APPENDIX D

TABLES FOR EMISSION REDUCTION AND COST-EFFECTIVENESS CALCULATIONS

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TABLES FOR EMISSION REDUCTION AND COST-EFFECTIVENESS CALCULATIONS

This appendix presents tables summarizing the data needed to calculate the emission reductions and cost-effectiveness of potential projects. Included are data such as engine emission factors, load factors, and other conversion factors used in the calculations discussed in Appendix C: Cost-Effectiveness Calculation Methodology.

	Table #
Heavy-Duty On-Road Projects	D-01 to D-08
Emergency Vehicles	D-09
Off-Road Diesel and Non-Mobile Agricultural (Ag) Projects	D-10 to D-14
Large Spark-Ignition (LSI) Projects	D-15 to D-18
Locomotive Projects	D-19 to D-21
Marine Projects	D-22 to D-27
All Engines – Fuel Consumption	D-28
Reference Tables	D-29

Table D-1a
Heavy Heavy-Duty Diesel Engines
Converted Emission Standards

Excutive Order (EO) Certification Level	Grams per brake horsepower-hour (g/bhp-hr)[a]			Grams per mile (g/mile)[b]			Grams per gallon (g/gal)[c]		
Oxides of Nitrogen (NOx) + Nonmethand Hydrocarbons (NMHC)	Diesel NOx	Diesel Reactive Organic Gases (ROG)	Alternative Fuel NOx	Diesel NOx	Diesel ROG	Alternative Fuel NOx	Diesel NOx	Diesel ROG	Alternative Fuel NOx
2.5[d]	2.21	0.09	2.00	6.41	0.26	5.80	40.86	1.67	37.00
1.2[e]	1.06	0.04	0.96	3.07	0.13	2.78	19.61	1.11	17.76
0.2[f]	0.18	0.01	0.16	0.51	0.02	0.46	3.27	0.13	2.96
Particulate Matter (PM) 10	**Diesel PM10**		**Alternative Fuel PM10**	**Diesel PM10**		**Alternative Fuel PM10**	**Diesel PM10**		**Alternative Fuel PM10**
0.01[g]	0.008		0.010	All Except Urban Bus			0.15		0.19
				0.023		0.029			
				Urban Bus					
				0.032		0.040			

a - Emission standards were converted where appropriate, using the NMHC and NOx fraction default values and the ultra low-sulfur diesel fuel correction factors listed in Tables D-25 and D-26, respectively.
b - Mileage based emissions factors were calculated using conversion factors from Table D-28.
c - Fuel based emissions factors were calculated using fuel consumption rate factors from Table D-24.
d - 2004 – 2006 emission standard for all on-road heavy-duty engines except diesel urban buses.
e - 2007 – 2009 emission standard for all on-road heavy-duty engines.
f - 2010+ emission standard for all on-road heavy-duty engines.
g - 2007+ emission standard for all on-road heavy-duty engines.

Table D-1b
Medium Heavy-Duty Diesel Engines 2007-2010
Converted Emission Standards

EO Certification Level	g/bhp-hr[a]			g/mile[b]			g/gal[c]		
NOx + NMHC	**Diesel NOx**	**Diesel ROG**	**Alternative Fuel NOx**	**Diesel NOx**	**Diesel ROG**	**Alternative Fuel NOx**	**Diesel NOx**	**Diesel ROG**	**Alternative Fuel NOx**
2.5[d]	2.21	0.09	2.00	3.98	0.16	3.60	40.86	1.67	37.00
1.2[e]	1.06	0.06	0.96	1.91	0.11	1.73	19.61	1.11	17.76
0.2[f]	0.18	0.01	0.16	0.32	0.01	0.29	3.27	0.13	2.96
PM10	**Diesel PM10**		**Alternative Fuel PM10**	**Diesel PM10**		**Alternative Fuel PM10**	**Diesel PM10**		**Alternative Fuel PM10**
0.01[g]	0.008		0.010	All Except Urban Bus			0.15		0.19
				0.014		0.018			
				Urban Bus					
				0.032		0.040			

a - Emission standards were converted where appropriate, using the NMHC and NOx fraction default values and the ultra low-sulfur diesel fuel correction factors listed in Tables D-25 and D-26, respectively.
b - Mileage based emissions factors were calculated using conversion factors from Table D-28.
c - Fuel based emissions factors were calculated using fuel consumption rate factors from Table D-24.
d - 2007 – 2009 emission standard for all on-road heavy-duty engines.
e - 2010+ emission standard for all on-road heavy-duty engines.
f - 2007+ emission standard for all on-road heavy-duty engines.

Table D-2a
Medium Heavy-Duty Alternative Fuel Engines
Converted Emission Standards

Model Year	g/bhp-hr		g/mile[a]		g/gal[b,c]	
	NOx	**PM10**	**NOx**	**PM10**	**NOx**	**PM10**
1988 – 1989	6.0	0.60	11.40	1.140	111.00	11.10
1990	6.0	0.60	10.80	1.080	111.00	11.10
1991 – 1993	5.0	0.25	9.00	0.450	92.50	4.63
1994 – 1997	5.0	0.10	9.00	0.180	92.50	1.85
1998 – 2001	4.0	0.10	7.20	0.180	74.00	1.85
2002 – 2006	2.0	0.10	3.60	0.180	37.00	1.85
2007	1.2	0.01	2.16	0.018	22.20	0.19
2010	0.2	0.01	0.36	0.018	3.70	0.19

a - Mileage based emissions factors were calculated using conversion factors from Table D-28.
b - Fuel based emissions factors were calculated using fuel consumption rate factors from Table D-24.
c - Fuel based factors are for engines less than 750 horsepower only.

Table D-2b
Heavy Heavy-Duty Alternative Fuel Engines
Converted Emission Standards

Model Year	g/bhp-hr		g/mile[a]		g/gal[b,c]	
	NOx	PM10	NOx	PM10	NOx	PM10
1988 – 1989	6.0	0.60	18.60	1.860	111.00	11.10
1990	6.0	0.60	18.00	1.800	111.00	11.10
1991 – 1993	5.0	0.25	15.00	0.750	92.50	4.63
1994 – 1997	5.0	0.10	14.50	0.290	92.50	1.85
1998 – 2001	4.0	0.10	11.60	0.290	74.00	1.85
2002 – 2006	2.0	0.10	5.80	0.290	37.00	1.85
2007	1.2	0.01	3.48	0.029	22.20	0.19
2010	0.2	0.01	0.58	0.029	3.70	0.19

a - Mileage based emissions factors were calculated using conversion factors from Table D-28.
b - Fuel based emissions factors were calculated using fuel consumption rate factors from Table D-24.
c - Fuel based factors are for engines less than 750 horsepower only.

Table D-3
Diesel Medium Heavy-Duty Vehicles 14,001-33,000 pounds (lbs) Gross Vehicle Weight Rating (GVWR)
Emission Factors (g/mile)[a]

Model Year	NOx	ROG	PM10
Pre-1984	17.21	0.29	0.792
1984 – 1986	16.65	0.29	0.720
1987 – 1989	14.60	0.18	0.504
1990	14.60	0.18	0.504
1991 – 1993	12.18	0.16	0.288
1994 – 1997	10.70	0.10	0.216
1998 – 2002	9.77	0.08	0.144
2003+	5.39	0.08	0.216
2004 – 2006	5.12	0.08	0.216
2007 – 2009	2.79	0.05	0.024
2010+	0.51	0.02	0.024

a - Emission factors incorporate the ultra low-sulfur diesel fuel correction factors in Table D-26.

Table D-4
Diesel Heavy Heavy-Duty Vehicles 33,000+ lbs GVWR
Emission Factors (g/mile) [a]

Model Year	NOx	ROG	PM10
Pre-1987	21.39	1.04	1.249
1987 – 1988	21.11	0.81	1.354
1989 – 1990	21.11	0.81	1.354
1991 – 1993	18.23	0.54	0.562
1994 – 1997	17.95	0.4	0.367
1998 – 2002	17.58	0.51	0.403
2003 – 2006	11.63	0.26	0.252
2007 – 2009	6.36	0.23	0.028
2010+	1.06	0.18	0.028

a - Emission factors incorporate the ultra low-sulfur diesel fuel correction factors listed in Table D-26.

Table D-5
Diesel Urban Buses
Converted Emission Standards

Model Year	g/bhp-hr			g/mile[a]			g/gal[b,c]		
	NOx	ROG	PM10	NOx	ROG	PM10	NOx	ROG	PM10
1987 – 1990[d]	5.58	1.17	0.432	22.32	4.68	1.728	103.23	21.65	7.99
1991 – 1993[d]	4.65	1.17	0.072	18.60	4.68	0.288	86.03	21.65	1.33
1994 – 1995[d]	4.65	1.17	0.050	18.60	4.68	0.200	86.03	21.65	0.93
1996 – 2002[d]	3.72	1.17	0.036	14.88	4.68	0.144	68.82	21.65	0.67
2003[d,e]	2.21	0.12	0.007	8.84	0.48	0.028	40.89	2.22	0.13
2004 – 2006[f]	-	-	-	-	-	-	-	-	-
2007 – 2009	1.20	0.19	0.010	4.80	0.76	0.040	22.20	3.52	0.19
2010	0.20	0.19	0.010	0.80	0.76	0.040	3.70	3.52	0.19

a - Mileage based emissions factors were calculated using conversion factors from Table D-28.
b - Fuel based emissions factors were calculated using fuel consumption rate factors from Table D-24.
c - Fuel based factors are for engines less than 750 horsepower only.
d - Emission standards were converted where appropriate, using the NMHC and NOx fraction default values and the ultra low-sulfur diesel fuel correction factors listed in Tables D-25 and D-26, respectively.
e - NOx +NMHC emission standard converted to NOx and ROG.
f - No diesel buses have been certified to the 0.5 g/bhp-hr for the 2004-2006 model year emission standard.

Table D-6
Natural Gas Urban Buses
Converted Emission Standards

Model Year	g/bhp-hr		g/mile[a]		g/gal[b,c]	
	NOx	PM10	NOx	PM10	NOx	PM10
1991 – 1993	5.00	0.100	20.00	0.40	92.50	1.85
1994 – 1995	5.00	0.070	20.00	0.28	92.50	1.30
1996 – 1997	4.00	0.050	16.00	0.20	74.00	0.93
1998 – 2002[e]	2.50	0.050	10.00	0.20	46.25	0.93
2003 – 2006[d,e,f]	1.44	0.020	5.76	0.08	26.64	0.37
2007 – 2009	1.20	0.010	4.80	0.04	22.20	0.19
2010+	0.20	0.010	0.80	0.04	3.70	0.19

a - Mileage based emissions factors were calculated using conversion factors from Table D-28.
b - Fuel based emissions factors were calculated using fuel consumption rate factors from Table D-24.
c - Fuel based factors are for engines less than 750 horsepower only.
d - NOx+NMHC emission standard converted to NOx only.
e - A majority of the natural gas urban buses have been certified to the optional standards. Therefore, these values are based on the optional standards.
f - Many natural gas urban buses have been certified to optional standards below this level.

Table D-7
Transport Refrigeration Units (TRU) and Auxiliary Power Unit (APU) Default Load Factors

Category	Horsepower	Load Factor
TRU	<25	0.64
	25 – 50	0.53
APU	<25	0.74

Table D-8
TRU and APU Emission Factors (g/bhp-hr)

Horsepower	Tier / Model Year	NOx	ROG	PM10
< 11	Pre-1995	9.30	1.80	0.720
	1995 – 1999	8.70	1.26	0.410
	Tier 1	5.76	0.82	0.376
	Tier 2	4.14	0.59	0.304
	Tier 4	4.14	0.59	0.152
11 – 24	Pre-1995	6.44	2.21	0.550
	1995 – 1999	6.44	1.08	0.413
	Tier 1	5.49	0.77	0.306
	Tier 2	4.33	0.69	0.306
	Tier 4	4.33	0.69	0.152
25 - 49	Uncontrolled pre-1988	6.51	2.21	0.547
	Uncontrolled 1988 +	6.42	2.17	0.547
	Tier 1	5.26	1.74	0.480
	Tier 2	4.63	0.29	0.280
	Tier 4 Interim	4.55	0.12	0.128
	Tier 4 Final	2.75	0.12	0.008

Table D-9a
Emergency Vehicle (Fire Apparatus)
Medium Heavy-Duty Diesel Engine
Converted Emission Standards

Model Year	g/bhp-hr	g/mile[(a)(b)]			g/gallon[(b)(c)(d)]		
	Certification Standard	NOx	ROG[(e)]	PM10	NOx	ROG[(e)]	PM10
pre-1990	6.0 NOx	10.60	0.55	0.821	103.23	5.33	7.992
1990	6.0 NOx	10.04	0.52	0.778	103.23	5.33	7.992
1991 - 1993	5.0 NOx	8.37	0.43	0.324	86.03	4.44	3.330
1994 - 1997	5.0 NOx	8.37	0.43	0.130	86.03	4.44	1.332
1998 - 2001	4.0 NOx	6.70	0.35	0.130	68.82	3.55	1.332
2002 - 2006	2.5 NOx + NMHC	3.98	0.21	0.130	40.86	2.11	1.332
2007	1.2 NOx + NMHC	1.91	0.10	0.014	19.61	1.01	0.148
2010	0.2 NOx + NMHC	0.32	0.02	0.014	3.27	0.17	0.148

a - Mileage based emissions factors were calculated using conversion factors from Table D-28.
b - Emission standards were converted where appropriate, using the NMHC and NOx fraction default values and the ultra low-sulfur diesel fuel correction factors listed in Tables D-25 and D-26, respectively.
c - Fuel based emissions factors were calculated using fuel consumption rate factors from Table D-24.
d - Fuel based factors are for engines less than 750 horsepower only.
e - ROG = Hydrocarbons (HC) * 1.22639.

Table D-9b
Emergency Vehicle (Fire Apparatus)
Heavy Heavy-Duty Diesel Engine
Converted Emission Standards

Model Year	g/bhp-hr	g/mile[(a)(b)]			g/gallon[(b)(c)(d)]		
	Certification Standard	NOx	ROG[(e)]	PM10	NOx	ROG[(e)]	PM10
pre-1990	6.0 NOx	17.30	0.89	0.821	103.23	5.33	7.992
1990	6.0 NOx	16.74	0.86	0.778	103.23	5.33	7.992
1991 - 1993	5.0 NOx	13.95	0.72	0.324	86.03	4.44	3.330
1994 - 1997	5.0 NOx	13.49	0.70	0.130	86.03	4.44	1.332
1998 - 2001	4.0 NOx	10.79	0.56	0.130	68.82	3.55	1.332
2002 - 2006	2.5 NOx + NMHC	6.41	0.33	0.130	40.86	2.11	1.332
2007	1.2 NOx + NMHC	3.07	0.16	0.014	19.61	1.01	0.148
2010	0.2 NOx + NMHC	0.51	0.03	0.014	3.27	0.17	0.148

a - Mileage based emissions factors were calculated using conversion factors from Table D-28.
b - Emission standards were converted where appropriate, using the NMHC and NOx fraction default values and the ultra low-sulfur diesel fuel correction factors listed in Tables D-25 and D-26, respectively.
c - Fuel based emissions factors were calculated using fuel consumption rate factors from Table D-24.
d - Fuel based factors are for engines less than 750 horsepower only.
e - ROG = HC * 1.26639.

Table D-10
Off-Road Diesel Engines Default Load Factors

Category	Equipment Type	Load Factor
Airport Ground Support	Aircraft Tug	0.54
	Air Conditioner	0.75
	Air Start Unit	0.90
	Baggage Tug	0.37
	Belt Loader	0.34
	Bobtail	0.37
	Cargo Loader	0.34
	Cargo Tractor	0.36
	Forklift	0.20
	Ground Power Unit	0.75
	Lift	0.34
	Passenger Stand	0.40
	Service Truck	0.20
	Other GSE	0.34
Mobile Agricultural	Agricultural Mowers	0.43
	Agricultural Tractors	0.70
	Balers	0.58
	Combines	0.70
	Hydro Power Units	0.48
	Sprayers	0.50
	Swathers	0.55
	Tillers	0.78
	Other Agricultural	0.51
Construction	Bore/Drill Rigs	0.50
	Cranes	0.29
	Crawler Tractors	0.43
	Crushing/Process Equipment	0.78
	Excavators	0.38
	Graders	0.41
	Off-Highway Tractors	0.44
	Off-Highway Trucks	0.38
	Pavers	0.42
	Other Paving	0.36
	Rollers	0.38
	Rough Terrain Forklifts	0.40

Table D-10
Off-Road Diesel Engines Default Load Factors
(Continued)

Category	Equipment Type	Load Factor
Construction	Rubber Tired Dozers	0.40
	Rubber Tired Loaders	0.36
	Scrapers	0.48
	Signal Boards	0.78
	Skid Steer Loaders	0.37
	Surfacing Equipment	0.30
	Tractors/Loaders/Backhoes	0.37
	Trenchers	0.50
	Other Construction Equipment	0.42
Industrial	Aerial Lifts	0.31
	Forklifts	0.20
	Sweepers/Scrubbers	0.46
	Other General Industrial	0.34
	Other Material Handling	0.40
Logging	Fellers/Bunchers	0.71
	Skidders	0.74
Oil Drilling	Drill Rig	0.50
	Lift (Drilling)	0.60
	Swivel	0.60
	Workover Rig (Mobile)	0.50
	Other Workover Equipment	0.60
Cargo Handling	Container Handling Equipment	0.59
	Cranes	0.43
	Excavators	0.57
	Forklifts	0.30
	Other Cargo Handling Equipment	0.51
	Sweeper/Scrubber	0.68
	Tractors/Loaders/Backhoes	0.55
	Yard Trucks	0.65
Non-Mobile Agricultural Engines	Irrigation Pump	0.65
	Other	0.51
Other	All	0.43

Table D-11
Uncontrolled Off-Road Diesel Engines
Emission Factors (g/bhp-hr)

Horsepower	Model Year	NOx	ROG	PM10
25 – 49	pre-1988	6.51	2.21	0.547
	1988 +	6.42	2.17	0.547
50 – 119	pre-1988	12.09	1.73	0.605
	1988 +	8.14	1.19	0.497
120+	pre-1970	13.02	1.59	0.554
	1970 – 1979	11.16	1.20	0.396
	1980 – 1987	10.23	1.06	0.396
	1988 +	7.60	0.82	0.274

Table D-12
Controlled Off-Road Diesel Engines
Emission Factors (g/bhp-hr)[a]

Horsepower	Tier	NOx	ROG	PM10
25-49	1	5.26	1.74	0.480
	2	4.63	0.29	0.280
	4 Interim	4.55	0.12	0.128
	4 Final	2.75	0.12	0.008
50-74	1	6.54	1.19	0.552
	2	4.75	0.23	0.192
	3[b]	2.74	0.12	0.192
	4 Interim	2.74	0.12	0.112
	4 Final	2.74	0.12	0.008
75-99	1	6.54	1.19	0.552
	2	4.75	0.23	0.192
	3	2.74	0.12	0.192
	4 Phase-Out	2.74	0.12	0.008
	4 Phase-In/ Alternate NOx	2.14	0.11	0.008
	4 Final	0.26	0.06	0.008
100-174	1	6.54	0.82	0.274
	2	4.17	0.19	0.128
	3	2.32	0.12	0.112
	4 Phase-Out	2.32	0.12	0.008
	4 Phase-In/ Alternate NOx	2.15	0.06	0.008
	4 Final	0.26	0.06	0.008
175-299	1	5.93	0.38	0.108
	2	4.15	0.12	0.088
	3	2.32	0.12	0.088
	4 Phase-Out	2.32	0.12	0.008
	4 Phase-In/ Alternate NOx	1.29	0.08	0.008
	4 Final	0.26	0.06	0.008

Table D-12
Controlled Off-Road Diesel Engines
Emission Factors (g/bhp-hr)[a]
(Continued)

Horsepower	Tier	NOx	ROG	PM10
300-750	1	5.93	0.38	0.108
	2	3.79	0.12	0.108
	3[b]	2.32	0.12	0.008
	4 Phase-Out	2.32	0.12	0.008
	4 Phase-In/ Alternate NOx	1.29	0.08	0.008
	4 Final	0.26	0.06	0.008
751+	1	5.93	0.38	0.108
	2	3.79	0.12	0.088
	4 Interim	2.24	0.12	0.048
	4 Final	2.24	0.06	0.016

Note: Engines that are participating in the "Tier 4 Early Introduction Incentive for Engine Manufacturers" program per California Code of Regulations, Title 13, section 2423(b)(6) are eligible for funding provided the engines are certified to the final Tier 4 emission standards. The ARB Executive Order indicates engines certified under this provision. The emission rates for these engines used to determine cost-effectiveness shall be equivalent to the emission factors associated with Tier 3 engines.

For equipment with baseline engines certified under the flexibility provisions per California Code of Regulations, Title 13, section 2423(d), baseline emission rates shall be determined by using the previous applicable emission standard or Tier for that engine model year and horsepower rating. The ARB Executive Order indicates engines certified under this provision.

a - Emission factors were converted using the ultra low-sulfur diesel fuel correction factors listed in Table D-27.
b - Alternate compliance option.

Table D-13
Off-Road LSI Equipment Default Load Factors

Category	Equipment Type	Load Factor
Agriculture	Agricultural Tractors	0.62
	Balers	0.55
	Combines	0.74
	Sprayers	0.50
	Swathers	0.52
	Other Agricultural Equipment	0.55
Airport Ground Support	A/C Tug	0.80
	Baggage Tug	0.55
	Belt Loader	0.50
	Bobtail	0.55
	Cargo Loader	0.50
	Forklift	0.30
	Ground Power Unit	0.75
	Lift	0.50
	Passenger Stand	0.59
	Other GSE	0.50
Construction	Asphalt Pavers	0.66
	Bore/Drill Rigs	0.79
	Concrete/Industrial Saws	0.78
	Cranes	0.47
	Paving Equipment	0.59
	Rollers	0.62
	Rough Terrain Forklifts	0.63
	Rubber Tired Loaders	0.54
	Skid Steer Loaders	0.58
	Tractors/Loaders/Backhoes	0.48
	Trenchers	0.66
	Other Construction	0.48
Industrial	Aerial Lifts	0.46
	Forklifts	0.30
	Sweepers/Scrubbers	0.71
	Other Industrial	0.54

Table D-14
Off-Road LSI Engines
Emission Factors (g/bhp-hr)

Horsepower	Fuel	Model Year	NOx	ROG	PM10
25 – 49	Gasoline	Uncontrolled – pre-2004	8.01	3.81	0.060
		Controlled 2001-2006	1.33	0.72	0.060
		Controlled 2007-2009[(a)]	0.89	0.48	0.060
		Controlled 2010+	0.27	0.14	0.060
	Alt Fuel	Uncontrolled – pre-2004	13.00	0.90	0.060
		Controlled 2001-2006	1.95	0.09	0.060
		Controlled 2007-2009[(a)]	1.30	0.06	0.060
		Controlled 2010+	0.39	0.02	0.060
50 – 120	Gasoline	Uncontrolled – pre-2004	11.84	2.66	0.060
		Controlled 2001-2006	1.78	0.26	0.060
		Controlled 2007-2009[(a)]	1.19	0.18	0.060
		Controlled 2010+	0.36	0.05	0.060
	Alt Fuel	Uncontrolled – pre-2004	10.51	1.02	0.060
		Controlled 2001-2006	1.58	0.11	0.060
		Controlled 2007-2009[(a)]	1.05	0.07	0.060
		Controlled 2010+	0.32	0.02	0.060
>120	Gasoline	Uncontrolled – pre-2004	12.94	1.63	0.060
		Controlled 2001-2006	1.94	0.16	0.060
		Controlled 2007-2009[(a)]	1.29	0.11	0.060
		Controlled 2010+	0.39	0.03	0.060
	Alt Fuel	Uncontrolled – pre-2004	10.51	0.90	0.060
		Controlled 2001-2006	1.58	0.09	0.060
		Controlled 2007-2009[(a)]	1.05	0.06	0.060
		Controlled 2010+	0.32	0.02	0.060

a - Emission factors for federally certified engines used in preempt equipment.

Table D-15
Emission Factors for Off-Road LSI Engine Retrofits
Verified to Absolute Emission Number (g/bhp-hr)

Manufacturers of LSI retrofit systems may verify to a percent emission reduction or absolute emissions. If a retrofit system is verified to a percent reduction, the emission factors will be that verified percent of the appropriate emissions factors in Table D-14. If a retrofit system is verified to an absolute emission number, use the following table for the emission factors.

Fuel	Verified Value	NOx	ROG	PM10
Gasoline	3.0 g/bhp-hr	1.78	0.26	0.060
	2.5 g/bhp-hr	1.48	0.22	0.060
	2.0 g/bhp-hr	1.19	0.18	0.060
	1.5 g/bhp-hr	0.89	0.13	0.060
	1.0 g/bhp-hr	0.59	0.09	0.060
	0.6 g/bhp-hr	0.36	0.05	0.060
	0.5 g/bhp-hr	0.30	0.04	0.060
Alt Fuel	3.0 g/bhp-hr	1.58	0.10	0.060
	2.5 g/bhp-hr	1.32	0.09	0.060
	2.0 g/bhp-hr	1.05	0.07	0.060
	1.5 g/bhp-hr	0.79	0.05	0.060
	1.0 g/bhp-hr	0.53	0.03	0.060
	0.6 g/bhp-hr	0.32	0.02	0.060
	0.5 g/bhp-hr	0.26	0.02	0.060

Table D-16
Off-Road LSI Engines Certified to Optional Standards
Emission Factors (g/bhp-hr)

Horsepower	Fuel	Optional Standard	NOx	ROG	PM10
25-50	Gasoline	1.50	0.67	0.36	0.060
		1.00	0.44	0.24	0.060
		0.60	0.27	0.14	0.060
		0.40	0.18	0.10	0.060
		0.20	0.09	0.05	0.060
		0.10	0.04	0.02	0.060
	Alt Fuel	1.50	0.98	0.05	0.060
		1.00	0.65	0.03	0.060
		0.60	0.39	0.02	0.060
		0.40	0.26	0.01	0.060
		0.20	0.13	0.01	0.060
		0.10	0.07	0.00	0.060
50-120	Gasoline	1.50	0.89	0.13	0.060
		1.00	0.59	0.09	0.060
		0.60	0.36	0.05	0.060
		0.40	0.24	0.04	0.060
		0.20	0.12	0.02	0.060
		0.10	0.06	0.01	0.060
	Alt Fuel	1.50	0.79	0.05	0.060
		1.00	0.53	0.03	0.060
		0.60	0.32	0.02	0.060
		0.40	0.21	0.01	0.060
		0.20	0.11	0.01	0.060
		0.10	0.05	0.00	0.060
>120	Gasoline	1.50	0.97	0.08	0.060
		1.00	0.65	0.05	0.060
		0.60	0.39	0.03	0.060
		0.40	0.26	0.02	0.060
		0.20	0.13	0.01	0.060
		0.10	0.06	0.01	0.060
	Alt Fuel	1.50	0.79	0.05	0.060
		1.00	0.53	0.03	0.060
		0.60	0.32	0.02	0.060
		0.40	0.21	0.01	0.060
		0.20	0.11	0.01	0.060
		0.10	0.05	0.00	0.060

LOCOMOTIVES

Table D-17a
Locomotive Emission Factors (g/bhp-hr)
Based on 1998 Federal Standards

Engine Model Year	Type	NOx[(a)]	ROG[(b)]	PM10[(a)]
Pre-1973	Line-haul and Passenger	12.22	0.51	0.275
	Switcher	16.36	1.06	0.378
1973-2001 Tier 0	Line-haul and Passenger	8.93	1.05	0.516
	Switcher	13.16	2.21	0.619
2002-2004 Tier 1	Line-haul and Passenger	6.96	0.58	0.387
	Switcher	10.34	1.26	0.464
2005-2011 Tier 2	Line-haul and Passenger	5.17	0.32	0.172
	Switcher	7.61	0.63	0.206

These factors are to be used for the project baseline emissions if the baseline locomotive is certified or required to be certified to the 1998 federal locomotive remanufacture standards, and for the reduced emission locomotive if the project locomotive is remanufactured to these 1998 standards. Factors are based upon Regulatory Impact Analysis: Final United States Environmental Protection Agency (U.S. EPA) Locomotive Regulation (2008).
a - NOx and PM10 emission factors have been adjusted by a factor of 0.94 and 0.86, respectively, to account for use of California ultra-low sulfur diesel fuel.
b - ROG = HC * 1.053

Table D-17b
Locomotive Emission Factors (g/bhp-hr)
Based on 2008 Federal Standards

Engine Model Year	Type	NOx[(a)]	ROG[(b)]	PM10[(a)]
1973-2001 Tier 0+	Line-haul and Passenger	6.96	0.58	0.189
	Switcher	11.09	2.21	0.224
2002-2004 Tier 1+	Line-haul and Passenger	6.96	0.58	0.189
	Switcher	10.34	1.26	0.224
2005-2011 Tier 2+	Line-haul and Passenger	5.17	0.32	0.086
	Switcher	7.61	0.63	0.112
2011-2014 Tier 3	Line-haul and Passenger	5.17	0.32	0.086
	Switcher	4.70	0.63	0.086
2015 Tier 4	Line-haul and Passenger	1.22	0.15	0.026
	Switcher	1.22	0.15	0.026

These factors are to be used for the project baseline emissions if the baseline locomotive is certified or required to be certified to the new (2008) federal locomotive remanufacture standards, and for the reduced emission locomotive if the project locomotive is remanufactured to the new standards or meets Tier 3 standards. Factors are based upon Regulatory Impact Analysis: Final U.S. EPA Locomotive Regulation (2008).
a - NOx and PM10 emission factors have been adjusted by a factor of 0.94 and 0.86, respectively, to account for use of California ultra-low sulfur diesel fuel.
b - ROG = HC * 1.053

Table D-18
Locomotive Idle-Limiting Device Emission Reduction Factors

Type	Factor
Switchers	0.90
Line-Haul	0.97
Passenger	0.97

Note: Factors based on assumption Idle Limiting Device (ILD) reduces locomotive engine idling by 50 percent. Multiply total baseline emissions by this factor to determine reduced emissions with ILD.

Table D-19a
Uncontrolled Harbor Craft Propulsion Engine
Emission Factors (g/bhp-hr)

Horsepower	Model Year	NOx	ROG	PM10
25-50	All	7.57	1.32	0.520
51-120	pre-1997	14.27	1.04	0.575
	1997+	9.70	0.71	0.524
121-250	pre-1971	15.36	0.95	0.527
	1971-1978	14.27	0.79	0.451
	1979-1983	13.17	0.72	0.376
	1984+	12.07	0.68	0.376
251+	pre-1971	15.36	0.91	0.506
	1971-1978	14.27	0.76	0.431
	1979-1983	13.17	0.68	0.363
	1984-1994	12.07	0.65	0.363
251-750	1995+	8.97	0.49	0.260
751+	1995+	12.07	0.60	0.363

Table D-19b
Controlled Harbor Craft Propulsion Engine
Emission Factors (g/bhp-hr)

Horsepower	Tier	NOx	ROG	PM10
25-50	1	6.93	1.30	0.580
	2	5.04	1.30	0.240
	3	5.04	1.30	0.176
51-120	1	6.93	0.71	0.524
	2	5.04	0.71	0.240
	3	5.04	0.71	0.176
121-175	1	8.97	0.49	0.290
	2	4.84	0.49	0.176
	3	3.60	0.49	0.077
176-750	1	8.97	0.49	0.290
	2	4.84	0.49	0.120
	3	3.87	0.49	0.068
751-1900	1	8.97	0.49	0.290
	2	5.24	0.49	0.160
	3	3.87	0.49	0.068
1901 +	1	8.97	0.49	0.290
	2	5.24	0.49	0.160
	3	4.14	0.49	0.085

Table D-20a
Uncontrolled Harbor Craft Auxiliary Engine
Emission Factors (g/bhp-hr)

Horsepower	Model Year	NOx	ROG	PM10
25-50	all	6.42	1.58	0.460
51-120	pre-1997	12.09	1.23	0.508
	1997+	8.14	0.85	0.417
121-250	pre-1971	13.02	1.13	0.466
	1971-1978	12.09	0.94	0.399
	1979-1983	11.16	0.86	0.333
	1984-1995	10.23	0.82	0.333
	1996+	7.75	0.59	0.255
251-750	pre-1971	13.02	1.08	0.448
	1971-1978	12.09	0.90	0.381
	1979-1983	11.16	0.81	0.321
	1984-1994	10.23	0.77	0.321
	1995+	7.60	0.58	0.230
751 +	pre-1971	13.02	1.08	0.448
	1971-1978	12.09	0.90	0.381
	1979-1986	11.16	0.81	0.321
	1987-1998	10.23	0.72	0.321
	1999+	7.75	0.58	0.255

Table D-20b
Controlled Harbor Craft Auxiliary Engine
Emission Factors (g/bhp-hr)

Horsepower	Tier	NOx	ROG	PM10
25-50	1	6.54	1.54	0.511
	2	5.04	1.54	0.240
	3	5.04	1.54	0.176
51-120	1	6.93	0.85	0.464
	2	5.04	0.85	0.240
	3	5.04	0.85	0.176
121-175	1	6.93	0.58	0.255
	2	4.84	0.58	0.176
	3	3.60	0.58	0.077
176-750	1	6.93	0.58	0.255
	2	4.84	0.58	0.120
	3	3.78	0.58	0.068
751-1900	1	6.93	0.58	0.255
	2	5.24	0.58	0.160
	3	3.87	0.58	0.068
1901 +	1	6.93	0.58	0.255
	2	5.24	0.58	0.160
	3	4.14	0.58	0.085

Table D-21
Harbor Craft Load Factors

Vessel Type	Propulsion Engine	Auxiliary Engine
Charter Fishing	0.52	0.43
Commercial Fishing	0.27	
Ferry/Excursion	0.42	
Pilot	0.51	
Tow	0.68	
Work	0.45	
Other	0.52	
Barge/Dredge	0.45	0.65
Crew & Supply	0.38	0.32
Tug	0.50	0.31

Table D-22
Shore Power
Default Emission Rates (Grams per kilowatt-hour)(g/kW-hr))

Pollutant	Emission Rate
NOx	13.9
ROG	0.49
PM10 (marine gas oil fuel with 0.11- 0.5 % sulfur content)	0.38
PM10 (marine gas oil fuel with <= 0.10 % sulfur content)	0.25

Table D-23
Shore Power
Default Power Requirements

Ship Category	Ship Size / Type Default (Twenty-foot Equivalent Unit (TEU))	Power Requirement (kW)
Container Vessel	<1,000	1,000
	1,000 – 1,999	1,300
	2,000 – 2,999	1,600
	3,000 – 3,999	1,900
	4,000 – 4,999	2,200
	5,000 – 5,999	2,300
	6,000 – 6,999	2,500
	7,000 – 7,999	2,900
	8,000 – 9,999	3,300
	10,000 – 12,000	3,700
Passenger Vessel	No Default Value – Use Actual Power Requirement[(a)]	
Reefer	Break Bulk	1,300
	Fully containerized	3,300

a - The average power requirement for passenger vessels is 7,400 kW (ARB Oceangoing Vessel Survey, 2005).

ALL ENGINES

Table D-24
Fuel Consumption Rate Factors (bhp-hr/gal)

Category	Horsepower/Application	Fuel Consumption Rate
Non-Mobile Agricultural Engines	ALL	17.5
Locomotive	Line Haul and Passenger (Class I/II)	20.8
	Line Haul and Passenger (Class III)	18.2
	Switcher	15.2
Other	< 750 hp	18.5
	≥ 750 hp	20.8

REFERENCES

The information in these tables has already been incorporated into the preceding emission factor tables. These tables are included for informational purposes.

Table D-25
Pollutant Fractions
NOx+NMHC Standards

Diesel Engines		Alternative Fuel Engines	
NOx	NMHC	NOx	NMHC
0.95	0.05	0.80	0.20

Table D-26
Fuel Correction Factors
On-Road Diesel Engines

Model Year	NOx	PM10	HC
Pre- 2007	0.93	0.72	0.72
2007+	0.93	0.80	0.72

Table D-27
Fuel Correction Factors
Off-Road Diesel Engines

Model Year	NOx	PM10
Pre-Tier 1	0.930	0.720
Tier 1+	0.948	0.800

Table D-28
Conversion Factors for NOx, ROG and PM10
Heavy-Duty Vehicle Projects (bhp-hr/mile)

Model Year	Medium Heavy-Duty 14,001-33,000 lbs	Heavy Heavy-Duty 33,000 lbs +	Urban Bus 33,000 lbs +
Pre-1989	1.9	3.1	4.0
1990 - 1993	1.8	3.0	4.0
1994 - 1995	1.8	2.9	4.0
1996+	1.8	2.9	4.0