the information regarding trip maker characteristics (e.g., income and auto ownership), roadway and transit system characteristics (e.g., in-vehicle time and out-of-vehicle time), and travel costs (e.g., auto operating costs, parking costs, and transit fare), the model splits the trips among all applicable modes of travel. The model uses a multinomial logic formulation for all the trip purposes. The commercial vehicle trips and external trips are estimated as vehicle trips and do not require a modal split. The trip purposes of HBW, HNW, and NHB have nine choice sets: drive alone, two occupant shared ride, three + occupancy shared ride, walk access to bus service, auto access to bus service, walk access to rail service, auto access to rail service, walk access to bus and rail service with transfer, and auto access to bus and rail service with transfer.

Roadway Assignment

The Roadway Assignment Model consists of simultaneous user equilibrium origin-destination assignments of drive alone, shared-ride, and truck vehicle classes for three separate time-of-day periods (6:30 a.m. – 8:59 a.m. Morning Peak, 3:00 p.m. – 6:29 p.m. Evening Peak, and the 18-Hour Off-Peak). The drive alone vehicle class is kept separate from the shared-ride vehicle class so that HOV assignments can be performed as an integral part of an equilibrium assignment.

Trucks are kept separate from the other vehicle classes so that the modeled truck volumes on all links can be tracked, and a separate value-of-time can be defined for them. A generalized cost path building technique is embedded within the model, in which the iterative calculation of zone-to-zone impedances are based on weighting factors applied to the capacity-restrained travel time, the distance (representing fuel cost), and tolls. As is standard with all User Equilibrium procedures, the TransCAD program uses an iterative process to achieve a convergent solution in which no travelers can improve their path by shifting routes. Since the results of the three time-of-day assignments can be combined to obtain total weekday modeled volumes, validation checks can be performed with either time-of-day or weekday observed traffic counts.

Speed Estimation Procedure

The link speed in TAFT is estimated by dividing the length of the link by its loaded travel time. The loaded travel time is the sum of the free-flow travel time, traffic congestion delay, and the delay caused by the traffic control devices (e.g., stop signs, yield signs, and signals). These three elements of the loaded travel time are all functions of the link volume to capacity ratio. These functions are programmed in the volume delay function (VDF) that is an essential input to the traffic assignment step. The result of the traffic assignment step is the final time-period-specific average loaded speeds for each of the links in the roadway network. The VMT and vehicle hours of travel (VHT) for different time periods is included in the output as well to obtain an overall average speed (VMT/VHT) for any desired length of time.

The free-flow (uncongested) speed is defined as the speed limit. Free-flow speeds are an important link attribute since they are the base for calculating the congested (loaded) speeds in the Traffic Assignment step.

The VDF in the TAFT uses a conical congestion delay form defined for each link functional classification, a non-linear delay curve based on the Webster's uniform delay formulation at signalized intersections, and a linear delay curve for the stop and yield controlled approaches.

The volume-delay functions were originally calibrated based on more than 8,000 traffic counts collected in 2004. These functions were later adjusted based on National Performance Management Research Data Set (NPMRDS) and 2014 time-of-day traffic counts collected at about 20,000 observations. NPMRDS contains travel time data by 5-minute interval.

Finally, all of the delay elements are added to the uncongested travel time (based on the free-flow speeds) to produce the total loaded travel time on each roadway segment. Appendix contains speeds by county for each hour of the day. The resulting congested TAFT county speeds, weighted by VMT, are listed in Exhibit 2.2.

Exhibit 2.2: Average Summer Midweek Loaded Speeds (miles per hour)

Counties	2019	2023	2026
Collin	34.31	34.00	33.73
Dallas	33.64	33.18	32.89
Denton	36.38	35.67	34.84
Ellis	47.01	46.14	45.19
Hood	40.43	40.38	40.11
Hunt	46.82	46.60	46.35
Johnson	42.20	41.57	41.02
Kaufman	47.22	45.86	45.06
Parker	43.47	43.31	43.01
Rockwall	40.20	39.57	39.83
Tarrant	36.03	35.48	34.87
Wise	45.01	44.25	43.63
12-County Average	41.06	40.50	40.04

Local Street VMT

The roadway network of TAFT does not contain the details of local (residential) streets; however, a VMT estimate is possible based on data provided by the travel model. Local street VMT is calculated for each county by multiplying the number of intrazonal trips by the intrazonal trip length and then adding the VMT from the zone centroid connectors. The temporal distribution is assumed to be the same as for non-local streets.

Adjustments

Seasonal, Daily, and Hourly Adjustments

The vehicle activity data used for this analysis is representative of summer and school season. Automatic Traffic Recorder (ATR) data collected by Texas Department of Transportation (TxDOT) is used to calculate the necessary conversions. ATR data, averaged over five years (2015-2019), was used.

TAFT Counties Seasonal and Daily Adjustments

ATR data is organized into four-day types: Sunday, Midweek, Friday, and Saturday. To adjust the representative average school season weekday (ASWT) VMT from TAFT to the specified day types in the school and summer season, ratios are calculated. The school portion of the ratio was estimated using traffic volumes recorded for February, April, May, September, and October months, and the summer portion of the ratio utilizes traffic volumes recorded for June, July, and August months. Seasonal and daily adjustments for TAFT counties are listed in Exhibit 2.3.

Exhibit 2.3: Seasonal/Daily Adjustment Factors for the DFW 12-County Modeling Domain

	County Type	Sunday	Midweek	Friday	Saturday
TAFT Counties (ASWT to Summer)	Core (Dallas/Tarrant)	0.740	1.008	1.106	0.919
	Rural (Collin/Denton)	0.739	0.978	1.039	0.901
	Perimeter (Other Counties)	0.982	1.041	1.227	1.032
TAFT Counties (ASWT to School)	Core (Dallas/Tarrant)	0.734	1.000	1.104	0.918
	Rural (Collin/Denton)	0.739	1.000	1.083	0.930
	Perimeter (Other Counties)	0.911	1.000	1.203	0.976

Hourly Adjustments

Daily volumes recorded for each of the four-day types described above are aggregated by hour to determine the percent of daily traffic occurring during each hour, representing hourly vehicle activity estimates. The TAFT county midweek is further detailed by utilizing a time period volume for aggregation, as opposed to the daily volumes provided for the other day types. These time periods correspond to the time periods utilized in TAFT, where AM Peak is 6:30 a.m. to 8:59 a.m., PM Peak is 3:00 p.m. to 6:29 p.m., and Off-Peak represents all other hours of the day (12:00 a.m. to 6:29 a.m., 9:00 a.m. to 2:59 p.m., and 6:30 p.m. to 11:59 p.m.). Periods split by mid-hour times utilize an equal division of traffic recorded during the hour.

Model VMT Adjustments (HPMS vs. TAFT)

Consistent with previous emission inventory practices, the DFW MPO used TxDOT's Highway Performance Monitoring System (HPMS) data to adjust modeled VMT to reflect the HPMS data for consistent reporting across the State. This adjustment is based on EPA's guidance for emission inventory development.

NCTCOG performed a validation on the TAFT model in 2014 in order to meet the transportation conformity requirements per the Code of Federal Regulations, which states, "Network-based travel models must be validated against observed counts (peak and off-peak, if possible) for a base year that is not more than 10 years prior to the date of the conformity determination" (40CFR §93.122(b)(1)(i). NCTCOG incorporated the updated TAFT model validation which is based on 2010 demographics. Exhibit 2.5 shows the calculation performed to develop the new HPMS adjustment factor, 0.9889, based on a comparison of 2014 VMT for HPMS and TAFT.

Exhibit 2.4: 2014 DFW and HPMS VMT Analysis

Model VMT Adjustment Factor	
	2014 VMT
HPMS (ASWT)[1]	178,714,289
TAFT (ASWT)	180,721,839
HPMS/TAFT Ratio	**0.9889**

[1]Annual Average Daily Traffic to ASWT conversion factor applied.

Nonrecurring Congestion

According to a paper published in the January 1987 *Institute of Transportation Engineers'* journal by Jeffrey A. Lindley entitled Urban Freeway Congestion: Quantification of the Problem and Effectiveness of Potential Solutions, congestion due to traffic incidents accounts for twice as much as congestion from bottleneck situations. Congestion due to incidents, or nonrecurring congestion, causes emissions not represented in the VMT-based calculations of the base emissions. In order to include these effects, the delay caused by nonrecurring congestion is added to the freeway travel times and congestion delay due to bottlenecks to obtain an increased freeway travel time, which translates into reduced speed on freeway facilities. Arterial street emissions are not significantly affected by incidents because alternate routes on the arterial system are generally available; therefore, this factor is not applied to non-freeway type facilities.

VMT Estimates

The 2019, 2023, and 2026 VMT estimates for different day types are shown in Exhibit 2.6 respectively for the 12-county area. Appendix contains the VMT by county by day for each hour for all counties.

Exhibit 2.5: Vehicle Miles of Travel

All Counties – 24-Hour Total					
Analysis Year	**Season**	**Midweek**	**Friday**	**Saturday**	**Sunday**
2019	**Summer**	224,539,933	222,159,965	241,117,937	238,518,080
	School	248,642,442	248,208,964	267,090,337	266,579,387
2023	**Summer**	207,600,697	206,027,413	222,991,850	221,239,154
	School	172,345,048	168,931,344	185,235,097	181,513,251
2026	**Summer**	224,539,933	222,159,965	241,117,937	238,518,080
	School	248,642,442	248,208,964	267,090,337	266,579,387

CHAPTER 3: VEHICLE POPULATION AND OFF-NETWORK ACTIVITY

The non-roadway-based inventory estimates (e.g., from vehicle starts, parked vehicle evaporative processes, non-roadway-based vehicle idling, hotelling activity) were calculated as the product of the amount of associated activity and the mass per unit of activity. To estimate the source hours parked (SHP) and vehicle starts activity, vehicle population estimates were needed. Hotelling activity estimates (composed largely of the emissions-producing source hours extended idling [SHEI] and diesel auxiliary power unit [APU] hours) were based on county-specific actual estimates.[1]

MOVES3 UTL (utilities) and the methodology provided by the Texas A&M Transportation Institute (TTI) is used to calculate the vehicle population and off-network activity estimates.

Vehicle Type Populations

TTI based the vehicle population estimates on vehicle registration data, vehicle population factors developed from the VMT mix, and additionally for future years, VMT growth estimates. For a historical year, the vehicle population estimates are based on mid-year TxDOT (or TxDMV) county registrations data, if available, and regional, all roads-weekday VMT mix-based vehicle type population factors for the analysis year. For future years, vehicle type populations were estimated as a function of base (e.g., latest available, if available, mid-year) registrations, grown to a future value (growth as a function of base and future VMT), and all roads-weekday VMT mix-based vehicle type population factors for the analysis year. This same procedure may be used to back-cast vehicle populations for earlier years for which vehicle registrations are unavailable.

ONI Hours

ONI hours (new with MOVES3) are not related to combination truck hotelling activity. These are idling activities that occur while a vehicle is idling in a parking lot, drive-through, 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 activity consistent with the MOVES methodology. This is accomplished in general using a formula that calculates ONI as a function of MOVES default relationships on total idling and total operating hours, derived from telematics data, in combination with local roadway network activity estimates (VMT and speeds), and MOVES default road idling fractions (proportions of vehicle idling while operating on roads).

SHP

The SHP was estimated as a function of total hours (hours a vehicle exists) minus its hours operating on roads (source hours operating [SHO]) and minus ONI hours. For a historical year, the vehicle type SHP estimates are based on VMT mix, link VMT and speeds, and the vehicle

[1] Base estimates of hotelling hours used in this analysis are 2017 winter weekday estimates, developed by TTI during the truck idling study that produced county 24-hour hotelling estimate totals for all Texas counties, sponsored by TCEQ starting in 2017.

population estimates. The VMT mix is applied to the link VMT to produce vehicle-type-specific VMT estimates. Link VMT is divided by the associated speed to produce SHO estimates, which are aggregated by vehicle type and subtracted from associated source hours resulting in SHP estimates. For a future year, the vehicle type SHP was estimated in the same manner as for historical years, except using the future year link VMT and speeds, VMT mix, and vehicle population estimates. This was performed by county and hour.

Starts

Engine starts were based on the MOVES national default starts per vehicle, and the local, county vehicle type population estimates. MOVES default weekday and weekend day starts per vehicle were used. Weekday results were used for Weekday and Friday scenarios and weekend day starts were used for Saturday and Sunday scenarios. 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.

SHI and APU Hours

The SHI and APU hours, two of four activity components comprising the diesel combination long-haul truck hotelling hours, were estimated for each county activity scenario using TTI's current procedure and base and activity estimates from TCEQ's 2017 truck idling study. NCTCOG used the winter weekday, 24-hour, 2017 base county level hotelling estimates from the truck idling study in combination with county scaling factors estimated from the base year and the analysis year link VMT and VMT mixes to produce the 2019 and 2023, county, hourly hotelling activity estimates. Hotelling hourly factors (estimated by inverting hourly VHT factors) were then applied to allocate the 24-hour hotelling hours estimates for each county to each hour of the day. Estimated SHEI and APU hours fractions of hotelling hours based on an updated hotelling activity distribution from the truck idling study (which is the same as the MOVES3 default) were used to separate SHEI and APU hours activity from total hotelling hours, for each county and hour.

CHAPTER 4: EMISSION FACTOR ESTIMATION PROCEDURE

MOVES3 Model and Input Parameters

The Environmental Protection Agency's (EPA) Motor Vehicle Emission Simulator version 3 (MOVES3) was used to develop 2019, 2023, and 2026 vehicle emission factors for this analysis. The emission factors are one component in the equation to determine emissions from the region's on-road vehicles. MOVES3 parameters are listed below in Exhibits 4.1 through 4.5 with the appropriate data source and/or methodology applied. Information listed applies to all counties, unless otherwise specified. Referenced files identifying specific local data and MOVES3 input files utilizing these parameters and data for each county are included in the Appendix.

Exhibit 4.1: MOVES3 Modeled Pollutants

Command	Input Parameter Values and Molecular Formulas	Description
Pollutant	VOC, CO, NO, NO_2, HONO, NO_X, CO_2, SO_2, CH_4, NH_3, $PM_{2.5}$, OC, EC, NonECPM, NCOM, PM_{10}, NO_3, NH_4, Cl, Na, K, Mg, Ca, Ti, Si, Al, Fe, Aerosol H_2O	Volatile Organic Compounds (VOC), Carbon Monoxide (CO), Nitrogen Oxide (NO), Nitrogen Dioxide (NO_2) Nitrous Acid (HONO), Oxides of Nitrogen (NO_X), Carbon Dioxide (CO_2), Sulfur Dioxide (SO_2), Methane (CH_4), Ammonia (NH_3), Particulate Matter size 2.5 or less ($PM_{2.5}$) – total, brake wear, tire wear, Organic Carbon (OC), Elemental Carbon (EC), sulfate, composite – nonECPM, and non-carbon organic matter(NCOM), Particulate Matter size 10 (PM_{10}) – total, brake wear, tire wear, Nitrate (NO_3), Ammonium (NH_4), Chloride (Cl), Sodium (Na), Potassium (K), Magnesium (Mg), Calcium (Ca), Titanium (Ti), Silicon (Si), Aluminum (Al), Iron (Fe), and Aerosol H_2O (H_2O)

Exhibit 4.2: MOVES3 External Conditions

Command	Input Parameter Values	Description
MOVES Model Version	MOVES3	This version was released in November 2020
Calendar Year	2019, 2023, and 2026	Base-Case and Attainment Demonstration Years
Evaluation Month	7	Representing summer season
Minimum/Maximum Temperature	N/A	Hourly Temperatures used in the Inputs
Hourly Temperatures	Average Summer (June, July, and August)	County-specific, provided by the Texas Commission on Environmental Quality (TCEQ)
Relative Humidity	Average Summer (June, July, and August)	County-specific, provided by TCEQ
Barometric Pressure	Average Summer (June, July, and August)	County-specific, provided by TCEQ

Exhibit 4.3: MOVES3 Input Parameters and Source

Input Parameter	Description	Source
Source Type Population	Input number of vehicles in geographic area to be modeled for each vehicle and apply the appropriate growth factor for the future analysis year (2020). The North Central Texas Council of Governments (NCTCOG) input parameter sheet is used to convert Texas Department of Motor Vehicles (TxDMV) registration data for each county into MOVES source use type (SUT).	End-of-year 2018 TxDMV registration data
Source Type Age Distribution	Input provides distribution of vehicle counts by age for each calendar year and vehicle type. TxDMV registration data used to estimate age distribution of vehicle types up to 30 years. Distribution of Age fractions should sum up to 1.0 for all vehicle types for each analysis year.	End-of-year 2018 TxDMV registration data. MOVES3 default used for buses
Vehicle Type VMT	County-specific vehicle miles of travel (VMT) is distributed to Highway Performance Monitoring S (HPMS) Vehicle types.	TAFT Output
Average Speed Distribution	Input average speed data specific to vehicle type, road type, and time of day/type of day into 16 speed bins. Sum of speed distribution to all speed bins for each road type, vehicle type, and time/day type is 1.0.	NCTCOG TAFT Output
Road Type Distribution (VMT Fractions)	Input county specific VMT by road type. VMT fraction distributed between the road type and must sum to 1.0 for each source type.	NCTCOG TAFT Output
Ramp Fraction	Input county specific fraction of ramp driving time on rural and urban restricted roadway type.	NCTCOG TAFT Output
Fuel Supply	Input to assign existing fuels to counties, months, and years, and to assign the associated market share for each fuel.	TCEQ, EPA Fuel Surveys and default MOVES3 input where local data unavailable
Meteorology	County specific data on temperature, humidity, and barometric pressure, and other data, as agreed upon and provided by TCEQ	Local data from TCEQ
Fuel Formulation	Input county specific fuel properties in the MOVES3 database.	TCEQ, EPA Fuel Surveys, and default MOVES input where local data unavailable

Input Parameter	Description	Source
Inspection and Maintenance Coverage	Input inspection and maintenance (I/M) coverage record for each combination of pollutants, process, county, fuel type, regulatory class, and model year are specified using this input.	State I/M Program data provided by TCEQ
Fuel Engine Fraction/Diesel Fraction (AVFT)	Input fuel engine fractions (i.e. Gasoline vs. Diesel Engines types in the vehicle population) for all vehicle types.	End-of-year 2018 TxDMV registration data. MOVES3 default used for light duty vehicles and buses

Exhibit 4.4: MOVES3 I/M Descriptive Inputs for Subject Counties

2019						
Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker, Rockwall, and Tarrant I/M Data*						
I/M Program ID	20	21	22	23	24	MOVES3
Pollutant Process ID	101, 102, 201, 202, 301, 302	101, 102, 201, 202, 301, 302	101, 102, 201, 202, 301, 302	112	112	MOVES3
Source Use Type	21, 31, 32	21, 31, 32	52, 54	21, 31, 32	21, 31, 32	MOVES3
Begin Model Year	1996	1988	1988	1988	1996	Annual testing; program specifications
End Model Year	2010	1995	2010	1995	2010	Annual testing; program specifications
Inspect Frequency	1	1	1	1	1	Annual testing; program specifications
Test Standards Description	Exhaust OBD Check	ASM 2525/ 5015 Phase-in Cut points	Two-mode, 2500 RPM/Idle Test	Evaporative Gas Cap Check	Evaporative Gas Cap and OBD Check	Annual testing; program specifications
I/M Compliance	94.00% for source use type 21, 90.35% for source use type 31 and 70.74% for source use type 32^					Expected compliance (%) - MOVES3 Default

Source: TCEQ
OBD – On-board Diagnostic; ASM – Acceleration Simulation Mode; RPM – Revolutions Per Minute
*Wise County does not have an I/M Program
^ MOVES3 Technical Guidance: Using MOVES to Prepare Emission Inventories for State Implementation Plans and Transportation Conformity (EPA-420-B-20-052, November 2020)

2023				
Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker, Rockwall, and Tarrant I/M Data*				
I/M Program ID	20	22	24	MOVES3
Pollutant Process ID	101, 102, 201, 202, 301, 302	101, 102, 201, 202, 301, 302	112	MOVES3
Source Use Type	21, 31, 32	52, 54	21, 31, 32	MOVES3
Begin Model Year	1996	1990	1996	Annual testing; program specifications
End Model Year	2018	2018	2018	Annual testing; program specifications
Inspect Frequency	1	1	1	Annual testing; program specifications
Test Standards Description	Exhaust OBD Check	Two-mode, 2500 RPM/Idle Test	Evaporative Gas Cap and OBD Check	Annual testing; program specifications
I/M Compliance	94.00% for source use type 21, 90.35% for source use type 31 and 70.74% for source use type 32^			Expected compliance (%) - MOVES3 Default

Source: TCEQ

OBD – On-board Diagnostic; ASM – Acceleration Simulation Mode; RPM – Revolutions Per Minute

*Wise County does not have an I/M Program

^ MOVES3 Technical Guidance: Using MOVES to Prepare Emission Inventories for State Implementation Plans and Transportation Conformity (EPA-420-B-20-052, November 2020)

2026				
Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker, Rockwall, and Tarrant I/M Data*				
I/M Program ID	20	22	24	MOVES3
Pollutant Process ID	101, 102, 201, 202, 301, 302	101, 102, 201, 202, 301, 302	112	MOVES3
Source Use Type	21, 31, 32	52, 54	21, 31, 32	MOVES3
Begin Model Year	1996	1990	1996	Annual testing; program specifications
End Model Year	2018	2018	2018	Annual testing; program specifications
Inspect Frequency	1	1	1	Annual testing; program specifications
Test Standards Description	Exhaust OBD Check	Two-mode, 2500 RPM/Idle Test	Evaporative Gas Cap and OBD Check	Annual testing; program specifications
I/M Compliance	94.00% for source use type 21, 90.35% for source use type 31 and 70.74% for source use type 32^			Expected compliance (%) - MOVES3 Default

Source: TCEQ
OBD – On-board Diagnostic; ASM – Acceleration Simulation Mode; RPM – Revolutions Per Minute
*Wise County does not have an I/M Program
^ MOVES3 Technical Guidance: Using MOVES to Prepare Emission Inventories for State Implementation Plans and Transportation Conformity (EPA-420-B-20-052, November 2020)

Exhibit 4.5: MOVES3 Fuel Properties

	2019			2021 and later (for analysis years 2023 and 2026)		
Fuel Type	**Gasoline**		**Diesel**	**Gasoline**		**Diesel**
Counties	**Core**	**Perimeter**	**All**	**Core**	**Perimeter**	**All**
fuelformulationID	19714	19702	30585	14714	14702	30600
fuelsubtypeID	12	12	21	12	12	21
RVP	7.10	7.77	\N	7.09	7.80	\N
sulfurLevel	17.88	19.64	5.85	10.00	10.00	6
ETOHVolume	9.71	9.56	\N	9.56	9.56	\N
MTBEVolume	0	0	\N	0	0	\N
ETBEVolume	0	0	\N	0	0	\N
TAMEVolume	0	0	\N	0	0	\N
aromaticContent	15.82	22.22	\N	16.96	22.22	\N
olefinContent	10.01	8.69	\N	10.13	8.69	\N
benzeneContent	0.43	0.58	\N	0.37	0.99	\N
e200	47.10	49.64	\N	47.00	49.64	\N
e300	85.67	84.60	\N	84.95	84.60	\N
VolToWtPercentOxy	0.3653	0.3653	\N	0.3653	0.3653	\N
BioDieselEsterVolume	\N	\N	4.86	\N	\N	4.86
CetaneIndex	\N	\N	\N	\N	\N	\N
PAHContent	\N	\N	\N	\N	\N	\N
T50	208.79	202.53	\N	210.35	202.53	\N
T90	322.01	319.75	\N	325.30	319.75	\N

Source: TTI

Area Specific Calculations and Procedures

Source use type age distributions are calculated from TxDMV vehicle registration data. End-of-year data sets of 2018 utilized for light- and heavy-duty vehicle classes. MOVES3 default values are used for bus categories. Light-duty registration data for Collin, Dallas, Denton, Ellis, Hood, Hunt, Johnson, Kaufman, Parker, Rockwall, Tarrant, and Wise counties are weighted for commute patterns with the County-to-County Worker Flow data from the Census Transportation Planning Products Program (CTPP) 2012 - 2016. Exhibit 4.6 identifies the percentages applied for this weighted adjustment. Exhibit 4.6 identifies the percentages applied for this weighted adjustment. The Texas A&M Transportation Institute (TTI) methodology is applied to the heavy-duty vehicle data for developing registration for all heavy-duty vehicles. These files are included in Appendix.

Exhibit 4.6: County to County Worker Flow

Resident County	County of Employment											
	Collin	Dallas	Denton	Ellis	Hood	Hunt	Johnson	Kaufman	Parker	Rockwall	Tarrant	Wise
Collin	55.22%	6.48%	13.29%	0.95%	0.67%	7.41%	0.23%	3.70%	0.21%	9.23%	0.93%	0.54%
Dallas	37.87%	82.64%	32.35%	36.93%	3.17%	17.36%	5.50%	47.96%	3.45%	49.85%	16.77%	5.52%
Denton	3.90%	2.18%	44.30%	0.62%	0.32%	0.62%	0.40%	0.84%	1.10%	0.39%	2.26%	9.26%
Ellis	0.05%	0.49%	0.04%	51.18%	0.02%	0.03%	2.50%	1.14%	0.06%	0.11%	0.30%	0.11%
Hood	0.00%	0.01%	0.01%	0.07%	65.80%	0.00%	0.93%	0.00%	1.98%	0.19%	0.12%	0.02%
Hunt	0.39%	0.10%	0.02%	0.10%	0.53%	61.57%	0.17%	1.02%	0.00%	5.35%	0.01%	0.00%
Johnson	0.03%	0.05%	0.06%	0.67%	3.62%	0.19%	45.79%	0.06%	0.98%	0.05%	0.81%	0.11%
Kaufman	0.03%	0.36%	0.02%	0.32%	0.00%	2.79%	0.00%	40.42%	0.01%	2.13%	0.03%	0.00%
Parker	0.02%	0.02%	0.06%	0.05%	4.89%	0.11%	0.58%	0.01%	45.90%	0.00%	0.60%	2.38%
Rockwall	0.47%	0.76%	0.04%	0.13%	0.00%	9.18%	0.00%	3.12%	0.00%	31.39%	0.02%	0.13%
Tarrant	2.02%	6.88%	9.55%	8.85%	20.89%	0.73%	43.79%	1.73%	44.87%	1.31%	77.86%	27.01%
Wise	0.01%	0.01%	0.25%	0.13%	0.08%	0.00%	0.11%	0.00%	1.45%	0.00%	0.28%	54.94%

Source: Census Transportation Planning Products Program (CTPP) 2012 - 2016

Fuel Engine Fraction

Diesel fractions for heavy-duty vehicle categories utilized 12-county summed yearly registration data for modeling all the analysis years. End-of-year 2018 registration data is used for modeling all analysis years. Light-duty and bus categories utilize MOVES3 default values. All diesel fraction files, included in the Appendix, list specific data used for this analysis.

MOVES3 Emission Factors

MOVES3 emission factors are reported in the Appendix.

Adjustments

Adjustments are applied to the emission factors in a post-process step. Texas Low Emission Diesel (TxLED) NO_X Adjustment is applied to the emission factors. VMT Mix adjustment is applied simultaneously with the emission calculation procedure.

TxLED NO_x Adjustment

NO_X emission factors for diesel vehicle classes are adjusted to apply the federal low emission diesel program. Exhibit 4.7 lists the appropriate adjustment for each vehicle class.

Exhibit 4.7: TxLED NO_X Adjustments

SourceUse Type	Adjustment Factors		
	2019	2023	2026
Passenger Car	0.9506	0.9514	0.9517
Passenger Truck	0.9470	0.9489	0.9498
Light Commercial Truck	0.9466	0.9485	0.9494
Intercity Bus	0.9461	0.9481	0.9494
Transit Bus	0.9499	0.9508	0.9512
School Bus	0.9476	0.9494	0.9503
Refuse Truck	0.9474	0.9495	0.9508
Single Unit Short-Haul Truck	0.9512	0.9518	0.9519
Single Unit Long-Haul Truck	0.9512	0.9516	0.9518
Motor Home	0.9453	0.9467	0.9483
Combination Short-Haul Truck	0.9503	0.9513	0.9517
Combination Long-Haul Truck	0.9488	0.9507	0.9514

Source: TCEQ

Vehicle Miles of Travel Mix (VMT Mix)

The VMT mix designates the vehicle types included in the analysis. It specifies the fraction of on-road fleet VMT attributable to each vehicle type by day type (i.e., average weekday) and MOVES road type.

The TTI provided the VMT mixes. TTI estimated the VMT mix based on TTI's 24-hour average VMT mix method, expanded to produce the four-period, time-of-day estimates.[2] The procedure sets Texas vehicle registration category aggregations for MOVES source use type (SUT) categories to be used in the VMT mix estimates and for developing other fleet parameter inputs needed in the process (e.g., vehicle age distributions). The VMT mix procedure produced a set of four-period, time-of-day average vehicle type VMT allocations by MOVES road type and by day type, estimated for each TxDOT district for use with each county for each year analyzed. The data sources used were recent 2009 to 2018 TxDOT vehicle classification counts, end-of-year 2018 TxDOT/Texas Department of Motor Vehicles (TxDMV) registration data and MOVES default data.

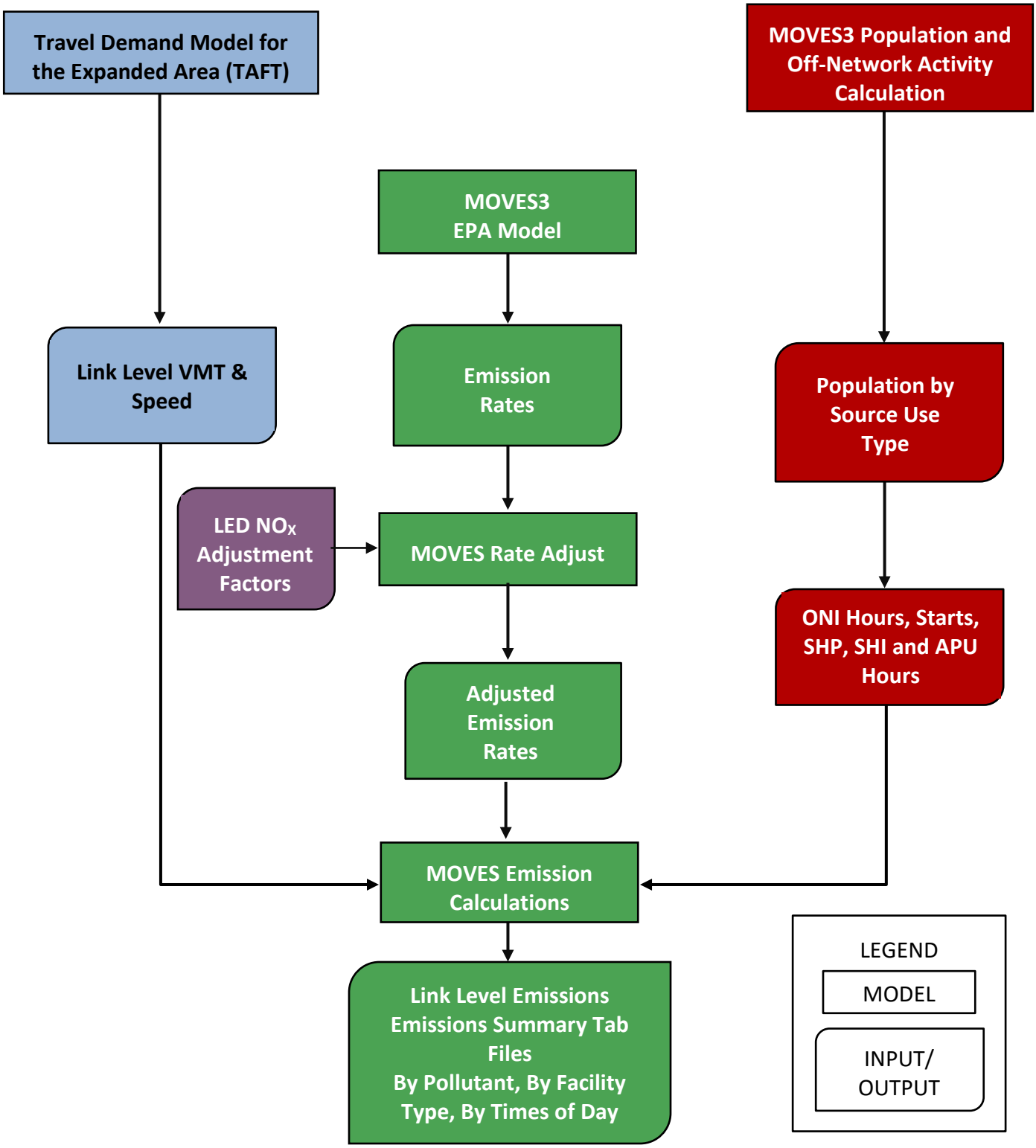
[2] MOVES Source Use Type and VMT Mix for Conformity Analysis, TTI, August 2017

CHAPTER 5: EMISSION CALCULATION

Emissions estimates are calculated using "*TTI emissions inventory estimation utilities using moves: MOVES3 UTL",* developed by the Texas A&M Transportation Institute. This software combines vehicle activity and emission factors to create emission estimates.

Exhibit 5.1 outlines the emission calculation modeling process used to calculate the emissions estimates for the Dallas-Fort Worth ozone nonattainment area.

Exhibit 5.1: MOVES3 Emission Calculation Modeling Process



CHAPTER 6: SUMMARY OF VEHICLE MILES OF TRAVEL, SPEED, AND EMISSIONS

Vehicle Miles of Travel Estimates

The final county emission estimates for school and summer season and for each analysis year are summarized in Exhibit 6.1. Appendix contains the summarized vehicle miles of travel (VMT) estimates by the analysis year and time-of-day (TOD) for all counties.

Speed Estimates

The final county emission estimates for school and summer season and for each analysis year are summarized in Exhibit 6.2. Appendix contains the summarized speeds by the analysis year and TOD for the counties.

Emission Estimates

The final county emission estimates for school and summer season and for each analysis year are summarized in Exhibit 6.3. Appendix contains the tab summary of VMT, speeds, and emissions for all counties by analysis year, control scenarios, TOD, functional class, and vehicle type.

Exhibit 6.1: Vehicle Miles of Travel (Miles/Day) Estimates for the DFW 12-County Modeling Domain

2019 Emissions Inventory VMT Summer Season				
Counties	**Midweek**	**Friday**	**Saturday**	**Sunday**
Collin	26,438,284	28,880,448	24,138,629	19,488,722
Dallas	86,054,261	94,317,491	78,467,809	63,232,102
Denton	20,600,687	22,418,956	18,832,734	15,236,760
Ellis	7,535,585	8,881,633	7,476,778	7,111,692
Hood	1,796,804	2,118,995	1,784,649	1,697,447
Hunt	4,413,566	5,202,730	4,380,825	4,166,758
Johnson	5,062,531	5,967,514	5,024,185	4,778,844
Kaufman	6,509,361	7,672,749	6,459,667	6,144,192
Parker	5,312,826	6,263,518	5,274,191	5,016,556
Rockwall	2,535,427	2,741,339	2,322,857	1,886,029
Tarrant	54,656,835	59,905,451	49,842,128	40,165,284
Wise	3,623,767	4,271,618	3,596,246	3,420,663
Total	224,539,933	248,642,442	207,600,697	172,345,048

2019 Emissions Inventory VMT School Season				
Counties	**Midweek**	**Friday**	**Saturday**	**Sunday**
Collin	26,341,758	29,002,831	24,228,080	19,349,867
Dallas	85,471,548	94,291,697	78,484,674	62,722,666
Denton	20,597,316	22,627,782	18,975,804	15,143,949
Ellis	7,240,186	8,711,516	7,066,109	6,596,833
Hood	1,726,367	2,078,407	1,686,625	1,574,560
Hunt	4,240,551	5,103,077	4,140,205	3,865,101
Johnson	4,864,077	5,853,212	4,748,227	4,432,876
Kaufman	6,254,190	7,525,786	6,104,864	5,699,379
Parker	5,104,560	6,143,547	4,984,502	4,653,378
Rockwall	2,550,217	2,791,057	2,355,997	1,877,865
Tarrant	54,287,482	59,890,251	49,853,606	39,841,849
Wise	3,481,713	4,189,799	3,398,720	3,173,021
Total	222,159,965	248,208,964	206,027,413	168,931,344

Exhibit 6.1: Vehicle Miles of Travel (Miles/Day) Estimates for the DFW 12-County Modeling Domain (continued)

2023 Emissions Inventory VMT Summer Season				
Counties	**Midweek**	**Friday**	**Saturday**	**Sunday**
Collin	28,670,816	31,311,716	26,179,518	21,139,464
Dallas	90,707,613	99,423,422	82,709,820	66,648,958
Denton	22,481,069	24,467,168	20,551,540	16,626,798
Ellis	8,353,667	9,845,832	8,288,473	7,883,777
Hood	1,941,078	2,289,151	1,928,053	1,833,811
Hunt	4,838,361	5,703,800	4,802,737	4,568,067
Johnson	5,583,181	6,581,121	5,540,873	5,270,245
Kaufman	7,258,835	8,556,149	7,203,447	6,851,665
Parker	5,698,419	6,718,113	5,657,138	5,380,738
Rockwall	2,816,851	3,054,611	2,578,196	2,090,003
Tarrant	58,817,903	64,483,001	53,631,919	43,212,894
Wise	3,950,145	4,656,254	3,920,135	3,728,676
Total	241,117,937	267,090,337	222,991,850	185,235,097

2023 Emissions Inventory VMT School Season				
Counties	**Midweek**	**Friday**	**Saturday**	**Sunday**
Collin	28,572,712	31,454,810	26,283,240	20,990,282
Dallas	90,089,362	99,389,859	82,723,483	66,111,106
Denton	22,475,932	24,692,749	20,706,182	16,525,204
Ellis	8,026,197	9,657,246	7,833,221	7,313,023
Hood	1,864,987	2,245,305	1,822,154	1,701,050
Hunt	4,648,694	5,594,551	4,538,942	4,237,356
Johnson	5,364,316	6,455,065	5,236,537	4,888,699
Kaufman	6,974,286	8,392,264	6,807,791	6,355,631
Parker	5,475,037	6,589,435	5,346,415	4,991,195
Rockwall	2,825,661	3,097,808	2,607,230	2,079,301
Tarrant	58,405,601	64,443,226	53,629,140	42,861,667
Wise	3,795,296	4,567,069	3,704,819	3,458,737
Total	238,518,080	266,579,387	221,239,154	181,513,251

Exhibit 6.1: Vehicle Miles of Travel (Miles/Day) Estimates for the DFW 12-County Modeling Domain (continued)

2026 Emissions Inventory VMT Summer Season				
Counties	**Midweek**	**Friday**	**Saturday**	**Sunday**
Collin	30,635,225	33,442,125	27,977,496	22,596,912
Dallas	93,803,498	102,822,483	85,531,330	68,920,462
Denton	24,056,478	26,204,563	21,986,211	17,779,122
Ellis	8,955,893	10,555,673	8,886,064	8,452,186
Hood	2,030,514	2,394,649	2,016,954	1,918,361
Hunt	5,164,560	6,088,463	5,126,627	4,876,132
Johnson	5,942,684	7,004,857	5,897,638	5,609,581
Kaufman	7,804,387	9,199,193	7,744,814	7,366,595
Parker	5,979,165	7,049,133	5,935,933	5,645,907
Rockwall	3,016,755	3,270,581	2,761,339	2,238,757
Tarrant	62,333,648	68,338,959	56,837,527	45,795,215
Wise	4,180,150	4,927,363	4,148,379	3,945,772
Total	253,902,956	281,298,042	234,850,311	195,145,002

2026 Emissions Inventory VMT School Season				
Counties	**Midweek**	**Friday**	**Saturday**	**Sunday**
Collin	30,543,067	33,615,036	28,101,267	22,440,226
Dallas	93,159,341	102,780,199	85,540,555	68,363,223
Denton	24,031,811	26,415,681	22,132,102	17,666,294
Ellis	8,604,817	10,353,487	8,397,987	7,840,281
Hood	1,950,917	2,348,782	1,906,170	1,779,478
Hunt	4,962,107	5,971,843	4,845,041	4,523,120
Johnson	5,709,728	6,870,686	5,573,704	5,203,469
Kaufman	7,498,450	9,022,994	7,319,424	6,833,284
Parker	5,744,777	6,914,114	5,609,896	5,237,166
Rockwall	3,026,853	3,317,889	2,793,111	2,227,436
Tarrant	61,895,457	68,294,847	56,833,311	45,422,718
Wise	4,016,287	4,832,985	3,920,526	3,660,115
Total	251,143,612	280,738,546	232,973,093	191,196,810

Exhibit 6.2: Speed (miles per hour) Estimates for the DFW 12-County Modeling Domain

2019 Emissions Inventory Speed Estimates Summer Season				
	Midweek	Friday	Saturday	Sunday
Collin	34.31	36.05	38.23	39.39
Dallas	33.64	35.22	38.22	39.86
Denton	36.38	38.00	40.13	41.32
Ellis	47.01	46.65	48.23	47.71
Hood	40.43	39.85	41.30	40.84
Hunt	46.82	46.31	47.62	47.22
Johnson	42.20	42.05	43.18	42.83
Kaufman	47.22	45.31	47.76	46.91
Parker	43.47	43.20	44.47	44.09
Rockwall	40.20	40.86	42.53	43.41
Tarrant	36.03	37.47	39.76	40.99
Wise	45.01	44.02	46.21	45.46
Average	41.06	41.25	43.14	43.33

2019 Emissions Inventory Speed Estimates School Season				
	Midweek	Friday	Saturday	Sunday
Collin	34.47	36.07	38.25	39.45
Dallas	33.83	35.26	38.23	39.94
Denton	36.48	37.94	40.10	41.37
Ellis	47.38	46.86	48.62	48.31
Hood	40.70	40.04	41.63	41.36
Hunt	47.06	46.46	47.92	47.68
Johnson	42.43	42.18	43.43	43.22
Kaufman	47.69	45.65	48.40	47.89
Parker	43.70	43.34	44.74	44.51
Rockwall	40.27	40.83	42.51	43.45
Tarrant	36.18	37.50	39.77	41.05
Wise	45.49	44.31	46.77	46.32
Average	41.31	41.37	43.36	43.71

Exhibit 6.2: Speed (miles per hour) Estimates for the DFW 12-County Modeling Domain (continued)

2023 Emissions Inventory Speed Estimates Summer Season				
	Midweek	Friday	Saturday	Sunday
Collin	34.00	36.08	38.31	39.51
Dallas	33.18	35.04	38.10	39.78
Denton	35.67	37.58	39.86	41.12
Ellis	46.14	45.96	47.66	47.09
Hood	40.38	39.74	41.31	40.80
Hunt	46.60	45.88	47.29	46.85
Johnson	41.57	41.42	42.72	42.31
Kaufman	45.86	43.45	46.49	45.40
Parker	43.31	43.03	44.32	43.93
Rockwall	39.57	40.50	42.21	43.12
Tarrant	35.48	37.12	39.53	40.81
Wise	44.25	42.68	45.25	44.35
Average	40.50	40.71	42.75	42.92

2023 Emissions Inventory Speed Estimates School Season				
	Midweek	Friday	Saturday	Sunday
Collin	34.16	36.09	38.32	39.57
Dallas	33.38	35.07	38.11	39.86
Denton	35.77	37.49	39.81	41.17
Ellis	46.57	46.19	48.08	47.74
Hood	40.68	39.94	41.67	41.37
Hunt	46.84	46.05	47.61	47.35
Johnson	41.85	41.58	43.03	42.78
Kaufman	46.45	43.88	47.28	46.64
Parker	43.54	43.17	44.60	44.36
Rockwall	39.64	40.45	42.18	43.16
Tarrant	35.64	37.15	39.53	40.88
Wise	44.78	43.03	45.93	45.39
Average	40.78	40.84	43.01	43.36

Exhibit 6.2: Speed (miles per hour) Estimates for the DFW 12-County Modeling Domain (continued)

2026 Emissions Inventory Speed Estimates Summer Season				
	Midweek	Friday	Saturday	Sunday
Collin	33.73	35.92	38.18	39.38
Dallas	32.89	34.82	37.94	39.65
Denton	34.84	36.90	39.39	40.76
Ellis	45.19	45.23	47.10	46.47
Hood	40.11	39.41	41.08	40.53
Hunt	46.35	45.51	47.01	46.53
Johnson	41.02	40.94	42.37	41.91
Kaufman	45.06	42.13	45.59	44.34
Parker	43.01	42.72	44.09	43.67
Rockwall	39.83	40.69	42.31	43.19
Tarrant	34.87	36.76	39.25	40.58
Wise	43.63	41.61	44.50	43.48
Average	40.04	40.22	42.40	42.54

2026 Emissions Inventory Speed Estimates School Season				
	Midweek	Friday	Saturday	Sunday
Collin	33.89	35.94	38.18	39.44
Dallas	33.10	34.85	37.95	39.73
Denton	34.96	36.84	39.35	40.81
Ellis	45.71	45.49	47.56	47.19
Hood	40.43	39.63	41.47	41.15
Hunt	46.62	45.69	47.37	47.08
Johnson	41.35	41.13	42.70	42.43
Kaufman	45.73	42.63	46.51	45.77
Parker	43.27	42.88	44.38	44.13
Rockwall	39.86	40.59	42.25	43.22
Tarrant	35.04	36.78	39.25	40.65
Wise	44.21	42.01	45.27	44.66
Average	40.35	40.37	42.69	43.02

Exhibit 6.3: Emission Estimates for the DFW 12-County Modeling Domain

2019 Emissions Inventory Oxides of Nitrogen (NO_X) (tons/day) Summer Season				
	Midweek	Friday	Saturday	Sunday
Collin	9.70	10.26	7.38	5.73
Dallas	35.76	37.58	27.28	21.19
Denton	8.89	9.34	6.47	4.99
Ellis	4.90	5.73	3.38	3.07
Hood	1.35	1.57	1.05	0.87
Hunt	4.26	4.78	3.45	3.02
Johnson	3.61	4.23	2.70	2.27
Kaufman	4.37	5.11	2.94	2.64
Parker	4.10	4.77	2.93	2.47
Rockwall	1.41	1.48	0.98	0.76
Tarrant	26.58	28.60	19.85	15.14
Wise	2.89	3.39	2.21	1.79
Total	107.83	116.84	80.63	63.95

2019 Emissions Inventory Oxides of Nitrogen (NO_X) (tons/day) School Season				
	Midweek	Friday	Saturday	Sunday
Collin	9.61	10.26	7.36	5.63
Dallas	35.25	37.36	27.10	20.84
Denton	8.86	9.42	6.49	4.91
Ellis	4.69	5.60	3.18	2.83
Hood	1.29	1.53	0.99	0.81
Hunt	4.08	4.69	3.26	2.81
Johnson	3.45	4.13	2.54	2.10
Kaufman	4.19	5.00	2.76	2.44
Parker	3.92	4.67	2.76	2.29
Rockwall	1.41	1.50	0.99	0.75
Tarrant	26.20	28.42	19.72	14.88
Wise	2.76	3.30	2.08	1.65
Total	105.71	115.86	79.23	61.95

Exhibit 6.3: Emission Estimates for the DFW 12-County Modeling Domain (continued)

2023 Emissions Inventory Oxides of Nitrogen (NO_X) (tons/day) Summer Season				
	Midweek	Friday	Saturday	Sunday
Collin	6.75	7.08	4.88	3.71
Dallas	24.41	25.39	17.60	13.45
Denton	6.31	6.57	4.34	3.29
Ellis	3.55	4.14	2.32	2.07
Hood	0.99	1.15	0.73	0.59
Hunt	3.06	3.45	2.40	2.08
Johnson	2.71	3.16	1.94	1.59
Kaufman	3.22	3.84	2.06	1.84
Parker	3.05	3.55	2.09	1.72
Rockwall	0.95	1.00	0.64	0.49
Tarrant	19.19	20.58	13.61	10.19
Wise	2.15	2.55	1.58	1.24
Total	76.35	82.45	54.20	42.27

2023 Emissions Inventory Oxides of Nitrogen (NO_X) (tons/day) School Season				
	Midweek	Friday	Saturday	Sunday
Collin	6.69	7.09	4.86	3.65
Dallas	24.02	25.23	17.47	13.20
Denton	6.28	6.64	4.35	3.23
Ellis	3.39	4.04	2.18	1.91
Hood	0.94	1.12	0.69	0.55
Hunt	2.93	3.38	2.27	1.93
Johnson	2.58	3.08	1.82	1.47
Kaufman	3.07	3.74	1.93	1.68
Parker	2.92	3.47	1.97	1.59
Rockwall	0.95	1.01	0.64	0.49
Tarrant	18.89	20.43	13.51	10.00
Wise	2.05	2.48	1.48	1.14
Total	74.72	81.70	53.17	40.84

Exhibit 6.3: Emission Estimates for the DFW 12-County Modeling Domain (continued)

2026 Emissions Inventory Oxides of Nitrogen (NO_X) (tons/day) Summer Season				
	Midweek	Friday	Saturday	Sunday
Collin	5.61	5.84	3.87	2.90
Dallas	19.67	20.34	13.57	10.20
Denton	5.17	5.35	3.43	2.56
Ellis	3.01	3.49	1.88	1.65
Hood	0.84	0.98	0.60	0.48
Hunt	2.63	2.96	2.01	1.73
Johnson	2.37	2.76	1.64	1.31
Kaufman	2.76	3.34	1.71	1.51
Parker	2.63	3.06	1.74	1.40
Rockwall	0.79	0.82	0.51	0.39
Tarrant	16.32	17.42	11.06	8.14
Wise	1.86	2.22	1.32	1.02
Total	63.67	68.57	43.35	33.29

2026 Emissions Inventory Oxides of Nitrogen (NO_X) (tons/day) School Season				
	Midweek	Friday	Saturday	Sunday
Collin	5.56	5.85	3.86	2.85
Dallas	19.33	20.19	13.46	10.00
Denton	5.14	5.40	3.44	2.51
Ellis	2.87	3.41	1.76	1.53
Hood	0.80	0.95	0.57	0.44
Hunt	2.52	2.90	1.90	1.61
Johnson	2.25	2.69	1.54	1.21
Kaufman	2.63	3.25	1.59	1.37
Parker	2.51	2.98	1.64	1.30
Rockwall	0.79	0.83	0.51	0.38
Tarrant	16.05	17.28	10.97	7.98
Wise	1.77	2.16	1.24	0.94
Total	62.22	67.89	42.48	32.11

Exhibit 6.3: Emission Estimates for the DFW 12-County Modeling Domain (continued)

2019 Emissions Inventory Volatile Organic Compounds (VOC) (tons/day) Summer Season				
	Midweek	Friday	Saturday	Sunday
Collin	5.91	6.03	5.31	4.95
Dallas	18.30	18.73	16.24	14.94
Denton	4.95	5.03	4.44	4.16
Ellis	1.51	1.62	1.37	1.34
Hood	0.54	0.57	0.50	0.49
Hunt	0.98	1.05	0.91	0.88
Johnson	1.28	1.36	1.18	1.15
Kaufman	1.19	1.29	1.07	1.04
Parker	1.20	1.28	1.08	1.04
Rockwall	0.68	0.69	0.61	0.57
Tarrant	13.08	13.39	11.77	10.95
Wise	0.80	0.87	0.72	0.70
Total	50.42	51.91	45.18	42.21

2019 Emissions Inventory Volatile Organic Compounds (VOC) (tons/day) School Season				
	Midweek	Friday	Saturday	Sunday
Collin	5.82	5.96	5.26	4.88
Dallas	18.00	18.50	16.07	14.73
Denton	4.88	4.98	4.40	4.10
Ellis	1.47	1.59	1.33	1.29
Hood	0.53	0.56	0.49	0.47
Hunt	0.95	1.03	0.87	0.84
Johnson	1.25	1.33	1.14	1.11
Kaufman	1.15	1.27	1.03	0.99
Parker	1.16	1.25	1.04	1.00
Rockwall	0.67	0.69	0.60	0.56
Tarrant	12.88	13.22	11.63	10.79
Wise	0.77	0.85	0.70	0.66
Total	49.53	51.23	44.55	41.43

Exhibit 6.3: Emission Estimates for the DFW 12-County Modeling Domain (continued)

2023 Emissions Inventory Volatile Organic Compounds (VOC) (tons/day) Summer Season				
	Midweek	Friday	Saturday	Sunday
Collin	4.75	4.82	4.28	4.03
Dallas	14.36	14.62	12.77	11.89
Denton	4.00	4.05	3.59	3.39
Ellis	1.19	1.27	1.08	1.06
Hood	0.43	0.45	0.40	0.39
Hunt	0.75	0.80	0.70	0.68
Johnson	1.02	1.07	0.93	0.91
Kaufman	0.93	1.01	0.84	0.82
Parker	0.93	0.98	0.84	0.81
Rockwall	0.54	0.55	0.48	0.46
Tarrant	10.41	10.61	9.40	8.84
Wise	0.62	0.67	0.56	0.54
Total	39.93	40.90	35.88	33.83

2023 Emissions Inventory Volatile Organic Compounds (VOC) (tons/day) School Season				
	Midweek	Friday	Saturday	Sunday
Collin	4.68	4.76	4.24	3.97
Dallas	14.13	14.44	12.64	11.73
Denton	3.95	4.01	3.56	3.35
Ellis	1.16	1.24	1.05	1.02
Hood	0.42	0.44	0.39	0.38
Hunt	0.73	0.79	0.68	0.65
Johnson	0.99	1.05	0.91	0.88
Kaufman	0.90	0.99	0.81	0.78
Parker	0.90	0.96	0.81	0.78
Rockwall	0.53	0.54	0.48	0.45
Tarrant	10.25	10.48	9.30	8.72
Wise	0.60	0.65	0.54	0.52
Total	39.25	40.37	35.40	33.25

Exhibit 6.3: Emission Estimates for the DFW 12-County Modeling Domain (continued)

2026 Emissions Inventory Volatile Organic Compounds (VOC) (tons/day) Summer Season				
	Midweek	Friday	Saturday	Sunday
Collin	4.11	4.16	3.70	3.50
Dallas	12.26	12.44	10.92	10.23
Denton	3.47	3.51	3.12	2.96
Ellis	1.03	1.09	0.93	0.91
Hood	0.37	0.39	0.35	0.34
Hunt	0.65	0.69	0.60	0.59
Johnson	0.87	0.92	0.80	0.79
Kaufman	0.80	0.87	0.72	0.70
Parker	0.79	0.83	0.71	0.69
Rockwall	0.47	0.47	0.42	0.40
Tarrant	8.94	9.08	8.07	7.63
Wise	0.53	0.57	0.48	0.47
Total	34.29	35.02	30.83	29.21

2026 Emissions Inventory Volatile Organic Compounds (VOC) (tons/day) School Season				
	Midweek	Friday	Saturday	Sunday
Collin	4.05	4.11	3.67	3.46
Dallas	12.07	12.29	10.81	10.10
Denton	3.42	3.47	3.09	2.92
Ellis	1.00	1.07	0.90	0.88
Hood	0.37	0.38	0.34	0.33
Hunt	0.64	0.68	0.59	0.57
Johnson	0.85	0.90	0.78	0.76
Kaufman	0.78	0.85	0.69	0.68
Parker	0.77	0.82	0.69	0.67
Rockwall	0.46	0.47	0.42	0.40
Tarrant	8.80	8.96	7.98	7.52
Wise	0.52	0.56	0.47	0.45
Total	33.72	34.57	30.43	28.73

Exhibit 6.3: Emission Estimates for the DFW 12-County Modeling Domain (continued)

2019 Emissions Inventory Carbon Monoxide (CO) (tons/day) Summer Season				
	Midweek	Friday	Saturday	Sunday
Collin	112.36	120.05	98.28	80.87
Dallas	375.28	402.12	325.70	266.38
Denton	86.62	91.88	75.29	62.14
Ellis	32.29	37.66	30.82	29.89
Hood	9.33	10.81	9.03	8.81
Hunt	21.59	24.90	21.06	20.24
Johnson	22.10	25.79	21.33	20.81
Kaufman	27.07	31.72	25.86	25.02
Parker	21.99	25.49	21.06	20.43
Rockwall	11.47	12.22	10.10	8.42
Tarrant	235.12	252.39	206.22	170.05
Wise	16.94	19.98	16.47	16.11
Total	972.17	1055.02	861.22	729.16

2019 Emissions Inventory Carbon Monoxide (CO) (tons/day) School Season				
	Midweek	Friday	Saturday	Sunday
Collin	110.90	119.54	97.86	79.59
Dallas	369.51	399.08	323.59	262.17
Denton	85.72	91.84	75.20	61.15
Ellis	30.88	36.76	29.07	27.68
Hood	8.91	10.53	8.51	8.17
Hunt	20.70	24.34	19.92	18.84
Johnson	21.10	25.11	20.07	19.24
Kaufman	25.90	30.98	24.28	23.10
Parker	21.01	24.88	19.84	18.92
Rockwall	11.40	12.27	10.13	8.29
Tarrant	231.30	250.15	204.60	167.14
Wise	16.19	19.47	15.50	14.87
Total	953.51	1044.95	848.58	709.16

Exhibit 6.3: Emission Estimates for the DFW 12-County Modeling Domain (continued)

2023 Emissions Inventory Carbon Monoxide (CO) (tons/day) Summer Season				
	Midweek	Friday	Saturday	Sunday
Collin	97.40	103.94	85.02	69.66
Dallas	319.42	341.34	276.17	225.21
Denton	75.66	80.11	65.38	53.70
Ellis	28.56	33.30	27.02	26.17
Hood	7.98	9.26	7.72	7.52
Hunt	18.95	21.91	18.38	17.67
Johnson	19.14	22.33	18.44	17.94
Kaufman	24.18	28.49	23.01	22.30
Parker	18.60	21.57	17.74	17.13
Rockwall	10.03	10.71	8.78	7.31
Tarrant	202.29	217.07	176.96	145.28
Wise	14.68	17.50	14.30	14.00
Total	836.90	907.52	738.92	623.90

2023 Emissions Inventory Carbon Monoxide (CO) (tons/day) School Season				
	Midweek	Friday	Saturday	Sunday
Collin	96.27	103.67	84.79	68.62
Dallas	314.72	338.98	274.56	221.81
Denton	74.97	80.19	65.35	52.90
Ellis	27.33	32.52	25.49	24.24
Hood	7.62	9.03	7.28	6.97
Hunt	18.17	21.44	17.39	16.43
Johnson	18.27	21.77	17.35	16.59
Kaufman	23.12	27.82	21.60	20.54
Parker	17.79	21.07	16.73	15.91
Rockwall	9.96	10.75	8.80	7.21
Tarrant	199.12	215.30	175.69	142.91
Wise	14.01	17.06	13.42	12.88
Total	821.35	899.60	728.45	607.01

Exhibit 6.3: Emission Estimates for the DFW 12-County Modeling Domain (continued)

2026 Emissions Inventory Carbon Monoxide (CO) (tons/day) Summer Season				
	Midweek	Friday	Saturday	Sunday
Collin	88.27	94.04	76.85	62.96
Dallas	282.36	301.49	243.38	198.03
Denton	68.87	72.91	59.27	48.56
Ellis	26.32	30.67	24.71	23.91
Hood	7.11	8.25	6.85	6.66
Hunt	17.73	20.47	17.09	16.42
Johnson	17.37	20.30	16.65	16.17
Kaufman	22.43	26.48	21.23	20.52
Parker	16.62	19.30	15.74	15.15
Rockwall	9.11	9.72	7.99	6.59
Tarrant	181.96	194.75	158.20	129.48
Wise	13.34	15.98	12.97	12.68
Total	751.49	814.36	660.93	557.14

2026 Emissions Inventory Carbon Monoxide (CO) (tons/day) School Season				
	Midweek	Friday	Saturday	Sunday
Collin	87.30	93.87	76.68	62.06
Dallas	278.26	299.45	242.03	195.10
Denton	68.22	72.96	59.26	47.85
Ellis	25.18	29.97	23.30	22.14
Hood	6.80	8.05	6.46	6.17
Hunt	17.01	20.04	16.17	15.26
Johnson	16.58	19.80	15.67	14.95
Kaufman	21.44	25.87	19.95	18.92
Parker	15.90	18.85	14.86	14.08
Rockwall	9.05	9.76	8.01	6.51
Tarrant	179.18	193.24	157.14	127.43
Wise	12.71	15.58	12.16	11.63
Total	737.62	807.45	651.69	542.10

Exhibit 6.3: Emission Estimates for the DFW 12-County Modeling Domain (continued)

2019 Emissions Inventory Carbon Dioxide (CO_2) (tons/day) Summer Season				
	Midweek	Friday	Saturday	Sunday
Collin	13,230	14,189	11,203	8,844
Dallas	44,219	47,373	37,168	29,251
Denton	10,482	11,167	8,734	6,870
Ellis	4,198	4,949	3,588	3,363
Hood	1,050	1,230	942	848
Hunt	2,908	3,333	2,599	2,366
Johnson	2,924	3,449	2,585	2,352
Kaufman	3,684	4,332	3,112	2,901
Parker	3,062	3,591	2,665	2,432
Rockwall	1,337	1,425	1,103	873
Tarrant	28,591	30,925	24,059	18,877
Wise	2,120	2,496	1,882	1,688
Total	117,805	128,458	99,638	80,665

2019 Emissions Inventory Carbon Dioxide (CO_2) (tons/day) School Season				
	Midweek	Friday	Saturday	Sunday
Collin	13,116	14,197	11,201	8,739
Dallas	43,675	47,179	37,035	28,880
Denton	10,442	11,247	8,774	6,797
Ellis	4,015	4,839	3,374	3,100
Hood	1,004	1,203	887	784
Hunt	2,788	3,266	2,453	2,194
Johnson	2,796	3,372	2,431	2,168
Kaufman	3,527	4,237	2,918	2,673
Parker	2,929	3,515	2,506	2,245
Rockwall	1,340	1,444	1,115	865
Tarrant	28,255	30,797	23,972	18,638
Wise	2,028	2,440	1,771	1,558
Total	115,916	127,736	98,436	78,642

Exhibit 6.3: Emission Estimates for the DFW 12-County Modeling Domain (continued)

2023 Emissions Inventory Carbon Dioxide (CO_2) (tons/day) Summer Season				
	Midweek	Friday	Saturday	Sunday
Collin	13,063	13,983	11,014	8,673
Dallas	42,628	45,512	35,615	27,993
Denton	10,438	11,083	8,625	6,772
Ellis	4,277	5,035	3,640	3,406
Hood	1,047	1,225	934	840
Hunt	2,911	3,346	2,591	2,364
Johnson	2,959	3,482	2,606	2,368
Kaufman	3,787	4,478	3,196	2,985
Parker	3,027	3,544	2,621	2,380
Rockwall	1,332	1,424	1,101	874
Tarrant	28,129	30,391	23,573	18,462
Wise	2,130	2,519	1,886	1,690
Total	115,727	126,022	97,402	78,808

2023 Emissions Inventory Carbon Dioxide (CO_2) (tons/day) School Season				
	Midweek	Friday	Saturday	Sunday
Collin	12,957	14,004	11,019	8,571
Dallas	42,100	45,319	35,484	27,636
Denton	10,398	11,163	8,663	6,699
Ellis	4,090	4,922	3,422	3,140
Hood	1,001	1,198	880	776
Hunt	2,789	3,279	2,445	2,189
Johnson	2,829	3,405	2,450	2,183
Kaufman	3,619	4,378	2,995	2,743
Parker	2,897	3,470	2,466	2,202
Rockwall	1,331	1,440	1,110	866
Tarrant	27,786	30,255	23,480	18,226
Wise	2,036	2,462	1,772	1,557
Total	113,833	125,295	96,187	76,787

Exhibit 6.3: Emission Estimates for the DFW 12-County Modeling Domain (continued)

2026 Emissions Inventory Carbon Dioxide (CO_2) (tons/day) Summer Season				
	Midweek	Friday	Saturday	Sunday
Collin	13,048	13,932	10,963	8,650
Dallas	41,092	43,826	34,244	26,886
Denton	10,396	11,028	8,594	6,748
Ellis	4,276	5,026	3,632	3,399
Hood	1,023	1,196	912	818
Hunt	2,923	3,354	2,594	2,369
Johnson	2,956	3,476	2,598	2,359
Kaufman	3,807	4,506	3,215	3,001
Parker	2,971	3,479	2,565	2,325
Rockwall	1,320	1,410	1,096	865
Tarrant	27,870	30,009	23,218	18,169
Wise	2,109	2,500	1,865	1,671
Total	113,793	123,742	95,495	77,260

2026 Emissions Inventory Carbon Dioxide (CO_2) (tons/day) School Season				
	Midweek	Friday	Saturday	Sunday
Collin	12,945	13,958	10,969	8,548
Dallas	40,572	43,626	34,114	26,539
Denton	10,343	11,093	8,624	6,673
Ellis	4,086	4,913	3,414	3,132
Hood	979	1,170	858	757
Hunt	2,801	3,286	2,447	2,193
Johnson	2,825	3,399	2,443	2,176
Kaufman	3,636	4,405	3,016	2,757
Parker	2,842	3,405	2,416	2,153
Rockwall	1,320	1,424	1,104	856
Tarrant	27,524	29,868	23,125	17,934
Wise	2,013	2,443	1,751	1,537
Total	111,887	122,991	94,280	75,255

Exhibit 6.3: Emission Estimates for the DFW 12-County Modeling Domain (continued)

2019 Emissions Inventory Nitrogen Oxide (NO) (tons/day) Summer Season				
	Midweek	Friday	Saturday	Sunday
Collin	7.90	8.35	6.11	4.79
Dallas	28.86	30.37	22.38	17.56
Denton	7.18	7.55	5.32	4.15
Ellis	3.89	4.54	2.74	2.50
Hood	1.07	1.23	0.84	0.71
Hunt	3.33	3.74	2.73	2.40
Johnson	2.84	3.32	2.16	1.84
Kaufman	3.46	4.03	2.37	2.15
Parker	3.20	3.72	2.33	1.99
Rockwall	1.13	1.18	0.80	0.63
Tarrant	21.16	22.75	16.09	12.42
Wise	2.26	2.64	1.75	1.44
Total	86.26	93.44	65.63	52.58

2019 Emissions Inventory Nitrogen Oxide (NO) (tons/day) School Season				
	Midweek	Friday	Saturday	Sunday
Collin	7.81	8.34	6.08	4.71
Dallas	28.43	30.17	22.21	17.26
Denton	7.14	7.60	5.33	4.09
Ellis	3.72	4.43	2.58	2.31
Hood	1.02	1.20	0.79	0.66
Hunt	3.19	3.66	2.58	2.23
Johnson	2.71	3.23	2.03	1.70
Kaufman	3.31	3.94	2.23	1.99
Parker	3.06	3.64	2.19	1.84
Rockwall	1.13	1.20	0.80	0.62
Tarrant	20.84	22.59	15.97	12.20
Wise	2.16	2.58	1.65	1.33
Total	84.53	92.59	64.46	50.93

Exhibit 6.3: Emission Estimates for the DFW 12-County Modeling Domain (continued)

2023 Emissions Inventory Nitrogen Oxide (NO) (tons/day) Summer Season				
	Midweek	Friday	Saturday	Sunday
Collin	5.15	5.41	3.82	2.96
Dallas	18.38	19.17	13.60	10.57
Denton	4.76	4.96	3.37	2.60
Ellis	2.60	3.02	1.75	1.58
Hood	0.72	0.83	0.55	0.45
Hunt	2.19	2.47	1.74	1.52
Johnson	1.96	2.28	1.44	1.20
Kaufman	2.34	2.77	1.55	1.39
Parker	2.19	2.54	1.54	1.28
Rockwall	0.71	0.75	0.49	0.39
Tarrant	14.17	15.19	10.33	7.88
Wise	1.55	1.82	1.16	0.93
Total	56.72	61.22	41.33	32.76

2023 Emissions Inventory Nitrogen Oxide (NO) (tons/day) School Season				
	Midweek	Friday	Saturday	Sunday
Collin	5.09	5.40	3.80	2.91
Dallas	18.08	19.02	13.48	10.36
Denton	4.73	5.00	3.37	2.56
Ellis	2.48	2.95	1.65	1.46
Hood	0.69	0.81	0.51	0.42
Hunt	2.10	2.42	1.65	1.42
Johnson	1.87	2.22	1.35	1.11
Kaufman	2.23	2.70	1.45	1.27
Parker	2.10	2.48	1.45	1.19
Rockwall	0.71	0.75	0.50	0.38
Tarrant	13.94	15.06	10.23	7.72
Wise	1.47	1.78	1.08	0.86
Total	55.47	60.59	40.53	31.66

Exhibit 6.3: Emission Estimates for the DFW 12-County Modeling Domain (continued)

2026 Emissions Inventory Nitrogen Oxide (NO) (tons/day) Summer Season				
	Midweek	Friday	Saturday	Sunday
Collin	4.04	4.20	2.86	2.20
Dallas	13.97	14.47	9.88	7.58
Denton	3.68	3.82	2.52	1.92
Ellis	2.08	2.40	1.34	1.19
Hood	0.58	0.67	0.42	0.34
Hunt	1.78	2.00	1.38	1.19
Johnson	1.61	1.87	1.14	0.93
Kaufman	1.89	2.27	1.20	1.07
Parker	1.79	2.07	1.21	0.99
Rockwall	0.56	0.59	0.37	0.29
Tarrant	11.35	12.09	7.89	5.93
Wise	1.27	1.50	0.92	0.72
Total	44.58	47.96	31.11	24.34

2026 Emissions Inventory Nitrogen Oxide (NO) (tons/day) School Season				
	Midweek	Friday	Saturday	Sunday
Collin	3.99	4.20	2.84	2.15
Dallas	13.71	14.34	9.78	7.42
Denton	3.65	3.84	2.51	1.88
Ellis	1.98	2.34	1.25	1.10
Hood	0.55	0.65	0.40	0.32
Hunt	1.70	1.95	1.30	1.11
Johnson	1.54	1.82	1.07	0.86
Kaufman	1.80	2.21	1.12	0.98
Parker	1.71	2.02	1.14	0.91
Rockwall	0.56	0.59	0.37	0.28
Tarrant	11.15	11.98	7.81	5.80
Wise	1.20	1.46	0.86	0.66
Total	43.53	47.41	30.46	23.47

Exhibit 6.3: Emission Estimates for the DFW 12-County Modeling Domain (continued)

2019 Emissions Inventory Nitrogen Dioxide (NO_2) (tons/day) Summer Season				
	Midweek	Friday	Saturday	Sunday
Collin	1.73	1.82	1.22	0.89
Dallas	6.62	6.91	4.68	3.47
Denton	1.64	1.72	1.10	0.80
Ellis	0.97	1.14	0.61	0.54
Hood	0.27	0.32	0.20	0.15
Hunt	0.89	1.00	0.70	0.60
Johnson	0.75	0.88	0.52	0.41
Kaufman	0.88	1.04	0.54	0.48
Parker	0.87	1.01	0.58	0.46
Rockwall	0.27	0.28	0.17	0.13
Tarrant	5.21	5.62	3.60	2.60
Wise	0.61	0.72	0.44	0.34
Total	20.71	22.47	14.35	10.86

2019 Emissions Inventory Nitrogen Dioxide (NO_2) (tons/day) School Season				
	Midweek	Friday	Saturday	Sunday
Collin	1.72	1.83	1.22	0.88
Dallas	6.54	6.90	4.67	3.42
Denton	1.64	1.75	1.11	0.79
Ellis	0.93	1.12	0.57	0.50
Hood	0.26	0.31	0.19	0.14
Hunt	0.86	0.98	0.66	0.55
Johnson	0.71	0.86	0.49	0.38
Kaufman	0.84	1.02	0.51	0.44
Parker	0.83	0.99	0.54	0.43
Rockwall	0.27	0.29	0.17	0.13
Tarrant	5.15	5.60	3.59	2.56
Wise	0.58	0.70	0.41	0.31
Total	20.33	22.35	14.13	10.53

Exhibit 6.3: Emission Estimates for the DFW 12-County Modeling Domain (continued)

2023 Emissions Inventory Nitrogen Dioxide (NO_2) (tons/day) Summer Season				
	Midweek	Friday	Saturday	Sunday
Collin	1.55	1.61	1.02	0.72
Dallas	5.83	6.02	3.86	2.77
Denton	1.50	1.56	0.94	0.66
Ellis	0.93	1.08	0.55	0.47
Hood	0.26	0.31	0.18	0.14
Hunt	0.84	0.95	0.64	0.54
Johnson	0.73	0.86	0.49	0.38
Kaufman	0.86	1.04	0.50	0.43
Parker	0.84	0.98	0.54	0.42
Rockwall	0.23	0.24	0.14	0.10
Tarrant	4.86	5.22	3.18	2.23
Wise	0.59	0.70	0.41	0.30
Total	19.02	20.57	12.43	9.17

2023 Emissions Inventory Nitrogen Dioxide (NO_2) (tons/day) School Season				
	Midweek	Friday	Saturday	Sunday
Collin	1.54	1.63	1.02	0.71
Dallas	5.75	6.00	3.84	2.73
Denton	1.51	1.59	0.95	0.65
Ellis	0.88	1.06	0.51	0.44
Hood	0.25	0.30	0.17	0.13
Hunt	0.81	0.93	0.60	0.50
Johnson	0.70	0.84	0.46	0.35
Kaufman	0.81	1.01	0.46	0.39
Parker	0.80	0.96	0.51	0.39
Rockwall	0.23	0.25	0.14	0.10
Tarrant	4.80	5.20	3.17	2.20
Wise	0.56	0.68	0.38	0.28
Total	18.65	20.45	12.22	8.86

Exhibit 6.3: Emission Estimates for the DFW 12-County Modeling Domain (continued)

2026 Emissions Inventory Nitrogen Dioxide (NO_2) (tons/day) Summer Season				
	Midweek	Friday	Saturday	Sunday
Collin	1.53	1.59	0.98	0.68
Dallas	5.55	5.71	3.58	2.54
Denton	1.44	1.49	0.89	0.62
Ellis	0.91	1.06	0.53	0.45
Hood	0.26	0.30	0.18	0.13
Hunt	0.83	0.94	0.62	0.52
Johnson	0.73	0.86	0.49	0.37
Kaufman	0.85	1.04	0.49	0.42
Parker	0.82	0.96	0.52	0.40
Rockwall	0.22	0.23	0.13	0.10
Tarrant	4.85	5.18	3.09	2.15
Wise	0.58	0.70	0.40	0.29
Total	18.58	20.06	11.89	8.68

2026 Emissions Inventory Nitrogen Dioxide (NO_2) (tons/day) School Season				
	Midweek	Friday	Saturday	Sunday
Collin	1.53	1.60	0.98	0.68
Dallas	5.47	5.69	3.57	2.50
Denton	1.45	1.52	0.90	0.61
Ellis	0.87	1.04	0.49	0.42
Hood	0.24	0.29	0.16	0.12
Hunt	0.80	0.92	0.59	0.49
Johnson	0.70	0.84	0.46	0.34
Kaufman	0.81	1.01	0.46	0.38
Parker	0.78	0.94	0.49	0.37
Rockwall	0.22	0.24	0.14	0.09
Tarrant	4.78	5.16	3.08	2.11
Wise	0.55	0.68	0.37	0.27
Total	18.19	19.93	11.68	8.38