APPENDIX 10

ON-ROAD RFP EMISSIONS INVENTORIES

DALLAS-FORT WORTH 2008 EIGHT-HOUR OZONE NONATTAINMENT AREA REASONABLE FURTHER PROGRESS ON-ROAD MOBILE SOURCE EMISSIONS INVENTORIES

This appendix documents the development of the on-road mobile emissions inventory (EI) for the updates to the Dallas-Fort Worth Ozone Nonattainment Area (DFW) Rate of Further Progress (RFP) State Implementation Plan.

The development of the RFP EIs was done by the North Central Texas Council of Governments (NCTCOG) at the request and under the direction of the Texas Commission on Environmental Quality (TCEQ). The on-road mobile source EIs and control strategy reduction estimates reflect the most recent planning assumptions for the DFW transportation network. Complete documentation of the development and resulting EI is provided in the attached document, DFW RFP Inventories, Control Strategy Reductions, and Contingency Estimates for 2011, 2017, 2018, and 2019. The final emissions estimates are summarized in Chapter 5: *Summary of Vehicle Miles Travel, Speed, and Emissions*, in Exhibit 5-1. The supporting electronic documents for the EI development, including MOVES2010b input and output files and the post processing spreadsheets used to summarize the inventories are available upon request in electronic format. Please contact the TCEQ, Air Quality Division, Area and Mobile Source Inventory and Data Support Team if a copy of the electronic information is needed.

The report also documents the development of control strategy reduction estimates for each of the RFP milestone years between 2011 and 2018, and the contingency analysis year 2019. Control strategy emission reduction estimates include the effects of the Federal Motor Vehicle Control Program, the DFW vehicle inspection and maintenance program, federal reformulated gasoline Phase 1 and Phase 2, and the Texas Low Emission Diesel Program. The emissions summaries include estimates for all control scenarios. The control scenarios are the basis for quantifying the reductions for each control strategy.

North Central Texas
Council of Governments

Dallas-Fort Worth

Motor Vehicle Emissions Simulator (MOVES) - Based Reasonable Further Progress On-Road Inventories and Control Strategy Reductions for 2011, 2017, 2018, and 2019

FINAL UPDATED
March 2014

Collin | Dallas | Denton | Ellis | Johnson | Kaufman | Parker | Rockwall | Tarrant | Wise

ABSTRACT

TITLE:	Dallas-Fort Worth Motor Vehicle Emissions Simulator (MOVES) - Based Reasonable Further Progress On-Road Inventories and Control Strategy Reductions
DATE:	March 2014
AUTHORS:	Chris Klaus Senior Program Manager Jenny Narvaez Principal Air Quality Planner
SUBJECT:	Reasonable Further Progress
SOURCES OF COPIES:	Transportation Department North Central Texas Council of Governments PO Box 5888 Arlington, Texas 76005-5888 (817) 695-9240
NUMBER OF PAGES:	40
ABSTRACT:	The North Central Texas Council of Governments conducted a Reasonable Further Progress emission inventory to support the Texas Commission on Environmental Quality's effort to develop a State Implementation Plan Reasonable Further Progress for the Dallas-Fort Worth ten-county nonattainment area for the pollutant ozone. The ten nonattainment counties are Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker, Rockwall, Tarrant and Wise. This report documents the on-road mobile methodologies applied and estimated emission results for analysis years 2011, 2017, 2018, and 2019. The ten-county estimated on-road mobile source emissions are reported for volatile organic compounds, carbon monoxide, oxides of nitrogen, carbon dioxide, sulfur dioxide, and hazardous air pollutants for controlled and uncontrolled scenarios.

ACKNOWLEDGEMENTS

The North Central Texas Council of Governments would like to thank the following individuals for their invaluable assistance in preparing this report.

Michael Morris, P.E.	Director of Transportation
Dan Kessler	Assistant Director of Transportation
Vickie Alexander	Administrative Program Supervisor
Berrien Barks	Senior Transportation Planner
Michael Burbank	Program Manager
Dawn Dalrymple	Grants and Contract Manager
Chad Edwards	Program Manager
Syeda Haque	Transportation System Modeler I
Cecilia Howard	Administrative Assistant II
Dan Lamers, P.E.	Senior Program Manager
Kurt Lehan	Transportation Planner II
Jody Loza	Air Quality Planner III
Arash Mirzaei, P.E.	Senior Program Manager
Behruz Paschai, Ph.D., P.E.	Transportation System Modeling Manager
Sam Simmons	Transportation Planner III
John Starnes	Grants and Contracts Coordinator II
Francisco Torres	Principal Transportation Planner
Mitzi Ward	Principal Transportation Planner
Kathleen Yu	Senior Transportation System Modeler
Madhusudhan Venugopal, P.E.	Providence Engineering and Environmental Group, LLC.
Mary McGarry-Barber	Texas Commission on Environmental Quality
Rachel Melton	Texas Commission on Environmental Quality
Chris Owen	Texas Commission on Environmental Quality
Leslie Schmidt	Texas Commission on Environmental Quality
Matthew Southard	Texas Commission on Environmental Quality

GLOSSARY OF ABBREVIATIONS

ABY	Adjusted Base Year
ATP	Anti-Tampering Program
ATR	Automatic Traffic Recorder
AVFT	Alternative Vehicle and Fuel Technologies
CAAA	Clean Air Act Amendments
CO	Carbon Monoxide
DFW	Dallas-Fort Worth
DFX	Dallas-Fort Worth Expanded Travel Model
DRAM	Disaggregate Residential Allocation Model
EMPAL	Employment Allocation Model
EPA	Environmental Protection Agency
GISDK	Geographic Information System Developer Kit
HBW	Home-Based Work
HNW	Home-Based Non-Work
HOV	High Occupancy Vehicle
HPMS	Highway Performance Monitoring System
I/M	Inspection & Maintenance Program
LED	Low Emission Diesel
MPA	Metropolitan Planning Area
MPO	Metropolitan Planning Organization
MOVES	Motor Vehicle Emissions Simulator
MVEB	Motor Vehicle Emissions Budgets
NAAQS	National Ambient Air Quality Standards
NCT	North Central Texas
NCTCOG	North Central Texas Council of Governments
NHB	Non-Home Based
NO_X	Nitrogen Oxides
NSWD	Non-Summer Week Day
O_3	Ozone
Pb	Lead
PM	Particulate Matter
$PM_{2.5}$	Particulate Matter 2.5 Microns
PM_{10}	Particulate Matter 10 Microns
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RFP	Reasonable Further Progress
SIP	State Implementation Plan
SO_2	Sulfur Dioxide
TCEQ	Texas Commission on Environmental Quality
TOD	Time of Day
TSZ	Traffic Survey Zone
TTI	Texas Transportation Institute
TxDOT	Texas Department of Transportation
VHT	Vehicle Hours of Travel
VMT	Vehicle Miles of Travel
VDF	Volume Delay Function
VOC	Volatile Organic Compounds

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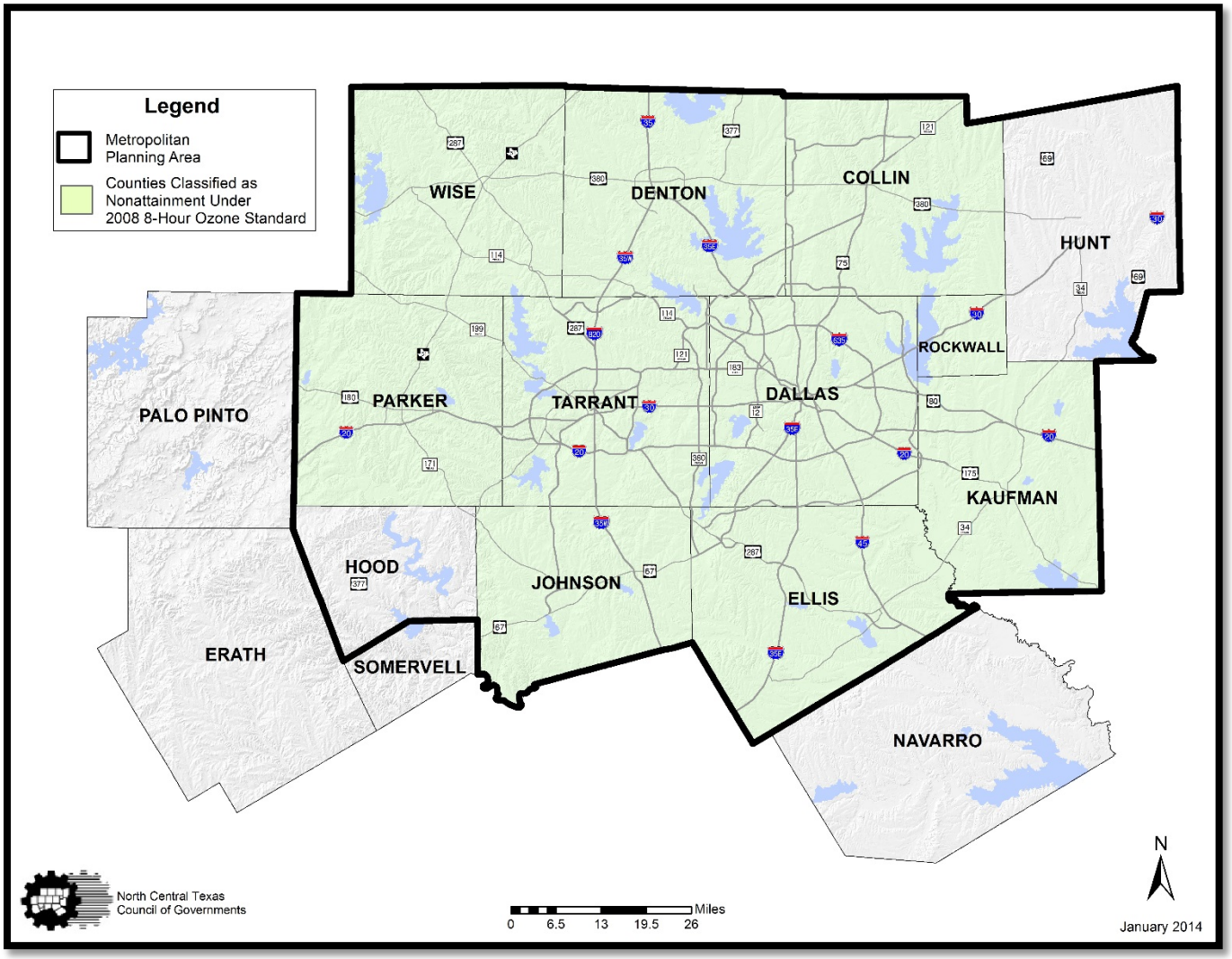
CHAPTER 1: INTRODUCTION

The North Central Texas Council of Governments (NCTCOG), in conjunction with the Texas Commission on Environmental Quality (TCEQ), has developed the Dallas-Fort Worth (DFW) Reasonable Further Progress (RFP) Emission Inventory.

This emission inventory covers the DFW ten-county nonattainment area of Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker, Rockwall, Tarrant, and Wise counties as shown in Exhibit 1-1.

Exhibit 1-1: DFW Nonattainment Area Map



This report documents the methodology and results of the RFP emission inventory. The RFP emission inventory analysis period includes 2011, 2017, 2018, and 2019. Chapter 1 outlines the background for the RFP emission inventory, the purpose and scope of the study, the modeling approach, and provides a summary of the ten-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 better reflect regional conditions. Seasonal and hourly adjustment factors were applied to produce 2011, 2017, 2018, and 2019 analysis year vehicle activity and report vehicle activity in hourly periods. Consistent with previous emission inventory practice, 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 parameters and inputs used to develop on-road mobile source emission factors by utilizing the United States Environmental Protection Agency's (EPA) mobile source model, Motor Vehicle Emission Simulator (MOVES) version 2010b. This chapter documents regionally specific calculations, procedures, MOVES2010b emission factors, and adjustments to better reflect regional vehicle emissions emitted. The calculations and procedures include vehicle registration, diesel fractions, hourly VMT, and trip length distribution. The adjustments include low emission diesel nitrogen oxide adjustments and VMT mix.

Chapter 4 documents the ten-county nonattainment area vehicle emission calculation procedure.

Chapter 5 summarizes emissions of all pollutants by county and analysis years.

The Appendix contains supplemental information, including a table containing all pollutants calculated, and electronic data that supports the DFW RFP Emissions Inventory.

1.1 BACKGROUND

The Clean Air Act Amendments (CAAA) of 1990 requires the EPA to set National Ambient Air Quality Standards (NAAQS) for widespread pollutants considered harmful to public health and the environment. The EPA has set NAAQS for six principal pollutants; Ozone (O_3), Particulate Matter (PM), Carbon Monoxide (CO), Sulfur Dioxide (SO_2), Nitrogen Oxides (NO_X), and Lead (Pb).

With the signing of the CAAA into law, the four counties of Collin, Dallas, Denton, and Tarrant County in the DFW region were designated as nonattainment under the 1-hour NAAQS for the pollutant ozone. The law also requires the EPA to periodically review the NAAQS to ensure that they provide adequate health and environmental protection and to update these standards as necessary. Upon completion of a

scientific review of the 1-hour NAAQS, EPA determined that the 1-hour NAAQS was insufficient to protect human health. As a result, the EPA developed the 1997 8-hour NAAQS to place greater emphasis on prolonged exposure to pollutants.

In April 2004, the EPA announced that Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker, Rockwall, and Tarrant counties comprise the new DFW nine-county nonattainment area for the pollutant ozone under the new stricter 1997 8-hour NAAQS. With an effective designation date of June 15, 2004, for the 8-hour NAAQS, these nine counties received a "moderate" ozone classification. That gave the North Central Texas (NCT) region until June 15, 2010, to reach attainment or face a reclassification to "serious". As a result of not reaching attainment by June 2010, the DFW region was classified as "serious" with the new attainment date of June 15, 2013. On May 21, 2012, the DFW region was redesignated and classified as "moderate" nonattainment for the 2008 8-hour ozone standard (≤75 ppb), Wise County was added as the tenth nonattainment county. Under this revised standard, the ten counties, shown in Exhibit 1-1, must reach attainment by December 31, 2018.

TCEQ, the state's environmental agency, is required under the CAAA to submit State Implementation Plan (SIP) revisions documenting that emission of ozone precursors are declining at rates that achieve the NAAQS. The SIP is an air quality plan that contains a collection of regulations and measures to reduce emissions from stationary, area, mobile (on-road and non-road) sources, and demonstrate attainment of the air quality standards. The section of the SIP that demonstrates the plan for the achievement of these emission reductions is subsequently defined as the "Reasonable Further Progress" plan.

On-road mobile is a key component of the SIP, as a SIP places emission limits on on-road mobile sources. These on-road mobile emission limits are termed motor vehicle emission budgets (MVEB) and have a direct impact on transportation planning. NCTCOG serves as the Metropolitan Planning Organization (MPO) for transportation in the DFW area and is responsible for developing and maintaining on-road mobile source emission inventories for the region. NCTCOG applies a four-step travel demand model process using TransCAD software to forecast regional vehicle activity and MOVES2010b (EPA MOBILE Emission Factor Model) with a post-processing application to estimate regional mobile source emissions.

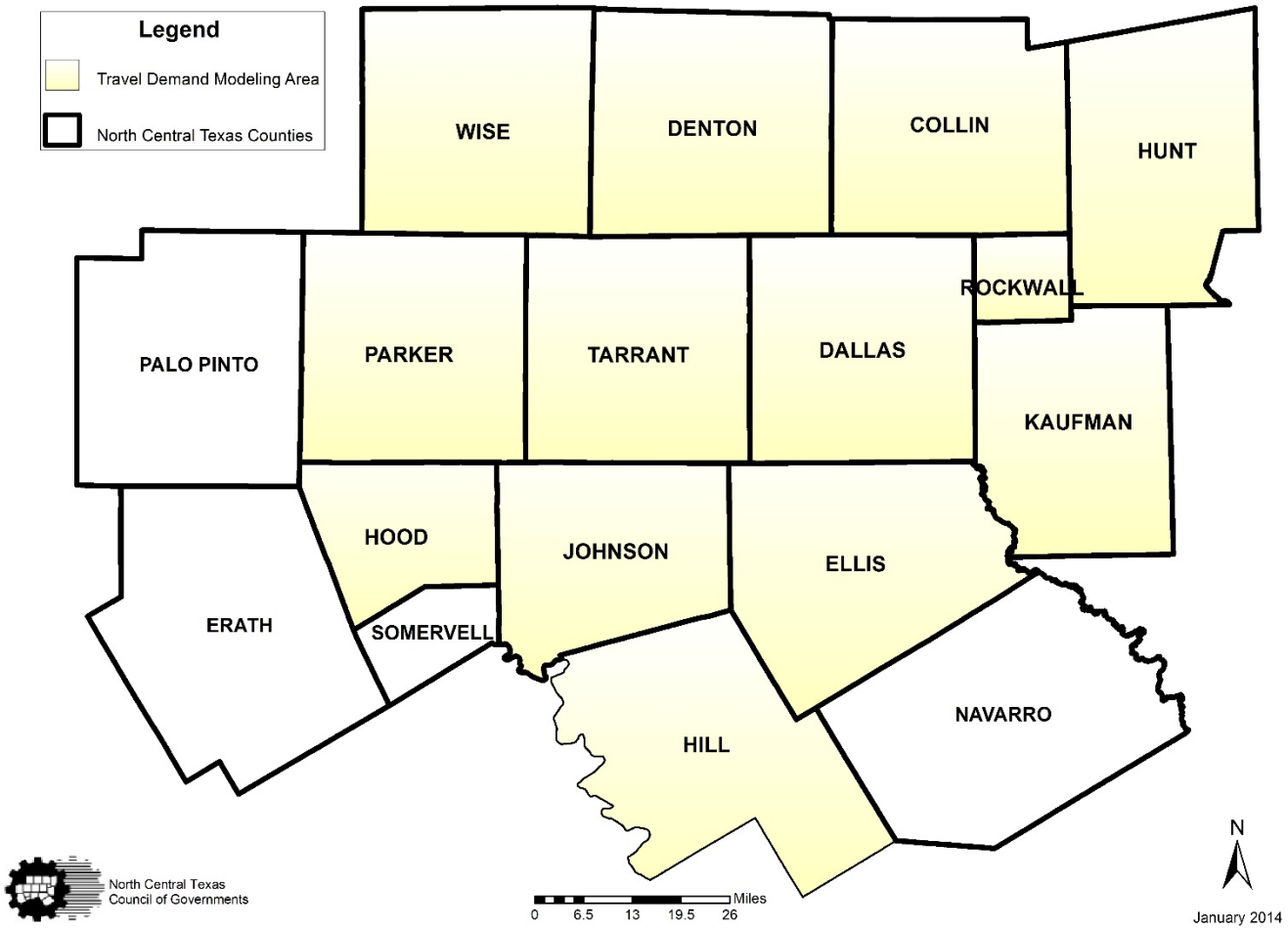
1.2 PURPOSE AND SCOPE OF STUDY

NCTCOG conducted 2011, 2017, 2018, and 2019 analysis year on-road emission inventories to support TCEQ's efforts to develop a RFP SIP for the DFW ten-county nonattainment area. The on-road mobile pollutants evaluated for these analysis years are Volatile Organic Compounds (VOC), (CO), Nitrogen Oxides (NO_X), Carbon Dioxide (CO_2), Sulfur Dioxide (SO_2), Particles less than ten micrometers in diameter (PM_{10}), Particles less than 2.5 micrometers in diameter ($PM_{2.5}$), and Hazardous Air Pollutants.

1.3 MODELING APPROACH

The Dallas-Fort Worth Expanded Travel Demand Model (DFX) is employed to estimate VMT and emissions for the 2011, 2017, 2018, and 2019 analysis year. 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 boundary. To capture travel from outside areas, Hill County was included in the modeling domain. The 12-county NCT modeling domain plus Hill County is shown in the Exhibit 1-2.

Exhibit 1-2: North Central Texas Modeling Domain Map



Several components of the model were updated as part of this model expansion. These include improvements to the mode-choice model; vehicle ownership model; external stations; volume-delay-function; transit assignment; and traffic assignment convergence criteria, which are discussed in Chapter 2.

Emissions are quantified by grouping control strategy scenarios as a model run. Exhibit 1-3 describes the control strategy scenarios modeled for all the analysis years. Adjusted Base Year (ABY) is modeled for 2017, 2018, and 2019 utilizing 2011 base year VMT.

Exhibit 1-3: Emissions Inventory Scenarios Modeled

Reasonable Further Progress Scenarios	Input Files
Pre-1990 Federal Motor Vehicle Control Program	PR90
Federal Reformulated Gasoline Model Only Phase 2	RFG
Adjusted Base Year	ABY
FMVCP Tier 1 FMVCP Tier 2 FMVCP – Heavy-Duty 2007	FMVCP
Expanded Inspection & Maintenance (I/M) and Anti-Tampering Program (ATP	Control Strategy
Texas Low-Emission Diesel[1]	TxLED

[1]Control Strategy emission factors will be used to estimate TxLED emission benefits.
[2]In the table above, each scenario contains the control strategies of all previous scenarios.

Final RFP on-road emission estimates by pollutant for summer weekday for each analysis year are shown in Exhibit 1-4.

Appendix D contains the detailed emissions by county by pollutant and by time-of-day for all NCT counties modeled.

Exhibit 1-4: On-Road Emissions

Reasonable Further Progress Emission Inventory DFW Ten-County Modeling Domain Summer Season, Midweek On-Road Emissions (tons/day)				
Nitrogen Oxides (NO_x)				
	2011	**2017**	**2018**	**2019**
ABY	N/A	771.03	770.98	770.74
PR90	764.33	924.67	945.96	968.33
FMVCP	384.93	257.48	239.30	224.52
RFG	264.22	162.98	150.63	140.34
CS	245.00	152.14	141.01	131.77
TxLED	238.51	148.54	137.73	128.72
Volatile Organic Compounds (VOC)				
	2011	**2017**	**2018**	**2019**
ABY	N/A	303.41	303.36	303.22
PR90	300.69	358.00	366.70	348.10
FMVCP	132.52	94.18	90.60	76.81
RFG	114.43	80.83	77.86	65.48
CS	102.32	71.20	68.56	57.89
TxLED	102.32	71.20	68.56	57.89

CHAPTER 2: VEHICLE MILES OF TRAVEL ESTIMATION PROCEDURE

This chapter discusses the methodology used in estimating the vehicle activity measures that influence the air quality in the North Central Texas area. These measures include the vehicle miles of travel and the average speed. The current expanded travel model covers the 12-county area of Collin, Dallas, Denton, Ellis, Hood, Hunt, Johnson, Kaufman, Parker, Rockwall, Tarrant, and Wise counties. The VMT and speeds were estimated with the DFX using a link-based methodology for each time period.

2.1 DALLAS-FORT WORTH EXPANDED TRAVEL MODEL COUNTIES

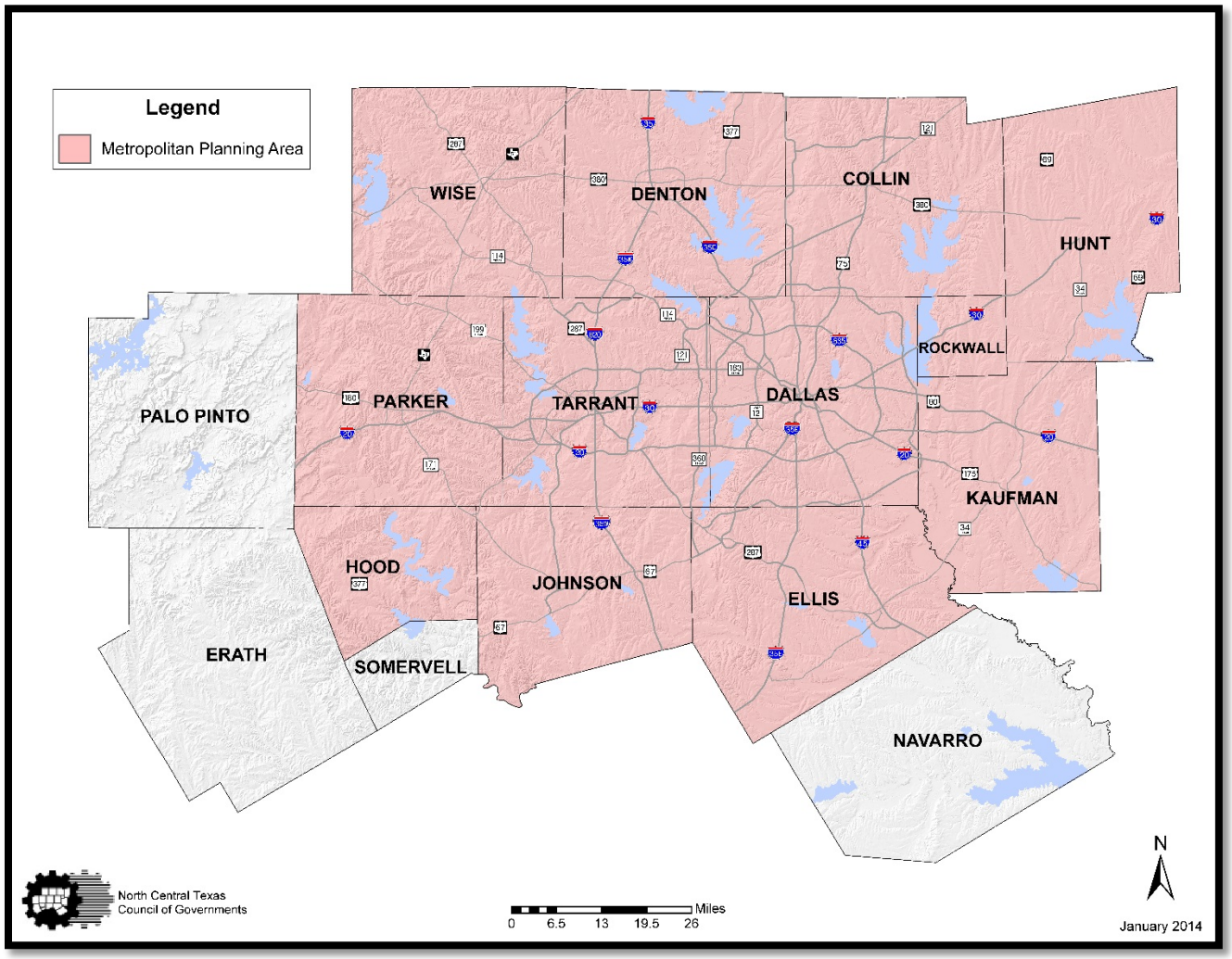
2.1.1 Dallas-Fort Worth Expanded Travel Model

The source of VMT estimates for the Reasonable Further Progress Emission Inventory for the nonattainment counties is the network-based DFX executed by the NCTCOG Transportation Department in the TransCAD environment. TransCAD is a Geographic Information System-based commercial travel demand software package for transportation planning. The DFX supports federally required regional transportation planning efforts for the DFW region. Since 1974, NCTCOG has served as the 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.

2.1.2 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 Assignment. Exhibit 2-1 shows NCTCOG's Metropolitan Planning Area (MPA) in which transportation planning efforts are concentrated and defines the geographical area covered by the DFX.

Exhibit 2-1: NCTCOG 16-County Region and MPA Boundary Map



The roadway network developed for the RFP Emissions Inventory contains over 30,000 unique segments constructed to replicate the transportation system of the coverage area. For this RFP inventory, the transportation network was developed for the years 2011, 2017, 2018, and 2019. Each facility link in the network has the following attributes:

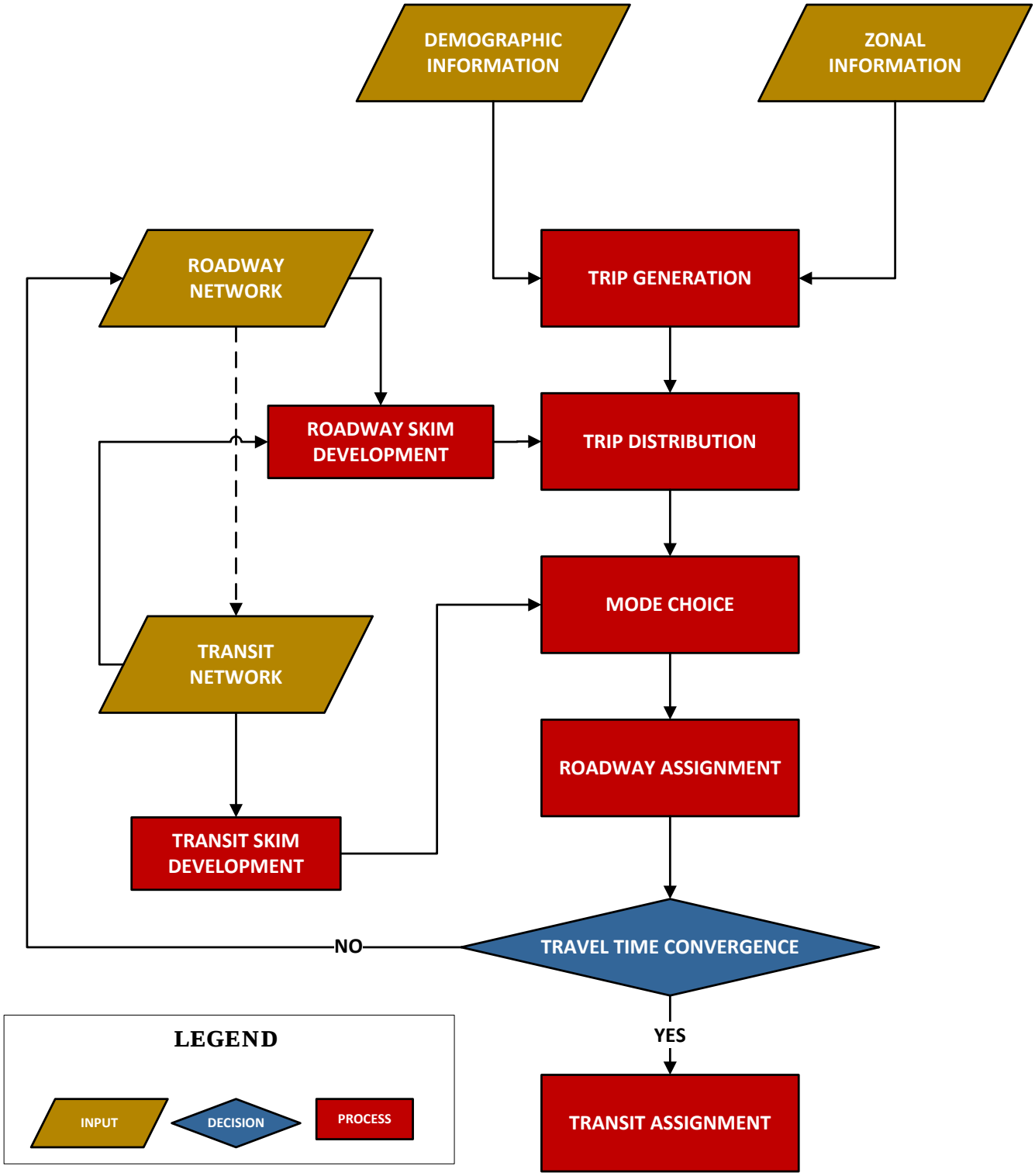
- Network node numbers (defining the beginning and end of each link)
- Functional classification
- Type of traffic control at each end of the link
- Number of operational lanes in the off-peak period
- Traffic survey zone
- Area type
- Hourly capacities
- Number of operational lanes in the AM and PM peak periods
- Divided/undivided roadway code
- Traffic direction (one-way or two-way)
- Estimated loaded speeds in each period
- Speed limit
- Tolls
- Truck exclusion code

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 socioeconomic variables for each zone. The data is organized by traffic survey zone (TSZ), the smallest zone size available in the DFX. The data for each TSZ includes zone centroid; median household income; number of households; population; basic, retail, and service employment; and land area. There are 5,386 TSZs in the model (5,303 internal zones plus 83 externals), which is the level of detail 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. Exhibit 2-2 depicts the flowchart of the DFW expanded travel model process, 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 or GISDK, and integrated with a user interface (UI) developed in visual basic programming language.

Exhibit 2-2: DFW Expanded Travel Model Process Forecast Flowchart



2.1.4 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 2011, 2017, 2018, and 2019 population and employment forecasts were generated with the Disaggregate Residential Allocation Model/Employment Allocation Model (DRAM/EMPAL) model using travel times from the Roadway and Transit Assignment Steps consistent with current planning practice. The data can be seen in Exhibit 2-3. 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 US 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 2-3: Socio-Economic Demographic Summary

Reasonable Further Progress Emission Inventory DFW Nonattainment Area				
Analysis Year	**2011**	**2017**	**2018**	**2019**
Population	6,573,214	7,352,255	7,486,913	7,621,422
Number of Households	2,353,312	2,626,680	2,674,127	2,721,531
Employment Types				
Basic	1,055,117	1,157,638	1,174,970	1,192,198
Retail	715,234	799,077	813,289	827,579
Service	2,372,740	2,683,812	2,737,399	2,790,920
Total Employment	4,143,091	4,640,527	4,725,658	4,810,697

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.

2.1.5 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.

2.1.6 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.

2.1.7 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 am to 9:00 am Morning Peak, 3:00 pm to 6:30 pm 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.

2.1.8 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 link capacity is defined as the Level-of-Service "E" capacity for each time period. The result of the traffic assignment step is the final time-period-specific average loaded speeds for each of the 30,000+ 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 curves were calibrated based on the available 2004 daily link traffic counts at more than 10,000 locations (collected by the Texas Department of Transportation [TxDOT]), and the travel time runs along freeway and arterial corridors (performed by several consultants as part of other projects). The time-of-day link counts were not available for the calibration of the model in each time period.

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 are listed in Exhibit 2-4.

Exhibit 2-4: Average Congested Speeds

Reasonable Further Progress Emission Inventory				
Counties	**2011**	**2017**	**2018**	**2019**
Collin	37.52	37.32	36.97	36.58
Dallas	34.83	35.09	34.92	34.72
Denton	39.08	40.31	39.96	39.62
Ellis	50.58	51.63	51.41	51.19
Johnson	47.09	46.76	46.64	46.53
Kaufman	52.47	51.83	51.46	51.04
Parker	51.11	52.68	52.53	52.33
Rockwall	43.96	41.84	41.33	40.79
Tarrant	37.27	37.99	37.72	37.50
Wise	52.15	53.86	53.65	53.44
Average	38.34	38.84	38.60	38.35

2.1.9 Local Street Speeds

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.

2.2 ADJUSTMENTS

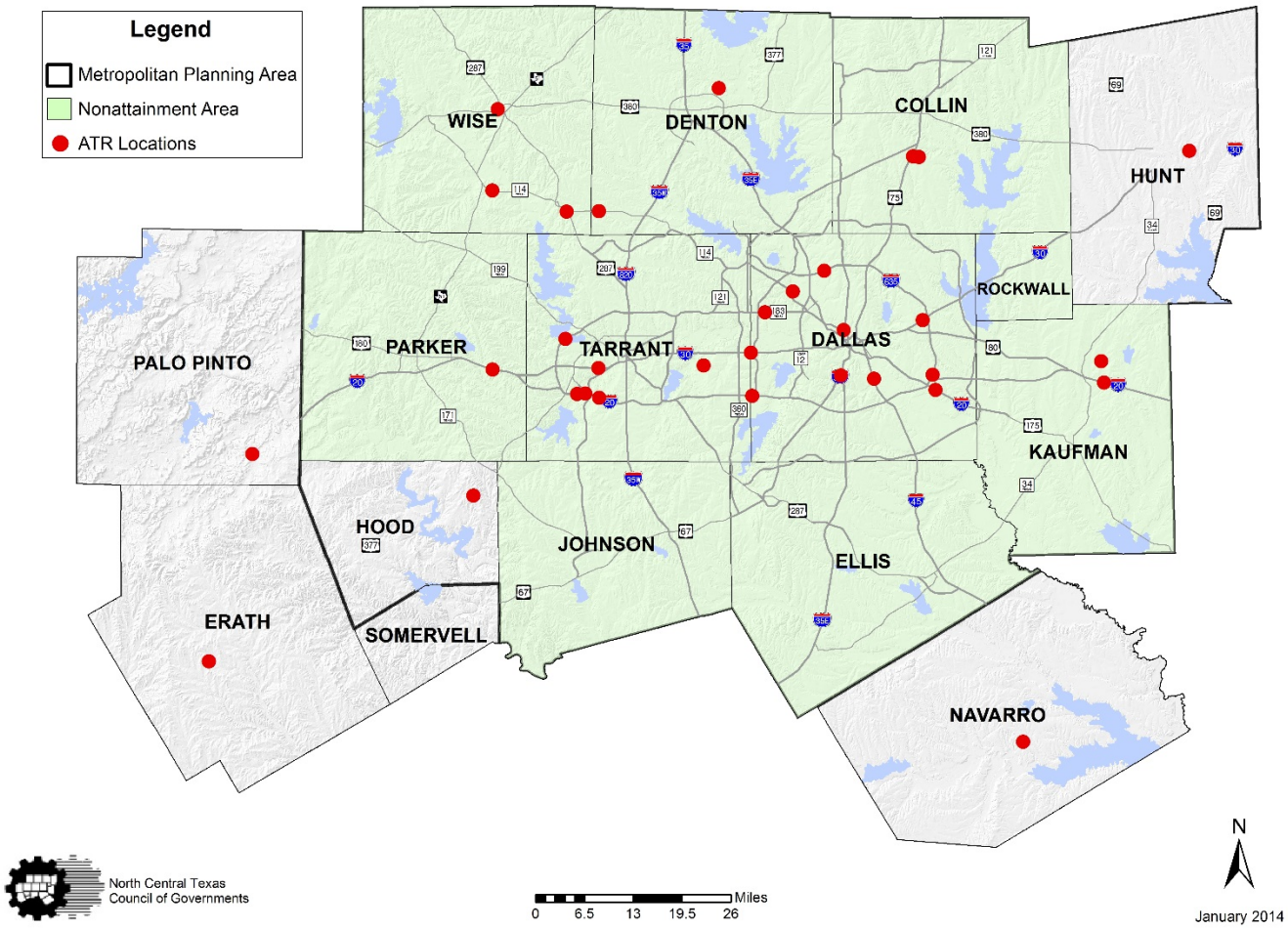
2.2.1 Seasonal, Daily, and Hourly Adjustments

The vehicle activity data used for this analysis is representative of the summer season. This section outlines the process used to convert the DFX non-summer weekday (NSWD) activity to summer (June, July, and August) weekday activity. The Automatic Traffic Recorder (ATR) data for 2011, collected by TxDOT, is used to calculate the necessary conversions. For 2017, 2018, and 2019, 2011 data was used to convert NSWD activity to summer. Exhibit 2-5 lists the stations used in this analysis and Exhibit 2-6 is a map showing the ATR locations.

Exhibit 2-5: ATR Stations

Reasonable Further Progress Emission Inventory		
Code TxDOT	**Roadway**	**County**
ATR A122	IH 20, 5.7 Miles West of IH 35W	Tarrant
ATR A301	SH 180, 2.7 Miles West of FM 157, Arlington	Tarrant
ATR S017	US 75, 1.2 Miles Southeast of IH 635, Dallas	Dallas
ATR S026	SH 5, 2.3 Miles South of FM 1378	Collin
ATR S027	FM 428, 1.0 Mile Northeast of Loop 288, Denton	Denton
ATR S040	IH 45, 5.6 Miles South of SH 31, Corsicana	Navarro
ATR S055	SH 183, 0.4 Miles West of SH 356, Dallas	Dallas
ATR S121	US 75, 0.5 Miles South of SH 121	Collin
ATR S126	IH 35E, 1.6 Miles Southeast of SH 356, Dallas	Dallas
ATR S130	IH 30, 3.2 Miles West of IH 35W, Fort Worth	Tarrant
ATR S133	US 80, 2.3 Miles East of SH 34, Terrell	Kaufman
ATR S145	IH 20, 3.0 Miles East of SH 34, Terrell	Kaufman
ATR S148	IH 35E, 0.3 Miles North of US 67, South Dallas	Dallas
ATR S170	IH 635	Dallas
ATR S171	IH 635, 2.0 Miles Northeast of IH 20, Dallas	Dallas
ATR S191	IH 20, 0.4 Miles West of Tarrant County Line, Dallas	Dallas
ATR S192	IH 30, 0.1 Mile West of Dallas County Line, Arlington	Tarrant
ATR S193	IH 820, West end of Lake Worth Bridge, Fort Worth	Tarrant
ATR S208	IH 20, 4.6 Miles West of Tarrant County Line, Weatherford	Parker
ATR S220	IH 45, 1.5 Miles North of Loop 12, Dallas	Dallas
ATR S221	IH 30, 3.1 Miles East of Loop 635	Dallas
ATR S234	IH 30	Hunt
ATR S237	Spur 348, .7 Miles East of SH 114	Dallas
ATR S264	SH 114, 2.0 Miles East of US 287 in Wise County	Wise
ATR S292	US 377/67, 2.5 Miles Southwest of FM 988	Erath
ATR S297	IH 20, 6.7 Miles West of IH 35W	Tarrant
ATR S337	SH 114, 1.8 Miles East of FM 51	Wise
ATR S338	US 380, 0.6 Mile West of US 287 at Decatur	Wise
ATR S339	US 287, 1.3 Miles West of SH 114 West	Wise
ATR S340	US 377, 4.3 Miles South of SH 171, Granbury	Hood
ATR S341	IH 20, 1.9 Miles West of SH 4	Palo Pinto

Exhibit 2-6: ATR Station Map



2.2.2 Seasonal and Daily Adjustments

ATR data is organized into five day types: Sunday, Monday, Midweek (Tuesday, Wednesday, and Thursday), Friday, and Saturday. To adjust the representative NSWD weekday data from the DFX to summer weekday, a NSWD to Summer ATR conversion ratio is calculated. The summer portion of the ratio includes traffic volumes recorded between June and August. Seasonal midweek (Tuesday-Thursday) adjustments by area type for DFX counties are listed in Exhibit 2-7. 2011 adjustment factors were used for all analysis years.

Exhibit 2-7: Seasonal/Daily Adjustment Factors

Reasonable Further Progress Emission Inventory DFW Modeling Domain			
DFX Counties (NSWD to Summer)	**Area Type**	**Year**	**Midweek**
	Urban	2011	1.03211
	Rural	2011	1.05552

2.2.3 Hourly Adjustments

Daily volumes recorded for each of the five 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 am to 8:59 am, PM Peak is 3:00 pm to 6:29 pm, and Off-Peak represents all other hours of the day (12:00 am to 6:29 am, 9:00 am to 2:59 pm, and 6:30 pm to 11:59 pm). Periods split by mid-hour times utilize an equal division of traffic recorded during the hour. Exhibit 2-8 shows the hourly adjustments for DFX counties for school and summer season.

Exhibit 2-8: DFW County Hourly Adjustment Factors

Reasonable Further Progress Emission Inventory DFW Modeling Domain					
	Sunday	Monday	Midweek	Friday	Saturday
12:00 am – 12:59 am	2.47%	0.97%	0.96%	1.04%	1.94%
1:00 am – 1:59 am	1.76%	0.64%	0.64%	0.70%	1.31%
2:00 am – 2:59 am	1.67%	0.62%	0.60%	0.69%	1.23%
3:00 am – 3:59 am	1.09%	0.63%	0.64%	0.65%	0.89%
4:00 am – 4:59 am	0.87%	1.09%	1.09%	1.01%	0.92%
5:00 am – 5:59 am	1.14%	2.82%	2.83%	2.46%	1.53%
6:00 am – 6:29 am	0.84%	2.73%	2.80%	2.42%	1.30%
6:30 am – 6:59 am	0.84%	2.73%	2.80%	2.42%	1.30%
7:00 am – 7:59 am	2.23%	6.93%	7.04%	6.17%	3.46%
8:00 am – 8:59 am	3.01%	6.20%	6.25%	5.58%	4.28%
9:00 am – 9:59 am	4.21%	5.23%	5.22%	4.87%	5.00%
10:00 am – 10:59 am	5.44%	5.08%	4.93%	4.89%	5.66%
11:00 am – 11:59 am	5.99%	5.32%	5.16%	5.26%	6.18%
12:00 pm – 12:59 pm	7.01%	5.57%	5.36%	5.56%	6.52%
1:00 pm – 1:59 pm	7.44%	5.69%	5.52%	5.77%	6.63%
2:00 pm – 2:59 pm	7.40%	6.07%	5.90%	6.15%	6.67%
3:00 pm – 3:59 pm	7.27%	6.72%	6.57%	6.69%	6.63%
4:00 pm – 4:59 pm	7.22%	7.40%	7.29%	7.03%	6.53%
5:00 pm – 5:59 pm	7.04%	7.62%	7.53%	7.00%	6.37%
6:00 pm – 6:29 pm	3.20%	2.99%	3.04%	3.04%	2.99%
6:30 pm – 6:59 pm	3.20%	2.99%	3.04%	3.04%	2.99%
7:00 pm – 7:59 pm	5.39%	4.23%	4.41%	4.92%	5.07%
8:00 pm – 8:59 pm	4.44%	3.28%	3.46%	3.88%	4.24%
9:00 pm – 9:59 pm	3.78%	2.78%	2.99%	3.44%	3.94%
10:00 pm – 10:59 pm	3.01%	2.17%	2.33%	3.04%	3.59%
11:00 pm – 11:59 pm	2.05%	1.49%	1.59%	2.27%	2.84%

2.3 MODEL VMT ADJUSTMENTS (HPMS VS. DFX)

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

To develop the Model VMT adjustment factor, 2004 annual non-summer HPMS VMT was used because 2004 data was used in validation and calibration of the DFX model. Exhibit 2-9 shows the comparison of VMT for HPMS and DFX. The adjustment ratio of 0.9695 between the HPMS and DFX data sets is the overall model adjustment factor for vehicle activity applied to model VMT.

Exhibit 2-9: Model VMT Adjustment Factor

DFW Area 2004 DFX and HPMS VMT Analysis	
	2004
	VMT
HPMS	155,607,158
DFX	160,504,490
HPMS/DFX Ratio	**0.9695**

2.4 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 VOC and 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.

2.5 VMT ESTIMATES

The RFP VMT estimates are located in Exhibit 2-10 for all counties in the nonattainment area. VMT is summarized by 2011, 2017, 2018, and 2019 model years for each county. Appendix E contains the VMT by county for each hour for all counties.

Exhibit 2-10: VMT for All Counties

Reasonable Further Progress Emission Inventory DFW Nonattainment Area (Thousands)				
Counties	**2011**	**2017**	**2018**	**2019**
Collin	20,769.96	26,157.38	26,940.78	27,732.93
Dallas	71,679.61	82,070.09	83,089.22	84,246.08
Denton	17,306.05	21,724.74	22,209.99	22,672.57
Ellis	7,239.27	8,937.90	9,165.68	9,431.05
Johnson	5,572.48	6,818.38	6,971.59	7,158.92
Kaufman	5,814.42	7,627.73	7,860.18	8,090.36
Parker	4,813.50	5,952.97	6,114.89	6,285.48
Rockwall	2,345.16	2,940.17	3,021.06	3,103.67
Tarrant	46,255.00	55,121.41	56,011.24	57,185.73
Wise	3,351.67	4,219.94	4,338.72	4,445.23
Total	185,147.12	221,570.70	225,723.36	230,352.03

CHAPTER 3: EMISSION FACTOR ESTIMATION PROCEDURE

3.1 MOBILE MODEL AND INPUT PARAMETERS

EPA's MOVES2010b Mobile Source Emission Factor Model is used to develop vehicle emission factors to conduct the RFP emission inventory for the DFW ten-county ozone nonattainment area for analysis years 2011, 2017, 2018, and 2019. The emission factors are one component in the equation to determine vehicle emissions emitted from the region's on-road vehicles. MOVES2010b parameters used to develop emissions inventory are listed in Exhibits 3-1 through 3-5 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 C. MOVES2010b input files utilizing these parameters and data for each county are included in Appendix B.

Exhibit 3-1: MOVES2010b Modeled Pollutants

Reasonable Further Progress Emission Inventory		
Command	**Input Parameter Values and Molecular Formulas**	**Description**
Pollutant	VOC, CO, NO, NO_2, NO_X, CO_2, SO_2, $PM_{2.5}$, PM_{10}, C_6H_6, CH_2O, C_2H_4O, C_4H_6, and C_3H_4O	Volatile Organic Compounds (VOC), Carbon Monoxide (CO), Nitrogen Oxide (NO), Nitrogen Dioxide (NO_2) Nitrogen Oxides (NO_X), Carbon Dioxide (CO_2), Sulfur Dioxide (SO_2), Fine Particulate Matter less than 2.5 micrometers in diameter ($PM_{2.5}$), Particulate Matter less than 10 micrometers in diameter (PM_{10}), Benzene (C_6H_6), Formaldehyde (CH_20), Acetaldehyde (C_2H_4O), 1,3-Butadiene (C_4H_6), and Acrolein (C_3H_4O)

Exhibit 3-2: MOVES2010b External Conditions

Reasonable Further Progress Emission Inventory		
Command	**Input Parameter Values**	**Description**
Calendar Year	2011, 2017, 2018, and 2019	RFP analysis years
Evaluation Month	7	Summer
Minimum/Maximum Temperature	N/A	See Hourly Temperatures
Hourly Temperatures	Average Summer	County specific, provided by TCEQ
Relative Humidity	Average Summer	County specific, provided by TCEQ

Barometric Pressure	Average Summer	County specific, provided by TCEQ

Exhibit 3-3: MOVES2010b Input Parameters

Reasonable Further Progress Emission Inventory MOVES Parameters and Source		
Input Parameter Name	**Description**	**Source**
Source Type Population	Input the number of vehicles in the geographic area which is to be modeled for each vehicle. Texas Transportation Institute's (TTI) MOVESpopulationBuild module is used to convert MOBILE6.2 based TxDOT registration data for each county into 13 MOVES SUT population.	2011 and 2013 TxDOT registration data
Source Type Age Distribution	Input that provides the distribution of vehicle counts by age for each calendar year and vehicle type. TxDOT registration data is used to estimate the age distribution of vehicle types up to 30 years. The distribution of age fractions should sum up to 1.0 for all vehicle types for each analysis year.	2011 and 2013 TxDOT registration data. MOVES default used for buses
Vehicle Type VMT	County specific VMT is distributed to 6 HPMS vehicle type.	Travel Model 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. The sum of speed distribution to all speed bins for each road type, vehicle type, and time/day type would be 1.0.	Travel Model Output
Road Type Distribution (VMT Fractions)	Input County Specific VMT by road type. VMT fraction is distributed between the road type and must sum to 1.0 for each source type.	Travel Model Output
Ramp Fraction	Input county specific fraction of ramp driving time on rural and urban restricted roadway type.	Travel Model 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 MOVES input where local data unavailable
Meteorology	County specific data on temperature and humidity	Local data from TCEQ
Fuel Formulation	Input county specific fuel properties in the MOVES database.	TCEQ, EPA fuel surveys and default MOVES input where local data unavailable
I/M Coverage	Input I/M coverage record for each combination of pollutants, process, county, fuel type, regulatory class, and model year are specified using this input.	Local data from TCEQ

Reasonable Further Progress Emission Inventory MOVES Parameters and Source		
Input Parameter Name	**Description**	**Source**
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.	2011 and 2013 TXDOT registration data. MOVES default used for light duty vehicles and buses

Exhibit 3-4: MOVES2010b I/M Descriptive Inputs for Subject Counties

Reasonable Further Progress Emission Inventory						
2011, 2017, 2018, and 2019						
Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker, Rockwall, and Tarrant I/M Data*						
I/M Program ID	20	21	22	23	24	Identifies program number with MOVES database
Pollutant Process ID	101, 102, 201, 202, 301, 302,	101, 102, 201, 202, 301, 302,	101, 102, 201, 202, 301, 302,	112	112	
Source Use Type	21, 31, 32	21, 31, 32	52, 54	21, 31, 32	21, 31, 32	
Begin Model Year	1996	X	X	X	1996	
End Model Year	Y	1995	Y	1995	Y	
Inspect Frequency	1	1	1	1	1	Annual testing; program specifications
Test Standards Description	Exhaust OBD Check	ASM 2525/501 5 Phase-in Cut Points	Two-mode, 2500 RPM/Idle Test	Evaporative Gas Cap Check	Evaporative Gas Cap and OBD Check	
I/M Compliance	93.12					Expected compliance (%) – MOVES2010b Default

Source: TCEQ
ASM – Acceleration Simulation Mode
RPM – Revolutions Per Minute
Note: Begin Model Year and End Model Year define the range of vehicle model years covered by I/M program. Begin Model Year, represented by "X" is calculated as YearID – 2 and End Model Year, represented by "Y" is calculated as YearID – 24.
*Wise County does not have an I/M program

Exhibit 3-5: MOVES2010b Fuel Properties

Reasonable Further Progress Emission Inventory						
	PR90			2011, 2017, 2018, 2019		
Counties	**Core**	**Perimeter**	**All**	**Core**	**Perimeter**	**All**
Fuel Type	**Gasoline**		**Diesel**	**Gasoline**		**Diesel**
Fuel Formulation ID	9500		20670	9500		20670
Fuel Subtype ID	10	10	20	12	12	20
RVP	7.8	8.7	0	6.97	7.8	0
Sulfur Level	402	575	338	24.93	30	11
ETOH Volume	0	0	0	9.69	10	0
MTBE Volume	0	0	0	0	0	0
ETBE Volume	0	0	0	0	0	0
TAME Volume	0	0	0	0	0	0
Aromatic Content	26.4	26.4	0	14.53	19.79	0
Olefin Content	11.9	11.9	0	12.03	12.51	0
Benzene Content	1.64	1.64	0	0.48	0.66	0
e200	50	50	0	47.23	54.32	0
e300	83	83	0	85.09	87.25	0
Vol To Wt Percent Oxy	0	0	0	0.3488	0.3488	0
BioDiesel Ester Volume	0	0	0	0	0	0
Cetane Index	0	0	0	0	0	0
PAH Content	0	0	0	0	0	0
T50	199.816	199.816	0	209.371	209.371	0
T90	329.409	329.409	0	325.918	325.918	0

Source: TCEQ and MOVES Default

3.2 AREA SPECIFIC CALCULATIONS AND PROCEDURES

SourceUse Type Distribution

SourceUse type age distributions are calculated from TxDOT's vehicle registration data. July data sets of corresponding analysis years are utilized for light- and heavy-duty vehicle classes. MOVES2010b default values are used for bus categories. Light-duty registration data for Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker, Rockwall, Tarrant, and Wise counties are weighted for commute patterns with the County-to-County Worker Flow data from the 2000 Census. Exhibit 3-6 identifies the percentages applied for this weighted adjustment. The 12-county summed heavy-duty vehicle data is used for developing the heavy-duty registration portion. These files are included in Appendix B.

Exhibit 3-6: County-to-County Worker Flow

Reasonable Further Progress Emission Inventory												
Residence County	**County of Employment**											
	Collin	**Dallas**	**Denton**	**Ellis**	**Johnson**	**Kaufman**	**Parker**	**Rockwall**	**Tarrant**	**Wise**	**Hood**	**Hunt**
Collin	63.80%	12.14%	3.23%	0.09%	0.04%	0.19%	0.13%	0.74%	0.54%	0.00%	0.00%	0.31%
Dallas	6.07%	23.41%	2.09%	0.62%	0.13%	0.57%	0.09%	0.81%	1.84%	0.02%	0.02%	0.17%
Denton	8.28%	10.87%	71.72%	0.17%	0.06%	0.08%	0.15%	0.07%	2.76%	0.29%	0.04%	0.08%
Ellis	1.45%	10.96%	0.44%	91.86%	1.89%	0.42%	0.04%	0.15%	2.17%	0.00%	0.02%	0.05%
Johnson	0.43%	1.97%	0.88%	4.22%	91.16%	0.10%	1.13%	0.07%	17.88%	0.10%	0.73%	0.06%
Kaufman	2.36%	12.70%	0.86%	1.06%	0.06%	89.60%	0.06%	2.67%	0.72%	0.00%	0.00%	0.43%
Parker	0.35%	1.02%	1.30%	0.26%	0.86%	0.00%	87.00%	0.00%	20.05%	1.56%	1.62%	0.02%
Rockwall	8.53%	13.66%	0.95%	0.23%	0.39%	4.07%	0.00%	83.69%	0.54%	0.00%	0.07%	4.23%
Tarrant	0.69%	5.20%	2.18%	0.45%	1.20%	0.06%	0.77%	0.05%	31.27%	0.13%	0.16%	0.05%
Wise	0.56%	1.71%	14.99%	0.26%	0.34%	0.06%	5.61%	0.00%	11.42%	97.90%	0.04%	0.00%
Hood	0.17%	1.17%	0.70%	0.49%	3.81%	0.04%	4.95%	0.00%	10.54%	0.00%	97.26%	0.00%
Hunt	7.30%	5.21%	0.65%	0.27%	0.04%	4.80%	0.07%	11.75%	0.27%	0.00%	0.05%	94.62%
Total	100 %	100 %	100 %	100 %	100 %	100 %	100.%	100.%	100.%	100.%	100.%	100.%

Source: 2000 Census

Diesel Fractions/Fuel Engine Fractions (AVFT)
AVFT for heavy-duty vehicle categories utilized 12-county summed yearly July registration data for modeling 2011, 2017, 2018, and 2019 analysis years. July 2011 registration data is used for modeling 2011 and July 2013 is used for modeling 2017, 2018, and 2019 analysis years.

Light-duty and bus categories utilize MOVES2010b default values. All AVFT files included in Appendix B lists specific data used for this analysis.

3.3 MOVES2010B EMISSION FACTORS

MOVES2010b emission factors for all the control scenarios are reported in Appendix C.

3.4 ADJUSTMENTS

Adjustments are applied to the emission factors in a post-process step. Low Emission Diesel (LED) NO_X Adjustment is applied to the emission factors. VMT Mix adjustment is applied simultaneously with the emission calculation procedure discussed in Chapter 4.

3.4.1 Low Emission Diesel NO_x Adjustment

NCTCOG developed TxLED factors for the DFW region for the years 2011, 2017, 2018, and 2019 using the TCEQ Excel template found in the following link ftp://amdaftp.tceq.texas.gov/pub/Mobile_EI/Statewide/mvs/txled/. The factors produced employed the TCEQ average diesel SUT NO_X adjustments using 4.8 percent reductions for 2002 and later, and 6.2 percent reductions for 2001 and earlier model years (NO_X reductions are from the EPA Memorandum, *Texas Low Emission Diesel (LED) Fuel Benefits,* September 2001).

The TxLED analyses employed 2011 and 2013 regional age distribution factors for MOVES2010b runs. NO_x, NO, and NO_2 emissions for Dallas County (DFW Area representative county) for all vehicle models years were produced for all analysis years of the RFP. MOVES emissions were extracted from the MOVES output table. The extracted emissions were used in the template to estimate TxLED factors for all diesel vehicles for the pollutants NO_x, NO, and NO_2. Exhibit 3-7 shows the TxLED factors used (provided by TCEQ).

Exhibit 3-7: LED NO_x Adjustments

Reasonable Further Progress Emission Inventory				
Source Use Type	**Adjustment Factors**			
	2011	**2017**	**2018**	**2019**
Passenger Car	0.9496	0.9516	0.9517	0.9496
Passenger Truck	0.9456	0.9490	0.9495	0.9456
Light Commercial Truck	0.9461	0.9488	0.9491	0.9461
Intercity Bus	0.9414	0.9431	0.9435	0.9414
Transit Bus	0.9417	0.9434	0.9438	0.9417
School Bus	0.9418	0.9434	0.9438	0.9418
Refuse Truck	0.9490	0.9510	0.9513	0.9490
Single Unit Short-Haul Truck	0.9493	0.9511	0.9513	0.9493
Single Unit Long-Haul Truck	0.9489	0.9509	0.9511	0.9489
Motor Home	0.9472	0.9497	0.9500	0.9472
Combination Short-Haul Truck	0.9458	0.9484	0.9489	0.9458
Combination Long-Haul Truck	0.9455	0.9487	0.9492	0.9455

Source: NCTCOG

3.4.2 Vehicle Miles of Travel Mix (or Fractions)

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 freeways, arterials, collectors, and HOV lanes for three time periods and each of the following three areas: Urban Counties (Dallas and Tarrant), Rural Counties (Collin and Denton), and Perimeter Counties (Ellis, Johnson, Kaufman, Parker, Rockwall, and Wise). These county groupings were determined by the vehicle activity behavior and demographics of the counties.

Vehicle counts reported in the latest available 2011 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 MOVES2010b Source Use Types by applying appropriate TxDOT registration data and/or MOVES2010b defaults. Exhibit 3-8 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 am to 9:00 am, PM peak is 3:00 pm to 6:30 pm, 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, to include buses, are defined as trucks.

Exhibit 3-8: Vehicle Classification Process

Reasonable Further Progress Emission Inventory					
Axle-Based Vehicle Classifications		**Intermediate Groups/HPMSVtypeID**		**Detailed Groups**	
C	Passenger Vehicles	PV	Passenger Vehicles (20)	Passenger Car	Passenger Gasoline Vehicle
					Passenger Diesel Vehicle
					Motorcycle (MC)^
P	2 Axle, 4 Tire Single Unit		Light Duty Trucks (30)	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*

Exhibit 3-8: Vehicle Classification Process (continued)

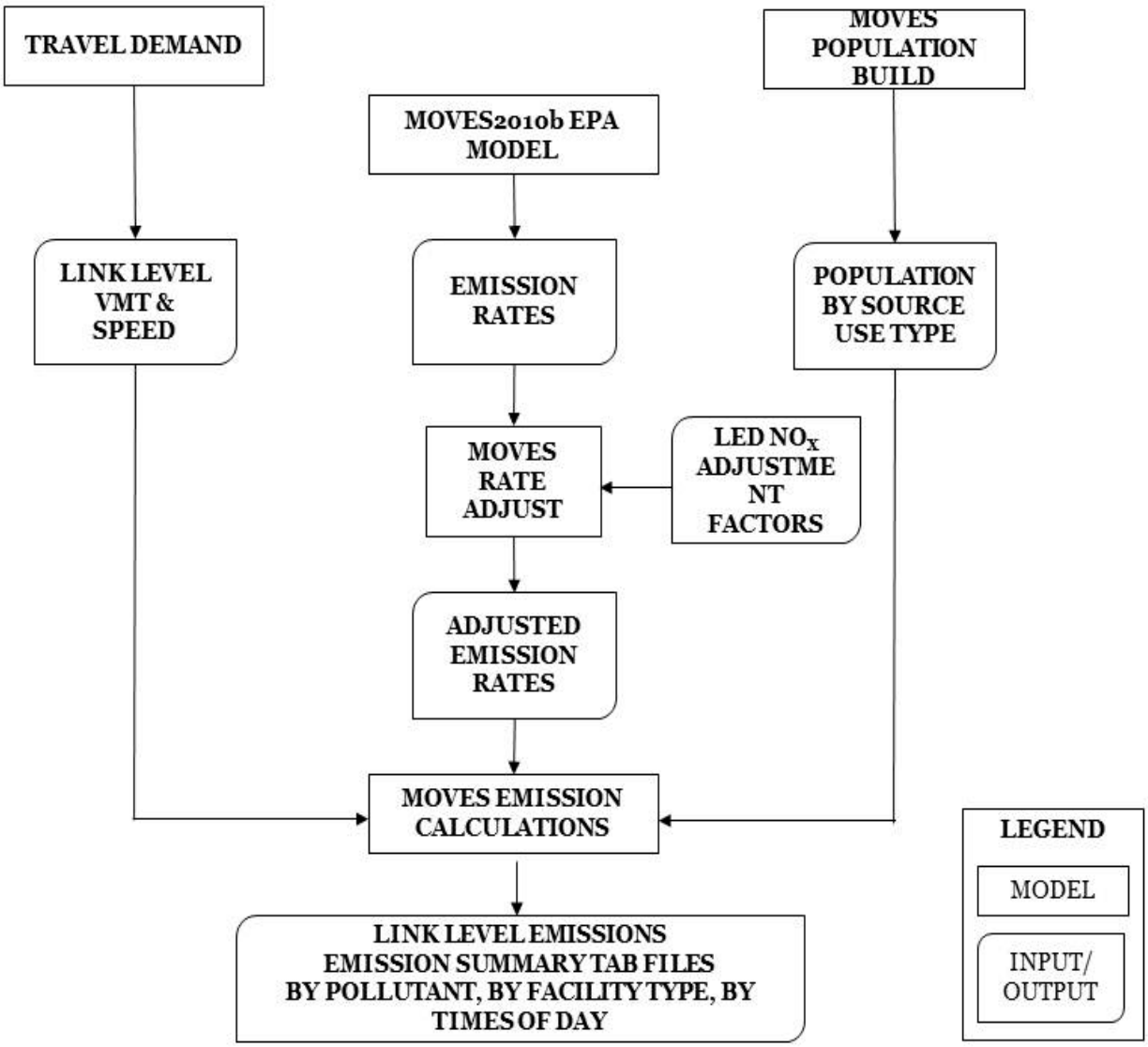
<table>
<tr><th colspan="6">Reasonable Further Progress Emission Inventory</th></tr>
<tr><th colspan="2">Axle-Based Vehicle Classifications</th><th colspan="2">Intermediate Groups/HPMSVtypeID</th><th colspan="2">Detailed Groups</th></tr>
<tr><td>SE5</td><td>5 Axle, Single Trailer</td><td rowspan="6">Heavy Duty Trucks</td><td rowspan="6">Combination Heavy-Duty Vehicles (60)</td><td rowspan="3">Combination Short-Haul Truck</td><td rowspan="2">Combination Short-Haul Gasoline Truck*</td></tr>
<tr><td>SE6</td><td>6+ Axle, Single Trailer</td></tr>
<tr><td>SD5</td><td>5 Axle, Multi Trailer</td><td>Combination Short-Haul Diesel Truck*</td></tr>
<tr><td>SD6</td><td>6 Axle, Multi Trailer</td><td colspan="2" rowspan="2">Combination Long-Hhaul Diesel Truck*</td></tr>
<tr><td>SD7</td><td>7+ Axle, Multi Trailer</td></tr>
</table>

Source: Dallas-Fort Worth Ozone Nonattainment Area SIP Support, 2013, Texas Transportation Institute
^Motorcycles are allocated as 0.1 percent for each functional class, subtracted from the light-duty vehicles
*Categories calculated using MOVES2010b defaults

CHAPTER 4: EMISSION CALCULATION PROCEDURE

Emissions estimates are calculated using "***TTI emissions inventory estimation utilities using moves: movesutl***" developed by TTI. This software combines vehicle activity and emission factors to create emission estimates. Exhibit 4-1 outlines the emission calculation modeling process that is used to calculate the emissions estimates for the DFW Worth ozone nonattainment area. Rate per Distance, Rate per Vehicle, and Rate per Profile are applied for DFX counties that are outlined in the following sections.

Exhibit 4-1: MOVES2010b Emission Modeling Process



4.1 EMISSION ESTIMATION

The DFX captures the vehicle activity information for each roadway segment in the transportation network in Collin, Dallas, Denton, Ellis, Hood, Hunt, Johnson, Kaufman, Parker, Rockwall, Tarrant, and Wise counties as discussed in Chapter 1. Emission estimation using MOVES2010b is broken down into three phases.

4.1.1 Rate Per Distance

These include emissions for the processes that occur while vehicles are operating (i.e., running exhaust tire wear, brake wear, evaporative permeation, evaporative fuel vapor venting, evaporative fuel leaks, crankcase running exhaust, refueling displacement, and refueling spillage). The quantity of emissions estimated is directly related to the activity.

Application of emission factors to each of these roadway network links requires assignment of vehicle mix, also known as VMT mix, and coordination of functional classes. First, an appropriate VMT mix is identified for each link. For principal and minor arterials, frontage roads, collectors, zone connectors, and intrazonal functional, rural or urban unrestricted access emission rates are applied depending on the area type the link represents. For Interstate, freeways, and HOV lanes, rural or urban restricted access emission rates are applied depending on the area type the link represents. Exhibit 4-2 shows the area type used to apply emission rates; links that fall under area type 1-4 are applied with an urban restricted/unrestricted emission rate and links that fall under area type 5 are applied with a rural restricted/unrestricted emission rate. Emission factors are specific to the speed identified on the roadway segments.

Exhibit 4-2: DFX Area Type

Reasonable Further Progress Emission Inventory		
Area Type	**Description**	**Activity Density Range (Per Acre)**
1	Central Business District	> 125
2	Outer Business District	30-125
3	Urban Residential	7.5-30
4	Suburban Residential	1.8-7.5
5	Rural	<1.8

4.1.2 Rate Per Vehicle

These include emissions for most processes that occur while vehicles are stationary (i.e., start exhaust, start crankcase, permeation, liquid leaks, and extended idle [long haul combination trucks only]).

4.1.3 Rate Per Profile

These include emissions from the vapor venting process when vehicles are stationary. Vapor venting emissions vary depending on activity and previous temperatures. Rateperprofile and ratepervehicle-based emissions are directly related to the source type population.

CHAPTER 5: SUMMARY OF VEHICLE MILES OF TRAVEL, SPEED, AND EMISSIONS

Summary emissions results are available in this chapter.

5.1 VEHICLE MILES OF TRAVEL ESTIMATES

Appendix E contains the summarized VMT estimates by the analysis year and time-of-day (TOD) for the counties.

5.2 SPEED ESTIMATES

Appendix E contains the summarized speeds by the analysis year and TOD for the counties.

5.3 EMISSION ESTIMATES

The final county emission estimates for each analysis year and control scenarios are summarized in Exhibit 5-1. Additional modeled pollutants not shown in this section are available in Appendices D, E and G. Appendix D contains the detailed emissions by pollutant, day, and TOD for all counties.

Appendix E contains the detailed tab summary of VMT, speeds, and emissions for all counties by analysis year, control scenarios, TOD, functional class, and vehicle type. Appendix G contains a summary of all emissions.

Exhibit 5-1: Final County Emission Estimates

Reasonable Further Progress Emission Inventory DFW Ten-County Modeling Domain Summer Season, Midweek				
Nitrogen Oxides Emissions (tons/day)				
Adjusted Base Year				
Counties	**2011**	**2017**	**2018**	**2019**
Collin	-	80.31	80.28	80.26
Dallas	-	282.39	282.35	282.25
Denton	-	72.12	72.12	72.12
Ellis	-	40.55	40.57	40.58
Johnson	-	27.99	28.00	28.00
Kaufman	-	30.14	30.15	30.16
Parker	-	26.27	26.28	26.29

Reasonable Further Progress Emission Inventory DFW Ten-County Modeling Domain Summer Season, Midweek				
Nitrogen Oxides Emissions (tons/day)				
Rockwall	-	11.06	11.06	11.06
Tarrant	-	181.69	181.67	181.53
Wise	-	18.51	18.50	18.49
Total	-	**771.03**	**770.98**	**770.74**
Pre-90 Controls				
Counties	**2011**	**2017**	**2018**	**2019**
Collin	79.43	99.99	103.27	104.39
Dallas	281.43	325.74	331.05	330.11
Denton	71.35	87.64	89.98	90.36
Ellis	39.61	51.39	53.02	54.20
Johnson	27.59	34.73	35.70	36.20
Kaufman	29.80	39.53	40.86	41.68
Parker	25.97	33.29	34.38	34.99
Rockwall	10.92	13.67	14.09	14.26
Tarrant	179.93	215.68	219.91	219.66
Wise	18.30	23.01	23.70	24.11
Total	**764.33**	**924.67**	**945.96**	**949.96**
FMVCP				
Counties	**2011**	**2017**	**2018**	**2019**
Collin	39.07	26.91	25.25	22.67
Dallas	143.37	92.50	85.43	75.67
Denton	34.62	23.23	21.70	19.35
Ellis	19.37	13.59	12.68	11.65
Johnson	14.46	9.92	9.22	8.33
Kaufman	14.66	10.37	9.70	8.82
Parker	12.11	8.26	7.74	7.04
Rockwall	5.53	3.72	3.47	3.13
Tarrant	92.65	62.74	58.28	51.76
Wise	9.09	6.24	5.83	5.33
Total	**384.93**	**257.48**	**239.30**	**213.75**
RFG				
Counties	**2011**	**2017**	**2018**	**2019**
Collin	26.10	16.58	15.47	13.90

Reasonable Further Progress Emission Inventory DFW Ten-County Modeling Domain Summer Season, Midweek				
Nitrogen Oxides Emissions (tons/day)				
Dallas	97.49	57.40	52.63	46.38
Denton	24.08	14.88	13.82	12.32
Ellis	14.13	9.33	8.69	8.00
Johnson	9.74	6.31	5.85	5.29
Kaufman	10.51	7.00	6.53	5.91
Parker	9.61	6.22	5.81	5.25
Rockwall	3.65	2.31	2.15	1.95
Tarrant	62.34	38.71	35.73	31.61
Wise	6.57	4.24	3.95	3.59
Total	**264.22**	**162.98**	**150.63**	**134.20**
Control Strategy				
Counties	**2011**	**2017**	**2018**	**2019**
Collin	24.08	15.41	14.43	13.01
Dallas	89.66	53.20	48.93	43.24
Denton	22.41	13.92	12.96	11.59
Ellis	13.41	8.87	8.28	7.64
Johnson	9.07	5.91	5.50	4.98
Kaufman	9.92	6.63	6.20	5.62
Parker	9.12	5.94	5.55	5.03
Rockwall	3.42	2.17	2.03	1.85
Tarrant	57.34	35.85	33.18	29.45
Wise	6.57	4.24	3.95	3.59
Total	**245.00**	**152.14**	**141.01**	**126.00**
TxLED				
Counties	**2011**	**2017**	**2018**	**2019**
Collin	23.48	15.07	14.11	12.73
Dallas	87.47	52.03	47.88	42.32
Denton	21.78	13.58	12.65	11.31
Ellis	12.93	8.60	8.03	7.41
Johnson	8.81	5.76	5.36	4.86
Kaufman	9.58	6.43	6.02	5.46
Parker	8.80	5.75	5.38	4.88
Rockwall	3.32	2.11	1.97	1.80

Reasonable Further Progress Emission Inventory DFW Ten-County Modeling Domain Summer Season, Midweek				
Nitrogen Oxides Emissions (tons/day)				
Tarrant	55.98	35.09	32.49	28.83
Wise	6.36	4.12	3.84	3.50
Total	**238.51**	**148.54**	**137.73**	**123.10**

Exhibit 5-1: Final County Emission Estimates (continued)

Reasonable Further Progress Emission Inventory DFW Ten-County Modeling Domain Summer Season, Midweek				
Volatile Organic Compounds (tons/day)				
Adjusted Base Year				
Counties	**2011**	**2017**	**2018**	**2019**
Collin	-	34.50	34.48	34.47
Dallas	-	116.99	116.97	116.92
Denton	-	28.41	28.41	28.40
Ellis	-	10.55	10.56	10.56
Johnson	-	9.25	9.25	9.25
Kaufman	-	7.64	7.64	7.64
Parker	-	7.07	7.07	7.07
Rockwall	-	3.96	3.96	3.95
Tarrant	-	80.22	80.20	80.15
Wise	-	4.82	4.82	4.81
Total	-	**303.41**	**303.36**	**303.22**
Pre-90 Controls				
Counties	**2011**	**2017**	**2018**	**2019**
Collin	34.07	42.39	43.77	41.62
Dallas	116.58	134.28	136.91	129.78
Denton	28.06	34.45	35.41	33.40
Ellis	10.20	12.52	12.89	12.59
Johnson	9.16	11.07	11.36	10.95
Kaufman	7.55	9.90	10.24	10.02
Parker	6.98	8.50	8.75	8.38
Rockwall	3.90	4.85	5.00	4.76
Tarrant	79.41	94.22	96.37	90.74
Wise	4.78	5.82	6.00	5.86

Reasonable Further Progress Emission Inventory DFW Ten-County Modeling Domain Summer Season, Midweek				
Volatile Organic Compounds (tons/day)				
Total	**300.69**	**358.00**	**366.70**	**348.10**
FMVCP				
Counties	**2011**	**2017**	**2018**	**2019**
Collin	13.78	10.41	10.12	8.55
Dallas	50.90	34.81	33.37	28.30
Denton	11.56	8.62	8.36	7.02
Ellis	5.01	3.54	3.38	2.96
Johnson	4.70	3.25	3.10	2.66
Kaufman	3.61	2.57	2.45	2.11
Parker	3.21	2.31	2.22	1.89
Rockwall	1.81	1.30	1.26	1.07
Tarrant	35.51	25.72	24.78	20.88
Wise	2.43	1.65	1.57	1.37
Total	**132.52**	**94.18**	**90.60**	**76.81**
RFG				
Counties	**2011**	**2017**	**2018**	**2019**
Collin	12.06	9.01	8.77	7.35
Dallas	44.19	29.93	28.71	24.15
Denton	10.17	7.51	7.29	6.07
Ellis	3.94	2.84	2.73	2.38
Johnson	3.71	2.63	2.52	2.15
Kaufman	2.75	2.01	1.93	1.66
Parker	2.81	2.04	1.96	1.66
Rockwall	1.45	1.07	1.04	0.88
Tarrant	31.45	22.47	21.65	18.08
Wise	1.90	1.32	1.26	1.10
Total	**114.43**	**80.83**	**77.86**	**65.48**
Control Strategy				
Counties	**2011**	**2017**	**2018**	**2019**
Collin	10.74	7.93	7.72	6.50
Dallas	39.33	26.21	25.11	21.21
Denton	9.09	6.63	6.44	5.38
Ellis	3.56	2.53	2.43	2.13
Johnson	3.34	2.32	2.23	1.91

Reasonable Further Progress Emission Inventory DFW Ten-County Modeling Domain Summer Season, Midweek				
Volatile Organic Compounds (tons/day)				
Kaufman	2.48	1.80	1.73	1.49
Parker	2.55	1.82	1.76	1.49
Rockwall	1.30	0.95	0.92	0.78
Tarrant	28.03	19.69	18.96	15.90
Wise	1.90	1.32	1.26	1.10
Total	**102.32**	**71.20**	**68.56**	**57.89**
TxLED				
Counties	**2011**	**2017**	**2018**	**2019**
Collin	10.74	7.93	7.72	6.50
Dallas	39.33	26.21	25.11	21.21
Denton	9.09	6.63	6.44	5.38
Ellis	3.56	2.53	2.43	2.13
Johnson	3.34	2.32	2.23	1.91
Kaufman	2.48	1.80	1.73	1.49
Parker	2.55	1.82	1.76	1.49
Rockwall	1.30	0.95	0.92	0.78
Tarrant	28.03	19.69	18.96	15.90
Wise	1.90	1.32	1.26	1.10
Total	**102.32**	**71.20**	**68.56**	**57.89**