Dallas-Fort Worth Area Link-Based On-road Emission Inventories with MOVES2014b for 2012 and 2020

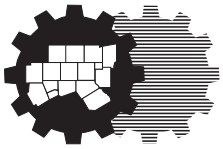
May 2019

What is NCTCOG?

The **North Central Texas Council of Governments** (NCTCOG) is a voluntary association of, by, and for **local governments** within the 16-county North Central Texas Region. The agency was established by state enabling legislation in 1966 to assist local governments in **planning** for common needs, **cooperating** for mutual benefit, and **coordinating** for sound regional development. Its purpose is to strengthen both the individual and collective power of local governments, and to help them recognize regional opportunities, resolve regional problems, eliminate unnecessary duplication, and make joint regional decisions – as well as to develop the means to implement those decisions.

North Central Texas is a 16-county **metropolitan region** centered around Dallas and Fort Worth. The region has a population of more than 7 million (which is larger than 38 states), and an area of approximately 12,800 square miles (which is larger than nine states). NCTCOG has 229 member governments, including all 16 counties, 167 cities, 19 independent school districts, and 27 special districts.

NCTCOG's **structure** is relatively simple. An elected or appointed public official from each member government makes up the **General Assembly** which annually elects NCTCOG's **Executive Board**. The Executive Board is composed of 17 locally elected officials and one ex-officio non-voting member of the legislature. The Executive Board is the policy-making body for all activities undertaken by NCTCOG, including program activities and decisions, regional plans, and fiscal and budgetary policies. The Board is supported by policy development, technical advisory and study **committees** – and a professional staff led by **R. Michael Eastland**, Executive Director.



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NCTCOG's Department of Transportation

Since 1974 NCTCOG has served as the Metropolitan Planning Organization (MPO) for transportation for the Dallas-Fort Worth area. NCTCOG's Department of Transportation is responsible for the regional planning process for all modes of transportation. The department provides technical support and staff assistance to the Regional Transportation Council and its technical committees, which compose the MPO policy-making structure. In addition, the department provides technical assistance to the local governments of North Central Texas in planning, coordinating, and implementing transportation decisions.

Prepared in cooperation with the U.S. Department of Transportation (Federal Highway Administration and Federal Transit Administration) and the Texas Department of Transportation.

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ABSTRACT

TITLE:	Dallas-Fort Worth Area Link-Based On-road Emission Inventories with MOVES2014b for 2012 and 2020
DATE:	May 2019
AUTHORS:	Chris Klaus Senior Program Manager Jenny Narvaez Program Manager Vivek Thimmavajjhala Transportation System Modeler Jackson Enberg Air Quality Operations Analyst
SUBJECT:	Development of 2012 and 2020 On-road Emission Inventories for Summer and School Season for the Dallas-Fort Worth Area
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 North Central Texas Council of Governments conducted a summer and school season emissions inventory to support the Texas Commission on Environmental Quality's photochemical modeling effort to develop an Attainment Demonstration State Implementation Plan for the pollutant ozone. This report documents the on-road mobile methodologies applied and estimated emission results for the 2012 and 2020 analysis years. This analysis covers the following counties: Collin, Dallas, Denton, Ellis, Hood, Hunt, Johnson,

Kaufman, Parker, Rockwall, Tarrant, and Wise. The 12-county estimated on-road mobile source emissions are reported for volatile organic compounds, carbon monoxide, nitrogen oxide, nitrogen dioxide, nitrous acid, oxides of nitrogen, carbon dioxide, methane, sulfur dioxide, ammonia, nitrous oxide, particulate matter with aerodynamic diameters equal to or less than 2.5 microns – 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 – total, brake wear, tire wear, nitrate, and ammonium, for summer and school days in the years 2012 and 2020.

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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
DFX	-	Dallas-Fort Worth Travel Model for the Expanded Area
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
MOVES2014b	-	Motor Vehicle Emissions Simulator version 2014b
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
TAME	-	Tertiary Amyl Methyl Ether
TCEQ	-	Texas Commission on Environmental Quality
TOD	-	Time-of-Day
TSZ	-	Traffic Survey Zone
TTI	-	Texas A and 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 2012 and 2020 on-road emissions inventory 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 (2012) validation and future year (2020) attainment demonstration in the 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), and ammonium (NH_4).

This report documents the methodology and results of the 2012 and 2020 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 more accurately reflect regional conditions. 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 off-network activity, i.e. the source hours parked (SHP), starts, source hours idling (SHI), and auxiliary power units (APU) hours.

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 2014b (MOVES2014b) model. Regionally specific calculations,

procedures, MOVES2014b 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, and 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.

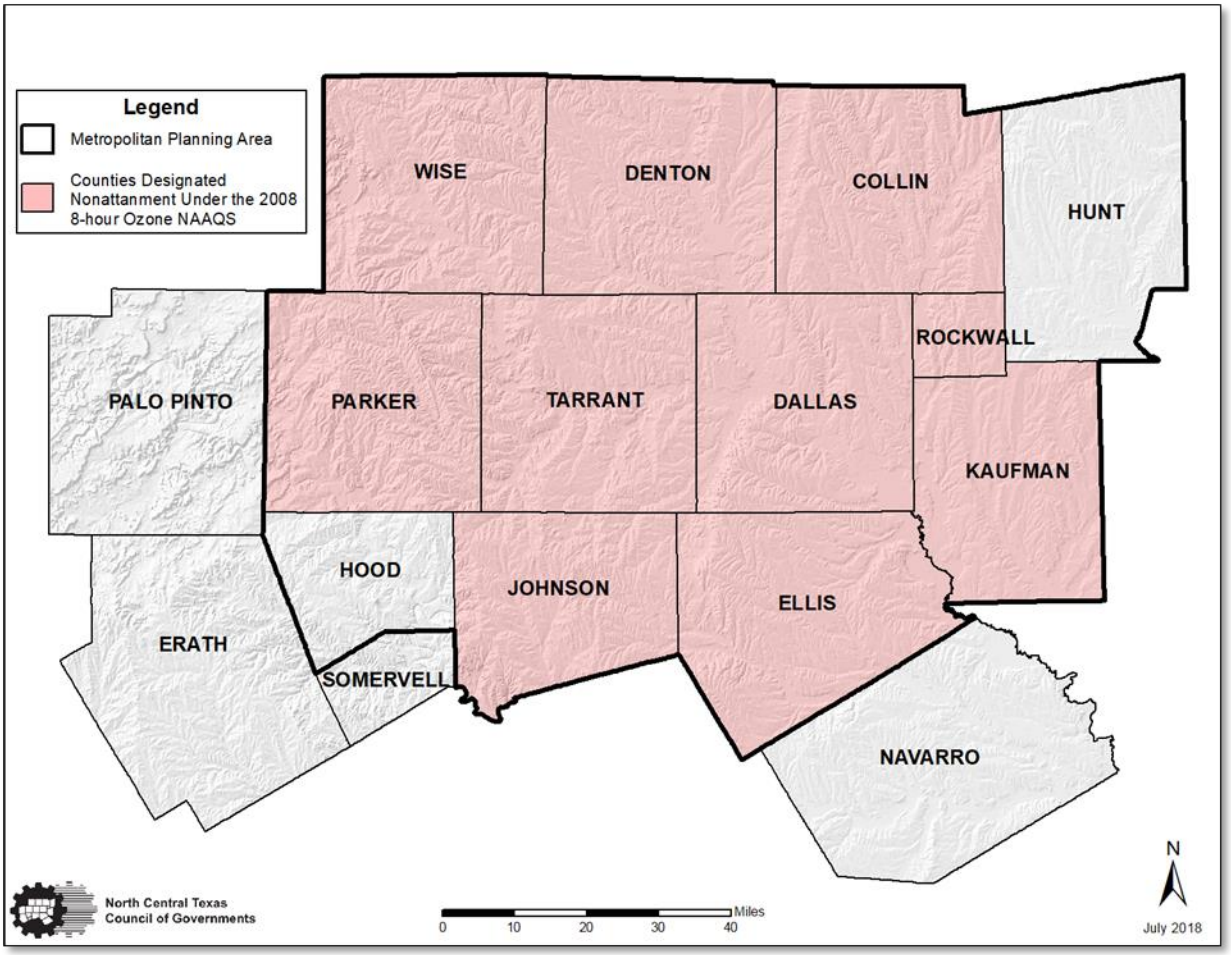
The Appendix contains supplemental information referenced in this document as well as the electronic data supporting the Dallas-Fort Worth (DFW) 2012 and 2020 On-road Mobile Emissions Inventory.

Appendix A: MOVES2014b External Files
Appendix B: MOVES2014b Input and Output Database Files
Appendix C: MOVES2014b Emission Factors
Appendix D: Emission County Files and Link Files (Tab-delimited Format)
Appendix E: Emission Summary Files (Tab-delimited Format)
Appendix F: SCC and XML Files
Appendix G: Project Quality Control Report and Travel Model Validation Report

Background

The TCEQ is planning for a future SIP submission to the U.S. EPA that may be required under the 2008 eight-hour ozone standard of 75 parts per billion (ppb). Under this standard, 10 counties within the DFW area are classified as nonattainment. Hood and Hunt counties are classified as attainment but are included in this work because they are contained within the travel demand model network managed by the NCTCOG. At this time, the 10-county DFW area (exhibit 1.1) is expected to be reclassified as a serious nonattainment area for the 2008 eight-hour ozone standard with an attainment date of July 20, 2021. If required, an attainment demonstration analysis would need to be based on future year emissions estimates for 2020, which represents the complete ozone season prior to the required attainment date. The TCEQ currently has a 2012 base case ozone episode spanning the five months of May through September. 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 10-County Nonattainment Area Map



NCTCOG applies a four-step travel demand model process using TransCAD software to forecast regional vehicle activity and utilizes EPA's MOVES2014b with a post-processing application to estimate regional mobile source emissions.

Modeling Approach

The DFW Travel Model for the Expanded Area (DFX) is employed to estimate VMT and emissions for the 2012 and 2020 summer and school seasons. DFX'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 DFX modeling domain is shown in Exhibit 1.2.

Several components of the model were updated as part of this model expansion. 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 2012 and 2020 on-road emission estimates

by pollutant for summer and school day types are shown in Exhibits 1.3 and 1.4. Appendix D 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

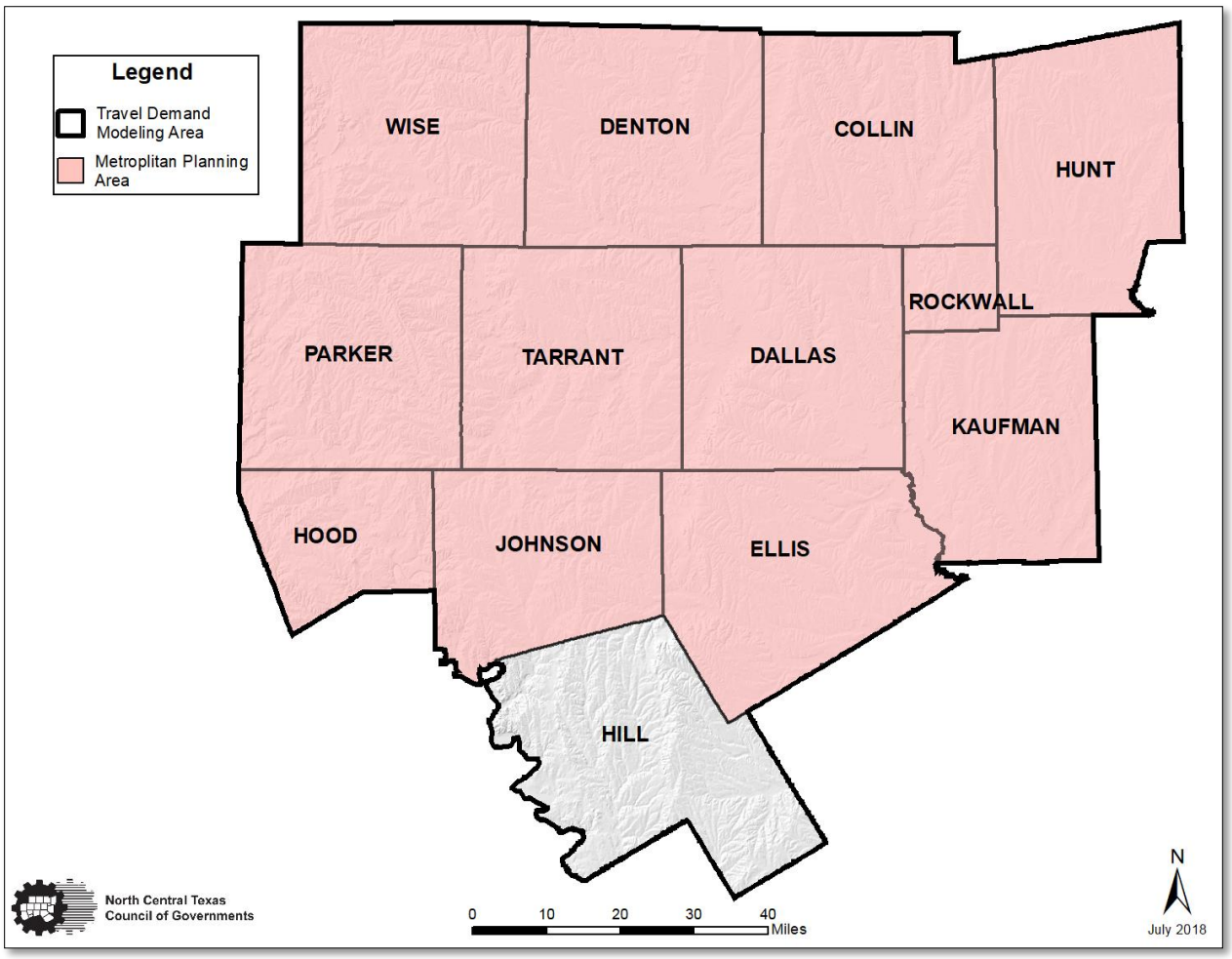


Exhibit 1.3: 2012 Emission Inventory Summary for the DFW 12-County MPA

Summer Season Total Emissions (tons per day)						
	NO_X	VOC	CO	CO_2	NO	NO_2
Midweek	230.74	95.99	1,236.98	109,176.44	206.01	22.88
Friday	236.95	98.36	1,336.11	116,903.49	211.33	23.73
Saturday	169.75	88.54	1,169.29	90,458.95	151.54	16.86
Sunday	154.89	84.04	1,019.02	76,320.21	138.58	15.06
School Season Total Emissions (tons per day)						
	NO_X	VOC	CO	CO_2	NO	NO_2
Midweek	226.73	95.27	1,221.14	107,237.12	202.47	22.45
Friday	237.52	98.56	1,340.96	117,500.27	211.82	23.80
Saturday	169.10	88.50	1,169.86	90,505.53	150.95	16.79
Sunday	151.42	83.39	1,002.15	74,562.98	135.52	14.69

Exhibit 1.4: 2020 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	92.88	54.90	979.98	116,055.25	77.58	14.55
Friday	94.49	55.83	1,062.78	124,037.40	79.13	14.61
Saturday	67.87	51.76	937.32	95,070.72	57.99	9.33
Sunday	62.82	49.97	814.29	80,346.85	53.64	8.67
School Season Total Emissions (tons per day)						
	NO_X	VOC	CO	CO_2	NO	NO_2
Midweek	91.33	54.60	967.26	113,883.91	76.33	14.27
Friday	94.65	55.89	1,065.71	124,575.48	79.26	14.63
Saturday	67.57	51.74	937.38	95,041.48	57.76	9.27
Sunday	61.51	49.70	800.30	78,434.29	52.58	8.44

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 vehicle miles of travel (VMT) and average speed. The current Dallas-Fort Worth Travel Model for the Expanded Area (DFX) 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 DFX using a link-based methodology for each time period.

Dallas-Fort Worth Expanded Travel Model

The source of VMT estimates for the Attainment Demonstration (AD) Emission Inventories for the nonattainment counties is the network-based DFX 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. DFX 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 the DFX is based on a four-step sequential process designed to model travel behavior and predict travel demand at regional, sub-area, or corridor levels. These four steps are: Trip Generation, Trip Distribution, Mode Choice, and Roadway Assignment.

The roadway network developed for the AD Emissions Inventories contains over 30,000 unique segments constructed to replicate the transportation system of the coverage area. For this AD inventory, the transportation network was developed for the years 2012 and 2020. 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.

Trip purposes in the DFX are defined in one of four 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; and other trips that include all truck trips as well as all external-internal, internal-external, and external-external vehicle trips.

The model process begins with an estimate of the socio-economic variables for each zone. The data is organized by traffic survey zone (TSZ), the smallest zone size available in the DFX. There are 5,386 TSZs in the model (5,303 internal zones plus 83 externals). The data for each TSZ includes: zone centroid; median household income; number of households; population; basic, retail, and service employment; and land area. This level of detail is retained in all four 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 DFX 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 visual basic programming language.

Trip Generation Model

The Trip Generation Model is a computer program written in GISDK script language by NCTCOG. 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 2012 and 2020 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 cross-classified trip production model is stratified by income quartile and household size. The allocation of TSZ households into the four income quartiles and six household size categories is based on distribution curves developed from the United States Census Population data. The cross-classified trip attraction model is stratified by area type, employment type (basic, retail, and service), and, for the case of the HBW trip purpose, income quartile. Area type designations are a function of the population and employment density of a zone.

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

	2012	2020
Population	6,610,007	7,680,766
Number of Households	2,388,532	2,737,331
Employment Types		
Basic	995,743	1,165,456
Retail	393,697	473,876
Service	2,739,328	3,278,063
Total Employment	4,128,768	4,917,395

The Trip Generation Model allows the user to input trip rates and trip generation units associated with special generators such as regional shopping malls, hospitals, and colleges/universities. At the end of the generation process, HBW trips are balanced to the estimated trip attractions. All other purposes are balanced to the estimated trip productions in that zone. Because of the uniqueness of the NHB trips, zonal productions for NHB trips are later set equal to the attractions in a given zone.

The regional trip productions and attractions are balanced for each trip purpose. The total trip attractions are balanced to the estimated trip productions in that zone for all other trip purposes.

Trip Distribution Model

The Trip Distribution Model creates the production-attraction person trip tables for each of the 5,386 model zones. The Trip Distribution Model uses the person trips produced by and attracted to each zone, generated in the Trip Generation Model, plus zone-to-zone minimum travel time information from the roadway network to estimate the number of person trips between each pair of zones for each trip purpose. All estimates of roadway travel times include a representation of the time needed for locating a parking space, paying for parking, and walking from the car to the final destination. Estimates of these terminal times were derived from NCTCOG's 1994 Workplace Survey and 1996 Household Travel Survey. NCTCOG is in the process of updating the trip distribution model component based on 2009 household survey data. 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.

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 nested logic formulation for all the trip purposes. The "other" trips are assumed to be vehicle trips with one occupant and are not processed by the Mode Choice Model. 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 the DFX 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 30,000 plus 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 DFX 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 locations. NPMRDS contained 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 E contains speeds by county for each hour of the day. The resulting congested DFX county speeds, weighted by VMT, are listed in Exhibit 2.2.

Exhibit 2.2: Average Loaded Speeds (miles per hour)

Counties	2012	2020
Collin	36.00	34.46
Dallas	33.41	32.83
Denton	38.14	37.55
Ellis	50.79	52.78
Hood	46.96	45.84
Hunt	53.40	54.15
Johnson	46.63	46.18
Kaufman	51.85	52.66
Parker	51.10	51.41
Rockwall	43.50	43.33
Tarrant	36.09	36.25
Wise	53.98	53.89
12-County (weighted average)	**36.82**	**36.50**

Local Street VMT

The roadway network of the DFX 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 (2013-2017), was used.

DFX 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 DFX 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 summer portion of the ratio utilizes traffic volumes recorded for June, July, and August months. Seasonal and daily adjustments for DFX 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
DFX Counties (ASWT to Summer)	Core (Dallas/Tarrant)	0.723	1.011	1.098	0.902
	Rural (Collin/Denton)	0.740	0.995	1.029	0.921
	Perimeter (Other Counties)	1.005	1.053	1.246	1.060
DFX Counties (ASWT to School)	Core (Dallas/Tarrant)	0.717	1.000	1.107	0.912
	Rural (Collin/Denton)	0.729	1.000	1.063	0.941
	Perimeter (Other Counties)	0.938	1.000	1.222	1.005

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 DFX 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 the DFX, 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. The hourly adjustments for DFX counties for 2020 summer season are shown in Exhibit 2.4 as an example.

Exhibit 2.4: 2020 Summer Season Hourly Adjustment Factors for the DFW 12-County Modeling Domain

	Sunday	Midweek	Friday	Saturday
1	0.022	0.009	0.010	0.018
2	0.015	0.006	0.007	0.012
3	0.013	0.006	0.006	0.010
4	0.009	0.006	0.007	0.008
5	0.008	0.011	0.011	0.009
6	0.011	0.028	0.026	0.016
7	0.016	0.058	0.048	0.026
8	0.022	0.077	0.060	0.034
9	0.031	0.069	0.055	0.043
10	0.043	0.050	0.049	0.051
11	0.055	0.047	0.049	0.058
12	0.062	0.049	0.052	0.063
13	0.072	0.051	0.055	0.067
14	0.076	0.053	0.058	0.067
15	0.075	0.057	0.061	0.067
16	0.075	0.067	0.067	0.067
17	0.074	0.074	0.070	0.067
18	0.071	0.076	0.070	0.065
19	0.065	0.062	0.062	0.060
20	0.055	0.045	0.051	0.051
21	0.045	0.035	0.040	0.043
22	0.037	0.029	0.035	0.038
23	0.028	0.022	0.030	0.034
24	0.019	0.015	0.022	0.026

Model VMT Adjustments (HPMS vs. DFX)

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.

Prior to beginning the development of this emission inventory for the Attainment Demonstration State Implementation Plan, NCTCOG performed a validation on the DFX model in order to meet the transportation conformity requirements per the *Code of Federal Regulation*s, 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). The previous DFX validation was performed in 2004, triggering an update to the validation. In order to be consistent with the planning assumptions incorporated in the *2014 Transportation Conformity*, NCTCOG incorporated the updated DFX model validation which is based on 2010 demographics. Exhibit 2.5 shows the calculation performed to develop the new HPMS adjustment factor, 0.9703, based on a comparison of 2010 VMT for HPMS and DFX.

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. Reducing the freeway speeds increases volatile organic compounds (VOC) and oxides of nitrogen (NO_X) emissions by 4.9 percent, resulting in a factor of 1.049 for freeway VOC and NO_X emissions in urban and rural counties. This is thought to be a conservative estimate of increased emissions due to nonrecurring congestion. 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.

Exhibit 2.5: 2010 DFW and HPMS VMT Analysis

Model VMT Adjustment Factor	
	2010 VMT
HPMS (ASWT)[1]	165,292,084
DFX (ASWT)	170,346,118
HPMS/DFX Ratio	**0.9703**

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

VMT Estimates

The 2012 and 2020 VMT estimates for different day types are shown in Exhibit 2.6 respectively for the 12-county area. Appendix E contains the VMT by county by day for each hour for all counties.

Exhibit 2.6: Vehicle Miles of Travel

All Counties – 24-Hour Total					
Analysis Year	**Season**	**Midweek**	**Friday**	**Saturday**	**Sunday**
2012	**Summer**	197,098,030	216,490,271	180,133,825	149,303,203
	School	193,945,845	217,546,531	180,306,951	146,099,810
2020	**Summer**	240,775,598	264,855,700	220,071,735	182,620,993
	School	236,789,931	265,978,460	220,141,930	178,642,069

CHAPTER 3: OFF-NETWORK ACTIVITY

To estimate the off-network (or parked vehicle) emissions using the mass per activity emissions rates, county-level analysis years 2012 and 2020 weekday estimates of the source hours parked (SHP), starts, source hours idling (SHI), and auxiliary power units (APU) hours are required by hour and vehicle (SHI 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 year county-level vehicle population. Appendix A contains the vehicle population and hourly SHP, starts, SHI, and APU hours.

Texas A&M Transportation Institute's (TTI) MOVESpopulationBuild module is used to convert Motor Vehicle Emissions Simulator version 2014b (MOVES2014b) based Texas Department of Motor Vehicles registration data for each county into 13 MOVES2014b source use type (SUT) population (or vehicle population). The county-level SHP, starts, SHI, and APU hours of off-network activity were developed using the "OffNetActCalc" utility and methodology provided by TTI.

Estimation of SHP

The first activity measure needed to estimate the off-network emissions using the mass per activity emissions rates are county-level analysis year weekday estimates of SHP by hour and vehicle type. For each hour, the county-level vehicle type SHP was calculated by taking the difference between the vehicle type total available hours minus the vehicle type vehicle hours travelled (VHT). Since this calculation was performed at the hourly level, the vehicle type total available hours was set equal to the vehicle type population. The Source Hours Operating (SHO) was calculated using the link vehicle miles of travel (VMT) and speeds and the VMT mixes by MOVES road-type category. Appendix A includes the 24-hour summaries of the county-level weekday estimates of SHP by hour and vehicle type for all analysis years.

Vehicle Type Total Available Hours

The vehicle type total available hours is typically calculated as the vehicle type population times the number of hours in the time period. Since this calculation was performed at the hourly level, the vehicle type total available hours for each activity scenario was set equal to the vehicle type vehicle population for the activity scenario year.

Vehicle Type VHT

To calculate the VHT for a given link, the VMT was allocated to each vehicle type using the Texas Department of Transportation district-level vehicle type VMT mixes by MOVES road-type category, which was then divided by the link speed to calculate the link vehicle type VHT. These VMT mixes are the same VMT mixes used to estimate emissions in the emissions estimation process. This SHO calculation was performed for each link in a given hour, aggregating the VHT to one value per vehicle type per hour.

Estimation of Starts

The second activity measure needed to estimate the off-network emissions using the mass per activity emissions rates are county-level analysis year weekday estimates of starts by hour and vehicle type. The vehicle type hourly default starts per vehicle were multiplied by the analysis year county-level vehicle type vehicle population to estimate the county-level vehicle type starts by hour. Appendix A includes the 24-hour summaries of the county-level vehicle type starts by hour for each analysis year.

For the hourly default starts per vehicle, the MOVES defaults were used. The MOVES activity output was used to estimate the hourly starts per vehicle for a MOVES weekday run by dividing the MOVES start output by the MOVES vehicle population output. These MOVES national default starts per vehicle do not vary by year, only by MOVES day type. For this weekday analysis, the MOVES national default "weekday" starts per vehicle were used.

Estimation of SHI 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 analysis year weekday heavy-duty diesel truck (SUT 62, fuel type 2 [CLhT_Diesel]) SHI and APU hours (hotelling activity). During hotelling, the truck's main engine is assumed to be in idling mode or its APU is in use. To calculate the SHI and APU hours activity, the hotelling hours activity were calculated, which was then allocated to the SHI and APU hours components.

The hotelling activity was based on information from a Texas Commission on Environmental Quality extended idling study, which produced 2017 winter weekday extended idling estimates for each Texas county and hotelling activity data from MOVES. Hotelling scaling factors (by analysis year) were applied to the base 2017 winter weekday hotelling values from the study to estimate the 24-hour hotelling by analysis year. Hotelling hourly factors were then applied to allocate the 24-hour hotelling by analysis year to each hour of the day. To ensure that valid hourly hotelling values are used, the hourly hotelling activity was compared to the CLhT_Diesel hourly SHP (i.e., hourly hotelling values cannot exceed the hourly SHP values). SHI and APU hours factors were then applied to the hotelling hours to produce the hourly SHI and APU hours of activity. Appendix A incudes the 24-hour summaries of the county-level estimates of hotelling hours, SHI, and APU hours for each analysis year.

Hotelling Activity Scaling Factors

To estimate the analysis year county-level 24-hour hotelling activity, county-level hotelling activity scaling factors were developed using the county-level 2017 winter weekday link-level VMT and speeds, the VMT mix (by MOVES road type), the county-level analysis year weekday link-level VMT and speeds, and the VMT mix (by MOVES road type). The 2017 winter weekday link-level VMT and speeds were developed using a process similar to the 2012 and 2020 weekday link-level VMT speed estimation. The vehicle type VMT mixes were the same VMT mixes used to estimate emissions in the emissions estimation process. For the base weekday vehicle type VMT mix, the 2017 weekday vehicle type VMT mix was used.

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 weekday VMT. Using a similar allocation process, the analysis year weekday CLhT_Diesel hourly and 24-hour VMT was calculated using the analysis year weekday link-level VMT and speeds and the analysis year vehicle type VMT mix. The county- level 24-hour hotelling activity scaling factors by analysis year were calculated by dividing the analysis year and day type CLhT_Diesel 24-hour VMT by the CLhT_Diesel 24-hour 2017 winter weekday VMT.

Hotelling Activity Hourly Factors

To allocate the analysis year weekday county-level 24-hour hotelling activity to each hour of the day, hotelling activity hourly factors were used. These hotelling activity hourly factors were calculated as the inverse of the analysis year weekday CLhT_Diesel hourly VMT fractions. The analysis year weekday CLhT_Diesel hourly VMT fractions were calculated using the hourly analysis year weekday CLhT_Diesel VMT. The hourly analysis year weekday CLhT_Diesel VMT was converted to hourly fractions, therefore creating analysis year weekday CLhT_Diesel hourly VMT fractions. The inverse of these hourly VMT fractions were calculated and the inverse for each hour was divided by the sum of the inverse hourly VMT fractions across all hours to calculate the county-level analysis year weekday hotelling activity hourly factors for each analysis year.

County-Level CLhT_Diesel Hotelling Activity by Hour Estimation

The four analysis years' weekday CLhT_Diesel hotelling activity by hour was calculated by multiplying the 24-hour 2017 winter weekday hotelling hours by the analysis year hotelling activity scaling factor and by the analysis year hotelling activity hourly factors. For each hour, the analysis year weekday hotelling activity was then compared to the analysis year weekday CLhT_Diesel SHP to estimate the final analysis year weekday hotelling activity by hour. If the analysis year weekday hotelling activity value was greater than the analysis year weekday SHP value, then the final analysis year weekday hotelling activity for that hour was set to the analysis year weekday CLhT_Diesel SHP value. Otherwise, the final analysis year weekday hotelling activity for that hour was set to the base analysis year weekday hotelling activity

value. All calculations (scaling factors, hotelling activity hourly factors, and hotelling activity by hour calculations) were performed by county and analysis year (i.e., 10 hotelling activity scaling factors were calculated per analysis year).

County-Level CLhT_Diesel SHI and APU Hours Estimation

Weekday hourly county-level hotelling activity for all analysis years was then allocated to SHI and APU hours activity components using the aggregate extended idle mode and APU mode fractions. For each hour, the analysis year weekday hotelling activity was multiplied by the SHI fraction to calculate the analysis year weekday hourly SHI activity and by the APU fraction to calculate the analysis year weekday hourly APU activity.

The aggregate SHI 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 activity distribution (i.e., a bi-modal distribution of 1.0 SHI prior to the 2010 model year and a 0.7/0.3 SHI/APU activity allocation for 2010 and later model years). 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 SHI and APU fractions (which sum to 1.0).

CHAPTER 4: EMISSION FACTOR ESTIMATION PROCEDURE

MOVES2014B Model and Input Parameters

The Environmental Protection Agency's (EPA) Motor Vehicle Emission Simulator version 2014b (MOVES2014b) was used to develop 2012 and 2020 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. MOVES2014b 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 are included in Appendix A. MOVES2014b input files utilizing these parameters and data for each county are included in Appendix B.

Exhibit 4.1: MOVES2014b 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	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), and Ammonium (NH_4).

Exhibit 4.2: MOVES2014b External Conditions

Command	Input Parameter Values	Description
MOVES Model Version	MOVES2014b	This version was released in August 2018
Calendar Year	2012, 2020	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 the TCEQ
Barometric Pressure	Average Summer (June, July, and August)	County-specific, provided by the TCEQ

Exhibit 4.3: MOVES2014b 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). NCTCOG input parameter sheet is used to convert TxDMV registration data for each county into 13 MOVES SUT.	2012 and 2014 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.	2012 and 2014 TxDMV registration data. MOVES2014b default used for buses
Vehicle Type VMT	County-specific vehicle miles of travel (VMT) is distributed to Highway Performance Monitoring S (HPMS) Vehicle types.	DFX 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 DFX 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 DFX Output
Ramp Fraction	Input county specific fraction of ramp driving time on rural and urban restricted roadway type.	NCTCOG DFX 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 MOVES2014b input where local data unavailable
Meteorology	County Specific data on temperature, humidity, and barometric pressure, and other data, as agreed upon and provided by the TCEQ	Local data from the TCEQ
Fuel Formulation	Input county specific fuel properties in the MOVES2014b database.	TCEQ, EPA Fuel Surveys, and default MOVES input where local data unavailable

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.	DFW nine-county I/M data as defined by, 30 TAC[1], Part 1, Chapter 114, Subchapter C
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.	2012 and 2014 TxDMV registration data MOVES2014b default used for light duty vehicles and buses

Exhibit 4.4: MOVES2014b I/M Descriptive Inputs for Subject Counties

2012						
Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker, Rockwall, and Tarrant I/M Data*						
I/M Program ID	20	21	22	23	24	MOVES2014b
Pollutant Process ID	101, 102, 201, 202, 301, 302	101, 102, 201, 202, 301, 302	101, 102, 201, 202, 301, 302	112	112	MOVES2014b
Source Use Type	21, 31, 32	21, 31, 32	52, 54	21, 31, 32	21, 31, 32	MOVES2014b
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	93.12% for source use type 21, 91.26% for source use type 31 and 85.67% for source use type 32^					Expected compliance (%) - MOVES2014b Default

Source: TCEQ
OBD – On-board Diagnostic; ASM – Acceleration Simulation Mode; RPM – Revolutions Per Minute
*Wise County does not have an I/M program
^http://www.epa.gov/otaq/models/moves/documents/420b15007.pdf

2020				
Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker, Rockwall, and Tarrant I/M Data*				
I/M Program ID	20	22	24	MOVES2014b
Pollutant Process ID	101, 102, 201, 202, 301, 302	101, 102, 201, 202, 301, 302	112	MOVES2014b
Source Use Type	21, 31, 32	52, 54	21, 31, 32	MOVES2014b
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	93.12% for source use type 21, 91.26% for source use type 31 and 85.67% for source use type 32^			Expected compliance (%) - MOVES2014b Default

Source: TCEQ
OBD – On-board Diagnostic; ASM – Acceleration Simulation Mode; RPM – Revolutions Per Minute
*Wise County does not have an I/M program
^http://www.epa.gov/otaq/models/moves/documents/420b15007.pdf

Exhibit 4.5: MOVES2014b Fuel Properties

	2011 (for Analysis Year 2012)			2018 and later (for Analysis Year 2020)		
Fuel Type	**Gasoline**		**Diesel**	**Gasoline**		**Diesel**
Counties	**Core**	**Perimeter**	**All**	**Core**	**Perimeter**	**All**
fuelformulationID	10707	10727	30572	18724	18734	30011
fuelsubtypeID	12	12	20	12	12	20
RVP	6.99	7.39	0	7.00	7.80	0
sulfurLevel	24.80	29.27	5.72	10.00	10.00	11.00
ETOHVolume	9.70	9.78	0	9.67	9.66	0
MTBEVolume	0	0	0	0	0	0
ETBEVolume	0	0	0	0	0	0
TAMEVolume	0	0	0	0	0	0
aromaticContent	14.48	25.23	0	14.74	25.35	0
olefinContent	11.79	11.16	0	10.74	8.33	0
benzeneContent	0.48	0.96	0	0.46	0.61	0
e200	47.19	49.08	0	49.21	49.45	0
e300	85.22	81.36	0	85.13	82.68	0
VolToWtPercentOxy	0.3653	0.3653	0	0.3653	0.3653	0
BioDieselEsterVolume	0	0	0	0	0	0
CetaneIndex	0	0	0	0	0	0
PAHContent	0	0	0	0	0	0
T50	209.44	204.74	0	202.52	203.73	0
T90	325.41	334.89	0	325.77	327.68	0

Source: TTI

Area Specific Calculations and Procedures

SourceUse Type DistributionSourceUse type age distributions are calculated from the TxDMV vehicle registration data. July data sets of 2012 and 2014 are utilized for light- and heavy-duty vehicle classes. MOVES2014b 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 2013 five-year American Community Survey. Exhibit 4.6 identifies the percentages applied for this weighted adjustment. The TTI methodology is applied to the heavy-duty vehicle data for developing registration for all heavy-duty vehicles. These files are included in Appendix B.

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	65.4%	10.2%	5.1%	0.3%	0.1%	4.2%	0.2%	1.0%	0.0%	7.6%	0.9%	0.0%
Dallas	19.1%	66.0%	10.2%	10.7%	0.9%	3.9%	1.3%	15.8%	1.0%	23.6%	7.7%	0.7%
Denton	11.5%	7.9%	75.6%	0.4%	0.3%	0.0%	0.2%	0.7%	0.9%	0.6%	3.3%	3.1%
Ellis	0.2%	1.8%	0.2%	79.4%	0.2%	0.1%	1.4%	0.7%	0.1%	0.0%	0.6%	0.2%
Hood	0.0%	0.1%	0.0%	0.1%	84.0%	0.0%	2.3%	0.0%	2.4%	0.0%	0.5%	0.4%
Hunt	0.8%	0.4%	0.1%	0.1%	0.0%	84.3%	0.0%	4.4%	0.0%	9.4%	0.0%	0.0%
Johnson	0.0%	0.3%	0.3%	3.5%	3.2%	0.0%	76.2%	0.0%	1.4%	0.2%	3.2%	0.7%
Kaufman	0.3%	1.6%	0.1%	0.7%	0.1%	1.2%	0.0%	72.6%	0.0%	3.6%	0.1%	0.0%
Parker	0.0%	0.1%	0.1%	0.1%	4.3%	0.0%	0.5%	0.0%	77.4%	0.0%	2.6%	5.9%
Rockwall	0.7%	1.2%	0.1%	0.1%	0.5%	5.6%	0.1%	3.7%	0.0%	53.9%	0.1%	0.1%
Tarrant	2.0%	10.3%	7.4%	4.6%	6.2%	0.4%	17.5%	1.1%	14.1%	1.0%	80.3%	10.7%
Wise	0.1%	0.1%	0.8%	0.0%	0.2%	0.2%	0.3%	0.0%	2.5%	0.0%	0.8%	78.2%

Source: 2013 5-year American Community Survey.

Fuel Engine Fraction

Diesel fractions for heavy-duty vehicle categories utilized 12-county summed July registration data for modeling 2012 and 2020 analysis years. July 2012 registration data is used for modeling the 2012 analysis year and July 2014 registration data is used for modeling the 2020 analysis year. Light-duty and bus categories utilize MOVES2014b default values. All diesel fraction files, included in Appendix B, list specific data used for this analysis.

MOVES2014b Emission Factors

MOVES2014b emission factors are reported in Appendix C.

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 discussed in Chapter 5.

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	
	2012	2020
Passenger Car	0.9411	0.9508
Passenger Truck	0.9467	0.9500
Light Commercial Truck	0.9434	0.9479
Intercity Bus	0.9416	0.9440
Transit Bus	0.9421	0.9449
School Bus	0.9421	0.9443
Refuse Truck	0.9440	0.9477
Single Unit Short-haul Truck	0.9496	0.9514
Single Unit Long-haul Truck	0.9498	0.9514
Motor Home	0.9441	0.9467
Combination Short-haul Truck	0.9456	0.9490
Combination Long-haul Truck	0.9445	0.9488

Source: TCEQ

Vehicle Miles of Travel Mix (VMT Mix)

VMT Mix is applied to the emission factors in a post-process methodology. The VMT mix enables assignment of emission factors by vehicle type to a total volume to calculate emissions on a link or functional class. VMT mix is estimated for rural and urban freeways, arterials, collectors and high occupancy vehicle lanes for three time periods.

Vehicle counts reported in the TxDOT Vehicle Classification Report provide a base for the distribution of vehicles by type and functional class for the freeway, arterial, and collector VMT Mixes. The number of vehicles in each of the 12 axle-based categories are combined into intermediate groups, and then disaggregated into MOVES2014b Source use types by applying appropriate TxDMV registration data, and/or MOVES2014b defaults. Exhibit 4.8 outlines this process. For each functional class, the values are aggregated across the total vehicles to determine the fraction of vehicles from each class. Motorcycles are allocated as 0.1 percent for each functional class, subtracted from the Light-duty Gasoline Vehicles category.

This “temporary” VMT mix calculation is then redistributed using local truck and non-truck splits identified by the DFX model. This process is performed for each of the three functional classes and three time periods, where AM peak is 6:30 a.m. – 8:59 a.m., PM peak is 3:00 p.m. – 6:29 p.m., and Off-peak represents all other hours of the day. Motorcycles, light-duty vehicles, and two-axle light-duty trucks are classified as non-trucks. Trucks and heavy-duty vehicles with three axles or more, including buses, are defined as trucks.

Exhibit 4.8: Vehicle Classification Process

Axle-based Vehicle Classifications		Intermediate Groups/HPMSVtypeID		Detailed Groups	
C	**Passenger Vehicles**	Passenger Vehicles	Light-duty Vehicles (25)	Passenger Car	Passenger Gasoline Vehicle
					Passenger Diesel Vehicle
					Motorcycle^
P	**2 Axle, 4 Tire Single Unit**			Passenger Truck	Passenger Gasoline Truck
					Passenger Gasoline Truck
				Light Commercial Truck	Light Commercial Gasoline Truck
					Light Commercial Gasoline Truck
B	**Buses**	Bus	Buses (40)	School Bus	Gasoline School Bus*
					Diesel School Bus*
				Transit Bus	Gasoline Transit Bus*
					Diesel Transit Bus*
				Diesel Intercity Bus*	
SU2	**2 Axle, 6 Tire Single Unit**	Heavy Duty Trucks	Single Unit Heavy-duty Vehicles (50)	Single Unit Short-haul Truck	* Single Unit Short-haul Gasoline Truck
SU3	**3 Axle, Single Unit**				Single Unit Short-haul Diesel Truck*
SU4	**4+ Axle, Single Unit**			Single Unit Long-haul Truck	Single Unit Long-haul Gasoline Truck*
SE4	**3 or 4 Axle, Single Trailer**				Single Unit Long-haul Diesel Truck*
SE5	**5 Axle, Single Trailer**	Heavy Duty Trucks	Combination Heavy-duty Vehicles (60)	Combination Short-haul Truck	Combination Short-haul Gasoline Truck*
SE6	**6+ Axle, Single Trailer**				
SD5	**5 Axle, Multi Trailer**				Combination Short-haul Diesel Truck*
SD6	**6 Axle, Multi Trailer**			Combination Long-haul Diesel Truck*	
SD7	**7+ Axle, Multi Trailer**				

Source: Dallas/Fort Worth Ozone Nonattainment Area SIP Support, 2003, TTI

* Categories calculated using MOVES2014b defaults

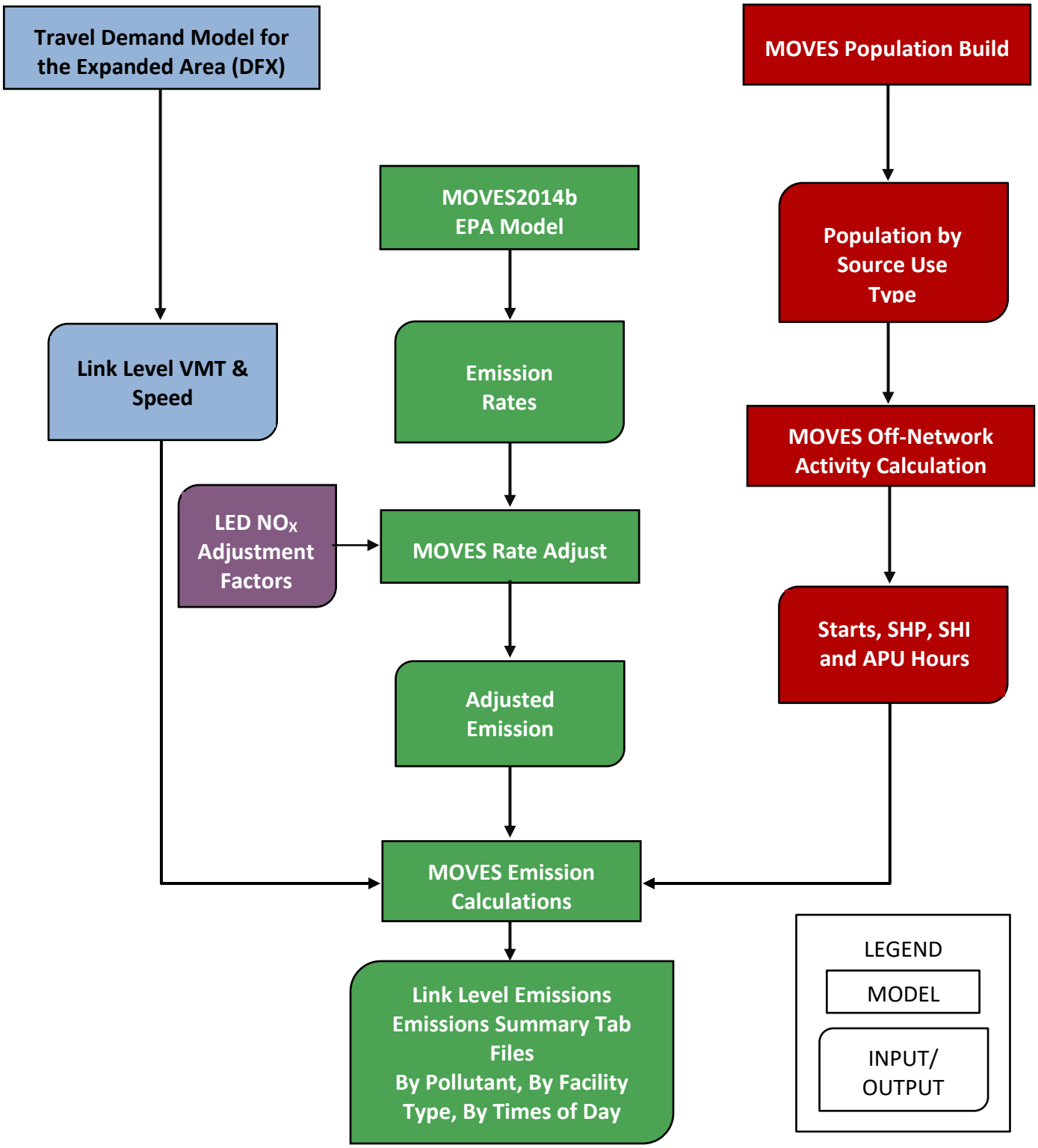
^ Motorcycles are allocated as 0.1 percent for each functional class, subtracted from the Light-duty

CHAPTER 5: EMISSION CALCULATION

Emissions estimates are calculated using "*TTI emissions inventory estimation utilities using moves: movesutl",* 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: MOVES2014b 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 E 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 E 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 E 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

2012 Emissions Inventory VMT Summer Season				
Counties	**Midweek**	**Friday**	**Saturday**	**Sunday**
Collin	22,003,297	23,739,855	19,736,432	15,832,376
Dallas	73,789,867	80,030,346	65,921,092	52,866,053
Denton	18,439,604	19,697,736	16,666,299	13,376,758
Ellis	6,941,036	8,208,548	6,987,233	6,620,290
Hood	1,872,143	2,213,900	1,884,429	1,785,473
Hunt	4,643,551	5,491,438	4,674,334	4,428,863
Johnson	5,030,860	5,949,536	5,064,320	4,798,362
Kaufman	5,863,362	6,934,027	5,902,309	5,592,345
Parker	5,040,341	5,960,527	5,073,507	4,807,085
Rockwall	2,397,278	2,557,156	2,169,060	1,741,070
Tarrant	47,533,227	51,516,654	42,487,744	34,074,794
Wise	3,543,463	4,190,549	3,567,065	3,379,734
Total	197,098,030	216,490,271	180,133,825	149,303,203

2012 Emissions Inventory VMT School Season				
Counties	**Midweek**	**Friday**	**Saturday**	**Sunday**
Collin	21,821,679	24,010,199	20,001,573	15,678,042
Dallas	73,055,171	80,732,533	66,734,134	52,386,161
Denton	18,346,856	20,021,046	16,924,528	13,229,586
Ellis	6,589,104	8,049,715	6,623,062	6,179,791
Hood	1,777,220	2,171,061	1,786,213	1,666,672
Hunt	4,408,109	5,385,179	4,430,712	4,134,175
Johnson	4,775,779	5,834,415	4,800,369	4,479,091
Kaufman	5,566,072	6,799,855	5,594,683	5,220,244
Parker	4,784,780	5,845,192	4,809,077	4,487,231
Rockwall	2,386,327	2,600,989	2,203,302	1,721,605
Tarrant	47,070,953	51,986,883	43,018,149	33,762,357
Wise	3,363,797	4,109,463	3,381,150	3,154,854
Total	193,945,845	217,546,531	180,306,951	146,099,810

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

2020 Emissions Inventory VMT Summer Season				
Counties	**Midweek**	**Friday**	**Saturday**	**Sunday**
Collin	28,487,874	30,729,893	25,557,002	20,501,809
Dallas	87,022,573	94,389,244	77,738,095	62,342,547
Denton	22,672,185	24,425,167	20,359,650	16,333,640
Ellis	8,815,744	10,425,607	8,874,437	8,408,384
Hood	2,152,577	2,545,438	2,166,580	2,052,814
Hunt	5,811,941	6,873,147	5,850,440	5,543,206
Johnson	6,367,351	7,530,086	6,409,706	6,073,093
Kaufman	7,671,899	9,072,821	7,722,885	7,317,310
Parker	6,628,052	7,838,108	6,671,700	6,321,348
Rockwall	3,000,807	3,213,438	2,707,106	2,172,497
Tarrant	57,824,382	62,703,608	51,665,148	41,433,757
Wise	4,320,214	5,109,143	4,348,983	4,120,589
Total	240,775,598	264,855,700	220,071,735	182,620,993

2020 Emissions Inventory VMT School Season				
Counties	**Midweek**	**Friday**	**Saturday**	**Sunday**
Collin	28,254,640	31,083,013	25,901,439	20,301,421
Dallas	86,153,976	95,213,860	78,695,645	61,777,243
Denton	22,496,000	24,721,558	20,639,492	16,171,328
Ellis	8,368,757	10,223,874	8,411,905	7,848,910
Hood	2,043,434	2,496,183	2,053,659	1,916,224
Hunt	5,517,256	6,740,153	5,545,515	5,174,372
Johnson	6,044,505	7,384,381	6,075,636	5,669,006
Kaufman	7,282,910	8,897,265	7,320,372	6,830,434
Parker	6,291,988	7,686,443	6,323,975	5,900,743
Rockwall	2,983,328	3,262,172	2,747,684	2,149,263
Tarrant	57,251,972	63,259,277	52,304,289	41,056,711
Wise	4,101,165	5,010,281	4,122,317	3,846,415
Total	236,789,931	265,978,460	220,141,930	178,642,069

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

2012 Emissions Inventory Speed Estimates Summer Season				
	Midweek	Friday	Saturday	Sunday
Collin	36.04	36.75	39.01	40.09
Dallas	35.92	36.50	39.16	40.41
Denton	37.10	37.68	39.92	41.29
Ellis	45.46	44.27	45.97	45.35
Hood	41.59	41.01	42.39	41.92
Hunt	46.58	45.72	47.13	46.65
Johnson	42.13	41.11	42.67	42.11
Kaufman	46.15	45.41	46.80	46.31
Parker	44.17	43.70	44.92	44.51
Rockwall	40.33	40.77	42.81	43.81
Tarrant	36.89	37.58	39.83	40.89
Wise	45.68	44.94	46.69	46.06
Average	41.51	41.29	43.11	43.28

2012 Emissions Inventory Speed Estimates School Season				
	Midweek	Friday	Saturday	Sunday
Collin	36.20	36.63	38.90	40.15
Dallas	36.11	36.37	39.04	40.47
Denton	37.21	37.43	39.73	41.37
Ellis	45.89	44.52	46.40	46.00
Hood	41.95	41.20	42.73	42.41
Hunt	46.92	45.91	47.46	47.15
Johnson	42.52	41.33	43.05	42.69
Kaufman	46.52	45.60	47.14	46.83
Parker	44.47	43.85	45.21	44.93
Rockwall	40.47	40.66	42.71	43.86
Tarrant	37.06	37.46	39.73	40.95
Wise	46.19	45.19	47.14	46.73
Average	41.79	41.35	43.27	43.63

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

2020 Emissions Inventory Speed Estimates Summer Season				
	Midweek	Friday	Saturday	Sunday
Collin	35.23	36.72	39.18	40.37
Dallas	35.74	36.51	39.84	41.41
Denton	37.07	38.23	41.03	42.42
Ellis	46.43	44.51	46.90	46.00
Hood	40.55	40.02	41.80	41.16
Hunt	46.61	45.26	47.08	46.43
Johnson	41.62	39.69	41.95	41.11
Kaufman	45.35	42.80	45.83	44.66
Parker	43.75	42.53	44.46	43.76
Rockwall	40.19	40.70	42.91	44.04
Tarrant	37.10	37.79	40.50	41.79
Wise	44.40	42.11	44.88	43.83
Average	41.17	40.57	43.03	43.08

2020 Emissions Inventory Speed Estimates School Season				
	Midweek	Friday	Saturday	Sunday
Collin	35.43	36.58	39.05	40.43
Dallas	35.98	36.34	39.68	41.49
Denton	37.28	38.07	40.89	42.49
Ellis	47.03	44.86	47.51	46.94
Hood	41.09	40.27	42.25	41.83
Hunt	47.06	45.52	47.54	47.11
Johnson	42.15	40.03	42.52	41.98
Kaufman	46.13	43.26	46.62	45.88
Parker	44.23	42.80	44.94	44.49
Rockwall	40.33	40.56	42.79	44.10
Tarrant	37.29	37.64	40.37	41.85
Wise	45.11	42.53	45.61	44.93
Average	41.59	40.70	43.31	43.63

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

2012 Emissions Inventory Oxides of Nitrogen (NO_X) (tons/day) Summer Season				
	Midweek	Friday	Saturday	Sunday
Collin	21.45	21.56	15.82	13.88
Dallas	78.47	79.15	57.52	50.21
Denton	20.31	20.05	14.48	12.74
Ellis	12.02	13.06	8.75	8.96
Hood	2.45	2.73	2.06	2.06
Hunt	11.65	12.91	8.66	8.90
Johnson	6.98	7.66	5.43	5.50
Kaufman	9.17	9.93	6.86	6.95
Parker	8.96	9.57	6.36	6.51
Rockwall	3.39	3.36	2.40	2.14
Tarrant	49.31	49.76	36.56	32.09
Wise	6.58	7.20	4.87	4.94
Total	230.74	236.95	169.75	154.89

2012 Emissions Inventory Oxides of Nitrogen (NO_X) (tons/day) School Season				
	Midweek	Friday	Saturday	Sunday
Collin	21.31	21.81	16.00	13.77
Dallas	77.77	79.79	58.11	49.85
Denton	20.24	20.39	14.68	12.63
Ellis	11.45	12.82	8.33	8.42
Hood	2.34	2.68	1.97	1.94
Hunt	11.09	12.67	8.23	8.34
Johnson	6.67	7.52	5.19	5.19
Kaufman	8.75	9.76	6.53	6.53
Parker	8.55	9.41	6.06	6.13
Rockwall	3.38	3.42	2.43	2.12
Tarrant	48.90	50.17	36.92	31.86
Wise	6.28	7.08	4.63	4.65
Total	226.73	237.52	169.10	151.42

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

2020 Emissions Inventory Oxides of Nitrogen (NO_X) (tons/day) Summer Season				
	Midweek	Friday	Saturday	Sunday
Collin	8.58	8.58	6.37	5.68
Dallas	31.17	31.07	22.47	20.02
Denton	7.92	7.81	5.63	5.05
Ellis	5.27	5.63	3.75	3.86
Hood	0.83	0.91	0.72	0.72
Hunt	3.78	4.14	2.84	2.90
Johnson	2.73	2.98	2.15	2.18
Kaufman	3.99	4.24	2.91	2.96
Parker	4.76	5.05	3.39	3.45
Rockwall	1.54	1.51	1.07	0.97
Tarrant	19.93	19.97	14.80	13.24
Wise	2.39	2.60	1.77	1.81
Total	92.88	94.49	67.87	62.82

2020 Emissions Inventory Oxides of Nitrogen (NO_X) (tons/day) School Season				
	Midweek	Friday	Saturday	Sunday
Collin	8.53	8.67	6.43	5.63
Dallas	30.91	31.30	22.67	19.89
Denton	7.87	7.90	5.69	5.01
Ellis	5.03	5.53	3.58	3.64
Hood	0.80	0.90	0.70	0.68
Hunt	3.61	4.06	2.71	2.73
Johnson	2.61	2.93	2.07	2.07
Kaufman	3.84	4.18	2.78	2.79
Parker	4.54	4.97	3.23	3.25
Rockwall	1.53	1.53	1.08	0.96
Tarrant	19.77	20.11	14.94	13.15
Wise	2.28	2.55	1.69	1.70
Total	91.33	94.65	67.57	61.51

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

2012 Emissions Inventory Volatile Organic Compounds (VOC) (tons/day) Summer Season				
	Midweek	Friday	Saturday	Sunday
Collin	10.13	10.27	9.37	8.83
Dallas	35.43	36.06	32.41	30.33
Denton	8.47	8.54	7.76	7.29
Ellis	3.31	3.54	3.08	3.06
Hood	1.11	1.17	1.08	1.07
Hunt	2.44	2.65	2.26	2.25
Johnson	2.68	2.85	2.59	2.57
Kaufman	2.43	2.60	2.26	2.23
Parker	2.35	2.49	2.11	2.10
Rockwall	1.40	1.41	1.26	1.19
Tarrant	24.40	24.78	22.69	21.46
Wise	1.85	1.99	1.66	1.66
Total	95.99	98.36	88.54	84.04

2012 Emissions Inventory Volatile Organic Compounds (VOC) (tons/day) School Season				
	Midweek	Friday	Saturday	Sunday
Collin	10.09	10.32	9.41	8.81
Dallas	35.26	36.22	32.56	30.24
Denton	8.45	8.61	7.80	7.27
Ellis	3.23	3.50	3.00	2.97
Hood	1.09	1.16	1.06	1.05
Hunt	2.37	2.62	2.20	2.17
Johnson	2.63	2.83	2.54	2.50
Kaufman	2.36	2.57	2.19	2.15
Parker	2.29	2.47	2.06	2.04
Rockwall	1.40	1.42	1.27	1.19
Tarrant	24.31	24.87	22.78	21.41
Wise	1.80	1.96	1.62	1.60
Total	95.27	98.56	88.50	83.39

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

2020 Emissions Inventory Volatile Organic Compounds (VOC) (tons/day) Summer Season				
	Midweek	Friday	Saturday	Sunday
Collin	6.09	6.13	5.76	5.53
Dallas	19.74	19.95	18.49	17.68
Denton	5.02	5.05	4.71	4.53
Ellis	1.80	1.90	1.69	1.69
Hood	0.63	0.65	0.62	0.62
Hunt	1.23	1.30	1.17	1.16
Johnson	1.52	1.59	1.49	1.48
Kaufman	1.32	1.40	1.24	1.23
Parker	1.45	1.52	1.31	1.30
Rockwall	0.80	0.80	0.73	0.71
Tarrant	14.38	14.53	13.69	13.18
Wise	0.94	0.99	0.87	0.87
Total	54.90	55.83	51.76	49.97

2020 Emissions Inventory Volatile Organic Compounds (VOC) (tons/day) School Season				
	Midweek	Friday	Saturday	Sunday
Collin	6.07	6.15	5.78	5.52
Dallas	19.67	20.02	18.55	17.65
Denton	5.00	5.07	4.73	4.53
Ellis	1.77	1.88	1.66	1.65
Hood	0.62	0.65	0.61	0.61
Hunt	1.20	1.29	1.15	1.13
Johnson	1.50	1.58	1.47	1.45
Kaufman	1.30	1.39	1.21	1.19
Parker	1.41	1.51	1.28	1.27
Rockwall	0.80	0.81	0.74	0.71
Tarrant	14.34	14.57	13.72	13.16
Wise	0.92	0.98	0.85	0.84
Total	54.60	55.89	51.74	49.70

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

2012 Emissions Inventory Carbon Monoxide (CO) (tons/day) Summer Season				
	Midweek	Friday	Saturday	Sunday
Collin	129.08	137.13	119.09	101.01
Dallas	476.29	506.63	441.98	374.85
Denton	103.30	108.93	96.04	81.54
Ellis	40.45	47.57	41.81	40.60
Hood	13.40	15.53	13.71	13.35
Hunt	29.11	34.39	30.65	29.43
Johnson	32.30	37.63	33.29	32.45
Kaufman	33.09	39.03	34.19	33.11
Parker	31.74	36.76	32.48	31.51
Rockwall	15.23	16.11	14.25	12.19
Tarrant	310.41	330.03	288.74	246.62
Wise	22.57	26.35	23.05	22.37
Total	1236.98	1336.11	1169.29	1019.02

2012 Emissions Inventory Carbon Monoxide (CO) (tons/day) School Season				
	Midweek	Friday	Saturday	Sunday
Collin	128.17	138.44	120.38	100.28
Dallas	472.60	510.07	446.14	372.29
Denton	102.88	110.54	97.29	80.87
Ellis	38.74	46.74	39.98	38.32
Hood	12.86	15.27	13.15	12.65
Hunt	27.87	33.80	29.30	27.76
Johnson	31.02	37.00	31.91	30.73
Kaufman	31.64	38.34	32.64	31.18
Parker	30.48	36.17	31.14	29.86
Rockwall	15.17	16.34	14.43	12.09
Tarrant	308.10	332.36	291.45	245.00
Wise	21.61	25.90	22.06	21.13
Total	1221.14	1340.96	1169.86	1002.15

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

2020 Emissions Inventory Carbon Monoxide (CO) (tons/day) Summer Season				
	Midweek	Friday	Saturday	Sunday
Collin	106.72	113.67	99.10	83.66
Dallas	371.18	395.18	349.20	295.31
Denton	81.57	86.85	76.02	64.44
Ellis	32.79	38.96	34.71	33.60
Hood	9.65	11.20	9.90	9.65
Hunt	22.33	26.52	23.88	22.92
Johnson	25.01	29.58	26.18	25.53
Kaufman	26.97	32.42	28.35	27.52
Parker	24.97	29.23	25.88	25.10
Rockwall	11.85	12.65	11.17	9.50
Tarrant	250.01	266.34	235.28	199.86
Wise	16.95	20.19	17.66	17.20
Total	979.98	1062.78	937.32	814.29

2020 Emissions Inventory Carbon Monoxide (CO) (tons/day) School Season				
	Midweek	Friday	Saturday	Sunday
Collin	105.94	114.77	100.20	83.03
Dallas	368.49	397.66	352.44	293.23
Denton	81.01	87.73	76.88	63.96
Ellis	31.38	38.27	33.15	31.65
Hood	9.25	11.01	9.49	9.14
Hunt	21.38	26.06	22.82	21.61
Johnson	23.96	29.05	25.02	24.08
Kaufman	25.72	31.78	26.98	25.79
Parker	23.94	28.74	24.77	23.72
Rockwall	11.79	12.80	11.30	9.43
Tarrant	248.19	268.04	237.48	198.50
Wise	16.20	19.81	16.84	16.16
Total	967.26	1065.71	937.38	800.30

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

2012 Emissions Inventory Carbon Dioxide (CO_2) (tons/day) Summer Season				
	Midweek	Friday	Saturday	Sunday
Collin	11,877	12,489	9,764	7,920
Dallas	40,048	42,261	32,586	26,393
Denton	10,142	10,530	8,307	6,745
Ellis	4,259	4,899	3,720	3,645
Hood	1,001	1,167	932	901
Hunt	3,417	3,920	2,893	2,861
Johnson	2,891	3,356	2,615	2,547
Kaufman	3,420	3,933	3,040	2,963
Parker	3,096	3,535	2,709	2,647
Rockwall	1,352	1,402	1,098	900
Tarrant	25,587	27,003	20,951	16,997
Wise	2,085	2,407	1,845	1,800
Total	109,176	116,903	90,459	76,320

2012 Emissions Inventory Carbon Dioxide (CO_2) (tons/day) School Season				
	Midweek	Friday	Saturday	Sunday
Collin	11,769	12,649	9,902	7,841
Dallas	39,596	42,675	33,008	26,147
Denton	10,087	10,731	8,447	6,668
Ellis	4,037	4,797	3,520	3,393
Hood	949	1,144	883	840
Hunt	3,241	3,841	2,739	2,666
Johnson	2,741	3,287	2,475	2,371
Kaufman	3,243	3,855	2,878	2,762
Parker	2,938	3,465	2,567	2,468
Rockwall	1,346	1,428	1,116	890
Tarrant	25,312	27,272	21,223	16,839
Wise	1,977	2,358	1,746	1,677
Total	107,237	117,500	90,506	74,563

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

2020 Emissions Inventory Carbon Dioxide (CO_2) (tons/day) Summer Season				
	Midweek	Friday	Saturday	Sunday
Collin	13,205	13,775	10,726	8,698
Dallas	41,663	43,758	33,364	27,030
Denton	10,618	11,050	8,538	6,943
Ellis	4,883	5,588	4,195	4,119
Hood	964	1,128	902	871
Hunt	3,420	3,934	2,943	2,883
Johnson	3,157	3,689	2,854	2,782
Kaufman	3,912	4,536	3,457	3,385
Parker	3,573	4,080	3,094	3,030
Rockwall	1,470	1,525	1,181	969
Tarrant	27,091	28,516	21,927	17,798
Wise	2,098	2,457	1,890	1,840
Total	116,055	124,037	95,071	80,347

2020 Emissions Inventory Carbon Dioxide (CO_2) (tons/day) School Season				
	Midweek	Friday	Saturday	Sunday
Collin	13,079	13,953	10,879	8,611
Dallas	41,176	44,198	33,802	26,777
Denton	10,523	11,202	8,663	6,872
Ellis	4,629	5,472	3,970	3,833
Hood	913	1,105	854	811
Hunt	3,244	3,853	2,786	2,685
Johnson	2,990	3,610	2,697	2,584
Kaufman	3,706	4,437	3,267	3,141
Parker	3,389	3,996	2,928	2,821
Rockwall	1,460	1,550	1,199	959
Tarrant	26,789	28,797	22,211	17,633
Wise	1,985	2,403	1,785	1,707
Total	113,884	124,575	95,041	78,434

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

2012 Emissions Inventory Nitrogen Oxide (NO) (tons/day) Summer Season				
	Midweek	Friday	Saturday	Sunday
Collin	19.15	19.23	14.13	12.44
Dallas	70.01	70.55	51.34	44.95
Denton	18.13	17.88	12.93	11.41
Ellis	10.74	11.65	7.80	8.00
Hood	2.19	2.43	1.84	1.83
Hunt	10.43	11.54	7.73	7.95
Johnson	6.25	6.85	4.85	4.92
Kaufman	8.17	8.84	6.09	6.18
Parker	7.98	8.52	5.66	5.80
Rockwall	3.03	3.00	2.14	1.91
Tarrant	44.10	44.45	32.72	28.81
Wise	5.84	6.38	4.31	4.38
Total	206.01	211.33	151.54	138.58

2012 Emissions Inventory Nitrogen Oxide (NO) (tons/day) School Season				
	Midweek	Friday	Saturday	Sunday
Collin	19.03	19.45	14.29	12.34
Dallas	69.40	71.12	51.86	44.63
Denton	18.07	18.18	13.10	11.30
Ellis	10.24	11.44	7.44	7.52
Hood	2.09	2.39	1.76	1.73
Hunt	9.93	11.33	7.35	7.45
Johnson	5.98	6.73	4.64	4.64
Kaufman	7.80	8.69	5.81	5.81
Parker	7.62	8.37	5.39	5.46
Rockwall	3.02	3.04	2.17	1.90
Tarrant	43.74	44.81	33.04	28.62
Wise	5.57	6.27	4.11	4.12
Total	202.47	211.82	150.95	135.52

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

2020 Emissions Inventory Nitrogen Oxide (NO) (tons/day) Summer Season				
	Midweek	Friday	Saturday	Sunday
Collin	7.26	7.28	5.50	4.91
Dallas	26.16	26.17	19.33	17.25
Denton	6.62	6.56	4.82	4.33
Ellis	4.30	4.61	3.12	3.20
Hood	0.71	0.78	0.63	0.62
Hunt	3.10	3.39	2.37	2.41
Johnson	2.30	2.51	1.85	1.87
Kaufman	3.24	3.46	2.41	2.44
Parker	3.80	4.05	2.77	2.81
Rockwall	1.24	1.23	0.88	0.81
Tarrant	16.91	16.99	12.85	11.51
Wise	1.93	2.10	1.46	1.49
Total	77.58	79.13	57.99	53.64

2020 Emissions Inventory Nitrogen Oxide (NO) (tons/day) School Season				
	Midweek	Friday	Saturday	Sunday
Collin	7.22	7.35	5.56	4.88
Dallas	25.95	26.36	19.50	17.14
Denton	6.59	6.63	4.88	4.30
Ellis	4.11	4.53	2.99	3.02
Hood	0.69	0.77	0.61	0.60
Hunt	2.96	3.34	2.26	2.27
Johnson	2.21	2.47	1.78	1.77
Kaufman	3.11	3.40	2.30	2.30
Parker	3.63	3.98	2.64	2.65
Rockwall	1.24	1.24	0.89	0.80
Tarrant	16.78	17.11	12.96	11.44
Wise	1.84	2.06	1.40	1.40
Total	76.33	79.26	57.76	52.58

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

2012 Emissions Inventory Nitrogen Dioxide (NO_2) (tons/day) Summer Season				
	Midweek	Friday	Saturday	Sunday
Collin	2.12	2.16	1.56	1.33
Dallas	7.82	7.96	5.72	4.86
Denton	2.02	2.01	1.44	1.23
Ellis	1.18	1.30	0.88	0.89
Hood	0.24	0.27	0.21	0.21
Hunt	1.13	1.27	0.86	0.88
Johnson	0.67	0.75	0.53	0.53
Kaufman	0.93	1.02	0.71	0.72
Parker	0.91	0.98	0.65	0.66
Rockwall	0.34	0.34	0.24	0.21
Tarrant	4.81	4.91	3.55	3.02
Wise	0.69	0.76	0.52	0.52
Total	22.88	23.73	16.86	15.06

2012 Emissions Inventory Nitrogen Dioxide (NO_2) (tons/day) School Season				
	Midweek	Friday	Saturday	Sunday
Collin	2.11	2.19	1.59	1.32
Dallas	7.75	8.04	5.79	4.82
Denton	2.01	2.05	1.46	1.22
Ellis	1.12	1.28	0.83	0.83
Hood	0.23	0.27	0.20	0.19
Hunt	1.08	1.24	0.81	0.82
Johnson	0.64	0.74	0.50	0.50
Kaufman	0.89	1.00	0.68	0.67
Parker	0.86	0.96	0.62	0.62
Rockwall	0.34	0.35	0.24	0.20
Tarrant	4.77	4.95	3.59	2.99
Wise	0.66	0.75	0.49	0.49
Total	22.45	23.80	16.79	14.69

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

2020 Emissions Inventory Nitrogen Dioxide (NO_2) (tons/day) Summer Season				
	Midweek	Friday	Saturday	Sunday
Collin	1.25	1.23	0.82	0.72
Dallas	4.76	4.65	2.96	2.61
Denton	1.23	1.19	0.76	0.68
Ellis	0.92	0.98	0.59	0.62
Hood	0.11	0.12	0.09	0.09
Hunt	0.65	0.71	0.45	0.47
Johnson	0.40	0.44	0.28	0.29
Kaufman	0.72	0.75	0.48	0.49
Parker	0.92	0.96	0.59	0.61
Rockwall	0.28	0.27	0.17	0.16
Tarrant	2.86	2.82	1.84	1.62
Wise	0.44	0.48	0.29	0.30
Total	14.55	14.61	9.33	8.67

2020 Emissions Inventory Nitrogen Dioxide (NO_2) (tons/day) School Season				
	Midweek	Friday	Saturday	Sunday
Collin	1.25	1.25	0.83	0.71
Dallas	4.71	4.70	2.99	2.59
Denton	1.22	1.21	0.77	0.67
Ellis	0.88	0.96	0.57	0.58
Hood	0.10	0.12	0.08	0.08
Hunt	0.62	0.69	0.43	0.44
Johnson	0.38	0.43	0.27	0.28
Kaufman	0.70	0.74	0.46	0.46
Parker	0.87	0.95	0.56	0.58
Rockwall	0.28	0.28	0.17	0.16
Tarrant	2.83	2.84	1.86	1.61
Wise	0.42	0.47	0.28	0.28
Total	14.27	14.63	9.27	8.44