

## Federal Oil Wells Summaries

Total Annual Emissions from Federal Oil Wells - RMP Year 20

Activity	Annual Emissions (Tons)											
	PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>2</sub>	CO	VOC	HAPs	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	CO <sub>2eq</sub>	CO <sub>2eq</sub> metric tonnes
Well Pad Construction - Fugitive Dust	0.062	0.006	---	---	---	---	---	---	---	---	---	---
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	2.003	0.207	0.102	0.000	0.121	0.042	0.004	26.694	0.001	0.000	26.822	24.339
Wind Erosion	0.071	0.011	---	---	---	---	---	---	---	---	---	---
<b>Sub-total: Construction</b>	<b>2.405</b>	<b>0.485</b>	<b>5.209</b>	<b>0.107</b>	<b>1.442</b>	<b>0.416</b>	<b>0.042</b>	<b>576.793</b>	<b>0.007</b>	<b>0.006</b>	<b>578.894</b>	<b>525.313</b>
Well Workover Operations - Fugitive Dust	0.038	0.004	---	---	---	---	---	---	---	---	---	---
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	0.002	0.001	0.000	0.248	0.000	0.000	0.250	0.227
Well Visits for Inspection & Repair - Operations	0.045	0.004	0.000	0.000	0.008	0.000	0.000	0.158	0.000	0.000	0.160	0.145
Recompletion Traffic	0.033	0.003	0.002	0.000	0.003	0.001	0.000	0.503	0.000	0.000	0.506	0.459
Water Tanks & Traffic	2.577	0.266	0.124	0.001	0.079	0.016	0.002	36.265	1.692	0.000	71.888	65.234
Oil Tanks & Traffic	0.180	0.024	0.083	0.000	0.052	7.082	0.467	24.273	0.404	0.000	32.814	29.777
Venting	---	---	---	---	---	5.967	0.485	0.194	7.473	0.000	157.123	142.580
Compression and Well Pumps	0.020	0.020	0.459	0.000	0.917	0.321	0.032	61.890	0.001	0.000	61.951	56.217
Dehydrators	0.000	0.000	0.001	0.000	0.001	1.534	0.190	0.991	1.027	0.000	22.568	20.480
Compression Station Fugitives	---	---	---	---	---	0.004	0.000	0.000	0.004	0.000	0.093	0.084
	0.046	0.011	0.134	0.002	0.047	0.010	0.001	10.755	0.000	0.000	10.796	9.796
<b>Sub-total: Operations</b>	<b>2.901</b>	<b>0.329</b>	<b>0.803</b>	<b>0.004</b>	<b>1.107</b>	<b>14.936</b>	<b>1.178</b>	<b>135.029</b>	<b>10.602</b>	<b>0.001</b>	<b>357.898</b>	<b>324.771</b>
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
<b>Sub-total: Maintenance</b>	<b>0.002</b>	<b>0.000</b>	<b>0.001</b>	<b>0.000</b>	<b>0.000</b>	<b>0.000</b>	<b>0.000</b>	<b>0.088</b>	<b>0.000</b>	<b>0.000</b>	<b>0.089</b>	<b>0.080</b>
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
<b>Sub-total: Reclamation</b>	<b>0.000</b>	<b>0.000</b>	<b>0.000</b>	<b>0.000</b>	<b>0.000</b>	<b>0.000</b>	<b>0.000</b>	<b>0.000</b>	<b>0.000</b>	<b>0.000</b>	<b>0.000</b>	<b>0.000</b>
<b>Total Emissions</b>	<b>5.308</b>	<b>0.815</b>	<b>6.013</b>	<b>0.110</b>	<b>2.550</b>	<b>15.352</b>	<b>1.219</b>	<b>711.911</b>	<b>10.609</b>	<b>0.007</b>	<b>936.881</b>	<b>850.164</b>

2.855

0.318

0.669

0.001

1.060

14.926

1.177

124.274

10.602

0.001

347.102

314.975

## Non-Federal Oil Wells Summaries

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

Activity	Annual Emissions (Tons)											
	PM <sub>10</sub>	PM <sub>2.5</sub>	NO <sub>x</sub>	SO <sub>2</sub>	CO	VOC	HAPs	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	CO <sub>2eq</sub>	CO <sub>2eq</sub> 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	0.11	0.10
Wind Erosion	0.00	0.00	---	---	---	---	---	---	---	---	---	---
<b>Sub-total: Construction</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.01</b>	<b>1.96</b>	<b>1.78</b>
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
Recompletion Traffic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Water Tanks & Traffic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oil Tanks & Traffic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Venting	---	---	---	---	---	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Compression and Well Pumps	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
Compression Station Fugitives	---	---	---	---	---	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<b>Sub-total: Operations</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>
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
<b>Sub-total: Maintenance</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.000</b>	<b>0.00</b>	<b>0.00</b>	<b>0.000</b>	<b>0.000</b>	<b>0.000</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>
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
<b>Sub-total: Reclamation</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.0000</b>	<b>0.00</b>	<b>0.000</b>	<b>0.0000</b>	<b>0.0000</b>	<b>0.0000</b>	<b>0.0000</b>	<b>0.0000</b>	<b>0.0000</b>
<b>Total Emissions</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.01</b>	<b>1.96</b>	<b>1.78</b>

## CONSTRUCTION - HEAVY EQUIPMENT OPERATIONS - FUGITIVE DUST

### Fugitive Dust Emissions From Well Pad Construction

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

<sup>a</sup> 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>.

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

<sup>c</sup> EPA, AP-42, Volume I, Section 13.2.4 Aggregate Handling and Storage Piles, Nov. 2006

<sup>d</sup> 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	Construction Days	Total # of Wells	Total Disturbed Acres	Emissions					
					(lbs/well)			(tons/year/well)		
					TSP	PM <sub>10</sub>	PM <sub>2.5</sub>	TSP	PM <sub>10</sub>	PM <sub>2.5</sub>
Improved Road	0.3	3	1	0.3	36	13	1.3	0.02	0.01	0.00
Well Pad and other structures	2.0	4	1	2.0	320	112	11.2	0.16	0.06	0.01
<b>Total</b>					<b>356</b>	<b>125</b>	<b>12.46</b>	<b>0.18</b>	<b>0.06</b>	<b>0.01</b>

Number of acres per well pad provided by data shown in SEIS.

# 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 <sub>x</sub>	PM <sub>10</sub>	SO <sub>2</sub>	CO	VOCs	PM <sub>2.5</sub>	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O <sup>a</sup>	
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

<sup>a</sup> Based on N<sub>2</sub>O 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)

Emission Estimates 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 <sub>x</sub>	PM <sub>10</sub>	SO <sub>2</sub>	CO	VOC	NO <sub>x</sub>	PM <sub>10</sub>	SO <sub>2</sub>	CO	VOC	PM <sub>2.5</sub>	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
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	1.47	0.000	0.000
	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	2.58	0.000	0.000
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	2.58	0.000	0.000
	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	2.75	0.000	0.000
									Subtotal		0.05	0.01	0.00	0.03	0.01	0.01	6.81	0.00	0.00			

### Exhaust Emission Factors for Diesel Powered Bore/Drill Rig Engines

Project Year/Hp Category	Emission Factors (g/hp-hr)								
	NO <sub>x</sub>	PM <sub>10</sub>	SO <sub>2</sub>	CO	VOCs	PM <sub>2.5</sub>	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O <sup>a</sup>
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

<sup>a</sup> Based on N<sub>2</sub>O 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 <sub>x</sub>	PM <sub>10</sub>	SO <sub>2</sub>	CO	VOC	NO <sub>x</sub>	PM <sub>10</sub>	SO <sub>x</sub>	CO	VOC	PM <sub>2.5</sub>	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
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	471.0	0.005	0.005
	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	33.7	0.000	0.000
	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	25.2	0.000	0.000
Well Completion & Testing	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	9.6	0.000	0.000
	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	1.7	0.000	0.000
	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	1.1	0.000	0.000
	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%) <sup>b</sup>	# 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	1.0	0.000	0.000
										Subtotal					5.05	0.26	0.10	1.29	0.37	0.26	543.29	0.01
									Total					5.11	0.27	0.11	1.32	0.37	0.26	550.10	0.01	0.01

# CONSTRUCTION DRILLING - COMMUTING VEHICLES - FUGITIVE DUST

Emission Factors for Industrial Unpaved Roads <sup>a</sup>			
E (lb/VMT) =	k (s/12) <sup>a</sup> (W/3) <sup>b</sup>	Parameter	PM <sub>10</sub> PM <sub>2.5</sub>
		k	1.5 0.15
		a	0.9 0.9
		b	0.45 0.45
E <sub>ext</sub> = E (1 - P/365)			
Function/Variable Description	Assumed Value	Reference	
E = size-specific emission factor (lb/VMT)			
E <sub>ext</sub> = 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 <sup>b</sup>	50%		

<sup>a</sup> Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006

<sup>b</sup> 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

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 <sub>10</sub>				PM <sub>2.5</sub>			
							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	12	47	564	1	1.01	570.03	0.29	0.29	0.10	57.00	0.03	0.03
	Pickup Trucks	5	12	3	36	1	0.39	13.96	0.01		0.04	1.40	0.00	
Well Pad	Semi Trucks	42	12	5	60	1	1.01	60.64	0.03	0.04	0.10	6.06	0.00	0.00
	Pickup Trucks	5	12	4	48	1	0.39	18.62	0.01		0.04	1.86	0.00	
Other Construction Activities	Semi Trucks	42	12	2	24	1	1.01	24.26	0.01	0.02	0.10	2.43	0.00	0.00
	Haul Trucks	25	12	2	24	1	0.80	19.21	0.01		0.08	1.92	0.00	
	Pickup Trucks	5	12	1	12	1	0.39	4.65	0.00		0.04	0.47	0.00	
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	42	12	44	528	1	1.01	533.65	0.27	0.64	0.10	53.36	0.03	0.06
	Fuel Haul Truck	25	12	6	72	1	0.80	57.62	0.03		0.08	5.76	0.00	
	Mud Haul Truck, Water Hauling	25	12	4	48	1	0.80	38.41	0.02		0.08	3.84	0.00	
	Rig Crew	5	12	51	612	1	0.39	237.38	0.12		0.04	23.74	0.01	
	Rig Mechanics	5	12	2	24	1	0.39	9.31	0.00		0.04	0.93	0.00	
	Co. Supervisor	5	12	20	240	1	0.39	93.09	0.05		0.04	9.31	0.00	
	Tool Pusher	25	12	8	96	1	0.80	76.83	0.04		0.08	7.68	0.00	
	Mud Logger	25	12	6	72	1	0.80	57.62	0.03		0.08	5.76	0.00	
	Mud Engineer	25	12	15	180	1	0.80	144.05	0.07		0.08	14.40	0.01	
	Logger, Engr Truck	25	12	1	12	1	0.80	9.60	0.00		0.08	0.96	0.00	
	Drill Bit Delivery	25	12	2	24	1	0.80	19.21	0.01		0.08	1.92	0.00	
Well Completion & Testing (continued below)	Semi Casing Haulers	42	12	6	72	1	1.01	72.77	0.04	0.10	0.10	7.28	0.00	0.01
	Semi Completion, Unit Rig	42	12	1	12	1	1.01	12.13	0.01		0.10	1.21	0.00	
	Semi Fracing, Blender	25	12	1	12	1	0.80	9.60	0.00		0.08	0.96	0.00	
	Semi Pumping/Tank Battery	25	12	6	72	1	0.80	57.62	0.03		0.08	5.76	0.00	
	Tubing Truck	25	12	2	24	1	0.80	19.21	0.01		0.08	1.92	0.00	
	Haul Cementer, Pump Truck	25	12	2	24	1	0.80	19.21	0.01		0.08	1.92	0.00	
Subtotal									1.09					0.11

# 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 <sub>10</sub>				PM <sub>2.5</sub>			
							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	12	3	36	1	0.80	28.81	0.01	0.90	0.08	2.88	0.00	0.09
	Haul Completion,	25	12	3	36	1	0.80	28.81	0.01		0.08	2.88	0.00	
	Haul Service Tools	25	12	2	24	1	0.80	19.21	0.01		0.08	1.92	0.00	
	Haul Perforators Logging Truck	25	12	1	12	1	0.80	9.60	0.00		0.08	0.96	0.00	
	Haul Anchor, Installation	25	12	1	12	1	0.80	9.60	0.00		0.08	0.96	0.00	
	Haul Anchor, Testing	25	12	1	12	1	0.80	9.60	0.00		0.08	0.96	0.00	
	Haul Fracing, Tank	25	12	1	12	1	0.80	9.60	0.00		0.08	0.96	0.00	
	Haul Fracing, Pump	25	12	1	12	1	0.80	9.60	0.00		0.08	0.96	0.00	
	Haul Fracing, Chemical	25	12	1	12	1	0.80	9.60	0.00		0.08	0.96	0.00	
	Haul Fracing, Sand	25	12	1	12	1	0.80	9.60	0.00		0.08	0.96	0.00	
	Haul Fracing, Other	25	12	1	12	1	0.80	9.60	0.00		0.08	0.96	0.00	
	Haul Welders	25	12	6	72	1	0.80	57.62	0.03		0.08	5.76	0.00	
	Haul Water Truck	25	12	150	1800	1	0.80	1,440.47	0.72		0.08	144.05	0.07	
	Pickup Cementer, Engineer	5	12	2	24	1	0.39	9.31	0.00		0.04	0.93	0.00	
	Pickup Casing Crew	5	12	2	24	1	0.39	9.31	0.00		0.04	0.93	0.00	
	Pickup Completion Crew	5	12	5	60	1	0.39	23.27	0.01		0.04	2.33	0.00	
	Pickup Completion, Pusher	5	12	5	60	1	0.39	23.27	0.01		0.04	2.33	0.00	
	Pickup Perforators, Engineer	5	12	2	24	1	0.39	9.31	0.00		0.04	0.93	0.00	
	Pickup Fracing, Engineer	5	12	1	12	1	0.39	4.65	0.00		0.04	0.47	0.00	
	Pickup Co. Supervisor	5	12	10	120	1	0.39	46.55	0.02		0.04	4.65	0.00	
	Pickup Miscellaneous Supplies	5	12	3	36	1	0.39	13.96	0.01		0.04	1.40	0.00	
	Pickup Roustabout Crew	5	12	4	48	1	0.39	18.62	0.01		0.04	1.86	0.00	
							Subtotal			0.90				0.09
							Total			1.99				0.20

# CONSTRUCTION AND DRILLING VEHICLES - EXHAUST

## Exhaust Emissions from Construction and Drilling Support Vehicles

### Emission Factors for Commuting Vehicles

Vehicle		Emission Factors (g/mi)								
Type	Class	NO <sub>x</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	SO <sub>x</sub>	CO	VOC	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O <sup>a</sup>
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

<sup>a</sup> Compendium of Greenhouse Gas Emission Methodologies for the Oil and Gas Industry, Table 4-17 for N<sub>2</sub>O (HDDV moderate control, LDGT oxidation catalyst, LDDT moderate control) , Mobile Source Combustion Factors, American Petroleum Institute (2009).

# 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 <sub>x</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	SO <sub>2</sub>	CO	VOC	NO <sub>x</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	SO <sub>2</sub>	CO	VOC										
Improved & Two-Track Road	Semi Trucks	HDDV	80	47	3760	1	22.5136	2.2812	1.9040	0.1094	14.2658	2.9344	0.0113	0.0011	0.0010	0.0001	0.0071	0.0015	0.012	0.001	0.001	0.000	0.009	0.002	3.3	0.0002	0.0000	
	Pickup Trucks	LDDT	80	3	240	1	1.2233	0.0575	0.0468	0.0030	3.3053	1.4534	0.0006	0.0000	0.0000	0.0000	0.0017	0.0017							0.1	0.0000	0.0000	
Well Pad	Semi Trucks	HDDV	80	5	400	1	2.3951	0.2427	0.2026	0.0116	1.5176	0.3122	0.0012	0.0001	0.0001	0.0000	0.0008	0.0002	0.002	0.000	0.000	0.000	0.003	0.001	0.3	0.0000	0.0000	
	Pickup Trucks	LDDT	80	4	320	1	1.4310	0.0767	0.0624	0.0040	4.4071	1.9379	0.0008	0.0000	0.0000	0.0000	0.0022	0.0010							0.1	0.0000	0.0000	
Other Construction Activities	Semi Trucks	HDDV	80	2	160	1	0.9580	0.0971	0.0810	0.0047	0.6071	0.1249	0.0005	0.0000	0.0000	0.0000	0.0003	0.0001	0.001	0.000	0.000	0.000	0.001	0.000	0.1	0.0000	0.0000	
	Haul Trucks	HDDV	80	2	160	1	0.9580	0.0971	0.0810	0.0047	0.6071	0.1249	0.0005	0.0000	0.0000	0.0000	0.0003	0.0001							0.1	0.0000	0.0000	
	Pickup Trucks	LDDT	80	1	80	1	0.4078	0.0192	0.0156	0.0010	1.1018	0.4845	0.0002	0.0000	0.0000	0.0000	0.0006	0.0002	Subtotal	0.015	0.001	0.001	0.000	0.013	0.004	4.199	0.000	0.000
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 <sub>x</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	SO <sub>2</sub>	CO	VOC	NO <sub>x</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	SO <sub>2</sub>	CO	VOC										
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	HDDV	80	44	3520	1	21.0765	2.1356	1.7825	0.1024	13.3552	2.7471	0.0105	0.0011	0.0009	0.0001	0.0067	0.0014	0.03							3.1	0.0001	0.0000
	Fuel Haul Truck	HDDV	80	6	480	1	2.8741	0.2912	0.2431	0.0140	1.8212	0.3746	0.0014	0.0001	0.0001	0.0000	0.0009	0.0002							0.4	0.0000	0.0000	
	Mud Haul Truck, Water Hauling	HDDV	80	4	320	1	1.9160	0.1941	0.1620	0.0093	1.2141	0.2497	0.0010	0.0001	0.0001	0.0000	0.0006	0.0001							0.3	0.0000	0.0000	
	Rig Crew	LDDT	80	51	4080	1	20.7958	0.9777	0.7960	0.0504	56.1899	24.7085	0.0104	0.0005	0.0004	0.0000	0.0281	0.0124	0.03	0.00	0.00	0.00	0.00	0.06	0.03	1.8	0.0000	0.0001
	Rig Mechanics	HDDV	80	2	160	1	0.9580	0.0971	0.0810	0.0047	0.6071	0.1249	0.0005	0.0000	0.0000	0.0000	0.0003	0.0001							0.1	0.0000	0.0000	
	Co. Supervisor	LDDT	80	20	1600	1	8.1552	0.3834	0.3122	0.0198	22.0353	9.6896	0.0041	0.0002	0.0002	0.0000	0.0110	0.0048							0.7	0.0000	0.0000	
	Tool Pusher	LDDT	80	6	480	1	3.2621	0.1534	0.1249	0.0079	8.5141	3.8758	0.0016	0.0001	0.0001	0.0000	0.0044	0.0019							0.3	0.0000	0.0000	
	Mud Logger	LDDT	80	6	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							0.4	0.0000	0.0000	
	Mud Engineer	LDDT	80	15	1200	1	6.1164	0.2876	0.2341	0.0148	16.5265	7.2672	0.0031	0.0001	0.0001	0.0000	0.0083	0.0036							0.5	0.0000	0.0000	
	Logger, Engr Truck	HDDV	80	1	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000	
	Drill Bit Delivery	LDDT	80	2	160	1	0.8155	0.0383	0.0312	0.0020	2.2035	0.9690	0.0004	0.0000	0.0000	0.0000	0.0011	0.0005							0.1	0.0000	0.0000	
	Semi Casing Haulers	HDDV	80	6	480	1	2.8741	0.2912	0.2431	0.0140	1.8212	0.3746	0.0014	0.0001	0.0001	0.0000	0.0009	0.0002							0.4	0.0000	0.0000	
	Semi Completion, Unit Rig	HDDV	80	1	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000	
Well Completion & Testing	Semi Fracing, Blender	HDDV	80	1	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000	
	Semi Pumping/Tank Battery	HDDV	80	6	480	1	2.8741	0.2912	0.2431	0.0140	1.8212	0.3746	0.0014	0.0001	0.0001	0.0000	0.0009	0.0002							0.4	0.0000	0.0000	
	Tubing Truck	HDDV	80	2	160	1	0.9580	0.0971	0.0810	0.0047	0.6071	0.1249	0.0005	0.0000	0.0000	0.0000	0.0003	0.0001							0.1	0.0000	0.0000	
	Haul Cementer, Pump Truck	HDDV	80	2	160	1	0.9580	0.0971	0.0810	0.0047	0.6071	0.1249	0.0005	0.0000	0.0000	0.0000	0.0003	0.0001							0.1	0.0000	0.0000	
	Haul Cementer, Cement Truck	HDDV	80	3	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	0.0000	0.0000	
	Haul Completion, Equip. Truck	HDDV	80	3	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	0.0000	0.0000	
	Haul Service Tools	LDDT	80	2	160	1	0.8155	0.0383	0.0312	0.0020	2.2035	0.9690	0.0004	0.0000	0.0000	0.0000	0.0011	0.0005							0.1	0.0000	0.0000	
	Haul Perforators Logging Truck	HDDV	80	1	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000	
	Haul Anchor, Installation	HDDV	80	1	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000	
	Haul Anchor, Testing	HDDV	80	1	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000	
	Haul Fracing, Tank	HDDV	80	1	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000	
	Haul Fracing, Pump	HDDV	80	1	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000	
	Haul Fracing, Chemical	HDDV	80	1	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000	
	Haul Fracing, Sand	HDDV	80	1	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000	
	Haul Fracing, Other	HDDV	80	1	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000	
	Haul Welders	HDDV	80	6	480	1	2.8741	0.2912	0.2431	0.0140	1.8212	0.3746	0.0014	0.0001	0.0001	0.0000	0.0009	0.0002							0.4	0.0000	0.0000	
	Haul Water Truck	HDDV	80	150	12000	1	71.8519	7.2804	6.0767	0.3492	45.5291	9.3651	0.0359	0.0036	0.0030	0.0002	0.0228	0.0047							10.5	0.0005	0.0001	
	Pickup Cementer, Engineer	LDDT	80	2	160	1	0.8155	0.0383	0.0312	0.0020	2.2035	0.9690	0.0004	0.0000	0.0000	0.0000	0.0011	0.0005							0.1	0.0000	0.0000	
	Pickup Casing Crew	HDDV	80	2	160	1	0.9580	0.0971	0.0810	0.0047	0.6071	0.1249	0.0005	0.0000	0.0000	0.0000	0.0003	0.0001							0.1	0.0000	0.0000	
Pickup Completion Crew	HDDV	80	5	400	1	2.3951	0.2427	0.2026	0.0116	1.5176	0.3122	0.0012	0.0001	0.0001	0.0000	0.0008	0.0002							0.3	0.0000	0.0000		
Pickup Completion, Pusher	LDDT	80	5	400	1	2.0388	0.0959	0.0780	0.0049	5.5088	2.4224	0.0010	0.0000	0.0000	0.0000	0.0028	0.0012							0.2	0.0000	0.0000		
Pickup Perforators, Engineer	LDDT	80	2	160	1	0.8155	0.0383	0.0312	0.0020	2.2035	0.9690	0.0004	0.0000	0.0000	0.0000	0.0011	0.0005							0.1	0.0000	0.0000		
Pickup Fracing, Engineer	HDDV	80	1	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000		
Pickup Co. Supervisor	LDDT	80	10	800	1	4.0776	0.1917	0.1561	0.0069	11.0176	4.8448	0.0020	0.0001	0.0001	0.0000	0.0055	0.0024							0.4	0.0000	0.0000		
Pickup Miscellaneous Supplies	LDDT	80	3	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							0.1	0.0000	0.0000		
Pickup Roustabout Crew	HDDV	80	4	320	1	1.9160	0.1941	0.1620	0.0093	1.2141	0.2497	0.0010	0.0001	0.0001	0.0000	0.0006	0.0001	Subtotal	0.09	0.01	0.01	0.00	0.11	0.04	22.69	0.001	0.000	
Total																			0.10	0.01	0.01	0.00	0.12	0.04	26.49	0.001	0.000	



# 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 <sup>a</sup>

E (lb/VMT) =	k (s/12) <sup>a</sup> (W/3) <sup>b</sup>	Parameter	PM <sub>10</sub>	PM <sub>2.5</sub>
		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 <sub>ext</sub> = 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 <sup>b</sup>	50%	

<sup>a</sup> Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006

<sup>b</sup> 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/Zy/PURL.cgi?Dockey=20008SFC>.

Assumption: Avg. Frequency & Duration: three days, once in the first year;  
Equipment: Truck-mounted Unit: capacity **600 hp**, fuel **60 gpd**, hours/day **10**  
Truck: Type **WO rig**, Round trip mileage: 12 miles on unpaved road  
Max. number of crews in the field on a given day considering weekends and inclement weather: **15**

### 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 <sub>10</sub>			PM <sub>2.5</sub>		
							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	12	1	12	1	2.02	24.26	0.01	0.20	2.43	0.00
	Haul Truck	42	12	1	12	1	2.02	24.26	0.01	0.20	2.43	0.00
	Pickup Truck	5	12	3	36	1	0.78	27.93	0.01	0.08	2.79	0.00
Total									0.04			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 <sub>x</sub>	PM <sub>10</sub>	SO <sub>x</sub>	CO	VOC	PM2.5	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O <sup>a</sup>
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.

<sup>a</sup> Based on N<sub>2</sub>O 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 <sub>x</sub>	PM <sub>10</sub>	SO <sub>x</sub>	CO	VOC	NO <sub>x</sub>	PM <sub>10</sub>	SO <sub>x</sub>	CO	VOC	PM2.5	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> 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	0.0001	0.0001

## Exhaust emission factors for commuting vehicles

Vehicle		Emission Factors (g/mi)								
Type	Class	NO <sub>x</sub>	PM <sub>10</sub> <sup>a, b</sup>	PM <sub>2.5</sub> <sup>a, b</sup>	SO <sub>x</sub> <sup>a</sup>	CO	VOC	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O <sup>a</sup>
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

<sup>a</sup> Compendium of Greenhouse Gas Emission Methodologies for the Oil and Gas Industry, Table 4-17 for N<sub>2</sub>O (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 <sub>x</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	SO <sub>x</sub>	CO	VOC	NO <sub>x</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	SO <sub>x</sub>	CO	VOC	CO <sub>2</sub>	CH <sub>4</sub>
Well Workover	WO Rig	HDDV	80	1	80	1	0.479	0.049	0.041	0.002	0.304	0.062	0.000	0.000	0.000	0.000	0.000	0.0698	0.0000	0.0000
	Haul Truck	HDDV	80	1	80	1	0.479	0.049	0.041	0.002	0.304	0.062	0.000	0.000	0.000	0.000	0.000	0.0698	0.0000	0.0000
	Pickup Truck	LDDT	80	3	240	1	1.223	0.058	0.047	0.003	3.305	1.453	0.001	0.000	0.000	0.000	0.002	0.001	0.1083	0.0000
Performed once in the first year of well operation							Total	0.001	0.0001	0.0001	0.000	0.002	0.001	0.2480	0.0000	0.0000				

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 <sup>a</sup>			
$E \text{ (lb/VMT)} = \frac{k (s/12)^a (S/30)^b}{(M/0.5)^c} - C$		Parameter	PM <sub>10</sub>
		k	1.8
		a	1
		d	0.5
		c	0.2
E <sub>ext</sub> = E (1 - P/365)		PM <sub>2.5</sub>	0.18
			1
			0.5
			0.2
Function/Variable Description	Assumed Value	Reference	
E = size-specific emission factor (lb/VMT)			
E <sub>ext</sub> = 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 <sub>2.5</sub>	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4
	PM <sub>10</sub>	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 <sup>b</sup>	50%		

<sup>a</sup> Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006

<sup>b</sup> 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
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### **Emission Estimations for Road Traffic - RMP Year 20**

Activity	Vehicle Type <sup>a</sup>	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Federal Wells Producing	PM <sub>10</sub>		PM <sub>2.5</sub>	
							Emission Factor (lb/VMT)	Emissions		Emission Factor (lb/VMT)
								(lbs/well/yr)	(tons/yr/well)	
Inspection Visits for Wells	Pickup Truck	40	2	150	300	1	0.30	89.08	0.04	0.03
										8.87
										0.00

### **Exhaust Emissions from Site Visits and Inspections**

#### ***Emission factors for Commuting Vehicles Exhaust***

Vehicle Class	Emission Factors (g/mi)							
	NO <sub>x</sub>	PM <sub>10</sub> <sup>a, b</sup>	PM <sub>2.5</sub> <sup>a, b</sup>	SO <sub>x</sub> <sup>a</sup>	CO	VOC	CO <sub>2</sub>	N <sub>2</sub> O <sup>a</sup>
Light-Duty Gasoline Truck	1.13	0.03	0.01	0.01	23.97	1.07	476.9	0.02

Source: MOBILE 6.2.03

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

<sup>a</sup> Compendium of Greenhouse Gas Emission Methodologies for the Oil and Gas Industry, Table 4-17 for N<sub>2</sub>O (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)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Federal Wells Producing	Emissions														
	Type	Class					(lbs/well/yr)						(tons/yr/well)								
							NO <sub>x</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	SO <sub>x</sub>	CO	VOC	NO <sub>x</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	SO <sub>x</sub>	CO	VOC	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
Inspection Visits for Wells	Pickup Truck	LDGT2	2	150	300	1	0.75	0.02	0.01	0.01	15.85	0.71	0.00	0.00	0.00	0.00	0.01	0.00	0.1577	0.0000	0.0000

## OPERATIONS - ROAD MAINTENANCE

### Exhaust Emissions from Heavy Equipment and Support Vehicles for Road Maintenance Given Data

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

<sup>a</sup> Road maintenance would be made twice in summer and once in winter every year

<sup>b</sup> Assume a motor grader 135 Hp.

<sup>c</sup> 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) <sup>a</sup>	1.00
Number of Wells	1
Cumulative Length of Roads <sup>b</sup> (miles/operation)	1

<sup>a</sup> Source: SEIS

<sup>b</sup> 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
<b>Total</b>					<b>0</b>	<b>2</b>

### Emission Factors for Grading - Fugitive Dust

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

<sup>a</sup> 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 <sup>a</sup>	Mean Vehicle Speed (mph)	Total Miles Traveled	PM <sub>10</sub>		PM <sub>2.5</sub>	
					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

<sup>a</sup> 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 <sub>x</sub>	PM <sub>10</sub>	SO <sub>2</sub>	CO	VOC	PM <sub>2.5</sub>	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O <sup>a</sup>
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

<sup>a</sup> Based on N<sub>2</sub>O 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

Emission Estimations for Grader, RMR Year 20																	
Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours <sup>a</sup>	Emissions													
				(lbs/activity/hr)					(tons/well)								
				NO <sub>x</sub>	PM <sub>10</sub>	SO <sub>x</sub>	CO	VOC	NO <sub>x</sub>	PM <sub>10</sub>	SO <sub>x</sub>	CO	VOC	PM <sub>2.5</sub>	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> 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

<sup>a</sup> 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<sup>a</sup>

		Parameter	PM <sub>10</sub>	PM <sub>2.5</sub>
E (lb/VMT) = $\frac{k (s/12)^a (S/30)^d}{(M/0.5)^c} \cdot C$		k	1.8	0.18
		a	1	1
		d	0.5	0.5
E <sub>ext</sub> = E (1 - P/365)		c	0.2	0.2

  

Function/Variable Description	Assumed Value	Reference
E = size-specific emission factor (lb/VMT)		
E <sub>ext</sub> = 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 <sub>2.5</sub>	0.00036 EPA AP-42 Section 13.2.2, Table 13.2.2-4
	PM <sub>10</sub>	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 <sup>b</sup>	50%	

<sup>a</sup> Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006

<sup>b</sup> 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>.

### 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 <sub>10</sub>			PM <sub>2.5</sub>		
						Emission Factor	Emissions		Emission Factor	Emissions	
							(lbs/yr)	(tons/yr)		(lbs/yr)	(tons/yr)
Road Maintenance	Pickup Truck	40	6	0.2	1	0.30	0.33	0.00	0.03	0.03	0.00

### Emission Factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)								
	NO <sub>x</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	SO <sub>x</sub>	CO	VOC	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O <sup>a</sup>
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

<sup>a</sup> Compendium of Greenhouse Gas Emission Methodologies for the Oil and Gas Industry, Table 4-17 for N<sub>2</sub>O (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)								
	Type	Class				NO <sub>x</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	SO <sub>x</sub>	CO	VOC	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> 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

## Water Tank and Hauling Emissions

### Water Tank and Hauling Emissions

#### Oil Well Water Tank Flashing Emissions

Project Year	Flashing Loss Emission Factor (lbs CH <sub>4</sub> / 1000 bbl of water) <sup>a</sup>	Water Production (bbl/year/well)	CH <sub>4</sub> Emissions (ton/yr/well)
All	31.31	108000	1.69

<sup>a</sup> Average Conditions for Table 5-10 of the API Compendium of GHG Emissions Methodologies for the Oil and Gas Industry, August 2009.

#### Emission Factors for Road Traffic

$E \text{ (lb/VMT)} = \frac{k \text{ (s/12)}^n (S/30)^d}{(M/O.5)^2} \cdot C$		Parameter	PM <sub>10</sub>	PM <sub>2.5</sub>
E <sub>nat</sub> = E (1 - P/365)		k	1.8	0.18
		a	1	1
		d	0.5	0.5
		c	0.2	0.2
Function/Variable Description		Assumed Value	Reference	
E = size-specific emission factor (lb/VMT)				
E <sub>nat</sub> = 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 <sub>2.5</sub>	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4	
	PM <sub>10</sub>	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 <sup>b</sup>		50%		

<sup>a</sup> Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006

<sup>b</sup> 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/EPA/ZyPURL.cgi?Dockey=20008SFC>.

#### Fugitive Dust Emission Estimations for Road Traffic - Based on Water Produced Per Barrel of Oil

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	Annual # of Round Trips/Well	Miles Traveled/Well	Total # of Wells	Emission Factor (lb/VMT)	PM <sub>10</sub> Emissions		Emission Factor (lb/VMT)	PM <sub>2.5</sub> Emissions	
								(lb/year/well)	(tons/year/well)		(lb/year/well)	(tons/year/well)
Produced Water Hauling	Haul Truck (130 bbl)	30	12	831	9972	1	0.51	5127.81	2.56	0.05	510.01	0.26

Assume no dust control measures (watering) would be used

#### Emission Factors for Water Transport Vehicles - Road Traffic

Vehicle Class	Emission Factors (g/mi)								
	NO <sub>x</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	SO <sub>x</sub>	CO	VOC	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O <sup>a</sup>
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

<sup>a</sup> Based on N<sub>2</sub>O 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).

#### On-Road Exhaust Emission Estimations for Road Traffic - Based on Water Produced Per Barrel of Oil

Activity	Vehicle		Round Trip Distance (miles)	Annual # of Round Trips/Well	Miles Traveled/Well	Total # of Wells	Emissions														
	Type	Class					(lbs/well/yr)						(tons/yr/well)								
							NO <sub>x</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	SO <sub>x</sub>	CO	VOC	NO <sub>x</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	SO <sub>x</sub>	CO	VOC	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
Produced Water Hauling	Haul Truck (130 bbl)	HDDV	50	831	41550	1	248.787	25.208	21.041	1.209	157.645	32.427	0.124	0.013	0.011	0.001	0.079	0.016	36.265	0.002	0.000

## Oil Tank, Loadout and Hauling Emissions

### Oil Tank, Loadout and Hauling Emissions

#### Oil Well Oil Separator Flashing and Tank Emissions<sup>a</sup>

Project Year	Emissions <sup>b</sup>			
	HAPs Emissions (ton/yr/well)	VOC Emissions (ton/yr/well)	CO <sub>2</sub> Emissions (ton/yr/well)	CH <sub>4</sub> Emissions (ton/yr/well)
All	0.177	3.18	0.18	0.40

<sup>a</sup> Based on average of data from Montana BLM (Laakso, 2010) and calculations using E&P Tanks, July, 2010. Assumes 20 BOPD per well.

<sup>b</sup> Assumes no emissions control.

#### Oil Well Oil Truck Loadout VOC Emissions

Emissions were estimated based on EPA, AP-42 Section 5.2.2.1.1 Equation 1

$$L_L = 12.46 \frac{SPM}{T}$$

$L_L$  = Loading Loss pounds per 1000 gallons (lb/10<sup>3</sup> gal) of liquid loaded

$S$  = a saturation factor

$P$  = true vapor pressure of liquid loaded, pounds per square inch absolute (psia)

$M$  = molecular weight of vapors, pounds per pounds-mole (lb/lb-mole)

$T$  = temperature of bulk liquid loaded (F+460)

$S$ =	0.6 from EPA, AP-42 Section Table 5.2-1
$P$ =	3.4 from EPA, AP-42 Section Table 7.2-1
$M$ =	50 from EPA, AP-42 Section Table 7.2-1
$T$ =	540 ave. temp.

$$L_L = 2.35$$

#### Oil Well Oil Truck Loadout Emissions - All Project Years<sup>a</sup>

Project Year	Emission Factor (lbs/1,000 gallons)	Annual Oil Volume (bbl) - per well	Oil (1,000 gallons)	VOC Emissions (tpy/well)	CO <sub>2</sub> Emissions (tpy/well)	CH <sub>4</sub> Emissions (tpy/well)	HAPs Emissions (ton/yr/well)
All	2.35	78,840	3,311	3.90	0.01	0.00	0.29

<sup>a</sup> Uses E&P Tanks Stream Data for W&S Gas mol % (shown below). E&P Tanks input data from Montana BLM (Laakso, 2010)

#### Emission Factors for Work Over Vehicles - Road Traffic

Vehicle Class	Emission Factors (g/mi)						CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O <sup>a</sup>
	NO <sub>x</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	SO <sub>x</sub>	CO	VOC			
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

<sup>a</sup> Based on H<sub>2</sub>O emissions of 0.002 g per gallon fuel (based activity of 0.002 g per gallon fuel) from the "Compensation of On-Road Emission Interdependencies for the On-Road Gas Industry," Table 4-17 (2009).

#### On-Road Exhaust Emission Estimations for Road Traffic - Based on Produced Per Barrel of Oil

Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well	Miles Traveled/Well	Total # of Wells	Emissions														
	Type	Class					(lb/well)						(tons/year/well)								
							NO <sub>x</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	SO <sub>x</sub>	CO	VOC	NO <sub>x</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	SO <sub>x</sub>	CO	VOC	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
Produced Oil Hauling	Haul Truck (200 bbl)	HDDV	70	394	27594	1	165.223	16.741	13.973	0.803	104.694	21.535	0.0826	0.0084	0.0070	0.0004	0.0523	0.0108	24.084	0.001	0.000
TOTAL													0.0826	0.0084	0.0070	0.0004	0.0523	0.0108	24.0839	0.0011	0.0002

# Oil Tank, Loadout and Hauling Emissions

## W&S Composition for Truck Load Out Emissions

W&S Gas Component	Mole Fraction <sup>a</sup>	Molecular Weight	Gas Weight	Weight Percent
	(%)	(lb/lb-mol)	(lb/lb-mol)	(wt%)
Methane	0.000	16.040	0.000	0.000
Ethane	4.732	30.070	1.423	2.476
Nitrogen	0.000	28.020	0.000	0.000
Water	0.000	18.015	0.000	0.000
Carbon Dioxide	0.224	43.990	0.098	0.171
Nitrous Oxide	0.000	44.020	0.000	0.000
Hydrogen Sulfide	1.018	34.060	0.347	0.603
Non-reactive, non-HAP	5.974	---	1.868	3.250
Propane	27.635	44.100	12.187	21.203
Iso-butane	10.353	58.120	6.017	10.468
n-butane	25.191	58.120	14.641	25.473
i-pentane	8.741	72.150	6.307	10.972
n-pentane	9.278	72.150	6.694	11.647
Hexanes	3.874	100.210	3.882	6.754
Heptanes	2.680	100.200	2.685	4.671
Octanes	1.820	114.230	2.079	3.616
Nonanes	0.302	128.258	0.388	0.675
Decanes+	0.000	142.29	0.000	0.000
Reactive VOC	89.873	---	54.879	95.481
Benzene	0.325	78.110	0.254	0.441
Ethylbenzene	0.011	106.160	0.012	0.021
n-Hexane	3.334	100.210	3.341	5.813
Toluene	0.350	92.130	0.322	0.560
Xylenes	0.133	106.160	0.141	0.246
HAPs	4.153	---	4.070	7.082
Totals	100.000	---	57.476	100.000

<sup>a</sup> E&P Tanks Stream Data for W&S Gas mol %. E&P Tanks input data from Montana BLM (Laakso, 2010)



Recompletion Support Vehicles

Fugitive Dust Emissions from Recompletion Support Vehicles

Emission Factors for Industrial Unpaved Roads <sup>a</sup>			
E (lb/VMT) =		Parameter	PM <sub>10</sub>
k (g/12) <sup>a</sup> (W/3) <sup>b</sup>		k	1.5
		a	0.9
		b	0.45
E <sub>nat</sub> = E (1 - P/365)			PM <sub>2.5</sub>
			0.15
			0.9
			0.45
Function/Variable Description	Assumed Value	Reference	
E = size-specific emission factor (lb/VMT)			
E <sub>nat</sub> = 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 <sup>b</sup>	50%		

<sup>a</sup> Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006

<sup>b</sup> 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>.

## Recompletion Support Vehicles

### Fugitive Dust Emission Estimations for Road Traffic

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 <sub>10</sub>				PM <sub>2.5</sub>			
							Controlled Em. Factor	(lbs/vehicle/well)	(tons/year/well)	(tons/well)	Controlled Em. Factor	(lbs/vehicle/well)	(tons/year/well)	(tons/well)
Well Recompletion	Fuel Haul Truck	25	12	6	72	1	0.80	57.62	0.03	0.66	0.08	5.76	0.00	0.07
	Mud Haul Truck, Water Hauling	25	12	4	48	1	0.80	38.41	0.02		0.08	3.84	0.00	
	Rig Crew	5	12	51	612	1	0.39	237.38	0.12		0.04	23.74	0.01	
	Rig Mechanics	5	12	1	12	1	0.39	4.65	0.00		0.04	0.47	0.00	
	Co. Supervisor	5	12	20	240	1	0.39	93.09	0.05		0.04	9.31	0.00	
	Semi Completion, Unit Rig	42	12	1	12	1	1.01	12.13	0.01		0.10	1.21	0.00	
	Semi Fracing, Blender	25	12	1	12	1	0.80	9.60	0.00		0.08	0.96	0.00	
	Semi Pumping/Tank Battery	25	12	6	72	1	0.80	57.62	0.03		0.08	5.76	0.00	
	Tubing Truck	25	12	2	24	1	0.80	19.21	0.01		0.08	1.92	0.00	
	Haul Cementer, Pump Truck	25	12	2	24	1	0.80	19.21	0.01		0.08	1.92	0.00	
	Haul Cementer, Cement Truck	25	12	3	36	1	0.80	28.81	0.01		0.08	2.88	0.00	
	Haul Completion,	25	12	3	36	1	0.80	28.81	0.01		0.08	2.88	0.00	
	Haul Service Tools	25	12	2	24	1	0.80	19.21	0.01		0.08	1.92	0.00	
	Haul Perforators	25	12	1	12	1	0.80	9.60	0.00		0.08	0.96	0.00	
	Logging Truck	25	12	1	12	1	0.80	9.60	0.00		0.08	0.96	0.00	
	Haul Fracing, Tank	25	12	1	12	1	0.80	9.60	0.00		0.08	0.96	0.00	
	Haul Fracing, Pump	25	12	1	12	1	0.80	9.60	0.00		0.08	0.96	0.00	
	Haul Fracing, Chemical	25	12	1	12	1	0.80	9.60	0.00		0.08	0.96	0.00	
	Haul Fracing, Sand	25	12	1	12	1	0.80	9.60	0.00		0.08	0.96	0.00	
	Haul Fracing, Other	25	12	1	12	1	0.80	9.60	0.00		0.08	0.96	0.00	
	Haul Water Truck	25	12	50	600	1	0.80	480.16	0.24		0.08	48.02	0.02	
	Pickup Cementer, Engineer	5	12	2	24	1	0.39	9.31	0.00		0.04	0.93	0.00	
	Pickup Casing Crew	5	12	5	60	1	0.39	23.27	0.01		0.04	2.33	0.00	
	Pickup Completion, Pusher	5	12	5	60	1	0.39	23.27	0.01		0.04	2.33	0.00	
	Pickup Perforators, Engineer	5	12	2	24	1	0.39	9.31	0.00		0.04	0.93	0.00	
	Pickup Fracing, Engineer	5	12	1	12	1	0.39	4.65	0.00		0.04	0.47	0.00	
	Pickup Co. Supervisor	5	12	10	120	1	0.39	46.55	0.02		0.04	4.65	0.00	
	Pickup Miscellaneous Supplies	5	12	3	36	1	0.39	13.96	0.01		0.04	1.40	0.00	
	Pickup Roustabout Crew	5	12	4	48	1	0.39	18.62	0.01		0.04	1.86	0.00	
							Subtotal		0.66				0.07	
							Total		0.66				0.07	

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

### Exhaust Emissions from Recompletion Support Vehicles

#### Emission Factors for Commuting Vehicles

Vehicle		Emission Factors (g/mi)								
Type	Class	NO <sub>x</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	SO <sub>x</sub>	CO	VOC	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O*
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

\* Compendium of Greenhouse Gas Emission Methodologies for the Oil and Gas Industry, Table 4-17 for N<sub>2</sub>O (HDDV moderate control, LDGT oxidation catalyst, LDDT moderate control) , Mobile Source Combustion Factors, American Petroleum Institute (2009).

# Recompletion Support Vehicles

## 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 <sub>x</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	SO <sub>2</sub>	CO	VOC	NO <sub>x</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	SO <sub>2</sub>	CO	VOC	NO <sub>x</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	SO <sub>2</sub>	CO	VOC	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
Well Recompletion	Fuel Haul Truck	HDDV	80	6	480	1	2.8741	0.2912	0.2431	0.0140	1.8212	0.3746	0.0014	0.0001	0.0001	0.0000	0.0009	0.0002	0.04	0.00	0.00	0.00	0.07	0.03	0.4	0.0000	0.0000
	Mud Haul Truck, Water Hauling	HDDV	80	4	320	1	1.9160	0.1941	0.1620	0.0093	1.2141	0.2497	0.0010	0.0001	0.0001	0.0000	0.0006	0.0001							0.3	0.0000	0.0000
	Rig Crew	LDDT	80	51	4080	1	20.7958	0.9777	0.7960	0.0504	56.1899	24.7085	0.0104	0.0005	0.0004	0.0000	0.0281	0.0124							1.8	0.0000	0.0001
	Rig Mechanics	HDDV	80	1	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000
	Co. Supervisor	LDDT	80	20	1600	1	8.1552	0.3834	0.3122	0.0198	22.0353	9.6896	0.0041	0.0002	0.0002	0.0000	0.0110	0.0048							0.7	0.0000	0.0000
	Semi Completion, Unit Rig	HDDV	80	1	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000
	Semi Fracing, Blender	HDDV	80	1	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000
	Semi Pumping/Tank Battery	HDDV	80	6	480	1	2.8741	0.2912	0.2431	0.0140	1.8212	0.3746	0.0014	0.0001	0.0001	0.0000	0.0009	0.0002							0.4	0.0000	0.0000
	Tubing Truck	HDDV	80	2	160	1	0.9580	0.0971	0.0810	0.0047	0.6071	0.1249	0.0005	0.0000	0.0000	0.0000	0.0003	0.0001							0.1	0.0000	0.0000
	Haul Cementer, Pump Truck	HDDV	80	2	160	1	0.9580	0.0971	0.0810	0.0047	0.6071	0.1249	0.0005	0.0000	0.0000	0.0000	0.0003	0.0001							0.1	0.0000	0.0000
	Haul Cementer, Cement Truck	HDDV	80	3	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	0.0000	0.0000
	Haul Completion, Equip Truck	HDDV	80	3	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	0.0000	0.0000
	Haul Service Tools	LDDT	80	2	160	1	0.8155	0.0383	0.0312	0.0020	2.2035	0.9690	0.0004	0.0000	0.0000	0.0000	0.0011	0.0005							0.2	0.0000	0.0000
	Haul Perforators Logging Truck	HDDV	80	1	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000
	Haul Fracing, Tank	HDDV	80	1	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000
	Haul Fracing, Pump	HDDV	80	1	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000
	Haul Fracing, Chemical	HDDV	80	1	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000
	Haul Fracing, Sand	HDDV	80	1	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000
	Haul Fracing, Other	HDDV	80	1	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000
	Haul Water Truck	HDDV	80	50	4000	1	23.9506	2.4268	2.0256	0.1164	15.1764	3.1217	0.0120	0.0012	0.0010	0.0001	0.0076	0.0016							3.5	0.0002	0.0000
	Pickup Cementer, Engineer	LDDT	80	2	160	1	0.8155	0.0383	0.0312	0.0020	2.2035	0.9690	0.0004	0.0000	0.0000	0.0000	0.0011	0.0005							0.1	0.0000	0.0000
	Pickup Completion Crew	HDDV	80	5	400	1	2.3951	0.2427	0.2026	0.0116	1.5176	0.3122	0.0012	0.0001	0.0001	0.0000	0.0008	0.0002							0.3	0.0000	0.0000
	Pickup Completion, Pusher	LDDT	80	5	400	1	2.0388	0.0959	0.0780	0.0049	5.5088	2.4224	0.0010	0.0000	0.0000	0.0000	0.0028	0.0012							0.2	0.0000	0.0000
	Pickup Perforators, Engineer	LDDT	80	2	160	1	0.8155	0.0383	0.0312	0.0020	2.2035	0.9690	0.0004	0.0000	0.0000	0.0000	0.0011	0.0005							0.1	0.0000	0.0000
	Pickup Fracing, Engineer	HDDV	80	1	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000
	Pickup Co. Supervisor	LDDT	80	10	800	1	4.0776	0.1917	0.1561	0.0099	11.0176	4.8448	0.0020	0.0001	0.0001	0.0000	0.0055	0.0024							0.4	0.0000	0.0000
	Pickup Miscellaneous Supplies	LDDT	80	3	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							0.1	0.0000	0.0000
	Pickup Roustabout Crew	HDDV	80	4	320	1	1.9160	0.1941	0.1620	0.0093	1.2141	0.2497	0.0010	0.0001	0.0001	0.0000	0.0006	0.0001							0.3	0.0000	0.0000
Subtotal																	0.04	0.00	0.00	0.00	0.07	0.03	10.06	0.000	0.000		
Total																	0.04	0.00	0.00	0.00	0.07	0.03	10.06	0.000	0.000		

# OPERATIONS - VENTING

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	65.450	16.040	10.498	42.544	18064.029	7.117
Ethane	15.330	30.070	4.610	18.681	7931.881	3.125
Nitrogen	3.260	28.020	0.913	3.702	1571.760	0.619
Water	0.000	18.015	0.000	0.000	0.000	0.000
Carbon Dioxide	0.620	43.990	0.273	1.105	469.295	0.185
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
<b>Non-reactive, non-HAP</b>	<b>84.660</b>	<b>---</b>	<b>16.294</b>	<b>66.031</b>		<b>11.046</b>
Propane	7.890	44.100	3.479	14.101	5987.096	2.359
Iso-butane	1.370	58.120	0.796	3.227	1370.083	0.540
n-butane	3.360	58.120	1.953	7.914	3360.203	1.324
i-pentane	1.000	72.150	0.722	2.924	1241.472	0.489
n-pentane	1.040	72.150	0.750	3.041	1291.131	0.509
Hexanes	0.680	100.210	0.681	2.761	1172.521	0.462
Heptanes	0.000	100.200	0.000	0.001	0.529	0.000
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
<b>Reactive VOC</b>	<b>15.340</b>	<b>---</b>	<b>8.382</b>	<b>33.969</b>		<b>5.682</b>
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 <sup>3</sup>	0.680	100.210	0.681	2.761	1172.521	0.462
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
<b>HAPs</b>	<b>0.680</b>	<b>---</b>	<b>0.681</b>	<b>2.761</b>		<b>0.462</b>
<b>Totals</b>	<b>100.000</b>	<b>---</b>	<b>24.676</b>	<b>100.000</b>		<b>16.729</b>

Oil well natural gas analysis for Formation: Madison, Lease: Berry 11-4

Volume Flow: 1216 SCF / bbl oil

BBL oil / day: 216 bbl oil / day

Completion activity duration: 3 days

Total Completion/Recompletion

Volume Flow per Well 0.787968 MMSCF/well

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

Venting Emissions from Well Re-Completion Activities (applied to 5% of operating wells)

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	65.450	16.040	10.498	42.544	18064.029	7.117
Ethane	15.330	30.070	4.610	18.681	7931.881	3.125
Nitrogen	3.260	28.020	0.913	3.702	1571.760	0.619
Water	0.000	18.015	0.000	0.000	0.000	0.000
Carbon Dioxide	0.620	43.990	0.273	1.105	469.295	0.185
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
<b>Non-reactive, non-HAP</b>	<b>84.660</b>	<b>---</b>	<b>16.294</b>	<b>66.031</b>		<b>11.046</b>
Propane	7.890	44.100	3.479	14.101	5987.096	2.359
Iso-butane	1.370	58.120	0.796	3.227	1370.083	0.540
n-butane	3.360	58.120	1.953	7.914	3360.203	1.324
i-pentane	1.000	72.150	0.722	2.924	1241.472	0.489
n-pentane	1.040	72.150	0.750	3.041	1291.131	0.509
Hexanes	0.680	100.210	0.681	2.761	1172.521	0.462
Heptanes	0.000	100.200	0.000	0.001	0.529	0.000
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
<b>Reactive VOC</b>	<b>15.340</b>	<b>---</b>	<b>8.382</b>	<b>33.969</b>		<b>5.682</b>
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 <sup>3</sup>	0.680	100.210	0.681	2.761	1172.521	0.462
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
<b>HAPs</b>	<b>0.680</b>	<b>---</b>	<b>0.681</b>	<b>2.761</b>		<b>0.462</b>
<b>Totals</b>	<b>100.000</b>	<b>---</b>	<b>24.676</b>	<b>100.000</b>		<b>16.729</b>

# OPERATIONS - COMPRESSOR

## Compressor Stations Emissions

### Emission Factors for Natural Gas-Fired Compressors and Pumps

Compressor / Pump		Horse-Power Rating	Units	Emission Factors									
				NO <sub>x</sub> <sup>a</sup>	PM <sub>10</sub> <sup>b</sup>	SO <sub>2</sub> <sup>b</sup>	CO <sup>a</sup>	VOC <sup>a</sup>	PM <sub>2.5</sub> <sup>b</sup>	CO <sub>2</sub> <sup>c</sup>	CH <sub>4</sub> <sup>c</sup>	HCHO <sup>b</sup>	N <sub>2</sub> O <sup>c</sup>
Compression Station	Lean 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
Oil Pump at Well Head	Lean Burn	40	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

<sup>a</sup> Source: assume compressors will comply with NSPS 40 CFR part 60 subpart JJJJ

<sup>b</sup> Source: EPA, AP-42 Section 3.2 Natural Gas Fired Reciprocating Engines

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

<sup>c</sup> EPA Mandatory GHG Reporting, Part 98, Subpart C, Tables C-1 and C-2.

### Emission Estimations for Compressors and Pumps - All Years

Emission Estimations for Compressors and Pumps - All Years					Emissions (tons/year/well)									
Type of Compressors / Pumps	Rate (Hp/well)	Annual # of Wells in Production	Annual Compression (Hp)	Operating Hours/Year	NOx	PM <sub>10</sub>	SO <sub>2</sub>	CO	VOC	PM <sub>2.5</sub>	CO <sub>2</sub>	CH <sub>4</sub>	HCHO	N <sub>2</sub> O
Compression Station	7.5	1.00	7.5	8,760	0.07	0.00	0.00	0.14	0.05	0.00	9.8	0.00	0.00	0.00
Oil Pump at Well Head	40	1.00	40	8,760	0.39	0.02	0.00	0.77	0.27	0.02	52.1	0.00	0.02	0.00
Total					0.46	0.02	0.00	0.92	0.32	0.02	61.9	0.00	0.03	0.00

HCHO = Formaldehyde

Compression rate of 5 compressors (300 hp each) per 200 wells based on BLM survey (Laakso, 2010)

Typical oil well head pump of 40 hp per BLM survey (Laakso, 2010)

### Compressor Station Fugitives

#### Fugitive Emissions from Equipment Leaks

Well Equipment Component	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% = 33.97

CO<sub>2</sub> Wt% = 1.11

CH<sub>4</sub> Wt% = 42.54

N<sub>2</sub>O Wt% = 0.00

### Emissions from Equipment Leaks at Compressor Station 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 <sub>2</sub> emissions per well (lb/hr)	CH <sub>4</sub> emissions per well (lb/hr)
valves	0.175	0.0099	0	0.0055	0	0.0002	0.002	0.001	0.000	0.001
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	0.250	0.0004	0	0.0005	0	0.0002	0.000	0.000	0.000	0.000
flanges	0.600	0.0009	0	0.0002	0	0.0000	0.001	0.000	0.000	0.000
open-ended lines	0.000	0.0044	0	0.0031	0	0.0006	0.000	0.000	0.000	0.000
<b>TOTAL emissions/well/hr =</b>							<b>0.002</b>	<b>0.001</b>	<b>0.000</b>	<b>0.001</b>

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)	CO <sub>2</sub> emissions (lb/yr)	CH <sub>4</sub> emissions (lb/yr)	CH <sub>4</sub> emissions (ton/yr)
Year 20	1	8760	7.03	0.00	0.23	0.00

## 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/m<sup>2</sup>/yr)     $M$  = Disturbed area (m<sup>2</sup>)  
 $U^*$  = Friction velocity (m/s)     $N$  = # of disturbances  
 $U_t$  = threshold velocity (m/s)     $k$  = 0.5 for PM<sub>10</sub>  
 $U_{10}$  = fastest wind speed (m/s)     $k$  = 0.075 for PM<sub>2.5</sub>

$U_{10}$  = 25.80    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 <sup>2</sup> /yr)	Road Erosion Potential ( $P$ ) (g/m <sup>2</sup> /yr)	Peak # of Wells Drilled per year	Average Disturbed acres per well *	Disturbed Area ( $M$ ) (m <sup>2</sup> )	Number of Disturbances ( $N$ )	PM <sub>10</sub> Emissions (tons/year/ well)	PM <sub>2.5</sub> Emissions (tons/year/ well)
Well pad construction	25.80	1.37	15.68		1.00	2.00	8096.65	1.00	0.07	0.01
Road and Pipeline Construction	25.80	1.37		1.02	1.00	0.30	1214.50	1.00	0.00	0.00
<b>TOTAL</b>									<b>0.07</b>	<b>0.01</b>

\* Average disturbed area shown in SEIS

## 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 <sup>a</sup>	Heavy Equipment	Diesel	100	N/A	10
	Commuting Vehicle	Gasoline	225	6	2

<sup>a</sup> 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	0.093
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
0.000	6	0.0000	0.0000
<b>Total</b>			<b>0</b>

Assume average miles/day = 6

## Emission Factors for 75-100 hp Off-Road Engines

Year	Emission Factors (g/hp-hr)								
	NO <sub>x</sub>	PM <sub>10</sub>	SO <sub>2</sub>	CO	VOC	PM <sub>2.5</sub>	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O <sup>a</sup>
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

<sup>a</sup> Emissions of PM<sub>2.5</sub> were assumed to be the same as those for PM<sub>10</sub>.

<sup>a</sup> Compendium of Greenhouse Gas Emission Methodologies for the Oil and Gas Industry, Table 4-17 for N<sub>2</sub>O (HDDV moderate control, LDGT oxidation catalyst, LDDT moderate control) , Mobile Source Combustion Factors, American Petroleum Institute (2009).

## Exhaust Emissions Estimation for Grader Road Reclaim

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions													
				(lbs/hour)					(tons/year/well)								
				NO <sub>x</sub>	PM <sub>10</sub>	SO <sub>x</sub>	CO	VOC	NO <sub>x</sub>	PM <sub>10</sub>	SO <sub>x</sub>	CO	VOC	PM <sub>2.5</sub>	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> 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	0.0000	0.0000	0.0000	0.0000

## Exhaust Emission Factors for Commuting Reclaim Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)								
	NO <sub>x</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	SO <sub>x</sub>	CO	VOC	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O <sup>a</sup>
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

<sup>a</sup> Compendium of Greenhouse Gas Emission Methodologies for the Oil and Gas Industry, Table 4-17 for N<sub>2</sub>O (HDDV moderate control, LDGT oxidation catalyst, LDDT moderate control) , Mobile Source Combustion Factors, American Petroleum Institute (2009).

Sheet Not used

RECLAMATION

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 <sub>x</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	SO <sub>x</sub>	CO	VOC	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> 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 <sub>x</sub>	PM <sub>10</sub>	SO <sub>x</sub>	CO	VOC	NO <sub>x</sub>	PM <sub>10</sub>	SO <sub>x</sub>	CO	VOC	PM <sub>2.5</sub>	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> 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	0.0000	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 <sub>x</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	SO <sub>x</sub>	CO	VOC	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> 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

### Emissions for Gas Dehydration

#### Emission Factors for Dehydrator Heaters

Unit	NO <sub>x</sub>	PM <sub>10</sub>	SO <sub>2</sub>	CO	VOC	PM <sub>2.5</sub>	CO <sub>2</sub>	CH <sub>4</sub>	HCHO	N <sub>2</sub> 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 <sup>a</sup>	Dehydrator Heater Size MMBtu/Hour	Fuel Usage MMCF/Year	Number of Dehydrator Stations / Well	Emissions (tons/year/well)									
				NO <sub>x</sub>	PM <sub>10</sub>	SO <sub>2</sub>	CO	VOC	PM <sub>2.5</sub>	CO <sub>2</sub>	CH <sub>4</sub>	HCHO	N <sub>2</sub> O
2,190	1	2.20	0.008	0.0008	0.0001	0.0000	0.0007	0.0000	0.0000	0.9910	0.0000	0.0000	0.0000

Values from Montana BLM (Laakso, 2010)

#### Annual Dehydrator Venting and Tank Flashing Emissions

Annual Well Gas Production MMscf	CH <sub>4</sub> Emission Factor (ton per MMscf)	CH <sub>4</sub> Emissions (TPY/well)	VOC Emission Factor (ton per MMscf)	VOC Emissions (TPY/well)	HAPs Emission Factor (ton per MMscf)	HAPs Emissions (TPY/well)
95.87	0.011	1.027	0.016	1.534	0.002	0.190

Gas analysis and dehydration process information provided by Montana BLM (Laakso, 2010)

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)