APPENDIX H

DEVELOPMENT OF TEXAS STATEWIDE AIRCRAFT TREND EMISSIONS INVENTORIES 2011 THROUGH 2045

Rusk-Panola Attainment Demonstration State Implementation Plan for the 2010 Sulfur Dioxide National Ambient Air Quality Standard

Project Number 2020-057-SIP-NR
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Eastern Research Group, Inc.

Development of Texas Statewide Aircraft Trend Emissions Inventories 2011 through 2045

Final

Prepared for:

Texas Commission on Environmental Quality
Air Quality Division

Prepared by:

Eastern Research Group, Inc.

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DEVELOPMENT OF TEXAS STATEWIDE AIRCRAFT TREND EMISSIONS INVENTORIES 2011 THROUGH 2045

TCEQ Contract No. 582-19-92744
Work Order No. 582-19-95489-01

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1.0 Executive Summary

The primary objective of this study is to develop 2011 to 2045 statewide trend inventories based on the 2017 emissions inventory (EI) from Work order No. 582-18-82508-19. These inventories for Texas airport activities include all counties in Texas and provide both controlled and uncontrolled emissions datasets.

Eastern Research Group (ERG) developed emissions inventories for criteria and hazardous air pollutants (HAPs). The inventory will be used to support the State Implementation Plan (SIP) and other airport-related inquiries.

The emission estimates for airport activities are attributed to the following sources with associated source classification codes (SCC):

- Commercial aviation/Air Carrier (SCC: 2275020000)
- Air taxis
    - Piston driven (SCC: 2275060011)
    - Turbine driven (SCC: 2275060012)
- General aviation
    - Piston driven (SCC: 2275050011)
    - Turbine driven (SCC: 2275050012)
- Military (SCC: 2275001000)
- Auxiliary Power Units (SCC: 2275070000)
- Ground Support Equipment
    - Compressed natural gas (CNG)-fueled (SCC: 2268008005)
    - Diesel-fueled (SCC: 2270008005)
    - Gasoline-fueled (SCC: 2265008005)
    - Liquefied petroleum gas (LPG)-fueled (SCC: 2267008005).

To estimate emissions from these sources, ERG projected the base year emissions inventory obtained for Work Order 582-18-82508-19 for calendar year 2017, which included controlled and uncontrolled emissions. The 2011 through 2045 emissions were projected based on growth factors from the Federal Aviation Administration's (FAA) Terminal Area Forecast (TAF) data[1].

In 2017, Commercial aircraft, also known as Air Carrier (AC), accounted for 67% of the total airport NO_x emissions followed by military (MIL), air taxi (AT) aircraft outfitted with jet engines, general aviation (GA) aircraft outfitted with jet engines, auxiliary power units (APU), ground support equipment (GSE), GA outfitted with piston, and AT outfitted with piston. Table 1-1 summarizes these NO_x emissions by SCC. Tarrant County and Harris County indicated the highest aircraft NO_x emissions in the state, accounting for 36% and 21% respectively.

In the projected inventories, there was a steady increase in emissions after the base year. Prior to the base year, emissions were more erratic based on actual historic data in the TAF dataset.

Table 1-1. 2017 Annual Controlled NO_X Emissions Summary by SCC Ranked

SCC	SCC Description	Emissions (tons per year)	Percent
2275020000	Commercial	9,728.06	67.26%
2275001000	Military	3,520.95	24.35%
2275060012	Air Taxi, Turbine	506.83	3.50%
2275050012	General Aviation, Turbine	176.88	1.22%
2275070000	APU	173.61	1.20%
2270008005	GSE, Diesel	145.71	1.01%
2265008005	GSE, 4-stroke Gasoline	132.20	0.91%
2275050011	General Aviation, Piston	74.95	0.52%
2275060011	Air Taxi, Piston	3.38	0.02%
	Total	14,462.56	

2.0 Emissions Projection Procedures

Using the 2017 emissions inventory as a base year, controlled and uncontrolled inventories were then projected to years 2011 through 2045 based on growth factors developed from the FAA's TAF data[1]. The TAF data included aircraft operations data by airport and general aircraft type (AT, GA, MIL, AC). A takeoff and a landing are two separate operations, and the two operations combined equal a landing and take-off (LTO) cycle. Therefore, the operations data were converted into LTO data by dividing by 2. Growth factors were calculated by dividing the projected year LTO data by the 2017 base year LTO data. This provided growth factors by airport and generic aircraft type. Where the airport/generic aircraft type data did not link up to the base year inventory, generic aircraft type growth factors were developed. These factors are discussed in more detail below in sections 2.2 and 2.3. Quality assurance checks implemented for this project are documented in Appendix A.

These growth factors were then applied to the 2017 controlled and uncontrolled base year inventories to develop the controlled and uncontrolled emissions inventories for 2011 through 2045. For more detailed information on the development of the 2017 base year inventories, please see the *2017 Texas Statewide Aircraft Emissions Inventory*.

2.1 National Data Source for Texas Airport Trend Activities

To obtain information required for this project, the FAA's TAF Dataset[1] was employed. This section discusses the TAF data used for this project, summarizing the publicly available data and noting any limitations or data gaps.

2.1.1 TAF Dataset

The TAF dataset is an FAA dataset derived from a variety of sources such as reported traffic at FAA towered facilities, data reported directly by airports and FAA derived estimates from historical information. This dataset includes airport, aircraft categories, and operations data. The aircraft categories included AC, AT, GA, and MIL. For consistency between TAF and the 2017 emissions inventories, the TAF operations data were converted into LTOs. The TAF dataset has historical data back to 1990 as well as projected data up to 2045. The TAF dataset is continually being updated so TAF data does change frequently.

2.2 Development of Projection Factors

The TAF dataset from 2011 through 2045 were downloaded for the entire state of Texas and used to develop the projection factors. The TAF data included aircraft operations data by airport and general aircraft type (AC, AT, GA, MIL). The operations data were then converted into LTO data. Growth factors were calculated by dividing the projected

year LTO data by the 2017 base year LTO data. ERG developed projection factors by calculating ratios of base year operations and projection year operations for the following scenarios, as applicable:

1. for airports only,
2. for aircraft types only, and
3. for a combination of airport and aircraft type.

2.2.1 Projection Factors

Due to the size, the full set of projection factors, summarized by county and SCC, were provided to TCEQ separate from the report and are available upon request. Tables 2-1 and 2-2 summarize the projection factors at a state level for all aircraft aggregated and at a state level by aircraft type disaggregated, respectively.

Table 2-1. Aggregated State Level Projection Factors for all Aircraft from 2011 through 2045

Projected Year	Average Projection Factor
2011	1.08914597
2012	1.068673494
2013	1.079081725
2014	1.089141337
2015	1.114950797
2016	1.115470688
2017	1
2018	1.018142069
2019	1.021693476
2020	1.024410358
2021	1.028047476
2022	1.031227956
2023	1.034201681
2024	1.038320847
2025	1.0428059
2026	1.047355047
2027	1.051973209
2028	1.056664655
2029	1.061433099
2030	1.066280492
2031	1.071204161
2032	1.076198165
2033	1.081265993
2034	1.086415639
2035	1.091645315
2036	1.096953481
2037	1.102343946
2038	1.107815459
2039	1.113363835
2040	1.119001307
2041	1.124721134
2042	1.130533031
2043	1.13643731
2044	1.142434175
2045	1.148531821

Table 2-2. Aggregated State Level Projection Factors by Aircraft Type from 2011 through 2045

Projected Year	AC	AT	GA	MIL
2011	2.29910411	1.22257478	1.02558151	1.59443971
2012	1.36648924	1.19178059	1.02568614	1.58533519
2013	1.68729634	1.28779786	1.03029612	1.50588678
2014	1.2018409	1.3255964	1.0271548	1.90953947
2015	1.69430155	1.2547964	1.04446994	1.97634871
2016	1.03333675	1.12607698	1.07549514	1.8176652
2017	1	1	1	1
2018	1.03642526	1.04777124	1.01607854	1.02246632
2019	1.05658362	1.0789535	1.01816224	1.02246632
2020	1.07826948	1.04202688	1.02247085	1.02246632
2021	1.09296445	1.02922442	1.0268432	1.02246632
2022	1.11036096	1.0027615	1.03128082	1.02246632
2023	1.12927303	0.96922751	1.03578296	1.02246632
2024	1.1405811	0.96545741	1.04035189	1.02246632
2025	1.15000707	0.96996637	1.04498745	1.02246632
2026	1.15949096	0.97450317	1.04969272	1.02246632
2027	1.16920917	0.97909578	1.05446792	1.02246632
2028	1.17930471	0.98371917	1.05931581	1.02246632
2029	1.18971286	0.98839961	1.0642408	1.02246632
2030	1.20045955	0.99319141	1.06924195	1.02246632
2031	1.21144047	0.99803655	1.07432136	1.02246632
2032	1.22250401	1.00291637	1.07947664	1.02246632
2033	1.23367008	1.00785358	1.0847102	1.02246632
2034	1.24509978	1.01286612	1.09002658	1.02246632
2035	1.25659699	1.01798291	1.09542684	1.02246632
2036	1.26817936	1.02313521	1.10091207	1.02246632
2037	1.27988195	1.02837578	1.10648332	1.02246632
2038	1.29154951	1.03364415	1.11214552	1.02246632
2039	1.3031702	1.03896935	1.11789287	1.02246632
2040	1.3148956	1.04444405	1.12373137	1.02246632
2041	1.32646005	1.04998237	1.1296635	1.02246632
2042	1.33830744	1.05558508	1.13569007	1.02246632
2043	1.35035931	1.06125185	1.14181324	1.02246632
2044	1.36254326	1.06698754	1.14803466	1.02246632
2045	1.37494581	1.0728701	1.15435795	1.02246632

2.3 Calculation of Projection Years

Baseline emissions were projected using the three following equations in descending order of priority where data were available:

Equation 1. $PE_{hijk} = \sum PF_{hik} EM2017_{hij}$

Where:

PE_{hijk} = projected emissions for airport h, aircraft type i, pollutant j and projection year k (tons/year)

PF_{hik} = projection factor for airport h, aircraft type i, and year k (unitless)

$EM2017_{hij}$ = Baseline (2017) emissions for airport h, aircraft type i and pollutant j, (tons/year)

Example Calculation projecting Love Field for GA piston to 2018 using Equation 1.

0.674 annual tons NO_X = 0.692 annual tons NO_X *0.97406 projection factor for Love Field GA Aircraft for 2018

If an aircraft type projection factor could not be derived from the TAF dataset for a specific airport the following equation was used.

Equation 2. $PE_{hjk} = \sum PF_{hk} EM2017_{hij}$

Where:

PE_{hijk} = projected emissions for airport h, aircraft type i, pollutant j and projection year k (tons/year)

PF_{hk} = projection factor for airport h, and year k (unitless)

$EM2017_{hij}$ = Baseline (2017) emissions for airport h and aircraft type i and pollutant j (tons/year)

In developing the projected emissions for this project, equation 2 was not used due to a lack of data for applicable scenarios.

If an airport projection factor could not be derived from the TAF dataset then the following equation was used.

Equation 3. $PE_{ijk} = \sum PF_{ik}\ EM2017_{hij}$

Where:

PE_{hijk} = projected emissions for airport h, aircraft type i, pollutant j and projection year k (tons/year)

PF_{ik} = State level projection factor for aircraft type i, and year k (unitless)

$EM2017_{hij}$ = Baseline (2017) emissions for airport h and aircraft type i and pollutant j (tons/year)

Example Calculation projecting Northwest Regional for GA piston to 2018 using Equation 3:

2.949 annual tons NO_X = 2.897 annual tons NO_X *1.0177 projection factor for Texas-wide GA aircraft for 2018

3.0 Summary of Texas Airport Emissions

The results of implementing the emissions projection procedures for the years 2011 through 2045 are presented in Table 3-1 through Table 3-4. These tables present the uncontrolled annual, controlled annual, uncontrolled daily, and controlled daily criteria and lead emissions at the state level. Emissions totals summarized by county and SCC were provided to TCEQ separate from the report and are available upon request.

Prior to 2017, emissions were more variable as they are derived from actual historic data in the TAF dataset as seen in Figure 3-1. For inventories after the base year 2017, Texas emissions steadily increase as seen in Figure 3-1.

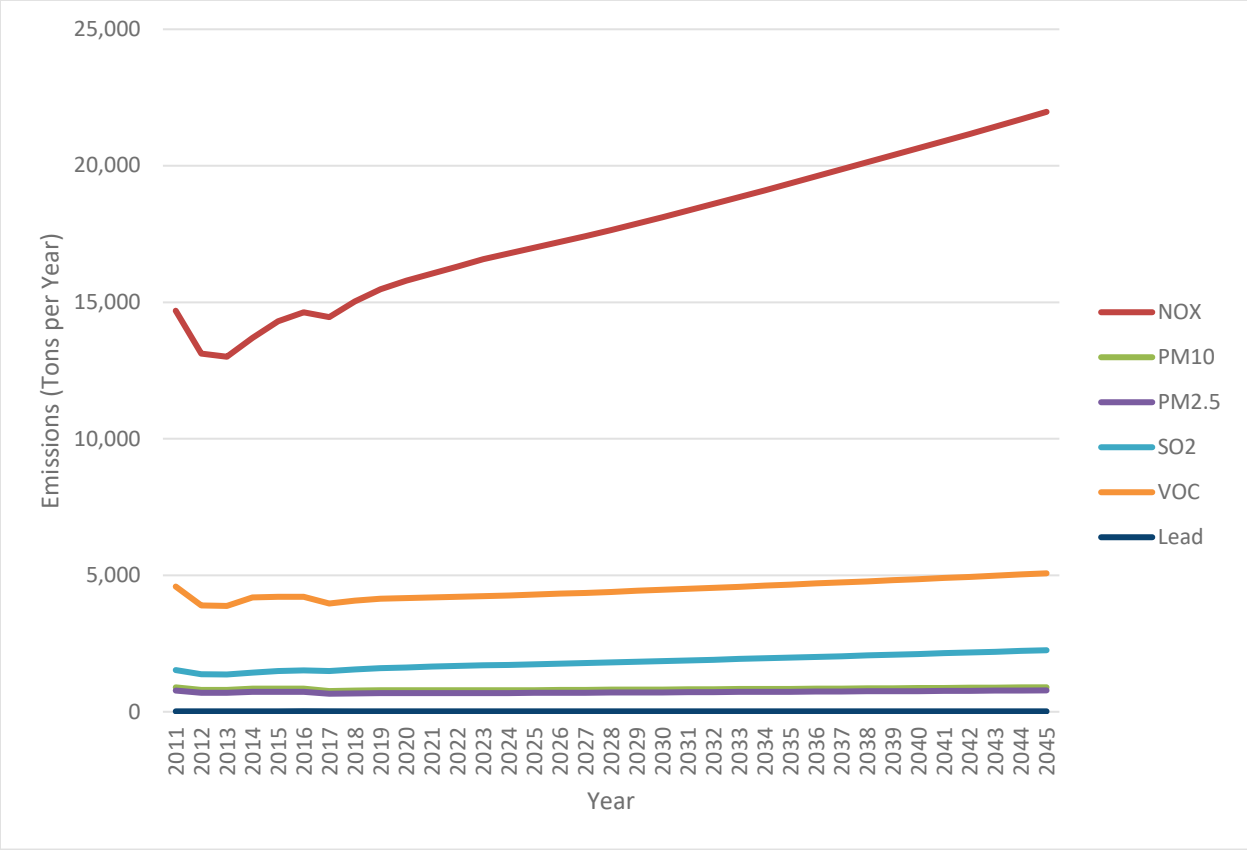

Figure 3-1. Controlled Annual Criteria Emissions from 2011 through 2045 for Texas

Table 3-1. Uncontrolled Annual Criteria Emissions from 2011 through 2045 (Tons Per Year)

Year	CO	NO_X	PM_{10}	$PM_{2.5}$	SO_2	VOC	Lead
2011	40,253	14,794	904	794	1,540	4,593	20
2012	38,386	13,217	819	710	1,387	3,910	20
2013	38,616	13,103	819	710	1,382	3,887	20
2014	39,530	13,790	860	750	1,448	4,194	20
2015	40,545	14,411	859	747	1,506	4,216	21
2016	41,293	14,734	864	750	1,534	4,222	21
2017	37,624	14,565	774	676	1,512	3,972	18
2018	38,617	15,139	793	693	1,568	4,081	18
2019	39,296	15,590	800	700	1,616	4,153	18
2020	39,599	15,904	800	700	1,644	4,175	19
2021	39,947	16,166	803	702	1,670	4,205	19
2022	40,235	16,430	804	703	1,694	4,226	19
2023	40,488	16,696	804	703	1,718	4,242	19
2024	40,819	16,915	807	706	1,740	4,270	19
2025	41,183	17,126	812	710	1,761	4,303	19
2026	41,549	17,338	816	714	1,783	4,336	19
2027	41,924	17,555	821	719	1,806	4,370	19
2028	42,312	17,780	826	723	1,829	4,405	19
2029	42,709	18,012	831	727	1,853	4,441	19
2030	43,118	18,252	836	732	1,877	4,478	19
2031	43,536	18,497	841	737	1,903	4,516	20
2032	43,958	18,744	846	741	1,928	4,554	20
2033	44,385	18,994	852	746	1,954	4,593	20
2034	44,821	19,249	857	751	1,980	4,633	20
2035	45,261	19,506	863	756	2,007	4,672	20
2036	45,704	19,764	868	761	2,033	4,713	20
2037	46,153	20,024	874	766	2,060	4,753	20
2038	46,603	20,285	879	771	2,087	4,794	20
2039	47,055	20,545	885	776	2,114	4,834	20
2040	47,511	20,807	891	781	2,141	4,876	21
2041	47,966	21,066	897	786	2,168	4,916	21
2042	48,429	21,331	902	792	2,195	4,958	21
2043	48,901	21,601	908	797	2,223	5,000	21
2044	49,379	21,874	915	802	2,251	5,043	21
2045	49,867	22,152	921	808	2,280	5,087	21

Table 3-2. Controlled Annual Criteria Emissions from 2011 through 2045 (Tons Per Year)

Year	CO	NO_X	PM_{10}	$PM_{2.5}$	SO_2	VOC	Lead
2011	40,131	14,693	889	779	1,524	4,583	20
2012	38,268	13,117	804	696	1,372	3,900	20
2013	38,499	13,005	804	695	1,367	3,878	20
2014	39,413	13,692	845	735	1,433	4,185	20
2015	40,427	14,309	844	733	1,490	4,206	21
2016	41,174	14,630	849	735	1,518	4,213	21
2017	37,506	14,463	759	661	1,497	3,962	18
2018	38,494	15,032	777	678	1,552	4,071	18
2019	39,168	15,478	784	684	1,599	4,143	18
2020	39,468	15,789	784	684	1,627	4,165	19
2021	39,814	16,048	786	686	1,652	4,195	19
2022	40,100	16,310	787	687	1,676	4,216	19
2023	40,350	16,574	787	686	1,700	4,232	19
2024	40,680	16,790	790	689	1,721	4,260	19
2025	41,041	16,999	794	693	1,743	4,292	19
2026	41,406	17,209	798	697	1,764	4,325	19
2027	41,778	17,424	803	701	1,786	4,359	19
2028	42,163	17,647	807	705	1,809	4,393	19
2029	42,558	17,876	812	709	1,833	4,429	19
2030	42,964	18,114	817	713	1,857	4,466	19
2031	43,380	18,356	822	717	1,882	4,504	20
2032	43,800	18,601	827	722	1,907	4,542	20
2033	44,224	18,848	832	726	1,933	4,581	20
2034	44,658	19,101	837	731	1,959	4,620	20
2035	45,094	19,355	842	735	1,985	4,660	20
2036	45,535	19,611	847	740	2,011	4,700	20
2037	45,981	19,869	852	745	2,038	4,740	20
2038	46,429	20,127	858	749	2,064	4,780	20
2039	46,877	20,384	863	754	2,091	4,821	20
2040	47,331	20,644	868	759	2,117	4,862	21
2041	47,783	20,901	874	764	2,144	4,902	21
2042	48,244	21,163	879	768	2,171	4,944	21
2043	48,713	21,430	885	773	2,198	4,986	21
2044	49,188	21,700	891	778	2,226	5,028	21
2045	49,673	21,976	896	784	2,254	5,072	21

Table 3-3. Uncontrolled Daily Criteria Emissions from 2011 through 2045 (Tons Per Day)

Year	CO	NO_X	PM_{10}	$PM_{2.5}$	SO_2	VOC	Lead
2011	111	41	2	2	4	13	0.05
2012	106	37	2	2	4	11	0.05
2013	107	36	2	2	4	11	0.06
2014	109	38	2	2	4	12	0.06
2015	112	40	2	2	4	12	0.06
2016	114	41	2	2	4	12	0.06
2017	104	41	2	2	4	11	0.05
2018	107	42	2	2	4	11	0.05
2019	109	44	2	2	5	11	0.05
2020	110	44	2	2	5	12	0.05
2021	111	45	2	2	5	12	0.05
2022	112	46	2	2	5	12	0.05
2023	113	47	2	2	5	12	0.05
2024	113	47	2	2	5	12	0.05
2025	115	48	2	2	5	12	0.05
2026	116	48	2	2	5	12	0.05
2027	117	49	2	2	5	12	0.05
2028	118	50	2	2	5	12	0.05
2029	119	50	2	2	5	12	0.05
2030	120	51	2	2	5	12	0.05
2031	121	52	2	2	5	13	0.05
2032	122	52	2	2	5	13	0.05
2033	124	53	2	2	5	13	0.05
2034	125	54	2	2	6	13	0.05
2035	126	55	2	2	6	13	0.05
2036	127	55	2	2	6	13	0.06
2037	129	56	2	2	6	13	0.06
2038	130	57	2	2	6	13	0.06
2039	131	58	2	2	6	13	0.06
2040	132	58	2	2	6	14	0.06
2041	134	59	2	2	6	14	0.06
2042	135	60	2	2	6	14	0.06
2043	136	61	3	2	6	14	0.06
2044	138	61	3	2	6	14	0.06
2045	139	62	3	2	6	14	0.06

Table 3-4. Controlled Daily Criteria Emissions from 2011 through 2045 (Tons Per Day)

Year	CO	NO_X	PM_{10}	$PM_{2.5}$	SO_2	VOC	Lead
2011	111	41	2	2	4	13	0.05
2012	106	36	2	2	4	11	0.05
2013	106	36	2	2	4	11	0.06
2014	109	38	2	2	4	12	0.06
2015	112	40	2	2	4	12	0.06
2016	114	41	2	2	4	12	0.06
2017	104	40	2	2	4	11	0.05
2018	107	42	2	2	4	11	0.05
2019	109	43	2	2	4	11	0.05
2020	110	44	2	2	5	12	0.05
2021	111	45	2	2	5	12	0.05
2022	111	46	2	2	5	12	0.05
2023	112	46	2	2	5	12	0.05
2024	113	47	2	2	5	12	0.05
2025	114	47	2	2	5	12	0.05
2026	115	48	2	2	5	12	0.05
2027	116	49	2	2	5	12	0.05
2028	117	49	2	2	5	12	0.05
2029	118	50	2	2	5	12	0.05
2030	120	51	2	2	5	12	0.05
2031	121	51	2	2	5	12	0.05
2032	122	52	2	2	5	13	0.05
2033	123	53	2	2	5	13	0.05
2034	124	53	2	2	5	13	0.05
2035	126	54	2	2	6	13	0.05
2036	127	55	2	2	6	13	0.06
2037	128	56	2	2	6	13	0.06
2038	129	56	2	2	6	13	0.06
2039	131	57	2	2	6	13	0.06
2040	132	58	2	2	6	13	0.06
2041	133	59	2	2	6	14	0.06
2042	134	59	2	2	6	14	0.06
2043	136	60	2	2	6	14	0.06
2044	137	61	2	2	6	14	0.06
2045	138	62	2	2	6	14	0.06

4.0 References

1. Federal Aviation Administration. Terminal Area Forecast (TAF). http://aspm.faa.gov/main/taf.asp. Accessed May 7, 2019.

Appendix A
Quality Assurance

Appendix A
Quality Assurance

QUALITY ASSURANCE

All resulting emission inventories developed during this project were subjected to internal review and QA/QC procedures outlined in the Quality Assurance Project Plan (QAPP) for Development of 2017 Statewide Emissions Inventories for Air Emissions Reporting Requirements and Reasonable Further Progress for Airport Sources Work Order No. 582-18-82508-19, as per the requirements of a Category III QAPP for Data Evaluation or Use for a Secondary Purpose.

The Category III QAPP establishes requirements for projects involving data use for secondary purposes. The internal review and QA/QC procedures were consistent with the NRML QAPP requirements. These procedures are outlined below.

A. Project Management

Project Staff: The project included a team of technical specialists trained to address each project objective. These staff and their primary responsibility area are delineated as follows.

Rick Baker: Mr. Baker is the overall ERG contract manager for this TCEQ contract. He ensures the project implementation follows all contract requirements and that project quality standards are met on all deliverables. He assists in interactions with the TCEQ as required.

Jeanette Alvis: Ms. Alvis provided peer review for the QAPP and oversaw the QA/QC procedures, ensuring Mr. Billing's reviews were all in line with the QAPP and ERG's corporate QA guidelines.

Roger Chang: Project manager for this study. Mr. Chang provided beta testing services to the FAA during testing of the AEDT model, which was used for this project. Additionally, he has been involved with the development of numerous airport emissions inventories for the United States Environmental Protection Agency (US EPA) and other federal agencies as well as the TCEQ.

Richard Billings: Mr. Billings has extensive knowledge and expertise on aircraft inventory development and worked as peer reviewer for the project, ensuring the following checks were made:

- Reviewed at least ten percent of project data files to check for data transfer issues and to ensure that database queries were implemented correctly.
- Project staff used appropriate methodologies and documented data quality activities and the deliverable review process.
- The preliminary data and draft/final reports were reviewed by technical staff to ensure that the project objectives and data quality objectives (DQOs) were met for this study.
- The report was reviewed by the project's editing staff prior to delivery of the draft version to the TCEQ.

Jennifer Sellers: Ms. Sellers is an environmental scientist who has extensive experience in aircraft emission inventories.

Heather Perez: Ms. Perez is an experienced environmental scientist and database manager who served as technical support and QA reviewer. She is experienced in aircraft emission inventories.

Jody Tisano: Ms. Tisano is an administrative assistant who provided administrative and clerical support. She has performed similar work on previous TCEQ projects.

Background: The purpose of this project was to develop 2011 through 2045 Statewide emissions inventories (EI) for all airport sources including aircraft, auxiliary power units (APU), and ground support equipment (GSE). These Els are needed to fulfill the Federal Air Emissions Reporting Requirements (AERR) and support State Implementation Plan (SIP) development. For this project, ERG developed the annual (tons per year) and average summer weekday (tons per day) emissions inventory estimates of criteria air pollutants (CAP), CAP precursors, and hazardous air pollutants (HAP) using the 2017 emissions inventory from Work order No. 582-18-82508-19 and projection factors based on the Federal Aviation Agency's (FAA) Terminal Area Forecast (TAF) data.

Project/Task Description:

To meet the project objectives, the following tasks were completed:

- Provided an emissions inventory development plan
- Recompiled the 2017 calendar year emission inventory from Work Order 582-18-82508-19
- Developed projection factors
- Projected the 2017 statewide emissions data to 2011 through 2045 and provided the draft and final inventories
- Provided the draft and final report

The project included producing Extensible Markup Language (XML) files and Excel summary files which were shared with the TCEQ Work Assignment Manager and used in our quality checks.

Quality Objectives and Criteria: ERG provided the TCEQ with comprehensive and accurate 2017 emission inventories based on the FAA's latest emissions estimating model (Aviation Environmental Design Tool Version 2d).

The projection factors were compared to previous projection factors developed for the 2017/2020 emissions inventory from Work order No. 582-18-82508-19 to see if there were any anomalies present in the newly developed 2017/2020 factors, shown in the attached excel spreadsheet (TCEQ Projection Factors Memo Tables.xlsx). Differences in the projection factors between the previous Work Order and the current Work Order were identified and noted. These noted differences were verified as being due to updates made to the TAF dataset by the FAA between the previous Work Order and the current Work Order. Additionally, a trends analysis was

performed to identify potential anomalies in the data between years. Any identified differences between 2017/2020 were also attributed to changes made in the TAF dataset. There were no irregularities found in the calculation of the projection factors. Figure A-1, in section D, notes that for all future years the projection factors had a gradual increase over time, whereas the historical years were more erratic due to actual historic data.

When outliers were identified, ERG investigated further to ensure that the data were correct and there were no errors in data handling, and the emissions queries were evaluated to ensure they were linking the data correctly.

The final emissions inventory and activity data were formatted to meet the TCEQ's Texas Air Emissions Repository (TexAER) and EPA's Consolidated Emissions Reporting Schema (CERS) XML requirements.

Special Training/Certification: No special training or certification is required.

Documents and Records: The process used to collect data and develop the inventories was documented from start to finish. All procedures and data sources used to create the inventories were presented such that the TCEQ or any third party have sufficient information to independently replicate any part of the process if needed.

The process of providing interim products for each work task and obtaining TCEQ review comments enhanced the completeness and quality of the documentation in the final project report. The final report includes this document in the QA section, discussion of any problems encountered, corrective actions taken, and limitation of the data identified in the process of developing the emissions inventories.

B. Data Generation and Acquisition

ERG recompiled the 2017 controlled and uncontrolled emissions data originally developed for Work Order 582-19-95489-01.

ERG obtained aircraft activity data for 2011 through 2045 from the FAA's TAF dataset to develop the projection factors for each year.

To develop the 2011 through 2045 aircraft emission inventories, ERG applied the projection factors developed from the FAA's TAF dataset to the 2017 emissions inventory.

a. Data Management

No hard copy data were received during the project. For this project, all data obtained were electronic. Working copies of the original data files were shared with the team, such that the integrity of the original files was maintained. The original files were never checked out, and only viewed a couple of times to confirm that the data in the working files were correctly transferred.

The electronic working files were stored in a specific project directory on ERG's network drive in Morrisville, North Carolina. The original data files were kept in a separate folder on the same network. All files on the Morrisville server are backed up daily.

Only project team members were granted access to the directories where the working files were stored, such that all members of the team had access to all project data and could perform their work using these files. Once the project was completed, all project electronic files were moved into an archive directory on the network for permanent storage.

C. Assessment and Oversight

Data collection efforts were coordinated so that all ERG team members understood the project goals. Following the kickoff discussions with TCEQ staff and submittal of the work plan, the ERG Project Manager and task leads had internal team meetings to discuss and verify data collection efforts for each project task. Each team member had a clear understanding of all project objectives and deliverables and the data that will be needed to support those deliverables. This coordinated process is seen as essential to efficient and productive data collection.

Peer reviewers knowledgeable about the source category but not directly involved in conducting day to day activities of the project reviewed all data handling methods and results of the work. ERG's peer reviewers were included in the initial planning stages of this project to ensure the planned approaches were technically sound and that quality checks were planned for critical points in the process. This included review of projection factors as well as the projection calculations.

ERG peer reviewers did not find any issues with data handling nor did they have any problem reproducing the 2011 through 2045 emission estimates using the project access database and associated queries.

All final products were reviewed by senior team members prior to submittal to the TCEQ to ensure the project procedures were properly implemented. The ERG Project Manager and task leads signed off on all deliverables to the TCEQ documenting that all quality checks were implemented and, where problems were identified, corrections were made in the preliminary or final dataset, and the draft or final report.

Reports to Management: The ERG project manager reported to the TCEQ project manager on a biweekly schedule or sooner if something urgent was raised.

D. Data Validation and Usability and Verification and Validation Methods

All information used to develop the emissions inventories were checked and reviewed for reasonableness to the extent possible. This included checking projection factors against the reference source, such as the FAA TAF datasets. A minimum of 10% of the data were audited by an independent reviewer not involved with the inventory development. 100 percent of all calculation queries were checked by having a second staff member replicate the result by independently applying the input data and assumptions to see if the same data were produced.

> **The ERG data review did not find any formatting issues with the data used for the projections or issues with the calculations.**

Projection factors and emissions data were reviewed by the Project Manager to ensure they were reasonable and consistent (i.e., extremely low or high values that are usually indicative of errors were flagged for further investigation). Any data that were found to be questionable were examined in greater detail to determine what was causing the issue and what adjustments, if any, were required. If data were revised, the procedures and assumptions used were documented. The Project Manager and task leads reviewed and approved all data adjustments, as documented in this QA summary.

Projection Factors to Previous 2017/2020 Projection Factors Comparison

The projection factors were compared to previous projection factors developed for the 2017/2020 emissions inventory from Work order No. 582-18-82508-19 to see if there were any anomalies present in the newly developed 2017/2020 factors. Differences in the projection factors between the previous Work Order and the current Work Order were identified and noted. These noted differences were verified as being due to updates made to the TAF dataset by the FAA between the previous Work Order and the current Work Order. Additionally, a trends analysis was performed to identify potential anomalies in the data between years. Any identified differences between 2017/2020 were also attributed to changes made in the TAF dataset. There were no irregularities found in the calculation of the projection factors. Figure A-1 notes that for all future years the projection factors had a gradual increase over time, whereas the historical years were more erratic due to actual historic data.

> **The noted differences were attributed to updates to the TAF dataset by the FAA between the previous Work Order and the Current Work Order; therefore, no changes were required based on this QA check.**

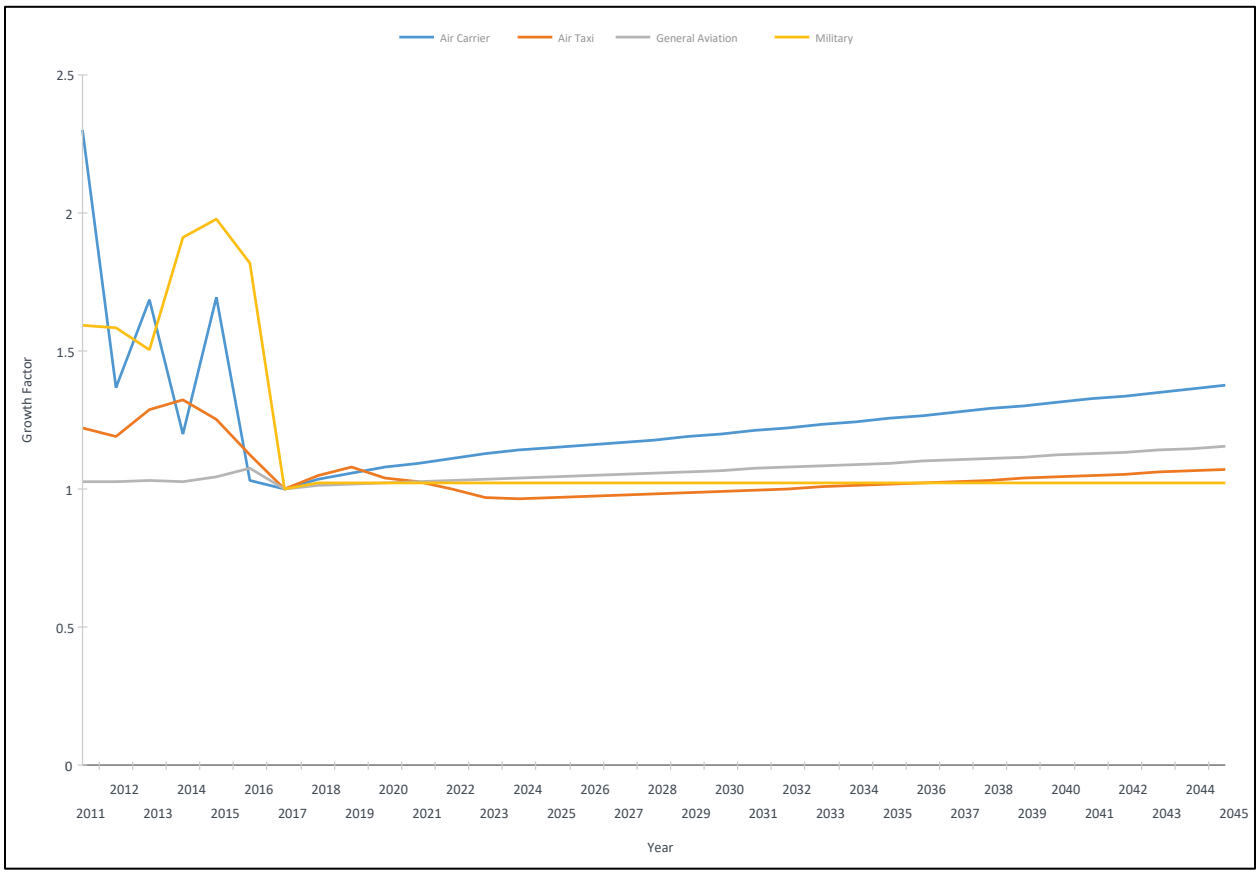

Figure A-1. 2011-2045 Projection Factors by Aircraft Type Category

Zero Projection Factor Analysis

Some of the projection factors were set to zero when the base year had LTOs but a projected year had zero LTOs. These zeroes were analyzed to see how much of the emissions were lost. ERG used the criteria emissions as a surrogate for all emissions. More emissions are lost in the historic years (2011-2015). No emissions were lost in 2016 or 2017, which is expected because 2017 is the base year. In summary, 0.0007% to 0.72% of emissions are lost for the criteria pollutants between 2011 and 2015, with the most emissions lost in 2013 (0.23% to 0.72%). From 2018 to 2045, the losses ranged from 0.0001% to 0.0771%. See Table A-1 for all losses. The FAA's TAF data was therefore assumed to be reasonably accurate and, where zeroes were present from year to year, the affects were considered minimal. In analyzing the data, the changes in LTOs between the base year of 2017 and other years were often small (generally less than a 100). There were a few instances of LTO changes being in the 1000's. Analysis was provided to TCEQ and it was decided the that ERG should proceed.

No changes were made since the impact is minimal.

Table A-1. Percent "Lost" Due to Zero Projection Factors

Year	Pollutant					
	CO	NOx	PM_{10}	$PM_{2.5}$	SO_2	VOC
2011	0.1408%	0.1555%	0.2752%	0.2949%	0.1720%	0.2395%
2012	0.1499%	0.1783%	0.3073%	0.3336%	0.1961%	0.2874%
2013	0.2253%	0.4563%	0.4833%	0.5407%	0.4364%	0.7213%
2014	0.1286%	0.3038%	0.3125%	0.3494%	0.2743%	0.4846%
2015	0.0061%	0.0007%	0.0064%	0.0058%	0.0008%	0.0022%
2016	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%
2017	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%
2018	0.0001%	0.0001%	0.0001%	0.0002%	0.0001%	0.0002%
2019	0.0001%	0.0001%	0.0001%	0.0002%	0.0001%	0.0001%
2020	0.0001%	0.0001%	0.0001%	0.0002%	0.0001%	0.0001%
2021	0.0001%	0.0001%	0.0001%	0.0002%	0.0001%	0.0001%
2022	0.0001%	0.0001%	0.0001%	0.0002%	0.0001%	0.0001%
2023	0.0001%	0.0001%	0.0001%	0.0002%	0.0001%	0.0001%
2024	0.0624%	0.0466%	0.0725%	0.0771%	0.0631%	0.0661%
2025	0.0619%	0.0460%	0.0721%	0.0767%	0.0623%	0.0656%
2026	0.0613%	0.0455%	0.0717%	0.0763%	0.0616%	0.0651%
2027	0.0608%	0.0449%	0.0713%	0.0758%	0.0608%	0.0646%
2028	0.0602%	0.0443%	0.0709%	0.0754%	0.0600%	0.0641%
2029	0.0597%	0.0438%	0.0705%	0.0750%	0.0593%	0.0635%
2030	0.0591%	0.0432%	0.0701%	0.0745%	0.0585%	0.0630%
2031	0.0585%	0.0426%	0.0697%	0.0741%	0.0577%	0.0625%
2032	0.0580%	0.0421%	0.0692%	0.0736%	0.0570%	0.0620%
2033	0.0574%	0.0415%	0.0688%	0.0732%	0.0562%	0.0614%
2034	0.0569%	0.0410%	0.0684%	0.0727%	0.0555%	0.0609%
2035	0.0563%	0.0404%	0.0680%	0.0723%	0.0547%	0.0604%
2036	0.0558%	0.0399%	0.0676%	0.0718%	0.0540%	0.0599%
2037	0.0552%	0.0394%	0.0672%	0.0714%	0.0533%	0.0594%
2038	0.0547%	0.0389%	0.0667%	0.0709%	0.0526%	0.0589%
2039	0.0542%	0.0384%	0.0663%	0.0705%	0.0520%	0.0584%
2040	0.0536%	0.0379%	0.0659%	0.0700%	0.0513%	0.0579%
2041	0.0531%	0.0374%	0.0655%	0.0696%	0.0507%	0.0574%
2042	0.0526%	0.0370%	0.0651%	0.0691%	0.0500%	0.0569%
2043	0.0521%	0.0365%	0.0647%	0.0687%	0.0494%	0.0564%
2044	0.0516%	0.0361%	0.0643%	0.0682%	0.0488%	0.0560%
2045	0.0511%	0.0356%	0.0639%	0.0678%	0.0482%	0.0555%

In addition to the checks above, ERG confirmed that annual and daily uncontrolled emissions were higher than controlled emissions, and that annual emissions were much higher than daily emissions. ERG also confirmed that emissions changed year to year.

E. Reconciliation with User Requirements

ERG applied basic quality assurance/quality control (QA/QC) considerations to conduct this project. As per the requirements of a Category III QAPP, more than 10% of the emission calculations were checked. Projection factors were also compared to projection factors used in earlier TCEQ aviation inventories.

Below is a summary of the QA findings:

- Projection calculations were check and numbers were spot checked.
- Overall trends were analyzed and confirmed that year to year changes matched projection factors.
- Emissions varied more for historical years where actual data were available. Future year emissions were smoother and predictable as data were forecasted.