

Federal NG Wells Summaries

Total Annual Emissions from Federal NG Wells - RMP Year 20

Activity	Annual Emissions (Tons)											
	PM ₁₀	PM _{2.5}	NO _x	SO ₂	CO	VOC	HAPs	CO ₂	CH ₄	N ₂ O	CO _{2eq}	CO _{2eq} metric tonnes
Well Pad Construction - Fugitive Dust	0.105	0.011	---	---	---	---	---	---	---	---	---	---
Heavy Equipment Combustive Emissions	0.269	0.262	5.107	0.106	1.321	0.374	0.037	550.099	0.006	0.006	552.073	500.973
Commuting Vehicles - Construction	0.173	0.022	0.077	0.000	0.091	0.032	0.003	20.020	0.001	0.000	20.116	18.254
Wind Erosion	0.095	0.014	---	---	---	---	---	---	---	---	---	---
Completion Venting	---	---	---	---	---	0.202	0.000	0.089	26.358	0.000	553.598	502.357
Sub-total: Construction	0.641	0.308	5.184	0.107	1.412	0.608	0.041	570.208	26.364	0.006	1125.787	1021.585
Well Workover Operations - Fugitive Dust	0.003	0.000	---	---	---	---	---	---	---	---	---	---
Well Workover Operations - On-site Exhaust	0.008	0.007	0.133	0.002	0.045	0.010	0.001	10.507	0.000	0.000	10.546	9.570
Well Workover Operations - On-road Exhaust	0.000	0.000	0.001	0.000	0.001	0.001	0.000	0.186	0.000	0.000	0.187	0.170
Well Visits for Inspection & Repair - Operations	0.004	0.000	0.000	0.000	0.001	0.000	0.000	0.013	0.000	0.000	0.013	0.012
Wellhead and Compressor Station Fugitives	---	---	---	---	---	0.003	0.000	0.001	0.354	0.000	7.430	6.742
Compression	0.009	0.009	0.207	0.000	0.413	0.145	0.014	27.893	0.001	0.000	27.920	25.336
Station Visits - Operations	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.000	0.000	0.007	0.006
Dehydrators	0.000	0.000	0.001	0.000	0.001	0.004	0.002	1.755	2.636	0.000	57.122	51.834
Workover subtotal:	0.011	0.008	0.134	0.002	0.046	0.010	0.001	10.693	0.000	0.000	10.733	9.740
Sub-total: Operations	0.028	0.018	0.342	0.002	0.461	0.161	0.018	40.361	2.990	0.000	103.224	93.670
Road Maintenance	0.002	0.000	0.001	0.000	0.000	0.000	0.000	0.088	0.000	0.000	0.089	0.080
Sub-total: Maintenance	0.002	0.000	0.001	0.000	0.000	0.000	0.000	0.088	0.000	0.000		0.080
Road Reclamation	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Well Reclamation	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sub-total: Reclamation	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total Emissions	0.672	0.326	5.526	0.109	1.874	0.769	0.058	610.658	29.355	0.006	1229.011	1115.335
Operations - workover	0.017	0.010	0.208	0.000	0.415	0.151	0.017	29.668	2.990	0.000	92.491	83.930

Non-Federal NG Wells Summaries

Total Annual Emissions from Non-Federal NG Wells - RMP Year 20

Activity	Annual Emissions (Tons)											
	PM ₁₀	PM _{2.5}	NO _x	SO ₂	CO	VOC	HAPs	CO ₂	CH ₄	N ₂ O	CO _{2eq}	CO _{2eq} metric tonnes
Well Pad Construction - Fugitive Dust	0.00	0.00	---	---	---	---	---	---	---	---	---	---
Heavy Equipment Combustive Emissions	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	1.85	1.68
Commuting Vehicles - Construction	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.07
Wind Erosion	0.00	0.00	---	---	---	---	---	---	---	---	---	---
Completion Venting	---	---	---	---	---	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sub-total: Construction	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	1.93	1.75
Well Workover Operations - Fugitive Dust	0.00	0.00	---	---	---	---	---	---	---	---	---	---
Well Workover Operations - On-site Exhaust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Well Workover Operations - On-road Exhaust	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.00	0.00	0.00	0.00	0.00
Well Visits for Inspection & Repair - Operations	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.00	0.00	0.00	0.00	0.00
Wellhead and Compressor Station Fugitives	---	---	---	---	---	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Compression	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Station Visits - Operations	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dehydrators	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sub-total: Operations	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Road Maintenance	0.00	0.00	0.00	0.000	0.00	0.00	0.000	0.00	0.00	0.00	0.00	0.00
Sub-total: Maintenance	0.00	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.00		0.00
Road Reclamation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Well Reclamation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sub-total: Reclamation	0.00	0.00	0.00	0.0000	0.00	0.000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total Emissions	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	1.93	1.75

CONSTRUCTION - HEAVY EQUIPMENT OPERATIONS - FUGITIVE DUST

Fugitive Dust from Heavy Construction Operations			
INPUTS & ASSUMPTIONS			
Description	Value	Source	Notes
Control Efficiency (C) of watering ^a	0.5	a	
TSP Emission Factor	1.2	b	Tons TSP/acre-month
Conversion factor for TSP to PM ₁₀	0.35	c	Percentage of TSP
Conversion factor for PM ₁₀ to PM _{2.5}	0.1	d	Percentage of PM ₁₀

^a Fitzpatrick, M. 1990. *User's Guide: Emission Control Technologies and Emission Factors for Unpaved Road Fugitive Emissions*, EPA/625/5-87/022. <http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=20008SFC>.

^b EPA, AP-42, Volume I, Section 13.2.3 Heavy Construction Operations, Jan. 1995 (Errata Feb. 2010)

^c EPA, AP-42, Volume I, Section 13.2.4 Aggregate Handling and Storage Piles, Nov. 2006

^d Midwest Research Institute. 2006. *Background Document for Revisions to Fine Fraction Ratios Used for AP-42 Fugitive Dust Emission Factors*, Report prepared for the Western Governors' Association, Western Regional Air Partnership (WRAP), MRI Project No. 110397,

Emissions Estimation for Construction Activities

Area Disturbed for Oil Wells	Avg. Disturbed Acres per well ^a	Construction Days	Total # of Wells	Total Disturbed Acres	Emissions					
					(lbs/well)			(tons/year/well)		
					TSP	PM ₁₀	PM _{2.5}	TSP	PM ₁₀	PM _{2.5}
Improved Road	1.0	3	1	1.0	120	42	4.2	0.06	0.02	0.00
Well Pad and other structures	3.0	4	1	3.0	480	168	16.8	0.24	0.08	0.01
Field Compressor Station	0.00	6	1	0.00	0	0	0.0	0.00	0.00	0.00
Sales Compressor Station	0.00	6	1	0.00	0	0	0.0	0.00	0.00	0.00
Total					600	210	21.00	0.30	0.11	0.01

^a Average disturbed area data for new CBNG wells shown in SEIS and for Compressor Stations provided by Montana BLM (Laakso, 2010)

CONSTRUCTION DRILLING – HEAVY EQUIPMENT OPERATIONS - EXHAUST

Exhaust Emissions from Well Pad Construction Heavy Equipment and Drilling Equipment

Emission Factors for Construction Equipment

Equipment	Emission Factors (g/hp-hr)									Equipment Category
	NO _x	PM ₁₀	SO ₂	CO	VOCs	PM _{2.5}	CO ₂	CH ₄	N ₂ O ^a	
Dozer - 175 Hp	4.37	0.34	0.12	1.52	0.35	0.33	535.76	0.005	0.006	Track-Type Tractor
Blade - 150 Hp	4.85	0.57	0.13	3.94	0.50	0.55	594.65	0.008	0.006	Motor Grader

Source: EPA NONROADS 2008a

NOTE: Use emission factors for 2008 for all project years = conservative estimate of fleet turnover

^a Based on N₂O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

Emission Estimations for Construction Equipment (using 2008 emission factors)

Construction Site	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Operating Hours/Day	# of Operating Days/Well	# of Operating Hours/Well	# of Wells	Max. Annual Emissions											
									(lbs/equipment type/well)					(tons/equipment type/well)						
									NO _x	PM ₁₀	SO ₂	CO	VOC	NO _x	PM ₁₀	SO ₂	CO	VOC	PM _{2.5}	CO ₂
Improved & Two-Track Road	Blade	150	1	75	10	2	20	1	24.06	2.83	0.64	19.54	2.48	0.01	0.00	0.00	0.01	0.00	0.00	1.4748
Well Pad	Blade	175	1	75	10	3	30	1	42.10	4.95	1.13	34.20	4.34	0.02	0.00	0.00	0.02	0.00	0.00	2.5809
	Dozer	175	1	80	10	3	30	1	40.46	3.15	1.11	14.07	3.24	0.02	0.00	0.00	0.01	0.00	0.00	2.7530
									Subtotal	0.05	0.01	0.00	0.03	0.01	0.01	0.01	6.8088	0.0001	0.0001	

Exhaust Emission Factors for Diesel Powered Bore/Drill Rig Engines

Project Year/Hp Category	Emission Factors (g/hp-hr)								
	NO _x	PM ₁₀	SO ₂	CO	VOCs	PM _{2.5}	CO ₂	CH ₄	N ₂ O ^a
Year 2018									
50 to 75	4.55	0.41	0.12	2.13	0.42	0.40	589.10	0.006	0.006
75 to 100	3.75	0.42	0.11	2.03	0.42	0.41	589.10	0.006	0.006
100 to 175	3.57	0.27	0.10	1.00	0.31	0.26	530.10	0.005	0.006
175 to 300	3.37	0.23	0.10	0.83	0.28	0.22	530.18	0.004	0.006
300 to 600	3.61	0.21	0.10	1.06	0.26	0.21	530.25	0.004	0.006
600 to 750	3.61	0.22	0.10	1.25	0.25	0.21	530.28	0.004	0.006
>750	5.13	0.26	0.10	1.29	0.37	0.25	529.92	0.006	0.006

Source: EPA NONROADS 2008a - Year 2018 accounts for mixture of Tier 1-3 engines

^a Based on N₂O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

Combustive Emissions Estimation for Industrial Engines

Construction Site	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Operating Hours/Day	# of Operating Days/Well	# of Operating Hours/Well	# of Wells	Max. Annual Emissions											
									(lbs/equipment type/well)					(tons/equipment type/well)						
									NO _x	PM ₁₀	SO ₂	CO	VOC	NO _x	PM ₁₀	SO _x	CO	VOC	PM _{2.5}	CO ₂
Rig-up, Drilling, and Rig-down	Main Deck	1,000	3	70	24	16	384	1	9,126	462	182	2,291	661	4.56	0.23	0.09	1.15	0.33	0.22	471.0375
	Auxiliary Pump	600	1	80	8	15	120	1	459	27	13	134	33	0.23	0.01	0.01	0.07	0.02	0.01	33.6670
	Generators	150	2	75	24	8	192	1	340	25	10	95	30	0.17	0.01	0.00	0.05	0.01	0.01	25.2427
	Main Deck	600	1	50	11	5	55	1	131	8	4	38	9	0.07	0.00	0.00	0.02	0.00	0.00	9.6442
Well Completion & Testing	Auxiliary Pump	225	1	80	8	2	16	1	21	1	1	5	2	0.01	0.00	0.00	0.00	0.00	0.00	1.6831
	Power Swivel	150	1	75	8	2	16	1	14	1	0	4	1	0.01	0.00	0.00	0.00	0.00	0.00	1.0518
	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%) ^a	# of Operating Hours/ Day	# of Operating Days/ Well	# of Operating Hours/ Well	# of Wells												
	Field Generators for Pumps & Lighting	55	1	75	12	3	36	1	14.90	1.33	0.38	6.98	1.38	0.01	0.00	0.00	0.00	0.00	0.00	0.9643
									Subtotal	5.05	0.26	0.10	1.29	0.37	0.26	543.2905	0.0056	0.0059		
									Total	5.11	0.27	0.11	1.32	0.37	0.26	550.0993	0.0057	0.0060		

CONSTRUCTION DRILLING - COMMUTING VEHICLES - FUGITIVE DUST

Emission Factors for Industrial Unpaved Roads ^a			
E (lb/VMT) =	k (s/12) ^a (W/3) ^b	Parameter	PM ₁₀ PM _{2.5}
		k	1.5 0.15
		a	0.9 0.9
		b	0.45 0.45
E _{ext} = E (1 - P/365)			
Function/Variable Description	Assumed Value	Reference	
E = size-specific emission factor (lb/VMT)			
E _{ext} = size-specific emission factor extrapolated for natural			
s = surface material silt content (%)	5.1	EPA AP-42 Section 13.2.2, Table 13.2.2-1	
W = mean vehicle weight (tons)	Listed in the table below		
M = surface material moisture content (%)	2.0	EPA AP-42 Section 13.2.2	
P = Number of days precip per year	41	EPA AP-42 Section 13.2.2, Figure 13.2.2-1	
CE = control efficiency of watering ^b	50%		

^a Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006

^b Fitzpatrick, M. 1990. User's Guide: Emission Control Technologies and Emission Factors for Unpaved Road Fugitive Emissions, EPA/625/5-87/022. <http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=20008SFC>.

Fugitive Dust Emission Estimations for Road Traffic - All Project Years

Construction Site Destination	Vehicle Type	Avg. Vehicle Weight (tons)	Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells	PM ₁₀				PM _{2.5}			
							Controlled Em. Factor (lb/VMT)	Emissions			Controlled Em. Factor (lb/VMT)	Emissions		
								(lbs/vehicle/ well)	(tons/ vehicle type/well)	(tons/well)		(lbs/vehicle/ well)	(tons/ vehicle type/well)	(tons/well)
Improved & Two-Track Road	Semi Trucks	42	1	47	47	1	1.01	47.50	0.02	0.02	0.10	4.75	0.00	0.00
	Pickup Trucks	5	1	3	3	1	0.39	1.16	0.00	0.00	0.04	0.12	0.00	0.00
Well Pad	Semi Trucks	42	1	5	5	1	1.01	5.05	0.00	0.00	0.10	0.51	0.00	0.00
	Pickup Trucks	5	1	4	4	1	0.39	1.55	0.00	0.00	0.04	0.16	0.00	0.00
Other Construction Activities	Semi Trucks	42	1	2	2	1	1.01	2.02	0.00	0.00	0.10	0.20	0.00	0.00
	Haul Trucks	25	1	2	2	1	0.80	1.60	0.00	0.00	0.08	0.16	0.00	0.00
	Pickup Trucks	5	1	1	1	1	0.39	0.39	0.00	0.00	0.04	0.04	0.00	0.00
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	42	1	44	44	1	1.01	44.47	0.02	0.02	0.10	4.45	0.00	0.00
	Fuel Haul Truck	25	1	6	6	1	0.80	4.80	0.00	0.00	0.08	0.48	0.00	0.00
	Mud Haul Truck, Water Hauling	25	1	4	4	1	0.80	3.20	0.00	0.00	0.08	0.32	0.00	0.00
	Rig Crew	5	1	51	51	1	0.39	19.78	0.01	0.01	0.04	1.98	0.00	0.00
	Rig Mechanics	5	1	2	2	1	0.39	0.78	0.00	0.00	0.04	0.08	0.00	0.00
	Co. Supervisor	5	1	20	20	1	0.39	7.76	0.00	0.00	0.04	0.78	0.00	0.00
	Tool Pusher	25	1	8	8	1	0.80	6.40	0.00	0.00	0.08	0.64	0.00	0.00
	Mud Logger	25	1	6	6	1	0.80	4.80	0.00	0.00	0.08	0.48	0.00	0.00
	Mud Engineer	25	1	15	15	1	0.80	12.00	0.01	0.01	0.08	1.20	0.00	0.00
	Logger, Engr Truck	25	1	1	1	1	0.80	0.80	0.00	0.00	0.08	0.08	0.00	0.00
	Drill Bit Delivery	25	1	2	2	1	0.80	1.60	0.00	0.00	0.08	0.16	0.00	0.00
Well Completion & Testing (continued below)	Semi Casing Haulers	42	1	6	6	1	1.01	6.06	0.00	0.00	0.10	0.61	0.00	0.00
	Semi Completion, Unit Rig	42	1	1	1	1	1.01	1.01	0.00	0.00	0.10	0.10	0.00	0.00
	Semi Fracing, Blender	25	1	1	1	1	0.80	0.80	0.00	0.00	0.08	0.08	0.00	0.00
	Semi Pumping/Tank Battery	25	1	6	6	1	0.80	4.80	0.00	0.00	0.08	0.48	0.00	0.00
	Tubing Truck	25	1	2	2	1	0.80	1.60	0.00	0.00	0.08	0.16	0.00	0.00
	Haul Cementer, Pump Truck	25	1	2	2	1	0.80	1.60	0.00	0.00	0.08	0.16	0.00	0.00
Subtotal										0.09	0.01			

CONSTRUCTION DRILLING - COMMUTING VEHICLES - FUGITIVE DUST

Emission Estimations for Road Traffic - All Project Years (continued)

Construction Site Destination	Vehicle Type	Avg. Vehicle Weight (tons)	Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells	PM ₁₀				PM _{2.5}			
							Controlled Em. Factor (lb/VMT)	Emissions			Controlled Em. Factor (lb/VMT)	Emissions		
								(lbs/vehicle type)	(tons/ vehicle type/well)	(tons/well)		(lbs/vehicle type)	(tons/ vehicle type/well)	(tons/well)
Well Completion & Testing (continued from above)	Haul Cementer, Cement Truck	25	1	3	3	1	0.80	2.40	0.00	0.08	0.08	0.24	0.00	0.01
	Haul Completion,	25	1	3	3	1	0.80	2.40	0.00		0.08	0.24	0.00	
	Haul Service Tools	25	1	2	2	1	0.80	1.60	0.00		0.08	0.16	0.00	
	Haul Perforators Logging Truck	25	1	1	1	1	0.80	0.80	0.00		0.08	0.08	0.00	
	Haul Anchor, Installation	25	1	1	1	1	0.80	0.80	0.00		0.08	0.08	0.00	
	Haul Anchor, Testing	25	1	1	1	1	0.80	0.80	0.00		0.08	0.08	0.00	
	Haul Fracing, Tank	25	1	1	1	1	0.80	0.80	0.00		0.08	0.08	0.00	
	Haul Fracing, Pump	25	1	1	1	1	0.80	0.80	0.00		0.08	0.08	0.00	
	Haul Fracing, Chemical	25	1	1	1	1	0.80	0.80	0.00		0.08	0.08	0.00	
	Haul Fracing, Sand	25	1	1	1	1	0.80	0.80	0.00		0.08	0.08	0.00	
	Haul Fracing, Other	25	1	1	1	1	0.80	0.80	0.00		0.08	0.08	0.00	
	Haul Welders	25	1	6	6	1	0.80	4.80	0.00		0.08	0.48	0.00	
	Haul Water Truck	25	1	150	150	1	0.80	120.04	0.06		0.08	12.00	0.01	
	Pickup Cementer, Engineer	5	1	2	2	1	0.39	0.78	0.00		0.04	0.08	0.00	
	Pickup Casing Crew	5	1	2	2	1	0.39	0.78	0.00		0.04	0.08	0.00	
	Pickup Completion Crew	5	1	5	5	1	0.39	1.94	0.00		0.04	0.19	0.00	
	Pickup Completion, Pusher	5	1	5	5	1	0.39	1.94	0.00		0.04	0.19	0.00	
	Pickup Perforators, Engineer	5	1	2	2	1	0.39	0.78	0.00		0.04	0.08	0.00	
	Pickup Fracing, Engineer	5	1	1	1	1	0.39	0.39	0.00		0.04	0.04	0.00	
	Pickup Co. Supervisor	5	1	10	10	1	0.39	3.88	0.00		0.04	0.39	0.00	
	Pickup Miscellaneous Supplies	5	1	3	3	1	0.39	1.16	0.00		0.04	0.12	0.00	
	Pickup Roustabout Crew	5	1	4	4	1	0.39	1.55	0.00		0.04	0.16	0.00	
							Subtotal			0.08				0.01
							Total			0.17				0.02

CONSTRUCTION AND DRILLING VEHICLES - EXHAUST

Emission Factors for Commuting Vehicles

Vehicle		Emission Factors (g/mi)								
Type	Class	NO _x	PM ₁₀	PM _{2.5}	SO _x	CO	VOC	CO ₂	CH ₄	N ₂ O ^a
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.006

[Source: MOBILE6.2.03]

^a Compendium of Greenhouse Gas Emission Methodologies for the Oil and Gas Industry, Table 4-17 for N2O (HDDV moderate control, LDGT oxidation catalyst, LDDT moderate control) , Mobile Source Combustion Factors, American Petroleum Institute (2009).

Combustive Emissions Estimation Road Traffic

Combustive Emissions Estimation Road Traffic																																																												
Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/Year	Miles Traveled/Well/Year	Total # of Wells	Emissions																																																					
	Type	Class					(lbs/vehicle type/well)						(tons/vehicle type/well)						(tons/well)																																									
							NO _x	PM ₁₀	PM _{2.5}	SO ₂	CO	VOC	NO _x	PM ₁₀	PM _{2.5}	SO ₂	CO	VOC	NO _x	PM ₁₀	PM _{2.5}	SO ₂	CO	VOC	CO ₂	CH ₄	N ₂ O																																	
Improved & Two-Track Road	Semi Trucks	HDDV	60	47	2820	1	16.8852	1.7109	1.4280	0.0821	10.6993	2.2008	0.0084	0.0009	0.0007	0.0000	0.0053	0.0011	0.009	0.001	0.001	0.000	0.007	0.002	2.4613	0.000115	0.000018																																	
	Pickup Trucks	LDDT	60	3	180	1	0.9175	0.0431	0.0351	0.0022	2.4790	1.0901	0.0005	0.0000	0.0000	0.0000	0.0012	0.0005							0.0813	0.000000	0.000003																																	
Well Pad	Semi Trucks	HDDV	60	5	300	1	1.7963	0.1820	0.1519	0.0087	1.1382	0.2341	0.0009	0.0001	0.0001	0.0000	0.0006	0.0001	0.002	0.000	0.000	0.000	0.002	0.001	0.2618	0.000012	0.000002																																	
	Pickup Trucks	LDDT	60	4	240	1	1.2233	0.0575	0.0468	0.0030	3.3053	1.4534	0.0006	0.0000	0.0000	0.0000	0.0017	0.0007							0.1083	0.000001	0.000004																																	
Other Construction Activities	Semi Trucks	HDDV	60	2	120	1	0.7185	0.0728	0.0608	0.0035	0.4553	0.0937	0.0004	0.0000	0.0000	0.0000	0.0002	0.0000	0.001	0.000	0.000	0.000	0.001	0.000	0.1047	0.000005	0.000001																																	
	Haul Trucks	HDDV	60	2	120	1	0.7185	0.0728	0.0608	0.0035	0.4553	0.0937	0.0004	0.0000	0.0000	0.0000	0.0002	0.0000							0.1047	0.000005	0.000001																																	
	Pickup Trucks	LDDT	60	1	60	1	0.3058	0.0144	0.0117	0.0007	0.8263	0.3634	0.0002	0.0000	0.0000	0.0000	0.0004	0.0002	0.001	0.000	0.000	0.000	0.010	0.003	3.149	0.000	0.000																																	
							Subtotal						0.011						0.001						0.000						0.010						0.003						3.149						0.000						0.000					

CONSTRUCTION AND DRILLING VEHICLES - EXHAUST

Combustive Emissions Estimation Road Traffic

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells	Emissions																					
	Type	Class					(lbs/vehicle type/well)					(tons/vehicle type/well)					(tons/well)											
							NO _x	PM ₁₀	PM _{2.5}	SO ₂	CO	VOC	NO _x	PM ₁₀	PM _{2.5}	SO ₂	CO	VOC	NO _x	PM ₁₀	PM _{2.5}	SO ₂	CO	VOC	CO ₂	CH ₄	N ₂ O	
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	HDDV	60	44	2640	1	15.8074	1.6017	1.3369	0.0768	10.0164	2.0603	0.0079	0.0008	0.0007	0.0000	0.0050	0.0010	0.03	0.00	0.00	0.00	0.05	0.02	2.3	0.000108	0.000017	
	Fuel Haul Truck	HDDV	60	6	360	1	2.1556	0.2184	0.1823	0.0105	1.3659	0.2810	0.0011	0.0001	0.0001	0.0000	0.0007	0.0001							0.3	0.000015	0.000002	
	Mud Haul Truck, Water Hauling	HDDV	60	4	240	1	1.4370	0.1456	0.1215	0.0070	0.9106	0.1873	0.0007	0.0001	0.0001	0.0000	0.0005	0.0001							0.2	0.000010	0.000002	
	Rig Crew	LDDT	60	51	3060	1	15.5968	0.7333	0.5970	0.0378	42.1425	18.5313	0.0078	0.0004	0.0003	0.0000	0.0211	0.0093							1.4	0.000007	0.000052	
	Rig Mechanics	HDDV	60	2	120	1	0.7185	0.0728	0.0608	0.0035	0.4553	0.0937	0.0004	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.000005	0.000001	
	Co. Supervisor	LDDT	60	20	1200	1	6.1164	0.2676	0.2341	0.0148	16.5265	7.2672	0.0031	0.0001	0.0001	0.0000	0.0063	0.0036							0.5	0.000003	0.000021	
	Tool Pusher	LDDT	60	8	480	1	2.4466	0.1150	0.0937	0.0059	6.6106	2.9069	0.0012	0.0001	0.0000	0.0000	0.0033	0.0015							0.2	0.000001	0.000008	
	Mud Logger	LDDT	60	6	360	1	1.8349	0.0863	0.0702	0.0044	4.9579	2.1802	0.0009	0.0000	0.0000	0.0000	0.0025	0.0011							0.2	0.000001	0.000006	
	Mud Engineer	LDDT	60	15	900	1	4.5873	0.2157	0.1756	0.0111	12.3948	5.4504	0.0023	0.0001	0.0001	0.0000	0.0062	0.0027							0.4	0.000002	0.000015	
	Logger, Engr. Truck	HDDV	60	1	60	1	0.3593	0.0364	0.0304	0.0017	0.2276	0.0468	0.0002	0.0000	0.0000	0.0000	0.0001	0.0000							0.1	0.000002	0.000000	
	Drill Bit Delivery	LDDT	60	2	120	1	0.6116	0.0288	0.0234	0.0015	1.6526	0.7267	0.0003	0.0000	0.0000	0.0000	0.0008	0.0004							0.1	0.000000	0.000002	
	Semi Casing Haulers	HDDV	60	6	360	1	2.1556	0.2184	0.1823	0.0105	1.3659	0.2810	0.0011	0.0001	0.0001	0.0000	0.0007	0.0001							0.3	0.000015	0.000002	
	Semi Completion, Unit Rig	HDDV	60	1	60	1	0.3593	0.0364	0.0304	0.0017	0.2276	0.0468	0.0002	0.0000	0.0000	0.0000	0.0001	0.0000							0.1	0.000002	0.000000	
Well Completion & Testing	Semi Fracing, Blender	HDDV	60	1	60	1	0.3593	0.0364	0.0304	0.0017	0.2276	0.0468	0.0002	0.0000	0.0000	0.0000	0.0001	0.0000	0.1	0.000002	0.000000							
	Semi Pumping/Tank Battery	HDDV	60	6	360	1	2.1556	0.2184	0.1823	0.0105	1.3659	0.2810	0.0011	0.0001	0.0001	0.0000	0.0007	0.0001	0.3	0.000015	0.000002							
	Tubing Truck	HDDV	60	2	120	1	0.7185	0.0728	0.0608	0.0035	0.4553	0.0937	0.0004	0.0000	0.0000	0.0000	0.0002	0.0000	0.1	0.000005	0.000001							
	Haul Cementer, Pump Truck	HDDV	60	2	120	1	0.7185	0.0728	0.0608	0.0035	0.4553	0.0937	0.0004	0.0000	0.0000	0.0000	0.0002	0.0000	0.1	0.000005	0.000001							
	Haul Cementer, Cement Truck	HDDV	60	3	180	1	1.0778	0.1092	0.0912	0.0052	0.6829	0.1405	0.0005	0.0001	0.0000	0.0000	0.0003	0.0001	0.2	0.000007	0.000001							
	Haul Completion, Equip. Truck	HDDV	60	3	180	1	1.0778	0.1092	0.0912	0.0052	0.6829	0.1405	0.0005	0.0001	0.0000	0.0000	0.0003	0.0001	0.2	0.000007	0.000001							
	Haul Service Tools	LDDT	60	2	120	1	0.6116	0.0288	0.0234	0.0015	1.6526	0.7267	0.0003	0.0000	0.0000	0.0000	0.0008	0.0004	0.1	0.000000	0.000002							
	Haul Perforators Logging Truck	HDDV	60	1	60	1	0.3593	0.0364	0.0304	0.0017	0.2276	0.0468	0.0002	0.0000	0.0000	0.0000	0.0001	0.0000	0.1	0.000002	0.000000							
	Haul Anchor, Installation	HDDV	60	1	60	1	0.3593	0.0364	0.0304	0.0017	0.2276	0.0468	0.0002	0.0000	0.0000	0.0000	0.0001	0.0000	0.1	0.000002	0.000000							
	Haul Anchor, Testing	HDDV	60	1	60	1	0.3593	0.0364	0.0304	0.0017	0.2276	0.0468	0.0002	0.0000	0.0000	0.0000	0.0001	0.0000	0.1	0.000002	0.000000							
	Haul Fracing, Tank	HDDV	60	1	60	1	0.3593	0.0364	0.0304	0.0017	0.2276	0.0468	0.0002	0.0000	0.0000	0.0000	0.0001	0.0000	0.1	0.000002	0.000000							
	Haul Fracing, Pump	HDDV	60	1	60	1	0.3593	0.0364	0.0304	0.0017	0.2276	0.0468	0.0002	0.0000	0.0000	0.0000	0.0001	0.0000	0.1	0.000002	0.000000							
	Haul Fracing, Chemical	HDDV	60	1	60	1	0.3593	0.0364	0.0304	0.0017	0.2276	0.0468	0.0002	0.0000	0.0000	0.0000	0.0001	0.0000	0.1	0.000002	0.000000							
	Haul Fracing, Sand	HDDV	60	1	60	1	0.3593	0.0364	0.0304	0.0017	0.2276	0.0468	0.0002	0.0000	0.0000	0.0000	0.0001	0.0000	0.1	0.000002	0.000000							
	Haul Fracing, Other	HDDV	60	1	60	1	0.3593	0.0364	0.0304	0.0017	0.2276	0.0468	0.0002	0.0000	0.0000	0.0000	0.0001	0.0000	0.1	0.000002	0.000000							
	Haul Welders	HDDV	60	6	360	1	2.1556	0.2184	0.1823	0.0105	1.3659	0.2810	0.0011	0.0001	0.0001	0.0000	0.0007	0.0001	0.3	0.000015	0.000002							
	Haul Water Truck	HDDV	60	150	9000	1	53.8889	5.4603	4.5575	0.2619	34.1468	7.0238	0.0269	0.0027	0.0023	0.0001	0.0171	0.0035	7.9	0.000367	0.000057							
	Pickup Cementer, Engineer	LDDT	60	2	120	1	0.6116	0.0288	0.0234	0.0015	1.6526	0.7267	0.0003	0.0000	0.0000	0.0000	0.0008	0.0004	0.1	0.000000	0.000002							
	Pickup Casing Crew	HDDV	60	2	120	1	0.7185	0.0728	0.0608	0.0035	0.4553	0.0937	0.0004	0.0000	0.0000	0.0000	0.0002	0.0000	0.1	0.000005	0.000001							
	Pickup Completion Crew	HDDV	60	5	300	1	1.7963	0.1820	0.1519	0.0087	1.1382	0.2341	0.0009	0.0001	0.0001	0.0000	0.0006	0.0001	0.3	0.000012	0.000002							
	Pickup Completion, Pusher	LDDT	60	5	300	1	1.5291	0.0719	0.0585	0.0037	4.1316	1.8168	0.0008	0.0000	0.0000	0.0000	0.0021	0.0009	0.1	0.000001	0.000005							
	Pickup Perforators, Engineer	LDDT	60	2	120	1	0.6116	0.0288	0.0234	0.0015	1.6526	0.7267	0.0003	0.0000	0.0000	0.0000	0.0008	0.0004	0.1	0.000000	0.000002							
	Pickup Fracing, Engineer	HDDV	60	1	60	1	0.3593	0.0364	0.0304	0.0017	0.2276	0.0468	0.0002	0.0000	0.0000	0.0000	0.0001	0.0000	0.1	0.000002	0.000000							
	Pickup Co. Supervisor	LDDT	60	10	600	1	3.0582	0.1438	0.1171	0.0074	8.2632	3.6336	0.0015	0.0001	0.0001	0.0000	0.0041	0.0018	0.3	0.000001	0.000010							
	Pickup Miscellaneous Supplies	LDDT	60	3	180	1	0.9175	0.0431	0.0351	0.0022	2.4790	1.0901	0.0005	0.0000	0.0000	0.0000	0.0012	0.0005	0.1	0.000000	0.000003							
	Pickup Roustabout Crew	HDDV	60	4	240	1	1.4370	0.1456	0.1215	0.0070	0.9106	0.1873	0.0007	0.0001	0.0001	0.0000	0.0005	0.0001	0.2	0.000010	0.000002							
							Subtotal							0.07							0.01	0.00	0.00	0.08	0.03	16.87	0.000646	0.000227
							Total							0.08							0.01	0.01	0.00	0.09	0.03	20.02	0.000784	0.000257

OPERATIONS - WELL WORKOVERS - EXHAUST

Exhaust and Fugitive Dust Emissions from Well Work Overs

Fugitive Dust from Heavy Equipment on Industrial Unpaved Roads

Emission Factors for Industrial Unpaved Roads ^a

E (lb/VMT) =	k (s/12) ^a (W/3) ^b	Parameter	PM ₁₀	PM _{2.5}
		k	1.5	0.15
		a	0.9	0.9
		b	0.45	0.45

$$E_{adj} = E (1 - P/365)$$

Function/Variable Description	Assumed Value	Reference
E = size-specific emission factor (lb/VMT)		
E _{adj} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)		
s = surface material silt content (%)	5.1	EPA AP-42 Section 13.2.2, Table 13.2.2-1
W = mean vehicle weight (tons)	Listed in the table below	
M = surface material moisture content (%)	2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year	41	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of watering ^b	50%	

^a Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006

^b Fitzpatrick, M. 1990. *User's Guide: Emission Control Technologies and Emission Factors for Unpaved Road Fugitive Emissions*, EPA/625/5-87/022. <http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=20008SFC>.

Assumption:	<p>Avg. Frequency & Duration: three days, once in the first year;</p> <p>Equipment: Truck-mounted Unit: capacity 600 hp, fuel 60 gpd, hours/day 10</p> <p>Truck: Type WO rig, Round trip mileage: 1 miles on unpaved road</p> <p>Max. number of crews in the field on a given day considering weekends and inclement weather: 15</p>
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Fugitive Dust Estimations for Road Traffic

Activity	Vehicle Type	Avg. Vehicle Weight (tons)	Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells Drilled	PM ₁₀			PM _{2.5}		
							Emission Factor (lb/VMT)	Emissions		Emission Factor (lb/VMT)	Emissions	
								(lbs/well)	(tons/year/ well)		(lbs/ well)	(tons/year/ well)
Well Workover	WO Rig	42	1	1	1	1	2.02	2.02	0.00	0.20	0.20	0.00
	Haul Truck	42	1	1	1	1	2.02	2.02	0.00	0.20	0.20	0.00
	Pickup Truck	5	1	3	3	1	0.78	2.33	0.00	0.08	0.23	0.00
Total									0.00			0.00

Number of wells is based on peak year applied to all project years (provides for a conservative estimate).

Round trip distance = 2 miles per SEIS

Exhaust Emissions from Well Work Overs

Emission Factors Bore/Drill Rig Engines 300-600 Hp

Fuel Type	Emission Factors (gm/hp-hr)								
	NO _x	PM ₁₀	SO _x	CO	VOC	PM2.5	CO ₂	CH ₄	N ₂ O ^a
Diesel	6.69	0.38	0.11	2.25	0.48	0.37	529.58	0.007	0.006

Source: EPA NONROADS 2008a. Year 2008.

^a Based on N₂O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

OPERATIONS - WELL WORKOVERS - EXHAUST

Emission Estimations for Engines

Activity	Equipment Type	Capacity (hp)	# of Operating Hours/Day	# of Operating Days/Well	# of Operating Hours/Well	Total # of Wells Drilled	Max. Annual Emissions													
							(lbs/well)					(tons/year/well)								
							NO _x	PM ₁₀	SO _x	CO	VOC	NO _x	PM ₁₀	SO _x	CO	VOC	PM2.5	CO ₂	CH ₄	N ₂ O
Well Workover	Truck-Mounted Unit	600	10	3	30	1	266	15	5	89	19	0.13	0.01	0.00	0.04	0.01	0.01	10.51	0.00	0.00

Exhaust emission factors for commuting vehicles

Vehicle		Emission Factors (g/mi)								
Type	Class	NO _x	PM ₁₀ ^{a, b}	PM _{2.5} ^{a, b}	SO _x ^a	CO	VOC	CO ₂	CH ₄	N ₂ O ^a
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.016
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.006

Source: MOBILE 6.2.03

Emission factors for 2008 used for all project years = conservative estimate of vehicle fleet turnover

^a Compendium of Greenhouse Gas Emission Methodologies for the Oil and Gas Industry, Table 4-17 for N2O (HDDV moderate control, LDGT oxidation catalyst, LDDT moderate control) , Mobile Source Combustion Factors, American Petroleum Institute (2009).

Emission Estimations for Road Traffic

Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells Drilled	Max. Annual Emissions															
							(lbs/well)						(tons/year/well)									
	Type	Class					NO _x	PM ₁₀	PM _{2.5}	SO _x	CO	VOC	NO _x	PM ₁₀	PM _{2.5}	SO _x	CO	VOC	CO ₂	CH ₄	N ₂ O	
Well Workover	WO Rig	HDDV	60	1	60	1	0.359	0.036	0.030	0.002	0.228	0.047	0.000	0.000	0.000	0.000	0.000	0.05	0.000	0.000		
	Haul Truck	HDDV	60	1	60	1	0.359	0.036	0.030	0.002	0.228	0.047	0.000	0.000	0.000	0.000	0.000	0.05	0.000	0.000		
	Pickup Truck	LDDT	60	3	180	1	0.917	0.043	0.035	0.002	2.479	1.090	0.000	0.000	0.000	0.000	0.001	0.001	0.08	0.000	0.000	
Performed once in the first year of well operation												Total	0.001	0.0001	0.0000	0.000	0.001	0.001	0.001	0.186	0.000	0.000

Performed once in the first year of well operation

Number of wells is based on peak year applied to all project years (provides for a conservative estimate).

Round trip distance = 2 based on data found in the SEIS

OPERATIONS - VEHICLE - FUGITIVE DUST AND EXHAUST

Fugitive Dust and Exhaust Emissions from Site Visits and Inspections

Fugitive Dust from Commuting Vehicles on Unpaved Roads

Emission Factors for Publicly Accessible Unpaved Roads^a

$E \text{ (lb/VMT)} = \frac{k \cdot (s/12)^b \cdot (S/30)^c}{(M/0.5)^c} \cdot C$		Parameter	PM ₁₀	PM _{2.5}
		k	1.8	0.18
		a	1	1
		d	0.5	0.5
		c	0.2	0.2
E _{adj} = E (1 - P/365)				
Function/Variable Description		Assumed Value	Reference	
E = size-specific emission factor (lb/VMT)				
E _{adj} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)				
s = surface material silt content (%)		5.1	EPA AP-42 Section 13.2.2, Table 13.2.2-1	
S = mean vehicle speed (mph)		Listed in the table below		
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	PM _{2.5}	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4	
	PM ₁₀	0.00047	EPA AP-42 Section 13.2.2, Table 13.2.2-4	
M = surface material moisture content (%)		2.0	EPA AP-42 Section 13.2.2	
P = Number of days precip per year		41	EPA AP-42 Section 13.2.2, Figure 13.2.2-1	
CE = control efficiency of watering ^b		50%		

^a Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006

^b Fitzpatrick, M. 1990. User's Guide: Emission Control Technologies and Emission Factors for Unpaved Road Fugitive Emissions, EPA/625/5-87/022. <http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=20008SFC>.

Assumption:	Frequency of visit: once/day/well
	Crew: 1 person and 1 light-duty truck
	Av. number of wells served by a pumper per day 25
	Round trip mileage per day: 50 total/25 wells = 2 miles/well on unpaved road

Emission Estimations for Road Traffic - RMP Year 20

Activity	Vehicle Type ^a	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Federal Wells Producing	PM ₁₀			PM _{2.5}		
							Emission Factor (lb/VMT)	Emissions (lbs/well/yr)	(tons/yr/well)	Emission Factor (lb/VMT)	Emissions (lbs/well/yr)	(tons/yr/well)
Inspection Visits for Wells	Pickup Truck	40	2	12	24	1	0.30	7.13	0.00	0.03	0.71	0.00

Exhaust Emissions from Site Visits and Inspections

Emission factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)							
	NO _x	PM ₁₀ ^{a, b}	PM _{2.5} ^{a, b}	SO _x ^a	CO	VOC	CO ₂	N ₂ O ^a
Light-Duty Gasoline Truck	1.13	0.03	0.01	0.01	23.97	1.07	476.9	0.07
							0.07	0.02

Source: MOBILE 6.2.03

Emission factors for 2008 used for all years = conservative estimate for fleet vehicle turnover

^a Compendium of Greenhouse Gas Emission Methodologies for the Oil and Gas Industry, Table 4-17 for N₂O (HDDV moderate control, LDGT oxidation catalyst, LDDT moderate control) , Mobile Source Combustion Factors, American Petroleum Institute (2009).

Emission Estimations for Road Traffic - RMP Year 20

Emission Estimations for Road Traffic - RMP Year 20																				
Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Federal Wells Producing	Emissions													
	Type	Class					(lbs/well/yr)						(tons/yr/well)							
							NO _x	PM ₁₀	PM _{2.5}	SO _x	CO	VOC	NO _x	PM ₁₀	PM _{2.5}	SO _x	CO	VOC	CO ₂	CH ₄
Inspection Visits for Wells	Pickup Truck	LDGT2	2	12	24	1	0.06	0.00	0.00	0.00	1.27	0.06	0.00	0.00	0.00	0.00	0.00	0.0126	0.0000	0.0000

OPERATIONS - ROAD MAINTENANCE

Exhaust Emissions from Heavy Equipment and Support Vehicles for Road Maintenance

Given Data

Maintenance ^a	Equipment/Vehicle			Road Length Worked on/Day (miles)	# of Operating Hours/Day
	Type	Fuel	Capacity (hp)		
Summer	Heavy Equipment ^b	Diesel-30 gpd	135	6	10
	Commuting Vehicle	Gas-5 gpd	225	6	1 ^c
Winter	Heavy Equipment ^b	Diesel-30 gpd	135	5	10
	Commuting Vehicle	Gas-5 gpd	225	6	1.5 ^c

^a Road maintenance would be made twice in summer and once in winter every year

^b Assume a motor grader 135 Hp.

^c Assume three round trips per two days.

Estimation of Total and Cumulative Length of Roads for the Project - RMP Year 20

Length of Improved Roads per Well (miles) ^a	1.00
Number of Wells	1
Cumulative Length of Roads ^b (miles/operation)	1

^a Source: SEIS

^b miles of road built per well * No. of operating wells/year

Estimation of Total Operation Days and Hours - RMP Year 20

Season	# of Operations per Season	Cumulative Length of Roads (miles/operation)	Road Length Worked On (mi/day)	# of Operating Hours per Day	Total # of Operating Days	Total # of Operating Hours
Summer	0.5	1	6	10	0.1	1
Winter	0.5	1	5	10	0.1	1
Total					0	2

Emission Factors for Grading - Fugitive Dust

Pollutant	Emission Factor Equation (lb/VMT)	S ^a (mph)	Em. Factors (lb/VMT)
PM ₁₀	$E = (0.6)(0.051) S^2$	5	0.765
PM _{2.5}	$E = (0.031)(0.04) S^{2.5}$	5	0.069

^a S = mean vehicle speed (S), assume 5 mph for grading

Source: EPA AP-42, Section 11.9, Table 11.9-1, Oct. 1998

Fugitive Dust Emission Estimations for Grader: RMP Year 20

Activity	Equipment	Total # of Operating Hours ^a	Mean Vehicle Speed (mph)	Total Miles Traveled	PM ₁₀		PM _{2.5}	
					Emissions (lb/year)	Emissions (tons/year)	Emissions (lb/year)	Emissions (tons/year)
Road Maintenance	Grader	1	5	6	4.21	0.00	0.38	0.00

^a Assume grader operates at 60% of the time (minus hours for clothing change, breaks, etc.)

Emission Factors for Construction Equipment Exhaust

Equipment	Emission Factors (g/hp-hr)								
	NO _x	PM ₁₀	SO ₂	CO	VOC	PM2.5	CO ₂	CH ₄	N ₂ O ^a
Grader 100-175 Hp	4.34	0.34	0.12	1.51	0.35	0.33	535.77	0.0053	0.006

Source: EPA NONROADS 2008a

Use emission factors for 2008 for all project years - conservative estimate of vehicle turnover

^a Based on N₂O emissions of 0.082 g/L of diesel fuel (diesel density of 850 g/L and heating value of 19,300 Btu/lb) from the "Compendium of GHG Emission Methodologies for the Oil and Gas Industry," Table 4-17 (2009).

OPERATIONS - ROAD MAINTENANCE

Emission Estimations for Grader: RMP Year 20

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours ^a	Emissions													
				(lbs/activity/hr)					(tons/well)								
				NO _x	PM ₁₀	SO _x	CO	VOC	NO _x	PM ₁₀	SO _x	CO	VOC	PM _{2.5}	CO ₂	CH ₄	N ₂ O
Road Maintenance	Grader	135	1	1.29	0.10	0.04	0.45	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00

^a Assume grader operates at 60% of the time (minus hours for clothing change, breaks, etc.)

Fugitive Dust from Commuting Vehicles on Unpaved Roads

Emission Factors for Publicly Accessible Unpaved Roads^a

$E \text{ (lb/VMT)} = \frac{k (s/12)^a (S/30)^d}{(M/0.5)^c} - C$		Parameter	PM ₁₀	PM _{2.5}
		k	1.8	0.18
		a	1	1
		d	0.5	0.5
		c	0.2	0.2
E _{ext} = E (1 - P/365)				
Function/Variable Description		Assumed Value	Reference	
E = size-specific emission factor (lb/VMT)				
E _{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)				
s = surface material silt content (%)		5.1	EPA AP-42 Section 13.2.2, Table 13.2.2-1	
S = mean vehicle speed (mph)		Listed in the table below		
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	PM _{2.5}	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4	
	PM ₁₀	0.00047	EPA AP-42 Section 13.2.2, Table 13.2.2-4	
M = surface material moisture content (%)		2.0	EPA AP-42 Section 13.2.2	
P = Number of days precip per year		90	EPA AP-42 Section 13.2.2, Figure 13.2.2-1	
CE = control efficiency of watering ^b		50%		

^a Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006

^b Fitzpatrick, M. 1990. *User's Guide: Emission Control Technologies and Emission Factors for Unpaved Road Fugitive Emissions*, EPA/625/5-87/022. <http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=20008SFC>.

OPERATIONS - ROAD MAINTENANCE

Emission Estimations for Road Traffic - RMP Year 20

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled (VMT/yr)	PM ₁₀			PM _{2.5}		
						Emission Factor	Emissions		Emission Factor	Emissions	
							(lbs/yr)	(tons/yr)		(lbs/yr)	(tons/yr)
Road Maintenance	Pickup Truck	40	6	0.2	1	0.25	0.28	0.00	0.03	0.03	0.00

Emission Factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)								
	NO _x	PM ₁₀	PM _{2.5}	SO _x	CO	VOC	CO ₂	CH ₄	N ₂ O ^a
Light-Duty Diesel Truck	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.016

Source: MOBILE 6.2.03

^a Compendium of Greenhouse Gas Emission Methodologies for the Oil and Gas Industry, Table 4-17 for N₂O (HDDV moderate control, LDGT oxidation catalyst, LDDT moderate control) , Mobile Source Combustion Factors, American Petroleum Institute (2009).

Emission Estimations for Road Traffic - RMP Year 20

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled (VMT/yr)	Emissions (tons/yr/well)								
	Type	Class				NO _x	PM ₁₀	PM _{2.5}	SO _x	CO	VOC	CO ₂	CH ₄	N ₂ O
Road Maintenance	Pickup Truck	LDDT	6	0.2	1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

CONSTRUCTION – WIND EROSION

Emission Factors for Industrial Wind Erosion

$$E \text{ (tons/year)} = \frac{k \cdot P \cdot M \cdot N}{453.6 \cdot 2000} \quad \text{AP-42 Section 13.2.5.3 Equation 2}$$

$$\text{Erosion Potential } P \text{ (g/m}^2\text{/year)} = 58(U^* - U_t)^2 + 25(U^* - U_t) \quad \text{for } U^* > U_t; P=0 \text{ otherwise} \quad \text{AP-42 Section 13.2.5.3 Equation 3}$$

$$\text{Friction Velocity } U^* \text{ (m/s)} = 0.053 U_{10} \quad \text{AP-42 Section 13.2.5.3 Equation 4}$$

P = Erosion Potential (gm/m²/yr) M = Disturbed area (m²)
 U^* = Friction velocity (m/s) N = # of disturbances
 U_t = threshold velocity (m/s) k = 0.5 for PM₁₀
 U_{10} = fastest wind speed (m/s) k = 0.075 for PM_{2.5}

U_{10} = 25.33 58.33 average fastest (mph) for Billings, Montana (1939-1987) from <http://www.itl.nist.gov/div898/winds/nondirectional.htm>
 U_t well pads = 1.02 AP-42 Industrial Wind Erosion Table 13.2.5-2, Overburden
 U_t roads/pipelines = 1.33 AP-42 Industrial Wind Erosion Table 13.2.5-2, Roadbed material

Construction Wind Erosion Emissions - Based on Peak Wells Drilled each Alternative

	Fastest Mile (U_{10}) (m/s)	Max. Friction Velocity (U^*) (m/s)	Well Erosion Potential (P) (g/m ² /yr)	Road Erosion Potential (P) (g/m ² /yr)	Peak # of Wells Drilled per year	Average Disturbed acres per well ^a	Disturbed Area (M) (m ²)	Number of Disturbances (N)	PM ₁₀ Emissions (tons/year/ well)	PM _{2.5} Emissions (tons/year/ well)
Well pad construction	25.33	1.34	14.09		1.00	3.00	12144.98	1.00	0.09	0.01
Road and Pipeline Construction	25.33	1.34		0.32	1.00	1.00	4048.33	1.00	0.00	0.00
TOTAL									0.10	0.01

^a Average disturbed area shown in SEIS

RECLAMATION

Emissions for Road and Well Pad Reclamation

Type	Equipment/Vehicle			Total Miles Worked on/Day	# of Operating Hours/Day
	Type	Fuel	Capacity (hp)		
Roads	Heavy Equipment	Diesel	80	6	10
	Commuting Vehicle	Gasoline	225	6	1.5
Wells ^a	Heavy Equipment	Diesel	100	N/A	10
	Commuting Vehicle	Gasoline	225	6	2

^a Assume 0.5 day with a blade and tractor each for reseeding per well at time of abandonment.

Source: values from SEIS

Estimation of Total Miles of Roads

Length of Roads Built per Well	0.25
Number of Roads Reclaimed Annually Per Well	0.000
Annual Miles of Roads reclaimed Per Well	0.000
Number of wells reclaimed (per well)	0.000

Reclamation rates derived from RMP (total Federal and non-Federal)

Estimation of Total Operation Days and Hours

Annual Miles of Roads Reclaimed	Daily Miles of Road Work	Total # of Operating Days	Annual Operating Hours
0.00	6	0.0000	0.0000
Total			0.000

Assume average miles/day = 6

Emission Factors for 75-100 hp Off-Road Engines

Year	Emission Factors (g/hp-hr)								
	NO _x	PM ₁₀	SO ₂	CO	VOC	PM _{2.5}	CO ₂	CH ₄	N ₂ O ^a
2008	5.36	0.65	0.13	4.15	0.66	0.63	600.5	0.010	0.016
2018	2.40	0.41	0.11	2.33	0.36	0.40	613.9	0.006	0.016
2027	0.64	0.19	0.10	0.75	0.18	0.19	608.6	0.003	0.016

Source: EPA NONROADS 2008a

^a Compendium of Greenhouse Gas Emission Methodologies for the Oil and Gas Industry, Table 4-17 for N₂O (HDDV moderate control, LDGT oxidation catalyst, LDDT moderate control) , Mobile Source Combustion Factors, American Petroleum Institute (2009).

RECLAMATION

Exhaust Emissions Estimation for Grader Road Reclaim

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions													
				(lbs/hour)					(tons/year/well)								
				NO _x	PM ₁₀	SO _x	CO	VOC	NO _x	PM ₁₀	SO _x	CO	VOC	PM _{2.5}	CO ₂	CH ₄	N ₂ O
Road Reclamation	Grader	80	0.000	0.4238	0.0720	0.0197	0.4106	0.0629	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000

Exhaust Emission Factors for Commuting Reclaim Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)								
	NO _x	PM ₁₀	PM _{2.5}	SO _x	CO	VOC	CO ₂	CH ₄	N ₂ O ^a
Light-Duty Diesel Truck	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.016

Source: MOBILE6.2.03

^a Compendium of Greenhouse Gas Emission Methodologies for the Oil and Gas Industry, Table 4-17 for N₂O (HDDV moderate control, LDGT oxidation catalyst, LDDT moderate control), Mobile Source Combustion Factors, American Petroleum Institute (2009).

Exhaust Emissions Estimation for Commuting Reclaim Vehicles: Road Traffic

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions								
	Type	Class				(tons/year/well)								
						NO _x	PM ₁₀	PM _{2.5}	SO _x	CO	VOC	CO ₂	CH ₄	N ₂ O
Road Reclamation	Pickup Truck	LDDV	6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Estimation of Annual Days and Hours for Well Reclamation

Equipment	# of Wells Reclaimed/Year	# of Hours/Day	Annual # of Days	Annual Hours of Operation
Grader	0.000	10	0.000	0.00

Assume grader works 0.5 day as a blade and tractor each per well.

Exhaust Emissions Estimation for Grader: Well Reclamation

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions													
				(lbs/hour)					(tons/year/well)								
				NO _x	PM ₁₀	SO _x	CO	VOC	NO _x	PM ₁₀	SO _x	CO	VOC	PM _{2.5}	CO ₂	CH ₄	N ₂ O
Well Reclamation	Grader	100	0.00	0.5297	0.0900	0.0246	0.5132	0.0786	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000

Exhaust Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions								
	Type	Class				(tons/year/well)								
						NO _x	PM ₁₀	PM _{2.5}	SO _x	CO	VOC	CO ₂	CH ₄	N ₂ O
Well Reclamation	Pickup Truck	LDDV	6	0.00	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

OPERATIONS - DEHYDRATOR

Emission Factors for Dehydrator Heaters

Unit	NO _x	PM ₁₀	SO ₂	CO	VOC	PM _{2.5}	CO ₂	CH ₄	HCHO	N ₂ O
lb/MMSCF	100	7.60	0.60	84	5.50	5.7	120000	2.3	0.075	2.2
lb/MMBTU	0.098	0.007	0.001	0.082	0.005	0.006	117.647	0.002	0.000	0.002

Source: EPA, AP-42 Section 1.4 Natural Gas Combustion

Emission Estimate for Dehydrator Heaters

Operating Hours per Year ^a	Dehydrator Heater Size MMBtu/Hour	Fuel Usage MMCF/Year	Number of Dehydrator Stations / Well	Emissions (tons/year/well)									
				NO _x	PM ₁₀	SO ₂	CO	VOC	PM _{2.5}	CO ₂	CH ₄	HCHO	N ₂ O
2,190	1	2.20	0.013	0.00	0.00	0.00	0.00	0.00	0.00	1.7545	0.000034	0.00	0.000032

Values from Montana BLM (Laakso, 2010)

Annual Dehydrator Venting and Tank Flashing Emissions

Annual Well Gas Production MMscf	CH ₄ Emission Factor (ton per MMscf)	CH ₄ Emissions (TPY/well)	VOC Emission Factor (ton per MMscf)	VOC Emissions (TPY/well)	HAPs Emission Factor (ton per MMscf)	HAPs Emissions (TPY/well)
169.73	0.016	2.636	0.000	0.004	0.000	0.002

Gas analysis and dehydration process information provided by Montana BLM (Laakso, 2010) and emissions estimated with GLYCalc Program.

Emission factor include emissions from dehy/regenerator still vents (no control) and flash tank emissions (no control).

Assumed 100% of gas production flows through dehydrators at sales compressor station (Laakso, 2010)

OPERATIONS - WELLHEAD

Wellhead Fugitives

Fugitive Emissions from Equipment Leaks

Well Equipment Component	TOC Emission Factor							
	Gas		Light Oil >20° API		Heavy Oil <20° API		Water/Oil	
	(kg/hr)	(lb/hr)	(kg/hr)	(lb/hr)	(kg/hr)	(lb/hr)	(kg/hr)	(lb/hr)
valves	4.50E-03	9.92E-03	2.50E-03	5.51E-03	8.40E-06	1.85E-05	9.80E-05	2.16E-04
pump seals	2.40E-03	5.29E-03	1.30E-02	2.87E-02	3.20E-05	7.05E-05	2.40E-05	5.29E-05
others	8.80E-03	1.94E-02	7.50E-03	1.65E-02	3.20E-05	7.05E-05	1.40E-02	3.09E-02
connectors	2.00E-04	4.41E-04	2.10E-04	4.63E-04	7.50E-06	1.65E-05	1.10E-04	2.43E-04
flanges	3.90E-04	8.60E-04	1.10E-04	2.43E-04	3.90E-07	8.60E-07	2.90E-06	6.39E-06
open-ended lines	2.00E-03	4.41E-03	1.40E-03	3.09E-03	1.40E-04	3.09E-04	2.50E-04	5.51E-04

Source: EPA-453/R-95-017 Protocol for Equipment Leak Emission Estimates, November 1995

Table 2-4, Oil and Gas Production Operations Average Estimation Factors

"Other" category includes compressor seals, pressure relief valves, diaphragms, drains, dump arms, hatches, instruments, meters, polished rods and vents

From Montana BLM provided NG analysis

VOC Wt% =	0.68
CO2 Wt% =	0.30
CH4 Wt% =	89.00
N2O Wt% =	0.00

Emissions from Equipment Leaks at Wellhead per Well

component	Ave. # in Gas Service	Emission factor (lb/hr)	Ave. # in Liquid service	Emission factor (lb/hr)	Ave. # in Water/Oil Service	Emission factor (lb/hr)	TOC emissions per well (lb/hr)	VOC emissions per well (lb/hr)	CO ₂ emissions per well (lb/hr)	CH ₄ emissions per well (lb/hr)
valves	7	0.0099	1	0.0055	0	0.0002	0.075	0.001	0.000	0.067
pump seals	0	0.0053	0	0.0287	0	0.0001	0.000	0.000	0.000	0.000
others	0	0.0194	0	0.0165	0	0.0309	0.000	0.000	0.000	0.000
connectors	24	0.0004	0	0.0005	0	0.0002	0.011	0.000	0.000	0.009
flanges	2	0.0009	0	0.0002	0	0.0000	0.002	0.000	0.000	0.002
open-ended lines	0	0.0044	0	0.0031	0	0.0006	0.000	0.000	0.000	0.000
TOTAL emissions/well/hr =							0.087	0.001	0.000	0.078

Number of components provided by Montana BLM FO personnel (Laakso, 2010)

Annual Emissions from Equipment Leaks Per Well								
Year	Number of Producing Wells	Operating Hours	VOC emissions (lb/yr)	VOC emissions (ton/yr)	CO ₂ emissions (lb/yr)	CO ₂ emissions (ton/yr)	CH ₄ emissions (lb/yr)	CH ₄ emissions (ton/yr)
Year 20	1	8760	5.22	0.003	2.29	0.001	680.28	0.34

OPERATIONS - VENTING

Speciated Analysis - NG & Venting Emissions from Well Completion Activities (applied to all wells drilled)

Gas Component	Mole Fraction	Molecular Weight	Gas Weight	Weight Percent	Weight	Emissions Mass Flow
	(%)	(lb/lb-mol)	(lb/lb-mol)	(wt%)	(lb/MMscf)	(ton/well)
Methane	93.716	16.040	15.032	88.998	37788.643	26.358
Ethane	1.624	30.070	0.488	2.891	1227.616	0.856
Nitrogen	4.297	28.020	1.204	7.128	3026.751	2.111
Water	0.000	18.015	0.000	0.000	0.000	0.000
Carbon Dioxide	0.115	43.990	0.051	0.300	127.173	0.089
Nitrous Oxide	0.000	44.020	0.000	0.000	0.000	0.000
Hydrogen Sulfide	0.000	34.060	0.000	0.000	0.000	0.000
Non-reactive, non-HAP	99.752	---	16.775	99.317		29.414
Propane	0.211	44.100	0.093	0.551	233.918	0.163
Iso-butane	0.019	58.120	0.011	0.065	27.760	0.019
n-butane	0.015	58.120	0.009	0.052	21.916	0.015
i-pentane	0.002	72.150	0.001	0.009	3.628	0.003
n-pentane	0.001	72.150	0.001	0.004	1.814	0.001
Hexanes	0.000	100.210	0.000	0.000	0.000	0.000
Heptanes	0.000	100.200	0.000	0.002	0.781	0.001
Octanes	0.000	114.230	0.000	0.000	0.000	0.000
Nonanes	0.000	128.258	0.000	0.000	0.000	0.000
Decanes+	0.000	142.29	0.000	0.000	0.000	0.000
Reactive VOC	0.248	---	0.115	0.683		0.202
Benzene	0.000	78.110	0.000	0.000	0.000	0.000
Ethylbenzene	0.000	106.160	0.000	0.000	0.000	0.000
<i>n</i> -Hexane ³	0.000	100.210	0.000	0.000	0.000	0.000
Toluene	0.000	92.130	0.000	0.000	0.000	0.000
Xylenes	0.000	106.160	0.000	0.000	0.000	0.000
HAPs	0.000	---	0.000	0.000		0.000
Totals	100.000	---	16.890	100.000		29.616

Sample taken 03-09-2010 at Baker South 7 W 0429.

Volume Flow: 465 MSCF/day/well
 Completion activity duration: 3 days
 Total Volume Flow per Well 1.395 MMSCF/well

Assume: Gas density is 0.04246 lb/scf (19.26 g/scf).

BTU value = 994 BTU/scf

OPERATIONS - COMPRESSOR

Compressor Station Emissions

Emission Factors for Natural Gas-Fired Compressors

Compressor			Horse-Power Rating	Units	Emission Factors								
					NO _x ^a	PM ₁₀ ^b	SO ₂ ^b	CO ^a	VOC ^a	PM _{2.5} ^b	CO ₂ ^c	CH ₄ ^c	HCHO ^b
Field Compression Station	Rich Burn	300	gm/bhp-hr	1.00	0.044	0.001	2.00	0.70	0.044	134.9	2.5E-03	0.064	2.55E-04
			lb/MMBTU		3.84E-02	5.88E-04			3.84E-02	116.9	2.2E-03	5.52E-02	2.20E-04
Sales Compression Station	Rich Burn	1,680	gm/bhp-hr	1.00	0.044	0.001	2.00	0.70	0.044	134.9	0.003	0.064	2.55E-04
			lb/MMBTU		3.84E-02	5.88E-04			3.84E-02	116.9	2.20E-03	5.52E-02	2.20E-04

^a Source: assume compressors will comply with NSPS 40 CFR part 60 subpart JJJJ

^b Source: EPA, AP-42 Section 3.2 Natural Gas Fired Reciprocating Engines

Note: Compressors assumed to be equipped with nonselective catalytic reduction (NSCR) catalyst.

^c EPA Mandatory GHG Reporting, Part 98, Subpart C, Tables C-1 and C-2.

Emission Estimations for Compressors

Emission Estimations for Compressor					Emissions (tons/year/well)									
Type of Compressors	Compression Rate (Hp/well)	Annual # of Wells in Production	Total Compression (Hp)	Operating Hours/Year	NOx	PM ₁₀	SO ₂	CO	VOC	PM _{2.5}	CO ₂	CH ₄	HCHO	N ₂ O
Field Compression Station	11	1	11	8,760	0.11	0.00	0.00	0.21	0.07	0.00	14.427	0.0003	0.01	0.00003
Sales Compression Station	10	1	10	8,760	0.10	0.00	0.00	0.20	0.07	0.00	13.465	0.0003	0.01	0.00003
Total					0.21	0.01	0.00	0.41	0.14	0.01	27.9	0.00	0.01	0.00

HCHO = Formaldehyde

Compression rate of 36 - 300 hp field compressors, and 6 - 1680 hp sales compressors per 867

CBNG wells based on BLM survey (Laakso, 2010). Values were scaled based on per well NG production.

Compressor Station Fugitives

Fugitive Emissions from Equipment Leaks

Well Equipment Component	TOC Emission Factor							
	Gas		Light Oil >20° API		Heavy Oil <20° API		Water/Oil	
	(kg/hr)	(lb/hr)	(kg/hr)	(lb/hr)	(kg/hr)	(lb/hr)	(kg/hr)	(lb/hr)
valves	4.50E-03	9.92E-03	2.50E-03	5.51E-03	8.40E-06	1.85E-05	9.80E-05	2.16E-04
pump seals	2.40E-03	5.29E-03	1.30E-02	2.87E-02	3.20E-05	7.05E-05	2.40E-05	5.29E-05
others	8.80E-03	1.94E-02	7.50E-03	1.65E-02	3.20E-05	7.05E-05	1.40E-02	3.09E-02
connectors	2.00E-04	4.41E-04	2.10E-04	4.63E-04	7.50E-06	1.65E-05	1.10E-04	2.43E-04
flanges	3.90E-04	8.60E-04	1.10E-04	2.43E-04	3.90E-07	8.60E-07	2.90E-06	6.39E-06
open-ended lines	2.00E-03	4.41E-03	1.40E-03	3.09E-03	1.40E-04	3.09E-04	2.50E-04	5.51E-04

Source: EPA-453/R-95-017 Protocol for Equipment Leak Emission Estimates, November 1995

Table 2-4 , Oil and Gas Production Operations Average Estimation Factors

Other category includes compressor seals, pressure relief valves, diaphragms, drains, dump arms, hatches, instruments, meters, polished rods and vents

From Montana BLM provided NG analysis

VOC Wt% = 0.68
CO₂ Wt% = 0.30
CH₄ Wt% = 89.00
N₂O Wt% = 0.00

Emissions from Equipment Leaks at Compressor Station per Well

component	Ave. # in Gas Service / Well	Emission factor (lb/hr)	Ave. # in Liquid service	Emission factor (lb/hr)	Ave. # in Water/Oil Service	Emission factor (lb/hr)	TOC emissions per well (lb/hr)	VOC emissions per well (lb/hr)	CO ₂ emissions per well (lb/hr)	CH ₄ emissions per well (lb/hr)
valves	0.258	0.0099	0	0.0055	0	0.0002	0.003	0.000	0.000	0.002
pump seals	0.000	0.0053	0	0.0287	0	0.0001	0.000	0.000	0.000	0.000
others	0.000	0.0194	0	0.0165	0	0.0309	0.000	0.000	0.000	0.000
connectors	0.369	0.0004	0	0.0005	0	0.0002	0.000	0.000	0.000	0.000
flanges	0.886	0.0009	0	0.0002	0	0.0000	0.001	0.000	0.000	0.001
open-ended lines	0.000	0.0044	0	0.0031	0	0.0006	0.000	0.000	0.000	0.000
TOTAL emissions/well/hr =							0.003	0.000	0.000	0.003

Number of components provided by Montana BLM FO personnel (Laakso, 2010)

Annual Emissions from Equipment Leaks Per Well							
Year	Number of Producing Wells	Operating Hours	VOC emissions (lb/yr)	VOC emissions (ton/yr)	CO ₂ emissions (lb/yr)	CO ₂ emissions (ton/yr)	CH ₄ emissions (lb/yr)
Year 20	1	8760	0.21	0.0001	0.0915	0.0000	27.1891
							0.0136

OPERATIONS - COMPRESSOR TRAFFIC

Emission Factors for Publicly Accessible Unpaved Roads*

$E \text{ (lb/VMT)} = \frac{k \cdot (s/12)^a \cdot (S/30)^d}{(M/0.5)^c} \cdot C$		Parameter	PM ₁₀	PM _{2.5}
		k	1.8	0.18
		a	1	1
		d	0.5	0.5
		c	0.2	0.2
E _{nat} = E (1 - P/365)				
Function/Variable Description		Assumed Value	Reference	
E = size-specific emission factor (lb/VMT)				
E _{nat} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)				
s = surface material silt content (%)		5.1	EPA AP-42 Section 13.2.2, Table 13.2.2-1	
S = mean vehicle speed (mph)		Listed in the table below		
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	PM _{2.5}	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4	
	PM ₁₀	0.00047	EPA AP-42 Section 13.2.2, Table 13.2.2-4	
M = surface material moisture content (%)		2.0	EPA AP-42 Section 13.2.2	
P = Number of days precip per year		41	EPA AP-42 Section 13.2.2, Figure 13.2.2-1	

* Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006

* Fitzpatrick, M. 1990. *User's Guide: Emission Control Technologies and Emission Factors for Unpaved Road Fugitive Emissions*, EPA/625/5-87/022. <http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=20008SFC>.

Fugitive Dust Emission Estimations for Road Traffic

Activity	Compressor Station	Vehicle Type	Avg. Vehicle Speed (mph)	# of Compressor Stations / Well	# of Inspection Visits/ Station/ Year	# of Inspection Visits/Well/Year	Total Miles/ Inspection	PM ₁₀			PM _{2.5}		
								Em. Factor (lb/VT)	Emissions		Em. Factor (lb/VT)	Emissions	
									(lbs/trip)	(tons/year/well)		(lbs/trip)	(tons/year/well)
Inspection Visits for Compressor Stations	Field Station	Pickup Truck	40	0.04	12	0.4	20	0.59	11.88	0.00	0.06	1.18	0.00
	Sales Station	Pickup Truck	40	0.01	52	0.3	20	0.59	11.88	0.00	0.06	1.18	0.00
Total										0.00			0.00

Assume no dust control (watering)

Compressor Station Inspection Traffic Exhaust Emissions

Emission factors for Commuting Vehicles Exhaust

Vehicle		Emission Factors (g/ml)								
Type	Class	NO _x	PM ₁₀	PM _{2.5}	SO _x	CO	VOC	CO ₂	CH ₄	N ₂ O*
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.016

Source: MOBILE6.2.03

* Compendium of Greenhouse Gas Emission Methodologies for the Oil and Gas Industry, Table 4-17 for N₂O (HDDV moderate control, LDGT oxidation catalyst, LDDT moderate control), Mobile Source Combustion Factors, American Petroleum Institute (2009).

Exhaust Emissions Estimation for Road Traffic

Extract Emissions Estimation for Road Vehicle																					
Activity	Compressor Station	Vehicle		# of Compressor Stations / Well	# of Inspection Visits/ Station	# of Inspection Visits/Well/Year	Total Miles/ Inspection	Emissions													
		Type	Class					(lbs/trip)						(tons/year/well)							
								NO _x	PM ₁₀	PM _{2.5}	SO _x	CO	VOC	NO _x	PM ₁₀	PM _{2.5}	SO _x	CO	VOC	CO ₂	CH ₄
Inspection Visits for Compressor Stations	CPF Compressor Station	Pickup Truck	LDDT	0.04	12	0.4	20	0.102	0.005	0.004	0.000	0.275	0.121	0.00	0.00	0.00	0.00	0.00	0.00400	0.00000	0.00000
	Primary Compressor Station	Pickup Truck	LDDT	0.01	52	0.3	20	0.102	0.005	0.004	0.000	0.275	0.121	0.00	0.00	0.00	0.00	0.00	0.00289	0.00000	0.00000
Total								0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.000	0.000	