APPENDIX D

DEVELOPMENT OF TEXAS STATEWIDE 2017 AERR INVENTORY FOR NON-ROAD MODEL CATEGORY MOBILE SOURCES

2015 Eight-Hour Ozone National Ambient Air Quality Standard Emissions Inventory State Implementation Plan for the El Paso County Portion of the El Paso-Las Cruces, Texas-New Mexico Nonattainment Area

2022-010-SIP-NR
SFR-122/2022-010-SIP-NR

Eastern Research Group, Inc.

DEVELOPMENT OF TEXAS STATEWIDE 2017 AERR INVENTORY FOR NONROAD MODEL CATEGORY MOBILE SOURCES

FINAL REPORT

TCEQ Contract No. 582-15-50416

Work Order No. 582-18-81185-013

Prepared for:

The Texas Commission on Environmental Quality

Air Quality Division

Prepared by:

Eastern Research Group, Inc.

October 26, 2018

ERG NO. 0345.00.017

Development of Texas Statewide 2017 AERR Inventory for NONROAD Model Category Mobile Sources

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Prepared for:

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Abstract

Eastern Research Group, Inc. (ERG) prepared county-level annual and summer season weekday emissions estimates for the 2017 calendar year for the Texas Commission on Environmental Quality (TCEQ). The outputs of the analysis will be submitted to the United States Environmental Protection Agency (EPA) for the 2017 Air Emissions Reporting Requirements (AERR). The AERR submission includes emissions and activity data for criteria air pollutants (CAPs) and their precursors as well as hazardous air pollutants (HAPs) from nonroad mobile equipment operating in Texas. EPA's MOVES2014b emissions model and a companion utility, TexN2, were used for this work. The report also compares the findings for 2017 with the state's 2014 AERR submittal. The comparison found general consistency between the estimates after accounting for the expected effects due to equipment population growth and turnover, as well as emission factor differences between current and prior emission models.

1.0 Introduction

The U.S. EPA promulgated the AERR in December 2008, requiring states to submit emissions inventories (EIs) for criteria pollutants to EPA's Emission Inventory System (EIS). The U.S. EPA uses these submittals along with other data sources (mainly for air toxics, if not submitted) to build the National Emissions Inventory (NEI). The NEI provides the official accounting of all emissions in the U.S. at a detailed level and serves as the foundation for trends analyses, air quality planning, regulation development, and health exposure analyses.

For nonroad model mobile sources, the U.S. EPA requires model inputs, rather than emissions, to generate the MOVES-based inventories for the NEI. The input data requirement for mobile sources includes either a set of MOVES county databases (CDBs, 1 per county) or a state database (SDB) that applies to all counties within a state. This report documents the development of a statewide 2017 EI for nonroad model category mobile sources and the development of 254 CDBs to meet the reporting requirement of the AERR. The AERR submission includes annual and summer weekday emissions and activity data for CAPs and their precursors as well as HAPs from nonroad mobile equipment operating in Texas. EPA's MOVES2014b emissions model and a companion utility, TexN2, were used for this work.

TexN2, developed by ERG for the TCEQ, facilitates the use of detailed Texas-specific nonroad equipment population, activity, fuels, and related data as inputs for MOVES2014b, and accounts for Texas-specific emission adjustments such as the Texas Low Emission Diesel (TxLED) program. The TexN2 utility is anticipated to be used by TCEQ staff, local air quality planning agencies, and other nonroad mobile stakeholders to facilitate the use of local data and conditions, and to standardize the emission estimation methodologies among the different agencies in Texas. The TCEQ supplies all interested parties with the latest model, which reflects TCEQ updates to specific data, and coordinates the integration of all local changes. The emission estimates developed using this integrated utility will be used for state implementation plan (SIP) modeling, EPA reporting requirements, trend analyses, and other air quality modeling activities.

This report describes the input data sources for fuels and meteorology, then presents 2017 emission inventory summaries resulting from application of the updated TexN2 utility with MOVES2014b. The relationship between the 2017 emissions and the previous 2014 AERR inventory are described next, and the report concludes by discussing challenges and providing recommendations for future improvements.

2.0 2017 Inputs for TexN2

ERG implemented two key data updates in the TexN2 database prior to executing the utility: seasonal fuel properties and meteorology.

2.1 Fuel Data

The TCEQ periodically collects and analyzes fuel samples taken from vehicle fueling stations across the state. The dataset ensures accuracy of local fuel information and provides the best data available to support SIP control strategy development. ERG incorporated the latest fuel sampling data conducted in the summer of 2017, and in winter of 2017 for the Houston and Dallas areas, into TexN2 (1).

2.2 Meteorological Data

The TCEQ provided 2017 temperature and relative humidity data to ERG in March 2018. The data were hourly by four seasons. ERG reformatted and compiled the following eight files:

1. tex-met-inputs-2017-temp-fall.xlsx
2. tex-met-inputs-2017-temp-spring.xlsx
3. tex-met-inputs-2017-temp-summer.xlsx
4. tex-met-inputs-2017-temp-winter.xlsx
5. tex-met-inputs-2017-rhum-fall.xlsx
6. tex-met-inputs-2017-rhum-spring.xlsx
7. tex-met-inputs-2017-rhum-summer.xlsx
8. tex-met-inputs-2017-rhum-winter.xlsx

Only minor reformatting was required, including: transforming county FIPS codes into 3-digit met station identification numbers with leading zeros; assigning a season letter code of “F,” “S,” “M,” or “W” for fall, spring, summer, and winter, respectively; and rearranging the sequence of temperature metrics to be ordered as: minimum, maximum, and average temperature, followed by relative humidity. The reformatted files were then compiled into a single long file, relabeled for the metYear 2017, and uploaded into the `climate` table in the TexN2 database.

3.0 Emissions Inventory Development

For the 2017 inventory, the MOVES version used was *MOVES2014b-20180726*, and the database version was *movesdb20180517*. MOVES2014b includes significant updates to nonroad category mobile source emissions, as discussed in Section 4.1. The TexN2 runs were executed in parallel using the Amazon Web Services (AWS) cloud computing environment.

3.1 Inventory Development

The TexN2 utility estimates nonroad emissions by source classification code (SCC) and county for all fuel types. In addition, it allows for the disaggregation of diesel construction equipment SCCs into subsectors (Diesel Construction Equipment subsectors, or DCEs) to account for differences in population, activity, etc. within these SCCs. Each DCE/SCC combination requires a separate MOVES-Nonroad run, resulting in up to 24 runs for each county, with a separate CDB created by TexN2 for each run.

However, NEI submissions require that each county be represented by a single CDB. Therefore, the emissions inventory development proceeded in multiple steps for each county to generate emissions estimates using the full complement of Texas-specific data while also generating a single CDB per county.

First, all of the MOVES-Nonroad runs required for the fully disaggregated DCEs were performed, and all emissions adjustments (e.g., for TxLED, altitude, etc.) were applied in post-processing. These runs provide the most accurate emissions estimate for each county given the available Texas-specific data, and therefore form the basis of the emissions totals reported for the emissions inventory and this report.

Next, the DCEs were aggregated to the SCC level using the aggregation functionality incorporated in the TexN2 utility, allowing the county's entire equipment fleet to be represented in a single CDB, as required by the NEI. MOVES-Nonroad was then run again using this aggregated CDB, without post-processing. Because the DCE model year distribution effects cannot be captured at the more aggregated SCC level, the emissions estimates from this run differed from the results obtained from the fully disaggregated runs.

To account for the model year distribution effects that are not captured in the aggregated CDB, ERG also developed an adjusted MOVES nrEmissionRate table that enables a MOVES-Nonroad run based on the aggregated CDB to recreate the emissions from the disaggregated runs, as described in an earlier memorandum to the TCEQ (2). The EPA is currently considering whether to accept these adjusted emission rates in NEI submissions, so individual CDBs with and without these adjusted nrEmissionRate tables are included with this report.

The TexN2 utility generates several standard reports providing emissions totals by various categories, such as by county, SCC, etc. In addition, it can output CERS XML format reports for submission to the TCEQ's Air Emissions Repository (TexAER) and the EPA's EIS. XML reports were generated for both annual and average summer weekday emissions. To facilitate loading into TexAER and stay under file size upload

limitations, the XML files were subsequently separated into CAPs and HAPs and then combined by groups of counties.

3.2 Emissions Estimates

Tables 1 through 13, A-1, and A-2 summarize the emissions for the 2017 AERR.

Table 1. 2017 OSD Criteria Emissions by Equipment Classification (Tons/Day)

Classification	VOC	NO_X	CO	PM_{10}-PRI	$PM_{2.5}$-PRI	SO_2	NH_3
Agricultural Equipment	15.52	161.64	165.62	13.97	13.54	0.18	0.38
Commercial Equipment	22.21	19.93	657.69	1.91	1.82	0.04	0.05
Construction and Mining Equipment	13.23	93.52	143.58	8.16	7.88	0.1	0.24
Industrial Equipment	3.2	26.12	84.1	1.26	1.24	0.04	0.03
Lawn and Garden Equipment (Com)	19.64	4.12	189.31	2.52	2.33	0.01	0.01
Lawn and Garden Equipment (Res)	22.68	3.15	414.2	0.92	0.85	0.02	0.02
Logging Equipment	1.05	0.55	9.37	0.17	0.16	0	0
Pleasure Craft	32.49	7.45	129.19	0.4	0.37	0.02	0.02
Railroad Equipment	0.11	0.65	0.47	0.08	0.08	0	0
Recreational Equipment	52.23	2.59	244.95	1.63	1.5	0.02	0.02
Total	**182.38**	**319.72**	**2038.48**	**31.02**	**29.76**	**0.42**	**0.78**

Table 2. 2017 Annual Criteria Emissions by Equipment Classification (Tons/Year)

Classification	VOC	NO_X	CO	PM_{10}-PRI	$PM_{2.5}$-PRI	SO_2	NH_3
Agricultural Equipment	3,483	40,561	36,177	3,199	3,102	41	91
Commercial Equipment	7,138	6,805	200,254	603	573	14	17
Construction and Mining Equipment	3,571	26,980	37,760	2,186	2,111	26	64
Industrial Equipment	964	8,636	23,854	399	391	10	10
Lawn and Garden Equipment (Com)	5,478	1,076	47,540	704	650	3	3
Lawn and Garden Equipment (Res)	8,079	1,195	141,255	341	314	8	8
Logging Equipment	332	189	2,894	53	49	0	0
Pleasure Craft	12,898	3,498	58,315	181	167	7	7
Railroad Equipment	32	191	138	23	22	0	0
Recreational Equipment	16,658	884	76,785	521	480	5	6
Total	**58,636**	**90,020**	**624,978**	**8,213**	**7,862**	**117**	**210**

Table 3. 2017 OSD Criteria Emissions by Selected Area (Tons/Day)

Regional Group	VOC	NO_X	CO	PM_{10}-PRI	$PM_{2.5}$-PRI	SO_2	NH_3
Alamo Area Council of Governments	15.92	16.8	152.54	1.91	1.83	0.02	0.04
Beaumont-Port Arthur Area	1.73	2.51	26.29	0.31	0.3	0	0.01
Capital Area Council of Governments	12.08	16.63	127.16	1.77	1.69	0.03	0.04
Dallas-Fort Worth Area (10 county)	28.61	44.75	462.59	4.58	4.37	0.06	0.1
El Paso	2.24	5.85	41.39	0.47	0.45	0.01	0.02
East Texas Council of Governments	3.24	6.61	40.87	0.61	0.59	0.01	0.02
Houston-Galveston-Brazoria Area	29.76	38.56	434.29	3.95	3.77	0.05	0.09
Victoria	0.59	1.25	7.66	0.13	0.13	0	0

Table 4. 2017 Annual Criteria Emissions by Selected Area (Tons/Year)

Regional Group	VOC	NO_X	CO	PM_{10}-PRI	$PM_{2.5}$-PRI	SO_2	NH_3
Alamo Area Council of Governments	5,041	4,773	46,683	524	499	6	12
Beaumont-Port Arthur Area	546	745	7,963	86	82	1	2
Capital Area Council of Governments	3,816	4,725	38,694	481	459	7	12
Dallas-Fort Worth Area (10 county)	9009	13,778	139,554	1,302	1,241	20	30
El Paso	714	1,654	12,643	129	124	2	4
East Texas Council of Governments	1,041	1,919	12,552	165	158	3	4
Houston-Galveston-Brazoria Area	9,824	11,741	134,808	1,130	1,077	17	27
Victoria	182	339	2,264	34	32	0	1

Table 5. 2017 Austin Area OSD Criteria Emissions (Tons/Day)

County	VOC	NO_X	CO	PM_{10}-PRI	$PM_{2.5}$-PRI	SO_2	NH_3
Bastrop	0.25	1.10	3.71	0.11	0.11	0.00	0.00
Blanco	0.20	0.28	1.24	0.03	0.03	0.00	0.00
Burnet	1.99	0.62	9.84	0.11	0.10	0.00	0.00
Caldwell	0.43	0.65	3.12	0.07	0.07	0.00	0.00
Fayette	0.80	1.32	5.22	0.13	0.13	0.00	0.00
Hays	0.81	0.93	7.80	0.11	0.10	0.00	0.00
Lee	0.31	1.66	2.50	0.11	0.11	0.00	0.00
Llano	0.72	0.34	3.97	0.04	0.04	0.00	0.00
Travis	4.93	5.70	68.98	0.66	0.63	0.01	0.01
Williamson	1.62	4.03	20.77	0.39	0.37	0.01	0.01
Total	**12.06**	**16.63**	**127.15**	**1.76**	**1.69**	**0.02**	**0.02**

Table 6. 2017 Beaumont-Port Arthur Area OSD Criteria Emissions (Tons/Day)

County	VOC	NO_X	CO	PM_{10}-PRI	$PM_{2.5}$-PRI	SO_2	NH_3
Hardin	0.24	0.54	3.18	0.07	0.07	0.00	0.00
Jefferson	0.94	1.59	17.38	0.18	0.18	0.00	0.00
Orange	0.55	0.39	5.73	0.06	0.05	0.00	0.00
Total	**1.73**	**2.52**	**26.29**	**0.31**	**0.30**	**0.00**	**0.00**

Table 7. 2017 Dallas-Fort Worth Area OSD Criteria Emissions (Tons/Day)

County	VOC	NO_X	CO	PM_{10}-PRI	$PM_{2.5}$-PRI	SO_2	NH_3
Collin	3.62	5.64	51.43	0.62	0.59	0.01	0.01
Dallas	12.23	17.34	220.10	1.82	1.73	0.03	0.04
Denton	2.49	3.60	33.94	0.35	0.33	0.01	0.01
Ellis	0.86	1.82	10.34	0.16	0.16	0.00	0.00
Johnson	0.49	1.71	7.62	0.17	0.16	0.00	0.00
Kaufman	0.62	1.67	7.71	0.17	0.17	0.00	0.00
Parker	0.67	1.37	6.81	0.14	0.14	0.00	0.00
Rockwall	0.67	0.64	6.22	0.07	0.07	0.00	0.00
Tarrant	6.43	9.69	113.62	0.95	0.91	0.01	0.02
Wise	0.54	1.26	4.79	0.12	0.12	0.00	0.00
Total	**28.62**	**44.74**	**462.58**	**4.57**	**4.38**	**0.06**	**0.08**

Table 8. 2017 El Paso OSD Criteria Emissions (Tons/Day)

County	VOC	NO_X	CO	PM_{10}-PRI	$PM_{2.5}$-PRI	SO_2	NH_3
El Paso	2.24	5.85	41.39	0.47	0.45	0.01	0.02

Table 9. 2017 Houston-Galveston-Brazoria Area OSD Criteria Emissions (Tons/Day)

County	VOC	NO_X	CO	PM_{10}-PRI	$PM_{2.5}$-PRI	SO_2	NH_3
Brazoria	1.96	2.61	20.66	0.27	0.25	0.00	0.01
Chambers	0.74	0.64	4.85	0.06	0.06	0.00	0.00
Fort Bend	1.68	3.28	27.54	0.35	0.33	0.00	0.01
Galveston	2.88	2.02	24.18	0.21	0.20	0.00	0.01
Harris	18.56	25.90	316.90	2.59	2.47	0.04	0.06
Liberty	0.42	0.89	4.65	0.10	0.09	0.00	0.00
Montgomery	3.18	2.47	31.79	0.31	0.29	0.00	0.01
Waller	0.33	0.73	3.72	0.08	0.08	0.00	0.00
Total	**29.75**	**38.54**	**434.29**	**3.97**	**3.77**	**0.04**	**0.10**

Table 10. 2017 San Antonio Area OSD Criteria Emissions (Tons/Day)

County	VOC	NO_X	CO	PM_{10}-PRI	$PM_{2.5}$-PRI	SO_2	NH_3
Atascosa	0.33	0.93	3.15	0.08	0.08	0.00	0.00
Bandera	1.47	0.23	6.37	0.06	0.06	0.00	0.00
Bexar	6.57	7.30	91.32	0.83	0.79	0.01	0.02
Comal	2.21	1.48	14.26	0.19	0.18	0.00	0.00
Frio	0.24	0.56	1.86	0.05	0.05	0.00	0.00
Gillespie	0.30	0.60	2.78	0.06	0.06	0.00	0.00
Guadalupe	0.87	1.43	8.78	0.15	0.15	0.00	0.00
Karnes	0.11	0.78	1.46	0.08	0.07	0.00	0.00
Kendall	0.92	0.41	5.39	0.06	0.06	0.00	0.00
Kerr	2.29	0.53	11.04	0.11	0.10	0.00	0.00
Medina	0.43	1.45	3.88	0.13	0.13	0.00	0.00
Wilson	0.17	1.10	2.25	0.10	0.10	0.00	0.00
Total	**15.91**	**16.80**	**152.54**	**1.90**	**1.83**	**0.01**	**0.02**

Table 11. 2017 Tyler-Longview Area OSD Criteria Emissions (Tons/Day)

County	VOC	NO_X	CO	PM_{10}-PRI	$PM_{2.5}$-PRI	SO_2	NH_3
Gregg	0.52	0.86	10.94	0.09	0.09	0.00	0.00
Harrison	0.77	1.88	6.30	0.14	0.14	0.00	0.00
Rusk	0.47	1.57	4.25	0.12	0.11	0.00	0.00
Smith	1.33	1.77	17.25	0.21	0.20	0.00	0.00
Upshur	0.15	0.54	2.13	0.05	0.05	0.00	0.00
Total	**3.24**	**6.62**	**40.87**	**0.61**	**0.59**	**0.00**	**0.00**

Table 12. 2017 Statewide OSD Hazardous Air Pollutant Emissions (Pounds/Day)

NEI Pollutant Code	Pollutant Name	Emissions Total (lbs/day)
108883	Toluene	29,882
1330207	Xylene	23,414
1634044	MTBE	0
540841	2,2,4-Trimethylpentane	17,331
71432	Benzene	12,092
50000	Formaldehyde	14,660
100414	Ethyl Benzene	8,509
110543	Hexane	4,349
75070	Acetaldehyde	4,813
106990	1,3-Butadiene	1,305
123386	Propionaldehyde	1,159
100425	Styrene	1,008
107028	Acrolein	1,019
91203	Naphthalene	622
85018	Phenanthrene	118
208968	Acenaphthylene	82.6277
86737	Fluorene	58.3410
83329	Acenaphthene	37.0031
129000	Pyrene	22.2438
206440	Fluoranthene	19.6899
93	Arsenic Compounds	0.4876
120127	Anthracene	12.4888
191242	Benzo(g,h,i)perylene	18.2538
7440020	Nickel Compounds	0.8846
56553	Benz(a)anthracene	4.3307
193395	Indeno(1,2,3,c,d)pyrene	6.9070
218019	Chrysene	4.2829
50328	Benzo(a)pyrene	6.8683
205992	Benzo(b)fluoranthene	4.4100
207089	Benzo(k)fluoranthene	4.3209
7439965	Manganese Compounds	0.4958
18540299	Chromium 6+	0.0024
53703	Dibenzo(a,h)anthracene	0.2033
200	Mercury Elemental Gaseous	0.0087
201	Mercury Divalent Gaseous	0.0016

NEI Pollutant Code	Pollutant Name	Emissions Total (lbs/day)
202	Mercury Particulate	0.0005
3268879	Octachlorodibenzo-p-dioxin	6.86E-06
35822469	1,2,3,4,6,7,8-Heptachlorodibenzo-p-Dioxin	1.07E-06
39001020	Octachlorodibenzofuran	1.71E-06
67562394	1,2,3,4,6,7,8-Heptachlorodibenzofuran	1.45E-06
19408743	1,2,3,7,8,9-Hexachlorodibenzo-p-Dioxin	8.18E-08
70648269	1,2,3,4,7,8-Hexachlorodibenzofuran	2.05E-07
51207319	2,3,7,8-Tetrachlorodibenzofuran	7.72E-07
60851345	2,3,4,6,7,8-Hexachlorodibenzofuran	1.21E-07
57653857	1,2,3,6,7,8-Hexachlorodibenzo-p-Dioxin	7.85E-08
57117314	2,3,4,7,8-Pentachlorodibenzofuran	3.28E-07
57117449	1,2,3,6,7,8-Hexachlorodibenzofuran	1.86E-07
39227286	1,2,3,4,7,8-Hexachlorodibenzo-p-Dioxin	3.44E-08
57117416	1,2,3,7,8-Pentachlorodibenzofuran	2.49E-07
1746016	2,3,7,8-Tetrachlorodibenzo-p-Dioxin	9.11E-08
72918219	1,2,3,7,8,9-Hexachlorodibenzofuran	8.84E-08
55673897	1,2,3,4,7,8,9-Heptachlorodibenzofuran	4.60E-08
40321764	1,2,3,7,8-Pentachlorodibenzo-p-Dioxin	3.28E-08

Table 13. 2017 Statewide Annual Hazardous Air Pollutant Emissions (Tons/Year)

NEI Pollutant Code	Pollutant Name	Emissions Total (tons/year)
108883	Toluene	4,890
1330207	Xylene	3,948
1634044	MTBE	0
540841	2,2,4-Trimethylpentane	2,894
71432	Benzene	1,929
50000	Formaldehyde	1,962
100414	Ethyl Benzene	1439
110543	Hexane	677
75070	Acetaldehyde	633
106990	1,3-Butadiene	214
123386	Propionaldehyde	152
100425	Styrene	168
107028	Acrolein	131
91203	Naphthalene	97.5409
85018	Phenanthrene	16.7640
208968	Acenaphthylene	12.2054

NEI Pollutant Code	Pollutant Name	Emissions Total (tons/year)
86737	Fluorene	8.0441
83329	Acenaphthene	5.0052
129000	Pyrene	3.4261
206440	Fluoranthene	3.0460
93	Arsenic Compounds	0.0675
120127	Anthracene	1.8849
191242	Benzo(g,h,i)perylene	2.8389
7440020	Nickel Compounds	0.1173
56553	Benz(a)anthracene	0.6752
193395	Indeno(1,2,3,c,d)pyrene	1.0722
218019	Chrysene	0.6633
50328	Benzo(a)pyrene	1.0668
205992	Benzo(b)fluoranthene	0.6898
207089	Benzo(k)fluoranthene	0.6783
7439965	Manganese Compounds	0.0662
18540299	Chromium 6+	0.0003
53703	Dibenzo(a,h)anthracene	0.0300
200	Mercury Elemental Gaseous	0.0012
201	Mercury Divalent Gaseous	0.0002
202	Mercury Particulate	6.84E-05
3268879	Octachlorodibenzo-p-dioxin	9.63E-07
35822469	1,2,3,4,6,7,8-Heptachlorodibenzo-p-Dioxin	1.49E-07
39001020	Octachlorodibenzofuran	2.43E-07
67562394	1,2,3,4,6,7,8-Heptachlorodibenzofuran	2.06E-07
19408743	1,2,3,7,8,9-Hexachlorodibenzo-p-Dioxin	1.14E-08
70648269	1,2,3,4,7,8-Hexachlorodibenzofuran	2.83E-08
51207319	2,3,7,8-Tetrachlorodibenzofuran	1.05E-07
60851345	2,3,4,6,7,8-Hexachlorodibenzofuran	1.77E-08
57653857	1,2,3,6,7,8-Hexachlorodibenzo-p-Dioxin	1.14E-08
57117314	2,3,4,7,8-Pentachlorodibenzofuran	4.44E-08
57117449	1,2,3,6,7,8-Hexachlorodibenzofuran	2.59E-08
39227286	1,2,3,4,7,8-Hexachlorodibenzo-p-Dioxin	5.04E-09
57117416	1,2,3,7,8-Pentachlorodibenzofuran	3.45E-08
1746016	2,3,7,8-Tetrachlorodibenzo-p-Dioxin	1.31E-08
72918219	1,2,3,7,8,9-Hexachlorodibenzofuran	1.20E-08
55673897	1,2,3,4,7,8,9-Heptachlorodibenzofuran	6.56E-09
40321764	1,2,3,7,8-Pentachlorodibenzo-p-Dioxin	4.82E-09

4.0 Relationship to 2014 AERR Inventory

There are large reductions in nonroad emissions in 2017 relative to the previous 2014 AERR inventory. Several factors led to the decreases in emissions. First, the population (and therefore annual hours) increased over the 3-year period. Although this growth increases the emissions, its impact was more than offset by other factors that tend to reduce emissions. For example, equipment turnover reduced the fleet average emission rates, as older equipment was scrapped and newer equipment meeting the latest emission standards was added. In addition, there were significant changes in emission estimates in MOVES2014b-Nonroad, compared to previous versions of Nonroad. These impacts are discussed further below.

4.1 MOVES2014b Updates

The 2017 AERR is the first of the Texas nonroad inventories to use MOVES2014b, and there are major changes to this version of the model. The update with the greatest impact results from incorporation of new emission rates for 2011+ model year Tier 4 engines (4). EPA's response to peer review comments on the model indicates that the new Tier 4 emissions rates are much lower than in previous versions of the model:

> "*According to our analysis, the newer engines certified for Tier-4 standards tend to have significantly lower emission rates (especially when equipped with a modern aftertreatment system) than previously estimated*" (4).

In addition, MOVES2014b makes different assumptions about growth patterns compared to MOVES2014a and NONROAD2008. Though these defaults do not affect the populations used in the Texas AERR inventories, they do affect the model year distributions. Model year distributions in MOVES-Nonroad are determined based on a combination of the growth patterns, which affect the rate of new equipment entering the population, and scrappage curves, which affect the rate at which old equipment leave the population.

To investigate the combined impact of the new Tier 4 rates and model year distributions on annual emissions, plus the three years of fleet turnover from 2014 to 2017, ERG ran the previous and current versions of MOVES at the national scale for these years. The previous version of MOVES was the December release of 2014a (which runs NONROAD2008), and the current version of MOVES was 2014b.

The test runs relied on the national average distribution of equipment, operating fuels, age, and technologies, etc. To remove the effect of differences in default population levels between MOVES model versions (because this isn't relevant to Texas AERR inventories), ERG normalized each set of test run emissions results, dividing by the

respective model's estimate of national equipment population, which was nearly 182 million units in year 2014 (MOVES2014a) and almost 151 million in year 2017 (MOVES2014b). In this way, the differences in population do not affect the percent changes in emissions. Table 14 shows that VOC, NO_X, and PM decrease by 23%, 10%, and 14% respectively, when moving from year 2014 (MOVES2014a) to year 2017 (MOVES2014b). These significant reductions aid in understanding the differences between the new 2017 AERR inventory and previous 2014 AERR results, discussed in section 4.2.

Table 14. Cumulative Impacts on National Annual Emissions (Pounds per Equipment Unit)

Pollutant	Emissions Per Equipment MOVES2014a, Year 2014	Emissions Per Equipment MOVES2014b, Year 2017	Percent Change
VOC	19.226	14.850	-23%
CO	150.797	158.956	5%
NO_X	15.242	13.724	-10%
PM_{10}	1.600	1.372	-14%
$PM_{2.5}$	1.521	1.303	-14%
SO2	0.035	0.022	-39%

Other changes made in MOVES2014b, which do not affect nonroad emissions for this inventory, include updates to nonroad diesel fuel sulfur levels; updates to CB05 and CB6CMAQ chemical mechanism outputs; and addition of SAPRC07T output (3). These are not expected to impact the Texas AERR: diesel sulfur levels come from the TexN2 input database rather than MOVES default data, and the chemical mechanism outputs are for air quality modeling and are only available for selection in the MOVES-Onroad model.

4.2 Changes in Emissions

According to the 2014 AERR report Table 5-3, the statewide equipment population totaled 10,345,070 units in 2014 (5). The output activity from the 2017 AERR emission inventory runs totaled 10,882,815 equipment units in 2017, or a 5% growth over the 3-year period.

To directly compare to the national trends that account for 3 years of turnover as well as MOVES model changes (specifically Tier 4 emission rates), ERG prepared Table 15, analogous to the national table (Table 14) with annual emissions expressed in pounds divided by population, at the state level.

Table 15 shows the percent change in 2017 AERR emissions relative to the 2014 AERR was a 25% decrease in VOC, which is similar to the national run test result (23% decrease in VOC). NO_X and PM show larger decreases (23% and 24% declines) than the national run with defaults (10% and 14% declines over the same period).

Table 15. Differences in Statewide 2017 and 2014 AERR Normalized Inventories (Pounds per Equipment Unit)

Pollutant	Emissions Per Equipment 2014 AERR	Emissions Per Equipment 2017 AERR	Percent Change
VOC	14.307	10.776	-25%
CO	140.671	114.857	-18%
NOx	21.557	16.543	-23%
PM10	1.982	1.509	-24%
PM25	1.901	1.444	-24%
SO2	0.033	0.015	-55%

The 2017 AERR has a larger percentage of population from diesel powered equipment (7% of total) compared to 2017 national defaults (5%). Furthermore, Texas has a larger portion of total nonroad sector NO_X and $PM_{2.5}$ from diesel (86% and 72%, respectively) relative to the nation (77% and 58%).

5.0 Recommendations

ERG has identified recommendations for potential modeling improvements.

- MOVES-Nonroad runtime.
    - Although MOVES-Nonroad uses the same core Nonroad model as the previous TexN model, runtime for MOVES-Nonroad is substantially greater than for the standalone Nonroad model. For example, an annual TexN + Nonroad run for Harris County, with all SCCs included, took approximately 11 minutes on a test machine. That same run with TexN2 + MOVES-Nonroad took approximately 254 minutes on the same machine, despite the calculations being split across 7 MOVES workers. In addition to being inconvenient, this long runtime is also costly when running the model in the AWS cloud: a complete inventory for a single county can take up to a day and a half of clock time, which costs approximately $30 for the AWS instance type used to develop this inventory. Multiplied by 254 counties, this results in over $7,500 just in CPU costs. ERG is still

investigating the root cause of the increased runtime, but it appears to be due to the time required for MySQL to transfer large amounts of data generated by the MOVES Workers and to perform final aggregation. Developing a solution to significantly improve runtime could provide substantial benefits at all stages of modeling and inventory development.

    - MOVES-Nonroad runtime also increases substantially as more pollutants are added – by approximately a factor of four when moving from just criteria pollutants to the full suite of pollutants available in MOVES. Moving some of these calculations off-model, i.e., into post-processing, could provide runtime benefits, though any solution would need to precisely match the emissions estimates currently generated by MOVES-Nonroad.

- Establish protocol for ensuring compatibility with national modeling platforms following the methodology outlined in (2).

6.0 References

1. ERG, 2017. *2017 Summer Fuel Field Study*. Final Report. Prepared for Mr. Michael Regan, Texas Commission on Environmental Quality. August.

2. ERG memorandum to the TCEQ: Adjusting emission rates to account for effects of model year distributions of disaggregated diesel construction equipment subsectors; TxLED NOx reductions; and other post-processing adjustments. August 9, 2018.

3. U.S. EPA, 2018a. *EPA Releases MOVES2014b Mobile Source Emissions Model: Questions and Answers.* Available online: https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100V7H1.pdf. EPA document number EPA-420-F-18-014. August.

4. U.S. EPA, 2018b. *Exhaust and Crankcase Emission factors for Nonroad Compression-Ignition Engines in MOVES2014b.* Available online: https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100UXEN.pdf. EPA document number EPA-420-R-18-009. July.

5. ERG, 2015. *Development of Texas Statewide 2014 AERR Inventory and Trends Data for NONROAD Model Category Mobile Sources.* Final Report. Prepared for the Texas Commission on Environmental Quality. September.

Appendix: Statewide Criteria Emissions by County

Table A- 1: 2017 OSD Criteria Emissions by County (Tons/Day)

County	VOC	NO_X	CO	PM_{10}-PRI	$PM_{2.5}$-PRI	SO_2	NH_3
Anderson	0.371	0.842	3.700	0.091	0.087	0.001	0.002
Andrews	0.068	0.393	1.048	0.033	0.032	0.000	0.001
Angelina	0.936	0.755	8.186	0.088	0.084	0.001	0.002
Aransas	2.039	0.423	9.497	0.057	0.053	0.001	0.001
Archer	0.171	0.937	1.784	0.082	0.079	0.001	0.002
Armstrong	0.071	0.682	0.836	0.055	0.054	0.001	0.002
Atascosa	0.334	0.926	3.153	0.084	0.081	0.001	0.002
Austin	0.344	1.015	3.333	0.105	0.102	0.001	0.002
Bailey	0.113	0.945	1.503	0.074	0.072	0.001	0.002
Bandera	1.470	0.234	6.370	0.060	0.056	0.001	0.001
Bastrop	0.255	1.097	3.710	0.111	0.107	0.001	0.003
Baylor	0.244	0.980	2.202	0.081	0.079	0.001	0.002
Bee	0.145	0.925	1.932	0.090	0.087	0.001	0.002
Bell	1.912	2.732	17.951	0.288	0.276	0.005	0.008
Bexar	6.575	7.297	91.317	0.832	0.792	0.011	0.019
Blanco	0.203	0.275	1.244	0.029	0.028	0.000	0.001
Borden	0.047	0.274	0.312	0.023	0.022	0.000	0.001
Bosque	0.597	1.008	3.600	0.102	0.099	0.001	0.003
Bowie	0.764	1.204	8.267	0.122	0.117	0.002	0.003
Brazoria	1.962	2.612	20.662	0.266	0.254	0.003	0.006
Brazos	0.887	1.185	10.596	0.143	0.136	0.002	0.003
Brewster	0.194	0.218	1.288	0.023	0.022	0.000	0.001
Briscoe	0.082	0.657	0.885	0.054	0.052	0.001	0.001
Brooks	0.500	0.308	2.274	0.043	0.041	0.000	0.001
Brown	0.585	1.621	4.825	0.157	0.152	0.002	0.004
Burleson	0.406	0.835	2.960	0.083	0.080	0.001	0.002
Burnet	1.994	0.622	9.842	0.109	0.102	0.001	0.002
Caldwell	0.434	0.654	3.125	0.072	0.069	0.001	0.002
Calhoun	2.291	1.061	10.841	0.085	0.081	0.002	0.002
Callahan	0.259	0.764	1.987	0.071	0.068	0.001	0.002
Cameron	4.748	2.668	33.621	0.325	0.309	0.004	0.007
Camp	0.431	0.267	2.291	0.034	0.032	0.000	0.001
Carson	0.120	1.040	1.574	0.082	0.079	0.001	0.002
Cass	0.430	0.574	3.469	0.061	0.058	0.001	0.001
Castro	0.198	1.881	2.590	0.147	0.142	0.002	0.004

County	VOC	NO_X	CO	PM_{10}-PRI	$PM_{2.5}$-PRI	SO_2	NH_3
Chambers	0.745	0.642	4.852	0.062	0.059	0.001	0.002
Cherokee	0.263	0.913	3.481	0.094	0.090	0.001	0.002
Childress	0.074	0.543	1.027	0.045	0.043	0.001	0.001
Clay	0.235	0.898	1.744	0.078	0.075	0.001	0.002
Cochran	0.077	0.842	0.913	0.064	0.062	0.001	0.002
Coke	0.081	0.229	0.711	0.019	0.019	0.000	0.001
Coleman	0.284	0.839	2.083	0.077	0.074	0.001	0.002
Collin	3.616	5.635	51.431	0.619	0.590	0.008	0.014
Collingsworth	0.084	0.790	1.036	0.064	0.062	0.001	0.002
Colorado	0.477	1.220	3.913	0.124	0.120	0.002	0.004
Comal	2.208	1.475	14.259	0.189	0.179	0.002	0.005
Comanche	0.191	0.975	2.095	0.088	0.085	0.001	0.002
Concho	0.217	0.600	1.372	0.053	0.051	0.001	0.001
Cooke	0.801	1.463	5.998	0.143	0.137	0.002	0.004
Coryell	0.202	1.056	2.751	0.100	0.097	0.001	0.003
Cottle	0.044	0.410	0.528	0.034	0.033	0.000	0.001
Crane	0.012	0.058	0.182	0.005	0.005	0.000	0.000
Crockett	0.197	0.342	1.189	0.034	0.033	0.000	0.001
Crosby	0.120	1.133	1.324	0.085	0.083	0.001	0.003
Culberson	0.021	0.191	0.236	0.016	0.015	0.000	0.000
Dallam	0.248	2.197	3.178	0.177	0.172	0.002	0.005
Dallas	12.232	17.343	220.101	1.820	1.733	0.026	0.039
Dawson	0.148	1.433	1.840	0.108	0.105	0.001	0.003
Deaf Smith	0.147	1.044	2.059	0.089	0.087	0.001	0.002
Delta	0.390	1.777	3.050	0.147	0.143	0.003	0.004
Denton	2.491	3.596	33.938	0.347	0.331	0.005	0.009
De Witt	0.152	1.006	2.053	0.095	0.092	0.001	0.002
Dickens	0.042	0.371	0.444	0.032	0.031	0.000	0.001
Dimmit	0.365	0.264	1.800	0.032	0.030	0.000	0.001
Donley	0.211	0.419	1.278	0.040	0.038	0.000	0.001
Duval	0.066	0.403	0.848	0.036	0.035	0.000	0.001
Eastland	0.317	0.973	2.869	0.091	0.088	0.001	0.002
Ector	0.589	0.892	11.391	0.085	0.081	0.001	0.002
Edwards	0.026	0.215	0.291	0.020	0.019	0.000	0.000
Ellis	0.857	1.819	10.342	0.164	0.157	0.002	0.004
El Paso	2.242	5.851	41.385	0.471	0.452	0.006	0.016
Erath	0.240	1.341	3.354	0.122	0.118	0.001	0.003
Falls	0.170	1.390	2.245	0.125	0.121	0.002	0.003
Fannin	0.243	1.501	3.139	0.142	0.137	0.002	0.004
Fayette	0.803	1.315	5.216	0.135	0.130	0.001	0.003

County	VOC	NO_X	CO	PM_{10}-PRI	$PM_{2.5}$-PRI	SO_2	NH_3
Fisher	0.076	0.707	0.795	0.059	0.057	0.001	0.002
Floyd	0.173	1.626	2.266	0.125	0.121	0.002	0.004
Foard	0.083	0.612	1.093	0.050	0.049	0.001	0.001
Fort Bend	1.677	3.282	27.538	0.350	0.334	0.004	0.008
Franklin	0.101	0.376	0.985	0.037	0.035	0.001	0.001
Freestone	0.217	1.606	2.007	0.115	0.112	0.002	0.004
Frio	0.240	0.565	1.857	0.053	0.051	0.001	0.001
Gaines	0.220	2.185	2.560	0.167	0.162	0.002	0.005
Galveston	2.881	2.023	24.182	0.207	0.196	0.003	0.005
Garza	0.070	0.432	0.608	0.035	0.034	0.000	0.001
Gillespie	0.302	0.602	2.785	0.060	0.058	0.001	0.001
Glasscock	0.054	0.564	0.565	0.045	0.043	0.001	0.001
Goliad	0.105	0.594	1.078	0.059	0.057	0.001	0.001
Gonzales	0.299	0.983	2.739	0.102	0.098	0.001	0.002
Gray	0.163	0.896	2.530	0.074	0.072	0.001	0.002
Grayson	2.170	2.145	15.253	0.216	0.207	0.004	0.005
Gregg	0.522	0.856	10.942	0.091	0.087	0.002	0.002
Grimes	0.338	0.947	2.907	0.097	0.093	0.001	0.002
Guadalupe	0.865	1.431	8.775	0.153	0.147	0.002	0.004
Hale	0.283	2.126	4.085	0.166	0.160	0.002	0.005
Hall	0.067	0.581	0.768	0.048	0.046	0.001	0.001
Hamilton	0.111	0.884	1.388	0.079	0.077	0.001	0.002
Hansford	0.159	1.179	2.188	0.093	0.090	0.001	0.003
Hardeman	0.225	0.569	1.562	0.050	0.049	0.001	0.001
Hardin	0.241	0.538	3.184	0.071	0.068	0.001	0.001
Harris	18.558	25.904	316.899	2.585	2.467	0.037	0.060
Harrison	0.767	1.882	6.303	0.142	0.137	0.002	0.004
Hartley	0.179	1.786	2.208	0.139	0.135	0.002	0.004
Haskell	0.204	1.360	2.292	0.109	0.105	0.002	0.003
Hays	0.811	0.935	7.797	0.109	0.104	0.001	0.002
Hemphill	0.066	0.469	0.793	0.042	0.041	0.000	0.001
Henderson	1.726	1.321	10.980	0.152	0.145	0.002	0.003
Hidalgo	5.472	3.937	45.538	0.476	0.452	0.005	0.011
Hill	0.928	1.879	6.217	0.183	0.176	0.003	0.005
Hockley	0.180	1.436	2.372	0.111	0.107	0.001	0.003
Hood	0.299	0.702	3.415	0.066	0.063	0.001	0.002
Hopkins	0.263	1.962	3.453	0.154	0.149	0.003	0.005
Houston	0.308	0.943	2.663	0.097	0.094	0.001	0.002
Howard	0.290	0.751	2.620	0.065	0.063	0.001	0.002
Hudspeth	0.192	0.438	0.994	0.039	0.038	0.000	0.001

County	VOC	NO_X	CO	PM_{10}-PRI	$PM_{2.5}$-PRI	SO_2	NH_3
Hunt	0.773	1.506	7.046	0.150	0.144	0.002	0.004
Hutchinson	0.162	0.805	2.195	0.066	0.064	0.001	0.002
Irion	0.020	0.154	0.246	0.014	0.013	0.000	0.000
Jack	0.122	0.610	1.163	0.055	0.053	0.001	0.001
Jackson	0.379	1.233	3.091	0.110	0.107	0.001	0.003
Jasper	0.241	0.353	3.093	0.043	0.041	0.001	0.001
Jeff Davis	0.167	0.166	0.756	0.019	0.018	0.000	0.000
Jefferson	0.937	1.587	17.380	0.184	0.175	0.002	0.004
Jim Hogg	0.037	0.273	0.422	0.027	0.026	0.000	0.001
Jim Wells	0.181	0.850	2.812	0.076	0.074	0.001	0.002
Johnson	0.492	1.712	7.616	0.169	0.163	0.002	0.004
Jones	0.363	1.498	3.383	0.124	0.120	0.003	0.004
Karnes	0.110	0.782	1.464	0.076	0.074	0.001	0.002
Kaufman	0.620	1.672	7.711	0.172	0.166	0.002	0.004
Kendall	0.919	0.414	5.394	0.062	0.058	0.001	0.001
Kenedy	0.138	0.269	0.635	0.024	0.024	0.000	0.001
Kent	0.028	0.248	0.364	0.022	0.021	0.000	0.001
Kerr	2.295	0.531	11.040	0.110	0.103	0.001	0.002
Kimble	0.184	0.206	1.030	0.023	0.022	0.000	0.001
King	0.030	0.321	0.290	0.027	0.026	0.000	0.001
Kinney	0.021	0.128	0.235	0.012	0.012	0.000	0.000
Kleberg	0.746	0.897	4.241	0.090	0.086	0.001	0.002
Knox	0.138	1.026	1.991	0.082	0.080	0.001	0.003
Lamar	0.368	1.722	5.022	0.165	0.160	0.003	0.004
Lamb	0.201	1.929	2.621	0.148	0.144	0.002	0.004
Lampasas	0.249	0.557	1.814	0.054	0.052	0.001	0.002
La Salle	0.192	0.241	0.955	0.026	0.025	0.000	0.001
Lavaca	0.163	1.046	2.266	0.103	0.100	0.001	0.003
Lee	0.310	1.663	2.505	0.111	0.108	0.002	0.004
Leon	0.269	2.491	2.577	0.168	0.163	0.002	0.006
Liberty	0.421	0.894	4.650	0.097	0.093	0.001	0.002
Limestone	0.417	1.248	3.071	0.114	0.110	0.002	0.003
Lipscomb	0.062	0.551	0.722	0.047	0.045	0.001	0.001
Live Oak	0.502	0.506	2.753	0.051	0.049	0.001	0.001
Llano	0.724	0.335	3.973	0.040	0.038	0.001	0.001
Loving	0.311	0.099	1.104	0.007	0.007	0.000	0.000
Lubbock	2.016	2.709	24.089	0.283	0.270	0.003	0.006
Lynn	0.126	1.370	1.314	0.104	0.100	0.001	0.003
McCulloch	0.125	0.941	1.280	0.076	0.073	0.002	0.004
McLennan	1.362	2.622	18.013	0.274	0.263	0.004	0.007

County	VOC	NO_X	CO	PM_{10}-PRI	$PM_{2.5}$-PRI	SO_2	NH_3
McMullen	0.130	0.275	0.587	0.022	0.021	0.000	0.001
Madison	0.085	0.545	1.067	0.054	0.052	0.001	0.001
Marion	0.306	0.243	1.951	0.024	0.023	0.000	0.001
Martin	0.071	0.762	0.803	0.058	0.056	0.001	0.002
Mason	0.184	0.226	1.031	0.025	0.024	0.000	0.001
Matagorda	2.688	1.605	13.529	0.143	0.137	0.002	0.004
Maverick	0.137	0.306	2.108	0.029	0.028	0.000	0.001
Medina	0.434	1.446	3.876	0.133	0.129	0.001	0.003
Menard	0.026	0.170	0.351	0.016	0.015	0.000	0.000
Midland	0.705	1.024	10.507	0.100	0.096	0.001	0.002
Milam	0.206	1.473	2.822	0.136	0.132	0.002	0.004
Mills	0.068	0.525	0.848	0.047	0.046	0.001	0.001
Mitchell	0.093	0.630	0.916	0.052	0.051	0.001	0.001
Montague	0.164	0.870	1.909	0.080	0.077	0.001	0.002
Montgomery	3.181	2.469	31.790	0.305	0.289	0.004	0.007
Moore	0.215	1.455	2.833	0.113	0.110	0.002	0.003
Morris	0.233	0.337	1.783	0.031	0.030	0.000	0.001
Motley	0.036	0.349	0.394	0.030	0.029	0.000	0.001
Nacogdoches	0.596	0.810	5.693	0.089	0.085	0.001	0.002
Navarro	1.083	1.701	7.150	0.166	0.160	0.002	0.004
Newton	0.377	0.144	2.329	0.029	0.028	0.000	0.001
Nolan	0.146	0.716	1.940	0.064	0.062	0.001	0.002
Nueces	3.064	3.462	30.286	0.371	0.355	0.005	0.009
Ochiltree	0.227	1.644	3.250	0.130	0.126	0.002	0.004
Oldham	0.070	0.679	0.810	0.057	0.055	0.001	0.002
Orange	0.549	0.387	5.725	0.056	0.053	0.001	0.001
Palo Pinto	0.350	0.800	2.857	0.072	0.069	0.001	0.002
Panola	0.507	1.457	3.533	0.108	0.104	0.002	0.004
Parker	0.667	1.375	6.813	0.143	0.137	0.002	0.004
Parmer	0.194	1.667	2.781	0.130	0.126	0.002	0.004
Pecos	0.522	0.423	2.652	0.048	0.046	0.001	0.001
Polk	0.933	0.541	5.885	0.065	0.062	0.001	0.001
Potter	1.431	1.207	12.690	0.140	0.134	0.002	0.003
Presidio	0.181	0.182	1.004	0.020	0.019	0.000	0.000
Rains	0.308	0.377	1.807	0.040	0.038	0.001	0.001
Randall	0.568	1.254	7.887	0.130	0.125	0.002	0.003
Reagan	0.039	0.322	0.542	0.027	0.026	0.000	0.001
Real	0.361	0.688	1.651	0.063	0.061	0.001	0.002
Red River	0.132	0.928	1.519	0.090	0.087	0.001	0.002
Reeves	0.364	0.276	1.656	0.021	0.020	0.000	0.001

County	VOC	NO_X	CO	PM_{10}-PRI	$PM_{2.5}$-PRI	SO_2	NH_3
Refugio	0.226	0.610	1.684	0.062	0.059	0.001	0.002
Roberts	0.035	0.337	0.348	0.029	0.028	0.000	0.001
Robertson	0.204	1.459	2.139	0.120	0.116	0.001	0.003
Rockwall	0.667	0.643	6.218	0.074	0.070	0.001	0.002
Runnels	0.343	1.383	2.899	0.111	0.108	0.002	0.003
Rusk	0.473	1.566	4.253	0.118	0.114	0.002	0.004
Sabine	1.675	0.488	7.419	0.039	0.036	0.001	0.001
San Augustine	0.527	0.272	2.672	0.024	0.023	0.000	0.001
San Jacinto	0.414	0.326	2.586	0.030	0.029	0.000	0.001
San Patricio	1.652	1.590	9.650	0.157	0.150	0.002	0.004
San Saba	0.065	0.402	0.919	0.036	0.034	0.001	0.001
Schleicher	0.031	0.271	0.389	0.023	0.022	0.000	0.001
Scurry	0.282	0.692	2.292	0.061	0.059	0.001	0.002
Shackelford	0.064	0.541	0.685	0.046	0.045	0.001	0.001
Shelby	0.146	0.543	1.938	0.056	0.054	0.001	0.001
Sherman	0.163	1.482	2.204	0.116	0.112	0.002	0.003
Smith	1.327	1.771	17.246	0.207	0.198	0.003	0.005
Somervell	0.661	0.269	3.095	0.041	0.039	0.000	0.001
Starr	0.193	1.083	2.373	0.103	0.099	0.001	0.003
Stephens	0.155	0.501	1.352	0.043	0.042	0.001	0.001
Sterling	0.016	0.120	0.218	0.011	0.011	0.000	0.000
Stonewall	0.047	0.409	0.555	0.035	0.034	0.001	0.001
Sutton	0.043	0.207	0.623	0.019	0.019	0.000	0.000
Swisher	0.160	1.336	2.050	0.108	0.105	0.001	0.003
Tarrant	6.432	9.694	113.621	0.955	0.911	0.015	0.021
Taylor	0.877	1.527	10.830	0.150	0.144	0.003	0.004
Terrell	0.015	0.129	0.152	0.012	0.011	0.000	0.000
Terry	0.175	1.618	2.205	0.123	0.119	0.002	0.004
Throckmorton	0.075	0.573	0.848	0.050	0.049	0.001	0.001
Titus	0.482	1.240	3.839	0.090	0.086	0.002	0.003
Tom Green	0.916	1.646	9.064	0.151	0.145	0.002	0.004
Travis	4.929	5.701	68.982	0.663	0.632	0.010	0.015
Trinity	1.011	0.370	4.800	0.056	0.053	0.001	0.001
Tyler	0.316	0.218	2.409	0.033	0.031	0.000	0.001
Upshur	0.149	0.537	2.131	0.055	0.053	0.001	0.001
Upton	0.034	0.234	0.523	0.019	0.019	0.000	0.001
Uvalde	1.208	0.761	5.998	0.094	0.089	0.001	0.002
Val Verde	0.939	0.534	5.094	0.060	0.057	0.001	0.001
Van Zandt	0.575	1.341	4.844	0.140	0.135	0.002	0.003
Victoria	0.586	1.246	7.658	0.132	0.127	0.002	0.003

County	VOC	NO_X	CO	PM_{10}-PRI	$PM_{2.5}$-PRI	SO_2	NH_3
Walker	0.748	0.600	5.238	0.075	0.072	0.001	0.002
Waller	0.331	0.731	3.722	0.079	0.076	0.001	0.002
Ward	0.037	0.106	0.588	0.010	0.009	0.000	0.000
Washington	0.477	0.963	4.052	0.099	0.096	0.001	0.002
Webb	1.044	2.056	14.099	0.209	0.201	0.002	0.005
Wharton	0.434	1.854	5.006	0.171	0.166	0.002	0.005
Wheeler	0.076	0.604	0.955	0.051	0.050	0.001	0.001
Wichita	0.852	1.663	10.900	0.154	0.148	0.002	0.004
Wilbarger	0.174	1.133	2.263	0.092	0.089	0.001	0.003
Willacy	0.282	1.141	2.283	0.096	0.093	0.001	0.003
Williamson	1.620	4.032	20.766	0.390	0.375	0.006	0.012
Wilson	0.169	1.096	2.249	0.102	0.098	0.001	0.003
Winkler	0.024	0.073	0.382	0.007	0.007	0.000	0.000
Wise	0.539	1.262	4.794	0.121	0.116	0.002	0.003
Wood	1.012	0.807	6.510	0.095	0.091	0.001	0.002
Yoakum	0.129	1.114	1.643	0.087	0.084	0.001	0.003
Young	0.474	0.825	3.495	0.080	0.077	0.001	0.002
Zapata	1.073	0.400	4.296	0.051	0.049	0.000	0.001
Zavala	0.052	0.339	0.635	0.030	0.029	0.000	0.001
Total	**182.380**	**319.713**	**2038.478**	**31.017**	**29.761**	**0.416**	**0.780**

Table A- 2. 2017 Annual Criteria Emissions by County (Tons/Year)

County	VOC	NO_X	CO	PM_{10}-PRI	$PM_{2.5}$-PRI	SO_2	NH_3
Anderson	117	226	1,120	22	22	0	1
Andrews	19	102	307	8	8	0	0
Angelina	333	239	2,735	26	24	0	1
Aransas	749	169	3,564	20	18	0	0
Archer	46	238	467	19	18	0	1
Armstrong	16	169	184	13	12	0	0
Atascosa	102	247	926	21	20	0	1
Austin	102	271	954	26	25	0	1
Bailey	28	237	382	18	17	0	1
Bandera	460	68	1,994	18	17	0	0
Bastrop	74	293	1,079	28	27	0	1
Baylor	72	251	593	19	18	0	1
Bee	40	241	527	21	20	0	1
Bell	622	776	5,567	77	74	1	2
Bexar	2,141	2,209	28,232	239	227	3	5
Blanco	62	74	374	8	7	0	0
Borden	14	71	93	5	5	0	0
Bosque	196	270	1,150	25	24	0	1
Bowie	259	349	2,649	32	31	1	1
Brazoria	671	780	6,595	73	70	1	2
Brazos	277	338	3,180	38	37	0	1
Brewster	61	59	395	6	6	0	0
Briscoe	20	166	215	13	12	0	0
Brooks	158	84	699	12	11	0	0
Brown	179	448	1,464	41	39	1	1
Burleson	132	224	931	20	20	0	1
Burnet	624	176	3,040	32	30	0	1
Caldwell	134	172	924	18	17	0	0
Calhoun	909	381	4,464	27	25	1	1
Callahan	75	197	563	17	17	0	0
Cameron	1,592	803	10,903	94	89	1	2
Camp	145	77	758	9	9	0	0
Carson	28	258	363	19	19	0	1
Cass	156	169	1,204	16	15	0	0
Castro	46	469	601	34	33	0	1
Chambers	270	198	1,740	17	16	0	0
Cherokee	80	249	1,045	23	22	0	1
Childress	18	139	264	11	10	0	0
Clay	73	235	527	18	18	0	1

County	VOC	NO_X	CO	PM_{10}-PRI	$PM_{2.5}$-PRI	SO_2	NH_3
Cochran	19	215	226	15	15	0	0
Coke	27	60	233	5	5	0	0
Coleman	83	212	581	18	18	0	0
Collin	1,123	1,730	15,319	172	164	2	4
Collingsworth	20	201	247	15	15	0	0
Colorado	145	325	1,130	31	30	0	1
Comal	710	429	4,394	54	51	1	1
Comanche	55	253	613	21	20	0	1
Concho	63	150	360	13	12	0	0
Cooke	264	401	1,900	36	34	0	1
Coryell	58	274	787	24	23	0	1
Cottle	10	104	128	8	8	0	0
Crane	4	16	56	1	1	0	0
Crockett	59	87	351	8	8	0	0
Crosby	31	293	354	21	20	0	1
Culberson	6	49	65	4	4	0	0
Dallam	58	552	736	42	41	1	1
Dallas	3,823	5,473	66,104	531	505	8	12
Dawson	38	368	490	26	26	0	1
Deaf Smith	38	266	577	21	20	0	1
Delta	123	478	868	36	34	1	1
Denton	811	1,167	10,496	101	96	2	3
De Witt	40	262	556	22	22	0	1
Dickens	10	95	113	7	7	0	0
Dimmit	111	69	548	8	8	0	0
Donley	63	108	369	10	9	0	0
Duval	18	103	242	9	8	0	0
Eastland	93	254	846	22	21	0	1
Ector	177	271	3,483	25	23	0	1
Edwards	7	55	77	5	5	0	0
Ellis	268	534	3,087	45	44	1	1
El Paso	714	1,654	12,643	129	124	2	4
Erath	65	349	953	29	28	0	1
Falls	43	356	569	29	28	0	1
Fannin	66	393	851	33	32	1	1
Fayette	269	358	1,690	33	32	0	1
Fisher	18	179	190	14	13	0	0
Floyd	41	410	541	30	29	0	1
Foard	18	151	236	12	11	0	0
Fort Bend	516	956	8,205	96	91	1	2

County	VOC	NO_X	CO	PM_{10}-PRI	$PM_{2.5}$-PRI	SO_2	NH_3
Franklin	32	101	302	9	8	0	0
Freestone	64	447	590	28	27	0	1
Frio	71	145	530	13	12	0	0
Gaines	54	555	633	40	39	1	1
Galveston	1,039	667	8,335	62	59	1	2
Garza	21	113	180	8	8	0	0
Gillespie	90	158	818	15	15	0	0
Glasscock	13	143	133	11	10	0	0
Goliad	31	152	303	14	13	0	0
Gonzales	88	255	780	24	23	0	1
Gray	43	230	699	18	17	0	0
Grayson	758	637	5,171	58	56	1	1
Gregg	167	265	3,332	26	25	0	1
Grimes	103	250	853	23	23	0	1
Guadalupe	267	389	2,592	40	38	0	1
Hale	73	544	1,085	40	39	1	1
Hall	17	150	202	12	11	0	0
Hamilton	28	224	370	18	18	0	0
Hansford	38	292	518	22	21	0	1
Hardeman	64	143	408	12	12	0	0
Hardin	74	158	954	19	19	0	0
Harris	6,017	7,924	97,298	749	714	12	18
Harrison	256	549	2,025	38	37	1	1
Hartley	41	442	490	32	31	0	1
Haskell	51	339	539	25	24	1	1
Hays	257	260	2,365	30	28	0	1
Hemphill	16	120	205	10	10	0	0
Henderson	600	393	3,727	41	39	1	1
Hidalgo	1,717	1,110	13,900	134	127	1	3
Hill	300	503	1,891	45	43	1	1
Hockley	48	372	657	27	26	0	1
Hood	100	198	1,086	17	16	0	1
Hopkins	74	535	986	37	36	1	1
Houston	93	248	774	23	22	0	1
Howard	86	199	784	17	16	0	0
Hudspeth	58	112	289	10	9	0	0
Hunt	258	415	2,228	38	36	1	1
Hutchinson	44	209	615	16	16	0	0
Irion	5	39	66	3	3	0	0
Jack	36	160	345	13	12	0	0

County	VOC	NO_X	CO	PM_{10}-PRI	$PM_{2.5}$-PRI	SO_2	NH_3
Jackson	130	329	966	27	26	0	1
Jasper	82	104	979	12	11	0	0
Jeff Davis	52	45	232	5	5	0	0
Jefferson	296	471	5,257	51	48	1	1
Jim Hogg	10	72	118	7	6	0	0
Jim Wells	52	222	807	19	18	0	1
Johnson	149	480	2,269	43	42	1	1
Jones	101	383	900	30	29	1	1
Karnes	29	201	397	18	17	0	0
Kaufman	185	459	2,233	44	42	1	1
Kendall	284	117	1,640	18	17	0	0
Kenedy	49	73	235	6	6	0	0
Kent	7	62	93	5	5	0	0
Kerr	717	155	3,427	33	31	0	1
Kimble	56	54	313	6	6	0	0
King	7	83	67	7	6	0	0
Kinney	5	33	66	3	3	0	0
Kleberg	255	250	1,419	23	22	0	1
Knox	31	254	453	19	18	0	1
Lamar	108	463	1,445	40	38	1	1
Lamb	49	486	641	35	34	0	1
Lampasas	74	152	537	14	13	0	0
La Salle	58	62	286	7	6	0	0
Lavaca	44	272	631	24	23	0	1
Lee	91	457	720	28	27	0	1
Leon	76	687	731	41	40	1	2
Liberty	130	247	1,397	25	24	0	1
Limestone	144	339	1,019	28	27	0	1
Lipscomb	15	138	175	11	10	0	0
Live Oak	182	145	982	13	13	0	0
Llano	241	104	1,366	12	11	0	0
Loving	113	40	493	3	2	0	0
Lubbock	608	761	7,230	77	74	1	2
Lynn	31	352	335	25	24	0	1
McCulloch	34	255	346	19	18	0	1
McLennan	426	731	5,384	72	69	1	2
McMullen	46	78	224	6	5	0	0
Madison	23	141	294	13	12	0	0
Marion	117	80	745	7	7	0	0
Martin	18	196	211	14	14	0	0

County	VOC	NO_X	CO	PM_{10}-PRI	$PM_{2.5}$-PRI	SO_2	NH_3
Mason	56	59	310	6	6	0	0
Matagorda	1,061	526	5,372	41	39	1	1
Maverick	39	85	645	8	7	0	0
Medina	125	372	1,105	32	31	0	1
Menard	7	45	102	4	4	0	0
Midland	212	294	3,192	28	27	0	1
Milam	54	382	757	32	31	0	1
Mills	17	133	227	11	11	0	0
Mitchell	26	161	251	12	12	0	0
Montague	47	230	558	19	18	0	1
Montgomery	1,081	772	10,143	88	84	1	2
Moore	56	367	727	27	26	0	1
Morris	87	100	637	8	8	0	0
Motley	9	90	102	7	7	0	0
Nacogdoches	204	233	1,833	24	23	0	1
Navarro	373	476	2,382	42	41	1	1
Newton	122	43	725	9	8	0	0
Nolan	40	187	537	16	15	0	0
Nueces	1,036	1,004	9,550	102	97	1	3
Ochiltree	52	409	753	30	29	0	1
Oldham	17	172	198	13	13	0	0
Orange	177	117	1,752	16	15	0	0
Palo Pinto	118	223	959	18	17	0	1
Panola	160	416	1,085	28	27	0	1
Parker	207	380	2,049	37	35	0	1
Parmer	46	417	667	30	30	0	1
Pecos	161	113	814	13	12	0	0
Polk	337	174	2,079	19	18	0	0
Potter	438	347	3,878	39	37	0	1
Presidio	57	49	309	5	5	0	0
Rains	104	105	601	10	10	0	0
Randall	162	338	2,288	34	32	0	1
Reagan	10	81	144	6	6	0	0
Real	111	193	501	17	17	0	0
Red River	35	242	411	21	20	0	1
Reeves	127	86	660	6	6	0	0
Refugio	68	157	470	15	14	0	0
Roberts	8	84	82	7	7	0	0
Robertson	58	391	602	29	28	0	1
Rockwall	232	203	2,019	21	20	0	0

County	VOC	NO_X	CO	PM_{10}-PRI	$PM_{2.5}$-PRI	SO_2	NH_3
Runnels	104	352	830	26	25	0	1
Rusk	152	446	1,320	30	29	1	1
Sabine	662	205	3,163	14	13	0	0
San Augustine	208	97	1,099	7	7	0	0
San Jacinto	161	105	999	8	8	0	0
San Patricio	603	455	3,336	42	40	1	1
San Saba	17	103	251	8	8	0	0
Schleicher	8	69	104	5	5	0	0
Scurry	85	182	686	15	15	0	0
Shackelford	16	138	174	11	10	0	0
Shelby	45	147	584	14	13	0	0
Sherman	37	366	488	27	26	0	1
Smith	420	515	5,232	56	54	1	1
Somervell	214	77	980	12	11	0	0
Starr	55	286	682	25	25	0	1
Stephens	49	135	433	11	10	0	0
Sterling	4	31	60	3	2	0	0
Stonewall	11	102	127	8	8	0	0
Sutton	12	54	177	5	5	0	0
Swisher	39	339	502	26	25	0	1
Tarrant	2,034	3,005	34,470	277	264	5	6
Taylor	261	418	3,222	39	37	1	1
Terrell	4	34	42	3	3	0	0
Terry	43	411	555	30	29	0	1
Throckmorton	18	144	200	11	11	0	0
Titus	152	354	1,173	24	23	0	1
Tom Green	278	447	2,754	40	38	1	1
Travis	1,563	1,720	20,986	190	180	3	4
Trinity	344	112	1,619	16	15	0	0
Tyler	106	65	779	9	9	0	0
Upshur	46	144	644	14	13	0	0
Upton	9	60	146	5	5	0	0
Uvalde	370	201	1,822	25	24	0	1
Val Verde	303	158	1,723	17	16	0	0
Van Zandt	179	358	1,450	34	33	0	1
Victoria	182	339	2,264	34	32	0	1
Walker	247	170	1,666	20	19	0	0
Waller	100	196	1,095	20	19	0	0
Ward	12	29	183	3	2	0	0
Washington	156	261	1,257	25	24	0	1

County	VOC	NO_X	CO	PM_{10}-PRI	$PM_{2.5}$-PRI	SO_2	NH_3
Webb	317	589	4,322	57	54	1	1
Wharton	126	480	1,382	42	40	1	1
Wheeler	19	155	250	12	12	0	0
Wichita	263	473	3,311	41	39	1	1
Wilbarger	43	283	552	21	21	0	1
Willacy	90	294	668	23	23	0	1
Williamson	501	1,111	6,150	103	99	2	3
Wilson	46	281	627	24	23	0	1
Winkler	7	20	119	2	2	0	0
Wise	176	347	1,508	30	29	0	1
Wood	341	231	2,128	25	24	0	1
Yoakum	32	283	415	21	20	0	1
Young	142	214	1,020	20	19	0	1
Zapata	351	122	1,500	15	14	0	0
Zavala	13	86	170	7	7	0	0
Total	**58,635**	**90,015**	**624,982**	**8,213**	**7,855**	**82**	**201**