
APPENDIX H
AIR EMISSIONS CALCULATIONS

**Alternative Actions - Powertrain PN64026
Corpus Christi Army Depot, Texas
Appendix H - Air Emission Calculations**

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Emission Calculations:

Construction/Demolition Equipment Emissions:

Construction EF (lb/1,000 ft²)= Average Construction Equipment Usage Rate (hr/ 1,000 ft²) x Equipment EF (lb/hr)

Where,

EF = emission factor

Pollutant Emissions (lbs) = Construction EF (lb/1,000 ft²) x total square feet of construction or demolition

Privately Owned Vehicle (POV) and On-Road Diesel Vehicle Emissions

Pollutant emissions = {Total vehicle miles traveled per year (miles/yr) * Pollutant EF (g/mile)}/453.59 g/lb

Where,

EF = emission factor

453.59 g/lb = conversion factor from grams to pounds

Grading: Fugitive Dust Emissions:

Annual PM₁₀ emissions = 0.11 ton PM₁₀/acre/month x (total acres) x total months of activity

Source: Western Regional Air Partnership (WRAP) Fugitive Handbook (11/04) Section 3.2 PM Emissions from construction.

Paving Equipment Equipment Emissions:

Paving EF (lb/1,000 yd³)= Average Paving Equipment Usage Rate (hr/ 1,000 yd³) x Equipment EF (lb/hr)

Where,

EF = emission factor

Pollutant Emissions (lbs) = Paving EF (lb/1,000 yd³) x total ft³ of asphalt/27 ft³/yard/1,000

Material Loading and Dumping: Fugitive Dust Emissions:

$$EF_{PM10/2.5} \text{ (lb/ton)} = (0.0032k) \frac{(U/5)^{1.3}}{(M/2)^{1.4}} \quad \text{Eq. 2, AP-42 13.2.4}$$

- k = Particle Size Multiplier
- U = Mean Wind Speed
- M = Surface Material Moisture Content (dry)

Table H-1
Summary of Annual Emissions from All Construction Sources^a
Powertrain PN64026
Corpus Christi Army Depot, Texas

Action	Annual Emissions (ton/yr)						
	VOC	CO	NO _x	PM ₁₀	PM _{2.5}	SO ₂	CO ₂
Alternative 1: Proposed	5.8	43.9	86.6	36.2	10.3	0.64	18,490
No Action Alternative	0.0	0.0	0.0	0.0	0.0	0.0	0.0

CO = carbon monoxide

CO₂ = carbon dioxide

NO_x = oxides of nitrogen

PM_{2.5} = particulate matter equal or less than 2.5 micrometers in diameter

PM₁₀ = particulate matter equal or less than 10 micrometers in diameter

SO₂ = sulfur dioxide

ton/yr = US (short)tons per year

VOC = volatile organic compounds

Notes:

a To be conservative, it has been assumed that all Alternative activities would take place in a single year.

Table H-2
Summary of Annual Construction Equipment Exhaust Emissions^a
Powertrain PN64026
Corpus Christi Army Depot, Texas

Action	Annual Emissions (ton/yr)						
	VOC	CO	NO _x	PM ₁₀	PM _{2.5}	SO ₂	CO ₂
Alternative 1: Proposed Action	5.2	40.1	77.9	4.7	4.7	0.15	16,534
No Action Alternative	0.0	0.0	0.0	0.0	0.0	0.0	0.0

CO = carbon monoxide

CO₂ = carbon dioxide

NO_x = oxides of nitrogen

PM_{2.5} = particulate matter equal or less than 2.5 micrometers in diameter

PM₁₀ = particulate matter equal or less than 10 micrometers in diameter

SO₂ = sulfur dioxide

ton/yr = US (short)tons per year

VOC = volatile organic compounds

	Action = Alternative 1	No-Action	
Total New Construction =	1,484,560	0	square feet/year
Total Demolition ^b =	994,458	0	square feet/year

Notes:

a To be conservative, it has been assumed that all activities would take place in a single year.

**Table H-3
Construction Emission Factors
Powertrain PN64026
Corpus Christi Army Depot, Texas**

Construction Equipment	Average Construction Equipment Usage Rates (hours) ^a			Equipment Emission Factors ^{b,c,d,e}						
	New Construction		Demolition	VOC (lb/hr)	CO (lb/hr)	NO _x (lb/hr)	PM ₁₀ (lb/hr)	PM _{2.5} (lb/hr)	SO ₂ (lb/hr)	CO ₂ (lb/hr)
	Single Story (per 1,000 ft ²)	Multi-Story (per 1,000 ft ²)	Single/Multi-Story (per 1,000 ft ²)							
Backhoe	2.6901	2.1943	-	0.007	0.084	0.107	0.011	0.011	0.0002	21.0
Bulldozer	1.1833	1.3866	-	0.077	0.390	1.157	0.069	0.069	0.002	245
Concrete Truck	7.5282	3.7641	-	0.143	1.135	2.138	0.128	0.128	0.004	454
Crane	10.3343	15.5449	3.0000	0.034	0.137	0.459	0.028	0.028	0.001	97.5
Dump Truck	4.2281	3.4009	7.9600	0.143	1.135	2.138	0.128	0.128	0.004	454
Front-end Loader	2.6800	2.5183	4.0000	0.015	0.070	0.202	0.018	0.018	0.0004	43.0
18-Wheel Truck	28.0799	30.0545	-	0.143	1.135	2.138	0.128	0.128	0.004	454

Pollutant	Construction Equipment Emission Factors		
	New Construction		Demolition
	Single Story (lb/1,000 ft ²)	Multi-Story (lb/1,000 ft ²)	Single/Multi-Story (lb/1,000 ft ²)
VOC	6.2	6.0	1.3
CO	47.5	45.3	9.7
NO _x	92.1	89.1	19.2
PM ₁₀	5.6	5.4	1.2
PM _{2.5}	5.6	5.4	1.2
SO ₂	0.2	0.2	0.0
CO ₂	19,544	18,898	4,076

CO = carbon monoxide

CO₂ = carbon dioxide

ft² = square feet

g/hp-hr = gram per horsepower - hour

hp = horsepower

lb = pound

lb/hr = pound per hour

NO_x = nitrogen oxides

PM₁₀ = particulate matter equal or less than 10 micrometers in diameter

PM_{2.5} = particulate matter equal or less than 2.5 micrometers in diameter

SO₂ = sulfur dioxide

VOC = volatile organic compound

Notes:

a Source: 1996 Means Building Construction Cost Data, 54th Annual Edition

b Source: USEPA, Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling-CI, July 2010. Assumed Tier 3 for all equipment.

The g/hp-hr emission factors converted to lb/hr; using horsepower from Nonroad Engine and Vehicle Emission Study (11/91), Table 2-04 and NONROAD2008 load factor.

c CO₂ emission factor source: Table 4.9 of USEPA's Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories, April 2009.

Emission factors given in Table 4.9 are based upon the reference in footnote b above. The g/hp-hr emission factors converted to lb/hr; using horsepower from Nonroad Engine and Vehicle Emission Study (11/91), Table 2-04 and NONROAD2008 load factor. Assumed Tier 3 for all equipment.

d Assumed PM_{2.5} = PM₁₀

e Assumed 15 ppm sulfur content.

Table H-4
Summary of Annual Emissions from Construction POV^a
Powertrain PN64026
Corpus Christi Army Depot, Texas

Car/Light Truck (Exhaust Emissions)

Days worked	Total Number of Worker Vehicles	Vehicles Miles Traveled (miles/day)	Vehicles Miles Traveled (miles/Action)	Emission Factor ^b (g/mile)						
				CO	NO _x	PM ₁₀	PM _{2.5}	SO ₂	VOC	CO ₂
250	40	50	500,000	1.3	0.12	0.0019	0.0017	0.0035	0.054	349

Car/Light Truck (Exhaust Emissions Continued)

Action	Annual Emissions Each Action (ton/yr)						
	CO	NO _x	PM ₁₀	PM _{2.5}	SO ₂	VOC	CO ₂
Alternative 1: Proposed	0.72	0.068	1.04E-03	9.53E-04	1.93E-03	0.030	193
No Action Alternative	0.0	0.0	0.0	0.0	0.0	0.0	0.0

CO = carbon monoxide

CO₂ = carbon dioxide

g/mile = gram mile

NO_x = oxides of nitrogen

PM_{2.5} = particulate matter equal or less than 2.5 micrometers in diameter

PM₁₀ = particulate matter equal or less than 10 micrometers in diameter

POV = privately owned vehicle

SO₂ = sulfur dioxide

ton/yr = US (short)tons per year

VOC = volatile organic compounds

Notes:

a Construction worker private vehicle travel to the work site. Assumed two workers per vehicle. Conservatively assumed every worker vehicle would travel 50 miles per day for each day worked. Workers and miles traveled assumed to be the same for each Alternative.

b Emission Factor Source: California Air Resources Board (CARB), EMFAC2011 on-road emission factor model.

Assumed all LDA-Gas passenger vehicle class with aggregated speed and aggregated model years for 2015.

Table H-5
Summary of Annual On-Road Diesel Vehicle Combustion Emissions
Powertrain PN64026
Corpus Christi Army Depot, Texas

Action	Annual Emissions (ton/yr)						
	CO	NO _x	PM ₁₀	PM _{2.5}	SO ₂	VOC	CO ₂
Alternative 1	0.17	0.94	0.011	9.69E-03	1.30E-03	0.041	136
Alternative 2	0.17	0.94	0.011	9.69E-03	1.30E-03	0.041	136
Alternative 3	0.17	0.94	0.011	9.69E-03	1.30E-03	0.041	136
No Action Alternative	0.17	0.94	0.011	9.69E-03	1.30E-03	0.041	136

CO = carbon monoxide

CO₂ = carbon dioxide

g/mile = grams per mile

mph = miles per hour

PM_{2.5} = particulate matter equal or less than 2.5 micrometers in diameter

PM₁₀ = particulate matter equal or less than 10 micrometers in diameter

NO_x = oxides of nitrogen

SO₂ = sulfur dioxide

ton/yr = US (short) tons per year

VMT = vehicle miles traveled

VOC = volatile organic compounds

Notes

a Annual emissions = EMFAC2011 EF (g/mile) * Annual VMT

EMFAC2011 Vehicle Type Category ^a	LHD1-DSL ^b		T6 ^c	
	Paved ^d		Paved ^d	
Annual Average VOC Emission Factor :	0.231	0.171		g/mile
Annual Average NO _x Emission Factor :	4.288	6.411		g/mile
Annual Average CO Emission Factor :	1.044	0.522		g/mile
Annual Average CO ₂ Emission Factor :	523.7	1165.4		g/mile
Annual Average SO ₂ Emission Factor :	0.0050	0.0111		g/mile
Annual Average PM ₁₀ Emission Factor :	0.0451	0.0784		g/mile
Annual Average PM _{2.5} Emission Factor :	0.0415	0.0721		g/mile

	LDDT ^e	HDDV3 ^f	
Total Annual VMT (Same for all Alternatives)	125,000	50,000	miles/yr

Notes:

a Emission Factor Source: California Air Resources Board (CARB), EMFAC2011 on-road emission factor model.

b LHD1-DSL = Light heavy duty diesel powered trucks (8,500 - 10,000 pounds.)

c T6 instate heavy = Medium-Heavy Duty Diesel instate Truck with GVWR>26000 lbs.

d Aggregate Speed and aggregated model years for 2015.

e LHD1 VMT based upon 10 vehicles traveling 50 miles/day for 250 working days/year.

f T6 VMT based upon 4 loads/day traveling 50 miles per load for 250 working days/year.

**Table H-6
Annual Emissions from Grading Operations^a
Powertrain PN64026
Corpus Christi Army Depot, Texas**

Equipment Operation (Exhaust Emissions)

Type	Days worked per year	Hours Operation (hr/day)	Hours Operation (hr/yr)	Horsepower ^b (hp)	Load Factor ^c (%)	Exhaust Emission Factors ^d						
						VOC (g/hp-hr)	CO (g/hp-hr)	NO _x (g/hp-hr)	PM ₁₀ (g/hp-hr)	PM _{2.5} (g/hp-hr)	SO ₂ (g/hp-hr)	CO ₂ ^e (g/hp-hr)
Light Truck	250	8	2,000	250	25	0.17	0.75	2.5	0.15	0.15	0.16	530.5
Dump Truck	250	8	2,000	658	25	0.17	1.33	2.5	0.15	0.15	0.16	530.5
Water Truck	250	8	2,000	658	25	0.17	1.33	2.5	0.15	0.15	0.16	530.5
Scraper	250	8	2,000	290	60	0.19	0.75	2.5	0.15	0.15	0.16	530.5
Front-end Loader	250	8	2,000	300	38	0.18	0.75	2.5	0.15	0.15	0.16	530.5
Grader	250	8	2,000	300	54	0.18	0.75	2.5	0.15	0.15	0.16	530.5
Bobcat	250	8	2,000	85	48	0.18	2.37	3.0	0.30	0.30	0.18	589.8

Equipment Operation (Exhaust Emissions Continued)

Type	Exhaust Emission Rates							Fugitive Dust Emissions ^f					
	VOC (ton/yr)	CO (ton/yr)	NO _x (ton/yr)	PM ₁₀ (ton/yr)	PM _{2.5} (ton/yr)	SO ₂ (ton/yr)	CO ₂ (ton/yr)	Action	Total Area (acre)	General Factor (ton/acre/month)	Duration of Project (months)	PM ₁₀ (ton/yr)	PM _{2.5} (ton/yr)
Light Truck	0.023	0.10	0.34	0.021	0.021	0.022	73.0	Alt. 1	59.9	0.011	12	7.9	1.6
Dump Truck	0.060	0.48	0.91	0.054	0.054	0.058	192	No Action	0	0.011	12	0.0	0.0
Water Truck	0.060	0.48	0.91	0.054	0.054	0.058	192						
Scraper	0.074	0.29	0.96	0.057	0.057	0.061	203						
Front-end Loader	0.046	0.19	0.63	0.038	0.038	0.040	133						
Grader	0.066	0.27	0.89	0.054	0.054	0.057	189						
Bobcat	0.016	0.21	0.27	0.027	0.027	0.016	53.0						
Total Each Action	0.35	2.0	4.9	0.30	0.30	0.31	1,036						

CO = carbon monoxide

CO₂ = carbon dioxide

ft² = square feet

g/hp-hr = gram per horsepower - hour

hp = horsepower

hr/day = hours per day

hr/yr = hours per year

NO_x = nitrogen oxides

PM_{2.5} = particulate matter equal or less than 2.5 micrometers in diameter

PM₁₀ = particulate matter equal or less than 10 micrometers in diameter

SO₂ = sulfur dioxide

ton/yr = tons per year

VOC = volatile organic compound

yd³ = cubic yard

Notes:

a Emissions are from the grading operations required during construction. It was assumed that each year would require 50 weeks (250 days/year working 8 hours/day).

b Assumed average horsepower for this type of equipment.

c Nonroad Engine and Vehicle Emission Study (11/91), Table 2-05

d Source: USEPA, Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling-CI, April 2004. Assumed Tier 3 for all equipment and PM_{2.5} = PM₁₀.

e CO₂ emission factor source: Table 4.9 of USEPA's Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories, April 2009. Table 4.9 based upon footnote d above.

f Calculations based upon emission factors from Western Regional Air Partnership (WRAP). "WRAP Fugitive Dust Handbook," 2004, Section 3.

It has been assumed that the entire new construction area of 1,484,560 ft² and demolition area of 1,123,458 ft² will require grading.

Table H-7
Summary of Annual Paving Equipment Exhaust Emissions^a
Powertrain PN64026
Corpus Christi Army Depot, Texas

Action	Annual Emissions (ton/yr)						
	VOC	CO	NO _x	PM ₁₀	PM _{2.5}	SO ₂	CO ₂
Alternative 1: Proposed Action	0.19	0.94	2.8	0.17	0.17	0.18	590
No Action Alternative	0.0	0.0	0.0	0.0	0.0	0.0	0.0

CO = carbon monoxide

CO₂ = carbon dioxide

NO_x = oxides of nitrogen

PM_{2.5} = particulate matter equal or less than 2.5 micrometers in diameter

PM₁₀ = particulate matter equal or less than 10 micrometers in diameter

SO₂ = sulfur dioxide

VOC = volatile organic compounds

Action =	Proposed	No Action	
Total concrete =	5,972	0.0	cubic yards/year ^b

Notes:

a It has been assumed that paving occurs during one year.

b Paving = 15 inches of portland cement.

**Table H-8
Paving Equipment Emission Factors
Powertrain PN64026
Corpus Christi Army Depot, Texas**

Average Paving Equipment Usage Rates (hours)				Equipment Emission Factors ^{b,c,d,e}						
Paving Operations				VOC	CO	NO _x	PM ₁₀	PM _{2.5}	SO ₂	CO ₂
Construction Equipment	Asphalt (per 1,000 yd ³)	Gravel/Dirt (per 1,000 yd ³)	Concrete (per 1,000 yd ³)	(lb/hr)	(lb/hr)	(lb/hr)	(lb/hr)	(lb/hr)	(lb/hr)	(lb/hr)
Blower	16.00	-	-	0.038	0.181	0.523	0.046	0.046	0.033	111.0
Bulldozer	6.15	6.15	16.00	0.077	0.390	1.157	0.069	0.069	0.074	245.5
Concrete Truck	-	-	203.26	0.143	0.720	2.138	0.128	0.128	0.137	453.7
Dump Truck	10.95	40.13	40.13	0.143	0.720	2.138	0.128	0.128	0.137	453.7
Front-end Loader	-	16.00	16.00	0.015	0.070	0.202	0.018	0.018	0.013	43.0
Paver	8.00	-	-	0.018	0.237	0.300	0.015	0.015	0.018	59.0
Roller	23.91	23.91	-	0.024	0.304	0.386	0.039	0.039	0.023	75.9
Scraper	4.80	-	-	0.069	0.282	0.942	0.083	0.083	0.060	200.0
Striper	16.00	-	-	0.038	0.181	0.523	0.046	0.046	0.033	111.0
18-Wheel Truck	-	-	182.17	0.143	0.720	2.138	0.128	0.128	0.137	453.7

Pollutant	Paving Operations		
	Asphalt (lb/1,000 yd ³)	Gravel/Dirt (lb/1,000 yd ³)	Concrete (lb/1,000 yd ³)
VOC	4.31	7.00	62.21
CO	26.61	39.71	313.94
NO _x	63.42	105.37	931.49
PM ₁₀	4.75	6.78	55.98
PM _{2.5}	4.75	6.78	55.98
SO ₂	4.01	6.71	59.62
CO ₂	13,279	22,219	197,699

CO = carbon monoxide

CO₂ = carbon dioxide

g/hp-hr = gram per horsepower - hour

hp = horsepower

lb = pound

lb/hr = pound per hour

NO_x = nitrogen oxides

PM₁₀ = particulate matter equal or less than 10 micrometers in diameter

PM_{2.5} = particulate matter equal or less than 2.5 micrometers in diameter

SO₂ = sulfur dioxide

VOC = volatile organic compound

yd³ = cubic yard

Notes:

a Source: 1996 Means Building Construction Cost Data, 54th Annual Edition

b Source: USEPA, Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling-CI, April 2004. Assumed Tier 3 for all equipment.

The g/hp-hr emission factors converted to lb/hr; using horsepower from Nonroad Engine and Vehicle Emission Study (11/91), Table 2-04 and NONROAD2008 load factor.

c CO₂ emission factor source: Table 4.9 of USEPA's Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories, April 2009.

Emission factors given in Table 4.9 are based upon the reference in footnote b above. The g/hp-hr emission factors converted to lb/hr; using horsepower from Nonroad Engine and Vehicle Emission Study (11/91), Table 2-04 and NONROAD2008 load factor. Assumed Tier 3 for all equipment.

d Assumed PM_{2.5} = PM₁₀

e Assumed 500 ppm sulfur content.

Table H-9
Material Loading and Dumping: Fugitive Dust Emissions^a
Powertrain PN64026
Corpus Christi Army Depot, Texas

Loading Material to Trucks and Truck Dumping (Fill material required for paving and raising grade.)

Action	M (moisture content)	U (mean wind speed)	k _{PM10} (particle size multiplier)	k _{PM2.5} (particle size multiplier)	Mass Material Moved (ton/yr)	Emission Rates	
						PM ₁₀ (ton/yr)	PM _{2.5} (ton/yr)
Proposed	14.0	12.0	0.35	0.053	100,932	23.1	3.5
No Action Alternative	0.0	12.0	0.35	0.053	0.0	0.0	0.0

Constants, Source Conditions, and Variables

Variable	Description of Variable	Value PM ₁₀	Value PM _{2.5}	Units	Reference
k	Particle Size Multiplier	0.35	0.053	-	AP-42 Section 13.2.4
U	Mean Wind Speed	12.0	12.0	mph	National Climatic Data Center
M	Surface Material Moisture Content (dry)	14	14	%	AP-42 Table 13.2.4-1

Loading Material to Trucks and Truck Dumping^b

$$EF_{PM_{10/2.5}} \text{ (lb/ton)} = (0.0032k) \frac{(U/5)^{1.3}}{(M/2)^{1.4}} \quad \text{Eq. 2, AP-42 13.2.4}$$

Notes:

a Fill Material required for pavement subgrades and fill material required to raise grade.

b Emission factors based upon AP-42 Sections 13.2.4 (1/95)

Mean Wind Speed Source: National Climatic Data Center - Climatic wind speed for Corpus Christi, TX. <http://www.ncdc.noaa.gov/sites/default/files/attachments/wind1996.pdf>

General Assumptions	Proposed	No Action	
Quantity of Material Moved =	249,500	0	cubic yard
Density of Material Moved =	2,697	2,697	lb/cubic yard (based upon bulk dry density of sand = 1.6 g/cm ³)
Mass of Material Moved =	100,932	0	tons/project

Table H-10
Additional Construction Data and Assumptions
Powertrain PN64026
Corpus Christi Army Depot, Texas

Action	Primary and Supporting Facilities	Total ft ²
Alternative 1: Proposed Action	New Construction All Phases	
	CEP	11,800
	PPS	150,900
	Completed Powertrain Facility	1,300,000
	Relocated NASCC Facilities (Same as demolition)	21,860
	Total	1,484,560

ft² = square feet
Notes

Table H-11
Other Feature Assumptions
Powertrain PN64026
Corpus Christi Army Depot, Texas

Action	Size	Units
Alternative 1: Proposed Action		
Building 8 Demolition	865,000	ft ²
Building 358 Demolition	1,200	ft ²
Building 362 Demolition	440	ft ²
Buildings 1152, 1209 and 1219 Demolition	18,528	ft ²
Building 1277 Demolition	2,856	ft ²
Building 1713 Demolition	4,221	ft ²
Building 1737 Demolition	2,693	ft ²
Building 1738 Demolition	7,650	ft ²
Building 1743 Demolition	4,000	ft ²
Building 1746 Demolition	87,870	ft ²
Paving	129,000	ft ²
Sub-base Material for Paved Area	8,759	yd ³
Fill Material for Raising Grade (Assumed entire Powertrain Facility area raised 5 ft.)	240,741	yd ³

ft² = square feet

yd³ = cubic yard

Notes