

Appendix F

Construction Emissions Estimates

National Grid Renewables Development, LLC
 Plum Creek Wind Farm Project
 Site Permit Amendment Request
 Construction Emission Calculations

Summary of Potential Construction Emissions (tons)										
Description	NOx	CO	VOC	SO ₂	PM ₁₀	PM _{2.5}	CO ₂	CH ₄	N ₂ O	CO ₂ e ^a
Off-Road Engine Emissions	126.82	29.38	9.11	0.06	5.02	5.01	4,719.20	0.19	0.04	4,734.70
Unpaved Roads	--	--	--	--	28.24	2.82	--	--	--	--
Commuters and Delivery Vehicles	--	--	--	--	--	--	1,485.67	0.00	0.00	1,485.67
Earthmoving	--	--	--	--	9.11	0.96	--	--	--	--
TOTAL	126.82	29.38	9.11	0.06	42.37	8.79	6,204.87	0.19	0.04	6,220.37

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Emission Factors for Construction Engines										
Equipment	Total Hours Used ^{a,b}	Max Power (HP)	Load Factor ^c	Loaded Power (HP)	NOx	CO	Emission Factors ^d (g/hp-hr)			
							VOC	SO ₂	PM ₁₀	PM _{2.5}
Air Compressor	900	80	1	80	4.700	2.366	0.367	0.002	0.240	0.240
ATV	2,440	20	0.5	10	4.440	2.161	0.438	0.002	0.267	0.267
Backhoe	2,400	75	0.8	60	4.700	2.366	0.367	0.002	0.240	0.240
Bulldozer	3,600	250	1	250	4.000	0.748	0.309	0.002	0.132	0.132
Compactor	6,300	300	1	300	4.335	0.843	0.167	0.002	0.132	0.132
Compactor, Vibratory	5,400	100	1	100	4.100	0.867	0.338	0.002	0.180	0.180
Fork Lift	3,600	120	1	120	4.335	0.843	0.167	0.002	0.132	0.132
Concrete Mixer Truck	22,500	325	1	325	4.100	0.867	0.338	0.002	0.180	0.180
Concrete Pump	2,850	300	1	300	4.100	0.867	0.338	0.002	0.180	0.180
Dump Truck	8,400	325	0.8	260	4.100	0.867	0.338	0.002	0.180	0.180
Excavator	4,650	138	1	138	4.000	0.748	0.309	0.002	0.132	0.132
Front End Loader	10,000	196	1	196	4.000	0.748	0.309	0.002	0.132	0.132
Generator	7,650	250	0.5	125	4.335	0.843	0.167	0.002	0.132	0.132
Guided Bore Machine	6,150	150	0.8	120	4.700	2.366	0.637	0.002	0.240	0.240
Light Tower	6,300	50	1	50	4.000	0.748	0.309	0.002	0.132	0.132
Manlift	6,150	50	1	50	4.100	0.867	0.338	0.002	0.180	0.180
Pickup Truck	900	150	0.25	38	4.335	0.843	0.167	0.002	0.132	0.132
Pickup Truck (on road travel only)	1,550	150	0.25	38	4.335	0.843	0.167	0.002	0.132	0.132
Piping Truck	1,800	300	1	300	4.000	0.748	0.309	0.002	0.132	0.132
Skid steer loader	6,100	50	1	50	4.000	0.748	0.309	0.002	0.132	0.132
Water truck	7,800	100	0.5	50	4.700	2.366	0.637	0.002	0.240	0.240
Welding machine	3,600	35	0.8	28	4.700	2.366	0.367	0.002	0.240	0.240
Grader	33,000	35	0.8	28	4.44	2.161	0.438	0.002	0.267	0.259
Large Crane	12,000	15	0.21	3	4.44	2.161	0.438	0.002	0.267	0.259
Medium Crane	0	450	0.7	315	4.0	0.7475	0.3085	0.002	0.132	0.128
Fuel Truck	0	200	0.59	118	4.0	0.7475	0.3085	0.002	0.132	0.128
Hydrovac Truck	0	200	0.59	118	4.0	0.7475	0.3085	0.002	0.132	0.128
Road Bore Machine	3,200	260	0.79	205	4.0	0.7475	0.3085	0.002	0.132	0.128
Pile Driver	8,000	49	1	49	4.7279	1.5323	0.2789	0.002	0.3389	0.3389
100 HP Tractor	6,500	100	0.21	100	4.1	0.867	0.338	0.002	0.18	0.18
Semitruck/Trailer	8,100	500	0.59	500	4.335	0.843	0.167	0.002	0.132	0.132

^a Total hours used includes equipment for the wind farm, two substations, the O&M building, and all other project components except the HVTL. Construction

^b Generally assumes work will occur 7 am - 7 pm, Monday through Saturday.

^c Load Factors from Appendix A of EPA 420_P-04-005, Median Life, Annual Activity, and Load Factor Values for Nonroad Engine Emissions Modeling, USEPA,

^d EPA 420-P-04-009, Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling - Compression Ignition, USEPA, April 2004 - Tier 2 Engines.

Assumption:

393.5 hp-hr/MMBtu

453.6 g/lb

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Emission Estimates from Construction Engines						
Equipment	Potential Emissions (tons)					
	NOx	CO	VOC	SO ₂	PM ₁₀	PM _{2.5}
Air Compressor	0.373	0.188	2.91E-02	0.000	0.019	0.019
ATV	0.119	0.058	1.18E-02	0.000	0.007	0.007
Backhoe	0.746	0.375	5.83E-02	0.000	0.038	0.038
Bulldozer	3.968	0.742	3.06E-01	0.002	0.131	0.131
Compactor	9.032	1.755	3.48E-01	0.004	0.274	0.274
Compactor, Vibratory	2.441	0.516	2.01E-01	0.001	0.107	0.107
Fork Lift	2.064	0.401	7.95E-02	0.001	0.063	0.063
Concrete Mixer Truck	33.049	6.986	2.73E+00	0.016	1.451	1.451
Concrete Pump	3.864	0.817	3.19E-01	0.002	0.170	0.170
Dump Truck	9.871	2.087	8.15E-01	0.005	0.433	0.433
Excavator	2.829	0.529	2.18E-01	0.001	0.093	0.093
Front End Loader	8.642	1.615	6.67E-01	0.004	0.284	0.284
Generator	4.570	0.888	1.76E-01	0.002	0.139	0.139
Guided Bore Machine	3.823	1.924	5.18E-01	0.002	0.195	0.195
Light Tower	1.389	0.260	1.07E-01	0.001	0.046	0.046
Manlift	1.390	0.294	1.15E-01	0.001	0.061	0.061
Pickup Truck	0.161	0.031	6.21E-03	0.000	0.005	0.005
Pickup Truck (on road travel only)	0.278	0.054	1.07E-02	0.000	0.008	0.008
Skid steer loader	1.345	0.251	1.04E-01	0.001	0.044	0.044
Water truck	2.021	1.017	2.74E-01	0.001	0.103	0.103
Welding machine	0.522	0.263	4.08E-02	0.000	0.027	0.027
Grader	4.522	2.201	4.46E-01	0.002	0.272	0.264
Large Crane	0.185	0.090	1.83E-02	0.000	0.011	0.011
Medium Crane	0.000	0.000	0.00E+00	0.000	0.000	0.000
Fuel Truck	0.000	0.000	0.00E+00	0.000	0.000	0.000
Hydrovac Truck	0.000	0.000	0.00E+00	0.000	0.000	0.000
100 HP Tractor	2.938	0.621	2.42E-01	0.001	0.129	0.129
Semitruck/Trailer	19.353	3.763	7.46E-01	0.009	0.589	0.589
TOTAL	126.82	29.38	9.11	0.06	5.02	5.01

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Fugitive Dust Emissions from Unpaved Roads								
Equipment	Quantity ^a	Total Days		W	Emission Factor (lb/VMT) ^c		Emissions (tons)	
		Used	VMT ^b		PM ₁₀	PM _{2.5}	PM ₁₀	PM _{2.5}
ATV	2	150	300	20	1.73	0.17	0.26	0.03
Backhoe	4	360	1,440	50	2.62	0.26	1.89	0.19
Bulldozer	7	360	2,520	20	1.73	0.17	2.18	0.22
Concrete Mixer Truck	35	240	8,400	20	1.73	0.17	7.28	0.73
Dump Truck	11	210	2,310	21	1.77	0.18	2.05	0.20
Excavator	6	285	1,710	22	1.81	0.18	1.55	0.15
Fork Lift	7	550	3,850	20	1.73	0.17	3.34	0.33
Front End Loader	6	465	2,790	23	1.85	0.18	2.58	0.26
Grader	5	465	2,325	20	1.73	0.17	2.02	0.20
Large Crane	2	90	180	50	2.62	0.26	0.24	0.02
Manlift	10	300	3,000	24	1.88	0.19	2.82	0.28
Medium Crane	4	270	1,080	25	1.92	0.19	1.04	0.10
Pickup Truck	4	270	1,080	24	1.88	0.19	1.02	0.10
Semitruck/Trailer	4	320	1,280	25	1.92	0.19	1.23	0.12
Skid steer loader	5	600	3,000	26	1.95	0.20	2.93	0.29
Water truck	5	500	2,500	20	1.73	0.17	2.17	0.22
Welding Machine	5	610	3,050	20	1.73	0.17	2.64	0.26
TOTAL	--	--	--	--	--	--	28.24	2.82
^a Equipment counts are estimated based current construction plan.								
^b Assumes each vehicle travels 1.0 mile per day on site								
^c AP-42 Section 13.2.2 Unpaved Roads, dated November 2006, Equations 1a and 2 TOTALS 11.19 1.12 Surface Silt content based on Table 13.2.2-1 - construction sites.								

Eq 1a: $E = k * (s/12)^a * (W/3)^b$

Eq 2: $E_{ext} = E * [(365-P)/365]$

where:

VMT = Vehicle Miles Traveled

W = Mean Vehicle Weight, tons

S = Mean Vehicle Speed, mph

P = 120 days with at least 0.01 inches rain, EPA's AP-42 Figure 13.2.2-1

s = 8.5 surface material silt content (%) for construction sites, EPA's AP-42 Table 13.2.2-1

E = size-specific emission factor, lb/ VMT

E_{ext} = annual size-specific emission factor extrapolated for natural migration, lb/VMT

Constants	PM	PM ₁₀	PM _{2.5}
k (lb/VMT)	4.9	1.5	0.15
a	0.7	0.9	0.9
b	0.45	0.45	0.45

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Fugitive Dust Emissions From Earthmoving Activities							
Construction Activity	Material Handling	Material	Average	Emission Factors ^{b-d}		Emissions	
	Rate ^a (ton/day)	Handling Time (days)	Exposed Area (acres)	PM ₁₀	PM _{2.5}	PM ₁₀	PM _{2.5}
OPTIMIZED ROUTE SEGMENT							
Topsoil removed by scraper ^e	846.0	200	---	0.058	0.0061	4.91	0.52
Topsoil replacement	846.0	200	---	0.012	0.0013	1.02	0.11
Wind erosion of exposed areas	---	200	83.90	0.38	0.03999	3.19	0.34
TOTAL - OPTIMIZED ROUTE SEGMENT	---	---	---	---	---	9.11	0.96
Notes and Assumptions:							
^a Soil density: 1.25 tons per yard.							
^b As worst case, PM ₁₀ is set equal to Total Particulate Matter. PM _{2.5} is set to 0.105 times PM ₁₀ per AP-42 Section 11.9 Table 11.9-1.							
^c Wind Erosion Exposed Areas emission factor: AP-42 Section 11.9 Western Surface Coal Mining, Table 11.9-4, July 1998, wind erosion of exposed areas							
^d Emission factor: AP-42 Section 11.9 Western Surface Coal Mining, Table 11.9-4, July 1998, topsoil removal by scraper.							
^e Assumes the entire workspace is cleared to 1 foot deep, 1.25 tons per cubic yard.							

Topsoil Removed by Scraper					
Facility	Construction Schedule (days)	Total (Acres)	Soil Volume (yd ³)	Soil Weight (ton)	Handling Rate (ton/day)
Wind Project - SPAR	200	83.90	135,359	169,198	846

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Summary of Potential Greenhouse Gas Emissions From Construction Engines (tons)				
Description	CO ₂	CH ₄	N ₂ O	CO ₂ e ^a
Off-Road Engine Emissions	4,719.20	0.19	0.04	4,734.70
Commuters and Delivery Vehicles	1,485.67	0.00	0.00	1485.67
TOTAL	6,204.87	0.19	0.04	6,220.37
^a CO ₂ e = carbon dioxide equivalent. Includes global warming potentials from US EPA's 2024 GHG Emission Factors Hub.				

Global Warming Potentials		
CO ₂	CH ₄	N ₂ O
1	25	298
Source: US EPA's 2024 GHG Emission Factors Hub.		

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Emission Estimates from Construction Engines														
Equipment	Quantity ^a	Hours per Day	Days per Week	Total Hours Used ^b	Max Power (HP)	Load Factor ^c	Loaded Power (HP)	Emission Factors ^{d,e} (g/hp-hr)			Potential Emissions ^f (tons)			
								CO ₂	CH ₄	N ₂ O	CO ₂	CH ₄	N ₂ O	CO ₂ e
100 HP Tractor	1	10	90	900	50	1	50	188.3	0.008	0.002	9.34	0.00	0.00	9.37
Air Compressor	7	8	660	2,440	80	1	80	188.3	0.008	0.002	40.51	0.00	0.00	40.64
ATV	2	8	150	2,400	20	0.5	10	188.3	0.008	0.002	4.98	0.00	0.00	5.00
Backhoe	4	40	360	3,600	75	0.8	60	188.3	0.008	0.002	44.83	0.00	0.00	44.97
Bulldozer	7	40	360	6,300	250	1	250	188.3	0.008	0.002	326.85	0.01	0.00	327.92
Compactor	6	40	360	5,400	300	1	300	188.3	0.008	0.002	336.19	0.01	0.00	337.29
Compactor, Vibratory	4	40	360	3,600	100	1	100	188.3	0.008	0.002	74.71	0.00	0.00	74.95
Concrete Mixer Truck	35	40	240	22,500	325	1	325	188.3	0.008	0.002	1,517.51	0.06	0.01	1,522.50
Concrete Pump	5	40	195	2,850	300	1	300	188.3	0.008	0.002	177.43	0.01	0.00	178.02
Dump Truck	11	40	210	8,400	325	0.8	260	188.3	0.008	0.002	453.23	0.02	0.00	454.72
Excavator	6	40	285	4,650	138	1	138	188.3	0.008	0.002	133.17	0.01	0.00	133.61
Fork Lift	7	40	550	10,000	120	1	120	188.3	0.008	0.002	249.03	0.01	0.00	249.85
Front End Loader	6	40	465	7,650	196	1	196	188.3	0.008	0.002	311.16	0.01	0.00	312.18
Fuel Truck	4	40	615	6,150	200	0.59	118	188.3	0.008	0.002	150.60	0.01	0.00	151.09
Generator	7	40	360	6,300	250	0.5	125	188.3	0.008	0.002	163.42	0.01	0.00	163.96
Grader	5	40	465	6,150	35	0.8	28	188.3	0.008	0.002	35.74	0.00	0.00	35.85
Guided Bore Machine	1	10	90	900	150	0.8	120	188.3	0.008	0.002	22.41	0.00	0.00	22.49
Hydrovac Truck	4	40	155	1,550	200	0.59	118	188.3	0.008	0.002	37.96	0.00	0.00	38.08
Large Crane	2	10	90	1,800	15	0.21	3	188.3	0.008	0.002	1.18	0.00	0.00	1.18
Light Tower	9	40	220	6,100	50	1	50	188.3	0.008	0.002	63.29	0.00	0.00	63.50
Manlift	10	40	300	7,800	50	1	50	188.3	0.008	0.002	80.93	0.00	0.00	81.20
Medium Crane	4	30	270	3,600	450	0.7	315	188.3	0.008	0.002	235.33	0.01	0.00	236.10
Pickup Truck	4	30	270	3,600	150	0.25	38	188.3	0.008	0.002	28.02	0.00	0.00	28.11
Semitruck/Trailer	4	40	320	3,200	50	1	50	188.3	0.008	0.002	33.20	0.00	0.00	33.31
Skid steer loader	5	40	600	8,000	50	1	50	188.3	0.008	0.002	83.01	0.00	0.00	83.28
Water truck	5	40	500	6,500	100	0.5	50	188.3	0.008	0.002	67.45	0.00	0.00	67.67
Welding machine	5	40	610	8,100	35	0.8	28	188.3	0.008	0.002	47.07	0.00	0.00	47.22
TOTAL	--	--	--	--	--	--	--				4,719.20	0.19	0.038	4,734.70

^a Equipment counts based on experience with construction of a similar projects.

^b Generally assumes work will occur 7 am - 7 pm, Monday through Saturday.

^c Load Factors from Appendix A of EPA 420_P-04-005, Median Life, Annual Activity, and Load Factor Values for Nonroad Engine Emissions Modeling , USEPA, April 2004.

^d EPA 420-P-04-009, Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling - Compression Ignition, USEPA, April 2004 - Tier 2 Engines.

^e GHG emission factors from Title 40 Subchapter C Part 98 Subpart C Table C-1 and C-2 to Subpart C.

^f CO₂e is carbon dioxide equivalent and includes global warming potentials from 40 CRF Part 98 Table A-1.

Global Warming Potentials		
CO ₂	CH ₄	N ₂ O
1	28	265

Source: US EPA's 2024 GHG Emission Factors Hub.

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Greenhouse Gas Emissions from On Road Construction Traffic						
	Vehicles	Miles	Number	Fuel Used	CO ₂ Emission Factor ^b	CO ₂ Emissions
	per day	per vehicle ^a	of Days	(gallons)	(g/gal)	(tons)
Commuter Vehicles - Gasoline ^c	300	60	150	112,500	8,780	1,088.81
Pickup Truck - Gasoline ^d	7	60	170	3,758	8,780	36.37
Concrete Mix Truck - Diesel ^e	35	60	90	29,077	10,210	327.25
Semitruck/Trailer - Diesel ^{e,f}	4	60	80	2,954	10,210	33.24
TOTAL						1,485.67

^a Assumes commuters travel 30 miles each way (60 miles round trip) per day.

^b Emission factors from US EPA's 2024 GHG Emission Factors Hub.

^c Assumes a commuter vehicle a fuel economy of 24 miles per gallon, per US EPA and US Department of Energy Fuel Economy data for combined city and highway driving in 2023, available online at: <https://www.fueleconomy.gov/feg/download.shtml>.

^d Assumes a pickup truck vehicle a fuel economy of 19 miles per gallon, per US EPA and US Department of Energy Fuel Economy data for combined city and highway driving in 2023, available online at: <https://www.fueleconomy.gov/feg/download.shtml>.

^e Assumes a delivery trucks fuel economy of 6.5 miles per gallon, industry average.