On-Road Heavy-Duty Vehicle Emissions Inventory Research for the Austin-Round Rock-Georgetown Metropolitan Statistical Area

Prepared by the Capital Area Council of Governments

December 17, 2021

The preparation of this report was financed through funding provided by the Texas Commission on Environmental Quality (TCEQ). The content, findings, opinions, and conclusions are the work of the author(s) and do not necessarily represent findings, opinions, or conclusions of the TCEQ.

1 EXECUTIVE SUMMARY

The purpose of this project is to estimate on-road emissions from heavy-duty vehicles owned and operated by members of CAPCOG's Clean Air Coalition (CAC) under Subtask 3.1 of CAPCOG's 2020-2021 Local Air Quality Planning Grant. Unlike standard county-wide emissions inventories such as the National Emissions Inventory (NEI) or those used by the U.S. Environmental Protection Agency (EPA) and the Texas Commission on Environmental Quality (TCEQ) as inputs for photochemical modeling, this project involves estimating organization-specific inventories. These fleet emissions inventories can serve as a point of comparison to area-wide emissions estimates to better understand the extent to which these organizations' fleets contribute to the region's air pollution and the extent to which actions by these organizations to control emissions from these vehicles could enhance regional air quality.

CAPCOG collected vehicle data from the following CAC members – City of Austin (Austin), Travis County, and the Capital Metropolitan Transportation Authority (CapMetro). CAPCOG focused on the following heavy-duty vehicle types with ULSD or biodiesel fuel types:

1. Refuse Hauler
2. School Bus
3. Transit Bus
4. Short Haul – Single Unit
5. Short Haul – Combination

CAPCOG used these vehicle data in conjunction with data from EPA's Diesel Emissions Quantifier (DEQ), documentation from EPA's MOVES model (for speciating hydrocarbon emissions), data from a prior Texas Commission on Environmental "Trends" on-road emissions inventory for the region (to convert annual to ozone season day emissions) to calculate emissions of these heavy-duty vehicles for carbon monoxide (CO), carbon dioxide (CO_2), volatile organic compounds (VOCs), nitrogen oxides (NO_X), and fine particulate matter ($PM_{2.5}$). CAPCOG then analyzed the emissions rates to calculate an emissions total for each organization's vehicle fleet by vehicle type for select heavy-duty vehicles.

Table 1-1. Summary Vehicle, Fuel, and Annual Pollutant Estimates for Modeled Vehicles for Austin, Travis County, and CapMetro for 2020, tons per year (tpy)

Organization	Number of Vehicles	Fuel Consumption (gallons)	$PM_{2.5}$	CO	CO_2	NO_X	VOCs
Austin	1,210	2,008,354.50	0.75	29.26	22,571.82	41.83	2.30
Travis County	114	104,747.58	0.06	1.08	1,178.41	2.30	0.15
CapMetro	413	4,130,755.20	0.35	63.13	46,471.00	101.72	3.98
TOTAL	**1,737**	**6,243,857.28**	**1.16**	**93.47**	**70,221.23**	**145.86**	**6.43**

TABLE OF CONTENTS

1 Executive Summary 2
2 Introduction 5
3 EPA's Diesel Emissions Quantifier 5
4 Methodology 6
5 Results 8
5.1 Austin 9
5.1.1 Refuse Trucks 9
5.1.2 Short Haul Single Unit Vehicles 9
5.1.3 Short Haul Combination Vehicles 10
5.1.4 Transit Buses 10
5.1.5 Summary of Austin Emissions Totals 11
5.2 Travis County 12
5.2.1 School Buses 12
5.2.2 Short Haul Single Unit Vehicles 13
5.2.3 Short Haul Combination Vehicles 13
5.2.4 Summary of Travis County's Emissions Totals 14
5.3 CapMetro 15
5.4 Emissions for All Organizations 16
6 Data Comparisons 17
6.1 TCEQ Trends Inventory Comparison 17
6.2 CapMetro NTD Comparison 19
7 Conclusion 21
Appendix A 22
Appendix B 23

Table 1-1. Summary Vehicle, Fuel, and Annual Pollutant Estimates for Modeled Vehicles for Austin, Travis County, and CapMetro for 2020, tons per year (tpy) 2
Table 5-1. Summary of Modeled Vehicles by Organization, 2020 8
Table 5-2. Annual Austin Refuse Vehicle Emissions Totals for CY 2020 (tons per year) 9
Table 5-3. OSD Austin Refuse Vehicle Emissions Totals for CY 2020 (tons per day) 9
Table 5-4. Annual Austin Short Haul Single Unit Vehicle Emissions Totals for CY 2020 (tons per year) 9
Table 5-5. OSD Austin Short Haul Single Unit Vehicle Emissions Totals for CY 2020 (tons per day) 10
Table 5-6. Annual Austin Short Haul Combination Vehicle Emissions Totals for CY 2020 (tons per year) 10
Table 5-7. OSD Austin Short Haul Combination Vehicle Emissions Totals for CY 2020 (tpd) 10
Table 5-8. Annual Austin Transit Buses Emissions Totals for CY 2020 (tons per year) 10

Table 5-9. Annual Austin All Modeled Vehicle Emissions Totals for CY 2020 (tons per year) 11
Table 5-10. OSD Austin All Modeled Vehicle Emissions Totals for CY 2020 (tons per day) 11
Table 5-11. Annual Travis County School Bus Emissions Totals for FY 2020 (tons per year) 13
Table 5-12. OSD Travis County School Bus Emissions Totals for FY 2020, tons 13
Table 5-13. Annual Travis County Short Haul Single Unit Emissions Totals for FY 2020 (tons per year) 13
Table 5-14. OSD Travis County Short Haul Single Unit Emissions Totals for FY 2020 (tons per day) 13
Table 5-15. Annual Travis County Short Haul Combination Emissions Totals for FY 2020 (tons per year) 13
Table 5-16. OSD Travis County Short Haul Combination Emissions Totals for FY 2020 (tons per day) 14
Table 5-17. Annual Travis County All Modeled Vehicle Emissions Totals for FY 2020, tons 14
Table 5-18. OSD Travis County All Modeled Vehicle Emissions Totals for FY 2020, tons 14
Table 5-19. Annual CapMetro Transit Bus Emissions Totals for FY 2020 (tons per year) 16
Table 5-20. OSD CapMetro Transit Bus Emissions Totals for FY 2020 (tons per day) 16
Table 5-21. Total Annual Pollutant Estimates for Modeled Vehicles for Austin, Travis County, and CapMetro for 2020 (tons per year) 16
Table 5-22. Total OSD Pollutant Estimates for Modeled Vehicles for Austin, Travis County, and CapMetro for 2020 (tons per day) 16
Table 6-1. TCEQ Trends Inventory Data for Travis County, 2020 18
Table 6-2. Comparison to TCEQ Trends Annual Inventory Data for Travis County (tons per year) 18
Table 6-4. Data Comparison of NTD Data and Submitted Fleet Data for CapMetro, 2019 and 2020 20
Table 6-5. Difference of Data Comparison of NTD Data and Submitted Fleet Data for CapMetro, 2020 to 2019 20
Table 6-6. Percent Difference of Data Comparison of NTD Data and Submitted Fleet Data for CapMetro, 2020 to 2019 20
Figure 5-1. Austin NO_X Emissions per Vehicle Comparison 12
Figure 5-2. Travis County NO_X Emissions per Vehicle Comparison 15
Figure 5-3. Modeled NO_X Emissions by Organization (tpy) 17

2 INTRODUCTION

The purpose of this project is to estimate on-road emissions from heavy-duty vehicles owned and operated by members of CAPCOG's Clean Air Coalition (CAC) under Subtask 3.1 of CAPCOG's 2020-2021 Local Air Quality Planning Grant. This project involves estimating fleet-specific inventories, which can be used to improve understanding of the extent to which emissions from these fleets may be contributing to regional air pollution and the extent to which emissions reductions could be achieved from these fleets. This information will help the region maintain compliance with the O_3 National Ambient Air Quality Standards (NAAQS), and will therefore be useful to the State Implementation Plan (SIP).

CAPCOG collected vehicle data from Austin, Travis County, and CapMetro, and calculated annual and ozone season day (OSD) emission totals using a combination of data from EPA's DEQ, TCEQ's Trends inventory, and documentation from EPA's MOVES model.

This inventory was generated using different methods than what would be used by the TCEQ or the EPA to develop county-wide data used for EPA's NEI or photochemical modeling inputs due to differences in purpose and difficulty in comparing the format of those types of inventories to the data available for individual vehicles for specific organizations that cover varying geographies. For example, while CAPCOG can probably reasonably assume that all of Travis County's vehicles spend all of their time in Travis County, Austin's territory extends into Williamson and Hays Counties, and the CapMetro service area includes part (but not all) of Travis and Williamson Counties. Likewise, whereas MOVES uses average emissions rates by source use type across all applicable vehicle weight classes, the DEQ enables users to model different emissions rates for different vehicle weight classes.

3 EPA'S DIESEL EMISSIONS QUANTIFIER

The Diesel Emissions Quantifier (DEQ)[1] is a web-based tool from the EPA that provides estimates of emissions reductions achievable through implementation of emission controls on existing heavy-duty diesel vehicles based on user inputs. The DEQ provides annual emissions estimates for CO, CO_2, hydrocarbons (HC), NO_X, and $PM_{2.5}$, as well as the amount of emission reductions that could be achieved by implementing emission reduction measures such as vehicle replacement or retrofits. CAPCOG used the latest version of the DEQ which is Version (v.) 9.0. For the factors of concern for CAPCOG, v. 9.0 primarily differs from the previous DEQ version, v. 8.4, for on-road engines in that:

1. On-road emission factors were been updated using EPA's MOtor Vehicle Emission Simulator (MOVES) 3;
2. On-road default values for annual fuel gallons, annual miles traveled, annual idling hours were updated using MOVES2014 (v. 6.1);
3. Default fuel volume were changed to consider the fuel type for the baseline vehicle group. All defaults were previously for ULSD vehicles. (v. 8.3)
4. Fuel consumption rates for on-road idling were updated using MOVES2014 (v. 7.2); and

[1] EPA DEQ, https://cfpub.epa.gov/quantifier/

5. Idling emission factors were updated using data from MOVES3.[2]

The DEQ can provide other information such a lifetime vehicle emissions, cost effectiveness, and health benefits of vehicle or equipment replacement. However, CAPCOG did not utilize the DEQ to generate such results for this project.

4 METHODOLOGY

CAPCOG's basic methodology can be summarized as applying DEQ emissions rates generated using default user inputs to fleet-specific activity data. As is described in further detail in this section, the dozens of emission rates generated using DEQ covered all combinations of vehicle type, model year, and fuel type for the data gathered from the 3 organizations, and then applied to the fuel consumption for those specific vehicles.

CAPCOG requested on-road heavy-duty vehicle fleet data from the Austin, Travis County, and CapMetro. The fleet data collected included:

1. Vehicle Type:
    1.1. Refuse Hauler (Class 6-7 or 8);
    1.2. Transit Bus (Class 4-5, 6-7, or 8);
    1.3. School Bus (Class distinction not needed for DEQ);
    1.4. Short Haul – Single Unit (Class 3, 4-5, 6-7, or 8);
    1.5. Short Haul – Combination (Class 6-7 or 8);
2. Model Year (MY);
3. Fuel Type;
4. Annual Fuel Gallons;
5. Annual Miles Traveled;
6. Annual Idling Hours; and
7. Estimated Remaining Life (in years).

For CAPCOG's purposes, short haul vehicles are considered vehicles that travel less than 200 miles/day.[3] Short haul single unit vehicles and short haul combination vehicles are differentiated by whether the vehicle has one unit for single unit or more than 1 unit for combination.

Austin provided fleet data for calendar year (CY) 2020, while Travis County and CapMetro provided data for fiscal year (FY) 2020 (October 1, 2019 – September 30, 2020). Despite this difference in time period used for this project, it should not significantly influence the results. The fleet data information that

[2] EPA, DEQ Release Notes, July 15, 2021, https://cfpub.epa.gov/quantifier/assets/docs/diesel_emission_quantifer_deq_release_notes.pdf

[3] EPA, Options for Simplifying MOVES Onroad Source Types and Ramps Presentation, Sept. 14, 2016, https://www.epa.gov/sites/default/files/2016-10/documents/options-for-simplifying-moves-onroad-source-types-and-ramps.pdf

each organization provided was consolidated in a spreadsheet for the three organization's fleet data, which is in Appendix A. Of note, no organization collected annual idling hours on their fleet vehicles for CY or FY 2020.

CAPCOG focused on the heavy-duty vehicles in the fleets with ULSD or biodiesel fuel types. Austin was the only organization to use biodiesel, and all of Austin's biodiesel is biodiesel 20 (B20). Vehicle information with other fuels were provided by the organizations, but CAPCOG focused on diesel or biodiesel fuel types for this analysis. Therefore, vehicles with a fuel other than a diesel or biodiesel type were not analyzed. Additionally, due to the variety of vehicles that fall under the Short Haul Single Unit Class 3 distinction and CAPCOG's time constraints, CAPCOG not did include Short Haul Single Unit Class 3 with any fuel types within the scope of the analysis. In addition to excluding Class 3 vehicles, if an organization had a vehicle type from the 5 unique types that did not meet the vehicle class criteria for the DEQ, that vehicle type was not included in the analysis since it could not be modeled with the DEQ.

CAPCOG ran the DEQ for each vehicle type class, MY, and fuel type (ULSD or B20) using DEQ's default annual fuel usage, annual miles traveled, and idling hours for the relevant combinations of these inputs in the fleet information provided by CapMetro, Austin, and Travis County fleets (i.e., if there was no diesel transit bus in the inventory with a 1998 model year, DEQ was not run for that combination). Each organization's unique combination of vehicle type class, MY, and fuel type was assigned a unique identification number (ID#) for CAPCOG's analyses. For example, Austin's Class 8 Refuse Truck with MY 2021 using B20 fuel was ID# R-COA-7; Austin had 19 refuse trucks with that same criteria, thus all 19 were given the ID# R-COA-7. Using the provided vehicle type class, fuel type, MY, and quantity of vehicles with the same criteria along with the default data, the DEQ generated annual emissions estimates for CO, CO_2, HC, NO_X, and $PM_{2.5}$ for each ID. Of note from the DEQ for B20, B20 default factors are not available for engine model year 2007 or newer; therefore, the DEQ uses diesel factors when alternative fuel factors are not available.

CAPCOG saved each resulting DEQ file for each ID number, and CAPCOG copied the resulting data into a consolidated spreadsheet for each organization's vehicle types. Once all the DEQ runs were generated for an organization's vehicle type, CAPCOG used the annual pollutant and fuel estimates from the DEQ results to proceed. Since the DEQ provided HC estimates, CAPCOG converted HC to VOCs using EPA's MOVES3 documentation of the "VOC/NMHC Ratio". The HC to VOCs conversion factor value depended on the MY.[4] Additionally, CAPCOG reduced the DEQ NO_X emissions by either 4.8% for MY 2002 and later, or 6.2%, MY 2001 and earlier, to reflect the use of Texas Low-Emissions Diesel (TxLED).[5]

Once CAPCOG converted the HC to VOCs estimates and applied the TxLED conversion to the NO_X estimates, CAPCOG consolidated the annual emissions estimates for the calculated VOCs and adjusted NO_X along with the DEQ's annual emissions estimates for CO, CO_2, $PM_{2.5}$, and fuel gallons into a new spreadsheet.

Next, CAPCOG generated an annual emission rate (pollutant ton/fuel gallon) by dividing the annual emissions estimates (tons/year) by the fuel estimates (gallons/year) from the DEQ. This calculated a default annual emission rates for each pollutant by model year, vehicle type, and fuel type.

[4] EPA, Speciation of Total Organic Gas and Particulate Matter Emissions from Onroad Vehicles in MOVES3, November 2020, Page 17, https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P1010THD.pdf

[5] Benefits based on 2001 memorandum from EPA to: https://www.epa.gov/sites/default/files/2016-11/documents/tx-led-fuel-benefit-2001-09-27.pdf

In order to calculate the actual emissions totals for the fleet vehicles analyzed, CAPCOG first calculated the total actual fuel consumption, based on the information provided by the organization, for each unique ID. Then, CAPCOG multiplied the total actual fuel value by the default annual emission rates for each pollutant in order to calculate the total emissions per year for CO, CO_2, VOCs, NO_X, and $PM_{2.5}$ for each unique ID#. Then, CAPCOG summed all of the emissions values by pollutant to generate total emissions, in tons per year, for the respective organization's vehicle types.

In order to generate ozone season day (OSD) emissions estimates, CAPCOG used TCEQ's "Trends" inventory for the Travis County geography and year 2020 to calculate the ratios of summer weekday emissions to annual emissions.[6] Using the calculated ratio from the "Trends" data, CAPCOG multiplied the final annual emissions estimates by the "Trends" ratio for CO, CO_2, VOCs, NO_X, and $PM_{2.5}$. This resulted in an OSD emissions estimate for each pollutant.

5 RESULTS

CAPCOG calculated annual emissions totals for CO, CO_2, VOCs, NO_X, and $PM_{2.5}$ by on-road heavy duty vehicle type - refuse truck, transit bus, school bus, short haul single unit truck, and short haul combination truck - for Austin, Travis County, and CapMetro. Table 5-1 shows a summary of each organization's vehicle types, vehicle class categories, fuel, and number of vehicles per type modeled.

Table 5-1. Summary of Modeled Vehicles by Organization, 2020

Organization	Vehicle Type	Vehicle Class Categories	Fuel	Number of Vehicles
Austin	Refuse Truck	Class 6-7 and 8	B20	166
	Refuse Truck	Class 8	ULSD	8
	Short Haul Single Unit	Class 4-5, 6-7, and 8	B20	979
	Short Haul Combination	Class 6-7 and 8	B20	53
	Transit Bus	Class 4-5	B20	4
Travis County	School Bus	Class 4	ULSD	5
	Short Haul Single Unit	Class 4-5 and 6-7	ULSD	104
	Short Haul Combination	Class 8	ULSD	5
CapMetro	Transit Bus	Class 6	ULSD	7
	Transit Bus	Class 8	ULSD	406
TOTAL	**N/A**	**N/A**	**N/A**	**1,737**

CAPCOG also included the total number of vehicles and the actual fuel consumption by vehicle. Additionally, CAPCOG summarized the annual vehicle type emissions totals for each organization. The following sections illustrate the results by organization and a comparison of the organizations.

[6] TCEQ Emissions Inventory On-Road Trends, September 2016, Travis County 2020 Summer Weekday and Annual, ftp://amdaftp.tceq.texas.gov/pub/EI/onroad/mvs14_trends/ei_tables/

5.1 AUSTIN

For 2020, Austin had the most vehicles in their fleet for the vehicle type and classes that could be modeled with the DEQ for the vehicle categories in this analysis. Austin's data is for CY 2020. Additionally, all the vehicles modeled in this analysis used B20 fuel with the exception of eight ULSD refuse trucks. The table below shows the breakdown of Austin's vehicles modeled. Austin operates vehicles with other fuels beyond B20 and ULSD; however, those vehicles were not in the scope of this analysis.

As described in the Methodology section, CAPCOG generated an emissions estimate for each vehicle type, model year, class category, and fuel type combination. The following sections display the emission totals for refuse trucks, short haul combination vehicles, short haul single unit vehicles, and transit buses for Austin.

5.1.1 Refuse Trucks

Austin owns and operates refuse trucks for single-family residential refuse collection through Austin Resource Recovery in the Austin city limits. Austin is the only organization in this analysis that operated refuse trucks in 2020.

Tables 5-2 and 5-3 show the final fuel consumption and emission for Austin's modeled refuse trucks by the year and by OSD.

Table 5-2. Annual Austin Refuse Vehicle Emissions Totals for CY 2020 (tons per year)

Number in Fleet	Fuel Consumption (gallons)	$PM_{2.5}$	CO	CO_2	NO_X	VOCs
174	763,304.40	0.12	10.18	8,587.17	12.71	0.47

Table 5-3. OSD Austin Refuse Vehicle Emissions Totals for CY 2020 (tons per day)

Number in Fleet	$PM_{2.5}$	CO	CO_2	NO_X	VOCs
174	0.0003	0.0295	25.1694	0.0329	0.0013

5.1.2 Short Haul Single Unit Vehicles

Of the vehicle types modeled for Austin's fleet, short haul single unit vehicles have the greatest number. This can be attributed to the variety of vehicle types and uses that fall under the short haul single unit category. Almost every department within Austin operates short haul single unit vehicles. This analysis included short haul single unit vehicles that were Class 4 and greater with B20 as the fuel type. Austin operates a number of Class 3 short haul single unit vehicles and vehicles with other fuel types, but those were not included in this analysis.

Tables 5-4 and 5-5 show the final fuel consumption and emissions for Austin's modeled short haul single unit vehicles by the year and by OSD.

Table 5-4. Annual Austin Short Haul Single Unit Vehicle Emissions Totals for CY 2020 (tons per year)

Number in Fleet	Fuel Consumption (gallons)	$PM_{2.5}$	CO	CO_2	NO_X	VOCs
979	1,144,857.00	0.61	18.03	12,879.64	27.31	1.75

Table 5-5. OSD Austin Short Haul Single Unit Vehicle Emissions Totals for CY 2020 (tons per day)

Number in Fleet	$PM_{2.5}$	CO	CO_2	NO_X	VOCs
979	0.0017	0.0542	38.3540	0.0720	0.0046

5.1.3 Short Haul Combination Vehicles

Short haul combination vehicles are considered a heavier-duty vehicle than short haul single unit vehicles. Austin uses short haul combination vehicles for the following departments:

- Austin Resource Recovery
- Austin Water
- Public Works
- Watershed Protection

All of Austin's short haul combination vehicles were modeled as they met the scope for this analysis. Tables 5-6 and 5-7 show the final fuel consumption and emissions for Austin's modeled short haul combination vehicles by the year and by OSD.

Table 5-6. Annual Austin Short Haul Combination Vehicle Emissions Totals for CY 2020 (tons per year)

Number in Fleet	Fuel Consumption (gallons)	$PM_{2.5}$	CO	CO_2	NO_X	VOCs
53	98,222.80	0.03	1.05	1,105.01	1.81	0.09

Table 5-7. OSD Austin Short Haul Combination Vehicle Emissions Totals for CY 2020 (tpd)

Number in Fleet	$PM_{2.5}$	CO	CO_2	NO_X	VOCs
53	0.0001	0.0031	3.2356	0.0047	0.0002

5.1.4 Transit Buses

Austin operates transit buses for departmental use. These buses are not operated like normal transit buses of public transportation agencies such as CapMetro. Austin used Class 4-5 transit buses with B20 fuel for the Parks and Recreation Department and Police Department for CY 2020.

In addition to the Class 4-5 buses that Austin operated, Austin operated Class 3 transit buses in CY 2020. However, those buses were not included in the analysis as the DEQ cannot model Class 3 buses. Additionally, this analysis does not include non-Class 3 buses that were not B20 or ULSD fuel types.

Table 5-8 shows the final fuel consumption and emissions for Austin's modeled transit buses by the year. Since the yearly estimates are so small, the OSD estimates are de minimis and are not presented in the body of this report. However, the OSD estimates are available in the Appendix B files.

Table 5-8. Annual Austin Transit Buses Emissions Totals for CY 2020 (tons per year)

Number in Fleet	Fuel Consumption (gallons)	$PM_{2.5}$	CO	CO_2	NO_X	VOCs
4	1,970.30	0.0003	>0.0001	>0.0001	>0.0001	>0.0001

5.1.5 Summary of Austin Emissions Totals

Table 5-9, Table 5-10, and Figure 5-1 present a summary of the emissions totals for Austin's four vehicle types modeled: refuse trucks, short haul single unit vehicles, short haul combination vehicles, and transit buses. Single-unit short-haul trucks make up a majority of the emissions for each pollutant.

Table 5-9. Annual Austin All Modeled Vehicle Emissions Totals for CY 2020 (tons per year)

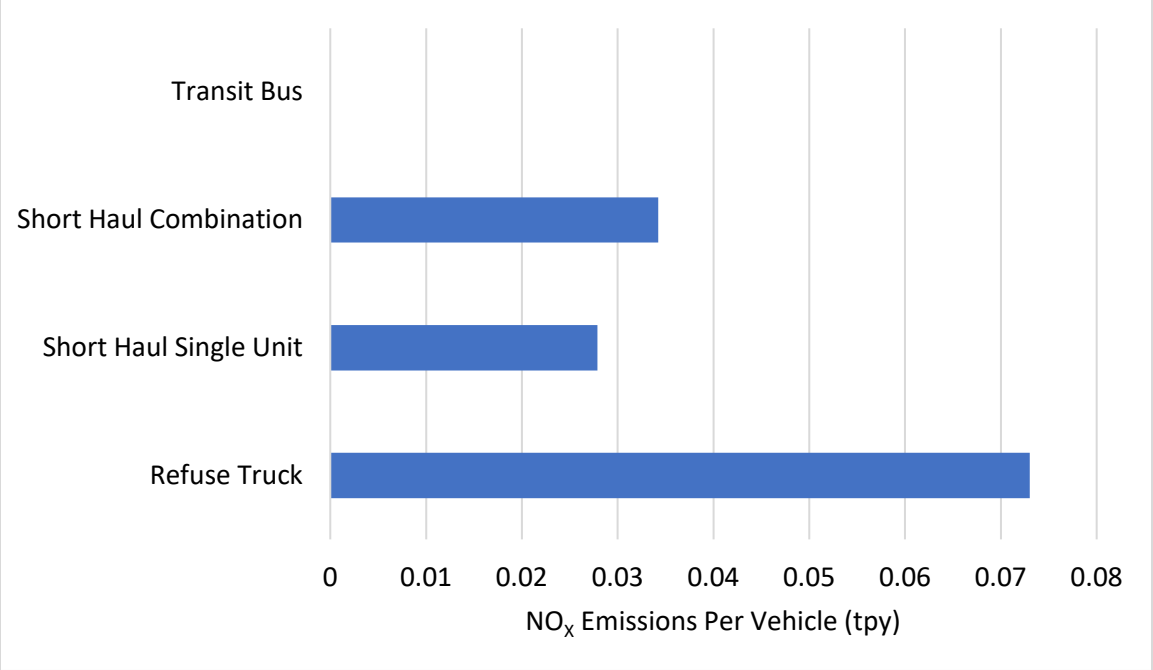
Vehicle Type	Vehicle Class Categories	Fuel	Number of Vehicles	$PM_{2.5}$	CO	CO_2	NO_X	VOCs
Refuse Truck	Class 6-7 and 8	B20 and ULSD	174	0.12	10.18	8,587.17	12.71	0.47
Short Haul Single Unit	Class 4-5, 6-7, and 8	B20	979	0.61	18.03	12,879.64	27.31	1.75
Short Haul Combination	Class 6-7 and 8	B20	53	0.03	1.05	1,105.01	1.81	0.09
Transit Bus	Class 4-5	B20	4	>0.01	>0.01	>0.01	>0.01	>0.01
TOTAL	**N/A**	**N/A**	**1,210**	**0.75**	**29.26**	**22,571.82**	**41.83**	**2.30**

Table 5-10. OSD Austin All Modeled Vehicle Emissions Totals for CY 2020 (tons per day)

Vehicle Type	Vehicle Class Categories	Fuel	Number of Vehicles	$PM_{2.5}$	CO	CO_2	NO_X	VOCs
Refuse Truck	Class 6-7 and 8	B20 and ULSD	174	0.0003	0.0295	25.1694	0.0329	0.0013
Short Haul Single Unit	Class 4-5, 6-7, and 8	B20	979	0.0017	0.0542	38.3540	0.0720	0.0046
Short Haul Combination	Class 6-7 and 8	B20	53	0.0001	0.0031	3.2356	0.0047	0.0002
Transit Bus	Class 4-5	B20	4	>0.0001	>0.0001	>0.0001	>0.0001	>0.0001
TOTAL	**N/A**	**N/A**	**1,210**	**0.0021**	**0.0867**	**66.7590**	**0.1097**	**0.0061**

Since prior studies by CAPCOG have shown that NO_X emissions drive local contributions to ambient O_3 concentrations, it is important to understand which vehicle types contribute the most NO_X emissions. Therefore, CAPCOG calculated the ratio of NO_X emissions to the number of vehicles per type in order to compare the results since the numbers of vehicle per type varied greatly in Austin's fleet. Figure 5-1 shows how the vehicle types compare in NO_X emissions for Austin.

Figure 5-1. Austin NO_X Emissions per Vehicle Comparison



As is evident in Figure 5-1, Austin's refuse trucks emit the most NO_X emissions per vehicle, followed by short-haul combination trucks and short-haul single unit trucks. Austin's small amount of transit buses modeled emitted a negligible amount of NO_X emissions per vehicle.

5.2 Travis County

Travis County provided fleet data for FY 2020. For this analysis, CAPCOG modeled Class 4 and greater vehicles with ULSD fuel for school buses, short haul single unit vehicles, and short haul combination vehicles. Travis County operated gasoline fuel vehicles of the three vehicle types mentioned in FY 2020. However, gasoline cannot be modeled in the DEQ, so those vehicles were excluded from this analysis.

As described in the Methodology section, CAPCOG generated an emissions estimate for each vehicle type, model year, class category, and fuel type combination. The following sections display the emission totals for school buses, short haul single unit vehicles, and short haul combination vehicles for Travis County.

5.2.1 School Buses

Travis County uses school buses for county prisoner transport. Therefore, these buses do not operate in the same manner as regular school buses. However, from the reported fuel usage from Travis County, these Travis County buses use a similar average amount of fuel at 1,016 gallons/year compared to the DEQ default fuel usage for a school bus of 1,360 gallons/year. It is notable that the newer buses in Travis County's fleet are used more, and thus use more fuel, than the older buses. Therefore, the older buses' small activity use has pulled the average fuel use for all Travis County school buses down. Travis County is the only organization in this analysis where school buses were modeled. The tables below show the final fuel and emissions total for Travis County's modeled school buses by the year and by OSD.

Table 5-11. Annual Travis County School Bus Emissions Totals for FY 2020 (tons per year)

Number in Fleet	Fuel Consumption (gallons)	$PM_{2.5}$	CO	CO_2	NO_X	VOCs
5	5,080.48	0.0007	0.0406	57.1554	0.0713	0.0025

Table 5-12. OSD Travis County School Bus Emissions Totals for FY 2020, tons

Number in Fleet	$PM_{2.5}$	CO	CO_2	NO_X	VOCs
5	>0.0001	0.0001	0.1688	0.0002	>0.0001

5.2.2 Short Haul Single Unit Vehicles

There were a number of short haul single unit vehicles in Travis County's fleet that were out of the scope of this analysis, either due to vehicle class, fuel type, or fuel usage. The majority of Travis County's short haul single unit vehicles are Class 2 or 3. Additionally, the majority of any vehicle class in Travis County's fleet are gasoline fuel types. Lastly, there were eighteen Class 5 or 6 ULSD vehicles that were not modeled since they had zero fuel usage for FY 2020, which indicated that they were not used. CAPCOG could not model vehicles with zero fuel usage and gasoline fuel. Any short haul single unit vehicle less than Class 4 was out of scope for this analysis. Therefore, CAPCOG only analyzed Class 4 and greater, diesel short haul single unit vehicles with fuel usage in FY 2020 for Travis County. Tables 5-13 and 5-14 show the final fuel and emissions total for Travis County's modeled short haul single unit vehicles by the year and by OSD.

Table 5-13. Annual Travis County Short Haul Single Unit Emissions Totals for FY 2020 (tons per year)

Number in Fleet	Fuel Consumption (gallons)	$PM_{2.5}$	CO	CO_2	NO_X	VOCs
104	95,737.80	0.05	0.97	1,077.05	1.96	0.13

Table 5-14. OSD Travis County Short Haul Single Unit Emissions Totals for FY 2020 (tons per day)

Number in Fleet	$PM_{2.5}$	CO	CO_2	NO_X	VOCs
104	0.0001	0.0029	3.2073	0.0052	0.0003

5.2.3 Short Haul Combination Vehicles

All, except for one, of Travis County's short haul combination vehicles were modeled as they met the scope for this analysis. The vehicle not modeled was a Class 5 short haul combination vehicle, and that vehicle class cannot be modeled in the DEQ for short haul combination vehicles. Tables 5-15 and 5-16 show the final fuel and emissions total for Travis County's modeled short haul combination vehicles by the year and by OSD.

Table 5-15. Annual Travis County Short Haul Combination Emissions Totals for FY 2020 (tons per year)

Number in Fleet	Fuel Consumption (gallons)	$PM_{2.5}$	CO	CO_2	NO_X	VOCs
5	3,929.30	0.01	0.07	44.20	0.27	0.01

Table 5-16. OSD Travis County Short Haul Combination Emissions Totals for FY 2020 (tons per day)

Number in Fleet	$PM_{2.5}$	CO	CO_2	NO_X	VOCs
5	>0.0000	0.0002	0.1294	0.0007	>0.0000

5.2.4 Summary of Travis County's Emissions Totals

Table 5-17, Table 5-18, and Figure 5-2 present a summary of the emissions totals for Travis County's three vehicle types modeled – school buses, short haul single unit vehicles, and short haul combination vehicles. Of all the vehicle types, CO_2 emissions are the largest, by far, with NO_X emissions second and CO emissions third. VOCs and PM_{25} emissions are the smallest of the 5 pollutants estimated.

Table 5-17. Annual Travis County All Modeled Vehicle Emissions Totals for FY 2020, tons

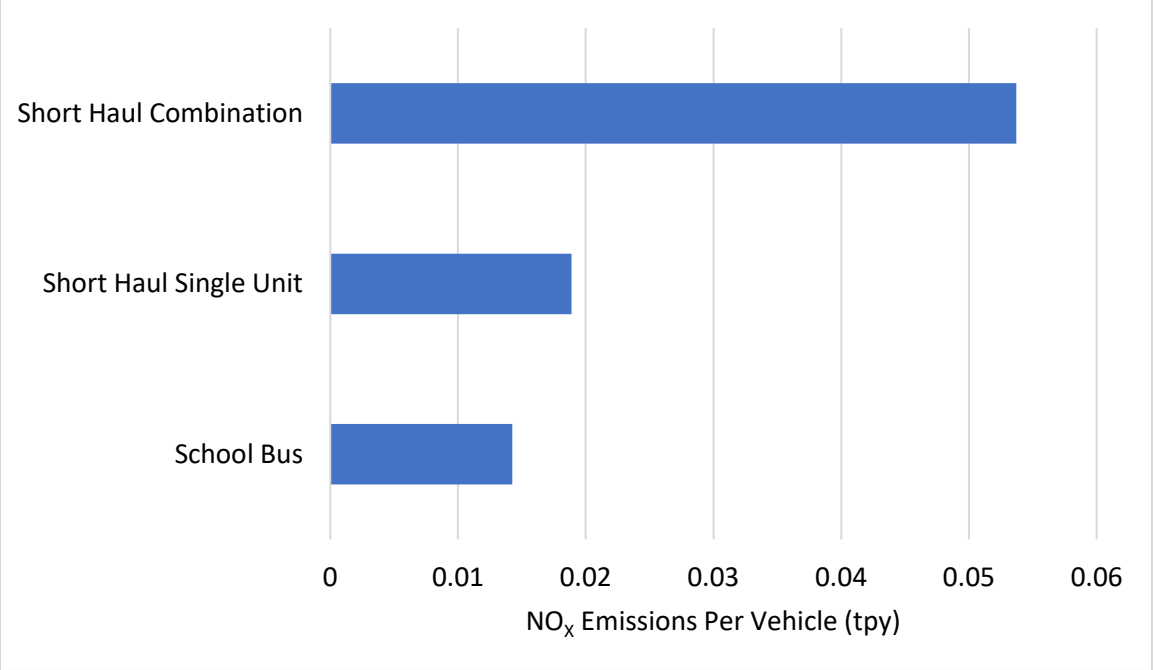
Vehicle Type	Vehicle Class Categories	Fuel	Number of Vehicles	$PM_{2.5}$	CO	CO_2	NO_X	VOCs
School Bus	Class 4	ULSD	5	0.0007	0.0406	57.16	0.0713	0.0025
Short Haul Single Unit	Class 4-5 and 6-7	ULSD	104	0.0492	0.9720	1,077.05	1.9639	0.1320
Short Haul Combination	Class 8	ULSD	5	0.0117	0.0652	44.20	0.2686	0.0137
TOTAL	**N/A**	**N/A**	**114**	**0.0616**	**1.0779**	**1,178.41**	**2.3038**	**0.1483**

Table 5-18. OSD Travis County All Modeled Vehicle Emissions Totals for FY 2020, tons

Vehicle Type	Vehicle Class Categories	Fuel	Number of Vehicles	$PM_{2.5}$	CO	CO_2	NO_X	VOCs
School Bus	Class 4	ULSD	5	>0.0000	0.0001	0.1688	0.0002	>0.0000
Short Haul Single Unit	Class 4-5 and 6-7	ULSD	104	0.0001	0.0029	3.2073	0.0052	0.0003
Short Haul Combination	Class 8	ULSD	5	>0.0000	0.0002	0.1294	0.0007	>0.0000
TOTAL	**N/A**	**N/A**	**114**	**0.0002**	**0.0032**	**3.5055**	**0.0061**	**0.0004**

Due to the importance of NO_X as an O_3 precursor in the region (noted earlier in this report), CAPCOG calculated the ratio of NO_X emissions to the number of vehicles per type in order to compare the results since the numbers of vehicle per type varied greatly in Travis County's fleet. The graph below shows how the vehicle types compare in NO_X emissions for Travis County.

Figure 5-2. Travis County NO_X Emissions per Vehicle Comparison



Evident in Figure 5-2, Travis County's short haul combination vehicles contribute the most NO_X emissions per vehicle type. This can be attributed to the fact that four of the five short haul combination vehicles are MY 2006 or earlier. Therefore, a higher share of these vehicles have higher emissions rates than MY 2007 or later vehicles as a result of new federal engine standards for heavy-duty diesel vehicles that started phasing in with MY 2007.

5.3 CapMetro

CapMetro is the region's largest public transportation provider that owns and operates transit buses. CapMetro provided fleet data for FY 2020. CapMetro operated the following transit bus types in FY 2020:

- Class 6
  - Mini buses, <29 feet long
- Class 8
  - Standard buses, 29-40 feet long
  - Coaches, 45 feet long
  - Articulated buses, 60 feet long

CapMetro had 12 battery electric buses in their fleet in FY 2020. While these vehicles do generate $PM_{2.5}$ from brakewear and tirewear, this cannot be modeled in the DEQ. Therefore, CAPCOG modeled the rest of the CapMetro buses since they are ULSD fuel type. Tables 5-19 and 5-20 show the final fuel and emissions total for CapMetro's modeled transit buses by the year and by OSD.

Table 5-19. Annual CapMetro Transit Bus Emissions Totals for FY 2020 (tons per year)

Number in Fleet	Fuel Consumption (gallons)	$PM_{2.5}$	CO	CO_2	NO_X	VOCs
413	4,130,755.20	0.35	63.13	46,471.00	101.72	3.98

Table 5-20. OSD CapMetro Transit Bus Emissions Totals for FY 2020 (tons per day)

Number in Fleet	$PM_{2.5}$	CO	CO_2	NO_X	VOCs
413	0.0010	0.1769	136.0498	0.2634	0.0110

Similarly to the other organizations, CapMetro buses have CO_2 emissions as the largest, by far, with NO_X emissions second and CO emissions third. VOCs and PM_{25} emissions are the smallest of the 5 pollutants estimated.

5.4 Emissions for All Organizations

The table below provides a summary of the emissions from the modeled vehicle types in the three organizations fleets.

Table 5-21. Total Annual Pollutant Estimates for Modeled Vehicles for Austin, Travis County, and CapMetro for 2020 (tons per year)

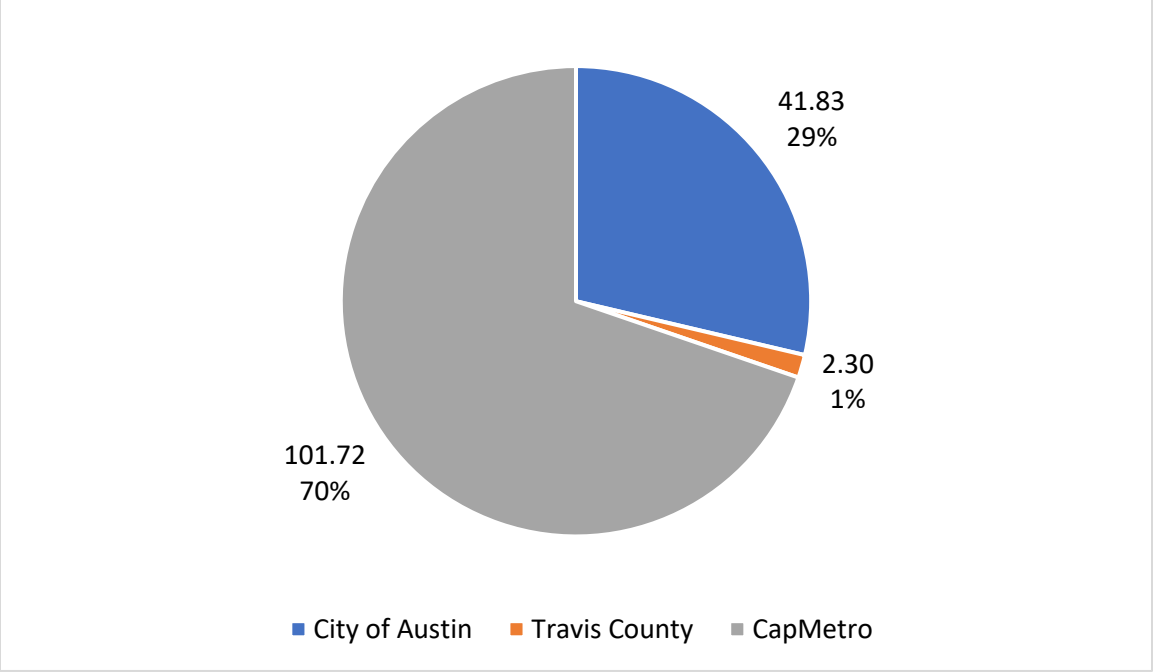
Organization	Number of Vehicles	$PM_{2.5}$	CO	CO_2	NO_X	VOCs
Austin	1,210	0.75	29.26	22,571.82	41.83	2.30
Travis County	114	0.06	1.08	1,178.41	2.30	0.15
CapMetro	413	0.35	63.13	46,471.00	101.72	3.98
TOTAL	**1,737**	**1.16**	**93.47**	**70,221.23**	**145.86**	**6.43**

Table 5-22. Total OSD Pollutant Estimates for Modeled Vehicles for Austin, Travis County, and CapMetro for 2020 (tons per day)

Organization	Number of Vehicles	$PM_{2.5}$	CO	CO_2	NO_X	VOCs
Austin	1,210	0.0021	0.0867	66.7590	0.1097	0.0061
Travis County	114	0.0002	0.0032	3.5055	0.0061	0.0004
CapMetro	413	0.0010	0.1769	136.0498	0.2634	0.0110
TOTAL	**1,737**	**0.0033**	**0.2669**	**206.3143**	**0.3791**	**0.0175**

Figure 5-3 shows the relative share of total NO_X emissions from each organization's modeled fleets.

Figure 5-3. Modeled NO_X Emissions by Organization (tpy)



6 Data Comparisons

CAPCOG compared the modeled emissions data and provided fleet data to TCEQ's Trends Emissions Inventories for 2020 for a Travis County geography for all modeled vehicle types for all organizations[7]. Additionally, CAPCOG compared the provided CapMetro fleet data to data that CapMetro provided to the National Transit Database (NTD)[8]. Since there were major changes in ridership of transit from 2019 to 2020 due to the COVID-19 pandemic, CAPCOG compared the 2020 to 2019 activity where available.

6.1 TCEQ Trends Inventory Comparison

CAPCOG compared the total pollutant estimates for the modeled vehicles across the three organizations to the data in TCEQ's Trends Emissions Inventories for 2020 annual for Travis County (the geographic area, not the organization). The TCEQ Trends inventory provides emissions estimates for all vehicle types based on estimated activity levels in Travis County for 2020. Table 6-1 summarizes the annual emissions of $PM_{2.5}$ exhaust, CO, CO_2, NO_X, and VOC from the relevant source use types examined in this study, as well as the total for all on-road sources. The relevant sources included diesel-powered transit buses (coded as TBus_Diesel in the TCEQ trends file), refuse trucks (RT_Diesel), short haul single unit (SUShT_Diesel) vehicles, short haul combination (CShT_Diesel) vehicles, and school buses (SBus_Diesel).

[7]TCEQ Emissions Inventory On-Road Trends, September 2016, Travis County 2020 Annual, ftp://amdaftp.tceq.texas.gov/pub/EI/onroad/mvs14_trends/ei_tables/

[8] Federal Transit Administration, The National Transit Database (NTD), https://www.transit.dot.gov/ntd

Table 6-1. TCEQ Trends Inventory Data for Travis County, 2020

Source Use Type	Fuel Type	$PM_{2.5}$ (exhaust)	CO	CO_2	NO_X	VOC
Transit Bus	Diesel	1.86	17.65	11,093.67	38.09	2.97
School Bus	Diesel	4.92	37.44	21,359.52	77.67	10.97
Refuse Truck	Diesel	2.04	15.85	20,629.52	44.16	2.65
Single Unit Short Haul	Diesel	7.42	143.07	232,722.91	250.28	22.97
Combination Short Haul	Diesel	19.03	186.15	328,391.29	537.20	28.62
Subtotal, Selected Source Use Types	Diesel	35.27	400.17	614,196.90	947.41	68.18
TOTAL	**Diesel and Gas**	**139.76**	**39,340.49**	**5,398,077.11**	**4,451.01**	**2,763.61**

Data for the subtotal of the source use types examined in this study from Table 6-1 are shown in Table 6-2 along with the data for the three fleets modeled in this study for comparison purposes.

Table 6-2. Comparison to TCEQ Trends Annual Inventory Data for Travis County (tons per year)

Item	$PM_{2.5}$ (exhaust)	CO	CO_2	NO_X	VOC
TCEQ Trends – All Vehicles	139.76	39,340.49	5,398,077.11	4,451.01	2,763.61
TCEQ Trends Annual – Select Vehicle Types	35.27	400.17	614,196.90	947.41	68.18
Modeled Fleets	1.16	93.47	70,221.23	145.86	6.43
Fleets as % of All On-Road Emissions	0.83%	0.24%	1.30%	3.28%	0.23%
Fleets as % of Select Vehicle Types	3.30%	23.36%	11.43%	15.40%	9.43%

There are several important methodological differences to note in the bases for the comparison above, including:

1. The Trends inventory uses a default 1% allocation of vehicle activity from heavy-duty vehicles to the transit bus source use type as the basis for those estimates, whereas this analysis involves actual vehicle counts and fuel usage from CapMetro buses;

2. Similar modeling assumptions were used to allocate activity from heavy-duty vehicles to other source use types in the Trends inventory, whereas this analysis involves direct modeling of specific source use types;
3. The Trends inventory uses average emission rates for all weight classes in a given source use type, whereas this analysis used emission rates specific to weight classes within each source use type;
4. The Trends inventory requires inputs for activity by roadway type, whereas this analysis used default emissions rates derived from DEQ, which does not include roadway type; and
5. The Trends inventory used area-wide inputs model year distributions to generate emissions rates, whereas individual model years were modeled separately in this analysis and then aggregated.

6.2 CapMetro NTD Comparison

For CapMetro, an additional point of comparison was available due to the Federal Transit Administration's reporting requirements and the availability of the National Transit Dataset (NTD). From the NTD, CAPCOG downloaded the data for CapMetro for CY 2019 and 2020. The data that CAPCOG downloaded was the Energy Consumption data, Revenue Vehicle Inventory data, and Service Mileage data. CAPCOG used the "Commuter Bus (CB)" and "Bus (MB)" modes from the NTD data as that corresponds to the data provided to CAPCOG by CapMetro. There are some limitations to the data such that an exact comparison of the NTD data and data provided to CAPCOG by CapMetro cannot be made. The main NTD data limitation is that the Service Mileage data is not distinguished by fuel type. However, the data is sufficient to make an estimation. Therefore, CAPCOG estimated the total mileage for diesel CB and MB buses by multiplying the ratio of diesel CB and MB fuel volume and all fuel volume to the total mileage for all fuel buses. Tables 6-4, 6-5 and 6-6 show the comparison of the 2019 and 2020 NTD data with the FY 2020 data submitted by CapMetro.

Between 2019 and 2020, the NTD shows that the number of buses and associated milage and fuel volume decreased. This is likely to changes in ridership due to the COVID-19 pandemic and stay-at-home orders. Comparing the 2020 data submitted by CapMetro to CAPCOG and the 2020 NTD data, the data is pretty consistent. Any significant difference could be attributed as to how the NTD data is reported versus the data provided to CAPCOG.

Table 6-3. Data Comparison of NTD Data and Submitted Fleet Data for CapMetro, 2019 and 2020

	2019 Number of Buses	2019 All Fuel Mileage	2019 Diesel Mileage	2019 Diesel Mileage/ Bus	2019 Diesel Fuel Volume	2019 Diesel Fuel Volume/ Bus	2019 Total Fuel Volume	2019 Diesel/All Fuel Volume Ratio	2019 Diesel Fuel/Mileage Ratio	2020 Number of Buses	2020 All Fuel Mileage	2020 Diesel Mileage	2020 Diesel Mileage/ Bus	2020 Diesel Fuel Volume	2020 Diesel Fuel Volume/ Bus	2020 Total Fuel Volume	2020 Diesel/All Fuel Volume Ratio	2020 Diesel Fuel/Mileage Ratio
NTD Bus and Commuter Bus Data	506	19,485,674	19,003,411	37,556	5,421,765	10,715	5,559,357	0.98	0.29	458	17,139,691	16,897,154	36,893	4,460,449	9,739	4,524,473	0.99	0.26
CapMetro Fleet Data Provided for FY 2020	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	425	N/A	16,521,375	38,874	4,130,755	9,719	N/A	N/A	0.25

Table 6-4. Difference of Data Comparison of NTD Data and Submitted Fleet Data for CapMetro, 2020 to 2019

	Difference Number of Buses	Difference All Fuel Mileage	Difference Diesel Mileage	Difference Diesel Mileage/Bus	Difference Diesel Fuel Volume	Difference Diesel Fuel Volume/Bus	Difference Total Fuel Volume	Difference Diesel/All Fuel Volume Ratio	Difference Diesel Fuel/Mileage Ratio
NTD Bus and Commuter Bus Data 2020 to 2019	-48	-2,345,983	-2,106,257	-663	-961,316	-976	-1,034,884	0.01	-0.02
CapMetro Fleet Data Provided for FY 2020 Compared to NTD 2020 Data	-33	N/A	-375,779	1,980	-329,694	-20	N/A	N/A	-0.01

Table 6-5. Percent Difference of Data Comparison of NTD Data and Submitted Fleet Data for CapMetro, 2020 to 2019

	Percent Difference Number of Buses	Percent Difference All Fuel Mileage	Percent Difference Diesel Mileage	Percent Difference Diesel Mileage/Bus	Percent Difference Diesel Fuel Volume	Percent Difference Diesel Fuel Volume/Bus	Percent Difference Total Fuel Volume	Percent Difference Diesel/All Fuel Volume Ratio	Percent Difference Diesel Fuel/Mileage Ratio
NTD Bus and Commuter Bus Data 2020 to 2019	1%	-2%	-9%	-12%	-11%	-2%	-18%	-9%	-19%
CapMetro Fleet Data Provided for FY 2020 Compared to NTD 2020 Data	-8%	N/A	-2%	5%	-8%	0%	N/A	N/A	-6%

7 CONCLUSION

This project developed estimates of emissions of CO, CO_2, NO_X, $PM_{2.5}$, and VOC from transit buses, refuse trucks, short haul single unit vehicles, short haul combination vehicles, and school buses, in the fleets owned and operated by three key Clean Air Coalition member organizations: Austin, Travis County, and CapMetro. While comparisons to other area-wide emissions data is somewhat difficult given the differing methodologies, this project provides a good screening-level understanding of the relative importance of the emissions from these fleet vehicles relative to area-wide on-road emissions inventories. Since EPA requires DEQ data in grant applications for Diesel Emission Reduction Act (DERA) funding, these data should also provide a useful tool for these organizations if they choose to pursue DERA funding in the future.

Future work using data developed in this project could include:

- Updating MOVES3 activity inputs, including vehicle counts, VMT, and model year distribution, for the transit bus source use type for Travis County[9];
- Using by-model-year MOVES3 outputs in conjunction with the activity data developed for this project to develop updated emissions estimates that would be consistent with data used in the NEI or photochemical modeling inputs; and
- Developing special activity profiles for the vehicles reviewed in this project that could be used for future research purposes.

[9] Data from the Capital Area Rural Transit Service and City of Round Rock would also need to be reviewed for such a project

APPENDIX A

Austin provided fleet data for calendar year (CY) 2020. While Travis County and CapMetro provided data for fiscal year (FY 2020). The fleet data information, that each organization provided, and a consolidated spreadsheet of the three organization's fleet data is in Appendix A. Of note, no organization had collected annual idling hours on their fleet vehicles for CY or FY 2020. These Appendix A spreadsheets are provided in a zip folder as an attachment to this report.

APPENDIX B

Appendix B contains the individual DEQ runs for each organization, the consolidated DEQ run data by vehicle type per organization, and each organization's vehicle type emissions analysis. These Appendix B spreadsheets are provided in a zip folder as an attachment to this report.