DDC School Bus Replacement Project Completion Report
(August 20, 2019)

This School Bus Replacement Project Completion Report is submitted in accordance with the requirements of Paragraph 31 and Appendix A of the Consent Decree in *United States v. Detroit Diesel Corporation,* Case No. 16-1982 (D.D.C. Oct. 6, 2016) ("Consent Decree"). This report and its attachments provide information describing the mitigation Project undertaken and completed by Detroit Diesel Corporation ("DDC") to fulfill the requirements of Section V and Appendix A of the Consent Decree with respect to providing financial incentives to School Districts for the replacement of qualifying school buses.

A. <u>Section V and Appendix A Requirements</u>

1. Consent Decree Requirements

Under Paragraph 11.a. and Appendix A of the Consent Decree, DDC was required to implement a school bus replacement project under which school buses owned and operated by qualifying school districts with model year 2006 and older diesel engines were replaced with new clean diesel-, LNG-, or CNG-powered school buses. Specifically, Paragraph 11.a. required DDC to expend no less than $10,875,000 on a school bus replacement project, and Appendix A of the Consent Decree required DDC to "offer financial incentives to replace qualifying school buses powered by a 2006 Model Year or earlier diesel engine with Model Year 2013 or newer school buses certified by EPA or CARB." Consent Decree, App. A, ¶ 1. The Consent Decree defines "qualifying school bus" as:

a. a vehicle used for the purpose of transporting 31 of more preprimary, primary, or secondary students to schools or homes; and
b. That vehicle has accumulated at least 10,000 miles over the last 12 months prior to [DDC's] offer of a financial incentive, or has been in use for at least 3 days per week during the current school year, or the previous school year if [DDC] offers a financial incentive outside of any current school year.

Consent Decree, App. A, ¶ 2. The Consent Decree required DDC to offer financial incentives only to state or local government bodies ("School Districts") that met the below criteria:

a. the School District must have an enrollment of more than 500 students, based upon the number of children ages 5 to 17 years old as estimated in relevant United States Census Bureau data available to [DDC] as of the Effective Date [of the Consent Decree];
b. the School District must not provide school bus transportation solely through contracts with private entities; and
c. the School District must operate a fleet of vehicles that includes at least one qualifying school bus.

Consent Decree, App. A, ¶ 3. Finally, the Consent Decree required DDC to offer an average financial incentive of no more than 75% of the fair market value of a given school bus to replace qualifying school buses powered by model year 1997 or earlier diesel engines with new buses ("Tier A"). If DDC was unable to reach an agreement with enough qualifying School Districts to satisfy its obligations under the Consent Decree through Tier A replacements, the Consent Decree required DDC to offer an average financial incentive of no more than 50% of the fair market value of a given school bus to replace qualifying school buses powered by model year 2006 or earlier engines with new buses ("Tier B"). Consent Decree, App. A, ¶ 4.

2. EPA Approval of DDC School Bus Mitigation Project

Pursuant to Paragraphs 12 and 16 of the Consent Decree, DDC submitted its School Bus Mitigation Plan on April 18, 2017. In response to this submission, EPA e-mailed DDC's counsel on May 12, 2017, and requested additional information relating to DDC's School Bus Mitigation Plan. On May 31, 2017, DDC submitted its Supplemental School Bus Mitigation Plan addressing the questions raised and information requested by EPA in its May 12 e-mail. Thereafter, EPA notified DDC on June 29, 2017 that DDC's School Bus Mitigation Plan, as supplemented, had been approved by EPA.

3. Terms of Approved School Bus Replacement Program

DDC's school bus replacement program ("SBRP"), as approved by EPA on June 29, 2017, sought to replace school buses powered by model year 2006 or earlier engines owned and operated by school districts across the United States with new buses equipped with clean drive technologies that meet or exceed applicable EPA emissions standards. DDC's SBRP implementation plan targeted school buses that were twenty or more years old (i.e., those with model year 1997 or earlier engines). DDC's plan also offered financial incentives to School Districts in low-income areas, statistical metropolitan areas, or non-attainment areas in an effort to distribute the replacement buses throughout the United States and to ensure that the environmental benefits were localized where they were most needed and where they would be the most impactful.

B. Project Completion Report Requirements

1. Date of Project Completion

On June 21, 2019, DDC made its final payment to its corporate sibling and SBRP implementation partner, Thomas Built Buses ("TBB"), to reimburse TBB for payments made to TBB dealers for the financial incentives that the dealers provided to School Districts. On or before that date, DDC had received confirmation that all 287 replacement buses had been delivered to the appropriate end users and that the replaced buses had been destroyed.

2. Results and Documentation of Project Implementation

As described in the five Semi-Annual Progress Reports submitted to EPA in accordance with Appendix A of the Consent Decree, TBB developed a master list of potential School Districts to which the financial incentives could be offered, and DDC submitted the master list to EPA, as Exhibit A to the July 31, 2017 Semi-Annual Progress Report, in accordance with Appendix A, Paragraph 4.a, of the Consent Decree. TBB then undertook a review process with its independent franchised dealers throughout the United States, analyzing the master list to identify School Districts that met all of the qualifying criteria specified in Appendix A, Paragraphs 1 through 3, of the Consent Decree. TBB dealer sales staff contacted qualifying School Districts and solicited bus replacement agreements pursuant to the SBRP. Information relating to these contacts was provided in Exhibit A to each of the Semi-Annual Progress Reports—most recently the July 31, 2019 Semi-Annual Progress Report.

Under DDC's SBRP, 287 replacement school buses were delivered to qualifying School Districts, and documentation of the destruction of the replaced school buses was received. In all, replacement school buses were delivered to 78 School Districts across the United States, as shown in Table 1 below.

Table 1. School Districts Receiving Replacement School Buses

	State	School District
1	AL	Lowndes County
2	AL	Marion County
3	AL	Sylacauga City
4	AR	Alma Public Schools
5	AR	Clarksville Public Schools
6	AR	El Dorado Public Schools
7	AR	Harmony Grove Public Schools
8	AR	Jonesboro Public Schools
9	AR	Lamar Public Schools
10	AR	Ozark Public Schools
11	AR	Shirley Public Schools
12	AR	Springdale Public Schools
13	AR	Trumann Public Schools
14	AR	Valley View
15	CA	Alhambra USD
16	CA	Antelope Valley Union Joint
17	CA	Central Unified School District
18	CA	Cutten USD
19	CA	Enterprise Elementary
20	CA	Happy Valley Union Elm
21	CA	Hart-Ransom
22	CA	Imperial USD
23	CA	Ojai Unified
24	CA	Roseville Joint
25	CA	San Jose USD
26	CA	San Luis Coastal
27	CA	Shasta Union High
28	CA	Vista Unified
29	GA	Dougherty County Schools
30	GA	Habersham County
31	GA	Houston County Schools
32	GA	Rockdale County
33	IL	Berwyn South SD 100
34	KY	Ashland Independent Schools
35	KY	Barbourville Independent Schools
36	KY	Gallatin County Schools
37	KY	Harlan County Schools
38	KY	Hart County Schools
39	KY	Henderson County Schools

Table 1. School Districts Receiving Replacement School Buses		
	State	**School District**
40	KY	Knott County Schools
41	KY	Knox County Schools
42	KY	Lawrence County Schools
43	KY	Lee County
44	KY	Livingston County Schools
45	KY	Martin County Schools
46	KY	McCreary County Schools
47	KY	Muhlenberg County Schools
48	KY	Owsley County Schools
49	KY	Perry County
50	KY	Rowan County Schools
51	KY	Whitley County Schools
52	LA	Calcasieu Parish School Board
53	LA	Livingston Parish School Board
54	LA	Ouchita Parish School Board
55	LA	St. Martin Parish School Board
56	LA	Tangipahoa Parish School Board
57	LA	Washington Parish School System
58	MS	Holmes County Schools
59	MS	Koscuisko Schools
60	MS	Scott County Schools
61	MS	Vicksburg/Warren
62	MS	Wilkinson County
63	NV	Douglas County
64	NV	Pershing County School District
65	OR	Centennial School District
66	OR	Estacada School District
67	SC	Greenville County Schools
68	VA	Carroll County Public Schools
69	VA	Halifax County Public Schools
70	VA	Martinsville City Public Schools
71	VA	Mecklenburg County Public Schools
72	VA	Roanoke County Public Schools
73	VA	Tazewell County Public Schools
74	WA	Bethel School District
75	WA	Evergreen School District
76	WA	Highline School District
77	WA	Pasco School District
78	WI	Marion School District

As a result of the SBRP, 14 states received new diesel-, natural gas-, or propane-fueled buses to replace model year 1984 through 1998 buses. The geographic and model year distribution of the replacement buses is shown in Table 2 below.

Table 2. Number of Buses Replaced by State and Model Year

	State														
MY	**AL**	**AR**	**CA**	**GA**	**IL**	**KY**	**LA**	**MS**	**NV**	**OR**	**SC**	**VA**	**WA**	**WI**	**Total**
1984		4	1												5
1985			1												1
1986		1	1												2
1987			2												2
1988			4												4
1989			8			2						1			11
1990			2	2											4
1991		1	3	3			1			2			5		15
1992		3	2	4		5	1	7		1	2	4			29
1993		9	1	4		6	1								21
1994		4	5			7	2	1				3	1		23
1995		6	2	1		1	7	10	4		2	6	1		40
1996		7	3	4		9	17	5	1	3			8		57
1997	9	7	5	2	1	15	16	2				11	2	1	71
1998		2													2
Total	9	44	40	20	1	45	45	25	5	6	4	25	17	1	287

To measure the emissions benefits of the SBRP, DDC contracted with Air Improvement Resource, Inc. ("AIR"), an independent company providing engineering and consulting services regarding mobile and stationary source emissions modeling and technology evaluation. Table 3 below provides AIR's analysis of the annual and 5-year emissions benefits attributable to the SBRP by state (and in all states combined). The combined benefits for all states over a 5-year period are estimated to be: 49.24 tons CO, 20.78 tons NMHC, 227.14 tons NO_x, and 14.22 tons PM2.5. AIR's full report is attached as Exhibit A.

Table 2. Annual and 5-Year Benefits of School Bus Program (tons)					
State	**CY**	**CO**	**NMHC**	**NOx**	**PM2.5**
AL	2019	0.32	0.13	1.38	0.10
	2020	0.32	0.13	1.38	0.10
	2021	0.32	0.13	1.38	0.10
	2022	0.32	0.13	1.38	0.10
	2023	0.31	0.13	1.36	0.10
	Total	**1.58**	**0.65**	**6.88**	**0.49**
AR	2019	1.55	0.64	7.05	0.42
	2020	1.55	0.64	7.05	0.42
	2021	1.55	0.64	7.05	0.42
	2022	1.55	0.64	7.05	0.42
	2023	1.53	0.64	6.92	0.42
	Total	**7.73**	**3.19**	**35.10**	**2.09**
CA	2019	1.38	0.58	7.23	0.41
	2020	1.38	0.58	7.23	0.41
	2021	1.38	0.58	7.23	0.41
	2022	1.38	0.58	7.23	0.41
	2023	1.36	0.58	7.12	0.41
	Total	**6.89**	**2.90**	**36.05**	**2.04**
GA	2019	0.58	0.29	3.06	0.17
	2020	0.58	0.29	3.06	0.17
	2021	0.57	0.29	3.06	0.17
	2022	0.57	0.29	3.06	0.17
	2023	0.57	0.29	3.01	0.17
	Total	**2.87**	**1.44**	**15.24**	**0.85**
IL	2019	0.04	0.01	0.15	0.01
	2020	0.04	0.01	0.15	0.01
	2021	0.04	0.01	0.15	0.01
	2022	0.04	0.01	0.15	0.01
	2023	0.03	0.01	0.15	0.01
	Total	**0.18**	**0.07**	**0.76**	**0.05**
KY	2019	1.51	0.65	7.01	0.44
	2020	1.51	0.65	7.01	0.44
	2021	1.51	0.65	7.01	0.44
	2022	1.51	0.65	7.01	0.44
	2023	1.49	0.65	6.89	0.44
	Total	**7.52**	**3.26**	**34.93**	**2.22**
LA	2019	1.58	0.65	6.91	0.48
	2020	1.58	0.65	6.91	0.48
	2021	1.58	0.65	6.91	0.48
	2022	1.58	0.65	6.91	0.48
	2023	1.56	0.65	6.78	0.48
	Total	**7.90**	**3.26**	**34.40**	**2.39**
MS	2019	0.88	0.36	3.84	0.24
	2020	0.88	0.36	3.84	0.24
	2021	0.88	0.36	3.84	0.24

Table 2. Annual and 5-Year Benefits of School Bus Program (tons)					
State	**CY**	**CO**	**NMHC**	**NOx**	**PM2.5**
	2022	0.88	0.36	3.84	0.24
	2023	0.87	0.36	3.77	0.24
	Total	**4.39**	**1.81**	**19.11**	**1.22**
NV	2019	0.18	0.07	0.77	0.05
	2020	0.18	0.07	0.77	0.05
	2021	0.18	0.07	0.77	0.05
	2022	0.18	0.07	0.77	0.05
	2023	0.17	0.07	0.75	0.05
	Total	**0.88**	**0.36**	**3.82**	**0.27**
OR	2019	0.21	0.09	0.92	0.05
	2020	0.21	0.09	0.92	0.05
	2021	0.21	0.09	0.92	0.05
	2022	0.21	0.09	0.92	0.05
	2023	0.21	0.09	0.90	0.05
	Total	**1.05**	**0.43**	**4.59**	**0.26**
SC	2019	0.14	0.06	0.61	0.04
	2020	0.14	0.06	0.61	0.04
	2021	0.14	0.06	0.61	0.04
	2022	0.14	0.06	0.61	0.04
	2023	0.14	0.06	0.60	0.03
	Total	**0.70**	**0.29**	**3.06**	**0.18**
VA	2019	0.88	0.36	3.90	0.26
	2020	0.88	0.36	3.90	0.26
	2021	0.88	0.36	3.90	0.26
	2022	0.88	0.36	3.90	0.26
	2023	0.87	0.36	3.83	0.25
	Total	**4.39**	**1.81**	**19.43**	**1.28**
WA	2019	0.60	0.25	2.61	0.16
	2020	0.60	0.25	2.61	0.16
	2021	0.60	0.25	2.61	0.16
	2022	0.60	0.25	2.61	0.16
	2023	0.59	0.25	2.56	0.16
	Total	**2.99**	**1.23**	**13.00**	**0.82**
WI	2019	0.04	0.01	0.15	0.01
	2020	0.04	0.01	0.15	0.01
	2021	0.04	0.01	0.15	0.01
	2022	0.04	0.01	0.15	0.01
	2023	0.03	0.01	0.15	0.01
	Total	**0.18**	**0.07**	**0.76**	**0.05**
All	2019	9.87	4.16	45.58	2.85
	2020	9.87	4.16	45.58	2.85
	2021	9.87	4.16	45.58	2.85
	2022	9.87	4.16	45.58	2.85
	2023	9.75	4.14	44.80	2.83
	Total	**49.24**	**20.78**	**227.14**	**14.22**

3. Actual Project Dollars Incurred

DDC paid $10,880,634 in financial incentives toward school bus replacements under the SBRP. This amount exceeds the $10,875,000 that DDC was required by Paragraph 11.a. of the Consent Decree to expend on its school bus replacement Project.

4. Certification Statement

Please find the certification statement required by Paragraph 34 of the Consent Decree attached.

Certification Statement

Certification of School Bus Replacement Project Completion Report
as Required by Paragraph 34 of the Consent Decree in
***United States v. Detroit Diesel Corporation*, Case No. 16-1982 (D.D.C. Oct. 6, 2016)**

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I have no personal knowledge that the information submitted is other than true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

8/19/19
Date

[signature]
Brian Burton
Secretary
Detroit Diesel Corporation

EXHIBIT A

Emission Benefits of School Bus Replacement
August 16, 2019
AIR, Inc.

Introduction

In a Consent Decree negotiated between Detroit Diesel Corporation (DDC) and EPA, DDC was required to replace a number of school buses with new buses in the U.S. As a part of this effort, DDC must estimate the emission reductions associated with the older bus replacement using EPA's MOVES2014a model.

The MOVES2014a model was used to obtain the by-model-year and by-age emission factors for the older buses as well as the new MY2019 replacement buses. EPA requires the use of the MOVES2014a model to estimate such emissions.

This report prepared by Air Improvement Resource, Inc. describes the methods and results associated with this bus replacement program. AIR's qualifications for conducting this study are found in Attachment 1.

Method

Emissions evaluated are exhaust non-methane hydrocarbons (NMHC), carbon monoxide (CO), oxides of nitrogen (NOx), and exhaust particulate matter (PM2.5).

Per vehicle emission reductions are estimated with the following expression:

$ER = \Sigma_{yr=1,5}\ 10{,}000\ mi * (E_s - E_n),$

Where:

Σ = sum from years 1-5
ER = emission reduction in total grams (converted to pounds or tons as necessary)
E_s = emissions of scrapped bus in g/mi from MOVES2014a (1984-1998 model years)
E_n = emissions of new bus in g/mi from MOVES2014a (2019 model year)
10,000 mi = assumption of minimum annual miles of travel for each bus (from Consent Decree)

The Consent Decree indicates that DDC should replace buses that would have been kept by fleets for another 5 years. Further, buses should be replaced that travel a minimum of 10,000 miles per year, or at least 3 days per week during the school year. For these reasons, we are estimating the emission reductions assuming a 5-year remaining life for the older buses, and 10,000 miles per year.

E_s and E_n were generated by MOVES2014a by assuming the buses are placed in service at the start of calendar year 2019. The model was run in by-model-year mode for all calendar years from 1990 to 2023, inclusive. To account for the model's emissions adjustments for age, the model output was processed to generate a detailed by-model-year and by-age database. National average default inputs were used, and emissions were estimated annually.

According to DDC, 287 buses are being replaced. Their distributions by state and model year are shown in Table 1.

Table 1. Number of Buses Replaced by State and Model Year

	State														
MY	AL	AR	CA	GA	IL	KY	LA	MS	NV	OR	SC	VA	WA	WI	Total
1984		4	1												5
1985			1												1
1986		1	1												2
1987			2												2
1988			4												4
1989			8			2						1			11
1990			2	2											4
1991		1	3	3			1			2			5		15
1992		3	2	4		5	1	7		1	2	4			29
1993		9	1	4		6	1								21
1994		4	5			7	2	1				3	1		23
1995		6	2	1		1	7	10	4		2	6	1		40
1996		7	3	4		9	17	5	1	3			8		57
1997	9	7	5	2	1	15	16	2				11	2	1	71
1998		2													2
Total	9	44	40	20	1	45	45	25	5	6	4	25	17	1	287

Several buses were replaced with new buses equipped with either natural gas or propane-fueled engines. The MOVES2014 model contains emissions for natural gas fired engines used in transit buses, but not natural gas school buses or propane engines. Because of the likely similarity in emissions, the MOVES2014 emissions for natural gas transit bus engines were used for both natural gas and propane school buses.

Results

Results of the analysis of emissions by model year are shown in Attachment 2. The by-state, and all states combined, annual and 5-year emission benefits are shown in Table 2.

Table 2. Annual and 5-Year Benefits of School Bus Program (tons)

State	CY	CO	NMHC	NOx	PM2.5
AL	2019	0.32	0.13	1.38	0.10
	2020	0.32	0.13	1.38	0.10
	2021	0.32	0.13	1.38	0.10
	2022	0.32	0.13	1.38	0.10
	2023	0.31	0.13	1.36	0.10
	Total	1.58	0.65	6.88	0.49
AR	2019	1.55	0.64	7.05	0.42

	2020	1.55	0.64	7.05	0.42
	2021	1.55	0.64	7.05	0.42
	2022	1.55	0.64	7.05	0.42
	2023	1.53	0.64	6.92	0.42
	Total	7.73	3.19	35.10	2.09
CA	2019	1.38	0.58	7.23	0.41
	2020	1.38	0.58	7.23	0.41
	2021	1.38	0.58	7.23	0.41
	2022	1.38	0.58	7.23	0.41
	2023	1.36	0.58	7.12	0.41
	Total	6.89	2.90	36.05	2.04
GA	2019	0.58	0.29	3.06	0.17
	2020	0.58	0.29	3.06	0.17
	2021	0.57	0.29	3.06	0.17
	2022	0.57	0.29	3.06	0.17
	2023	0.57	0.29	3.01	0.17
	Total	2.87	1.44	15.24	0.85
IL	2019	0.04	0.01	0.15	0.01
	2020	0.04	0.01	0.15	0.01
	2021	0.04	0.01	0.15	0.01
	2022	0.04	0.01	0.15	0.01
	2023	0.03	0.01	0.15	0.01
	Total	0.18	0.07	0.76	0.05
KY	2019	1.51	0.65	7.01	0.44
	2020	1.51	0.65	7.01	0.44
	2021	1.51	0.65	7.01	0.44
	2022	1.51	0.65	7.01	0.44
	2023	1.49	0.65	6.89	0.44
	Total	7.52	3.26	34.93	2.22
LA	2019	1.58	0.65	6.91	0.48
	2020	1.58	0.65	6.91	0.48
	2021	1.58	0.65	6.91	0.48
	2022	1.58	0.65	6.91	0.48
	2023	1.56	0.65	6.78	0.48
	Total	7.90	3.26	34.40	2.39
MS	2019	0.88	0.36	3.84	0.24
	2020	0.88	0.36	3.84	0.24
	2021	0.88	0.36	3.84	0.24
	2022	0.88	0.36	3.84	0.24
	2023	0.87	0.36	3.77	0.24
	Total	4.39	1.81	19.11	1.22
NV	2019	0.18	0.07	0.77	0.05
	2020	0.18	0.07	0.77	0.05

	2021	0.18	0.07	0.77	0.05
	2022	0.18	0.07	0.77	0.05
	2023	0.17	0.07	0.75	0.05
	Total	0.88	0.36	3.82	0.27
OR	2019	0.21	0.09	0.92	0.05
	2020	0.21	0.09	0.92	0.05
	2021	0.21	0.09	0.92	0.05
	2022	0.21	0.09	0.92	0.05
	2023	0.21	0.09	0.90	0.05
	Total	1.05	0.43	4.59	0.26
SC	2019	0.14	0.06	0.61	0.04
	2020	0.14	0.06	0.61	0.04
	2021	0.14	0.06	0.61	0.04
	2022	0.14	0.06	0.61	0.04
	2023	0.14	0.06	0.60	0.03
	Total	0.70	0.29	3.06	0.18
VA	2019	0.88	0.36	3.90	0.26
	2020	0.88	0.36	3.90	0.26
	2021	0.88	0.36	3.90	0.26
	2022	0.88	0.36	3.90	0.26
	2023	0.87	0.36	3.83	0.25
	Total	4.39	1.81	19.43	1.28
WA	2019	0.60	0.25	2.61	0.16
	2020	0.60	0.25	2.61	0.16
	2021	0.60	0.25	2.61	0.16
	2022	0.60	0.25	2.61	0.16
	2023	0.59	0.25	2.56	0.16
	Total	2.99	1.23	13.00	0.82
WI	2019	0.04	0.01	0.15	0.01
	2020	0.04	0.01	0.15	0.01
	2021	0.04	0.01	0.15	0.01
	2022	0.04	0.01	0.15	0.01
	2023	0.03	0.01	0.15	0.01
	Total	0.18	0.07	0.76	0.05
All	2019	9.87	4.16	45.58	2.85
	2020	9.87	4.16	45.58	2.85
	2021	9.87	4.16	45.58	2.85
	2022	9.87	4.16	45.58	2.85
	2023	9.75	4.14	44.80	2.83
	Total	**49.24**	**20.78**	**227.14**	**14.22**

Attachment 1

Air Improvement Resource, Inc. Qualifications

AIR IMPROVEMENT RESOURCE, Inc. (AIR) was formed in 1994 to provide engineering and consulting services in the area of mobile and stationary source emissions modeling and technology evaluation. AIR provides expert services on a broad spectrum of projects to national and international industries, associations, legal firms and governmental agencies. AIR performs studies in the following areas:

- emission inventory modeling and analysis
- emission characterization, including the effect of fuel composition on emissions
- statistical analysis of emission data
- technology assessment
- analysis of fuel properties and the effects of different fuel properties on emissions
- development of fuel economy models and future fuel economy projections
- costs and cost-effectiveness of on-highway and off-highway vehicle engine/fuel-related emission regulatory controls
- health effects and exposure/risk assessment of air toxins analysis of ambient air data
- emissions and air quality trends analysis
- analysis of Inspection and Maintenance (I/M) programs and program data
- air quality plan development including U.S. State and Federal Implementation Plans
- greenhouse gas (GHG) emissions analysis and modeling

Thomas L. Darlington

President, Air Improvement Resource Inc.

Profile

Thomas L. Darlington is President of Air Improvement Resource, a company formed in 1994 specializing in mobile source emission modeling. He is an internationally recognized expert in mobile source emissions modeling, lifecycle analysis, and land use modeling.

Professional Experience

1994-Present	President, Air Improvement Resource
1993-1994	Director, Mobile Source Programs, Systems Application International
1989-1994	Senior Engineer, General Motors Corporation, Environmental Activities
1988-1989	Senior Project Engineer, Detroit Diesel Corporation
1979-1988	Project Manager, U.S. EPA, Ann Arbor, Michigan

Recent Major Projects

- Participating on behalf of Growth Energy in EPA's MOVES model development stakeholder meetings
- Creating a new emissions model for offroad equipment
- Currently publishing an Society of Automotive Engineers paper at SAE World Congress in 2017 (April 2017) on modeling GHG emission reductions with a high octane, low carbon biofuel (Minnesota Corn Growers and others)
- Published an SAE paper at the 2016 World Congress on our review of EPA's EPAct fuels testing and modeling (Growth Energy)
- Developed Life Cycle reports and complete applications for 8 plants for the California Low Carbon Fuel Standard
- Participated in and provided written comments on California's three 2014 Indirect Land Use (iLUC) workshops (Growth Energy)
- With Purdue University, conducted study of iLUC emissions of rapeseed and other oilseeds in 2013 utilizing an updated version of GTAP (European Biodiesel Board)
- Reviewed EPA's palm oil iLUC emissions in 2013 (NESTE)
- Submitted comments on ARB's new GREET2.0 model
- Reviewed CARB's land use emissions for soybean biodiesel

- Reviewed the land use impacts of the RFS2 from EPA, including the notice of Proposed Rule, Regulatory Impact Analysis, and approximately one hundred documents in the rulemaking docket.
- Completed a land use study for Renewable Fuels Association and reviewed California Air Resource Board's Initial Statement of Reasons for the Low Carbon Fuel Standard
- Represented three stakeholders in the recent development of the ARB Predictive Model for reformulated gasoline in California (Alliance of Automobile Manufacturers, Renewable Fuels Association and Western States Petroleum Association)
- Represented two stakeholders in EPA's development of the MOVES on-highway emissions model (Alliance of Automobile Manufacturers and Engine Manufacturers Association)
- Developed the effects of ethanol permeation on on-highway and off-highway mobile sources in California and other states for the American Petroleum Institute
- Studied gasoline and diesel fuel options for Southeast Michigan (for SEMCOG, API and Alliance of Automobile Manufacturers)

Recent Publications

Darlington, T., Herwick, G., Kahlbaum, D., and Drake, D., "Modeling the Impact of Reducing Vehicle Greenhouse Gas Emissions with High Compression Engines and High Octane Low Carbon Fuels," SAE 2017-01-0906, 2017, doi: 10.4271/2017-01-0906.

Darlington, T., Kahlbaum, D., Van Hulzen, S., and Furey, R., "Analysis of EPAct Emission Data Using T70 as an Additional Predictor of PM Emissions from Tier 2 Gasoline Vehicles", SAE Technical Paper 2016-01-0996, 2016, doi: 10.4271/2016-01-0996.

"Study of Transportation Fuel Life Cycle Analysis: Review of Economic Models Used to Assess Land Use Effects", CRC-E-88-3, July 2014.

"Land Use Change Greenhouse Gas Emissions of European Biofuel Policies Utilizing the Global Trade Analysis Project Model", Darlington, Kahlbaum, O'Connor, and Mueller, August 30, 2013.

"A Comparison of Corn Ethanol Lifecycle Analyses: California Low Carbon Fuels Standard (LCFS) Versus Renewable Fuels Standard (RFS2)", June 14, 2010. Renewable Fuels Association and Nebraska Corn Board. This study compared and contrasted the corn ethanol lifecycle analyses performed by both CARB (as a part of the LCFS) and the EPA (as a part of RFS2).

"Review of EPA's RFS2 Lifecycle Emissions Analysis for Corn Ethanol", September 25, 2009. Conducted for Renewable Fuels Association. This study reviewed EPA's land use GHG emissions assessment for corn ethanol, including the FASOM and FAPRI models and Winrock land-use types converted and emission factors by ecosystem type. The study made many recommendations for improving the land-use and emissions modeling.

"Review of CARB's Low Carbon Fuel Standard Proposal", April 15, 2009. Conducted for Renewable Fuels Association. This study reviewed CARB's analysis of land use emissions using GTAP6 and CARB's overall lifecycle emissions for corn ethanol. This study made many recommendations for improving the land use and lifecycle emissions of corn ethanol.

"Emission Benefits of a National Clean Gasoline", August 2008. Conducted for the Alliance of Automobile Manufacturers. This study evaluated the nationwide criteria pollutant emission reductions of a national clean gasoline standard.

"Land Use Effects of Corn-Based Ethanol", February 25, 2009. Conducted for Renewable Fuels Association. This study evaluates possible land use changes and GHG emissions associated with these land use changes as a result of the renewable fuel standard mandated 15 billion gallons of corn ethanol required by calendar year 2015. The study utilized projections of land use in the US and rest of world performed by Informa Economics, LLC, as well as newer estimates of the land use credits of co-products produced by ethanol plants to evaluate possible land use changes.

"On-Road NOx Emission Rates From 1994-2003 Heavy-Duty Trucks", SAE2008-01-1299, conducted for the Engine Manufacturers Association. This study examined manufacturers consent decree emissions data to determine on-road NOx emission rates, and deterioration in emissions from heavy-duty vehicles. (Peer reviewed publication)

"Evaluation of California Greenhouse Gas Standards and Federal Energy Independence and Security Act - Part 2: CO2 and GHG Impacts", SAE2008-01-1853, conducted for the Alliance of Automobile Manufacturers. This paper evaluated the comparison of greenhouse gases from cars and light trucks in the US under both the Federal and California GHG policies. (Peer reviewed publication)

"Effectiveness of the California Light Duty Vehicle Regulations as Compared to Federal Regulations", June 15, 2007. Conducted with NERA Economic Consulting and Sierra Research for The Alliance of Automobile Manufacturers. This study compares the emission benefits of the California and Federal light duty vehicle regulations for HC, CO, NOx, PM, SOx, and Toxics taking into account the difference in emission standards, new vehicle costs and its effect on fleet turnover, new vehicle fuel economy and its effect on vehicle miles traveled, and other factors. Both the EPA MOBILE6 and ARB EMFAC on-road emissions models were used to estimate changes in emissions inventories.

"The Case for a Dual Tech 4 Model Within the California Predictive Model", May 20, 2007. Conducted with ICF International and Transportation Fuels Consulting for the Renewable Fuels Association (RFA). This study developed separate emissions vs fuel property models for lower and higher Tech 4 (1986-1995) vehicles, and showed that utilizing this alternative Predictive Model would result in a higher compliance margin for fuels containing higher volumes of ethanol. It was thought that this could lead to higher ethanol concentrations in the state, but even if the dual model is not used, it is a better representation of the 2015 inventory than the ARB single model.

"Updated Final Report, Effects of Gasoline Ethanol Blends on Permeation Emissions Contribution to VOC Inventory From On-Road and Off-Road Sources, Inclusion of E-65 Phase 3 Data and Other Updates", June 20, 2007. Conducted for the American Petroleum Institute. This report updates the earlier March 3, 2005 report for API utilizing data collected by CRC and others since of the time of the earlier report.

Final Report, Development of Technical Information for a Regional Fuels Strategy, February 28, 2006. Conducted for the Lake Air Directors Consortium (LADCO). This report provided guidance to the LADCO states (Midwestern states) concerning how to model different types of fuel control programs (in particular) using EPA mobile source models, and how to set up the baseline input files so that results are consistent between the different states.

"Emission Reductions from Changes to Gasoline and Diesel Specifications and Diesel Engine Retrofits in the Southeast Michigan Area", February 23, 2005. Conducted for the Southeast Michigan Council of Governments (SEMCOG), the Alliance of Automobile Manufacturers, and the American Petroleum Institute. This study examined the on-road and off-road emission benefits of many different possible gasoline and diesel fuel specifications that the state could adopt to help meet the 8-hour ozone standards. This study formed the basis for the state's move to lower RVP summer gasoline.

"Examination of Temperature and RVP Effects on CO Emissions in EPA's Certification Database, Final Report", CRC Project No. E-74a, April 11, 2005. Conducted for the Coordinating Research Council. This study compared CO vs temperature results from the MOBILE6 model to the certification data, and recommended further testing, which is being conducted by the CRC at this time.

"Effects of Gasoline Ethanol Blends on Permeation Emissions Contribution to VOC Inventory From On-Road and Off-Road Sources" March 3, 2005. Conducted for the American Petroleum Institute (API). Using data from the CRC-E-65 program, and data collected by the California EPA and Federal EPA, this study estimated the impacts of ethanol use on increasing permeation VOC emissions from on-road vehicles, off-road equipment and vehicles, and from portable containers. Emission inventory estimates were made for a number of geographical areas including the state of California, and results showed that the permeation effect increases anthropogenic VOC inventories by 2-4%.

Review of EPA Report "A Comprehensive Analysis of Biodiesel Impacts on Exhaust Emissions", February 11, 2003. Conducted for the American Petroleum Institute. This study critically examined the methods that EPA used to develop the impacts of biodiesel fuels on HC, CO, NOx, and PM emissions.

"Well-To Wheels Analysis of Advanced Fuel/Vehicle Systems – A North American Study of Energy Use, Greenhouse Gas Emissions, and Criteria Pollutant Emissions", May 2005. Conducted for General Motors Corporation, with Argonne National Labs.

This study examined many different well to wheels pathways for various fuels, and their impacts on GHG and criteria pollutant emissions.

“Potential Delaware Air Emission Impacts of Switching From MTBE to Ethanol in the Reformulated Gasoline Program”, May 26, 2005. Conducted for Lyondell Chemical Company. This study examined the HC, CO, and NOx impacts of switching from MTBE to ethanol.

“Potential Massachusetts Air Emission Impacts of Switching From MTBE to Ethanol in the Reformulated Gasoline Program” June 17, 2005. Conducted for Lyondell Chemical Company. This study is similar to the Delaware study above.

“Potential Maryland Air Emission Impacts of a Ban on MTBE in the Reformulated Gasoline Program”, October 18, 2005. Conducted for Lyondell Chemical Company. This study is similar to the Delaware study above.

“MOBILE6.2C with Ethanol Permeation and Ethanol NOx Effects”, February 8, 2005. Conducted for Health Canada. This study modified the MOBILE6.2C model for ethanol permeation VOC and ethanol NOx effects.

Education

B. Sc., (Materials and Metallurgical Engineering), University of Michigan, Ann Arbor, 1979
Post Graduate Courses (Business Administration), University of Michigan, Ann Arbor, 1982

Attachment 2

MOVES2014a Emission Factors (EF)								
		Old Diesel Bus			New Diesel Bus			EF
Pollutant	Calendar Year	Model Year	Age	EF g/mi	Model Year	Age	EF g/mi	Reduction g/mi
CO	2019	1984	30	4.1863	2019	0	0.9930	3.1933
CO	2019	1985	30	4.1859	2019	0	0.9930	3.1929
CO	2019	1986	30	4.1856	2019	0	0.9930	3.1926
CO	2019	1987	30	4.1858	2019	0	0.9930	3.1928
CO	2019	1988	30	4.1866	2019	0	0.9930	3.1936
CO	2019	1989	30	4.1873	2019	0	0.9930	3.1943
CO	2019	1990	29	4.1873	2019	0	0.9930	3.1943
CO	2019	1991	28	4.1873	2019	0	0.9930	3.1943
CO	2019	1992	27	4.1873	2019	0	0.9930	3.1943
CO	2019	1993	26	4.1873	2019	0	0.9930	3.1943
CO	2019	1994	25	4.1873	2019	0	0.9930	3.1943
CO	2019	1995	24	4.1873	2019	0	0.9930	3.1943
CO	2019	1996	23	4.1873	2019	0	0.9930	3.1943
CO	2019	1997	22	4.1873	2019	0	0.9930	3.1943
CO	2019	1998	21	4.1873	2019	0	0.9930	3.1943
CO	2020	1984	30	4.1863	2019	1	0.9935	3.1928
CO	2020	1985	30	4.1859	2019	1	0.9935	3.1925
CO	2020	1986	30	4.1856	2019	1	0.9935	3.1921
CO	2020	1987	30	4.1858	2019	1	0.9935	3.1924
CO	2020	1988	30	4.1866	2019	1	0.9935	3.1931
CO	2020	1989	30	4.1873	2019	1	0.9935	3.1938
CO	2020	1990	30	4.1878	2019	1	0.9935	3.1943
CO	2020	1991	29	4.1878	2019	1	0.9935	3.1943
CO	2020	1992	28	4.1878	2019	1	0.9935	3.1943
CO	2020	1993	27	4.1878	2019	1	0.9935	3.1943
CO	2020	1994	26	4.1878	2019	1	0.9935	3.1943
CO	2020	1995	25	4.1878	2019	1	0.9935	3.1943
CO	2020	1996	24	4.1878	2019	1	0.9935	3.1943
CO	2020	1997	23	4.1877	2019	1	0.9935	3.1943
CO	2020	1998	22	4.1878	2019	1	0.9935	3.1943
CO	2021	1984	30	4.1863	2019	2	0.9940	3.1923
CO	2021	1985	30	4.1859	2019	2	0.9940	3.1920
CO	2021	1986	30	4.1856	2019	2	0.9940	3.1916
CO	2021	1987	30	4.1858	2019	2	0.9940	3.1919
CO	2021	1988	30	4.1866	2019	2	0.9940	3.1926
CO	2021	1989	30	4.1873	2019	2	0.9940	3.1933
CO	2021	1990	30	4.1878	2019	2	0.9940	3.1938
CO	2021	1991	30	4.1882	2019	2	0.9940	3.1943

CO	2021	1992	29	4.1883	2019	2	0.9940	3.1943
CO	2021	1993	28	4.1882	2019	2	0.9940	3.1943
CO	2021	1994	27	4.1883	2019	2	0.9940	3.1943
CO	2021	1995	26	4.1882	2019	2	0.9940	3.1943
CO	2021	1996	25	4.1882	2019	2	0.9940	3.1943
CO	2021	1997	24	4.1882	2019	2	0.9940	3.1942
CO	2021	1998	23	4.1882	2019	2	0.9940	3.1942
CO	2022	1984	30	4.1863	2019	3	0.9944	3.1919
CO	2022	1985	30	4.1859	2019	3	0.9944	3.1915
CO	2022	1986	30	4.1856	2019	3	0.9944	3.1912
CO	2022	1987	30	4.1858	2019	3	0.9944	3.1914
CO	2022	1988	30	4.1866	2019	3	0.9944	3.1922
CO	2022	1989	30	4.1873	2019	3	0.9944	3.1929
CO	2022	1990	30	4.1878	2019	3	0.9944	3.1934
CO	2022	1991	30	4.1882	2019	3	0.9944	3.1938
CO	2022	1992	30	4.1887	2019	3	0.9944	3.1943
CO	2022	1993	29	4.1887	2019	3	0.9944	3.1943
CO	2022	1994	28	4.1887	2019	3	0.9944	3.1943
CO	2022	1995	27	4.1887	2019	3	0.9944	3.1942
CO	2022	1996	26	4.1887	2019	3	0.9944	3.1943
CO	2022	1997	25	4.1887	2019	3	0.9944	3.1942
CO	2022	1998	24	4.1887	2019	3	0.9944	3.1942
CO	2023	1984	30	4.1863	2019	4	1.0348	3.1515
CO	2023	1985	30	4.1859	2019	4	1.0348	3.1511
CO	2023	1986	30	4.1856	2019	4	1.0348	3.1508
CO	2023	1987	30	4.1858	2019	4	1.0348	3.1510
CO	2023	1988	30	4.1866	2019	4	1.0348	3.1518
CO	2023	1989	30	4.1873	2019	4	1.0348	3.1525
CO	2023	1990	30	4.1878	2019	4	1.0348	3.1530
CO	2023	1991	30	4.1882	2019	4	1.0348	3.1534
CO	2023	1992	30	4.1887	2019	4	1.0348	3.1539
CO	2023	1993	30	4.1890	2019	4	1.0348	3.1542
CO	2023	1994	29	4.1890	2019	4	1.0348	3.1542
CO	2023	1995	28	4.1890	2019	4	1.0348	3.1542
CO	2023	1996	27	4.1890	2019	4	1.0348	3.1542
CO	2023	1997	26	4.1890	2019	4	1.0348	3.1542
CO	2023	1998	25	4.1890	2019	4	1.0348	3.1542
NMHC	2019	1984	30	1.3547	2019	0	0.0404	1.3143
NMHC	2019	1985	30	1.3546	2019	0	0.0404	1.3143
NMHC	2019	1986	30	1.3546	2019	0	0.0404	1.3143
NMHC	2019	1987	30	1.3546	2019	0	0.0404	1.3142
NMHC	2019	1988	30	1.3547	2019	0	0.0404	1.3143
NMHC	2019	1989	30	1.3547	2019	0	0.0404	1.3144
NMHC	2019	1990	29	1.3547	2019	0	0.0404	1.3143

NMHC	2019	1991	28	1.3547	2019	0	0.0404	1.3143
NMHC	2019	1992	27	1.3547	2019	0	0.0404	1.3143
NMHC	2019	1993	26	1.3547	2019	0	0.0404	1.3143
NMHC	2019	1994	25	1.3547	2019	0	0.0404	1.3143
NMHC	2019	1995	24	1.3547	2019	0	0.0404	1.3143
NMHC	2019	1996	23	1.3559	2019	0	0.0404	1.3155
NMHC	2019	1997	22	1.3559	2019	0	0.0404	1.3155
NMHC	2019	1998	21	1.3559	2019	0	0.0404	1.3155
NMHC	2020	1984	30	1.3547	2019	1	0.0404	1.3143
NMHC	2020	1985	30	1.3546	2019	1	0.0404	1.3143
NMHC	2020	1986	30	1.3546	2019	1	0.0404	1.3143
NMHC	2020	1987	30	1.3546	2019	1	0.0404	1.3142
NMHC	2020	1988	30	1.3547	2019	1	0.0404	1.3143
NMHC	2020	1989	30	1.3547	2019	1	0.0404	1.3143
NMHC	2020	1990	30	1.3547	2019	1	0.0404	1.3143
NMHC	2020	1991	29	1.3547	2019	1	0.0404	1.3143
NMHC	2020	1992	28	1.3547	2019	1	0.0404	1.3143
NMHC	2020	1993	27	1.3547	2019	1	0.0404	1.3143
NMHC	2020	1994	26	1.3547	2019	1	0.0404	1.3143
NMHC	2020	1995	25	1.3547	2019	1	0.0404	1.3143
NMHC	2020	1996	24	1.3559	2019	1	0.0404	1.3155
NMHC	2020	1997	23	1.3559	2019	1	0.0404	1.3155
NMHC	2020	1998	22	1.3559	2019	1	0.0404	1.3155
NMHC	2021	1984	30	1.3547	2019	2	0.0404	1.3143
NMHC	2021	1985	30	1.3546	2019	2	0.0404	1.3142
NMHC	2021	1986	30	1.3546	2019	2	0.0404	1.3142
NMHC	2021	1987	30	1.3546	2019	2	0.0404	1.3142
NMHC	2021	1988	30	1.3547	2019	2	0.0404	1.3143
NMHC	2021	1989	30	1.3547	2019	2	0.0404	1.3143
NMHC	2021	1990	30	1.3547	2019	2	0.0404	1.3143
NMHC	2021	1991	30	1.3548	2019	2	0.0404	1.3144
NMHC	2021	1992	29	1.3547	2019	2	0.0404	1.3143
NMHC	2021	1993	28	1.3547	2019	2	0.0404	1.3143
NMHC	2021	1994	27	1.3547	2019	2	0.0404	1.3143
NMHC	2021	1995	26	1.3548	2019	2	0.0404	1.3144
NMHC	2021	1996	25	1.3559	2019	2	0.0404	1.3155
NMHC	2021	1997	24	1.3560	2019	2	0.0404	1.3156
NMHC	2021	1998	23	1.3560	2019	2	0.0404	1.3156
NMHC	2022	1984	30	1.3547	2019	3	0.0404	1.3143
NMHC	2022	1985	30	1.3546	2019	3	0.0404	1.3142
NMHC	2022	1986	30	1.3546	2019	3	0.0404	1.3142
NMHC	2022	1987	30	1.3546	2019	3	0.0404	1.3142
NMHC	2022	1988	30	1.3547	2019	3	0.0404	1.3143
NMHC	2022	1989	30	1.3547	2019	3	0.0404	1.3143

NMHC	2022	1990	30	1.3547	2019	3	0.0404	1.3143
NMHC	2022	1991	30	1.3548	2019	3	0.0404	1.3143
NMHC	2022	1992	30	1.3548	2019	3	0.0404	1.3143
NMHC	2022	1993	29	1.3548	2019	3	0.0404	1.3143
NMHC	2022	1994	28	1.3548	2019	3	0.0404	1.3144
NMHC	2022	1995	27	1.3548	2019	3	0.0404	1.3144
NMHC	2022	1996	26	1.3560	2019	3	0.0404	1.3156
NMHC	2022	1997	25	1.3560	2019	3	0.0404	1.3156
NMHC	2022	1998	24	1.3560	2019	3	0.0404	1.3156
NMHC	2023	1984	30	1.3547	2019	4	0.0447	1.3100
NMHC	2023	1985	30	1.3546	2019	4	0.0447	1.3099
NMHC	2023	1986	30	1.3546	2019	4	0.0447	1.3099
NMHC	2023	1987	30	1.3546	2019	4	0.0447	1.3099
NMHC	2023	1988	30	1.3547	2019	4	0.0447	1.3100
NMHC	2023	1989	30	1.3547	2019	4	0.0447	1.3100
NMHC	2023	1990	30	1.3547	2019	4	0.0447	1.3100
NMHC	2023	1991	30	1.3548	2019	4	0.0447	1.3100
NMHC	2023	1992	30	1.3548	2019	4	0.0447	1.3100
NMHC	2023	1993	30	1.3548	2019	4	0.0447	1.3100
NMHC	2023	1994	29	1.3548	2019	4	0.0447	1.3100
NMHC	2023	1995	28	1.3548	2019	4	0.0447	1.3100
NMHC	2023	1996	27	1.3560	2019	4	0.0447	1.3112
NMHC	2023	1997	26	1.3560	2019	4	0.0447	1.3112
NMHC	2023	1998	25	1.3560	2019	4	0.0447	1.3113
NOx	2019	1984	30	20.2726	2019	0	0.6134	19.6593
NOx	2019	1985	30	20.2726	2019	0	0.6134	19.6592
NOx	2019	1986	30	20.2726	2019	0	0.6134	19.6592
NOx	2019	1987	30	20.2726	2019	0	0.6134	19.6592
NOx	2019	1988	30	20.2726	2019	0	0.6134	19.6592
NOx	2019	1989	30	20.2726	2019	0	0.6134	19.6593
NOx	2019	1990	29	15.6570	2019	0	0.6134	15.0436
NOx	2019	1991	28	14.5353	2019	0	0.6134	13.9219
NOx	2019	1992	27	14.5353	2019	0	0.6134	13.9219
NOx	2019	1993	26	14.5353	2019	0	0.6134	13.9219
NOx	2019	1994	25	14.5353	2019	0	0.6134	13.9219
NOx	2019	1995	24	14.5353	2019	0	0.6134	13.9219
NOx	2019	1996	23	14.5353	2019	0	0.6134	13.9219
NOx	2019	1997	22	14.5353	2019	0	0.6134	13.9219
NOx	2019	1998	21	13.4691	2019	0	0.6134	12.8557
NOx	2020	1984	30	20.2726	2019	1	0.6134	19.6593
NOx	2020	1985	30	20.2726	2019	1	0.6134	19.6592
NOx	2020	1986	30	20.2726	2019	1	0.6134	19.6592
NOx	2020	1987	30	20.2726	2019	1	0.6134	19.6592
NOx	2020	1988	30	20.2726	2019	1	0.6134	19.6592

NOx	2020	1989	30	20.2726	2019	1	0.6134	19.6593
NOx	2020	1990	30	15.6570	2019	1	0.6134	15.0437
NOx	2020	1991	29	14.5353	2019	1	0.6134	13.9219
NOx	2020	1992	28	14.5353	2019	1	0.6134	13.9219
NOx	2020	1993	27	14.5353	2019	1	0.6134	13.9219
NOx	2020	1994	26	14.5353	2019	1	0.6134	13.9219
NOx	2020	1995	25	14.5353	2019	1	0.6134	13.9219
NOx	2020	1996	24	14.5353	2019	1	0.6134	13.9219
NOx	2020	1997	23	14.5353	2019	1	0.6134	13.9219
NOx	2020	1998	22	13.4691	2019	1	0.6134	12.8558
NOx	2021	1984	30	20.2726	2019	2	0.6134	19.6593
NOx	2021	1985	30	20.2726	2019	2	0.6134	19.6592
NOx	2021	1986	30	20.2726	2019	2	0.6134	19.6592
NOx	2021	1987	30	20.2726	2019	2	0.6134	19.6592
NOx	2021	1988	30	20.2726	2019	2	0.6134	19.6592
NOx	2021	1989	30	20.2726	2019	2	0.6134	19.6593
NOx	2021	1990	30	15.6570	2019	2	0.6134	15.0437
NOx	2021	1991	30	14.5353	2019	2	0.6134	13.9219
NOx	2021	1992	29	14.5353	2019	2	0.6134	13.9219
NOx	2021	1993	28	14.5353	2019	2	0.6134	13.9219
NOx	2021	1994	27	14.5353	2019	2	0.6134	13.9219
NOx	2021	1995	26	14.5353	2019	2	0.6134	13.9219
NOx	2021	1996	25	14.5353	2019	2	0.6134	13.9219
NOx	2021	1997	24	14.5353	2019	2	0.6134	13.9219
NOx	2021	1998	23	13.4691	2019	2	0.6134	12.8557
NOx	2022	1984	30	20.2726	2019	3	0.6134	19.6593
NOx	2022	1985	30	20.2726	2019	3	0.6134	19.6592
NOx	2022	1986	30	20.2726	2019	3	0.6134	19.6592
NOx	2022	1987	30	20.2726	2019	3	0.6134	19.6592
NOx	2022	1988	30	20.2726	2019	3	0.6134	19.6592
NOx	2022	1989	30	20.2726	2019	3	0.6134	19.6593
NOx	2022	1990	30	15.6570	2019	3	0.6134	15.0437
NOx	2022	1991	30	14.5353	2019	3	0.6134	13.9219
NOx	2022	1992	30	14.5353	2019	3	0.6134	13.9219
NOx	2022	1993	29	14.5353	2019	3	0.6134	13.9219
NOx	2022	1994	28	14.5353	2019	3	0.6134	13.9219
NOx	2022	1995	27	14.5353	2019	3	0.6134	13.9219
NOx	2022	1996	26	14.5353	2019	3	0.6134	13.9219
NOx	2022	1997	25	14.5353	2019	3	0.6134	13.9219
NOx	2022	1998	24	13.4691	2019	3	0.6134	12.8557
NOx	2023	1984	30	20.2726	2019	4	0.8674	19.4052
NOx	2023	1985	30	20.2726	2019	4	0.8674	19.4052
NOx	2023	1986	30	20.2726	2019	4	0.8674	19.4052
NOx	2023	1987	30	20.2726	2019	4	0.8674	19.4052

NOx	2023	1988	30	20.2726	2019	4	0.8674	19.4052
NOx	2023	1989	30	20.2726	2019	4	0.8674	19.4052
NOx	2023	1990	30	15.6570	2019	4	0.8674	14.7896
NOx	2023	1991	30	14.5353	2019	4	0.8674	13.6679
NOx	2023	1992	30	14.5353	2019	4	0.8674	13.6679
NOx	2023	1993	30	14.5353	2019	4	0.8674	13.6679
NOx	2023	1994	29	14.5353	2019	4	0.8674	13.6679
NOx	2023	1995	28	14.5353	2019	4	0.8674	13.6679
NOx	2023	1996	27	14.5353	2019	4	0.8674	13.6679
NOx	2023	1997	26	14.5353	2019	4	0.8674	13.6679
NOx	2023	1998	25	13.4691	2019	4	0.8674	12.6017
PM2.5	2019	1984	30	1.0856	2019	0	0.0095	1.0761
PM2.5	2019	1985	30	1.0856	2019	0	0.0095	1.0761
PM2.5	2019	1986	30	1.0856	2019	0	0.0095	1.0761
PM2.5	2019	1987	30	1.0857	2019	0	0.0095	1.0762
PM2.5	2019	1988	30	0.9546	2019	0	0.0095	0.9451
PM2.5	2019	1989	30	0.9546	2019	0	0.0095	0.9451
PM2.5	2019	1990	29	0.9546	2019	0	0.0095	0.9451
PM2.5	2019	1991	28	0.6109	2019	0	0.0095	0.6014
PM2.5	2019	1992	27	0.6109	2019	0	0.0095	0.6014
PM2.5	2019	1993	26	0.6109	2019	0	0.0095	0.6014
PM2.5	2019	1994	25	1.0017	2019	0	0.0095	0.9922
PM2.5	2019	1995	24	1.0017	2019	0	0.0095	0.9922
PM2.5	2019	1996	23	1.0017	2019	0	0.0095	0.9922
PM2.5	2019	1997	22	1.0017	2019	0	0.0095	0.9922
PM2.5	2019	1998	21	0.4745	2019	0	0.0095	0.4650
PM2.5	2020	1984	30	1.0856	2019	1	0.0095	1.0761
PM2.5	2020	1985	30	1.0856	2019	1	0.0095	1.0761
PM2.5	2020	1986	30	1.0856	2019	1	0.0095	1.0761
PM2.5	2020	1987	30	1.0857	2019	1	0.0095	1.0762
PM2.5	2020	1988	30	0.9546	2019	1	0.0095	0.9451
PM2.5	2020	1989	30	0.9546	2019	1	0.0095	0.9451
PM2.5	2020	1990	30	0.9546	2019	1	0.0095	0.9451
PM2.5	2020	1991	29	0.6109	2019	1	0.0095	0.6014
PM2.5	2020	1992	28	0.6109	2019	1	0.0095	0.6014
PM2.5	2020	1993	27	0.6109	2019	1	0.0095	0.6014
PM2.5	2020	1994	26	1.0017	2019	1	0.0095	0.9922
PM2.5	2020	1995	25	1.0017	2019	1	0.0095	0.9922
PM2.5	2020	1996	24	1.0017	2019	1	0.0095	0.9922
PM2.5	2020	1997	23	1.0017	2019	1	0.0095	0.9922
PM2.5	2020	1998	22	0.4745	2019	1	0.0095	0.4650
PM2.5	2021	1984	30	1.0856	2019	2	0.0095	1.0761
PM2.5	2021	1985	30	1.0856	2019	2	0.0095	1.0761
PM2.5	2021	1986	30	1.0856	2019	2	0.0095	1.0761

PM2.5	2021	1987	30	1.0857	2019	2	0.0095	1.0762
PM2.5	2021	1988	30	0.9546	2019	2	0.0095	0.9451
PM2.5	2021	1989	30	0.9546	2019	2	0.0095	0.9451
PM2.5	2021	1990	30	0.9546	2019	2	0.0095	0.9451
PM2.5	2021	1991	30	0.6109	2019	2	0.0095	0.6014
PM2.5	2021	1992	29	0.6109	2019	2	0.0095	0.6014
PM2.5	2021	1993	28	0.6109	2019	2	0.0095	0.6014
PM2.5	2021	1994	27	1.0017	2019	2	0.0095	0.9922
PM2.5	2021	1995	26	1.0017	2019	2	0.0095	0.9922
PM2.5	2021	1996	25	1.0017	2019	2	0.0095	0.9922
PM2.5	2021	1997	24	1.0017	2019	2	0.0095	0.9922
PM2.5	2021	1998	23	0.4745	2019	2	0.0095	0.4650
PM2.5	2022	1984	30	1.0856	2019	3	0.0095	1.0761
PM2.5	2022	1985	30	1.0856	2019	3	0.0095	1.0761
PM2.5	2022	1986	30	1.0856	2019	3	0.0095	1.0761
PM2.5	2022	1987	30	1.0857	2019	3	0.0095	1.0762
PM2.5	2022	1988	30	0.9546	2019	3	0.0095	0.9451
PM2.5	2022	1989	30	0.9546	2019	3	0.0095	0.9451
PM2.5	2022	1990	30	0.9546	2019	3	0.0095	0.9451
PM2.5	2022	1991	30	0.6109	2019	3	0.0095	0.6014
PM2.5	2022	1992	30	0.6109	2019	3	0.0095	0.6014
PM2.5	2022	1993	29	0.6109	2019	3	0.0095	0.6014
PM2.5	2022	1994	28	1.0017	2019	3	0.0095	0.9922
PM2.5	2022	1995	27	1.0017	2019	3	0.0095	0.9922
PM2.5	2022	1996	26	1.0017	2019	3	0.0095	0.9922
PM2.5	2022	1997	25	1.0017	2019	3	0.0095	0.9922
PM2.5	2022	1998	24	0.4745	2019	3	0.0095	0.4650
PM2.5	2023	1984	30	1.0856	2019	4	0.0140	1.0716
PM2.5	2023	1985	30	1.0856	2019	4	0.0140	1.0717
PM2.5	2023	1986	30	1.0856	2019	4	0.0140	1.0717
PM2.5	2023	1987	30	1.0857	2019	4	0.0140	1.0717
PM2.5	2023	1988	30	0.9546	2019	4	0.0140	0.9406
PM2.5	2023	1989	30	0.9546	2019	4	0.0140	0.9406
PM2.5	2023	1990	30	0.9546	2019	4	0.0140	0.9406
PM2.5	2023	1991	30	0.6109	2019	4	0.0140	0.5969
PM2.5	2023	1992	30	0.6109	2019	4	0.0140	0.5969
PM2.5	2023	1993	30	0.6109	2019	4	0.0140	0.5969
PM2.5	2023	1994	29	1.0017	2019	4	0.0140	0.9877
PM2.5	2023	1995	28	1.0017	2019	4	0.0140	0.9877
PM2.5	2023	1996	27	1.0017	2019	4	0.0140	0.9877
PM2.5	2023	1997	26	1.0017	2019	4	0.0140	0.9877
PM2.5	2023	1998	25	0.4745	2019	4	0.0140	0.4606

MOVES2014a Emission Factors (EF)								
		Old Diesel Bus			New CNG Bus			EF Reduction g/mi
Pollutant	Calendar Year	Model Year	Age	EF g/mi	Model Year	Age	EF g/mi	
CO	2019	1990	29	4.1873	2019	0	3.3295	0.8578
CO	2019	1991	28	4.1873	2019	0	3.3295	0.8578
CO	2019	1997	22	4.1873	2019	0	3.3295	0.8578
CO	2020	1990	30	4.1878	2019	1	3.3353	0.8525
CO	2020	1991	29	4.1878	2019	1	3.3353	0.8525
CO	2020	1997	23	4.1877	2019	1	3.3353	0.8525
CO	2021	1990	30	4.1878	2019	2	3.3412	0.8466
CO	2021	1991	30	4.1882	2019	2	3.3412	0.8470
CO	2021	1997	24	4.1882	2019	2	3.3412	0.8470
CO	2022	1990	30	4.1878	2019	3	3.3475	0.8403
CO	2022	1991	30	4.1882	2019	3	3.3475	0.8407
CO	2022	1997	25	4.1887	2019	3	3.3475	0.8411
CO	2023	1990	30	4.1878	2019	4	3.3539	0.8339
CO	2023	1991	30	4.1882	2019	4	3.3539	0.8343
CO	2023	1997	26	4.1890	2019	4	3.3539	0.8350
NMHC	2019	1990	29	1.3547	2019	0	0.0621	1.2926
NMHC	2019	1991	28	1.3547	2019	0	0.0621	1.2926
NMHC	2019	1997	22	1.3559	2019	0	0.0621	1.2938
NMHC	2020	1990	30	1.3547	2019	1	0.0621	1.2926
NMHC	2020	1991	29	1.3547	2019	1	0.0621	1.2926
NMHC	2020	1997	23	1.3559	2019	1	0.0621	1.2938
NMHC	2021	1990	30	1.3547	2019	2	0.0621	1.2926
NMHC	2021	1991	30	1.3548	2019	2	0.0621	1.2926
NMHC	2021	1997	24	1.3560	2019	2	0.0621	1.2939
NMHC	2022	1990	30	1.3547	2019	3	0.0621	1.2926
NMHC	2022	1991	30	1.3548	2019	3	0.0621	1.2926
NMHC	2022	1997	25	1.3560	2019	3	0.0621	1.2939
NMHC	2023	1990	30	1.3547	2019	4	0.0621	1.2926
NMHC	2023	1991	30	1.3548	2019	4	0.0621	1.2926
NMHC	2023	1997	26	1.3560	2019	4	0.0621	1.2939
NOx	2019	1990	29	15.6570	2019	0	1.2944	14.3626
NOx	2019	1991	28	14.5353	2019	0	1.2944	13.2409
NOx	2019	1997	22	14.5353	2019	0	1.2944	13.2409
NOx	2020	1990	30	15.6570	2019	1	1.2944	14.3627
NOx	2020	1991	29	14.5353	2019	1	1.2944	13.2409
NOx	2020	1997	23	14.5353	2019	1	1.2944	13.2409
NOx	2021	1990	30	15.6570	2019	2	1.2944	14.3627
NOx	2021	1991	30	14.5353	2019	2	1.2944	13.2409
NOx	2021	1997	24	14.5353	2019	2	1.2944	13.2409
NOx	2022	1990	30	15.6570	2019	3	1.2944	14.3627

NOx	2022	1991	30	14.5353	2019	3	1.2944	13.2409
NOx	2022	1997	25	14.5353	2019	3	1.2944	13.2409
NOx	2023	1990	30	15.6570	2019	4	1.2944	14.3627
NOx	2023	1991	30	14.5353	2019	4	1.2944	13.2409
NOx	2023	1997	26	14.5353	2019	4	1.2944	13.2409
PM2.5	2019	1990	29	0.9546	2019	0	0.0014	0.9532
PM2.5	2019	1991	28	0.6109	2019	0	0.0014	0.6095
PM2.5	2019	1997	22	1.0017	2019	0	0.0014	1.0003
PM2.5	2020	1990	30	0.9546	2019	1	0.0014	0.9532
PM2.5	2020	1991	29	0.6109	2019	1	0.0014	0.6095
PM2.5	2020	1997	23	1.0017	2019	1	0.0014	1.0003
PM2.5	2021	1990	30	0.9546	2019	2	0.0014	0.9532
PM2.5	2021	1991	30	0.6109	2019	2	0.0014	0.6095
PM2.5	2021	1997	24	1.0017	2019	2	0.0014	1.0003
PM2.5	2022	1990	30	0.9546	2019	3	0.0014	0.9532
PM2.5	2022	1991	30	0.6109	2019	3	0.0014	0.6095
PM2.5	2022	1997	25	1.0017	2019	3	0.0014	1.0003
PM2.5	2023	1990	30	0.9546	2019	4	0.0022	0.9524
PM2.5	2023	1991	30	0.6109	2019	4	0.0022	0.6088
PM2.5	2023	1997	26	1.0017	2019	4	0.0022	0.9995

MOVES2014a Emission Factors (EF)								
		Old Diesel Bus			New Propane Bus			EF Reduction g/mi
Pollutant	Calendar Year	Model Year	Age	EF g/mi	Model Year	Age	EF g/mi	
CO	2019	1993	26	4.1873	2019	0	3.3295	0.8578
CO	2019	1996	23	4.1873	2019	0	3.3295	0.8578
CO	2019	1997	22	4.1873	2019	0	3.3295	0.8578
CO	2020	1993	27	4.1878	2019	1	3.3353	0.8525
CO	2020	1996	24	4.1878	2019	1	3.3353	0.8525
CO	2020	1997	23	4.1877	2019	1	3.3353	0.8525
CO	2021	1993	28	4.1882	2019	2	3.3412	0.8471
CO	2021	1996	25	4.1882	2019	2	3.3412	0.8470
CO	2021	1997	24	4.1882	2019	2	3.3412	0.8470
CO	2022	1993	29	4.1887	2019	3	3.3475	0.8412
CO	2022	1996	26	4.1887	2019	3	3.3475	0.8412
CO	2022	1997	25	4.1887	2019	3	3.3475	0.8411
CO	2023	1993	30	4.1890	2019	4	3.3539	0.8351
CO	2023	1996	27	4.1890	2019	4	3.3539	0.8351
CO	2023	1997	26	4.1890	2019	4	3.3539	0.8350
NMHC	2019	1993	26	1.3547	2019	0	0.0621	1.2926
NMHC	2019	1996	23	1.3559	2019	0	0.0621	1.2938
NMHC	2019	1997	22	1.3559	2019	0	0.0621	1.2938
NMHC	2020	1993	27	1.3547	2019	1	0.0621	1.2926
NMHC	2020	1996	24	1.3559	2019	1	0.0621	1.2938
NMHC	2020	1997	23	1.3559	2019	1	0.0621	1.2938
NMHC	2021	1993	28	1.3547	2019	2	0.0621	1.2926
NMHC	2021	1996	25	1.3559	2019	2	0.0621	1.2938
NMHC	2021	1997	24	1.3560	2019	2	0.0621	1.2939
NMHC	2022	1993	29	1.3548	2019	3	0.0621	1.2926
NMHC	2022	1996	26	1.3560	2019	3	0.0621	1.2938
NMHC	2022	1997	25	1.3560	2019	3	0.0621	1.2939
NMHC	2023	1993	30	1.3548	2019	4	0.0621	1.2926
NMHC	2023	1996	27	1.3560	2019	4	0.0621	1.2938
NMHC	2023	1997	26	1.3560	2019	4	0.0621	1.2939
NOx	2019	1993	26	14.5353	2019	0	1.2944	13.2409
NOx	2019	1996	23	14.5353	2019	0	1.2944	13.2409
NOx	2019	1997	22	14.5353	2019	0	1.2944	13.2409
NOx	2020	1993	27	14.5353	2019	1	1.2944	13.2409
NOx	2020	1996	24	14.5353	2019	1	1.2944	13.2409
NOx	2020	1997	23	14.5353	2019	1	1.2944	13.2409
NOx	2021	1993	28	14.5353	2019	2	1.2944	13.2409
NOx	2021	1996	25	14.5353	2019	2	1.2944	13.2409
NOx	2021	1997	24	14.5353	2019	2	1.2944	13.2409
NOx	2022	1993	29	14.5353	2019	3	1.2944	13.2409

NOx	2022	1996	26	14.5353	2019	3	1.2944	13.2409
NOx	2022	1997	25	14.5353	2019	3	1.2944	13.2409
NOx	2023	1993	30	14.5353	2019	4	1.2944	13.2410
NOx	2023	1996	27	14.5353	2019	4	1.2944	13.2409
NOx	2023	1997	26	14.5353	2019	4	1.2944	13.2409
PM2.5	2019	1993	26	0.6109	2019	0	0.0014	0.6095
PM2.5	2019	1996	23	1.0017	2019	0	0.0014	1.0003
PM2.5	2019	1997	22	1.0017	2019	0	0.0014	1.0003
PM2.5	2020	1993	27	0.6109	2019	1	0.0014	0.6095
PM2.5	2020	1996	24	1.0017	2019	1	0.0014	1.0003
PM2.5	2020	1997	23	1.0017	2019	1	0.0014	1.0003
PM2.5	2021	1993	28	0.6109	2019	2	0.0014	0.6095
PM2.5	2021	1996	25	1.0017	2019	2	0.0014	1.0003
PM2.5	2021	1997	24	1.0017	2019	2	0.0014	1.0003
PM2.5	2022	1993	29	0.6109	2019	3	0.0014	0.6095
PM2.5	2022	1996	26	1.0017	2019	3	0.0014	1.0003
PM2.5	2022	1997	25	1.0017	2019	3	0.0014	1.0003
PM2.5	2023	1993	30	0.6109	2019	4	0.0022	0.6088
PM2.5	2023	1996	27	1.0017	2019	4	0.0022	0.9995
PM2.5	2023	1997	26	1.0017	2019	4	0.0022	0.9995